CIRA ANNUAL REPORT FY 2014/2015

(Reporting Period July 1, 2014 – March 31, 2015)

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE

DIRECTOR'S MESSAGE

The Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU) is one of a number of cooperative institutes (CIs) that support NOAA's mission. Although this mission continues to evolve, there continue to be strong reasons for partnering between NOAA and the fundamental research being done in the University environment and the students it entrains into NOAA's mission. Strengthening these ties in satellite remote sensing and regional/global weather and climate prediction, as well as application development, education/training, data assimilation, and data distribution technology make CIRA a valuable asset to NOAA. As the Director of CIRA, I have tried to do everything possible to strengthen CIRA's ties not only among CSU's Department of Atmospheric Science, the College of Engineering, and the University, but also the ties among the different groups within CIRA that now covers researchers in Fort Collins and College Park associated with NESDIS, researchers in Boulder working closely with OAR and researchers in Kansas City working with the National Weather Service. With a renewed emphasis on interactions and joint initiatives, we are expanding our collaboration to bring more satellite data to bear upon model evaluations such as we are doing with the High Impact Weather Prediction Project or our new Data Assimilation that are bringing the satellite knowledge gained at the Fort Collins facility to bear on CIRA's Boulder and College Park groups. With this, we hope to fulfill the promise of being the conduit for developing ground breaking research to address socially-relevant problems that face NOAA and our society today as well as to help train a new workforce that has a broader perspective needed to continue developing decision support tools guided by scientific advances.

CIRA is fortunate in that its corporate culture and proximity to many of the Nation's top research institutions have allowed it to work with talented researchers and support staff who continue to perform at the highest possible level. There are many important accomplishments that are highlighted in this report and summarized in the executive summary. Not as obvious, but equally important, are the activities that CIRA carries out with the National Park Service, and the activities with NASA through the CloudSat data processing facility and OCO algorithm development. While not funded by NOAA, these activities are highly synergistic in the areas of algorithm development, modeling and data distribution. They allow CIRA researchers working on exciting new satellite data such as Suomi/NPP's VIIRS instrument to have access to other experts with whom they can consult as they develop their own projects. This progress report constitutes the first full year of reporting under the second 5-year term of the Cooperative Agreement. With it, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship with NOAA, other National programs, the Department of Atmospheric Science at CSU, and the University as a whole.

Christian D. Kummerow

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE

The Cooperative Institute for Research in the Atmosphere (CIRA) was established in 1980 at Colorado State University (CSU). CIRA serves as a mechanism to promote synergisms between University scientists and those in the National Oceanic and Atmospheric Administration (NOAA). Since its inception, CIRA has expanded and diversified its mission to coordinate with other Federal agencies, including the National Aeronautics and Space Administration (NASA), the National Park Service (NPS), the U.S. Forest Service, and the Department of Defense (DoD). CIRA is a multi-disciplinary research institute within the College of Engineering (CoE) and encompasses several cooperative agreements, as well as a substantial number of individual grants and contracts. The Institute's research for NOAA is concentrated in five theme areas and two cross-cutting research areas:

Satellite Algorithm Development, Training and Education - Research associated with development of satellite-based algorithms for weather forecasting, with emphasis on regional and mesoscale meteorological phenomenon. This work includes applications of basic satellite products such as feature track winds, thermodynamic retrievals, sea surface temperature, etc., in combination with model analyses and forecasts, as well as in situ and other remote sensing observations. Applications can be for current or future satellites. Also under this theme, satellite and related training material will be developed and delivered to a wide variety of users, with emphasis on operational forecasters. A variety of techniques can be used, including distance learning methods, web-based demonstration projects and instructor-led training.

Regional to Global Scale Modeling Systems - Research associated with the improvement of weather/climate models (minutes to months) that simulate and predict changes in the Earth system. Topics include atmospheric and ocean dynamics, radiative forcing, clouds and moist convection, land surface modeling, hydrology, and coupled modeling of the Earth system.

Data Assimilation - Research to develop and improve techniques to assimilate environmental observations, including satellite, terrestrial, oceanic, and biological observations, to produce the best estimate of the environmental state at the time of the observations for use in analysis, modeling, and prediction activities associated with weather/climate predictions (minutes to months) and analysis.

Climate-Weather Processes - Research focusing on using numerical models and environmental data, including satellite observations, to understand processes that are important to creating environmental changes on weather and short-term climate timescales (minutes to months) and the two-way interactions between weather systems and regional climate.

Data Distribution - Research focusing on identifying effective and efficient methods of quickly distributing and displaying very large sets of environmental and model data using data networks, using web map services, data compression algorithms, and other techniques.

Cross-Cutting Area 1: Assessing the Value of NOAA Research via Societal/Economic Impact Studies - Consideration for the direct and indirect impacts of weather and climate on society and infrastructure. Providing metrics for assessing the value of NOAA/CI research and tools for planners and decision makers. Achieving true 'end-to-end' systems through effective communication of information to policy makers and emergency managers.

Cross-Cutting Area 2: Promoting Education and Outreach on Behalf of NOAA and the University - Serving as a hub of environmental science excellence at CSU for networking resources and research activities that align with NOAA mission goals throughout the University and with its industrial partners. Engaging K-12 and the general public locally, regionally, nationally and internationally to promote both awareness and informed views on important topics in environmental science.

Annually, CIRA scientists produce over 200 scientific publications, 30% of which appear in peer-reviewed publications. Among the important research being performed at CIRA is its support of NESDIS' next-generation satellite programs: GOES-R and NPOESS. These two multi-billion dollar environmental satellite programs will support weather forecasting and climate monitoring for the next 2-3 decades. They will include vastly improved sensors and will offer higher-frequency data collection. CIRA research is building prototype products and developing training, based on the new sensor technology, to assure maximum exploitation of these data when the sensors are launched.

CIRA EDUCATION, TRAINING AND OUTREACH ACTIVITIES: 2014-2015

From the CIRA Mission Statement: *"Important bridging elements of the CI include the communication of research findings to the international scientific community, transition of applications and capabilities to NOAA operational users, education and training programs for operational user proficiency, outreach programs to K-12 education and the general public for environmental literacy, and understanding and quantifying the societal impacts of NOAA research."*

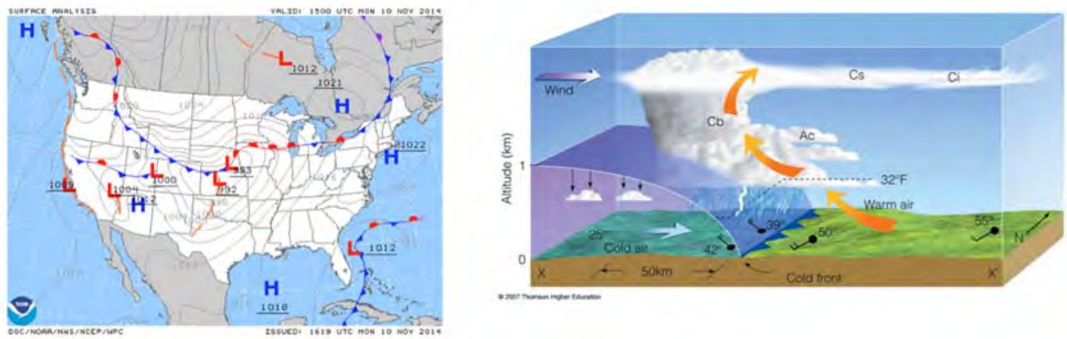
Outreach and Education at CIRA Enters a New Era

2014 saw a new year for education and outreach efforts at CIRA, with new opportunities and new audiences for CIRA research and science to reach. New partnerships with educational and professional organizations made in 2014 provide new avenues of collaboration, which coupled with an increase in funding opportunities for education and outreach programs in 2015, offer some exciting new potential areas of growth for both outreach and science alike.

Teacher Professional Development: Fifth-Grade Weather Standard

One of the key ways CIRA has continued to develop is through involvement in teacher professional development programs. The forthcoming Next Generation Science Standards (NGSS), currently being adopted by states nationwide, specify comprehensive metrics for understanding climate and weather patterns as part of the Earth Science component across grade levels; the fifth- and sixth-grade weather standards, in particular, offer challenges to teachers unaccustomed to the background of synoptic meteorology. While the rigor of the standards will ultimately provide a high bar for learning in the United States, getting teachers up to speed so they can effectively teach to that standard is an ongoing challenge in the education arena.

CIRA's expertise in both atmospheric science and in education and outreach makes CIRA positioned extremely well to address this issue. Spinning up a draft program offered previously, CIRA education and outreach coordinator Matt Rogers offered two in-person and one email training session on the fundamentals of weather for fifth-grade teachers, breaking down the complex mechanisms behind the Earth's changing weather and climate system into a format more easily understood by teachers, and then mapping this knowledge set to the standards teachers are to meet in their classroom. By getting the teachers on top of the material first and foremost, this approach empowers instructors and helps improve classroom efficiency.



Component	Before	During	After
Temperature	Warm	Sudden decrease	Steady drop
Pressure	Steady decrease	Bottoms out, rises	Rising
Winds	South/southwesterly	Gusty, shifting	Northerly, westerly
Humidity (RH)	Lower	Sudden increase	Higher
Clouds	Some cirrus, then Cb	TCu or Cb	Cu, clearing
Precipitation	Possible short showers	Heavy rain/snow	clearing

Figure 1. Breakdown of weather basics related to observations required by the fifth-grade NGSS Earth Science standard for weather and climate. Mapping of changes in six variables as a function of cold-front passage, with relevant diagrams, is shown here.

One of the primary goals of CIRA's E&O efforts here is to highlight the role of the scientist as a subject-matter-expert (SME) in engaging with standards-based education – as educational models continue to move towards a 'meet the standard' approach, educators are increasingly tasked with becoming experts on topical issues in which they have little or no background. Developing a method for breaking down scientific content into formats accessible by teachers to ensure success in the standards-based education model is the ultimate goal of CIRA's efforts in this arena. CIRA presented work detailing an early version of this method at the 2014 Fall Meeting of the AGU. Continued development of this project should be applicable to all Earth Science disciplines, with CIRA envisioned to continue leading the way in this important and difficult task.

CIRA Webpage and Social Media

2014 also saw the redevelopment of its presence online with a revamped webpage. Initiated as a response to the five-year review, content from the webpage was reorganized to fit an improved navigational system, reducing redundancies and improving access to CIRA content. The new website, powered by the Drupal content management system, was developed by Rob Viola with input from the entire CIRA staff, and features a vastly improved login system. Additionally, the new CIRA webpage features WYSIWYG editing functions with assignable editorial roles for CIRA staff, reducing the load on the CIRA webmaster and allowing direct control over website content by responsible CIRA personnel. Publications, budget and personnel, presentations and conferences, and news articles are now directly updateable by CIRA staff responsible for creating said content, which improves the speed at which content is updated on the website.

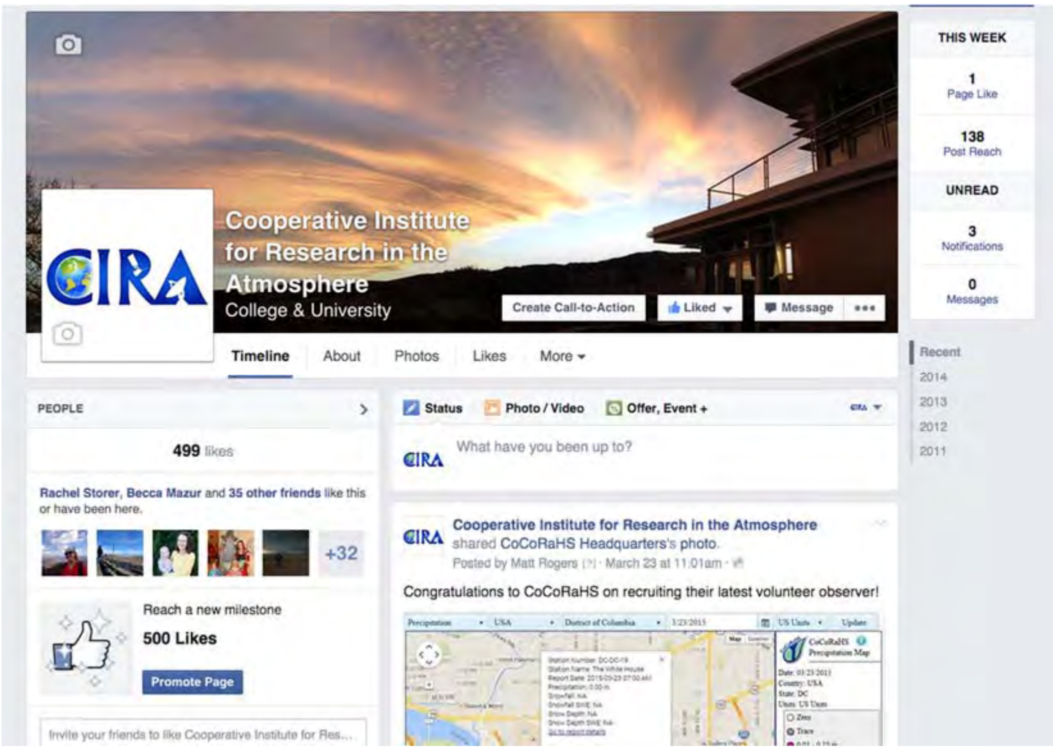


Figure 2. CIRA's Facebook feed, reaching hundreds of followers and offering new and faster connections to traditional media for CIRA science.

CIRA continued its online presence in the social media world through continued postings on Facebook. Notable events included several postings of satellite-remotely sensed observations of severe cyclones in the West Pacific, notably Typhoons Rammasun and Hagupit. The evolving role of social media in the news cycle became apparent as several of CIRA's Facebook posts made appearances in the Washington Post, among other publications, increasing the visibility of CIRA products and researchers and leading to several interviews and follow-ups. CIRA will continue to develop a social media presence and better integrate our content with those from other CIs and across NOAA in 2015.

Collaborations

Little Shop of Physics

CIRA continued its long and prosperous partnership with the Little Shop of Physics in 2014. Supported by the NSF-funded Center for Multiscale Modeling of Atmospheric Processes and the CSU Physics Department, the Little Shop of Physics (online at http://littleshop.physics.colostate.edu) develops hands-on demonstrations of physical concepts for the K-12 audience and supports professional development and science education for K-12 teachers. Utilizing undergraduate and graduate student volunteers, the Little Shop of Physics tours nationally, bringing science demonstrations to a large audience. Additionally, the Little Shop produces a cable-access TV program, also available online, and presents demonstrations at national conferences including the AMS and NSTA Annual Meetings, and hosts an annual Open House on the CSU Campus that draws nearly 10,000 participants.

Fort Collins Museum of Discovery

CIRA developed a new partnership with the Fort Collins Museum of Discovery (FCMoD), partnering with the Department of Atmospheric Science at Colorado State University to host an atmosphere-themed Earth Day on April 18th, 2014. Featuring several radiosonde launches, presentations, and activities led by CIRA researchers and staff, the event drew more than a hundred participants. Future activities with the FCMoD are planned, including potential museum exhibits and public presentations of CIRA research potentially hosted at the Museum.

AMS: FORTCAST

The redevelopment of the student chapter of the American Meteorological Society (AMS) at Colorado State University into a full-fledged local chapter, including professional and academic members, led to a renaissance in CIRA involvement with the organization. The FORT Collins Atmospheric ScienTists (FORTCAST) chapter of the AMS began meeting regularly in late 2013 and developed the majority of its programs in 2014. CIRA E&O Coordinator Matt Rogers currently serves as the Education and Outreach Chair of FORTCAST and has had success leveraging CIRA activities and researchers along with interest from the student side of the chapter into enhanced outreach activities benefiting the chapter and CIRA alike.

With the assistance of FORTCAST volunteers, CIRA's traditional involvement with such activities as Club Tres, an after-school program benefiting low-income students in the Poudre School District, has drastically increased the involvement of scientists and graduate students in community education and outreach. FORTCAST recently took 3rd place in the AMS Annual Meeting poster competition based on CIRA-involved activities and continued partnership between CIRA and FORTCAST is expected to bear additional fruit throughout 2015.

Community Outreach

After-school weather club: Scientists at CIRA and CSU students – all members of the local AMS chapter of Northern Colorado called FORTCAST (Fort Collins Atmospheric Scientists) volunteered for the weekly after-school weather club on Tuesdays for Putnam Elementary (K-5). The fall session ran for 8 weeks during October through early December 2014. There was a 90 minute session each week. Sessions included helping with homework and leading an activity. The topics covered included wind speed and direction, clouds, colors of the rainbow, lightning, angular momentum, arctic ice, freezing solids (ice cream!), as well as measurements that are associated with these weather occurrences. Volunteers included Bernie Connell, Matt Rogers, Doug Stolz, Erin Dagg, Marie McGraw, and Melissa Burt. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!

A presentation on GOES and GOES-R and the characteristics of its channels was given to a Remote Sensing/ Geographic Information Systems class at the Metropolitan State University of Denver on November 30. Since their Remote Sensing class focuses mainly on earth resource topics, the students were presented with the perspective of how meteorologists view and use satellite imagery.

Interaction with World Meteorological Organization Regional Training Centers through the WMO Virtual Laboratory

CIRA is an active member of the World Meteorological Organization (WMO) Virtual Laboratory (VLab) and collaborates with WMO Regional Training Centers (RTC) in Costa Rica, Barbados, Argentina, and Brazil to promote satellite focused training activities. One of our most productive activities with these RTCs continues to be providing support to monthly virtual weather/satellite briefings. Our group is the WMO Focus Group of the Americas and the Caribbean and we are a model group for other WMO

countries. Participation in our monthly virtual satellite weather briefings is an easy and inexpensive way to simultaneously connect people from as many as 32 different countries, view imagery from Geostationary and polar orbiting satellites, and share information on global, regional, and local real time and climatic weather patterns, hurricanes, severe weather, flooding, and even volcanic eruptions. Forecasters and researchers are able to “build capacity” by being able to readily communicate with others in their discipline from different countries and discuss the impacts of their forecasts or impacts of broad reaching phenomena such as El Niño. Participants view the same imagery (geostationary and polar orbiting) using the VISITview tool and utilize GoToWebinar for voice over the Internet. For more information on various RTC activities and recording of the sessions, visit:
http://rammb.cira.colostate.edu/training/rmtc/focusgroup.asp

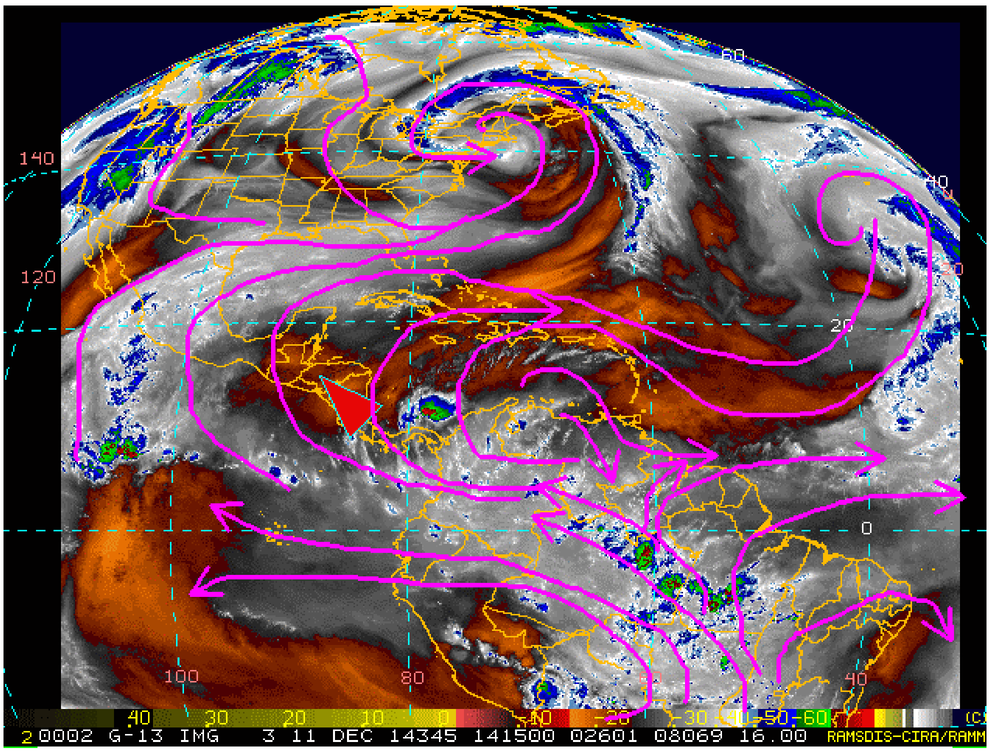


Figure 3. Screen capture during the December 2014 Regional Focus Group Session. The VISITview browser software allows the leader to draw upper level synoptic patterns on the water vapor imagery with ease. Some prominent features depicted include deep polar troughs over the eastern US and eastern Atlantic and a strong subequatorial ridge over the Caribbean.

Science on a Sphere™, Keith Searight, Michael Biere, Steven Albers

During this reporting period, 12 new SOS systems were installed at sites in Japan, North Carolina, Maryland, Mexico, India, Philippines, Illinois, California, Turkey, United Arab Emirates, Hong Kong, and Alabama. Notably, a large number of these were “first-ever” SOS installations: for the Middle East region (UAE) and for the countries of Japan, India, Philippines, and Turkey. At last count, the total number of SOS systems installed worldwide has reached 115.

In support of scientific education and outreach, the portable SOS system and SOS team members travelled to conferences and workshops around the county, including the World Science Festival (New York), Super Computing, American Meteorological Society, the 6th SOS Users Collaborative Network Workshop (St. Paul), Southern Hills Middle School (Boulder), and the State Department’s Our Ocean conference (DC).

A special highlight of the year came in January 2015, when the SOS team was awarded the NOAA Bronze Medal for 2014. The Bronze Medal Award is the highest honor award granted by the Under Secretary of Commerce for Oceans and Atmosphere. The citation was described as follows: "The award is in recognition of the accomplishment of over 100 SOS installs and 33 million annual viewers which exceeds by orders of magnitude any requested requirement for this group. This accomplishment is the product of uncommon will, determination, and focus along with an expectation of quality and excellence."

Advanced High Performance Computing-ACEs T. Henderson, J. Middlecoff, J. Rosinski, N. Wang, J. Schramm

Served on the GSD program review committee and the NOAA Earth Information System (NEIS) committee (a project listed in NOAA's 2011 Annual Guidance Memorandum as a priority for NOAA). CIRA researchers attended several meetings and gave talks on GPU and Xeon Phi research at the Programming Weather, Climate, and Earth Systems Models Workshop, GPU Technology Conference, the AOLI meeting at Boulder, an RRTMG meeting at NCAR, and Supercomputing 14. CIRA researchers also attended an Intel "dungeon" for a week of in-depth application-specific interactions with Intel hardware and software engineers. Lessons learned have already been incorporated into the NIM codebase.

Citizen Weather Observer Program (CWOP) Leigh Cheatwood, Randall Collander, Tom Kent

This public-private partnership has three main goals: 1) to collect weather data contributed by citizens; 2) to make these data available for weather services and homeland security; and 3) to provide feedback to the data contributors so that they have the tools to check and improve their data quality. There are currently 18,311 active stations (citizen and ham radio operators) out of a total of 31,200 stations in the CWOP database. CWOP members send their weather data via Internet alone or Internet-wireless combination to the findU (http://www.findu.com) server and then the data are sent from the findU server to the NOAA MADIS ingest server every five minutes. The data undergo quality checking and then are made available to users through the MADIS distribution servers. CWOP is in the process of transitioning to operations within the NCO IDP MADIS system.

More database procedures were streamlined through development and implementation of scripts to auto-correct missing and typographical errors in new member sign-up requests, and through introduction of automated site geographic location and elevation verification algorithms. Interactions occurred with users via email regarding site setup, data transmission issues, quality control and general meteorology. Various web-based documents and databases were updated on a daily, weekly or monthly basis depending on content, and statistics and other informational graphics revised and posted.

In 2014, there were approximately 2400 stations added to the database. There were about 2800 revisions made to site metadata. Adjustments include latitude, longitude and elevation changes in response to site moves, refinement of site location, and site status change (active to inactive, vice-versa).

TerraViz- Jebb Stewart and Jeff Smith

Continued development of a consumer version of TerraViz, called Science on a Sphere Explorer (or SOS Explorer), is a beta with a release scheduled for summer 2015. Developed "Tour" capability. Similar to Google Earth tour capability, this allows users to define a sequence of data to load, locations to move to, highlight areas by either drawing shapes to the screen as well as pop up's with text content. Tours can also be used to save user preferences for a particular data type such as color palate or contour color. This allows users to define preferences to load data such as datasets, color, and type of visualization.

Virtual Lab (VLab), Ken Sperow, Michael Giebler, John Crockett

The NWS has created a service and IT framework that enables NOAA, in particular the NWS, and its partners to share ideas, collaborate, engage in software development, and conduct applied research from anywhere. Ken Sperow continued as the VLab technical lead, as well as the technical lead of the Virtual Lab Support Team (VLST). This team currently consists of 11 members to whom Ken provides support and training. Under Ken and Stephan Smith's (the NOAA PI) leadership, the VLab continues to grow in importance and visibility within the NWS and NOAA. Ken demonstrated the VLab to NOAA, non-NWS NOAA line offices and top-level staff within the NWS, including NCEP directors. Providing web-based services to help manage projects via issue tracking, source control sharing, code review, and continuous integration, VLab Development Services (VLDS) has grown by almost 100% this year to support over 100 projects and 836 developers. Under Ken's leadership, the VLab is now an essential and required component in the transition of research to operations for the NWS AWIPS. All development organizations now must use VLab to check in, review, and verify AWIPS II code before it is included in the operational baseline.

Developmental Testbed (DTC) Publications – Edward Tollerud, Jeff Beck, Jim Frimel, Isidora Jankov, Hongli Jiang

At recent Science Advisory Board and DTC Executive Committee meetings, a need has been indicated for additional 'get-out-the-word' activities for the DTC mission and its accomplishments. In response, the DTC is now (via this project) publishing a quarterly newsletter (linkable at http://www.dtcenter.org/newsletter/). Another part of this objective is to hasten presentation and publication of research results from DTC activities. To address this effort, results from collaborative verification of ensemble modeling during three years of Hydrometeorological Testbed (HMT) field experiments have been targeted for presentation at AMS and other relevant meetings, for formal publication in BAMS and other AMS journals, and for informal reports for WGNE and AMS extended abstracts.

Organization of the first NMMB tutorial and all supporting documentation, including a User's Guide. The team (Jeff Beck, Isidora Jankov, Hongli Jiang) has been responsible for organizing the first Nonhydrostatic Multiscale Model on the B-grid (NMMB) user tutorial. This was a two-day event starting on April 1, 2015 in College Park, MD at EMC. The objective of this event is to provide an introduction to the model, the NEMS system and a practical session on executing the model. During the first day the model developers and advanced users provided lectures on various aspects of the model. During the second day, the team provided a practical session for all participants where they will be able to run sample cases using the NMMB.

In addition to the in-person tutorial, the team has been responsible for writing the User's Guide and detailed practical session instructions. The User's Guide consists of six chapters, and includes detailed information related to the installation of NEMS-NMMB, the NEMS Pre-processing System (NPS), initialization and execution of the NMMB model, and post-processing.

These supporting documents, as well as an announcement for the tutorial can be found on the DTC NMMB tutorial website: http://www.dtcenter.org/nems-nmmb/users/tutorial/.

Hydrologic Research and Water Resources Applications Outreach – Lynn Johnson

The primary objective is to provide support to and coordination between HMT and NOAA Partners and Stakeholders. Major activities include:

--Assist in coordination with water management stakeholders such as the Corps of Engineers, U.S. Geological Survey, and other federal, state, and local water management agencies.

--Act as a liaison across NOAA Line Offices, particularly between NWS-OHD, PSD, CNRFC, NMFS and Line Office Headquarters;

--Provide guidance related to technical aspects of the national water resources information system, including system interoperability and data exchanges, eGIS and geo-Intelligence, integrated information delivery, the acquisition and management of observations and surveillance, and technological research and development;
--Support the planning for an HMT/IWRSS Russian River and California Pilot Study;
--Develop briefings and reports related to high-level needs (NOAA, Other Agency, and Legislative).

Instructional Development for NOAA's OMAO, Jenna Dalton

OMAO Training Portal
The OMAO training portal is a Google site created as a "One Stop" site to assist OMAO staff by providing the who, what, when, where and why answers to training questions. It is updated daily with calendar events, links to various new and upcoming training opportunities and links directly to required and career development learning paths. Jenna Dalton, task lead, provides relevant content and training events in support of the OMAO scientific data collection mission and personnel needs to maintain a ready staff.

IDP Video
The Department of Commerce, NOAA, and OMAO encourage employees to create and use Individual Performance Plans (IDP) to assist supervisors and employees in progress towards their work-related, professional, and personal goals. OMAO provides guidance for staff and supervisors to integrate this "best practice" into the operational environment to optimize mission readiness. An OMAO priority, all employees are asked to complete an IDP, in conjunction with their supervisor, which in turn becomes the foundation to plan and resource for the following fiscal year. For the first time In FY2016, an Annual Training Plan budget will be created from the OMAO employee IDP input for mandated and discretionary training and development. The IDP video was created to define how and why an IDP benefits an employee and aligns them for success. The entire video can be viewed at:

https://www.youtube.com/watch?v=bgLEUmq_Cbw&feature=youtu.be.

Training Events
OMAO's internal leadership courses, Mid-Grade Week 1 and Week 2, fulfill the Office of Personnel Management (OPM), DOC, and NOAA requirements for new supervisor training and provide an additional cross mission development venue for the organization. These courses, held at the National Weather Service Training Center (NWSTC), include NOAA Corps Officers, wager mariners, and civilian staff. CIRA associate, Jenna Dalton, supported the leadership training as the resource manager of travel and budget, director of course logistic coordination, and course liaison.

The OMAO co-located its Chief Learning Officer (CLO) with the National Weather Service Training Center (NWSTC) in Kansas City, MO in September of 2013 as part of an investment to advance the organizational training program. This partnership permits the sharing of development resources and provides for mutual support on common core leadership training. The OMAO training support specialist participated in resident course preparations including planning, agenda development, course logistics, and managing classrooms. The OMAO / NWSTC leadership training and educational resources collaboration began in 2010 and is the only joint NOAA training program sharing resources to address growing training demands.

CoCoRaHS

CoCoRaHS, the Community Collaborative Rain, Hail and Snow network (http://www.cocorahs.org/) was founded by the Colorado Climate Center at Colorado State University. This citizen-science project started in Fort Collins, Colorado after a devastating flash flood in 1997. The flood caused over $200 million in damages (including major damages to the CSU campus) and the loss of five lives, but also pointed out the need for timely and localized precipitation data. Precipitation is known to be extremely variable, and with the help of volunteers who are trained and equipped, the gaps between official weather stations are being supplemented by volunteer data. The network quickly grew and now consists of over

20,000 volunteers in all 50 States, Canada and Puerto Rico, with 10,000-12,000 reports submitted daily (Figure 4). One key to the project's success is that the data are used by the public as well as professionals including scientists and meteorologists at the National Weather Service.

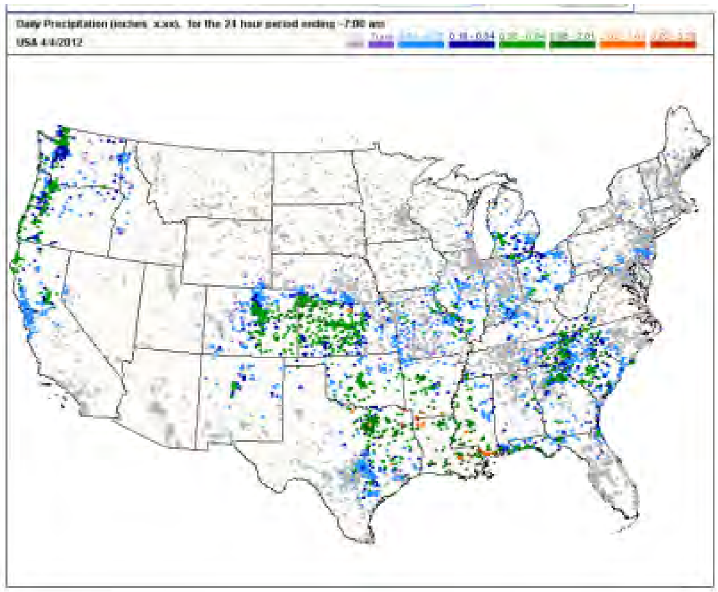


Figure 4. A plot of the 20,000 station plots of CoCoRaHS volunteers

CoCoRaHS is also implementing new educational materials including animation based videos. In an effort to promote and facilitate weather and climate literacy, CoCoRaHS released the first in the series, 'The Water Cycle' (Figure 5). This educational piece not only grabbed the attention of the Jackson Hole Science Media Awards where it became a finalist in the category 'Best Short Program', but has quickly become the single most popular video on the CoCoRaHS YouTube channel, now reaching over 330,000 views by the end of 2014. A second piece was added in 2014 titled "Weather Vs. Climate" and had over 20,000 views by the end of the year (Figure 6).

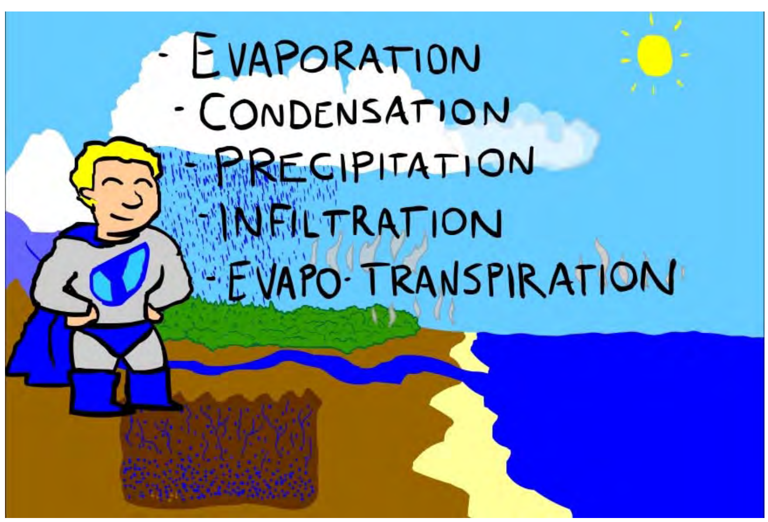


Figure 5. Animation still from CoCoRaHS-developed animation project on the water cycle.

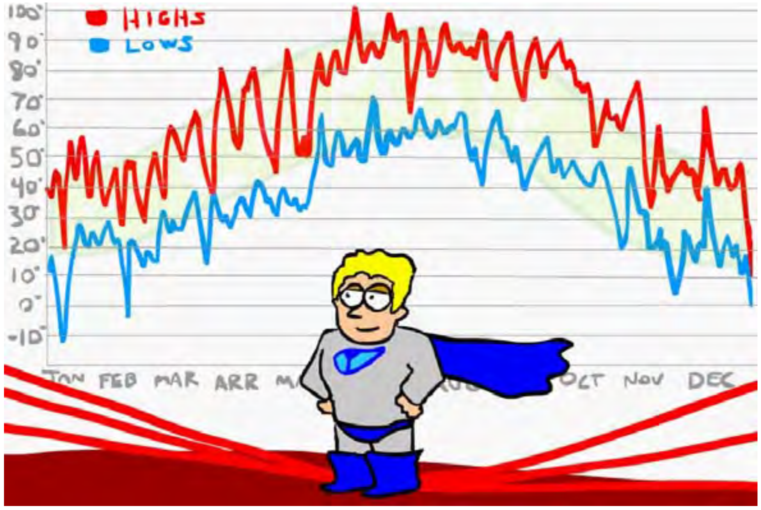


Figure 6. Animation still from CoCoRaHS-developed animation project on weather vs. climate

CoCoRaHS piloted an effort in 2012 to reach out to schools. Initially in Colorado, where the Governor declared 2012 as the 'Year of Water', CoCoRaHS recruited nearly 150 schools around the state. Many of them submitted data, and even more success was realized by holding two campaigns per year called 'Rain Gauge Week'. After the initial pilot and proven success, the model expanded to all 50 states, Canada and Puerto Rico with over 850 schools registered in the database by the end of 2014. The bi-annual 'Rain Gauge Week' occurs in May and September and results with nearly half of the registered schools participating. An outside evaluator, through surveys and focus groups, found that teachers believe that by participating in CoCoRaHS, their students science process skills improved. They also reported that their students really liked collecting real data that are used by scientists.

An informal partnership with NASA Global Precipitation Measurement (GPM) was formed. Two webinars were produced, hosted by CoCoRaHS and NASA to show the relationship between the satellite and ground observations. A field campaign in the Delmarva Peninsula began in late 2014, with a goal of asking existing CoCoRaHS volunteers in the area to collect data from nearby ground validation sites operated by NASA, and to also recruit new observers to add data to the existing campaign for ground validation purposes.

National Park Service Night Skies Program Measures, Trains and Educates

The National Park Service Night Skies Program at CIRA became part of the NPS Natural Resource Stewardship & Science, Natural Sounds and Night skies Division in 2011. The program researches and measures the night sky quality in national parks (Figure 7), advises parks about dark sky friendly lighting strategies, trains and educates park rangers about the importance of preserving dark skies, and promotes existing dark sky parks to preserve the natural night lightscape for future generations to experience. Each of these Sky Rangers will then educate thousands of park visitors on the importance of dark skies as a natural resource. Successfully trained park rangers have the potential of helping thousands of park visitors to connect with the cosmos as a natural extension of the unique park environment. Such experiences can inspire youth to pursue study in the sciences and to take a larger view of their world.

Figure 7. The summer Milky Way bisects the night sky over Mitten Park in Dinosaur National Monument, Utah, a location from which sky quality measurements indicate excellent dark sky conditions.

To further help park rangers, the Night Skies Program has continued the Astronomy Volunteer In the Parks or Astro-VIP program. This program matches amateur astronomer volunteers to work in national parks. Astro-VIP's help park rangers develop and run night sky viewing programs with telescopes for park visitors. For more information see:

http://www.nature.nps.gov/air/lightscapes/astroVIP/index.cfm.

In addition, the Night Skies Program continues its partnership with Astronomy From The Ground Up (AFGU) to train Sky Rangers in developing night sky education programs in over 40 national parks. For more information about the Night Sky Program see:

http://www.nature.nps.gov/air/lightscapes.

Learning is a lifelong pursuit. The CIRA/NPS group goal is to work with researchers to make science more accessible to the general public. Outreach plays an important role in connecting scientific research, natural resources, and a diverse public in contexts that are that are relevant to their environments and social experiences.

National Park Service Air Quality Research and Outreach

The National Park Service CIRA outreach group works with air quality scientists and researchers to create and deliver products that enable a diverse audience to better understand how air pollution affects natural resources and human health, to understand where pollutants come from, and to be aware that individual actions can make a difference to ecosystem health. Our goal is to nurture connections between researchers, land managers, and communities – especially with young people. Through education we hope to encourage good environmental stewardship and community-based conservation, foster engagement by all ages to notice what is happing to our natural environments, and inspire our next generation of young people to be part of future solutions to these complex, interconnected environmental problems.

Using software to simulate visibility in several National Parks using historical aerosol data at different points in time, the CIRA/NPS science team is able to demonstrate visually the improvement in visibility over time. Images are available online at:

http://vista.cira.colostate.edu/improve/Studies/HazeTrends/StudyHazeTrends.htm

Figure 8. Visibility in Great Smoky Mountains National Park from 1990 (left) and 2013 (right)

Fourth-Sixth Grades Outreach

In the last year we have begun to develop some handouts and activities that staff can use in hands-on learning experiences in local schools. The packet includes a bookmark, a sorting activity for kids that asks them to order photos in order of good to bad visibility, and appreciation stickers. These products were used successfully by National Park Service air quality staff that participated in the Science Technology Engineering and Math Expo at Ben Franklin Academy in Denver and were included in teachers' packets at the National Earth Science Week event last year. We hope to further develop this package in the coming year.

Figure 9: Sample stickers for the clean air program

This bookmark tilts to show good and bad visibility days at Grand Canyon National Park. These are given to kids when they participate in the park's school outreach program.

Interactive Air Quality Exhibits

Air quality impacts have been documented in many national parks, wilderness areas, and fish and wildlife refuges across the nation. A wealth of supporting scientific data has been collected over the last two decades to better understand visibility, ozone, and atmospheric formation and deposition of sulfur and nitrogen. Levels of contaminants like mercury are also being documented. Visitor center displays are extremely successful in reaching large numbers of people with place-relevant interpretive messages about the state of research and air quality effects. New exhibits are being developed this year for visitor centers along the East Coast.

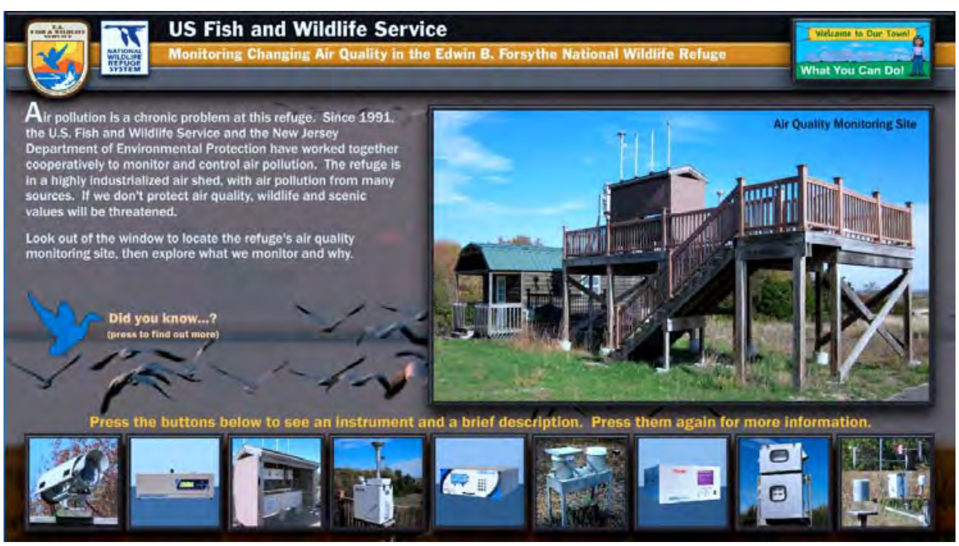


Figure 10. Interactive air quality exhibits

This interactive exhibit was installed at the new visitor center in Edwin B. Forsythe National Wildlife Refuge in summer 2012. Pages describe the instruments visitors see and the air quality issues that manifest in the refuge. Connections are made between the scientific data that is gathered, pollutant effects, and how the monitoring program is making a difference in protecting refuge resources.

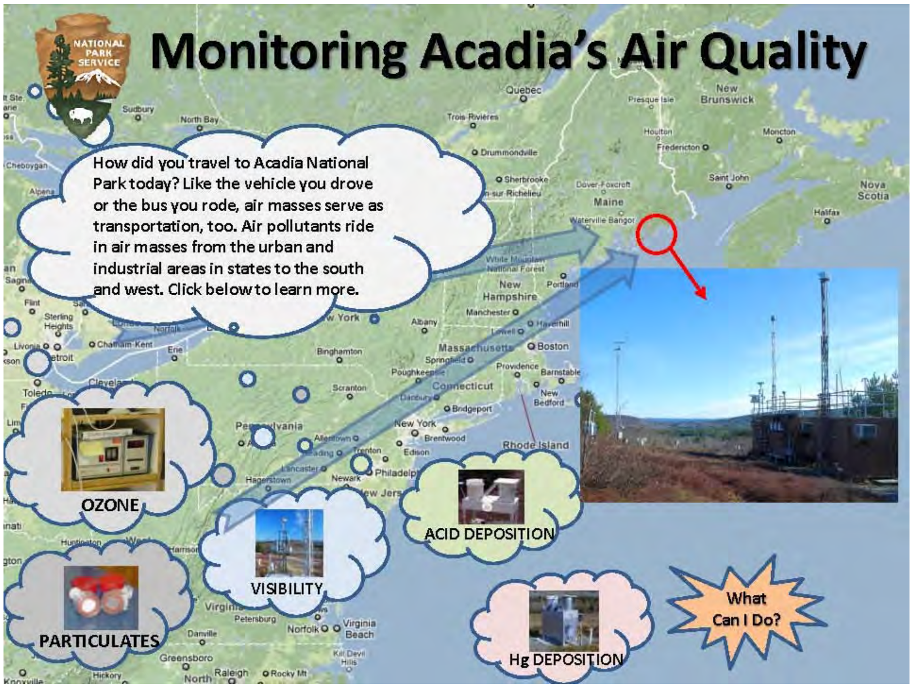


Figure 11. Air quality activity example

An air quality interactive exhibit for the learning and nature center at Acadia National Park is currently being designed in cooperation with resource management and science educators at the Park. The project will explore air quality impairment on park resources and look at how monitoring is used to understand how pollutants cause damage in the park, where they come from, and how we can make a difference.

Although this display is not interactive, it bears mentioning because it alerts visitors to human health issues at Hawaii Volcanoes National Park. Three monitors in various locations around the park cycle through a series of informative screens that show the location and direction of volcano gas plumes, current levels of sulfur dioxide are frequently updated, and the health advisory scale is simply presented to help visitors decide if it is unhealthy to visit the volcanoes that day. Information is frequently updated from real time measurements of sulfur dioxide and particulate matter.

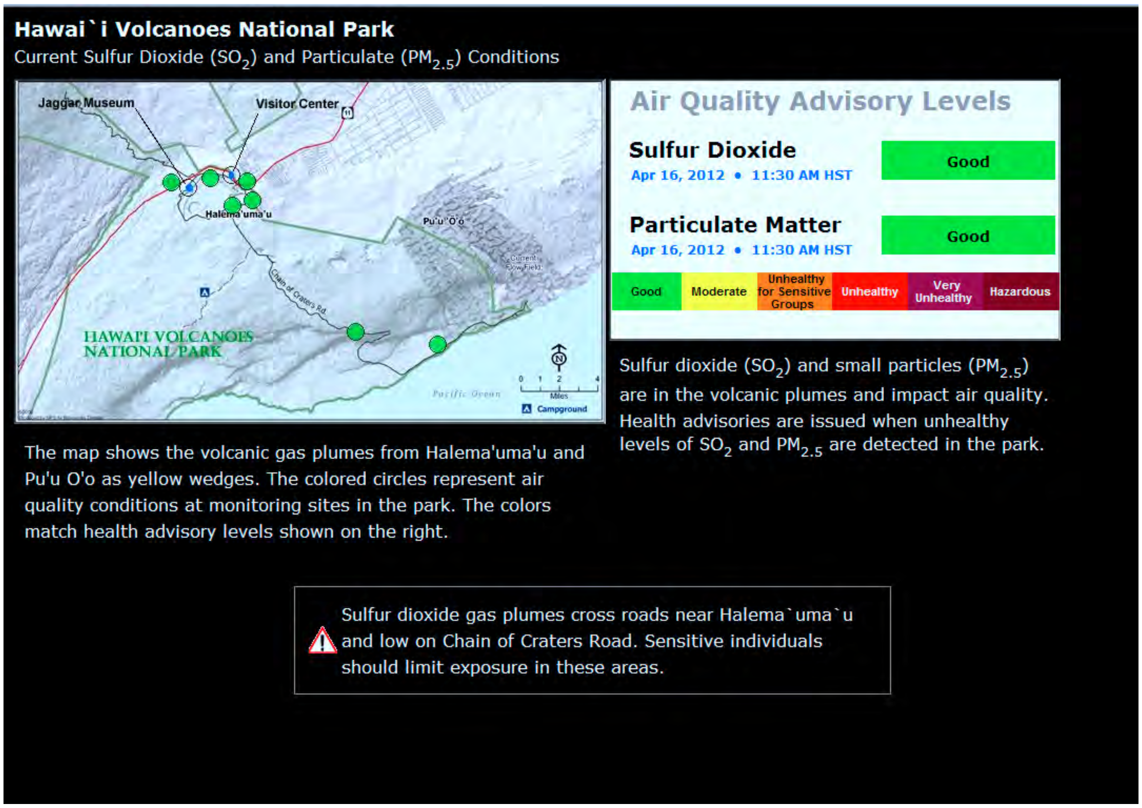


Figure 12. Air quality monitor display for Hawai'I Volcanoes National Park

Summary

New partnerships, new funding opportunities, and a continued development of CIRA E&O activities, coupled with the continuing development of world-class atmospheric science research at CIRA promise to bring increasingly relevant and compelling outreach and educational programs to the public, to the benefit of all. Stay tuned for more developments as they unfold!

NOAA AWARD NUMBERS FOR CIRA

Award Number	Identifier	Project Title	Principal Investigators/ Project Directors
NA09OAR4320074	Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Chris Kummerow (Graeme Stephens)
NA14OAR4320125	Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Chris Kummerow (Lead), Steven Miller
NA10SEC0080012	Competitive	CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful Citizen Science Network	Chris Kummerow (Lead), Nolan Doesken
NA11OAR4310208	Competitive	Development of a Probabilistic Tropical Cyclone Prediction Scheme	Andrea Schumacher
NA11OAR4310204	Competitive	Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis	Chris Kummerow
NA14OAR4310148	Competitive	Following Emissions from Non-traditional Oil and Gas Development Through Their Impact on Tropospheric Ozone	Emily Fischer, Delphine Farmer
NA13OAR4590187	Competitive	Guidance on Intensity Guidance	Andrea Schumacher
NA13OAR4310080	Competitive	Improving CarbonTracker Flux Estimates for North Americas Using Carbonyl Sulfide (OCS	Ian Baker
NA12OAR4310077	Competitive	Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models	Eric Maloney
NA14OAR4310141	Competitive	Observational Constraints on the Mechanisms that Control Size- and Chemistry-resolved Aerosol Fluxes Over a Colorado Forest	Delphine Farmer
NA13OAR4310103	Competitive	Research to Advance Climate and Earth System Models Collaborative Research: A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models	David Randall
NA13OAR4310077	Competitive	Towards Assimilation of Satellite, Aircraft and Other Upper-air CO2 Data into CarbonTracker	David Baker
NA13OAR4590190	Competitive	Upgrades to the Operational Monte Carlo Wind Speed Probability Program	Andrea Schumacher
NA13OAR4310163	Competitive	Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation	Eric Maloney

NOAA AWARD NUMBERS FOR CIRA

NA14OAR4830122	Competitive - Sandy	CIRA Assimilation of Moisture and Precipitation Observations in Cloudy Regions of Hurricane Inner Core Environments to Improve Hurricane Intensity, Structure and Precipitation	Chris Kummerow, Milija Zupanski
NA14NWS4830020	Competitive - Sandy	CIRA – Distance Learning Materials on Blended Numerical Guidance Products	Chris Kummerow, Bernie Connell
NA14NWS4830018	Competitive - Sandy	CIRA – Distance Learning Materials on Tropical Storm Forecasting and Threats	Chris Kummerow, Bernie Connell
NA14NWS4830056	Competitive - Sandy	CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates	Andrea Schumacher
NA14OAR4830110	Competitive - Sandy	ESRL/GSD Participation in the Establishment of a NOAA Lab Activity for OSSEs	Sher Schranz, Ning Wang
NA14OAR4830114	Competitive - Sandy	Evaluation of Earth Networks Total Lightning Products for NWS Warning Services in the Hazardous Weather Testbed	Sher Schranz
NA14NWS4830034	Competitive - Sandy	Incorporating the GOES-R Geostationary Lightning Mapper Assimilation into the GSI for Use in the NCEP Global System	Milija Zupanski, Karina Apodaca
NA14NWS4830009	Competitive - Sandy	MADIS Transition to NWS Operations	Sher Schranz, Tom Kent
NA14OAR4830111	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Ensemble Statistical Post-processing	Sher Schranz, Isidora Jankov
NA14OAR4830109	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Real-time IT Operations	Sher Schranz
NA14OAR4830112	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Fine-grain Computing	Sher Schranz
NA14OAR4830113	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Visualization and Extraction via NEIS	Sher Schranz
NA14OAR4830167	Competitive - Sandy	NOAA' S Observing System Experiments and Observing System Simulation Experiments in Support of the "Sensing Hazards with Operational Unmanned Technology" (SHOUT) Program – Development and Testing of Sampling Strategies for Unmanned Aerial Systems	Sher Schranz, Ning Wang
NA14OAR4830166	Competitive - Sandy	Sensing Hazards with Operational Unmanned Technology (SHOUT) – Data Management and Visualization	Sher Schranz, Jebb Stewart

VISION AND MISSION

The overarching Vision for CIRA is:

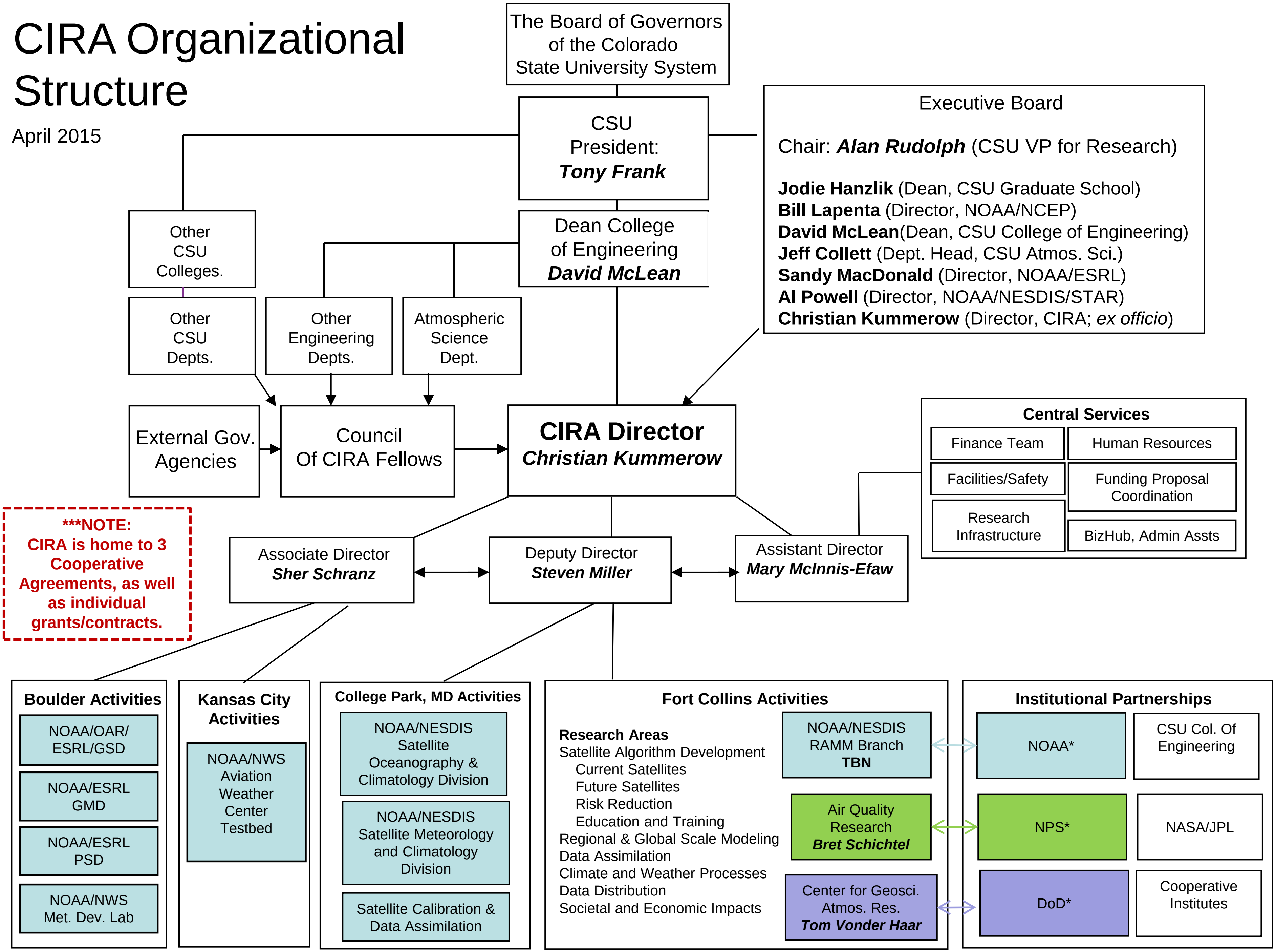
To conduct interdisciplinary research in the atmospheric sciences by entraining skills beyond the meteorological disciplines, exploiting advances in engineering and computer science, facilitating transitional activity between pure and applied research, leveraging both national and international resources and partnerships, and assisting NOAA, Colorado State University, the State of Colorado, and the Nation through the application of our research to areas of societal benefit.

Expanding on this Vision, our Mission is:

To serve as a nexus for multi-disciplinary cooperation among CI and NOAA research scientists, University faculty, staff and students in the context of NOAA-specified research theme areas in satellite applications for weather/climate forecasting. Important bridging elements of the Institute include the communication of research findings to the international scientific community, transition of applications and capabilities to NOAA operational users, education and training programs for operational user proficiency, outreach programs to K-12 education and the general public on environmental literacy, and understanding and quantifying the societal impacts of NOAA research.

CIRA Organizational Structure

April 2015



EXECUTIVE SUMMARY—Research Highlights

The Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU) serves as both an active collaborator and formal interface between academic expertise and multiple agencies holding both basic and applied research interests in atmospheric science. Under its capacity as NOAA's Cooperative Institute for exploiting satellite applications for improvements in regional and global-scale forecasting, CIRA provides an important and practical connection between two NOAA line offices—Oceanic and Atmospheric Research (OAR) and the National Environmental Satellite, Data and Information Service (NESDIS). Diverse expertise in satellite remote sensing, science algorithm and application development, education/training, regional/global weather and climate modeling, data assimilation, and data distribution technology make CIRA a valuable asset to NOAA in terms of transitioning research concepts to operational stakeholders.

The CIRA Annual Report provides summaries of the contributions emerging from our research partnership with NOAA, with more detail to be found in the peer reviewed and technical conference publications cited within this report as appropriate. Highlighted below are accomplishments from the current reporting period and drawn from both the NOAA reports contained herein as well as from the broader palette of research conducted at CIRA. These examples underscore intra- and inter-agency partnerships that present opportunities for leveraging activities of other agencies.

- With the launch of GOES-R now imminent, and JPSS following shortly thereafter, much of the core focus in the satellite algorithm development and training work has focused on these two sensors. The GOES-R risk reduction, in particular, has a number of elements designed to improve the prediction of tropical cyclone genesis, understanding its structure and changes in structure leading to improved predictions of both track and intensity forecasts. This is coupled with activities designed to prepare forecasters to make optimal use of the new satellite radiances and products as soon after launch as possible by creating synthetic products and imagery to represent the new satellite capabilities. As can be seen, this is further coupled to a strong program in education and training activities such as CIRA's participation in the Virtual Institute for Satellite Integration Training (VISIT), the Satellite Hydro-Meteorological training and education activity (SHyMET), and the International Virtual Laboratory (VLab).

- An area of great excitement continues to be the work being done with the Day/Night band of Suomi-NPP in preparation for JPSS. Not only is detection of smoke, dust, and fog possible at night, but results appear far better than originally anticipated and have generated a lot of excitement in the community. Much work was done in this previous year related to quantifying the arctic winter clouds that are often difficult to detect with infra-red methods alone. The VIIRS Sensor is also being used extensively for more established applications related to Sea Surface Temperature and Ocean Color products produced by CIRA Research Scientists working directly with NOAA STAR employees in College Park, MD. Perhaps not evident when evaluating a single proposal, however, is the synergy that CIRA provides across projects through its internal communications and collaborations. A careful review of all the activities related to satellite algorithm development, training and education and training, however, clearly reveals these synergies and the benefits that these create on behalf of NOAA.

- This past year, collaborations with the Global Systems Division (GSD), the Physical Sciences Division (PSD), and the Global Monitoring Division (GMD) of the NOAA Earth System Research Lab (ESRL) in Boulder were productive in both continuing and new research areas. CIRA researchers either led or were immersed in every branch and virtually every project in GSD. Project leadership and integral support were provided for: Fire Weather Modeling and Research, the FAA NextGen Network-Enabled Weather (NNEW—now known as CSS-Wx), the NWS NextGen, and Aviation Weather Forecast Evaluation programs; meteorological workstation development, including the AWIPS II Extended Tasks for both Collaboration and Hazard Services, FX-NET Thin Client, AWIPS II Thin Client, and MADIS; high performance computing (especially related to GPU processing); and the design, development and implementation of various regional and global weather and climate models, including the RR, HRRR, WRF-Chem, FIM, and NIM as well as the LAPS/STMAS data assimilation systems and ensemble model post-processing and technology leadership in the Science on a Sphere® (SOS) program and the new NOAA Environmental Information System (NEIS) project. NOAA testbed research resulted in improvements to the ensemble models in the Hydrometeorological Testbed (HMT), downscaled additions to the CONUS Experimental Warning Program (EWP) domain in the Hazardous Weather Testbed (HWT) and changes to the SREF configuration in the Developmental Test Center (DTC) Ensemble Testbed. For program management and proposal development efforts on many of these programs, Sher Schranz won a 2013 CIRA Research Initiative Award.

- As part of the NWS NextGen Program, CIRA researchers at ESRL continued their research into the technology and science of populating a four-dimensional airspace with atmospheric data, extraction methodologies, distribution formats, and input mechanisms to be used by aviation decision support systems. They supported NWS 4D Data Cube by prototyping the iWXXM observation data format required by the international aviation weather community, including the transition of software to NOAA data providers.

- CIRA researchers collaborated on the development of a prototype of TerraViz, a 3D spinning globe application that will be the visualization front end of the new NOAA Environmental Information System (NEIS) initiative. This capability relies on Unity3D—software that has traditionally been used for 3D video games--to present high-volume datasets in stunning displays. TerraViz is also being used to create 3D visualization capabilities for the FIM and NIM models.

- Support for the Science On a Sphere® (SOS) Program continued with the addition of the ability to download global model data in near-real-time via FTP to selected SOS sites. SOS systems were installed at 11 sites this year in Florida (2), Indiana (2), Silver Spring, MD (NOAA HQ), Hawaii, Italy, Czech Republic, Taiwan, Mexico and the People's Republic of China. Worldwide, there are now 104 SOS sites.

- Vital collaboration with the ESRL Global Monitoring Division continued on CO_2 data assimilation and OSSE research as well as enhancements to the CarbonTracker (CT) program. Changes to the CT this year included a reworked architecture to separate the transport model from the flux inversion used to assimilate data. Portions of the PCTM and variational carbon data assimilation code were parallelized enabling faster turnaround on model results and analysis. Collaboration with the ESRL Physical Sciences Division was initiated on hydrologic research and applications development for the NOAA HMT, along with water resources applications outreach coordination involving the Russian River and California Integrated Water Resources Science and Services (IWRSS) Pilot and national-level eGIS activities.

- The on-going partnership with the NWS Meteorological Development Lab continued on several fronts. CIRA took the lead in prototyping, setting up, and customizing the Virtual Lab (VLab) using LifeRay's open source java portal framework. The operational VLab continues to be expanded and updated by the CIRA team. The portal component of the VLab provides NWS employees and research partners a web-enabled virtual location to collaborate and innovate. The AWIPS II software development environment has been installed within the Virtual Lab which will become the development environment for all NWS tool development and software management. New development projects in this environment included a new meteogram tool developed by the NASA SPoRT program. Research collaboration was begun to transition the AutoNowcaster (ANC) tool to operations. The CIRA research team members have been added as leaders and/or members of the NWS MDL Configuration Control Board, the VLab support group, the NWS national Impacts Catalog Project and the NWS Systems Engineering Center AWIPS II design team.

- Ensemble model research activities were added to the CIRA collaborations this year. CIRA researchers participated in the development of MET-Based ensemble verification techniques in the NOAA Developmental Testbed Center (DTC) resulting in a BAMS publication. An Ensemble Processor (EP) tool was developed for AWC forecasters (supporting Traffic Flow Management) to allow access to and analysis of the HWRF and SREF ensemble model members. Operational transition work was begun this year as well.

- CIRA researchers continued close collaborations with research and operations personnel at the Aviation Weather Testbed at the NWS Aviation Weather Center in Kansas City, MO. Primary goals of the partnership are to actively engage in the research-to-operations process and to develop, test, and evaluate new and emerging scientific techniques, products, and services in support of the aviation weather community. Research and development efforts have been centered in two research areas; 1) Aviation Impact Variables (AIV's) which are tested during the AWC Summer and Winter Aviation Weather Experiments and include AWRP upgrades to CIP and FIP, and the upgrade to the Collaborative Convective Forecast Product (CCFP); 2) NWS NextGen aviation weather data format prototyping for international standards, and efficient data and product distribution. One member of the CIRA research team (Ben Schwedler) at AWC were nominated, along with their federal collaborators for a NOAA Personnel Advisory Committee (PMAC) award, one administrator was also nominated (Jenna Dalton).

- Project management and planning work was begun in 2013 for the High Impact Weather Prediction Project (HIWPP), part of the Hurricane Sandy Supplemental funding work. Research in OSSE's, high performance computing, information systems, global models, and model verification will be performed in 2014 for this program.

- Over the past year the CIRA group working with the National Park Service (NPS) continued its research on issues related to visibility and air quality at our Nation's National Parks. Their research, while focused on areas of importance to the National Park Service, overlaps considerably with a number of new CIRA initiatives related to pollutant transport such as those released by fires that are of great interest to the Park Service and NOAA and thus continues to be an integral partner in what we do as CIRA.

- The CloudSat Mission continues to enjoy strong support from NASA despite some anomalies with the spacecraft during the previous year. The CloudSat program, with its Data Processing Center running operationally at CIRA on behalf of NASA has facilitated multiple research activities that are of benefit to NOAA. Chief among these is CIRA's ability to quickly make use of the CloudSat data to provide a unique validation for cloud base height retrievals produced by the VIIRS instrument on Suomi-NPP. In addition, CIRA has compiled a 6-year cloud-class dependent climatology of cloud geometric thickness, partitioned by season, latitude and surface type. This database will serve as an invaluable testbed for VIIRS Cloud retrievals that contains less information than is available for CloudSat.

This Annual Report is broken into several chapters which represent the NOAA-defined themes of CIRA's Cooperative Institute. In our *Satellite Algorithm Development, Training and Education* theme, we describe ongoing efforts in developing applications for the upcoming GOES-R and JPSS satellite program. This work is related to estimating tropical cyclone formation probability and the cost-savings of improved track forecasting, and contributions to the VISIT and SHyMET satellite training programs. We continue to expand our activities related to existing NPP and planned JPSS sensors – particularly the VIIRS sensor. Our *Regional to Global-Scale Modeling Systems* theme continues to focus on the development of the Flow-following finite-volume Icosahedral Model (FIM) and Non-hydrostatic Icosahedral Model (NIM) development along with advanced high performance computing necessary to run these models efficiently.

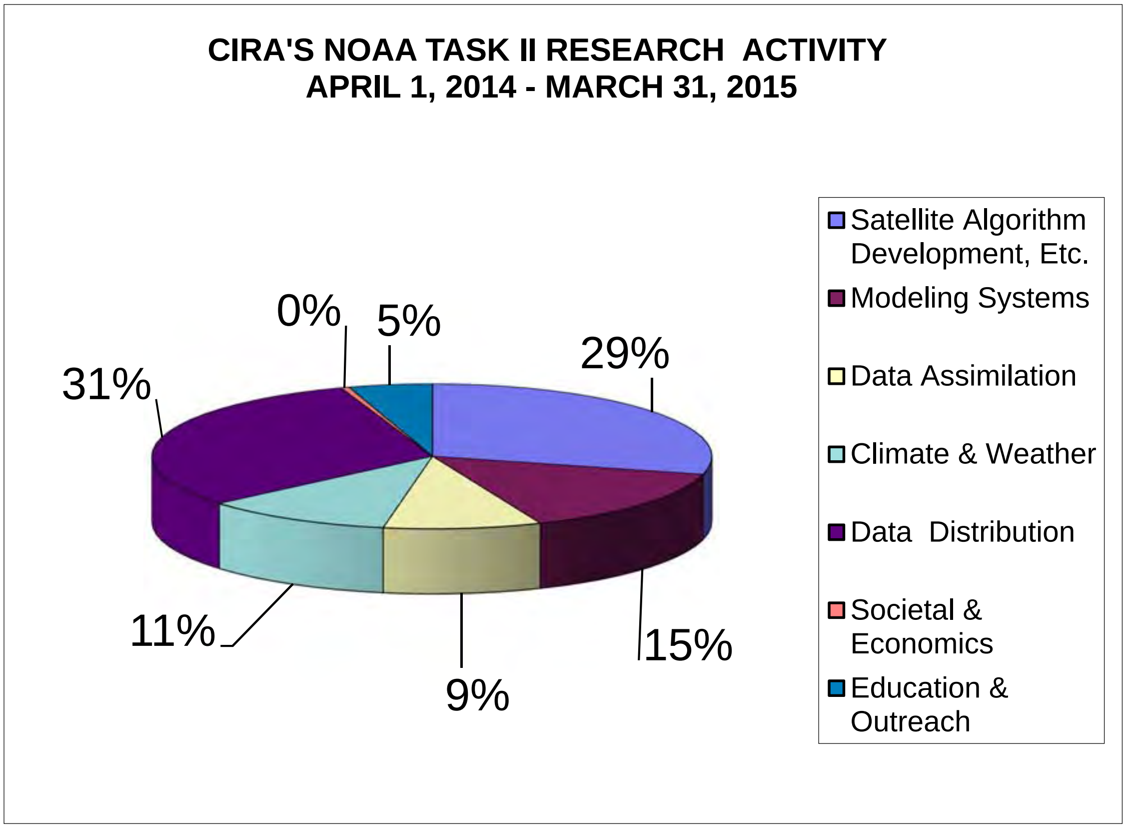
Our *Data Assimilation* theme showcases developments of Ensemble Data Assimilation for Hurricane Forecasting as well as specific applications of these techniques with GOES data. While perhaps not completely evident from this report that focuses on accomplishments related to our NOAA grants, the

Data Assimilation activity benefits tremendously from other funding sources that spur the theoretical innovation that is then applied to existing NOAA problems such as CO_2 data assimilation within NOAA's CarbonTracker program or the hybrid Variational-Ensemble Kalman Filter approach used to assimilate Lightning data.

Highlighted in CIRA's *Data Distribution* theme is work with the National Weather Service (NWS) Meteorological Development Lab for migration of AutoNowcast to operations for improved convective initiation and situational awareness, multiple efforts toward improving aviation forecast support systems via the FAA NNEW and NWS Nextgen projects, preparations for the next-generation AWIPS-II interface, the Meteorological Assimilation Data Ingest System (MADIS) transition to NWS operations, and development of a novel drought early warning system. While a completely separate activity, the severe weather visualization tools connect well with CIRA's support of the CASA Demonstration network that is intended to predict severe weather through the utilization of many small Doppler radar systems. It is also connected very well with CIRA's NASA activity to process and distribute CloudSat data and products. While these efforts occur in parallel, it showcases the power of having Universities involved that are ultimately interested in exploiting these systems in a symbiotic fashion that lets us learn and apply the best aspects of each system to the mutual benefit of the others.

Interspersed among these major research themes are important contributions from CIRA's NESDIS postdoctoral and young researcher program in data distribution, assimilation, and satellite algorithm development. Located in College Park, MD, and integrated closely with NOAA technical contacts at STAR, these scientists are immersed in research ranging from refinements to the Community Radiative Transfer Model (CRTM), data assimilation of cloudy radiances, satellite-based sea surface temperature (SST) algorithm development, techniques for monitoring and quality control of long term SST records, and ocean color algorithm development for global climate and coastal/in-land water ecosystem monitoring. Some of the techniques and web interfaces being developed by this outstanding group of Research Scientists is a constant reference source for other CIRA activities with similar objectives.

This Annual Report is the sixth in a series to be completed under CIRA's Cooperative Agreement established with NOAA. With this first report in the second five year lifecycle of the Cooperative Institute, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship among NOAA, the Department of Atmospheric Science at CSU, Departments of the University, and the other major programs within CIRA. As we pursue new directions of growth within our NOAA research themes, we look forward to the challenges and rewards for helping NOAA achieve its goals of understanding and predicting changes in climate, weather, oceans and coasts.


CIRA'S NOAA TASK II RESEARCH ACTIVITY
APRIL 1, 2014 - MARCH 31, 2015
0%
5%
29%
31%
11%
9%
15%
Satellite Algorithm Development, Etc.
Modeling Systems
Data Assimilation
Climate & Weather
Data Distribution
Societal & Economics
Education & Outreach

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Glen Liston, Senior Research Scientist, CIRA, CSU
Alexander "Sandy" MacDonald, NOAA
William Malm, Senior Research Scientist, CIRA; National Park Service (retired)
Steven Miller, CIRA Deputy Director, CSU
Roger Pielke, Sr., Senior Research Scientist, CIRES, U of Colorado
James Purdom, Senior Research Scientist, CIRA, CSU
Robert Rabin, NOAA/National Severe Storms Laboratory
Steven Rutledge, Atmospheric Science Department, CSU
John Schneider, NOAA/ESRL/Global Systems Division
George Smith, Riverside Technologies
Graeme Stephens, JPL and Atmospheric Science Department, CSU
Pieter Tans, NOAA/CMDL
Thomas Vonder Haar, CIRA Director Emeritus and Atmospheric Science Department, CSU
Fuzhong Weng, NOAA/NESDIS/STAR
Milija Zupanski, Senior Research Scientist, CIRA

Scheduled Meetings:
2014/15 Meeting of the CIRA Council May 6, 2015
2014/15 Meeting of the CIRA Executive May 18, 2015

TASK I – A COOPERATIVE INSTITUTE TO INVESTIGATE SATELLITE APPLICATIONS FOR REGIONAL/GLOBAL-SCALE FORECASTS

Task I activities are related to the administrative management of the CI. As reflected in the pie chart appearing earlier in this report, expenses covered by Task I are primarily salary and benefits, annual report production costs and some travel. This task also includes some support of postdoctoral and visiting scientists.

SEMINARS SUPPORTED BY TASK I

April 3, 2014, C. Dollard, S. Baumgarn (CSU). Campus on a Carbon Diet: CSU Energy and Greenhouse Gas Footprint Issues and Opportunities.

April 4, 2014, Y. Richardson (Penn State University). An Investigation of Tornado Maintenance and Demise Using VORTEX2 Observations.

April 8, 2014, J.J. Puschell (Raytheon). Persistent Day-night Visible Wavelength Observations of the Arctic.

April 11, 2014, A. Maycock (University of Cambridge). Stratospheric Water Vapour and Climate: From Radiative Forcing to the Global Circulation.

April 11, 2014, M. Zhizhin (CIRES/NOAA). Multispectral Remote Sensing of the Nighttime Combustion Sources.

April 18, 2014, A. Didlake (NASA Goddard). Dynamics of Secondary Eyewall Formation Observed in Hurricane Rita.

April 25, 2014, S. Denning (CSU ATS). Revisiting the Rectifier: How CALIPSO LIDAR Data Help Quantify the Global Carbon Budget.

May 2, 2014, J. Volckens (CSU). Air Pollution and You: The Fort Collins Commuter Study.

May 6, 2014, Herbert Riehl and Alumni Award Ceremony.

May 8, 2014, T. Schneider (NOAA/ESRL/GSD). The NOAA High Impact Weather Prediction Project.

May 9, 2014, L. Pan (NCAR). Observational Studies of the Coupling between Dynamics and Chemistry in the Upper Troposphere and Lower Stratosphere (UTLS) from Recent Field Campaigns.

May 28, 2014, H. Morrison (NCAR). A New Approach for Parameterizing Cloud Microphysics Based on the Prediction of Ice-phase Particle Properties.

June 16, 2014, X. Liu (China Agricultural College, Beijing). Atmospheric Nitrogen Deposition in China and Its Environmental Impact.

June 17, 2014, J. Persing (Naval Postgraduate School). Insights from the Prototype Hurricane Problem: Asymmetries and WISHE.

July 8, 2014, J. Metz (UND). Gravity Wave Drag in FIM.

July 8, 2014, C. Dacey (FSU). WMO Verification Standard.

July 8, 2014, M. Fiorino (NOAA/ESRL). T-LIM TC Structure Change Modeling.

August 11, 2014, S. Ackerman (University of Wisconsin). Satellites and Clouds.

August 11, 2014, Colorado Climate Center (CSU). The History of the Fort Collins Weather Station—What We Have Learned.

August 21, 2014, M. Zheng (Peking University). Fine Particulate Matter in China: Current Understanding and Challenges.

August 21, 2014, D. Vietor (CIRA/AWC Kansas City). Using Web Services and Open Geospatial Tools to Modernize the Aviationweather.gov Website.

August 27, 2014, N. Klingaman (University of Reading). The Benefits of Coupling to a Mixed-layer Ocean for Global Climate Simulations.

August 29, 2014, ATS Faculty (CSU). Various presentations.

September 3, 2014, S. Bililign, Y-L. Lin, J. Zhang, A. Mekonnen and Y. Rastigejev. Atmospheric Science Research and Education at North Carolina A&T State University.

September 5, 2014, K. Rasmussen (University of Washington/NCAR). Convective Initiation and Hydrometeorological Influence of Extreme Storms in Subtropical South America.

September 12, 2014, U. Nair (Huntsville). Land-use and Land-cover Change Impacts on Regional Climate.

September 19, 2014, M. Bell (University of Hawaii). Observations of Tropical Cyclone Eyewall Convection Structure and Forcing.

September 26, 2014, S. Murphy (University of Wyoming). Reducing Uncertainties in Two Significant Climate Forcers: Biomass Burning Emissions and Methane Leakage from Oil and Gas.

October 3, 2014, W-C. Lee (NCAR). Distance Velocity Azimuth Display (DVAD) – New Interpretation and Analysis of Doppler Velocity.

October 10, 2014, Young Scientists Symposium (ATS). Various.

October 17, 2014, A. Tandon (University of Massachusetts). Non-QG Sub-mesoscale Ocean Dynamics and a Recent Update from the Indian Ocean.

October 24, 2014, T. Auligne (NCAR). Analysis and Prediction of Clouds Using Satellite All-sky Radiances: Lessons Learned and Perspectives.

October 30, 2014, D. Birkenheuer (NOAA/GSD). Development of the GPS- met (IPW) Forward Model and Adjoint.

November 6, 2014, K. Muinonen (University of Helsinki). Scattering of Light by Complex Atmospheric Particles.

November 7, 2014, K. Emanuel (MIT). Radiative-convective Equilibrium and Its Instability: Implications for Weather and Climate.

November 14, 2014, N. Arnold (CSU). Global-scale Convective Self-aggregation and the Madden-Julian Oscillation.

November 21, 2014, P. Alpert (Tel-Aviv University). Recent Advances in Environmental Monitoring Using Commercial Microwave Links.

December 5, 2014, A. Donohoe (University of Washington). Shortwave and Longwave Radiative Contributions to Global Warming Under Increasing CO_2.

December 12, 2014, J. Dias (NOAA). Influence of the Basic State Zonal Flow on Convectively Coupled Equatorial Waves.

January 23, 2015, A. Pendergrass (NCAR). The Rain is Askew: Changes in the Distributions of Rain and Vertical Velocity.

February 5, 2015, J. Dunion (NOAA/AOML). The Tropical Cyclone Diurnal Cycle – The Great Hurricane Exhale.

February 6, 2015, B. Ervens (NOAA/ESRL/CIRES). Secondary Organic Aerosol Formation: The Role of Chemical Processes in the Aqueous Phase of Clouds and Aerosol Particles.

February 12, 2015, G. Stephens (JPL). Where is the Heat Going?

February 13, 2015, B. Gail (Global Weather Corporation). After Climate Change, What Next?

February 19, 2015, J. Walker (USEPA). Soil-canopy-atmosphere Interactions in Ammonia Air-surface Exchange.

February 20, 2015, C. Davis (NCAR). Hurricanes from Scratch.

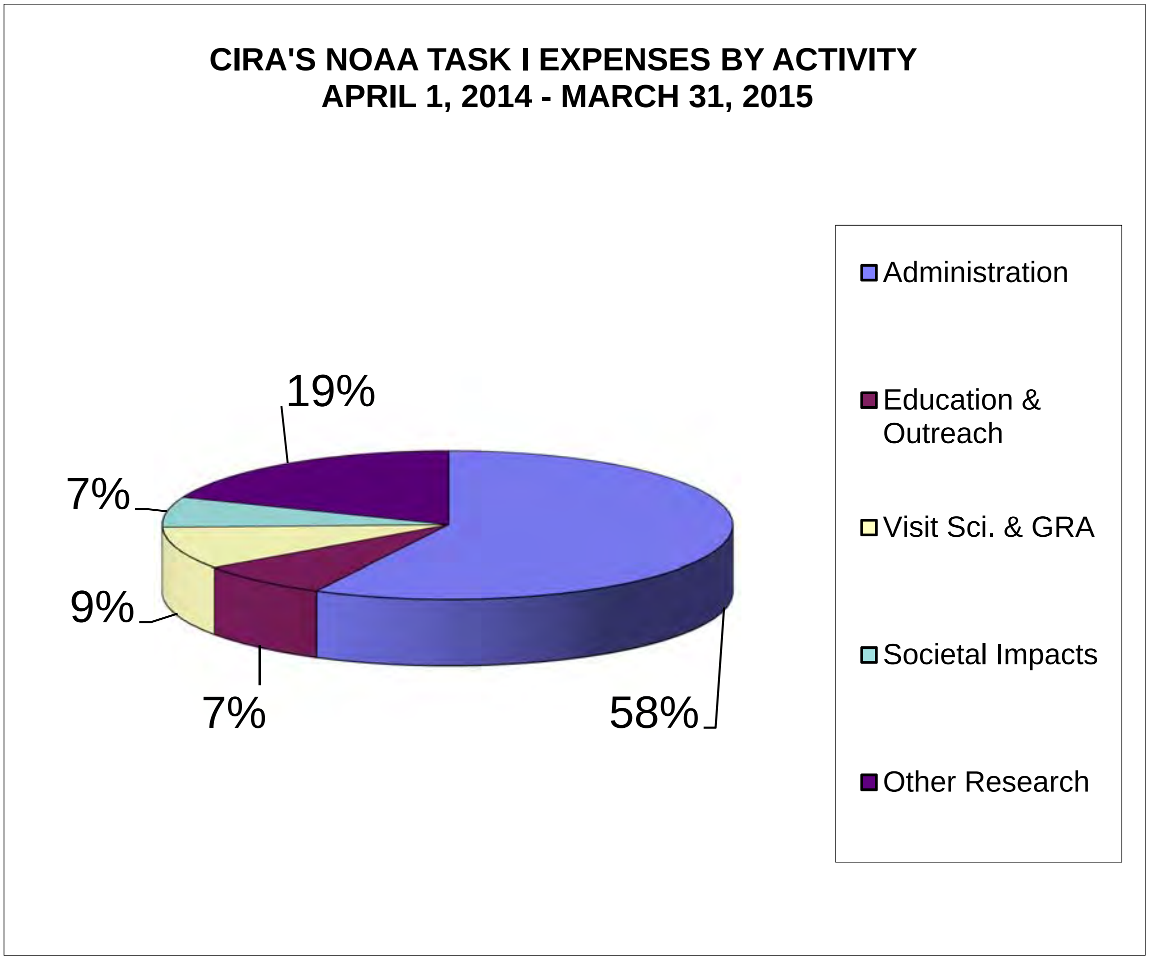
February 27, 2015, D.J. Raymond (New Mexico Tech). The Formation of Tropical Cyclones.

March 6, 2015, Z. Lebo (NOAA). Have We “Resolved” the Aerosol Effects on Deep Convection Problem?

March 11, 2015, G. Liston (CIRA). Arctic Field Expedition.

March 13, 2015, R. Schumacher (CSU/ATS). Elevated Convective Systems and Extreme Rainfall.

March 27, 2015, E.A. Stone (University of Iowa). Uncontrolled Combustion of Shredded Tires in a Landfill.


CIRA'S NOAA TASK I EXPENSES BY ACTIVITY
APRIL 1, 2014 - MARCH 31, 2015
19%
7%
9%
7%
58%
Administration
Education & Outreach
Visit Sci. & GRA
Societal Impacts
Other Research

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NOAA AWARD NUMBERS & AMENDMENTS FOR REPORT PROJECTS

Award Number	Identifier	Project Title	Principal Investigators/ Project Directors
NA14OAR4320125	Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Chris Kummerow (Lead), Steven Miller
NA10SEC0080012	Competitive	CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful Citizen Science Network	Chris Kummerow (Lead), Nolan Doesken
NA11OAR4310208	Competitive	Development of a Probabilistic Tropical Cyclone Prediction Scheme	Andrea Schumacher
NA11OAR4310204	Competitive	Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis	Chris Kummerow
NA14OAR4310148	Competitive	Following Emissions from Non-traditional Oil and Gas Development Through Their Impact on Tropospheric Ozone	Emily Fischer, Delphine Farmer
NA13OAR4590187	Competitive	Guidance on Intensity Guidance	Andrea Schumacher
NA13OAR4310080	Competitive	Improving CarbonTracker Flux Estimates for North Americas Using Carbonyl Sulfide (OCS	Ian Baker
NA12OAR4310077	Competitive	Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models	Eric Maloney
NA14OAR4310141	Competitive	Observational Constraints on the Mechanisms that Control Size- and Chemistry-resolved Aerosol Fluxes Over a Colorado Forest	Delphine Farmer
NA13OAR4310103	Competitive	Research to Advance Climate and Earth System Models Collaborative Research: A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models	David Randall
NA13OAR4310077	Competitive	Towards Assimilation of Satellite, Aircraft and Other Upper-air CO2 Data into CarbonTracker	David Baker
NA13OAR4590190	Competitive	Upgrades to the Operational Monte Carlo Wind Speed Probability Program	Andrea Schumacher
NA13OAR4310163	Competitive	Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation	Eric Maloney

NOAA AWARD NUMBERS & AMENDMENTS FOR REPORT PROJECTS

NA14OAR4830122	Competitive - Sandy	CIRA Assimilation of Moisture and Precipitation Observations in Cloudy Regions of Hurricane Inner Core Environments to Improve Hurricane Intensity, Structure and Precipitation	Chris Kummerow, Milija Zupanski
NA14NWS4830020	Competitive - Sandy	CIRA – Distance Learning Materials on Blended Numerical Guidance Products	Chris Kummerow, Bernie Connell
NA14NWS4830018	Competitive - Sandy	CIRA – Distance Learning Materials on Tropical Storm Forecasting and Threats	Chris Kummerow, Bernie Connell
NA14NWS4830056	Competitive - Sandy	CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates	Andrea Schumacher
NA14OAR4830110	Competitive - Sandy	ESRL/GSD Participation in the Establishment of a NOAA Lab Activity for OSSEs	Sher Schranz, Ning Wang
NA14OAR4830114	Competitive - Sandy	Evaluation of Earth Networks Total Lightning Products for NWS Warning Services in the Hazardous Weather Testbed	Sher Schranz
NA14NWS4830034	Competitive - Sandy	Incorporating the GOES-R Geostationary Lightning Mapper Assimilation into the GSI for Use in the NCEP Global System	Milija Zupanski, Karina Apodaca
NA14NWS4830009	Competitive - Sandy	MADIS Transition to NWS Operations	Sher Schranz, Tom Kent
NA14OAR4830111	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Ensemble Statistical Post-processing	Sher Schranz, Isidora Jankov
NA14OAR4830109	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Real-time IT Operations	Sher Schranz
NA14OAR4830112	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Fine-grain Computing	Sher Schranz
NA14OAR4830113	Competitive - Sandy	NOAA's High Impact Weather Prediction Project (HIWPP) Test Program – Visualization and Extraction via NEIS	Sher Schranz
NA14OAR4830167	Competitive - Sandy	NOAA' S Observing System Experiments and Observing System Simulation Experiments in Support of the "Sensing Hazards with Operational Unmanned Technology" (SHOUT) Program – Development and Testing of Sampling Strategies for Unmanned Aerial Systems	Sher Schranz, Ning Wang
NA14OAR4830166	Competitive - Sandy	Sensing Hazards with Operational Unmanned Technology (SHOUT) – Data Management and Visualization	Sher Schranz, Jebb Stewart

NOAA AWARD NUMBERS & AMENDMENTS FOR REPORT PROJECTS

Amendments Award #NA14OAR4320125

Type	ID	Title	Status
Award Package	2478931	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Special Award Condition Report	2478931	Special Award Condition Report	
Award File 0	2478815	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 1	2486219	Blended Hydrometeorological Products	Accepted
Award File 2	2487155	CIRA support: Getting Ready for NOAA's Advanced Remote Sensing Programs	Accepted
		A Satellite Hydro-Meteorology (SHyMet) Education and Outreach Proposal	
Award File 3	2488641	CIRA Support for the JPSS Proving Ground and Risk Reduction Program: Application of JPSS Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting	Accepted
Award File 4	2491422	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 5	2489188	CIRA Support of NOAA's commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory	Accepted
Award File 6	2495512	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 7	2488558	CIRA Support to the JPSS Proving Ground and Risk Reduction Program: Seeing the Light: Exploiting VIIRS Day/Night Band	Accepted
Award File 8	2489265	CIRA Support of the Virtual Institute for Satellite Integration Training (VISIT)	Accepted
Award File 9	2488553	SSMI and SSMIS Fundamental Climate Data Record Sustainment and Maintenance	Accepted
Award File 10	2489670	Algorithm development for AMSR-2	Accepted
Award File 11	2489691	Weather Satellite Data and Analysis Equipment and Support for Research Activities	Accepted
Award File 12	2489082	CIRA Support for Feature-Based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting	Accepted
Award File 13	2489686	Support for the 2015 JCSDA Summer Colloquium to be hosted by CIRA	Accepted

NOAA AWARD NUMBERS & AMENDMENTS FOR REPORT PROJECTS

Award File 14	2489681	Applications of concurrent super rapid sampling from GOES-14 SRSOR, radar and lightning data	Accepted
Award File 15	2486813	CIRA Support to a GOES-R Proving Ground for National Weather Service Forecaster Readiness	Accepted
Award File 16	2486808	CIRA Support for Tropical Cyclone Model Diagnostics and Product Development	Accepted
Award File 17	2488603	CIRA Support to the JPSS Science Program: S-NPP VIIRS EDR Imagery Algorithm and Validation Activities and S-NPP VIIRS Cloud Validation	Accepted
Award File 18	2489060	CIRA Support for Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting	Accepted
Award File 19	2496525	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 20	2495520	CIRA Support to the NESDIS Cooperative Research Exchange Program	Accepted
Award File 21	2497195	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 22	2497181	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 23	2496807	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 24	2495693	EOY CIRA Support to RAMMB Infrastructure for GOES-R Rebroadcast Data Collection at CIRA/CSU	Accepted
Award File 25	2496490	NESDIS Environmental Applications Team (NEAT)	Accepted
Award File 26	2496040	Explicit Forecasts of Recurrence Intervals for Rainfall: Evaluation and Implementation Using Convection-allowing Models	Accepted
Award File 27	2495157	Building a "citizen science" soil moisture monitoring system utilizing the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS)	Accepted
Award File 28	2496378	Estimating Peatland Fire Emissions Using Nighttime Satellite Data	Accepted
Award File 29	2496383	Integrating GPM and Orographic Lifting into NOAA???s QPE in Mountainous Terrain	Accepted
Award File 30	2495162	Instructional Development and Learning Support for NOAA's OMAO's Chief Learning Officer (CLO), OMAO Kansas City, Missouri	Accepted

NOAA AWARD NUMBERS & AMENDMENTS FOR REPORT PROJECTS

Award File 31	2465060	CIRA Research Collaborations with the NWS Meteorological Development Lab on Virtual Laboratory, Innovation Web Portal, and AWIPS II Projects	Accepted
Award File 32	2490588	CIRA Research Collaborations with the NWS Meteorological Development Lab on Virtual Laboratory, and AWIPS II Projects	Accepted
Award File 33	2491622	Environmental Applications Research (EAR)	Accepted
Award File 34	2491359	Research Collaboration at the NWS Aviation Weather Center in Support of the Aviation Weather Testbed, Aviation Weather Research Program, and the NextGen Weather Program	Accepted
Award File 35	2496023	Hydrologic and Water Resources Research and Applications Outreach	Accepted
Award File 36	2501944	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted
Award File 37	2514836	Research Collaboration at the NWS Aviation Weather Center in Support of the Aviation Weather Testbed, Aviation Weather Research Program, and the NextGen Weather Program	Accepted
Award File 38	2513184	Environmental Applications Research (EAR)	Accepted
Award File 39	2515553	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Accepted

AWARDS ENDING PROJECT LIST

NA090AR4320074

--A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts
--Algorithm Development for AMSR-2
--Application of JPSS Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting
--CIRA Research Collaborations with the NOAA Earth System Research Lab/global Monitoring Division on Carbon Tracker Model Enhancements
--CIRA Research Collaborations with the NWS Meteorological Development Lab on Autonowcaster and AWIPS II Projects
--CIRA Support for Feature-based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting
--CIRA Support for Transition of Tropical Cyclone Forecast Products
--Getting Ready for NOAA's Advanced Remote Sensing Programs: A Satellite Hydro-Meteorology (SHyMet) Training and Education Proposal
--CIRA Support of NOAA's Commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory
--CIRA Support of the Virtual Institute for Satellite Integration Training (VISIT)
--CIRA Support to GOES Improvement and Product Assurance Program
--CIRA Support to GOES-R Proving Ground for National Weather Service Forecaster Readiness
--CIRA Support to GOES-R Proving Ground for National Weather Service Forecaster Readiness
--CIRA Support to Production of Real-time Nested NAM-based GOES-R Synthetic Imagery
--CIRA Support to Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting and Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events
--CIRA Support to the CASA Dallas Fort Worth Urban Demonstration Network
--CIRA Support to the JPSS Proving Ground and Risk Reduction Program
--CIRA Support to the JPSS Science Program: NPP VIIRS EDR Imagery Algorithm and Validation Activities and NPP VIIRS Cloud Validation
--CIRA Support to Tropical Cyclone Model Diagnostics and Product Development
--Design, Development, Evaluation, Integration and Deployment of New Weather Radar Technology
--Effective Collaborative NIDIS Drought Monitoring and Early Warning in the Upper Colorado Basin
--Environmental Applications Research (EAR
--Hydrological Research and Water Resources Applications Outreach Coordination
--Impact Assessment and Data Assimilation of NOAA NPP/JPSS Sounding Products and Quality Control Parameters
--Legacy Atmospheric Sounding Data Set Project
--NESDIS Environmental Applications Team (NEAT)
--NEAT Expanded
--POES-GOES Blended Hydrometeorological Products
--Quantitative Precipitation Estimation (QPE)
--RAMMB Infrastructure for Product Development, Demonstration and Operational Transition at CIRA/CSU
--Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting; and Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events
--Research Collaboration with the Aviation Weather Testbed in Support of the NWS NextGen Weather Program
--Research Collaboration at the NWS Aviation Weather Center in Support of the Aviation Weather Testbed, Aviation Weather Research Program, and the NextGen Weather Program
--Scientific Support to the GOES-R Algorithm Review Board
--Severe Weather/Aviation Impact from Hyperspectral Assimilation
--Software Engineering Support for the Joint Polar Satellite System (JPSS) Common Ground System Interface Data Processing Segment (IDPS)

AWARDS ENDING PROJECT LIST

--SSMI and SSMIS Fundamental Climate Data Record Sustainment and Maintenance
--Summer School on Atmospheric Modeling
--Variability in Snow Sublimation Across Basin Scale Systems
--Weather Satellite Data and Analysis Equipment and Support for Research Activities

NA10NES440012 – Utility of GOES-R Instruments for Hurricane Data

NA13NWS4830023 – Tropical Cyclone Model Diagnostics and Product

NA11OAR4310203 – Improvements in Statistical Tropical Cyclone Forecast Models

NA11OAR 4310208 - Development of a Probabilistic Tropical Cyclone Prediction Scheme

RESEARCH THEME REPORTS

SATELLITE ALGORITHM DEVELOPMENT, TRAINING & EDUCATION

Research associated with development of satellite-based algorithms for weather forecasting, with emphasis on regional and mesoscale meteorological phenomenon. This work includes applications of basic satellite products such as feature track winds, thermodynamic retrievals, sea surface temperature, etc., in combination with model analyses and forecasts, as well as in situ and other remote sensing observations. Applications can be for current or future satellites. Also under this theme, satellite and related training material will be developed and delivered to a wide variety of users, with emphasis on operational forecasters. A variety of techniques can be used, including distance learning methods, web-based demonstration projects and instructor-led training.

PROJECT TITLE: Algorithm Development for AMSR-2

PRINCIPAL INVESTIGATOR: Christian Kummerow

RESEARCH TEAM: David Duncan, ATS & David Randel, ATS

NOAA TECHNICAL CONTACT: Ralph Ferraro, NOAA NESDIS

NOAA RESEARCH TEAM: Ralph Ferraro, NOAA NESDIS

PROJECT OBJECTIVE(S):

The Japanese Aerospace Exploration Agency (JAXA) launched the AMSR-2 instrument aboard its GCOM-W satellite in February 2012. This proposal outlines an effort to (1) Assess the quality of the AMSR2 calibration and (b) adapt the Goddard Profiling Algorithm (GPROF) - an existing rainfall retrieval code originally developed for TRMM TMI and Aqua AMSR-E – for use in the NESDIS AMSR-2 processing stream.

PROJECT ACCOMPLISHMENTS**:**

The assessment of AMSR-2 calibration has continued in light of the fact that rainfall retrievals from AMSR-E and AMSR-2 were quite different despite good agreement for non-raining parameters as reported in the previous year. All indications are that this is due to non-linearities in the calibration curve that have not been properly captured by the JAXA team. These non-linear effects would primarily affect mid-range Tbs where much of the precipitation signal originates from but beyond the non-raining Tb ranges.

The main work going into the AMSR-2 retrieval algorithm was the construction of an a-priori database using GPM's DPR for rainfall over both land and ocean. Early indications are that the algorithm works quite well until the atmosphere gets exceedingly cold and the wind channels are no longer able to sense the small ice crystals associated with snow at temperatures colder than roughly 255K. Initial testing of the next generation AMSR-2 algorithm looks really promising over both ocean and land. An example of the code applied to all imaging radiometers currently in orbit is shown in Figure 1 below. The consistency between sensors bodes well for a NOAA unified algorithm.

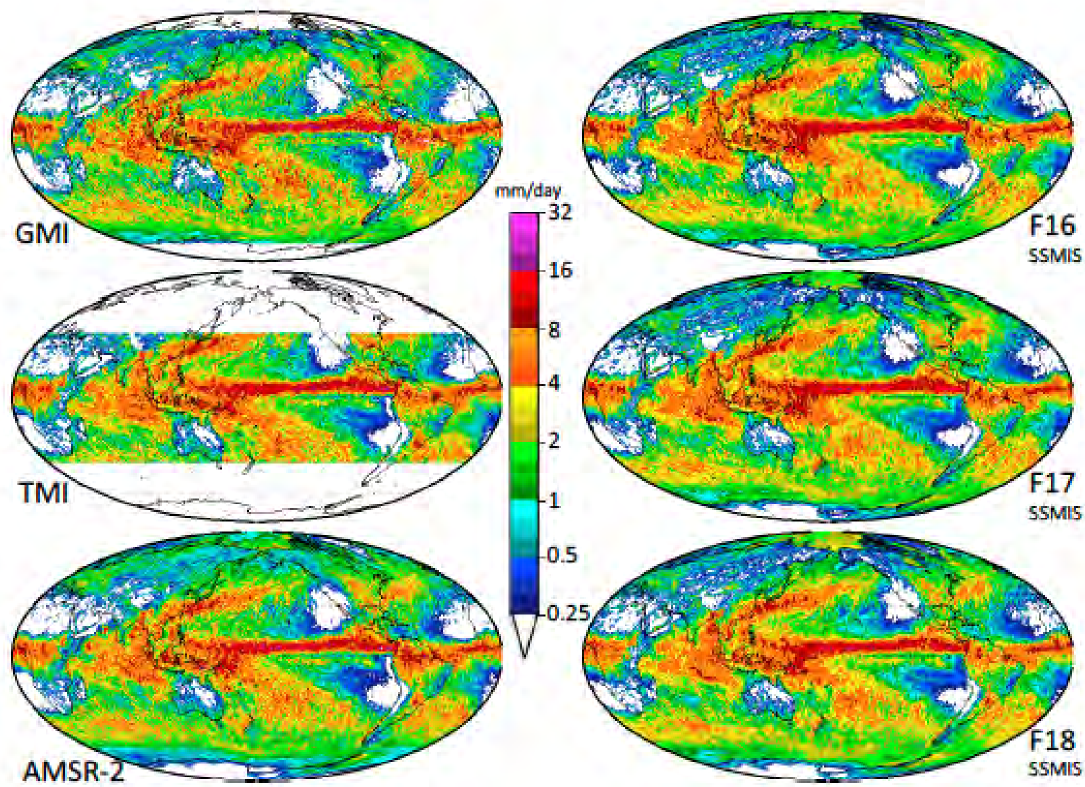

Figure 1. April, May, and June, 2014, average mean surface precipitation from operational imaging radiometers suing GPROF 2014, version 1.4

PROJECT PUBLICATIONS:

Results were presented at ASMR2 as well as GPM science team meetings. A paper on the general algorithm framework has been submitted to the J. of Oceanic and Atmospheric Technology. " The Evolution of the Goddard Profiling Algorithm to a Fully Parametric Scheme", by Christian Kummerow, David L. Randel, Mark Kulie, Nai-Yu Wang, Ralph Ferraro, S. Joseph Munchak, and Veljko Petkovic

PROJECT TITLE: Applications of Concurrent Super Rapid Sampling from GOES-14 SRSOR Radar and Lightning Data

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Steve Albers

NOAA TECHNICAL CONTACT: Bob Rabin (NSSL)

PROJECT OBJECTIVE:

Utilize high-frequency radar and satellite data to initialize LAPS/WRF simulations.

PROJECT ACCOMPLISHMENTS:

This is in collaboration with NSSL. We have been gathering data for several Local Analysis and Prediction System (LAPS) case reruns, starting with the Moore tornado case from May 20, 2013. This involves retrieving routinely archived observational data from NOAA's High Performance Computing Mass Storage. In addition, Level-II Doppler radar data are being obtained from the National Climatic Data Center. Our processing scripts are being updated to support the new Java application for converting this into NetCDF. Special cloud-drift wind data from the 1-minute GOES-R data have also been reformatted to be readable by LAPS. Preliminary reanalysis runs with the routinely archived data have been performed. We've also tested with rerunning the WRF forecast on this case, and we plan to rerun this with the recent reanalysis fields.

Additional cases have been selected for several days in 2014, and the GOES-R cloud-drift wind data have been processed. We will be gathering the other observational data so we can perform LAPS/WRF reruns.

PROJECT TITLE: CIRA Support for Feature-based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting

PRINCIPAL INVESTIGATORs: Jack Dostalek and Galina Chirokova

RESEARCH TEAM: Robert DeMaria, Dave Watson, Steve Finley, Rosemary Borger, Renate Brummer

NOAA TECHNICAL CONTACT: Chris Brown (NESDIS/NESDIS) and Philip Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: John Knaff (NOAA/NESDIS/StAR)

PROJECT OBJECTIVES:

The purpose of this work is to determine the utility of the Microwave Integrated Retrieval System (MIRS) retrievals for a specific region (the Tropics) and for a specific application (tropical cyclone analysis) to complement the broader Cal/Val activities at STAR. The MIRS soundings generated from both the AMSU (Advanced Microwave Sounding Unit) instrument aboard the NOAA and MetOp satellites, and from the ATMS (Advanced Technology Microwave Sounder) instrument aboard Suomi-NPP will be analyzed. The validation of the MIRS soundings will consist of standard error analysis of the thermodynamic profile in addition to comparing their performance in four products relevant to tropical cyclone analysis and forecasting: Maximum Potential Intensity (MPI), vertical velocity profile from an entraining plume model, the Multiplatform Satellite Surface Wind Analysis, and a statistical intensity and wind radii estimate. Comparisons will be made not only between retrievals from the AMSU and the ATMS instruments, but also between the AMSU retrievals generated from MIRS and AMSU retrievals generated from an older, statistical algorithm. Dropsondes from tropical cyclone reconnaissance flights will provide the “ground truth” measurements.

This project supports the following NOAA mission goals: Weather and Water.

PROJECT ACCOMPLISHMENTS: Past Fiscal Year by Objective:

1--A database of collocations between dropsondes and MIRS retrievals from both the AMSU (NOAA-18, NOAA-19, MetOp-A, and MetOp-B satellites) and ATMS (S-NPP satellite) was created for Atlantic tropical cyclones for the years 2012-2014.
2--An automated procedure was created to add to the database mentioned in (1) by downloading available dropsondes from the National Hurricane Center. The dropsondes are decoded and run through a quality assessment which eliminates bad data. The procedure then checks the available AMSU or ATMS data to determine if a collocation is possible.
3--Real-time dropsonde/AMSU retrieval collocations have been added to the RAMMB-CIRA TC Real-Time Page, http://rammb.cira.colostate.edu/products/tc_realtime/. This display joins the dropsonde/ATMS collocations and the ATMS MPI estimates, which were leveraged from the JPSS-PGRR_TC project. The product displays the vertical temperature and moisture profiles of dropsondes collocated with AMSU retrievals in the vicinity of tropical cyclones. The AMSU retrieval closest to the dropsonde is selected, and must be within one hour and 100 km from the dropsonde release time and location. Additional information included on the collocation includes the ATCF tropical cyclone id, the tropical cyclone heading angle, the distance from the TC center to the dropsonde, and the horizontal distance between the dropsonde release location and the AMSU retrieval. A collocation will be displayed for any tropical cyclone within 2000 km of a dropsonde. Figure 1 is a screen capture of this portion of the TC Real-Time page for Hurricane Edouard (2014). The online availability of collocations between dropsondes and retrievals allows for the monitoring of the performance of satellite retrievals as a tropical cyclone is occurring.

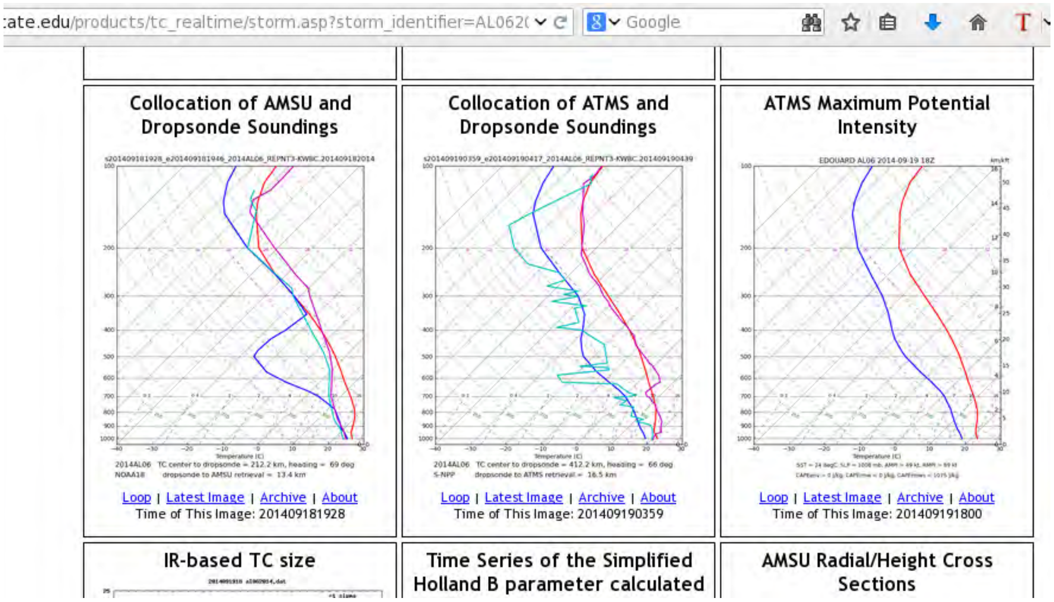

Figure 1. Screen capture from the RAMMB-CIRA TC Real-Time page of Hurricane Edouard, showing the dropsonde collocations with an AMSU retrieval, an ATMS retrieval, as well as the ATMS MPI estimate.

PROJECT TITLE: CIRA Support for Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting

PRINCIPAL INVESTIGATOR**:** Steve Miller

RESEARCH TEAM: Renate Brummer, Cindy Combs, Jack Dostalek, Louie Grasso, Andrea Schumacher, Kevin Micke, Bernie Connell, Dan Bikos, Jeff Braun, Hiro Gosden, Dave Watson, Mike Hiatt

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Phil Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: Mark DeMaria, Donald W. Hillger, John Knaff, Dan Lindsey, Deb Molenar (NESDIS/STAR)

PROJECT OBJECTIVES:

The next generation GOES satellites (beginning with GOES-R) will include the Advanced Baseline Imager (ABI) with vastly improved spectral, spatial and temporal resolution relative to the current GOES I-P series satellites. It will also include a Geostationary Lightning Mapper (GLM) which, together with the ABI, offers the potential to significantly improve the analysis and forecasts of mesoscale weather and natural hazards. The GOES-R era will begin in the middle of this decade, and will be part of a global observing system that includes polar-orbiting satellites with comparable spatial and spectral resolution instrumentation. This annual report combines CIRA's different projects conducted in the areas of GOES-R Risk Reduction (R3). The overall goal of these science studies is to contribute to the reduction of time needed to fully utilize GOES-R as soon as possible after launch and to provide the necessary proxy data to the algorithm groups for testing proposed algorithms and therefore to contribute to an improved algorithm selection and algorithm refinement.

GOES-R3 Research Areas:
CIRA's GOES-R3 work can be divided into the following eleven different projects:

Project 1-- Tropical Cyclones: Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes.
Project 2-- Proxy Radiance Data Testbed: Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground
Project 3-- Precipitation: Improvements to QPE using GOES visible ABI and model data.
Project 4-- Infrastructure - RGB Products in AWIPS II
Project 5-- Diagnosis and anticipation of tropical cyclone behavior from new and enhanced GOES-R capabilities
Project 6-- Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts.
Project 7-- Synthetic Imagery Generation over Alaska and Hawaii for GOES-R Product Development
Project 8-- GOES–R AWG Proxy Data Application
Project 9-- GOES–R AWG Imagery Team
Project 10-- National and International Training Development, Delivery, and Distribution and PCS User Readiness
Project 11-- Supporting Projects

PROJECT ACCOMPLISHMENTS:

Project 1-- Tropical Cyclones: Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes.
This tropical cyclone project was a collaboration project between CIRA, NESDIS/StAR/RAMMB and CIMSS. The goal of this project was to develop new tools that enhance the current capabilities to diagnose tropical cyclone (TC) structure and location using GOES-R advanced baseline imagery (ABI) and GOES lightning mapper (GLM) proxies. The GOES-R Algorithm Working Group supports one TC algorithm, which estimates TC intensity. While intensity is an important operational TC metric, the diagnosis and forecasts of the wind field structure is also an operational requirement and is often considered equally important in determining the impacts of landfalling TCs, initializing numerical weather prediction models, emergency preparedness and disaster mitigation. Using current satellite data and GOES-R ABI and GLM proxies the CIRA research contributed to advancing a number of outstanding problems in TC research and forecasting techniques, like the improvement of TC location estimates; an increase in the understanding of the linkages between TC structure, intensity, the TC's environment, and internal dynamics; and the development of improved techniques to estimate the inner-core wind structure and TC-related parameters.

Specific accomplishments made during the reporting period are listed below.

--Global infrared (IR) images 1979-2012 from two sources were used to construct an objective 1-D TC size metric that provides a consistent measure of storm size and allows for inter-comparison studies. This has led to one refereed publication, Knaff et al. (2014a) and a new real-time product (TC size) which is being displayed on the TC real-time web page http://rammb.cira.colostate.edu/products/tc_realtime/ . The scaling method may provide a way to accommodate for TC size variations during intensity algorithm development. Results of the scaling technique were presented at the AMS Conference on Hurricanes and Tropical Meteorology.

--Using analyses of aircraft reconnaissance a 2-D IR-based flight-level wind reconstruction/proxy method has been developed (see Figure 1). The documentation of this method was presented at the AMS Conference on Hurricanes and Tropical Meteorology, has been conditionally accepted for publication (i.e., Knaff et al. 2014b), and has led to new experimental versions of the Multi-satellite-Platform Tropical Cyclone Surface Wind Analysis (MTCSWA) being produced on the TC-realtime website.

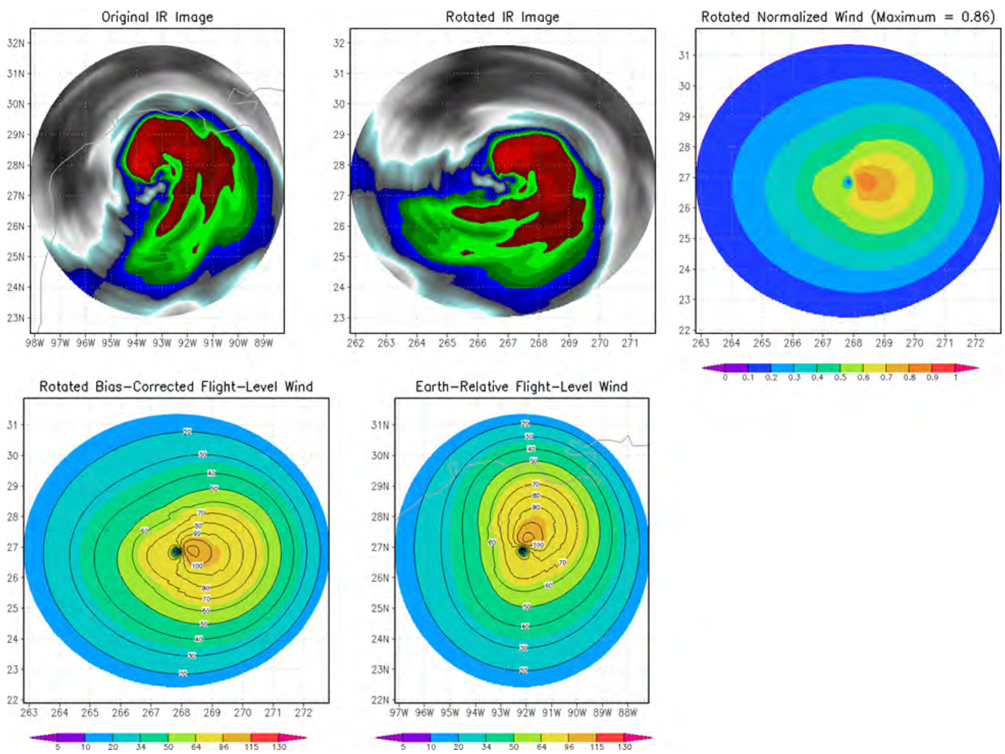

Figure 1. An illustration of the steps taken to estimate the wind field. The progression is from left to right and then top to bottom. Imagery are mapped to a polar grid and then rotated with respect to direction. Rotated imagery (via principle components), translation speed, latitude and intensity are then used to estimate the normalized wind field. The observed intensity is then applied. Finally the wind field is rotated back to its earth relative directional component. This case is from Hurricane Ike (2008) on September 12 at 1145 UTC.

--Using the TC size metric as the dependent variable and information contained in the SHIPS developmental dataset, the development of a statistical-dynamical method to forecast TC size changes began. Dependent statistics indicate that roughly 50-60 % of the variance of TC size changes as measured by the IR TC size metric is possible beyond 72 hours.

--The 1-D TC size metric combined with the current intensity and TC motion vector has been statistically related to operationally important wind radii as shown in Figure 2. This allows for the explicit prediction of wind radii using SHIPs intensity forecasts and forecasts of the TC size metric discussed above.

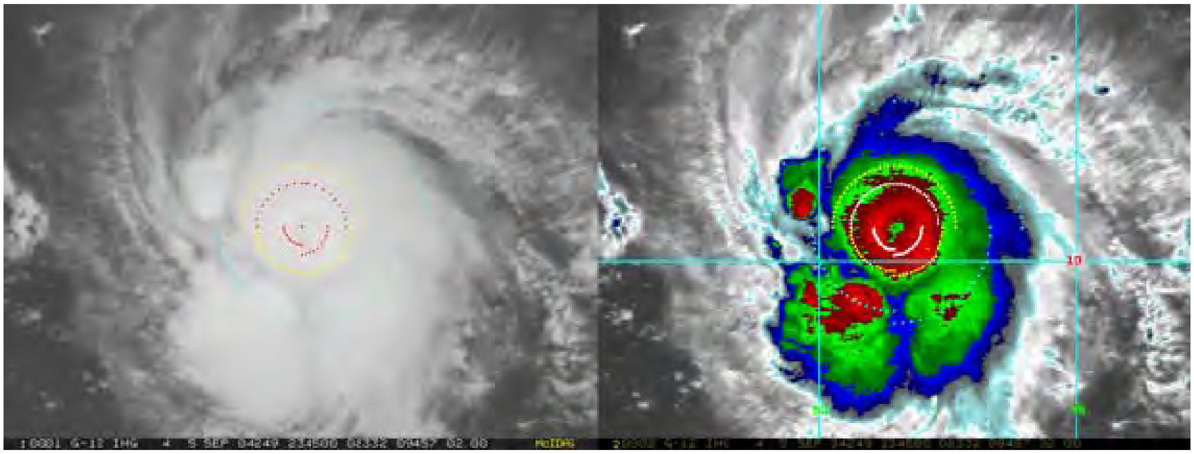

Figure 2. IR and enhanced IR image of Hurricane Ivan 5 September 2004 at 2345 UTC showing objectively estimated wind radii. 34-kt wind radii are show in cyan, 50-kt wind radii are shown in yellow and 64-kt wind radii are shown in red (left), white (right). Ivan had a maximum sustained wind of 115 kt and its motion was 315 at 5 kt.

--A calibrated, developmental dataset of storm-centered passive microwave imagery (19, 37, and 85-GHz) data interpolated to standard cylindrical grids was developed for Atlantic and Eastern Pacific TCs (1995-2012). Using the aircraft reconnaissance data described above and estimates of the storm's current intensity, position, and motion, a regression-based tool for estimating the 2D wind structure of TCs from passive microwave imagery has been developed. The methodology is similar to that described in Knaff et al. (2014b). Results will be documented in the to-be-submitted manuscript, Rozoff et al. (2014).

Project 2-- Proxy Radiance Data Testbed: Ensemble Simulation of GOES-R Proxy Radiance Data from CONUS Storm-Scale Ensemble Forecasts, Product Demonstration and Assessment at the Hazardous Weather Testbed GOES-R Proving Ground

This proxy radiance data testbed project was a collaboration project between three cooperative institutes: CAPS, CIMSS, and CIRA. The project employed 4-km storm-scale ensemble forecasts (SSEFs) produced by the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma (OU) for the NOAA Hazardous Weather Testbed (HWT) Spring Experiments. Most of these project tasks were completed during the previous reporting year. Utilizing national supercomputing resources, synthetic imagery was generated in real-time, for several infrared channels from 10-15 ensemble members, at hourly intervals. Three radiative transfer model packages were employed in the project. They included the Community Radiative Transfer Model (CRTM) package from NESDIS, the package based on the Successive Order of Interaction (SOI) RTM from CIMSS, University of Wisconsin, and an RTM package from CIRA of Colorado State University. They were used to generate synthetic brightness temperatures for selected Advanced Baseline Imager (ABI) and current GOES infrared channels. Through collaborations, a better understanding of the interaction between cloud microphysics and radiative transfer modeling was achieved so as to provide insights for improving the CRTM system, which is part of the operational data assimilation systems at NCEP.

CIRA scientists collaborated closely with the CAPS proxy data team (Louie Grasso, Ming Xue, Fanyou Kong, and Youngsun Jung) on this project. Ming Xue, the director of CAPS, asked that CIRA provide code that would compute particle size of each of the five habit types (cloud, rain, snow, graupel, and ice) that are available in five microphysical schemes (Morrison, Milbrandt-Yau, NSSL, Thompson, and WDM6) available in WRF-ARW forecast model. This task was accomplished with the additional collaboration of Jason Otkin (CIMSS) and Ted Mansel (NSSL).

In addition, the performance of the wsm6 microphysical scheme was evaluated for the forecast periods of July 2011 through September 2012 and for summer of 2013. Results indicated that the amount of upper level cloud ice produced by the wsm6 scheme was significantly under predicted when compared to observations. This conclusion was based on histograms we produced of synthetic and observed GOES-13 10.7 µm brightness temperatures for those forecast periods. Further, specific examples of convective events were used for side-by-side comparisons of synthetic and observed GOES-13 imagery. During this reporting period the results of this research were successfully published in a peer reviewed manuscript to Monthly Weather Review titled "Evaluation of and Suggested Improvements to the WSM6 Microphysics in WRF-ARW Using Synthetic and Observed GOES-13 Imagery".

Project 3-- Precipitation: Improvements to QPE using GOES visible ABI and model data.

This precipitation project was a collaboration project between NSSL, CIMSS, CIRA, and CIMMS. The project addresses the need for remote sensing-based estimates of precipitation in portions of the U.S. and its coastal waters where WSR-88D radar is limited due to the radar beam being blocked and/or overshooting the precipitation. Heavy precipitation poses threats of flash flooding, but existing satellite techniques often perform poorly in pinpointing locations of heavy rain, especially when cloud tops are relatively warm.

Improvements to the existing Self-Calibrating Multivariate Precipitation Retrieval (SCaMPR) algorithm was made using high resolution cloud structure from the GOES visible imagery (daytime), estimates of cloud top phase and particle size derived from GOES, and moisture and wind fields from numerical weather model and model and satellite "blended" data. Preliminary work at the National Severe Storms Laboratory (NSSL) indicated that a simple technique to identify small-scale convective cloud tops in visible imagery performs better than IR techniques in matching radar echoes in many situations. GOES-R will provide about twice the resolution of the 1-km observations available from the current GOES. CIRA's contribution to the project was primarily to provide cloud-top effective radius retrievals for selected case studies. This task was completed by the end of last year.

Project 4-- Infrastructure - RGB Products in AWIPS II

RGB products have been demonstrated within AWIPS at WFOs and N-AWIPS at National Centers. The products are created from single and multi-band satellite imagery to produce a single 8-bit image file external to the AWIPS environment. A fundamental requirement to augment the AWIPS II capabilities for 24-bit RGB imagery will be to develop a satellite visualization plugin or tool that can access individual satellite channels, paired channel differences, or comparable measurements from the AWIPS II database for assignment to the RGB intensities. These intensities must then be combined to display a resulting 24-bit color without assigning transparencies to the individual RGB color inputs themselves.

AWIPS II has 2 display components: D2D & NCP. D2D is used primarily at the NWS Forecast Offices, and NCP is used primarily at the NOAA National Centers. 24/32 display capabilities have been developed for D2D. The objective of this project is to work with NOAA NCO software development staff to determine if the D2D RGB capabilities can be ported directly to the NCP.

During this reporting period, CIRA software development staff participated in multiple telecons with NCO, CIMSS and SPoRT staff to determine the best path forward. An August on-site meeting at NCWCP in College Park, MD provided a chance to review the NCWCP environment and meet personally with the NCO software development team. Subsequent work at a software development workshop held in Huntsville, AL, provided the opportunity to document differences between D2D and NCP display code. It was determined that two major software components necessary for RGB display in NCP do not exist. The group will meet with NCO staff again in the summer of 2015 to determine tasks for development of the missing components.

Because the RGB software development task was larger than initially expected, CIRA/RAMMB staff held hands-on training for AWIPS II NCP instead. Three NOAA satellite liaisons attended the 2-day training session, which covered general AWIPS II utilization and configuration, and provided exercises on how to ingest and display experimental CIRA/RAMMB satellite products in NCP.

Project 5-- Diagnosis and anticipation of tropical cyclone behavior from new and enhanced GOES-R capabilities

This project builds on previous tropical cyclone (TC) research, makes use of unique datasets, and leverages the NOAA Hurricane Forecast Improvement Program (HFIP) resources. The project goal is to learn how to better diagnose and anticipate TC behavior with the new and enhanced capabilities of the next generation of GOES satellites. Our on-going work addresses three important aspects of TC behavior. The first topic (**Topic 1**) addresses how to interpret the occasional variations of cloud-top microphysics associated with TCs. GOES-R products include cloud effective particle size (EPS) estimates and the precision of the Advanced Baseline Imager (ABI) will enable many qualitative products (e.g., RGB combinations) that provide users with information about EPS. GOES-R will greatly enhance our ability to see where and when small ice particles are being generated atop the TC. In this work we describe efforts to interpret such observations. The second topic (**Topic 2**) addresses work to better statistically infer the TC structure from IR imagery. In the past, such work relied heavily on composited aircraft reconnaissance data to provide the necessary inferences. HWRF model output from NOAA's HFIP program provides both simulated IR imagery and instantaneous ground truth at multiple levels. If successful, these relationships will allow the inference TC wind structure from a combination of observed IR imagery and routinely available information (intensity and translation). The final area (**Topic 3**) of this project will investigate methods to anticipate TC eye formation. Eye formation has long been known to indicate that a TC has reached hurricane intensity and is a primary pattern used to infer tropical cyclone intensity. In fact, the appearance of a clear eye can result in Dvorak-based intensity estimates of more than 40 knots in 24 hours.

Topic 1: Variations of cloud-top microphysics
The CloudSat Tropical Cyclone Database (CTCD) has been updated to include all CloudSat ancillary products and extended the dataset with tropical cyclone overpasses through Dec 2014 for a total of 8,127 intersections within 1000 km of tropical systems. GFS one degree resolution vertical wind shear at seven different levels was also included. Table 1 lists all of the products included in each overpass and a summary of key parameters important to this study.

Product Name	Description	Key Parameters
2B-CLDCLASS-LIDAR	Co-located CALIPSO lidar, CloudSat radar and MODIS observations to classify clouds	Cloud phase, Cloud type, Cloud top and base height
2C-ICE	Co-located CALIPSO lidar and CloudSat radar ice cloud estimates	Ice water content, optical depth, effective radius
2B-TAU	MODIS and CloudSat CPR radar only optical depth estimates	Optical depth, effective radius (liquid + ice)
2B-GEOPROF-LIDAR	Occurrence of hydrometeor layers in the vertical column	Identify as aerosol or cloud layer and the height in the vertical column

Table 1. CloudSat products and parameters.

Work has begun in developing software to match each CloudSat overpass of a tropical cyclone to additional satellite imagery such as GOES, MODIS and METEOSAT satellite instruments.

CTCD is documented in the following journal article, Tourville N., G. Stephens, M. DeMaria, and D. Vane, 2015: Remote Sensing of Tropical Cyclones: Observations from CloudSat and A-Train Profilers. Accepted to *Bull. Amer. Meteor. Soc.*

Topic 2: TC structure from simulated IR imagery
HWRF model output and synthetic satellite brightness temperatures for 2014 have been downloaded from NOAA super computers. Additional grids for HWRF model output and synthetic satellite brightness temperatures are in the process of being downloaded for 2012-2014. Software has been written to convert synthetic IR imagery to more convenient Mcidas image format; enabling easy display on a common projection. Hurricane Gonzalo (2014) has been used as a test case for the software. An example of the 9 km grid for a 48 hour forecast of Hurricane Gonzalo valid at 00 UTC on 16 Oct 2014 is shown in Figure 3. In addition, software has been written to convert the analysis of the IR and wind fields to a common polar analysis grid. Hurricane Gonzalo (2014) has been used as a test case for the software.

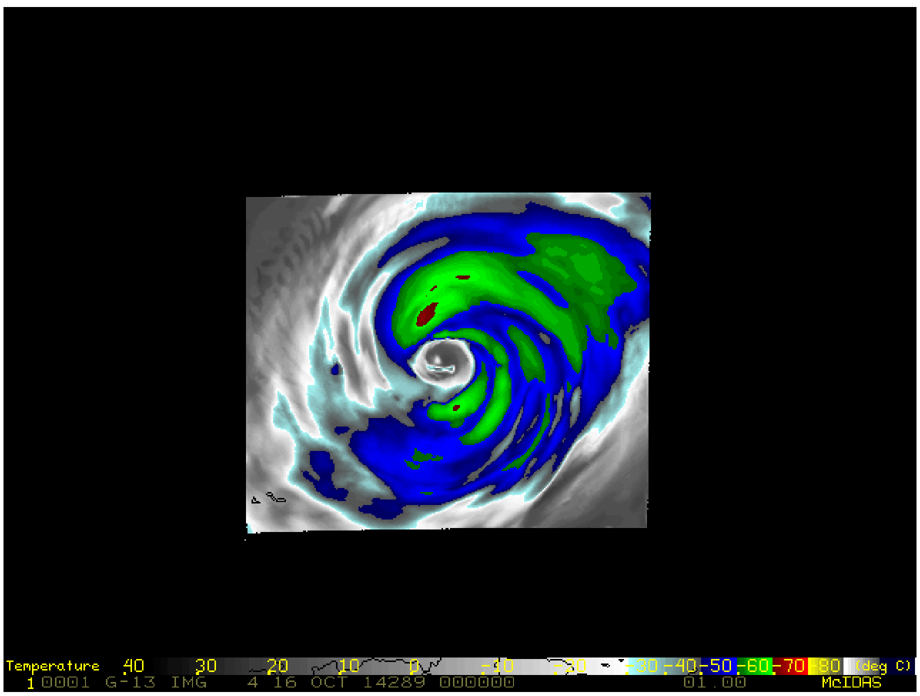

Figure 3. HWRF synthetic satellite imagery of Hurricane Gonzalo (2014), from the forecast initialized 14 Oct 2014 00 UTC, the 48 hour forecast valid at 16 Oct 2014 00 UTC. The 9 km grid is displayed.

Topic 3**:** Anticipate TC eye formation
A subjectively-based eye/no-eye dataset was constructed using a combination of the CIRA/RAMMB tropical cyclone image archive and six-hourly operational Dvorak fix information. Figure 4 shows an example from the western North Pacific.

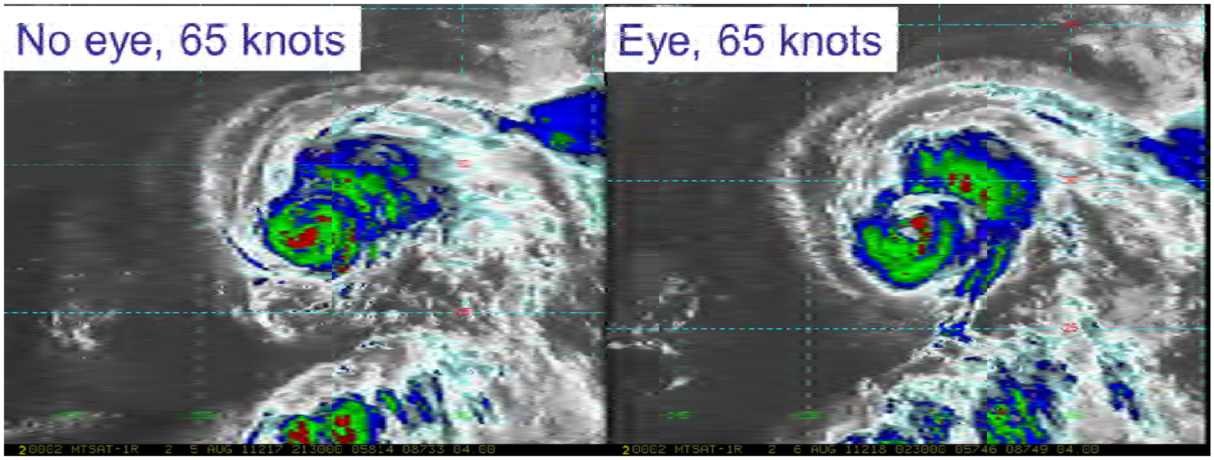

Figure 4. West Pacific case showing an eye/no-eye example, WP122011 MERBOK (65 knots). The image on the left shows a no-eye case 6 hours prior to the image on the right which was subjectively determined to have an eye.

An objective method to detect eye formation has been developed, but under JPSS funding. Results were presented at the Annual AMS meeting. The method is based on IR brightness temperatures within 80 km of the TC's center. A PCA analysis then reduces the dimension of the problem. The resulting PCs are then used as predictors in a quadratic discriminant analysis scheme.   This will be used in this project to provide the timing of first eye formation in the CIRA/RAMMB TC IR image archive.

<u>Project 6-- Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts.</u>

Determining how lightning activity within the inner core or the rainbands of TCs is related to intensity change(s) has been hampered by an overall lack of observations of total lightning activity within these systems. Both theory and observations, however, suggest that total lightning flash rates in the TC's inner core depict when and where convective hot towers develop. The purpose of this work is to improve our knowledge of these relationships and, ultimately, use them to improve our ability to forecast the genesis and intensity changes of TCs. Two lines of research are being conducted to achieve this objective; one builds upon recent TC modeling research led by Dr. Fierro and a second is based on statistical approaches applied on observational data led by A. Schumacher at CIRA and M. DeMaria at NHC.

The CIRA line of research is to develop an asymmetric total lightning predictor for the operational Rapid Intensification Index (RII) for TCs by using retrospective studies of the relatively large sample of tropical mesoscale convective systems (tropical depressions, tropical storms and TCs). An experimental version of the RII that includes lightning density input from the ground-based World Wide Lightning Location Network (WWLLN) has already been developed and is being tested in the Satellite Proving Ground at the National Hurricane Center (NHC). However, the WWLLN dataset is still dominated by cloud to ground strikes, and, thus, is not an optimal proxy for the Geostationary Lightning Mapper (GLM). The next step towards improving the RII with total lightning information input from the GLM is to test a synthetic RII based on total lightning data from EarthNetworks. Inter-comparisons with the WWLNN data will be performed to begin the development and optimization of a total-lightning RII. Also, the proper utilization of the total lightning requires an improved understanding of the relationships between storm intensity and total lightning, which will be achieved through the high-resolution simulations by Dr. Fierro.

The chief rationale for developing enhanced operational predictors for total lightning arises from the upcoming launch of the GLM on the Geostationary Operational Environmental Satellite R series (GOES-

R) in FY2016. The GLM will be capable of mapping both cloud-to-ground and in-cloud lightning day and night, year-round, with a spatial resolution of 8 and 12 km over the Americas and surrounding oceans.

Tropical Cyclone (TC) forecasts affect risk mitigation activities of industry, public and governmental sectors and therefore directly supports NOAA's Weather and Water mission goals.

Two project accomplishments are reported below:
1--ENTLN total lightning flash data from 2009-2013 were acquired from B. Callahan and S. Prinzivalli at EarthNetworks. Only a few months of ENTLN data were available in 2009 so the analysis dataset chosen for this study only includes cases spanning the 2010-2013 period. The mean annual ENTLN lightning flash density (LD) was calculated (Figure 5, right) for each of these years and compared to the 1998-2010 OTD/LIS-based LD climatology values (Figure 5, left). A simple calibration procedure, developed for the WWLLN data, was performed. Calibration results confirm results published in Rudlosky 2014 whereby ENTLN has a higher detection efficiency over the Atlantic and N.E. Pacific tropical cyclone basins relative to WWLLN, and hence may be a better proxy for the GLM. Additional comparisons of ENTLN and WWLLN data in a TC-centered framework suggest that the two ground-based networks are showing different patterns in inner core lightning activity. For example, Figure 6 shows the azimuthal average inner core (r=0-100km) and rainband (r=200-300km) WWLLN (top) and ENTLN (bottom) lightning density for all 2010-2013 Atlantic TCs. The corresponding correlation coefficients between these two series remains rather low, with r(inner core) = 0.5 and r(rainband) = 0.6. A preliminary analysis of azimuthal average ENTLN lightning activity and TC intensity change suggests that increases in eyewall total lightning flash rates may precede TC intensification (Figure 7), a signal that was not seen in the WWLLN cloud-to-ground lightning flash data (DeMaria et al. 2012).

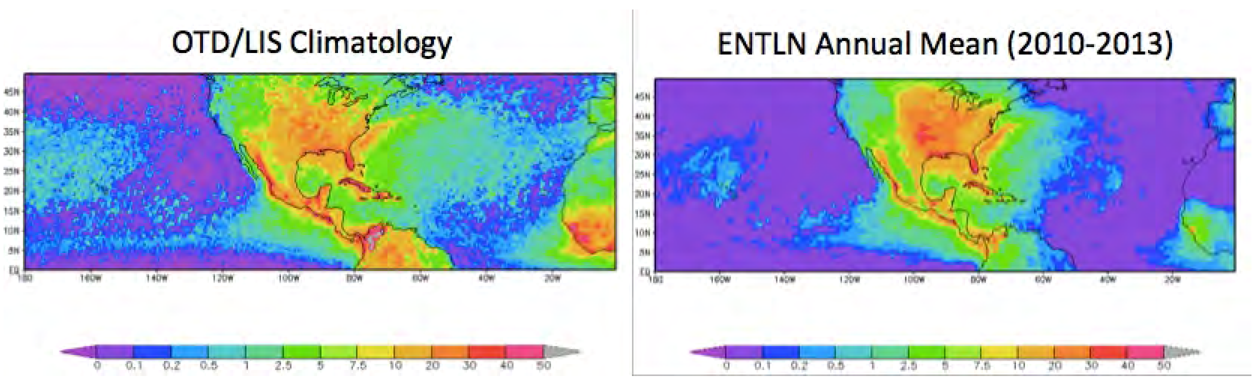

Figure 5. Mean annual lightning flash density (LD) from the OTD/LIS 1998-2010 climatology (left) and ENTLN (right).

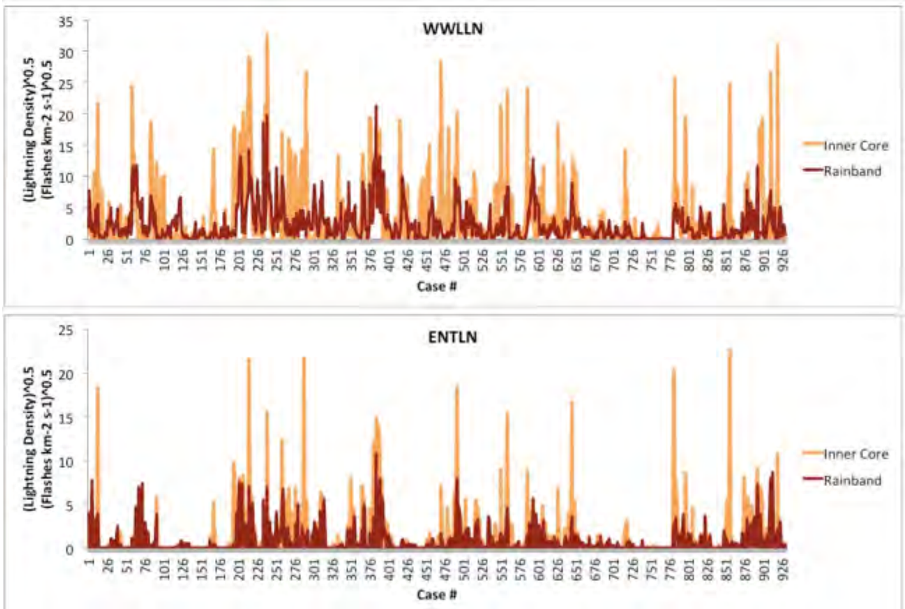

Figure 6. Azimuthal average inner core (r=0-100km) and rainband (r=200-300km) WWLLN (top) and ENTLN (bottom) lightning density for all 2010-2013 Atlantic tropical cyclones.

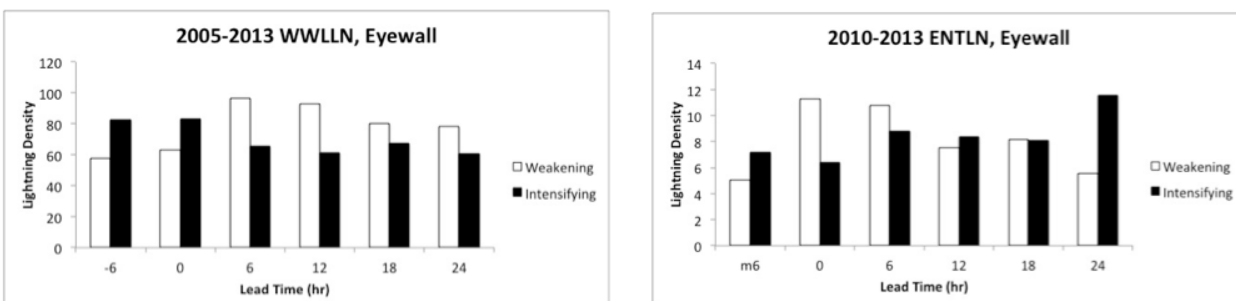

Figure 7. Azimuthal average eyewall (r=0-50km) WWLLN (left) and ENTLN (right) lightning density at lead times from 24-h to -6h for intensifying and weakening cases.

2--ENTLN total lightning data have been assembled and calibrated (see 1), and are ready to be tested in the NESDIS formation probability product.

<u>Project 7-- Synthetic Imagery Generation over Alaska and Hawaii for GOES-R Product Development</u>

The generation of GOES-R synthetic Advanced Baseline Imager (ABI) data has been an important part of several previous GOES-R Risk Reduction projects. The imagery has provided several major benefits, including: 1) It serves as proxy data for the GOES-R ABI and can therefore be used to develop GOES-R products using the new ABI spectral bands, 2) Forecasters have provided overwhelmingly positive feedback on the helpfulness of synthetic imagery in visualizing Numerical Weather Prediction (NWP) model forecast output (Bikos et al. 2012), and 3) Forecasters can become accustomed to how the new bands on the ABI will look. Continued support for synthetic imagery generation will allow for additional product development and tools to assist in NWP model improvement and visualization for forecasters.

Up to this point, all synthetic imagery from high resolution NWP models has been over the Continental U.S. (CONUS) and has excluded both Alaska and Hawaii. This project began with generating synthetic imagery of GOES-R ABI bands over these 2 new domains. The synthetic data can then be used in GOES-R product development, be used to evaluate the model from which the data is generated, and be sent to National Weather Service (NWS) offices as a visualization tool of the model output.

Specific project accomplishments for this reporting period are mentioned below:

--Purchase, build, and configure new machine: Additional nodes were purchased and configured with a 64-bit cluster at CIRA. A total of seven machines each with twelve 2 GHz processors were added. During the development stages of the imagery, all new nodes were also tested for integrity.

--Work with EMC to set up data staging/delivery for the required fields from the NAM Alaska Nest: Brad Ferrier at EMC has scripts that stage the relevant NAM Alaska Nest output in grib files on their ftp server from each 00 Z run, and scripts at CIRA pull the data each evening.

--Configure CRTM to read NAM Alaska Nest input data, and create test images at 3.9 µm, 6.95 µm, and 10.35 µm: We first obtained a sample set of Alaska NAM NEST data for one case. This case was used for testing of code and scripts that were developed to produce synthetic GOES-R ABI imagery. Example images were made at several GOES-R ABI bands. Such images were then made available on the web and converted into AWIPS and/or AWIPS-2 and sent to the Alaska Region via the LDM.

--Set up scripts to begin simulating the 3.9, 6.95, and 10.35 µm bands in real time: Scripts are now running to create real-time synthetic imagery. Currently, we're simulating the 3 ABI water vapor bands (6.2, 6.95, and 7.34 µm), the 8.5 µm band, and the 10.35 µm IR Window band. All are available on CIRA's GOES-R Proving Ground webpage (http://rammb.cira.colostate.edu/ramsdis/online/goes-r_proving_ground.asp#Synthetic_Imagery_from_the_NAM_Alaska_Nest) . For examples see Figure 8 and Figure 9 below.

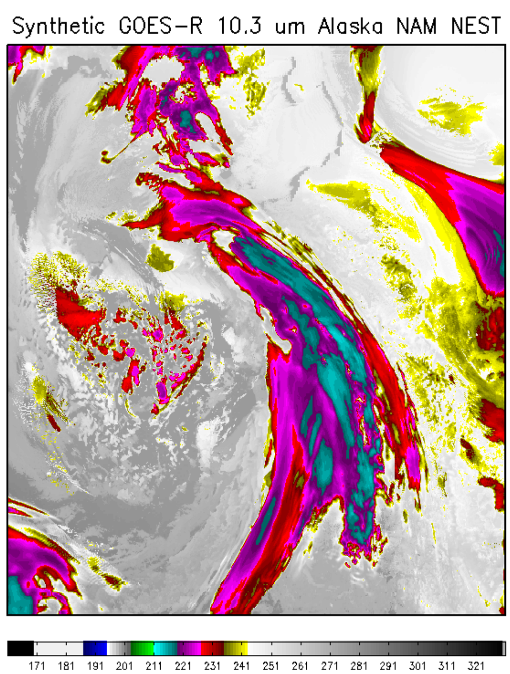

Figure 8. Synthetic GOES-R ABI imagery at 10.35 um from the Alaska NAM NEST.

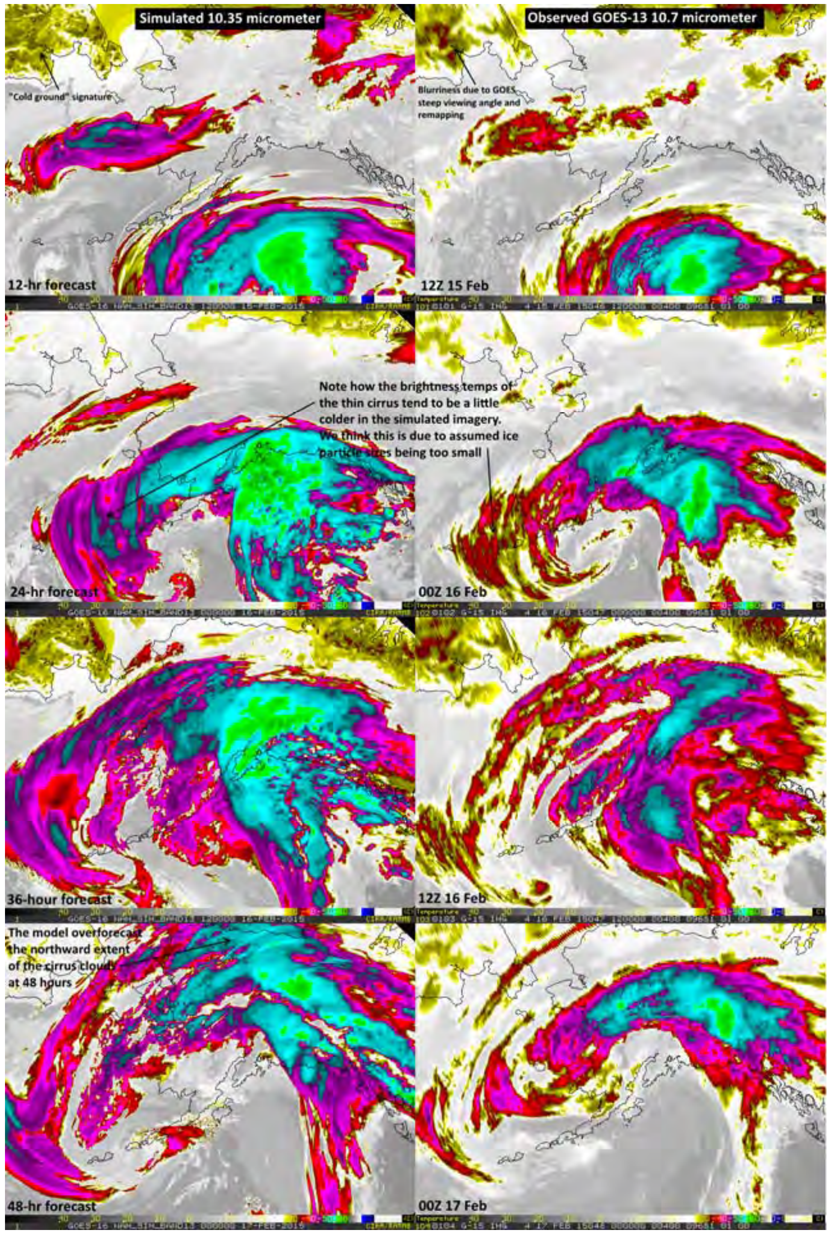

Figure 9. Comparison between simulated 10.35 μm band (left column) and the corresponding GOES-15 10.7 μm band (right column) from the 00Z 15 Feb. 2015 run of the NAM Alaska Nest. Some features of interest are noted on the figure.

In setting up 3.9 μm imagery, we noticed a dependency of synthetic brightness temperatures on the size of hydrometeors from the Ferrier microphysical scheme, so before putting this band online, we're investigating this further and will work with Brad Ferrier to determine the optimal formulation of ice particle size.

--Begin work on making the real-time Alaska synthetic imagery forecast imagery available on the web, convert it to AWIPS and/or AWIPS-2, and send to Alaska Region via the LDM. As noted above, 5 bands are available in real time on the web, and 2 of the bands are being converted to AWIPS-2 format and sent to the LDM. Fairbanks WFO has been sent instructions on how to pull in and display the data, and currently we're working with them on ironing out the details.

Project 8-- GOES–R AWG Proxy Data Application

The goal of this GOES-R AWG project was for the CIRA proxy data team to collaborate closely with Brad Pierce (NOAA/NESDIS/STAR/ASPB) to create a tool that will incorporate observed GOES-13 fire "hot spots" into the real-time CONUS proxy radiances dataset. Further CIRA was tasked to work with the AWG fire detection lead (CIMSS) to help evaluate the fire detection algorithm.

Note that real-time CONUS proxy synthetic radiance data currently does not contain brightness temperatures of observed GOES-13 fire hotspots although it does use the GOES-13 fire detections to constrain smoke emissions from the fires. In order to use this data to exercise the AWG fire detection algorithm, fire hotspots are needed in the CONUS proxy synthetic radiance data.

Initial project planning began in July and August in close collaboration with Brad Pierce. In September 2014, the CIRA team acquired a complete WF-ABBA dataset for one 24-hour period. Code modification took place in September to read all WF-ABBA files. After specifying the lat/lon bounds of the simulated domain, all retrieved fires from the WF-ABBA files were extracted. Code was developed that mapped the location of a WF_ABBA hotspot to the corresponding location within a simulated GOES-13 image.

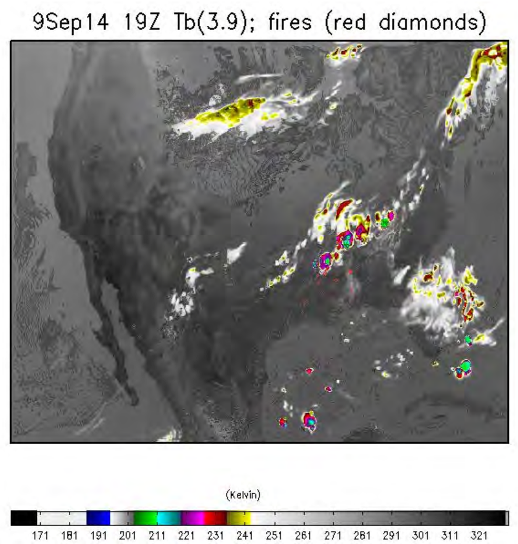

Figure 10. Synthetic GOES-13 image at 3.9 µm for 9 September 2014 at 19 UTC. Cold clouds are enhanced with the color table shown. Fires from WF-ABBA are indicated by red diamonds over southern portions of the US and northwest Mexico.

This technique was then tested for a few WF_ABBA data at different times. After the lat/lon with the simulated GOES-13 image was located, the simulated 3.9 and 10.7 um brightness temperatures were replaced with the corresponding temperatures from the WF_ABBA dataset.

The code was further modified to map all WF-ABBA hotspots into simulated GOES-13 imagery. Since all simulated GOES-13 imagery is available on-the-hour, all WF-ABBA hotspots from the previous hour were added into simulated imagery on-the-hour. In December 2014, the CIRA team handed over all code to Brad Pierce. As part of our second phase of the project, we provided guidance and evaluation of output from our code that was implemented by Brad. An example image is included above (Figure 10).

Project 9-- GOES–R AWG Imagery Team

The 16-band GOES-R Advanced Baseline Imager (ABI) was built without the green spectral band needed to create true-color imagery directly from the available radiances. The green band was not considered a priority at the time the spectral bands were selected for ABI. Due to band number limitations, the decision was made to include additional spectral bands desired for cloud detection. However, if the ABI spectral band plan had been a more recent decision, the green band would likely have been included, since true-color imagery is increasingly popular and important among satellite image products.

In order to compensate for the lack of a green band, the neighboring reflective spectral bands of ABI can be used to synthesize a green band to a high degree of accuracy. That green band synthesis has been successfully applied to both MODIS (ABI proxy) imagery and to synthesized ABI Imagery. These sources served as both training and verification for the ABI green band. See the works of Hillger et al (2011) and Miller et al (2012) for details. An Algorithm Theoretical Basis Document (ATBD) also describes the process of creating the green band for ABI.

With the advent of Himawari-8 Advanced Himawari Imagery (AHI) in late 2014, a green band has been restored to an ABI-like instrument. That allows true-color imagery to be created for the AHI-viewed side of the world. For the USA, however, the challenge of true-color imagery remains, but now AHI is the preferred data to both train and verify the green band synthesis for ABI.

To date, a limited amount of AHI data have been decoded and displayed. Realtime access to AHI is expected, which will allow a large variety of AHI scenes to be used in the training of the green band algorithm. Work continues as Rayleigh correction will be developed specifically for AHI, as the training imagery needs to be corrected for satellite and solar viewing angles as well as for atmospheric scattering. This project anticipates that AHI training will result in better green and true-color imagery for ABI than is possible up to this point with other proxy data.

<u>Project 10-- National and International Training Development, Delivery, and Distribution and PCS User Readiness</u>

This project provided partial support for organizing and conducting sessions and then processing the recordings of the monthly international virtual Regional Focus Group.

Through the first long term part of this project, we continue to build on the framework of the national VISIT and SHyMet training programs and international WMO Virtual Laboratory (VLab) training activities, so that we can ensure that weather forecasters will be well prepared to deal with GOES-R products (Baseline and Decision Aids) by the time GOES-R will be in orbit. This is being accomplished in numerous ways: through contributions to the VISIT Blog, examples in training sessions, and presentations. Training activities focus on the evaluation of training trends, expanded interaction with our international partners, and dissemination of training materials through GEONETCast.

The VLab (http://vlab.wmo.int) falls under the guidance of the WMO Coordination Group for Meteorological Satellites (CGMS) and it also receives direction from the WMO Expert Team on Satellite Utilization and Products (ET-SUP). CGMS and ET-SUP have expressed deep appreciation for the training and user preparedness efforts occurring in NOAA's GOES-R Proving Ground activities. Through the VLab and the WMO Technical Support Officer (TSO), we interact with WMO Satellite Operators and Training Centers throughout the world and share expertise and training materials.

The GEONETCast Americas System is supported by NOAA. GEONETCast is a near real time, global network of satellite-based data dissemination system designed to distribute space-based, air-borne and in situ data, metadata and products to diverse communities. GEONETCast was developed in support of the Global Earth Observation System of Systems (GEOSS).

The VISIT program has provided the structure for virtual training, and the knowledge and expertise of the trainers. The second part of this project "PCS User Readiness" ensures that the VISIT structure as well as tracking metrics continue to support GOES-R training. One of the mechanisms used to announce lectures and provide brief product examples to the international community is the through the international virtual Regional Focus Group list and their monthly Focus Group Sessions. The WMO Virtual Laboratory Regional Focus Group of the Americas and Caribbean conducted monthly English and Spanish weather briefings through VISITview using GOES and POES satellite Imagery from CIRA:

(http://rammb.cira.colostate.edu/training/rmtc/focusgroup.asp). We used GoToWebinar for voice over the Internet. The participants from the U.S. included CIRA, the International Desk at NCEP, NWS Training Division, UCAR/IA-NWS, and UCAR/COMET. The number of countries participating each month ranged between 8 and 13 (average 10); and the number of participants each month ranged between 16 and 51 (average 31). The participants include researchers and students as well as forecasters and other trainers. Mike Davison at NCEP International Desk led the discussions.

Project 11-- Supporting Projects

In a basis consistent with our long-standing Memorandum of Understanding between NOAA and Colorado State University, the CIRA GOES- R3 budget specifically included support for administrative and clerical personnel directly associated with the technical and managerial administration of this project. This support is "quid pro quo" for the reduced indirect cost rate agreed upon in the long-standing subject memoranda. CIRA's administrative support person provided communication and collaboration support, assisted in the acquisition and distribution of reference materials relevant to the conception and execution of the project, technical editing of scientific manuscripts, specialized reports and conference papers. In addition, this grant included support for management oversight for the individual GOES-R3 projects. CIRA also provided some administrative support for the wider GOES-R program, including planning for the annual review and tracking of project progress.

Professor Tom Vonder Haar, Member of the National Academy of Engineering, will continue to serve on the Independent Advisory Committee (IAC) for GOES-R. The IAC reports to the GOES-R SDEB and supports tasks assigned to them and by the GOES-R Program Scientist, Dr. Steve Goodman. The range of advisory tasks includes all aspects of the Program such as algorithm development and testing; Instrument and Product Cal/Val both before and after launch; User training and outreach; Science and operational applications; and combined products from GOES and JPSS.

PROJECT TITLE: CIRA Support for the JPSS Proving Ground & Risk Reduction Program: Application of Joint Polar Satellite System (JPSS) Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting

PRINCIPAL INVESTIGATOR**:** Galina Chirokova

RESEARCH TEAM**:** Robert DeMaria, Jack Dostalek, Kate Musgrave, Andrea Schumacher, Hiro Gosden, Dave Watson, Kevin Micke, Renate Brummer, Kathy Fryer

NOAA TECHNICAL CONTACT**:** Chris Brown (NOAA/NESDIS) and Phil Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM**:** Mark DeMaria (NOAA/NWS/NHC) and John Knaff (NOAA/NESDIS/STAR)

PROJECT OBJECTIVES:

The time scale of tropical cyclone track and intensity changes is on the order of 12 hours, which makes JPSS instruments well suited for the forecasting of these parameters. Two tropical cyclone applications of JPSS data are currently being developed. The first uses temperature and moisture retrievals from the Advanced Technology Microwave Sounder (ATMS) in the near storm environment to improve intensity analysis and forecasting. This new information is being incorporated into existing intensity estimation techniques and to an operational statistical-dynamical intensity forecast model to improve their performance. The second one uses GOES IR data and VIIRS high-resolution IR data together with machine learning algorithms to develop an objective automated eye-detection algorithm. TC eye-formation is often associated with intensification and the objective method could further help with intensity forecasting. The goal is to make these new products available in the satellite Proving Ground to operational forecasters at the National Hurricane Center (NHC) and Joint Typhoon Warning Center (JTWC) for evaluation and feedback.

Tropical Cyclone (TC) forecasts affect risk mitigation activities of industry, public and governmental sectors and therefore supports directly NOAA's Weather and Water mission goals. Improving forecasts of tropical cyclone track and intensity is a top NOAA and DoD priority.

PROJECT ACCOMPLISHMENTS:

1-- Run LGEM intensity model with MIRS input and compare with operational version.

The recently developed global version of SHIPS/LGEM/RII code was successfully adopted for use with ATMS input. A short version of the global SHIPS code was created to allow RII calculation from MIRS input. The global version of the code now allows running LGEM for the West Pacific Basin using maximum potential intensity (MPI) calculated from ATMS profiles, in addition to Atlantic (AL) and East Pacific (EP) cases that we examined previously. Table 1 shows preliminary statistics for RII with ATMS/GFS input. As shown in Table 1, Brier Score (BS) in all cases is slightly smaller when using ATMS profiles to calculate MPI, which indicates slight improvement. Brier Skill Score (BSS) and bias, which is always smaller when using ATMS profiles, also indicates slight improvement in RI forecasts for all AL and WP cases. While these results look encouraging, only a very small number of cases is used for each calculation. This can be seen in the last column in Table 1. A considerably larger sample size is required to obtain reliable statistics. The statistics for the East Pacific cases cannot be calculated at this time because we have only one RI case for the EP basin in our database.
The LGEM model was run with MPI calculated from GFS and ATMS profiles, and compared with the operational version. Figure 1 shows LGEM intensity error comparisons between three runs: CTRL, GFS, and ATMS. CTRL is the control run that uses statistical MPI calculated from the SST only, and uses the same settings as operational LGEM. The GFS run uses GFS MPI, and the ATMS run uses MPI estimated from ATMS profiles. Unlike RII, which is a short-term forecast (24 hours), the LGEM intensity forecast is made up to 5 days, and is therefore less likely to be improved by using ATMS-based MPI at a single time at hour zero. As can be seen from Figure 1, the GFS run shows a slight improvement over the control run in the AL basin; however, the ATMS run performs much worse than the GFS and CTRL runs. For the EP basin both GFS and ATMS show a slight improvement up to the 48 hour forecast. For the WP basin, the ATMS run shows better results than the GFS run. However, both are worse than the control run. Again, all these results should be considered preliminary because of the small number of the available cases. We are investigating several possibilities that might contribute to better forecasts of both RII and intensity. For example, we are looking into using a combination of GFS and ATMS data to obtain more realistic soundings and surface data to use as input to the MPI algorithm (partially leveraged by CIRA Cal/Val project).

Basin	RI	BS GFS	BS ATMS	BS Mean	BSS A/G	BSS G/M	BSS A/M	Bias GFS	Bias ATMS	#Cases RII
AL	25 kt	964.55	**957.98**	854.27	**0.68**	-12.91	-12.14	1.63	**1.44**	13
AL	30 kt	723.53	**718.46**	667.83	**0.70**	-8.34	-7.58	1.30	**1.15**	10
AL	35 kt	477.11	**467.65**	413.10	**1.98**	-15.49	-13.20	1.26	**1.00**	6
AL	40 kt	248.40	**243.55**	211.88	**1.95**	-17.24	-14.95	1.63	**1.37**	3
WP	30 kt	1044.39	**996.30**	1586.00	**4.60**	34.15	37.18	0.56	**0.61**	31

Table 1. Statistics for RII. Table shows Brier Score (BS), Brier Skill Score (BSS), and Bias for predicted vs observed RI, as estimated by SHIPS model using MPI calculated using GFS (G) and ATMS (A) profiles.

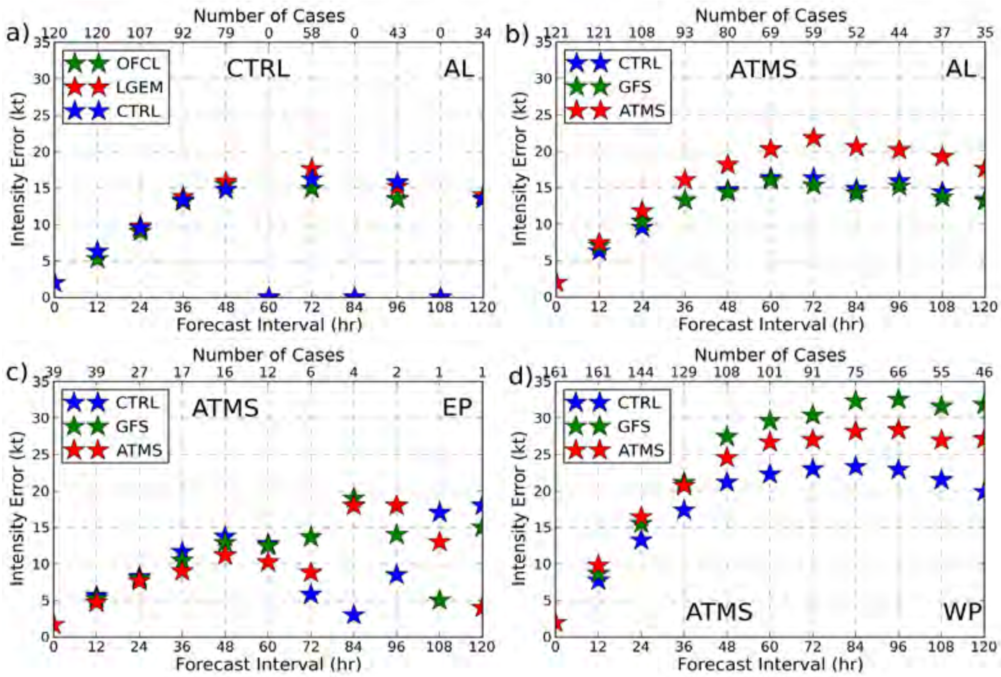

Figure 1. Forecast intensity errors for LGEM. (a) Control run for AL (green – NHC official forecast, red LGEM as run at NHC, and blue – control run, LGEM rerun with the same settings as used at NHC). (b) AL, (c) EP, and (d) WP comparisons of control run (using statistical MPI) with runs using GFS MPI and ATMS MPI. Blue stars show the control run (with the same settings as operational LGEM), green stars show runs with the GFS MPI, and red stars show runs with the ATMS MPI.

2-- Run maximum potential intensity product in real-time for Proving Ground demonstration

The experimental version of ATMS environmental soundings and MPI estimates is now available on the RAMMB/CIRA TC Real-Time web page at http://rammb.cira.colostate.edu/products/tc_realtime/.
The new product, the "Advanced Technology Microwave Sounder (ATMS) - based Sounding and MPI" is using ATMS-MIRS data to calculate environmental sounding for each active TC at each synoptic time. The ATMS-MIRS temperatures and moisture profiles are used together with weekly Reynolds SSTs for this product. The ATMS Maximum Potential Intensity (AMPI) estimates are obtained using Bister and Emanuel's (1998) algorithm, using the following as input: the temperature profile, mixing ratio profile, and sea level pressure (SLP) azimuthally averaged between 200 and 800 km from the storm center, and SST at the center of the storm. For comparison we also calculated RMPI, the SST-based MPI (DeMaria and Kaplan, 1994). Also printed on each plot are: SST at the storm center (SST, degC), environmental SLP (SLP, mb), AMPI (kt), RMPI (kt), environmental CAPE (CAPEenv, J/kg), CAPE at the radius of maximum winds (CAPErmw, J/kg), and saturated CAPE at the radius of maximum winds (CAPErmws, J/kg). Figure 2 shows an example of the new product as seen on the web page. The loop showing sounding and MPI changes during 2014 Major Hurricane Amanda could be also seen here: http://rammb.cira.colostate.edu/products/tc_realtime/loop.asp?product=snppasnd&storm_identifier=EP012014&starting_image=2014EP01_SNPPASND_201405230000.

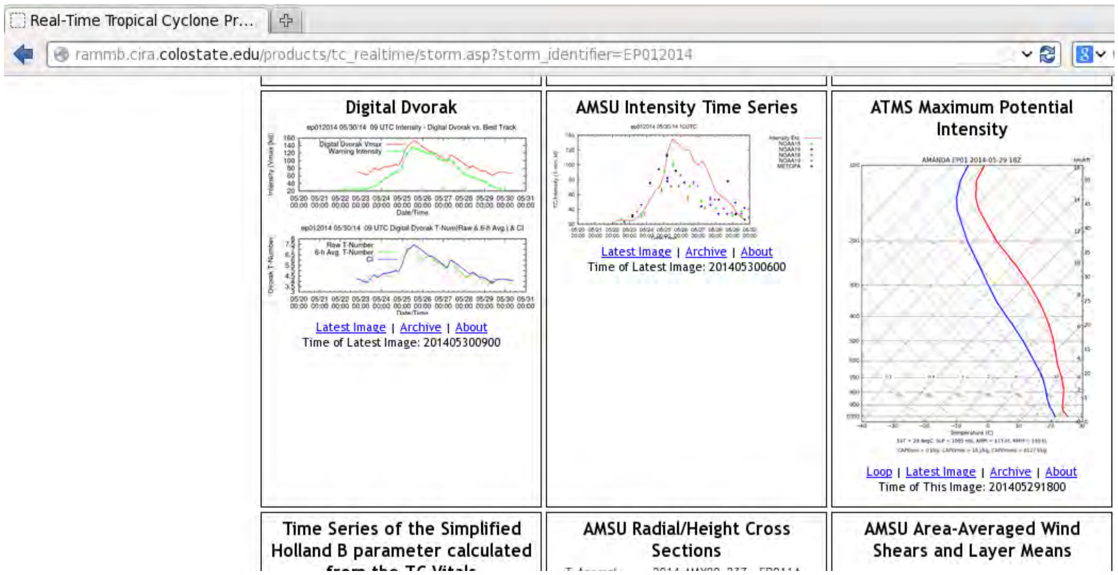

Figure 2. MIRS-ATMS real-time tropical cyclones sounding and MPI product, a snapshot from RAMMB/CIRA TC Real-Time page. The snapshot shows the ATMS MPI product among other similar products available on TC Real-Time page. The ATMS-MPI product image shows the environmental sounding and calculated values of CAPE and MPI for 2014 East Pacific Major Hurricane Amanda. The snapshot shows soundings for May 29, 2014.

3-- Use low-resolution infrared imagery to train a machine learning algorithm to perform classification to automatically determine if an eye is present in an image. (CIRA)

The training of a machine learning algorithm to perform classification to automatically determine if an eye is present in an image has been completed. A dataset consisting of 2677 IR images contained in the CIRA/RAMMB TC image archive (Knaff et al. 2014) from the years 1996-2013, and comprising just those tropical cyclone cases with maximum wind speed greater than 50 knots (26 ms^{-1}), has been assembled for use with this project. Within each of these images, an area of 80x80 pixels near the storm center, as determined from Automated Tropical Cyclone Forecasts (ATCF; Sampson and Schrader 2000) best track data, was selected for use with the algorithm. This area was unrolled to form a 6400 element vector. Each of these vectors were combined to form a 2677x6400 element matrix. Each image has an eye or no-eye classification associated with it which was derived from information contained in the operational Dvorak intensity fixes (see Velden 2006) produced by the Tropical Analysis and Forecast Branch (TAFB) at the National Hurricane Center (NHC). These fixes are typically generated every six hours and are considered truth for the algorithm development described here. Dimension reduction using Principle Component Analysis (PCA) (Zito et al, 2008) was performed on the training dataset. As a result, 11 eigenvectors were found that account for 90% of the variance of the data. Figure 3 shows the first two most significant eigenvectors.

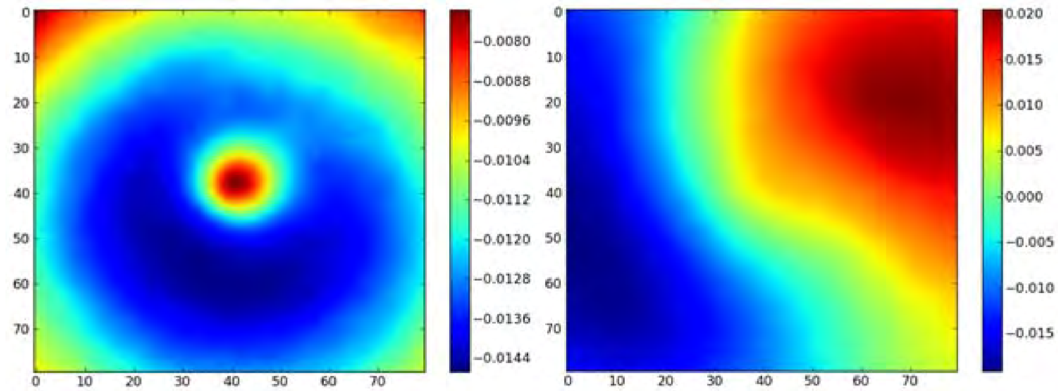

Figure 3. The First (left) and second (right) most significant of the 11 eigenvectors that explain 90% of the variance in the IR dataset.

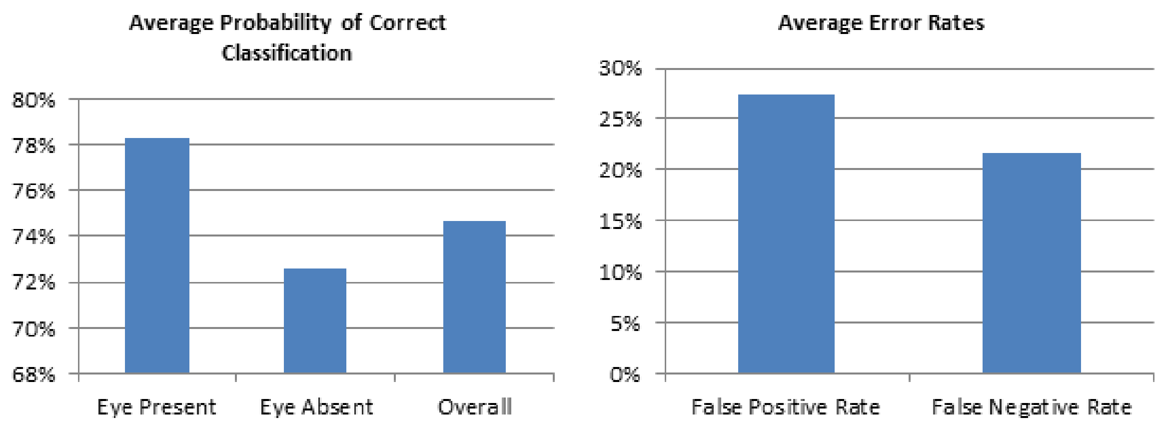

Figure 4. Average eye-detection error statistics where data was shuffled 1200 times. Left Panel: average fraction of correct classifications. Right Panel: average fraction of incorrect classifications.

The training set with reduced dimension was used to train a Quadratic Discriminant Analysis (QDA) implementation (Zito, et al, 2008). In order to gain an accurate view of how well the eye-detection algorithm performs, the estimated classifications obtained with QDA were compared to the previously generated subjective classification performed by the TAFB at NHC. To ensure that the accuracy of the algorithm was not an anomaly bound to a particular shuffling of the original data, the algorithm was run 1200 times. Each time the input data was shuffled and then partitioned into different training and testing sets. Figure 4 shows the accuracy and error statistics averaged over all of these runs. Figure 4 (left) shows that, on average, roughly 75% of the images were correctly classified. Images with eyes in them were correctly classified approximately 78% of the time, and images without eyes were correctly classified about 72% of the time. Figure 4 (right) illustrates that, on average, 28% of the images without eyes were incorrectly classified (False Positive). Additionally, roughly 22% of the images with eyes were incorrectly classified (False Negative).

4—Complete MPI and RII algorithm testing using preliminary pre-operational dataset, perform algorithm testing and tuning uning 2014 season TC data.

Advanced Technology Microwave Sounder (ATMS) and Dropsonde Collocation product has been added to the RAMMB-CIRA TC Real Time Page, http://rammb.cira.colostate.edu/products/tc_realtime/.
This product displays the vertical temperature and moisture profiles of collocated dropsondes and ATMS retrievals. To perform the collocation, the ATMS sounding closest to the dropsonde is selected within one

hour and 100 km from the dropsonde release time and location. A separate plot is created for each TC within 2000 km of a dropsonde, and the corresponding storm ATCF id is displayed at the bottom of the plot. It is possible that the same dropsonde could be used in more than one plot if multiple systems are present. For each plot the distance from the TC center to the dropsondes, the heading angle, and the horizontal distance between the dropsonde release location and the ATMS sounding is calculated and displayed on the plot. Figure 5 shows the snapshot from the TC Real-Time page, showing the dropsondes and ATMS sounding collocation next to the ATMS MPI product. The differences between ATMS and dropsonde soundings have been monitored in real time to assess the quality of soundings used as input into the MPI algorithm.

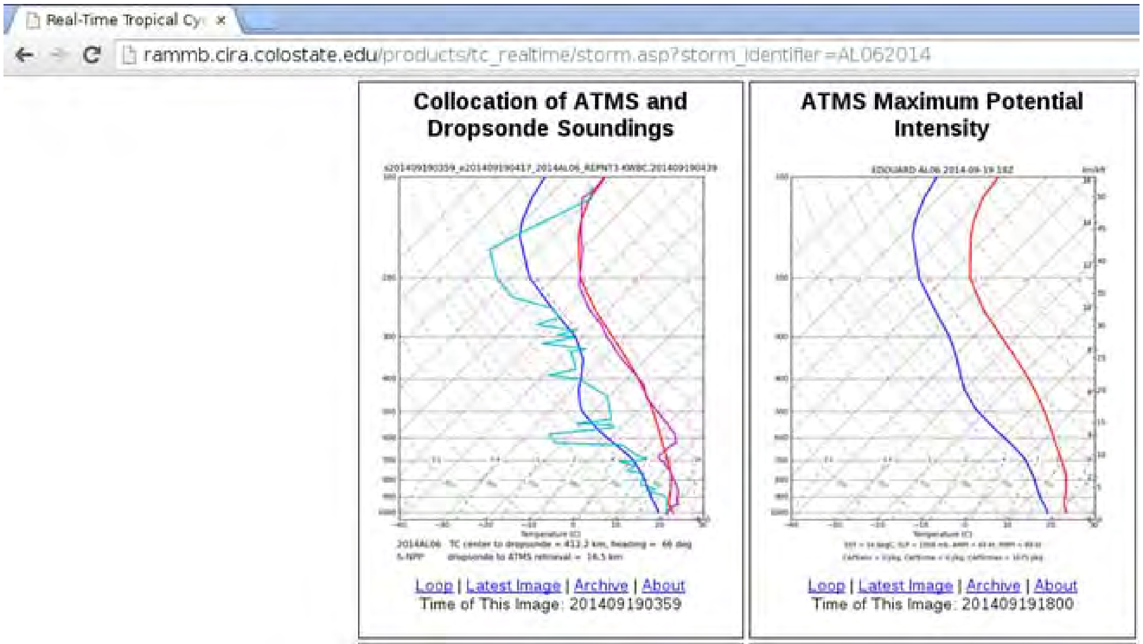

Figure 5. The snapshot from RAMMB-CIRA TC Real-Time page, showing the dropsonde and ATMS sounding collocation plot next to the MPI sounding product for Hurricane Edouard, AL062014. The red and blue lines are T and T_d profiles from ATMS, respectively, and the purple and teal lines are T and T_d from the dropsondes. The description for both products is available online, at
http://rammb.cira.colostate.edu/products/tc_realtime/about.asp#SNPPASND
http://rammb.cira.colostate.edu/products/tc_realtime/about.asp#DSATSNSD

5-- Interaction with operational partners.

The low-latency VIIRS DNB Imagery has been added to the RAMMB-CIRA TC Real Time page in October, 2014, when CIRA started getting VIIRS DNB images with relatively low-latency, usually within 2 hours, thanks to NASA IDPS making it available via GRAVITE. The product is running in a testing mode when the low-latency imagery is available. The low-latency storm-centered VIIRS DNB imagery from the CIRA TC webpage has been utilized in the NHC Proving Ground and has shown utility for TC analysis. Figure 6 shows a screenshot for TC ANA, 2014CP02, on Oct 21, displaying the Visible Image, DNB Image, and IR Image. The DNB image was just a couple of hours old, and was displayed significantly earlier than the Visible and IR SDR images, which were not provided with low latency.

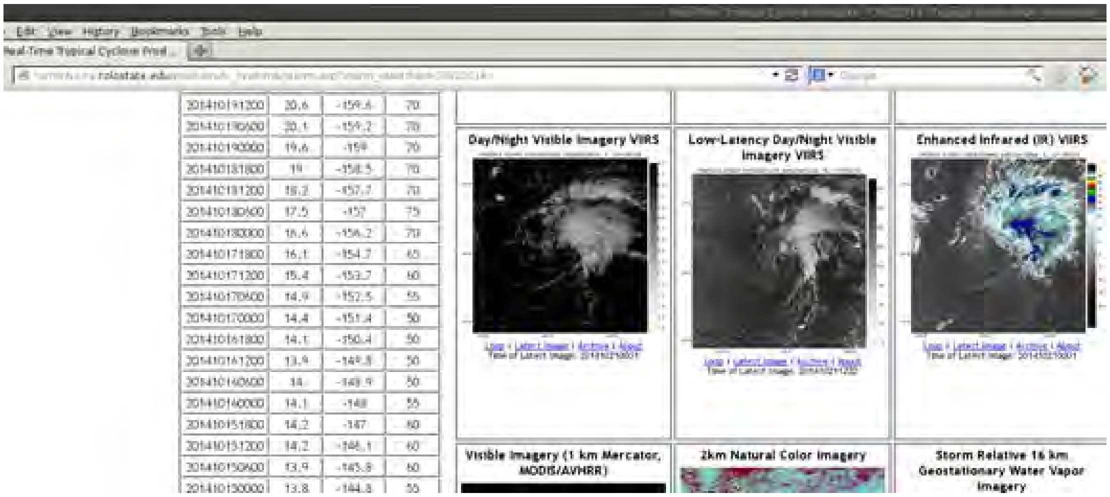

Figure 6. The screenshot from RAMMB-CIRA TC Real-Time page, showing Visible (left), DNB (middle), and IR (right) VIIRS images for TC ANA, CP022014. The DNB image is low-latency, and is displayed several hours ahead of the previously-available Visible and IR SDR images, which were not available with low latency.

PROJECT TITLE: CIRA Support: Getting Ready for NOAA's Advanced Remote Sensing Programs: A Satellite Hydro-Meteorology (SHyMet) Training and Education Proposal

PRINCIPAL INVESTIGATORS: Bernadette Connell, Dan Bikos

RESEARCH TEAM: Ed Szoke

TECHNICAL CONTACT: Chris Brown, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Tony Mostek (NOAA/NWS), Brian Motta (NOAA/NWS)

PROJECT OBJECTIVES:

The overall objective of the SHyMet program is to develop and deliver comprehensive distance-learning courses on satellite hydrology and meteorology. This project leverages the structure of the VISIT training program but is distinct in that VISIT focuses on individual training modules, while SHyMet organizes modules into courses. SHyMet takes a topic approach and selects content for the topic. It is able to draw on training materials not only within the VISIT program, but outside the program as well. This work is being done in close collaboration with experts at CIRA, the Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Cooperative Program for Operational Meteorology, Education and Training (COMET), the National Weather Service (NWS) Training Center (NWSTC), and the NWS Warning Decision Training Branch (WDTB). The challenge is to provide necessary background information to cover the many aspects of current image and product use and interpretation as well as evaluate data and products available from new satellite technologies and provide new training on the these tools to be used operationally.

Specific Objectives:
1-- Maintain existing SHyMet Courses:
2-- Interact with NWSTC, GOES-R and JPSS Satellite Proving Ground Partners, and other education and outreach groups in the US, including the NWS Training Division, FDTB, WDTB, COMET, SPoRT, and CIMSS. Interaction will also include groups external to the US including the WMO VLab and the WMO Regional Centers of Excellence.
3-- Contribute content and support to virtual monthly real-time sessions: national and international (July 1, 2014 – June 30, 2015)

PROJECT ACCOMPLISHMENTS:

1-- Maintain existing SHyMet Courses:
The following four courses continue to be administered:
- The SHyMet *Intern* course touches on Geostationary and Polar orbiting satellite basics (areal coverage and image frequency), identification of atmospheric and surface phenomena, and provides examples of the integration of meteorological techniques with satellite observing capabilities. (http://rammb.cira.colostate.edu/training/shymet/intern_intro.asp).
This continues to be the most popular course.
- The SHyMet for *Forecaster* course covers satellite imagery interpretation and feature identification, water vapor channels, remote sensing applications for hydrometeorology, aviation hazards, and what to expect on future satellites. http://rammb.cira.colostate.edu/training/shymet/forecaster_intro.asp
- The *Tropical* track http://rammb.cira.colostate.edu/training/shymet/tropical_intro.asp of the SHyMet Course covers satellite imagery interpretation and application of satellite derived products in the tropics as well as the models used at NHC for tropical cyclone forecasting.
- The *Severe* Thunderstorm Forecasting Course
http://rammb.cira.colostate.edu/training/shymet/severe_intro.asp
covers how to integrate satellite imagery interpretation with other datasets in analyzing severe thunderstorm events.

SHyMet metrics are tracked by leveraging the expertise of the VISIT program and the NOAA Commerce Learn Center Learning Management System.

SHyMet Course	Total since debut		Jan-Dec 2014		Course Debut
	Completions	Registrations	Completions	Registrations	
Intern	348	462	23	25	April 2006
Forecaster	45	67	2	1	January 2010
Tropical	22	42	0	1	August 2010
Severe	38	60	2	1	March 2011

Over the past couple of years, the NWS experienced budget cuts that resulted in a hiring freeze and much reduced training. The previous year included significant budget cuts and a government shutdown, particularly at the beginning of the year. Both of these contributed to a drop in registrations and completions on the user end. As we moved into the latter part of the current year, we did see a pickup in the number of registrations, particularly for the Intern course.

2-- Interact with NWSTC, GOES-R and JPSS Satellite Proving Ground Partners and other education and outreach groups on development of SHyMet GOES-R Instruments, Products, and Operational Applications course.
Course structure: A customized / personalized training experience with training needs assessed during signup.

Course execution: Assign the individual modules at the time of registration. The webpages will group the various topics but we will ask the participant at the time of registration what their training needs are and then determine which modules to assign.
- Preparations on the SHyMet GOES-R Instruments, Products, and Operational Applications course:
Web pages are being drafted and reviewed internally and externally with partner organizations.
http://rammb.cira.colostate.edu/training/shymet/goes-r_intro.asp

- The 2014 Satellite Proving Ground/User Readiness meeting on 2-6 June at the NWS Training Center in Kansas City, MO brought together Satellite Liaisons, NWS Science and Operations Officers, NWS Satellite Services Division chiefs, GOES-R and JPSS program Scientists, data providers and other users and many of our training partners.

Presentations and follow-up discussions from the satellite liaisons and SOOs were very informative on what types of training worked best. Overall, shorter training “bits” are desirable (20 minutes or less) as the user has limited time available for training. It was also recognized that within a forecast office or national center, individuals hold different levels of satellite knowledge (intern, intermediate, advanced, expert) and have different ways of learning (visual, auditory, hands on). While it was recognized that shorter training is the goal, it was also recognized that some stages of learning will require training that is longer than 20 minutes. It will continue to be a challenge to find the right mix of materials for the varied audiences, so it is important to collaborate with our training partners so that different levels of training can be offered with minimal overlap.

One of the outcomes of the Satellite PG/User Readiness meeting was the formation of a Satellite User Readiness Training (SART) Team consisting of Science and Operations Officers (SOOs) from NCEP and from each NWS Region as well as a Development and Operations Hydrologist (DOH). “The SART Team is charged with identifying immediate and long term training requirements that will lead to the effective and efficient use of satellite data and products in the forecast and warning process.” We will continue on our path of gathering content and creating materials and incorporate their input as it becomes available.

- New Module:
“Global Precipitation Measurement (GPM) mission overview.”
The module was produced in cooperation with funding received from a Hurricane Sandy Supplemental Grant

- Module recorded:
“Identifying Snow with Daytime RGB Satellite Products”
Initially offered as teletraining through the VISIT structure January through March 2014. The session was recorded and posted to the web in June 2014
http://rammb.cira.colostate.edu/training/visit/training_sessions/identifying_snow_with_daytime_rgb_satellite_products/

-- New approaches to presenting materials for user communities expecting a new satellite were presented to the international community at CALMet Online 2014 (Creating Activities for Learning Meteorology). An example of graphs comparing the channels on various satellites across the globe was presented and a few of them are listed below in Figure 1. http://rammb.cira.colostate.edu/training/rmtc/newsat.asp

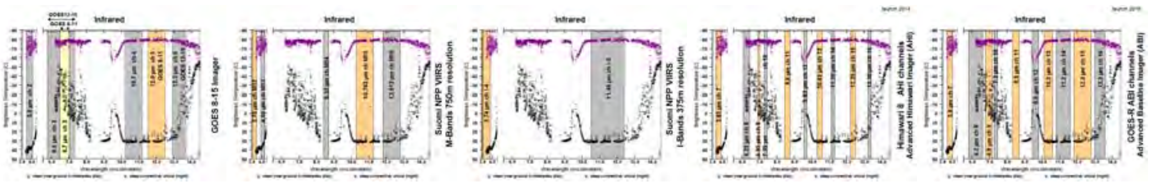

Figure 1. Brightness temperature data for 2 points from the Atmospheric Infrared Sounder (AIRS) with channel spectral range from GOES, VIIRS M and I bands, GOES-R, and Himiwari represented as the simple full width at half maximum. See the link below for the full loop.

A way to integrate this information with imagery for better interpretation was explored through Prezi software: http://prezi.com/qyjxg3kqec3e/?utm_campaign=share&utm_medium=copy&rc=ex0share Some of these new approaches to presenting materials will be used in the SHyMet course. Feedback on these new approaches from both the national and international communities helps build better training and hence understanding of strengths as well as the limitations of satellite imagery and products.

3-- Support to the VISIT Satellite Chat and WMO VLab monthly Focus Group Sessions.
-- The SHyMet and VISIT team organized 12 monthly chat sessions to discuss recent significant weather events with the objective of demonstrating satellite products that can be applied to operational forecasting. These sessions are brief and often lead to products being made available or further discussed in the VISIT blog. During the past year, 8 external presenters were engaged to promote dialog between research and operations and to engage peer-to-peer learning. Recorded sessions are found here: http://rammb.cira.colostate.edu/training/visit/satellite_chat/

-- Twelve monthly virtual weather briefing sessions were partially supported for the WMO Virtual Laboratory (VLab) Regional Focus Group (RFG) of the Americas and Caribbean. The RFG efforts reached a total of 260 participants over the 12 monthly sessions.

- In addition to the monthly weather briefing sessions, the WMO VLab RFG of the Americas and Caribbean has also hosted special seminars.
Recordings for the monthly sessions and the special seminars can be found online:
http://rammb.cira.colostate.edu/training/rmtc/fg_recording.asp
The special seminars include:
- Dr. Jose Galvez of the NOAA's Weather Prediction Center/International Desks introduced the Galvez-Davison Index for Convective Instability (GDI) for experimental field testing. A Spanish version was presented on Wednesday 26 March 2014, and an English version was presented on Thursday 27 March 2014.
- On 8 April, Dr. Mitch Goldberg, NOAA, presented “JPSS Polar Satellite System’s operational and research applications”.
- On 9 April, Liam Gumley, SSEC, presented “The Community Satellite Processing Package for real-time date received by direct broadcast from Suomi NPP, POES, Metop, and EOS.”
- On 27 May 2014, a bi-lingual (English and Spanish) presentation “Product Updates from the National Hurricane Center for the Coming Tropical Season” was given by Todd Kimberlain and Gladys Rubio.

Community Outreach
-- After-school weather club: Scientists at CIRA and CSU students – all members of the local AMS chapter of Northern Colorado called FORTCAST (Fort Collins Atmospheric Scientists) volunteered for the weekly after-school weather club on Tuesdays for Putnam Elementary (K-5). The fall session ran for 8

weeks during October through early December 2014. There was a 90-minute session each week. Sessions included helping with homework and leading an activity. The topics covered included wind speed and direction, clouds, colors of the rainbow, lightning, angular momentum, arctic ice, freezing solids (ice cream!), as well as measurements that are associated with these weather occurrences. Volunteers included Bernie Connell, Matt Rogers, Doug Stolz, Erin Dagg, Marie McGraw, and Melissa Burt. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!

-- B. Connell gave a presentation on GOES and GOES-R and the characteristics of its channels to a Remote Sensing/ Geographic Information Systems class at the Metropolitan State University of Denver on November 30. Since their Remote Sensing class focuses mainly on earth resource topics, the students were presented with the perspective of how meteorologists view and use satellite imagery.

PROJECT TITLE: CIRA Support of NOAA's Commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory

PRINCIPAL INVESTIGATORS: Bernadette Connell

RESEARCH TEAM: Luciane Veeck and Dan Bikos

TECHNICAL CONTACT: Chris Brown and John Cortinas / NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Anthony Mostek NOAA/ NWS/OCWWS Training Division

PROJECT OBJECTIVES:

The World Meteorological Organization (WMO) Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) is a collaborative effort joining major operational satellite operators across the globe with WMO regional training centers of excellence in satellite meteorology. Those regional training centers serve as the satellite-focused training resource for WMO Members. Through its Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU), NOAA/NESDIS sponsors Regional Training Centers of Excellence (CoE) in Argentina, Barbados, Brazil, and Costa Rica.

The top-level objectives of the VLab are:
1-- To provide high quality and up-to-date training and supporting resources on current and future meteorological and other environmental satellite systems, data, products and applications;
2-- To enable the regional training centers to facilitate and foster research and the development of socio-economic applications at the local level through the National Meteorological and Hydrological Services.

Enhanced training and coordination of training accomplished under this project will prepare forecasters and managers on how to utilize imagery and products to provide services in these areas.

Specific Objectives:
1-- Provide JPSS image and product examples for various audiences.
2-- Provide virtual JPSS lectures and partial support for international virtual Regional Focus Group sessions.
3-- Disseminate instructional material through GEONETCAST.

4-- Participate in quarterly virtual meetings of the WMO VLab Management Group.
5-- Attend CALMET conference and Eumetcal workshop.
6-- Partial support for the WMO Technical Support Officer position.

PROJECT ACCOMPLISHMENTS:

1-- One of the outreach activities includes "priming": getting the intended audience familiar with JPSS imagery and products in an informal way. The more one hears of JPSS imagery and products, both as a quick or a more formal example, the more one is inclined to recognize it. Equally important is putting the new product in context with the seasoned knowledge that the user already has.

- In October, John Knaff (NESDIS/STAR/RAMMB) led a virtual VISIT chat discussion on VIIRS applications from Super Typhoon Vongfong (http://rammb.cira.colostate.edu/training/visit/satellite_chat/20141015/). The discussion was also made into a VISIT training session (http://rammb.cira.colostate.edu/training/visit/training_sessions/viirs_imagery_interpretation_of_super_typhoon_vongfong). This work was done in collaboration with VISIT and Hurricane Sandy Supplemental projects,

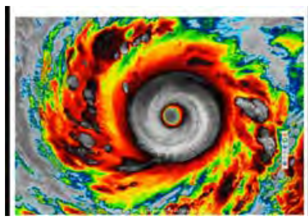

Figure 1. Infrared VIIRS imagery for Super Typhoon Vongfong presented during the VISIT satellite chat on October 15.

A blog entry was written by Kate Musgrave (CIRA) and posted to the VISIT blog. The topic focused on VIIRS imagery applications to Super Typhoon Hagupit during peak intensity as it was east of the Philippines (http://rammb.cira.colostate.edu/training/visit/blog/index.php/2014/12/05/typhoon-hagupit/). This activity was also coordinated with activities funded by the Hurricane Sandy Supplemental project.

2-- Provide virtual JPSS lectures and partial support for international virtual Regional Focus Group sessions.

- WMO VLab featured two virtual presentations in April 2014 on direct readout capability of JPSS. On 8 April, Mitch Goldberg, NOAA, presented "JPSS Polar Satellite System's operational and research applications" and on 9 April, Liam Gumley, SSEC, presented "The Community Satellite Processing Package for real-time date received by direct broadcast from Suomi NPP, POES, Metop, and EOS". There were participants from the U.S.: CIRA, SSEC/UW, ScanEx/SSEC/UW, AWC/SSEC/UW, NOAA/JPSS as well as outside the U.S.: Argentina, Brazil, Costa Rica, Germany, Great Britain, Greece, Japan, and Oman. Both sessions were well attended as represented by the US along with 6 and 8 countries, with 40 and 36 participants respectively. Resources for these sessions as well as information on past sessions in this series on direct readout capabilities for polar orbiting systems can be found online at: http://www.wmo-sat.info/vlab/satellite-direct-readout/.

- The WMO Virtual Laboratory Regional Focus Group of the Americas and Caribbean conducted 12 monthly bilingual (English/Spanish) weather briefings. The briefings made use of VISITview software to present GOES and POES satellite imagery from CIRA and GoToWebinar for voice communication over the Internet. Over the year, the participants from the U.S. included: CIRA, the NWS International Desk at NCEP, NWS/OCWWS Training Division, the UCAR/NWS International Activities Office, and UCAR/COMET. Thirty countries outside the US participated: Algeria, Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Cayman, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Germany, Grenada, Haiti, Honduras, Jamaica, Netherland Antilles, Panamá, Peru, Poland, St. Kitts and Nevis, St. Lucia, Trinidad and Tobago, Suriname, and Uruguay. M. Davison at the NCEP International Desk led the discussion. Participants offered comments for their regions and tended to also bring interesting questions to the discussion. The number of countries participating each month ranged between 7 and 23 (average 10); and the number of participants each month ranged between 11 and 69 (average 27).
The sessions were recorded and can be found here:
http://rammb.cira.colostate.edu/training/rmtc/fg_recording.asp

3-- In 2014, 2 training video clips from the monthly Focus Group Sessions were disseminated through GEONETCast during September and October.

-- In support of GEONETCast activities, this project provided planning support for a “Train the Trainers” GEONETCast workshop to be held 25-26 April 2015 prior to the NOAA Satellite Conference (27 April – 1 May 2015). This workshop will focus on the many aspects of GNC-A, including software packages to view and do simple manipulations with the data. We are planning a hands-on session that will include VIIRS imagery.

-- As a follow on to the GEONETCast “Train the Trainer” activities at the April 2013 NOAA Satellite Conference and the GEONTECast virtual event week on 3-5 December, 2013, a GNC-A Coordination Group was established by NOAA/NESDIS and NWS. B. Connell participated in 5 GEONETCast Americas (GNC-A) Coordination Group telecons on 21 May, 12 June, 16 September, and 9 December, 2014 and 3 March 2015. The discussions focused on GEOTIFF files that NOAA has started broadcasting through GNC-A, as well as the organization of 4 sub-committees: Broadcast Operations, Ground Receive Stations, Content, and Users. B. Connell will be on the Users Sub-committee and is particularly interested in the aspect to “Develop trainings and tutorials on how to use the data and products on the system and on what software packages work with the data and products.”

4-- Virtual Laboratory Management Group Web Meetings – CIRA participated in the virtual VLMG meeting on 25 November 2014 and 10 March 2015. The meetings were organized by the TSO mentioned below and the meeting reports can be found in the WMO VLab site http://www.wmo-sat.info/vlab/meeting-reports/

5-- Attend CALMET conference and Eumetcal workshop.
Due to the late arrival of FY13 funds, the project scientists were unable to attend the CALMET conference and Eumetcal workshop in August 2013. The travel funds were used by 3 project scientists to attend the 7th VLab Management Group meeting that was hosted by Roshydromet and the Russian State Hydrometeorological University (RSHU) at RSHU in St. Petersburg on 22-25 July, 2014. Travel was provided for B. Connell, CIRA; K.-A. Caesar, CIMH in Barbados and current co-chair for VLMG; and V. Castro, VLab Costa Rica. In consultation with Tony Mostek and input from COMET as well, B. Connell prepared and provided the Satellite Operator VLab Activity Report on behalf of NOAA for the period September 2012 to December 2013.

The Virtual Laboratory (VLab) (http://vlab.wmo.int) was established under the WMO Coordination Group for Meteorological Satellites (CGMS) to promote effective use of satellite meteorology throughout the

WMO member countries. The VLab consists of members from major satellite operators across the globe collaborating with WMO centres of excellence. The meeting included representation from supporting satellite operators [CMA (China), CONAE (Argentina virtually) EUMETSAT (Europe), JMA (Japan virtually), KMA (Korea virtually) NOAA/NESDIS via CIRA, ROSHYDROMET (Russian Federation)] as well as WMO training centers of excellence [Argentina, Australia, Costa Rica, Barbados, Brazil (virtually), China, Kenya, Morocco, Niger, Oman, Russian Federation, and South Africa] and other partners. The VLMG members reported on activities and experiences with the VLab to date and worked on developing the training plan for the next 5 years. B. Connell gave two presentations: “CIRA and NOAA Contributions to the WMO VLab” and “GEONETCast Americas (GNC-A) Training Activities.” In its 15 years of existence, the VLab has demonstrated its capability to deliver global – scale events on training and education in satellite meteorology. In the coming years VLab will continue to strength its global commitments and address these objectives: 1) To achieve better exploitation of data from the Space Based global observing system for services that are increasingly reliant on satellite data, and 2) To globally share knowledge, experience, methods and tools related to satellite meteorology, especially in support of services with limited resources. Meeting website: http://training.eumetsat.int/course/view.php?id=216

VLMG co-Chairs and the Technical Support Officer; the VLMG-7 poster; and Sunset at 11 PM for the 7th WMO Virtual Laboratory Management Group Meeting held at the Russian State Hydrometeorological University in St. Petersburg, Russia, 22-25 July 2014.

6-- The following coordination activities of Luciane Veeck, VLab Technical Support Officer, were partially supported under this project:

-- Direct Readout Events - VLab started organizing a series of online events about the direct readout capabilities of polar orbiting systems in 2013. Giving continuation to the series, NOAA presented two sessions about the Suomi NPP on the 8th and 9th of April. Sessions were organized by the TSO and CIRA using the GoToWebinar conferencing system. A Moodle area was set up to create automatic certificates of participation for those attending the live sessions and a post-event survey set up for evaluation of the event. A page was created in the VLab website to make the resources produced (webcast and slides) available after the session. This page can be accessed at http://www.wmo-sat.info/vlab/satellite-direct-readout/
-- Maintenance of the VLab central website the VLab calendar of events http://vlab.wmo.int
-- VLab Report to ET-SUP-8 – A report of the VLab activities was drafted by the TSO and approved by the co-chairs to be submitted to the “Expert Team on Satellite Utilization and Products eightieth session”

(ET-SUP-8), which took place in Geneva (14-17 April). Slides were also prepared by the TSO and presented at the meeting by Volker Gärtner (VLab co-chair). The full report can be downloaded from the VLab website under Publications/Other reports.
-- VLab Report to CGMS-42 – A report of the VLab activities was drafted by the TSO and approved by the co-chairs to be submitted to the "Coordination Group for Meteorological Satellites 42nd meeting" (CGMS-42), which took place in Guangzhou, China (19-23 May 2014). Slides were also prepared by the TSO and presented at the meeting by Dr Wenjian Zhang (Director of the WMO Space Programme). The full report can be downloaded from the VLab website under Publications/Other reports.
-- WMO "Train the Trainer" Course 2014 (WMO TtT) – Part one of the TtT course (online) took place from 15 March to the end of May. The TSO helped with the facilitation of the course, coordinating some of the activities related to topics such as roles of trainers, learning activities and training management and delivery. Trainers from the four VLab CoEs in Africa (South Africa, Kenya, Niger and Morocco) and also from CoEs Oman and Barbados attended Part one of the course.
-- VLMG-7 Meeting - Preparations for the meeting included activities such setting the agenda with the VLab Co-Chairs, contacting participants and plenary presenters, running online test sessions with remote presenters (from Australia, South Africa, Japan and Brazil), coordinating hotel bookings, airport pick-ups and other practical arrangements with local organisers, helping participants deal with visa issues, and uploading documents to the VLab Moodle site. During the Meeting (San Petersburg, Russian Federation, 22-25 July), the TSO worked closely together with the local organisers, being responsible for daily updates to the agenda, collecting and uploading presentations, updating the Moodle site and writing up the actions and recommendations during the sessions. After the meeting, the TSO prepared a report, which was discussed and approved by the VLab co-chairs and WMO Space Programme before being shared with the meetings' participants.
-- VLab presentations – The TSO presented the VLab work in two events within the period of this report (both were online presentations). They were: 1) CEOS Working Group on Capacity Building and Data Democracy Meeting (WGCapD) – India, 24 April; 2) Workshop on the use of Open-Source Software and Satellite Data in the Prevention of, and Response to, Disasters in Mesoamerica – Mexico, 20 May.

PROJECT TITLE: CIRA Support of the Virtual Institute for Satellite Integration Training (VISIT)

PRINCIPAL INVESTIGATORS: Dan Bikos and Bernadette Connell

RESEARCH TEAM: Edward Szoke, Kevin Micke, Isabelle Granger-Frye, Rosemary Borger.

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Philip Hoffman / NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Dan Lindsey (NOAA/NESDIS/STAR/RAMMB)

PROJECT OBJECTIVES:

The primary objective of the VISIT program is to accelerate the transfer of research results based on atmospheric remote sensing data into National Weather Service (NWS) operations. This transfer is accomplished through web-based distance learning modules developed at CIRA and delivered to NWS forecasters. There are two types of distance learning methods. The first is teletraining, which is a "live" training session utilizing the VISITview software and a conference call so that there is interaction between instructor and students. The second type is an audio / video playback format that plays within a web-browser. The latter type is popular because it may be taken by a student individually whenever they choose. The combination of live teletraining and audio / video playback versions (Fig. 1) reaches out to as broad an audience as possible given the busy schedule of NWS forecasters. Over 25,000 participants have completed VISIT training since April 1999, and most student feedback suggests a direct applicability to current forecast problems. CIRA is also actively involved in tracking of participants, and the collection and summarization of course feedback material. Because the VISIT program has been so successful within the NWS, it is being leveraged for other training activities in the US (Satellite Hydrology and Meteorology Courses (SHyMet), and the GOES-R Proving Ground) and is being utilized by the International community in training programs under the World Meteorological Organization (WMO). For more information on the VISIT program, see: http://rammb.cira.colostate.edu/visit/

Specific Objectives:
1--Develop and deliver teletraining, recorded modules, and blog entries on the utilization of new satellite products that are available on AWIPS. This includes collaborating with and offering assistance to the GOES-R and JPSS satellite proving ground projects and other NOAA offices in the development and delivery of training materials.
2--Conduct monthly virtual “VISIT Satellite Chat” sessions.
3--Keep training participation metrics through the NOAA Commerce Learning Center
4--Attend meteorological and education conferences and symposiums and participate in other relevant organizational meetings. Engage in Community Outreach.

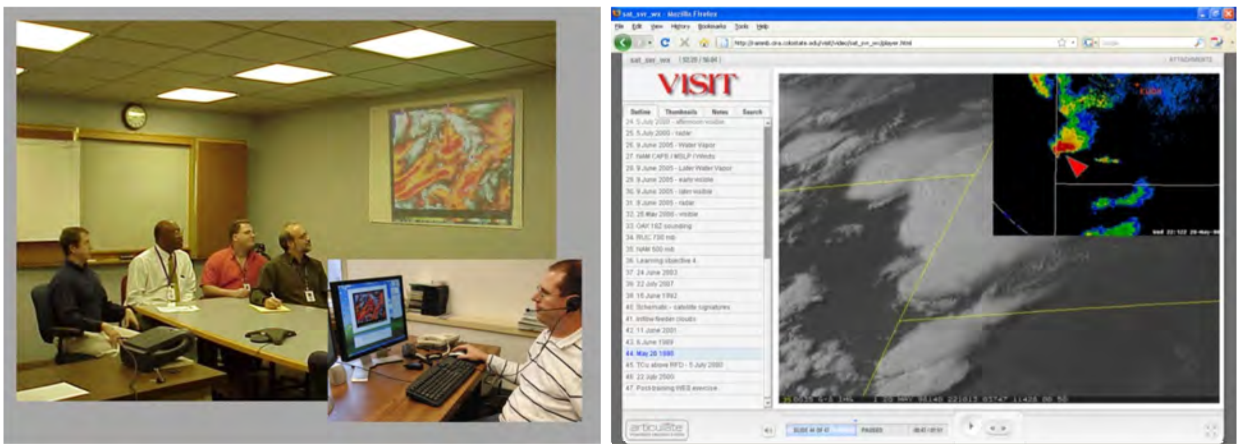

Figure 1. Live VISIT teletraining (left), and audio / video playback VISIT training module (right).

PROJECT ACCOMPLISHMENTS:

1--Training sessions:

--Delivered the training session titled “1-minute visible satellite imagery applications for severe thunderstorms.”
--Delivered the training session titled “VIIRS imagery interpretation of Super Typhoon Vongfong” based on a recent VISIT satellite chat session.
--Delivered the training session titled “GPM Mission Overview.”
--Updated the training session titled “An Overview of Tropical Cyclone Track Guidance Models used by NHC.”
--Updated the training session titled “An Overview of the Tropical Cyclone Intensity Guidance Models used by NHC.”

VISIT blog:

--The blog is intended to open the doors of communication between the Operational, Academic and Training Meteorology communities. The blog averages around 300 views per week and is located here: http://rammb.cira.colostate.edu/training/visit/blog/

2--VISIT Satellite Chat:

--Since February 2012, the VISIT team has led monthly chat sessions to discuss recent significant weather events with the objective of demonstrating satellite products that can be applied to operational forecasting. These sessions are brief and often lead to products being made available for further discussion in the VISIT blog. In the past year, we've had more external presenters to lead these sessions, including:

--Jason Jordan (NOAA/NWS, WFO Lubbock, TX) on the West Texas total lightning mapping array.
--Todd Lindley (NOAA/NWS, WFO Amarillo, TX) on a heavy snow event in their CWA during January.
--Alan Cope (NOAA/NWS, WFO Mt. Holly, NJ) and Joe Dellicarpini (NOAA/NWS, WFO Taunton, MA) on ENTLN lightning data for a Massachusetts tornado event in July.
--Mark DeMaria (NOAA/NHC) on tropical cyclone rapid intensification in September.
--John Knaff (NOAA/NESDIS/STAR) on VIIRS imagery interpretation for Supertyphoon Vongfong in October.
--Jack Dostalek (CIRA) on the CIRA Cold Air Aloft product over Alaska in December.
--Dan Lindsey (NOAA/NESDIS/STAR) on synthetic imagery available over Alaska in December.
--Brad Pierce (NOAA/NESDIS/STAR) on satellite trace gases and aerosol retrievals for air quality forecasting in April.

Recorded sessions are located here:
http://rammb.cira.colostate.edu/training/visit/satellite_chat/

3--VISIT training metrics April 1, 2014 – March 2, 2015:

--Live teletraining: 33 sessions delivered to 125 participants.
Audio / video playback (through NOAA's Learning Management System as well as directly through CIRA's web interface): 313 participants.

4--Community Outreach:

--After-school weather club: Scientists at CIRA and CSU students – all members of the local AMS chapter of Northern Colorado called FORTCAST (Fort Collins Atmospheric Scientists) volunteered for the weekly after-school weather club on Tuesdays for Putnam Elementary (K-5). The fall session ran for 8 weeks during October through early December 2014. There was a 90-minute session each week. Sessions included helping with homework and leading an activity. The topics covered included wind speed and direction, clouds, colors of the rainbow, lightning, angular momentum, arctic ice, freezing solids (ice cream!), as well as measurements that are associated with these weather occurrences. Volunteers included Bernie Connell, Matt Rogers, Doug Stolz, Erin Dagg, Marie McGraw, and Melissa Burt. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!
--B. Connell gave a presentation on GOES and GOES-R and the characteristics of its channels to a Remote Sensing/ Geographic Information Systems class at the Metropolitan State University of Denver on November 30. Since their Remote Sensing class focuses mainly on earth resource topics, the students were presented with the perspective of how meteorologists view and use satellite imagery.

PROJECT TITLE: CIRA Support to GOES-R Proving Ground for National Weather Service Forecaster Readiness

PRINCIPAL INVESTIGATORS: Steve Miller and Renate Brummer

RESEARCH TEAM: Ed Szoke, Dan Bikos, Renate Brummer, Bernadette Connell, Greg DeMaria, Robert DeMaria, Jack Dostalek, Kathy Fryer, Hiro Gosden, Lewis Grasso, Stan Kidder, Kevin Micke, Steve Miller, Andrea Schumacher, Dave Watson

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Philip Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: Donald W. Hillger, John Knaff, Dan Lindsey, Deb Molenar (NOAA/NESDIS/STAR)

PROJECT OBJECTIVES:

The next generation GOES environmental satellite systems, beginning with GOES-R, will contain a number of advanced instruments including the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). National Weather Service (NWS) forecasters and other operational users of satellite data must be introduced to and be trained properly on these new capabilities in order to maximize the utility of GOES-R. CIRA is leveraging its existing capabilities to provide this training and experience directly to NWS forecasters through ongoing support of the NOAA Proving Ground project, where simulated and proxy GOES-R products are demonstrated at NWS Weather Forecast Offices (WFOs) in their native Advanced Weather Information Processing System (AWIPS) display systems, as well as at NOAA Operational Centers such as the National Hurricane Center (NHC), Storm Prediction Center (SPC) and Aviation Weather Center (AWC). This project supports the following NOAA mission goals: Weather and Water, Commerce and Transportation and Climate. Enhanced training will also prepare the forecaster/manager on how to utilize imagery and products to provide services in these areas.

Most CIRA PG products are also made available in real time on the CIRA webpage at http://rammb.cira.colostate.edu/ramsdis/online/goes-r_proving_ground.asp A portion of the webpage is shown below in Figure 1.

GOES-R - CIRA Product List

Information

Experimental and operational data are used to demonstrate subsets of what will be available from GOES-R. The real time demonstrations include GOES-R AWG products, product variants, new products and new imagery/visualization techniques. The table below summarizes the products, with a clickable link to more information.

CIRA Product List (click headings to re-sort):

Product	Contact	Related Training	Data Display	WFO / Testbed Feedback	Product Type	Usage
GeoColor Imagery	Steve Miller	Product Description	AWIPS web	WFO	New Imagery / Visualization Technique	Visualization
MODIS Simulated True Color Imagery	Steve Miller	Product Description	web	WFO	New Product	Visualization
GOES Low Cloud / Fog Imagery	Don Hillger	Product Description COMET	AWIPS web	WFO	Product Variant	Cloud determination
MODIS Cirrus Detection	Steve Miller	Product Description	AWIPS web	WFO	New Product	Cloud determination
Orographic Rain Index (ORI)	Steve Miller	Product Description	AWIPS web	HWT	New Product	Rainfall
Marine Stratus Cloud Climatology	Cindy Combs	Product Description VISIT student guide		WFO	New Product	Cloud determination
GOES Blowing Dust	Don Hillger	Product Description COMET COMET EUMETSAT training	AWIPS web	HWT	Product Variant	Volcanic Emissions / Dust
MODIS Based Blowing Dust	Steve Miller	Product Description COMET COMET EUMETSAT training	AWIPS web	HWT	Product Variant	Volcanic Emissions / Dust
MODIS Cloud / Snow Discriminator	Steve Miller	Product Description COMET	AWIPS web	WFO	Product Variant	Snow / Cloud determination
MODIS Cloud Layers & Snow Cover Discriminator	Steve Miller	Product Description COMET	AWIPS web	WFO	Product Variant	Snow / Cloud determination

Figure 1. Webpage that provides access to the CIRA Proving Ground products and training.

The webpage provides much information on each of the CIRA Proving Ground (PG) products, including the developer and point of contact as well as a concise but informative “Product Description” that details how the product is made, why it is a PG product, and how it can be used in operations. All of the products are available to forecasters through their AWIPS (I or II) system if requested, but typically interested National Weather Service (NWS) Weather Forecast Offices (WFOs) who work with CIRA will ingest only a few products at any one time for testing and evaluation. The webpage however allows real-time access to all the products for quick viewing, as well as a 4-week archive. This enables forecasters to use them online, or decide if they would like to ingest them into the AWIPS at their WFO (we work with individual WFOs to provide instructions on how to do this). Bandwidth limitations often prevent some WFOs from ingesting too many (or at times any) products, so having the webpage presentations can be a useful alternative display mechanism.

CIRA works in collaboration with other Proving Ground partners at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison, the NASA Short-term Prediction Research and Transition (SPoRT) Center located in Huntsville, Alabama, and the GOES-R Proving Ground Satellite Liaisons.

PROJECT ACCOMPLISHMENTS:

Work was conducted in the following six areas:

1--Decision Aid Product Development:
--CIRA continued to generate and serve the following products to the NHC: RGB Airmass, RGB Dust, RII, SRSO, and the new GOES-R Natural Color Imagery Product. CIRA’s collaboration with SPoRT continued, with SPoRT making the RGB products available in NAWIPS, the display system at NHC.
--CIRA continued to generate GOES-R ABI synthetic imagery based on output from NSSL’s 4-km WRF ARW. Throughout the year, imagery was produced for 6.95 µm, 7.34 µm, 8.50 µm, 10.35 µm, and 12.3 µm for forecast periods out to 36 hours. In addition, CIRA continued to simulate the thermal-only 3.9 µm band (i.e., neglecting the solar reflected component) and the band difference product 10.35 µm - 3.9 µm (referred to as the “fog product” by forecasters) in real-time. Additional band differences created were 10.35 µm – 12.3 µm, 8.5 µm - 10.35 µm, and 8.5 µm - 12.3 µm. CIRA also generated GOES-R ABI synthetic imagery based on output from the NCEP NAM Nest (CONUS scale 4-km model available to forecasters on AWIPS I/II) 00 UTC run. Bands were generated to produce the standard AWIPS IR and Water Vapor imagery, out to 60 hours. Synthetic imagery was added for Alaska using the 00 UTC run of the NCEP NAM Nest for Alaska for 6.2 µm, 6.95 µm, 7.34 µm, 8.50 µm, and 10.35 µm for forecast periods out to 60 hours. The Alaska imagery was also made available to forecasters. The synthetic imagery continued to receive very favorable feedback from forecasters at many different WFOs, SPC and AWC. Synthetic imagery represents one way to provide Proving Ground products for bands or combinations of bands that do not currently exist with the operational GOES satellites.
-- CIRA produces a variety of Proving Ground products, including GOES blowing dust, MODIS-based dust enhancement, GOES cloud/snow discrimination (3-color technique), MODIS cloud/snow (binary) discriminator, MODIS cloud layers/snow discriminator, MODIS Cirrus, GOES low cloud/fog, GeoColor (with and without city lights, per user request), and the Orographic Rain Index (ORI). These products are generally generated using bands on Polar orbiting satellites, or in combination with current GOES imagery. Polar products represent another way to replicate GOES-R type products, since these satellites have many of the bands that will be available on GOES-R (though of course at limited time resolution). Most CIRA PG Decision Aid products were moved into AWIPS and are being served to partnering WFOs.
--The ORI product continued to be delivered to WFOs in Hawaii and San Juan, Puerto Rico and WFO Monterey. Work continued to verify the ORI product (with a journal paper submitted) as well as making adjustments to the input to ORI per feedback from forecasters. Feedback from Hawaii has been positive, and the SOO at WFO Monterey has given us good feedback on ORI during an Atmospheric River event in December.
--The RGB Airmass GOES sounder product was also distributed to the NOAA Weather Prediction Center (WPC) and the Ocean Prediction Center (OPC).

2--Interaction with NWS Forecast Offices and National Centers:
-- Participated in the 2014 High Impact Weather workshop in Norman, OK.
-- Continued close working relationship with partner WFOs at Boulder and Cheyenne. CIRA's WFO Liaison Ed Szoke is also a NOAA/ESRL/GSD employee, and the Boulder WFO is located in the same building in Boulder. Ed interacts frequently with the Boulder WFO, including working occasional forecast shifts to gain a better appreciation of operational forecast problems and issues. We also work closely with the Cheyenne WFO, and staff from WFO Cheyenne visited CIRA in late January, while CIRA staff visited the WFO in late summer and in January.
-- Expanded the distribution of PG products to additional WFOs. Many requests come after exposure via VISIT training or evaluation exercises conducted by Satellite Liaison Chad Gravelle, through conversation with neighboring WFOs, or through interactions following CIRA blog postings.
-- Continued to emphasize the collection of forecaster feedback regarding CIRA PG products. Feedback is being received via email, AFDs, blogs, semi-annual National Center reports, shift logs, verbal communication, and specially created feedback links on our webpages. Feedback comments are being archived. A couple of blogs written about the blowing dust episodes in March of 2014 from eastern Colorado southward through the Texas Panhandle generated interest from affected WFOs. An even more widespread event occurred on 27 April 2014, also a big severe weather day, behind the strong cold front through the central and southern Great Plains. An image from the CIRA pink dust product is shown in Figure 2.
-- Worked closely with all the Proving Ground Liaisons. The Liaisons visited Fort Collins and Boulder in early September.
-- Working with AWC Liaison Amanda Terborg, CIRA delivered GeoColor to the AWC where it is being tested on the operational floor.
-- Continued to demonstrate and evaluate Total Lightning at both the Boulder and Cheyenne WFOs (in cooperation with SPoRT), using lightning data from the Colorado Lightning Mapping Array (CO LMA) maintained by Colorado State University. Presentations were made by CIRA staff and a WFO Boulder forecaster at the 95th AMS Annual Meeting in Phoenix in January.
-- Close interaction with the NWS Scientific Services Divisions (SSDs) ensured that the Regional Headquarters are well informed about PG product distribution to their WFOs.
-- Participation in the SPC Spring Experiment in Norman, Oklahoma in May-June to observe use of CIRA's WRF-ARW and NAM Nest based synthetic imagery products.
-- CIRA's close interaction with NHC continued; several visits to NHC offered good opportunities to conduct person-to-person training regarding our NHC PG products.
-- CIRA continued its close interaction with OPC and WPC primarily through their Satellite Proving Ground liaison Michael Folmer. Several products demonstrated to NHC are also demonstrated at OPC and WPC, including most recently GeoColor imagery.
-- CIRA participated in the AWC Summer Experiment.
-- Dan Lindsey visited WFOs in Riverton, Wyoming and Rapid City, South Dakota during the summer of 2014.
-- CIRA provided synthetic imagery for the AWC Winter Experiment. Feedback was very positive. An image from the experiment is shown in Figure 3.

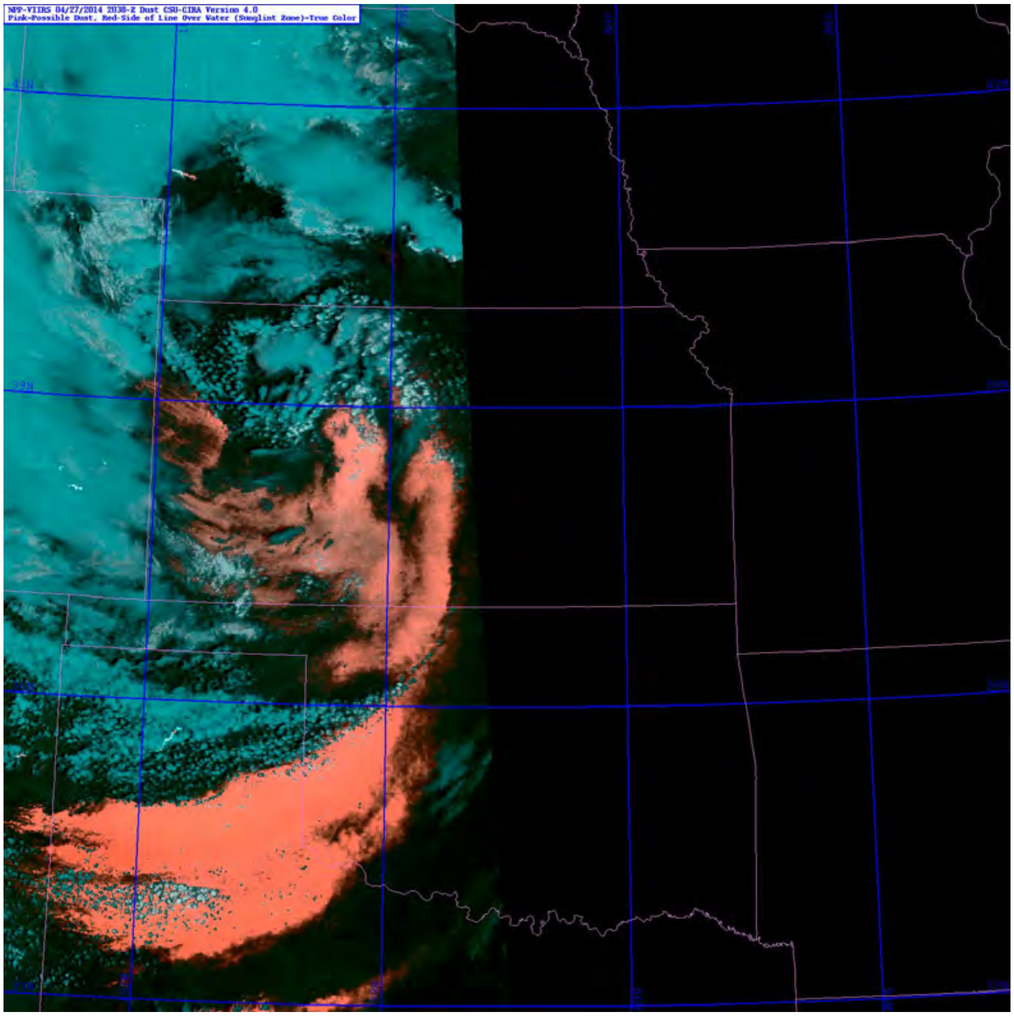

Figure 2. CIRA "pink" dust product for a huge dust storm from Kansas south through the Texas Panhandle on 27 April 2014. The image is created from NPP VIIRS imagery at 2038 UTC.

Figure 3. Aviation Weather Center (AWC) Proving Ground Liaison Amanda Torberg is seen examining two CIRA PG products during the AWC Summer Testbed Experiment in August 2015. On the left is the synthetic imagery fog product, and in the center screen is a GeoColor image.

3--Proving Ground Website Development:
-- CIRA's real-time PG product webpage is continuously being updated to display the latest products and adhere to presentation formats endorsed by the PG program. New links have been provided to product descriptions and to allow for feedback as well.

4--AWIPS I & II Development:
-- Port of CIRA's AWIPS I PG products to AWIPS II is complete. Real-time products are being disseminated via the LDM.
-- CIRA's PG products are being demonstrated via AWIPS I, N-AWIPS, webpages, and AWIPS II. Special instruction sets were created for each WFO to facilitate the display of CIRA's Proving Ground products. In addition, CIRA participated in the initial PG Partners working group to develop a standardized AWIPS II product installation template that will be available via the NWS Virtual Lab.
-- CIRA continued to participate in the AWIPS II – Raytheon working group and attend AWIPS II workshops.
-- CIRA continued participation in the monthly NDE-AWIPS Working Group telecons. The meetings provide a framework for technical staff communication regarding problems associated with the establishment of the flow of S-NPP data from NDE into AWIPS II, and allow CIRA to plan for upgrades of NOAAPORT infrastructure that will be needed for GOES-R data ingest.
-- D. Molenar participated in the April SPoRT D2D RGB software development working group. The RGB capabilities can now be configured from the Localization Perspective (as opposed to earlier versions which required a plugin) in OB14.4.1. Several findings by the group prompted Raytheon software modifications to improve image display functionality.
-- Continued hardware procurement and implementation to improve/expand in-house AWIPS II capabilities. A high-end workstation was procured and configured as the primary CIRA EDEX server. Even this machine was not enough to be able to ingest all AWIPS I SBN products in AWIPS II. Efforts are underway to evaluate threading modifications and even higher end hardware that has been shown by Metro State College to work using the standalone software that the CI's receive. Three additional AWIPS

II CAVE workstations were procured and configured. The workstations are used for VISIT case study development, for software development and for researcher familiarization with AWIPS II.   In addition, the 3 workstations were utilized to provide a 2 day AWIPS II National Centers Perspective training session for 3 satellite liaisons. Various versions of 64 bit OB14.x are supported to meet National Center and Forecast Office support requirements.
-- D. Molenar and S. Longmore attended the September EPDT working group held at SPoRT. S. Longmore worked on mapping the differences between D2D and NCP image display to determine software development necessary for RGB display in the NCP. D. Molenar worked on software to display simulated GOES-R data.
-- Continued work to port AWIPS I PG MODIS products to AWIPS II. Cloud/Snow & Fire Detection products have been converted to NAWIPS & AWIPS II and are being disseminated via CIRA's real-time LDM feed.
-- Implemented port of CIRA GeoColor product to N-AWIPS format for distribution to the Aviation Weather Center. The NAWIPS version of CIRA GeoColor product is now available for 3 sectors (East Pacific, Atlantic, and CONUS) at 1KM resolution. The product is being disseminated in real time to SPC, OPC, CPC and AWC. The AWIPS II version of the 1 KM CONUS product has also been installed at several NWS Weather Forecast Offices.
-- Continued participation in the PG Partners efforts to develop standard template for AWIPS II Installation. A formal standard template has yet to be developed, but forecaster feedback on existing installation procedures from CIRA, SPoRT and CIMSS has helped with the creation of a de-facto installation procedure.
-- Procedures were developed to add HRRR data to the NCP grid display. These procedures were provided to the satellite liaisons during the CIRA NCP training.
-- CIRA staff attended a 3-day Unidata workshop providing training on the Unidata AWIPS II software that will be utilized by the university community.
-- Significant progress has been made on the implementation of a GOES-R Groundsystem at CIRA. An antenna has been ordered, and installation arrangements have been made with CSU Facilities. A GOES-R simulator arrived at CIRA in March 2015. High-end storage options are under evaluation. CSPP beta software that will be used to process the GRB data has been installed and IT staff familiarization is underway.

5--Product Documentation and User Readiness:
-- CIRA continued to leverage VISIT and SHyMet in-house capabilities to evaluate PG activities. Efforts were made to complete the analysis of the ORI product performance for selected West Coast locations, correlating the index with precipitation and stream gauge data and identifying strengths/weaknesses of the algorithm. The algorithm is being reprogrammed to allow for more flexibility in order to address concerns raised by forecasters. A formal publication has been submitted to the Journal of Hydrology.
-- CIRA expanded its efforts to post BLOGS on the VISIT webpage. We were able to follow-up with selected WFOs that were affected by the weather highlighted in the blog posts.
-- CIRA continued to merge PG modules with on-going activities.
-- CIRA collaborated closely with CIMSS, SPoRT and COMET on training activities.
-- CIRA participated in training discussions at COMET during the Satellite Liaison visit.

6--Colorado Lightning Network (CO LMA):
-- The CO LMA data stream is maintained by CSU with a communications contract has been established and is working well. A few stations in the network experienced technical problems that were addressed. All stations are currently on line and operating well. Live CO LMA data were ingested into the Boulder and Cheyenne WFOs and are being used by forecasters to help identify severe weather and rapidly evolving convective storms, as well as other applications that the forecasters have discovered. Displays of the data are available on AWIPS II through our arrangement with SPoRT, as well as on a situational awareness wall-mounted monitor that displays the CO LMA website.
-- Presentation on total lightning and the non-supercell tornado at DIA on 13 Jun 2013 was presented as an oral talk by Ed Szoke at the AMS Severe Local Storms Conference in Madison in November and at NOAA Science Week in Boulder in February.
-- Bernie Meier, forecaster at the Boulder WFO, presented a talk at the AMS Annual Meeting in January on the use of total lightning for issuing TAFs.

PROJECT TITLE: CIRA Support to RAMMB Infrastructure for GOES-R Rebroadcast Data Collection at CIRA/CSU

PRINCIPAL INVESTIGATOR**:** Renate Brummer and Michael Hiatt

RESEARCH TEAM: Renate Brummer, Michael Hiatt, Natalie Tourville

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Philip Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM**:** Don Hillger and Deb Molenar (NESDIS/STAR/RAMMB)

PROJECT OBJECTIVES:

CIRA and RAMMB are key players in the GOES-R Proving Ground, GOES-R Risk Reduction activities, and GOES-R algorithm development. Up to this point, algorithm development has required the use of proxy GOES-R data. This includes current GOES data, data from instruments such as MODIS and VIIRS aboard polar-orbiting satellites, and model-simulated data. After GOES-R is launched and the real data begins flowing, having access to a real-time feed from its Advanced Baseline Imager (ABI) will be critical. The volume of data will be far too large to obtain from offsite servers via the web, so having the ability to collect the GOES-R rebroadcast data here at CIRA is a necessity. CIRA's current ground station collects rebroadcast data from NOAA's geostationary satellites. This past year, work began on a significant upgrade to the system in preparation to collect data from GOES-R after it was launched.

PROJECT ACCOMPLISHMENTS:

The new GOES-R ground station contains the following parts to support reception, processing, distribution, and archiving of GOES-R data:

-- 4.5 Meter GRB Antenna
--High Performance Dual Polarity Low Noise Amplifier (LNA)
--Antenna Installation including Foundation, Cables, and Conduits
--GOES-R GRB Demodulator
--GOES-R SDI Pre-processor
--GOES-R Ingest/Processor
--Archive and Distribution System

Colorado State University has agreed to provide matching funding and will support CIRA's GOES-R Groundsystem Infrastructure efforts with $75,000.00 for the 4.5 Meter S-Band Antenna.
The plan is for the antenna to be set up in June/July 2015.

NESDIS/StAR made end-of-the-year funding available to CIRA which allowed the CIRA Groundsystem team to begin purchasing and setting up the computer equipment needed for a GOES-R ground station. CIRA's Primary Ground Station Engineer has the technical expertise to build the equipment needed for the ground system in-house at CIRA, which results in significantly less cost than buying any of the equipment.

The grant we received covered the cost of:
1-- two GOES-R Ingest/Processor computers
2-- two large storage devices (Synology NAS with Seagate hard drive)
3-- two Blu-Ray Back-up writer systems
Not all of these equipment pieces have been purchased yet at the time of this reporting period.

During this reporting period, work began on building the ingest and processor computers as well as on a first storage device. In addition to purchasing and building the necessary hardware, the CIRA GOES-R

Groundstation team organized several planning meetings together with CIRA directors, CIRA technical experts, and Federal RAMMB colleagues to discuss how best to proceed with this project. Final decisions regarding the exact antenna size, the types of ingest/processing computers and the timing of setting up the antenna were made in these meetings.

The plan is to have the GOES-R Groundstation completed around the time of the GOES-R launch in spring of 2016.

PROJECT TITLE: CIRA Support to the JPSS Proving Ground and Risk Reduction Program: 'Seeing the Light': Exploiting VIIRS Day/Night Band Low Light Visible Measurements in the Arctic and Advancing Nighttime VIIRS Cloud Products with the Day/Night Band

PRINCIPAL INVESTIGATOR**:** Steve Miller

RESEARCH TEAM**:** Curtis Seaman, Yoo-Jeong Noh, Fang Wang, Scott Longmore, Renate Brummer, Steve Finley

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Phil Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: Andy Heidinger (NESDIS/STAR/CRPD/ASPB); Project 2

PROJECT OBJECTIVES:

There are two related projects reported on as part of this JPSS Proving Ground and Risk Reduction (PGRR) task. The first demonstrates the unique and unprecedented capabilities of the Visible/Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) low-light visible nighttime imagery in the Arctic, emphasizing the use of moonlight during the winter season when solar illumination is limited or unavailable and where polar-orbiter temporal refresh is most practical to operational users. These demonstrations are conducted in cooperation with University of Alaska-Fairbanks (UAF) Geographic Information Network of Alaska (GINA) and its suite of operational partners, and coordinated under the auspices of NOAA's Satellite Proving Ground to ensure a connection and dialogue with end users. New capabilities for detecting low cloud/fog, snow cover, volcanic ash, sea ice and ice-free passages, auroral boundaries, and other parameters exploiting the 740 m spatial resolution of the VIIRS/DNB low-light visible measurements coupled for the first time with spatially/temporally co-located multi-spectral shortwave and thermal infrared bands, are demonstrated in near real-time. We leverage tools and techniques for lunar availability and irradiance prediction as well as hands-on experience with VIIRS/DNB data gained via concurrent participation in the JPSS VIIRS Cal/Val program. Training on DNB imagery capabilities and interpretation for these new observations is an implicit component of this work, and examples derived from this research will provide subject matter for those involved in formal training efforts connected with the Proving Ground and more generally with the environmental satellite user community.

The second project under this JPSS/PGRR task specializes in the quantitative exploitation of the DNB for cloud optical property information at night. Clouds are a fundamental meteorological parameter in describing the energy balance of the planet. Knowledge of cloud cover is critical not only to operational users in the context of characterizing current weather-related hazards, but also to the production of high quality climate data records. Beyond the characterization of cloud coverage itself, identification of cloudy scenes is a key first-level filter to numerous other satellite-derived products that must either require cloud-free conditions or knowledge of cloud presence in order to produce accurate retrievals. Without this a priori knowledge, retrievals will contain biases that can propagate to errors in numerical weather prediction models, climate prediction models, and introduce ambiguity to the long-term satellite record of key climate parameters. For these reasons, the critical task of cloud masking resides at a high level in the VIIRS EDR processing chain. This project modifies the baseline VIIRS cloud mask and properties algorithms to utilize moonlight reflectance, when it is available, in an effort to augment the capabilities of the nighttime cloud products in terms of improved cloud mask, microphysical and macrophysical properties (and indirectly, improving downstream products that are reliant on an accurate cloud mask). The improved performance will be validated using independent, active-based cloud detection from the CALIPSO lidar. Comparisons to the baseline VIIRS cloud parameters will be conducted both in terms of case studies and statistics to infer the benefits of nighttime visible data and postulate implications for the satellite-based climate data records predating the availability of this information.

These projects directly address NOAA's Weather and Water Goal, which seeks to serve society's needs for weather and water information. This research also falls within the NOAA-defined CIRA thematic area of Satellite Algorithm Development, Training and Education, as new, multi-spectral applications involving the Day/Night Band are being designed and demonstrated.

Project 1--('Seeing the Light'—VIIRS/DNB Arctic)

Objectives

1-- Continue demonstrations of VIIRS/DNB capabilities

2-- Code updates for VIIRS/DNB processing

3-- Manuscript preparation on selected VIIRS/DNB topic

Research Conducted

1-- Demonstrations of VIIRS DNB to various users continued along several fronts. We presented a comprehensive overview of DNB capabilities (anticipated and emergent) at EUMETSAT/Geneva. The presentation was well received by the international user community and has generated significant follow-up discussions on several fronts. We continue to interact with the GINA group, with Eric Stevens serving as our conduit to the user community.

Blog entries on various topics of high-latitude relevance were delivered to the 'Seeing the Light' website. (http://rammb.cira.colostate.edu/projects/alaska/blog/). DNB-relevant entries for this period are:

a) *The Calving of B-31*: Use of DNB to chronicle a major iceberg calving event in the Antarctic
b) *Camouflage Clouds*: The ability of the DNB to capture difficult-to-detect clouds at high latitudes
c) *Glow in the Dark Water*: Imagery analysis of the 'moon glint' phenomenon (Figure 1)
d) *Funny River Isn't Laughing*: Analysis of Funny River, Alaska wildfire
e) *Revisiting Scale on the Solstice*: Introduction to the ERF Scaling technique

2—We have installed and tested new IDL processing codes on the GINA virtual machine. Our new Error Function Scaling (ERF; Seaman and Miller, 2015) was also installed on the GINA system, and with the assistance of Liam Gumley and Kathy Strabala the codes was also included in the Community Satellite Processing Package (CSPP). Figure 2 shows an example of the ERF scaling in comparison to a standard Near-Constant-Contrast (NCC) product for a scene over Alaska.

3-- During this period work proceeded on several DNB-related papers.
--A journal article on nightglow gravity waves atop tropical cyclones, although not directly related to high latitudes, bears relevance to the Arctic as waves are produced in all regions. The energy deposited by these waves influences the structure of the upper atmosphere and thus affects weather/climate in the full-system response, as well as immediate impacts to GPS performance.

--Another paper was drafted on the error function scaling approach, which provides a fast and straightforward means to scaling the highly dynamic DNB imagery apart from the Near Constant Contrast (NCC) product.
--A third paper, detailing the utility of DNB observations of nighttime ship lights, was prepared a Remote Sensing special issue.
--Finally, work continued with editors of Scientific American on a DNB feature piece.

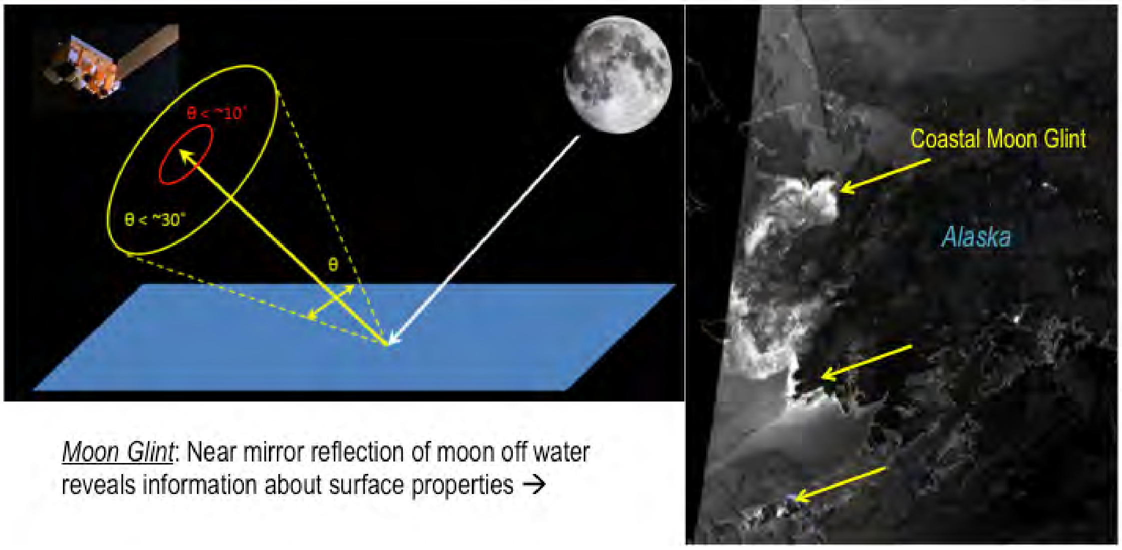

Figure 1. Example of moon glint, explained geometrically and illustrated for a case study along the coastal waters of western Alaska.

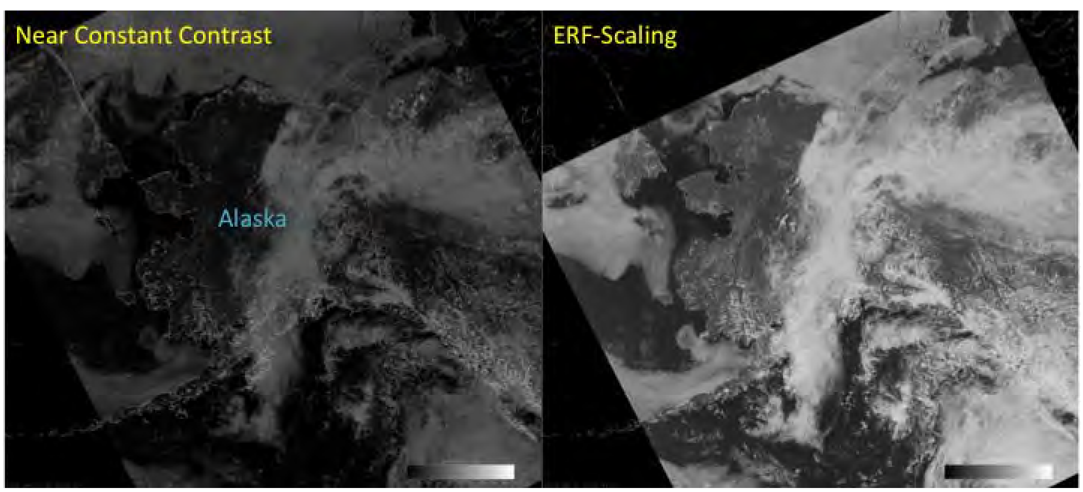

Figure 2. Example of Near Constant Contrast (NCC) and ERF-scaled imagery for an example scene over Alaska. The DNB also provides useful imagery during the Day, as shown in this example from 21 June 2014 (2201 UTC).

Project 2--(Advancing VIIRS Nighttime Cloud Products)

Objectives

1-- Continued updates to lunar model

2-- Conduct a statistical evaluation of nocturnal cloud cover for various regions, comparing against legacy cloud techniques

3--Determine requirements for Proving Ground demonstration

Research Conducted

1-- Fundamental to this research is the conversion from DNB measurements of radiance to lunar reflectance. This conversion enlists a lunar irradiance model developed by the project PI in coordination with the Naval Research Laboratory. During this reporting period we have been continuing our work to assess and improve the model through various methods. Work continued on a lunar phase-angle-dependent albedo correction. The need for this correction arises from the lunar irradiance model's implicit assumption of a phase-angle-independent albedo (homogeneous surface). In reality, the lunar disk contains heterogeneous variations in albedo arising from the distribution of brighter Highlands and darker Maria regions. The correction attempts to mitigate departures from the constant albedo (e.g., arising from the mean lunar disk albedo being too dark compared to the waxing moon and too bright compared to the waning moon).

a) *Stable Reflecting Target Analyses*: We have focused on Salar de Uyuni, as this location provides a high-altitude (smaller potential for atmospheric contamination), horizontally uniform (as opposed to the dune geometry of White Sands), and approximately spectrally flat behaviour that is ideal for this analysis. We have collected data over multiple years for this target and used it to reveal the phase-dependent biases that are due to lunar surface heterogeneity. We computed a linear-fit as a first-order correction, but a better account for the albedo variation with phase will require direct lunar observations. Figure 3 shows time series of daytime and nighttime (via model) surface reflectance at Salar de Uyuni.

b) *MeteoSat SEVIRI Direct Lunar Views:* We have worked with Meteosat Second Generation (MSG) Spin-Enhanced Visible Infrared Imager (SEVIRI) dataset of lunar views between +/- 150˚ phase angle. The data set is provided courtesy of Bartolomeo Viticchie and Sebastien Wagner of the Meteosat team at EUMETSAT. The wealth of observations at high lunar phase angle sampling resolution is ideal for producing a detailed correction (i.e., a higher-order correction than the linear one mentioned above). To conduct this analysis, we modified the lunar irradiance code to simulate the SEVIRI measurements at various bands by convolving the model's 1 nm resolution standard geometry data to the SEVIRI band response functions and modifying the model geometry to re-cast the problem in terms of the Sun/Moon/Satellite configuration as opposed to the default Sun/Moon/Earth system. These geometric differences produce non-trivial departures in the lunar irradiance. The analysis was conducted on a multi-year database, and revealed the phase-dependent biases consistent with what was being observed in the day/night comparisons at Salar de Uyuni. A phase-dependent correction term was thus introduced and the performance is now being evaluated. Figure 4 shows the correction terms derived from that analysis. Polynomial fits to these data have been incorporated into software, and that software was delivered to Andi Walther for incorporation into the nighttime lunar cloud optical and microphysical properties (NLCOMP) retrieval code.

2-- We have conducted a series of evaluations for the VIIRS nocturnal cloud mask, with and without DNB reflectance information included. NOAA's CLAVR-x software package is used as the foundation for these tests. Our focus was on a region of the southeast Pacific where there have been known problems with cloud detection historically from the International Satellite Cloud Climatology Project (ISCCP). Figure 5 shows example results that illustrate how the retrieved cloud mask is impacted by the addition of DNB information. For this case, we see that the DNB adds confidence to the probably clear and probably cloudy mask. Strong lunar reflection contrast in the DNB reduces ambiguity (the 'probably' categories).

3-- Proving Ground demonstrations of selected products is ongoing at CIRA, and code has been ported to the VIIRS processing systems which can be adopted for packaging the imagery into AWIPS/NAWIPS

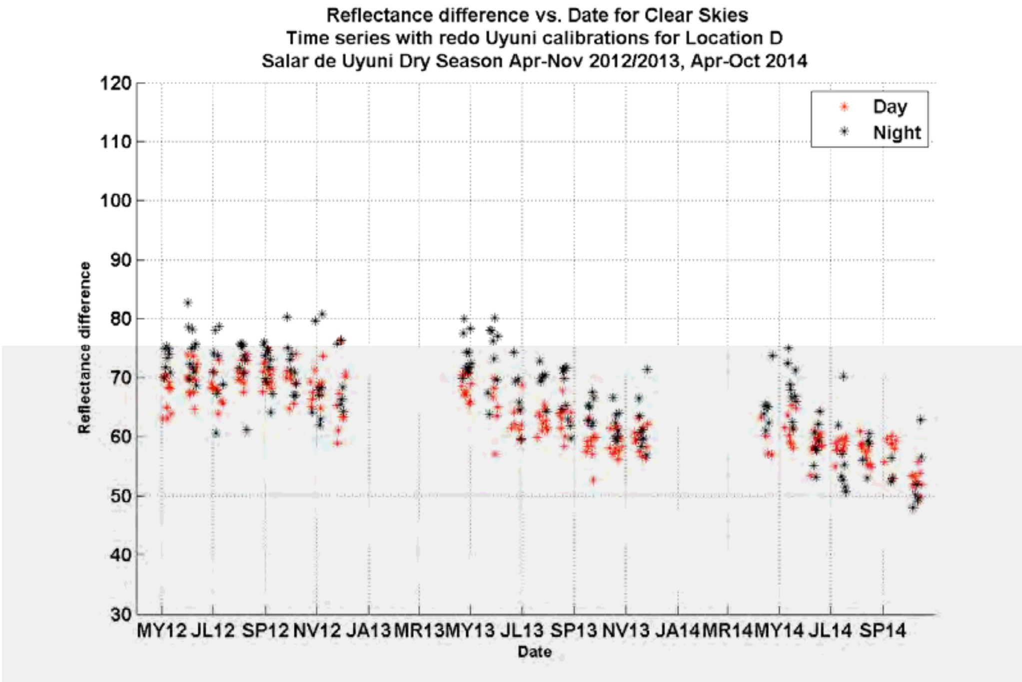

Figure 3. Time series of surface reflectance at Salar de Uyuni, with linear corrections applied for phase-dependent errors in lunar albedo. The variation over time is due to seasonal changes in surface albedo associated with flooding of the basin. The tracking of day vs. night shows that the model is performing nominally.

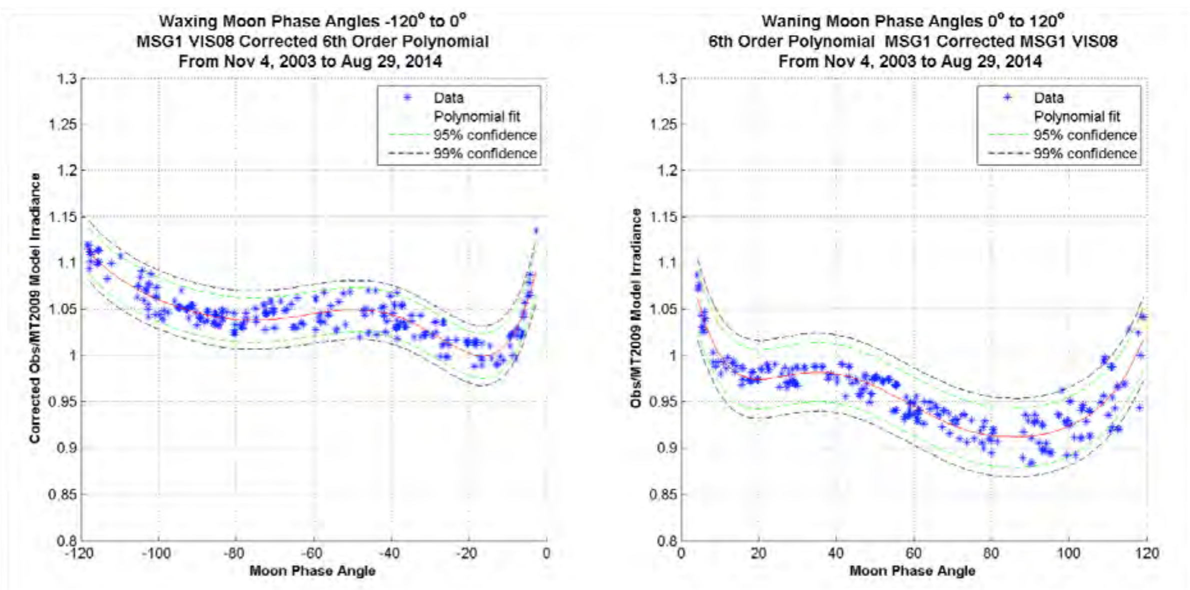

Figure 4. Phase angle dependent corrective factors determined via comparisons between multi-year MSG/SEVIRI lunar measurements and the lunar irradiance model for waxing (left) and waning (right) lunar cycles.

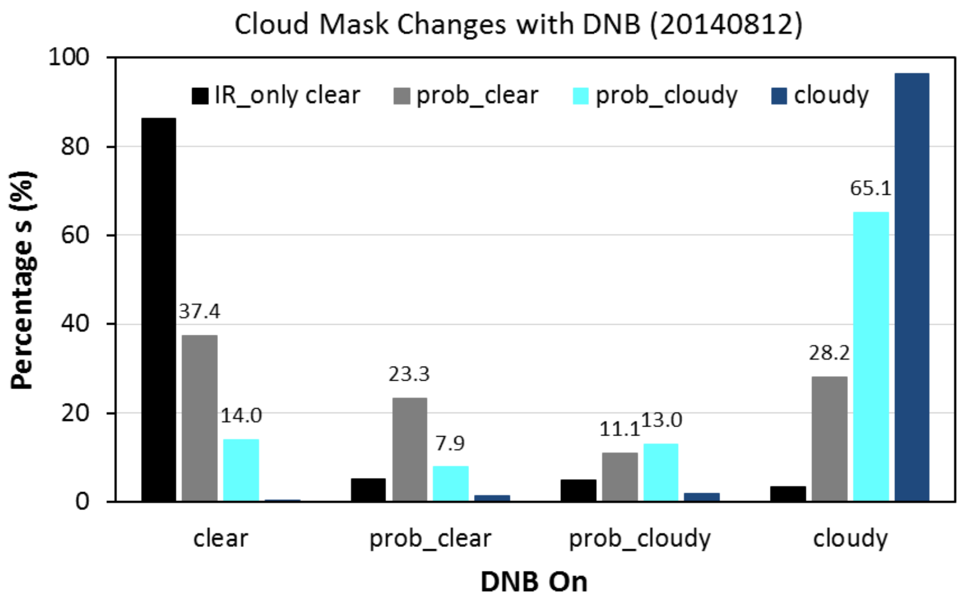

Figure 5. Statistical analysis of changes to VIIRS cloud mask when introducing DNB observations, for a case study in the southeast Pacific Ocean. The abscissa shows the cloud classification categories for results that include the DNB information, and the vertical bars show the distribution of corresponding results for IR-only classification.

PROJECT TITLE: Estimating Peatland Fire Emissions Using Nighttime Satellite Data

PRINCIPAL INVESTIGATOR: Tomohiro Oda

RESEARCH TEAM: Tom Oda

NOAA TECHNICAL CONTACT: Dr. Chris Elvidge, NOAA National Geophysical Data Center (NGDC)

NOAA RESEARCH TEAM: Dr. Chris Elvidge (NGDC), Dr. David Hsu (CIRES, University of Colorado/NGDC), Dr. Mikhail Zhizhin (CIRES, University of Colorado/NGDC), Ms. Kimberly Baugh (CIRES, University of Colorado/NGDC)

PROJECT OBJECTIVE:

To modify the NCAR FINN fire emission model to accept parameters estimated by the VIIRS Nightfire (VNF) algorithm and implement FINN runs to produce fire emissions for fire seasons for 2013 and 2014 in Sumatra, Indonesia.

PROJECT ACCOMPLISHMENTS:

The VIIRS Nightfire (VNF) algorithm, which was developed by Dr. Elvidge and colleagues, detects combustion events and estimates parameters that indicate combustion characteristics (e.g. combustion temperature, source size and radiant heat). Under the guidance of Collaborator Dr. Christine Wiedinmyer at NCAR, Dr. Oda developed an interface function for FINN to accept the combustion parameters informed by the VNF. The interface function that Dr. Oda developed applies a set of screening criteria to combustion event entries in the raw VNF files and remove entries with inadequate quality. The function also calculates the fractions of land cover and vegetation density in the area indicated by the VNF using the MODIS Land Cover Type (LCT) data and Global Land Cover-SHARE product for 2014 (GLC). The land cover types of the products were also reclassified to the six generic land cover types in FINN. The VNF combustion parameters and calculated statistics are put into input files which are given to FINN. The combustion events with temperature higher than 1300K, are removed as well with a suspect of gas flaring events. The temperature threshold is tentative, but it seems to be working well at this point. As seen in Figure 1, combustion events with high temperature are mostly located over the ocean and close to the coastline. Some of the high temperature combustion events however were identified over the land (Figure 1 left). It suggests that the combustion type identification will need to be studied using ground truth.

Using the input file created, monthly emissions are calculated over the fire seasons in 2013 (Phase 1) and 2014 (Phase 2) in Sumatra, Indonesia. The fire counts from VNF were comparable to MODIS fire counts, but the emission calculated by the FINN-VNF was significantly smaller than that of the default FINN run (see Figure 2). The underestimation could be largely attributable to the small source size estimated by VNF (See Figure 1 right). The comparison made by Elvidge with colleagues using LandSat images confirmed that the burn area estimates are smaller compared to the area actually burnt. The next step will be to investigate how to relate the VNF source size estimates to the area burnt. Another approach could be the use of the radiant heat also reported by VNF. The VNF radiant heat (in MW) shows very good correlation with the MODIS fire radiative power. These will be studied in Dr. Oda's new NASA-funded project. The research outcome of this project was made available at https://www.ngdc.noaa.gov/eog/viirs/download_peatland_indonesia.html.

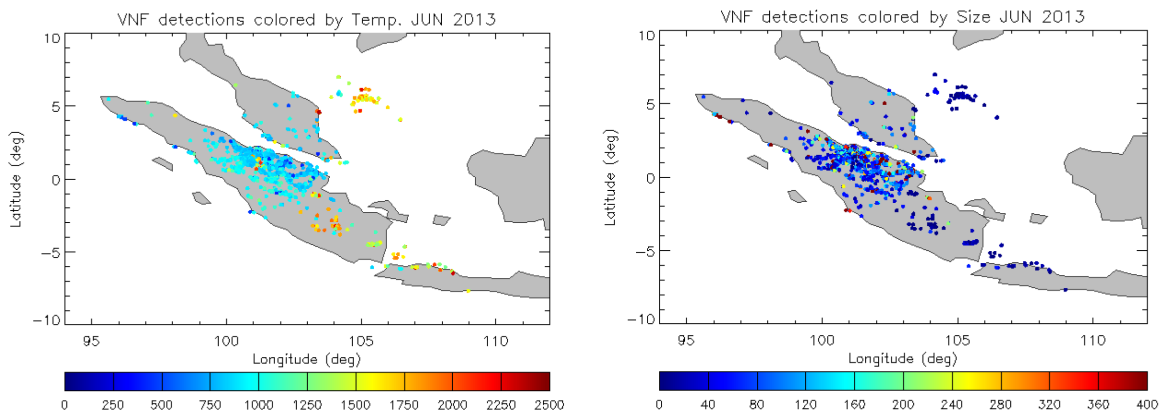

Figure 1. Combustion events detected by the VNF algorithm. Dots are colored by combustion temperature (left) and source size (right). The units are K and m^2 respectively.

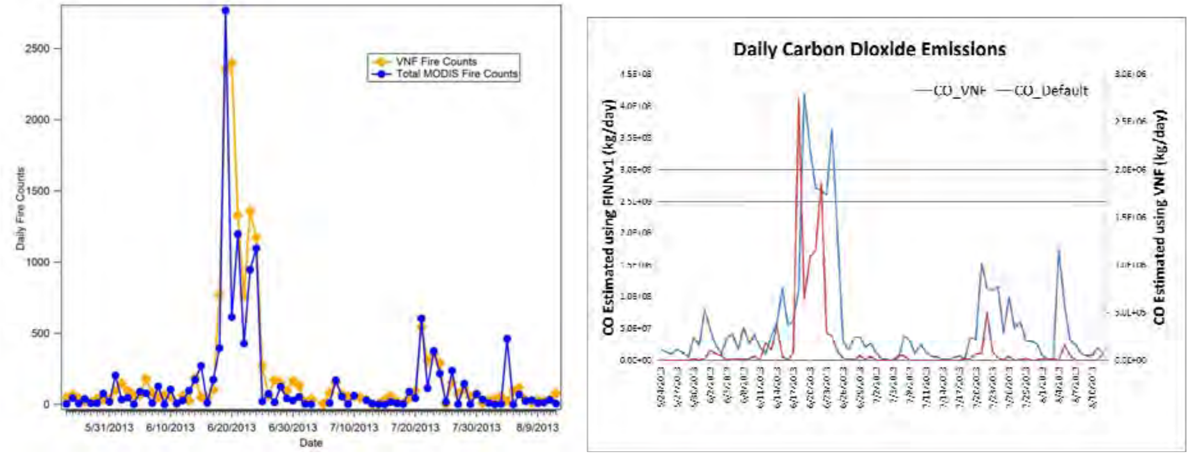

Figure 2. Fire count comparison (left) and Carbon monoxide emissions calculated by the VNF-FINN and the default FINN.

PROJECT TITLE: Integrating GPM and Orographic Lifting into NOAA's QPE in Mountainous Terrain

PRINCIPAL INVESTIGATORS: Edward Szoke, Dan Bikos, Steve Miller, Christian Kummerow

RESEARCH TEAM: Stanley Kidder, Cindy Combs, Paula Brown, Mel Nordquist

NOAA TECHNICAL CONTACT: Paul Neiman (NOAA/ESRL/PSD)

NOAA RESEARCH TEAM: Paul Neiman (NOAA/ESRL/PSD)

PROJECT OBJECTIVES:

This project seeks to improve the quantitative precipitation estimate (QPE) over mountainous terrain by combining the Global Precipitation Mission (GPM) satellite precipitation estimate with the Orographic Rain Index (ORI). The GPM consists of a dual frequency radar and microwave radiometers for precipitation estimates. Over mountainous terrain, the microwave radiometer estimate has limitations where orographic enhancement may not correlate with an abundance of additional ice particle production in certain atmospheric conditions (i.e., warm rain, high precipitation efficiency processes). The dual frequency radar, however, does not have these limitations since its retrievals are nearly insensitive to the character of the underlying surface. Over mountainous terrain, the only negative impact caused by the surface is clutter. The objective of this study is to compare estimates of precipitation from the dual frequency radar with the microwave radiometer for Atmospheric River events along the West Coast in regions where terrain is significant (i.e. coastal mountain ranges). The next objective is to compare ORI with the estimates of precipitation over coastal mountain ranges to assess if ORI can add value to the microwave radiometer estimates. Two measures of "ground truth" were used, 1) the land-based radar estimate of precipitation rate from the NMQ (National Mosaic and Q2 system) and 2) the GPM dual frequency radar.

PROJECT ACCOMPLISHMENTS:

1—Collected cases of Atmospheric River events along the West Coast as GPM passes were available.

The team monitored the West Coast for Atmospheric River events. During these events, it was determined if a GPM pass was available, if so, then it was analyzed (for accomplishment #2).

2—Analysis of available cases, compare GPM dual frequency radar with microwave radiometer precipitation estimate.

From the available cases, the GPM dual frequency radar was compared with the microwave radiometer precipitation estimate. These were compared over ocean and coastal mountain ranges as available. An example case study from 12 December 2014 is shown in Figures. 1-2.

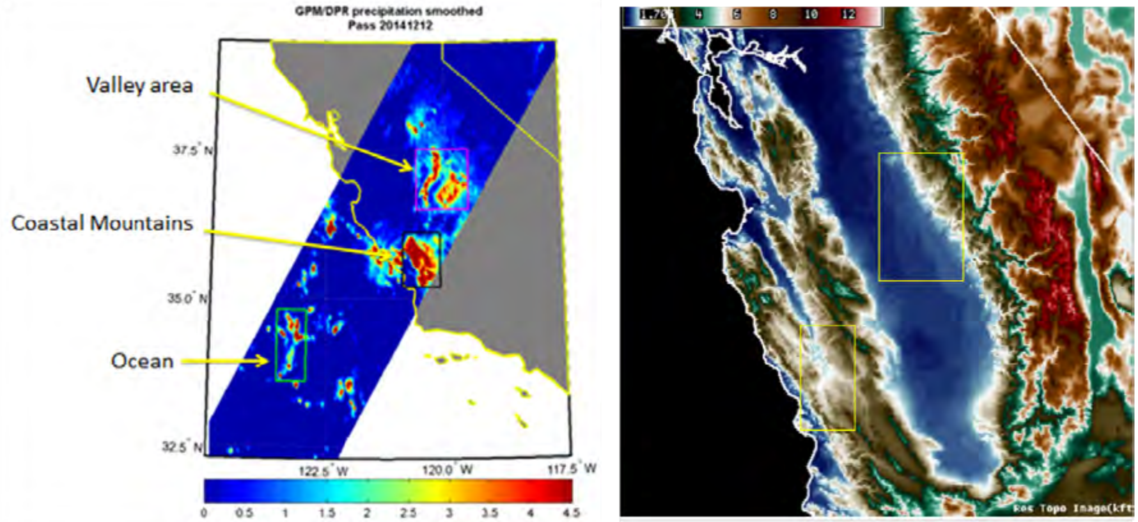

Figure 1. GPM dual frequency radar pass at 1500 UTC 12 December 2014 (left) and terrain (right; kft.). This identifies the 3 boxes that were selected, 2 of which are detailed in Fig. 2.

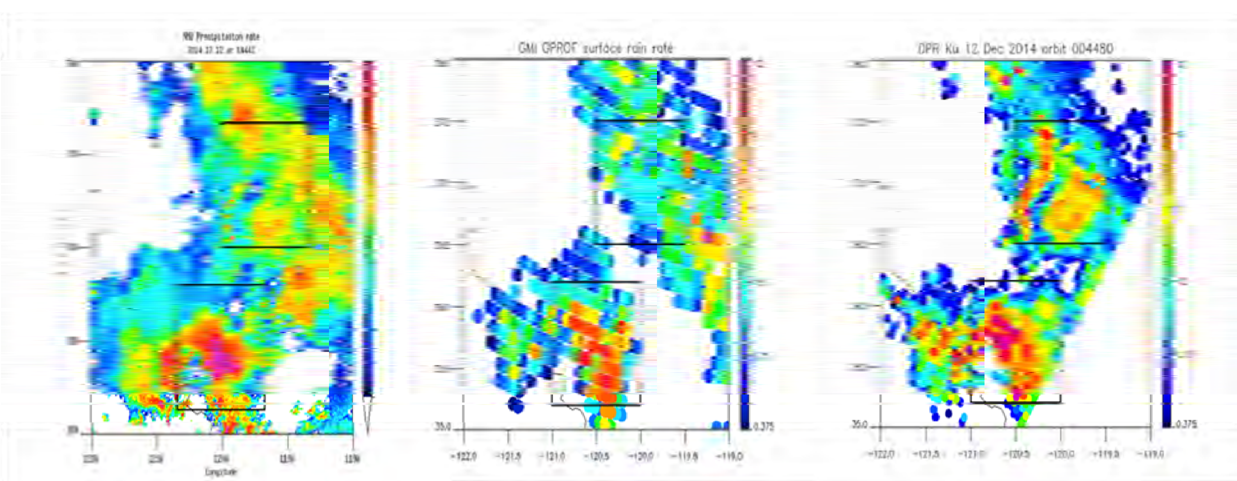

Figure 2. NMQ precipitation rate at 1444 UTC 12 December 2014 (left), GPM microwave radiometer pass at 1500 UTC 12 December 2014 (middle), GPM dual frequency radar pass at 1500 UTC 12 December 2014 (right). This illustrates some of the issues with the microwave radiometer over higher terrain, note the lower precipitation rates in the middle panel compared to the left / right panels.

3—Compare ORI with GPM precipitation estimates from the microwave radiometer

Assess the impact of ORI on GPM precipitation estimates from the microwave radiometer. Could the ORI product add value to the GPM microwave radiometer estimates over regions of terrain? An example case study from an Atmospheric River event on 7 February 2015 is shown in Fig. 3-4.

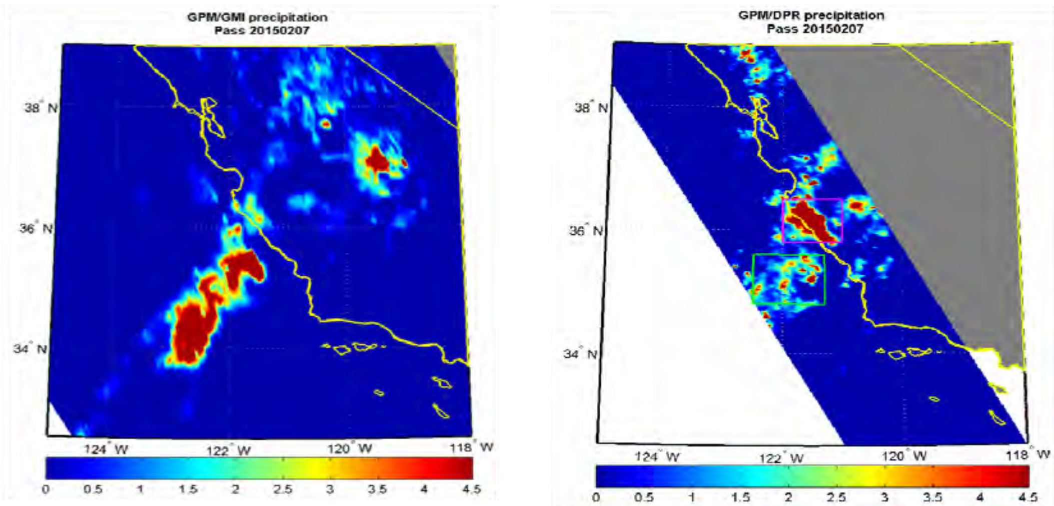

Figure 3. GPM precipitation from the microwave radiometer (left) and dual frequency radar (right) approximately 1500 UTC 7 February 2015. This sector is over central coastal California. For this case, over the magenta box, we see that precipitation rates are lower from the microwave radiometer compared to the dual frequency radar within this region of coastal mountains. This is an area where ORI has the potential to add value (increase) to the microwave radiometer precipitation rate estimates.

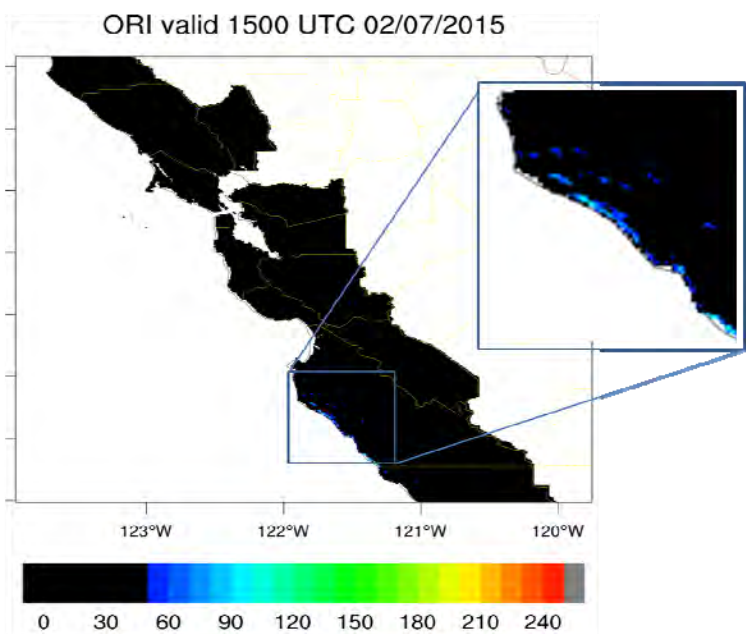

Figure 4. ORI product valid 1500 UTC 7 February 2015 (same time as Fig. 3) over central coastal region of California. Higher ORI values are observed within the box where the coastal range rises abruptly (highlighted insert). This suggests that ORI could adjust the microwave radiometer precipitation rate estimates upward, where they were observed to be too low.

PROJECT TITLE: NESDIS Environmental Applications Team – Prasanjit Dash, Research Scientist - NOAA SST Quality Monitor (SQUAM)

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Prasanjit Dash

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Yury Kihai, John Stroup

PROJECT OBJECTIVE(S):

1--Complete inclusion of NAVO VIIRS SST in high resolution (HR) SQUAM

2--Similar to above but for (A)ATSR Reprocessing for Climate (ARC) level-2P (L2P) SST

3--Optimize SQUAM performance with a newer gridding function (IDL+C hybrid code)

4--In the HR module, make *maps* and *dependence* (daily, Hovmöller) available two ways: with and without outliers (with improved gridding), in the *operational mode*. (Earlier it was only for 'without outliers'. In the previous term, it was done for GAC.)

5--Same as above, but for the *in situ* part, redone for the entire time series and not from a particular day (*stewardship mode*)

6--Add CMC v2.0 L4 SST as an additional reference for HR SSTs

7--Explore reinstating the Level-4 SQUAM module and add new products

8--Form SQUAM Delivered Algorithm Package (DAP), including scripts/codes. Transition to J. Stroup for inclusion in VIIRS stewardship SSTs (RAN) with Univ. of Wisconsin

9--Develop SQUAM capabilities for VIIRS L3 SST (ongoing work)

10--Improve SQUAM web codes for cross-browser consistency

11--Support for JPSS programmatic status report meetings

12--Ensure, as much as is possible, a seamless functioning of SQUAM diagnostic system

13--Investigate the potential *use* of correlated error analysis

14--Publications, presentations and/or white papers

15--Other professional activities

PROJECT ACCOMPLISHMENTS:

1--Included NAVO VIIRS SST in the high resolution SQUAM module (HR; *http://www.star.nesdis.noaa.gov/sod/sst/squam/HR/*), against both L4 and *in situ*. Diagnostics against L4 SSTs are made available on a daily basis and against *in situ* on both daily and monthly basis. VIIRS and

L4 SST data are accessed *via* JPL PO.DAAC and ancillary data from NOAA ESRL is appended for comprehensive diagnostics in SQUAM. Inter-comparison of three VIIRS products (two available before and newly added NAVO) is shown below in Fig. 1. The major observations are (a) IDPS and ACSPO provide comparable number of retrievals, with ACSPO consistently outperforming IDPS. (b) NAVO and ACSPO performances are comparable (especially recently), but ACSPO retrievals are available in a factor of 2.5 larger domain.

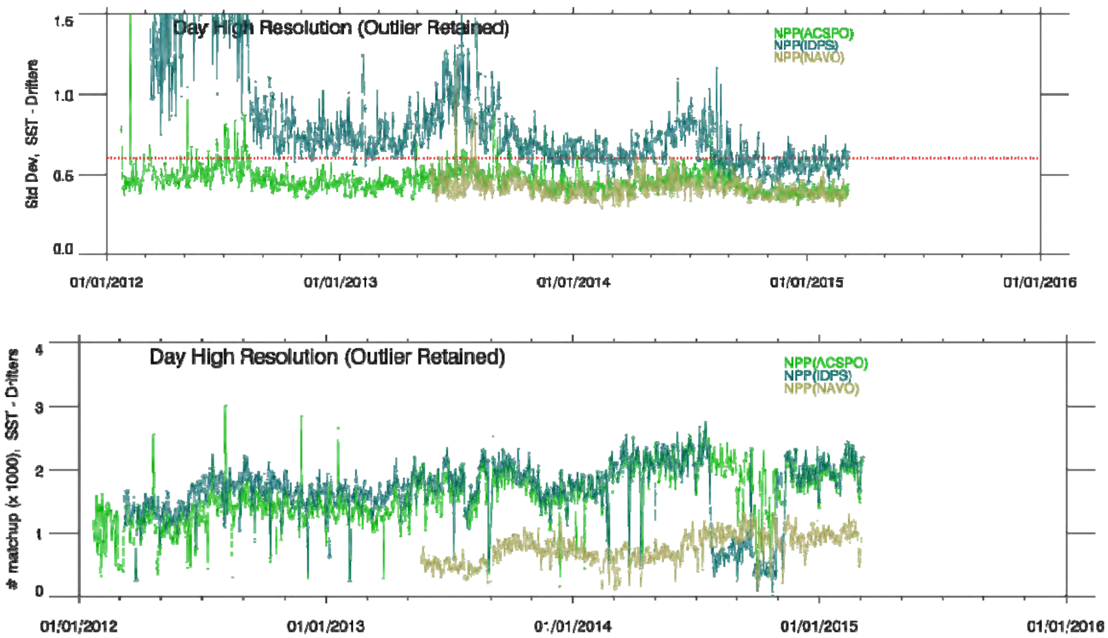

Figure 1. Comparison of daily daytime VIIRS SST performances for NOAA ACSPO, NAVO, and IDPS products. Top: standard deviation against drifters, Bottom: number of matches. The dotted red line (top panel) denotes the minimum performance requirement.

2--Included (A)ATSR Reprocessing for Climate (ARC) level-2P (L2P) SST datasets from 1-Nov-1991 to 8-Apr-2012 in HR SQUAM as part of NOAA's involvement in the future Sentinel-3 mission and engagement in the S3 Validation Team (S3VT) See "summary report" at: *www.eumetsat.int/website/home/News/ConferencesandEvents/DAT_2326254.html*

3--Optimized SQUAM performance by using a newer gridding function (IDL+C hybrid code; developed by Y. Kihai). This addition is critical as the resolution and volume of satellite data in HR SQUAM has dramatically increased with inclusion of three different VIIRS products (ACSPO, NAVO, IDPS) and two different AVHRR FRAC products (ACSPO, OSISAF).

4--In the SQUAM HR module, *maps* and *dependencies* (daily, Hovmöller) are now available two ways: with and without outliers (with improved gridding code). (Earlier it was only 'without outliers'.) This is done for both L4 SST and *in situ* as references.

5--Uniformly regenerated *in situ* validation (daily and monthly) with improved gridding code *for the entire available time-series* in HR module (*stewardship mode*), for 11 products, to yield diagnostics both ways.

6--Added CMC v2.0 L4 SST as an additional reference for HR SSTs. Fig. 2 shows an example nighttime map of ‘ACSPO VIIRS *minus* CMC’. The usefulness of such maps and other diagnostics are detailed in relevant presentations (see publication list).

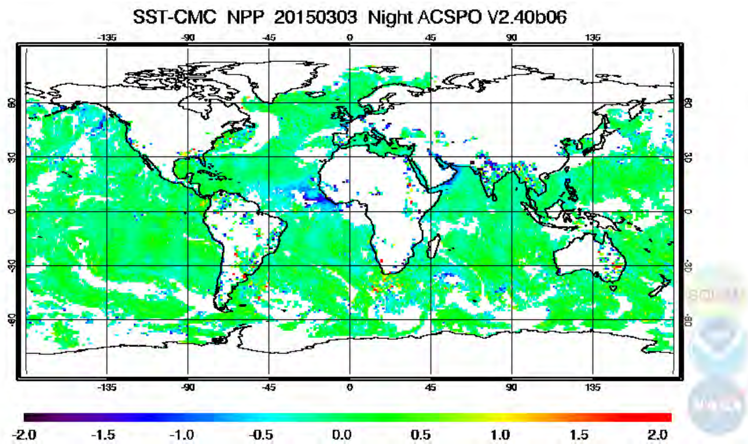

Figure 2. ACSPO VIIRS L2 SST minus CMC L4 SST for Mar-03-2015.

7--Partly reinstated the Level-4 SQUAM module; also, a new product (Danish OI) was included. Fig. 3 shows an example of ‘DMI OISST *minus* GHRSST Median Product Ensemble (GMPE)’. A fuller reinstatement is an incremental process.

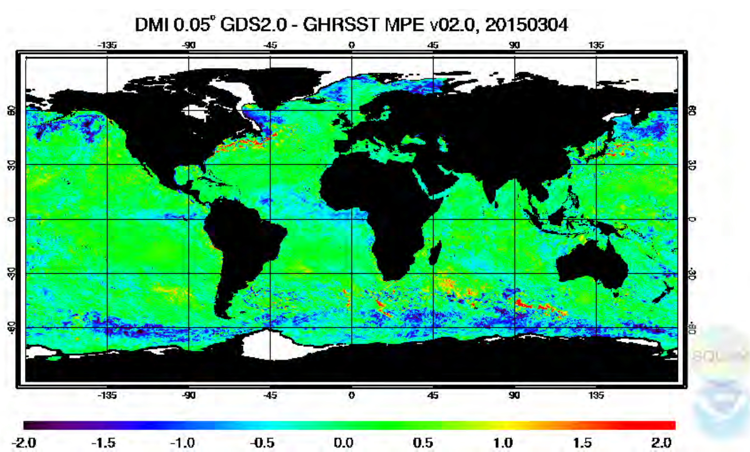

Figure 3. Danish OI L4 SST *minus* GMPE L4 SST for Mar-04-2015.

8--For ACSPO VIIRS SST Reanalysis (RAN) at U. Wisconsin, developed an initial version of SQUAM Delivered Algorithm Package (DAP) and handed over to J. Stroup. A new DAP may be delivered if significant SQUAM code changes occur or RAN needs arise.

9--Based on users’ demand, the NOAA SST Team has developed a new ACSPO VIIRS Level-3 (L3U) product. Initial codes/scripts were developed and delivered to J. Stroup. Also, a separate off-line web-page was set-up expanding the SQUAM framework (*cf.* Fig. 4). Additional efforts are required to make it fully functional and make it public.

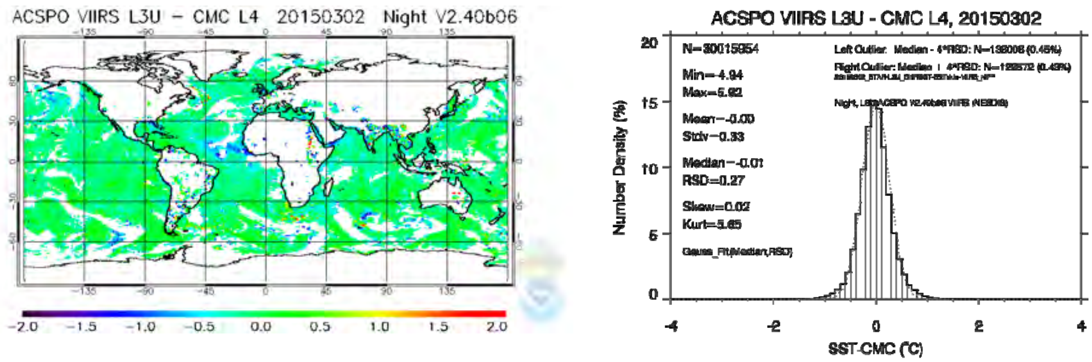

Figure 4. Example monitoring of ACSPO L3U VIIRS SST in SQUAM (future work).

10--Improved SQUAM web codes for cross-browser consistency – minor but useful. Changing of browser behavior is a normal happening and requires tuning if something does not function well. At this moment, SQUAM has been tested for and works well with the following browsers: *Mozilla Firefox v8.0* onwards, *MS Internet Explorer v10.0* on, *Apple Safari v4.0*, *Mozilla SeaMonkey 1.1.15*, *Opera 9.6* on, *Google Chrome 39.0* on.

11--Supported and provided presentation materials to the PI for JPSS programmatic status report meetings under stringent time pressure. I believe that they have been helpful in saving us time and convincing the upper management of our progress.

12--Worked to ensure seamless functioning of SQUAM. Dealt with severe outages of our computational facilities and also individually replaced diagnostics for HR-SQUAM for those selected days where the data were apparently corrupt.

13--Building upon further analyses of correlated error, performed product error analysis using a Triple Collocation Method (TCM) and determined product specific random errors in 8 HR SSTs and *in situ* data. Standard validation statistics are subject to error in references and is not a true representation of “noise” in a product. A separation is achieved using a TCM (*cf.*, O’Carroll *et al*, JTech, 2008). Initial results based on gridded collocation were presented at the GHRSST meeting (Jun 2014), and somewhat improved version at the NASA SST and S3VT meetings (Dec 2014). Errors in drifters derived from multiple collocated triplet combinations are shown in Table 1. Note that the results from different triplet combinations are consistent, adding confidence in the implementation of the TCM.

Table 1. Random errors in drifters from triplets of drifters and satellites with similar local equatorial crossing time (ECT), employing TCM, shown separately for day and night. The collocations are for a year worth of data.

~ECT	Target product	Triplets Satellites with too different local ECT are not combined. To avoid the effect of correlated errors, products from the same processor or satellite are not combined.	# of triplets	Random error from TCM
Night				
Night	Drifters	Drifters, IDPS NPP, ACSPO Aqua	109,103	0.25
		Drifters, NAVO NPP, ACSPO Aqua	43,661	0.26
Evening		Drifters, OSISAF Metop-A, ACSPO Metop-B	115,762	0.26
		Drifters, OSISAF Metop-A, ACSPO Terra	83,856	0.26
Day				
Afternoon	Drifters	Drifters, IDPS NPP, ACSPO Aqua	104,492	0.36
		Drifters, NAVO NPP, ACSPO Aqua	35,293	0.30
Morning		Drifters, OSISAF Metop-A, ACSPO Metop-B	135,716	0.35
		Drifters, OSISAF Metop-A, ACSPO Terra	102,875	0.34

14--Other professional activities (the first point is within the scope of my current tasks):

--Participated in GHRSST XV Science Team Meeting (Jun 2014, Cape Town, S. Africa). Co-chaired one session, acted as rapporteur in two other sessions, gave three oral presentations, and online demo of SQUAM and iQuam.
--Presented at NASA SST Team Meeting (Dec 2014, Annapolis, MD).
--Reviewed papers for IEEE and IJRS.
--Contributed to GHRSST representation at the Ocean Science Meeting 2014 (Feb 2014, Honolulu, HI), including logistics and presentations.
--Involved in GHRSST internal discussions.
--Respond to external requests about SST datasets helping to identify a suitable product.

PROJECT TITLE: NESDIS Environmental Applications Team – Lide Jiang, Post Doc

PRINCIPAL INVESTIGATOR: Steven Miller

RESEARCH TEAM: Lide Jiang

NOAA TECHNICAL CONTACT: Menghua Wang, STAR/SOCD/MEB

NOAA RESEARCH TEAM: Menghua Wang

PROJECT OBJECTIVE(S):

1--Near-real-time ocean color data support
2--Implement new/improved ocean color algorithms in NOAA-MSL12
3--NPP VIIRS OCC EDR Cal/Val support
4--VIIRS ocean color Level-1 -> Level-2 -> Level-3 data processing and distribution
5--COMS GOCI ocean color data processing and analysis

PROJECT ACCOMPLISHMENTS:

1--Near-real-time ocean color data support
1.1--Supported a two-month NOAA NMFS, SEFSC, Miami Lab cruise in Gulf of Mexico during May and June of 2014 by providing near-real-time (12 hours delay) chlorophyll-a images (Figure 1)

2--Implement new/improved ocean color algorithms in NOAA-MSL12
2.1--Efficient SDR processing has been incorporated into NOAA-MSL12 package so that the improved VIIRS ocean color products can be directly produced from old SDR with new F-LUTs without the need to generate the new SDR.
2.2--Implemented daily sea ice flag into NOAA-MSL12 and switched the nLw-based sea ice mask to another flag bit in order to keep both available to users.
2.3--Implemented a new NIR-based atmospheric correction algorithm – BMW, into automatic daily global VIIRS ocean color data processing system (Figure 2)
2.4--Implemented Kd(PAR) product in the NOAA-MSL12 processing system as well as in the L3BIN generation code - L3BIN_GEN
2.5--Identified and corrected a bug in NOAA-MSL12 on subsetting when BMW is invoked, which enable efficient vicarious calibration when using BMW in the atmospheric correction.
2.6--Implemented netCDF output with improved metadata information in NOAA-MSL12.
2.7--Change the polarization correction scheme for VIIRS in NOAA-MSL12 and evaluate the performance.

3--NPP VIIRS OCC EDR Cal/Val support
3.1--Re-performed vicarious calibration for VIIRS ocean color EDR using MOBY data, with BMW as the NIR correction algorithm.
3.2--Updated the near-real-time monitoring introduction pdf file on our website

4--VIIRS ocean color Level-1 -> Level-2 -> Level-3 data processing and distribution
4.1--Updated the ocean color Level-3 composite image website with regional monitoring capabilities (Figure 3)
4.2--Added Coral Reef Watch locations to the regional ocean color Level-3 composite images on our website
4.3--Added true color images to regional monitoring (Figure 4)

5--COMS GOCI ocean color data processing and analysis
5.1--Performed research activities on feature tracking of GOCI Kd(490) images to extract tidal currents. The results are presented at Ocean Optics XXII, Oct. 26-31, 2014, Portland, ME (Figures 5 & 6).

Figure 1. Sample Chl-a image for Gulf of Mexico region

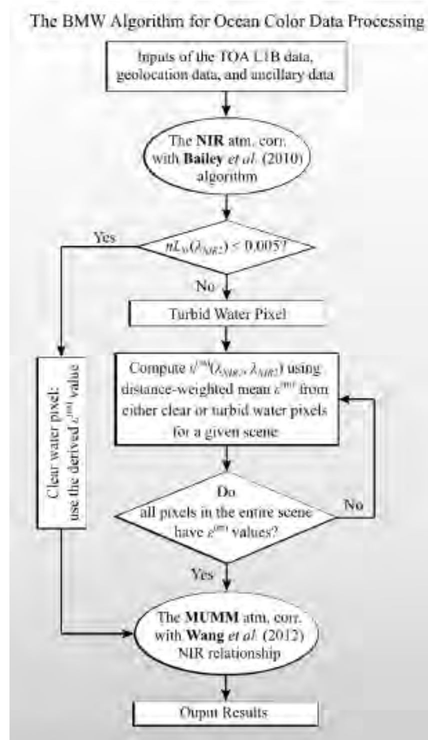

Figure 2. Decision hierarchy of the BMW processing approach.

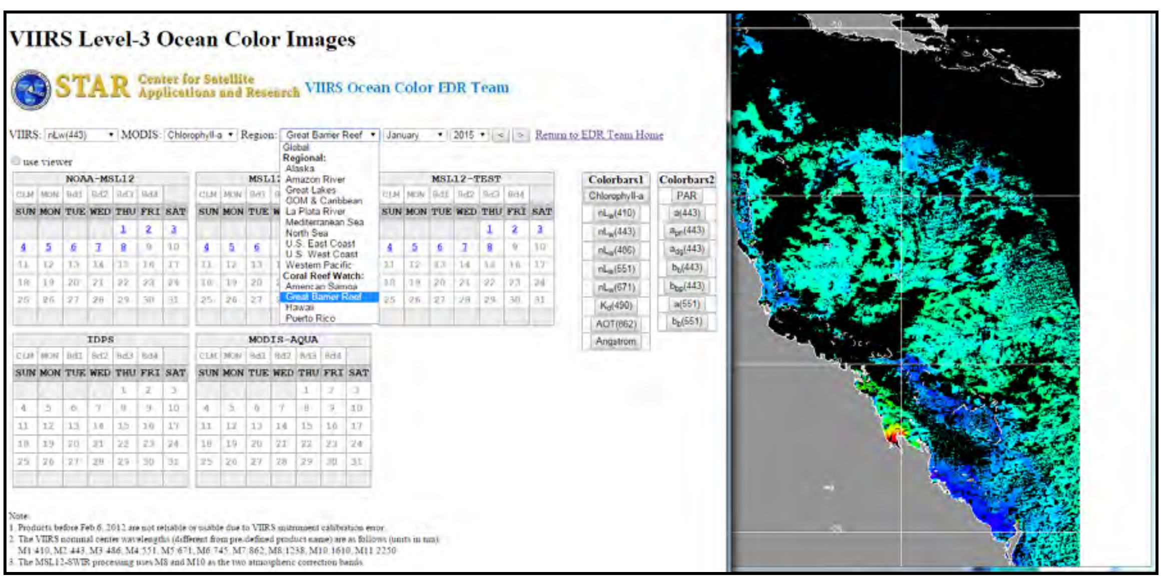

Figure 3. Ocean Color Team webpage showing regional monitoring of coral reef watch areas

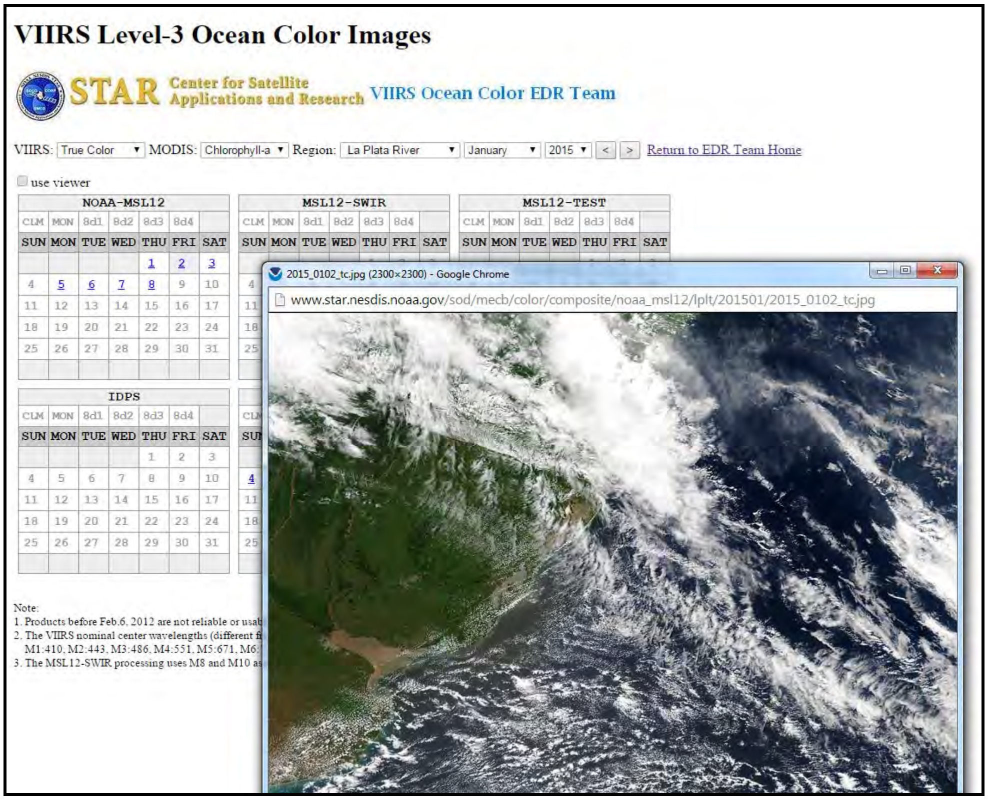

Figure 4. Ocean Color Team webpage showing regional true color images

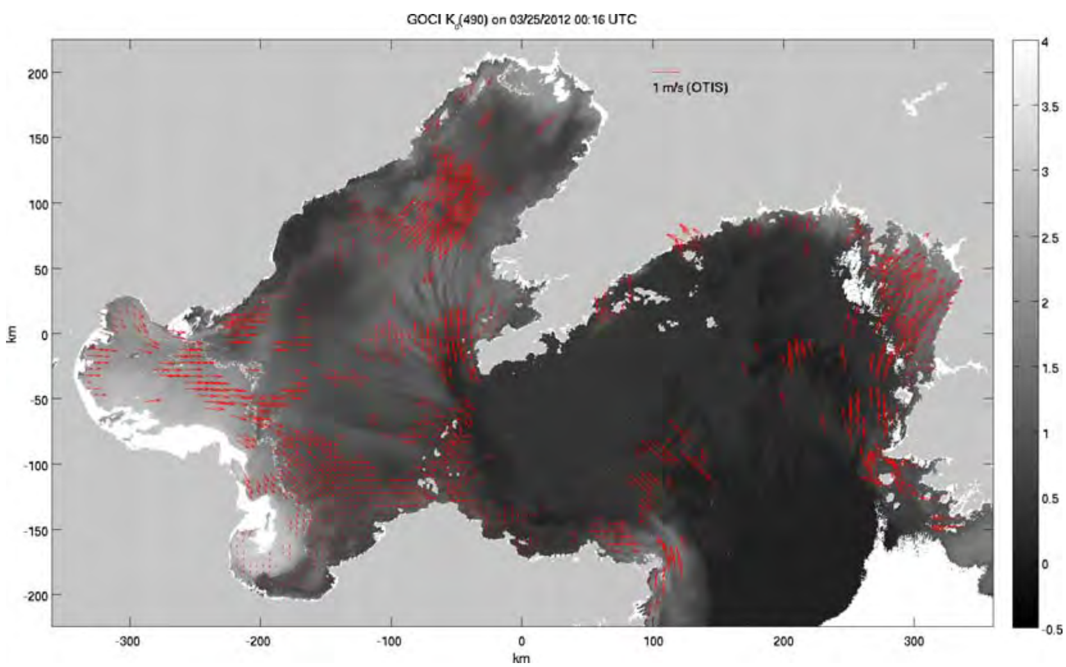

Figure 5. Tidal currents from tidal database on 03/25/2012 00:46 UTC, with background being the GOCI Kd(490) at 00:16 UTC,

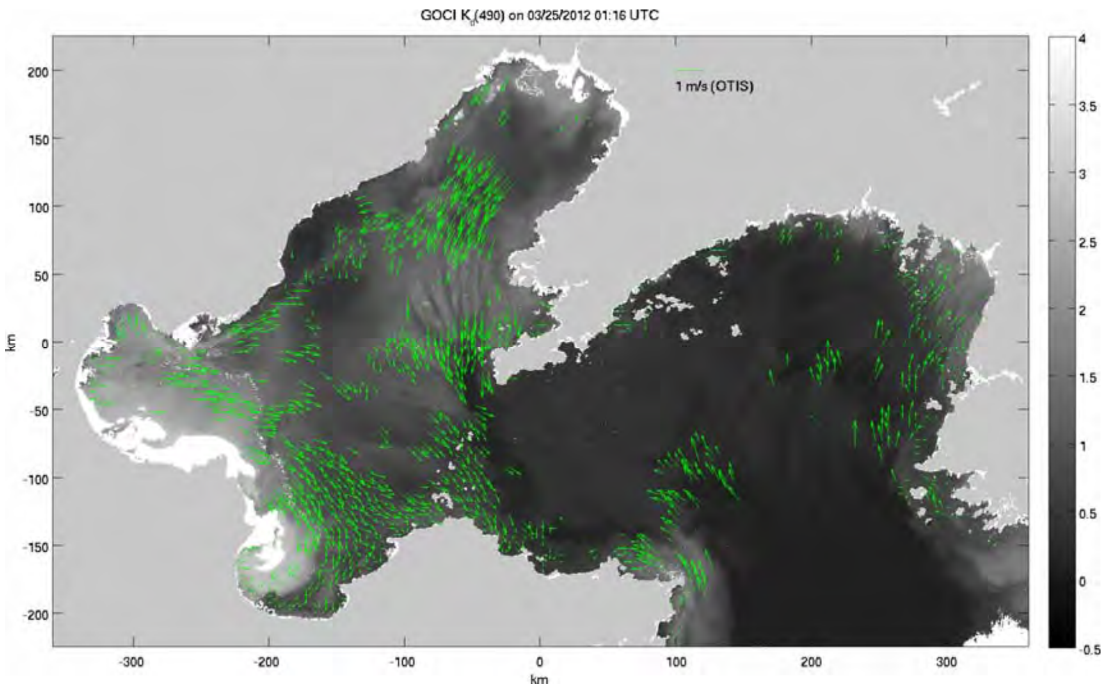

Figure 6. Tidal currents from feature tracking on GOCI Kd(490) images from 03/25/2012 00:16 UTC and 01:16 UTC, with background being the GOCI Kd(490) at 01:16 UTC

PROJECT TITLE: NESDIS Environmental Applications Team – Xingming Laing, Research Scientist - Monitoring of IR Clear-sky Radiances over Ocean for SST (MICROS)

PRINCIPAL INVESTIGATOR: Steve Miller

CIRA RESEARCH TEAM: Xingming Laing

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Alexander Ignatov, John Sapper, John Stroup, Kai He, Xinjia Zhou, Boris Petrenko, Yury Kihai

PROJECT OBJECTIVE:

Sustain, enhance and optimize NOAA MICROS online near-real time system (www.star.nesdis.noaa.gov/sod/sst/micros/); Establish mirror MICROS page for monitoring CRTM results with ECMWF input; Compare with GFS results in the main MICROS page; Document relative merits of ECMWF (www.star.nesdis.noaa.gov/sod/sst/xliang/micros_v7_ecmwf/) vs. GFS profiles; Contribute to testing new versions of the Advanced Clear-Sky Processor for Oceans (ACSPO) NOAA SST system.

PROJECT ACCOMPLISHMENTS:

During the reporting period, MICROS was updated from V7 to V8. In V8, minimum and maximum model minus observation (M-O) biases were added to facilitate analyses of outliers. Destriped S-NPP VIIRS and Terra/Aqua MODIS SDR/L1b data are now used. By users' requests, a radio button was added to download ACSPO L2 and L3 products. The data availability menu was expanded to also include monitoring of ACSPO reanalysis, in addition to real-time data. Due to departure of Korak Saha, his codes to calculate global maps of standard deviation (SD), geophysical and environmental parameters dependences of SD, ambient cloud, bathymetry and proximity to coast dependences of M-O biases and SD, and corresponding NOBS dependencies have been initially adopted, and then rewritten, optimized and included in MICROS.

MICROS V8 code was optimized and framework expanded, to speed up MICROS/ACSPO processing. Most time-consuming codes (e.g., the ambient cloud dependencies) were rewritten and heavily optimized (for instance, individual analysis for three bands and SST were combined together). This reduced the processing time by more than a factor of 2, compared to V7. Postscript-to-gif conversion was completely removed in V8, and ImageMagick processing significantly reduced. Instead, high-quality gifs are now generated in IDL and used on the web. Multi-stream processing of ACSPO Fortran code (with L2 and L3U files, in NetCDF formats including GDS2), and MICROS IDL codes, were modified for more flexible MICROS cron processing. Also, a delivered algorithm packages (DAP) was created as a stand-alone module, and delivered to the SST team for implementation in VIIRS processing at U. Wisconsin. The processing for different cloud masks, day and night, ambient cloud dependencies have been integrated in one module, with several options to allow flexible selection for the user. The integrated module is under testing and expected to reduce the total MICROS processing time by another 30%.

ECMWF profiles are tested vs. GFS in CRTM and validated in MICROS. The focus is on understanding the GFS “hot spots” (warm M-O biases) in the tropics. Comparison of global distributions of the ECMWF and GFS M-O biases, and plotting as functions of column water vapor (CWV), shows that elevated M-O biases are associated with underestimated CWV in GFS data. This result was presented at WWOSC-2014 in Montreal and at GSICS-2014 in Beijing. A manuscript is currently under internal review. A mirror MICROS page with ECMWF results (www.star.nesdis.noaa.gov/sod/sst/xliang/micros_v7_ecmwf/) was established to monitor ECMWF performance.

As before, MICROS was used to test the three new ACSPO versions (2.30, 2.31, and 2.40). As the SST Team transitions to the new cluster IT environment, data gaps occur and those are being processed and filled in a timely fashion, adding a substantial overhead to other tasks.

In 2014, I received a NOAA "Technology" Award (with Yury Kihai, Boris Petrenko, and John Stroup) for the contribution to the development of the Advanced Clear-Sky Processor for Ocean (ACSPO) system.

This work was published and presented at various international meetings/conferences (see list below).

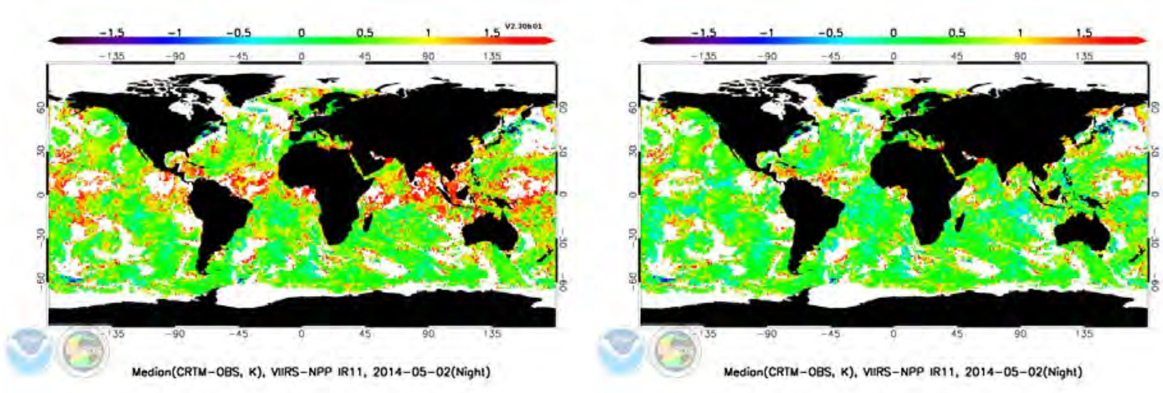

Figure 1. Nighttime M-O biases in IR11 on May 2, 2014 for S-NPP VIIRS. CRTM simulation using: (left) GFS; (right) ECMWF profiles as input. The GFS M-O biases (note hot spots in the tropics) are significantly reduced and more spatially uniform when ECMWF is used. This suggests that there may be progressively increasing “dry bias” with total precipitable water (TPW) in GFS profile in the tropics.

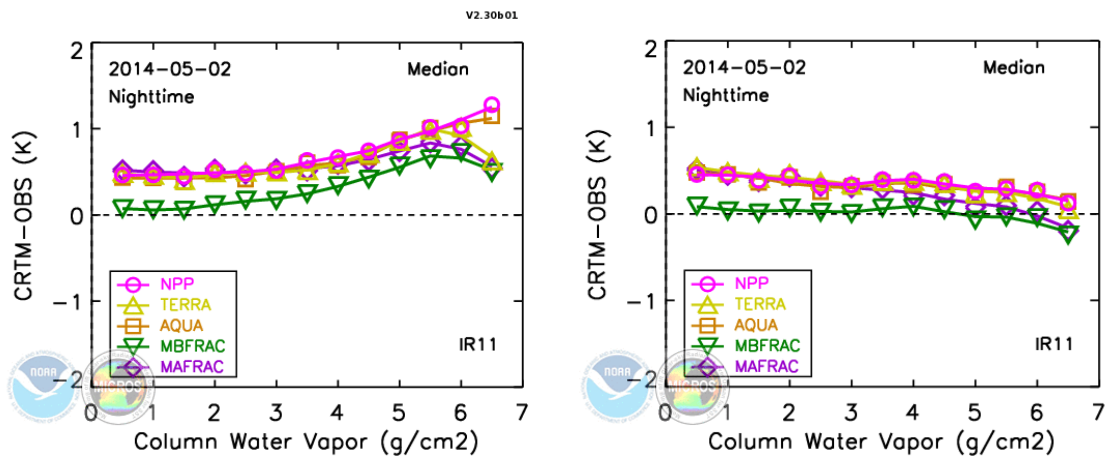

Figure 2. Column water vapor (CWV) dependencies of M-O biases: (left) GFS; (right) ECMWF. The non-flat GFS dependencies are significantly reduced and more flat as a function of CWV when ECMWF is used.

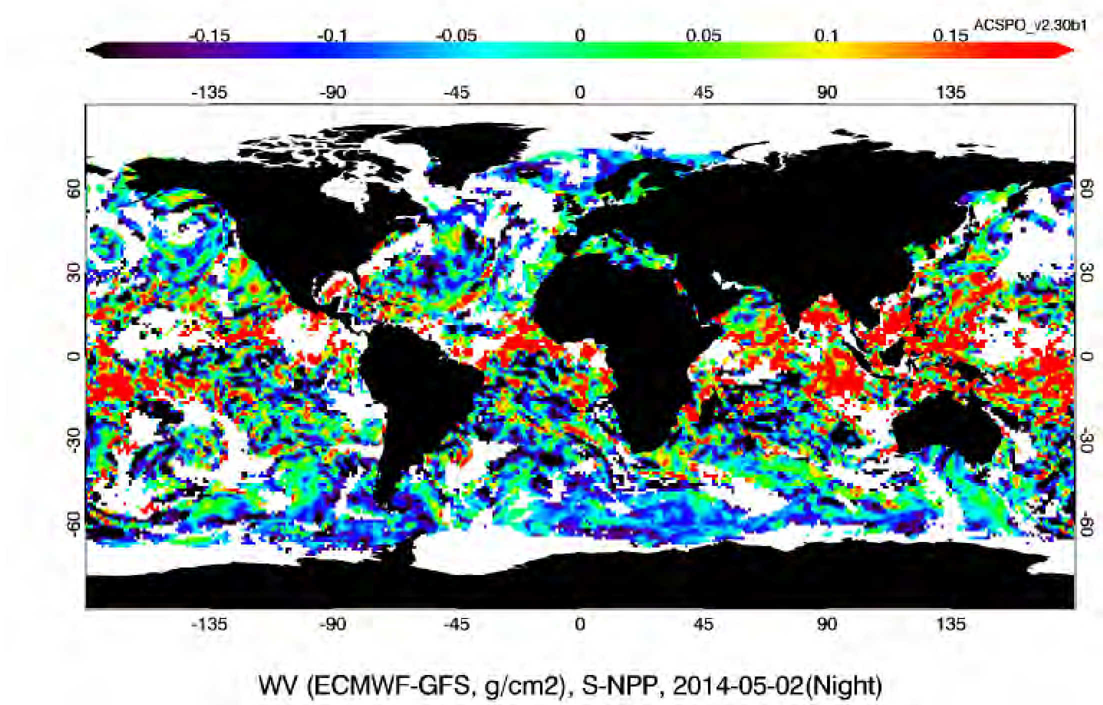

Figure 3. ΔCWV = ECMWF – GFS. GFS CWV shows a “dry bias” relative to ECMWF in the tropics, particularly in the Tropical Indian and Pacific Oceans. The GFS “dry” areas are consistent with the distribution of hot spots in Figure 1.

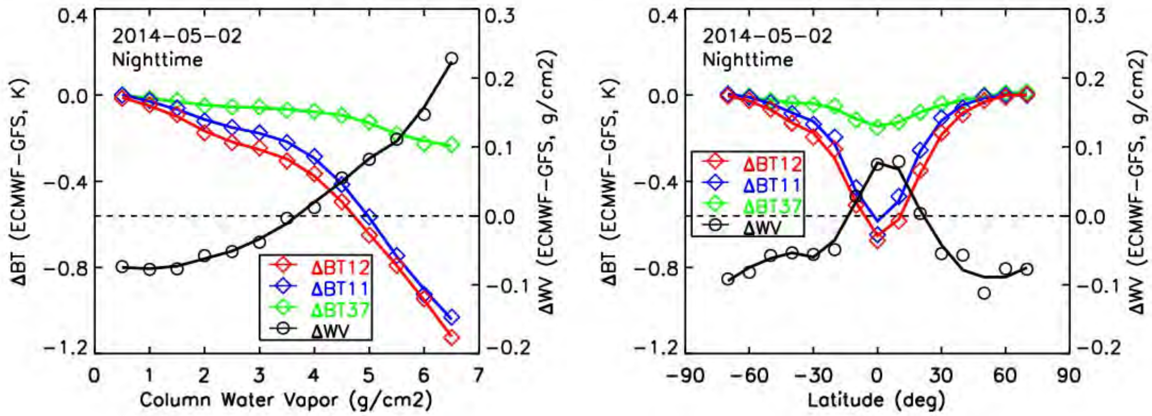

Figure 4. ΔCWV and ΔBT are shown as functions of (left) CWV and (right) latitude. With increasing CWV, the ΔCWVs increases from -0.1 to 0.25 g/cm^2, but ΔBTs decrease from 0 to -1.2 K. The drop-off rate in ΔBT is faster for ΔCWV>0 (i.e., when ECMWF CWV is larger than GFS).

PROJECT TITLE: NESDIS Environmental Applications Team – Xiaoming Liu, Research Scientist - Ocean Color Algorithm Development and Ocean Process Study with Satellite Ocean Color Remote Sensing

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Xiaoming Liu

NOAA TECHNICAL CONTACT: Menghua Wang

NOAA RESEARCH TEAM: Menghua Wang

PROJECT OBJECTIVES:

1--Calibration/Validation and monitoring of VIIRS ocean color products
2--Conduct ocean color related applications and research

PROJECT ACCOMPLISHMENTS:

1--Calibration/Validation and monitoring of VIIRS ocean color products

--Continue monitoring the VIIRS ocean color products and compare with in situ measurements and MODIS measurements in 9 regions: Hawaii, South Pacific Gyre, upper Chesapeake Bay, mid Chesapeake Bay, lower Chesapeake Bay, U.S. east coast, AERONET-CSI, AERONET-LISCO and AERONET-USC. These processes are automated on our Linux servers and posted on the web weekly: (http://www.star.nesdis.noaa.gov/sod/mecb/color/validation/). Figure 1 shows the Satellite and in situ data comparison at Hawaii MOBY site.

--Continue monitoring VIIRS SDR for bands M1-11 at Libya and the South Pacific Gyre. This is also an automated process, and the results are posted on our internal websites. Figure 2 shows the SDR time series at Libya site.

--Routinely monitoring the global deep water and oligotrophic water ocean color products from MODIS (2002-2015) and VIIRS (2012-2015), to evaluate the calibration of VIIRS ocean color products (Figure 3).

--Developed and maintained the near-real-time regional ocean color product images for 8 coastal regions: Amazon River, Great Lakes, Gulf of Mexico, La Plata River, Mediterranean Sea, North Sea, U.S. east coast, U.S. west coast and western Pacific; and 4 Coral Reef Watch (CRW) regions: American Samoa, Great Barrier Reef, Hawaii and Puerto Rico. (Figure 4)
(http://www.star.nesdis.noaa.gov/sod/mecb/color/composite/)

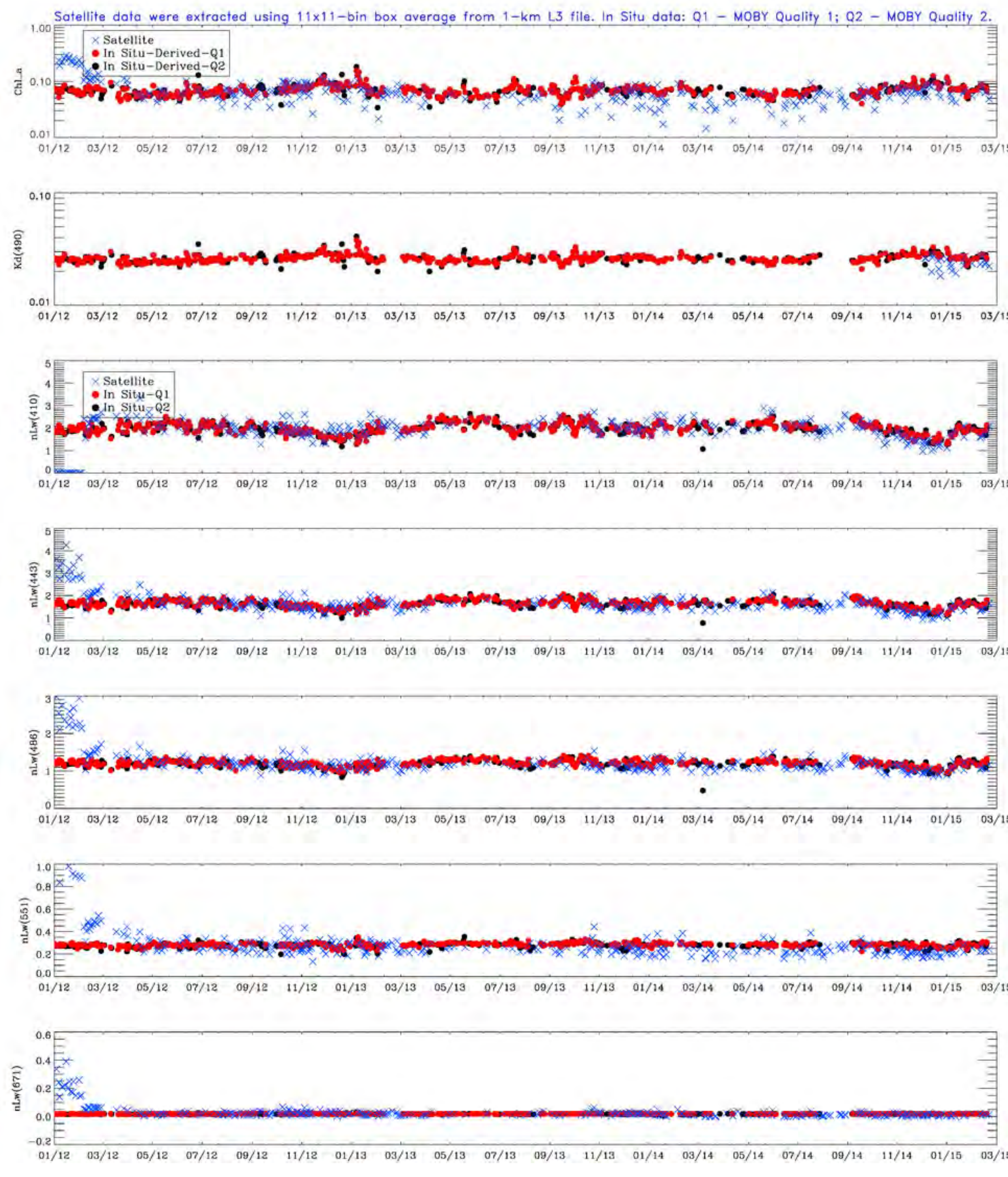

Figure 1. Near-real-time comparison of VIIRS ocean color data with in situ measurements at Hawaii MOBY site (http://www.star.nesdis.noaa.gov/sod/mecb/color/validation/).

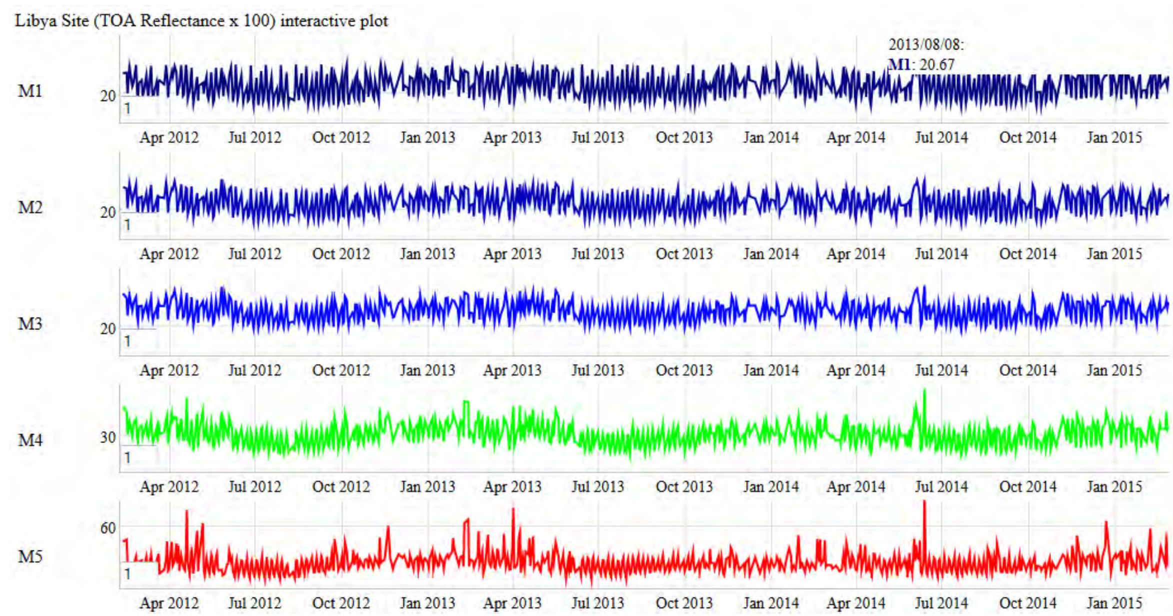

Figure 2. Near-real-time monitoring VIIRS SDR TOA reflectance at Libya site (24.42 °N, 13.35 °E).

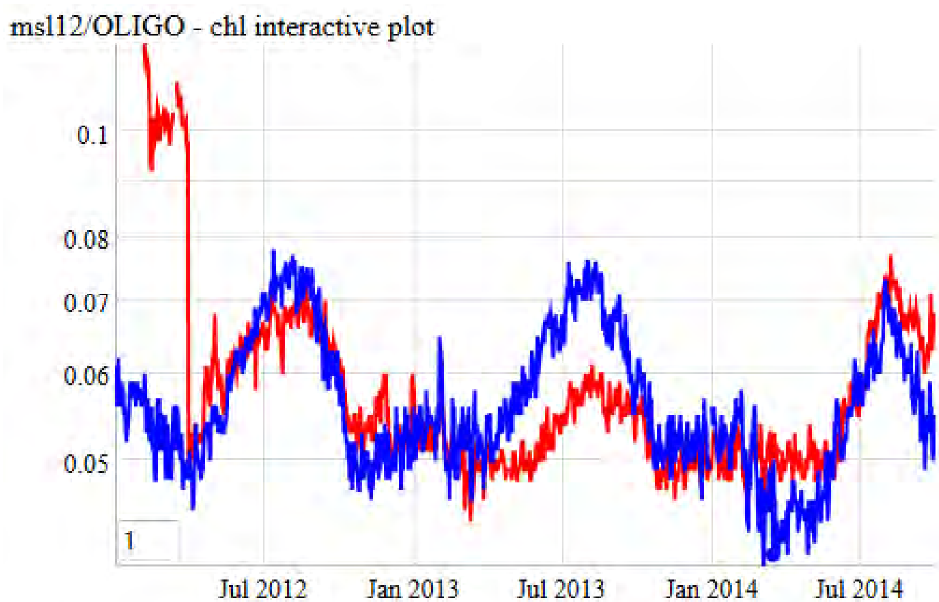

Figure 3. Near-real-time monitoring of global oligotrophic water Chlorophyll-a concentration (red – VIIRS, blue – MODIS).

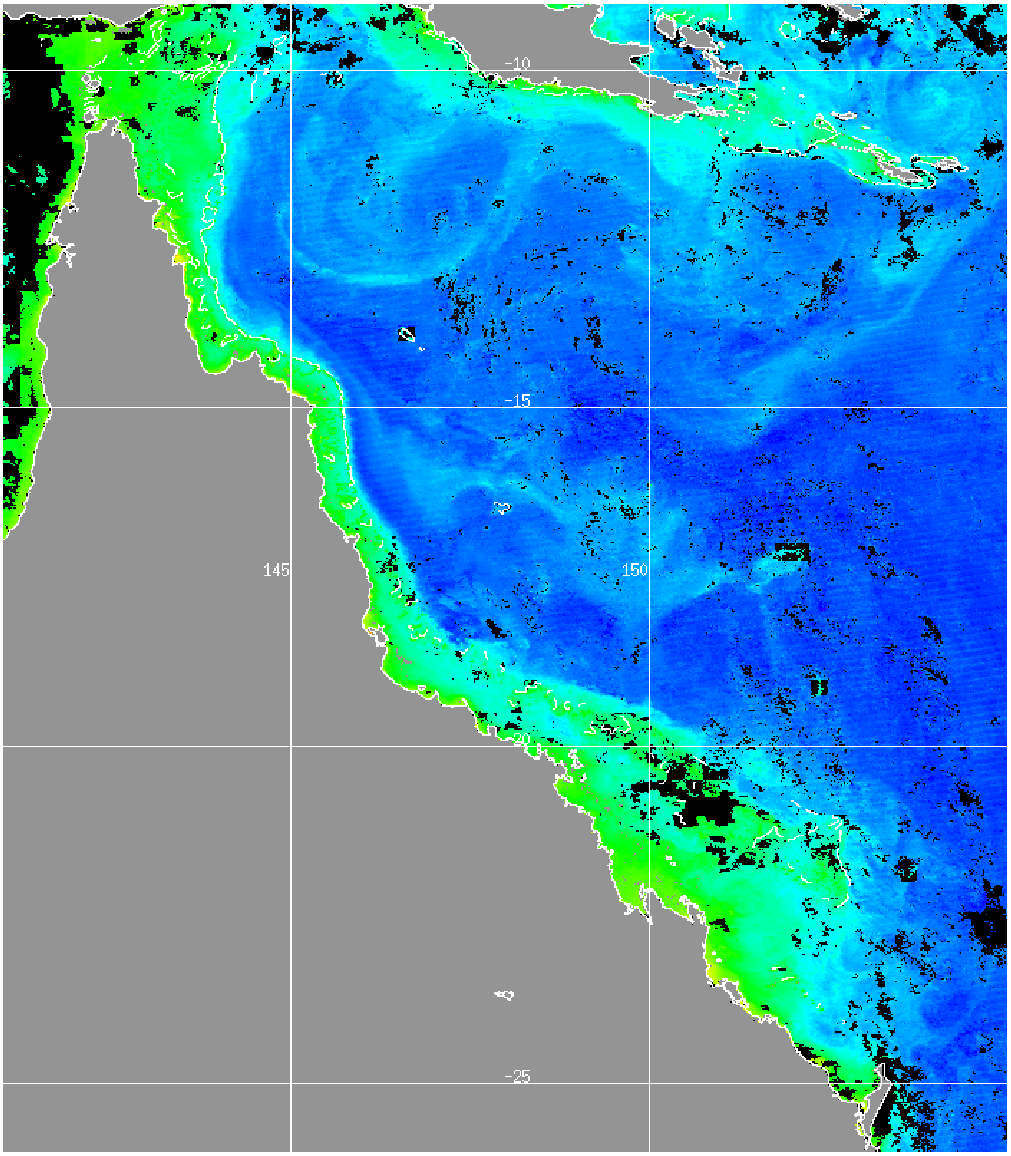

Figure 4. 8-day (Feb. 18-25, 2015) composite chlorophyll-a image of the Great Barrier Reef region for supporting Coral Reef Watch (CRW). Daily images are generated in near-real-time.

2--Conduct ocean color related applications and research

--River Runoff Effect on the Suspended Sediment Property in the Upper Chesapeake Bay Using MODIS Observations and ROMS Simulations, Xiaoming Liu and Menghua Wang, JGR Oceans, Dec. 2014, doi:10.1002/2014JC010081

Abstract: Ocean color data derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the satellite Aqua from 2002–2012 and simulations from the Regional Ocean Modeling System (ROMS) are used to study the impact of the Susquehanna River discharge on the total suspended sediment (TSS) concentration in the upper Chesapeake Bay. Since the water in the upper Chesapeake Bay is highly turbid, the shortwave infrared (SWIR)-based atmospheric correction algorithm is used for deriving the normalized water-leaving radiance nLw spectra from MODIS-Aqua measurements. nLw spectra are further processed into the diffuse attenuation coefficient at the wavelength of 490 nm Kd(490) and TSS. MODIS-Aqua-derived monthly TSS concentration in the upper Chesapeake Bay and in situ Susquehanna River discharge data show similar patterns in seasonal variations. The TSS monthly temporal variation in the upper Chesapeake Bay is also found in phase with the monthly averaged river discharge data. Since the Susquehanna River discharge is mainly dominated by a few high discharge events due to winter-spring freshets or tropical storms in each year, the impact of these high discharge events on the upper Chesapeake Bay TSS is investigated. Both MODIS-measured daily TSS images and sediment data derived from ROMS simulations show that the Susquehanna River discharge is the dominant factor for the variations of TSS concentration in the upper Chesapeake Bay. Although the high river discharge event usually lasts for only a few days, its induced high TSS concentration in the upper Chesapeake Bay can sustain for ~10–20 days. The elongated TSS rebounding stage is attributed to the enhanced tidal resuspension in the estuarine turbidity maximum (ETM) zone. Further downstream of the ETM zone, the high TSS concentration was mainly due to horizontal advection of slowly settling fine sediment from the Susquehanna River.

--Applications of satellite ocean color product in HYCOM model simulations, Xiaoming Liu and Menghua Wang, Ocean Optics, Portland Maine, Oct. 2014

Abstract: Solar radiation is an important factor for sea surface temperature (SST) variations and ocean mixed-layer dynamics. The penetration of the solar radiation in the upper oceans highly depends on the ocean turbidity. Currently, the Hybrid Coordinate Ocean Model (HYCOM) uses the monthly climatology of the diffuse attenuation coefficient for the downwelling photosynthetically available radiation (PAR), Kd(PAR), to formulate the solar radiation heating in the upper ocean. However, the high-frequency and seasonal and inter-annual variability of ocean turbidity is generally significant due to biological activities and sediment transportation, especially in the marginal seas of the Pacific Ocean near the east and south coast of China (e.g., the Bohai Sea, Yellow Sea, and East China Sea). In this study, satellite-derived daily and monthly averaged Kd(PAR) data are used in HYCOM simulations. In particular, water diffuse attenuation coefficient data derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the satellite Aqua and the Visible Infrared Imaging Radiometer Suite (VIIRS) on board the Suomi National Polar-orbiting Partnership (SNPP) are derived and used to study the sensitivity of Kd(PAR) values to SST and ocean mixed-layer dynamics in HYCOM simulations. Specifically, results will be compared to simulations using monthly climatology Kd(PAR) to analyze the sensitivity of ocean mixed-layer and SST to different (more accurate) Kd(PAR) usage. Thus, satellite ocean color products can be used in HYCOM simulations to derive more accurate ocean products for various weather applications.

--Evaluation of VIIRS Ocean Color Products, Menghua Wang, Xiaoming Liu, Lide Jiang, SeungHyun Son, Junqiang Sun, Wei Shi, Liqin Tan, Puneeta Naik, Karlis Mikelsons, Xiaolong Wang, and Veronica Lance, SPIE Beijing, Oct. 2014

--VIIRS Ocean Color Data Visualization and Processing With IDL-Based NOAA-SeaDAS, Xiaolong Wang, Xiaoming Liu, Lide Jiang, Menghua Wang, and Junqiang Sun, SPIE Beijing, Oct. 2014

PROJECT TITLE: NESDIS Environmental Applications Team – Puneeta Naik, Post Doc

PRINCIPAL INVESTIGATOR: Steven Miller

RESEARCH TEAM: Puneeta Naik

NOAA TECHNICAL CONTACT: Menghua Wang (NOAA/NESDIS/STAR/SOCD/MEB)

NOAA RESEARCH TEAM: Menghua Wang

PROJECT OBJECTIVE(S):

1--In-situ bio-optical data quality control from various aquatic regions
2--Satellite Ocean color products validation for MODIS and VIIRS

PROJECT ACCOMPLISHMENTS:

1--Studied the effect of straylight flag on ocean color data match-up analysis for various clear and turbid water regions. Concluded that there is a significant effect of straylight flag application in clear waters relative to turbid waters.

2--Continued in-situ marine bio-optical data quality control and assessed performance of VIIRS and MODIS primary ocean color products for various oceanic regions e.g. MOBY site, BOUSSOLE site, Chesapeake Bay, Aeronet-OC sites, HOT site, northern Gulf of Mexico.

3--Determined the out-of-band contribution and effective band center wavelengths for several ocean color sensors, e.g., SGLI, OCM1, GOCI, MODIS, VIIRS. A paper based on these results will be submitted to a peer-reviewed scientific journal.

4--Updated the calculation of MODIS and VIIRS weighted normalized water leaving radiance spectra from hyperspectral data for MOBY from 2002-present.

5--Developed a regional algorithm for chlorophyll-a in the Bering Sea and analyzed its annual and seasonal trends in relation to other environmental variables (e.g. Sea Ice, SST). A paper based on these results is submitted to a peer-reviewed scientific journal.

6--Presented talks and posters at 4 conferences/meetings.

PROJECT TITLE: NESDIS Environmental Applications Team – Wei Shi, Research Scientist - Ocean Color Algorithm Development and Ocean Process Study with Satellite Ocean Color Remote Sensing

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Wei Shi CIRA/CSU

NOAA TECHNICAL CONTACT: Menghua Wang, NOAA National Environmental Satellite, Data, and Information Service (NESDIS)

NOAA RESEARCH TEAM: Menghua Wang (NOAA)

PROJECT OBJECTIVES:

--Development of new ocean color algorithm
--Application of satellite ocean color data for coastal and in-land water ecosystem monitoring

PROJECT ACCOMPLISHMENTS:

During this period, long-term hydrological changes of the Aral Sea observed by satellites was studied. This is a major contribution to satellite remote sensing. It was featured as the cover page in the *Journal of Geophysical Research, Oceans*. In addition, I also conducted research on NIR-based IOP algorithm for highly turbid waters. Research was also conducted to study the biological variability in the equatorial Pacific during the 2009-2011 ENSO cycle. The following is a summary of accomplishments.

--Long-term Hydrological Changes of the Aral Sea Observed by Satellites
--Ocean reflectance spectra at the red, near-infrared, and shortwave infrared from highly turbid waters: A study in the Bohai Sea, Yellow Sea, and East China Sea.
--Satellite-observed biological variability in the equatorial Pacific during the 2009-2011 ENSO cycle.
--Evaluation of VIIRS ocean color products.

Project Publications from Past Fiscal Year (including Conferences):

Title: Ocean reflectance spectra at the red, near-infrared, and shortwave infrared from highly turbid waters: A study in the Bohai Sea, Yellow Sea, and East China Sea
Author(s): Shi, Wei; Wang, Menghua
Limnol. Oceanogr., 59(2), 2014, 427–444, 2014.

Abstract: Normalized water-leaving radiance spectra $nL_w(\lambda)$ at the red, near-infrared (NIR), and shortwave infrared (SWIR) are quantified and characterized in highly turbid waters of the western Pacific using three-year (2009–2011) observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the satellite Aqua. $nL_w(645)$ (red), $nL_w(859)$ (NIR), and $nL_w(1240)$ (SWIR) were higher in the coastal region and river estuaries, with SWIR $nL_w(1240)$ reaching up to ~0.2 mW cm^{-2} μm^{-1} sr^{-1} in Hangzhou Bay during winter. The NIR ocean reflectance spectral shape represented by the ratio of the normalized water-leaving reflectance $\rho_{wN}(\lambda)$ at the two NIR bands $\rho_{wN}(748)$:$\rho_{wN}(869)$ is highly dynamic and region-dependent. The NIR spectral feature associated with the sediment source from the Yellow River and Ancient Yellow River is noticeably different from that of the Yangtze River. There are non-negligible SWIR $nL_w(1240)$ contributions for waters with the NIR $nL_w(859)$ > ~2.5 mW cm^{-2} μm^{-1} sr^{-1}. Estimation of the NIR ocean reflectance with iterative approaches might only be accurate for turbid waters with $nL_w(859)$ < ~1.5 mW cm^{-2} μm^{-1} sr^{-1}. Thus, the SWIR atmospherics correction algorithm for satellite ocean color data processing is indispensible to derive accurate $nL_w(\lambda)$ for highly turbid waters. Current existing satellite algorithms for chlorophyll *a*, diffuse attenuation coefficient at the wavelength of 490 nm ($K_d(490)$), total suspended matter (TSM), and inherent optical properties (IOPs) using $nL_w(\lambda)$ at the red band for coastal waters are limited and can only be applied to turbid waters with $nL_w(859)$ < ~1.5 mW cm^{-2} μm^{-1} sr^{-1}. Thus, the NIR $nL_w(\lambda)$ measurements are required to characterize water properties for highly turbid waters.

Based on the fact that pure water absorption is significantly larger than other absorption components in the NIR wavelengths, we show that it is feasible to analytically derive accurate IOP data for turbid waters with combined satellite-measured visible-NIR $nL_w(\lambda)$ spectra data.

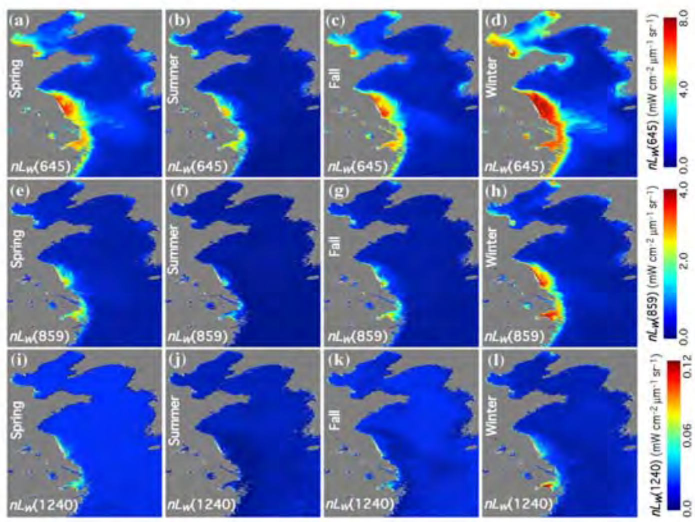

Fig. 2

Figure 1. Three-year mean seasonal images of (a–d) $nL_w(645)$, (e–h) $nL_w(859)$, and (i–l) $nL_w(1240)$ derived from MODIS-Aqua observations between 2009 and 2011 in the Bohai Sea, Yellow Sea, and East China Sea for the season of (a, e, i) spring (March–May), (b, f, j) summer (June–August), (c, g, k) fall (September–November), and (d, h, l) winter (December–February).

Title: Long-term hydrological changes of the Aral Sea observed by satellites

Author(s): Shi, Wei; Wang, Menghua

J. Geophys. Res. Oceans, 119, 3313-3326 (2014).

Abstract: The Aral Sea has been shrinking since the former Soviet Union constructed irrigation projects to divert water from its main rivers in the 1960s. The diminishing of the Aral Sea is “one of the worst environmental disasters in the world” (from United Nations Secretary-General Ban Ki-moon). In this study, 33 years of satellite observations from Advanced Very High Resolution Radiometer (AVHRR) and 21 years of satellite altimetry sea level data from TOPEX/Poseidon, Jason-1, and Jason-2 are used to quantify the long-term hydrological changes in the Aral Sea. A simple algorithm with AVHRR channels 1 and 2 albedo is developed to identify and discriminate the water pixels from land and cloud. Thus, monthly water coverage in the region can be reliably generated. The water coverage maps since 1981 show constant decline of the Aral Sea. The coverage dropped from ~4.7–4.8 × 10^4 km^2 in 1981 to about ¼ of this value in the recent years. In fact, drastic hydrological change was observed in the main Aral Sea during the 2000s. In the South Aral Sea, sea level shows a steady decrease from 35 m above sea level to <26 m since 1993. Total loss of water storage since 1993 is estimated to be ~2.0 × 10^2 km^3 for the South Aral Sea with a rate of ~16−20 km^3/yr before 2002, and a smaller value after 2002. In 1990, the North Aral Sea was observed to be separate from the main Aral Sea. Water coverage, sea level, and total water storage were kept relatively stable for the period between 1993 and 2013 in the North Aral Sea. A water

level increase and coverage expansion occurred during the 2005−2006 period when a dam was built in 2005 between the North Aral Sea and the South-East Aral Sea.

AVHRR-derived Water Coverage in August Since 1981

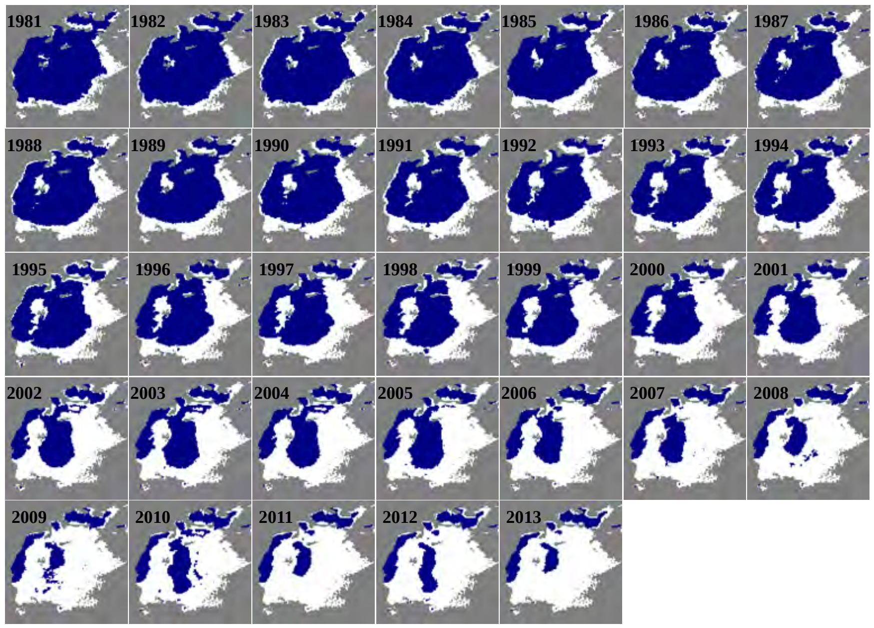

Figure 2. Images of the water coverage in the month of August for (a2gg) the corresponding sequential year of 1981–2013. Note that dark blue color denotes water coverage.

Title: Satellite-observed biological variability in the equatorial Pacific during the 2009-2011 ENSO cycle
Author(s): Shi, Wei; Wang, Menghua
Adv. Space Res., 54, 1913-1923.

Abstract: The event of 2009–2011 El Niño Southern Oscillation (ENSO) provides an opportunity to gain insight into the biological variability of the equatorial Pacific Ocean for an entire ENSO cycle with satellite and in situ observations. Even though El Niño and La Niña in general led to respectively weakened and enhanced chlorophyll-a concentration and net primary production (NPP) along the equatorial Pacific Ocean during the 2009–2011 ENSO cycle, biological responses were highly disparate along the equator and attributed to different driving mechanisms. In the eastern equatorial Pacific east of 150°E, the El Niño-La Niña biological change was in general small except for the transition period even though sea surface temperature (SST) showed over ~5 °C drop from El Niño to La Niña. In the central-eastern (170°W–140°W) equatorial Pacific, moderate change of biological activity is attributed to the changes of thermocline driven by the eastward propagating equatorial Kelvin waves and changes of zonal currents and undercurrents. Highest biological response in this ENSO cycle was located in the central (170°E–170°W) and central-western (150°E–170°E) equatorial Pacific with quadruple chlorophyll-a concentration and over ~400 mg C m^{-2} d^{-1} increase of NPP from El Niño in 2009 to La Niña in 2010. However, spatial pattern of ENSO biological variability as represented with NPP is not exactly the same as chlorophyll-a variability. Wind-driving mixing of nutrients and eastward advection of the oligotrophic warm pool waters are attributed to this significant biological variability in this region.

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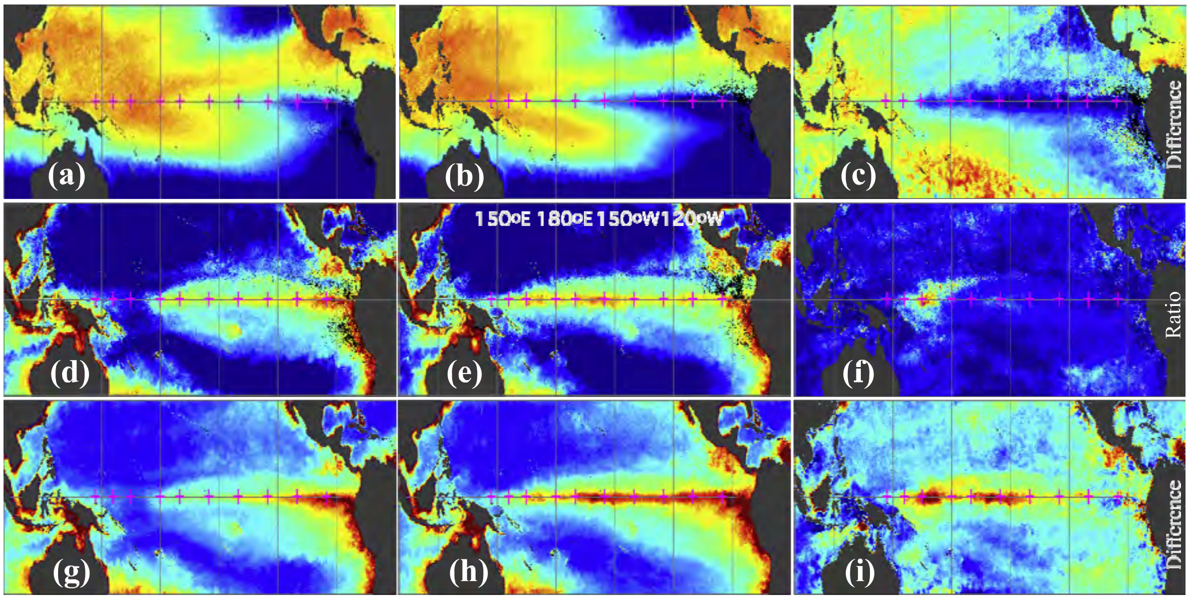


Figure 3. SST, Chl-a, and NPP derived from MODIS-Aqua measurements for El Niño (a, d, and g) (July 2009–September 2009), (b, e, and h) La Niña (July 2010–September 2010), and (c, f, and i) differences between La Niña (July 2010–September 2010) and El Niño (July 2009–September 2009). Red pink crosses in the figure show the locations of the Tropical Atmosphere Ocean (TAO) moorings along the equator. Note that Chl-a images (panels 2d and 2e) are in logarithmic scale, while others are all in linear scale.

<u>Title:</u> Evaluation of VIIRS ocean color products
Author(s): Wang, M., X. Liu, L. Jiang, S. Son, J. Sun, W. Shi, L. Tan, P. Naik, K. Mikelsons, X. Wang, and V. Lance
Proc. SPIE 9261, Ocean Remote Sensing and Monitoring from Space, 92610E (8 November, 2014).

Abstract: The Suomi National Polar-orbiting Partnership (SNPP) was successfully launched on October 28, 2011. The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi NPP, which has 22 spectral bands (from visible to infrared) similar to NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), is a multi-disciplinary sensor providing observations for the Earth's atmosphere, land, and ocean properties. In this paper, we provide some evaluations and assessments of VIIRS ocean color data products, or ocean color Environmental Data Records (EDR), including normalized water-leaving radiance spectra nLw(λ) at VIIRS five spectral bands, chlorophyll-a (Chl-a) concentration, and water diffuse attenuation coefficient at the wavelength of 490 nm Kd(490). Specifically, VIIRS ocean color products derived from the NOAA Multi-Sensor Level-1 to Level-2 (NOAA-MSL12) ocean color data processing system are evaluated and compared with MODIS ocean color products and in situ measurements. MSL12 is now NOAA's official ocean color data processing system for VIIRS. In addition, VIIRS Sensor Data Records (SDR or Level- 1B data) have been evaluated. In particular, VIIRS SDR and ocean color EDR have been compared with a series of in situ data from the Marine Optical Buoy (MOBY) in the waters off Hawaii. A notable discrepancy of global deep water Chl-a derived from MODIS and VIIRS between 2012 and 2013 is observed. This discrepancy is attributed to the SDR (or Level-1B data) calibration issue and particularly related to VIIRS green band at 551 nm. To resolve this calibration issue, we have worked on our own sensor calibration by combining the lunar calibration effect into the current calibration method. The ocean color products derived from our new calibrated SDR in the

South Pacific Gyre show that the Chl-a differences between 2012 and 2013 are significantly reduced. Although there are still some issues, our results show that VIIRS is capable of providing high-quality global ocean color products in support of science research and operational applications.

PROJECT TITLE: NESDIS Environmental Applications Team - SeungHyun Son, Research Scientist

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Seunghyun Son

NOAA TECHNICAL CONTACT: Menghua Wang, STAR/SOCD/MEB

NOAA RESEARCH TEAM: Menghua Wang

PROJECT OBJECTIVES:

1--Processing and validation/evaluation of the JPSS VIIRS data
2--Development of bio-optical and biogeochemical algorithms for the satellite ocean color data use in the various ocean waters (clear open ocean, coastal and inland waters).

PROJECT ACCOMPLISHMENTS:

1--The VIIRS data sets from various processing methods (e.g., IDPS-EDR, NOAA-MSL12) have been processed over the various ocean waters (Hawaii region, South Pacific Gyre, US east coast, Yellow & East China seas, Mediterranean Sea, etc.). In situ bio-optical data were compared for validation of the VIIRS data in various regions.

2--New blended algorithm of water diffuse attenuation coefficients for photosynthetically available radiation (PAR), K_d(PAR), for the global (clear open and coastal) ocean waters has been developed. The results were published in the international scientific (peer-reviewed) journal. The new K_d(PAR) will be implemented for the VIIRS operational products in NOAA.

3--Regional algorithms for Sea-Ice mask and turbidity for use of satellite ocean color data in the Great Lakes are developed and updated, and the optical properties in the Great Lakes are characterized. The results were presented in an international conference and will be submitted to a peer-reviewed journal.

4--Existing chlorophyll-a algorithms were evaluated (particularly for the very clear open ocean waters). Modified chl-a algorithm has been derived for the global open ocean waters.

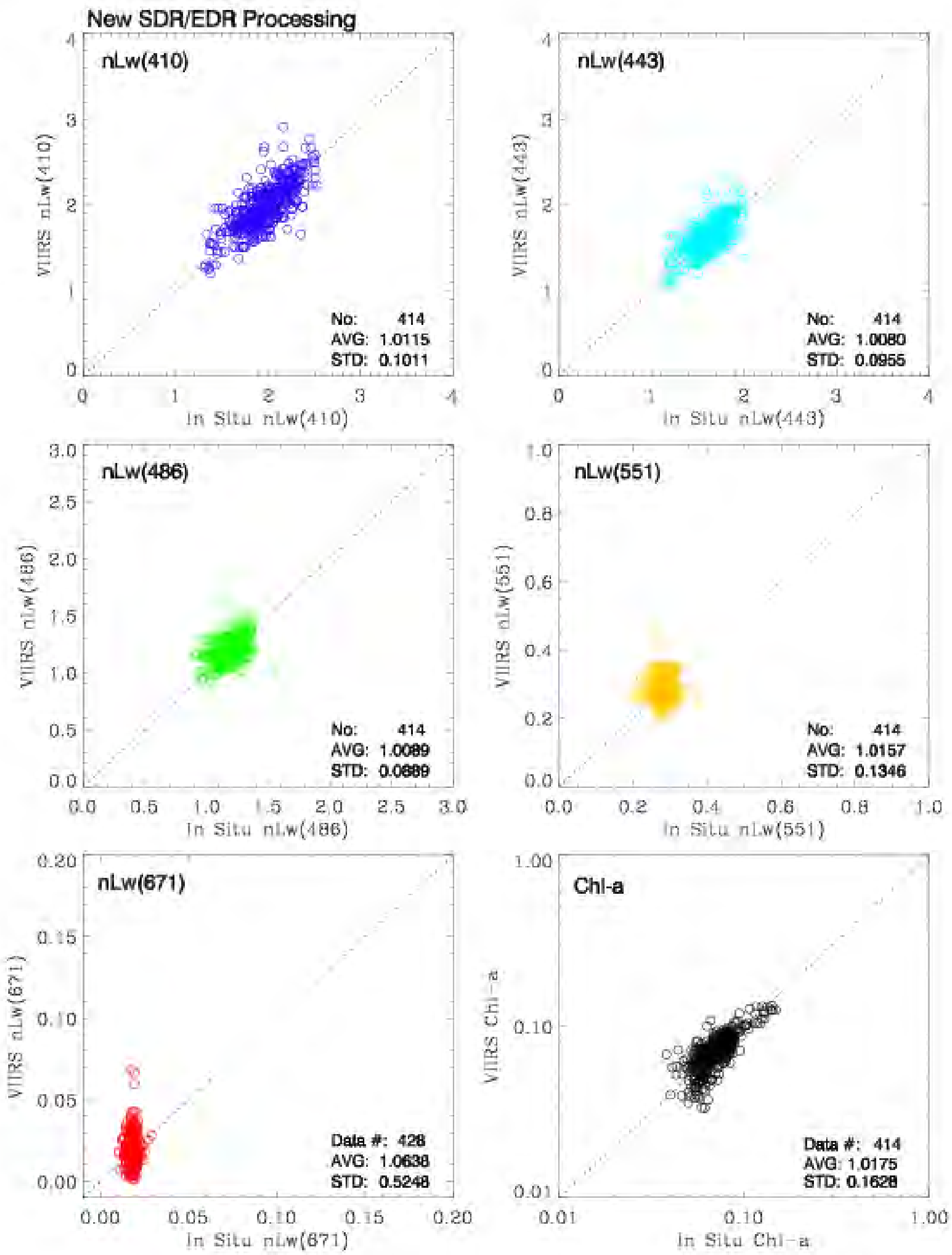


Figure 1. Matchup comparison between MOBY in situ and VIIRS-derived $nL_{dw}(\lambda)$ and Chl-a measurements using the new SDR/EDR processing.

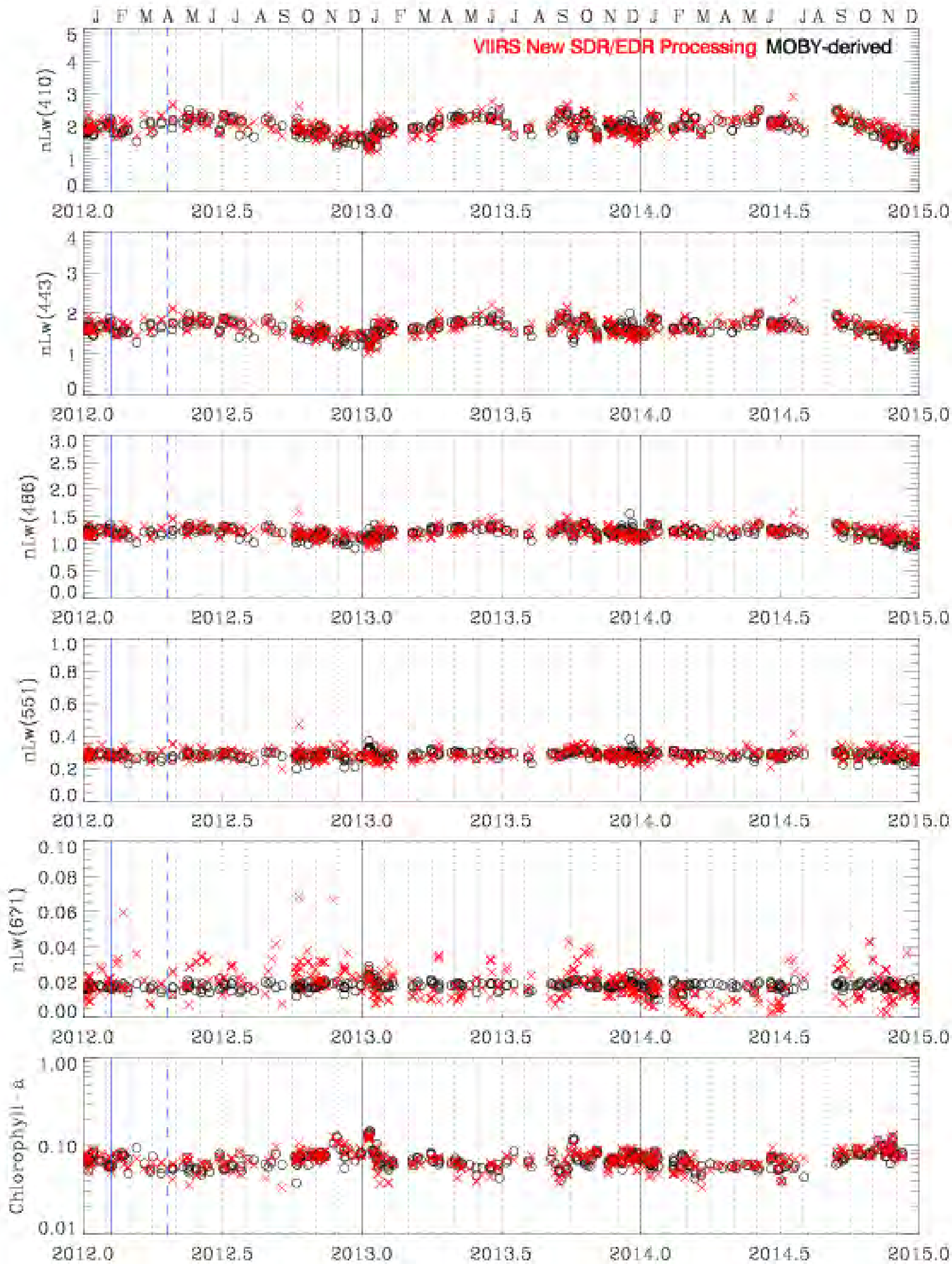


Figure 2. Time series of MOBY in situ and VIIRS-derived $nL_{dw}(\lambda)$ and Chl-a measurements using the new SDR/EDR processing.

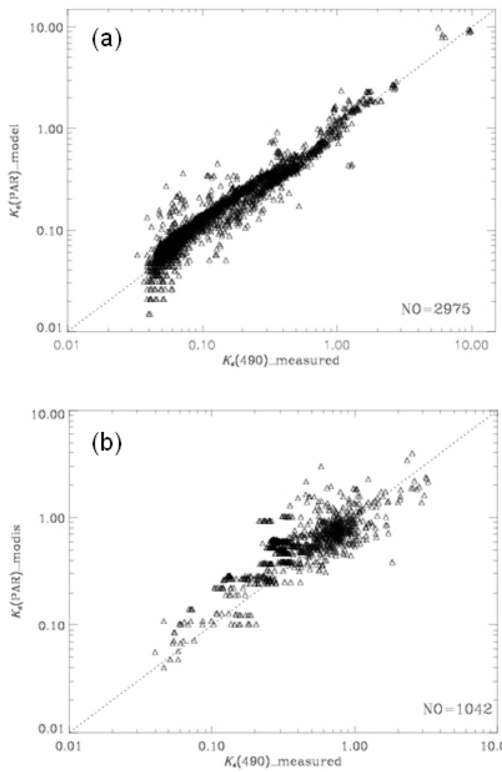


Figure 3. (a) Comparison of the model-derived K_d(PAR) using the K_d(PAR) model with SeaBASS in situ K_d(PAR) measurements, (b) Matchup comparison results of the MODIS-Aqua-derived K_d(PAR) data with the in situ K_d(PAR) measurements.

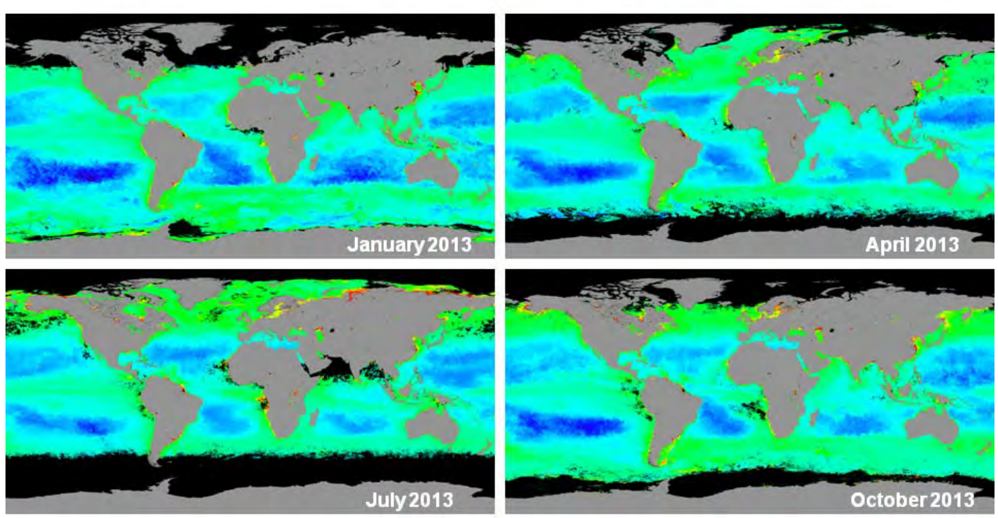


Figure 4. VIIRS-derived global monthly composite images of K_d(PAR) from the new K_d(PAR) model.

PROJECT TITLE: NESDIS Environmental Applications Team – Liqin Tan, Research Associate - CIRA Support to the JPSS Science Program: S-NPP VIIRS EDR Imagery Algorithm and Validation Activities and S-NPP VIIRS Cloud Validation & CIRA Support to the JPSS Proving Ground and Risk Reduction Program

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM**:** Liqin Tan (CIRA/CSU)

NOAA TECHNICAL CONTACT: Menghua Wang

NOAA RESEARCH TEAM**:** Menghua Wang (NOAA team lead)

PROJECT OBJECTIVES:

--Performing VIIRS instrument characterization and calibration for ocean color (OC) data processing and applications. Evaluating the effect of VIIRS instrument performance on the science data quality and quantify the impact
--Understanding, evaluating, and refining VIIRS ocean color (OC) data processing system

PROJECT ACCOMPLISHMENTS:

--Collaborated with SNPP-VIIRS SDR team to monitor the development of VIIRS instrument calibration activities, operational IDPS SDR production, and Discrepancy Records (DRs). Participated in VIIRS SDR team weekly teleconference. Routinely retrieve the operational IDPS Fast-Track SDR LUTs (including the F LUTs) from the Raytheon Common CM. Helped to assess the VIIIRS SDR AUTOCAL and its possible impact on the Ocean Color EDR products.
--Enhanced the ADL-based RDR to SDR data reprocessing tool and updated it with option of ADL4.2 Mx8.6.
--Implemented the solar vector angle correction to the Common Geo Library of our ADL4.1_Mx7.1 installation. The test resulting from the OBC-IP solar and lunar data are consistent with NASA VCST. Generated and corrected the VIIRS OBC-IP data from RDRs using the modified ADL code.
--Developed tools to run parallel batch jobs of RDR to SDR reprocessing on a 10-server new cluster for improved efficiency.
--Developed tools to convert the team-developed new versions of daily VIIRS RSB bands calibration coefficients F factor tables into VIIRS-SDR-F-PREDICTED-LUT binary files with correct metadata to be consistent with IDPS data format for ADL processing.
--Applied our team-developed most updated daily VIIRS RSB calibration F-factor Looking-Up Tables(LUTs) with the “solar vector angle correction” and “c0=0” in our RDR to SDR data processing system, reprocessed mission-long VIIRS SDR data for Hawaii MOBY site, South Pacific Gyre, and other in-situ sites, reprocessed global VIIRS SDR data from RDR for two more years (11/2011 to 5/2014) since the mission start to support the team’s VIIRS OCC EDR reprocessing and to help identify the possible VIIRS SDR calibration issues that led to lower global Chl-a for global deep waters during 2013. It was demonstrated that the reprocessed SDRs significantly improved the ocean color products.
--Contributed to the development and testing of a more efficient new F factor ratio method for VIIRS SDR data reprocessing from old SDR data and updated F factor. Partially finished mission-long VIIRS gain state data generation for the new F-factor ratio approach of SDR reprocessing. Generated F-factor ratio files for in-situ sites mission-long SDR reprocessing. Co-authored paper on the efficient reprocessing of SDR has been published by IEEE Geoscience and Remote Sensing Letters.
--Continued to retrieve VIIRS gain status data from the raw VIIRS RDR as input required by the new F factor ratio method for VIIRS SDR data reprocessing.
--Continued to develop the tools to retrieve IDPS operational VIIRS SDR operational F factor required by the new effective SDR reprocessing scheme.

--Wrote paper on “VIIRS RDR to SDR data processing for Ocean Color EDR” and prepared poster for the SPIE Asia Pacific Remote Sensing 2014 conference.

Title: VIIRS RDR to SDR data processing for ocean color EDR

Author(s):
Liqin Tan, Menghua Wang, Junqiang Sun, Lide Jiang

Status:
Published. *Proc. SPIE 9261, Ocean Remote Sensing and Monitoring from Space*, 92611I (8 November, 2014).

Abstract:
The Visible Infrared Imaging Radiometer Suite (VIIRS) ocean color (OC) Environmental Data Records (EDR) (or Level-2 data) is one of the most important product sets derived from the visible and near-infrared (NIR) moderate resolution (M) bands of VIIRS Sensor Data Records (SDR or Level-1B) data. The NOAA Interface Data Processing System (IDPS) only produces the operational SDR from Raw Data Records (RDR or Level-0 data) in the forward mode (no reprocessing). As the ocean color EDR are highly sensitive to the quality of the SDR, while the forward processed SDR by nature have large uncertainty, VIIRS SDR need to be reprocessed from RDR periodically with improved instrument calibration algorithm and look-up tables (LUTs), primarily the F-factors LUTs (F-LUTs), for ocean color EDR. The NOAA VIIRS ocean color team has been building the capability of processing the RDR to SDR efficiently for VIIRS' entire mission as well as any selected areas with any selected time periods. In this paper, we describe our effort to develop two approaches in VIIRS RDR to SDR data processing. The first one is to process the raw RDR data into SDR using an internal offline-processing tool, which is based on the Joint Polar Satellite System (JPSS) Algorithm Development Library (ADL) with updated calibration LUTs. This tool allows one to select the IDPS/ADL version and input auxiliary/ancillary data for the VIIRS RDR to SDR reprocessing. The second approach, however, is for the case where only the F-LUTs are updated (most cases). We have developed a ratio approach, which is based on the linear relationship between the SDR radiance/reflectance and the F-factors. This approach requires only about one hundredth computational effort compared to the ADL approach and can also significantly reduce the storage requirements. With the ratio approach, the updated SDR are generated from the old SDR and only the bands that are of interest are processed.

Title: An Efficient Approach for VIIRS RDR to SDR Data Processing

Author(s):

Junqiang Sun, Menghua Wang, Liqin Tan, and Lide Jiang

Status:
IEEE Geosci. Remote Sens. Lett., 11, 2037–2041, 2014.

Abstract:
The Visible Infrared Imaging Radiometer Suite (VIIRS) Raw Data Records (RDR) (or Level-0 data) are processed using the current standard Algorithm Development Library (ADL) to produce Sensor Data Records (SDR) (or Level-1B data). The ocean color Environmental Data Records (EDR), one of the most important product sets derived from VIIRS, are processed from the SDR of the visible and near-infrared (NIR) moderate resolution (M) bands. As the ocean color EDR are highly sensitive to the quality of the SDR, the bands from which the EDR data arise must be accurately calibrated. These bands are calibrated on-orbit using the on-board Solar Diffuser (SD) and the derived calibration coefficients are called F-factors. The F-factors used in the forward operational process may have large uncertainty due to various reasons, and thus to obtain high quality ocean color EDR, the SDR needs to be reprocessed with improved F-factors. The SDR reprocessing, however, requires tremendous computational power and storage space, which is about 27 terabytes for one year of ocean color related SDR data. In this letter, we present an efficient and robust method for reduction of the computational demand and storage

requirement. The method is developed based on the linear relationship between the SDR radiance/reflectance and the F-factors. With this linear relationship, the new SDR radiance/reflectance can be calculated from the original SDR radiance/28 reflectance and the ratio of the updated and the original F-factors at approximately 100th or less of the original CP requirement. The produced SDR with this new approach fully agrees with those generated using the ADL package. This new approach can also be implemented to directly update the SDR in the EDR data processing, which eliminates the hassle of a huge data storage requirement as well as that of intensive computational demand. This approach may also be applied to other remote sensors for data reprocessing from raw instrument data to science data.

PROJECT TITLE: NESDIS Environmental Applications Team – Sirish Uprety, Research Associate - Suomi NPP VIIRS Calibration and Validation

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Sirish Uprety

NOAA TECHNICAL CONTACT: Changyong Cao (5825 University Research Ct., M-sq Building, College Park, MD)

NOAA RESEARCH TEAM: Changyong Cao (NOAA/NESDIS/STAR)

PROJECT OBJECTIVES:

On-orbit calibration and validation of Suomi NPP VIIRS:

1--S-NPP VIIRS radiometric performance monitoring and evaluation using AQUA MODIS and Landsat OLI as a reference.

2--Develop automated system to estimate the S-NPP VIIRS radiometric bias at high latitudes (SNO) and at low latitudes (SNO-x)

3--Evaluate Radiometric consistency of VIIRS and NOAA series AVHRR using SNO and SNO-x

4--Analyze the radiometric accuracy and stability of VIIRS using vicarious calibration sites and by comparing with AQUA MODIS and Landsat OLI.

5--Perform inter-comparison of GOSAT TANSO-FTS and S-NPP VIIRS using

a--Libya-4 desert calibration site
b--Extended SNO based inter-calibration using North Africa deserts

PROJECT ACCOMPLISHMENTS:

1--S-NPP VIIRS radiometric performance monitoring and evaluation through inter-comparison with AQUA MODIS.

The on-orbit radiometric performance of VIIRS is continuously monitored to ensure that the data quality meets specification very well. VIIRS measurements are evaluated by comparing with MODIS using SNO and SNO-x techniques. VIIRS has undergone a number of major look up table updates in the past to improve the calibration stability and accuracy. Inter-comparison with MODIS using SNOs and SNO-x suggest that most of the VIIRS bands agree with MODIS within 2% ± 1%. It was also observed that the time series of VIIRS bias estimated through SNO-x technique can be used to track the F factor anomalies very well. This study can potentially be used to track the VIIRS gain change over time and the impacts due to calibration updates on VIIRS data product such as ocean color. Figure 1a shows the VIIRS bias for bands M1-3. Similarly, Figure 1b shows the VIIRS bias over desert and ocean plotted along with the operational IDPS F factors. Bias over both the ocean and desert correlate very well with F factor change.

2--Develop automated system to estimate the S-NPP VIIRS radiometric bias at high latitudes (SNO) and at low latitudes (SNO-x)

Automated software has been developed to estimate the VIIRS radiometric bias over ocean using extended SNOs. The software is capable of collecting VIIRS and MODIS L1b data, mapping VIIRS into MODIS, extracting the clear sky collected region of interests and estimating the bias. This is a significant achievement in an effort to save manual tasks and time to monitor VIIRS on-orbit radiometric performance through inter-comparison with MODIS.

3--Continue evaluating radiometric consistency of VIIRS & NOAA series AVHRR using SNO and SNO-x

Multiple independent cal/val studies of VIIRS since launch have suggested that the VIIRS absolute radiometric accuracy for most of the RSB bands is within 2%. VIIRS is a follow-on mission for MODIS and AVHRR. Thus it is very important to perform cross-comparisons between VIIRS and NOAA AVHRR to establish data continuity for multi-decadal Earth observation from AVHRR with VIIRS for global climate change studies. The study uses two major approaches: one is using a simultaneous nadir overpass (SNO) approach over higher latitudes and the other is an extension of SNO to low latitudes (SNO-x). The radiometric consistency is quantified using both approaches from early 2012 to mid-2014 (Figure 2). The radiometric bias estimated is further validated at highly stable vicarious calibration sites such as Antarctica Dome C.

4--Analyze the radiometric accuracy and stability of VIIRS using vicarious calibration sites

The radiometric stability and accuracy of VIIRS is critical to make its data useful for weather and climate applications. This study is focused on analyzing VIIRS radiometric performance using well- established calibration sites and through the inter-comparison with other satellite instruments such as AQUA MODIS and Landsat 8 OLI. The study analyzes the stability of VIIRS reflective solar bands over more than two years by using sites such as Libya 4, Sudan 1 and Dome C. For VIIRS band M11 (2.1 um), since there is no matching MODIS band pair, this study uses matching SWIR band from Landsat 8 OLI as a reference to quantify the absolute calibration accuracy of M11. The study shows that VIIRS moderate resolution reflective solar bands are stable with better than 0.5% for most of the bands with uncertainty less than 1%. After accounting for the spectral differences, the absolute radiometric bias estimated through VIIRS and MODIS inter-calibration is within 2% for bands M1-5, M10 and about 3% for bands M7-8 (Figure 3). Similarly, M11 bias estimated using VIIRS and OLI inter-comparison is 5.4%.

5--Perform inter-comparison of GOSAT TANSO-FTS and S-NPP VIIRS using
- a--Libya-4 desert calibration site
- b--Extended SNO based inter-calibration using North Africa deserts

Comparison of SNPP VIIRS and GOSAT FTS has been performed to evaluate the on-orbit radiometric consistency for VIIRS CO_2 absorption band M10 (1.6 µm). The inter-sensor radiometric comparison was performed basically using two techniques, one by generating the TOA reflectance time series of both the instruments over Libya-4 desert and comparing the reflectance trends and the second by using extended SNO technique over North African deserts (Figure 4). It was observed that VIIRS and TANSO-FTS measurements agree very well to within 2%. S polarized measurements were found to agree much better to within 1% with VIIRS compared to P polarized measurements.

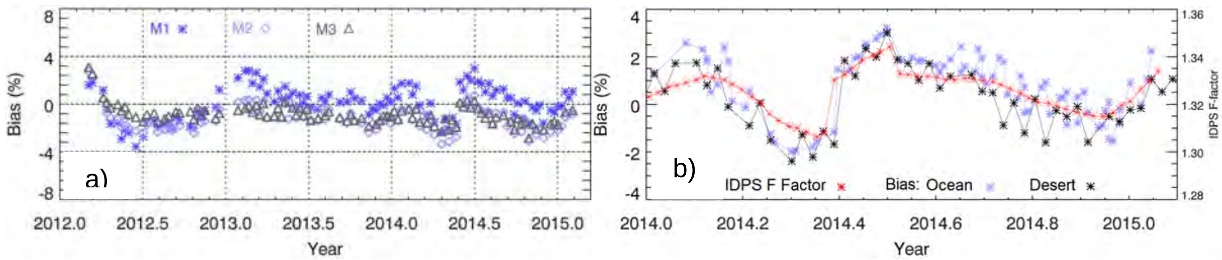


Figure 1. Left: VIIRS bias estimated over desert for M1-3 using extended SNOs, Right: VIIRS bias for M1 over desert and ocean along with IDPS F factors.

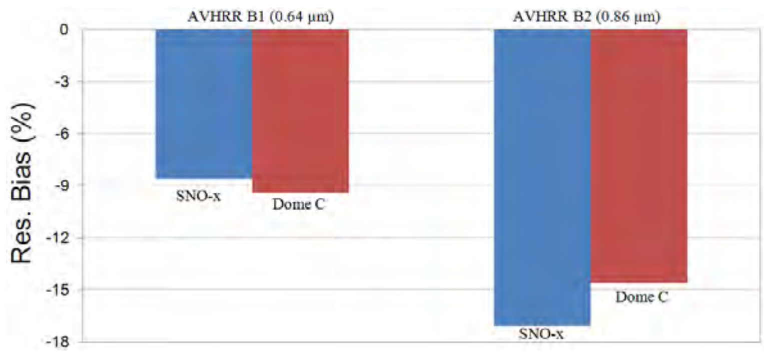


Figure 2. AVHRR residual bias Blue: Bias estimated using SNO-x over desert and Red: Bias estimated over Antarctica Dome C through TOA reflectance trending

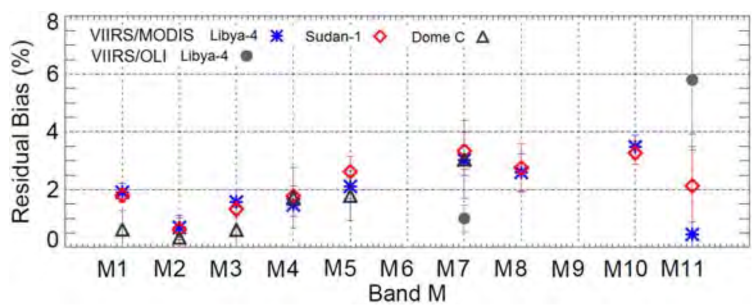


Figure 3. VIIRS radiometric bias (VIIRS - MODIS)*100%/M or (VIIRS - OLI)*100%/OLI

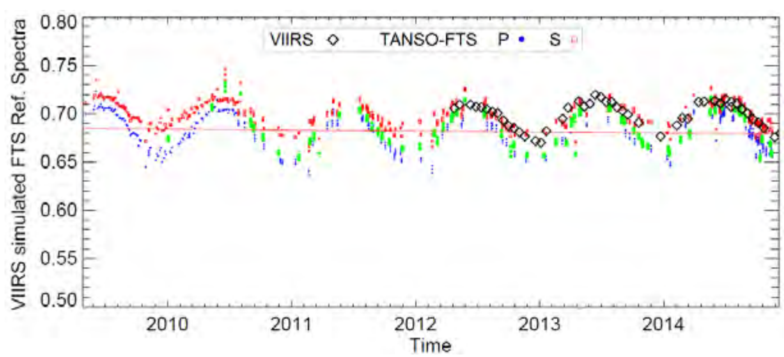


Figure 4. S-NPP VIIRS and GOSAT TANSO-FTS TOA reflectance time series

PROJECT TITLE: NESDIS Environmental Applications Team – Xiao-Long Wang, Research Associate - Software Development for Satellite Data Analysis and Processing

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Xiao-Long Wang, Lide Jiang, Xiaoming Liu, Wei Shi, Liqin Tan, SeungHyun Son, Puneeta Naik

NOAA TECHNICAL CONTACT: Menghua Wang

NOAA RESEARCH TEAM: NOAA SOCD

PROJECT OJBECTIVE:

Develop a satellite data visualization and processing system to support NPP VIIRS, MODIS, and GOCI Ocean color products.

PROJECT ACCOMPLISHMENTS:

Actively made progresses on VIIRS image visualization for various products (SDR/EDR, NOAA-MSL12, L2bin, L3bin, Quality Flags, Masks etc.) and data analysis/processing.

1--Continuously improve VIIRS SDR/EDR and NOAA-MSL12 image data visualization with IDL-based satellite data processing system. Supported all VIIRS Ocean Color products in image visualization, image data manipulation, multiple band image difference computation, geo-registration, image mapping/re-projection, graphic utility and new netCDF output.

2--Enabled large area coverage high quality true-color image generation with more granule image data aggregation and image composition for marine environmental monitoring.

3--Implemented routine run in world-wide regional ocean color monitoring with daily automatically generated true-color images from multiple VIIRS spectrum band data. Enabled near-realtime automatic routine operation to support daily coastal data analysis and marine reef monitoring.

4--Provided batch scripts to implement routine run global L3 data regional data extraction and computation to monitor trends of various ocean-color products. Enabled automatic routine operation to support daily VIIRS data analysis and validation.

5--Improved image visualization tools with finer ocean bathymetry and land elevation data to provide higher resolution terrain contours for coastal environment and in-land water studies.

6--Implemented VIIRS L2bin and L3bin function to support VIIRS L3 binning processing with new netCDF format output.

7--Published paper to introduce functionalities and capabilities of OCDAPS - Ocean Color Data Analysis and Processing System to international ocean science community.

8--Continuously provided convenient GUI mode and command mode support to perform various image band data computations and image data analysis and processing for group user's batch jobs and command scripts.

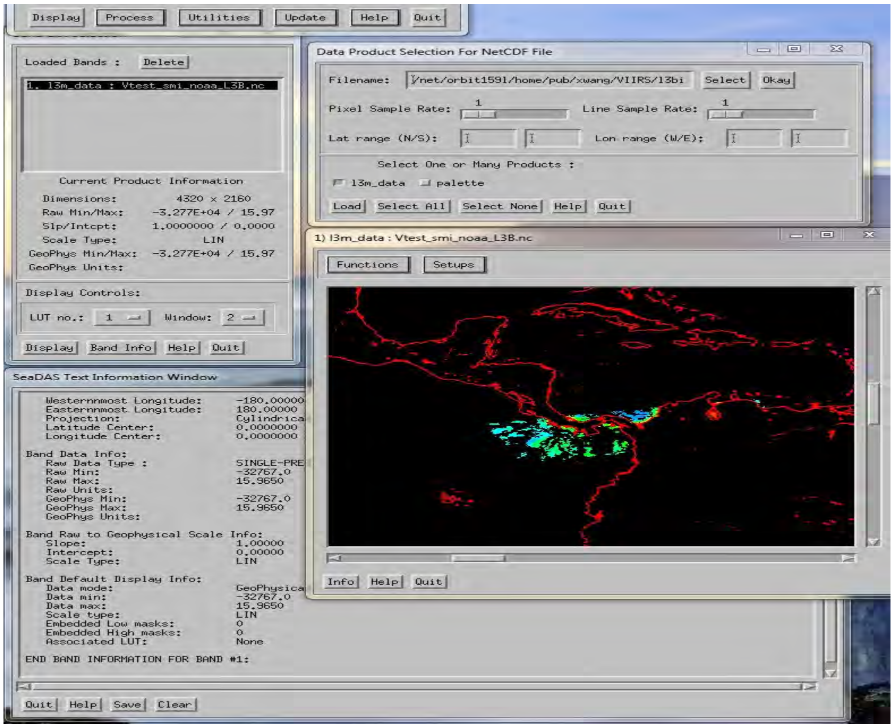


Figure 1. Enabled VIIRS L3bin function for data binning and processing with netCDF format output.

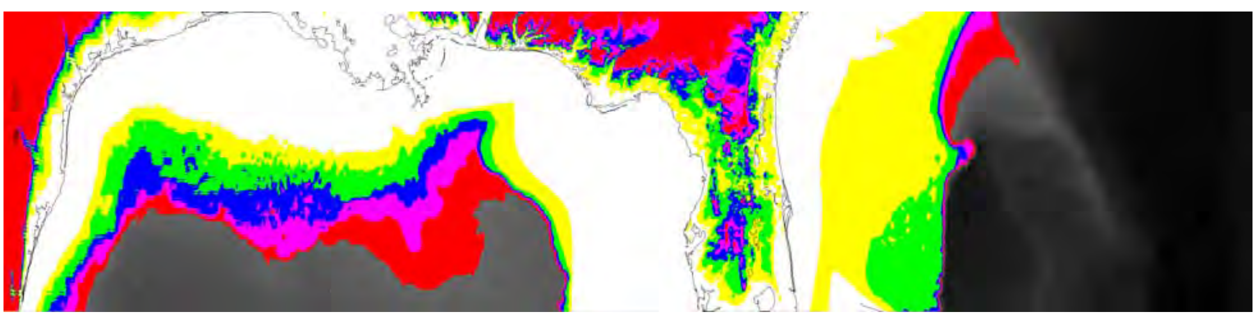
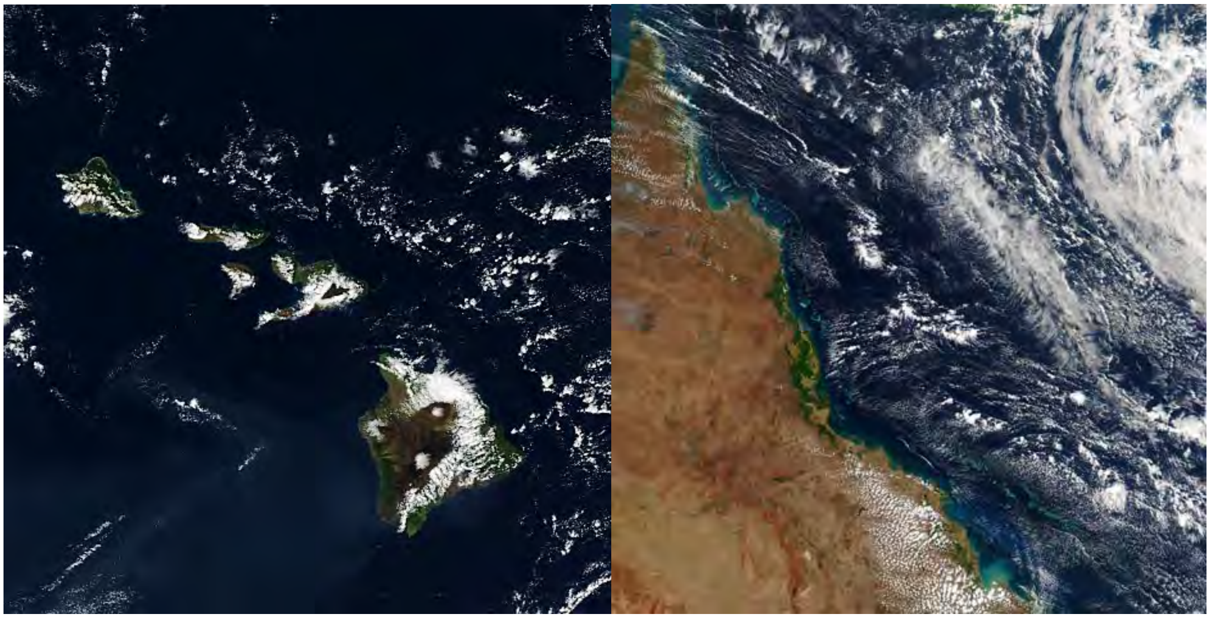


Figure 2. Upgraded high resolution ocean bathymetry and land elevation contour plots in US Gulf of Mexico region.

Figure 3. Mapped true-color image from multiple VIIRS SDR granule data



Puerto Rico (left) and American Samoa (right) regions**.**

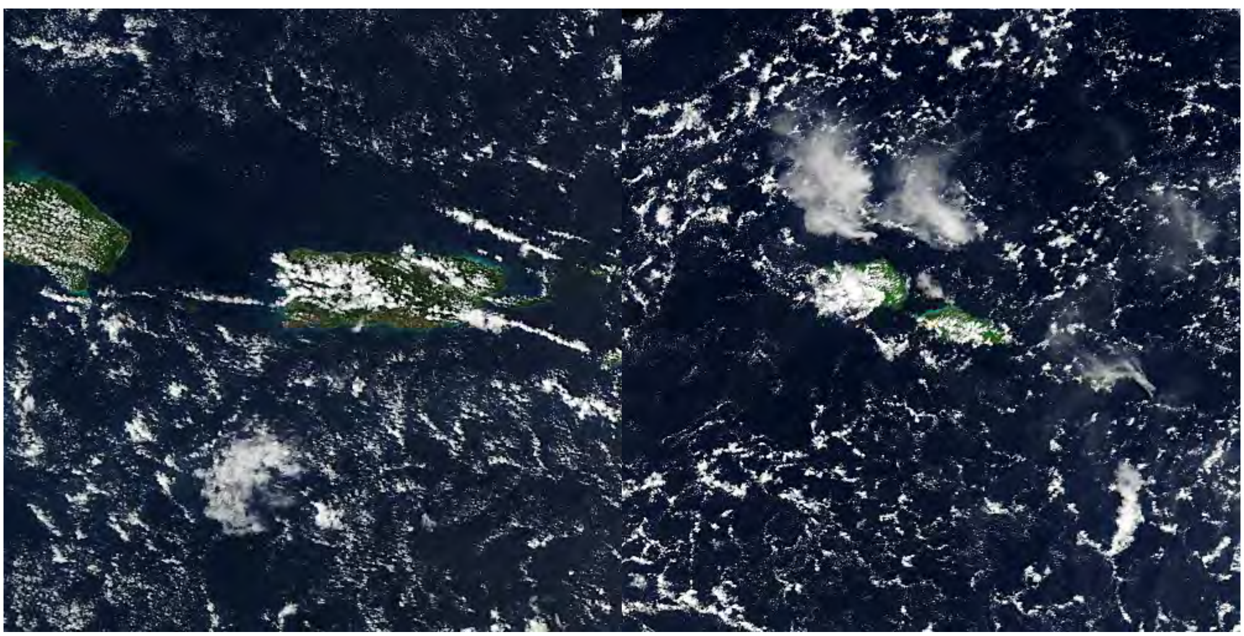


Figure 4. Daily true-color images for world-wide marine reef monitoring: Hawaii (left) and Great Barrier Reef (right) region,

PROJECT TITLE: NESDIS Environmental Applications Team - Xinjia Zhou, Research Associate - AVHRR GAC SST Reanalysis and Validation

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Xinjia Zhou, Prasanjit Dash, XingMing Liang

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Boris Petrenko, Yury Kihai, John Stroup, Feng Xu

PROJECT OBJECTIVE(S):

Perform long-term Reanalysis (RAN) of AVHRR GAC SST with the Advanced Clear-Sky Processor for Oceans (ACSPO); Adopt/Optimize the previously developed by P. Dash SST Quality Monitor (SQUAM) system (www.star.nesdis.noaa.gov/sod/sst/squam/ACSPOGAC/index_rp.html) and display RAN results online; Redesign the previously developed by F. Xu NOAA in-situ SST Quality Monitor (iQuam) and release version 2 (www.star.nesdis.noaa.gov/sod/sst/iquam/v2/); Generate match-ups with of ACSPO AVHRR GAC SST with iQuam and publish results on SQUAM RAN page.

PROJECT ACCOMPLISHMENTS:

Thirteen years (2002-pr) of AVHRR GAC L1b from seven AVHRRs onboard Metop-A, -B, NOAA-15,-16,-17,-18,-19 data have been processed with ACSPO code and the derived L2 SSTs displayed on the page (www.star.nesdis.noaa.gov/sod/sst/squam/ACSPOGAC/index_rp.html). The processing was scripted and cronned, so the data are now regularly updated in SQUAM-RAN in near-real time (Figs. 1-3). The sensor stability ranked from best to worst are: Metop-A, NOAA-17, Metop-B, NOAA-19, NOAA-18, NOAA-16, and NOAA-15. This work was presented at the GHRSST-XV meeting in Cape Town. S. Africa, in June 2014, and at the SPIE 2014 Conference in Beijing, China, in October 2014.

Previously developed by P. Dash NOAA SQUAM system was adopted to display the RAN results, and heavily optimized for long-term historical and real time data processing. SQUAM framework has been expanded to allow quick generation of monthly, annual, and decennial statistics (Fig.1). The most time-consuming codes (e.g., updating long term time series in near real time) were rewritten and heavily optimized (Fig. 2). In collaboration with X. Liang, the postscript-to-gif conversion is now completely removed in SQUAM RAN, and high-quality png images are now generated in IDL and used on the web. The SQUAM-RAN processing time is now shorter than, or comparable to, the ACSPO and in situ match-up processing, so that SQUAM is no longer the bottleneck in generating climate quality data record.

This task has required redesign of the previously developed F. Xu NOAA iQuam system. The iQuam2 beta version was released for internal and limited external evaluation (Fig. 4). The new developments include extending time series back to 1981 (from 1991 in v1), processing 4 more in-situ SST types (ARGO floats, ships in trackob format, High-Resolution GHRSST drifting buoys, and coral reef watch buoys), more sophisticated quality controls and robust automatic gap-filling. Output format was changed to NetCDF4, which is the standard format in the SST community. The expected official version release time is Spring 2015.

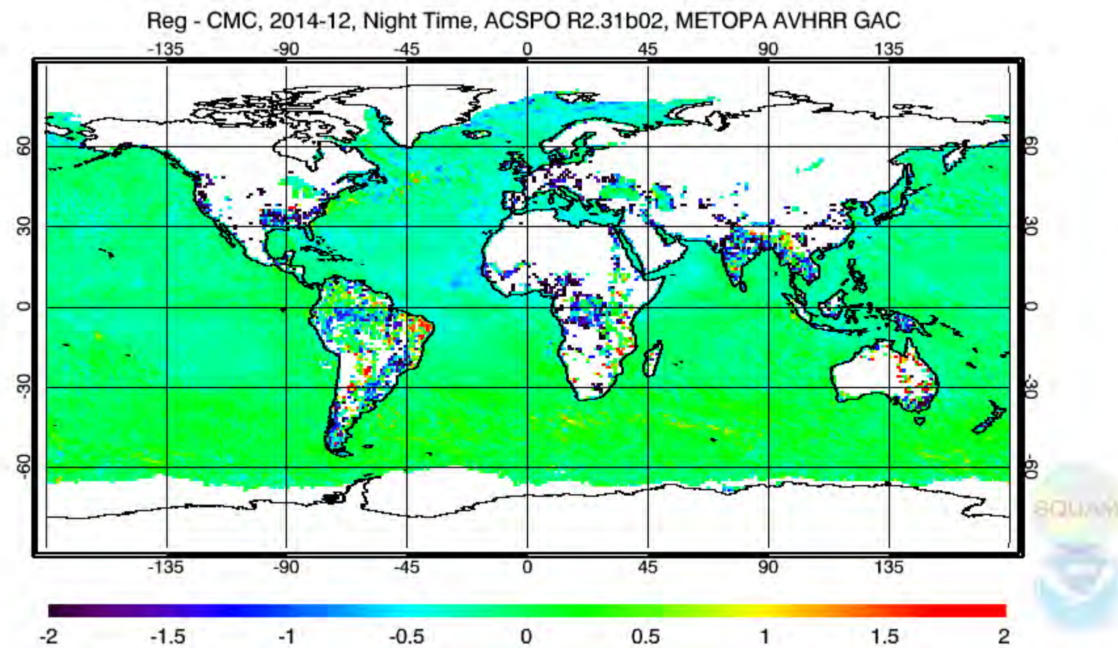


Figure 1. Monthly mean nighttime bias of ACSPO AVHRR GAC L2 minus CMC L4 SST. Plotting monthly plots wrt L4 analyses was very time consuming, but currently processing time significantly reduced.

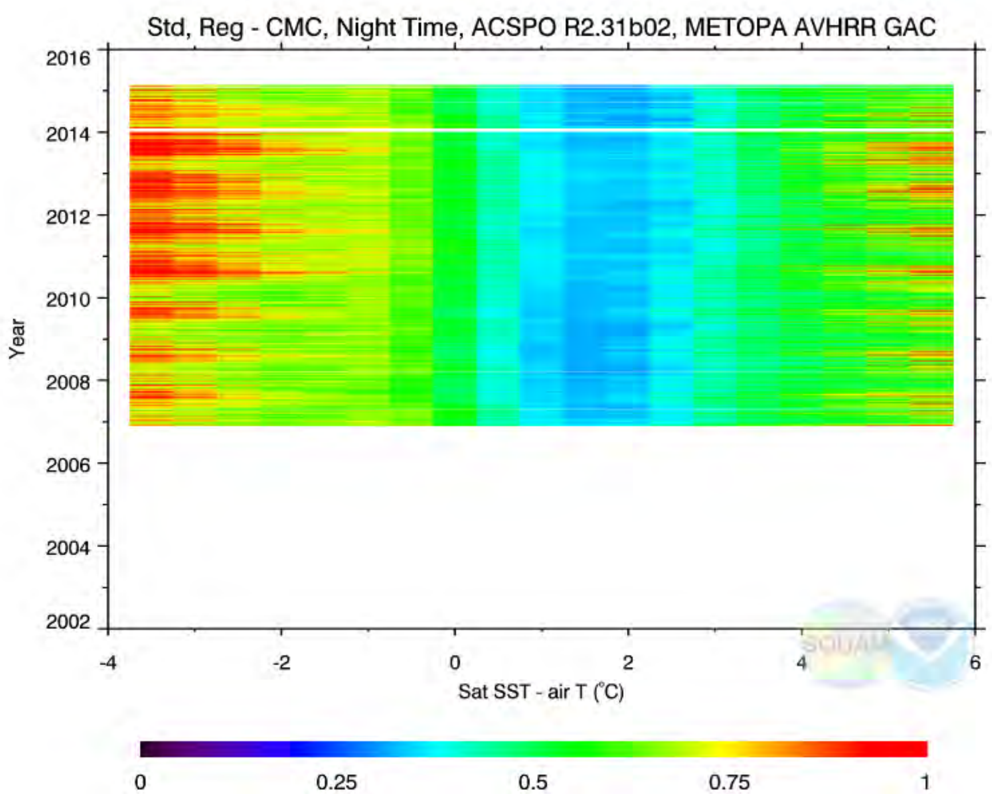


Figure 2. Hovmoller diagrams of ACSPO RAN2 AVHRR GAC L2 SST minus CMC L4 SST. It was time consuming to draw this kind of plots in real time mode before, but currently it is much faster.

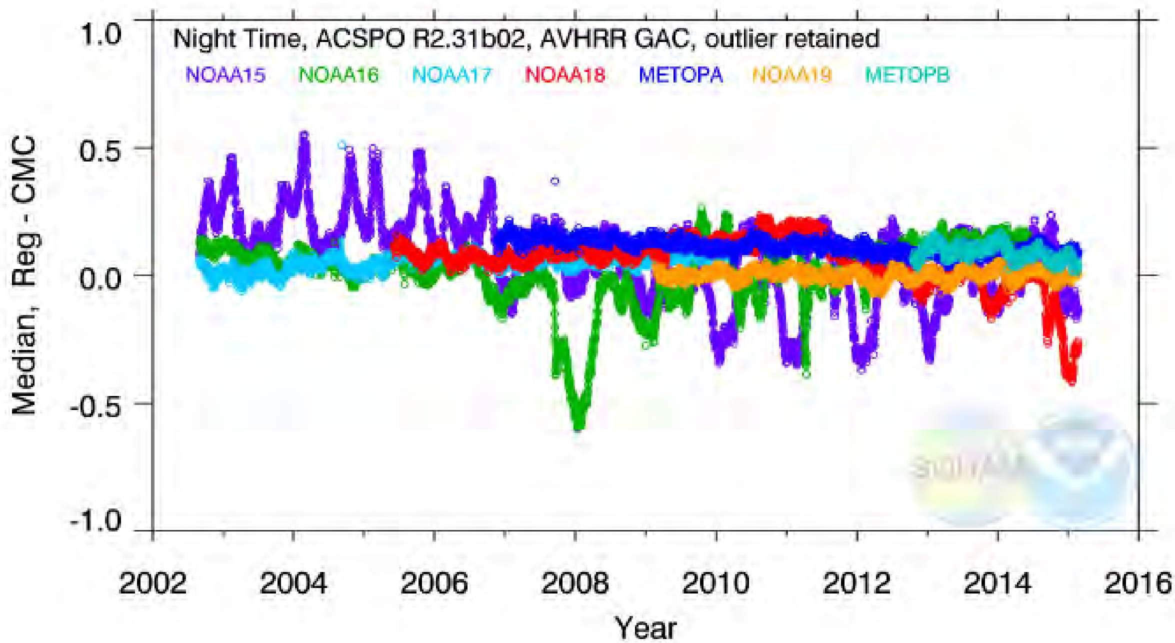


Figure 3. Time series of night time ACSPO RAN2 AVHRR GAC L2 SST minus CMC L4 SST. Each symbol is one day average bias.

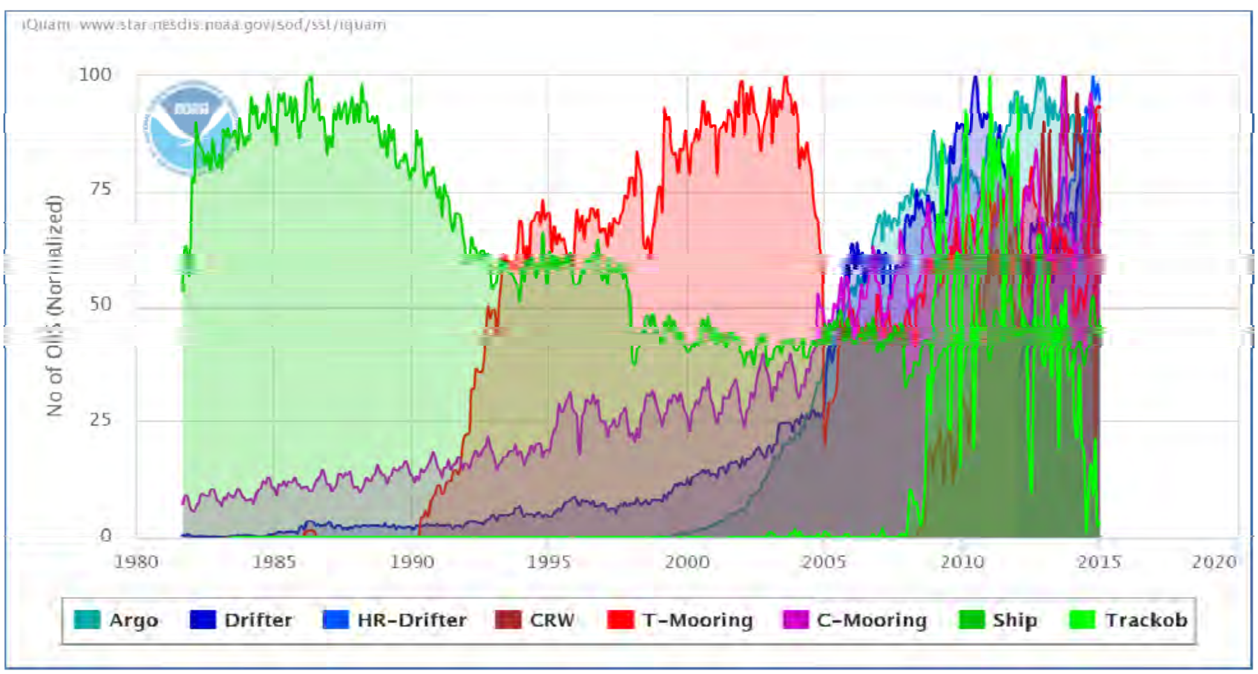


Figure 4. Time series of normalized in-situ observation number on iQuam2 webpage. Eight instrument types are included, compared to the 4 types in iQuam1.

PROJECT TITLE: NESDIS Environmental Applications Team – Tong Zhu, Research Scientist - Satellite Observation System Assessment and Optimization

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: (CIRA/CSU): Tong Zhu

NOAA TECHNICAL CONTACT: Sid Boukabara (NOAA/NESDIS/JCSDA)

NOAA RESEARCH TEAM: Kevin Garrett (Riverside@NOAA/NESDIS/STAR/JCSDA), Michiko Masutani (ESSIC@NOAA/NWS/NECP/EMC), Sean Casey (ESSIC@NOAA/NWS/NECP/EMC), Mark Liu (NOAA/NESDIS/STAR).

PROJECT OBJECTIVES:

--Support the impact assessment of the global observing system at both global and regional scales,
--Support the JPSS data gap mitigation study,
--Support OSSE experiments through radiance simulations,
--Proxy data generation to improve future satellite data assimilation readiness,
--Support research in cloudy/raining data assimilation with an emphasis on extreme weather events.

PROJECT ACCOMPLISHMENTS:

1--Development of the Community Satellite Data Thinning and Representation Optimization Tool

A new thinning scheme, Community Satellite Data Thinning and Representation Optimization Tool (CSTROT), is developed to optimize satellite data selection in GSI data assimilation procedure for global and regional modeling systems. The thinning strategy is based on the derived standard deviation (STD) of the satellite data to be thinned. High-density observations will be kept within high data variational regions, such as tropical cyclone and frontal systems. High-density data can also be selected by giving the locations of the areas of interest. Figure 1 shows the CSTROT thinning result for NOAA-18 AMSU-A observations on 0000 UTC, July 23, 2013. It can be seen that Ch-2 selection can add additional observation points in cloudy/weather regions, such as in ITCZ. The additional selection by Ch-4 gives more points over high altitude and sea-ice regions. Ch-10 responds to stratosphere temperature variation, which provides additional selections around the edge of strong south polar vortex.

2--Evaluate a new band transmittance scheme, OSS (Optimal Spectral Sampling)

We have worked on obtaining the OSS coefficients from AER for CRTM model simulation. The new coefficients we archived are for AIRS, IASI, CrIS and CrIS high resolution (2211 bands), along with the iasiB1_metop-a delivered before. In a benchmark test, the simulated radiance difference between AER's and our (JCSDA) results for iasiB1_metop-a are within 4x10^-8 [mW/(m^2.sr.cm^-1)]. After benchmark, we performed speed tests and compared with CRTM-ODPS. For the forward simulation of iasiB1_metop-a 2260 bands, OSS is about 8% faster than ODPS. The simulation using another newly delivered OSS iasiB1_metop-a coefficients, with less nodes (or less accuracy), is about 2.13 times faster than CRTM-ODPS simulation. When simulating all iasi 8461 bands, OSS is about 2.54 times faster than ODPS. We also compared the difference of the simulated radiances for iasiB1 between OSS and CRTM-ODPS schemes (Figure 2). This difference is similar to the difference found between ODPS and LBLRTM simulations (in AER report). We are working on implementing the OSS scheme into the CRTM model.

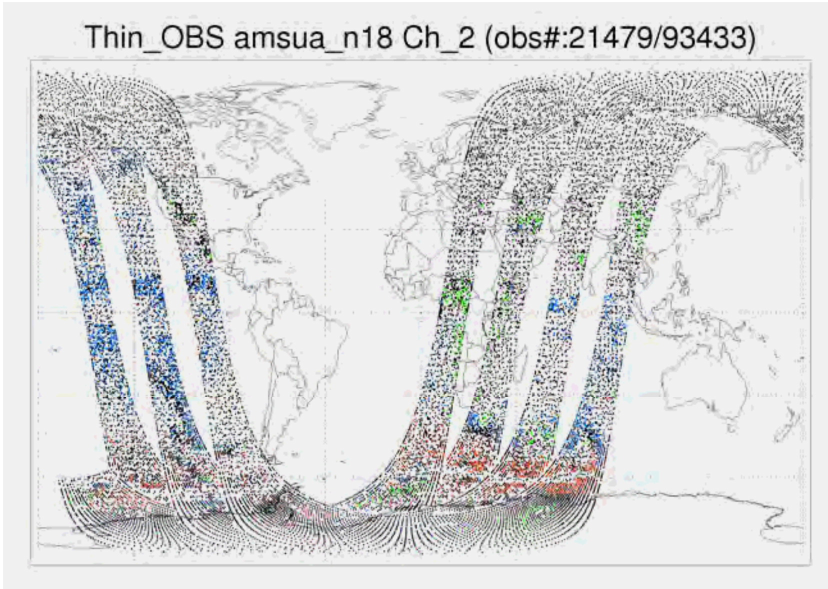


Figure 1. The observation points selected by CSTROT thinning scheme based on the union of AMSU-A N18 channel 2, 4 and 10 selections. Black points are the same observation points selected by all three channels. Blue, green and red points are the additional observations selected by Ch-2, 4 and 10, respectively.

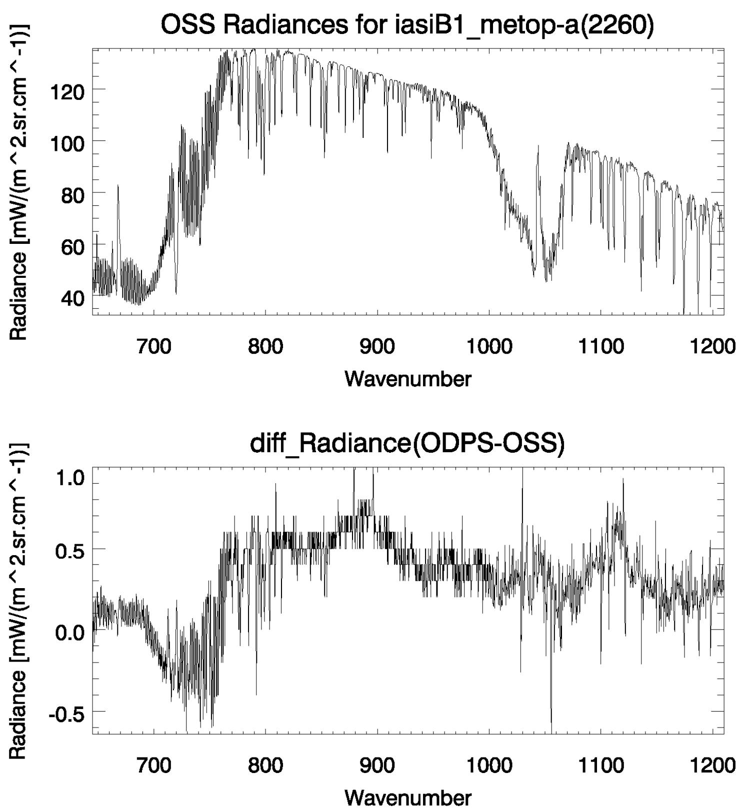


Figure 2. CRTM simulations of iasiB1_metop-a sensor by using (a) OSS scheme, and (b) ODPS-OSS, with two variable gases, H2O and O3.

PROJECT TITLE: Polar-Geo Blended Hydrometeorological Products

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: John Forsythe, Andy Jones

NOAA TECHNICAL CONTACT: Limin Zhao (NESDIS/OSPO/SPSD/SPB)

NOAA RESEARCH TEAM: Limin Zhao (NESDIS/OSPO/SPSD/SPB), Sheldon Kusselson (NESDIS/OSPO/SPSD/SAB), John Paquette (NESDIS/OSPO/SPSD), Ralph Ferraro (NESDIS/STAR/CRPD/SCSB), and others

PROJECT OBJECTIVE:

Provide science support to Operational Blended TPW and RR products, including

1--GPS TPW data dropouts
2--MIRS TPW quality issues over land, especially over cold land
3--Histogram correction issues
4--Other problems as they arise

PROJECT ACCOMPLISHMENTS:

1--We communicated with the OAR/ESRL/GSD personnel who produce the GPS TPW data stream. Yes, there are occasional data dropouts for unknown reasons. We have written code which substitutes the previous hour's GPS TPW data for sites without the current hour's data. This has lowered the number of cases/areas with no GPS TPW data. The code is ready for transition to OSPO.

2--We provided feedback to the MIRS developers. They informed us that OSPO is not using the latest version of the MIRS products (Version 11), which has improvements related to this cold land problem. We recommend that OSPO upgrade the MIRS processing as soon as possible.

3--In conjunction with the AMSR-2 data upgrade, we wrote a new version of the histogram correction code which (a) works over both land and ocean, (b) doesn't have individual corrections for each scan angle (and thus can't introduce anomalous across-track striping), and (c) allows different reference satellites for each satellite and for land and ocean. The code has been tested and delivered to OSPO for implementation.

4--Two anomalies in TPW have been noted this winter: (a) GPS TPW "bull's-eyes" (i.e., extremely high, but short-lived values at a single station) and (b) high MIRS TPW values in sea ice area. The GPS TPW bull's-eyes have unknown causes which are being investigated by GSD. We currently don't have a fix, although some sort of quality control routine could be written. The latest version of MIRS reportedly has better sea-ice detection, which is yet another reason for OSPO to upgrade to the latest MIRS version.

PROJECT TITLE: Tropical Cyclone Model Diagnostics and Product Development

PRINCIPAL INVESTIGATORS: Wayne Schubert, Kate Musgrave

RESEARCH TEAM: Scott Longmore, Andrea Schumacher, Louie Grasso, Robert DeMaria, Chris Slocum, Jack Dostalek

TECHNICAL CONTACT**:** Fred Toepfer (NOAA/NCEP/EMC) and Phil Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: John Knaff (NOAA/NESDIS/STAR)

PROJECT OBJECTIVES:

The National Oceanic and Atmospheric Administration (NOAA) initiated the Hurricane Forecast Improvement Project (HFIP) to reduce the errors in tropical cyclone track and intensity forecasts. This reduction will be accomplished through improved coupled ocean-atmosphere numerical hurricane models, better use of observations through advanced data assimilation techniques and ensemble forecasts. Model diagnostic techniques will also be developed to determine the sources of model errors and guide future improvements. The CIRA team performed nine tasks that contribute to this HFIP effort. Details on these tasks are described in the next section.

The CIRA HFIP activities directly address NOAA's Weather Ready Nation objectives. This research falls within the NOAA-defined CIRA thematic area of Satellite Algorithm Development.

PROJECT ACCOMPLISHMENTS:

1--Retrospective forecasts using updated SPICE model

-- One of the main accomplishments of the CIRA HFIP project has been the development of improved statistical intensity forecast models. SPICE is one of these models. It uses input from a number of dynamical models with a variety of tracks as input to two statistical models to form a consensus. Each hurricane season, the HFIP program runs experimental models in real time for evaluation by the National Hurricane Center. To become eligible for the demonstration and designated a Stream 1.5 model, the model must be run on retrospective cases from the past three hurricane seasons and delivered to the Tropical Cyclone Modeling Team (TCMT). SPICE was designated a Stream 1.5 model for the real-time demonstration period in 2014 after completing the retrospective testing process. The SPICE model is currently undergoing upgrades and retrospective testing on the 2012-2014 hurricane seasons in preparation for the 2015 season.

2--Real-time forecasts using updated SPICE model

-- The SPICE model was designated to run during the real-time demonstration period of the 2014 hurricane season due to its performance in the retrospective testing. SPICE was successfully run during that demonstration period from 1 August 2014 to 1 November 2014. Preliminary verification of the SPICE model for the 2014 hurricane season has been performed. SPICE had lower mean absolute errors in the Atlantic basin than either Decay-SHIPS or LGEM at longer forecast times.

3--Experimental Version of SHIPS and LGEM (based on ECMWF)

-- The operational versions of the statistical SHIPS and LGEM intensity models use input from the NCEP global forecast model. Work continues on adapting these models to use input from the ECMWF global forecast model, and the forecast errors will be compared with the operational version. The grib decoder routines used in the operational version of SHIPS and LGEM on NCEP's WCOSS system were modified to use 1 degree ECMWF model output instead of the 1 degree GFS model output. A parallel version of the operational SHIPS/LGEM script was also created with a switch to run off the ECMWF fields instead of the GFS fields. A side benefit of this approach is that the operational Rapid Intensification Index (RII) will also be run off the ECMWF fields for comparison with the GFS version. Access to the ECMWF grib files on WCOSS has been obtained, and testing is underway to produce the necessary diagnostic files for the experimental SHIPS, LGEM, and RII from the model fields contained within the ECMWF 1 degree model output. The ECMWF versions of SHIPS and LGEM may be candidates for inclusion of future versions of the SPICE model.

4--Development of Experimental Version of SPICE

-- The version of SPICE used in the HFIP real-time demonstration combines SHIPS and LGEM forecasts from the NCEP operational models GFS, HWRF, and GFDL. CIRA is developing an experimental version of SPICE, which includes SHIPS and LGEM components based on the ECMWF forecast fields. Further development of the SPICE model includes experiments with the parameters and weighting used in the model. Figure 1 shows an evaluation of the weighting from the current version of SPICE against an unweighted version, as well as both the SHIPS and LGEM component consensus. The weighted version of SPICE does not improve upon the unweighted version in the 2011-2013 Atlantic sample, due to higher errors associated with the LGEM component at longer lead times.

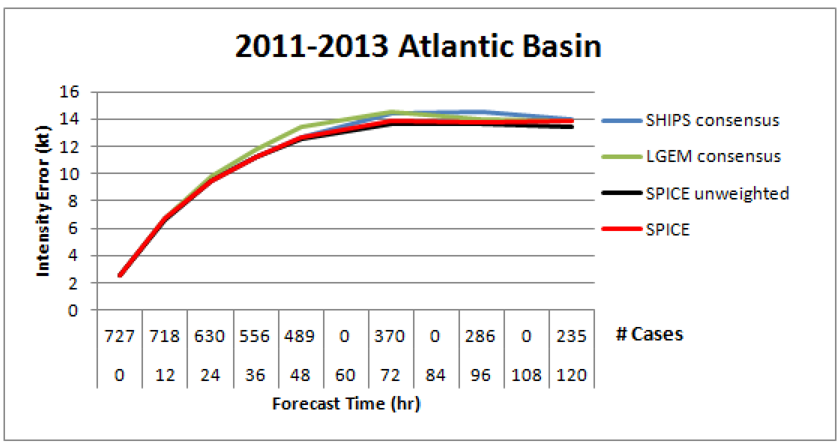


Figure 1. Mean absolute error (in kt) of the forecast intensity from SPICE (red), an unweighted version of SPICE (black), the consensus of the LGEM component models (green), and the consensus of the Decay-SHIPS component models (blue) for the 2011-2013 Atlantic hurricane sesasons.

5--Development of Large-Scale Diagnostic Code

-- A program to diagnose a number of variables from hurricane models was developed under HFIP and is being improved by adding new parameters. Variables thought to be important for intensity change, such as vertical shear, relative humidity, etc., are being diagnosed from several real-time global and regional models, and products that show their differences are being developed and displayed in real time. A multi-model comparison plot featuring the operational models GFS, HWRF, and GFDL was provided to the HFIP products website (http://www.hfip.org/products/) during the real-time demonstration from 1 August 2014 to 1 November 2014. Model diagnostic verification was developed for real-time display (http://rammb.cira.colostate.edu/products/tc_realtime/), as shown in Figure 2 for the GFDL model for Hurricane Gonzalo (2014).

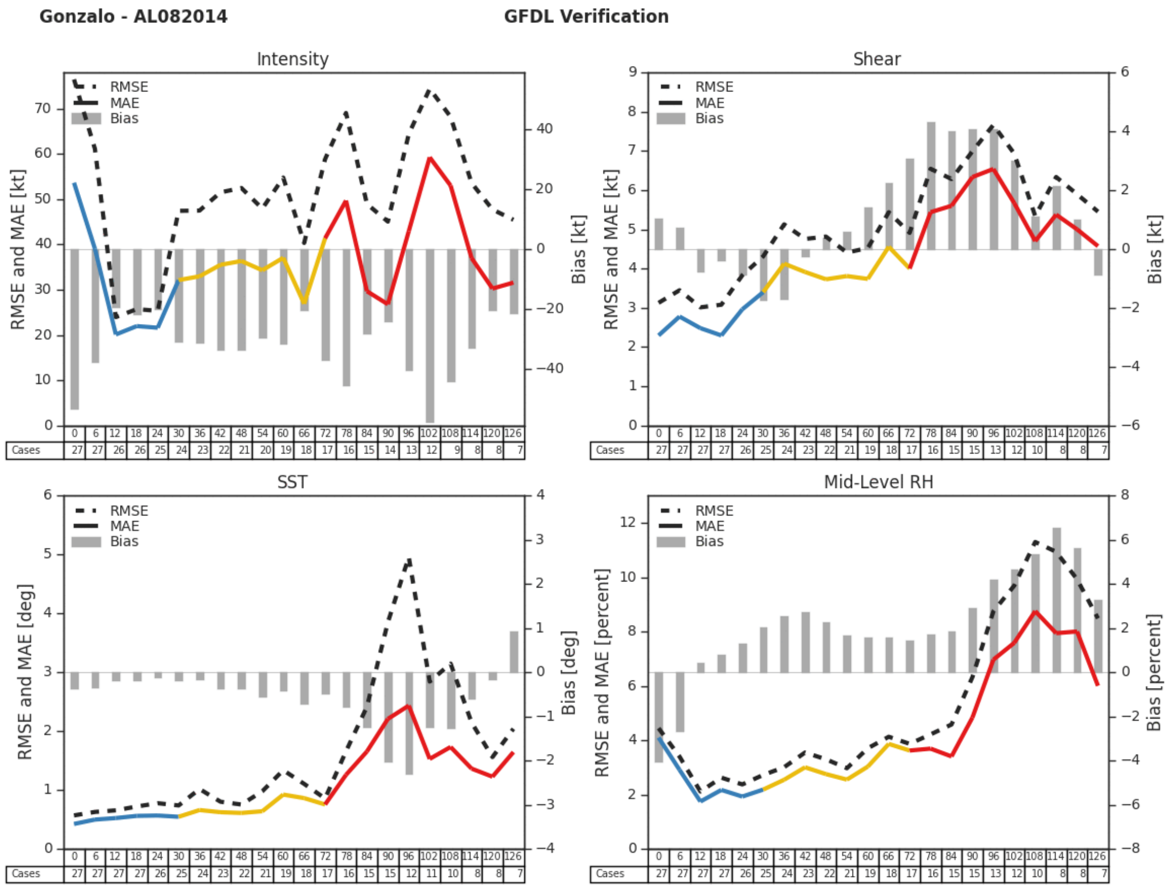


Figure 2. Model diagnostic verification plot for Hurricane Gonzalo (2014). This plot compares forecasts of TC and environmental variables from GFDL with the operational best track and the model environment derived from GFS analysis fields. Intensity (10 m maximum sustained winds in kt) is displayed in the top-left panel, 850-200 mb vertical wind shear (in kt) is displayed in the top-right panel, sea surface temperature (in K) is displayed in the bottom-left panel, and 700-500 mb relative humidity (in percent) is displayed in the bottom-right panel. The mean absolute error is displayed in the colored line, root-mean square error is displayed in the dashed black line, and the bias is displayed in the gray-shaded bars. The colors denote the average track error for the GFDL forecasts included in the diagnostic verification: less than 100 nmi in blue, between 100 and 200 nmi in yellow, and greater than 200 nmi in red.

6--Update SHIPS and LGEM database for the 2014 season

-- Datasets were collected during the 2014 season for inclusion in the SHIPS and LGEM database. These datasets include satellite infrared imagery, satellite total precipitable water, ocean heat content, and fields from the Global Forecast System (GFS).

7--Verification of Large-scale HWRF Synthetic Imagery and Model Moisture

-- One of the difficulties of verifying hurricane models is the lack of observations near the storm, especially in the upper levels. Observations of the moisture fields are also very sparse near tropical cyclones. To aid in the evaluation and verification of the HFIP forecast models, synthetic GOES satellite data and total precipitable water (TPW) fields have been created from the model output, and compared to the real GOES satellite imagery, and a microwave-based satellite TPW product. Figure 3 displays a comparison of the blended satellite TPW and HWRF, allowing for spatial comparison and feature assessment.

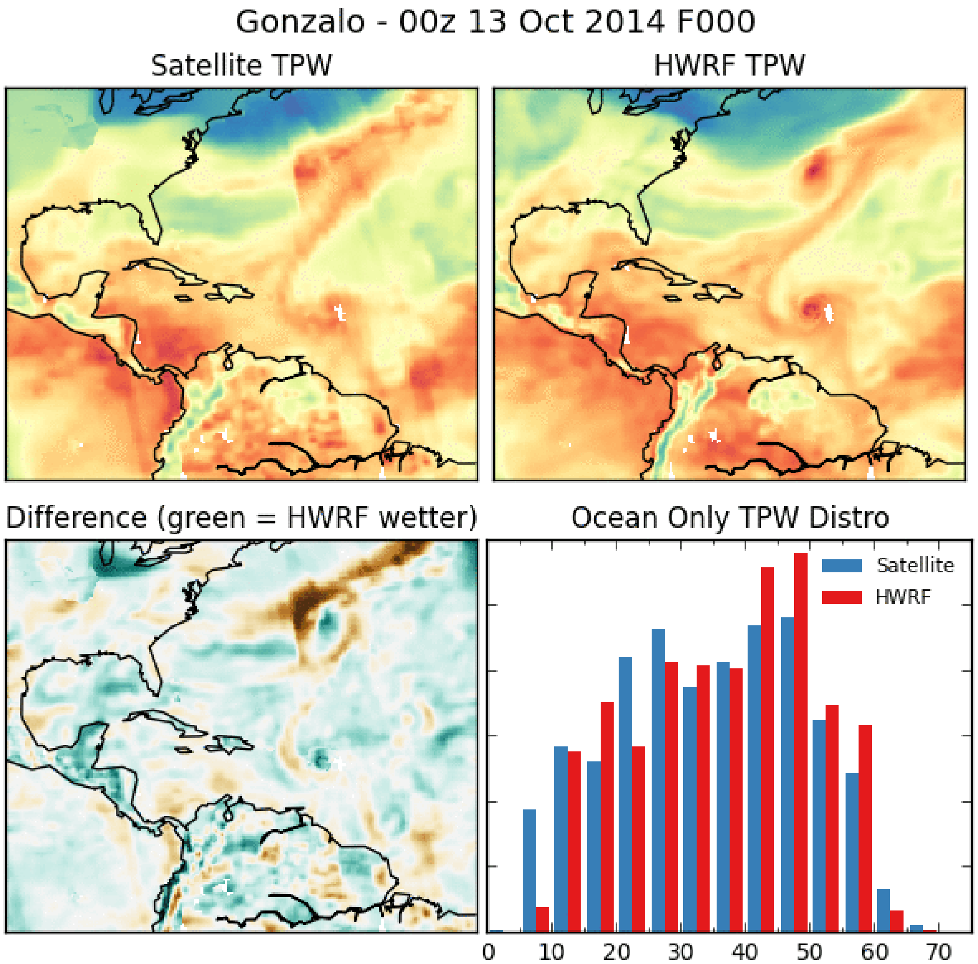


Figure 3. Total precipitable water (in mm) for Hurricane Gonzalo at 00z on 13 October 2014: satellite blended TPW (top left), HWRF (top right), difference between satellite and HWRF (bottom left), and histogram of the ocean-only distribution for satellite and HWRF (bottom right).

8--Run an Experimental Hybrid Version of NHC's Operational Wind Speed Probability Program

-- An experimental version of NHC's operational tropical cyclone wind speed probability (WSP) model was run for the 2014 Atlantic, N.E. Pacific, and N.W. Pacific tropical cyclones, with graphical output provided to the HFIP products website (http://www.hfip.org/products/). The experimental version uses track information from a set of dynamical model ensembles, instead of from randomly sampling from the tropical cyclone track forecast errors from the past five years, as is used in the statistical version used in operations. The intensity and structure perturbations are determined in the same way (using random sampling of forecast errors) as the statistical version. The experimental hybrid version can represent more complex scenarios such as clustering of tracks and bimodal distributions.

Final best tracks are not yet available for 2014 for the Atlantic, N.E. Pacific, or N.W. Pacific basins for post-season validation. In order to get a sense of how the hybrid WSPs compared to the statistical WSPs this year, a preliminary verification was performed using provisional Best Track data. Since the hybrid wind speed probabilities are only run at 0 and 12Z, post-season reruns were conducted to create a homogeneous sample of hybrid and statistical 34, 50, and 64-kt wind speed probabilities. The percent improvement in Brier score seen by using the hybrid WSPs versus the statistical WSPs in each basin are shown in Figure 4. In general, the hybrid WSPs demonstrated an improvement over the basin-wide Brier scores, and at times this improvement is as high as 15%. However, it does appear that the hybrid 34-kt WSPs performed worse in the N.E. Pacific than the statistical version for 2014. This result will be looked into in more detail once the final Best Tracks are obtained for the official post-season validation.

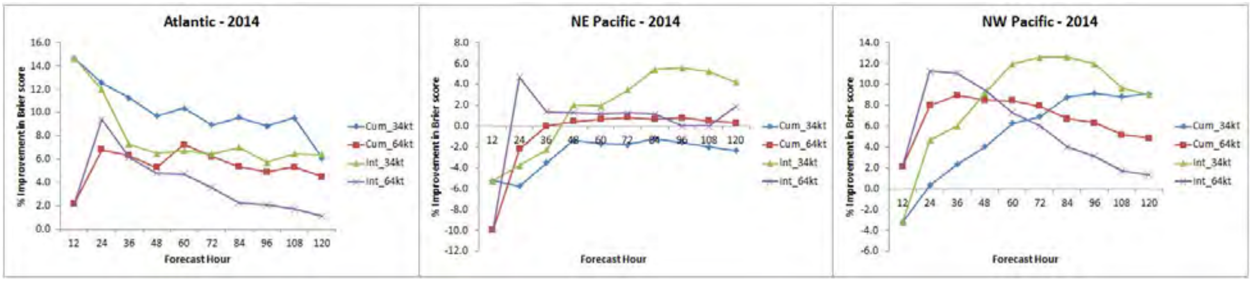


Figure 4. The percent improvement of Brier scores (reduction in Brier score = improvement) given by the hybrid WSPs as compared to the statistical WSPs for the Atlantic (left), N.E. Pacific (center), and N.W. Pacific (right) basins in 2014.

9--Expand SHIPS Diagnostics Model Intercomparison Graphics

-- A program to diagnose a number of variables from hurricane models was developed under HFIP and is being improved by adding new parameters. Variables thought to be important for intensity changes, such as vertical shear, relative humidity, etc., are diagnosed from several real-time global and regional models, and products that show their differences are displayed in real time. The display products are being expanded to include the HFIP experimental Stream 1.5 models as well as the operational global and regional models.

REGIONAL TO GLOBAL SCALE MODELING SYSTEMS

Research associated with the improvement of weather/climate models (minutes to months) that simulate and predict changes in the Earth system. Topics include atmospheric and ocean dynamics, radiative forcing, clouds and moist convection, land surface modeling, hydrology, and coupled modeling of the Earth system.

PROJECT TITLE: EAR - Rapid Update Cycle (RUC)/WRF (RAP) and HRRR Model Development and Enhancement

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Kevin Brundage, Tracy Smith

NOAA TECHNICAL CONTACT: Stanley Benjamin (OAR/ESRL/GSD/EMB Chief)

NOAA RESEARCH TEAM: Curtis Alexander (CIRES), Steve Weygandt (OAR/ESRL/GSD/EMB)

PROJECT OBJECTIVES:

The primary focus of the GSD Earth Modeling Branch (EMB) is the refinement and enhancement of the Rapid Refresh, High Resolution Rapid Refresh (RAP and HRRR) and development of the Weather Research and Forecast (WRF) model. In addition to refinement and enhancements of the RR and HRRR, CIRA researchers collaborate on the development of the Weather Research and Forecast (WRF) model used by CIRA and GSD researchers.

The HRRR is a NOAA real-time 3-km resolution, hourly updated, cloud-resolving atmospheric model, initialized by 3km grids with 3km radar assimilation over a 1-h period (since 5 April 2013), adding further detail to the HRRR initial conditions otherwise determined by the hourly data assimilation from the 13km radar-enhanced Rapid Refresh

The primary goal this year was to assimilate convective initiation information derived from GOES satellite data into the Rapid Refresh and HRRR forecast systems.

PROJECT ACCOMPLISHMENTS:

For this year's research goals, GOES cloud-top cooling rate data provided by the University of Alabama Huntsville (UAH) are assimilated into an experimental Rapid Refresh version. Within this RAP modeling framework, the cloud-top cooling rate data are mapped to latent heating profiles and are applied as prescribed heating during the diabatic forward model integration part of the RAP digital filter initialization (DFI). A similar forward integration only procedure is used to prescribe heating in the HRRR one-hour pre-forecast cycle. For both the RAP and the HRRR, the GOES-satellite-based cloud-top cooling rate information is blended with data from radar reflectivity and lightning flash density to create a unified convective heating rate field. In the current HRRR configuration, four 15-min cycles of latent heating are applied during a pre-forecast hour of integration. This is followed by a final application of GSI at 3-km to fit the latest conventional observation data.

Previous work on this project has demonstrated that these cloud-top cooling rates can help with the location and intensity of storms in the RAP system. A new retrospective period of June 15-22, 2014 has been chosen to continue investigation of the use of cloud-top cooling rates in partnership with other satellite derived convective initiation indicators in the RAP forecasts. This period was quite active with severe storms, especially in the northern Plains states, with numerous tornadoes and large hail reports over the period. In addition to the RAP model, we are also investigating the impact of the satellite derived cloud-top cooling rates in the HRRR model that uses the RAP for boundary conditions. Other parameters to be evaluated are the CI probability information provided by UAH and the impact in variation in the vertical structure of the assumed heating profile using information on the cumulus clouds as derived from GOES.

A full discussion of the results is presented:
https://ams.confex.com/ams/27SLS/webprogram/Paper255489.html.

The HRRR became operational on September 30, 2014 with significant improvements incorporated on January 1, 2015. RAP Version 2 was implemented at NCEP on 25 February 2014.

PROJECT TITLE: EAR - Rapid Update Cycle (RUC) Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) Models Project

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Brian Jamison, Ed Szoke

NOAA TECHNICAL CONTACT: Steven Weygandt (OAR/ESRL/GSD/EMB)

PROJECT OBJECTIVES:

Tasks for this project include: creation and management of automated scripts that generate real-time graphics of output fields, management of websites for display of those graphics, and management of graphics for hallway public displays.

PROJECT ACCOMPLISHMENTS:

Each of the webpages for RAP http://rapidrefresh.noaa.gov/RAP/, HRRR http://rapidrefresh.noaa.gov/HRRR/ , and RUC http://ruc.noaa.gov/RUC/ have been refined with new developmental model versions, difference plots, better graphics and new fields.

Two cold-start versions of the RAP were added, as was a new version of the HRRR with chemistry.

The HRRR became an operational NWS model this year, and is run at the National Centers for Environmental Prediction (NCEP). GSD receives the operational data, and creates all graphics for GSD's HRRR webpage, including all subdomains and soundings. The in-house HRRR was renamed HRRR Experimental (HRRRX) to distinguish it from the operational version.

Many improvements and some new products were added to the model suites, including five new subdomains centered over Seattle, San Francisco, Milwaukee, New York and Washington D.C. (Figure 1), which coincide with the locations of the HRRR cross sections.

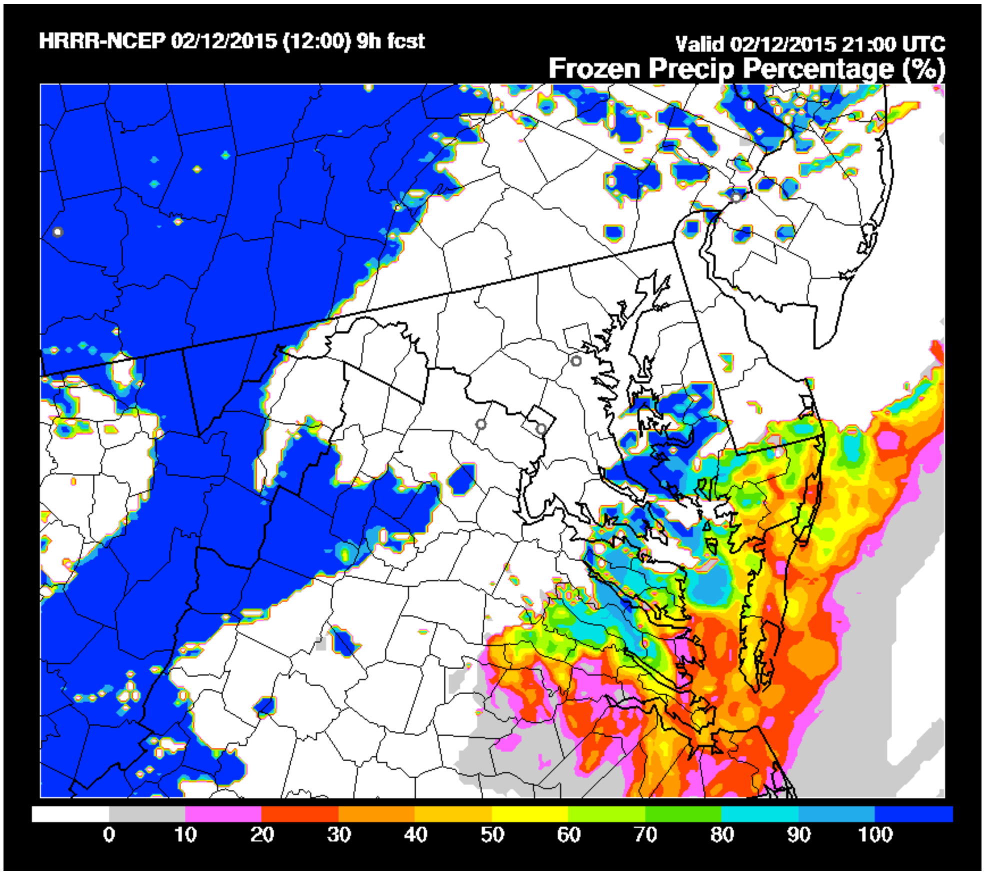


Figure 1. HRRR subdomain of Washington D.C. showing a forecast of frozen precipitation percentage.

A dual-monitor hallway display on the second floor of the David Skaggs Research Center (DSRC) displays HRRR model graphics for public viewing. Currently, a montage loop of four output fields is regularly displayed and updated automatically.

The various graphics are used for real-time monitoring of the different versions of the HRRR and for more detailed studies of individual cases. At times the graphics are shared with NOAA/NCEP to discuss HRRR (operational and experimental versions) performance for a weather event, in particular through their Model Evaluation Group (MEG) nationally broadcast meetings once per week on Thursday mornings. In addition, graphics are kept online and made easily available for particularly significant cases, such as the September 2013 Colorado floods, with additional graphics from reruns for this and other cases also made available. This allows for studies to be carried out and presentations made at various conferences. One highlight of a presentation made this past year came at the National Weather Association (NWA) Annual Meeting in October in Salt Lake City. This conference typically attracts the largest audience of operational (NWS and private) forecasters of any conference, and the HRRR poster was extremely popular. The poster was being presented just after the HRRR's official transition to NCEP, and a number of forecasters stopped by to provide many positive comments about the HRRR.

PROJECT TITLE: EAR - Advanced High Performance Computing

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Thomas Henderson, Jacques Middlecoff, James Rosinski, Jeff Smith, Ning Wang, Julie Schramm

NOAA TECHNICAL CONTACT: Mark Govett (OAR/ESRL/GSD/ATO)

PROJECT OBJECTIVES:

--Collaborate with ESRL meteorologists on the objective of running the Non-hydrostatic Icosahedral Model (NIM) at sub 5KM global resolution. Running at 5KM resolution requires accelerator technology and research in the area of grid generation and optimization, pre- and post-processing, and development of numerical algorithms. Running NIM at 5KM resolution also requires the enhancement of the software suite known as the Scalable Modeling System (SMS).

--Provide software support to ESRL scientists including software design advice and expertise on a variety of software/web/database technologies. CIRA researchers continue to modify the Flow-following, Finite volume Icosahedral Model (FIM) software to enhance interoperability with National Center for Environmental Prediction's (NCEP's) NEMS architecture implemented via the ESMF and continue to collaborate closely with Tom Black and others at NCEP to further generalize the NEMS ESMF approach so it meets requirements of NCEP models (GFS, NMMB) as well as FIM.

--Interact with the ESMF Core development team to specify requirements for features needed by FIM, NIM, and other NOAA codes.

--Serve on the National Unified Operational Prediction Capability (NUOPC) Common Model Architecture (CMA) and Content Standards subcommittees.

--Fine-tune software engineering processes used during FIM development, ensuring that these processes remain suitable for a candidate production NWP code, optimize FIM run-time performance, port FIM to new machines, and incorporate new features such as the ongoing integration of WRF-CHEM and WRF-ARW physics into FIM.

--Collaborate with the Developmental Testbed Center Ensemble Team (TDC/DET) to modify WRF Portal to support running complex WRF ensembles on the GSD Jet and TACC Ranger supercomputers. Also develop, improve, and support WRF Portal, FIM Portal, and WRF Domain Wizard.

--Develop improved capabilities in the (NextGen) NNEW Testing Portal—a Flash web application (with server side Java) that tests NextGen OGC web services (WFS, WCS, and RegRep), performs load tests, generates graphs and reports, and enables guided ad-hoc querying of these web services.

--Serve on the GSD program review committee and the NOAA Earth Information System (NEIS) committee (a project listed in NOAA's 2011 Annual Guidance Memorandum as a priority for NOAA).

--Collaborate with CIRES researchers to develop TerraViz—a 3D visualization application for environmental datasets (similar in some respects to Google Earth) that is a core component of NEIS.

--Assist the Space Weather Prediction Center in maintaining the Ionosphere Plasmasphere Electrodynamics (IPE) code.

PROJECT ACCOMPLISHMENTS:

CIRA researchers continued to optimize serial and parallel NIM on NVIDIA GPU, Intel's® Xeon® Phi, and CPUs from Intel® and AMD®. They continued to use NIM as a test case to investigate the stability and features of new commercial OpenACC GPU compilers from Portland Group and Cray and for the Intel compiler for the Xeon Phi. Note that Xeon Phi is the Intel product that competes directly with NVIDIA's GPUs in the massively parallel fine-grained (MPFG) arena. Several stand-alone test cases were created and shipped to vendors to illustrate specific shortcomings of vendor products. Many compiler bugs and limitations were found and fed back to the vendors yielding improved products that better address our needs. CIRA researchers improved I/O and OpenMP performance of NIM. They repeatedly integrated major changes from the model developers onto the NIM trunk and parallelized for both distributed-memory parallel and MPFG architectures.

CIRA researchers created a 3km NIM dynamics benchmark for the computational part of the Sandy Supplemental program's High Impact Weather Prediction Project (HIWPP) multi-model evaluation effort. This effort included porting and tuning, creating input and output datasets, assessment criteria, and creating documentation. The NIM dynamical core was overhauled to minimize MPI communications and CIRA researchers demonstrated good scaling of the 3km NIM dynamical core out to 240,000 cores on the ORNL Titan supercomputer.

CIRA researchers enhanced the capabilities of SMS including processor-to-processor communication (exchange). The SMS exchange function was optimized to completely eliminate memory copies induced by pack and unpack routines. This was accomplished by taking advantage of indirect addressing to introduce a small number of "duplicate" columns properly placed to allow direct use of the model arrays as MPI communication buffers. CIRA researchers improved SMS to allow exchanges to be overlapped with computation. CIRA researchers rearranged the NIM code to provide more computations to overlap with exchanges. In many cases the time to exchange an overlapped variable was reduced to essentially zero. CIRA researchers continue to assist SMS users and to find and fix bugs.

CIRA researchers assisted FIM developers with integration, parallelization errors, test suite issues, I/O issues, repository issues, interruptions in real-time runs, and general debugging. They assisted the FIM team with several time-critical tasks required to meet FIM project deadlines.

CIRA researchers continued collaborating with NCEP, Navy, NCAR, and NASA to define aspects of a Common Modeling Architecture (CMA) for the National Unified Operational Prediction Capability (NUOPC). The primary objective of the NUOPC's CMA is to reduce long-term costs of integrating and sharing software between the nation's three operational global weather prediction centers; Air Force Weather Agency (AFWA), Fleet Numerical Meteorology and Oceanography Center (FNMOC), and NCEP. They also served on the NUOPC Physics Interface to define APIs and conventions to allow easier sharing of physical parameterizations among NWP modeling systems. They continued collaborating with NCEP's John Michalakes on porting NWP codes to Intel Xeon Phi. And they continued attending NCEP's weekly UMIG meetings to discuss ongoing upgrades to NEMS and ensure that FIM continues to be NEMS-compliant.

CIRA researchers interviewed and hired Julie Schramm to join our team. Since her arrival Julie has upgraded NEMS inside FIM to bring it up to the standard of NCEP's NMMB model. She is now working to replace our use of the venerable Lahey compiler with the more modern NAG compiler in both FIM and NIM. These compilers are very good at catching difficult-to-find programming errors, greatly reducing development costs and risks.

CIRA researchers continued evaluating Intel's® Xeon® Phi (a.k.a. MIC, a.k.a. KNC) for the FIM and NIM models. We continue to work closely with an Intel team led by Mike Greenfield to tune performance of NIM on Xeon Phi without adversely impacting performance on traditional CPU architectures. Adopted cache-blocking scheme from John Michalakes' work on WSM5 microphysics scheme to WSM6 scheme used in MPAS, GRIMS, and NIM. Tuned it for performance with assistance from Mike Greenfield's group. Extended John Michalakes' approach to further improve performance of WSM* packages by applying optional compile-time constants to speed up "k-inside" loops in WSM6. Applied this technique to WSM5 and to the RRTMG longwave radiation with good speedup on both Xeon® and Xeon® Phi devices. Both the Intel® and Cray® Fortran compilers benefit from this optimization.

CIRA researchers continued to improve software engineering processes for FIM and NIM. CIRA researchers continued to assist NIM collaborators from CSU.

CIRA researchers attended several meetings and gave talks on GPU and Xeon Phi research at the Programming Weather, Climate, and Earth Systems Models workshop, GPU Technology Conference, the AOLI meeting at Boulder, an RRTMG meeting at NCAR, and Supercomputing 14. CIRA researchers also attended an Intel "dungeon" for a week of in-depth application-specific interactions with Intel hardware and software engineers. Lessons learned have already been incorporated into the NIM codebase.

PROJECT TITLE: EAR - Flow-following Finite-volume Icosahedral Model (FIM) Project

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Brian Jamison, Ning Wang, Ed Szoke

NOAA TECHNICAL CONTACT: Stanley Benjamin (OAR/ESRL/GSD/EMB Chief)

NOAA RESEARCH TEAM: Jian-Wen Bao (OAR/ESRL/PSD), Mark Govett (OAR/ESRL/GSD/ATO)

PROJECT OBJECTIVES:

1--Develop and improve FIM for global and continental scale weather prediction,
2--Develop and implement accurate and efficient numerical schemes for FIM on massively parallel computer systems,
3—Generate graphics of output fields, creation and management of websites for display of those graphics, and,
4—Create and manage graphics for public displays, including software for automatic real-time updates.

PROJECT ACCOMPLISHMENTS:

A website for display of FIM model output http://fim.noaa.gov/FIM/ was updated and currently has 7 separate versions of FIM with up to 63 products available in 21 regions for perusal with 6-hourly forecasts going out to 14 days. Many regions have improved resolution by using direct interpolation from the native icosahedral grid to a 0.125 degree global grid (approximately 14 km grid spacing).

Difference plots are generated and available, as are plots of forecast error. Cross sections are also being generated and are available at http://fim.noaa.gov/FIMxs/. Plot loops that show the progression of forecasts from model runs with the same valid time (dProg/dt) have been added and can be viewed at http://fim.noaa.gov/FIMdpdt/.

Many improvements and some new products were added to the model suites, including 6, 12 and 24-hour snowfall totals, run total snowfall, and integrated cloud condensate (Figure 1).

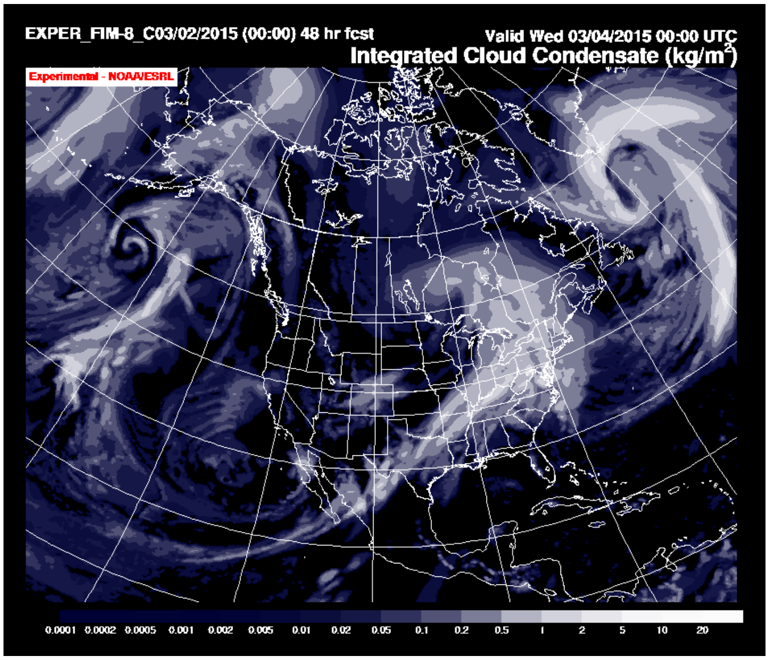


Figure 1. FIM subdomain showing integrated cloud condensate over N. America.

New processing techniques were installed to efficiently generate GRIB and binary data on multiple grids and provide faster production of graphics and better use of space saving applications to allow for products to be added and managed.

A dual-monitor hallway display on the second floor of the David Skaggs Research Center (DSRC) displays FIM model graphics for public viewing. Currently, a montage loop of four output fields is displayed and updated regularly.

A new spherical interpolation has been added to the FIM software package. The new interpolation produces a more accurate initial condition on icosahedral grid from an initial model state on a global Cartesian grid that has greater variation in spatial resolution.

New spherical spectral transform software was implemented to meet the need to use NCEP 13km high resolution initial condition data sets (T1534 spherical spectral data sets). The new software reduces both computation time and memory usage.

Two new high-order flux computation schemes have been implemented and experimented for FIM dynamics during 2014 hurricane season.

Frequent subjective evaluation is done with the various FIM versions using graphics from the FIM website, in order to compliment the ongoing objective verification that includes performance scores such as the Anomaly Correlation (AC) at 500 mb. Sometimes “dropouts” in the AC scores identify potential cases to pursue, otherwise challenging and significant weather events are identified. For example, the series of storms that hit the Northeast in a month-long period from late January into February have provided a number of interesting cases that are still being studied, and will be presented at an upcoming American Meteorological Society - Numerical Weather Prediction - Weather and Forecasting Conference this summer. The forecasts from the various FIM versions are compared, providing a check on whether the model version is performing as expected. Additionally, FIM model forecasts are compared to forecasts from other global models from the various operational centers, including models such as the GFS and ECMWF. AWIPS displays provide one source for the other models, but extensive use is made of an excellent model website maintained by GSD. Generally the various cases are presented at weekly FIM meetings, but also at conferences and other venues.

PROJECT TITLE: EAR - Nonhydrostatic Icosahedral Model (NIM) Project

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Ning Wang, Ka Yee Wong, Jung-Eun Kim, Thomas Henderson, Jacques Middlecoff, and James Rosinski

NOAA TECHNICAL CONTACT: Jin Luen Lee (OAR/ESRL/GSD/OD)

NOAA RESEARCH TEAM: Jian-Wen Bao (OAR/ESRL/PSD), Mark Govett (OAR/ESRL/GSD/ATO)

PROJECT OBJECTIVES:

--Develop Nonhydrostatic Icosahedral Model (NIM) for kilometer-scale resolution on multiple Central Processing Units (CPUs) and multiple Graphical Processing Units (GPUs) computing systems.
--Explicit prediction of small-scale weather systems such as topographic precipitation as well as convective macro-phenomenon like the Madden-Julian Oscillation (MJO).
--Diagnose and resolve atmospheric phenomenon using the NIM modeling system.

PROJECT ACCOMPLISHMENTS:

--Implemented and optimized dynamics and physics software for parallel CPU and GPU processing (via MPI and OpenMP) in preparation of ultra-high resolution runs.
--Improved and optimized pre-processing and post-processing software for parallel CPU and GPU processing (via OpenMP) for high resolution real data runs.
--GRIMs Cloud-Radiation interaction investigation under aqua- and land/sea planet.
--Upgraded the debugging and diagnostic package for NIM output analysis and visualization in HIWIP case and real data case.

PROJECT TITLE: EAR - Improving Short-Range Forecasts of Severe Weather and Aviation Weather from Enhancements to the Assimilation of Satellite Infrared Radiance Data from SEVIRI and GOES-R ABI (was EAR -Improving Mesoscale Forecasts of Severe Weather and Aviation Weather from Enhancements to Hyperspectral Satellite Data)

PRINCIPAL INVESTIGATOR: Haidao Lin and Sher Schranz

RESEARCH TEAM: Haidao Lin

NOAA TECHNICAL CONTACT: Steven Weygandt (OAR/ESRL/GSD/EMB)

NOAA RESEARCH TEAM: Curtis Alexander (CIRES)

PROJECT OBJECTIVE:

Investigate the impact from satellite hyperspectral data on severe storm forecasts in the Rapid Refresh and the increase in accuracy of short-range mesoscale model forecasts from the assimilation of satellite data into the Rapid Refresh.

PROJECT ACCOMPLISHMENTS:

In the past year, work has continued to evaluate the radiance data impact with the hybrid variational/Ensemble Kalman Filter (EnKF) data assimilation system within the Rapid Refresh (RAP) model. In preparation for the RAPv3 implementation at the National Center for Environmental Prediction (NCEP) in the middle of 2015, a series of one-month retrospective runs and multi-month real-time RAP runs with and without radiance data have been performed to evaluate the radiance impact within RAPv3 as well to evaluate the impact from Regional ATOVS Retransmission Services (RARS) real-time data files. The RARS data have better real-time coverage than the regular feed. Figure 1 shows the statistical results based on one-month (05/01/2013-05/31/2013) data sets for AMSU-A channel 3 from the NOAA-18 platform. It can be seen that the regular feed data have daily average of 5.8% while the RARS feed have around 41%, thus showing that the RARS feed data can significantly increase the hourly radiance data coverage for RAP. This is the same case for the hourly averaged percent (Figs. 1b,c).

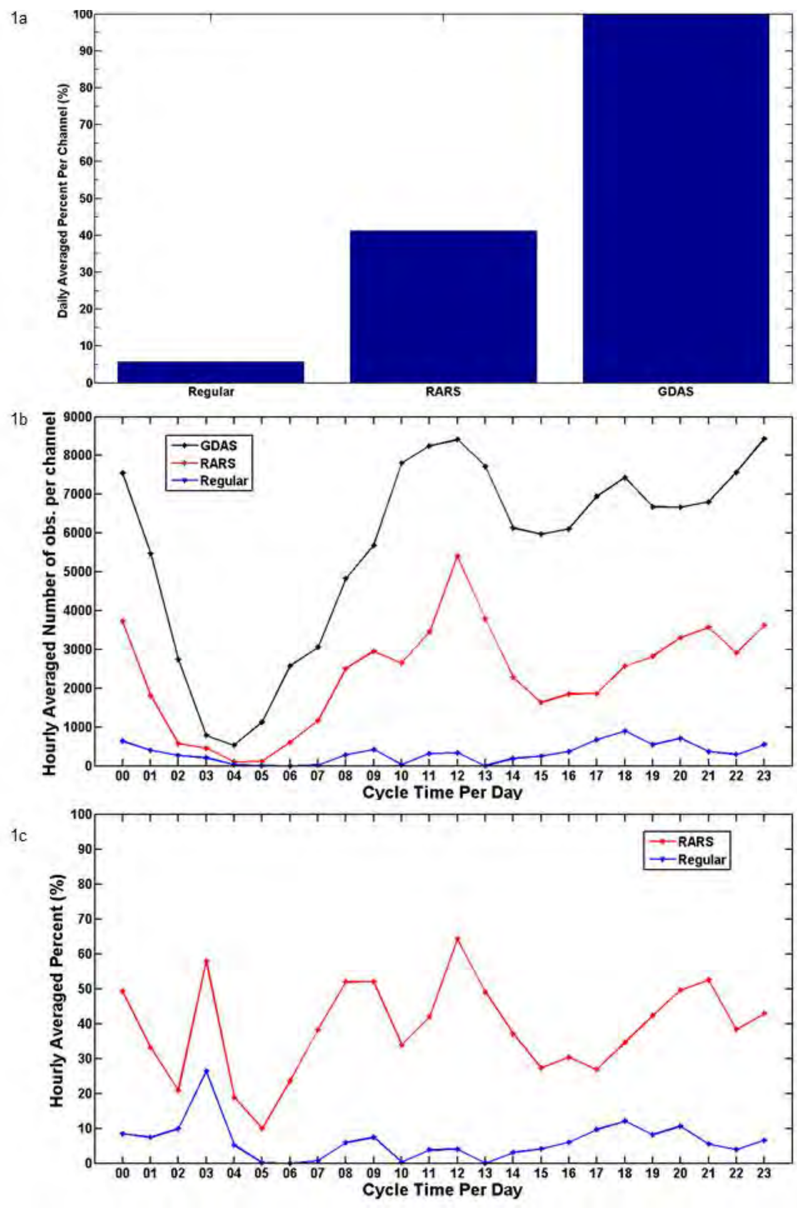


Figure 1. (a) Daily averaged percent (%) and (b) Hourly averaged observation number, for regular feed, RARS feed, and ideal condition GDAS conditions, (c) hourly averaged observation percent for regular feed and RARS feed against ideal conditions. Statistics are computed for from NOAA-18 AMSU-A channel 3 over the RAP domain over one-month period (05/01/2013-05/31/2013). The time window is +/- 1.5 hour.

Figure 2 shows the mean percent reduction in forecast error [(CNTL – EXPT)/CNTL], computed against radiosonde observations, with positive values indicating reduced errors, for the one-month retrospective experiments in which radiance regular feed (blue) and RARS feed data are assimilated. The control run used conventional data only. The radiance retrospective runs use the radiance updates for RAPv3. The black error bar indicates the ±2 standard error from the mean impact, representing the 95% confidence threshold for significance. It is noted from Fig. 2 that satellite radiance data have consistent encouraging positive impact for all forecast hours and for all variables with 95% statistical significance, with the largest impact around 1.2%-1.5% for temperature, moisture, and wind from the RARS included experiment.

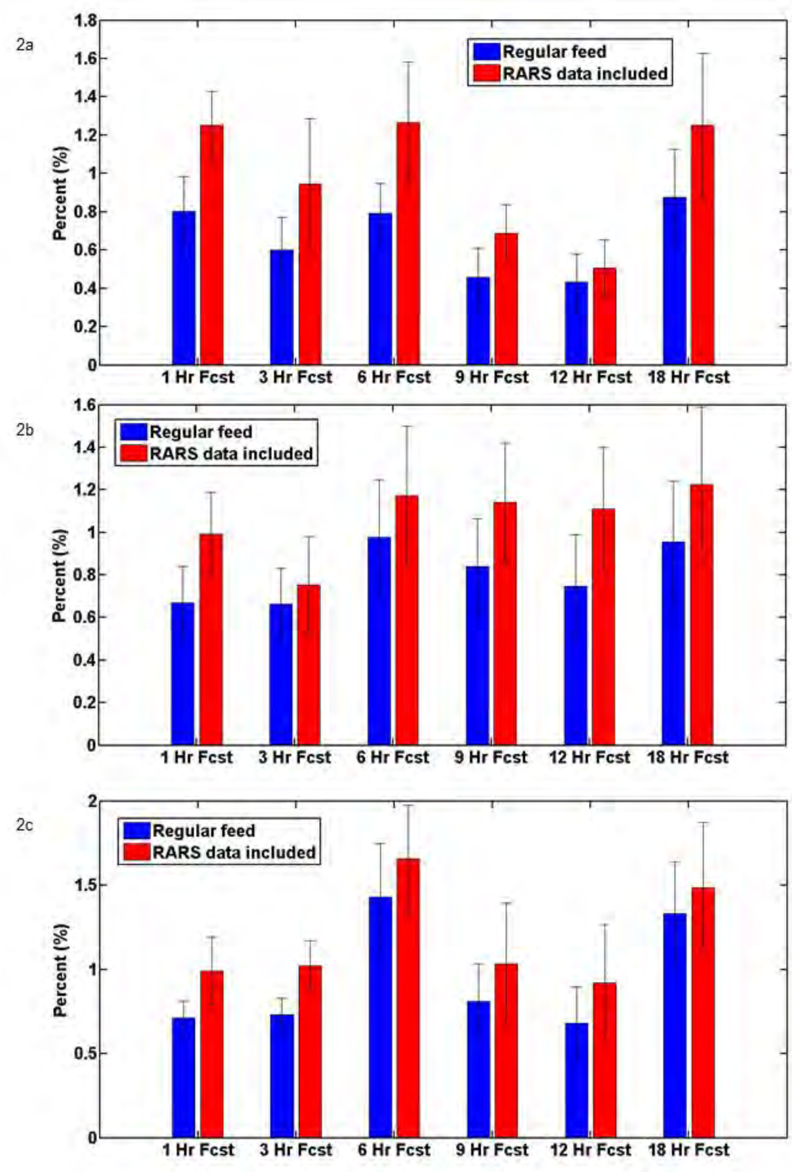


Figure 2. Normalized error reduction [(CNTL – EXPT)/CNTL] (%) from RAP real time regular feed data (blue), real time data plus RARS feed data (red), for (a) temperature, (b) relative humidity, and (c) wind. The control run uses conventional data only. Statistics are computed for 1000-100-hPa layer over the RAP domain. The retrospective period is from May 01 to May 31 2013. The error bar indicates the ±2 standard error from the mean impact, representing the 95% confidence threshold for significance.

In order to evaluate the relative impact of radiance data compared with other observation sets, two additional hourly one-month aircraft and radiosonde data denial retrospective runs for the same period with Fig. 2 are performed. Figure 3 shows the normalized error reduction from radiance denial (red), aircraft denial (blue), and radiosonde denial (yellow), experiments, normalized to the control experiment, which assimilated all data (including radiance, aircraft, radiosonde, and other available conventional data). From Fig. 3, it is noted that radiance data have similar impact (around 1-2% error reduction) with radiosonde data and have much smaller impact than the aircraft data, which have the largest impact (up to around 13% error reduction for temperature) within RAP. It is also noted that the relative impact between radiance and aircraft for moisture verification is much smaller than temperature and wind.

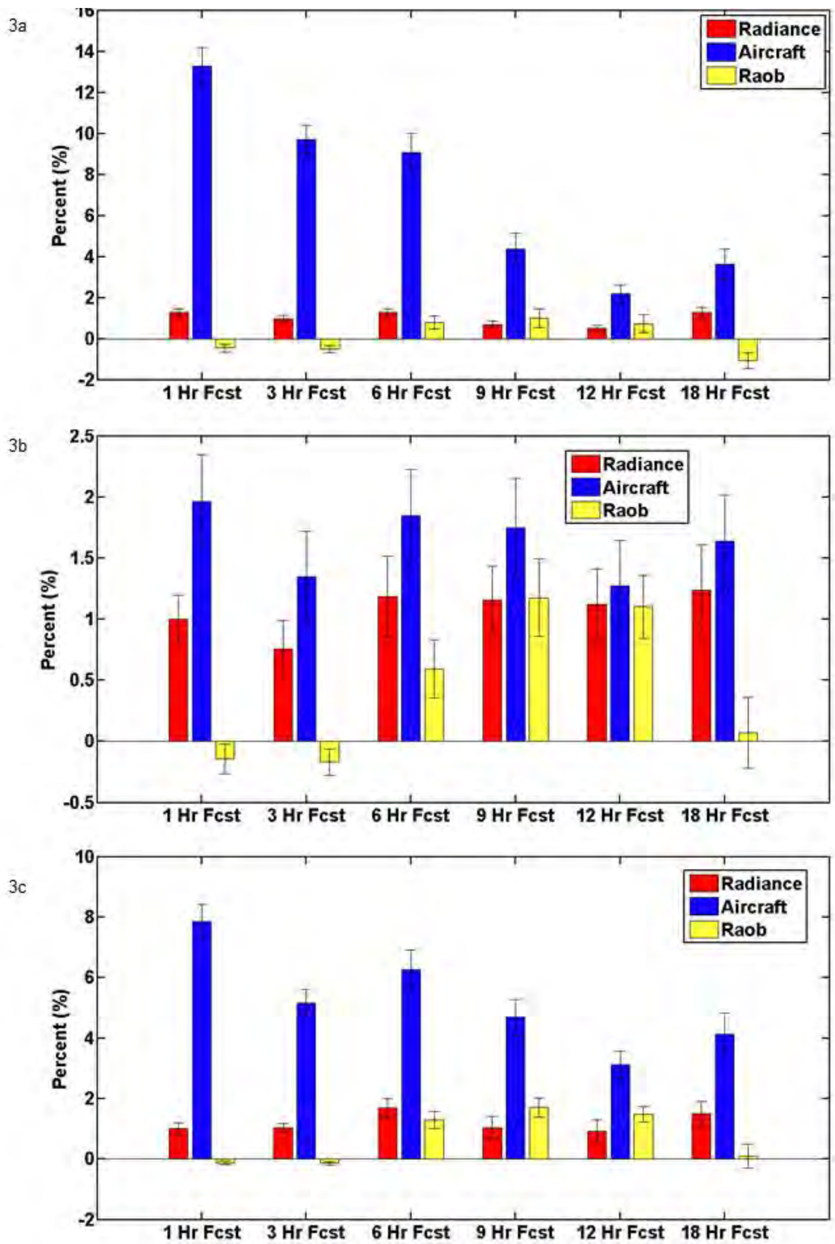


Figure 3. Normalized error reduction (%) for radiance (red), aircraft (blue), and radiosonde data (yellow) for (a) temperature, (b) relative humidity, and (c) wind. The control run uses all data. Statistics are computed for 1000-100-hPa layer over the RAP domain. The retrospective period is from May 01 to May 31 2013. The error bar indicates the ±2 standard error from the mean impact, representing the 95% confidence threshold for significance.

Work has also been focused on the preparation of a manuscript for AIRS radiance assimilation within RAP, including several one-month (May01-May31 2010) RAP retrospective runs with and without AIRS radiance data. Figure 4 shows the 3-, 6-, 9-, and 12-h forecast normalized impact (%) for temperature and relative humidity for different atmospheric layers. Assimilation of AIRS radiance has an overall small positive impact with significance for most layers and forecast hours for temperature and relative humidity. For the full atmospheric layer (1000-100 hPa for temperature, and 1000-400 hPa for relative humidity), positive normalized impact (with the largest impact nearly 0.3% and 0.6% respectively) has been seen for temperature and moisture for all forecast hours. The maximum normalized impact for temperature (around 0.9%) is obtained for the 800-400-hPa-layer at the 3-h forecast. For relative humidity, the maximum normalized impact is nearly 0.8% and is also for the 800-400-hPa layer but at the 6-h forecast.

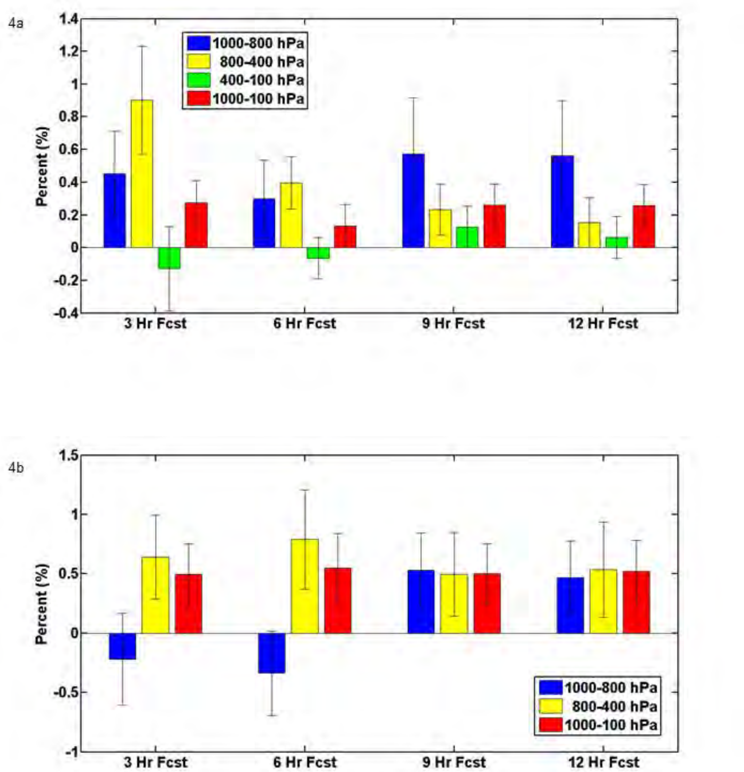


Figure 4. Normalized impact (%) from AIRS radiance experiment for (a) temperature and (b) moisture for different vertical layers (1000-800-hPa: blue; 800-400-hPa: yellow; 400-100-hPa: green; 1000-100-hPa: red) computed against available radiosonde observations over one-month period. The error bar indicates the ±2 standard error from the mean impact, representing the 95% confidence threshold for significance.

In addition, as the first step to extend GSD's ability on radiance assimilation under global framework, we've also begun the satellite radiance work within GDAS/GFS global system, starting from the learning and testing of the GDAS/GFS system. A control run including the SEVIRI radiance data within GDAS has finished. More experiments using GOES-R ABI proxy infrared data within GDAS/GFS system are underway.

PROJECT TITLE: EAR - Fire Weather Modeling and Research

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Sher Schranz, Evan Polster

NOAA TECHNICAL CONTACT: Peter Roohr (NWS/OST)

NOAA RESEARCH TEAM: Robyn Heffernen (NWS/OCWWS), Steven Peckham (CIRES)

PROJECT OBJECTIVES:

A NOAA Research to Operations Letter of Intent was accepted by NOAA to provide funding for this project. At this point there are no NOAA funds available to this program.

PROJECT ACCOMPLISHMENTS:

No fire weather presentations were reported this year. A NASA ROSES Proposal sustained this effort and results will be presented to NOAA at the March 25th meeting.

DATA ASSIMILATION

Research to develop and improve techniques to assimilate environmental observations, including satellite, terrestrial, oceanic, and biological observations, to produce the best estimate of the environmental state at the time of the observations for use in analysis, modeling, and prediction activities associated with weather/climate predictions (minutes to months) and analysis.

PROJECT TITLE: EAR - Assimilation of Aerosol Observations using GSI and EnKF with WRF-Chem and CMAQ

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Mariusz Pagowski

NOAA TECHNICAL CONTACT: Georg Grell (OAR/ESRL/GSD/EMB)

PROJECT OBJECTIVES:

1--Improve aerosol data assimilation methods for air quality forecasting.
2--Perform evaluation of forecasts.

PROJECT ACCOMPLISHMENTS:

Our activities concentrated on examining the effects of aerosols on weather, improving PM2.5 forecasts with WRF-Chem, and operational implementation of PM2.5 assimilation to CMAQ model.
Aerosol simulations are improved thanks to the assimilation of MODIS Aerosols Optical Depth (AOD), which crucially affects scattering and absorption of shortwave atmospheric radiation. Physical parameterizations of the model allow for aerosol feedbacks which can be turned on and off in sensitivity studies. Verification statistics for aerosols and weather forecasts derived over a 3-month-long summer period are presented. We refer the reader to the manuscript for details.

A talk on the effects of aerosols on meteorology based on results from WRF-Chem simulations over North America has been presented at The World Weather Open Science Conference in Montreal, during August of 2014, and a manuscript has been prepared for publication in the Journal of Geophysical Research. Also, we participated in an experiment from a Working Group for Numerical Experimentation (WGNE) which is focused on aerosol impacts on weather prediction. The WGNE participants included the European Center for Medium-range Weather Forecasting (ECMWF), NASA, JMA, and NCEP.

Accurate prediction of surface PM2.5 concentrations for twelve or more hours remains beyond the capacity of known operational air quality models. From our experience with WRF-Chem and CMAQ we can demonstrate that the positive impact of surface PM2.5 assimilation is immediate and significant but not long-lasting. Unreliable estimates of emissions sources are a primary contributor to the error of forecasts. In the current work we attempt to improve on emissions using Ensemble Kalman Filter (EnKF). Through the mechanics of the filter the emissions can be corrected via a process referred to as parameter estimation. Using the new emissions inventory based on NEI-2011 (McKeen and Ahmadov, 2014, personal communication), we performed an assimilation and emission estimation study for a month-long simulation. In Figure 1 statistics for this study are shown. They demonstrate that the emission estimation improves the forecast correlation but has worse bias compared to simulations without the source emission adjustment. This stems from the fact that estimation procedures can lead to unrealistic negative values of emissions that need to be set to zero to remain physical. We are currently working on modifying our approach by replacing model concentrations and emissions with their logarithms to prevent negativity. Still, the approach with logarithms is not straightforward since concentrations can relate to emissions via linear regressions that are used by the filter. This cannot be done by logarithms of emissions. We plan to test whether an improvement in forecasts can be achieved if instead logarithms of total aerosol mass and total emissions are first regressed and then split into the individual aerosol species and emission sources based on their a-priori contribution.

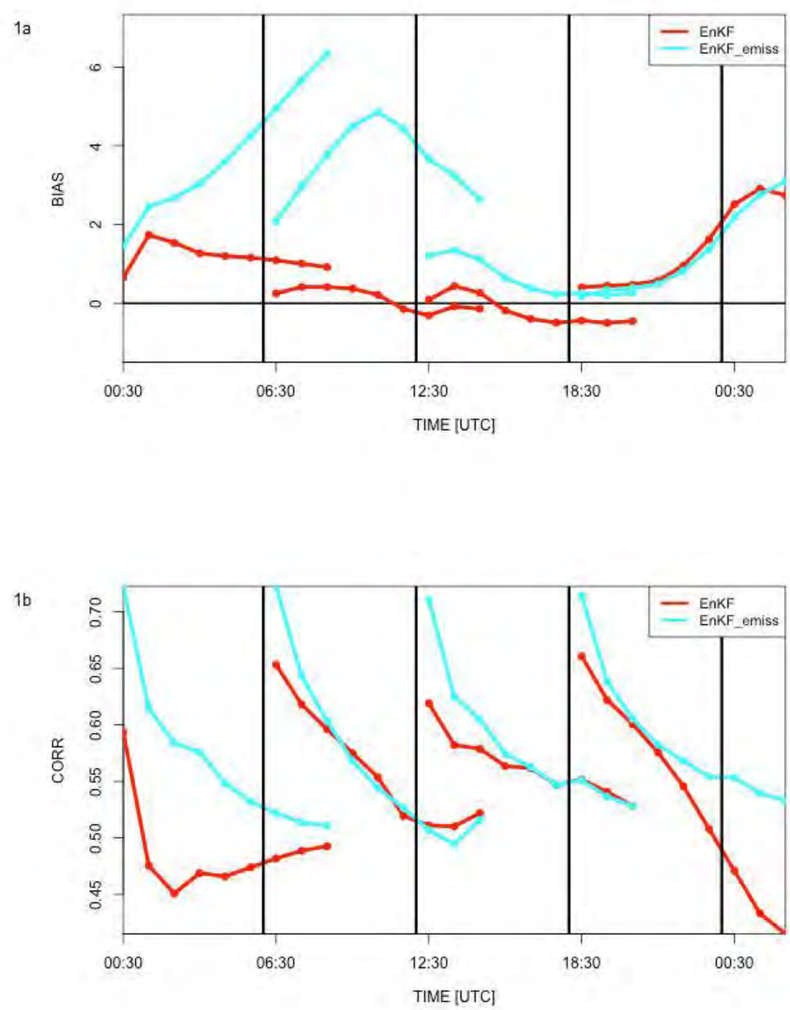


Figure 1. Bias (a) and correlation (b) of forecasts. (A) With EnKF data assimilation and (B) without emission adjustment.

Also, during the reporting period we helped to implement PM2.5 assimilation at Shanghai Weather Bureau for their real-time operational aerosol forecasts. A study by Wu et al. (2014) detailing results of this collaboration has been accepted for publication.

Finally, we contributed to a manuscript on a review of existing data assimilation methods in coupled chemistry-meteorology models by Bocquet et al. (2014), currently under review.

We continue to work towards operational implementation of surface PM2.5 assimilation for national aerosol forecasts using the CMAQ model. Data assimilation will be based on a 3D-Var methodology using the Gridpoint Statistical Interpolation (GSI) analysis system. In collaboration with NCEP's air quality group we are testing CMAQ on Zeus. We derived background error statistics for summer and winter seasons. These statistics are plotted in Figure 2. We are currently working on the implementation of PM2.5 assimilation for CMAQ within the GSI. Computer code that we previously deposited in the GSI trunk is not working properly in the recent version of the GSI and requires modifications and testing. This remains our most urgent task and we plan to provide NCEP with operational code during the next reporting period.

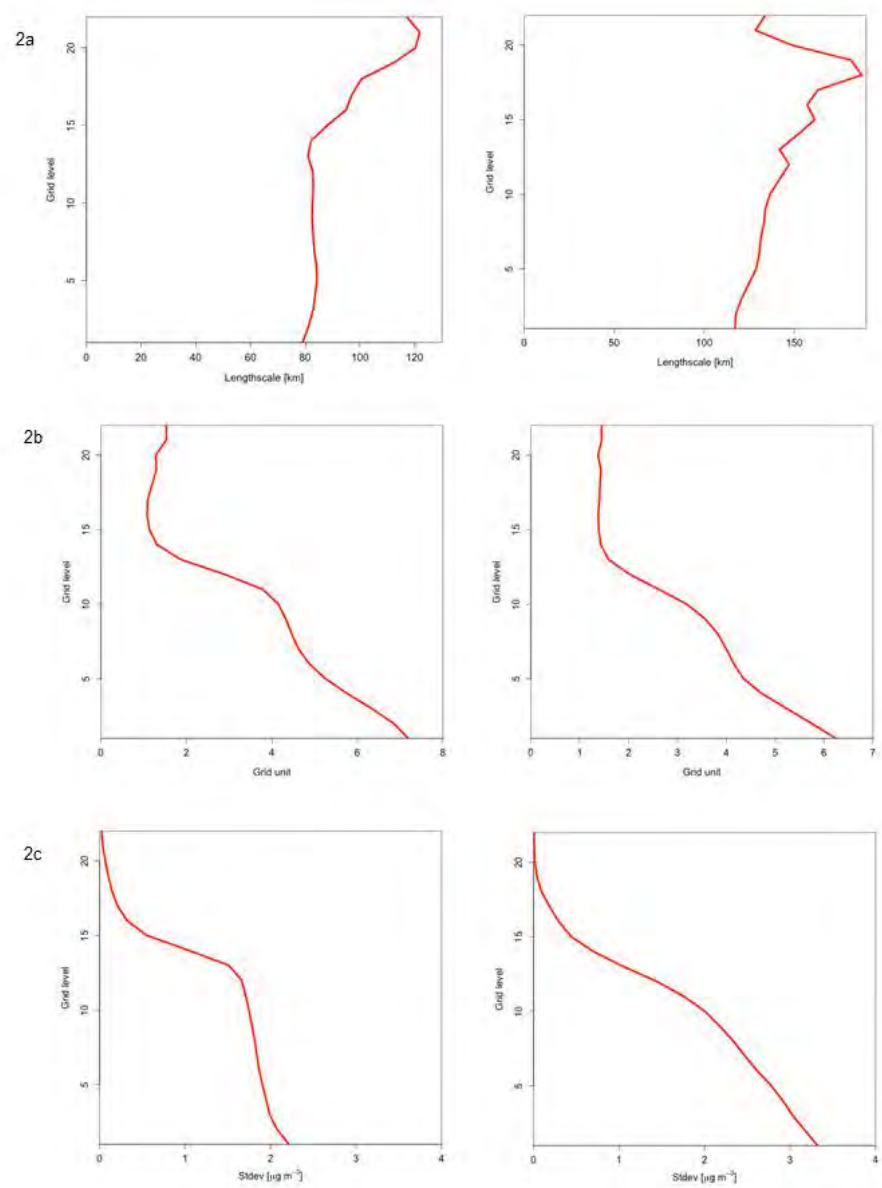


Figure 2. Background error statistics for summer (left) and winter (right). From the top: (a) horizontal error correlation lengthscales, (b) vertical error correlation lengthscales, (c) standard error deviation.

PROJECT TITLE: EAR - Local Analysis and Prediction System

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Steven Albers, Hongli Jiang, Hongli Wang

NOAA TECHNICAL CONTACT: Stan Benjamin (OAR/ESRL/GSD/ EMB Chief)

PROJECT OBJECTIVES:

Improve and enhance the LAPS in providing real-time, three-dimensional, local-scale analyses and short-range forecasts for domestic and foreign operational weather offices, facilities, and aviation and other field operations.

Examine and evaluate issues associated with model initialization and cycling process, and work towards improvement of these processes.

Study improvements to analysis techniques, diabatic initialization and balance package, WRF model initialization, ensemble forecasting techniques as well as model forecast verification at various LAPS sites.

Continue long-term collaboration with GSD to have LAPS (also referred to as the traditional LAPS to distinguish from vLAPS) and variational LAPS (aka STMAS, hereafter denoted as vLAPS) software running in the National Weather Service Weather Forecast Offices (WFOs) for evaluation and use by operational forecasters in both AWIPS and AWIPS II.

Support HMT operations in California as part of HMT-WEST legacy. Similar efforts, including support of the analysis and modeling system, will continue in support of the California Dept. of Water Resources (DWR). Furthermore, CIRA will participate in support of the analysis and forecast systems as well as model forecasting, including ensembles, for the HMT-EAST field project.

Participate in Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP), and Warn on Forecast activities.

PROJECT ACCOMPLISHMENTS:

1--LAPS/WRF Improvements
Within FAB and EMB, CIRA personnel continue to play a leading role in development and implementation of meteorological analyses (e.g. wind, clouds, temperature, and precipitation), data ingest, and auxiliary processing, and web displays within the LAPS. This includes overall management of the configuration, updates, and distribution of the LAPS (including vLAPS) system. We've thus been highly motivated to lead the coordination of new ideas for development in LAPS including variational LAPS. For LAPS and vLAPS, we worked to improve the analyses with a particular focus in the following areas:
--First Guess Processing
--Observational Data Sets
--Cloud / Precipitation Analyses
--LAPS/VLAPS Model Initialization/Post Processing
--General Software Improvements & Portability
--LAPS Implementation

We maintain the LAPS software distribution and the associated website. This involves more than 100 users both in the U.S. and internationally.

Various in-house runs are being supported including a high-resolution 500m LAPS 3D analysis with a 15-min cycle. A global analysis is also being run.

WWW LAPS Interface

Webpages were significantly improved for plotting analysis and forecast fields for LAPS including vLAPS. The "on-the-fly" page has additional cloud related fields and improved animation capability. Our achievements for this project compare favorably with the goals projected in the statement of work.

All-sky Camera

CIRA is conducting exploratory development in the use of an all-sky camera for model validation and assimilation. The LAPS cloud analysis uses satellite (including IR and 1-km resolution visible imagery, updated every 15-min), METARs, radar, aircraft and model first guess information to produce 3-D fields of cloud fraction, cloud liquid, cloud ice, rain, snow, and precipitating ice. This analysis is currently being done by the long-standing, largely sequential data insertion procedure developed within LAPS, though we are presently developing a variational version of this procedure. To help visualize and validate the cloud analysis a ray-tracing procedure was developed to construct simulated all-sky imagery. The visualization procedure efficiently considers various aspects of radiative transfer in clouds, precipitation, and aerosols. The terrain is also visualized from vantage points located on the Earth's surface. The all-sky imagery, in either a polar or cylindrical projection, can show either analysis or forecast fields. We will present ongoing results of this simulated imagery, along with comparisons to actual CCD images produced by an all-sky camera that is located within our Colorado 500m resolution domain. These comparisons check the skill of the existing analysis at high-resolution, and help communicate the model results in a visual manner to scientific and lay audiences. LAPS/WRF hot-started forecasts are also being visualized, one example being the case of the Moore, Oklahoma tornado on May 20, 2013. The simulated images can be made any time of the day or night, using sunlight, twilight, moonlight, or city lights as light sources. Our plans include using all-sky cameras directly in data assimilation to help fill observational gaps at small-scales.

Figure 1. In these 360 degree panoramic views, the top is a simulated LAPS image and bottom is a remapped camera image from an all-sky camera maintained by the Earth Systems Research Laboratory. South is at the center of each image and north is at the edges.

2--VLAPS-3D Development and Improvements, Analysis and Data-Assimilation improvements

We are running a hybrid system with vLAPS where analysis modules from both the new variational LAPS software are combined with some from “traditional” LAPS. This provides an ideal testing platform as we phase in vLAPS improvements. As the vLAPS analysis is embedded within the overall LAPS software package, most improvements mentioned regarding LAPS have a direct benefit to vLAPS. There are also items we will highlight that are more specific to vLAPS analysis development.

One LAPS improvement relates to the variational cloud analysis where some improved cost function routines were developed to help improve the fit to visible and 11-micron IR satellite imagery. Cloud analysis improvements were made on several additional fronts, for example improved analysis of thin cirrus clouds. Blending between model first guess, METAR, and visible/IR satellite (including cloud albedo and optical depth) were all improved to be done in a more consistent manner to produce microphysical analysis fields. We continue to look at the use of satellite products such as cloud optical thickness and liquid water path to help provide input to the variational cost function. Observation operators for the cloud optical path assimilation have been developed and incorporated into the vLAPS system. Additionally we are setting up an option to use CRTM or similar radiative transfer models as forward models working more directly with satellite radiances in the cloudy areas.

To provide a best background for vLAPS, a scale-dependent blending scheme for WRF model was developed. Due to limitation of the domain size and limited observations used in regional data assimilation and forecasting systems, regional forecasts suffer a general deficiency in effective representation of large-scale features as those in global analyses and forecasts. The scale-dependent blending scheme using a low-pass Raymond tangent implicit filter was implemented to re-introduce large-scale weather features from global model forecasts. The impacts of the scheme on vLAPS analysis and forecast will be examined in future.

In connection with the all-sky camera work mentioned in section 1, we are planning and testing development using our object oriented software design. This can give us a good strategy for actually assimilating camera images in the variational cloud analysis, using a forward operator derived from our all-sky visualization data. Hopefully CRTM can also be improved to allow all-sky camera assimilation similar to what is done with satellite data. Thus a unified set of libraries is supporting image/radiance data from both cameras and satellites. This software is being designed to be interoperable with various analysis systems including LAPS and GSI, and global 4DVAR analysis.

3--Range Standardization and Automation (RSA) Project
We coordinated with federal personnel to give support to the western launch range (WR) at Vandenberg, CA to use a recently updated version of the LAPS analysis along with the WRF forecast model. This includes support of an on-site visit by NOAA personnel at Vandenberg in January, 2015.

4—NWS Interaction
--AWIPS and AWIPSII
We continue a long-term effort to have LAPS software running in the National Weather Service WFO's (on AWIPS) for evaluation and use by operational forecasters.

Discussions are being held about ongoing efforts to upgrade LAPS and introduce LAPS and vLAPS in the new AWIPS-II workstations running in National Weather Service WFOs. There are two AWIPS-II builds where LAPS analysis is included as an operational system and LAPS is being supported in some legacy AWIPS-I WFO locations.

A new version of the vLAPS surface is nearing the end of development and testing, which is:
--Multivariate analysis
--Topography incorporated
--Background flow dependent
--Simple surface constraints used

The test version of vLAPS is presently being evaluated at the Boulder WFO. A high resolution (1-km horizontal grid spacing) WRF-ARW model run is available four times per day for potential use by the local NWS office in Boulder.

EFF Activities
We continued our interaction with the local NWS WFO in Boulder, located in the David Skaggs Research Center. CIRA Researchers took part in presenting weather briefings.

5--Hydrometeorological Testbed (HMT) / California Department of Water Resources (DWR) Model Ensembles and Ensemble Post Processing
Ensemble forecast system testing and implementation continued in support of the Hydrometeorological Testbed and the project supported by California's Department of Water Resources. The Experimental Regional Ensemble Forecast (*ExREF*) System runs over the North American domain and California sub-region have continued during the winter season of 2013-2014. We are evaluating real-time precipitation verification of our runs. The ensemble design in terms of dynamic cores and physics stayed the same as previous years (3 WRF-ARW runs with various microphysics and one WRF-NMM run). The additional variety has been added by using the GFS ensemble members to provide lateral boundary conditions for the HMT/DWR ensemble members.

6--Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP)
Three domains were set up for participating in the HWT EWP 2014. One is a CONUS domain (surface analysis only) with 2.5km resolution, the second is a regional (800x800 km), on demand, re-locatable 1km domain, and the third is sub-regional (200x200 km), on demand, re-locatable, 1 km resolution domain for 3-D analyses and forecasts. All three domains generate output at 15 min frequency. The sub-regional domain is too small to be used widely. Below we will focus on the CONUS and the 800x800 domains.

The 1km resolution forecast was initialized hourly using the vLAPS analysis, and forecast out 4 hours. A list of meteorological variables of interest generated and derived from vLAPS was transferred to National Severe Storm Laboratory (NSSL) in Norman, OK and evaluated by the forecasters over the four-week period of HWT 2014 Spring Forecast Experiment (EWP). These results were used in experimental warning preparation and comparison among several models and observations. Hongli Jiang and Steve Albers each spent periods in Norman to participate the daily activities during the EWP. Results of EWP 2013 and 2014 were presented at the AMS 2015 conference and have been submitted to BAMS for publication. Forecaster feedback was very valuable.

Real-time verification was further developed and made available online so we can look at the quality of radar reflectivity and other forecasts. All analyses and forecast data were archived during EWP 2014 for future case studies.

7--Army Research Lab (ARL)
In collaboration with NOAA colleagues, CIRA is working with ARL to perform case reruns of the LAPS/WRF system. Various nudging and assimilation techniques are being tested to see which ones produce optimal forecasts.

8--Victoria Cloud Project
CIRA is leading a potentially funded project to refine a version of vLAPS for implementation over the Lake Victoria region of Africa. Discussions have continued with NOAA and WMO officials on the best ways for CIRA to contribute. There are two areas of Africa that would be of interest, one near Lake Victoria and another in and around South Africa.

9--Global Precipitation Measurement
CIRA is participating in a funded project to utilize Global Precipitation Measurement (GPM) proxy data to initialize a LAPS/WRF simulation. We engaged in advisory work with federal partners on the best methodologies for acquiring and processing Tropical Rainfall Measurement Mission (TRMM) space-borne radar data so that it can be read into and analyzed by LAPS.

10--Applications of Concurrent Super Rapid Sampling from GOES-14 SRSOR Radar and Lightning Data, in cooperation with NESDIS: CIRA is leading FAB's role in a funded project to utilize high-frequency radar and satellite data to initialize LAPS/WRF simulations. This is in collaboration with NSSL. We have been gathering data for several Local Analysis and Prediction System (LAPS) case reruns, starting with the Moore tornado case from May 20, 2013. This involves retrieving routinely archived observational data from NOAA's High Performance Computing Mass Storage. In addition, Level-II Doppler radar data are being obtained from the National Climatic Data Center. Our processing scripts are being updated to support the new Java application for converting this into NetCDF. Special cloud-drift wind data from the 1-minute GOES-R data have also been reformatted to be readable by LAPS. Preliminary reanalysis runs with the routinely archived data have been performed. We've also tested with rerunning the WRF forecast on this case, and we plan to rerun this with the recent reanalysis fields.

Additional cases have been selected for several days in 2014, and the GOES-R cloud-drift wind data have been processed. We will be gathering the other observational data so we can perform LAPS/WRF reruns.

A related activity is a collaboration to add a severe weather probability index based on 3-dimensional LAPS forecast fields. We are presently evaluating the software package to see if it can be linked into the LAPS forecast post-processor.

11--Other activities
A project is being developed with a company in Colorado Springs called PEMDAS using the LAPS cloud analysis and possibly forecasts. This is in support of US Air Force drone operations.

In collaboration with the GSD/ATO branch, a director's discretionary fund proposal is being prepared for visualization of clouds and related fields from model data in a computer display system capable of a fly through environment (TerraViz).

PROJECT TITLE: NESDIS Environmental Applications Team – Tanvir Islam, Post Doc

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Tanvir Islam

NOAA TECHNICAL CONTACT: Xiwu Zhan, NOAA/NESDIS/STAR

NOAA RESEARCH TEAM: Xiwu Zhan, Sid Boukabara, Christopher Grassotti, Kevin Garrett, Craig Smith, Pan Liang

PROJECT OBJECTIVES:

1--MiRS v11 algorithm package readiness for operational implementation

2--Extend and enhance the capability and performance of the Microwave Integrated Retrieval System (MiRS) for GMI onboard GPM Satellite

3--Integration of snowfall rate (SFR) retrieval algorithm in the MiRS framework

PROJECT ACCOMPLISHMENTS:

Objective 1: MiRS v11 algorithm package readiness for operational implementation

A newer version of the MiRS system (version 11) has been released operationally to be applied to all operational satellite platforms. In this new release, significant changes have been made that have led to improved retrievals for certain geophysical products. The notable updates in the MiRS v11 release include- 1) updated forward modeling capability from pCRTM version to CRTM v2.1.1, 2) updated microwave sea surface emissivity model (FASTEM-5), 3) implementation of a dynamic spatially and temporally varied a priori database, and 4) improved retrieval of hydrometeor quantities with a modified physically-based surface rain rate relationship.

Figure 1 demonstrates one example by illustrating the performance of MiRS/MetopB temperature sounding retrieval in comparison with the ECMWF analysis field for v9.2 and v11 releases.

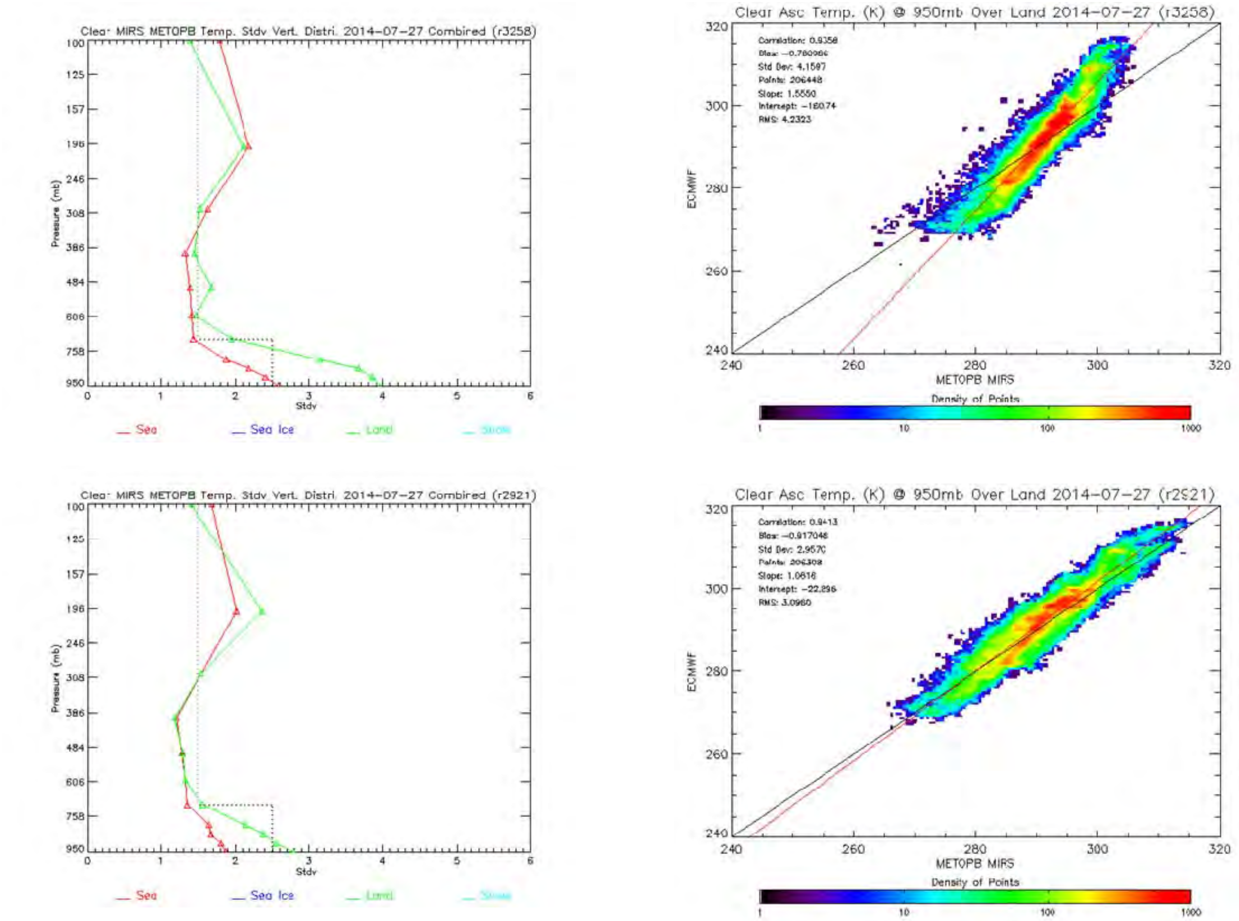


Figure 1. An example illustrating the performance of MiRS/MetopB temperature retrieval in comparison with the ECMWF analysis field for v9.2 (top), and v11 (bottom) releases, (left) error profiling, (right) scattergrams at 950 mb.

Objective 2: Extend and enhance the capability and performance of the Microwave Integrated Retrieval System (MiRS) for GMI onboard GPM Satellite

The Microwave Integrated Retrieval System (MiRS), which is the official NOAA microwave retrieval algorithm for processing passive microwave observations from more than 7 different operational satellites, has been extended to data from the recently launched GPM Microwave Imager (GMI). Using a variational approach, the system simultaneously retrieves hydrometeor profiles (e.g. cloud, rain, and ice), as well as sounding and surface state parameters, which are all parts of the multidimensional state vector. Once the state vector is retrieved, further post-processing is carried out to derive important hydrometeor products such as the cloud water path, ice water path, and rain water path, which are then converted to surface rain rate using a physical relationship between water path amount and surface rain rate derived from offline simulations of a mesoscale model. Additional derived geophysical products include total precipitable water from vertical moisture profiles, and the sea ice concentration and the snow water equivalent from emissivity spectra. Since the surface emissivity is included as part of the state vector, an all-surface retrieval has been possible without compromising a smooth transition of the geophysical products across different surfaces. The algorithm is readily applicable to both cross-track sounders and conical imagers without needing any cross-calibration of radiometric measurements between the sensors in the GPM constellation.

An example of retrieved hydrometeor parameters using the MiRS 1DVAR algorithm applied to measurements from the GMI sensor on-board the GPM core satellite is shown in Figure 2 for typhoon Hagupit case.

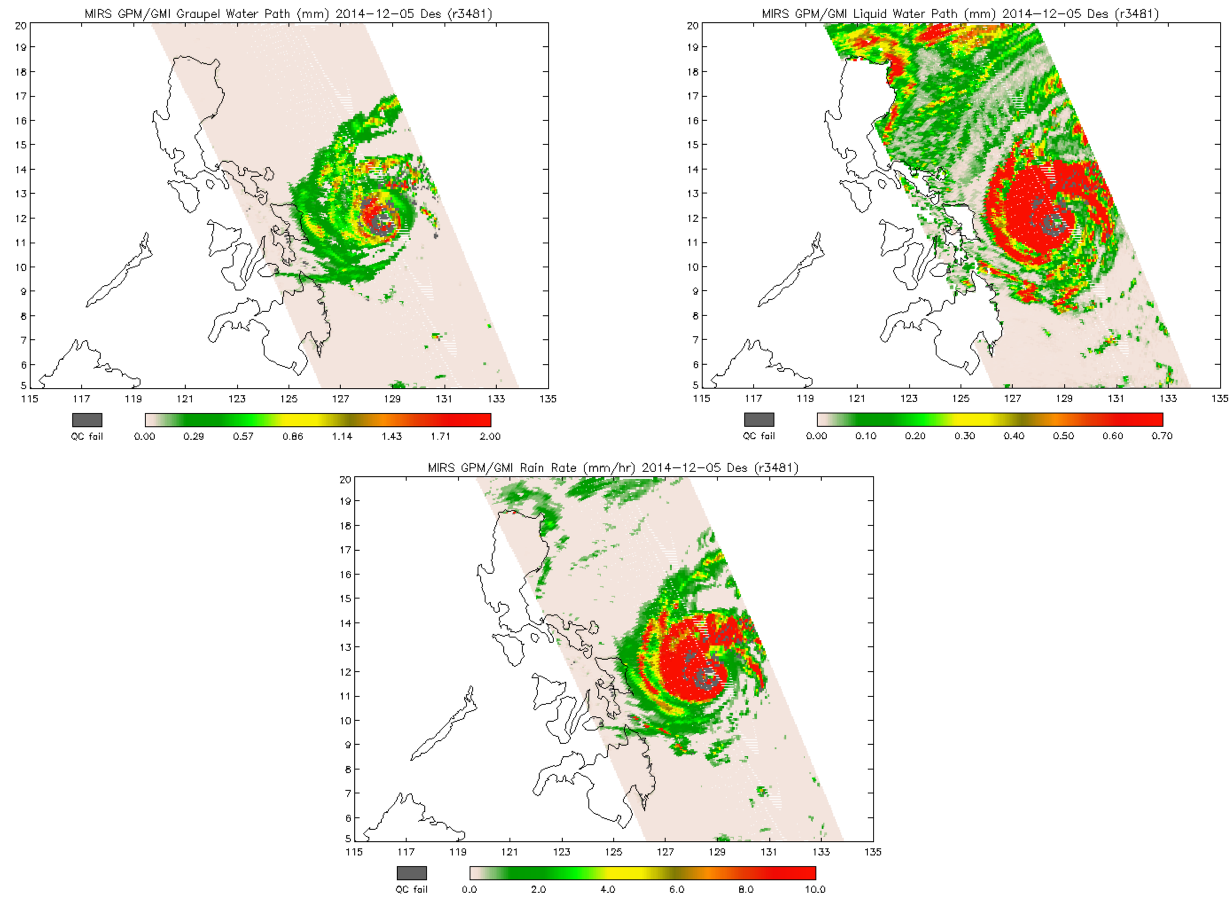


Figure 2. An example of retrieved hydrometeor parameters using the MiRS 1DVAR algorithm applied to measurements from the GMI sensor on-board the GPM core satellite for Typhoon Hagupit case.

Objective 3: Integration of snowfall rate (SFR) retrieval algorithm in the MiRS framework

The snowfall rate retrieval algorithm for AMSU-A/MHS sensors onboard NOAA and Metop satellites, which was originally developed for the MSPPS system, is now integrated in the MiRS framework. The algorithm will soon replace the heritage MSPPS algorithm for NOAA's unique SFR product generation. Figure 3 provides an example of MiRS snowfall rate map over the US continent and compares it against the SNODAS product.

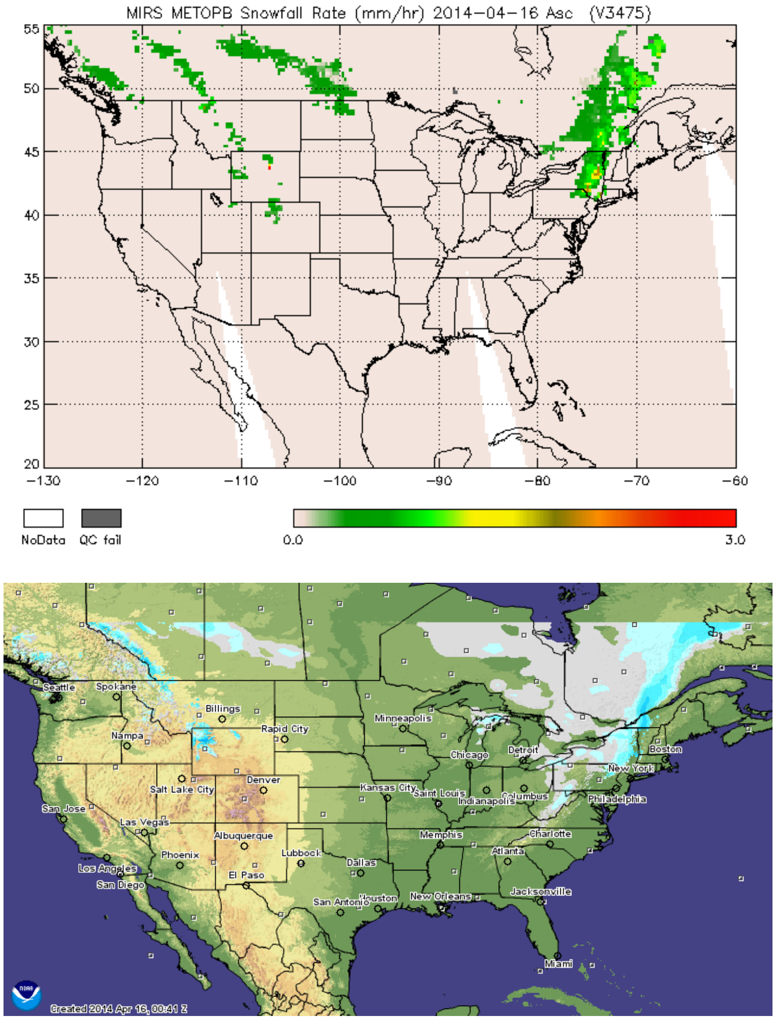


Figure 3. An example of MiRS snowfall rate map over the US continent (top) and corresponding SNODAS product for comparison (bottom).

CLIMATE-WEATHER PROCESSES

Research focusing on using numerical models and environmental data, including satellite observations, to understand processes that are important to creating environmental changes on weather and short-term climate timescales (minutes to months) and the two-way interactions between weather systems and regional climate.

PROJECT TITLE: Building a "Citizen Science" Soil Moisture Monitoring System Utilizing the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS)

PRINCIPAL INVESTIGATOR: Nolan Doesken, Dept. of Atmospheric Science, CSU

RESEARCH TEAM: Julian Turner, Noah Newman, Zach Schwalbe, Peter Goble, Henry Reges, Wendy Ryan

NOAA TECHNICAL CONTACT: Veve Dehaza, NOAA NIDIS Program Office, Boulder, CO

NOAA RESEARCH TEAM: NA

PROJECT OBJECTIVE(S):

Soil moisture is a key lead indicator in the development, severity and impact of drought but is not adequately monitored in most parts of the country. A new NASA satellite mission – the Soil Moisture Active Passive (SMAP) satellite has recently been launched and will be capable of sensing soil moisture near the skin surface of the Earth but not in the root zone of most plants.

The objective of this project is to develop and propagate a low cost, low tech, soil moisture monitoring program utilizing the existing cyberinfrastructure and human resources of the Community Collaborative Rain, Hail and Snow network (CoCoRaHS). The goal is to provide useful information to support calibration and validation for SMAP while also producing root zone soil moisture estimates to support U.S. Drought Monitoring and early warning efforts. An equally important objective is education – demonstrating the variability and seasonality of volumetric soil moisture and how this varies geographically across the country. If this small demonstration proves successful, we hope this effort could lead to greater citizen participation in drought monitoring and more timely warnings of the onset of significant drought.

PROJECT ACCOMPLISHMENTS:

Soil moisture monitoring, be it with electronic sensors or with basic manual methods, is much more challenging than meets the eye. The following activities have taken place in our effort to develop a simple and low cost approach to measuring soil moisture that still yields specific, quantitative results needed for several science applications.
1--Reviewed classical approaches to qualitative soil moisture monitoring using guidance from USDA and Extension soil scientists

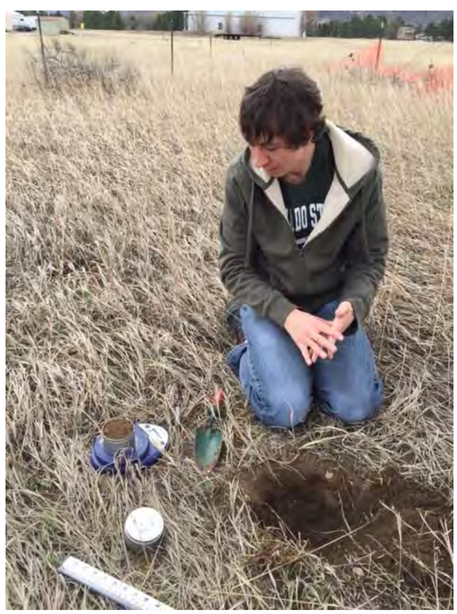
2--Participated in several phone meetings with Deb Harms, soil scientist with the USDA Natural Resources Conservation District Soil Climate Analysis Network (SCAN) who has many years of experience with soil moisture measurement.
3--Explored soil moisture monitoring protocols developed by the GLOBE program and more recent low cost protocol recommended by the NASA SMAP mission for gathering data
4--Established test plots for soil moisture monitoring using both manual methods and electronic sensors at the Colorado State University Foothills Campus Christman Field research facility
5--Recruited a small number of volunteers to test observing methodologies in differing climate zones and soil types across the country.
6--Met with NASA SMAP soil moisture trainer and GLOBE program advisors/leaders
7--Purchased and/or acquired soil coring tubes, sampling canisters, soil heating/drying devices
8--Met with Parker Street animators to explore possibility of developing a soil moisture measurement animation video similar to the training videos they have done for other CoCoRaHS protocols

As of March 2015 we are finalizing an acceptable protocol that can provide quantitative measurements of both near-surface soil moisture (needed for SMAP validation) and also sampling down to about 8" depth to provide a useful root zone soil moisture estimate for agricultural and landscape drought monitoring applications.

We have concluded that consistent measuring devices will be needed at all volunteer sites. We are still in the process of finalizing our recommendations for the type of coring tube that will be used and also a safe and satisfactory heat source for soil drying. We have low cost scales selected that appear robust and satisfactory, and have selected measurement units (water content for specified volume of soil) that are relatively standard.

We have invested time in planning the components of the web interface for gathering, displaying and analyzing volunteered soil moisture measurements, but have concluded that until the protocol is agreed upon and measurement kit components are finalized, we cannot yet proceed with the web infrastructure or web training. We are only a few weeks from that.

Peter Goble testing out soil sampling methods



Peter Goble weighing soil samples in the field

Project Publications from Past Fiscal Year (including Conferences): None yet

PROJECT TITLE: CIRA Support to the JPSS Science Program: S-NPP VIIRS EDR Imagery Algorithm and Validation Activities and S-NPP VIIRS Cloud Validation

PRINCIPAL INVESTIGATOR**:** Steve Miller

RESEARCH TEAM: Stan Kidder, Yoo-Jeong Noh, Curtis Seaman, Steve Finley, Hiro Gosden, Dave Watson, Kevin Micke, Renate Brummer, Kathy Fryer

NOAA TECHNICAL CONTACT: Chris Brown (NOAA/NESDIS) and Phil Hoffman (NOAA/OAR)

NOAA RESEARCH TEAM: Don Hillger, John Knaff, Dan Lindsey (NOAA/NESDIS/STAR/RAMMB)

PROJECT OBJECTIVES:

The Suomi National Polar-orbiting Partnership mission (NPP), serving as risk-reduction to the Joint Polar Satellite System (JPSS) and providing continuity to the National Aeronautics and Space Administration's (NASA) Earth Observing System (EOS) climate mission, was launched successfully on 28 October 2011. The Visible/Infrared Imaging Radiometer Suite (VIIRS) on board Suomi NPP provides atmospheric, cloud, and surface imagery for both weather and climate applications. VIIRS is the next-generation to the Advanced Very High-Resolution Radiometer (AVHRR) that has flown on board the Polar-Orbiting Environmental Satellites (POES) since NOAA-15 in 1998. VIIRS was originally designed to merge the capabilities of the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) and the NASA Moderate-resolution Imaging Spectroradiometer (MODIS).

This is a multi-agency research project with teams involved from NOAA/NESDIS/StAR, CIRA, CIMSS, NRL, NGDC, NGAS, and Aerospace. CIRA's research in this area is divided in into two distinct elements: I) VIIRS Imagery Algorithm and Validation Activities and II) VIIRS Cloud Base Height (CBH) and Cloud Cover/Layers (CCL) Validation. Progress on each element is detailed below.

These projects directly address NOAA's Weather and Water goal, which seeks to serve society's needs for weather and water information. This research also falls within the NOAA-defined CIRA thematic area of Satellite Algorithm Development, Training and Education, as calibration/validation is an integral and critical first step in the algorithm development process. Outcomes of the current research may in some cases lead to adjustments in the original algorithm to correct issues discovered during the calibration/validation analysis.

Project 1--VIIRS Imagery Algorithm and Validation Activities

Objectives:
1-- Setup imagery test environments and visualization tools for verification of the EDRs produced by the IDPS code.

2-- Incorporate performance constraints upon the imagery obtained from the ADL code, including both quantitative statistical tests and qualitative imagery "viewability" measures.

3-- Support the assessment of deviation/waiver requests pertaining to VIIRS performance when bearing relevance to imagery quality.

4-- Interact with the JPSS Office in the formal algorithm change process if algorithm changes are suggested.

Research Conducted

1-- Imagery processing tools for display, analysis and verification of imagery EDRs, were established in IDL. This data analysis and visualization package is ideal for quantitative analyses as well as high quality graphical display of VIIRS imagery. The tools are linked to the VIIRS data ingested at CIRA from various near real-time sources and the products are hosted on RAMMB web servers. As an independent means of cal/val monitoring, selected multi-spectral VIIRS products are generated with a TeraScan processing package. The processing is useful for monitoring the status of VIIRS imagery quality and provides material for case study analyses.

2-- We have evaluated various aspects of imagery EDR performance via both quantitative comparisons with other sensors (e.g., scan edge resolution improvements over heritage systems) and quantitatively via examination of data quality-control flags. An example of the latter is shown in Figure 1, which shows pixel trim zones (deletion of overlapping 'bow-tie effect' pixels) in VIIRS sea surface temperature EDRs and the 0.865 µm M7 band. This was done as part of an analysis to understand ground track Mercator (GTM) remapping performance. Shown here are subtle differences between the SDR and non-imagery EDR, with the latter trimming additional pixels after reception of the data on-ground. The GTM remapping will sometimes utilize pixels that have been deleted on-ground, resulting in apparent gaps in the EDR imagery. Such analyses can help to improve the presentation of VIIRS products.

3-- We have participated in numerous deviation/waiver request meetings, particularly those surrounding the VIIRS Day/Night Band. Extensive discussions surrounding options for J1 involve consideration of noise vs. resolution trade-offs. Other topics include detector cross talk studies and recommendations based on observed performance under high-stress scenarios (point sources of light on dark nights). Detectors 1 and 16 have been flagged by lab-testing as being 'recipients' of cross talk, and on-orbit variance tests have confirmed slightly higher variance in these detectors. Figure 2 shows an example of the variance and an image that identifies possible spurious cross talk in the vicinity of gas flares in the Persian Gulf.

4-- Monthly teleconferences are held with the distributed imagery cal/val team, where topics related to imagery quality and outstanding discrepancy reports and waiver requests are discussed.

5-- We performed an evaluation of the terrain correction in the SDR geolocation files and demonstrated that the EDR geolocation files are not terrain-corrected, which has been a source of confusion for users. This evaluation is in the form of animated images highlighting Mt. Logan and Mt. St. Elias, the second and third tallest mountains in North America, respectively, in successive overpasses. These images along with additional discussion are available at the JPSS Imagery Cal/Val webpage: http://rammb.cira.colostate.edu/projects/npp/calval/. A similar evaluation was performed when the terrain-corrected geolocation information was added to the GDNBO (Day/Night Band geolocation) files, but is not shown.

6-- The VIIRS Imagery Team Blog continues to be updated with cases demonstrating the uses and value of VIIRS Imagery. In the past year, 9 in-depth and highly detailed blog posts have been added covering diverse topics, including: lake-effect and sea-effect snowstorms, volcanic eruptions, wildfires and agricultural burning, severe thunderstorms inducing gravity waves in the upper atmosphere, and an unusual sighting of military ships in a remote part of the North Pacific Ocean. The goal of the blog is to highlight the benefits of VIIRS imagery, while educating and entertaining both operational users and members of the general public.

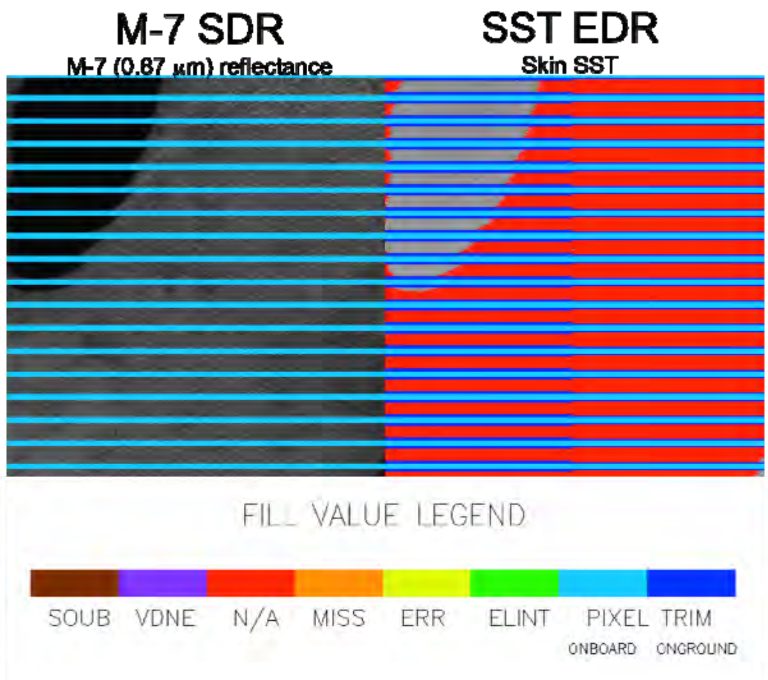


Figure 1. Comparison of M7 band reflectance and VIIRS sea surface temperature environmental data record (EDR), showing differences in the pixel trim strategies (light/dark blue) showing the root cause of discrepancies the ground track Mercator projection software of the EDRs.

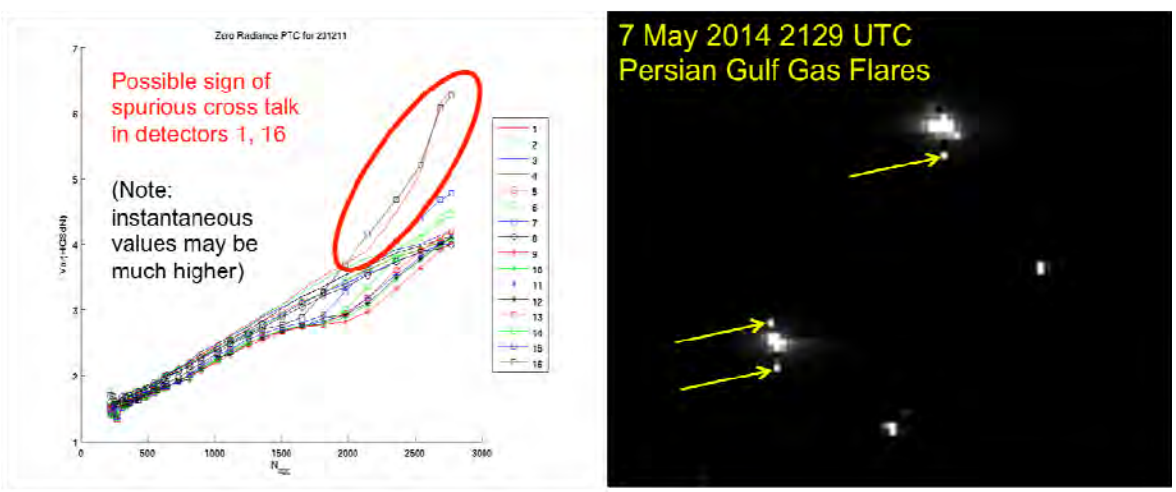


Figure 2. Detector variance (left; courtesy L. Liao, Northrop Grumman) in the Day/Night Band imager, and example of possible cross talk pixels in the Persian Gulf (right).

Project 2--Support of the VIIRS Cloud Validation Activities

Objectives

1-- Continue work on validation of CCL/CBH Intermediate Products (IDPS) based on a growing collection of CloudSat/CALIPSO/S-NPP matched data for an extended period to provide more robust statistics.

2-- Continue to compile statistics on VIIRS Cloud EDR performance as a function of cloud optical and microphysical properties, season, region, etc., using CloudSat and CALIPSO.

3-- Support NOAA team in analysis of CBH retrievals based on NPP Data Exploitation (NDE; legacy NOAA operational codes) cloud input in coordination with CIMSS.

4-- Examine potential CBH algorithm improvements to the IDPS-furnished CBH algorithm including superior water content assumptions and cloud statistics derived from CloudSat data.

Research Conducted

1-- We performed the global mean analysis of the current VIIR IDPS and NDE (CLAVR-x) products for September-October 2013 VIIRS-CloudSat overpass periods. We have focused on a 'Golden Month' of September 2013, and are now adding October 2013 match-up cases. For the extended period, we compiled statistics on CBH and other upstream cloud property EDR performance for various cloud types as well as global analysis. Figure 3 shows the comparison results of CTH and CBH between IDPS and NOAA NDE. Work continued on validation of VIIRS Cloud Cover Layers (CCL) and Cloud Base Height (CBH) products against CloudSat data and CALIPSO data as available, matched in space/time to VIIRS. CBHs have been calculated in-house from our IDL version code with NDE DCOMP and CTH retrievals. For the extended validation periods, many statistical methods of validation were also conducted, including stratification on cloud type and cloud optical depth.

2-- We have been supporting the NOAA team in analysis of CBH retrievals based on NPP Data Exploitation (NDE) cloud input (as opposed to IDPS input). In coordination with CIMSS, we continue to run the NDE (legacy NOAA operational codes) cloud property retrieval algorithm with VIIRS Level-1B data and validate the cloud property products and CBH from our local version of the CBH code (developed from, and validated against, the IDPS operational VIIRS CBH algorithm) with NDE input (generated from CLAVR-x algorithms). These results were also validated against CloudSat for the extended matchup period and performance compared to IDPS. Statistical inter-comparisons were performed to support validation of CIMSS' extinction based cloud height products.

3-- In anticipation of the algorithm replacement to NOAA-heritage processing, we have worked on a separate CBH algorithm operation coupled to CLAVR-x which was installed on our local machine. The CLAVR-x code maintains consistency with the NOAA operational version via SVN checking, and the most updated version with the new netCDF lookup tables and required libraries was successfully installed. Our CBH improvement efforts will be integrated within the CLAVR-x frame.

4-- For potential CBH algorithm improvements, the CIRA team examined the IDPS-furnished CBH algorithm by changing to superior water content assumptions. Also, we began development of statistically based CBH retrieval, predicated on the formation of relationships between observed cloud geometric thickness (from CloudSat) and cloud water path (CWP) expressed as a function of cloud top height. For this purpose, we have reprocessed the CloudSat data statistics on geometric thickness and water contents using VIIRS cloud typing logic applied to Aqua MODIS data as a way of building up VIIRS cloud-type-dependent cloud geometric thickness estimates. CloudSat statistics for single layer clouds are used to derive relationships between geometric thickness and water path. Figure 4 shows the VIIRS cloud type dependent CTH and CBH statistics from 2007-2010 four July CloudSat data, which may serve as a constraint to CBH algorithm improvement. We are now investigating the statistical relationships between water path and cloud top/base heights by processing CloudSat and MODIS data. The statistics from CloudSat and Aqua MODIS which fly together in the NASA A-Train will provide statistically-robust datasets for a CBH algorithm revision.

5-- The team participated in bi-weekly tag-up teleconferences to discuss various issues for overcoming problems and evaluating the performance of algorithm changes, and supplied materials for reporting.

6-- We continue to assist in nighttime lunar-based cloud optical property assessments for a future-focused research direction for the project (nighttime cloud base height is not yet part of the NOAA operational processing plan).

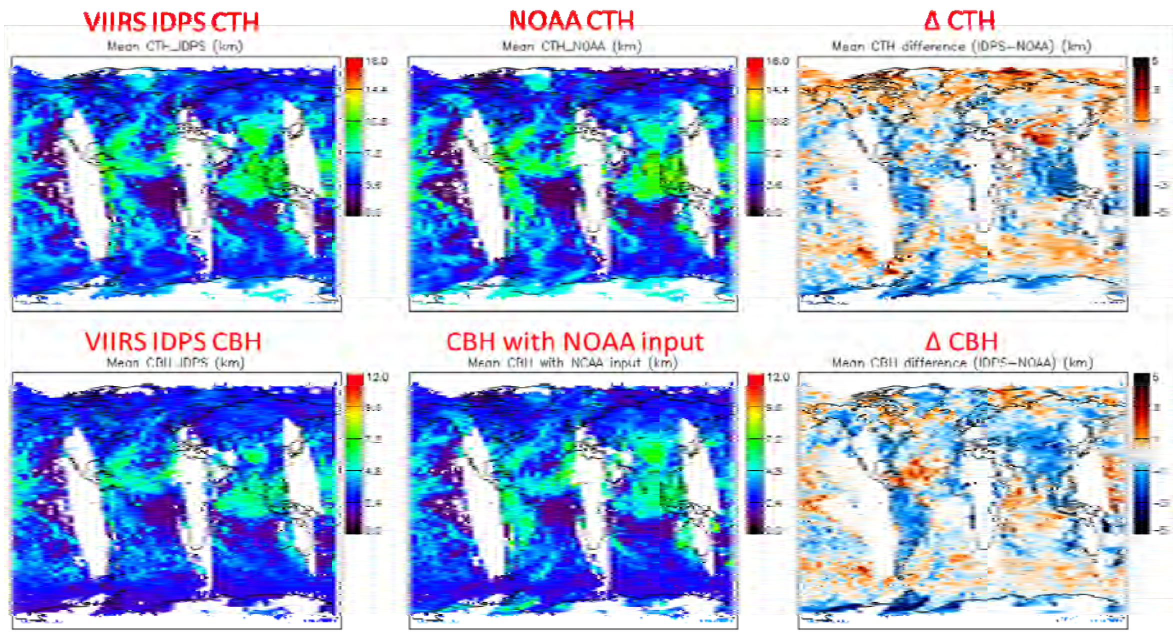


Figure 3. Global mean distributions of CTH and CBH from the current IDPS and NDE. CBH is also calculated from CIRA's own version code based on the current VIIRS CBH IDPS OAD with NDE input. CTH and CBH values are averaged over all the pixels within a 1 degree x 1 degree grid box. The grids with less than 1000 pixels remain blank.

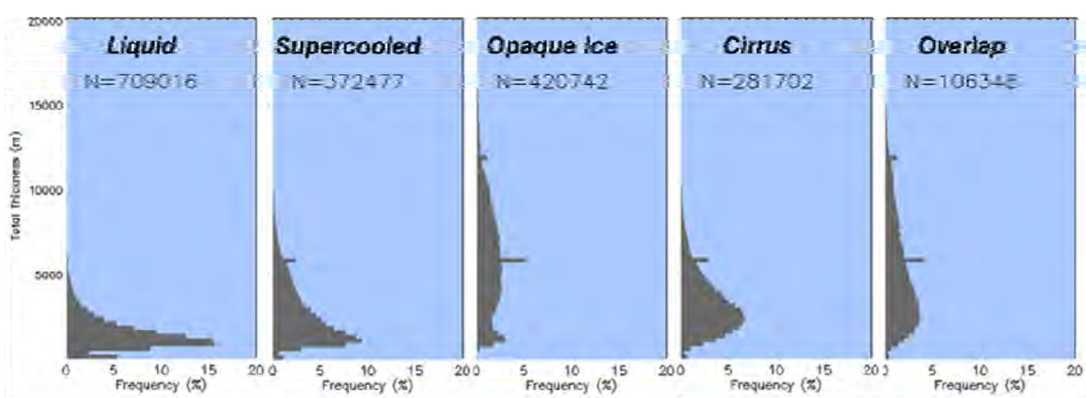


Figure 4. Upper most layer cloud thickness statistics for the four July (2007-2010) CloudSat radar-only dataset with the total profile number for each cloud type.

PROJECT TITLE: Explicit Forecasts of Recurrence Intervals for Rainfall: Evaluation and Implementation Using Convection-allowing Models

PRINCIPAL INVESTIGATOR: Russ Schumacher, CSU

RESEARCH TEAM: Russ Schumacher, CSU; Greg Herman, CSU (graduate student); Dan Lindsey, CIRA (collaborator)

NOAA TECHNICAL CONTACT: Gary Wick, NOAA/ESRL, Boulder, CO

NOAA RESEARCH TEAM: Kelly Mahoney, CIRES (collaborator), Gary Wick, ESRL (collaborator); Rob Cifelli, ESRL (collaborator)

PROJECT OBJECTIVE:

The primary objective of this project is to evaluate high-resolution numerical model forecasts of heavy precipitation by comparing the quantitative precipitation forecast (QPF) values against observed historical recurrence intervals for precipitation (i.e., the "100-year rain event, etc.) This method offers additional insight into the magnitude of the rainfall being predicted by the model, heightens situational awareness for forecasters, and allows for the identification of model biases.

PROJECT ACCOMPLISHMENTS:

Graduate student Greg Herman, under the supervision of PI Russ Schumacher, has made substantial progress on this project in several areas. He has analyzed forecast output from several convection-allowing numerical models, namely the NAM 4-km nest; the CSU 4-km WRF; the NSSL 4-km WRF; and the High Resolution Rapid Refresh (HRRR) over the time periods that each is available. This analysis has revealed a variety of characteristics of these different models as they relate to observations, and as they compare to one another. Two specific examples of these results are provided here, with a more thorough summary of the results currently being prepared as part of Greg's thesis and subsequent journal submission.

One example of this type of evaluation was the identification of a large increase in the number of points exceeding the 100-year recurrence interval threshold after the upgrade to the NAM model in August 2014. In the months prior to the upgrade, the NAM nest predicted extreme 24-h rainfall accumulations at a frequency similar to that in the NSSL 4-km WRF, and to that identified in the Stage IV analysis. After the upgrade, however, the NAM nest began producing extreme accumulations much more frequently over the western US, which was inconsistent with other model configurations and with the available observations. The reasons for these very large localized rain amounts in the NAM nest is not yet clear, but we have raised the issue with Eric Aligo of the NAM microphysics development team for further exploration.

A second example relates to differences in the timing of heavy precipitation in a preliminary comparison of the NSSL 4-km WRF and the HRRR over the warm seasons of 2012 and 2013. Both the NSSL and the HRRR predicted rainfall above the 50-year recurrence interval for 6-h accumulated precipitation far more frequently than what was shown in the Stage-IV analysis, but this may be, in part, a reflection of poor radar and gauge coverage in the western US rather than purely overprediction by the models. Perhaps more importantly, the HRRR infrequently predicts rain accumulations above this threshold in the 1200-1800 UTC timeframe, and predicts it much more frequently in the 1800-0000 UTC timeframe, whereas the NSSL WRF has a less dramatic increase between these two time periods. Greg presented a poster at the AMS annual meeting summarizing the results of the project at that time, and he has also submitted an abstract to present at the AMS Numerical Weather Prediction Conference in June 2015.

An additional accomplishment of the project is that PI Schumacher and GRA Herman attended the "Flash Flood and Intense Rainfall" (FFaIR) experiment organized by the Hydrometeorological Testbed in July 2014. This experiment brings together forecasters, researchers, and product developers to examine the current and possible future products at the cutting edge of extreme rainfall and flash flood forecasting. We participated in the forecast and evaluation activities for one week, and also provided an early version of our website for real-time monitoring of extreme QPF (http://schumacher.atmos.colostate.edu/qpf_monitor/) for evaluation during the project.

PROJECT TITLE: Hydrologic Research and Water Resources Applications Outreach Coordination

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Lynn Johnson

NOAA TECHNICAL CONTACT: Rob Cifelli (OAR/ESRL/PSD)

NOAA RESEARCH TEAM: Allen White (OAR/ESRL/PSD)

PROJECT OBJECTIVES:

Hydrologic Research and Applications Development
Objective: Provide expert guidance and consultation on hydrologic applications in NOAA'S Hydrometeorology Testbed (HMT). Major activities include:
--Assist in the design, coordination and development of hydrological modeling and water resources management applications for regional demonstrations with the HMT, NWS/OHD, WWA and NIDIS programs;
--Provide guidance and leadership in carrying forward the hydrological research agenda defined in the HMT Hydrological and Surface Processes (HASP) plan, including publication in peer-reviewed journals;
--Support the HMA Project Manager in identifying and tracking candidate (and past) tools, techniques and knowledge transfers to NWS and key stakeholders.

Water Resources Applications Outreach Coordination
Objective: Provide support to and coordination between HMT and NOAA Partners and Stakeholders. Major activities include:
--Assist in coordination with water management stakeholders such as the Corps of Engineers, U.S. Geological Survey, and other federal, state, and local water management agencies.
--Act as a liaison across NOAA Line Offices, particularly between NWS-OHD, PSD, CNRFC, NMFS and Line Office Headquarters;
--Provide guidance related to technical aspects of the national water resources information system, including system interoperability and data exchanges, eGIS and geo-Intelligence, integrated information delivery, the acquisition and management of observations and surveillance, and technological research and development;
--Support the planning for an HMT/IWRSS Russian River and California Pilot Study;
--Develop briefings and reports related to high-level needs (NOAA, Other Agency, and Legislative).

PROJECT ACCOMPLISHMENTS:

-On the topic of hydrologic research and applications development for the HMT, several sub-topics were addressed, including development of the HMT Hydrologic Research Plan and various hydrologic research extensions for companion PSD Water Cycle Branch (WCB) projects. The HMT Hydrologic Research Plan is intended to address the HMT major activity area on Hydrological and Surface Processes (HASP) research activities. The near-term focus is on the HMT-West where a priority requirement is to enhance the coupling of atmospheric and hydrologic models. There are several companion WCB projects which involve a hydrological research dimension. These include the North Fork of the American River, the Russian and Napa Rivers, the San Francisco Bay Regional system, and other activities in the Pacific Northwest and the HMT Southeast (HMT-SE).

--The distributed hydrologic model (DHM) of the Russian River, CA accounts for the spatial distribution of rain, topography, soils, land use and runoff. It is a primary tool to assess the quality of precipitation nowcasts and forecasts products, and is being prototyped for deployment in real-time forecast operations. The DHM has been calibrated for several tributary watersheds in the Russian-Napa river basins for the full range of flows – flood peaks and volumes, and low flows.

The RDHM has been integrated into the CHPS-FEWS hydrologic operations system for prototyping real-time operations.

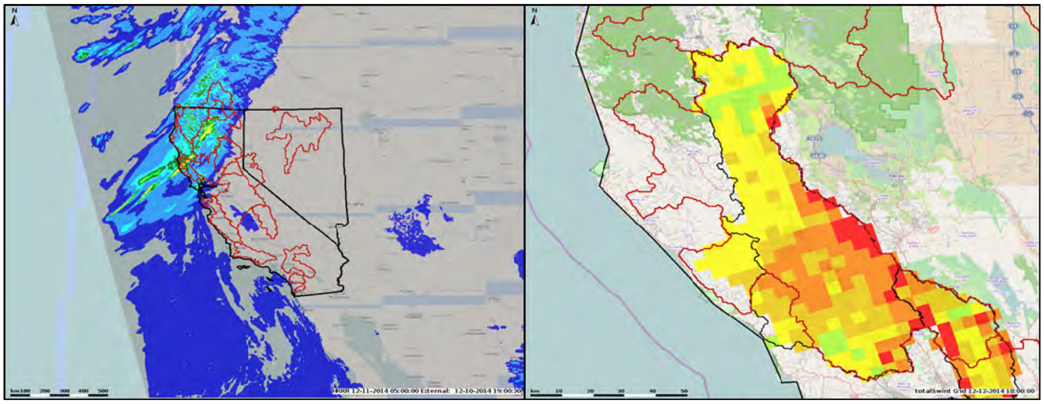


Figure 1. RDHM integration into CHPS-FEWS system has been accomplished to support real-time prototyping of distributed model in the Russian River basin.

On the topic of water resources applications outreach, there are several sub-topics being addressed, including the Russian River and California Integrated Water Resources Science and Services (IWRSS) Pilot and national-level eGIS (enterprise Geographical Information Systems) activities. The IWRSS program is a national-level initiative seeking interoperability of water resources information within NOAA and other federal agencies. The Russian River IWRSS Pilot involves representatives from federal, state and local agencies assembled to consider approaches and benefits that could accrue through coordinated water data exchange and decision support. Coordination activities are directed to a multi-agency focus on the Russian River as an IWRSS pilot demonstration; extensions to other sites in California, the Pacific NW and other regions are expected. Identified activities include HMT research applications for distributed hydrologic modeling, Sonoma County Water Agency hydrologic index decision support and US Army Corps of Engineers (ACE) and US Geological Survey (GS) data interoperability.

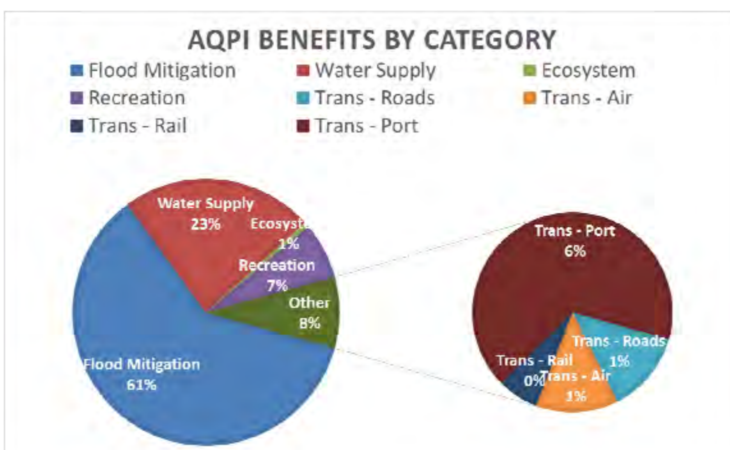


Figure 2. Assessment of benefits of an Advanced Quantitative Precipitation Information system yields benefit:cost ratio estimate of 5:1.

DATA DISTRIBUTION

Research focusing on identifying effective and efficient methods of quickly distributing and displaying very large sets of environmental and model data using data networks, using web map services, data compression algorithms, and other techniques.

PROJECT TITLE: CIRA Research Collaborations with the NWS Meteorological Development Lab on Virtual Laboratory, Innovation Web Portal, Impacts Catalog and AWIPS II Projects

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Kenneth Sperow, John Crockett, Michael Giebler

NOAA TECHNICAL CONTACT: Stephan Smith (NWS/OST/MDL)

NOAA RESEARCH TEAM: Mamoudou Ba (NWS/OST/MDL), Lingyan Xin (NWS/OST/MDL), Matt Davis (NWS/OST/MDL), John Schattel (NWS/OST/MDL), Michael Churma (NWS/OST/MDL), Tom Filiaggi, (NWS/OST/MDL)

PROJECT OBJECTIVES:

Virtual Lab (VLab)
The NWS has created a service and IT framework that enables NOAA, in particular the NWS, and its partners to share ideas, collaborate, engage in software development, and conduct applied research from anywhere. The VLab helps to:
A--Reduce the time and cost of transitions of NWS field innovations to enterprise operations;
B--Minimize redundancy and leverage complementary, yet physically separated, skill sets;
C--Forge scientific and technical solutions based on a broad, diverse consensus; and
D--Promote a NOAA/NWS culture based on collaboration and trust.

AWIPS II
The NWS is in the process of evolving AWIPS to an open source, service-oriented architecture (SOA). The major objective of this project is to provide the functionality of AWIPS build OB9 in this new SOA infrastructure.
The MDL is not directly responsible for the migration of its applications from AWIPS to AWIPS II; this is the responsibility of Raytheon, the prime contractor. However, the MDL will be overseeing the migration of its current applications, developing new applications in the new framework, and enhancing existing applications beyond OB9, which falls outside the scope of Raytheon's migration. AWIPS II uses many technologies (JAVA, Mule, Hibernate, JavaScript, JMS, JMX, etc.) that are new to the MDL and the NWS. In order for the MDL to be in a position to add value, they need people who have a working understanding of these technologies.

AutoNowCaster (ANC)
Originally developed by the Research Applications Laboratory (RAL) at the National Center for Atmospheric Research (NCAR), ANC Nowcasts convective initiation. It is currently experimental and runs solely at the MDL. The project's objectives are the following:
A--Develop a more complete understanding of ANC's architecture and configuration and document that understanding.
B--Where possible and/or necessary, optimize ANC's software and streamline its configuration.
C--Contribute to experiments designed to improve, better understand, or showcase ANC.

D--Transition ANC to operations so that its nowcasts of convective initiation are available to interested entities.

Impacts Catalog
The National Weather Service's Weather-Ready Nation Roadmap calls out the creation of a national Impacts Catalog, a system whereby the NWS can improve its Impact-based Decision Support Services (IDSS) to its core partners by providing those partners information regarding the impacts which relevant meteorological variables will have on those partners' operations. The project's objectives are the following:
A--Provide leadership and technical expertise.
B--Contribute to the engineering of the Impacts Catalog's software.

PROJECT ACCOMPLISHMENTS:

VLab
A--Ken Sperow continued as the VLab technical lead, as well as the technical lead of the Virtual Lab Support Team (VLST). This team currently consists of 11 members to whom Ken provides support and training.

B--Under Ken Sperow's and Stephan Smith's (the NOAA PI) leadership, the VLab continues to grow in importance and visibility within the NWS and NOAA.
1--Ken Sperow demonstrated the VLab to NOAA, non-NWS NOAA line offices and top-level staff within the NWS, including NCEP directors.
2--Providing web-based services to help manage projects via issue tracking, source control sharing, code review, and continuous integration, VLab Development Services (VLDS) has grown by almost 100% this year to support over 100 projects and 836 developers.

C--Under Ken Sperow's leadership, the VLab is now an essential and required component in the transition of research to operations for the NWS AWIPS. All development organizations now must use VLab to check in, review, and verify AWIPS II code before it is included in the operational baseline.

D—Ken, with the National Centers for Environmental Prediction (NCEP) Central Operations (NCO), successfully moved the VLab from the NWS Internet Dissemination System (NIDS) and NWS HQ to the NOAA's Integrated Dissemination Program (IDP) infrastructure at the NCO. The IDP webfarm will provide the VLab with a stable, redundant, and expandable environment to continue serving current and future customers as well as evolve the VLab to meet future needs. Ken carried out the following tasks:
1--Led the transition of VLab to IDP for MDL as the project and technical lead.
2--Created step-by-step instructions on the installation of VLab within IDP, creating Virtual Machines to insure the process worked as expected.
3--Carried out the application and database installation, configuration, and testing within first the development environment, and then the operational environment.
4--Worked closely with NCO on the monitoring and failover of VLab in IDP.
5--Conducted the final migration of services to IDP and subsequent testing with core partners to ensure a successful migration.

E--Michael Giebler joined the team over the summer and immediately added technical value to the VLST as a Liferay development expert. Michael's first task with CIRA was to help with the migration of VLab's Collaboration Service from Liferay 6.1 to 6.2 Enterprise Edition (EE). Michael successfully led the effort to modify VLab's theme to work with Liferay 6.2 EE.

F--Michael Giebler's past experience allowed him to be the technical lead and sole developer on a high-priority VLab project called the Project Repository. The Project Repository will provide an interface for all of NOAA to enter project information into the VLab, enabling tracking of projects' transitions from research and development to operations, commercialization, and other uses.
1--Michael Giebler successfully demonstrated the Project Repository to the NOAA Line Office Transition Managers Committee (LOTMC) and Research and Development Enterprise Committee (RDEC) resulting

in their recommendation for a memo to go out from NOAA Chief Scientist to NOAA directing all NOAA bench scientists to add their projects to the VLab Project Repository.
2--Under Michael's development, the Project Repository is moving into operations.
3--Michael Giebler found, tested, and recommended a reporting portlet that will be used in conjunction with the VLab Project Repository.

G--Ken Sperow and Michael Giebler provided technical guidance to the VLab Focal Points at monthly meetings – instructing on different ways to use and modify the VLab.

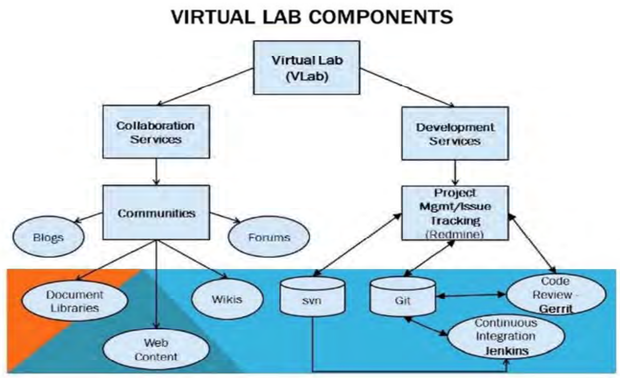


Figure 1. VLab running at IDP.

AWIPS II
A--Ken Sperow assisted NWS Systems Engineering Center management with the high-level design of AWIPS II configuration management and governance.

B--Ken continues to provide technical assistance to the AWIPS II community on building and deploying AWIPS II.

C--Ken continued to provide AWIPS II support to MDL developers and to install new releases of the AWIPS II software on the system for knowledge transfer and development activities.

D--Ken Sperow led the development of a meteogram tool within AWIPS II in coordination with the NASA Short-term Prediction Research and Transition Center (SPoRT) within the VLab. Ken worked with NASA SPoRT and tested the tool within the NWS Operations Proving Ground in Kansas City, MO and also at the Hazardous Weather Testbed (HWT) in Norman, OK.

AutoNowCaster (ANC)
A--John Crockett continues to support the day-to-day running of ANC at the MDL.

B--John Crockett continues to maintain and update all of the documentation related to ANC.

C--John Crockett continues to modify ANC applications in order to reduce overall CPU and disk usage, finding and fixing software bugs as needed.

D--John Crockett continued the process of transitioning ANC from an experimental system at the MDL to an operational system at the National Centers for Environmental Prediction (NCEP). As part of this work, John Crockett carried out the following tasks:
1--Modified ANC so that it is able to run on a 64-bit Linux server on which is installed the most up-to-date libraries on which ANC depends, e.g., the NetCDF library from Unidata.

2--Modified ANC so that it is able to ingest and use the operational 2-D Multi-Radar/Multi-Sensor (MRMS) radar reflectivity data from NCEP.
3--Modified ANC so that it compiles successfully in “debug” mode.
4--Continued to simplify ANC’s source code structure.
5--Created a script by which ANC can be compiled, linked, and deployed in one step.

E--John Crockett traveled to Taipei, Taiwan in order to assist Taiwan’s Central Weather Bureau (CWB) further with its understanding and use of both the software used to tune ANC objectively and ANC itself. At the CWB, John Crockett carried out the following tasks:
1--Along with NOAA research team member Lingyan Xin, gave presentations both on the MDL's use of the software used to tune ANC objectively and on how the CWB might best choose those data to use for objectively tuning the CWB’s version of ANC.
2--Helped the CWB understand the possible paths for using forecast interest fields formatted using NetCDF.
3--Taught the CWB how to build ANC from source code and provided to the CWB a document with the step-by-step commands needed to do so.
4--Answered any and all questions as they arose and provided to the CWB a list of recommendations for them to consider with respect to their use of ANC.

Impacts Catalog
A--John Crockett continues to function as the manager of the Virtual Laboratory's Impacts Catalog Community. This included writing periodic blog posts so that the community was kept abreast of the project’s status.

B--John Crockett continued to function as a member of the project's Integrated Working Team (IWT).

C--While Technical Lead of the national Impacts Catalog Project, John Crockett carried out the following tasks:
1--At the monthly MDL-SEC AWIPS Development meetings, kept management aware of planned connectivity between the Impacts Catalog and AWIPS II.
2--Merged the IWT’s consensus votes on the initial set of requirements and, along with NOAA research team member Matt Davis, finalized those requirements needed to develop a prototype of the Impacts Catalog.
3--As needed, arranged and conducted feedback interviews both with the project's Operational Test and Evaluation (OT&E) sites and with NOAA’s Policy and Planning Division as part of the prototype development process.
4--Coordinated the process which led to National Digital Forecast Database (NDFD) data being able to be obtained and used by the prototype.
5--Coordinated the onboarding of the development team through the NOAA Rotational Assignment Program (NRAP), including writing the requisite position descriptions and training one of the developers.
6--Managed the prototype’s initial development, its rollout, and its continued development, including conducting daily scrum chats and weekly teleconferences with the development team.
7--With the help of NOAA research team member Matt Davis, conducted demonstrations of the prototype both for the OT&E sites and for NWS upper-level management, including Deputy Director Laura Furgione.
8--Arranged and led a meeting at the MDL with staff from the Charleston, WV WFO (one of the OT&E sites) regarding that site’s use the prototype and the project’s direction.
9--Solicited, reviewed, and responded to feedback from the OT&E sites regarding the prototype’s official OT&E period, and, in coordination with the project manager, subsequently wrote the FY 2014, Prototype National Impacts Catalog, OT&E Final Report.
10--Helped arrange and conduct a 3-day project Design and Development Conference at the NWS Training Center in Kansas City, MO.
11--Along with NOAA technical contact Stephan Smith, participated in meetings at which the project’s executive sponsors were kept abreast of the project’s status.
12--In coordination with NOAA technical contact Stephan Smith, presented the project’s expected status in the first quarter of FY 2015 to Michael Farrar, the MDL Director.

13--In coordination with NOAA technical contact Stephan Smith and NOAA research team member Matt Davis, began to investigate how the Impacts Catalog can be moved from its current home on a Central Region server to the new Integrated Dissemination Program (IDP) web farm in College Park, MD, and created the following project documents:
a--FY 2014 and FY 2015 Technical Needs
b--NOAA IDP Impacts Catalog/Iris and iNWS Project Charter

D--John Crockett took on primary responsibility for the re-engineering and further development of the prototype's contact management system. This included fixing more than 30 bugs and implementing more than 15 new features, all the while simplifying the server-side database, the overlying Spring/Hibernate code, and the client-side software.

PROJECT TITLE: EAR - Aviation Weather Forecast Impact and Quality Assessment

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Melissa Petty, Paul Hamer, Michael Turpin, Michael Leon

NOAA TECHNICAL CONTACT: Micahel Kraus (OAR/ESRL/GSD/EDS Chief)

NOAA RESEARCH TEAM: Brian Etherton (OAR/ESRL/GSD/EDS), Matt Wandishin (CIRES), Geary Layne (CIRES), Joan Hart (CIRES), Michael Rabellino (CIRES), Laura Paulik (CIRES)

PROJECT OBJECTIVES:

1--Scientific research and quality assessments
2--Technology development

PROJECT ACCOMPLISHMENTS:

Scientific Research and Quality Assessments
CIRA program management and engineering support was provided to FIQAS scientific research and quality assessment activities. Major accomplishments include:

Completion of Evaluation of the Graphical Turbulence Guidance version 3 (GTG3): FIQAS was tasked with an evaluation of version 3 of the GTG algorithm, which provides a forecast of Eddy Dissipation Rate (EDR) as a measure of turbulence. This version incorporated several new features, including mountain wave forecasts, extension of the forecast to include low altitude levels in addition to the current mid and upper altitude levels, and extension of the forecast from 12 out to 18 hrs. The 2014 activities for the evaluation included completion of the evaluation, which included a comparison of GTG3 to the previous version (2.5), and reporting of results. Primary findings included:
- Notable differences existed between the field distributions of GTG3 and 2.5 (the GTG3 distribution is more constrained (i.e., lower variance, weaker tails) and the peak of the distribution is shifted from near-zero values to around 0.1)
- GTG3 is consistently better at discriminating turbulence events from non-events than GTG2.5
- When evaluating skill using the same threshold for forecast and observations, GTG3 outperforms 2.5 for only a small range of EDR values, however, with calibration this range is broadened to light to moderate EDR values or greater.

These results were presented to the FAA and an independent Technical Review panel, who approved GTG3 to progress to the next stage of transition to operations, a Safety Risk Management Assessment.

Preparation for Evaluation of the Graphical Turbulence Guidance Nowcast (GTGN): FIQAS was tasked with an evaluation of the Nowcast component of GTG, which produces turbulence (EDR) nowcasts every 15 minutes over the CONUS. Activities for 2014/15 included: Adaptation of existing forecast verification techniques to the Nowcast component; presentation of verification procedures for the assessment for review by the FAA and the Turbulence Product Development Team (product developer, NCAR); and preliminary implementation of verification techniques. Assessment is planned for completion in summer of 2015.

Completion of Evaluation of CIP/FIP Version 1.1 (Current Icing Product/Forecast Icing Product): The CIP/FIP product is a CONUS-domain predictor of icing probability, severity, and super cooled large drops (SLD) , and a new version (1.1) containing minor upgrades was recently released for evaluation. FIQAS performed an evaluation of CIP/FIP version 1.1 as compared to the previous version (1.0) to ensure product quality was not compromised due to these changes. Primary findings included:
- Field distributions between the two products were very similar or identical, except for icing severity;
- Most differences in the CIP products were due to different observation inputs owing to different operating centers of the two versions
- The skill of CIP and FIP 1.1 is as good as or better than 1.0.

Version 1.1 has not yet transitioned to operations but is planned for transition along with other minor upgrades.

Evaluation of Icing Product Alaska (IPA): The algorithm used for the CONUS-domain FIP has been adapted to produce a forecast of icing probability, severity, and SLD over the Alaska domain. An in-depth quality assessment is being performed to establish a baseline measure of product quality. Activities for 2014/15 included implementation completion, data collection and processing, and analysis of results. Reporting of assessment results to the FAA will be completed in spring of 2015.

Completion of the Comparison of MRMS and CIWS Forecast and Analysis Products: The NWS has transitioned the MRMS (Multi-Radar Multi-Sensor) product into operations for use as a convective weather product. FIQAS performed a comparison of MRMS to the CIWS (Corridor Integrated Weather System) convective weather product to evaluate the differences between the two products, with a focus on their respective VIL and Echo Top fields. The assessment found that CIWS generally represents convection of a greater extent and intensity than MRMS does, which will warrant some user training on the different characteristics between the two products to those who have historically used CIWS, at least in the case of aviation planning. These results were presented to the NWS NextGen program.

Assessment of the Automated-CCFP Product: The Collaborative Convective Forecast Product was a human-generated forecast product provided by the Aviation Weather Center. Starting in March 2015, this product will be replaced with an automated version known as the CDM Convective Forecast Planning Guidance (CCFP). FIQAS performed a performance assessment of the automated product as compared to the human-produced product. Activities for 2014/15 included: Identification of techniques to be used for the assessment, development and review of the formal verification procedures, data collection for the assessment, implementation, analysis, and reporting of results to FAA and the Aviation Weather Center (AWC) management. Primary findings were that the auto-generated product produced more areas and coverage of convection as opposed to the human generated; the human-generated has a stronger diurnal signal in forecast characteristics; the characteristics of VIL and Echo Top identified in convective areas are similar in both products; the two products have similar overall skill, but for different reasons (auto- has higher detection rate, human- has fewer false alarms); and the human is able to provide more precise information in cases where Traffic Management Initiatives were enacted due to significant convection.

Technology Development
CIRA was responsible for application development in support of FIQAS activities, including FIQAS assessments as well as the development of technologies for external users. Accomplishments include:

Verification Requirements and Monitoring Capability (VRMC; Figure 1): The VRMC currently provides ongoing verification metrics for the operational GTG and CIP/FIP products, as well as results from the FIQAS assessments performed prior to the transition of these products into operations. The VRMC was extended in 2014/15 to support further analysis of GTG3 and the Icing Product Alaska.

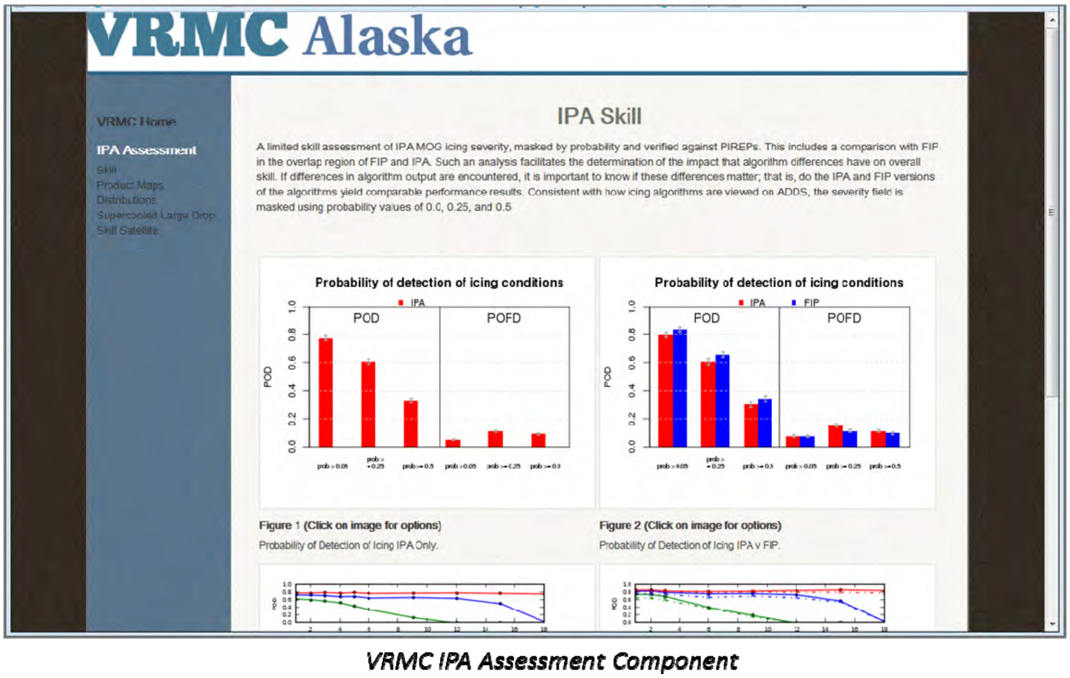
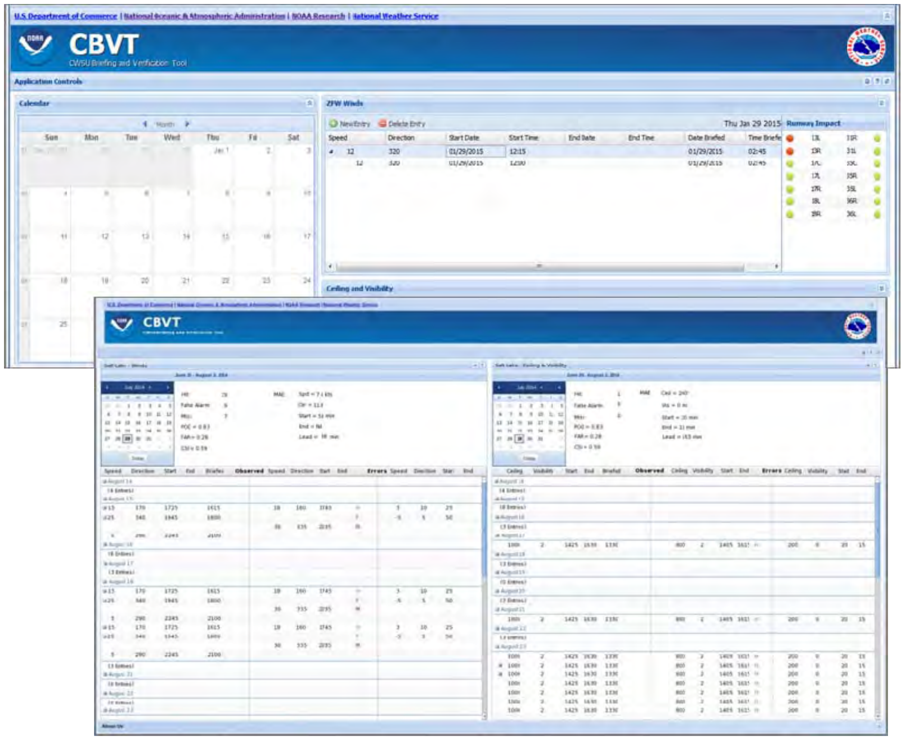


Figure 1. Verification Requirements and Monitoring Capability.

CWSU Briefing and Verification Tool (CBVT; Figure 2): NWS CWSUs (National Weather Service, Center Weather Service Units) provide decision support services at FAA Air Route Traffic Control Centers. The CWSU meteorologists provide briefings containing weather forecast information critical to FAA Traffic Flow Management decisions. FIQAS was tasked to develop an automated verification tool to allow user entry of briefing information and provide ongoing forecast performance results to replace what is currently a manual verification process performed by the individual CWSU. Activities for 2014/15 included coordination with a CWSU focus group to identify tool requirements and business processes to be captured in the tool and implementation of prototype capabilities for the User Entry and Verification Components of the tool. Completion of the prototype is planned for May 2015.

CBVT Briefing Entry



CBVT Prototype Verification Page

Figure 2. CWSU Briefing and Verification Tool.

TRACON (Terminal Radar Approach Control Facilities) Gate Forecast Verification Tool (Figure 3): TRACON Approach and Departure gate forecasts are being produced by CWSUs to provide greater detail of convective occurrence with respect to TRACON activities. A centralized version of this product is being developed by AWC to produce forecasts for a predefined set of CWSUs. FIQAS was tasked with the development of verification techniques and implementation of an automated verification tool to support ongoing monitoring of performance of this forecast product. Work was performed in 2014 to develop techniques to verify these forecasts, followed by implementation of these techniques into an automated tool later in 2014/15. Implementation activities included development of backend verification capabilities and design and prototyping of a web-based user interface to provide ongoing performance results. Completion of the end-to-end prototype is planned for May 2015.

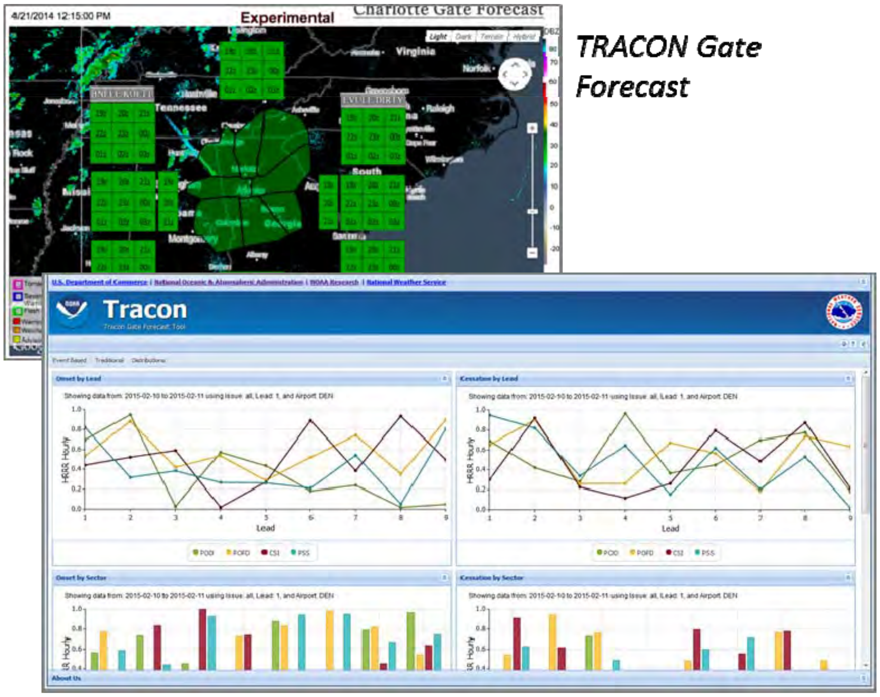


Figure 3. Terminal Radar Approach Control Facilities Gate Forecast Verification Tool.

Integrated Support for Impacted air-Traffic Environments (INSITE; Figure 4): INSITE is a web-based application developed for use in the convective weather forecast process. It aligns with NWS Weather Ready Nation initiatives to provide Impact Based Decision Support Services by blending raw convective weather information with traffic data to highlight potential weather-related impacts to aviation operations. INSITE version 3.0 was completed June 2014 and was made available to NWS CWSU and AWC forecasters for evaluation during the summer. The prevailing feedback was that the inclusion of current and planned traffic data to identify airspace constraints would be a valuable addition—this feature is being implemented into version 3.5, planned for release in May 2015. INSITE 3.5 is targeted for use by NWS AWC forecasters, National Aviation Meteorologists, and CWSUs as part of their general weather services to the FAA, as well as to support a new process known as Operational Bridging, the output of which is an event-driven product known as the Collaborative Aviation Weather Statement, to communicate potential impacts to aviation operations due to convective weather.

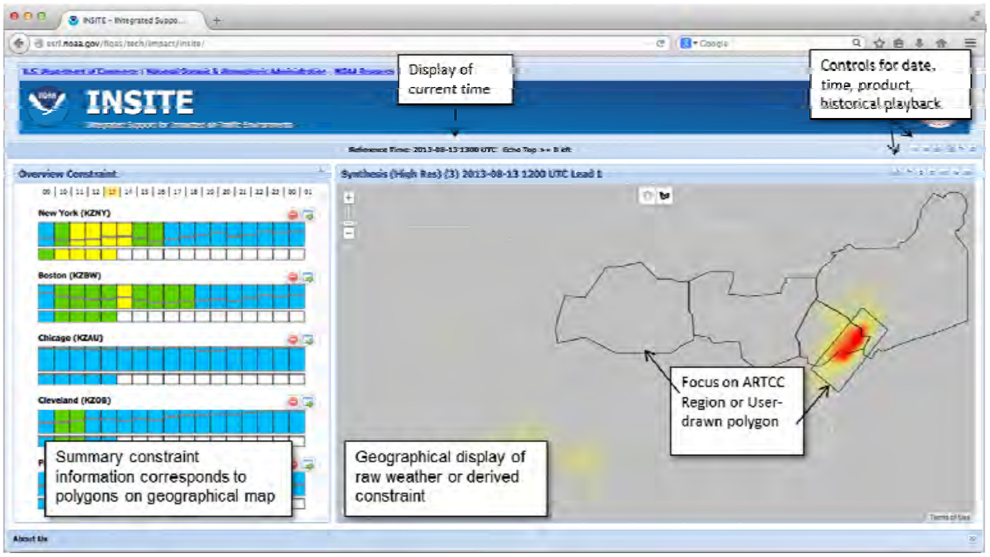


Figure 4. Integrated Support for Impacted air-Traffic Environments

PROJECT TITLE: EAR – AWIPS I & AWIPS II Workstation Development

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Daniel Schaffer, James Ramer, U Herb Grote, Evan Polster, Amenda Stanley, Kevin Manross, Sarah Pontius

NOAA TECHNICAL CONTACT: Woody Roberts (OAR/ESRL/GSD/EDS)

PROJECT OBJECTIVES:

The ongoing objective of this program is to research and maintain AWIPS-related service solutions for researchers and field personnel using those solutions, as well as supporting the NWS in the future development and delivery of those solutions. AWIPS I is the original Advance Weather Information Processing System used by the NWS Weather Forecast Offices (WFO) since the 1990s. AWIPS II (also known as A2) is the re-factored version of the AWIPS I system.

The long-term objective of this project is to develop a forecast workstation with advanced interactive display capabilities that includes interoffice and external collaboration and integrates existing hazard services. The collaboration capability can improve forecast consistency between offices and permit better coordination with external partners.

PROJECT ACCOMPLISHMENTS:

AWIPS II Extended Task – Hazard Services Project
The goal of the hazard services project is to integrate current AWIPS applications that are used to generate hazard weather watches, warnings, and advisories. These discrete applications are WarnGen, Graphical Hazard Generator, RiverPro, and the NWS National Center hazard generation functionality.

The hazard services project is a multi-year effort to integrate the various warning, watch, and advisory tools used by the NWS. In the process, CIRA staff sought to transition the current hazard generation programs from a paradigm of issuing products to one of decision support.

This effort is multi-faceted. The first facet is the continued vetting of requirements with Hazard Services users. CIRA personnel participated in weekly discussions including the presentation of code designs and implementations. These meetings then rolled over into more formal Integrated Working Team meetings starting in early 2015.

A second facet is the continued development of code that implements the requirements for Hazard Services. CIRA personnel assisted in this development process. The team helped to deliver an initial operating version of Hazard Services as part of the A2 15.1.1 version to be made available to forecasters in September 2015. This delivery included the following items:
--Migration of legacy metadata formats into the Hazard Services format.
--Development of part of the product generation functionality included in Hazard Services.
--Adding capabilities to the Hazard Services Spatial Display such as the ability to add and remove counties from hazard events.
--Fixing a variety of bugs and making enhancements to the previously developed code.

A third aspect is continued support of operational testing of Hazard Services. This effort included providing input to the NWS-led operational test team along with the development of the capability for testing to be done remotely using the NoMachine technology. An instance of Hazard Services has now been deployed to the GSD Demilitarized Zone (DMZ). Any tester with a good internet connection can log on to this machine and test Hazard Services via NoMachine.

In support of efforts to test Hazard Services, work has begun to be able to build A-II review cases for some significant weather events that exercise the various aspects of Hazard Services. The plan is to be able to both build historical cases based on ITS archived NOAAPORT data and to build cases based on an ongoing event by picking up selected data sets from the archive partition on a2dp in real time. We expect to have at least one useable case built by the end of this evaluation period. It is hoped that the ability to build A-II review cases will be useful for other development efforts related to A-II.

The team collaborates closely with the AWIPS II contractor, who is responsible for developing specific portions of the code and also for ensuring that the software will work in the AWIPS II environment. Regularly-scheduled coordination meetings allow all members of the team to be properly informed on the software development tasks.

AWIPS II Transition Task - Migrate LAPS and MSAS to AWIPS-II
This work continued at a high level of effort this year and can be broken down into these major subtasks:

Respond to trouble reports from sites that already have the A2 LAPS/MSAS running.

Developed scripting that grabs selected real-time data sets from our production clustered EDEX and pushes them through a local EDEX. This allows one to work on LAPS & MSAS easily in a standalone development environment, and there was a great deal of synergy between this work and the effort to develop a review case capability for Hazard Services.

Updated the LAPS/MSAS install such that it can be installed on computers that were not previously legacy system computers. This work was not only originally requested by the training branch but was also key for allowing one to work on LAPS & MSAS in a standalone development environment.

Updated the workset used to build the LAPS/MSAS install tars such that the LAPS executables are built from source code as part of the process that creates the install tars, instead of putting LAPS executables directly into CM. Building LAPS executables directly made it practical to begin the effort to hand the LAPS/MSAS code off to Raytheon.

Added the ability to switch to DAF access for LAPS/MSAS. (The DAF version of the access scripts were provided to us by RTS).

Continued work on the new version of the A2 LAPS with a domain change GUI and ability to read most EDEX datasets in real time instead of converting to legacy system format by cron.

The LAPS/MSAS task is a joint effort with government staff from GSD's Evaluation and Decision Support Branch and the Earth Modeling Branch.

AWIPS II Transition Task - Migrate Existing User-Created Procedures and Color Tables.
The basic development for this task has been done for over a year, but there are still occasional trouble tickets to respond to in this area. During this evaluation period, this work has averaged about a half day per month, but is trending downward. Once the deployments are finished later this year, we may well close the book on this task for good

AWIPS II Transition Task - Forecast Decision Support Environment - Ensemble Feature Migration
Referred to as the Ensemble Tool project, CIRA personnel (Evan Polster) were tasked with migrating Ensemble application features from the AWIPS-I D/2D workstation into the AWIPS-II CAVE workstation.

The Ensemble Tool is a navigator/explorer widget and tool layer that is integrated into the CAVE workstation. It simplifies end-user experience of visualizing and manipulating large amounts of gridded data, as is the case when processing an Ensemble perturbation member set.

Phase 1 of this effort occurred January, 2014 through February, 2015 and involved:
--Integration into the AWIPS-II application development environment.
--Development of fundamental components of this feature including: Visualization, manipulation, data introspection, and user-specified calculation capabilities for ensemble sets, delivered as a CAVE (Eclipse Rich Client Platform) plug-in.
--Integration of the solution into the NWS (source code) OB 14.4.1 baseline through Raytheon and OS&T peer-review processes.

AWIPS I and II Task - Formatters
The current HLS was broken up into two new formatters. A new non-segmented HLS and a segmented TCV. Both formatters are currently going through beta testing, and we hope to use them during the upcoming hurricane season. This new format will impact how products are issued to tropical storm-prone areas.

As part of the Enhanced Digital Aviation Services project, a TAF (Terminal Aerodrome Forecast) formatter is being worked on. It is still under development and with plans to deploy it to more sites in the future.

POTENTIAL TASKS
CIRA researchers at GSD are involved with submitting multiple proposals for migrating the National Severe Storms Laboratory's (NSSL) prototype Probabilistic Hazards Information (PHI) workflow into the AWIPS II Hazard Services Recommender framework. The aim of this work is to produce probability (and derived) grids pertaining to hazardous weather impacts. Implementing the PHI workflow and output

products in Hazard Services would be an important step in getting such capabilities in an operational setting.

The “PHI into Hazard Services” work, if funded, would be the backbone of the Forecasting A Continuum of Environmental Threats (FACETs) initiative. <http://www.nssl.noaa.gov/projects/facets/>

Forecasting a Continuum of Environmental Threats (FACETs) is a proposed next-generation severe weather watch and warning framework that is modern, flexible, and designed to communicate clear and simple hazardous weather information to serve the public. FACETs supports NOAA's Weather-Ready Nation initiative to build community resilience in the face of increasing vulnerability to extreme weather and water events.

Funding awards are anticipated to be announced by the end of summer 2015.

PROGRAM TITLE: EAR - AWIPS I & AWIPS II Workstation Development (Formerly FX-Net and Gridded FX-Net)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Evan Polster, Amenda Stanley

NOAA TECHNICAL CONTACT: Mike Kraus (OAR/ESRL/GSD/EDS Chief)

NOAA RESEARCH TEAM: Robyn Heffernan, NOAA/NWS/Fire Weather Program, Susan Williams (OAR/ESRL/GSD/EDS), Woody Roberts (OAR/ESRL/GSD/EDS), Vivian Lefebvre (OAR/ESRL/GSD/ATO), Paul Schultz (CIRES)

PROGRAM OBJECTIVES:

This is no longer a NOAA-Funded Project. This project was funded by NOAA/NWS for 16 years and is now funded through GSD by the National Interagency Fire Center (NIFC), which is a multi-agency federal group supporting fire-fighting operations. NOAA/NWS discontinued funding for this project at the end of 2013.

The ongoing objective of this program is to research and maintain AWIPS-related service solutions for NIFC Predictive Services Fire Weather Forecaster, researchers and field personnel using those solutions, as well as supporting the NWS in the future development and delivery of those solutions.

The long-term objective of this project is to develop a forecast workstation with advanced interactive display capabilities that includes inter-office and external collaboration, and integrates existing hazard services. The collaboration capability can improve forecast consistency between offices and permit better coordination with external partners.

PROGRAM ACCOMPLISHMENTS:

AWIPS I Ongoing Task - FX-Net Project
The FX-Net project continues on its 17+ year journey.

FX-Net as a service solution is in its planned obsolescence phase, with a tentative project end date of late 2016 or early 2017, to be replaced by AWIPS II based solutions (see FxCAVE Project below).

Tasks of the last 16 months mostly involved maintenance of hardware systems and support of field personnel. Customers include the National Interagency Fire Center, Colorado Water Board, and the Chief Presidential Support Element in charge of the Executive Fleet at Andrews AFB, as well as local researchers. Demand for this support was nominal as things mostly ran smoothly.

Since the introduction of new high-resolution model data delivered over the Satellite Broadcast Network (SBN), FX-Net data servers have been unable to successfully ingest this new data due to architectural size constraints of the underlying release AWIPS I OB 9.2. Efforts of the last few months have been focused on rebuilding FX-Net data and application servers to/on the more capable AWIPS I OB 9.15. This is considered necessary during the transition period (between AWIPS I to AWIPS II based solutions) as field personnel will be dependent on these legacy services while still learning the AWIPS II services. This effort will carry over into the next task year.

AWIPS II Extended Task - FxCAVE Project
The FxCAVE project is now the new name for the FX-Net project.

Whereas FX-Net service solutions are based on AWIPS I infrastructure, the FxCAVE service solutions are based on AWIPS II.

The FxCAVE mission includes:
--Provide AWIPS II services and applications to customers (field personnel).
--Provision physical hardware (on behalf of customers) with FxCAVE meteorological workstation.
--Provide maintenance and support of research-regular production-based EDEX servers.
--Provide maintenance and support of fielded FxCAVE workstations.
--Provide data ingest for third-party, research-regular, meteorological data.

FxCAVE as a service solution is composed of the AWIPS II application (EDEX) servers and a pared-down version of the Common AWIPS Visualization Environment (CAVE) meteorological workstation, which has been rebranded to the Forecast eXperimental CAVE (FxCAVE).

These solution services include continual support of the National Interagency Fire Center (NIFC) and their satellite Geographical Area Coordination Center (GACC) offices.

For FxCAVE project, the following accomplishments have been made over the past 16 months:
--Provisioned two physical desktop FxCAVE workstations for the NIFC control center (NICC) and the Redding CA (“North Ops”) GACC. These machines are in the process of being vetted by the Bureau of Land Management (BLM) Data Center (Federal Center in Lakewood, CO). Once vetted, 9 more machines will be purchased by NIFC on behalf of the related inter-agencies (BLM, US Forest Service, US Park Service, etc.) and provisioned with FxCAVE, and shipped back to the GACC offices in Spring 2015.
--Provisioned, maintained and supported multiple versions of EDEX servers including AWIPS II OB 13.5 through OB 14.3.
--Provisioned and maintained FxCAVE workstation on Linux and WIndows 7 through multiple versions including AWIPS II OB 13.5 through OB 14.3.
--Research on Virtualization (“FxCAVE in the Cloud”):
----successfully provisioned the OB 14.3.1 EDEX server using Virtualization.
----successfully provisioned the OB 14.3.1 FxCAVE client (Windows 7) using Virtualization
----research includes load testing of multiple remote Virtual clients against one Virtual EDEX server.
----research includes performance and usability testing.
--Initiated ingest of the Rocky Mountain Center’s (Fort Collins, CO) WRF 12km ForFlux model
--Initiated ingest of the Global Systems Division HRRR Chemical 3km model (over Western US only)
--Initiated ingest of the medium-term GFS384 model.

PROJECT TITLE: EAR - Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Tom Kent, Leigh Cheatwood-Harris, Randall Collander, Jim Frimel, and Amenda Stanley

NOAA TECHNICAL CONTACT: Greg Pratt (OAR/ESRL/GSD/ATO)

NOAA RESEARCH TEAM: Leon Benjamin (CIRES), Gopa Padmanabhan (CIRES), Michael Vrencur (ACE Info Sol)

PROJECT OBJECTIVES**:**

MADIS is dedicated toward making value-added quality control (QC) data available for the purpose of improving weather forecasting. MADIS data helps to provide support for use in local weather warnings and products, data assimilation, numerical weather prediction, and the whole meteorological community in general. This is accomplished by partnerships with both federal and state government agencies, universities, airlines, private companies, and individual citizens. MADIS provides over 170 surface networks with more than 66,000 stations producing nearly 13 million observations per day; 630,000 aircraft observations per day, 113 profiler sites, as well as global radiosonde and satellite observations.

The objectives are:
Continue to add new functionality and data sources to MADIS;
Provide support to the user community;
Transition new and enhanced MADIS research to operations at NWS National Centers for Environmental Prediction (NCEP).

Some of the upcoming enhancements include adding CLARUS into MADIS to transition Department of Transportation (DoT) data, metadata, and QC algorithms to operations at NCEP Central Operations (NCO). MADIS is also a partner in the National Mesonet program working with various providers on IOOS standards for data and metadata which will make it much easier for data delivery and decoding. Some providers have begun to send data in this format and that effort is expected to ramp up this year as MADIS builds a standardized conduit for easier transition of new observational data from research to operations. Agreements are also in place for an NWS-FAA partnership for a direct feed of real-time 1 minute ASOS data. Work is also being done on the FAA NextGen/NWS AWIPS data discovery and delivery project.

PROJECT ACCOMPLISHMENTS**:**

MADIS achieved Final Operating Capability (FOC) at the NCO in January 2015. The NCO facility is located in College Park, MD and is the center of operations with its new Integrated Dissemination Program (IDP) infrastructure for NOAA wide data dissemination. The IDP was created to integrate all the various NOAA stovepipe dissemination systems into an enterprise wide program. MADIS was one of the first two projects to go through the rigorous process to on-board software to operations at the IDP and helped to provide valuable lessons learned for future NOAA projects about to make the same transition. One of the many advantages of the new IDP setup is the centralization of the MADIS ingest, processing, and distribution all running on virtual machines at the same facility. Before FOC, MADIS ingest and distribution ran at the TOC while the processing ran at NCO WCOSS. Another advantage of the IDP is that MADIS will now have the two data access points contained within the NOAA security framework with the College Park facility and the backup IDP which will be built in Boulder, CO in 2016. GSD will no longer be an operational backup and instead will go back to its mission of research and enhancements to MADIS for transfer to operations. GSD will still be providing Tier 3 support. In order to stay on track with a very aggressive FOC schedule, MADIS staff traveled to meet NCO personnel in person as well as conduct multiple weekly meetings between developers, IT staff, and managers. A large amount of CIRA staff time was spent on training NCO personnel on MADIS support so they could take over the system at

FOC. This included training in providing MADIS support such as solving user problems, data delivery problems, data archive requests, firewall issues, LDM set-up, web server setup and troubleshooting, new accts, password resets and a host of other issues. Numerous web documents were written as end-to-end information for each network as well as many Google docs for Software Design, Implementation, Execution, and Troubleshooting guidance. A monitoring mechanism was also put into place for all the data and communication processes. Many new scripts were written to automate some of the maintenance as well as for performance metrics and graphical displays. More enhancements to the MADIS Web Surface Display using Google Maps were put into production as well as a display for aircraft data. These tools allow users to see all the data points as well as some of the metadata in a concise manner in addition to allowing for easy subsetting of the desired data. A completely new MADIS webpage was also developed using the NOAA/NWS web template.

A link to a NOAA web article about the transition can be found here:
http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/11037/NOAA%E2%80%99s-growing-weather-observations-database-goes-into-full-operations.aspx

PROJECT AWARDS:

The MADIS/IDP team has been nominated for a NOAA Gold Medal for reaching this big FOC milestone.

PROJECT TITLE: EAR - Citizen Weather Observer Program (CWOP)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Leigh Cheatwood-Harris, Randall Collander, and Tom Kent

NOAA TECHNICAL CONTACT: Greg Pratt (OAR/ESRL/GSD/ATO)

NOAA RESEARCH TEAM: Leon Benjamin (CIRES), Gopa Padmanabhan (CIRES), Michael Vrencur (ACE Info Sol.)

PROJECT OBJECTIVES:

The Citizen Weather Observer Program (CWOP) database is now maintained by the GSD MADIS Staff. CIRA researchers administer the CWOP through database updates, interactions with CWOP members answering questions and discussing suggestions, refreshing related web pages and documents, verifying that station listings and other reference data required by MADIS are complete and accurate, and confirming that routine backups of database and related files are performed.

The CWOP is a public-private partnership with three main goals:
Collect weather data contributed by citizens;
Make these data available for weather services and homeland security;
Provide feedback to the data contributors so that they have the tools to check and improve their data quality.

There are currently 18,311 active stations (citizen and ham radio operators) out of a total of 31,200 stations in the CWOP database. CWOP members send their weather data via internet alone or internet-wireless combination to the findU (http://www.findu.com) server and then the data are sent from the findU server to the NOAA MADIS ingest server every 5 minutes. The data undergo quality checking and then are made available to users thru the MADIS distribution servers. CWOP is in the process of transitioning to operations within the NCO IDP MADIS system.

PROJECT ACCOMPLISHMENTS:

More database procedures were streamlined through development and implementation of scripts to auto-correct missing and typographical errors in new member sign-up requests, and through introduction of automated site geographic location and elevation verification algorithms. Interactions occurred with users via email regarding site setup, data transmission issues, quality control and general meteorology. Various web-based documents and databases were updated on a daily, weekly or monthly basis depending on content, and statistics and other informational graphics revised and posted.

In 2014, there were approximately 2400 stations added to the database. There were about 2800 revisions made to site metadata. Adjustments include latitude, longitude and elevation changes in response to site moves, refinement of site location, and site status change (active to inactive, vice-versa).

PROJECT TITLE: EAR - Research Collaborations with Information and Technology Services

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Leslie Ewy, Patrick Hildreth, Robert Lipschutz, Chris MacDermaid, Glen Pankow, Randy Pierce, Richard Ryan, Amenda Stanley, and Jennifer Valdez

NOAA TECHNICAL CONTACT: Scott Nahman (OAR/ESRL/GSD/ITS Chief)

NOAA RESEARCH TEAM: Alex Mendoza (ACE Info Sol.)

PROJECT OBJECTIVES:

CIRA researchers in Information and Technology Services (ITS) develop and maintain systems that acquire, process, store, and distribute global meteorological data in support of weather model and application R&D projects throughout GSD. CIRA researchers collaborate with ITS and other GSD researchers to provide services that meet the specified requirements. CIRA researchers also provide research support as team members of several projects.

PROJECT ACCOMPLISHMENTS:

--GSD Central Facility - CIRA researchers managed the GSD/ITS 6-host data processing cluster, extending the configuration to handle a variety of new data sets, including operational HRRR (High Resolution Rapid Refresh) model data, SYNOP surface observation data, Meteosat Second Generation (MSG) imager channel data, and Navy Global Environmental (NAVGEM) model data. CIRA researchers completed the transition from the last remaining legacy physical servers onto new Virtual Machines (VM), and transitioned off the legacy NOAAPORT Receive Systems in preparation for increased data being sent over NOAAPORT.

-HIWPP High-Impact Weather Prediction Project (HIWPP) - CIRA researchers collaborated with researchers across NOAA, and with researchers in the atmospheric sciences outside NOAA, toward development and evaluation of high-resolution global weather models. CIRA researchers were responsible for developing data services and many elements of the software infrastructure for this project. In particular, CIRA researchers implemented methods to efficiently transfer large-model data sets from the NOAA R&D High Performance Computing System (RDHPCS) to the HIWPP data distribution and visualization systems and configured various data transport and processing elements to deliver needed data to HIWPP developers and researchers. CIRA researchers also began development of a web framework for the presentation of verification statistics that will address several limitations of the legacy methods.

--NOAA Earth Information System (NEIS) - CIRA researchers collaborated on the NEIS demonstration program, developing a set of services for metadata management and searching, web proxying and data caching. This year CIRA refactored many of the services to increase reliability, maintainability, and performance.

--Federal Aviation Administration (FAA) Common Support Services-Weather (CSS-Wx) - CIRA researchers collaborated with CSS-Wx researchers in GSD, NCAR (National Center for Atmospheric Research), and MIT (Massachusetts Institute of Technology)/Lincoln Laboratory on services to improve the quality, safety and cost of air traffic by more effectively making decision makers aware of current and upcoming weather. CIRA researchers completed the Product Data Descriptions (PDD) for GOES (Geostationary Operational Environmental Satellite), HRRR model, SIGMETS, MDCRS (Meteorological Data Collection and Reporting System), and RAP (Rapid Refresh) model.

--NextGen IT Web Services Program (NGITWS) – CIRA researchers collaborated with researchers from NOAA's Meteorological Development Laboratory, NOAA's Aviation Weather Center, and NCAR to develop a web-based data dissemination service to revolutionize the accessibility, discoverability, and machine-to-machine communication and processing of National Weather Service (NWS) data sets. The initial deployment will focus on the aviation-centric data sets to support the FAA. CIRA researchers provided subject matter expertise to the program on data translation services, data dissemination services, and data formats.

--GSD Web Services - CIRA researcher, Jennifer Valdez, serves as GSD Webmaster, providing numerous services to GSD scientists, RDHPCS management, and external community members. Activities included establishing a new publications database for GSD, developing an Account Information Management system for RDHPCS, serving on the NOAA Web Committee, and collaborating on developing a website and portal for the High Impact Weather Prediction Project (HIWPP).

PROJECT TITLE: EAR - Common Support Services – Weather (CSS-Wx)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jim Frimel, Patrick Hildreth, Michael Leon, Chris MacDermaid, Glen Pankow,

NOAA TECHNICAL CONTACT: Lynn Sherretz (OAR/ESRL/GSD/ACE)

NOAA RESEARCH TEAM: Charles Burton (Ace Info Sol.)

PROJECT OBJECTIVES:

1--Maintain the GSD Web Services Testbed.
2--Advise the FAA CSS-Wx management and technical team on web-services technology and OGC web services standards.
3--Develop Product Data Descriptions for use in the FAA NextGen CSS-Wx contract procurement.

PROJECT ACCOMPLISHMENTS:

The CSS-Wx Program is dedicated to using and developing technologies and standards that will support effective weather data dissemination within the NextGen environment. Among the CSS-Wx team members are National Center for Atmospheric Research, Research Applications Laboratory (NCAR/RAL), Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL), NOAA Earth Systems Research Laboratory/ Global Systems Division (GSD), MITRE, and the FAA's William J. Huges Technical Center (WJHTC). Together, these organizations are working in partnership to lay the foundation for NextGen weather data distribution.

1--Support and maintenance of the CSS-Wx Web Service Testbed
CIRA researches supported and maintained the Open Geospatial Consortium (OGC) Web Feature Service Reference Implementation (WFSRI), OGC Web Coverage Service Reference Implementation (WCSRI), and the OGC Web Map Service Reference Implementation (WMSRI). CIRA researchers also maintained the Testing Portal for testing the FAA's and NOAA Web Services. These efforts included conducting functional and performance testing, enabling the services to use real-time data and ensuring the services adhered to OGC standards.

2--Technical Support to CSS-Wx Program Office
CIRA researchers attended technical meetings with other agencies and the JPDO and responded to ad-hoc requests for information from the CSS-Wx Program Office.

3--Product Data Descriptions (PDDs)
CIRA researchers created PDDs in accordance with FAA Std 65A for GOES (Geostationary Satellite Server) data, METAR station data, HRRR (High-Resolution Rapid Refresh) and RAP (Rapid Refresh) numerical weather prediction models.

The FAA discontinued the funding for this project in July, 2014. The NWS is now funding this project (see the NextGen Web Services report.

PROJECT TITLE: EAR- NextGen IT Web Services/ Integrated Dissemination Program (IDP)

PRINCIPAL INVESTIGATOR: Chris MacDermaid

RESEARCH TEAM: Patrick Hildreth, Jim Frimel, Michael Leon, Robert Lipschutz, and Glen Pankow

NOAA TECHNICAL CONTACT: Greg Pratt (OAR/ESRL/GSD/ATO), Ryan Solomon (NWS/AWC)

NOAA RESEARCH TEAM: Leon Benjamin (CIRES)

PROJECT OBJECTIVES:

CIRA researchers are providing subject matter expertise and developing services for the NextGen IT Web Services Program (NGITWS). The National Oceanic and Atmospheric Administration (NOAA) Integrated Dissemination Program (IDP) is fielding NGITWS, a web-based data dissemination service that will revolutionize the accessibility, discoverability, and machine-to-machine communication and processing of National Weather Service (NWS) data sets. Focused on Open Geospatial Consortium (OGC) standard services and data formats for maximum interoperability, initial operational capabilities will be available from two geographically-diverse state-of- the-art data centers in College Park, Maryland and Boulder, Colorado. While the initial deployment will focus on aviation-centric data sets to support the Federal Aviation Administration (FAA) Next Generation Air Transportation (NextGen) system, others are preparing to take advantage of this new service including the NWS Advanced Weather Interactive Processing System (AWIPS) and Aviation Weather Center (AWC) Web Services.

PROJECT ACCOMPLISHMENTS:

--CIRA researchers attended technical interchange meetings with the FAA, the National Weather Service (NWS), and the National Center for Atmospheric Research (NCAR) in their role as subject matter experts to discuss dissemination techniques, atmospheric data formats, and web services. CIRA researchers also presented on NGITWS at the NOAA Environmental Data Committee Workshop and attended the Air Transportation Information Exchange Conference in support of the program.

--CIRA researchers reviewed Product Data Description (PDD) documents for GOES (Geostationary Operational Environmental Satellite) data, HRRR model ouput, SIGMETS, MDCRS (Meteorological Data Collection and Reporting System), and the RAP (Rapid Refresh) model. CIRA researchers revised the PDDs with the information from the reviews. CIRA researchers will be completing development on the AMDAR (Aircraft Meteorological Data Relay) PDD and creating the initial version of a MADIS (Meteorological Assimilation Data Ingest System) AMDAR WXXM (Weather Information Exchange Model) 2.0 mapping.

PROJECT TITLE: EAR - NOAA Environmental Information System (NEIS)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jebb Stewart, Jeff Smith, Randy Pierce, Chris MacDermaid, Mary Sue Schultz

NOAA TECHNICAL CONTACT: John Schneider (OAR/ESRL/GSD/ATO Chief)

NOAA RESEARCH TEAM: Alexander MacDonald (OAR/ESRL Director), Eric Hackathorn (OAR/ESRL/GSD/ATO), Tracy Hansen (OAR/ESRL/GSD/EDS), Chris Golden (CIRES), Julien Lynge (CIRES)

PROJECT OBJECTIVES:

NOAA is challenged to ingest, manage, generate and provide reliable access to the increasing volume of data associated with their high caliber environmental systems. The objective of the NEIS project is to make data easily accessible to people across the country and around the world. NOAA can benefit from leveraging an existing information management and storage solution to allow easy and open information sharing of big data services throughout the user community. NOAA can use proven Portals, Apps, App Chaining, Collaboration Tools, Information Management & Storage, and Business Analytics within NEIS. http://www.esrl.noaa.gov/neis/
The core capabilities of this new system will meet requirements to:
1--Provide discovery and access to all information and data for all time scales,
2--Provide the information when the user needs it,
3--Provide the information in a form the user can interpret,
4--Make information available on all platforms.

The CIRA team's objectives are to investigate, prototype and explore:
--improving data discoverability and access,
--data management capabilities, and,
--how interoperable processing and analysis services are integrated into the system.

The CIRA team is also dedicated to conduct this research with a collaborative team of NOAA, university and private sector developers.

PROJECT ACCOMPLISHMENTS:

This report on NEIS is supplemental to the Sandy Supplemental Quarterly Reports as a portion of the project was funded by GSD Director's funds in 2014.

The NEIS team, along with other GSD scientists, developed initial system architecture for the High Impact Weather Prediction Project (HIWPP) http://hiwpp.noaa.gov. Subsequently the team identified, procured, and installed hardware necessary for high performance visualization of HIWPP data.

Staff researched and developed three different encoding techniques to transmit data for visualization. These approaches were evaluated based on performance and overall compression ratio. Currently NEIS uses Compressed DDS images. The techniques were as follows:
--Simple Run Length Encoding compression was able to achieve 70-80% reduction on data sets,
--More advanced GPU Wavelet compression achieved 90% reduction for data but requires advanced client side hardware,
--Compressed DDS images have best result for transmission size, speed of decompression, and reading data directly to GPU for visualization

The team developed research real-time data ingest system for gathering metadata from incoming datasets, pre-processing of expected popular data items to improve performance of commonly requested items, and store data for future retrieval from NEIS Visualization system. Data is available for minimum of 24 hours and up to 7 days depending on underlying dataset.

New data sets were added to ingest and visualization system for HIWPP project including:
--High Resolution GFS data,
--High resolution NAVGEM,
--Additional run of high resolution FIM data from Jet supercomputer,
--Surface point data METAR, Maritime, and SYNOP reports,
--Upper Air Point Data from Soundings.

Developed point data access service and visualization capability for surface and upper air point observations.

Expanded NEIS visualization capabilities integrating HIWPP related data services provide side by side or multiple sphere displays (Figure 1) for comparing data, user interface to interact with remote processing capability and various user interface enhancements.

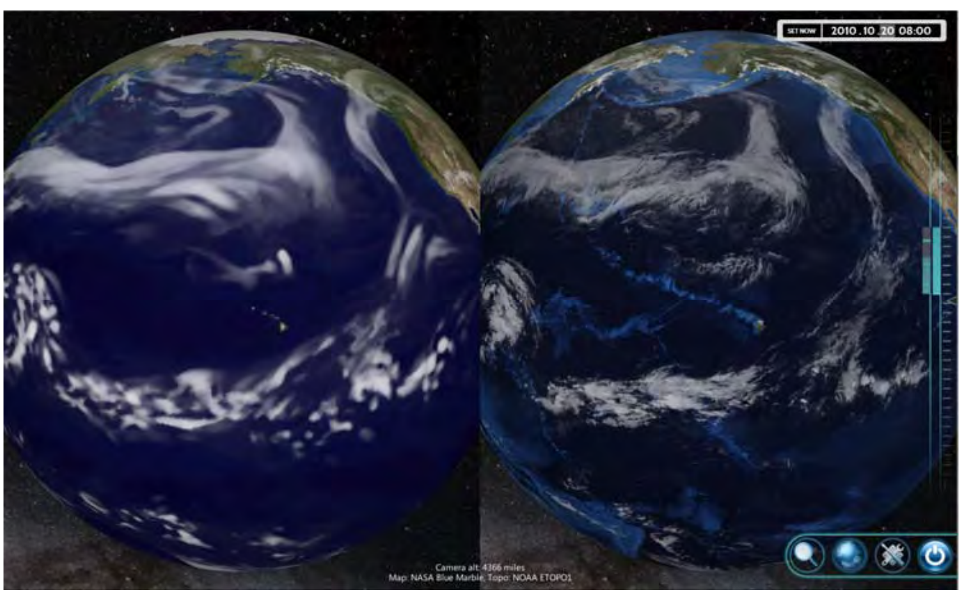


Figure 1. NEIS visualization of Derived IR Satellite Imagery from the FIM model compared with Observed Global Composite IR Satellite Imagery.

The NEIS team developed "Tour" capability which is similar to the Google Earth tour capability. This allows users to define a sequence of data to load, locations to move to, highlight areas by either drawing shapes to the screen as well as pop up's with text content. Tours can also be used to save user preferences for a particular data type such as color palate or contour color. This allows users to define preferences to load data such as datasets, color, and type of visualization. Similar to Google Earth tour capability

Developed initial service-based processing capability allowing the development of algorithms in multiple languages (i.e. Java, R, Javascript, Python, etc.) to run remotely on server closest to data. The team also integrated user interface elements into the visualization platform allowing users to dynamically define inputs to remote algorithms. Development is progressing to fine tune service-based processing which makes it easier to work with data not in a common projection or grid size. Common projection and grid size is needed for model output comparisons.

NEIS Visualization client was made available to CIRA staff and other preliminary testers in mid-October 2014. The latest visualization client as of December 15th, 2014 will be used for the first release as part of the HIWPP Open Data Initiative program launched in January 2015.

PROJECT TITLE: EAR - Science on a Sphere® (SOS) Development

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Keith Searight, Michael Biere, Steve Albers

NOAA TECHNICAL CONTACT: John Schneider (OAR/ESRL/GSD/ATO Chief)

NOAA RESEARCH TEAM: Beth Russell (CIRES), Ian McGinnis (CIRES), Vincent Keller (CIRES), Hilary Peddicord (CIRES)

PROJECT OBJECTIVES:

1--Continue to develop and enhance near-real-time global data sets for use at SOS sites.
2--Provide software and technical support for existing SOS systems sites, new and proposed SOS installations, and travelling SOS exhibits that conduct scientific education and outreach.
3--Plan and release new versions of the SOS system software with prioritized features.
4--Research new technologies and configurations for future innovations in SOS.

PROJECT ACCOMPLISHMENTS:

The Science on a Sphere® (SOS) Development project advances NOAA's crosscutting priority of promoting environmental literacy. SOS displays and animates global data sets in a spatially accurate and visually compelling way on a 6-foot diameter spherical screen. CIRA provides key technical leadership and developments to the SOS project, particularly research and implementation of effective controls and user interfaces for the system, new visualization techniques, and new data sets.

1--Near-real-time global data sets

The SOS team continued to support the automated transfer of large volumes of near-real-time weather model data to SOS sites via private FTP. Recently collected statistics documented a monthly average of over 7 TB of SOS datasets downloaded, which doubled in volume over the previous year.

Highlights for this reporting period included:
--Maintaining the continued production and delivery of the real-time global weather models LAPS, FIM, and GFS for SOS.
--Developing and maintaining other real-time datasets for SOS, including global weather satellite, earthquakes, and solar extreme ultraviolet images from the STEREO spacecraft.
--Collaborating with other CIRA associates to make our innovative global FIM-derived cloud visualization output available in real-time on SOS. Additionally, this simulated visible image is now available along with a companion infrared satellite image to HIWPP for display on high-resolution flat-screens.
--Creating a real-time dataset for SOS that shows trajectory wind streamers from the FIM model at the 500mb level.
--Contributing to the creation of updated SOS datasets for Saturn's moons using new maps generated by the Lunar and Planetary Institute.
--Giving live real-time weather demonstrations on the traveling SOS in the highly visible NOAA ESRL booth at the AMS 2015 conference in Phoenix, Arizona.

2--Software and technical support for SOS systems

The SOS team provided regular support to SOS sites by e-mail and telephone. The issues handled include upgrades and problems with the SOS software, hardware, and equipment, finding and accessing datasets, and questions about operating the SOS system.

During this reporting period, 12 new SOS systems were installed at sites in Japan, North Carolina, Maryland, Mexico, India, Philippines, Illinois, California, Turkey, United Arab Emirates, Hong Kong, and Alabama. Notably, a large number of these were “first-ever” SOS installations: for the Middle East region (UAE) and for the countries of Japan, India, Philippines, and Turkey. At last count, the total number of SOS systems installed worldwide has reached 115.

In support of scientific education and outreach, the portable SOS system and SOS team members travelled to conferences and workshops around the county, including the World Science Festival (New York), Super Computing, American Meteorological Society, the 6th SOS Users Collaborative Network Workshop (St. Paul), Southern Hills Middle School (Boulder), and the State Department’s Our Ocean conference (DC) (see Figure 1).

Figure 1. The portable SOS System at Our Ocean Conference.

3--Plan and release new SOS capabilities

Under CIRA staff’s leadership, the SOS team did extensive strategic planning work to evaluate the near-term, mid-term, and long-term opportunities and priorities for SOS. Part of this planning process was to adopt a regular software release cycle with development timelines following industry best practices. As a result of this process, two SOS software releases were planned during this reporting period with a set of prioritized deliverables.

SOS v4.2 (June 2014) met all planned objectives on schedule. Major highlights were:
--SphereCasting enhancements: including audio/video of the presenter appearing in a picture-in-picture (PIP) on the sphere and the capability to transmit all the advanced SOS features in real-time from the host sphere to all the receiving sphere sites.
--New usage statistics tools: to capture data from SOS sites and generate aggregated statistics about dataset usage and popularity on the public SOS web site.

SOS v4.3 (March 2015) will meet all planned objectives on schedule. Major highlights are:
--Automated alignment innovation: A new technique developed to align the four projectors in SOS automatically using webcams and computer vision algorithms. Aligning the sphere is currently a laborious manual process that is difficult for sites to perform well and this key innovation has great potential for keeping fielded SOS systems in better alignment, which will provide an optimal user experience.
--Data catalog re-architecture and metadata quality control: The SOS team collaborated with the SOS users network to devise a new major- and sub-category structure for the nearly 500 datasets in the SOS data catalog. The SOS website and its underlying database schema were also re-engineered to support the new data catalog metadata and to enhance data catalog integrity, utility, and maintainability.
--A major upgrade of the iPad remote used to control the SOS system: An update to the user interface look 'n' feel for iOS 8, eliminating Internet and Wi-Fi connectivity requirements, rewriting and expanding dataset browsing, searching and filtering options (see Figure 2), adding an audio volume control, improving dataset layers management, providing easy access to over 40 contributed Live Programs, adding a new playlist builder to create and edit presentation playlists, and implementing a widely requested new presenter notes editing and viewing capability.

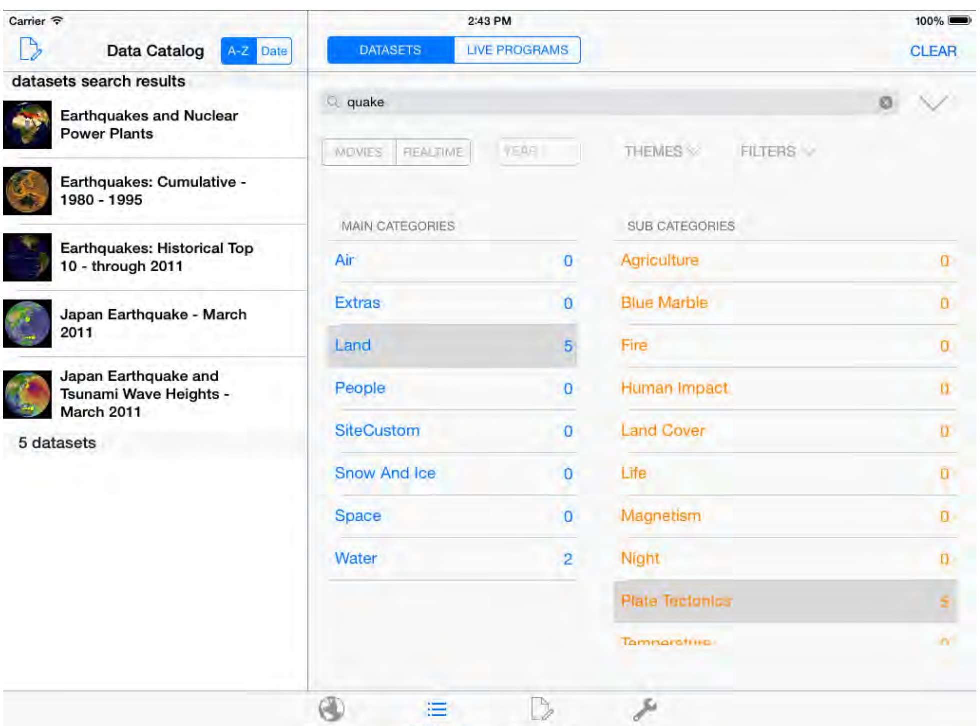


Figure 2. SOS iPad search upgrade.

4--Research new technologies and configurations for future innovations in SOS

To keep SOS at the forefront of spherical display technologies and support more venue flexibility, the SOS team evaluated new configurations of SOS different from the current equipment setups typically recommended for SOS sites. Investigations conducted include:
--Testing new SOS configurations: Alternatives for SOS installations were evaluated by conducting experiments to assess the viability of using a partial sphere with fewer projectors, determining minimum projector distances for smaller venue spaces, developing guidelines for brightness of ambient lighting, and creating systems using larger spheres. Some conclusions that resulted from these experiments were that SOS could successfully be deployed on both partial and larger spheres with the current software and that having low ambient lighting is a key to a good viewing experience.
--Evaluating SOS for 4K: Higher resolution datasets were obtained and tested with the SOS software to begin preparations for using 4K projectors, which are now becoming available at a reasonable cost. The SOS software was modified to support these datasets and the image quality was assessed using 4K monitors. High-resolution movies were also tested with the current SOS system to check for limits on maximum frame rates. Initial findings indicate that SOS will be able to smoothly transition to work with 4K projectors and will be ready to take advantage of high-resolution datasets. This advancement will result in SOS audiences experiencing more detailed and realistic visual displays with highly legible text and crisp vector graphics.

PROJECT AWARDS:

A special highlight of the year came in January 2015, when the SOS team was awarded the NOAA Bronze Medal for 2014. The Bronze Medal Award is the highest honor award granted by the Under Secretary of Commerce for Oceans and Atmosphere: The citation was described as follows: “The award is in recognition of the accomplishment of over 100 SOS installs and 33 million annual viewers which exceeds by orders of magnitude any requested requirement for this group. This accomplishment is the product of uncommon will, determination, and focus along with an expectation of quality and excellence.”

PROJECT TITLE: EAR- TerraViz (also branded as SOS Explorer)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jeff Smith, Jebb Stewart

NOAA TECHNICAL CONTACT: John Schneider (OAR/ESRL/GSD/ATO Chief)

NOAA RESEARCH TEAM: Hilary Peddicord (CIRES), Eric Hackathorn (OAR/ESRL/GSD/ATO), Jonathan Joyce (CIRES), Chris Golden (CIRES)

PROJECT OBJECTIVES:

Our objective is to create an easy-to-use Windows and Mac application that seamlessly combines and visualizes many types of 2D and 3D environmental data across time and from the bottom of the ocean through the atmosphere and into space.

PROJECT ACCOMPLISHMENTS:

Some accomplishments below were completed as joint effort with the NOAA Earth Information System project.

NOAA filed a provisional patent for TerraViz in the names of the four principal inventors (including Jeff and Jebb) in September 2014.

Continued development of a consumer version of TerraViz, called Science on a Sphere Explorer (or SOS Explorer), is a beta with a release scheduled for summer 2015.

Developed “Tour”capability. Similar to Google Earth tour capability, this allows users to define a sequence of data to load, locations to move to, highlight areas by either drawing shapes to the screen as well as popups with text content. Tours can also be used to save user preferences for a particular data type such as color palate or contour color. This allows users to define preferences to load data such as datasets, color, and type of visualization.

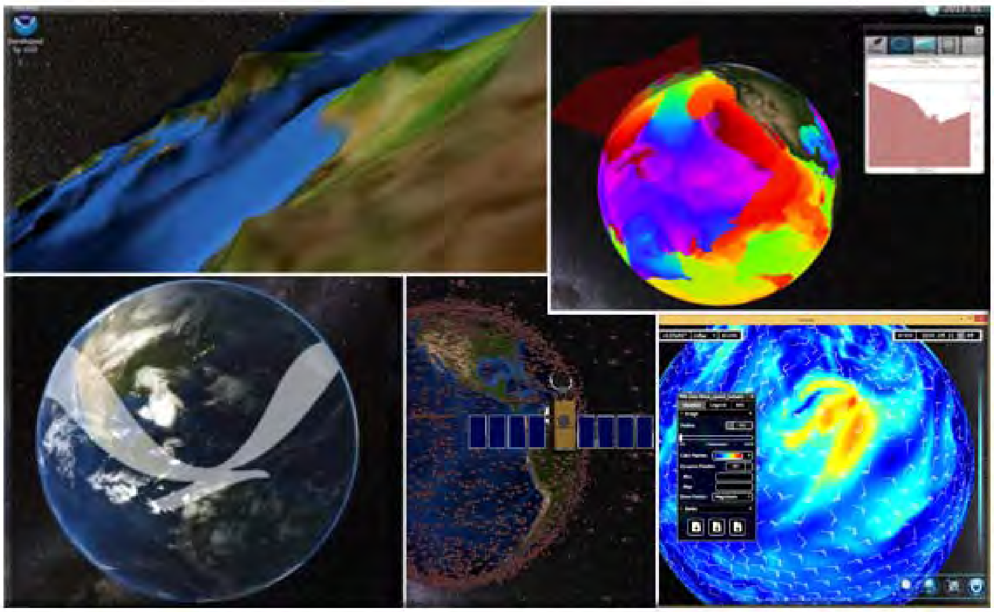


Figure 1. Examples of “Tour” capability.

EAR- TerraViz (also branded as SOS Explorer) Presentations:
July 13-15 - SOS Teacher Workshop - Teacher's used SOS Explorer to build lesson plans around SOS datasets for the classroom.
August 15th – Boulder Valley School District Back to School Teacher Professional Development - The Colorado Floods: A Lasting Teaching Moment
September 12th - Colorado Floods - What happened? Centennial Middle School
November 21st - Colorado Science Conference
December 17-18th - Colorado Floods - What happened? Casey Middle School
March 12-15th, 2015 - NSTA - SOS Explorer: A New Tool for the Classroom

PROJECT TITLE: EAR - Developmental Testbed Center (DTC) Support

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jeff Beck, Jim Frimel, Isidora Jankov, Hongli Jiang, Edward Tollerud,

NOAA TECHNICAL CONTACT: Stan Benjamin (OAR/ESRL/GSD/EMB Chief), Kevin Kelleher (OAR/ESRL/GSD Chief)

NOAA RESEARCH TEAM: Ligia Bernardet (CIRES), Steve Weygandt (OAR/ESRL/GSD/EMB)

PROJECT OBJECTIVES:

Task 1-- At recent Science Advisory Board and DTC Executive Committee meetings, a need has been indicated for additional 'get-out-the-word' activities for the DTC mission and its accomplishments.

Task 2--The DTC Hurricane Task provides support to users and developers of the Hurricane Weather Research and Forecasting (HWRF) model, with the goal of providing the NOAA Environmental Modeling Center with codes and information that can improve the operational HWRF model.

Task 3--Organization of the first NMMB tutorial and all supporting documentation, including a User's Guide

Task 4--The DTC ensemble task activities include preliminary tests of North American Rapid Refresh Ensemble (NARRE) configuration and adding RUC Land Surface Model to the operational NMMB model physics suite. The focus of the pre-NARRE effort is to work toward the development and implementation of the hourly updated NARRE forecasting system. This new system is planned to be implemented into operations as an extension of the Short Range Ensemble Forecasting (SREF) system during 2017. This new system will be providing improved probabilistic forecasts for aviation and other short-range applications. The work is conducted collaboratively by the GSD/Earth Modeling Branch, model/assimilation development team with the EMC Mesoscale Modeling Branch and DTC staff.

PROJECT ACCOMPLISHMENTS:

Task 1-- In response, the DTC is now (via this project) publishing a quarterly newsletter (linkable at http://www.dtcenter.org/newsletter/). Another part of this objective is to hasten presentation and publication of research results from DTC activities. To address this effort, results from collaborative verification of ensemble modeling during 3 years of Hydrometeorological Testbed (HMT) field experiments have been targeted for presentation at AMS and other relevant meetings, for formal publication in BAMS and other AMS journals, and for informal reports for WGNE and AMS extended abstracts.

Task 2--CIRA is implementing changes to the HWRF work flow code base to support the research and meet the needs of the scientific community. Changes this year are to implement the Atlantic Oceanographic & Meteorological Laboratory Hurricane Research Division's multiple storm basin scale software within the new DTC HWRF python code base. This will provide a framework using the current HWRF front end python scripts and allow for running the HWRF model with input from multiple storms.

Task 3--The team (Jeff Beck, Isidora Jankov, Hongli Jiang) has been responsible for organizing the first Nonhydrostatic Multiscale Model on the B-grid (NMMB) user tutorial. This was a 2-day event on April 1, 2015 and took place in College Park, MD at EMC. The objective of this event was to provide an introduction to the model, the NEMS system and a practical session on executing the model. During the first day the model developers and advanced users provided lectures on various aspects of the model. During the second day, the team provided a practical session for all participants, where they were able to run sample cases using the NMMB.

In addition to the in-person tutorial, the team has been responsible for writing the User's Guide and detailed practical session instructions. The User's Guide consists of six chapters, and includes detailed information related to the installation of NEMS-NMMB, the NEMS Pre-processing System (NPS), initialization and execution of the NMMB model, and post-processing.

These supporting documents, as well as an announcement for the tutorial can be found on the DTC NMMB tutorial website: http://www.dtcenter.org/nems-nmmb/users/tutorial/.

Task 4 -- In NARRE, at the beginning, the model-related uncertainty was addressed using a multi-dycore and multi-physics approach. The multi-dycore includes use of the WRF-ARW and NEMS-NMMB dynamic cores. In terms of physics packages, suites used in current operational systems (e.g., RAP and NAM) will be included. Parameterization schemes within these operational systems are well-tested and integrated for optimal performance. In addition, NARRE will include at least two physics variations from the operational packages. These variations will result in six to eight NARRE members total. For initial testing we matched the Rapid Refresh (RAP) domain. In a later phase, the domain will be slightly enlarged. Configuration tests have been performed for retrospective experiments.

This year's activities include preliminary testing of the impact that changes in physical parameterizations have on the ensemble performance over a limited time period of one week each during a spring and winter season. For this purpose, three different physics configurations were included along with the operational physics suite for the RAP (WRF-ARW) members. For the NMMB members, only the operational physics suite was utilized – no other physics diversity was employed. For all pre-NARRE members, different initial and lateral boundary conditions were used. This setup resulted in a total of eight pre-NARRE members. Out of 56 physics permutations from the operational physics suite for ARW core, three favorable configurations were selected based on the full ensemble performance measures (e.g. skill, reliability, sharpness, bias). The chosen baseline pre-NARRE configuration is illustrated in Table 1, along with some of the ensemble statistics.

	MP	Sfclay	Sfcphy	PBL	CU	IC/LBs
rap	Thompson	MYNN	RUC	MYNN	GF	GFS
rap1	Thompson	MO-MYJ	RUC	MYJ	BMJ	GEP01
rap2	Ferrier	MO-MYJ	RUC	MYJ	BMJ	GEP02
rap3	Ferrier	MYNN	RUC	MYNN	GF	GEP03
nmb	Ferrier	MYJ	NOAH	MYJ	BMJ	GFS
nmb1	Ferrier	MYJ	NOAH	MYJ	BMJ	GEP01
nmb2	Ferrier	MYJ	NOAH	MYJ	BMJ	GEP02
nmb3	Ferrier	MYJ	NOAH	MYJ	BMJ	GEP03

Table 1. Pre-NARRE configuration that has been implemented into the real-time system.

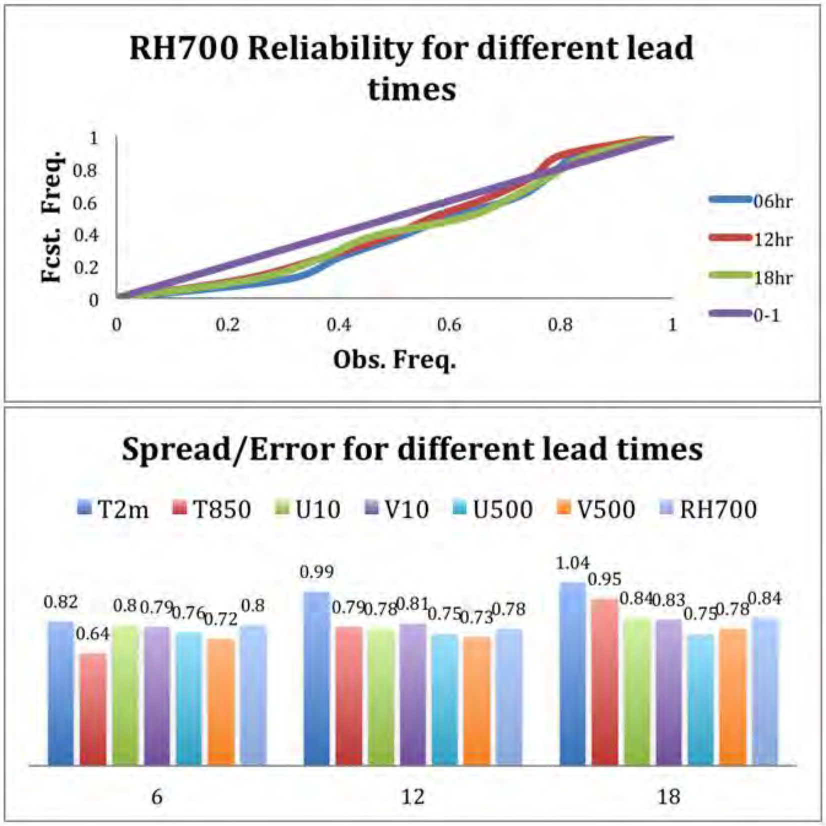


Figure 1. Reliability curve for 700mb Relative Humidity and Spread/Error ratio for different lead times and different variables for the warm season testing period.

This configuration has been running in real time since November 15, 2014 for the purpose of the WPC Winter Weather Experiment. As a part of the WWE, pre-NARRE has been evaluated alongside operational and an experimental version of SREF (Figure 2). A summary of the WWE findings and pre-NARRE performance will be presented at the NOAA Testbed Workshop.

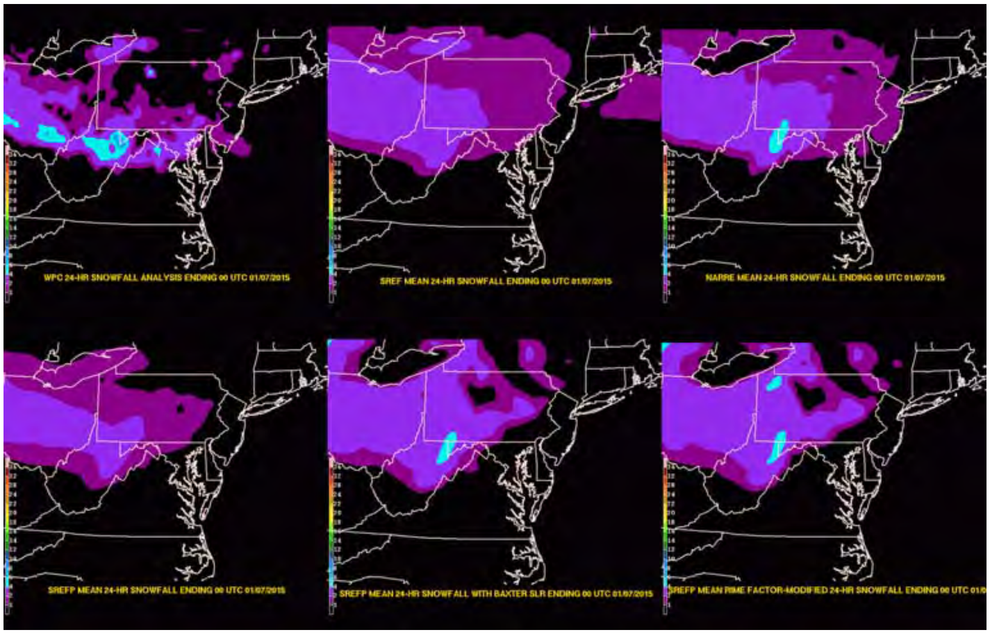


Figure 2. An example of WWE evaluations. 48 hr snow analysis and forecasts from NARRE and various SREF options valid on January 7, 2015 at 00Z.

As a part of the general NARRE work this year, advancements to NEMS-NMMB core have been made in collaboration with EMC colleagues. The team contributed to the evaluation of a new, Thompson microphysics option available in NMMB. Retrospective simulations from all four seasons using Thompson microphysics will be compared with identical Ferrier-Aligo microphysics runs to assess the viability of using the Thompson scheme in the operational NAM. Also, the team implemented RUC LSM as an addition to the NMMB physics suite. Performance of the new LSM option will be evaluated next year.

Recently, a proposal that will secure funding for next year's NARRE activity has been approved. The next year, in addition to several activities that will focus on further development of the NARRE framework the team will explore use of stochastic physics as an option to address model uncertainty in NARRE.

PROJECT TITLE: Research Collaboration with the Aviation Weather Testbed in Support of the NWS NextGen Weather Program

National Weather Service NextGen 4D Data Cube

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Benjamin Schwedler, Larry Greenwood

NOAA TECHNICAL CONTACT: David Bright (NOAA/NWS/NCEP/AWC)

NOAA RESEARCH TEAM: Mark Miller (NWS/OST), Steven A. Lack (NWS/AWC), Ryan L. Solomon (NWS/AWC)

PROJECT OBJECTIVES:

CIRA support for this project is in three primary areas
--NextGen Content - Guiding the implementation and development of content for population of NextGen data dissemination.
--NextGen Dissemination - Installation and support of NextGen data dissemination technologies.
--Aviation Weather Testbed - Development, maintenance, and testing of tools and products within the Aviation Weather Testbed for implementation into AWC forecast operations.

PROJECT ACCOMPLISHMENTS:

NextGen Content
As a primary provider of aviation weather forecast information to the domestic and international stakeholders, the Aviation Weather Center has a major stake in how aviation weather data will be represented. Throughout the last year, CIRA staff at the AWC has been actively involved in the development of data models and XML schema to represent non-gridded weather data. Members of the AWC CIRA staff attended the Air Transportation Information Exchange Conference in August 2014 to coordinate these enhancements with other developers working with aviation weather information exchange.

As one of the two World Area Forecast Centers (WAFCs), the AWC produces Significant Weather (SigWx) feature and gridded forecasts. Gridded forecasts will be disseminated using Web Coverage Service (WCS), an OGC standard, while the feature forecasts will be disseminated via a Web Feature Service (WFS), also an OGC standard. To represent the features, SigWx data models using Unified Modeling Language (UML) were developed by the AWC NextGen Development Meteorologist. These data models translate to XML schema that is part of the WXXM (Weather Exchange Model) 2.0 release. While the International Civil Aviation Organization (ICAO) has governance over the SigWx products, it is currently not included in I-WXXM, the XML schema governed by the ICAO. A joint effort between the FAA (Federal Aviation Administration) and EuroControl, WXXM has become a staging ground for international products that will eventually be adopted into I-WXXM.

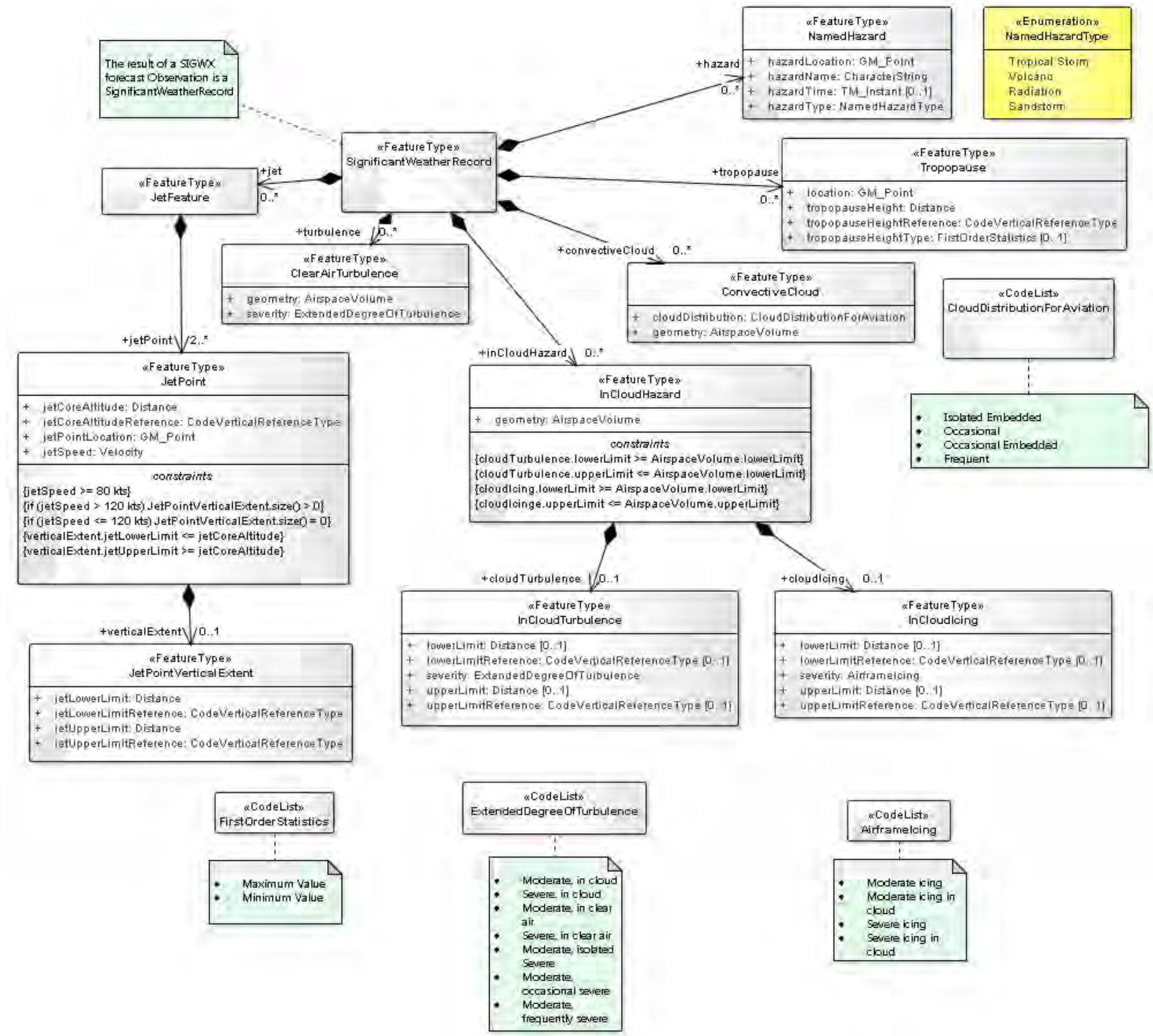


Figure 1. UML Context diagram for the ICAO Significant Weather forecasts that have been included in WXXM 2.0.

In addition to the AWC international forecast branch producing the high-level and mid-level Significant Weather forecasts to support international aviation customers, the domestic forecast branch produces low-level significant weather forecasts to support domestic general aviation. Both the international and domestic SigWx forecasts include turbulence and cloud elements. Due to the similarity between these two products, the low-level forecast product can be represented by extending the schema used for the high-level product. The AWC is now distributing the low-level Significant Weather forecast using and extension of WXXM 2.0 through the Web Feature Service Reference Implementation currently running on the AWC Web Services.

NextGen Dissemination

In addition to developing data models and schema to represent aviation significant weather forecasts, CIRA AWC staff has been serving as subject matter experts assisting developers of the NextGen IT Web Services (NGITWS). As part of the NOAA Integrated Dissemination program, NGITWS will satisfy the NextGen data dissemination requirements by providing the FAA with aviation weather information leveraging OGC standard services.

One of the tasks associated with NGITWS is conversion of legacy traditional alphanumeric codes (TAC) like METARs and TAFs into XML products represented with the appropriate WXXM schema. In order to ensure accurate transformations, CIRA associates have helped NGITWS staff increase their familiarity and understanding of the aviation products to be disseminated through the NGITWS system. As the system matures, AWC subject matter experts will work with the NGITWS project to verify that the WXXM formatted products represent the information contained within the TAC products until the WXXM products become the primary means of data transmission.

In addition, the CIRA NextGen Development meteorologist has been involved with developing product description documents, creating and editing metadata records, and validating gridded weather forecast information produced by the NIDS team.

Aviation Weather Testbed

This year, CIRA staff at the AWC contributed toward several projects that move AWC forecast operations toward the decision support paradigm that is a major part of both the NWS WeatherReady Nation and the NextGen effort. Since the 2012 Aviation Weather Testbed (AWT) experiment, the AWC has been working with the FAA and the airline industry to develop the Collaborative Aviation Weather Statement (CAWS). As part of the Collaborative Decision Making (CDM) process within the FAA, the CAWS was designed as a tool for meteorologists from the NWS, the FAA, and private industry to provide collaborative, value-added information to support traffic flow management decision making.

Following the 2012 AWT experiment, additional demonstrations of the CAWS were performed over two summers by the National Aviation Meteorologists (NAMs) at the FAA Air Traffic Control System Command Center. Because of the decision support mission of the NAMs and the demand for their time, it was determined that the CAWS would not be produced by the NAMs, but by the AWC staff located in Kansas City.

Producing the CAWS without any changes in staffing would require a change in the forecast responsibilities without any reduction in services. To achieve this, AWC Aviation Support Branch staff began to experiment with leveraging operational numerical weather prediction model output to produce forecast information similar to the Collaborative Convective Forecast Product (CCFP). To replicate the current operational CCFP, information derived from model forecasts needs to include information about the coverage of convective weather, as well as the confidence in the forecast. Forecasters have recognized the value of high-resolution forecast models in helping determine the mode of convective activity. With the operational implementation of the high resolution rapid refresh (HRRR) model run every hour on the operational NWS supercomputing system, high-resolution modeling solutions were a natural place from which information about convective coverage could be obtained.

On November 1st, 2014, the Aviation Weather Center implemented an experimental automated forecast product that includes information from the Short-Range Ensemble Forecast System (SREF), the Hi-resolution window ARW, and the HRRR. Image processing techniques were applied to the output fields of each model to translate the model forecast into convective coverage. Additionally the diverse model solutions were combined to incorporate the confidence information contained in the current operational CCFP. By comparing the similarity in solutions across multiple modes, information about the "confidence" in the automated CCFP was determined. If all models ingested into the automated CCFP depicted a similar solution, the confidence portion of the CCFP would be high. Conversely, if the scenarios vary presented by the component models, the automated CCFP generates a low confidence solution. By combining forecast models in this manner, both the coverage and confidence information contained in the human-produced CCFP can be mimicked. The CDM Convective Forecast Planning guidance was designed to produce a forecast product similar to the human-produced CCFP. The product was designed in this way to ensure that the traffic flow planners would be able to use the updated CCFP in a similar manner.

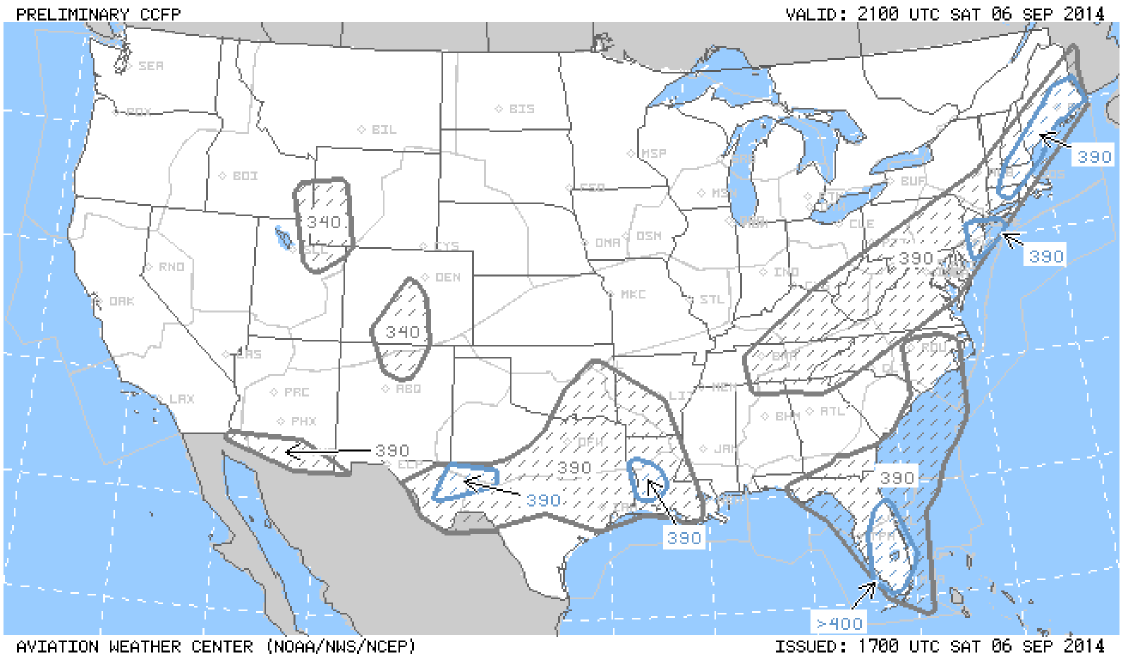
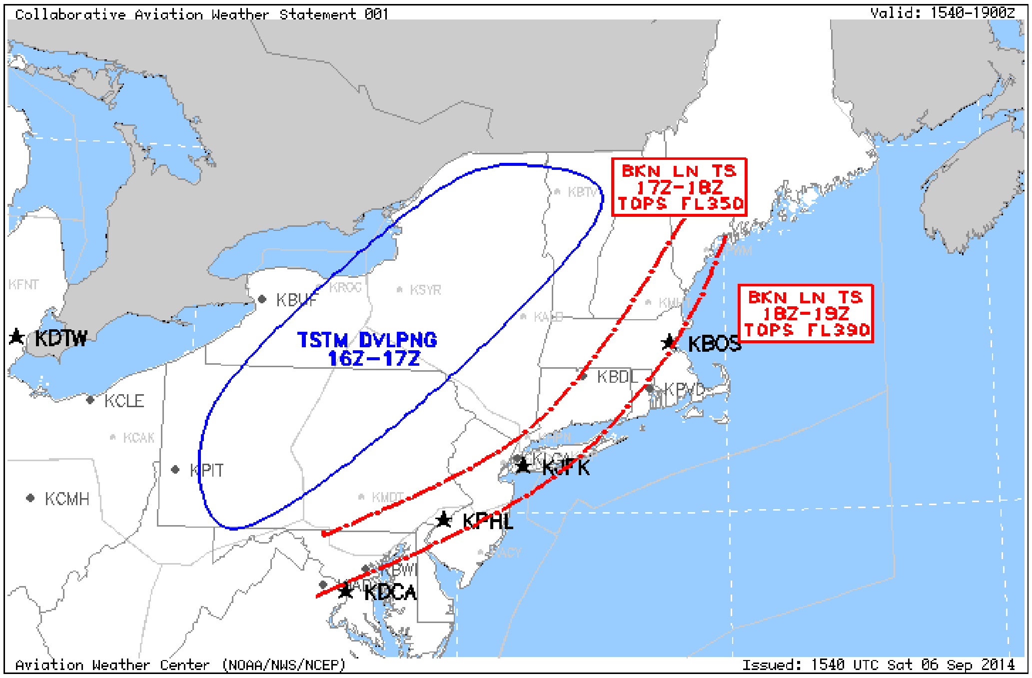


Figure 2. Example of a CDM Convective Forecast Planning guidance forecast.

The experimental implementation of the CDM Convective Forecast Planning guidance allowed the AWC forecasters who had previously been producing the CCFP forecast to shift to produce the Collaborative Aviation Weather Statement product. Rudimentary tools had been developed to support the demonstration of this product from 2012-2014, but improvements were needed in order to make the process to generate the CAWS product viable within AWC forecast operations. The first step in this development was expanding the tool to support product issuances across the entire continental United States instead of just the northeastern high-traffic corridors that had been the focus in previous aviation weather statement demonstrations.

CIRA support staff at the AWC led the effort to develop the tools to generate the forecast product, methods to disseminate the forecast information, and the web display capabilities for presentation of this product. Currently while the product is only disseminated in text and graphic format, the eventual plan is that the CAWS will be disseminated with geo-referenced information within the NextGen framework, which will allow all external users and stakeholders to ingest the raw forecast information (allowing them to display and process the air traffic constraint information relevant to their operations).

The CIRA NextGen meteorologist helped to facilitate the training of the 10 forecasters that will be initially working the CAWS desk to produce this product. Over the course of 2 weeks, the forecasters were provided with classroom style training and hands-on training with the tools and techniques used to produce and disseminate the CAWS. The CAWS product implementation of March 3, 2015 was a result of the development efforts within the AWC Aviation Support Branch.



Collaborative Aviation Weather Statement 001
NWS Aviation Weather Center Kansas City MO
1540 UTC Sat 06 Sep 2014

Weather: Thunderstorms
Valid: 1540-1900Z

ARTCCs affected: ZBW, ZDC, ZNY
Terminals affected: KBOS, KBWI, KDCA, KEWR, KIAD, KJFK, KLGA, KPHL

SUMMARY: Thunderstorms expected to impact New York and DC metros.

DISCUSSION: An area of thunderstorms is expected to develop over much of western NY and PA between 16Z-17Z. This area will evolve into a broken line and will begin impacting the western gates of the NY metros as early as 17Z with direct impact from 18Z-19Z. KBOS expected to see impact by 18Z. Broken line of storms will expand south and impact the DC metros by 19Z.

BOUNDING BOX: 44.96,-80.59 38.48,-80.25 37.72,-72.35 42.71,-68.59 45.44,-66.55 46.60,-79.41 44.92,-80.55 44.96,-80.59

Figure 3. Example of a CAWS product that was issued as part of the training exercises leading up to implementation of the CAWS product in March 2015.

In addition to development of products and tools to specifically help the AWC advance its mission, CIRA researchers have continued to partner with other federal and university researchers and developers to produce additional guidance and forecasts to support the operational aviation weather community. Over the last year, a larger portion of the AWC development staff has been actively involved in the evaluation of new developments in the operational National Weather Service models.

CIRA staff at the AWC participated in the evaluation and implementation of the High-Resolution Window models, the Short-Range Ensemble Forecast system, the North American Mesoscale model, the High-Resolution Rapid Refresh, and the Real-Time Mesoscale Analysis. In addition to formal implementations, one of the major efforts the AWC has been pushing in model development is in the forecast of cloud fields. Ceiling and visibility are two parameters that numerical weather prediction models typically have challenges forecasting. Some recent model implementations have already improved the forecast of these parameters important for general aviation, but the AWC is part of a larger effort within NOAA research and operational divisions to improve the forecasting of ceiling and visibility.

PROJECT TITLE: Research Collaboration at the NWS Aviation Weather Center (AWC) in Support of the Aviation Weather Testbed (AWT), Aviation Weather Research Program (AWRP), and the NextGen Weather Program

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Daniel Vietor, Chad Hill, Larry Greenwood, Adrian Noland, Anders (Mick) Ohrberg, Brian Pettegrew, Lee Powell, Benjamin Schwedler, Jenna Dalton, Robyn Tessmer

NOAA TECHNICAL CONTACT: David Bright (NWS/AWC) AWT Program Manager

NOAA RESEARCH TEAM: Steven A. Lack (NWS/AWC)

PROJECT OBJECTIVES:

The Aviation Weather Center (AWC) Support Branch (ASB) is primarily responsible for providing technical and developmental expertise to the www.aviationweather.gov website, providing technical and system engineering support to the network and server infrastructure at the AWC as well as being a part of the design and implementation team in research to operations processes.

The primary goal of the ASB is to maintain the internal network, servers, and workstations at the AWC to ensure continuity of operations. CIRA system engineering and software development support is critical to AWC forecast and web operations. The ASB collaborates with the other NCEP centers and the NWS to provide data and research to operations (R2O) support. The branch supports the research operations at the AWC, headed by a team of federal Technique Development Meteorologists (TDMs). This includes support for the Aviation Weather Testbed (AWT) as well as support for the FAA Aviation Weather Research Program (AWRP). The AWRP products include Current and Forecast Icing Products (CIP/FIP), Graphical Turbulence Guidance (GTG), National Ceiling and Visibility Analysis (NCVA), and the National Convective Weather Diagnostic/Forecast (NCWD/F). The ASB also supports the AWC website which includes ADDS, WAFS Internet File service (WIFS) and the International Flight Folder (IFFDP) project.

As part of the CIRA effort, the ASB has close links to the research and development projects going on at the AWC. This includes:
--Supporting NextGen and AWRP;
--Providing better tools to decrease weather impacts to the National Airspace System (NAS) including efforts at the FAA Command Center and the Traffic Flow Management (TFM) project;
--Providing direct support to the TDMs at the AWC for ongoing research projects including GOES-R, ensemble model diagnostics and product verification; and
--Expanding collaboration efforts with the other testbeds within NOAA and the NWS focusing on R2O projects.

PROJECT ACCOMPLISHMENTS:

In the past year efforts have been centered on five primary projects:
1--Continued maintenance of the www.aviationweather.gov website,
2--The AWC Summer Weather Experiment,

3--The Collaborative Aviation Weather Statement (CAWS) project,
4--The Helicopter and Emergency Medical Services (HEMS) tool, and
5--The PIREP Submit tool.

The www.aviationweather.gov Website
In March 2014, the new website was moved to production. This was a complete remaking of the site including a new layout based on the weather.gov website, a cleaned up and unified user interface, streamlined PHP code written on top of Zend Framework and a new set of interactive tools utilizing OpenLayers (see Figure 1). Much of early 2014 was spent eliminating bugs and updating help pages, making sure all new functionality was properly documented.

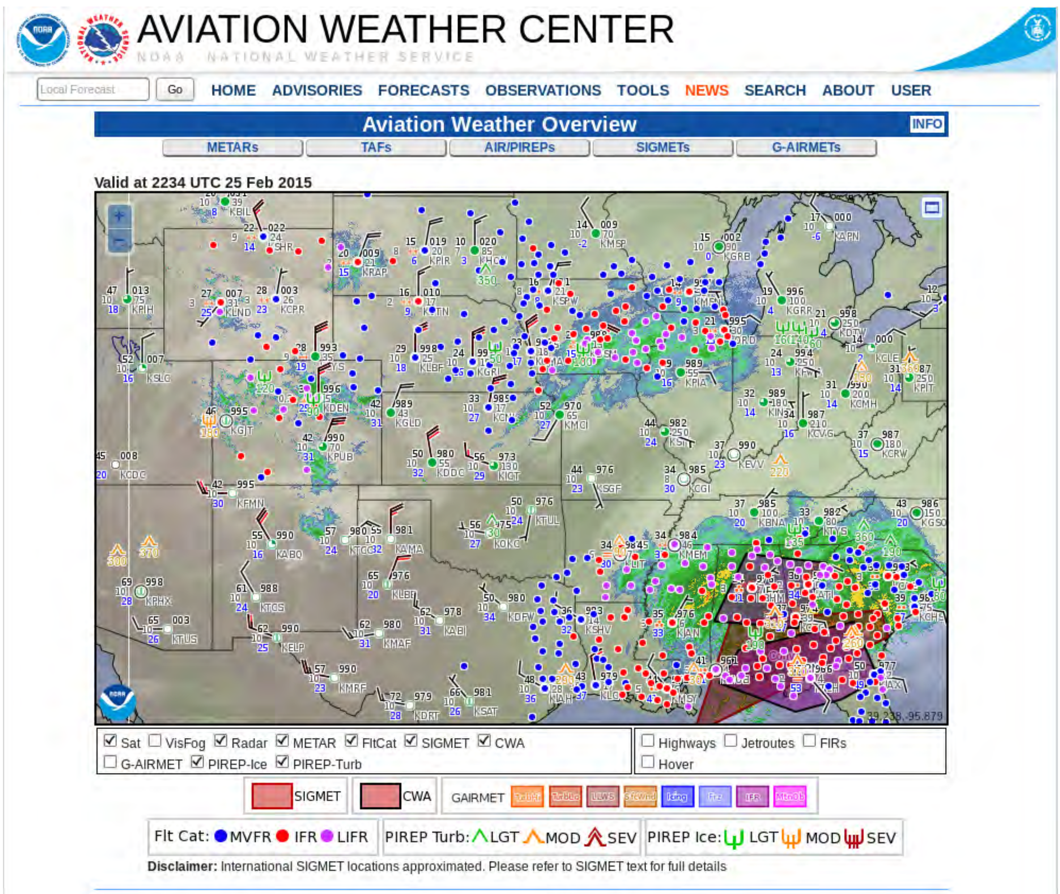


Figure 1. The AviationWeather website with new satellite and radar data layers.

Once the new website went live, responding to user feedback became the primary concern. Adrian Noland spent the most time responding to user feedback which was initially mixed but many liked the new format. The users highlighted several small bugs and weaknesses to the site and the web development group rolled out several quick updates to address these concerns in April and May. Some of these updates included:
--Ability to turn off the interactive maps for slow computers or slow network connections
--A user favorites menu at the top of the webpage for frequently visited pages
--A new user settings environment tied into user logins
--Updates to the help pages as well as a FAQ (Frequently Asked Question) page
--A new “news item” setup and page

New functionality was added to the website over the summer. This included a global satellite composite, a radar mosaic and new user settings for pages and interactive views. Initially, the satellite and radar sources were external but neither source was truly operational and were too slow and unreliable for use on the website. This functionality was removed before the website went live but work began on a replacement service using locally generated satellite and radar data. These went operational in June and July and they were monitored 24x7 and maintained operationally. The radar service was eventually replaced with MRMS (Multi-Radar Multi-Sensor) mosaics when they became operational in September.

In addition, work began on a new set of high function interactive tools that would overlay numerous data layers. The first one is the HEMS Tool which will be put into production early in 2015 (discussed later). The second will be a tool to aid general aviation and will serve as a partial replacement to the area forecast product. The area forecast is scheduled to be decommissioned by early 2016. This tool will be heavily based on the work done on HEMS and add products for all flight levels. HEMS concentrates on weather conditions up to 5000 feet above ground level.

2014 Summer Weather Experiment

The 2014 AWT Summer Experiment was held at AWC in Kansas City, MO from 11-15 August 2014. The primary themes for the 2014 experiment were ceiling and visibility improvements and convection.

Figure 2. Participant briefing during the summer experiment.

Ceiling and visibility (C&V) impacts flight operations throughout the year, with aviation impacts ranging from accidents to significant National Airspace System (NAS) delays. The C&V portion of the experiment focused on assessing the ability of mesoscale and convection-allowing models and ensembles to forecast flight rule conditions across the CONUS, Gulf of Mexico, Caribbean, and Alaska (see Figure 3). By assessing the NWP model and ensemble prediction systems, forecasters can better understand the capabilities of existing numerical guidance. The resulting feedback can be provided to modelers that may improve C&V guidance (see Fig. 4) and progress toward NextGen-based advanced probabilistic decision support services.

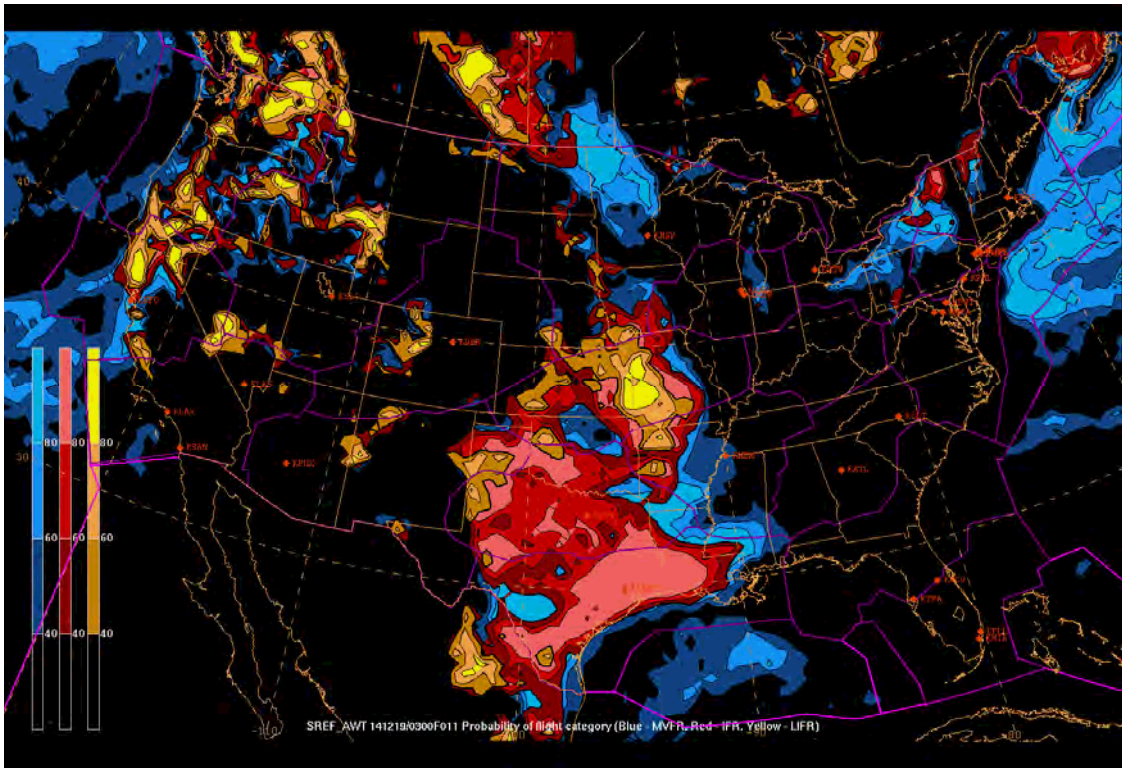


Figure 3. Example of probabilistic ceiling and visibility forecast guidance evaluated during the summer experiment. The Short-Range Ensemble Forecast (SREF) was used to provide probabilistic information for regions of MVFR, IFR, and LIFR

The convective portion of the experiment focused on providing enhanced decision support for tactical and strategic air traffic planning. The issuance of the event-driven Aviation Weather Statements (AWS) as a complement to the routinely issued Collaborative Convective Forecast Product (CCFP) was the primary goal. The FAA has described the AWS as an aviation warning for NAS Traffic Flow Management (TFM). The AWS will become a collaborative product between AWC and CWSU meteorologists, FAA, and industry participants (see Collaborative Aviation Weather Statement in B. Schwedler's report) and this experiment was a good opportunity for dialogue between the groups in defining and shaping the new CAWS service. Convective guidance for the AWS was provided by convection-allowing, mesoscale numerical models and ensembles, as well as experimental observation data sets. GOES-R proxy products and GOES-14 Super Rapid Scan Operations (SRSOR) available to NWS forecasters were used and evaluated during the experiment.

Ben Schwedler and Brian Pettegrew were part of the AWC team and participated in the daily running of the experiment. They developed several of the products used in the experiment and provided support and training for other products used in the experiment. The rest of the ASB team provided data, server and hardware support for the experiment.

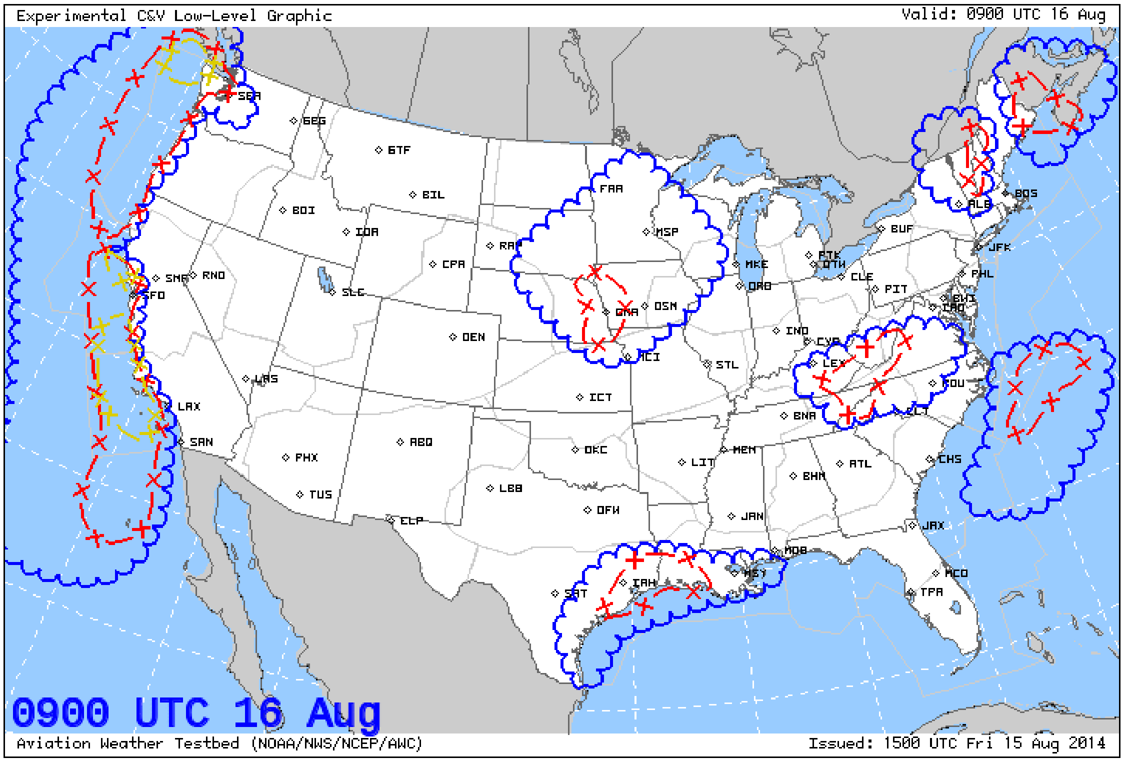


Figure 4. Example of an experimental Ceiling and Visibility forecast issued during the 2015 AWT summer experiment. Areas outlined in blue are MVFR conditions, red are IFR conditions, and yellow are LIFR.

HEMS (Helicopter and Emergency Medical Services) Tool

At the request of the FAA, a tool specifically designed to show weather conditions for short-distance and low-altitude flights that are common for the Helicopter and Emergency Medical Services (HEMS) community was created. HEMS operators are extremely sensitive to changing and/or adverse weather conditions and need weather information presented for non-weather experts quickly and effectively.

The HEMS tool integrates several critical weather parameters into an interactive tool that is intuitive and focuses on small local regions at low altitudes (see Figure 5). The tool shows:

--radar,

--satellite,

--ceiling and visibility analyses,

--icing severity and probability (from CIP and FIP),

--temperature, relative humidity and winds (from the RAP model),

--current METARs, TAFs,

--SIGMETs, G-AIRMETs, CWA (Center Weather Advisories),

--navigational aids, and

--airport and heliport locations.

Parameters such as icing, temperature and winds are available in 1000 foot increments above ground level to provide an assessment of the low-level weather conditions. The tool also allows the user to move backwards in time up to 6 hours or forward in time up to 6 hours to get forecasted conditions.

Initial work on the Java-based version occurred in 2013 but it was decided to move the tool to a browser-based Javascript environment, primarily to support mobile devices such as tablets and smart phones. Work began on an OpenLayers version in spring 2014 with a prototype version available in mid-summer.

Dan Vietor is the primary developer on the HEMS Tool. A 3-month evaluation period started in August 2014 and the Safety and Risk Mitigation was performed in December 2014. The tool will be ready for release in early spring of 2015.

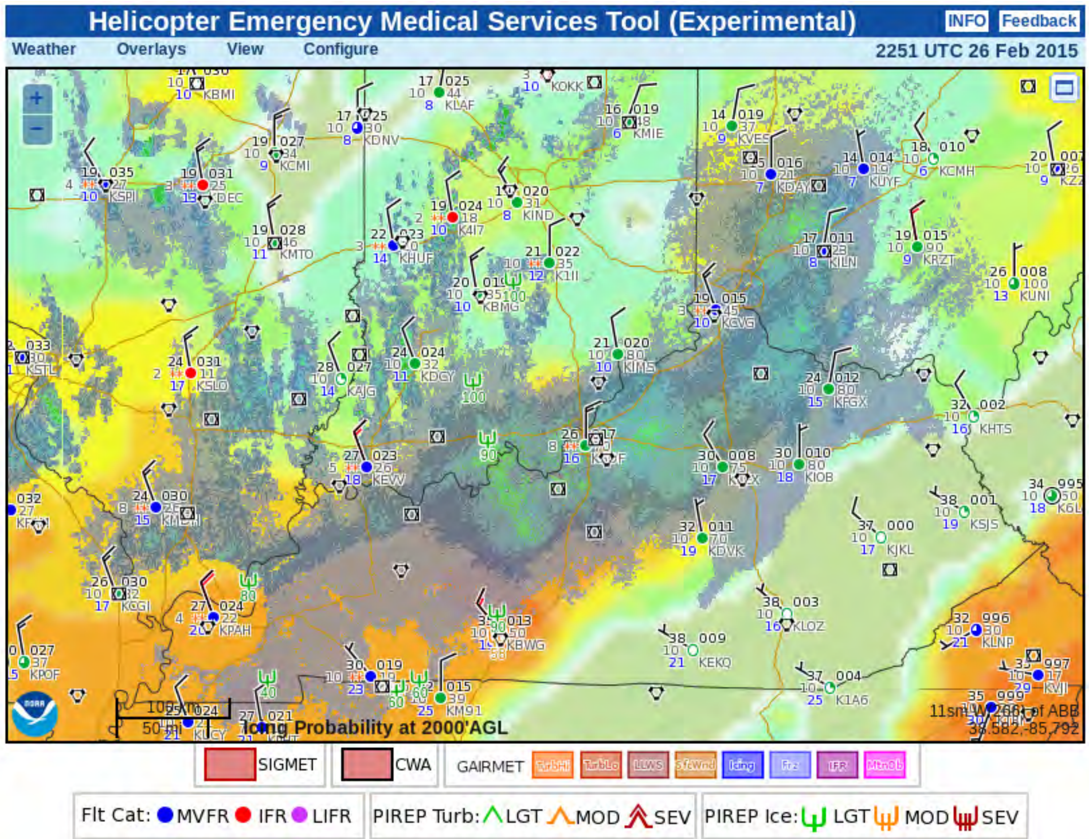


Figure 5. Sample HEMS tool display showing snow and icing conditions around Louisville, KY.

PIREP Submit Tool

The desire to expand submission of PIREPs to a broader community is a new FAA initiative started in 2014. As a part of this, the decision was made to make the long-used experimental PIREP submit tool an operational product. The tool allows a user, typically a pilot or airline dispatcher, to enter all pertinent parts of a PIREP guiding them through the data entry process (see Figure 6) with simultaneous validation.

The major changes are:

--cleaning up the layout,

--utilizing existing web infrastructure,

--updating and debugging the Javascript code,

--adding capabilities to enter PIREPs over the Pacific Ocean using latitude/longitude coordinates as opposed to VOR locations,

--updating the VOR and FIX databases using the latest FAA data, and

--better validation of input data.

Larry Greenwood and Adrian Noland headed up the efforts to upgrade and transition the code into production. The first release including the updated layout, upgraded Javascript and oceanic locations was pushed to production in February 2015.

The addition of new users to the submission process is still being finalized but it is planned that new users can start submitting PIREPs in the spring of 2015.

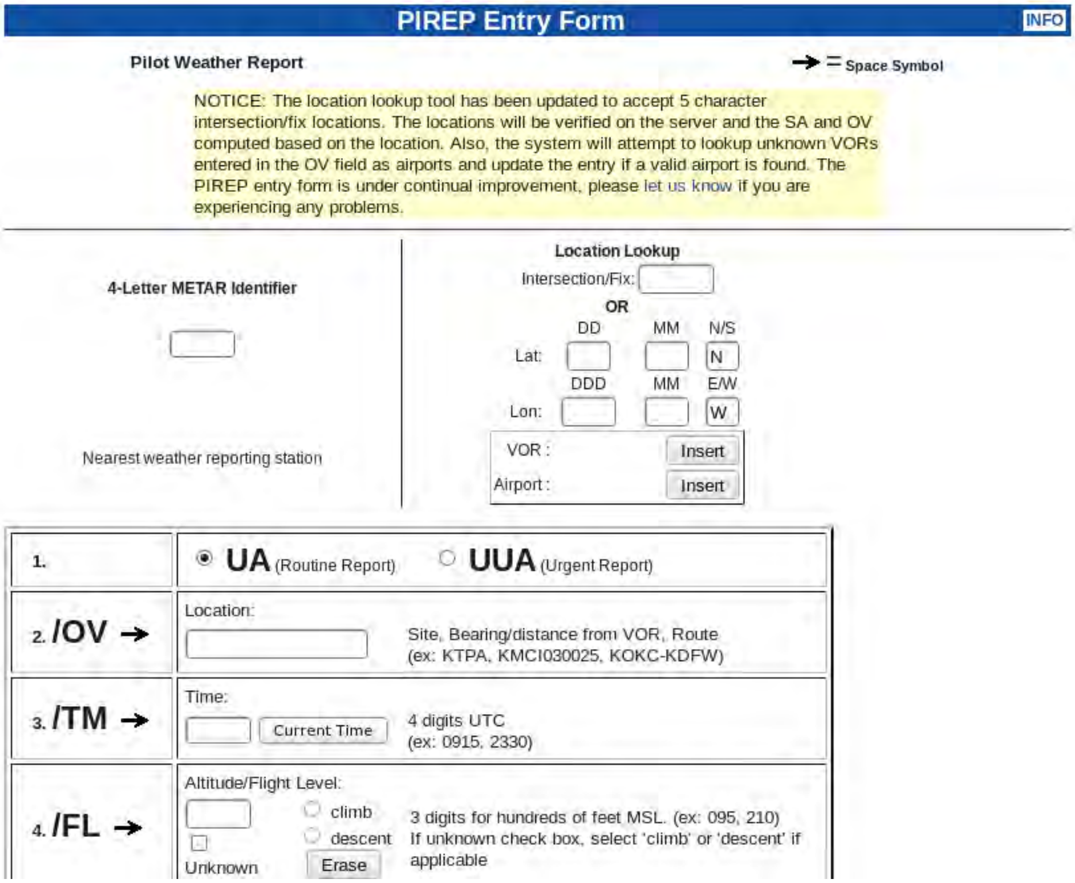


Figure 6. The online PIREP submit form.

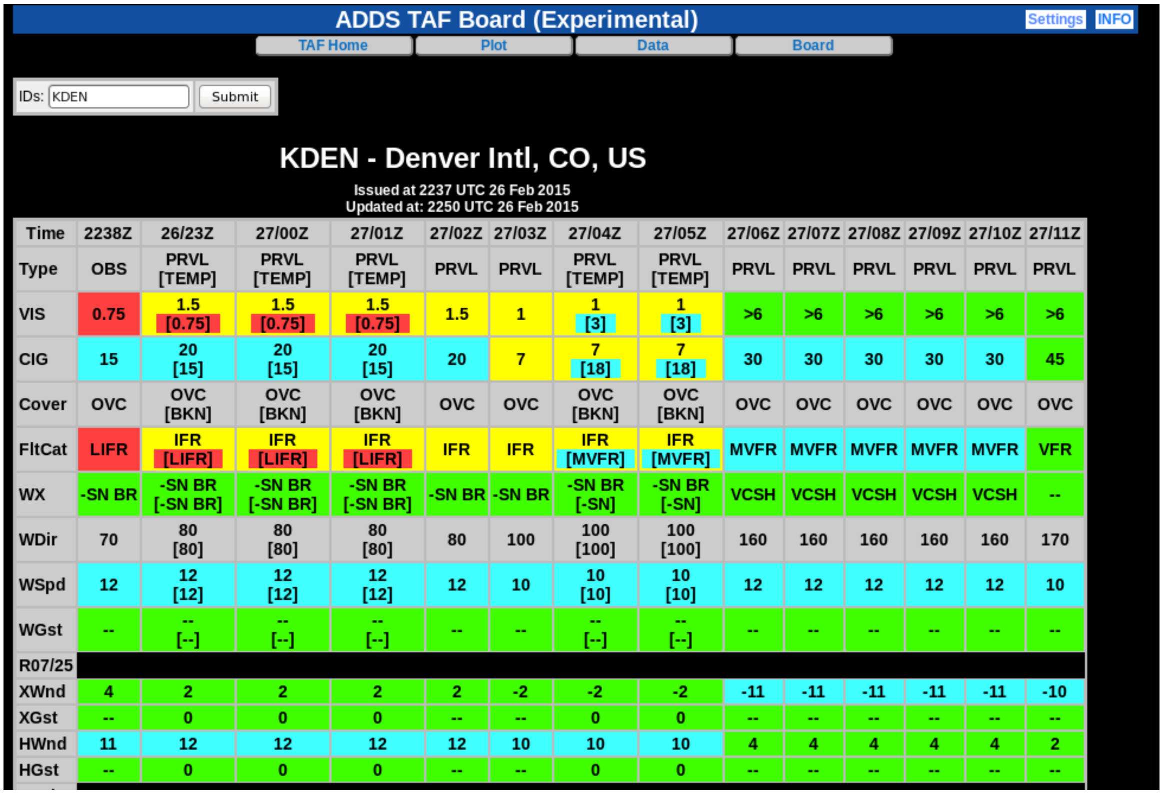
Traffic Flow Management (TFM) project

The Traffic Flow Management project helps create tools for use by traffic flow managers at various air traffic control centers as well as the FAA Command Center. There were two major tools in the project, both scheduled for release in early 2015. Dan Vietor was the primary developer on the project.

The TAF Tactical Decision Aid (TDA)

The first is the TAF TDA board. This is a tabular presentation of the TAF (Terminal Aerodrome Forecast) data out to twelve hours into the future. The idea is to highlight weather conditions that might affect flights in and out of those airports (see Figure 7). Typically, the coloring is based on the standard flight rule (VFR, IFR, and LIFR) criteria for C&V. There is a condensed dashboard view where several airports can be viewed at once as well as an expanded view for specific airports. The criteria, colors, background and other options can be set for each individual user or site.

Since flight rule conditions are standard and apply to all airports, a new set of airport-specific criteria needs to be created. Thresholds can differ substantially from airport to airport and region to region. A new site-based impacts catalog is being researched and will be created over the next 12 months. When finished those threshold settings will be added to the TDA tool.



ADDS TAF Board (Experimental)

Settings INFO

TAF Home | Plot | Data | Board

IDs: KDEN Submit

KDEN - Denver Intl, CO, US

Issued at 2237 UTC 26 Feb 2015
Updated at: 2250 UTC 26 Feb 2015

Time	2238Z	26/23Z	27/00Z	27/01Z	27/02Z	27/03Z	27/04Z	27/05Z	27/06Z	27/07Z	27/08Z	27/09Z	27/10Z	27/11Z
Type	OBS	PRVL [TEMP]	PRVL [TEMP]	PRVL [TEMP]	PRVL	PRVL	PRVL [TEMP]	PRVL [TEMP]	PRVL	PRVL	PRVL	PRVL	PRVL	PRVL
VIS	0.75	1.5 [0.75]	1.5 [0.75]	1.5 [0.75]	1.5	1	1 [3]	1 [3]	>6	>6	>6	>6	>6	>6
CIG	15	20 [15]	20 [15]	20 [15]	20	7	7 [18]	7 [18]	30	30	30	30	30	45
Cover	OVC	OVC [BKN]	OVC [BKN]	OVC [BKN]	OVC	OVC	OVC [BKN]	OVC [BKN]	OVC	OVC	OVC	OVC	OVC	OVC
FltCat	LIFR	IFR [LIFR]	IFR [LIFR]	IFR [LIFR]	IFR	IFR	IFR [MVFR]	IFR [MVFR]	MVFR	MVFR	MVFR	MVFR	MVFR	VFR
WX	-SN BR	-SN BR [-SN BR]	-SN BR [-SN BR]	-SN BR [-SN BR]	-SN BR	-SN BR	-SN BR [-SN]	-SN BR [-SN]	VCSH	VCSH	VCSH	VCSH	VCSH	--
WDir	70	80 [80]	80 [80]	80 [80]	80	100	100 [100]	100 [100]	160	160	160	160	160	170
WSpd	12	12 [12]	12 [12]	12 [12]	12	10	10 [10]	10 [10]	12	12	12	12	12	10
WGst	--	-- [--]	-- [--]	-- [--]	--	--	-- [--]	-- [--]	--	--	--	--	--	--
R07/25														
XWnd	4	2	2	2	2	-2	-2	-2	-11	-11	-11	-11	-11	-10
XGst	--	0	0	0	--	--	0	0	--	--	--	--	--	--
HWnd	11	12	12	12	12	10	10	10	4	4	4	4	4	2
HGst	--	0	0	0	--	--	0	0	--	--	--	--	--	--

Figure 7. The TAF TDA site view for Denver, CO.

Gate Forecasts

The second is the gate forecast project. There are several arrival and departure gates or sectors at major airports. It is important for traffic flow managers to know when these gates will be affected by severe weather such as thunderstorms. Several algorithms have been developed to provide a first guess for gate forecasts, some using NDFD and the LAMP model output and others using model data such as the SREF. The algorithm initially implemented comes from the Atlanta CWSU and uses the HRRR model composite reflectivity forecast to determine thunderstorm coverage in a particular sector (see Figure 8).

During the summer of 2014, the Atlanta algorithm was implemented and tested. Initially, the gate forecasts are being produced for Atlanta, Charlotte and Dallas, Fort Worth while three additional sites (Miami, Denver and Chicago O’Hare) are being tested.

The gate forecasts will be going into production in the spring of 2015.

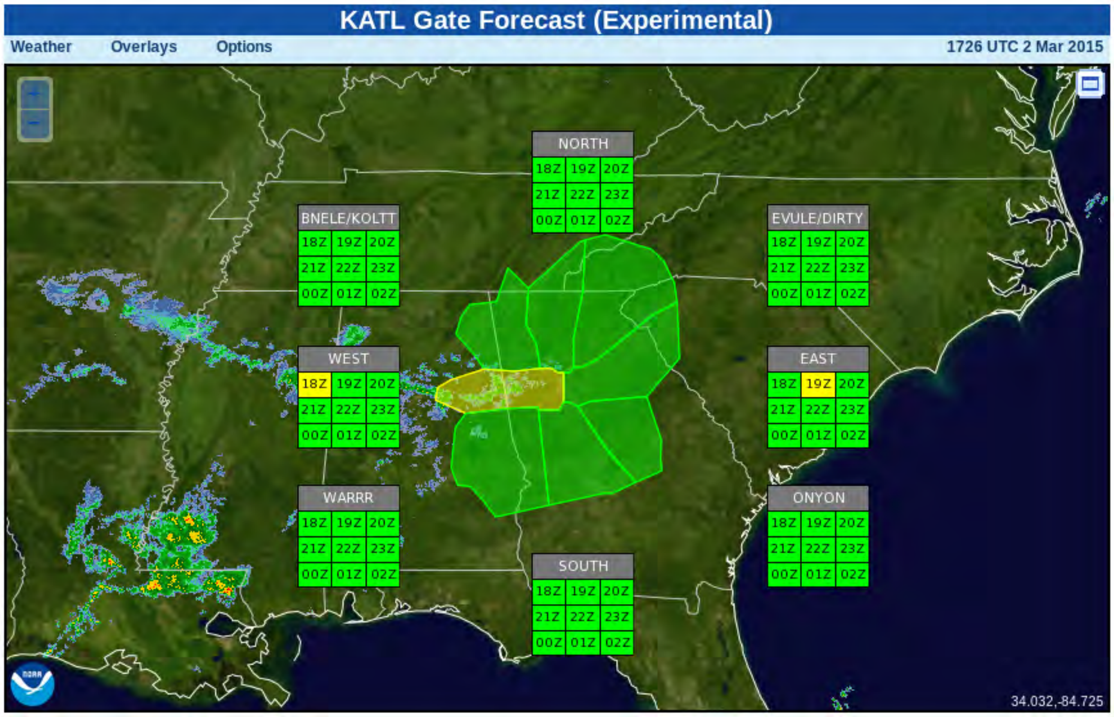


Figure 8. The one-to-nine-hour gate forecasts for Atlanta. The four arrival (BNELE, EVULE, ONYON, WARRR) gates and the four departure gates are shown.

Production Dashboard

Upgrades and enhancements to the production dashboard continued throughout 2014. This includes:

--the ability to handle non-scheduled products such as SIGMETs,

--better handling of cancellations,

--the addition of a timeliness dashboard, and

--the addition of a sent check at the TOC (Telecommunications Operations Center) to make sure products made it out to the public.

Aviation Weather Research Program (AWRP) Update

The AWRP project had two objectives this year. One was the continued effort to get GTG version 3.0 transitioned to the Weather & Climate Operational Supercomputing System (WCOSS). The WCOSS version of GTG version 3.0 was successfully installed in fall 2014 and testing continued into early 2015. It is scheduled to produce data operationally by June 2015. In addition, work began on transitioning CIP and FIP icing products into WCOSS.

The second project was to get the 13km CIP and FIP codes into production. After extensive testing, the new high-resolution version were approved for operational use and AWC started outputting the 13km grids in early September 2014 with additional forecast hours being added in February 2015. Additional work to get the 13km graphics on ADDS was completed in October.

Brian Pettegrew is the lead on the AWRP project and continues to work with NCEP and NCAR on AWRP development and testing.

Other Accomplishments
--Work began on the move of the website to IDP (Integrated Dissemination Program). This requires a rework of the website and back end code to fit within the guidelines of IDP.
--Adrian Noland and Larry Greenwood helped with responding to user inquiries related to the new web-site and were key on updating code and fixing bugs.
--Adrian Noland worked on the migration of the CCFP (Collaborative Convective Forecast Product) to a new automated product for the winter of 2014-15.
--Brian Pettegrew continued work on clear air turbulence algorithms using ensemble model output. He also started working on a mountain wave algorithm.
--Brian Pettegrew continued work on lightning density products while looking to expand this globally using Vaisala's global lightning product. (Figure 9)

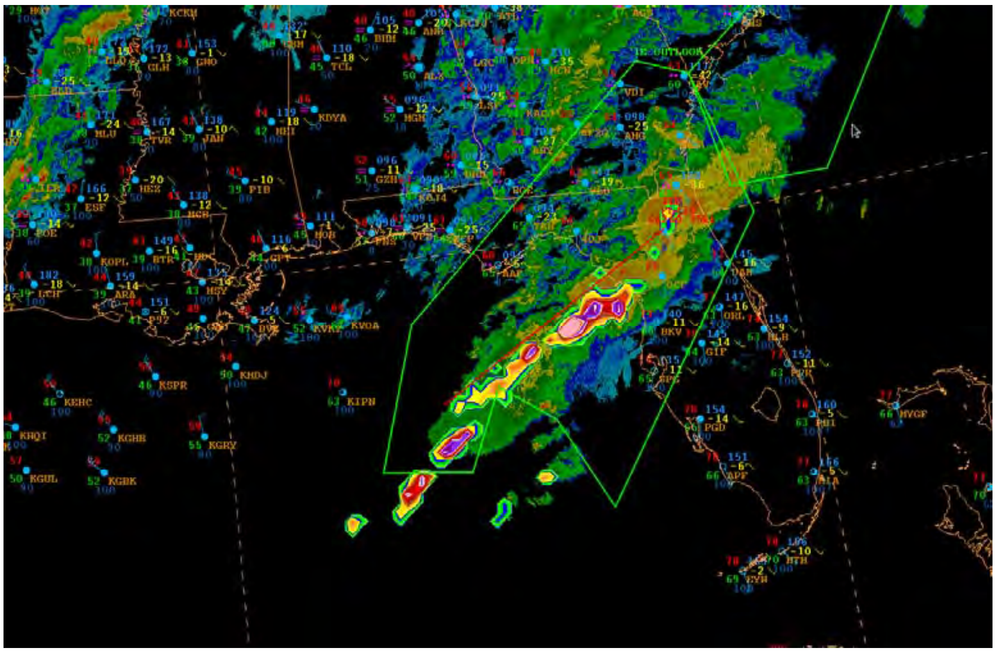


Figure 9. Sample lightning density plot over radar.

--Brian Pettegrew worked on negotiations to get more aircraft EDR (Eddy Dissipation Rate) turbulence data into operations at AWC.
--Brian Pettegrew started working on new global icing potential products.
--Larry Greenwood worked with Amanda Terborg to create a GOES-R display page to support the AWC Summer Experiment.
--Dan Vietor and Larry Greenwood developed scripts to monitor WIFS (WAFS Internet File Service) usage and produce timeliness statistics.
--Jenna Dalton and Robyn Tessmer provide project support at the AWC to ensure continuity of operations through procurement, budgetary analysis and administrative efforts throughout FY14.

PROJECT AWARDS:

Dan Vietor received the prestigious CSU/CIRA Research Initiative Award for 2014. Dan earned this award by leading the critical investigations and establishing priorities and infrastructure needed to re-design and quickly implement the widely-used Aviation Digital Data Service.

PROJECT TITLE: Research Collaboration at the NWS Aviation Weather Center (AWC) in Support of the Aviation Weather Testbed (AWT), Aviation Weather Research Program (AWRP), and the NextGen Weather Program

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Chad Hill, Anders (Mick) Ohrberg, Lee Powell

NOAA TECHNICAL CONTACT: David Bright (NWS/AWC)
NOAA RESEARCH TEAM: Steven A. Lack (NWS/AWC)

PROJECT OBJECTIVES:

The Aviation Weather Center (AWC) Support Branch (ASB) is primarily responsible for providing support to the www.aviationweather.gov website, providing support and maintenance to the network and server infrastructure at the AWC as well as supporting the research to operations processes.

The primary goal of the ASB is to maintain the internal network, servers and workstations at the AWC to ensure continuity of operations. The 24x7 support is critical to AWC forecast and web operations. The ASB collaborates with the other NCEP centers and the NWS to provide data and research-to-operations support. The branch supports the research operations at the AWC, headed by a team of Technique Development Meteorologists (TDMs). This includes support for the Aviation Weather Testbed (AWT) as well as support for the FAA Aviation Weather Research Program (AWRP). The AWRP products include Current and Forecast Icing Products (CIP/FIP), Graphical Turbulence Guidance (GTG), National Ceiling and Visibility Analysis (NCVA), and the National Convective Weather Diagnostic/Forecast (NCWD/F). The ASB also supports the AWC website which includes ADDS, WAFS Internet File service (WIFS) and the International Flight Folder (IFFDP) project.

PROJECT ACCOMPLISHMENTS:

Network Infrastructure -
This past year was significant for AWC from a datacenter investment perspective. The technologies we are now using to deliver products and services to our customers, forecasters and support staff is truly of enterprise quality and of the highest logical design. A network goes through many layers of transition over time, typically only a single layer would be replaced as the layers age. As all of AWC's layers were pending failure or needed rework, we took on the challenge.

The first stage required a complete rebuild and clean-up of the network data cables to the client locations. New cable was run overhead building-wide. The purpose of the overhead design was to free up the computer room drop floor to allow the cleanup of various cables and wires that had been accumulating for over a decade.

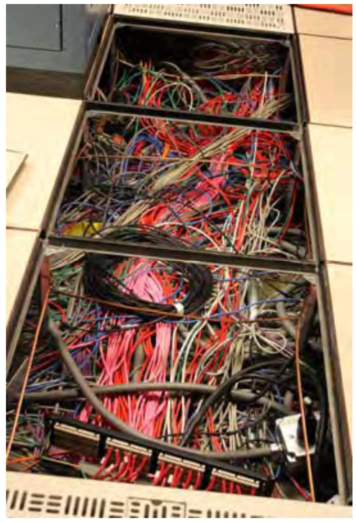


Figure 1. Before cable re-organization.

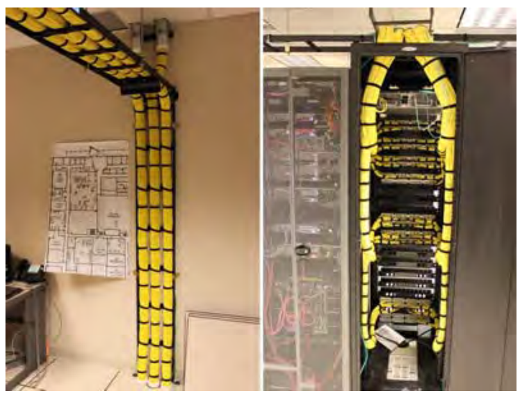


Figure 2. After cable re-organization.

During Stage two, a complete network replacement was required. Switches were intermittently failing, and the traffic was limited to 1 Gigabyte per second.

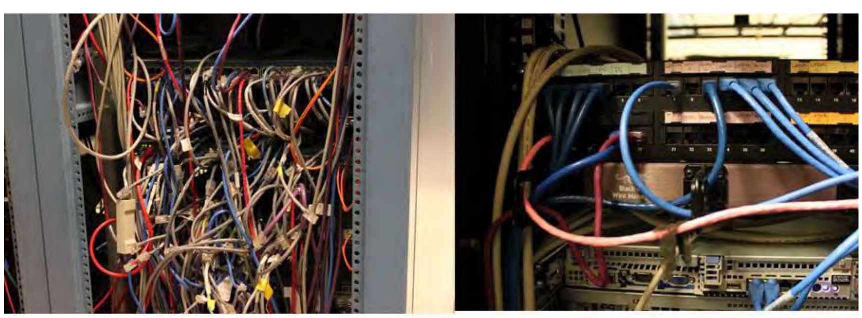


Figure 3. Before network equipment upgrade.

Figure 4. After network equipment upgrade.

The old network was replaced with the latest high-end Cisco equipment. The new equipment was installed into two new Network Racks, is fully redundant and can serve over 10 Gigabytes per second to the servers and client workstations, but most clients remain at 1 Gigabyte per second. Several of the servers run 40 Gigabytes per second, which has greatly improved AWC researchers' ability to view and manipulate images and data sets. The two Cisco Nexus 6001 switches (the Core of the network) share data back and forth at an incredible rate of 160 Gigabytes per second.

As servers, workstations, and many other devices were migrated to the new hardware, we took the opportunity to dismantle, rebuild, and re-cable all of the server cabinets. It is important to note in the two pictures above that over 90% of the blue and white cables you see were cut to custom lengths, capped with RJ45 connectors, and tested out to their full limit.

Virtualization
Virtualization is the key to AWC's future. Presently 7 physical servers control and manage 88 virtual servers. The space savings, ease of management, and the ability to update important hardware requirements (i.e. CPU and RAM memory) on the fly are just a few of the benefits of virtualization. There are only a few physical servers dedicated to individual tasks, and these will be virtualized soon.

Servers were the obvious first choice to migrate into a virtual environment. And several of the workstations have now been deployed virtually with more to come. Presently we have 4 Dell Wyse terminals used daily by 3 users and a common use terminal in AWC's large conference room.

Figure 5. Dell Wyse Terminal.

These small boxes serve up the key Human Interface Devices (HID); mouse, keyboard, monitors, etc., but the operating system, CPU, and RAM are all virtual.

Other Accomplishments:
--Migrated VOIP network to new design using stacked PoE 3750-x switches, including phones.
--NetApp file server installation and configuration including data migration, seamless to the user.
--Excessed nearly three quarters of a million dollars in old equipment.
--Researched and advised AWC management on the purchase of three state of the art projection systems.
--Completed several cross-training events onsite where one of the ASB staff share tips and tricks of their particular specialty, vSphere, VOIP phone system, etc.
--Built "AWC in a Box"-- a complete recreation of the AWC network environment to test migration scenarios.
--Broken exterior camera removed, firmware updated, control captured, cleaned and remounted.
--Cable clean-up in testbed before the Summer Experiment.
--Cable clean-up of the OPS Cube areas.
--Lee created and deployed Citrix XenDesktop to bring Virtual Desktop Infrastructure to AWC.
--Lee was also the Architect for vSphere 5.5 environment including virtual switching and storage connectivity.
--Mick arranged for satellite dish (Spare GOES) to be repaired after wind-induced damage.
--Mick updated several websites' core software in order to move them from physical servers to the virtual environment.
--Chad is in the final stages of planning the removal of KTOM, building-wide internal television services.
--Chad Completed SANS SEC401: Security Essentials Bootcamp training.
--All three ASC CIRA staff completed (Interconnecting Cisco Networking Devices) ICND2.1 and ICND2.2 training.

--Lee and Chad have Completed NetApp Data ONTAP v8.3 network filer training.
--We were offered a space to “do with as we please”. Cubicle walls were dismantled, tables and projectors were acquired, walls were painted, and a collaborative work space dubbed the “Command Center” (Fig 6) was completed this year. This space provides a workspace where the Federal and CIRA teams monitor the network and server systems. It provides a common picture of the health of systems and applications in a collaborative space.

Project Awards:

A NOAA award nomination was granted to Lee Powell as follows, "Lee was absolutely instrumental in the AWC network migration process. With tireless attention to detail, a monstrous sense of urgency and integrity, no detail was small enough to be overlooked." Lee's efforts were extremely important in minimizing the impact to users.

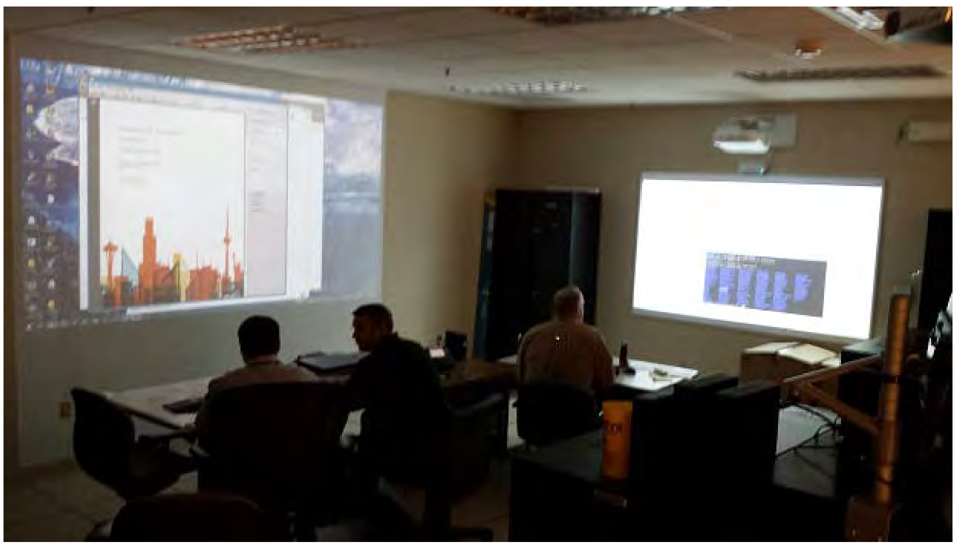


Figure 6. ASB Command Center.

PROJECT TITLE: Research Collaboration with the NWS Aviation Weather Center (AWC) in Support of the Ensemble Model Processor and WRF Domain Wizard (WRF Portal) for the Aviation Weather Testbed (AWT)

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jeff Smith, Brian Pettegrew, Benjamin Schwedler

NOAA TECHNICAL CONTACT: David Bright (NWS/AWC/AWT) Program Manager

PROJECT OBJECTIVES:

The development of this TestBed version of Ensemble Procecssor (EP) software system is needed to fill a gap in current ensemble post-processing capabilities within NCEP, and is targeted toward mission specific applications. Aviation examples under development in the Ensemble Processor include mountain obscuration, ceiling and visibility diagnostics, mountain waves, icing, and turbulence.

The goal of this project is to re-code portions of the existing architecture, plus use state-of-the art techniques to allow users to make quick additions and changes, to allow for a more robust research-to-operations process. Since the software relies on using GEMPAK data as both input and output, the new code will use a more up-to-date GRIB2 I/O interface. Additionally, the system will be modular and adaptable to allow for rapid infusion of new scientific ideas and calculations of ensemble data.

PROJECT ACCOMPLISHMENTS:

Improved the efficiency of EP ingest of grib2 files that form the operational NCEP Short Range Ensemble Forecast (SREF) into a geospatial database, in real time, as the files become available. The SREF data then becomes available for interactive queries via the SREF Query Tool, a web application that guides forecasters in selecting and subsetting the desired data. New wind barb visualizations for airports within the U.S., animated wind particle trails, new statistical and probabilistic queries, as well as support for hi-res 16KM SREF data were add during the past year.

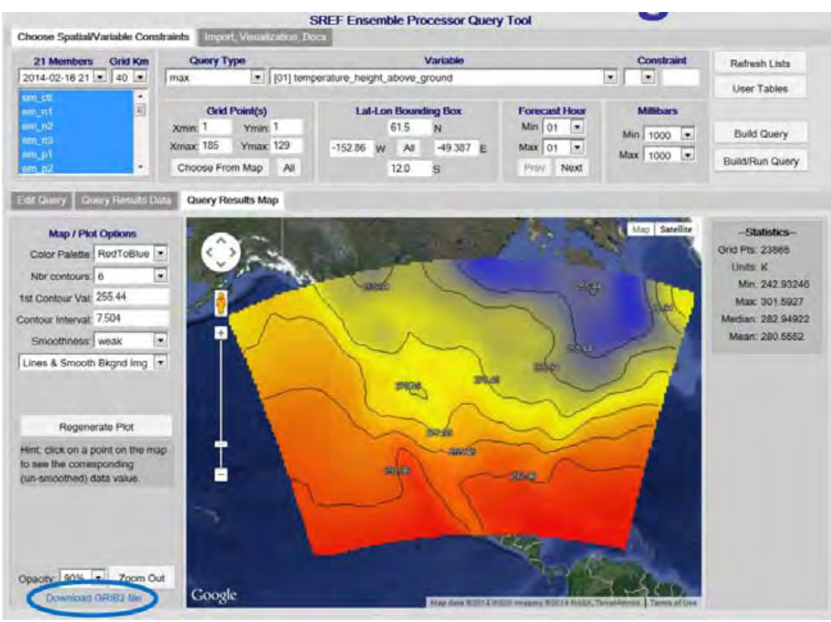


Figure 1. SREF Query Tool Displaying Ensemble Max Temperature With Option To Export/Download As GRIB2 File.

In collaboration with AWC researchers, the project created post-processing algorithms that predict icing, low-level wind shear, mountain obscuration, mountain waves, and turbulence. These algorithms, written in Java, were designed to run in real time, as SREF forecast data becomes available and in parallel on many cores.

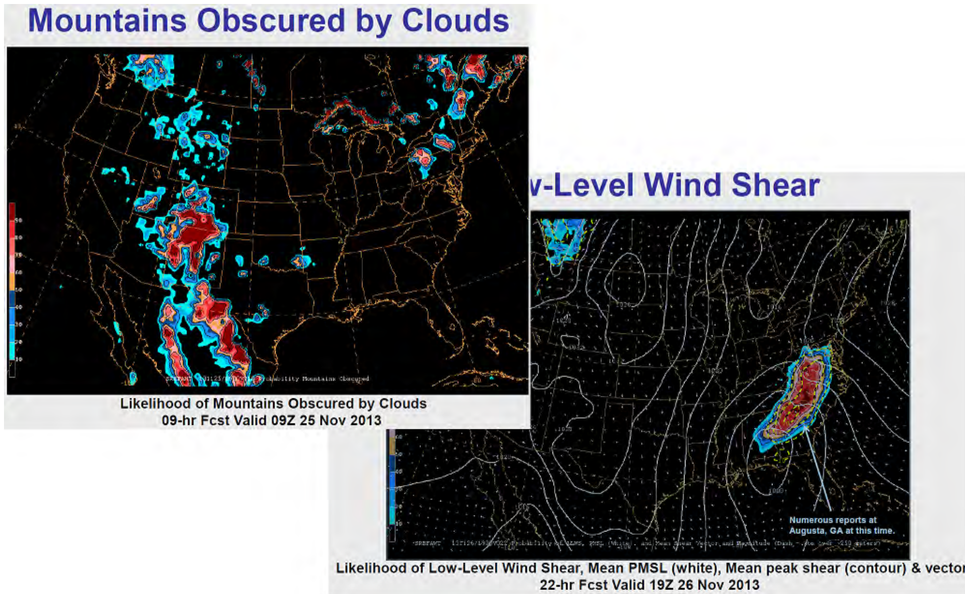


Figure 2. Example of Two EP Post Processing Algorithms (Mountain Obscuration and Low-level Wind Shear).

PROJECT TITLE: Instructional Development and Learning Support for NOAA's OMAO's Chief Learning Officer (CLO), OMAO Kansas City, MO

PRINCIPAL INVESTIGATOR: Sher Schranz

RESEARCH TEAM: Jenna Dalton

NOAA TECHNICAL CONTACT: Scott Tessmer (NOAA/OMAO)

PROJECT OBJECTIVE**:**

Provide comprehensive on-site technical and administrative support to the OMAO CLO. This support includes varied instructional development, educational outreach and course support functions.

PROJECT ACCOMPLISHMENTS:

In the initial six months of this project, commencing September 2014, efforts have been centered on four primary projects:
1--OMAO Training Portal maintenance and content management,
2--Individual Development Plan (IDP) informational and training video development,

3--Department of Commerce (DOC) Learning Management System (LMS) migration to transition to a new system (vendor), and,
4--Resource management for the OMAO Chief Learning Officer (CLO) including budget, travel, and administrative support.

OMAO Training Portal
The OMAO training portal is a Google site created as a "One Stop" site to assist OMAO staff by providing the who, what, when, where and why answers to training questions. It is updated daily with calendar events, links to various new and upcoming training opportunities and links directly to required and career development learning paths. Jenna Dalton, task lead, provides relevant content and training events in support of the OMAO scientific data collection mission and personnel needs to maintain a ready staff. A screenshot of the portal site is located below in Figure 1.

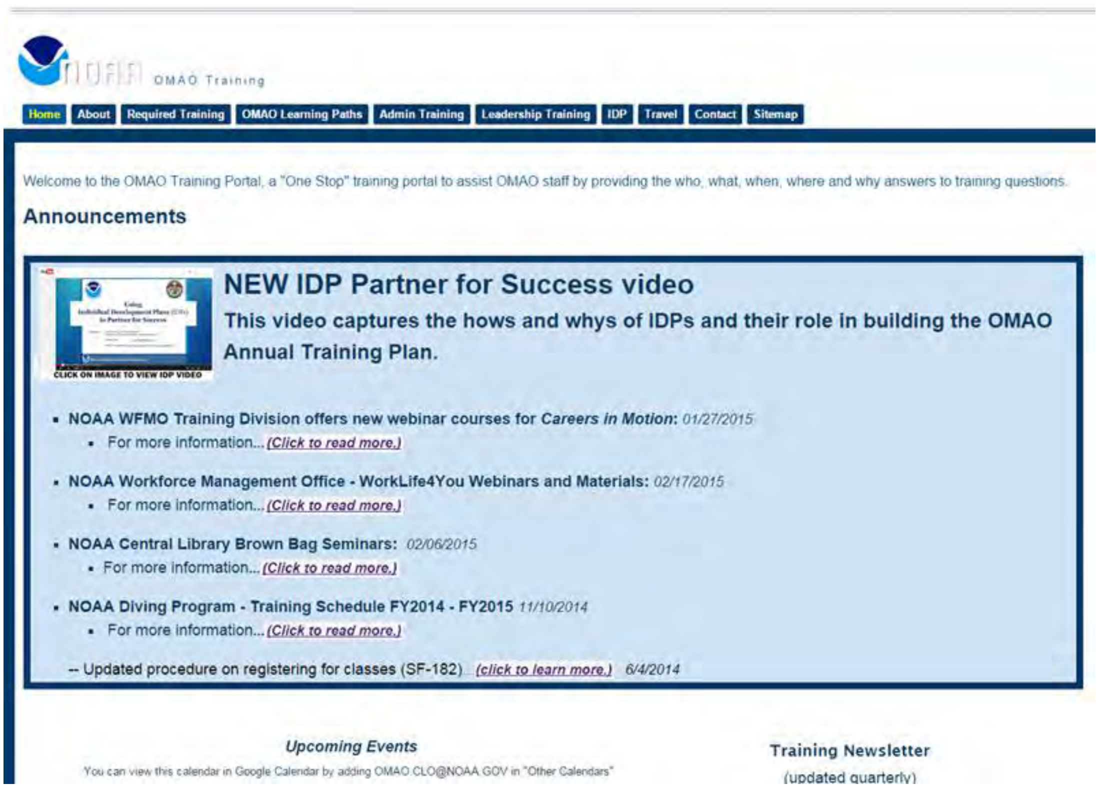


Figure 1. OMAO Training Portal.

IDP Video
The Department of Commerce, NOAA, and OMAO encourage employees to create and use Individual Performance Plans (IDP) to assist supervisors and employees in progress towards their work-related, professional, and personal goals. OMAO provides guidance for staff and supervisors to integrate this “best practice” into the operational environment to optimize mission readiness. An OMAO priority, all employees are asked to complete an IDP, in conjunction with their supervisor, which in turn becomes the foundation to plan and resource for the following fiscal year. For the first time In FY2016, an Annual Training Plan budget will be created from the OMAO employee IDP input for mandated and discretionary training and development. The IDP video was created to define how and why an IDP benefits an employee and aligns them for success. A screenshot of the IDP video created using Adobe software and

hosted on the National Weather Service YouTube channel is shown in Figure 2. The entire video can be viewed at https://www.youtube.com/watch?v=bgLEUmq_Cbw&feature=youtu.be.

Figure 2. Individual Development Plans (IDP) YouTubeVideo.

Resource management for OMAO Learning, Development, and Training

Resource management for the OMAO Chief Learning Officer (CLO) including budget, travel, and administrative support comprise the essentials for the administration of training events and program support. OMAO's internal leadership courses, Mid-Grade Week 1 and Week 2, fulfill the Office of Personnel Management (OPM), DOC, and NOAA requirements for new supervisor training and provide an additional cross-mission development venue for the organization. These courses, held at the National Weather Service Training Center (NWSTC), include NOAA Corps Officers, Wager Mariners, and civilian staff. CIRA associate, Jenna Dalton, supported the leadership training as the resource manager of travel and budget, director of course logistic coordination, and course liaison.

OMAO Wage Marine New Employee Orientation also began to utilize the NWSTC facility as a result of the new support provided through the CIRA project. This course, traditionally held in Norfolk, Virginia, provides all Wager Mariners onboarding with OMAO the required administrative, safety, and personnel training needed before reporting to their assignments in science and data collection. OMAO Course attendees from December 2014 to February 2015 as shown in Figure 3.

Figure 3. OMAO Course attendees December 2014 – February 2015.

The OMAO co-located its Chief Learning Officer (CLO) with the National Weather Service Training Center (NWSTC) in Kansas City, MO in September of 2013 as part of an investment to advance the organizational training program. This partnership permits the sharing of development resources and provides for mutual support on common core leadership training. The OMAO training support specialist participated in resident course preparations including planning, agenda development, course logistics, and managing classrooms. The OMAO / NWSTC leadership training and educational resources collaboration began in 2010 and is the only joint NOAA training program sharing resources to address growing training demands. An image of NWSTC is shown in in Figure 4.

Figure 4. National Weather Service Training Center and Office of Marine and Aviation Operations CLO co-location.

PROJECT TITLE: SSMI and SSMIS Fundamental Climate Data Record Sustainment and Maintenance

PRINCIPAL INVESTIGATOR: Christian Kummerow

RESEARCH TEAM: Wes Berg, ATS

NOAA TECHNICAL CONTACT: Candace Hutchins, NOAA NESDIS/NCDC

NOAA RESEARCH TEAM: Hilawe Semunegus

PROJECT OBJECTIVES:

The Climate Data Record Program (CDRP) leads NOAA's development and provision of authoritative satellite climate data records (CDRs) for the atmospheres, oceans and land. This project's objective is to provide NOAA with a fundamental climate data record of Special Sensor Microwave/Imager (SSMI) and Special Sensor Microwave Imager and Sounder (SSMIS) data records. For the currently orbiting SSMIS sensors, the records are broken into Interim Climate Data Records (ICDR) produced rapidly using automated QC and trending information as well as the fundamental data record (FCDR) produced roughly six months after acquisition. In addition, NOAA has requested the delivery of gridded ICDR/FCDR files over the entire data record. The objectives further relate to distribution of data, interface for the community, and including new satellite data streams when these become available.

PROJECT ACCOMPLISHMENTS:

An updated SSMI(S) Brightness Temperature Implementation Plan that describes the deliverables and major tasks for this period was delivered December 10, 2014. It specifies ongoing delivery of daily ICDR updates, evaluation and conversion of ICDR to FCDR files, and development and delivery of gridded Tb products. We have been working with NCDC on the official request for the gridded products and plan to deliver prototype gridded files to NCDC shortly. Another task specified in the implementation plan involves the evaluation of data from the SSMIS on board F19 and development/delivery of ICDR data from this sensor. We are well under way with this task and plan to deliver F19 ICDR files to NCDC soon. Development and delivery of FCDR files will require much more data than the few months currently available.

The implementation plan also details the external dependencies, and details the quality control procedure we have implemented. We also provided a quality assurance document in August of 2014 that highlights the progress made in monitoring the quality of the intercalibrated Tb. Part of the quality assurance involves evaluation of retrieved geophysical products as shown in the following comparison of F17 and F19 precipitation estimates.

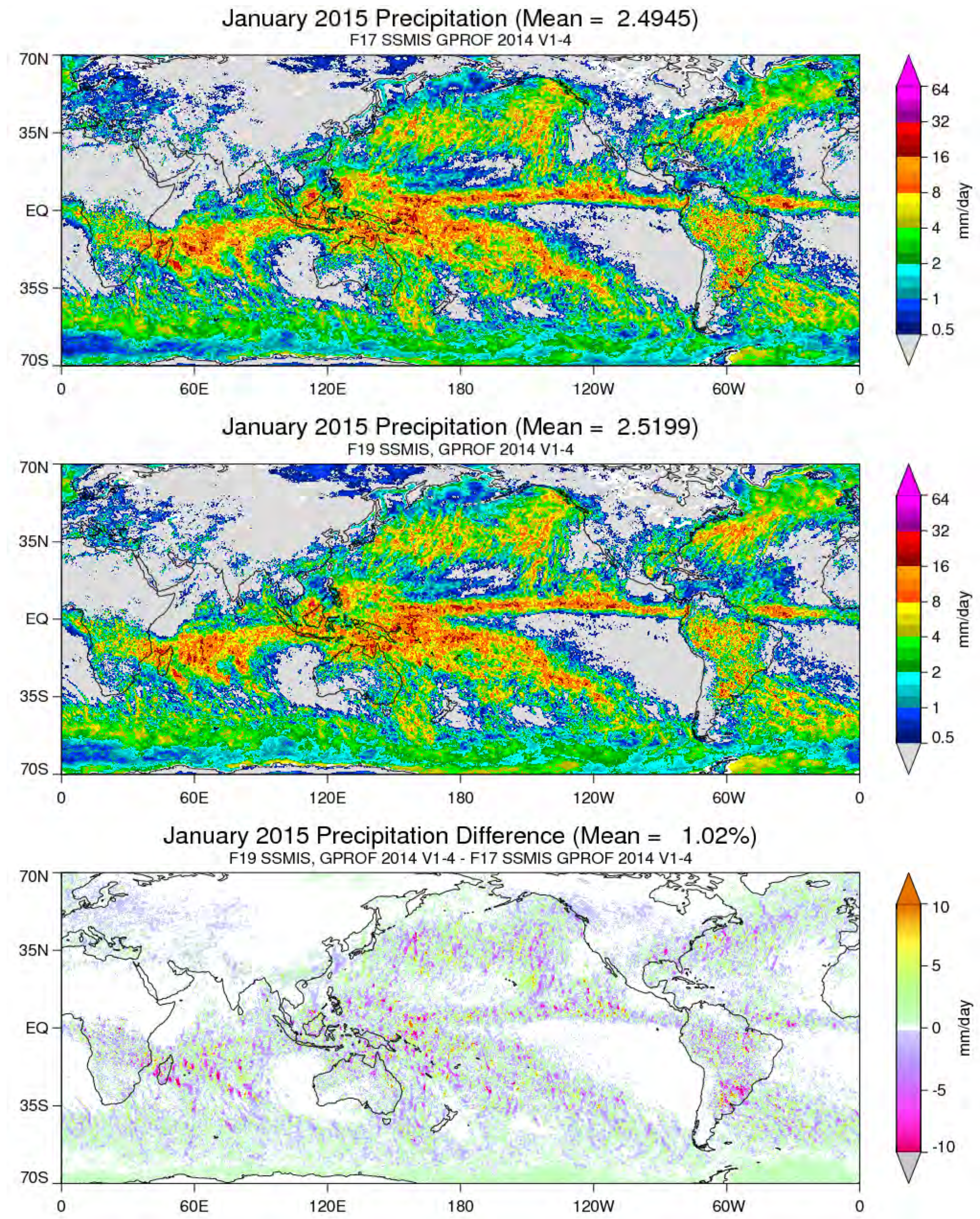


Figure 1. January 2015 monthly mean precipitation from the operational GPM retrieval algorithm for the SSMIS sensors on board a) F17, b) F19, and c) F19 – F17. Preliminary corrections have been developed and applied for cross-track biases, geolocation/pointing errors, and intercalibration adjustments over both cold and warm scenes. The comparison with F17 is shows as the local ascending equatorial crossing time is very similar, but not identical, between these two sensors. As a result, some residual differences due to diurnal cycle effects is expected, particularly over land.

PROJECT TITLE: Weather Satellite Data and Analysis Equipment and Support for Research

PRINCIPAL INVESTIGATOR: Chris Kummerow/Michael Hiatt

RESEARCH TEAM: Michael Hiatt

NOAA TECHNICAL CONTACT:

NOAA RESEARCH TEAM: None

PROJECT OBJECTIVES:

1—Earthstation: Operations and maintenance for 4 antennas and associated telemetry, network, ingest, processing, distribution, and archive,
2—Data Collection: All direct readout GOES GVAR via 3 GOES systems, GOES special collections, MSG via 7M DOMSAT system, and 19 project products via Internet,
3—Data Distribution and Archive: Blu-ray media, archive writers, and online RAID storage,
4—Personnel Salary: Part-time coverage for one Electrical Engineer.

PROJECT ACCOMPLISHMENTS:

1—All data sets collected, processed, cataloged, distributed, and archived at 99.9% level. Online archive now spans from 1992-2015 with approximately 380TB online data and Blu-ray backups,
2—Two large RAID NAS units added for additional storage,
3—Two Blu-ray writers replaced,
4—One processing server upgraded,
5—Telemetry repair.

PUBLICATIONS MATRIX

	2010	2011	2012	2013	2014
CI Lead Author	24 Peer Reviewed 45 Non-peer Reviewed	21 Peer Reviewed 71 Non-peer Reviewed	31 Peer Reviewed 114 Non-peer Reviewed	23 Peer Reviewed 98 Non-peer Reviewed	28 Peer Reviewed 13 Non-peer Reviewed
NOAA Lead Author	16 Peer Reviewed 33 Non-peer Reviewed	23 Peer Reviewed 70 Non-peer Reviewed	25 Peer Reviewed 69 Non-peer Reviewed	28 Peer Reviewed 40 Non-peer Reviewed	21 Peer Reviewed 17 Non-peer Reviewed
Other Lead Author	20 Peer Reviewed 20 Non-peer Reviewed	29 Peer Reviewed 35 Non-peer Reviewed	30 Peer Reviewed 43 Non-peer Reviewed	31 Peer Reviewed 33 Non-peer Reviewed	51 Peer Reviewed 5 Non-peer Reviewed

PUBLICATIONS & PRESENTATIONS

PUBLICATIONS

(All publications fall under NA14OAR4320125 unless otherwise noted)

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CIRA Support for the JPSS Proving Groundand Risk Reduction Program: Application of JPSS Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting

Extended Abstracts

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Zhu, T., and S. Boukabara, 2014: Impact of geostationary satellite data on Superstorm Sandy Forecast. World Weather Open Science Conference, August 16-21, 2014, Montreal, Canada.

Zhu, T. and S. Boukabara, 2015: Development and impact study of community satellite data thinning and representation. 95th AMS Annual Meeting, January 04-08, 2015, Phoenix, Arizona.

Tropical Cyclone Model Diagnostics and Product Development

DeMaria, M., C.R. Sampson, J.A. Knaff and K.D. Musgrave, 2014: Is tropical cyclone intensity guidance improving? Bull. Amer. Meteor. Soc., 95, 387-398

Jin, Y., S. Wang, J. Nachamkin, J.D. Doyle, G. Thompson, L.D. Grasso, T. Holt, J. Moskaitis, H. Jin, R.M. Hodur, Q. Zhao, M. Liu, and M. DeMaria, 2014: Evaluation of microphysical parameterizations for tropical cyclone prediction. Mon. Wea. Rev. 142:2, 606-625.

Knaff, J.A., S.P. Longmore, and D.A. Molenar, 2014: An objective satellite-based tropical cyclone size climatology. J. Climate, 27, 455-476. doi: http://dx.doi.org/10.1175/JCLI-D-13-00096.1

Slocum, C. J., G. J. Wililams, R. K. Taft, and W. H. Schubert, 2014: Tropical cyclone boundary layer shocks. J. Adv. Model. Earth Syst. (accepted).

Publications - Competitive Projects

Guidance on Intensity Guidance (NA13OAR4590187)

Bhatia, K. T. and D. S. Nolan, 2013: Relating the skill of tropical cyclone intensity forecasts to the synoptic environment. Wea. Forecasting, 28, 961–980.

Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models (NA120AR4310077)

Benedict, J. J. E. D. Maloney, A. H. Sobel, and D. M. Frierson, 2014: Gross moist stability and MJO simulation skill in three full-physics GCMs. *J. Atmos. Sci*., 71, 3327-3349.

Jiang, X.-A., E. D. Maloney, J.-L. F. Li, and D. E. Waliser, 2013: Simulations of the eastern north Pacific intraseasonal variability in CMIP5 GCMs. *J. Climate*, **26**, 3489-3510.

Kim, D, P. Xavier, E. Maloney, M. Wheeler, D. Waliser, K. Sperber, H. Hendon, C. Zhang, R. Neale, Y.-T. Hwang, and H. Liu, 2014: Process-oriented MJO simulation diagnostic: Moisture sensitivity of simulated convection. *J. Climate*, 27, 5379-5395.

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Maloney, E. D., and S.-P. Xie, 2013: Sensitivity of MJO activity to the pattern of climate warming. J. Adv. Modeling Earth Sys., 5, 32-47.

Maloney, E. D., and C. Zhang, 2015: Dr. Yanai's contribution to the discovery and science of the MJO. Meteor. Monographs, accepted.

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Rydbeck, R. V., and E. D. Maloney, 2015: On the Convective Coupling and Moisture Organization of East Pacific Easterly Waves. J. Atmos. Sci., submitted.

Serra, Y. L., X. Jiang, B. Tian, J. Amador Astua, E. D. Maloney, and G. N. Kiladis, 2014: Tropical intra-seasonal oscillations and synoptic variability. Annual Review of Environment and Resources, **39**, 189–215.

Shaman, J., and E. D. Maloney, 2012: Shortcomings in climate model simulations of the ENSO-Atlantic hurricane teleconnection. Climate Dynamics, **38**, 1973-1988.

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Slade, S. A., 2012: A Statistical Prediction Model for East Pacific and Atlantic Tropical Cyclone Genesis. M.S. thesis, Colorado State University, 126pp.

Slade, S. A., and E. D. Maloney, 2013: A Statistical Prediction Model for East Pacific and Atlantic Tropical Cyclone Genesis. Mon. Wea. Rev., 141, 1925–1942.

Van Roekel, L. P., and E. D. Maloney, 2012: Mixed layer modeling in the east Pacific warm pool during 2002. Climate Dynamics, 38, 2559-2573.

Zhou, Z.-Q., S.-P. Xie, X.-T. Zheng, Q. Liu, and H. Wang, 2014: Global warming-induced changes in El Nino teleconnections over the North Pacific and North America. J. Climate, 27, 9050-9064, doi: 10.1175/JCLI-D-14-00254.1.

Upgrades to the Operational Monte Carlo Wind Speed Probability Program (NA13OAR4590190)

DeMaria, M., J.A. Knaff, M. Brennan, D. Brown, R. Knabb, R.T, DeMaria, A.B. Schumacher, C. Lauer, D. Roberts, C. Sampson, P. Santos, D. Sharp, and K. Winters, 2013: Improvements to the operational tropical cyclone wind speed probability model. Wea. Forecasting, 28, 586-602. doi: http://dx.doi.org/10.1175/WAF-D-12-00116.1

Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation (NA12OAR4310163)

Hannah, W. M., and E. D. Maloney, 2014: The Moist Static Energy Budget in NCAR CAM5 Hindcasts during DYNAMO. *J. Adv. Modeling Earth Sys*., accepted pending major revisions.

Hannah, W. M., and E. D. Maloney, 2014: DYNAMO Hindcast Experiments in SP-CAM. *J. Adv. Modeling Earth Sys*., to be submitted.

Hannah, W. M., and E. D. Maloney, 2014: The Moist Static Energy Budget in NCAR CAM5 Hindcasts during DYNAMO. *J. Adv. Modeling Earth Sys*., **6**, doi:10.1002/2013MS000272.

Hannah, W. M., E. D. Maloney, and M. Pritchard, 2015: Consequences of Systematic Model Drift in DYNAMO MJO Hindcasts with SP-CAM and CAM5. J. Adv. Modeling. Earth Sys., accepted pending revision.

Wolding, B. O., and E. D. Maloney, 2015: Objective Diagnostics and the Madden-Julian Oscillation. Part I: Methodology. *J. Climate*, in press.

Wolding, B. O., and E. D. Maloney, 2015: Objective Diagnostics and the Madden-Julian Oscillation. Part II: Application to Moist Static Energy and Moisture Budgets. *J. Climate*, accepted pending revision.

Publications - Competitive Projects – Sandy Supplemental

CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates (NA14NWS4830056)

DeMaria, M., J.A. Knaff, M. Brennan, D. Brown, R. Knabb**,** R.T DeMaria, A.B. Schumacher**,** C. Lauer, D. Roberts, C. Sampson, P. Santos, D. Sharp, and K. Winters, 2013: Improvements to the operational tropical cyclone wind speed probability model. *Wea. Forecasting*, 28, 586-602. doi: http://dx.doi.org/10.1175/WAF-D-12-00116.1

PRESENTATIONS

(All presentations fall under NA14OAR4320125 unless otherwise noted)

Algorithm Development for AMSR-2

Results were presented at ASMR2 as well as GPM science team meetings.

CIRA Support for Feature-based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting

Chirokova, G., M. DeMaria, R. T. DeMaria, J. F. Dostalek, and J. L. Beven, 2015: Improving Tropical Cyclone Intensity Forecasting with JPSS ATMS-MIRS Retrievals. 2015 NOAA Satellite Science Week, 23-28 February 2014, Boulder, CO.

Chirokova, G., M. DeMaria, R. T. DeMaria, J. F. Dostalek, and J. L. Beven, 2015: Use of JPSS ATMS-MIRS Retrievals to Improve Tropical Cyclone Intensity Forecasting. 95th AMS Annual Meeting, 4-8 January 2015 Phoenix, AZ.

Dostalek J. F., G. Chirokova, K. D. Musgrave, and M. DeMaria, 2014: A Comparison of Two Microwave Retrieval Schemes in the Vicinity of Tropical Storms. AMS 31st Conference on Hurricanes and Tropical Meteorology, March 31 - April 4, 2014, San Diego, CA.

CIRA Support for Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting

Bikos, D., Szoke, E., Kidder, S., Miller, S., and H. Gosden, 2014: The Orographic Rain Index (ORI) Product at CIRA. AMS Mountain Meteorology Conference. August 18-22, San Diego.

Brummer, R., E. Szoke, D.T. Lindsey, L.D. Grasso, D.W. Hillger and D. Bikos, 2014: Synthetic satellite imagery development at CIRA. EUMETSAT 2014 Meteorological Satellite Conference, 22-26 September. Geneva, Switzerland.

Grasso, L. , Y.-J., Noh, D. Lindsey, and D. Hillger, 2015: GOES-R ABI Synthetic Imagery at 3.9 and 2.25 µm. NOAA Satellite Science Week, Boulder, Colorado, 23-27 March 2015.

Knaff, J.A., G. Chirokova, M. DeMaria, R. DeMaria, J.F. Dostalek, A.B. Schumacher, and S. Longmore, 2014: Opportunities to Improve Tropical Cyclone Forecasts with JPSS and GOES-R. 2014 GOES-R/JPSS OCONUS R2O Interchange Meeting, 28-31 July. NOAA Inouye Regional Center, Honolulu, HA.
Lindsey, D.T., 2014: GOES-R synthetic imagery. Glasgow, Montana NWS office, 29 May 2014, Remote presentation.

Lindsey, D. and L. Grasso, 2015: GOES-R synthetic imagery over Alaska. NOAA Satellite Science Week, Boulder, Colorado, 23-27 February 2015.

Lindsey, D.T., and L.D. Grasso, 2015: GOES-R Synthetic Imagery over Alaska. NOAA Satellite Science Week, Boulder, Colorado, 23-27 February 2015.

Lindsey, D., L. Grasso, and D. Bikos, 2015: Synthetic Satellite Imagery: A New Tool for GOES-R User Readiness and Cloud Forecast Visualization. 2015 NOAA Satellite Conference, April 2015.

Molenar, D.A., 2014: Support and Utilization of the National Weather Service Advanced Weather Interactive Processing System II in a Research Environment UCAR Software Engineering Assembly, 7-11 April, Boulder, CO.

Molenar, D.A. and S.Longmore, 2015: CIRA GOES and JPSS RGB Product Development Updates for AWIPS II D2D and NCP, NOAA Satellite Science Week meeting in Boulder, Colorado February 23 - 27, 2015

Musgrave, K., J. Knaff, C. Slocum, L. Grasso, and M. DeMaria, 2014: Evaluation of HWRF Synthetic Satellite Brightness Temperatures, 2014 AGU Annual Meeting, 15-19 December 2014, San Francisco, CA.

Sampson, C.R., J.A. Knaff, J. Courtney, B. Strahl, F. Fujita, N. Koide, O. Bousquet, T. Dupont, M. Brennan, V. Tallapragada, T. Marchok, S.G. Gopalakrishnan, B. Chen, M. Mohapatra, S.D. Kotal, U.C. Mohanty, M. Fiorino, J. Doyle, and R. Elsberry, 2014: Topic 2.7 Advances in intensity guidance, WMO International Workshop on Tropical Cyclones – VIII, Jeju Island, Republic of Korea, 2-8 December, 26 pp.

Schumacher, A. B., M. DeMaria, and R. DeMaria, 2015. “Using Total Lightning Data to Improve Tropical Cyclone Intensity and Genesis Forecasts,” 7th Conference on the Meteorological Applications of Lightning Data at the 95th AMS Annual Meeting, Phoenix, AZ, 4-8 January 2015.

Schumacher, A.B. and M. DeMaria, 2014: Current State of Proving Ground User Readiness at the National Hurricane Center. GOES-R / JPSS Proving Ground / User-Readiness Meeting, 2-6 June, Kansas City.

Schumacher, A. B., M. DeMaria, and R. DeMaria, 2015 (poster). “Using Total Lightning Data to Improve Tropical Cyclone Intensity and Genesis Forecasts,” NOAA Satellite Science Week, Boulder, CO, 23-27 February 2015.

Schumacher, A.B., M. DeMaria, J.A. Knaff, L. Ma, H. Syed, 2014: Updates to the NESDIS Tropical Cyclone Formation Probability Product. 31st Conference on Hurricanes and Tropical Meteorology. 30-March-4 April, San Diego, CA.

Szoke, EJ., D. Bikos, R. Mazur, R. Cox, D. Barjenbruch, R. Kleyla, and R. Glancy. 2014: Can total lightning data help give warning lead time for non-supercell tornadoes? AMS 27th Severe Local Storms Conference, 3-7 November, Madison, Wisconsin, Talk 3B.2.

Tourville, N., J. Knaff, M. DeMaria, G. Stephens, D. Vane, 2014: CloudSat & A-Train Observations of Tropical Cyclones: Examining Effects of Wind Shear on Storm Structure, Abstract 24827 presented at the 2014 Fall Meeting, AGU, San Francisco, CA, 15-19 December.

CIRA Support for the JPSS Proving Ground and Risk Reduction Program: Application of JPSS Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting

Chirokova, G., M. DeMaria, R. T. DeMaria, J. F. Dostalek, and J. L. Beven, 2015: Improving Tropical Cyclone Intensity Forecasting with JPSS ATMS-MIRS Retrievals. Poster at the the 2015 NOAA Satellite Science Week, 23-28 February 2014, Boulder, CO.

Chirokova G., M. DeMaria, R. T. DeMaria, J. F. Dostalek, and J. Beven, 2014: Improving Tropical Cyclone Track and Intensity Forecasting with JPSS Imager and Sounder Data. AMS 31st Conference on Hurricanes and Tropical Meteorology, March 31 - April 4, 2014, San Diego, CA.

Chirokova, G., M. DeMaria, R. T. DeMaria, J. F. Dostalek, and J. L. Beven, 2015: Use of JPSS ATMS-MIRS Retrievals to Improve Tropical Cyclone Intensity Forecasting. 95th AMS Annual Meeting, 4-8 January 2015 Phoenix, AZ.

Chirokova G, M. DeMaria, and J. Dostalek: Rapid Intensification Index Estimates with ATMS profiles. NCAR/NOAA/CSU Tropical Cyclone Workshop, Jan 8, 2014, Boulder, CO

DeMaria M. and R.T. DeMaria: Application of the Computer Vision Hough Transform for Automated Tropical Cyclone Center-Fixing from Satellite data. NCAR-CSU Tropical Cyclone Workshop, Jan 8, 2014, Boulder, CO

DeMaria, R., G. Chirokova, J. Knaff, and J. Dostalek, 2014: Machine Learning Algorithms for Tropical Cyclone Center Fixing and Eye Detection. 95th AMS Annual Meeting, 4-8 January 2015 Phoenix, AZ.

DeMaria, R., J. Knaff, and J. Dostalek, and G. Chirokova, 2014: Objective Methods for Tropical Cyclone Center Fixing and Eye Detection. Poster at the 2015 NOAA Satellite Science Week, 23-28 February 2014, Boulder, CO.

Dostalek J. F., G. Chirokova, K. D. Musgrave, and M. DeMaria, 2014: A Comparison of Two Microwave Retrieval Schemes in the Vicinity of Tropical Storms. AMS 31st Conference on Hurricanes and Tropical Meteorology, March 31 - April 4, 2014, San Diego, CA

Knaff, J, G. Chirokova, M. DeMaria, R. DeMaria, J. Dostalek, A. Schumacher, and S. Longmore, 2014: Opportunities to Improve Tropical Cyclone Forecasts with JPSS and GOES-R. 2014 GOES-R/JPSS OCONUS R2O Interchange Meeting (TIM), July 29 – August 1, 2014, Ford Island, Honolulu, HI

CIRA Support: Getting Ready for NOAA's Advanced Remote Sensing Programs—A Satellite Hydro-meteorology (SHyMet) Education and Outreach Proposal

Connell, B., D. Bikos, E. Szoke, S. Bachmeier, S. Lindstrom, T. Mostek, B. Motta, and L. Veeck, 2015: Satellite Training Activities: VISIT, SHyMet, and WMO VLab. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Connell, B., 2015: An Observational Approach for Training to Enhance User Understanding of New Channels on VIIRS and GOES-R. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Connell, B., 2014: Preparing for a new satellite: new and old challenges mixed with opportunities. CALMet Online 2014 (Community for the Advancement of Learning Meteorology), 6 Oct. – 28 Nov. 2014. Asynchronous Session during 27 Oct. – 7 Nov.

Szoke, E., D. Bikos, R. Brummer, H. Gosden, D. Lindsey, D. Molenar, D. Hillger, S. Miller and C. Seaman, 2015: An update of CIRA's GOES-R and JPSS Proving Ground activities. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Community Outreach

-- After-school weather club: Scientists at CIRA and CSU students – all members of the local AMS chapter of Northern Colorado called FORTCAST (Fort Collins Atmospheric Scientists) volunteered for the weekly after-school weather club on Tuesdays for Putnam Elementary (K-5). The fall session ran for 8 weeks during October through early December 2014. There was a 90 minute session each week. Sessions included helping with homework and leading an activity. The topics covered included wind speed and direction, clouds, colors of the rainbow, lightning, angular momentum, arctic ice, freezing solids (ice cream!), as well as measurements that are associated with these weather occurrences. Volunteers included Bernie Connell, Matt Rogers, Doug Stolz, Erin Dagg, Marie McGraw, and Melissa Burt. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!

-- B. Connell gave a presentation on GOES and GOES-R and the characteristics of its channels to a Remote Sensing/ Geographic Information Systems class at the Metropolitan State University of Denver on November 30. Since their Remote Sensing class focuses mainly on earth resource topics, the students were presented with the perspective of how meteorologists view and use satellite imagery.

CIRA Support of NOAA's Commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory

Connell, B., 2015: An Observational Approach for Training to Enhance User Understanding of New Channels on VIIRS and GOES-R. NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.
Poster

Connell, B., 2014: Preparing for a new satellite: new and old challenges mixed with opportunities. CALMet Online 2014 (Community for the Advancement of Learning Meteorology), 6 Oct. – 28 Nov. 2014. Asynchronous Session during 27 Oct. – 7 Nov.

Connell, B., 2014: CIRA and NOAA Contributions to the WMO VLab. Virtual Laboratory Management Group Seventh Meeting (VLMG-7) Saint Petersburg, Russian Federation, 22 – 25 July 2014. Presentation.

Connell, B., 2014: GEONETCast Americas (GNC-A) Training Activities. Virtual Laboratory Management Group Seventh Meeting (VLMG-7) Saint Petersburg, Russian Federation, 22 – 25 July 2014. Presentation.

Connell, B., D. Bikos, E. Szoke, S. Bachmeier, S. Lindstrom, T. Mostek, B. Motta, and L. Veeck, 2015: Satellite Training Activities: VISIT, SHyMet, and WMO VLab. NOAA Satellite Science Week, 23-27 February, Boulder, Colorado. Poster

Kuna, M., Veeck, L., Ghelli, A., Smiljanic, I., and Chiariello, A. 2014: Webinar Checklist. CALMet Online 2014 (Community for the Advancement of Learning Meteorology), 6 Oct. – 28 Nov. 2014. Asynchronous Session during 20 Oct. – 2 Nov.

CIRA Support of the Virtual Institute for Satellite Integration Training (VISIT)

Bikos, D., Szoke, E., Kidder, S., Miller, S., and H. Gosden, 2014: The Orographic Rain Index (ORI) Product at CIRA. August 18-22, 2014, San Diego, CA, Amer. Meteor. Soc. Mountain Meteorology Conference.

Bikos, D., E. Szoke, S. Miller, S. Kidder, C. Kummerow, C. Combs, S. Longmore, and P. Brown, 2015: An orographically adjusted GPM precipitation retrieval for NOAA's QPE over mountainous terrain. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Connell, B., 2014: "Preparing for a New Satellite: New and Old Challenges Mixed with Opportunities." 6 October - 30 November, Creating Activities for Learning Meteorology (CALMet) Online Conference. Two-week asynchronous session.

Connell, B., 2015: An Observational Approach for Training to Enhance User Understanding of New Channels on VIIRS and GOES-R. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Connell, B., D. Bikos, E. Szoke, S. Bachmeier, S. Lindstrom, T. Mostek, B. Motta, and L. Veeck, 2015: Satellite Training Activities: VISIT, SHyMet, and WMP VLab. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Szoke, E., D. Bikos, R. Brummer, H. Gosden, D. Lindsey, D. Molenar, D. Hillger, S. Miller and C. Seaman, 2015: An update of CIRA's GOES-R and JPSS Proving Ground activities. Poster, NOAA Satellite Science Week, 23-27 February, Boulder, Colorado.

Szoke, E., D. Bikos, G. Stano, P. Kennedy, S. Rutledge, R. Kleyla, D. Barjenbruch, R. Glancy, R. Cox and R. Mazur, 2015: Total lightning and non-supercell tornadoes. Poster, NOAA Science Week, 23-27 March, Boulder, Colorado.

CIRA Support to a GOES-R Proving Ground for National Weather Service Forecaster Readiness

Beven, J.L., M. J. Brennan, H. D. Cobb III, M. DeMaria, J.A. Knaff, A.B. Schumacher, C. Velden, S.A. Monette, J.P. Dunion, G.J. Jedlovec, K.K. Fuell, and M.J. Folmer, 2014: The Satellite Proving Ground at the National Hurricane Center. 31st Conference on Hurricanes and Tropical Meteorology. 30 March-4 April, San Diego, CA.

Bikos, D., Szoke, E., Kidder, S., Miller, S., and H. Gosden, 2014: The Orographic Rain Index (ORI) Product at CIRA. AMS Mountain Meteorology Conference. August 18-22, San Diego.

Brummer, R., E. Szoke, D.T. Lindsey, L.D. Grasso, D.W. Hillger and D. Bikos, 2014: Synthetic satellite imagery development at CIRA. EUMETSAT 2014 Meteorological Satellite Conference, 22-26 September. Geneva, Switzerland.

Brummer, R., E. Szoke, D.T. Lindsey, S.D. Miller, B.H. Connell, L.D. Grasso, D.A. Molenar, 2014: CIRA Proving Ground activities. EUMETSAT 2014 Meteorological Satellite Conference, 22-26 September. Geneva, Switzerland.

Chirokova, G., M. DeMaria, R. DeMaria, J.F. Dostalek, J.L. Beven, 2014: Improving Tropical Cyclone Track and Intensity Forecasting with JPSS imager and Sounder Data. 31st Conference on Hurricanes and Tropical Meteorology, 30 March-4 April, San Diego, CA.

Connell, B.H., 2014: GEONETCast Americas (GNC-A) Training Activities. 7th Meeting of the World Meteorological Organization Virtual Laboratory Management Group (WMO VLMG-7), RSHU, 21-25 July. St. Petersburg, Russia.

Dostalek, J.F., G. Chirokova, K.D. Musgrave, M. DeMaria, 2014: A Comparison of Two Microwave Retrieval Schemes in the Vicinity of Tropical Storms. 31st Conference on Hurricanes and Tropical Meteorology. 30-March-4 April, San Diego, CA.

Grasso, L. , Y.-J., Noh, D. Lindsey, and D. Hillger, 2015: GOES-R ABI Synthetic Imagery at 3.9 and 2.25 µm. NOAA Satellite Science Week, Boulder, Colorado, 23-27 March 2015.

Hillger, D.W., C.J. Seaman, S.D. Miller, T.J. Kopp, R.Williams, and G.Mineart, 2015: Suomi NPP VIIRS Imagery Update. AMS 95th Annual Meeting, 11th Annual Symposium on New Generation Operational Environmental Satellite Systems, 5-8 January, Phoenix, AZ.

Knaff, J.A., G. Chirokova, M. DeMaria, R. DeMaria, J.F. Dostalek, A.B. Schumacher, and S. Longmore, 2014: Opportunities to Improve Tropical Cyclone Forecasts with JPSS and GOES-R. 2014 GOES-R/JPSS OCONUS R2O Interchange Meeting, 28-31 July. NOAA Inouye Regional Center, Honolulu, HA.

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Liang, X., and A. Ignatov, 2014: MICROS update for GSICS, GSICS Annual Meeting, Darmstadt, Germany, March 2014 (Oral.)

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Petrenko, B., et al., 2014: SST algorithms in ACSPO reanalysis of AVHRR GAC data from 2002-2013, GHRSST XV STM, 2-6 Jun 2014, Cape Town, S. Africa.

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Son, S., M. Wang, and L. Harding, 2014: Satellite-measured net primary production in the Chesapeake Bay from MODIS and VIIRS (at NASA Ocean Science Research Meeting 2014, Silver Spring, MD, USA), May 5-7.

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Stroup, J., and Team, 2014: VIIRS SST Products, JPSS Mission Partners Forum, 12 June 2014 (Oral).

Wang, M., J. Lide, X. Liu, S. Son, W. Shi, P. Naik, J. Sun, X. Wang & V. Lance,2014: Evaluation of VIIRS Ocean Color Products (at SPIE Asia-Pacific Remote Sensing 2014 Conference, Beijing, China), October 13-16.

Wang, M., J. Lide, X. Liu, S. Son, W. Shi, P. Naik, J. Sun, X. Wang & V. Lance, 2014: VIIRS Ocean Color Products (at Ocean Optics XXII Meeting 2014, Portland, ME, USA), October 25-31.

Wang, M. and X. Liu, L. Jiang, S-H. Son, J. Sun, W. Shi, L. Tan, P. Naik, K. Mikelsons, X. Wang, and V. Lance, 2014: Evaluation of VIIRS Ocean Color Products , SPIE Beijing, October 2014

Wang, X., X. Liu, L. Jiang, M. Wang, and J., 2014: Sun --VIIRS Ocean Color Data Visualization and Processing With IDL-Based NOAA-SeaDAS, , SPIE Beijing, October 13-16.

Wang, M., S. Son, L. Jiang & W. Shi, 2014: Ocean diurnal variations measured by the Korean Geostationary Ocean Color Imager (GOCI) (at the 3rd GOCI PI Workshop in the International Symposium of Remote Sensing, Busan, South Korea), April 16-18.

Zhou, X., and Team, 2014: ACSPO AVHRR GAC SST Reanalysis from 2002-2013**,** SPIE, Oct 2014, Beijing (oral).
Zhou,X., A. Ignatov, P. Dash, B. Petrenko, X. Liang, F. Xu (2014), Initial evaluation of the first ACSPO AVHRR SST Reanalysis from 2002-2014, SPIE Asia Pacific Remote Sensing Conf, Beijing, 13-17 Oct 2014.

SSMI and SSMIS Fundamental Climate Data Record Sustainment and Maintenance

Berg, W. and Chris Kummerow, A 27-Year Climate Data Record of Intercalibrated Brightness Temperatures and Precipitation Estimates from the DMSP Microwave Imagers, presented at the 20th AMS Satellite Conference, Phoenix, Arizona, 4-8 January, 2015.

Tropical Cyclone Model Diagnostics and Product Development

Musgrave, K. D., and M. DeMaria, 2014: Further development of a statistical-dynamical ensemble for tropical cyclone intensity. 31st Conf. on Hurr. And Trop. Met., March 30-April 4, San Diego, CA

Slocum, C. J. and W. H. Schubert, 2014: Tropical cyclone boundary layer shocks and shock-like structures. 31st Conf. on Hurr. And Trop. Met., March 30-April 4, San Diego, CA

Presentations - Competitive Projects

CoCoRaHS: Capitalizing on Technological Advancements to Expand Environmental Literacy Through a Successful Citizen Science Network (NA10SEC0080012)

Poster: Henry Reges, CoCoRaHS/Colorado State Univ., Fort Collins, CO; and N. Newman, N. Doesken, Z. Schwalbe, and J. Turner, 2013: "Why people are participating in citizen science . . . a CoCoRaHS fifteen year perspective from our volunteer rainfall network". Ninth Symposium on Policy and Socio-Economic Research, Atlanta, GA, February 2014.

Poster: Benjamin L. Ruddell, Arizona State University, Mesa, AZ; and N. J. Doesken, H. Reges, N. Selover, N. Chhetri, M. Roy, and S. Jordan, 2014. "Temperature, Citizen Science, and CoCoRaHS (T)". Ninth Symposium on Policy and Socio-Economic Research, Atlanta, GA, February 2014.

Poster: Kelly Helm Smith, National Drought Mitigation Center, Lincoln, NE; and M. D. Svoboda, H. Reges, D. Gutzmer, Q. Guan, C. C. Poulsen, R. Li, S. Owen, and M. J. Hayes, 2014. "The Drought Impact Reporter as a Framework for Citizen Science". Ninth Symposium on Policy and Socio-Economic Research, Atlanta, GA, February 2014.

Poster: NIDIS Engaging Preparedness Communities Drought Webinar - CoCoRaHS presentation — January 2014

NOAA Chesapeake WX Ready Conference, Silver Spring, MD - via Webinar - February 2014

Cooperative Extension Agriculture & Natural Resources Programs Webinar, Globe, AZ - February 2014

Webinar #26 - Thursday, January 16, 2014
The Hydrologic Cycle: How River Forecast Centers Measure the Parts
Greg Story
NOAA/NWS/West Gulf River Forecast Center, Fort Worth, TX

Webinar #27 - Thursday, February 20, 2014
Life as a climatologist – what the heck does a climatologist do?
Ryan Boyles, North Carolina State Climatologist, North Carolina Climate Center, Raleigh, NC

Webinar #28 - Thursday, March 27, 2014
Keeping an eye on the Blue Marble: How NASA studies Earth's weather, climate and hydrology from space.
Dalia Kirschbaum, Physical Scientist, NASA/Goddard Space Flight Center, Greenbelt, MD

Webinar #29 - Thursday, April 17, 2014
Air Quality: Local, Regional, and Global Perspectives
Sonia Kreidenweis, Colorado State University, Fort Collins, CO

Webinar #30 - Friday, May 2, 2014
Aviation Meteorology: "All you ever wanted to know . . . topics from what causes clear air turbulence to how airports' traffic flow is impacted by weather."
Mike Bardou, Lead Forecaster/Aviation Program Leader, National Weather Service Chicago/Romeoville, Romeoville, IL
Robb Kaczmarek, National Weather Service Aviation Meteorologist, NOAA/NWS/Chicago Air Route Traffic Control Center, Aurora, IL

Webinar #31 - Thursday, June 19, 2014
Waterspouts: The Wet-Whirlwind Cousin to the Tornado
Dr. Joseph H. Golden, Golden Research & Consulting, Boulder, CO

Webinar #32 - Thursday, July 24, 2014
Space Weather: What is it and why should you care?
Dr. Rodney Viereck, Director, Space Weather Prediction Testbed, NOAA/Space Weather Prediction Center, Boulder, CO

Webinar #33 - Thursday, August 14, 2014
Weather CSI - Forensic Meteorology
Pam Knox, CCM, Agricultural Climatologist, Crop and Soil Sciences Department,
College of Agricultural and Environmental Sciences University of Georgia, Athens, GA

Webinar #34 - Thursday, September 11, 2014 "A day in the life of a NWS Forecast Office"
John Gordon, National Weather Service Forecast Office, Louisville, KY

Guidance on Intensity Guidance (NA13OAR4590187)

Bhatia, K. T., D. S. Nolan, and A. B. Schumacher, 2015: Guidance on Intensity Guidance. Tropical Cyclone Research Forum / 69th Interdepartmental Hurricane Conference, 2-5 March 2015, Jacksonville, FL.

Upgrades to the Operational Monte Carlo Wind Speed Probability Program (NA13OAR4590190)

Schumacher, A.B., 2015: Upgrades to the Operational Monte Carlo Wind Speed Probability Program, Tropical Cyclone Research Forum / 69th Interdepartmental Hurricane Conference, 2-5 March 2015, Jacksonville, FL

Presentations - Competitive Projects – Sandy Supplemental

CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates (NA14NWS4830056)

Schumacher, A.B., 2015: Upgrades to the Operational Monte Carlo Wind Speed Probability Program, Tropical Cyclone Research Forum / 69th Interdepartmental Hurricane Conference, 2-5 March 2015, Jacksonville, FL.

CIRA EMPLOYEE MATRIX

CIRA Personnel							
Category	**Number**	**None**	**B.S.**	**M.S.**	**PhD.**		
Research Scientist	24				24		
Visiting Scientist	5				5		
Postdoctoral Fellow	3				3		
Research Support Staff	68	3	28	31	6		
Administrative	3		2	1			
Total (≥ 50% support)	103						
Undergraduate Students	1						
Graduate Students	13		7	6			
Employees that receive < 50% NOAA Funding (not including students)	67	13	18	19	17		
		GSD	**MDL**	**PSD**	**GMD**	**NGDC**	**AWC**
Located at Lab (name of lab)	69	50	3	2	2	0	12
Obtained NOAA employment with the last year	0						

Other Agency Awards 2014/15
(Sorted by Awarding Agency)

PI	Title	Lead NOAA Collaborator	Awarding Agency	Total Funding Amount
Baker	A Global High-resolution Fossil Fuel CO_2 Inventory Built from Assimilation of in situ and Remotely-sensed Datasets to Advance Satellite Greenhouse Gas	No	Arizona State (NASA)	$37,268
Lu	Downscaling NCEP Global Climate Forecast System (CFS) Seasonal Predictions for Hydrologic Applications Using Regional Atmospheric Modeling System (RAMS)	(NOAA-funded CPPA Program)	CU/CIRES	$116,644
Vonder Haar	Five Year Cooperative Agreement for Center for Geosciences/ Atmospheric Research	No	Department of Defense	$2,363,000
Miller	Advanced Algorithm Development for Next-Generation Satellite Systems	No	Department of Defense NRL	$322,630
Wang	Estimation of Initial and Forecast Error Variances for the NCEP's Operational Short-Range Ensemble Forecast (SREF) System	No	DTC Visitor Program	$391,996
Hand	Air Quality & Climate Change Interpretive Kiosk Project	No	FWS	$607,800
Liston	Snow Datasets for Arctic Terrestrial Applications	No	FWS	$125,000
Jones	Agricultural RE-Analysis of Precipitation Data	No	Global Dev. Analytics (BMGF prime)	$98,253
Miller	CIRA Data Processing Center Support for the CloudSat Mission	No	JPL	$90,348
Baker	A Global High-resolution Atmospheric Data Assimilation System for Carbon Flux Monitoring and Verification	No	NASA	$88,702

McClure	Enabling the Use of NASA and NAAPS Products in the Air Quality Decision-making Processes Involved in Daily Forecasting, Exceptional Event Analysis, and Development of Standards	No	NASA	$65,985
Zupanski	Ensemble-based Assimilation and Downscaling of the GPM Satellite Precipitation Information: Further Development and Improvements of WRF-EDAS	No	NASA	$91,989
Baker	Fine Resolution CO_2 Flux Estimates from AIRS and GOSAT CO_2 Retrievals: Data Validation and Assimilation	No	NASA	$194,778
Baker	GOES-CARB: A Framework for Monitoring Carbon Concentrations and Fluxes	No	NASA (via Pawson)	$220,000
O'Dell	North American Regional-scale Flux Estimation and Observing System Design for the NASA Carbon Monitoring System	No	NASA	$25,000
Liston	Snow on Sea Ice: Data Fusion Using Remote Sensing and Modeling	No	NASA	$617,277
Schranz	Wildland Fire Behavior and Risk Forecasting	No	NASA	$163,022
Miller	Satellite Techniques for Improving the Accuracy of Solar Forecasting	No	NCAR (DoE)	$80,348
Hand	Assistance for Instrument Development to Measure the Relationship of Air Quality with Night Sky Visibility	No	NPS	$160,872
Hand	Assistance for Visibility Data Analysis and Image Display Techniques	No	NPS	$814,101
Hand	Assistance for Visibility Data Analysis and Image Display Techniques	No	NPS	$972,903
Hand	Engaging and Training Citizens in Stewardship of Night Skies	No	NPS	$84,755
Hand	Web-based Environmental Database Supporting Air Resource Management in National Park and Forest Service Lands	No	NPS	$90,000

McClure	Data Warehouse for Air Quality Modeling in the Oil and Gas Regions of Wyoming, Utah, and Colorado	No	NPS	$215,850
Fletcher/ Jones	Analyzing the Impacts of Non-Gaussian Errors in Gaussian Data Assimilation Systems	No	NSF	$191,390
Liston, Hiemstra	Collaborative Research: AON A Snow Observing Network to Detect Arctic Climate Change-Snow Net II	No	NSF	$409,463
Lu	Collaborative Research: Sensitivity of Regional Climate Due to Land-cover Changes in the Eastern U.S. Since 1650	No	NSF	$390,639
Schranz, MacDermaid	EAGER: Collaborative Research: Interoperability Testbed-Assessing a Layered Architecture for Integration of Existing Capabilities	No	NSF	$17,972
Zupanski, Zupanski	Ensemble Data Assimilation for Nonlinear and Nondifferentiable Problems in Geosciences	No	NSF	$399,056
Schuh, Ogle	Quantification of the Regional Impact of Terrestrial Processes on the Carbon Cycle Using Atmospheric Inversions	No	Penn State (NASA)	$26,227
Liston	Blending Fine-scale Terrestrial Snow Information with Coarse-scale Remote Sensing Data Using Inferential and Modeling Methods	No	UAF	$421,319
Zhang	Impact Assessment of Cloud-affected AMSU-A Radiance Assimilation in TC Inner-core Region Using Hybrid Data Assimilation Approaches	No	UCAR/ NCAR	$11,502
Connell	Tasks Related to Technical Support of the WMO-GGMS Virtual Lab for Education and Training	No	WMO	$38,462
Kummerow	A Collaborative Effort to Improve Geostationary Products of Hydrologic Variables	No	Yonsei University	$28,087

CIRA AWARDS & RECOGNITION

NOAA Bronze Medal (2015) Awarded to the Science on a Sphere Team

The NOAA Bronze Medal is the most prestigious award that the Under Secretary of Commerce for Oceans and Atmosphere may present to federal employees. In keeping with the spirit of the NOAA-University Cooperative Institute Program, a group comprised of both NOAA and CIRA scientists was selected to receive this high honor. Although technically ineligible for a Bronze Medal owing to their non-federal status, CIRA would like to formally recognize the efforts of **Mike Biere, Jebb Stewart** and **Steve Albers** for their participation in the winning Science On a Sphere (SOS®) Team. The impressive achievements of the SOS® team would not have been possible had it not been for their tireless efforts in collaboration with their NOAA colleagues.

The group was cited for achieving the 100th worldwide SOS® installation thereby continuing to grow the reach of NOAA science to a worldwide audience. In fact, last year over 33 million visitors saw the SOS® system in 15 countries and 28 states and the network continues to grow with 3 new distributorships, 12 new installations and 3 temporary exhibits last year. At the same time, the SOS® team also managed to develop 75 new data sets to bring the current total to over 450 data sets! Such a vast library greatly enriches the potential programming for SOS® users. Indeed, the spherical display is now found in 106 locations worldwide.

In short, thanks to the efforts of our 3 CIRA staff and their NOAA partners, the accomplishment of over 100 SOS® installs and 33 million annual viewers exceeds by orders of magnitude any anticipated requirements. This impressive milestone is the product of the entire team's will, determination and focus while never losing sight of the quality and excellence for which SOS® is known.

CIRA Exceptional Service Award

Dale Reinke, a Research Associate III at CIRA and a member of the CloudSat Data Processing Center team, was recently nominated by his federal colleagues for going above and beyond expected duties in support of a key operational processing transition. Dale is responsible for the ingest of all CloudSat spacecraft and instrument data at the DPC and the algorithms that convert them to data products. In anticipation of a move from one system to another, Dale developed a shadow structure to provide verification and validation capabilities for new the CloudSat Multi-Mission Satellite Operations Center (MMSOC). This effort was developed under the existing scope of work and was solely the product of Dale's incredible ingenuity. Dale's vision was the key to the success in transitioning to the new ground system at Kirtland, delighting the otherwise apprehensive transition team. As a result of his resourceful efforts, Dale was lauded by JPL and awarded a CIRA Exceptional Service Award in December.

GSD Posters of the Month: January, February 2015

CIRA staff members are on a roll winning two consecutive months in the GSD Poster of the Month award! Congratulations to January winner **Hongli Jiang** for her AMS poster entitled, "Case Studies of Severe Storms during HWT 2013 Using Variational LAPS." The February winner was **Missy Petty** for her poster entitled "Use of the Flow Constraint Index: Combining Weather and Traffic Information to Identify Constraint." Each of the winning posters is displayed for the month outside of the GSD Director's Office.

CIRA Research Initiative Award Winner Announced

Dan Vietor was recognized with the 2014 CIRA Research Initiative Award. Dan is a Senior Research Meteorologist who has been working tirelessly as part of the CIRA-NOAA partnership to modernize the NOAA/NWS Aviation Weather Center website. The AWC's mission has been focused on the use of web services to deliver operational interactive decision support services. This necessitated addressing many backend functionalities including an easy-to-maintain data back-end leveraging ADDS (Aviation Digital Data Service), formatting the data for efficient and reliable delivery to the browser, better support for domestic and especially international customers, better support for mobile devices, the application of modern Open Geospatial Consortium standards, and the upgrade of the Aviation Weather website to incorporate these new tools. Dan's work culminated in the debut of the new website at last year's Oshkosh air show. There Dan and his team were able to collect immediate user feedback on many of the changes they'd deployed. The opinions were strongly positive and the user feedback was incorporated into the website for its operational release.

GSD's Team Member of the Month for March 2014

The NOAA Assimilation and Modeling Branch nominated CIRA Research Scientist **Dr. Haidao Lin** as GSD's Team Member of the Month in March 2014. The nomination included the following highlights: "Since joining AMB in late 2010, Haidao has become a vital contributor to the Rapid Refresh (RAP) development team, an expert on satellite data assimilation, and a highly visible member of the national satellite data assimilation community. His work in developing and improving mesoscale satellite radiance assimilation methods for the Rapid Refresh has enabled noticeable forecast improvement from these data within the hourly updated RAP model. These type of improvements are difficult to achieve within limited-area models and have occurred because of Dr. Lin's diligent work in optimizing the radiance bias correction and channel selection algorithms within the community-based Gridpoint Statistical Interpolation (GSI) analysis package used for the RAP. Dr. Lin's work has involved coordination and collaboration with the operational satellite data assimilation community, and developing this collaboration with key member groups, including NCEP's Environmental Modeling Center, has significantly enhanced GSD's ability to participate in community-based satellite assimilation efforts for both regional and global modeling. Dr. Lin is a very talented and hard-working and a great team member.

Two CIRA Fellows Named University Distinguished Professors (UDP)

The title of UDP is restricted to approximately 1% of the CSU faculty and is granted in recognition of outstanding scholarship and achievement. This rare honor was just awarded to two of CIRA's own Fellows. We proudly salute **Dr. Sonia Kreidenweis-Dandy** and **Dr. V. "Chandra" Chandrasekar** for their initiation into this illustrious group. Dr. Kreidenweis-Dandy was recognized for her outstanding research involving atmospheric aerosols and their impacts on cloud formation, haze, and climate. Sonia is the 4th member of the ATS faculty to be designated as UDP, following Tom Vonder Haar, Graeme Stephens, and Dave Randall. Dr. V. "Chandra" Chandrasekar from the Department of Electrical and Computer Engineering was recognized for his pioneering contributions in the area of polarimetric radar observations of the atmosphere and urban observation networks.

STAR Scientist and CIRA Associate, Dr. Don Hillger Honored with Dept. of Commerce 2014 Bronze Medal

On Thursday, January 23, 2014 NOAA Acting Under Secretary Dr. Kathy Sullivan announced the 2014 Bronze Medal and Distinguished Career awards. The Department of Commerce Bronze Medal is the highest honor award that the Under Secretary of Commerce for Oceans and Atmosphere may bestow. 18 STAR scientists were honored with Bronze Medals including long-time CIRA Associate, **Dr. Don Hillger**. Don was recognized for his work as part of the Suomni NPP Environmental Data Product team. The Team was cited for their efforts to increase the scientific value of the Suomi satellite environmental data products to meet NOAA users' needs. The award recipients were honored at a ceremony on May 20, 2014.

CIRA Recipients of the First Annual NOAA/NESDIS/STAR Awards

CIRA scientists were well represented on the winners list in the first annual NOAA/NESDIS/STAR awards. The announcements came in late May and were in categories such as Science, Technology, and Best Paper. Please read below for the list of winners.

Wei Shi: NOAA/NESDIS/STAR Award for Science.
Dr. Shi was recognized for scientific excellence in the demonstration of innovative methods leading to significantly improving satellite ocean color products in coastal and inland waters. He was further commended for his significant contribution in the development and demonstration of an innovative approach using shortwave infrared (SWIR) bands on NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor. His work has helped improve the satellite-derived ocean color products in the coastal ocean regions and he has conducted several studies to further improve the SWIR algorithm. From 2009 to present, Dr. Shi has authored and co-authored 23 peer-reviewed publications.

Xingming Liang: Member of the SST Team selected for NOAA/NESDIS/STAR Award for Technology.
As a member of the SST Team along with Yury Kihai (GST), John Stroup (GST), and Boris Petrenko (GST), Dr. Liang was cited for contributions to the development of the Advanced Clear-Sky Processor for Ocean (ACSPO) System. The ACSPO line of SST products has been extensively evaluated and compared with similar community products produced by the EUMETSAT, Navy and NASA. In all cases, the ACSPO retrieval domain was found to be larger, and SST performance statistics superior, than for the alternate products. The ACSPO POES and JPSS, and future GOES-R SST operational products are widely used by many customers by the scientific community, commercial and sport fishing industries, environmental decision-makers, shipping industry, fisheries managers, educators, weather and climate forecasters, at NOAA (e.g., Coral Reef Watch, POES/GOES blended SST, NCEP, Coast Watch/NOS) and elsewhere.

Steven Miller: NOAA/NESDIS/STAR Award- Best Paper.
Dr. Miller was recognized along with his colleagues Stephen Mills (NGAS), Christopher Elvidge NGDC, Thomas Lee (NRL), Jeffrey Hawkins (NRL), and Dan Lindsey (CoRP) for their influential paper describing new capabilities to image cloud and surface features by way of reflected airglow, starlight, and zodiacal light illumination. The Suomi satellite brings to light a unique frontier of nighttime environmental sensing capabilities. In a comprehensive publication printed in September 2012, it is thoroughly described how the Suomi-NPP Day-Night-Band scan see clouds at night even without a moon, using airglow, starlight, and zodiacal light illuminations.

GSD Scientific Poster of the Month Winners

Jebb Stewart, **Chris MacDermaid**, **Randy Pierce**, and **Jeff Smith** along with colleagues Julien Lynge and Eric Hackathorn were selected for the GSD Scientific Poster of the Month Award in May 2014. Their poster was titled, "NOAA Earth Information System." The poster with identifying banner was displayed on the bulletin board in the GSD Director's Office hallway and an electronic copy was posted on the GSD Intranet where it remains for folks to view at their leisure.

Former CIRA Director and University Distinguished Professor Emeritus Graeme Stephens Elected to the National Academy of Engineering

On February 5, 2015 the National Academy of Engineering elected 67 new members and 12 foreign members. CIRA former Director and CIRA Fellow **Prof. Graeme Stephens** was one of those honored. Election to the NAE is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to “engineering research, practice or education”.

CSU College of Engineering Awards

Director, **Chris Kummerow**, and Assistant to the Director, **Joanne DiVico**, were each recognized with major College of Engineering awards at the All College Meeting on December 2nd. Dean McLean presented Chris with the Abell Outstanding Faculty Research Award and Joanne with the Outstanding Classified Employee Award.

The Abell Award is presented each year in recognition of high-quality, nationally-acclaimed research productivity with a particular focus on the preceding 5 years’ of work; and Chris and his research fit this description impeccably. Chris has been extremely busy with his research since coming to the Atmospheric Science Department in June 2000.

The Outstanding Classified Award is also presented each year and is bestowed upon a State Classified Employee who exemplifies dedication and commitment to the college, the university, and fellow department employees, students and staff. The recipient is one who strives for excellence in every aspect of their work.

Kudos to the following CIRA staff who earned service milestones in 2014

Linn Barrett – 15 years
Dan Bikos – 15 years
Kevin Brundage – 20 years
Leigh Cheatwood-Harris – 10 years
Scott Copeland – 20 years
Paul Hamer – 15 years
John Haynes – 10 years
Patrick Hildreth – 10 years
Jeff Lemke – 20 years
Mary McInnis-Efaw – 15 years
Kate Musgrave – 10 years
Evan Polster – 15 years
Dale Reinke – 25 years
Daniel Schaffer – 15 years
Andrew Schuh – 10 years
Jebb Stewart – 10 years
Dave Watson – 25 years
Loretta Wilson – 30 years
Tong Zhu – 10 years

NOAA PROJECTS BY TITLE

NOAA Competitive Projects

Competitive Projects – Sandy Supplemental

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
A Collaborative Effort to Improve Geostationary Products of Hydrologic Variables	Yonsei Univ	Kummerow	x						
A Global High-resolution Atmospheric Data Assimilation System for Carbon Flux Monitoring and Verification	NASA	Baker			x				
A Global High-resolution Fossil Fuel CO_2 Inventory Built From Assimilation of in situ and Remotely-sensed Datasets to Advance Satellite Greenhouse Gas	AZ State/ NASA	Baker		x		x			
Advanced Algorithm Development for Next-Generation Satellite Systems	DoD Navy (NRL)	Miller	x						
Agricultural Re-Analysis of Precipitation Data	Global Dev. Analytics	Jones	x				x		
Air Quality & Climate Change Interpretive Kiosk Project	FWS	Hand					x		
Algorithm Development for AMSR-2	NOAA	Kummerow	x						
Analyzing the Impacts of Non-Gaussian Errors in Gaussian Data Assimilation Systems	NSF	Fletcher			x				
Applications of Concurrent Super Rapid Sampling from GOES-14 SRSOR, Radar and Lightning Data	NOAA/ NESDIS	Schranz, Albers	x						

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Assistance for Instrument Development to Measure the Relationship of Air Quality with Night Sky Visibility	NPS	Hand			x				
Assistance for Visibility Data Analysis and Image Display Techniques	NPS	Hand		x			x		
Blending Fine-scale Terrestrial Snow Information with Coarse-scale Remote Sensing Data Using Inferential and Modeling Methods	UAF	Liston		x					
Building a "Citizen Science" Soil Moisture Monitoring System Utilizing the CoCoRaHA Network	NOAA/ OAR	Doesken				x			
CIRA Assimilation of Moisture and Precipitation Observations in Cloudy Regions of Hurricane Inner Core Environments to Improve Hurricane Intensity, Structure and Precipitation (Sandy Competitive)	NOAA/ Sandy	Kummerow, Zupanski			x				
CIRA Data Processing Center Support for the CloudSat Mission	JPL	Miller					x		
CIRA - Distance Learning Materials on Blended Numerical Guidance Products (Sandy Competitive)	NOAA/ Sandy	Kummerow, Connell	x						
CIRA-Distance Learning Materials on Tropical Storm Forecasting and Threats (Sandy Competitive)	NOAA/ Sandy	Kummerow, Connell	x						
CIRA Research Collaborations with the NWS Meteorological Development Lab on Virtual Laboratory, Innovation Web Portal, Impacts Catalog and AWIPS II Projects	NOAA/ OAR	Schranz					x		
CIRA Support for Feature-based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting	NOAA	Dostalek	x						

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
CIRA Support for Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting	NOAA/ NESDIS	Miller	x						
CIRA Support for the JPSS Proving Ground and Risk Reduction Program: Application of JPSS Impagers and Sounders to Tropical Cyclone Track and Intensity Forecasting	NOAA/ NESDIS	Chirokova	x						
CIRA Support: Getting Ready for NOAA's Advanced Remote Sensing Programs A Satellite Hydro-Meteorology (SHyMet) Education and Outreach Proposal	NOAA/ NESDIS	Connell, Bikos	x						
CIRA Support of NOAA's Commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory	NOAA	Connell	x						x
CIRA Support of the Virtual Institute for Satellite Integration Training (VISIT)	NOAA	Bikos, Connell	x						
CIRA Support to GOES-R Proving Ground for National Weather Service Forecaster Readiness	NOAA	Miller, Brummer, Szoke	x						
CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates (Sandy Competitive)	NOAA/ Sandy	Schumacher	x				x		
CIRA Support to RAMMB Infrastructure for GOES-R Rebroadcast Data Collection at CIRA/CSU	NOAA/ NESDIS	Brummer, Hiatt	x						
CIRA Support to the JPSS Proving Ground and Risk Reduction Program: "Seeing the Light": Exploiting VIIRS Day/Night Band Low Light Visible Measurements in the Arctic and Advancing Nighttime VIIRS Cloud Products with the Day/Night Band	NOAA/ NESDIS	Miller	x						

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
CIRA Support to the JPSS Science Program: NPP VIIRS EDR Imagery Algorithm and Validation Activities and S-NPP VIIRS Cloud Validation	NOAA	Miller				x			
CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy Through a Successful Citizen Science Network *(Competitive)*	NOAA	Doesken				x			x
Collaborative Research - AON: A Snow Observing Network to Detect Arctic Climate Change - SnowNet II	NSF	Liston, Hiemstra				x			
Collaborative Research: Sensitivity of Regional Climate Due to Land-Cover Changes in the Eastern U.S. Since 1650	NSF	Lu				x			
Data Warehouse for Air Quality Modeling in the Oil and Gas Region of Wyoming, Utah, and Colorado	NPS	McClure			x		x		
Development of a Probabilistic Tropical Cyclone Prediction Scheme *(Competitive)*	NOAA	Schumacher	x						
Development of a Real-Time Automated Tropical Cyclone Surface Wind Analysis *(Competitive)*	NOAA	Brummer				x			
DoD Center for Geosciences/Atmospheric Research at CSU	DoD	Vonder Haar	x		x	x	x		

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Downscaling NCEP Global Climate Forecast System (CFS) Seasonal Predictions for Hydrologic Applications Using Regional Atmospheric Modeling System (RAMS) (CU/CIRES)	CU/ CIRES	Lu		x	x	x			
EAGER: Collaborative Research: Interoperability Testbed-Assessing a Layered Architecture for Integration of Existing Capabilities	NSF	Schranz, MacDermaid					x		
Enabling the Use of NASA and NAAPS Products in the Air Quality Decision-making Processes Involved in Daily Forecasting, Exceptional Event Analysis, and Development of Standards	NASA	McClure			x		x		
Engaging and Training Citizens in Stewardship of Night Skies	NPS	Hand							x
Ensemble-based Assimilation and Downscaling of the GPM-like Satellite Precipitation Information: Further Development and Improvements of WRF-EDAS	NASA	Zupanski, D.			x				
Ensemble Data Assimilation for Nonlinear and Nondifferentiable Problems in Geosciences	NSF	Zupanski, Zupanski			x				
Environmental Applications Research	NOAA	Schranz		x	x	x	x		x
ESRL/GSD Participation in the Establishment of a NOAA Lab Activity for OSSEs (Sandy Competitive)	NOAA/ Sandy	Schranz, Wang			x				

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Estimating Peatland Fire Emissions Using Nighttime Satellite Data	NOAA/ NGDC	Oda	x						
Estimation of Initial and Forecast Error Variances for the NCEP's Operational Short-Range Ensemble Forecast (SREF) System	DTC Visitor	Wang, H-L.			x				
Evaluation of Earth Networks Total Lightning Products for NWS Warning Services in the Hazardous Weather Testbed (Sandy Competitive)	NOAA/ Sandy	Schranz					x		
Explicit Forecasts of Recurrence Intervals for Rainfall: Evaluation and Implementation Using Convection-allowing Models	NOAA (USWRP Prime)	Schumacher, R., Lindsey				x			
Fine-resolution CO_2 Flux Estimates from AIRS and GOSAT CO_2 Retrievals: Data Validation and Assimilation	NASA	Baker	x	x	x				
Following Emissions from Non-traditional Oil and Gas Development Through Their Impact on Tropospheric Ozone *(Competitive)*	NOAA/ OAR	Farmer, Fischer				x			
GOES-CARB: A Framework for Monitoring Carbon Concentrations and Fluxes	NASA	Baker		x					
Guidance on Intensity Guidance *(Competitive)*	NOAA/ JHT	Schumacher		x					
Hydrological Research and Water Resources Applications Outreach Coordination	NOAA/ OAR	Schranz (Lynn Johnson)				x			

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Impact Assessment and Data Assimilation of NOAA NPP/JPSS Sounding Products and Quality Control Parameters	NOAA/ NESDIS	Fletcher			x				
Impact Assessment of Cloud-affected AMSU-A Radiance Assimilation in TC Inner-core Region Using Hybrid Data Assimilation Approaches	UCAR/ NCAR	Zhang			x				
Improving CarbonTracker Flux Estimates for North America Using Carbonyl Sulfide (OCS) *(Competitive)*	NOAA	Baker, Ian		x					
Incorporating the GOES-R Geostationary Lightning Mapper Assimilation into the GSI for Use in the NCEP Global System (Sandy Competitive)	NOAA/ Sandy	Zupanski, Apodaca			x				
Instructional Development and Learning Support for NOAA's OMAO's Chief Learning Officer (CLO), OMAO Kansas City, Missouri	NOAA/ OAR	Schranz							x
Integrating GPM and Orographic Lifting into NOAA's QPE in Mountainous Terrain	NOAA/ OAR	Szoke	x						
Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models *(Competitive)*	NOAA	Maloney				x			
MADIS Transition to NWS Operations (Sandy Competitive)	NOAA/ Sandy	Schranz, Kent			x				
NEAT Expanded	NOAA	Matsumoto	x						
NEAT: NESDIS Environmental Applications Team	NOAA	Matsumoto	x	x		x			

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
NOAA’s High Impact Weather Prediction Project (HIWPP) Test Program—Ensemble Statistical Post-Processing (Sandy Competitive)	NOAA/ Sandy	Schranz, Jankov		x					
NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Fine-Grain Computing (Sandy Competitive)	NOAA/ Sandy	Schranz					x		
NOAA’s High Impact Weather Prediction Project (HIWPP) Test Program—Real-Time IT Operations (Sandy Competitive)	NOAA/ Sandy	Schranz		x					
NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Visualization and Extraction via NEIS (Sandy Competitive)	NOAA/ Sandy	Schranz					x		
NOAA’s Observing System Experiments and Observing System Simulation Experiments in support of the “Sensing Hazards with Operational Unmanned Technology” (SHOUT) Program - Development and Testing of Sampling Strategies for Unmanned Aerial Systems (Sandy Competitive)	NOAA/ Sandy	Schranz, Wang			x				
North American Regional-scale Flux Estimation and Observing System Design for the NASA Carbon Monitoring System	NASA	O'Dell			x				
Observational Constraints on the Mechanisms that Control Size- and Chemistry-resolved Aerosol Fluxes Over a Colorado Forest *(Competitive)*	NOAA	Farmer				x			
Polar-Geo Blended Hydrometeorological Products	NOAA	Kidder, Jones	x		x	x	x		
Quantification of the Regional Impact of Terrestrial Processes on the Carbon Cycle Using Atmospheric Inversions	Penn State	Schuh, Ogle				x			

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Research Collaboration at the NWS Aviation Weather Center in Support of the Aviation Weather Testbed, Aviation Weather Research Program, and the NextGen Weather Program	NOAA	Schranz		x	x		x		
Research to Advance Climate and Earth System Models Collaborative Research: A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models *(Competitive)*	NOAA	Randall		x		x			
Satellite Techniques for Improving the Accuracy of Solar Forecasting	NCAR (DoE)	Miller	x						
Sensing Hazards with Operational Unmanned Technology (SHOUT) - Data Management and Visualization (Sandy Competitive)	NOAA/ Sandy	Schranz, Stewart					x		
Snow Datasets for Arctic Terrestrial Applications	FWS	Liston		x					
Snow on Sea Ice: Data Fusion Using Remote Sensing and Modeling	NASA	Liston				x			
SSMI and SSMIS Fundamental Climate Data Record Sustainment and Maintenance	NOAA	Kummerow, Berg, Alvarez					x		
Tasks Related to Technical Support of the WMO-GGMS Virtual Lab for Education and Training	WMO	Connell	x						
Towards Assimilation of Satellite, Aircraft, and Other Upper-air CO_2 Data into CarbonTracker *(Competitive)*	NOAA	Baker, D.			x				

2014-2015 NOAA and Other Funding Project Theme Maxtrix

TITLE	Agency	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Tropical Cyclone Model Diagnostics and Product Development	NOAA/ NESDIS	Schubert, Musgrave	x	x					
Upgrades to the Operational Monte Carlo Wind Speed Probability *(Competitive)*	NOAA/ JHT	Schumacher		x					
Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation *(Competitive)*	NOAA	Maloney				x			
Weather Satellite Data and Analysis Equipment and Support for Research Activities	NOAA	Kummerow, Hiatt					x		
Web-based Environmental Database Supporting Air Resource Management in National Park and Forest Service Lands	NPS	Hand			x		x		
Wildland Fire Behavior and Risk Forecasting	NASA	Schranz	x	x			x		

COMPETITIVE PROJECTS

1--CoCoRaHS: Capitalizing on Technological Advancements to Expand Environmental Literacy Through a Successful Citizen Science Network (NA10SEC0080012)

2--Development of a Probabilistic Tropical Cyclone Prediction Scheme (NA11OAR4310208)

3--Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis (NA11OAR4310204)

4--Following Emissions from Non-traditional Oil and Gas Development Through Their Impact on Tropospheric Ozone (NA14OAR4310148)

5--Guidance on Intensity Guidance (NA13OAR4590187)

6—Improving CarbonTracker Flux Estimates for North America Using Carbonyl Sulfide (OCS) (NA13OAR4310080)

7--Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models (NA12OAR4310077)

8--Observational Constraints on the Mechanisms that Control Size- and Chemistry-resolved Aerosol Fluxes Over a Colorado Forest (NA14OAR4310141)

9—Research to Advance Climate and Earth System Models Collaborative Research: A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models (NA13OAR4310103)

10—Towards Assimilation of Satellite, Aircraft, and Other Upper-air CO_2 Data into CarbonTracker (NA13OAR4310077)

11--Upgrades to the Operational Monte Carlo Wind Speed Probability Program (NA13OAR4590190)

12—Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation (NA13OAR4310163)

<u>Sandy Supplemental Competitive Projects</u>

S1--CIRA Assimilation of Moisture and Precipitation Observations in Cloudy Regions of Hurricane Inner Core Environments to Improve Hurricane Intensity, Structure and Precipitation (NA14OAR4830122)

S2--CIRA - Distance Learning Materials on Blended Numerical Guidance Products (NA14NWS4830020)

S3--CIRA - Distance Learning Materials on Tropical Storm Forecasting and Threats (NA14NWS4830018

S4--CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates (NA14NWS4830056)

S5--ESRL/GSD Participation in the Establishment of a NOAA Lab Activity for OSSEs (NA14OAR4830110)

S6--Evaluation of Earth Networks Total Lightning Products for NWS Warning Services in the Hazardous Weather Testbed (NA14OAR4830114)

S7--Incorporating the GOES-R Geostationary Lightning Mapper Assimilation into the GSI for Use in the NCEP Global System (NA14NWS4830034)

S8--MADIS Transition to NWS Operations (NA14NWS4830009)

S9--NOAA’s High Impact Weather Prediction Project (HIWPP) Test Program—Ensemble Statistical Post-Processing (NA14OAR4830111)

S10--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Fine-Grain Computing (NA14OAR4830112)

S11--NOAA’s High Impact Weather Prediction Project (HIWPP) Test Program—Real-Time IT Operations (NA14OAR4830109)

S12--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Visualization and Extraction via NEIS (NA14OAR4830113)

S13--NOAA’s Observing System Experiments and Observing System Simulation Experiments in support of the SHOUT Program - Development and Testing of Sampling Strategies for Unmanned Aerial Systems (NA14OAR4830167)

S14--Sensing Hazards with Operational Unmanned Technology (SHOUT) - Data Management and Visualization (NA14OAR4830166)

COMPETITIVE PROJECT TITLE: CoCoRaHS: Capitalizing on Technological Advancements to Expand Environmental Literacy Through a Successful Citizen Science Network (NA10SEC0080012)

The following is the most recent report previously submitted to the Technical Sponsor.

NOAA Office of Education

Semi-Annual Project Progress Report

The following is a summary of the information that your semi-annual progress reports to NOAA's Office of Education should contain. Please contact your program officer (oed.grants@noaa.gov) if you have any questions.

- **OVERVIEW**
  - Award Number: NA10SEC0080012
  - Award Title: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful citizen Science Network
  - Funded Institution: Colorado State University
    - Congressional District of Funded Institution: Colorado 2nd District
    - Total Annual Visitorship to Funded Institution (if applicable): _____NA_______visitors/year
    - Annual Visitorship to NOAA-funded Exhibit (if known): ____NA_______visitors/year
  - PI Name: Nolan Doesken

    Phone: 970-491-3690 or 970-491-8545

    Email: Nolan@atmos.colostate.edu
  - Project Website (if applicable): http://www.cocorahs.org
  - Award Period: From 10/1/2010 To 9/30/2013
  - Period Covered by this Report: From 4/1/2014 To 9/30/2014

- **PROGRESS**

  - Please provide a narrative description of activities undertaken and accomplishments achieved during the period covered by this progress report.

This report summarizes accomplishments during the last half of year-one of this project's No Cost Extension. The CoCoRaHS Project continued full speed ahead during this period but with a focused emphasis on project evaluation. David Heil and Associates (DHA) completed a draft summative report at the end of this reporting period. After several iterations, two reports were submitted – one for the internal use of CoCoRaHS staff and one for our NOAA funders that can be shared and distributed as need be. We will go into more detail about this later in this report and will attach the DHA Summative Evaluation report for the NOAA Office of Education.

While we did not emphasize new partnerships, new products or much new national or local outreach during this period, we continued to enjoy high rates of volunteer participation with over 11,000 daily precipitation data reports per day for nearly the entire 6-month period and over 12,000 reports per day on at least 20 individual days. Over 17,000 volunteers submitted at least a few reports during this time period with continued high quality data useful for both operational and scientific applications. Social media continued to be a standard mode of communication with hundreds more Facebook friends registered despite no focused recruiting efforts. We also experience high usage of CoCoRaHS raw data and analyses, as awareness in CoCoRaHS as a source of reliable nationwide precipitation data continues to spread.

The CoCoRaHS WxTalk Webinar series continues with month after month of exceptional speakers and high quality presentations. CoCoRaHS animated instructional materials remain popular, but are also now mostly taken for granted, The new "Weather versus Climate" animation had several thousand views on YouTube. "The Water Cycle" animation remains the most popular education video from CoCoRaHS with over 275,000 hits so far and several hundred more every day.

Further description of our recent progress is presented in the following sections. Categories of activities are based on the "Citizen Science Toolkit" that provide a logical framework for tracking activities and accomplishments.

Refine Protocols

No efforts to refine protocols were undertaken during this period but a proposal was submitted to NOAA's National Integrated Drought Information System (NIDIS) to develop and test a protocol for manual measurements of soil moisture to help fill this important monitoring gap across the country. Work on refining this protocol will take place during the next 6 months.

Recruit Participants

The March Madness recruiting campaign, described in the last project report, had carryover effects into this reporting period with strong recruiting rates continuing in April and with steady new recruiting throughout the rest of the summer. We did not emphasize recruiting as much as in the past. Still a total of 2,345 new volunteers signed up during this 6-month period. Sixty-nine percent (1,618) of these new recruits have begun reporting precipitation data as of early October 2014. This is one of our highest engagement rates since the project began. But total number of active volunteers only grew slightly during the summer months. For reasons that we don't yet fully understand, we have seen higher attrition rates over the past year from some of our longer-term and older participants. To keep our total number of active data collectors steady, we currently have to add about 200 new volunteers to the network each month. To see appreciable growth, we now need to be adding approximately 400 new volunteers each month – a non-trivial effort.

CoCoRaHS Education Coordinator, Noah Newman, continued to work with the NASA/GPM partnership – focusing on an upcoming campaign to recruit new observers in the Salisbury/Pokonoke area of MD to drive to nearby NASA sites where tipping bucket and CoCoRaHS gauges are installed side-by-side for comparison and analysis with GPM satellite data. Noah also joined the locally formed group "Teen

Science Café” where professionals are invited to speak to interested teens in the area. He is not yet on the calendar to present, but is networking within this community in hopes of future recruiting.

We have begun work on a comprehensive assessment of “recruiting and retention” that we hope to publish during 2015. National Weather Service recruiting at the local field office level remains one of the single most effective recruiting methods, but increasingly word of mouth and social media (more so than traditional news media) account for a larger fraction of new recruits. Very active recruiting in parts of Canada helped increase our numbers.

Train Participants

We placed little emphasis on developing new or improving existing training materials during this period, but training new recruits is an ongoing function. Practical experiences measuring rain, hail and snow in combination with our feedback from our CoCoRaHS data quality control team continue to be an effective teaching method for new participants. A few state, regional and county volunteer coordinators do local face-to-face group and individual training sessions for new volunteers, but the vast majority of training is unmonitored and takes place utilizing our various on-line options. Based on the quality of data being provided by our volunteers, our informal approach to training seems to be working, especially during the summer months when frozen precipitation is limited.

Noah Newman, Education Coordinator, conducted 6 separate events concerning training participants (or potential participants) on how to read the precipitation gauge and report data to CoCoRaHS. Of these 6 events, some were specific school visits while other presentations were ‘family science day’ events. A total of 550 people were reached in this period through these events.

We continue to deliver training and education content by means of our “Message of the Day”, the monthly newsletter called “the Catch” and through our Wx Talk Webinar educational series.

Here is the list of webinars from the past 6 months – each featuring a nationally known expert on the topic. In several cases, the expert presenter is also a CoCoRaHS volunteer. This was a particularly diverse set of topics, but all drew good audiences. The one on “space weather” was best attended.

Webinar #29 - Thursday, April 17, 2014
Air Quality: Local, Regional, and Global Perspectives
Sonia Kreidenweis, Colorado State University, Fort Collins, CO

Webinar #30 - Friday, May 2, 2014
Aviation Meteorology: "All you ever wanted to know . . . topics from what causes clear air turbulence to how airports’ traffic flow is impacted by weather."
Mike Bardou, Lead Forecaster/Aviation Program Leader, National Weather Service Chicago/Romeoville, Romeoville, IL
Robb Kaczmarek, National Weather Service Aviation Meteorologist, NOAA/NWS/Chicago Air Route Traffic Control Center, Aurora, IL

Webinar #31 - Thursday, June 19, 2014
Waterspouts: The Wet-Whirlwind Cousin to the Tornado
Dr. Joseph H. Golden, Golden Research & Consulting, Boulder, CO

Webinar #32 - Thursday, July 24, 2014
Space Weather: What is it and why should you care?
Dr. Rodney Viereck, Director, Space Weather Prediction Testbed, NOAA/Space Weather Prediction Center, Boulder, CO

Webinar #33 - Thursday, August 14, 2014
Weather CSI - Forensic Meteorology
Pam Knox, CCM, Agricultural Climatologist, Crop and Soil Sciences Department,
College of Agricultural and Environmental Sciences University of Georgia, Athens, GA

Webinar #34 - Thursday, September 11, 2014

"A day in the life of a NWS Forecast Office"
John Gordon, National Weather Service Forecast Office, Louisville, KY

We have met our grant obligations regarding webinars, but we've come to really enjoy the process. Henry Reges heads up the effort and has lined up speakers for several more months. The content and delivery of each webinar continues to be exceptional. Attendance is lower than we wish considering the very high quality of each presentation, but people outside our program tell us that our webinar attendance (typically 100-200 with a comparable number of views of the archived YouTube versions) is excellent considering the length -- often at least 75 minutes including Q&A,

CoCoRaHS Education Coordinator, Noah Newman attended and presented at 10 different events, ranging from youth water festival presentations to classroom presentations as well as teacher professional development training sessions. An approximate total of 800 people were reached through these outreach and training events.

Our educational animation "The Water Cycle", which targets an important aspect of climate literacy, got another 75,000 views in the past 6 months. The next educational animation "Weather Versus Climate" was released at the end of March 2014 and has had good reviews and about 10,000 views so far. The success of CoCoRaHS animations has resulted in our animator being hired by several others involved in science education including the University Corporation for Atmospheric Research.

The role of our CoCoRaHS "Help Desk" and our data quality assurance team (composed now of Andrew Muniz in combination with dozens of our state and regional volunteer coordinators) in providing effecting participant training cannot be understated. Zach Schwalbe staffs the CoCoRaHS Help Desk and continues to personally and promptly answer on average about 50 questions a day – often from new volunteers, This personal attention has likely played a large role in training and long-term engagement of our participants.

Accept Data

The CoCoRaHS cyber-infrastructure was updated to add support for Puerto Rico. The system was also updated to support the Canadian provinces of Alberta and British Columbia. The planned upgrades to the CoCoRaHS cyber-infrastructure were presented and discussed at the annual WERA 1012 meeting where system requirements were revised based on stakeholder feedback.

During this recent 6-month period we have been receiving CoCoRaHS precipitation reports at a rate of close to 350,000 per month. Since inception, we've now gathered over 26 million daily precipitation reports and all are public and readily accessible. In addition to daily precipitation reports, CoCoRaHS also receives hail reports, significant weather reports, drought impact reports and evapotranspiration (ET) reports. We enjoyed modest growth in ET reports this year

A growing number of reports are now coming in via the CoCoRaHS iOS and Android apps. Use is modest in areas that CoCoRaHS is well established (less than 15% of all reports in most states). However, in Canada where CoCoRaHS is relative new, use of apps is higher. Interestingly, in Puerto Rico, the newest member of CoCoRaHS, the majority of observers are using the apps to enter their daily reports.

No other major changes were made but some small adjustments to the iOS and Android data entry apps were made based on user feedback.

We completed the process of training a replacement for Peter Goble for heading up the CoCoRaHS data quality team. Andrew Muniz, formerly a classmate of Peter's at the meteorology program at the University of Northern Colorado, is now performing this work. Data QC is an essential part of accepting data from citizen volunteers and cannot be fully automated at this time.

Analyze Data

Small incremental progress continues to be made in data analysis and visualization . Our efforts to implement a more powerful CoCoRaHS data mapping system continue to be stymied by slow performance of large data queries in our database. We have a very functional prototype mapping system, and several new adjustments were made. But unfortunately it still runs too slowly to be suitable for open access on our public website.

Our long-term partnership with the PRISM group at Oregon State University continues to pay large dividends. The CoCoRaHS PRISM climate portal continues to provide a way for volunteers to see their relatively short term data contributions of a few months to a few years in the much larger and longer framework of climate with national data back to 1895. PRISM also imports CoCoRaHS daily reports into their national mapping enterprise where CoCoRaHS is the largest source of data for the creation of daily precipitation maps http://www.prism.oregonstate.edu/mtd/ This incredible product integrates CoCoRaHS data with precipitation measurements and estimates from other monitoring systems to add value and utility to our CoCoRaHS efforts. We encourage our volunteers and data users to make use of these integrated products and services.

At the end of September we completed our 5th year producing water year summary reports and graphics.

"Water Balance Charts" http://www/cocorahs.org/ViewData/StationWaterBalanceChart.aspx

Current and previous years' water summary reports were generated producing 270,000 separate data files totaling 25GB. While likely underappreciated by our volunteers in this age of "Big Data", for us and our project these annual water year summary reports for every participating station in the network constitute a major achievement in data analysis.

Except for our challenges implementing a more robust North American mapping system, in most other ways we continue to see improvements in database and website performance to enable many and varied data analysis queries such as total precipitation summary reports, station summaries, water balance sumamreis and various data "sorts" for longer periods and larger areas. The better our system performs, the more we are able to encourage more "inquiry" by our volunteers.

CoCoRaHS continues to contribute to data analysis on a much broader scale. Since CoCoRaHS data became accessible through NOAA's National Climatic Data Center "Global Historical Climate Network" a few years ago and through ACIS – the "Applied Climate Information System" last year, now CoCoRaHS data can be integrated into nearly all precipitation data analysis and research activity utilizing NOAA data. This includes access via the popular "NowData" tab featured on National Weather Service local webpages through the "Climate/Local" links.

Disseminate Results

CoCoRaHS "dissemination" occurs at several levels. Raw observations of precipitation are shared far a wide. Website dissemination makes CoCoRaHS results readily accessible both to participants, sponsors and to the general public. Efficient bulk data export provides efficient distribution of raw data to local, state and federal entities including NOAA and USDA. Improvements to data export system were made this summer based on data user requests including additional filtering capabilities and bulk export functionality.

Dissemination to our community of participants is critically important and is carried out primarily through our website, our "Message of the Day" feedback sent out after each data entry is submitted, our Blog (thanks to our state coordinator from Illinois, Steve Hilberg) and our e-newsletter ("The Catch") which goes out about once or twice a month..

The CoCoRaHS Social Networking channels continue to grow. Our Facebook followers as of September 30, 2014 totaled 5,300 (increase of 480). Twitter followers grew by about 500 to nearly 3000. The rate of growth of Twitter usage continues to exceed Facebook at this time even though we are not preferentially emphasizing Twitter.

Our YouTube channel activity has been modest. Total CoCoRaHS YouTube channel subscribers increased to 900 (increase of about 30%). Thousands of new views continue every month of our training and education resources. "The Water Cycle" animation still leads the way with about 75,000 views in the past 6 months. The new "Weather versus Climate" animation has had about 10,000 views but the rate is increasing now each month.

Through our participation in the WERA 1012 annual coordinating committee meeting in Estes Park this year, Noah Newman was able present to the group about the CoCoRaHS for Schools efforts – providing advice and tips for other coordinators in different states (and Canada).
Following the meeting, Noah worked with the Canadian Coordinators – specifically in Manitoba – to assist with linking CoCoRaHS activities to education standards in Canada.

We had very few formal oral and poster presentations during this performance period as our travel funds for this project are largely expended.

Reges, Henry W, CoCoRaHS/Colorado State Univ., Fort Collins, CO; and Tamara G. Houston, NOAA/NCDC, 2014: "Weather and Climate Extremes: Assessments, Opportunities, Resources". American Public Gardens Association 2014 Annual Conference, Denver, CO, June 2014.

We were unable to attend this year's NSTA conference in Boston, but a presentation about CoCoRaHS and how teachers can utilize the program in their classrooms was organized by a coordinator and teacher who were in attendance.

However, we continue to speak about CoCoRaHS every chance we get. For example, at this year's American Association of State Climatologists annual meeting in Washington State, at least 6 states reported on their progress extending and utilizing CoCoRaHS observations in their states. CoCoRaHS results and impacts were shared at a special meeting of the Western States Water Council in San Diego, CA in June.

More progress towards publishing results in peer-reviewed journals has been made. Julian Turner, our web developer completed participation in an NSF DataONE Public Participation in Scientific Research working group which completed a draft publication about the value and usage of data from citizen science projects. This should appear in print within the next year.

Measure Effects

Evaluation was the primary focus of this performance period. In collaboration with Dr. Kelly Riedinger of David Heil and Associates (our outside evaluator) we finalized the questions for our project-wide "Participant Survey" in April and May. The survey was launched using Survey Monkey software in late May and was left open for two weeks . This was basically a professionally crafted follow-up survey to the initial participant survey developed by and administered by the CoCoRaHS staff back in 2009. It was a longer and more rigorous survey that, for better or worse, weeded out the "impatient" or the "uninterested". For most, it took a focused 30 minutes or longer to complete the survey. We received several e-mails saying that it was too hard, too complicated and/or too redundant. Still, nearly 5,000 participants completed the survey during the two week period. The sample size was substantial even though participants tended to be our most engaged participants. We did incentivize participation of less engaged volunteers by offering some gift cards. But in the end the sample size of "less engaged" volunteers was found to be too small (just a few dozen) to provide meaningful results to compare to the larger pool. So they were lumped in with the larger sample.

Analysis of survey results was completed by DHA during the summer. A draft summative evaluation report was submitted in late September 2014. This report covered not only the project-wide "Participant Survey" but also most of the other components of the project that were evaluated objectively.

There were aspects of the project evaluation that were not addressed to our full satisfaction. The evaluation did cover most of what was outlined in our initial proposal. The DHA initial logic model was largely employed. However, the change in staff at DHA last fall meant that the person who had tracked the project most closely was not involved in writing the summative evaluation. As such, the result is truly an objective "outside evaluation" from someone who had access to all the survey tools and results but had not been personally involved until the end. This does provide some advantages of objectivity and Dr Riedinger is clearly a qualified and competent evaluator and writer. But we feel that some of the heart, soul and story of CoCoRaHS were not captured, and various other evaluation opportunities may have been missed. For example, a great deal of data from the final survey was only lightly analyzed and fairly few cross cutting analyses were done (e.g. difference in responses as a function of age, gender, experience, etc). We don't fully agree with all of the numbers and interpretation of results contained in the report, either. For example, the report states that "CoCoRaHS recruited an additional 3,000 active volunteers" over the duration of the project" In fact, we recruited nearly 3 times that number who signed up and began reporting. But the net gain in total active observers was indeed about 3.000 when you include the impact of attrition (consistent with the accompanying graph). But perhaps this is just interpretive semantics.

Our contract with DHA has now ended, so the report contained here represents the conclusion of their work. Additional evaluation work can and likely will be continued. We are not quite sure how to go about this, but we appear to be seeing changes in the effectiveness of e-mail as a means of leading a large national project. In the past, personalized e-mails sent via our large e-mail list (currently close to 35,000) to our participants resulted in immediate and measurable results. For example, if Nolan sent out one of his periodic newsletters encouraging a particular measurement or response, a spike in participation nearly always followed. Direct e-mail is no longer eliciting a strong response suggesting that fewer people are reading or reacting or both. How do we lead a large national/international project going forward if e-mail is no longer effective? We will be asking ourselves and others and exploring options to e-mail communications. We look forward to feedback from NOAA Office of Education staff regarding this evaluation that might guide our further work in our final year (no cost extension year two) of this project.

COMMUNITY COLLABORATIVE RAIN, HAIL & SNOW NETWORK
"Because every drop counts"

The Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS)

End of Project Evaluation Report (NOAA)

Prepared by: Kelly Riedinger, Ph.D.
Director of Research and Evaluation

September 2014

Submitted to the Community Collaborative Rain, Hail & Snow Network Project Leadership

DAVID HEIL & ASSOCIATES, INC.
Innovations in Science Learning

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Prepared for the Community Collaborative Rain, Hail, & Snow Network

Executive Summary

The Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS), with major funding from National Oceanic and Atmospheric Association (NOAA), implemented a series of improvements and enhancements in an effort to promote climate literacy among volunteer observers. In particular, the NOAA grant project had the following primary goals:

1) **Refine protocols**: The CoCoRaHS project team reviewed and revised existing data collection and reporting protocols. In addition, the measurement of evapotranspiration was added;
2) **Recruit participants:** An effort was made to expand the CoCoRaHS network through recruitment efforts that specifically targeted younger audiences and a more diverse audience;
3) **Train participants:** A variety of new training tools were implemented by CoCoRaHS for training participants to serve as research partners. These trainings focused on educating the public to collect and report precipitation data and introduced climate education topics;
4) **Accept data:** CoCoRaHS leveraged advanced technologies to improve data collection (e.g., via mobile devices on web browsers and text messaging);
5) **Analyze data:** New technologies were added to the CoCoRaHS Network to encourage data analysis and interpretation including new mapping products, water year summary reports, data visualizations, and improved cyberinfrastructure;
6) **Disseminate results:** The project also focused on greater dissemination of results to participants, volunteer coordinators, professionals (e.g., NOAA partners), and peers through a combination of previously used strategies (e.g., “Message of the Day”, blogs, newsletter) as well as the addition of new strategies (e.g., social networking sites).

The evaluation team from David Heil & Associates, Inc. (DHA) conducted formative and summative evaluation over the duration of the NOAA, three-year grant. DHA implemented a complementary, mixed-methods evaluation study to examine the implementation of the project deliverables and measure resulting outcomes and impacts. Data collection included pre-post surveys, interviews with project leadership, focus group discussions, and observations of outreach activities. This report specifically discusses the summative evaluation data and related findings that resulted from implementation of the NOAA grant project and associated activities.

Key Findings

Results from the evaluation study indicated that:

- The CoCoRaHS project leadership was successful in implementing activities and deliverables in alignment with the objectives identified in the NOAA grant;
- CoCoRaHS was successful in sustaining and expanding the network through a focused recruitment effort. In three years, CoCoRaHS recruited an additional 3,000 active volunteers. However, there was limited success in recruiting diverse new audiences;
- Participants noted moderate to high levels of engagement with most CoCoRaHS activities including: submitting daily precipitation reports and multiday reports, engaging with data analysis tools, using training resources, and reading the *Message of the Day* and *The Catch.* CoCoRaHS volunteers indicted limited engagement with activities such as measuring evapotranspiration, participating in webinars, and accessing social media tools;

- Formative feedback collected from participants suggested that CoCoRaHS was successful at the reactions assessment level. A large majority of survey and focus group respondents rated the CoCoRaHS features and activities favorably;
- Participation in CoCoRaHS positively influenced participants in the following ways: volunteers developed their science process skills and demonstrated increased levels of engagement in science activities. In addition, students' awareness of science careers increased and teachers believed that more students were considering STEM career options as a result of engagement in CoCoRaHS activities;
- Although there was evidence to suggest that the project was successful at the reactions level, participants offered a number of suggestions for further development and improvement of CoCoRaHS activities and associated materials and resources. While some of the respondents' recommendations were idiosyncratic, DHA's analysis of the formative data found that there were several themes that emerged which are incorporated in the key recommendations outlined below and expanded upon in the conclusion section of this report.

Key Recommendations

- Continue to build on the success of the CoCoRaHS network and related program components;
- Continue using a variety of recruitment strategies and events to maintain and expand the CoCoRaHS volunteer network;
- Collect demographic information from new CoCoRaHS registrants to more accurately and reliably measure success in recruiting diverse audiences;
- Offer opportunities for volunteers to connect and interact with one another;
- Consider ways to recruit more webinar participants;
- Gather additional feedback and input regarding CoCoRaHS social media resources such as the Facebook page and Twitter account;
- Provide tools and additional activities to further develop volunteers' data analysis skills;
- Find strategies for introducing students to STEM-related careers.

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Introduction

The Community Collaborative Rain, Hail and Snow (CoCoRaHS) network is a citizen science project based out of the Colorado Climate Center at Colorado State University. CoCoRaHS is a grassroots, community-based network of volunteers of all ages and backgrounds working together to measure, report and map precipitation data using low-cost measurement tools. Volunteers take daily measurements of rain, hail and snow from as many locations as possible which are reported on the CoCoRaHS website. The data are compiled and then displayed and organized using data visualization tools accessible on the website. By emphasizing training and education as well as utilizing an interactive website, CoCoRaHS seeks to provide high quality precipitation data for natural resource, education and research applications.

The CoCoRaHS network began in 1998 as a small, local network of volunteers in Ft. Collins, Colorado, largely due to a devastating flood that hit the area a year earlier. During the flash flood of 1997, a localized storm dumped more than a foot of rain in several hours in parts of Ft. Collins while other areas of the city received only a few inches. This event pointed to a need for better mapping and reporting of precipitation data; thus, the notion of a network of volunteers collecting and reporting data was conceptualized. As more volunteers contributed data, maps of rain, hail and snowfall were produced for every storm. By 2010, CoCoRaHS became a nationwide volunteer network.

At the writing of this report, CoCoRaHS is in all 50 states and has expanded to Canada and Puerto Rico. The CoCoRaHS website and precipitation data are used by diverse individuals and organizations including (but not limited to): the National Weather Service, the USDA, meteorologists, atmospheric researchers, hydrologists, emergency managers, ranchers and farmers, engineers, educators, students, and citizens.

CoCoRaHS Project History

The CoCoRaHS network of volunteers initially began during the spring of 1998, prompted by the storm and flood events from the previous year. During this time, the Colorado Climate Center at Colorado State University began recruiting volunteers to join the network to contribute rain and hail observations. Within a few days, nearly 150 volunteers joined the network (Cifelli et al., 2005). Since then, the CoCoRaHS network has been partially supported through NSF and NOAA grant funding. In 2000, a small grant from the Geoscience Education program supported initial project development and youth leadership participation. Later, in 2003, the CoCoRaHS network received additional NSF funding through the Informal Science Education (ISE) program to expand to rural communities and increase formal teacher education (Bonney et al., 2009; Cifelli et al., 2005). The network was further extended in 2006 when the project received a NOAA Environmental Literacy Grant (ELG) Priority 2 Grant. Since then, the project received additional NSF and NOAA grant funding to continue network expansion while also enhancing the website, data collection activities, and education outreach components. The current report focuses on the implementation of a three-year, NOAA ELG Informal/Nonformal science education grant received in 2010. The primary purpose of this 2010 NOAA ELG grant was to promote climate literacy among CoCoRaHS participants. As a means to address this goal, CoCoRaHS engaged in the following project activities:

1) **Refine protocols**: The CoCoRaHS project team reviewed and revised existing data collection and reporting protocols. In addition, the measurement of evapotranspiration was added;
2) **Recruit participants:** An effort was made to expand the CoCoRaHS network through recruitment efforts that specifically targeted younger audiences and a more diverse audience;

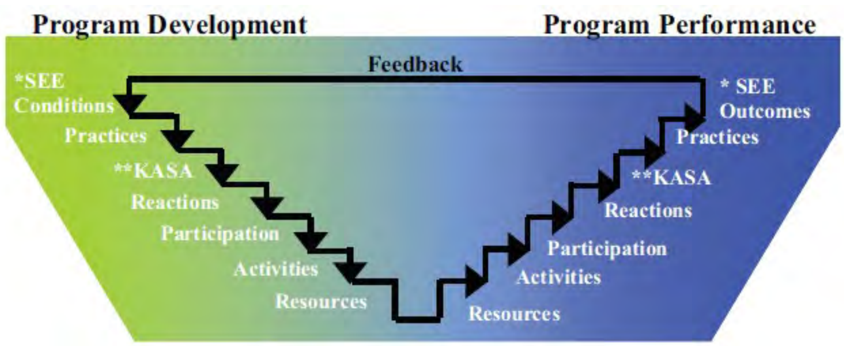
3) **Train participants:** A variety of new training tools were implemented by CoCoRaHS for training participants to serve as research partners. These trainings focused on educating the public to collect and report precipitation data and introduced climate education topics;
4) **Accept data:** CoCoRaHS leveraged advanced technologies to improve data collection (e.g., via mobile devices on web browsers and text messaging);
5) **Analyze data:** New technologies were added to the CoCoRaHS Network to encourage data analysis and interpretation including new mapping products, water year summary reports, data visualizations, and improved cyberinfrastructure;
6) **Disseminate results:** The project also focused on greater dissemination of results to participants, volunteer coordinators, professionals (e.g., NOAA partners), and peers through a combination of previously used strategies (e.g., "Message of the Day", blogs, newsletter) as well as the addition of new strategies (e.g., social networking sites).

The CoCoRaHS project leadership contracted David Heil & Associates, Inc. (DHA) to serve as an external evaluator throughout the duration of this NOAA ELG three-year grant as well as during the one-year, no-cost extension. DHA's recent efforts during the no-cost extension year have focused on summative evaluation of the program and this report represents a comprehensive analysis and overview of the evaluation measures and data collected throughout the duration of this NOAA ELG grant.

Evaluation Model

In 2010, the National Research Council (NRC) published a text that reviewed and critiqued NOAA's education program (NRC, 2010). Specifically, chapter 5 in the text, "*Current Evaluation Framework and Existing Evaluation Efforts"* was used to inform this evaluation study of the CoCoRaHS three-year ELG grant. The document can be accessed at the following web address: http://www.nap.edu/openbook.php?record_id=12867. The Bennett Targeting Outcomes of Programs (TOP) model (Bennett & Rockwell, 1995) was selected and used as an evaluation model for this study. The model includes seven assessment levels including (in order): resources, activities, participation, reactions, KASA (knowledge, attitudes, skills and aspirations), practices, and SEE (social, economic, and environmental changes) and is depicted in Figure 1.

Figure 1. TOP Evaluation Model (Bennett & Rockwell, 1995; NRC, 2010)



CoCoRaHS Logic Model

The logic model presented in Figure 2 visually depicts the theory of action for the CoCoRaHS NOAA grant initiative and highlights specific ways in which the inputs and activities lead to programmatic outcomes. The logic model outlines the inputs, outputs, and the proposed outcomes for the project and is representative of the theory of action that guided the evaluation. Visually representing the theory of action and causal chain allowed DHA to identify appropriate evaluation questions to guide the study.

Figure 2. Logic Model

Outputs	Short-Term Outcomes	Long-Term Outcomes
Improvement & Expansion of… **Participant Recruitment** • New and experimental approaches for recruiting younger and more diverse audiences **Software Capabilities for Accepting Data** • Quality control mechanisms • Additional measurements • Photo capabilities • Text message support • Data entry via smart phones **Software Capabilities for Analyzing Data** • Faster/more flexible querying • Data analysis via smart phones • Client-side mapping • PRISM comparison maps • Climate dashboard • Water Year Summary Reports • Charts & Graphs **Disseminating Results** • Social network integration	**Participant Opportunities to…** **Use data in inquiry- and evidence-based activities by…** • Collecting samples • Analyzing samples • Recording data • Analyzing data • Interpreting data and drawing conclusions • Disseminating conclusions **Explore weather and climate topics by…** • Engaging in the scientific data collection and analysis • Participating in social networking experiences • Participating in online trainings and webinars	**Improvements in…** **Level of engagement in scientific activities by diverse audiences** **Understanding of weather and climate-related concepts** **Understanding of the scientific process** **Scientific skills related to using measurement instruments, following data collection protocols, and analyzing data**

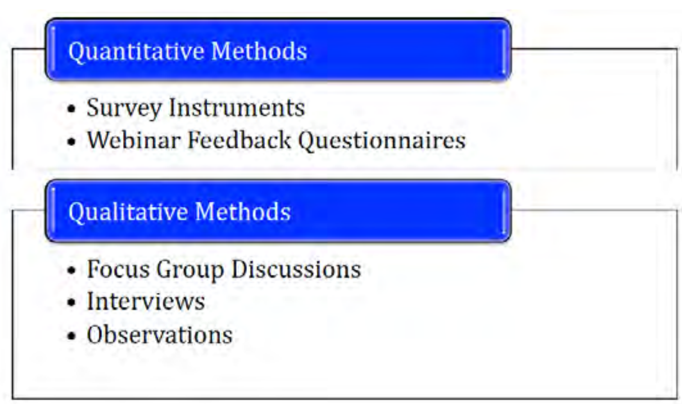
Evaluation Questions

- Over the course of the three-year project, does CoCoRaHS show an increase in participation by previously underserved groups (e.g., younger audiences, women, minorities)?
- Do observers report improvement in their understanding of the scientific process?
- Do observers report gains in skills related to using measurement instruments, following data collection protocols, and analyzing data?
- Do observers and non-observers report an increase in their understanding of the weather and climate-related topics?
- Do observers and non-observers change their stewardship of the local and global environment?
- What is the association between level of participation in the CoCoRaHS community and the long-term outcomes of interest?

Methodology

DHA used a complementary, mixed-methods approach to collect data and insights relevant to the stated evaluation questions and project objectives. A complementary methods approach was warranted as it explores a question or problem from multiple perspectives and incorporates both quantitative and qualitative data (Creswell, 2008). Each type of data is viewed as complementary; the quantitative data provided a broad understanding of the implementation of the deliverables and resulting outcomes while the qualitative data allowed for a more in-depth and detailed understanding of participants' experiences in the program. The data collection strategies implemented for this cohort's evaluation study included: surveys, focus group discussions, interviews with project leadership, webinar feedback questionnaires, and on-site observations of outreach sessions. Figure 3 provides an overview of the data collection strategies used for this complementary evaluation study approach.

Figure 3. Data Collection Strategies



Surveys

Creswell (2008) explained that surveys are suitable for quantifying variables to identify broad trends. Similarly, Berends (2006) posited that survey methods describe characteristics of a sample, providing information that can add to a methodological approach. Particularly with regard to the evaluation of education programs, Pattison, Cohn, and Kollmann (2013) explained that surveys are useful to gather participants' perspectives and feedback regarding an education program, gather information from a broad audience in a short amount of time, and allows for respondents to provide input confidentially or anonymously.

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Several surveys were administered throughout the three-year grant period and during the funded extension years. The survey data were collected to provide formative and summative feedback related to CoCoRaHS activities and materials as well as to document general outcomes and impacts that resulted from the three-year project. This data collection method provided measures on broad outcomes; in particular, the surveys measured the extent to which quantitative indicators were achieved. The surveys contained open-ended question items as well as Likert-scale, close-ended items. Figure 4 displays the surveys administered over the duration of the grant.

Figure 4. Surveys Administered to CoCoRaHS Network During Grant Period

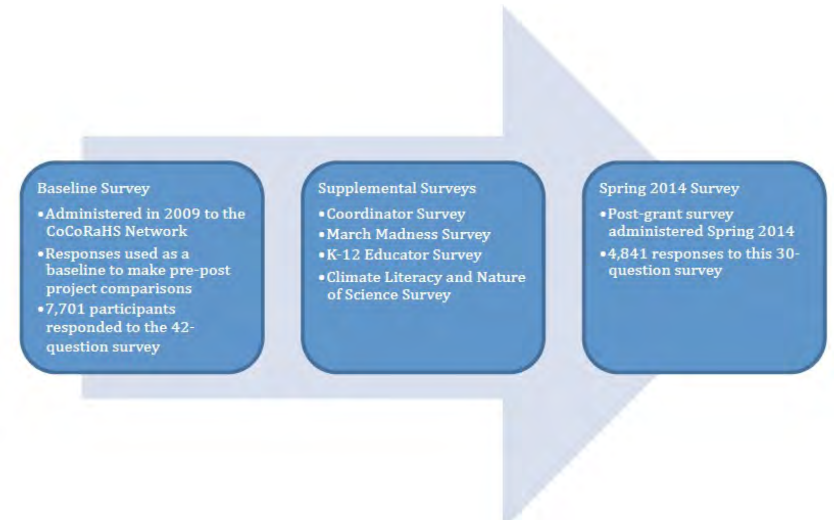

Table 1 provides additional details regarding each of the surveys administered:

Table 1: CoCoRaHS Survey Information

Pre-Post Surveys	Surveys were administered before and after the grant period to understand what impacts and outcomes directly resulted from the grant activities. The baseline survey was administered in 2009 before the grant began and the 2014 Spring Survey was administered after the grant activities concluded. Both surveys collected demographic information and measured outcomes of participation
Coordinator Survey	A survey was administered in the spring of 2011 to CoCoRaHS state, regional, and local coordinators. There were 83 respondents to the coordinator survey. The items on this survey were designed to gather data such as (but not limited to): coordinators' perceptions of their role in the CoCoRaHS Community Network, their success with recruiting, and motivations to
March Madness Survey	During the spring of 2011, a survey was administered to new participants who joined as a result of a March Madness recruitment event. In total, 273 participants responded to this survey. An objective of this survey was to gather feedback regarding the success of the CoCoRaHS recruitment efforts
K-12 Educator Survey	A survey was administered specifically to K-12 educators in the CoCoRaHS Community Network during the spring of 2013. An aim of this survey was to gather input and feedback from educators regarding the CoCoRaHS K-12 curriculum materials and outreach efforts. There were 80 K-12 educators who responded to this
Climate Literacy and Nature of Science Survey	This survey was designed to examine the extent to which engagement in the CoCoRaHS Community Network influenced participants' climate literacy and nature of science beliefs. The survey was administered in the spring of 2012 to new participants who signed up as part of the March Madness recruitment event. A second, follow-up survey was sent to these same participants a year later. A total of 59 respondents

Webinar Feedback Questionnaires

As a means to assess the quality of the *Wx Talk Weather Talk* educational webinars as well as resulting outcomes, a short questionnaire was administered to webinar participants at the conclusion of each session (31 webinars total). The questionnaires sought to assess the quality of the webinars as well as measure outcomes of participation. The questionnaires prompted respondents to indicate the extent to which they agreed with statements such as (but not limited to): "*The webinar was informative"; "I would attend a future webinar"; "I learned something new about weather/climate";* and "*The webinar met my expectations."* The data collected from the short questionnaires associated with each webinar were analyzed using quantitative methods. Specifically, DHA used SPSS to calculate descriptive statistics for each questionnaire item for all 31 webinars conducted over the course of the grant period.

Focus Group Discussions

DHA facilitated two focus group discussions with CoCoRaHS participants who were K-12 educators. A copy of the focus group discussion guide used to facilitate the conversations is included in Appendix A. The focus group discussions sought to gather input and feedback from K-12 educators who participated with their students in CoCoRaHS activities. K-12 educators in the Colorado Springs, Colorado area and surrounding regions were recruited to participate in the discussions. The first discussion was held in May of 2012 and included three teachers. The second focus group discussion was held in May of 2014 and also included three teachers. The discussions were held during DHA site visits to the Colorado Climate Center at Colorado State.

Interviews

The lead evaluator from the DHA team conducted on-site interviews with the CoCoRaHS project leadership during a site visit in May 2014. The interviews with the leadership team served as an opportunity to gather data regarding their perspective on the ways in which the project and grant deliverables had been implemented to date. The interviews also allowed DHA to elucidate the extent to which the grant objectives had been addressed as well as gather evidence regarding lessons learned from implementation. DHA's interview protocol included prompts designed to elicit responses related to the guiding evaluation questions. A copy of the protocol for these interviews can be found in Appendix B.

Observations

To provide feedback regarding the CoCoRaHS education outreach programs, the lead investigator from the DHA team attended two outreach events during May of 2014. Specifically, the evaluator attended an outreach event at a local, Colorado water festival in Greeley, Colorado as well as outreach sessions in three classrooms at a local elementary school in Colorado Springs near Colorado State University.

During the observations, the DHA evaluator maintained field notes documenting the activities of each attended session. The data was interpreted using current science education reform documents to highlight the extent to which the activities aligned with current recommendations such as scientific inquiry, active learning, and incorporating nature of science concepts and scientific practices. The observation data provided feedback from the CoCoRaHS project leadership to continue modifying and improving the education outreach events and activities for K-12 students.

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Anecdotal Information

Since the initiation of the grant in 2010, DHA and the CoCoRaHS team have collected and compiled anecdotal evidence from a variety of sources including participants' unsolicited feedback (via email), news reports, and comments in submitted daily reports. The anecdotal data was reviewed and methods of qualitative analysis were used to note any themes in the artifacts collected. In addition, some of the comments were used to corroborate findings from other data collection strategies.

Data Analysis

The survey data and feedback questionnaires were analyzed using quantitative methods to compute descriptive statistics (e.g., frequencies, percentages, measures of central tendency) and inferential statistics (e.g., t-tests, chi-square analysis) using the statistics software, SPSS. The descriptive statistics are summarized and displayed throughout the report using tables and bar graphs. The use of inferential statistics guided DHA in making comparisons across a variety of variables (e.g., levels of engagement, age, race/ethnicity, gender, etc.). Data were disaggregated and DHA conducted cross-tabulations through chi-square analysis tests to identify any differences due to respondent characteristics or demographics. Further, pre-post survey responses were compared using independent sample t-tests to draw inferences regarding the influence of the grant project.

Open-ended survey items, focus group discussion responses, observation field notes and anecdotal data were analyzed using qualitative methods. Methods of analytical induction were employed to identify emergent themes from the data collected. Members of the DHA team individually coded the qualitative data to identify patterns and themes and then met to negotiate the codes, reconcile any differences between codes developed, collapse categories, and identify relationships between categories. Through this iterative process, DHA was able to continually refine codes and identify the meaningful patterns and trends from the corpus of data collected. The qualitative data are descriptive and provide an in-depth, nuanced understanding of the NOAA ELG Grant project implementation. Qualitative findings are presented in narrative form and where appropriate, participants' quotes are reported to further elucidate findings.

Study Limitations

The evaluation findings presented in this report are based largely on survey data collected at several time points over the duration of the grant period. Although the findings provide evidence that the CoCoRaHS Community Network has had positive outcomes for participants, the study relies primarily on participants' self-reported data on survey measures. This limitation should be kept in mind when interpreting the findings.

A second limitation of the study is related to the representativeness of the sample. Though an effort was made to recruit participants who are less engaged or no longer active in the CoCoRaHS Community Network, a majority of the respondents were those who are highly engaged in the data collection activities. The sample was also overly represented by white, male volunteers over the age of 55.

With these limitations in mind, the findings from this comprehensive, summative report provide evidence that the CoCoRaHS Community Network has had positive outcomes for participants as well as for the education community.

Findings

This section provides an overview of the formative and summative evaluation data collected over the duration of the NOAA ELG three-year grant. The findings are organized by the assessment levels identified in the TOP Evaluation Model (Bennett & Rockwell, 1995; NRC, 2010). In particular, this evaluation study focused on the following levels of assessment: activities, participation, reactions, KASA, and practices.

Activities and Participation

The activities and participation levels of the TOP Evaluation Model, as defined by Bennett and Rockwell (1995) and described by the National Research Council (2010), refer to the implementation of program components as well as the involvement of learners and volunteers. For this evaluation study, it specifically referred to the outputs and project activities identified in the CoCoRaHS logic model (Figure 2) including: refine protocols; new software capabilities to accept and analyze data; dissemination of results; participant education/training; and participant recruitment.

Activities. Since receiving the grant in 2010, the CoCoRaHS team has implemented numerous program deliverables in alignment with the proposed goals and activities for the NOAA ELG grant project. Table 2 highlights the deliverables that have been implemented as a result of the NOAA grant and provides evidence that the activities have exceeded identified aims.

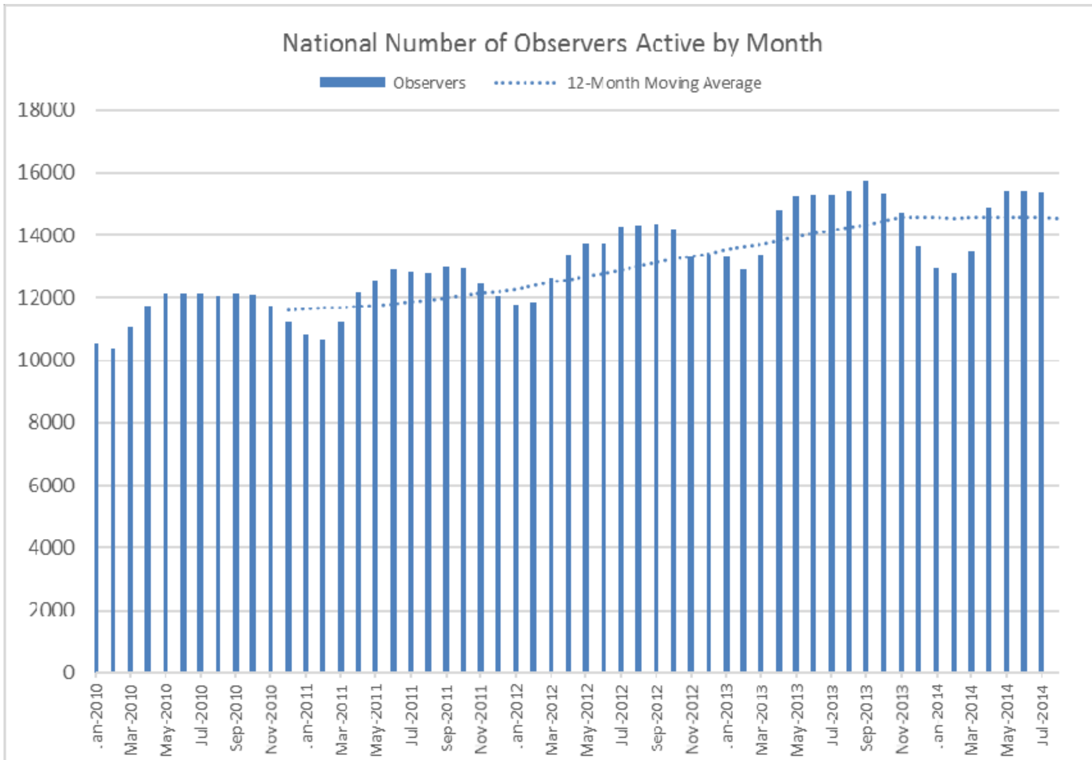
Table 2. NOAA Grant Deliverables and Activities

Grant Deliverables	
Refine Protocols	• Added protocols for the measurement and reporting of Evapotranspiration
New Software Capabilities	• Implemented new software to provide maps with additional capabilities to zoom and pan while also enabling the ability to click on specific data points for further details • Added new data analysis features including water year summaries, the PRISM portal and data visualization capabilities • Updated the CoCoRaHS infrastructure to accept data from mobile devices • New software capabilities to streamline data uploads
Dissemination of Results	• Targeted social media outlets including Facebook, Twitter, and YouTube to disseminate results and other CoCoRaHS materials • Developed and implemented a CoCoRaHS Blog. As of September 2014, 298 blog entries have been posted since 2011. • Participated in 24 science and education conferences (e.g., 2014 Annual Meeting of the National Science Teachers Association, American Meteorological Society)
Volunteer Education & Training	• As of September 2014, 34 webinars have been implemented on various weather and climate topics • Developed and posted 13 training videos and 8 education animations to YouTube

Participation. A goal of the current NOAA ELG grant was to maintain the 15,000 volunteers who indicated active participation on the 2009 baseline survey while also expanding the CoCoRaHS network through efforts to recruit a more diverse audience. In particular, the CoCoRaHS project team sought to recruit younger audiences and volunteers from groups historically underrepresented in STEM fields (e.g., females, minorities). A variety of recruitment efforts were employed over the three-year duration of the grant including: supporting and expanding state and regional leadership teams, "March Madness" annual state recruitment event and competition, and implementation of emerging technologies (e.g., data entry and analysis through mobile devices, recruit and disseminate through social media outlets).

As of September 2014, there were approximately 18,000 active CoCoRaHS observers, a net increase in 3,000 active volunteers since the baseline survey in 2009. This provides evidence that the CoCoRaHS team was successful in maintaining the 15,000 CoCoRaHS volunteers while also expanding the network through the recruitment efforts that resulted from the grant's objectives and deliverables. Figure 5 further corroborates the success of the project at the participation level. The graph is illustrative of the increased participation by CoCoRaHS observers over the duration of the grant period while also highlighting specific changes by month from January 2010 to July 2014.

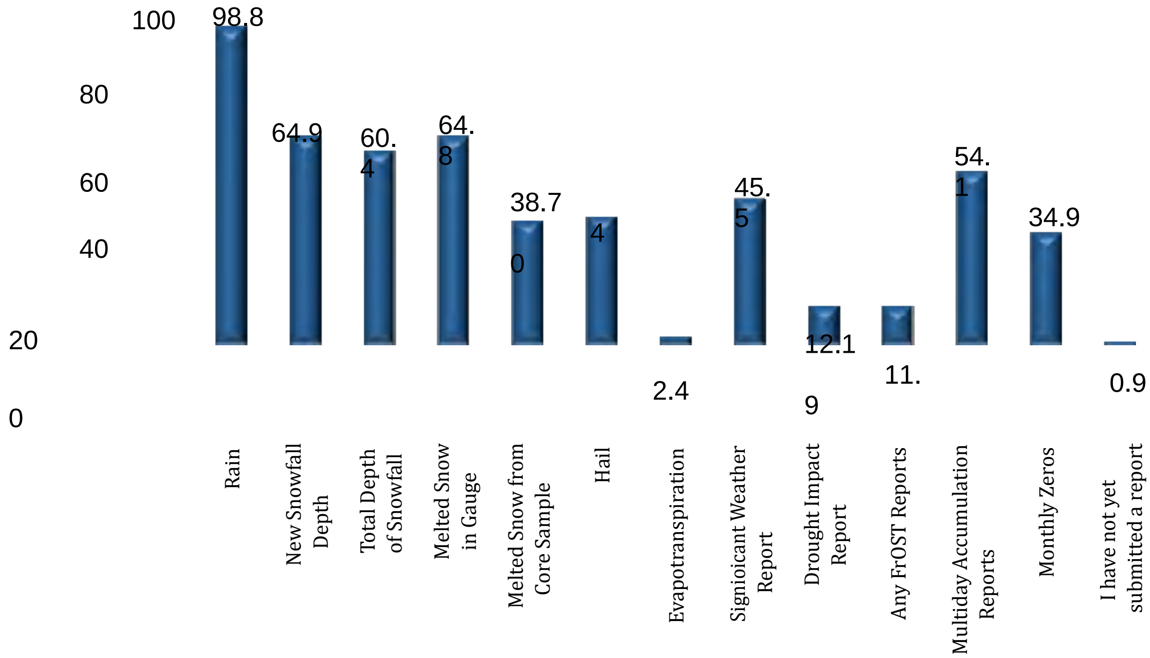
Figure 5. Number of Active CoCoRaHS Observers by Month[1]



An item on the Spring 2014 survey gathered data related to CoCoRaHS observers' engagement in various data collection activities. Specifically, the survey item asked respondents to indicate the types of precipitation reports that they typically submitted. Figure 6 displays results related to this survey item and suggests that observers most often submit rain reports. Snowfall measurements (i.e., new snowfall depth, total depth of snowfall, and melted snow in gauge) were also reported relatively often — approximately 60-65% of respondents indicated they submitted various types of snow reports. These results provide further details regarding the participation level of the evaluation model and demonstrate the particular data collection activities in which CoCoRaHS observers are most often involved.

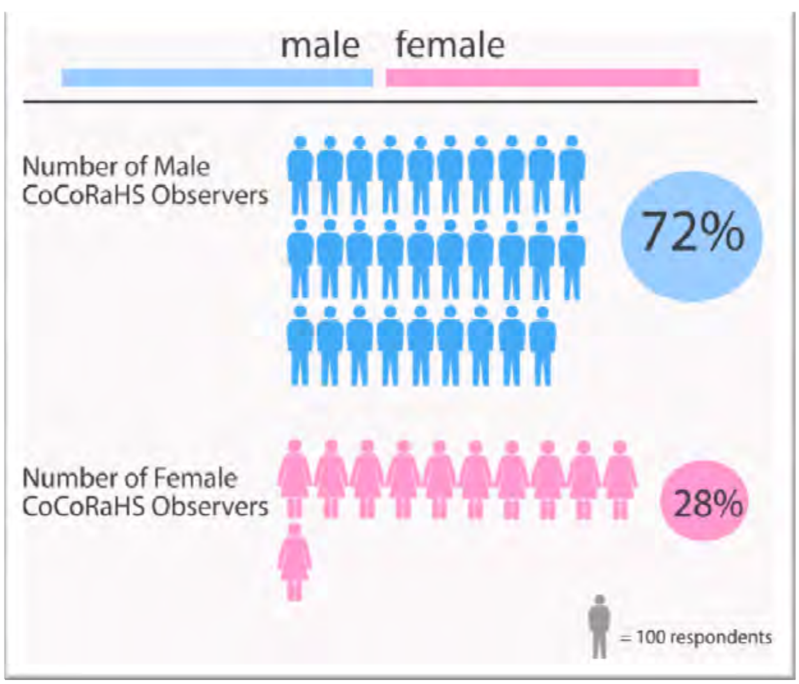
[1] Observers were considered active if they submitted at least one precipitation report during that month.

Figure 6. Types of Precipitation Reports Submitted by Respondents



An aim of the grant project was to recruit a more diverse audience, specifically with regard to gender, age, and race/ethnicity. Figure 7 depicts demographic data related to survey respondents' gender. As highlighted in the graphic, a majority of respondents to the Spring 2014 survey identified as males which was similar to demographic trends from 2010.

Figure 7. Survey Respondents' Gender



The recruitment efforts also targeted younger audiences. In particular, new technologies and reporting methods (e.g., reporting and data analysis on mobile devices, enable the development of a CoCoRaHS app, disseminate through social media outlets such as Facebook, Twitter) were employed in an effort to recruit younger CoCoRaHS observers. Table 3 highlights findings related to this goal. While significant changes were noted, the percentage of younger audiences decreased slightly. One interpretation of this finding is that survey respondents may not be reflective of the broader CoCoRaHS observer population.

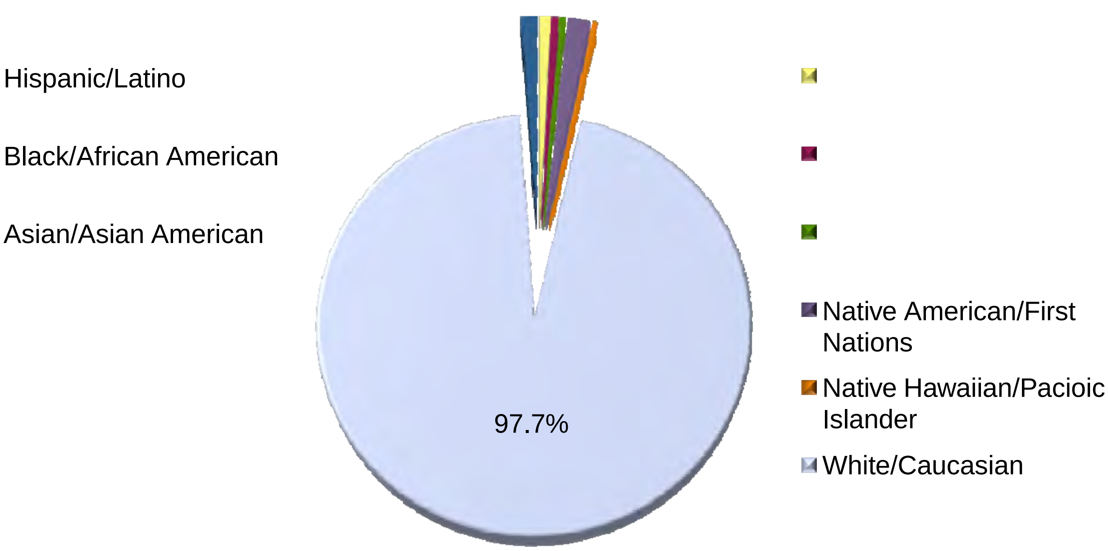
Table 3: Age of CoCoRaHS Survey Respondents[2]

	Pre-	***Post-***	***Overall Change***
0-24 years of age	1.4%	1.1%	-0.3%*
25-54 years of age	35.5%	20.6%	-14.9%*
55-84 years of age	62.1%	77.1%	+15%*
85+ years of age	1.0%	1.2%	+0.2%*

* Indicates statistically significant at the .01 level (P < .01)

The Baseline Survey administered to CoCoRaHS volunteers in 2009 indicated that roughly 97% of respondents identified as Caucasian/White. Another recruitment goal identified in the 2010 NOAA ELG grant was to diversify the CoCoRaHS network by recruiting new audiences from groups historically underrepresented in STEM fields. A comparison of respondents from the Baseline Survey and the 2014 Spring Survey indicated there were no significant changes in CoCoRaHS survey respondents in terms of race/ethnicity (Figure 8). The number of respondents identifying as Caucasian/White remained at approximately 97%.

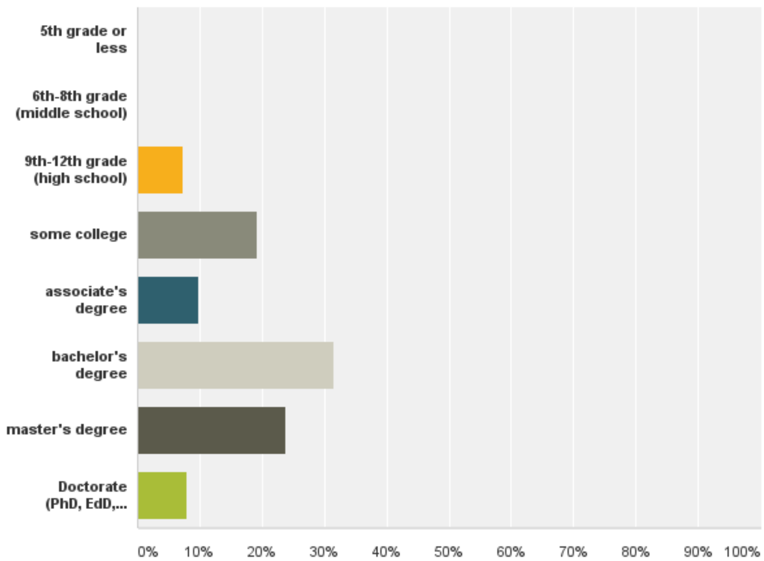
Figure 8. Race/Ethincity of CoCoRaHS Survey Respondents



2 The Spring 2014 survey included 11 age categories. The categories were too fine-grained to run an analysis, particularly given that a majority of participants fell into only 2 categories (i.e., 55-64 years of age and 65-74 years of age). Therefore, the categories were collapsed for analysis and guided by the goals of the project (to recruit a younger audience).

Several questions included on the Spring 2014 survey collected additional information regarding demographics for respondents. Findings related to respondents' education level item were widely distributed; as noted in Figure 9, the majority of participants (55.4%) had either a bachelor's or master's degree. When prompted to indicate occupation, more than half of participants (54%) indicated that they were retired, 21% indicated "other" and 17% indicated they were an educator (e.g., K-12 teacher, adult/college educator, informal educator). The remaining respondents suggested a range of other occupations, though there was no notable trend.[3]

Figure 9. Respondents' Level of Education



A cross-tabulation analysis suggested that there was no statistically significant difference in report type submitted based on education level. An analysis of variance suggested that there were some significant differences at the $p < .05$ level based on education level for the following CoCoRaHS resources:

- I read the "Message of the Day";
- I view suggested websites and links provided in the "Message of the Day";
- I read the CoCoRaHS blog;
- I explore "Things to know about rain/hail/snow";
- I view evapotranspiration information and reports;
- I explore NOAA or other sponsors from the CoCoRaHS homepage;
- I view archived WxTalk webinars;
- I use the CoCoRaHS app on my phone to enter or view data;
- I watch CoCoRaHS animations;
- I view water year summary reports;
- I view the master gardener guide;
- I use the links to other websites/resources;
- I explore the FAQ section or request help from the Help Desk;
- I explore "drought impacts" materials;

[3] The question for this survey item included 35 options. All of the remaining occupations had less than 7% of the responses.

- I connect with CoCoRaHS on Facebook or Twitter;
- I view CoCoRaHS videos on YouTube.

Table 4 indicates the specific differences identified based on education level for each of these resources and highlights where differences were noted. As evidenced by the findings presented in the table, most differences were at the K-8 level. This is likely due to the lack of representation by this group on the survey (less than .5% of respondents indicated they were younger than 5th grade or in 6th-8th grade) due to Internet safety rules and regulations. Otherwise, no statistically significant differences based on education level were identified.

Table 4: Use of CoCoRaHS Resources by Highest Education Level Completed[4]

	5th grade	6th-8th grade	9th-12th grade	some college	Associate's	Bachelor's	Master's Degree	Doctorate
I read the "Message of the	4.3	2.9	4.3	4.3	4.2	4.1	3.9	4.2
I view suggested websites and links provided in the	4.3	2.2	3.7	3.7	3.7	3.5	3.5	3.3
I read the CoCoRaHS Blog	3.7	2.8	3.5	3.5	3.4	3.3	3.1	3.4
I explore "Things to know about	4.3	2.9	3.7	3.7	3.7	3.4	3.2	3.2
I view evapotranspiration	1.3	2.3	2.5	2.5	2.6	2.3	2.3	2.4
I explore NOAA or other sponsors from the CoCoRaHS	4.7	3.7	3.4	3.5	3.6	3.2	3.1	3.0
I explore the PRISM climate portal	1.7	2.2	2.6	2.6	2.7	2.4	2.4	2.6
I view archived WxTalk webinars	2.3	1.4	2.3	2.4	2.5	2.3	2.3	2.2
I use the CoCoRaHS app on my phone to enter or view data	3.0	1.8	2.4	2.4	2.5	2.3	2.2	2.2
I watch CoCoRaHS animations	1.7	2.7	2.9	2.8	3.0	2.7	2.7	2.6
I view water year summary	2.3	2.1	3.8	3.7	3.8	3.7	3.7	3.8
I view the master gardener guide	1.3	1.4	2.2	2.4	2.5	2.2	2.2	2.2
I use the links to other	2.3	2.4	3.0	3.0	3.2	2.9	2.9	2.8
I explore the FAQ section or request help from the Help	2.0	2.6	2.6	2.6	2.8	2.5	2.5	2.4
I explore "drought	2.0	1.8	2.7	2.7	2.9	2.6	2.5	2.5
I connect with CoCoRaHS on Facebook or Twitter	1.3	1.6	2.4	2.3	2.4	2.2	2.1	2.0
I view CoCoRaHS videos on YouTube	1.7	1.8	2.6	2.5	2.7	2.4	2.4	2.4

[4] Likert-responses for this item ranged from 1 ("never or almost never use this resource") to 5 ("always or nearly always use this resource").

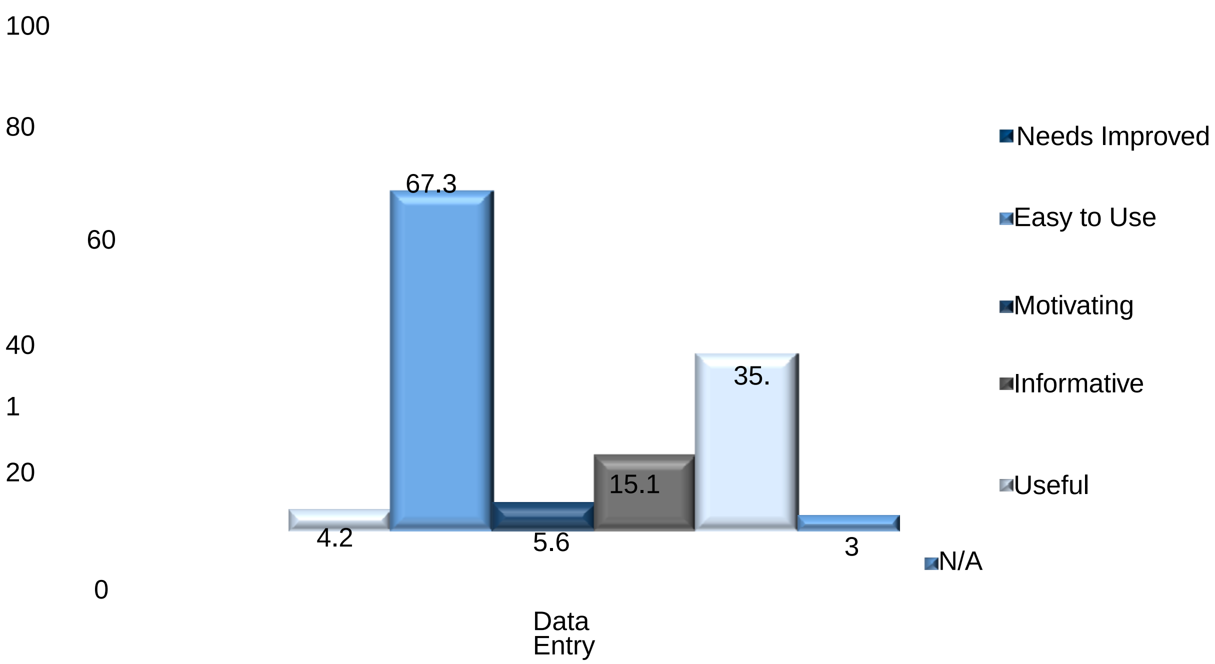
Summary. Findings related to the activities and participation assessment level demonstrated that CoCoRaHS exceeded aims related to grant deliverables. Project activities aligned with each objective identified in the grant and were implemented with success. However, with regard to participation, and in particular, recruitment of new audience groups, CoCoRaHS demonstrated limited success in engaging females, younger participants, and individuals from minority backgrounds.

Reactions

The reactions assessment level refers to participants' satisfaction and feedback related to program activities. This includes formative data as well as levels of engagement in various project components. The findings presented below focus specifically on the deliverables implemented as a result of the NOAA ELG grant.

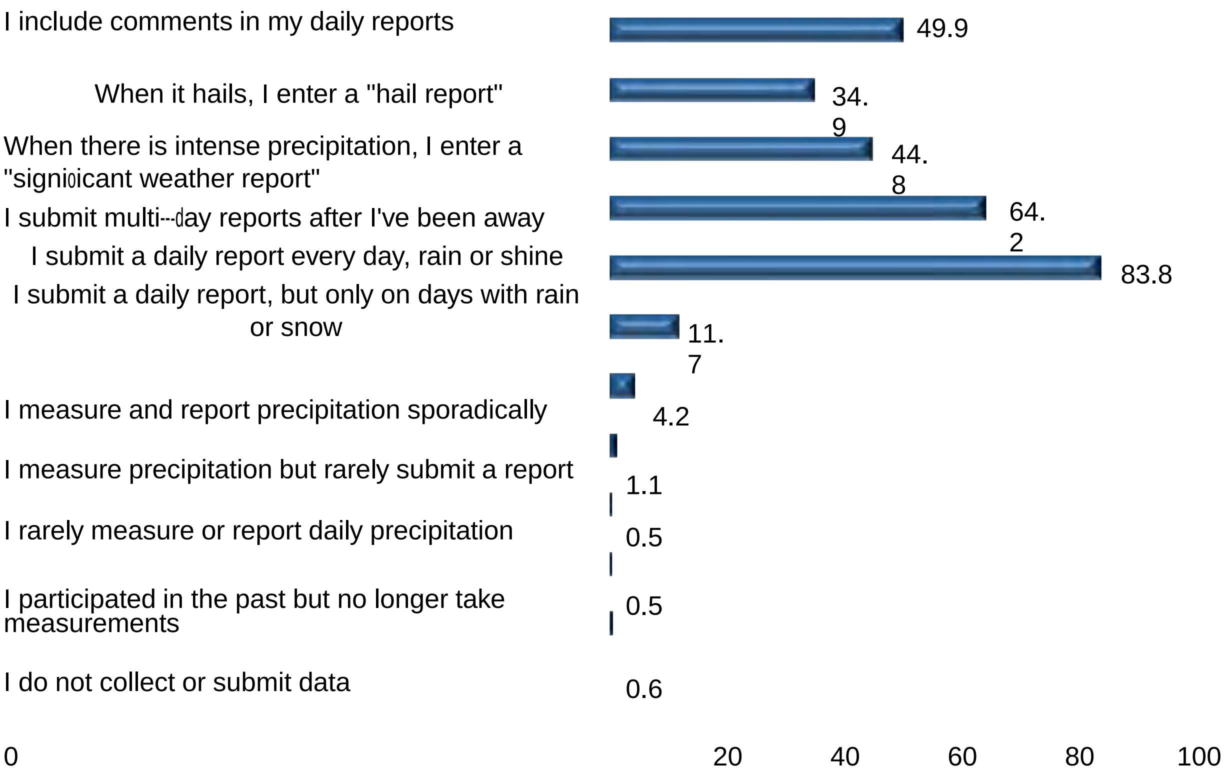
Data Entry and Precipitation Reporting. CoCoRaHS volunteers' reactions to the data entry and precipitation reporting tools and activities were measured through several items included on the Spring 2014 survey. Overall, survey respondents were generally satisfied with these aspects of CoCoRaHS. Roughly two thirds (67%) of survey respondents believed the data entry features on the CoCoRaHS website were "easy to use" and only 4% indicated that they "need to be improved." Figure 10 illustrates respondents' ratings of the CoCoRaHS data entry features.

Figure 10. Ratings of the CoCoRaHS Data Entry Features



The survey also measured respondents' level of engagement in data entry and precipitation reporting activities. Respondents indicated high engagement in submitting daily precipitation reports (83.8%) and many submitted multi-day reports after being away (64.2%) (Figure 11). Roughly half of participants suggested that they enter significant weather reports and include comments in their daily reports (Figure 11).

Figure 11. Level of Participation in CoCoRaHS Activities



On an open-ended survey item "What suggestions do you have for improving CoCoRaHS resources?", survey respondents offered input regarding data entry and reporting features. Specifically, they offered the following suggestions:

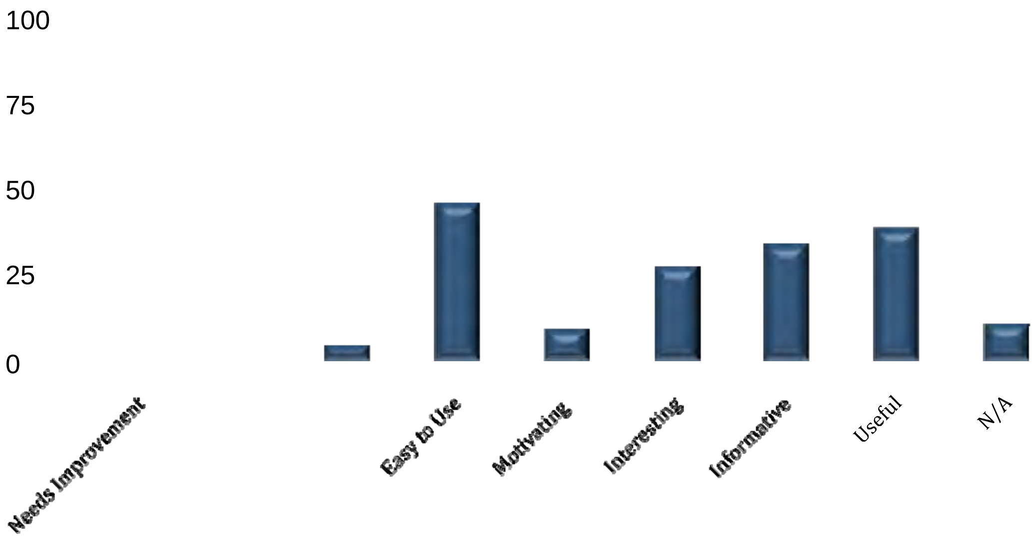
- **Incorporate data entry for all precipitation types on one form**: "*Data entry, while easy to use, there should be a single data entry screen. Incorporate the FROST, multi-day, hail, etc. [reports] on to a single page and let the software parse it out. [Adding] simple check boxes could dynamically add other fields that are needed when the box is checked.*"
- **Accept data reports by email**: *"Data entry [by] email would be a huge plus. I get emails for similar things every day, and it reminds me to send the data in."*
- **Enable preliminary data quality control at time of report submission**: *"Regarding data entry, when somebody makes a mistake where they [significantly] overinflate/understate their precipitation report…I would like them to immediately receive an error message"; "We need better quality control…there are probably some automated algorithms that could be applied to immediately flag suspicious [entries.]"*
- **Date of last submitted report:** *"I would like to see on the multi-day accumulation data entry the date when I last reported precipitation. Sometimes I forget when my last report date was before I left town."*

Though respondents provided input to inform improvement of the CoCoRaHS Network, in general, volunteers were satisfied and highly engaged with the data entry and reporting procedures.

Data Analysis and Visualization Tools. Survey and focus group respondents generally reacted positively to the new data analysis features and visualization tools implemented as a result of the grant project. Figures 12 and 13 display participants' ratings of CoCoRaHS data visualization and analysis tools.

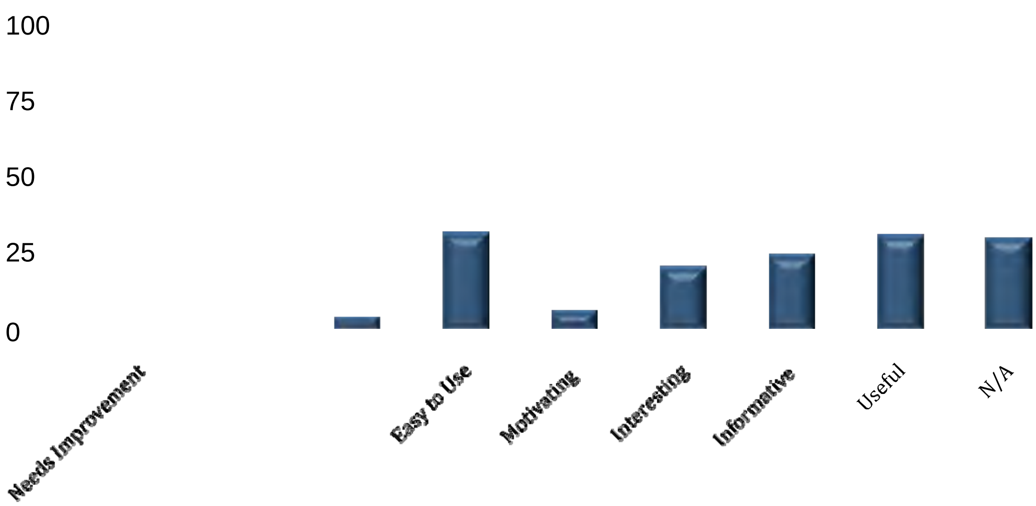
As depicted in Figure 12, very few respondents (4.4%) believed the data visualizations "needs improvement" while most participants indicated the tools were "easy to use," "motivating," "interesting," "informative," or "useful."

Figure 12. Participants' Ratings of CoCoRaHS Data Visualizations



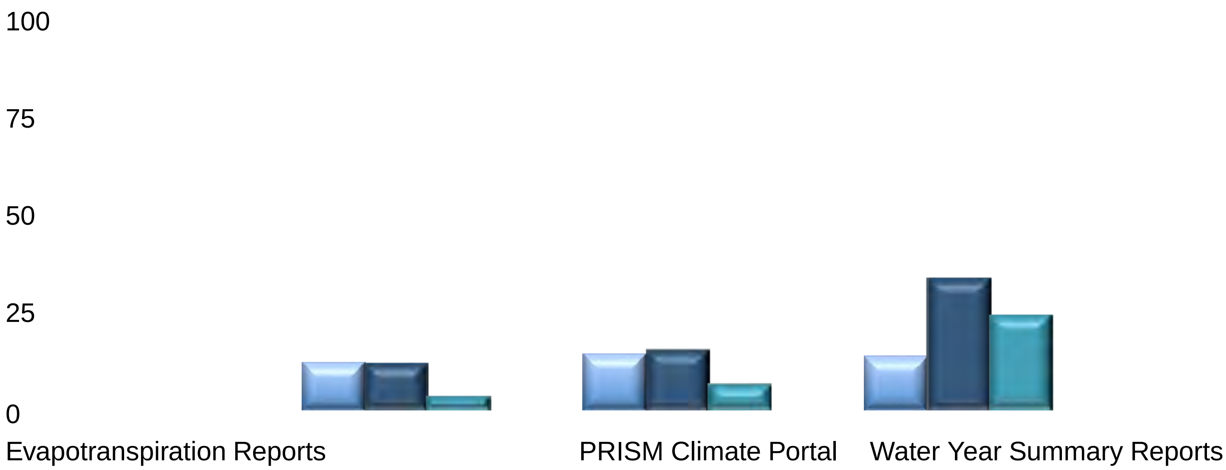
Similarly, the CoCoRaHS data analysis tools were also rated favorably by survey respondents. Figure 13 highlights participants' ratings of the data analysis tools. Only 3.7% indicated the tools "need improvement" and most participants believed the tools were ""easy to use," "motivating," "interesting," "informative," or "useful."

Figure 13. Participants' Ratings of CoCoRaHS Data Analysis Tools



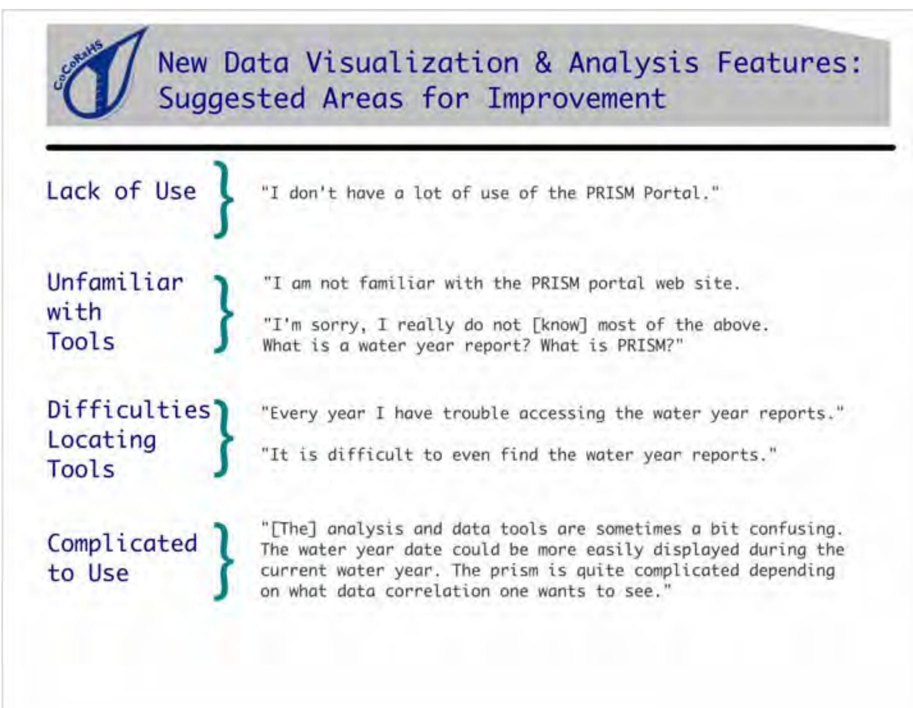
When prompted to rate specific data visualization and analysis tools, more than a quarter of participants (27%) rated the evapotranspiration reports as "good," "very good," or "exemplary." Likewise, 36.8% and 72.2%, respectively, rated the PRISM climate portal and water year summary reports favorably ("good," "very good," or "exemplary") (Figure 14). Though the ratings for the evapotranspiration reports appeared to be rated less favorably than the other features, 68.6% of respondents selected “not applicable” suggesting that they either were unfamiliar or had limited engagement with these data analysis reports.

Figure 14. Participants’ Ratings of New CoCoRaHS Data Analysis Tools



Feedback on open-ended survey items further elucidated CoCoRaHS participants’ reactions to the data visualization and analysis tools. Though the data visualization and analysis tools were well received by CoCoRaHS observers, they offered suggestions for further improvement (Figure 15).

Figure 15. Respondents Suggestions for Improving Data Analysis Features



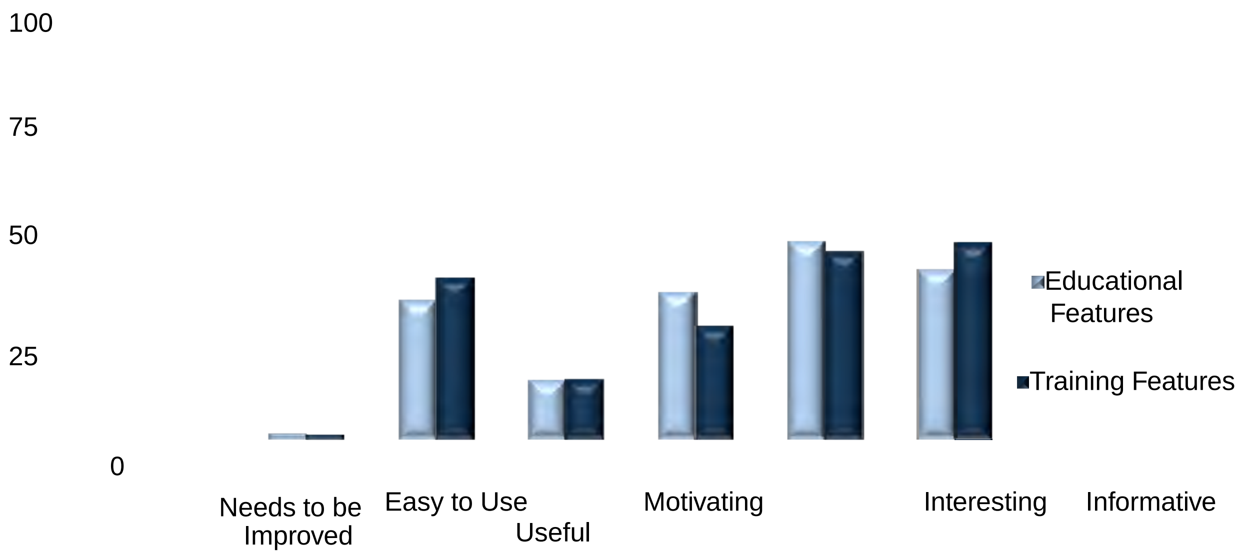
Overall, CoCoRaHS participants had positive reactions to new data analysis features (e.g., Water Year Summaries, the PRISM Portal, data visualizations) and indicated various levels of engagement with these resources.

Education and Training Resources. To address the goal of preparing CoCoRaHS volunteers as research partners, a variety of training and education materials were developed and implemented. The resources included trainings for observers as well as education materials related to climate education. This section focuses on formative feedback provided by participants that highlight their reactions to these education and training materials.

On the Spring 2014 survey, CoCoRaHS volunteers were asked to specify their use of the education and training resources. Survey respondents indicated various levels of engagement with the education and training resources developed and implemented on both the CoCoRaHS website and YouTube page. Nearly half of survey respondents (46.7%) suggested that they did not participate in any education or training features over the last year. On the other hand, 35.4% indicated they viewed a training slide show, 32.8% viewed a training video, 25.4% viewed an education animation, 7.7% attended a live webinar, and 10.1% viewed an archived webinar.

Figure 16 highlights findings related to survey respondents' ratings of these education and training materials. As depicted in the graph, respondents overall rated the education and training resources satisfactorily. Slightly more than a quarter of respondents selected "N/A" suggesting they had not engaged with these features. However, of the respondents who had utilized these resources, indicated the education and training features were "easy to use," "motivating," "interesting," or "useful." Only 1% indicated the features "need to be improved."

Figure 16. Participants' Ratings of Education and Training Materials



The Spring 2014 survey asked participants to rate the quality of each education and training feature. Across all of the education and training features, a high percentage of respondents (40-65%) selected "N/A" which suggests that they had not used these CoCoRaHS features (Figure 16). This finding was corroborated by the qualitative data collected through open-ended survey items and focus group discussions. For instance, one CoCoRaHS volunteer stated, "*I don't use [the resources] much. I generally just enter my info and check national maps. I don't think I've done any animations, nor the portal.*" This points to a need for both better advertising of the education and training features as well as gaining additional input regarding the interests and needs of CoCoRaHS audiences to further develop and improve these resources. Nearly all of the respondents who indicated that they had utilized the resources rated the slideshow training, online videos, and education animations positively (i.e., “good,” “very good,” or “exemplary”) (Figure 17). The webinars were rated the least positively as compared to the other resources.

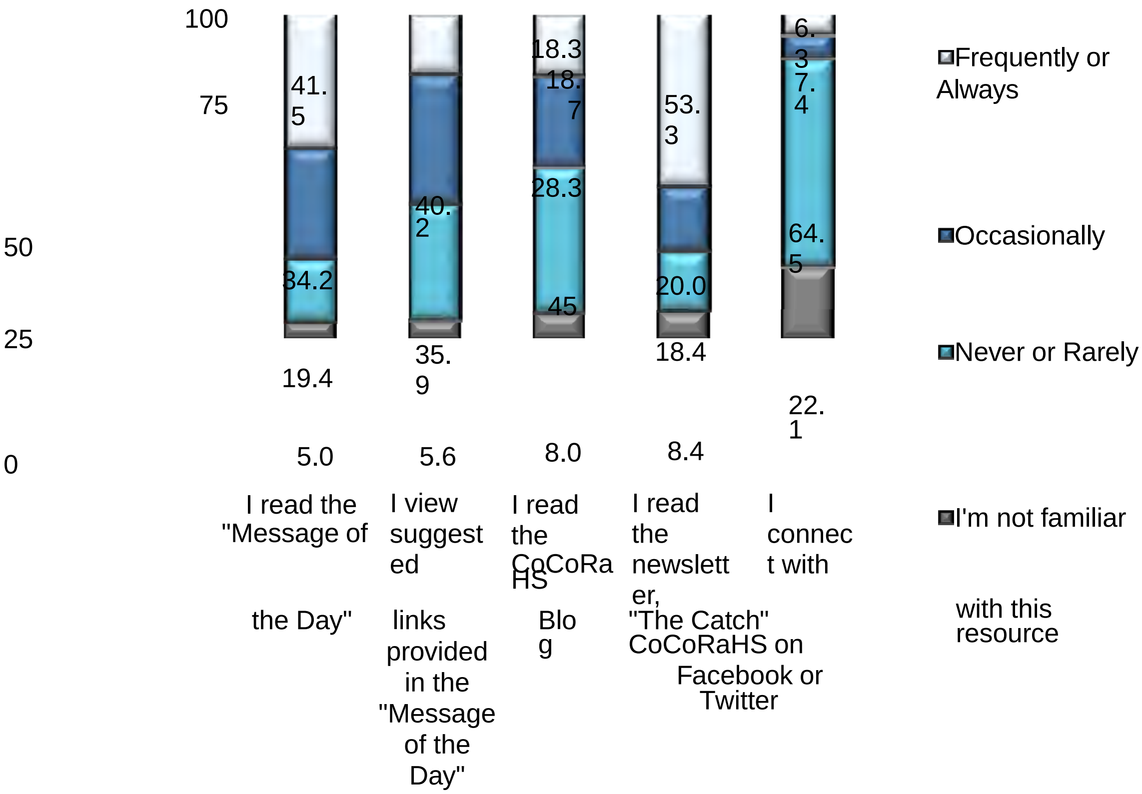
Figure 17. Participants’ Ratings of Specific Education and Training Materials

While to some extent respondents indicated low engagement with education and training features, those who had used the resources generally rated them favorably. Respondents indicated that the slideshows, videos, webinars and animations were “good,” “very good,” or “exemplary” suggesting that participants’ reactions were generally positive.

Disseminating Results. The grant also sought to disseminate results through currently employed strategies as well as by taking advantage of social media (e.g., Facebook, Twitter, YouTube). In particular, CoCoRaHS sought to disseminate information and results through a *Message of the Day* email, CoCoRaHS Blog, *The Catch* newsletter, Facebook and Twitter.

Figure 17 visually displays findings from the 2014 Spring survey related to various CoCoRaHS dissemination strategies. With the exception of CoCoRaHS on Facebook and Twitter, it appears that most of the respondents were familiar with these dissemination methods; only 5-8% of participants selected, “I’m not familiar with this resource” on the survey. On the other hand, about a quarter of participants noted that they were not aware of CoCoRaHS on Facebook or Twitter. Those who were familiar with the resources noted different levels of engagement. Respondents most often read the *Message of the Day* and explored links and websites provided. Similarly, most respondents indicated they “occasionally,” “frequently,” or “always” read Nolan’s newsletter, *The Catch.* Facebook and Twitter were used the least often; 64.5% of respondents indicated they “never” ‘almost never”, or “rarely” connected with this resource (Figure 18).

Figure 18. Participants' Engagement with CoCoRaHS Dissemination Methods



Respondents' ratings of these dissemination methods were generally positive (Table 5). Most of the dissemination strategies were generally rated "good" or "very good"; however, ratings for the Facebook page and Twitter account were the lowest, likely due to respondents indicating they were unfamiliar with these resources.

Table 5: Ratings of CoCoRaHS Dissemination Methods

	Needs to be Improved	Fair	Good	Very Good	Exemplary
"Message of the Day"	0.4%	4.1%	29.9%	6.3%	23.2%
CoCoRaHS Blog	0.5%	4.3%	19.8%	19.6%	5.6%
"The Catch"	0.4%	2.7%	17.8%	34.4%	22.5%
CoCoRaHS Facebook page or Twitter Account	1.4%	3.3%	8.8%	10.1%	3.3%

Comments on the open-ended survey items and in response to the focus group discussion questions suggested only one area for improvement related to the dissemination strategies. In particular, respondents would like more opportunities to connect with other CoCoRaHS observers and felt that some of the dissemination tools might afford opportunities for interaction. One survey respondent requested, "*a way to communicate with other observers"* and another respondent suggested a way to create dialogue between CoCoRaHS volunteers would be to allow "*people to comment on the blog and message of the day."*

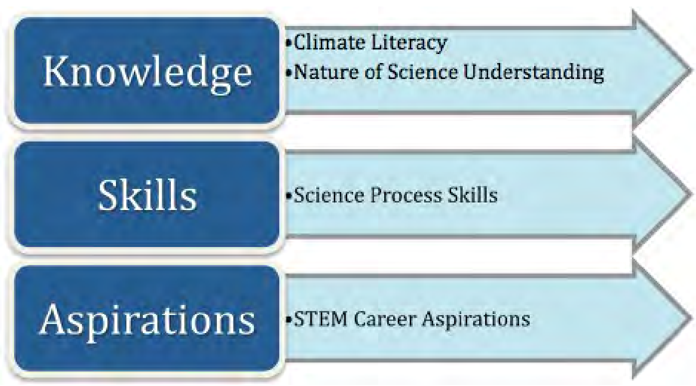
The dissemination methods seemed to be well received by respondents as highlighted by their ratings of features such as the *Message of the Day, CoCoRaHS Blog,* and *The Catch* newsletter. CoCoRaHS survey respondents suggested that they at least "occasionally" made use of these resources, with the exception of the Facebook page and Twitter accounts. However, many respondents indicated that they were unfamiliar with the Facebook page and Twitter account and rarely engaged with these resources.

Summary. At the reaction assessment level, participants appeared satisfied with the grant deliverables for the NOAA project and indicated various levels of engagement. Survey and focus group respondents suggested they engaged with most of the activities and resources that resulted from the project and they generally provided positive ratings for each. This provides evidence that the CoCoRaHS team was successful at meeting objectives and goals identified in the grant.

KASA

The next assessment level in the top evaluation model includes the knowledge, attitudes, skills and aspirations (KASA) of participants that result from the project. This level of assessment was measured through summative data collected as part of the evaluation study. Figure 19 highlights the specific knowledge, skills and aspirations that were measured for this evaluation. In particular, respondents' climate literacy, nature of science understandings, science process skills and STEM career aspirations (for students) were measured through items on the surveys to gain insight regarding the outcomes and impacts of the CoCoRaHS NOAA grant project.

Figure 19. KASA Assessment Level



Knowledge: Climate Literacy. An overarching goal of the NOAA grant project was to improve participants' climate literacy. Climate literacy was measured using a survey that contained Likert-scale questions designed to align with NOAA's Climate Literacy Principles[5]. These principles can be accessed at the following web address:
http://cpo.noaa.gov/sites/cpo/Documents/pdf/ClimateLiteracyPoster-8_5x11_Final4-11.pdf

The survey was administered to new CoCoRaHS registrants in April and May of 2012 to measure participants' Climate Literacy before participating in the project. A second, post-survey was administered a year later during April through June of the following year in 2013. Participants' responses to survey items were matched and DHA conducted paired sample t-tests to make inferences regarding the influence of CoCoRaHS participation on gains in observers' Climate Literacy. Overall, there were no statistically significant changes in participants' Climate Literacy as a result of one year participating in CoCoRaHS. However, there were numerous positive, small gains on several Climate Literacy items (e.g., "*An inland location has greater annual and daily temperature ranges than coastal locations*") and the few negative changes noted in the table were minimal.

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[5] This survey was developed by a doctoral student at Monmouth University for a pilot study and was not developed by the
DHA evaluator or CoCoRaHS project leadership.

One interpretation of these findings is that participants choosing to engage with CoCoRaHS likely have an interest in weather and climate and may start with a general understanding of Climate Literacy principles. This was supported by the data collected in the survey; for 18 out of the 26 items on the pre-survey, participants had views that already tended to align with the climate literacy guiding principles. Another interpretation is that one-year is not enough time for substantial changes in participants' Climate Literacy.

Knowledge: Nature of Science Understanding. Similar to the Climate Literacy outcomes, participants' Nature of Science views were measured using a survey that contained Likert-scale questions and administered to new registrants during the spring of 2012 and again in 2013 following one-year of engagement in CoCoRaHS. The survey questions were designed to measure the following Nature of Science concepts:

- Scientific knowledge is tentative;
- Scientific knowledge is the product of observation and inference;
- There is no single, universal step-by-step scientific method that captures the complexity of the scientific process. Scientists use many methods to develop knowledge;
- Science is empirical and evidence-based;
- Scientific laws and theories are different kinds of knowledge.

Responses on the two surveys were matched and DHA conducted paired samples t-tests to identify any changes in participants' Nature of Science views that resulted from one-year of participation in CoCoRaHS. Table 6 highlights findings from this analysis. With the exception of one item, no statistically significant changes were noted in participants' Nature of Science views. On the item, "*Science has one uniform way of conducting research called the scientific method,"* participants' responses significantly decreased from before to after one-year of participating in CoCoRaHS. This is a common misconception in the scientific community and likely could have been reinforced through limited engagement in the scientific process. That is, CoCoRaHS participants largely participate in data collection and analysis steps of the scientific process and are not necessarily involved in asking research questions, designing procedures, nor interpreting or drawing evidence-based conclusions. As such, their view that science follows a linear scientific method may have been confirmed through following step-by-step protocols for collecting precipitation data.

Table 6: Nature of Science Views

Survey Item	***Before CoCoRahS***	***After 1 year of Participating in CoCoRaHS***
Science produces only tentative conclusions that can change.	.22	.09
Science has one uniform way of conducting research called "the scientific method".	.06	-.15*
When being scientific, one must have faith only in what is justified by empirical evidence.	.09	-.06
Scientific theories are just ideas about how something works.	.15	-.03
An accepted scientific theory is a hypothesis that has been confirmed by considerable evidence and has endured	.66	.72
Scientists construct theories to guide further research.	.73	.71
Observations of the natural world are an important part of	.89	.92

* Indicates statistically significant at the .05 level (P < .05)

Overall, it appears that CoCoRaHS had a very minimal effect on participants' Nature of Science views. Engaging participants in all aspects of the scientific process (e.g., encouraging volunteers to ask their own questions and design their own investigations) may result in more significant, positive outcomes.

Skills: Science Process Skills. Padilla (1990) defines science process skills as the skills necessary to engage in the scientific process as well as skills for scientific and critical thinking. Science process skills refer to basic skills such as: observing, inferring, measuring, communicating, classifying and predicting. In addition, science process skills involve controlling variables, defining operational variables, formulating hypotheses, experimenting, interpreting data and developing models.
Science process skills outcomes that result from CoCoRaHS participation were measured at two levels including both outcomes for adult volunteer observers as well as the development of science process skills with K-12 students. As such, outcomes related to science process skills were measured for this evaluation study using items on both the Spring 2014 survey as well as items included on the K-12 teacher survey.

A survey item included on the Spring 2014 survey asked participants to rate their level of understanding about the scientific process both before and after their participation in CoCoRaHS. Half of respondents (50.7%) believed they had a "high" or "very high" understanding of the scientific process before CoCoRaHS; on the same survey question, 63.6% of respondents noted that their understanding of the scientific process increased as a result of engaging in CoCoRaHS activities. Results from an independent samples t-test suggested that this change was statistically significant. Related to specific science process skills, 66.8% of respondents "agreed" or "strongly agreed" that participation increased their data collection skills while 55.8% "agreed" or "strongly agreed" that participation improved their data analysis skills.

Likewise, K-12 educators believed that engaging students in CoCoRaHS activities resulted in gains related to science process skills. In fact, more than 85% of educators who responded to the K-12 educator survey had "moderate" or "high" expectations that CoCoRaHS would increase students' skills in collecting data, analyzing data, interpreting data, and drawing evidence-based conclusions. Nearly two-thirds (72.7%) of K-12 educators "agreed" or "strongly agreed" that CoCoRaHS contributed to their students' understanding of the scientific process while almost 90% of K-12 educators "agreed" or "strongly agreed" that their students learned the importance of making accurate measurements. Findings from the Spring 2014 and K-12 Educators Survey provide strong evidence that adult and student participants' science process skills increased as a result of engagement in CoCoRaHS data collection activities.

An open-ended item on the Spring 2014 survey prompted respondents to identify what they learned as a result of participating in CoCoRaHS. Table 7 highlights themes that emerged from DHA's analysis of responses to this survey question. These comments further highlight the gains in participants' science process skills and provide a more detailed understanding of the outcomes that result from engagement in CoCoRaHS data collection and analysis activities.

Table 7: Ways that CoCoRaHS Develops Participants' Science Process Skills

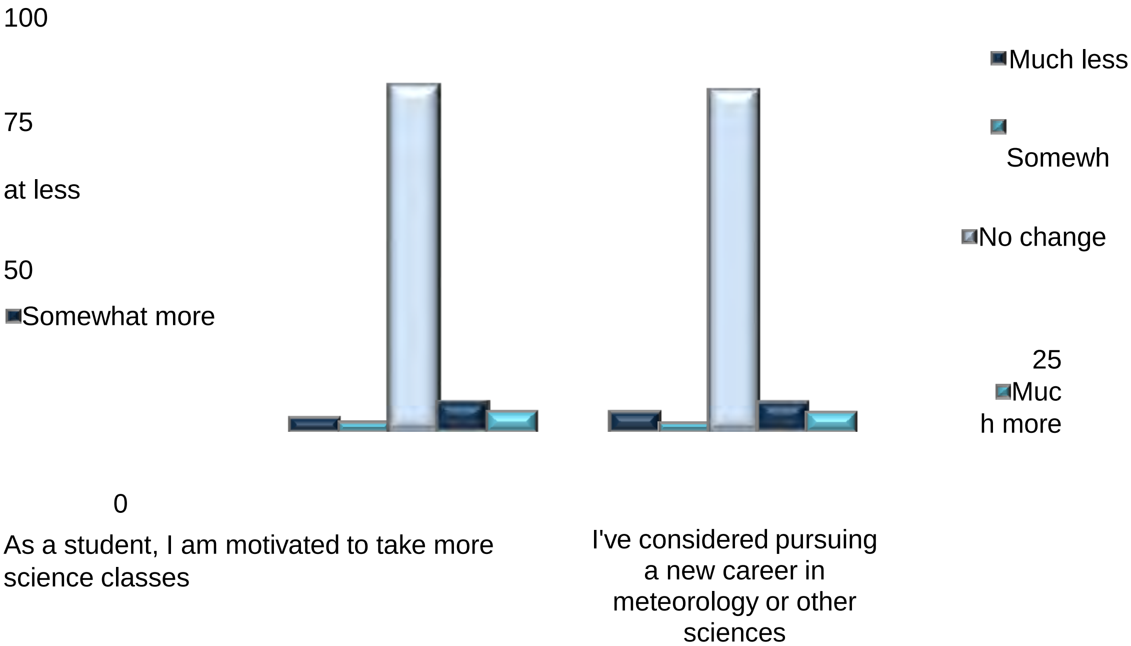
ta Collection Methods for easuring Different Kinds of Precipitation	***"I learned [methods] for how to measure rain, snow, and sleet." "[I learned] how to measure water content of snow." "[I learned] how snow moisture is calculated."***
Importance of Standardized Protocols	***"[I learned] that without a standard procedure, snowfall data is difficult to collect." "Daily readings at the same specific time are important."***
Variability of ecipitation Data	***"I have learned that precipitation is quite variable, even on the local level."***
Accuracy and Precision of Data Measurements	***"Locating the gauge away form buildings and trees is critical for consistent, reliable measurements."***

It is important to note that the findings from Spring 2014 survey and the K-12 Educators survey from 2013 point specifically to science process skills related to precipitation measurements and data collection. There was less of an increase in participants' perceptions of their data analysis skills and few survey respondents indicated gains related to data analysis on the open-ended survey item. This points to an area for continued improvement; that is, volunteer observers might benefit from more training and education resources related to data analysis as well as greater opportunities to engage in data analysis activities.

Aspirations: Students' STEM Career Aspirations. A series of survey items on the K-12 Educator Survey administered during the Fall of 2013 as well as the Spring 2014 survey intended to measure any changes in students' STEM career aspirations as a result of participating in CoCoRaHS activities. When asked to indicate motivations for engaging in CoCoRaHS education activities on the K-12 educators survey, 71% of educators indicated that they had "moderate" or "strong" expectations that students would increase their awareness of potential weather and climate related careers. Roughly two-thirds (76.8%) of the educators who responded on the survey suggested they had a "moderate" or "strong" expectation that students would increase their interest in pursuing STEM careers.

On the Spring 2014, a survey item prompted respondents, including K-12 and college students, to indicate outcomes and changes that have resulted from engagement in various CoCoRaHS activities. Figure 20 highlights findings related to respondents' STEM career aspirations. CoCoRaHS appeared to have a minimal influence on participants' interest in science and career aspirations. Most respondents (roughly 82%) selected "no change" when asked how participation in CoCoRaHS changed their motivation to take more science classes or pursue a new career in meteorology or other science field.

Figure 20. Respondents' STEM Career Aspirations



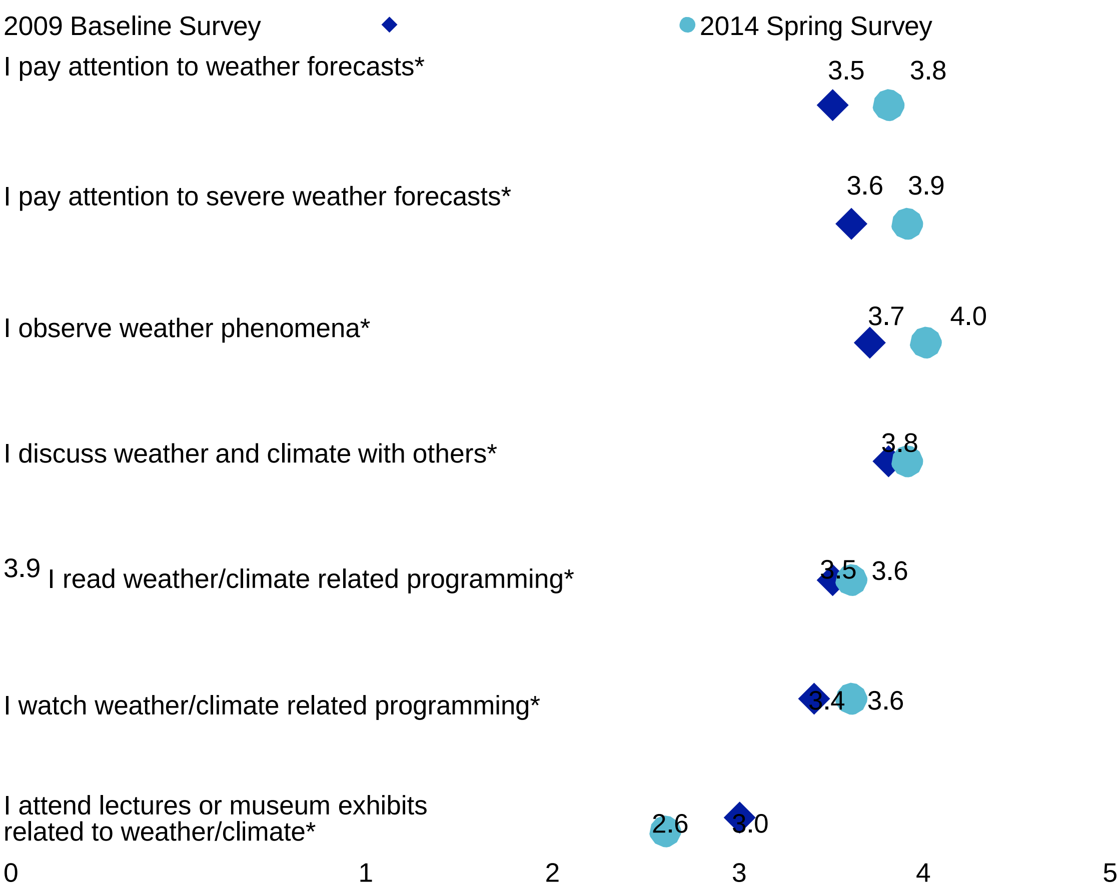
Summary. Findings related to the KASA assessment level were mixed; while some gains in participants' knowledge, skills and aspirations were noted, other predicted outcomes were limited. Increases in participants' Climate Literacy and Nature of Science views were either minimal or changed in an unanticipated direction. However, gains related to participants' science process skills were positive and significant as were students' STEM career aspirations. This demonstrates that overall, CoCoRaHS was successful in influencing participants' knowledge, skills and aspirations.

Practices

The practices level of assessment in the TOP evaluation model refers to changes in practice amongst participants that result as an outcome of engagement in a program or project. For the CoCoRaHS NOAA grant project, anticipated behavioral outcomes (represented in the CoCoRaHS Logic Model in Figure 2) primarily included increased levels of engagement in scientific activities, particularly for participants from diverse audiences. This outcome was evaluated both through Likert-scale items included on the survey instruments as well as participants' responses to open-ended questions. Survey items measured participants' engagement in science activities such as watching weather forecasts, observing weather phenomena, reading and watching climate/weather related programming, discussing weather and/or climate content with others, and attending lectures or museum exhibits focused on weather and/or climate topics.

To understand the influence of CoCoRaHS on volunteers' engagement in science, DHA conducted an independent samples t-test to note differences in responses on the 2009 Baseline survey as compared to the 2014 Spring survey. Figure 21 displays findings for survey items related to participants' engagement in science activities. For all of the items, statistically significant changes resulted over the duration of the grant project. Nearly all of the items demonstrated positive increases in participants' engagement in science activities. However, for one item, "*I attend lectures or museum exhibits related to weather/climate,"* negative changes resulted.

Figure 21. Differences in Participants' Engagement in Science Activities from the Baseline to Spring 2014 Survey



A specific goal of the project was to increase engagement in science for new audiences including younger audiences, females, and groups historically underrepresented in STEM fields. Tables 8 and 9 display findings related to science engagement for new CoCoRaHS audience groups.

Table 8: Differences in Science Engagement by Age Groups

As a result of participating in CoCoRaHS, how have the following changed?	*Younger than 55*	*Over 55*	*Mean Differenc*
I pay attention to weather forecasts	3.7	3.8	0.1*
I pay attention to severe weather forecasts	3.8	3.9	0.1*
I observe weather phenomena	3.9	4.0	0.1
I discuss weather and climate with others	3.9	3.9	0.0
I read weather/climate related programming	3.6	3.6	0.0
I watch weather/climate related programming	3.6	3.6	0.0
I attend lectures or museum exhibits related to	2.8	2.5	0.3*
I seek out climate/weather related web applications	3.2	2.8	0.4*
I talk to others about my participation in CoCoRaHS	3.9	3.9	0.0
I teach others about precipitation, weather, and/or climate	3.5	3.0	0.5*

* Indicates statistically significant at the .01 level (P < .01)

Findings related to engagement in science activities by age demonstrated minimal influences on younger audiences. The results of an independent samples t-test suggested that on a majority of items, there was either no statistically significant difference by age or older audiences were more engaged in the activities (e.g., "*I pay attention to weather forecasts,"* and *"I pay attention to severe weather forecasts"*). There were only three items in which younger audiences were more engaged (e.g., *"I attend lectures or museum exhibits related to weather/climate;" "I seek out climate/weather related web applications;"* and *"I teach others about precipitation, weather, and/or climate")* (Table 8).

Table 9. Differences in Science Engagement by Gender

As a result of participating in CoCoRaHS, how have the following changed?	*Male*	*Female*	*Mean Differenc*
I pay attention to weather forecasts	3.7	3.9	0.2*
I pay attention to severe weather forecasts	3.9	4.0	0.1*
I observe weather phenomena	3.9	4.1	0.2*
I discuss weather and climate with others	3.9	4.0	0.1*
I read weather/climate related programming	3.5	3.6	0.1*
I watch weather/climate related programming	3.6	3.7	0.1*
I attend lectures or museum exhibits related to	2.6	2.5	0.1!
I seek out climate/weather related web applications	2.9	2.7	0.2*
I talk to others about my participation in CoCoRaHS	3.9	4.0	0.1*
I teach others about precipitation, weather, and/or climate	3.1	3.2	0.1

* Indicates statistically significant at the .01 level (P < .01)
! Indicates statistically significant at the .05 level (P < .05)

A few differences due to gender were noted in relation to respondents' engagement in science activities (Table 9). On eight out of the ten survey items, females indicated greater levels of engagement compared to males. Most of these differences were found to be statistically significant. However, females were less engaged than males for the following activities: "*I attend lectures or museum exhibits related to weather/climate"* and *"I seek out weather/climate related web applications."*

The results of a one-way ANOVA suggested that there were only two statistically significant differences in engagement due to race/ethnicity; participants who indicated they were from an underrepresented group (e.g., Black, Hispanic/Latino(a), Native American) were significantly more likely to pay attention to severe weather forecasts and take more science classes.

Summary. The CoCoRaHS logic model predicted practices/behavior outcomes particularly related to changes in participants' level of engagement in science activities. There was evidence to suggest that the project was successful in influencing participants' practices and behavior, particularly with regard to increased engagement in weather and climate science activities.

Conclusions and Recommendations

Findings from the evaluation data collected by DHA indicated that overall, the CoCoRaHS NOAA ELG grant deliverables and activities were implemented successfully and effectively over the grant funding period. Formative feedback collected from CoCoRaHS Network participants led DHA to conclude that the project was implemented with quality and was generally well received. The TOP Evaluation model (Bennett & Rockwell, 1995; NRC, 2010) is used here as an organizing principle to structure conclusions regarding the implementation of the program and resulting outcomes and impacts. The conclusions address each of the assessment levels identified in the TOP model.

Resources

- Satisfactory resources were present in the various grant deliverables and activities to achieve identified aims and project goals.

Activities and Participation

- The activities exceeded the project goals. CoCoRaHS successfully implemented grant deliverables in alignment with the project goals; and
- At the participation level, the project achieved limited success. While the CoCoRaHS network has grown steadily and consistently over time, there were not significant gains in recruiting more diverse audiences.

Reactions

- At the reactions level, formative evaluation feedback indicated high levels of engagement in CoCoRaHS activities and these activities were generally well received by participants;
- The resources and activities implemented as a result of this grant were rated highly by participants with only minor and idiosyncratic suggestions for improvement offered.

Knowledge, Attitudes, Skills and Aspirations (KASA)

- The outcomes of KASA (knowledge, skills, and aspirations) showed that for skills and aspirations, the CoCoRaHS project evidenced much success. There were significant postive changes in participants' science process skills and career aspirations;
- For the "knowledge" outcome, the evidence was not as conclusive with very little positive evidence and a few negative outcomes on participants' responses to survey items. In general, there was limited evidence to suggest that one-year of participating in CoCoRaHS resulted in gains in Climate Literacy or Nature of Science views.

Practices/Behaviors

- The practices/behaviors level was measured using pre-post survey instruments to measure outcomes related to participants' engagement in various science activities (including a particular focus on weather and climate activities).

The findings from DHA's evaluation study show evidence of various outcomes and impacts in alignment with the assessment levels identified in the TOP evaluation model (Bennett & Rockwell, 1995; NRC, 2010). While the NOAA ELG grant project on the whole was successful, input collected from CoCoRaHS Network participants through various evaluation measures indicated that there were areas for continued improvement. Survey respondents and focus group participants offered a number of specific suggestions for improving the CoCoRaHS Network. Based on compilation and analysis of the evaluation data, DHA offers the following recommendations:

1. Continue to build on the success of the CoCoRaHS Network.

Over the past few years, the general approach of the CoCoRaHS leadership and project team has been highly effective in developing and supporting a precipitation database for use by (but not limited to) scientists, resource managers, farmers, engineers, hydrologists, and educators. In just a few years, CoCoRaHS grew from 15,000 in 2010 to over 18,000 volunteers in 2014 during the duration of the NOAA grant. Volunteer observers who participated in evaluation data collection activities indicated moderate to high levels of engagement in CoCoRaHS precipitation measurements and associated activities. These respondents also positively rated the CoCoRaHS activities and related materials and resources. In general, CoCoRaHS has demonstrated much success and the findings from this evaluation study provide evidence to support this assertion. DHA recommends continuing to build on this success through continued recruitment efforts and maintaining high quality materials and resources. Additionally, consider new and novel ways for volunteer observers to engage in CoCoRaHS as a means to hold the interest of and retain participants (e.g., engage participants in new aspects of the scientific process; encourage participants to develop their own scientific investigations and share findings through new features on the CoCoRaHS website; provide ways for volunteers to interact with one another; develop and implement new education resources).

2. Continue using a variety of recruitment strategies to maintain and expand the CoCoRaHS Network.

Since its conception in the spring of 1998, CoCoRaHS has demonstrated great success in recruiting and engaging a network of volunteers. Over the years, CoCoRaHS has grown to a network of 18,000 active volunteers who collect, submit, and analyze precipitation data. New registrant data has demonstrated a steady increase each year, as illustrated in Figure 5. In the four years since receiving the grant, CoCoRaHS recruited an additional 5,000 volunteer observers. DHA recommends continuing with the recruitment strategies employed to date (e.g., March Madness recruitment event, state and regional coordinators) while also considering additional new methods for recruiting a more diverse audience (e.g., establish new partnerships with individuals and organizations in the community; host or participate in family science nights; translate materials to Spanish; implement culturally relevant activities and learning opportunities).

3. Collect demographic information from new CoCoRaHS observers.

As a means to further document demographic characteristics of CoCoRaHS observers while also measuring the success of recruiting a more diverse audience, consider prompting new volunteers for information on the “Join CoCoRaHS” registration form. Specifically, consider prompting new registrants to provide demographic information including their age, gender, racial and ethnic background, as well as their education level. For this evaluation report, DHA relied heavily on survey responses to document any changes related to the recruitment of a more diverse audience. However, findings related to this evaluation objective are limited by the sample of CoCoRaHS volunteers who elected to respond to the survey. Though this may be reflective of the larger CoCoRaHS population, the survey appeared to be overly represented by older, male volunteers who are highly engaged in the data collection activities. A more valid and reliable method for documenting changes would be to rely on registration data of new volunteers to document changes in audience demographics over time.

4. Offer opportunities for volunteers to connect and interact with one another.

The feedback provided during focus group discussions and in response to open-ended items on the survey suggested that participants would like opportunities to interact with one another. With new technologies emerging, there are a variety of methods for synchronous and asynchronous interactions between CoCoRaHS volunteers. For instance, CoCoRaHS could host Google Hangout meetings or create a discussion board available on the main page of the website which could be organized into various forums with different topics. Another strategy would be to encourage local coordinators to organize state and regional meet-ups and social events where CoCoRaHS volunteers could meet and interact. These strategies for encouraging interactions between volunteers might additionally serve as a means to retain volunteers by offering new and novel experiences.

5. Gather additional feedback and input regarding CoCoRaHS social media resources.

The findings from the survey suggested that respondents were unfamiliar with the CoCoRaHS social media resources (e.g., Facebook page, Twitter account). Further, many respondents indicated low engagement with these resources. DHA recommends better advertising these features to increase awareness of the Facebook page and Twitter account among volunteers. Another useful step would be to collect formative data specifically focused on these resources to provide a more detailed understanding of why CoCoRaHS volunteers are not accessing and using the Facebook page and Twitter account. Additional feedback regarding what would motivate participants to use these resources might further increase engagement.

6. Provide tools and activities to further develop volunteers' data analysis skills.

Roughly two-thirds of respondents suggested that engaging in CoCoRaHS increased their data collection skills; however, only half of respondents believed their skills in data analysis improved. This points to an area for continued improvement. Volunteers might benefit from more guidance on how to analyze data through resources such as training slideshows and videos. Another recommendation is related to motivations to engage in data analysis activities. While the data collection is submitted and shared through CoCoRaHS to develop a precipitation database, data analysis appears to be largely at the individual level and not necessarily shared with others. Volunteers might be more motivated to engage in these data analysis activities if there were greater opportunities to engage in analysis in ways that supports the project.

7. Find strategies for introducing students to STEM-related careers.

While the data collected provided some evidence that participants, especially students, were introduced to STEM careers, a majority of participants indicated "no change" when asked how CoCoRaHS influenced their decision to pursue a STEM career. While one interpretation of this finding is that students interested in a STEM career may seek out opportunities to be involved in data collection through projects such as CoCoRaHS — suggesting they already have an interest in a STEM career and would not change as a result of participation — there is also reason to believe that only limited changes would result without a focused effort to feature STEM careers. If this is a goal of CoCoRaHS, DHA recommends taking strategies to more explicitly introduce students to STEM careers (e.g., provide Skype sessions to classrooms where scientists serve as guest speakers to discuss their careers; periodically featuring meteorologists and/or climatologists on the CoCoRaHS website or Facebook page, with a particular focus on those historically underrepresented in STEM fields; developing new videos on the YouTube page that explore various weather and climate related STEM careers).

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Appendix A: Focus Group Discussion Guide

CoCoRaHS'Teacher'Participants!! !

! Focus!Group!Discussion!Guide'

'

Teacher'Participants' Focus'Group'Discussion'Guide'

Date:!Thursday,!May!1st!!

'

Location:!Climate!Center,!Colorado!State!University!

!

Introduction'

Briefly!make!the!following!points:!

- Explain!the!nature!of!the!project!
- DHA!contracted!by!the!CoCoRaHS!project!leaders!to!evaluate!the!program.!!I! am!not!an!employee!of!either!CoCoRaHS!or!Colorado!State!University.!!DHA!is! conducting!an!evaluation!to!learn!more!about!how!teachers!use!the!website! and!education!materials!as!well!as!how!they!engage!with!the!project!with! students.!
- Discuss!informed!consent;!confidentiality!will!be!protected!to!the!extent! possible!and!individual!names!will!not!be!used!in!reporting!
- The!conversation!will!be!recorded!and!notes!will!be!taken!during!the!focus! group!to!capture!participants'!comments!and!ideas!
- Mention!that!we!are!looking!for!participants'!input!and!opinions;!there!are! no!right/wrong!answers!
- We!are!not!seeking!consensus;!everyone!has!different!backgrounds!as!well!as! experiences!and!some!disagreement!is!expected!
- Speak!one!at!a!time;!no!need!to!raise!hands!
- May!call!on!individual!people!in!an!effort!to!hear!everyone's!perspective!

!

First,'let's'start'by'talking'about'your'background'and'teaching'position.'

Please!state!your!name.!Where!do!you!teach?!What!grade!level!and!content!do!you! teach?!!

!

I'would'like'to'learn'more'about'your'involvement'with'CoCoRaHS.'

How!did!you!learn!about!the!CoCoRaHS!project!and/or!website?!

! Why!did!you!decide!to!participate!in!the!K`12!CoCoRaHS!program!with!your! students?!

What!were!your!expectations!for!participating!in!the!CoCoRaHS!program!with!your! students?!To!what!extent!were!your!expectations!met?!

In!what!ways,!if!at!all,!have!you!participated!in!the!K`12!CoCoRaHS!program!with! your!students?!

If!you!haven't!participated!in!CoCoRaHS!with!students,!why!not?!

CoCoRaHS|!Teacher!Participants!Focus!Group!Discussion!Guide!

Prepared!by!David!Heil!&!Associates,!Inc.!|!4614!SW!Kelly!Ave.,!Suite!100,!Portland, !Oregon!97239!

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CoCoRaHS'Teacher'Participants!! !

! Focus!Group!Discussion!Guide'

!

Have!you!accessed!and/or!used!any!of!the!education!resources/tools!on!the! CoCoRaHS!website?!!

What!resources!and/or!tools!from!the!CoCoRaHS!education!site!have!been!the!most! useful!or!helpful!to!you!this!year?!Why?!

! To!what!extent,!if!at!all,!have!you!implemented!or!used!these!resources/tools?! (Refer!to!short!survey!completed).!!

If!you!haven't!used!any!of!the!resources!or!tools!yet,!why!not?!

Now,'let's'discuss'the'potential'benefits'and'outcomes'of'the'program.'

If!you!have!participated!in!the!CoCoRaHS!program!with!your!students,!what!do!you! believe!have!been!the!benefits!or!outcomes!of!participating!(for!you!and/or! students)?!

To!what!extent,!if!at!all,!do!you!feel!that!the!CoCoRaHS!education!program!aligns! with!standards?!

I'would'like'to'gather'some'input'regarding'suggestions'and/or'areas'for' improvement'of'the'program."

What!do!you!believe!could!be!improved!about!the!program!to!assist!you!or!other! teachers!in!participating!in!CoCoRaHS!with!students?!

Other'Ideas,'Concerns,'Questions?'

Are!there!any!other!ideas!or!concerns!you!wish!to!share?!!

'

'

Be'sure'to'turn'in'your'survey'forms'in'exchange'for'your'gift'card."This'is'a'small' token'of'our'appreciation'for'your'participation'in'this'discussion."Thanks!!

'

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Prepared!by!David!Heil!&!Associates,!Inc.!|!4614!SW!Kelly!Ave.,!Suite!100,!Portland, !Oregon!97239!
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Prepared for the Community Collaborative Rain, Hail, & Snow Network

Appendix B: Project Team Interview Protocol

Community)Collaborative)Rain,)Hail,)Snow)Network)(CoCoRaHS))

!

Project!Leadership!Interview!Protoc
ol)

)**CoCoRaHS)Project)Leadership)Interview)Protocol)**

)

Date:)April)30th)&)May)1st)2014)

Location:)Climate)Center)at)Colorado)State)University)

)

Briefly!make!the!following!points:!

- Thank!you!for!participating!
- Explain!the!nature!of!the!project,!DHA!is!a!collaborator!to!conduct!evaluation!
- Interview!will!center!on!successes!of!the!program!as!well!as!lessons!learned!
- Consent!&!confidentiality,!interview!will!last!approximately!30:45!minutes!
- Permission!to!record!

!

First,'let's'start'by'talking'about'your'background'and'involvement'in'the'CoCoRaHS'project.'

1.!Please!state!your!name!and!your!specific!role!with!CoCoRaHS.!

2.!How!long!have!you,!personally,!been!involved!with!the!CoCoRaHS!project?!

I'would'like'to'discuss'the'objectives'of'the'CoCoRaHS'NOAA'and'NSF'grants'and'the'extent'to'which' you'believe'they've'been'met."

1.!What!were!the!main!objectives!or!goals!of!the!NOAA!grant!and!to!what!extent!do!you!think! these!objectives/goals!have!been!met?!

2.!What!were!the!main!objectives!or!goals!of!the!NSF!grant!and!to!what!extent!do!you!think!these! objectives/goals!have!been!met?!

Let's'talk'about'successes'of'the'project'as'well'as'challenges'and'areas'for'continued'improvement'of' the'CoCoRaHS'program.'

1.!What!do!you!believe!have!been!the!greatest!successes!of!the!CoCoRaHS!projects?!

2.!What!do!you!think!have!been!the!greatest!challenges!of!the!project?!

3.!What!have!you!through!CoCoRaHS!that!might!inform!other!Citizen!Science!projects?!

4.!What!areas!can!you!identify!for!continued!improvement!of!the!CoCoRaHS!program/website?!

Now'let's'talk'specifically'about'your'role'with'CoCoRaHS."

1.!As!the!_______________!of!CoCoRaHS,!what!have!been!your!greatest!successes?!Biggest!challenges?!

2.!What!lessons!have!you!learned!through!the!process!of!implementing!the!NOAA/NSF!grant! objectives!and!deliverables?!

3.!Describe!any!new!and/or!future!CoCoRaHS!initiatives.!

Other'Ideas,'Concerns,'Questions?'

1.!!Are!there!any!other!ideas!or!thoughts!you!wish!to!share?!

CoCoRaHS!|End:of:Grant!Interviews!|!Project!Leadership!Interview!Protocol!
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– Briefly describe any new partnerships that have been formed as part of, or as a result of, your project during the past six months. Please list each new partner by name. (You may add additional rows to the table as needed.)
Note: you do not need to list partners that were included in your original project narrative or listed in previous progress reports

Name of New Partner	**Role of New Partner in Project**
Denver Botanical Gardens	Already an active rainfall monitoring site, the Gardens will be utilizing CoCoRaHS recruiting information and data visualizations for their 'Science Pyramid' exhibit opening in November, 2014
Front Range Teen Science Café (here in Colorado)	An opportunity for local teens to meet and interact with local scientists, CoCoRaHS education coordinator is attending meetings and is working to be a speaker at an upcoming meeting.
NASA Global Precipitation Measurement Mission (GPM)	This was already a loose and informal partnership that we sought out (due to the obvious relevance) But now CoCoRaHS and GPM have planned a campaign to recruit volunteers in the area surrounding Wallops Island for a GPM ground-truth test (Calibration/Validation) with CoCoRaHS gauges alongside NASA tipping bucket gauges. Campaign is in planning stages now but may commence in November-December 2014.
West Greeley Conservation District (also, here in Colorado)	Planning stages for a student campaign /contest with prizes to see if 5th grade students in rural eastern Colorado can be enticed into participating.

– Indicate specific outputs produced during the period covered by this progress report (see definition of outputs below). Record your outputs in the table provided, selecting from the output type categories listed below the table. You may add additional rows to the table as needed. An example has been provided for you.

Note: the list of output types is still being refined. If you feel that one or more outputs from your project do not fit any of the suggested categories, please contact the NOAA Office of Education at oed.grants@noaa.gov or 202-482-0793

Outputs[1]: the immediate results of an action (e.g., services, events, and products) that document the extent of implementation of a particular activity. They are typically expressed numerically - e.g., the number of persons who visit a museum exhibit or listen to a radio program or the number who attend a series of professional development workshops, etc.

	Output type (see list)	**Number of outputs**	**Target Audience/ Participants**	**Number of users/ participants (total)**	**Average contact hours per participant (if applicable)**
Volunteer data collection	*Experiential activities – daily precipitation report, hail reports, significant weather reports, drought impact reports*	*1*	*CoCoRaHS trained volunteers*	*18,500 of which about 11,200 participate daily*	*2.5 hours per month per active volunteer for 6 months*
CoCoRaHS WxTalk Webinar Series	Web/Multidmedia (live and archived)	6	CoCoRaHS volunteer participants	814 live 1358 later	1.2
Presentations at meetings, and other professional conferences	Conference meetings	1	Professionals in meteorology/climatology	1	0.3
CoCoRaHS Water Cycle animation	Web/multimedia	1	CoCoRaHS volunteers and general YouTube public visitors	63,500 in past 6 months	0.1
CoCoRaHS Weather V. Climate	Web/multimedia	1	CoCoRaHS volunteers and general YouTube public visitors	5,760 views in past 6 months	.1
CoCoRaHS training animations	Web/multimedia	8	CoCoRaHS volunteers and potential volunteers	19,423 views total (based on YouTube hits)	0.1
PRISM precipitation	Data Access tool	1	Current participants in	2000 (est. based on	0.5 hours

analysis tool	development		CoCoRaHS	webhits)	
CoCoRaHS Social Media (FB/Blog/Twitter)	Web/multimedia		CoCoRaHS trained observers and general public	5,300 likes on Facebook, 3000 twitter followers. (conservative Estimate)	<0.1 hours per engagement
Water Year summary reports with 30-year climate normals	Data access tool development	1	CoCoRaHS participants	2500 (est)	0.2 hours
Water Balance Graphs and Drought Impact Reports	Data Access tool development	2	CoCoRaHS trained observers and general public	500 (est)	0.1 hour
Student and teacher outreach events	Experiential activity	6	Students and teachers	800	0.2

Notes/Comments: There are other events and outputs mentioned in the general narrative report not contained in this summary table.

Output types:

- Experiential activity (activities, trips, programs, measurement protocols)
- Exhibit installation (spheres, domes, panels, kiosks, stations, etc.)
- Professional development (sessions, workshops, webinars)
- Conference/Meeting
- Curriculum/a (lesson plans, units, modules, frameworks, standards)
- Web/Multimedia (websites, web 2.0 features, videos, broadcasts, podcasts, games, apps)
- Educational/Opinion Research (reports)
- Exhibit/Education Space Upgrade (equipment upgrades, structural upgrades, layout upgrades)
- Visualization (data visualizations, spherical display modules, etc.)
- Data access tool development (hardware packages, software packages)
- Network development (networks, network members, new partnerships)

[1]Adapted from the *Framework for Evaluating Impacts of Informal Science Education Projects Report from a National Science Foundation Workshop (p.35,* http://insci.org/resources/Eval_Framework.pdf*)*

– Indicate specific outcomes achieved during the period covered by this progress report (see definition below[1]). Record your outcomes in the table provided, selecting from the outcome type categories listed below the table. You may add additional rows to the table as needed. An example has been provided for you. **Note that outcomes are often determined through independent evaluation, and projects in their early stages may not yet have outcomes to report.**
Note: the list of outcome types is still being refined. If you feel that one or more outcomes from your project do not fit any of the suggested categories, please contact the NOAA Office of Education at oed.grants@noaa.gov or 202-482-0793

Outcomes[2]: the changes that show movement toward achieving ultimate goals and objectives - e.g., the number of persons who, as a result of their participation in a project, demonstrate changes in: awareness and knowledge of specific concepts and/or issues; interest in and/or attitudes toward certain issues, careers, or courses of action; and behavior or skills.

Outcome description	Outcome type (see list)	Activity/ Activities leading to the outcome	Target Audience/ Participants	How outcome was measured
The following table is largely unchanged from previous report				**More of the findings below are now also supported by the results of recent "participant Survey"**
5-year high quality nationwide precipitation data set	Knowledge, understanding	Keeping on keeping on		26 million daily precipitation records archived and accessible
CoCoRaHS is contributing to advances in weather, climate and water resources research	Knowledge, understanding	Long-time participation by large numbers of volunteers		Google scholar reveals a substantial and growing number of peer-reviewed scientific journal articles based at least in-part on CoCoRaHS-

				provided data
Older participants stick with CoCoRaHS for many years	Engagement	Recruiting, training	General public, CoCoRaHS volunteers	Evaluation results
A growing number of new volunteers are being recruited through Facebook, Twitter and other more traditional "word of mouth" methods	Engagement	Social networking emphasis and use of Web 2.0	General public New volunteers	Tracking "how did you find out about CoCoRaHS" on on-line volunteer application forms.
CoCoRaHS volunteers are staying engaged in data collection over multi-year periods and are participating many days of the year. A sizable fraction of participants try to report precipitation nearly every day of the year.	Engagement	Volunteer training, data entry, data viewing, data analysis and impact from multiple outreach and engagements activites	CoCoRaHS active participants	"CoCoRaHS activity report" provides statistics on duration and level of activity of all recruits and participants Many volunteers are in this for the long haul.
CoCoRaHS volunteers have become highly committed to sustaining the project	Engagement	2013 Year-end fundraiser	Current and past active and inactive volunteers.	Number and size of financial donations made by current and past CoCoRaHS volunteers
Topical "Webinars" are resulting in pursuit of greater knowledge by a significant number of volunteers	Awareness, knowledge, understanding	CoCoRaHS WxTalk Webinars	Current CoCoRaHS participants	Participant statistics from "GoToWebinar" and the results of exit surveys conducted after each event and outside evaluation report
CoCoRaHS is nationally and	Awareness, knowledge,	Long-term stability of the	Professional science	CoCoRaHS selected for

internationally recognized as a highly successful citizen science program	understanding	CoCoRaHS network	education community	2014 "Special Award" from the American Meteorological Society
Professional Organizations, including PRISM, the National Weather Service, the National Climatic Data Center and the National Drought Mitigation Center, routinely download and use CoCoRaHS data for scientific applications and broader dissemination	Awareness, Knowledge and Understanding Capacity	Volunteer training, data quality control, and the large number of consistent measurements provided by volunteers		Based on sustained and growing list of data export subscribers plus agency testimonies.
CoCoRaHS participants are becoming increasingly active in outreach and recruiting	Engagement	Volunteer recruiting	CoCoRaHS volunteers	Metadata are showing a growing number of new CoCoRaHS recruits are being recruited by our current pool of volunteers. Many generational (parent-child-grandchild and sibling) volunteers now
CoCoRaHS participants are likely to also participate in other Citizen Science endeavors	Engagement/intesest	Full participation in CoCoRaHS over time	CoCoRaHS active participants	We have been informed by the National Phenology Program, that some of their most effective recruiting is from our ranks of active CoCoRaHS volunteers
Young	Aspirations	Participation in	CoCoRaHS	We have

CoCoRaHS participants are seeking careers in science		CoCoRaHS as youth and/or family and/or school	active participants	documented a handful of college students or college graduates who participated in CoCoRaHS in their youth and are now prepared or preparing for careers. CoCoRaHS' roll may be incidental or significant – more followup would be required to confirm

Notes/Comments:

Over time, outcomes become more apparent – very satisfying

Outcome types:

- Awareness, knowledge, understanding
- Skills
- Engagement or interest
- Attitude
- Aspirations/Intention to act
- Behavior
- Societal or Environmental
- Capacity

[2]Adapted from the *Framework for Evaluating Impacts of Informal Science Education Projects Report from a National Science Foundation Workshop (p.35,* http://insci.org/resources/Eval_Framework.pdf*)*

– For this reporting period, provide a comparison of actual accomplishments and/or activities with those listed in the milestone chart from the approved project narrative in your application. (Please add additional rows to the milestone chart as needed)

Milestone Chart				
Task Activity	**Expected completion date from approved project narrative timeline**	**Expected completion date listed in previous progress report**	**Actual or current expected completion date**	**Explanation of any discrepancy**
We have maintained the same format for reporting guiding by the initial project milestone chart			**Not all of our original tasks were found to be of equal importance, so some changes in priority have evolved over the 4 years ot this project**	**We are now operating in year one of a no cost extension. An additional one year extension (to a total of five) has been requested**
Accept Data (CST) -Add support for Evapotranspiration	Sep 2011 - 2013		Completed	ET data collection is expanding gradually in 2014 – success but not the rousing success we initially hoped for
Accept Data (CST) - QC System	Sep 2011 - 2013		This will be a continuing "work in progress" throughout the project. Now that we are such a large provider of data to professional users, we could literally put two full time scientists/programmers to work on this task	With the volumes of data and the heavy use of CoCoRaHS information, we could put the entire budget to use on this endeavor. Our distributed manual approach to QC works but not uniformly across the country.
Accept Data (CST) - Implement development SQL Azure cloud database and evaluate the feasibility of the cloud for the reporting database	Sep 2011 - 2013		Completed –	We found that while cloud computing seemed to have advantages for CoCoRaHS, in the end a dedicated local database has proven to be cheaper and faster – both very important considerations.
Accept Data (CST) - Transactional reporting database in production	Sep 2011 - 2013		May not be needed	The separate reporting database has not been needed due to the performance gains by upgradeing the current database to a dedicated virtual environment. The

				system is pre-generating data analysis as needed for improved performance. The upgrade that we will need imminently is specific and separate mapserver so that our planned data mapping will function independently of our primary database
Recruit Participants (CST) -- improve registration process and provide registration to non-observers	Sept 2011	2012	2015	This is might be important but we simply haven't found the time or made it a priority since the existing system works "well enough"
Recruit Participants (CST) Support and expand local leadership teams -- acknowledge observer/coordinator contributions	Ongoing through Sept 2013	2012	No real end date -- ongoing	State and regional volunteer coordinator communications via e-mail, listserv and webinar continued to hold together the nearly 250 volunteer leaders that we rely on to maintain and expand this network. There is still room for improvement
Refine Protocols (CST) Evapotranspiration	Sept 2011	Sept 2011	May 2012	Completed during late spring of 2012 and successfully implemented. Data collected during 2012 very effectively showed drought development and improvement through the combination of water ET and precipitation.
Refine Protocols (CST) Adapt and Improve – document additions and improvements and justifications for changes	Ongoing through Sept 2013	ongoing through Sept 2013	Same	CoCoRaHS decided to retain the independent collection of both gauge catch and snow board snow water content as separate fields (this deviates from NWS procedures) but we feel we gather both

				scientifically and educationally valuable information that is missing from NWS data sets
Train Participants (CST) Observer Training Short narrated modules Webinar training Training for Mobile Devices	2012 - 2013	2012-2013	Same but ongoing, too	Based on quality of data being collected, seems that training methods may be adequate, but we have not exploited any of the opportunities for customized training on mobile devices.
Train Participants (CST) Climate Education Webinar Series	Ongoing through 2013 but first webinar planned for spring 2011	Beginning spring 2011	Beginning fall 2011 and now going strong	We now have a great program lead by Henry Reges with speakers arranged through the end of 2014. Every webinar so far has been excellent. We've had trouble with volunteers having issues getting on the webinar. Many attendees are repeaters who have mastered the process and love to learn. But getting more than about 200 attendees for a weekday midday webinar has proven to be difficult Likewise getting people to view a 75 minute YouTube video is also a stretch. So maybe we should be very content with what we have and realize that this is a large time commitment and 100-200 live attendees and a similar number of YouTube views may be the best we can do for now.

Train Participants (CS)) Informal Education Through Training and support	Ongoing through 2013	Ongoing through 2013	Ongoing through 2014	We are keeping up. This seems to be a strength of our current system as we are able to accommodate several thousand new recruits each year and give them a fairly personal and customized services.
Analyze Data (CST) Functional reporting database Services available on mobile devices	Start Later 2011 Complete in 2012 and 2013	2012-2013	Same	Much progress here although not as originally designed. We are getting much higher performance out of our database, and are making all system modificaitions with mobile devices in mind. All CoCoRaHS interface development has occurred with the requirement of supporting mobile devices. Our interactive water year summary charts are an example of this. They work in mobile web browsers, modern browsers, and older browsers back to IE6.
Analyze Data (CST) Mapping enhancements and connection to PRISM products	Start on PRISM products later in 2011, Other stuff comes later	Late 2011 and following	Launched fall of 2012	Done and working great!! PRISM Climate Group was great to work with and continues to implement upgrades to the system that we haven't needed to ask or pay for
Analyze Data (CST) Climate Dashboard	Progression of deliverables beginning early 2011	2012	2015?	This is something we've wanted to do but found to be a lower priority. We're still interested if we get the chance.
Analyze Data (CST) Water Year Summary reports	Start later 2011 and deliver in 2012	Fall 2010 and following	Staying on or ahead of schedule here	This has been a total success since the first year and we've kept up each year. WY summary reports appear to be one

				of the best “thankyou” gifts we can do to recognize the efforts of our volunteers
Analyze Data (CST) Other activities – PRISM collaboration, Observer activity reports, charts and graphs, etc.	Not specified	On schedule	On schedule	The PRISM portal was launched in the fall of 2012 with a number of interactive charts and data analysis tools allowing observers to learn about the climate at their station locations and throughout the country. In addition to instructional material on the website. A webinar demonstrating the tools and discussing the difference between weather and climate is available via the CoCoRaHS YouTube channel.
Disseminate Results (CST) Social Networking – Blog, Facebook Twitter YouTube, etc	Fall 2010 and ongoing	Fall 2010 and ongoing	On schedule and high impact	We continue to increase the number followers and participation on Facebook and Twitter. The blog is excellent thanks to the amazing unsolicited volunteer efforts of Illinois state coordinator Steve Hilberg
Disseminate Results (CST) “The Catch”	Fall 2010 and ongoing with specific technology deliverables summer-fall 2011	Fall 2010 and ongoing with specific tech deliverables summer-fall 2011	We upgraded to formatted mail chimp messages in fall 2013 and are continuing	Producing these regularly and continues to get strong positive feedback from many of our volunteers. The new formatted mail service looks good but no evidence that its overall impact is different or better than the old emails. But it does make it easier for us to track response and include links to supporting resources.
Disseminate Results (CST) Data Export enhancements	Series of deliverables beginning spring/summer 2011	Same	We’ve kept up with this to satisfy the needs of diverse users	This is the invisible side of CoCoRaHS –and one that we never scheduled time or resources for. We do it because it adds

				value to everything else we do..
Measure Effects (CST) Project Evaluation	Series of deliverables beginning fall 2010	Same as first written	Participant survey and Summative evaluation completed fall 2014	Summative report is contained in the "measuring effects" section of this report. We've completed a satisfactory evaluation report but much more could be gleaned. Fortunately, the Cornell Lab of Ornithology is also evaluating CoCoRaHS externally and may provide additional insight in the context of other citizen science projects.

– Describe reasons why established objectives were not met, if applicable.

We have accomplished a great deal in 4 years. Yet we often feel disappointed as we have not yet met all of our initial goals. The larger and older we are (CoCoRaHS), the less nimble we seem to have become. Changes are increasingly hard to agree on and implement since the impacts are farther reaching now. Just implementing smart phone apps took longer and required more iterations than we expected. Managing some 20,000 volunteers and training around 4,500 new participants each year is a task that doesn't let go We love it, but it takes time. Data quality control and customer care never goes away either. While more and more participants become rock solid, reliable and self-sufficient, new observers fill in behind them who end up making all the same mistakes and asking the same questions.

For us, not being able to successfully implement a dynamic national mapping system that incorporates all new data in a multi-feature user interface has been discouraging. What we've developed works and looks good (not great) but just runs too slow. More money and computer resources could help solve this but both are out of range right now. The current simple mapping system works exceedingly well for what it is – but does not provide the click and zoom feature and topographic backgrounds that many crave. Will we get it working in the final year of the project? We don't totally know.

And then there is the question of the future. As we now complete the 4th year of this grant our eyes are on our exciting but uncertain future as we migrate from grant funding to some other combination of subscription, sponsorship and donations. We have had some success in this new world, which is why we have been able to extend this project to four years and now on to five. But these are also distractions that interfere with completing project deliverables.

Does our summative evaluation live up to expectations? I don't know. This has been harder than we hoped and expected, but a result is delivered. We look forward to your response and reaction.,

This has been a fun ride and we hope it continues for years to come.

- We encourage you to submit a highlight from the work your project has accomplished over the past six months. Highlights help the Office of Education to publicly acknowledge and share the extraordinary work being done by our grantees. See the Highlights template that accompanies this document for further instructions.
-

Progress Report Prepared By: Nolan Doesken
Date: December 3, 2014

COMPETITIVE PROJECT TITLE: Development of a Probabilistic Tropical Cyclone Prediction Scheme (NA11OAR4310208)

The following is the most recent report previously submitted to the Technical Sponsor.

NOAA Joint Hurricane Testbed (JHT)
Project Final Report

Date:	February 28, 2014
Reporting Period:	September 1, 2013 – February 28, 2014
Project Title:	Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme
Principal Investigator:	Jason Dunion, University of Miami/CIMAS – NOAA/HRD
Co-PIs:	John Kaplan, NOAA/HRD Andrea Schumacher, CSU/CIRA
Co-Investigator:	Joshua Cossuth, Florida State University
Award Period:	August 1, 2011 – July 31, 2014

1. Long-term Objective and Specific Plans to Achieve Them:

The main goal of this project is to develop a disturbance-following tropical cyclone (TC) genesis index (TCGI) to provide forecasters with an objective tool for identifying the 0-48hr and 0-120hr probability of TC genesis in the North Atlantic basin. Predictors from a variety of sources were tested and potentially integrated into this new scheme and included Dvorak T-number / CI value estimates, environmental and convective parameters currently used in the NESDIS TC Formation Probability (TCFP) product (fixed grid scheme), environmental parameters from the Statistical Hurricane Intensity Prediction Scheme (SHIPS) that are relevant to TC genesis, and total precipitable water (TPW) retrievals from microwave satellites. Six robust TCGI predictors were identified and have been incorporated into an experimental real-time version of TCGI. The proposal team evaluated the performance of the scheme for several 2013 tropical disturbances in the Atlantic and made the TCGI code and output available to NHC forecasters on 11 September 2013. NHC forecasters are currently evaluating TCGI for possible transition to operations in the future.

2. Accomplishments:

a. Develop code for running real-time TCGI (0-48h and 0-120h)

The real-time code development phase of this project has been completed and required some re-evaluation of the TCGI predictors that were identified during the previous reporting period and resulted in a more robust scheme. These six predictors and their relative weights in TCGI for the 0-48 and 0-120 hr forecast periods are shown in Fig. 1. Figure 1 also depicts the TCGI genesis occurrence frequency relative to the range of binned discriminant function values that could be produced by TCGI during a given forecast cycle. Higher binned discriminant function values are associated with combinations of TCGI predictor values that favor higher TC genesis probabilities. The skill of the optimized TCGI relative to a climatological reference forecast derived from the developmental dataset (2001-2010) is shown in Fig. 2. These assessments indicate that TCGI has ~30 % and 39% skill relative to climatology for the 0-48 and 0-120 hr forecast periods respectively.

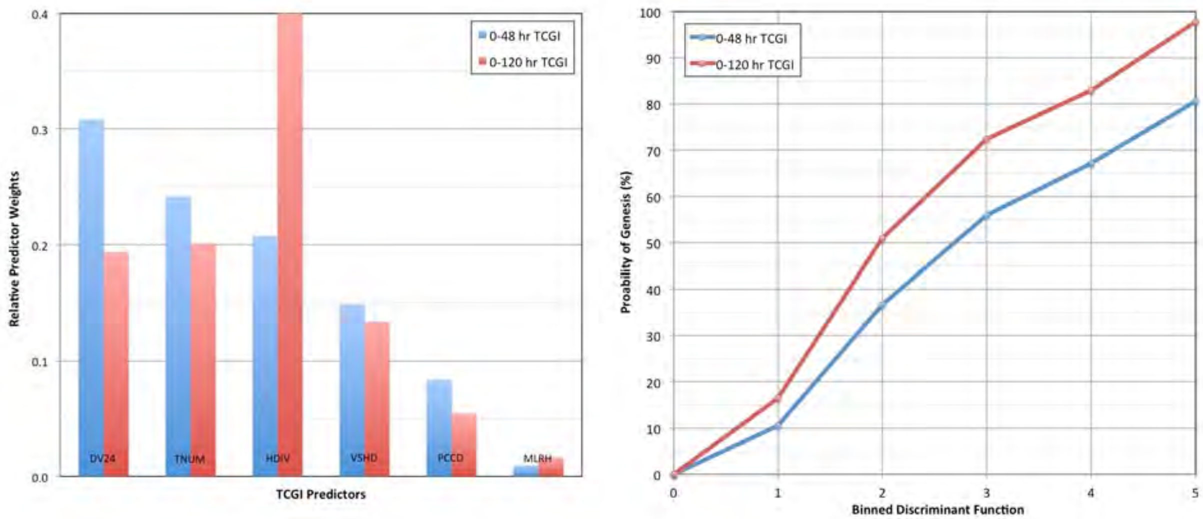

Fig. 1: The relative predictor weights (left) for the real-time TCGI and the corresponding genesis occurrence frequency (%) for the five quantiles that were utilized (see Kaplan et al. 2010 for more details). The predictors used in the TCGI are GFS 24-hr vortex tendency (DV24), 850-hPa divergence (HDIV), 850-200 hPa vertical shear (VSHD), Dvorak T-number (TNUM), GOES percent of cold cloud (<-40 C) pixel coverage (PCCD), and GFS 600-hPa relative humidity (MLRH). Note that DV24, HDIV, VSHD, PCCD, and MLRH are averaged over a radius of 500km and that all predictors are evaluated along the entire disturbance forecast track with the exception of two T=0 predictors (TNUM and PCCD).

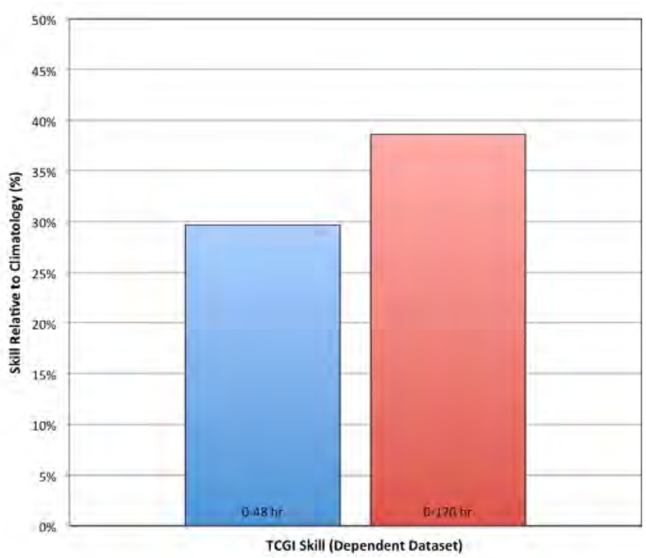

Fig. 2: TCGI skill (0-48 & 0-120-hr) relative to climatology (2001-2010 dependent TCGI dataset).

b. Perform real-time tests of TCGI (0-48h and 0-120h) either on NESDIS computers at CIRA with output being made available via an ftp site or on JHT computers

The real-time TCGI code that has been developed is currently running at CIRA and was tested and evaluated by the proposal team from July-September 2013. This evaluation period helped the team identify a few potential areas for TCGI improvement. TCGI utilizes both early and late cycle track guidance from the NOAA Global Forecast System (GFS) to determine positions for analyzed tropical disturbances. However, GFS forecast positions are not always available for weak disturbances (especially out to the 144 hours needed for TCGI runs) and therefore, a special Beta and Advection Model, Medium Layer (BAMM) was developed to support the TCGI project. This model, BAMG, required significant testing and evaluation by the proposal team in recent weeks and has resulted in its successful integration into the real-time TCGI scheme. BAMG is now a vital component of TCGI and allows the scheme to run even if GFS tracks are not available or other forecast model guidance is not run by NHC. One important aspect of integrating a new forecast tool such as TCGI into an operational environment is to maximize product transparency to potential users. The proposal team has incorporated predictor information into the TCGI real-time output that describes the specific contributions of each predictor for both the 0-48 and 0-120 hr forecast periods (Fig. 3). This information is designed to help the user more easily interpret the TCGI forecasts.

```
                      *          ATLANTIC TC GENESIS INDEX               *
                      *           AL972013 10/01/13 18 UTC               *

TIME (hr)            0     6    12    18    24    36    48    60    72    84    96   108   120
TCGI (%)                                                45.1                               65.0

HDIV (x10-7s-1)   -3.0  -4.0  -1.0  -3.0  -5.0   0.0  -6.0   1.0  -5.0   0.0  -4.0   0.0   0.0
VORT (x10-6s-1)    1.3   1.6   1.6   1.7   1.6   1.5   1.1   0.8   1.0   0.5   1.1   1.1   1.1
DV24 (x10-6s-1)    0.3   0.0  -0.1  -0.7  -0.5  -0.7  -0.1  -0.3   0.1   0.6   0.0  -0.1  -0.3
VSHD (kt)            5     9    11     9     9    17    19    19    19    26    24    28    27
MLRH (%)            67    67    64    63    67    64    68    62    64    52    54    52    54
PCCD (%)            42   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A
TNUM              1.00   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A

LAT  (deg N)      16.8  17.2  17.8  18.5  20.3  22.9  25.0  26.3  27.6  28.3  29.2  30.1  31.4
LON  (deg W)      83.0  83.5  84.4  85.1  85.8  87.0  87.4  87.5  86.8  86.5  85.5  84.4  82.9
DTL  (km)          169   172   217   259   132   154   382   358   270   188    56    -5  -140
TRACK SOURCE      AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO

Prob of Genesis (t= 48h) =  45.1 is  1.6 times the sample mean ( 27.9)
Prob of Genesis (t=120h) =  65.0 is  1.6 times the sample mean ( 40.3)

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CONTRIBUTIONS OF CLIMATOLOGY AND INDIVIDUAL PREDICTORS TO TCGI PROBABILITY

               *******  48-HR ******    ******* 120-HR ******
                   AVG   FCST  %CONT        AVG   FCST  %CONT
CLIM (%)                        27.9                     40.3
HDIV (x10-7s-1)   -1.3   -3.1    9.1       -1.2   -2.2   15.9
DV24 (x10-6s-1)   -0.2   -0.3   -1.8       -0.2   -0.1    3.1
VSHD (kt)         16.8   12.3    4.8       19.0   18.5    0.7
MLRH (%)          64.9   66.0    0.1       61.3   60.8   -0.1
PCCD (%)          29.1   41.8    2.9       28.7   41.8    2.6
TNUM               0.9    1.0    2.1        0.9    1.0    2.4

%CONT = % contribution to TCGI probability

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PREDICTOR DEFINITIONS (Averaged Over 500 km Radius)

CLIM = Climatological Probability of Genesis (Source: NHC-TAFB Invest Database)
HDIV = 850-mb GFS Horizontal Divergence
DV24 = 24-hr Change in GFS 850-mb Vorticity (VORT)
VSHD = 850-200 mb GFS Vertical Shear
MLRH = 600-mb GFS Relative Humidity
PCCD = % GOES WV Pixels Colder Than -40C
TNUM = TAFB T-Number
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Fig. 3: Experimental TCGI output format.

c. 2011-2013 TCGI Verification

TCGI forecasts were verified for tropical disturbances tracked during the 2011-2013 Atlantic hurricane season. Storm positions, genesis times and Dvorak T-numbers were determined using a combination of ATCF A- and F-Decks and resulted in a verification database that included 61 developing storms and 27non-developing tropical disturbances. Statistics generated from these 88 disturbances included 468 individual 48- and 475 120-hr TCGI forecasts and were compared to a homogenous dataset of NHC TWO forecasts. Note that the NHC 120-hr TWO did not become operational until 2013 and was not available for the full 3-yr analysis. Fig. 4 shows the reliability diagrams for the TCGI and NHC TWO 0-48 and 0-120-hr forecasts. Although there was some tendency for the TCGI to under-forecast at the lower (~0-40%) and upper (~70-100%) forecast probability bins, it was competitive with the NHC TWO statistics. Figure 5 shows the TCGI and NHC TWO 0-48 and 0-120-hr lead-times for the 2011-2013 verification dataset, while Fig. 6 present the Brier skill scores for these same forecasts. The latter analyses provide an alternative measure of the forecast skill that is provided by the reliability diagrams (Fig. 4).

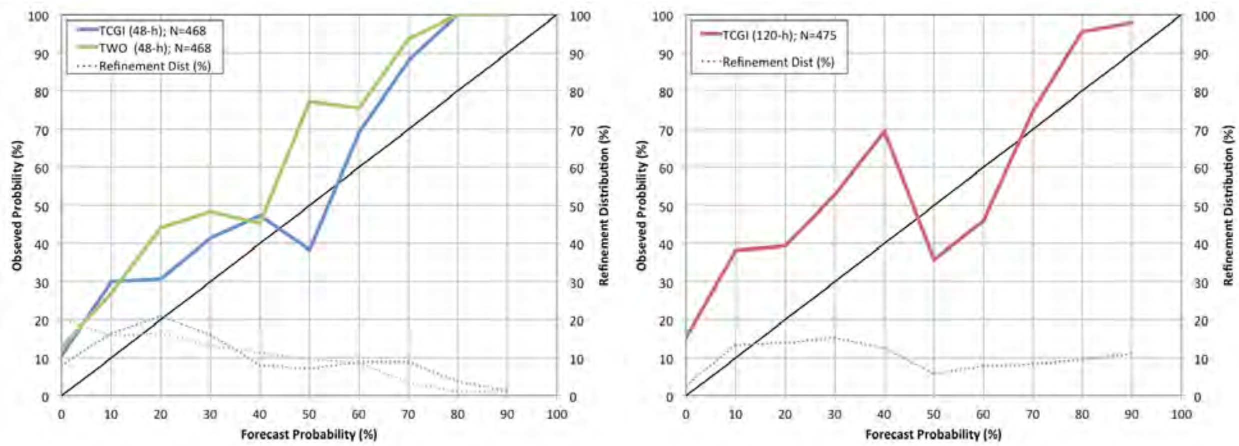

Fig. 4: Reliability diagrams for TCGI and a homogeneous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2011-2013 North Atlantic hurricane seasons. The verification includes forecasts from 61 developing and 27 non-developing disturbances. The solid blue/green (red) lines indicate the relationship between the 48-hr (120-hr) forecast and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the corresponding forecasts were distributed among the possible forecast values.

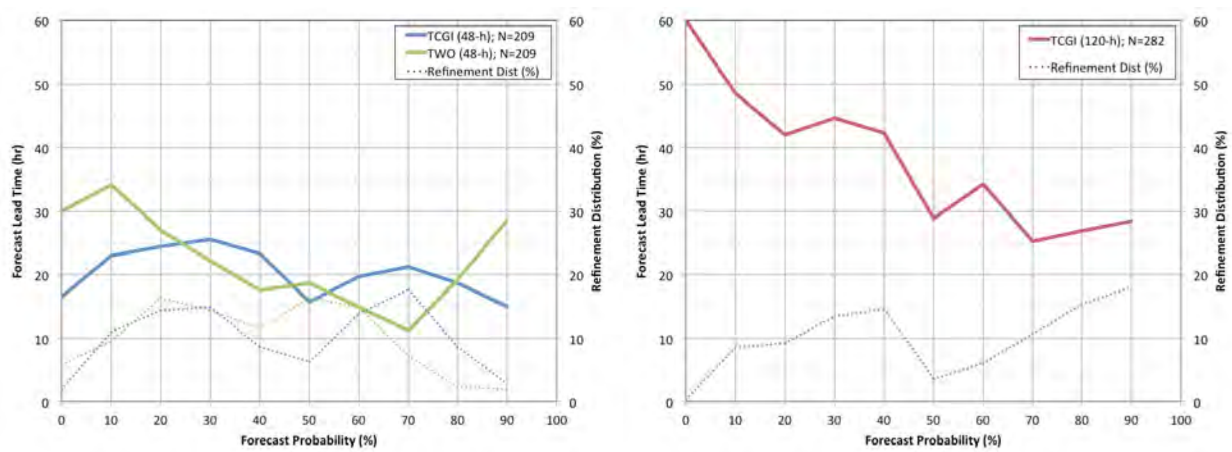

Fig. 6: Forecast lead times (hours before genesis) for TCGI and NHC TWO Atlantic probabilistic TC genesis forecasts for the 2011-2013 North Atlantic hurricane seasons. The datasets include 209 48-hr and 282 120-hr forecasts from 61 developing disturbances. The solid blue/green (red) lines indicate the relationship

between the 48-hr (120-hr) forecast probability and the forecast lead-time. The dashed lines indicate how the corresponding forecasts were distributed among the possible forecast values.

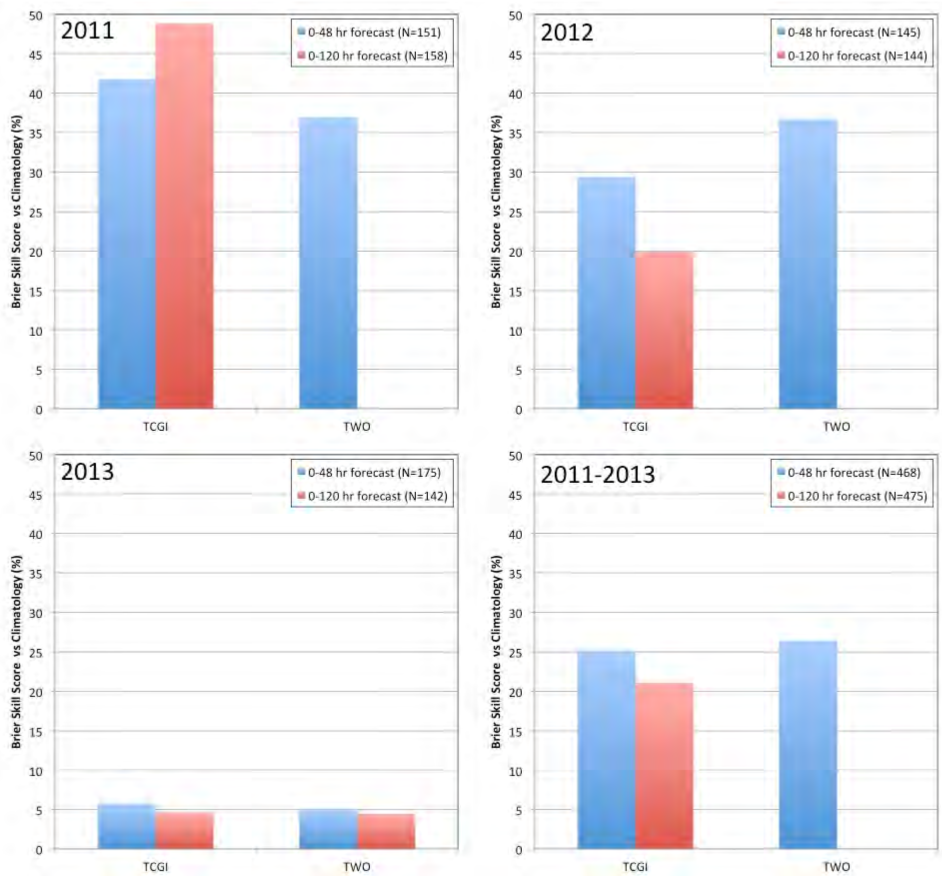

Fig. 7: Brier Skill Scores for TCGI and a homogenous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2011-2013 North Atlantic hurricane seasons. Skill was measured against the climatological probability of tropical cyclogenesis determined from a 2001-2010 dataset of North Atlantic invests.

3. Current / Future Efforts:

The proposal team has completed the TCGI project and turned over the real-time output (available on a CIRA web link) to the assigned NHC JHT points of contact on 11 September 2013. The proposal team has been and will continue to work closely with NHC forecasters as they evaluate TCGI for possible transition to operations. The TCGI code will be made available to NHC upon request.

COMPETITIVE PROJECT TITLE: Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis (NA11OAR4310204)

The following is the most recent report previously submitted to the Technical Sponsor.

NOAA Joint Hurricane Testbed (JHT)
Final Progress Report

Date: 23 July 2014
Project Title: *Development of a Real-Time Automated Tropical Cyclone Surface Wind Analysis*
Principal Investigators: Renate Brummer, Mark DeMaria (Co-I), John Knaff (Co-I)
Affiliations: Brummer (CIRA/CSU), DeMaria and Knaff (NOAA/NESDIS)
Project Dates: August 2011-June 2014

1. Long-Term Objectives and Specific Plans to Achieve Them

Although surface and near surface wind observations and flight-level winds and their proxies exist in sufficient quantity to create high quality tropical cyclone surface wind analyses (cf., H*Wind analyses; Powell et al. 1998), a real-time and fully automated surface wind analysis system is not available at the National Hurricane Center (NHC). Such analyses could however be invaluable; providing useful information for a variety of current and future operational products.

In this project we created a real-time and fully automated surface wind analysis system at CIRA by combining accepted operational wind reduction procedures and a comparably simple variational data analysis methodology (Knaff et al. 2011). Results were then made available to NHC in real-time and in formats they requested. Specifically, this project made use of the Franklin et al (2003) flight-level to surface wind reduction findings along with current operational procedures and incorporated the analysis and quality control (QC) procedures used in the multi-platform tropical cyclone surface wind analyses (MTCSWA; Knaff et al. 2011). The real-time operationally-available aircraft reconnaissance wind data (i.e. HDOBS), and the MTCSWA satellite-based MTCSWA were used as input data. The MTCSWA serves as a first guess field with very low weighting and the aircraft-based data will be composited over a finite period (maximum of 9 hours@ three hours after synoptic time) and analyzed. The analyses are performed on a polar grid at a common 700-hPa level and then adjusted to the surface level (i.e. 10-meter). The polar grid resolution and domain size was specified by the JHT and is consistent with the resolution of the aircraft reconnaissance data and the needs of the forecasters.

If acceptable to operations, the wind analysis would run at NHC and make use of the local data stream and JHT servers. The resulting two-dimensional wind analysis would then produce 1-min sustained winds valid for 10 meter (m) marine exposure with sufficient resolution to properly capture the radii of maximum winds.

2. Accomplishments

a. Software development

In August 2011 the project began with discussions with NHC about what data would be used to create surface wind analyses. The data used included the data available in the real-time HDOBS (flight-level winds, pressures, and SFMR surface wind speed estimates) and the operational satellite-based MTCSWA flight-level wind fields. Routines were developed to ingest the HDOBS and MTCSWA fields and store the information in a common data format. To provide estimates of real-time cyclone information, a track from a combination of operational best track positions, aircraft fixes and the OFCI forecast locations was created. In consultation with NHC hurricane specialists data weights for the flight-level and SFMR wind speed information that was a function of flight-level wind speed were implemented (Table 1). Another consideration requiring input from NHC was how the flight-level wind analysis would be reduced to the surface. Here we relied upon the information in Franklin et al. (2003) to provide the mean reduction factors (F_r) and other operational guidelines. Specifically we attempt to define a convective eyewall region and an outer region based on the radius of maximum wind (*RMW*) with azimuthal variation of 4% and 17%, respectively. Finally, the width of the eyewall region is at largest 20 nmi beyond the *RMW*. Examples of F_r are shown in Figure 1. The input and track information were then used to create a series of motion relative analyses and those results were presented at the IHC in 2012.

Table 1: A description of how the flight-level wind-speed-dependent data weights for the variational wind analysis are determined for the wind analysis.

Flight-Level Wind Speed (V[kt])	Flight-Level Zonal Weight	Flight-Level Meridional Weight	SFMR Wind Speed Weight
V ≥ 64	0.175	0.175	1.0
50 < V < 64	0.5–(V-50)(2.36E-2)	0.5–(V-50)(2.36E-2)	0.25+(V-50)(4.71E-2)
V ≤ 50	0.500	0.500	0.250

Near the end of the first year of this project scripts were written to generate analyses in a real-time manner using operationally available data within the CIRA computer infrastructure. Runs were scheduled at the synoptic time minus 30 minutes, plus 30 minutes and plus 90 minutes We also reran the analyses for the 2010 and 2011 hurricane season to better refine the algorithm. The output of the real-time 2012 and post 2010/11 analyses were made available via ftp to forecasters and NHC's JHT representatives. We also attempted to move the scripts and other software to NHC, but abandoned that effort after finding out that the JHT servers were outside the firewall.

It was also clear after the 2012 Hurricane season that some work was still needed on the existing scripts and software. We also were asked to improve methods of distribution of the analyses to better facilitate the use of these analyses in the NHC operational environment. Results were presented at the 2013 IHC. Since the IHC, several software features were corrected that were related to the errant negative weighting of the MTCSWA, too stringent gross error checking, and errors in the F_r estimation routine. Our script would also not run multiple aircraft cases at the same synoptic time.

During the 2013 Hurricane season real-time analyses were also created. Analyses were run one hour following the synoptic hour – a lesson learned from 2012. These analyses were then converted to GEMPAK format to better facilitate viewing by NHC forecasters (i.e. on N-AWIPS). The distribution was accomplished via ftp and naming conventions were coordinated with JHT operational representatives. Files were tested and they could be viewed in N-AWIPS, however the images were never imported in a real-time manner into NHC's operations. Thus, the operational utility of these analyses could not be evaluated.

Readers of the report will recognize that the 2012 milestones related to running this analysis at NHC were not met due to more pressing priorities at NHC, changes in network security and the reliance on external (to operations) JHT servers. As are result the code was never moved to the JHT servers and real-time testing was conducted solely at CIRA. Near the end of the 2013 hurricane season all of the cases 2010-2013 were rerun using the final software and script versions. In 2013 we were also able to process all of the aircraft cases in real-time. Issues with the creation of GEMPAK grids were rectified. Some of those results are now presented.

It is quite difficult to summarize how well an analysis system performs when ground truth data is based on subjective analysis of the same information. In addition automating the input data preparation and analysis presents a number of issues. Quality controls can be too stringent; removing important data or too lacks allowing errant points into the analysis. In addition the data weights in the variation analysis are based on observed generalizations and may not always be appropriate or representative of how a human analyst would weigh the data. Finally, HDOBS are undoubtedly undersampling the wind field, which will result in our analyses often having lower maximum wind speeds than the corresponding best track verification time. Nonetheless, we feel we have developed a method that can provide real-time objective analyses of aircraft-based observations (i.e. HDOBS). Furthermore, because these analyses are performed on a polar grid, do not suffer from square grid aliasing. The resulting wind fields when differentiated to estimate vorticity and convergence fields do not exhibit any features that result from the analysis grid. In the following discussion we examine some of these analyses and present some of the potential operational enhancements these analyses could offer NHC operations.

b. Example cases

To examine some of these issues we present analyses associated with two 2011 hurricane cases, namely Hurricane Jova, 10 October 18 UTC and Hurricane Irene, 25 August 00 UTC. In the cases 2 and 61 input data were removed by the quality control, as part of the Jova and Irene analyses. Irene had several SFMR wind estimates that were in excess of 105 kt that were removed by the gross quality control operations – noting that the best track intensity estimate was 95 kt. Both cases also had a complete alpha flight pattern and thus similar amounts of flight-level observations.

Case 1: Hurricane Jova (2011), 10 October 18 UTC:

Best Track Intensity: 110 kt
Best Track R34: 90, 90, 60, 60
Best Track R50: 35, 40, 30, 30
Best Track R64: 25, 20, 20, 15

Some details of the automated analysis of Hurricane Jova are shown in Figure 2. The larger domain shows that region of analyzed gale-force winds is quite a bit larger than the best tracked R34 values. In addition the asymmetries appear shifted 90 degrees in the analysis with the strongest winds occurring in the SE and SW quadrants of the storm. R50 and R64 have similar values as the best track, but again the asymmetries seem rotated to the southern quadrants in the analysis. The maximum wind was estimated at 95 knots based on a maximum analyzed flight-level wind as 109 knots. The lower right panel of Figure 2 shows the flight-level wind speeds and SFMR equivalent flight-level wind speed inputs following quality control plotted as a function of latitude, along with a horizontal line representing the maximum wind found in the analysis at flight level (112 kt). It is clear that the analysis is under estimating the maximum found in the SFMR observations. However the analyzed maximum flight-level wind speed is slightly nudged toward those SFMR observations (i.e., the analyzed flight-level wind is larger than the observed maximum flight-level winds (109 kt) based on several SFMR observations that indicate higher surface winds than the flight-level winds would indicate). We note here that the 140 kt SFMR flight-level equivalent wind speeds that pass QC would supported by a 109 kt SFMR observation. The analysis on the other hand, produced a 95 kt maximum surface wind based on 112 kt at flight-level (F_r=.85). For the analysis as a whole, the fit to the wind speed data at flight level produced biases of -3.3 kt, mean absolute errors of 7.5 kt, and RMSE or 10.4 kt (n=1013). Tangential and radial wind RMSE's were 4.8 kt and 4.4 kt, respectively (n=455).

Case 2: Hurricane Irene (2011), 25 August 00 UTC:

Best Track Intensity: 95 kt
Best Track R34: 220, 180, 100, 150
Best Track R50: 100, 90, 50, 80
Best Track R64: 60, 60, 25, 50

Irene represented different challenges as it had a broad horizontal wind profile and the analysis produced poorer results in terms of maximum winds. The wind field in the NE quadrant was rather strong and constant. However, the azimuthally averaged radius of maximum wind was 18 nmi and the storm was moving to the northwest. The analyzed flight-level maximum wind was 101 kt and this was a little lower than the observations would suggest. The strongest flight-level winds were not close to the azimuthal mean radius of maximum wind so the estimated F_r for that point was ~ 0.7 (cf. Figure 1). As a result the maximum surface wind for Irene was estimated at 71 kt, which represents an underestimate of 25%. For the analysis as a whole, the fit to the wind speed data at flight level produced biases of -4.8 kt, mean absolute errors of 6.7 kt, and RMSE or 9.9 kt (n=1196). Tangential and radial wind RMSE's were 5.1 kt and 4.9 kt, respectively (n=557). The analysis based wind radii were also generally smaller than the best track values, especially the northeast quadrant, where the MTCSWA flight-level winds reduced to the surface were not indicating gale-force winds beyond 120 nmi, but F_r was order 0.63, which might be too small.

While there seems to be a general low bias associated with the maximum surface wind estimates, these analyses do provide detailed information concerning both the 64- and 50-kt wind radii. In addition objective estimates of the radius of maximum wind and location are also provided. Objective guidance for these quantities does not currently exist. Furthermore, since the wind field is output other information could be ascertained from the digital wind field if that is desired in operations.

By the end of the extended project time (June 2014) the 2013 surface wind analysis cases were updated for all aircraft cases and results were posted on the CIRA web page at http://rammb.cira.colostate.edu/research/tropical_cyclones/tc_surface_wind_analyses/cases.asp

c. Estimation of maximum winds

We examined a few cases when several days of consecutive aircraft sorties and analyses were performed to estimate the maximum wind speed estimates. Figure 4 shows three cases. Generally these are lower than the best track estimates. However, the analysis of flight-level maximum winds agrees quite well with the flight-level observations data as shown in Figures 2 and 3 and is true for most other cases. The mean F_r that would remove much of the bias in the maximum surface wind estimates is around 0.95. At this time it is unclear if there are problems with the F_r being used or if the underestimates are caused by undersampling the wind field (cf, Ehlhorn and Nolan 2012). As a result it is not clear how to rectify this shortcoming. However, both applying a bias correction to account for under sampling and modifying the F_r rules are relatively easy to implement within the software.

d. Wind structure

One of the potentially useful capabilities of these analyses is the monitoring of the wind structure over time. Figure 5 shows the azimuthally averaged profiles of wind speed, radial wind and tangential wind for Hurricane Earl. Analyses are separated by approximately one day. The evolution of the radius of maximum wind, radial convergence and steepness of the tangential wind can be compared between different analyses. These analyses could be particularly useful for detection of secondary wind maximum development, and initial eye formation. However, display methods would need to be developed to make such information easily accessible in operations.

3. Operational Transition Considerations

If the NHC desires to make this an operational capability there are a number of factors that need to be considered.

a. Software

The current software requires a FORTRAN 90 compiler, Python 6.4 or higher, Bash shell script, Gempak, and GrADS. The GrADS options can be easily removed from the scripts, but GrADS-based graphics may be useful for quick looks after the season.

A master script runs at 1 hour after synoptic time. It creates a production location and copies all the information and data it needs to that directory, and runs the executables in the proper order. Active storms are identified, and short-term tracks of each active storm are created that include the aircraft fix locations when available. HDOBs for the last couple of days are then copied to the processing location. Python code then reformats the aircraft information into a simple ASCII input file. The short-term tracks and reformatted HDOBS are then used as input the analysis executable. Each analysis takes less than 3 minutes on a five-year-old Linux workstation running RH5 32bit.

Scripts will likely have to be rewritten to operational standards, but the FORTRAN code follows NESDIS operational standards. Developers are willing to assist in any revisions.

b. Input data

Input data comes from three sources. The operational locations and aircraft fix information comes from the databases of the ATCF. In the CIRA implementation we have a mirror of NHCs a, b, f, and e decks in one directory location. When the analysis is run we copy a, b and f decks to a production area for each run. HDOBS are also mirrored at CIRA in one location from their locations on the NHC web server (http://www.nhc.noaa.gov/archive/recon/2013/AHONT1/ and http://www.nhc.noaa.gov/archive/recon/2013/AHOPN1/). Data from the last couple of days is typically used as input the analysis executable after being reformatted by a python routine. The final input are the flight-level MTCSWA files (*.WIN). The MTCSWA is also mirrored at CIRA from it location at the National Satellite Operations Facility (ftp://satepsanone.nesdis.noaa.gov/MTCSWA). The master script figures out what MTCSWA to use as a first guess/environmental field. The mirroring of HDOBS and MTCSWA is accomplished using wget (a gnu tool) scripts.

c. Output files

A number of files are archived from the surface wind analysis software A list of files and a brief description of each is provided below. The master script can be modified to save fewer files if that is desired.

2011082500_2011al09_L_TCWA.AAV	Ascii, azimuthal mean radial profiles
2011082500_2011al09_L_TCWA.AIRC	Ascii, flight-level wind, location, weights
2011082500_2011al09_l_tcwa_airc.dat	Ascii, GEMPAK input flight-level wind
2011082500_2011al09_l_tcwa_airc.sfc	Binary, Gempak SFMR at flight-level
2011082500_2011al09_l_tcwa_airc.tbl	Ascii, Gempak locations for surface data
2011082500_2011al09_L_TCWA.bin	Binary, Grads binary grid
2011082500_2011al09_L_TCWA.ctl	Ascii, Grads control file
2011082500_2011al09_L_TCWA.DIA	Ascii, Diagnostic file
2011082500_2011al09_L_TCWA.fgue	Ascii, first guess from MTCSWA
2011082500_2011al09_L_TCWA.FIX	Ascii, ATCF fix
2011082500_2011al09_L_TCWA.gif	Binary, large-scale surface wind plot
2011082500_2011al09_L_TCWA.grd	Binary, Gempak gridded analysis
2011082500_2011al09_L_TCWA.gs	ASCII, grads script that makes the plot
2011082500_2011al09_L_TCWA_hr.gif	Binary, small-scal surface wind plot
2011082500_2011al09_L_TCWA.hrgs	Ascii, grads script that make the hr plot

2011082500_2011al09_L_TCWA_hr.ps	Postscript file of small-scale plot
2011082500_2011al09_L_TCWA.inp	Ascii, Short-term track file
2011082500_2011al09_L_TCWA.log	Ascii, production log
2011082500_2011al09_L_TCWA.obs	Ascii, formatted HDOBS
2011082500_2011al09_L_TCWA.ps	Postscript file of large-scale plot
2011082500_2011al09_L_TCWA_RECO.fld	Ascii, all recon obs, locations, weights
2011082500_2011al09_L_TCWA_RECO.gif	Plot of motion relative recon obs
2011082500_2011al09_L_TCWA_RECO.ksh	Script that make the above plot
2011082500_2011al09_L_TCWA_s.fil	Ascii, Gempak input to grid wind speed
2011082500_2011al09_L_TCWA.SSFM	Ascii, SFMR @ fl, locations and weights
2011082500_2011al09_l_tcwa_ssfm.dat	Ascii, Gempak input to make SFMR@fl
2011082500_2011al09_l_tcwa_ssfm.sfc	Binary, Gempak file SFMR@ fl
2011082500_2011al09_l_tcwa_ssfm.tbl	Ascii, Gempak locations for SFMR
2011082500_2011al09_L_TCWA_u.fil	Ascii, Gempak input to grid u wind
2011082500_2011al09_L_TCWA_v.fil	Ascii, Gempak input to grid v wind

4. Summary

This project strived to create an automated tropical cyclone surface wind analysis that effectively analyzed the real-time data from aircraft reconnaissance using a satellite-based surface wind product as a first guess. The project was successful in this endeavor, but the work was never transitioned to pre-operations at NHC. The output analyses (see locations below) also tend to be low biased with respect to the maximum wind reported in the best track record. It is unclear if this low bias is due to the assumptions made to reduce the flight-level wind analysis to the surface or due to undersampling the wind field. Regardless of the exact cause, the method developed here could be easily modified to account for undersampling (bias correction) and/or modification of F_r. So with a little effort these methods could be tuned to alleviate many of the shortcomings of the current surface wind estimates. Furthermore, the application could easily be installed in NHCs operations (details in Section 3) and would provide an enhancement to operations by improved utilization of aircraft reconnaissance data. We summarize what worked and what did not in bullets following the details on the output locations.

Output (gif image, by atcf number) 2010-2013 available at
ftp://rammftp.cira.colostate.edu/Knaff/JHT_TCSWA/
N-AWIPS files
ftp://rammftp.cira.colostate.edu/Knaff/JHT_TCSWA/nawips/
ATCF Fixes
ftp://rammftp.cira.colostate.edu/Knaff/JHT_TCSWA/atcf/

What worked?
- Software to grab the available HDOBS and analyse these data in a motion-relative composite manner
- Estimate wind structure from the analyses (R34, R50, R64, RMW)
- Create ATCF formatted fixes
- Create graphics and GEMPAK-formatted binaries
- Make real-time analysis information and binaries available via ftp

What did not work?
- We were unable to install any of the software in NHCs operational environment
- GEMPAK-formatted binaries were never imported into NHC's N-AWIPS
- Output was never viewed by specialists during their operational duties.
- Estimating Maximum winds from these analyses
- ATCF fixes were never imported to the operational ATCF.

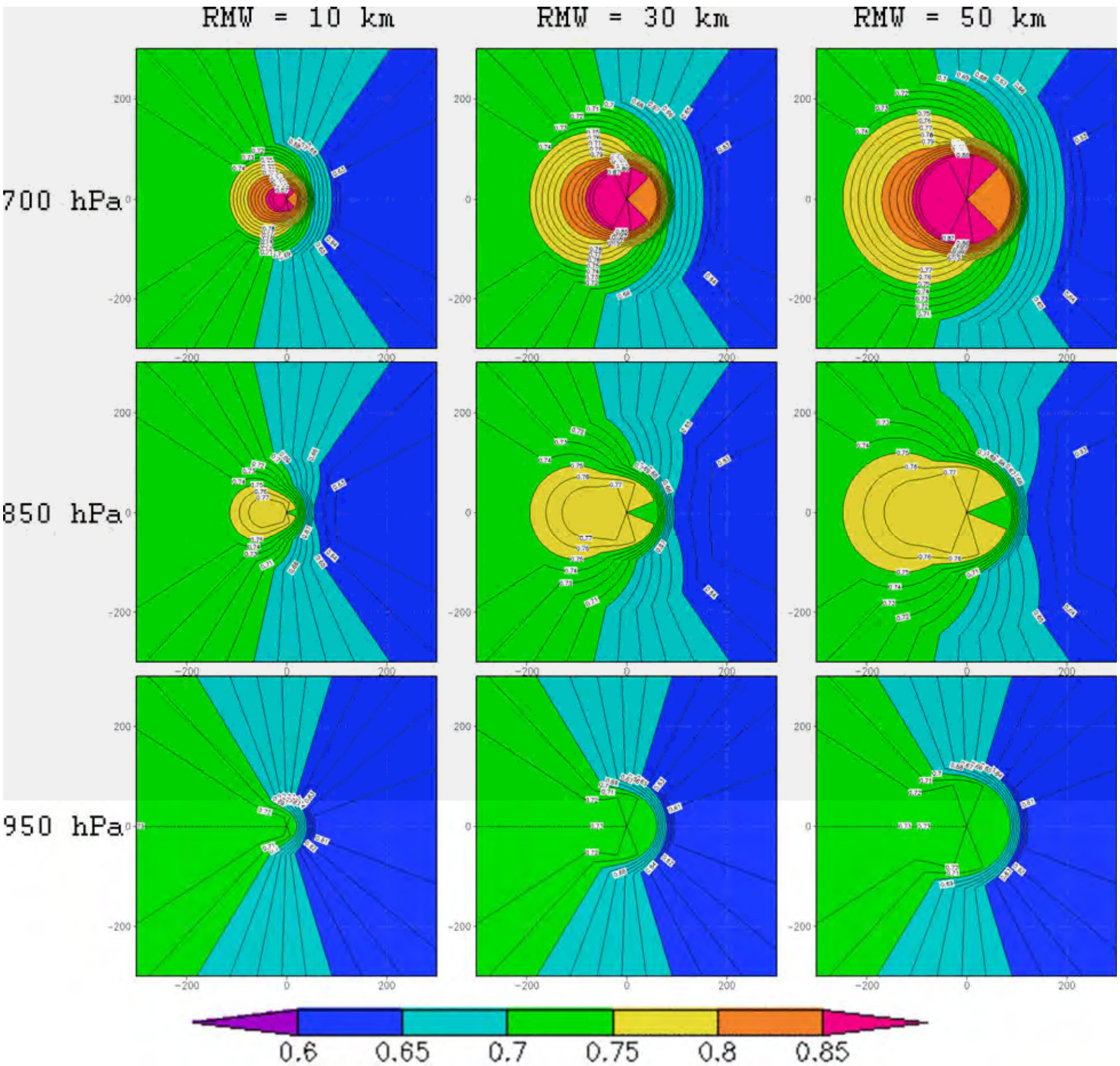

Figure 1: Examples of the flight-level to surface wind reduction factors (F_r) used for this application. These examples show the F_r values for a storm moving toward the top of the page for three values of RMW and three typical flight-level pressures.

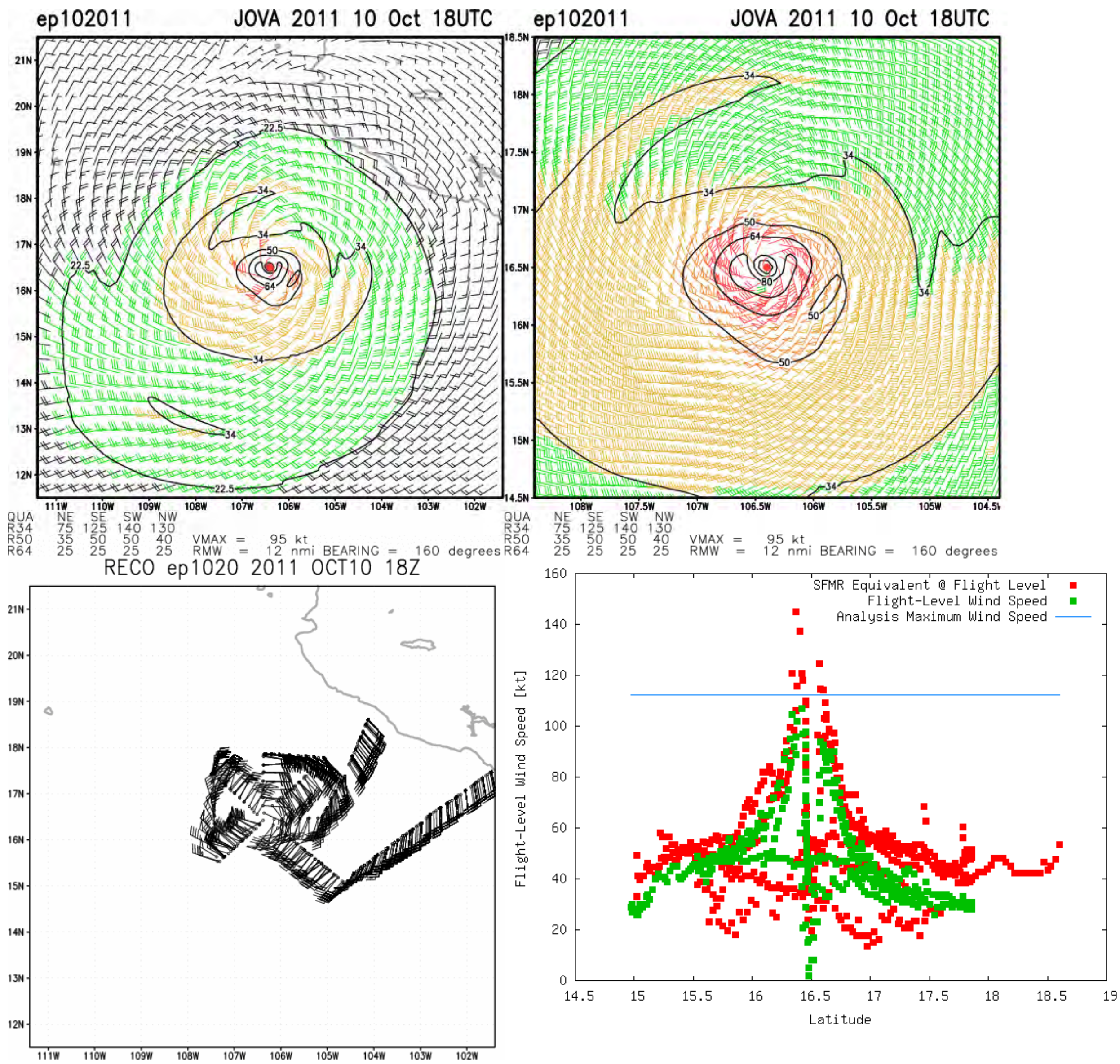

Figure 2: Some details of the surface and flight-level wind analysis associated with Hurricane Jova (2009) October 10 18UTC. (Top left) Large scale analysis showing the effective combination of MTCSWA and HDOBS data, (top right) small-scale view of the wind analysis showing the details of the wind asymmetries and inner core winds, (bottom left) a schematic showing the storm-motion-relative aircraft flight paths for this analysis, and (bottom left) plot of winds speeds as a function of latitude that have been standardized to a 700-hPa flight-level and the maximum analyzed flight-level wind is indicated by the horizontal line.

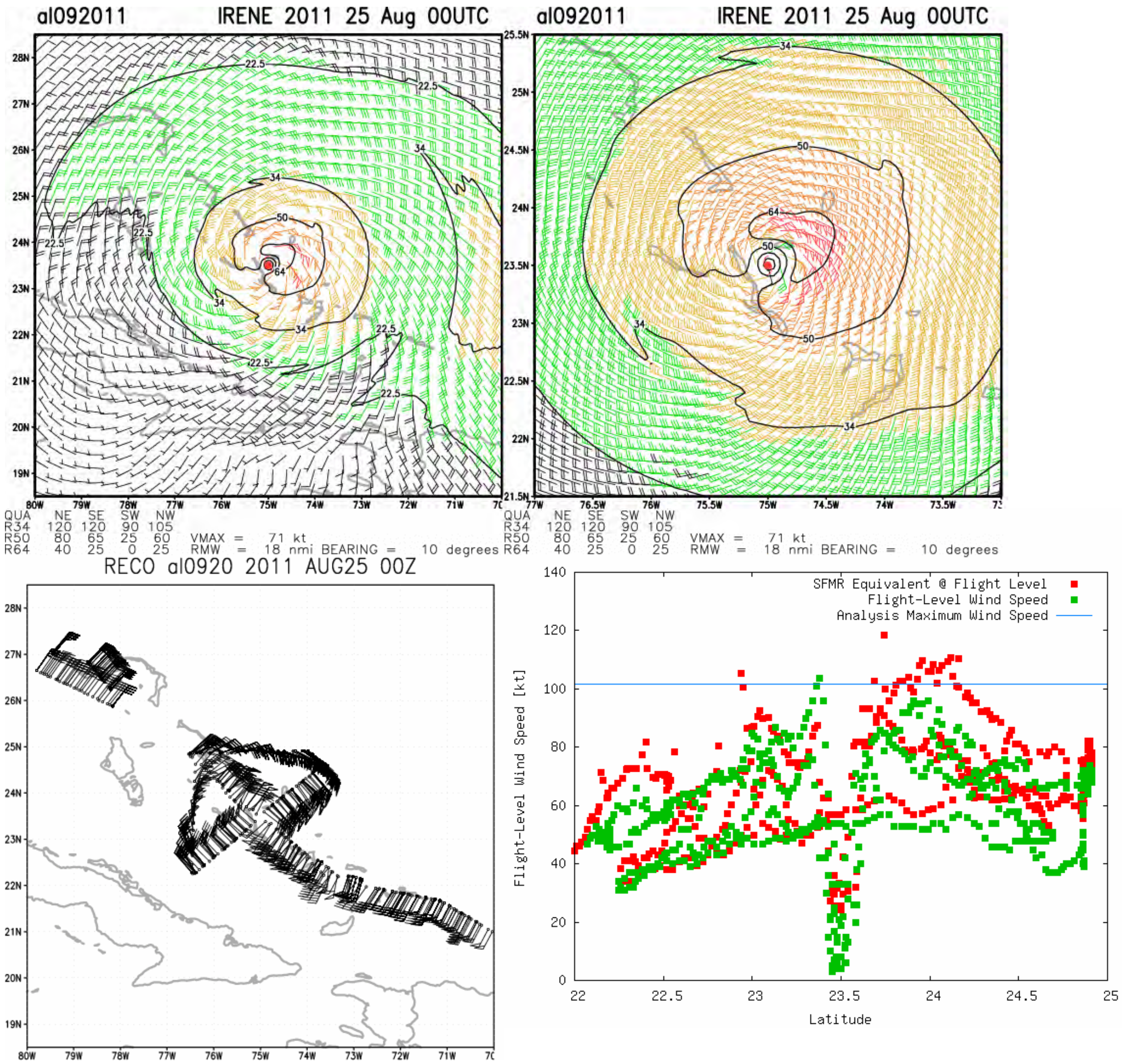

Figure 3: Same as Figure 2, except for Hurricane Irene (2011) on 25 August at 00 UTC.

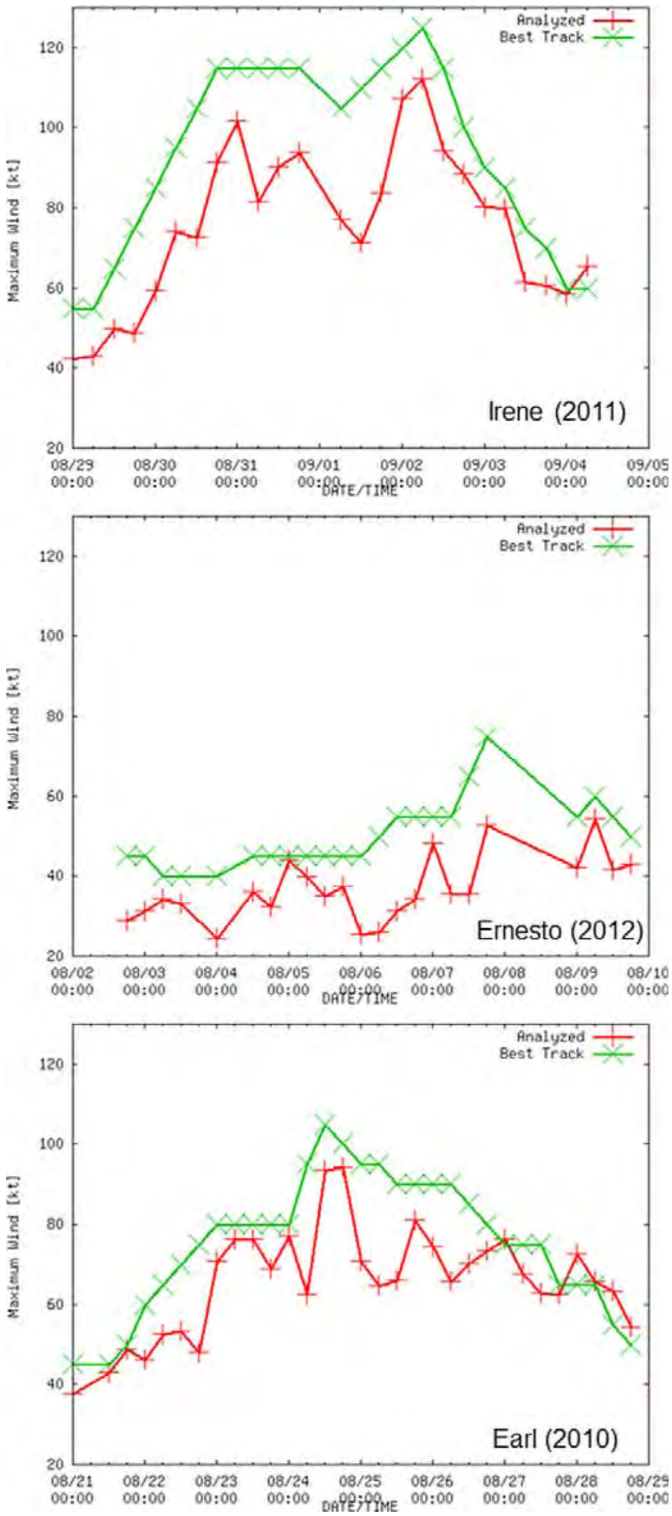

Figure 4: Time series comparison of analyzed maximum winds and best track maximum wind estimates for three hurricane cases.

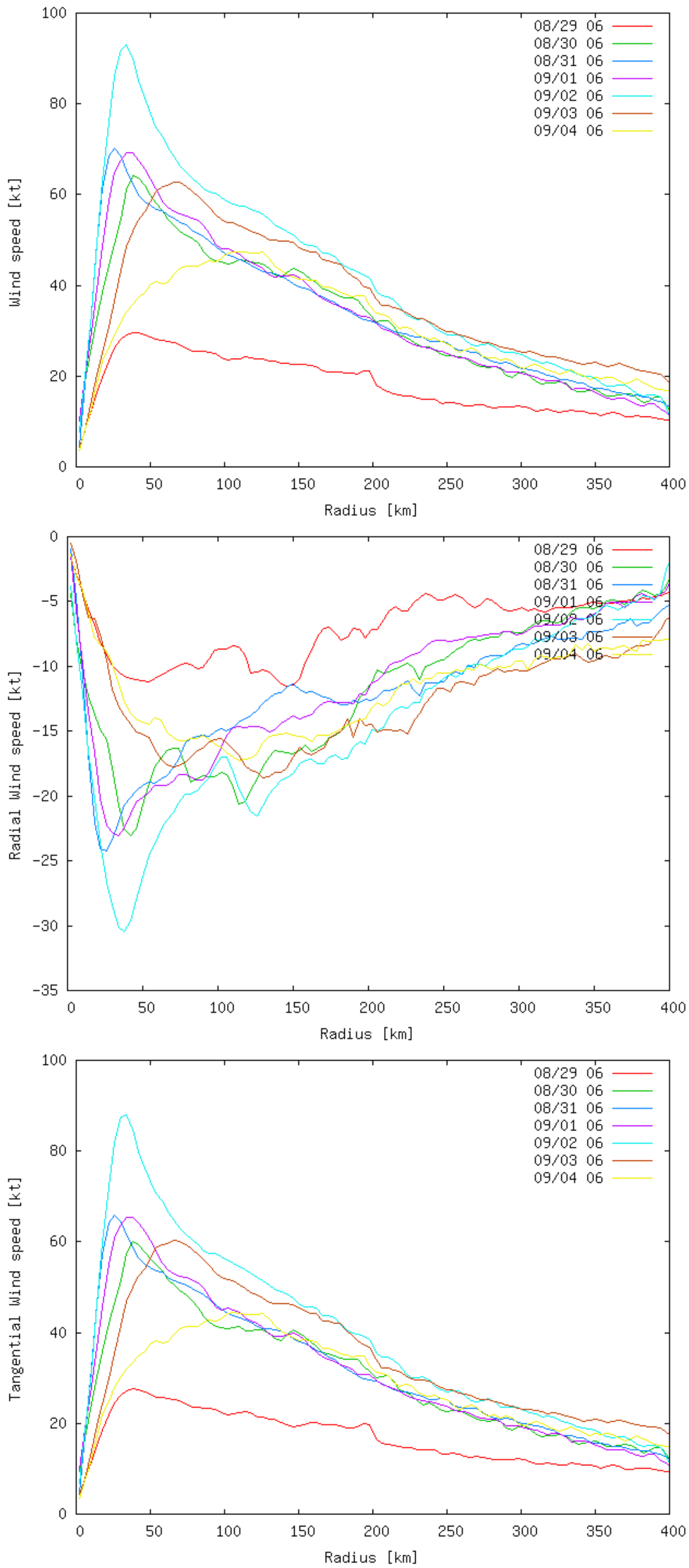
Wind speed [kt]
Radius [km]
08/29 06
08/30 06
08/31 06
09/01 06
09/02 06
09/03 06
09/04 06
Radial Wind speed [kt]
Radius [km]
08/29 06
08/30 06
08/31 06
09/01 06
09/02 06
09/03 06
09/04 06
Tangential Wind speed [kt]
Radius [km]
08/29 06
08/30 06
08/31 06
09/01 06
09/02 06
09/03 06
09/04 06

Figure 5: Azimuthally averaged radial wind profiles from each day there were analyses for Hurricane Earl (2010). The total wind speed is shown at the top, radial wind in the middle and tangential winds in the bottom panels.

Appendix A: Original Milestones.

Year 1

Aug 2011 – Project begins
Aug 2011 – Discussions with NHC to determine desired analysis properties
Aug 2011 – Begin the development of local data ingest design
Aug 2011 – Develop routines to ingest aircraft flight-level, SFMR, and GPS sonde data
Sep 2011 – Develop scripts to combine aircraft center fixes, operational best tracks and OFCI
Nov 2011 – Combine the TC track and the analysis (CIRA and CIMAS)
Dec 2011 – Develop methods to standardize the data types based on NHC's preferences
Feb 2012 – Meet with NHC specialists to discuss options for data weights and smoothing constraints.
Mar 2012 – Present progress at the IHC (ALL)
Mar 2012 – Begin Development scripts to automate the local (CIRA) data ingest, quality control and analysis on a JHT workstation
Apr 2012 – Work with NHC to develop text and graphical output.
May 2012 – Begin testing of the automated analysis routines on past events (CIRA, FSU)
May 2012 – Evaluation of past events and their sensitivity to weight and smoothing, confer with NHC.
May 2012 – Start to test the automated routines in real-time at CIRA
July 2012 – Respond to feedback from NHC (ALL)

Year 2

Aug 2012 – Real-time testing continues
Dec 1012 – Evaluation of the analyses, gather feedback from NHC
Jan 2013 – Modify analysis parameters based on feedback and evaluation results
Feb 2013 – Rerun cases, if necessary
Mar 2013 – Present results at the IHC
May 2013 – Prepare the analysis for a full season of real time testing
July 2013 – Gather feedback and make appropriate changes to the analysis system
July 2013 – Project ends

Year 3

June 2014 – update surface wind analysis cases for all aircraft cases of 2013 on the CIRA web page (http://rammb.cira.colostate.edu/research/tropical_cyclones/tc_surface_wind_analyses/cases.asp)

References:

Franklin, J. L., M. L. Black, and K. Valde, 2003: GPS dropwindsonde wind profiles in hurricanes and their operational implications. *Wea. Forecasting*, **18**, 32–44.

Knaff, J.A., M. DeMaria, D.A. Molenar, C.R. Sampson and M.G. Seybold, 2011: An automated, objective, multi-satellite platform tropical cyclone surface wind analysis. *J. of App. Meteor.,* **50**, 2149-2166.

Powell, M. D., S. H. Houston, L. R. Amat, and N. Morisseau-Leroy, 1998: The HRD real-time hurricane wind analysis system. *J. Wind Eng. Ind. Aerodyn.*, **77-78**, 53–64.

Uhlhorn, E.W., and D.S. Nolan, 2012. Observational undersampling in tropical cyclones and implications for estimated intensity. *Monthly Weather Review*, **140**(3) p.825-840.

COMPETITIVE PROJECT TITLE: Following Emissions from Non-traditional Oil and Gas Development Through Their Impact on Tropospheric Ozone (NA14OAR4310148)

This is a new project. No reports have been submitted to NOAA as yet.

PRINCIPAL INVESTIGATOR(S) (CIRA/CSU PI): Emily Fischer (PI), Delphine Farmer (co-PI)

RESEARCH TEAM:

Andrew Abeleira, 3 months in reporting period
Jake Zaragoza, 3 months in reporting period
Ilana Pollack, 1.5 months in reporting period

NOAA TECHNICAL CONTACT: Monika Kopacz, Competition Manager

NOAA RESEARCH TEAM: None

PROJECT OBJECTIVE(S):
The proposed work tackles these questions:

1--What are characteristic O_3 production rates and efficiencies in air masses influenced by emissions from oil and gas production?
2--To what extent have emissions from oil and gas production impacted the extent of NO_x versus NMVOC limited O_3 production?
3--Through which chemical pathways do emissions from oil and gas production propagate most efficiently to global O_3 production?
4--How do emissions from this sector affect radiative forcing through perturbations to tropospheric O_3, methane, and remote aerosol formation?

PROJECT ACCOMPLISHMENTS:

We are testing instruments for the SONGNEX deployment, and will deploy instruments the week of March 16th. We have also recently begun creating a new ethane emissions inventory for oil and gas operations for the U.S. The inventory will be based on a 2009–2011 methane emissions inventory constrained by observations from the Greenhouse Gases Ob- 2 serving SATellite (GOSAT).

Project Publications from Past Fiscal Year (including Conferences): None as yet

COMPETITIVE PROJECT TITLE: Guidance on Intensity Guidance (NA13OAR4590187)

PRINCIPAL INVESTIGATORS: Andrea Schumacher

RESEARCH TEAM: Robert DeMaria, Dave Watson, and Renate Brummer

NOAA TECHNICAL CONTACT: Mark DeMaria (NOAA/NWS/NHC)

NOAA RESEARCH TEAM: Mark DeMaria (NOAA/NWS/NHC)

PROJECT OBJECTIVES:

An operational algorithm to estimate the confidence of the intensity forecasts from NHC's primary intensity models and their consensus will be developed. The models include the statistical-dynamical Decay-SHIPS (DSHP) and Logistic Growth Equation Model (LGEM) and the early versions of the GFDL and HWRF coupled ocean-atmosphere models (GHMI and HWFI). The technique builds on the results of Bhatia and Nolan who demonstrated that the errors and biases of DSHP, LGEM, and GFDL have significant systematic variability as a function of a number of storm environmental variables that are available in real time, including the magnitude of the vertical shear, the direction of the shear, the initial intensity, and the maximum potential intensity. The intensity model error will be estimated from a linear combination of these predictors, supplemented with other variables. These include additional synoptic parameters, inner core structure from infrared imagery and the eye diameter and radius of maximum wind parameters from the Automated Tropical Cyclone Forecast (ATCF) system, ocean input from the sea surface temperature and oceanic heat content, the spread of the individual intensity models forecasts, and the recent performance of each model from times before the forecast time. Versions will be developed for the Atlantic and the combined East/Central Pacific. This algorithm will be referred to as the Prediction of Intensity Model Error (PRIME) model. The PRIME model will be run at the end of the SHIPS model script. Assuming the model errors can be reliability estimated, the output from the PRIME model will be used to develop a corrected consensus forecast, which will be an unequally weighted combination of DSHP, LGEM, GHMI and HWFI forecasts. The error analysis will also be used to provide guidance for improvements to the DSHP and LGEM models.

Tropical Cyclone (TC) forecasts affect risk mitigation activities of industry, public and governmental sectors and therefore supports directly NOAA's Weather and Water mission goals.

PROJECT ACCOMPLISHMENTS: Past Fiscal Year by Objective:

1--Complete prototype PRIME model for the Atlantic and implement as part of the operational SHIPS script

The Atlantic prototype PRIME model has been completed and is currently running at CIRA. Unexpected delays during development precluded the incorporation of this prototype into the operational SHIPS script for the 2014 Atlantic hurricane season. Project scientists are currently coordinating with the NHC points of contact to determine whether the Atlantic PRIME will be implemented as part of SHIPS for the 2015 season or (most likely) will continue to run in quasi-real-time at CIRA (output available at http://rammb.cira.colostate.edu/research/tropical_cyclones/prime_intensity_guidance/).

The remaining project objectives for this reporting period are being led by Co-PI D. Nolan and his graduate student K. Bhatia at the U. of Miami. These tasks included assembling and analyzing the east Pacific dataset, selecting preliminary PRIME predictors for the east Pacific, and presenting results at the 2015 Interdepartmental Hurricane Conference.

The following is the report previously submitted to the Technical Sponsor.

NOAA Joint Hurricane Testbed (JHT)
Annual Project Progress Report, End of Year 1

Date:	September 30, 2014
Reporting Period:	September 1, 2013 – August 31, 2014
Project Title:	Guidance on Intensity Guidance
Principal Investigators:	David S. Nolan, RSMAS, University of Miami, and Andrea Schumacher, CIRA, Colorado State University
Award Period:	September 1, 2013 – August 31, 2015

1. Long-term Objectives and Specific Plans to Achieve Them:

This goal of this project is to develop a system for real-time prediction of the expected errors of individual hurricane intensity forecast models and to use this information to improve operational forecasts. In the first year of the project, we have built on the recent results of Bhatia and Nolan (2013) to construct a model that predicts the expected error of each intensity forecast model at each forecast interval based on real-time synoptic and climatological information, such as wind shear, current intensity, and latitude. Error prediction models have been developed for each of the "early" intensity forecast models that are available to forecasters: DSHP, LGEM, GHMI, and HWFI. Our goal by the end of year 1 was to have a prototype of this prediction system running in real-time during the 2014 hurricane season. As noted below, this goal was not quite met by the end of year 1. In year 2, we plan to build a corrected consensus model that will weight each of the four intensity models based on their relative expected errors at each time.

2. Year 1 Accomplishments:

a. Development of model error and predictor databases

In the first year of this project, we developed a comprehensive database of intensity forecasts, intensity forecast errors, and synoptic and environmental information from the 2007-2013 hurricane seasons. All information such as storm intensity, wind shear, maximum potential intensity, ocean heat content, etc., comes from the SHIPS database (stext files), information that is available in real-time during operational forecasts.

From this database, a large number of candidate predictors of error have been selected. These can be divided into synoptic predictors (which include information about the storm itself, such as its current intensity and location) and "proxy" predictors that are indicative of the stability of the atmospheric flow or the uncertainty of the initial condition. For each forecast, the synoptic predictors are computed at the analysis time (zero hour) and for the average of the forecast period (e.g., the 48 hour average wind shear magnitude during a 48 hour forecast).

Since all the models used are updated almost every year, it should be most effective to use forecasts and errors based on the versions of the model that are used in the present year. Fortunately, the staff at NCEP/EMC has generously provided us with the results of retrospective forecasts from the GHMI, HWFI, DSHP and LGEM for four years using the 2014 versions of each model. These forecasts and their errors have also been tested as the training data for the multilinear regressions.

b. Predictor selection, adjustment, and results

The methodology for the development of the error prediction models is very similar to that used for SHIPS (DeMaria and Kaplan 1994). Multiple linear regression models have been derived using the synoptic and proxy predictors to predict both the absolute error (AE) and the actual error (bias) of DSHP, LGEM, GHMI, and HWFI every 12 hours from 24 to 120 h (the 12 h error forecast will be included in future iterations). While we did not originally intend to predict bias (the positive or negative error value), this has since been included (see below) in response to feedback from NHC staff.

The standard "cross-validation" approach is used, whereby all but one of the years from 2007-2013 are used as the training data, and then the excluded year is used for validation; this is repeated for all years. As in SHIPS, a backward stepping stepwise regression procedure was used to select the predictors. The regression equation starts with all of the predictors and then the least significant predictor is removed. This process is repeated until the weighting coefficients associated with the predictors are all different from 0 at the 95% confidence level. For each model, the same set of predictors is used at all forecast times (this greatly simplifies implementation), but the weighting coefficients can be different for each model. The top 10 predictors for each predictand are listed in Table 1.

AE	BIAS
Intensity deviation from ensemble mean	Intensity deviation from ensemble mean
Intensity forecast standard deviation	Forecast intensity
Average latitude	0 hour intensity
0 hour latitude (2nd order Gaussian fit)	0 hour land distance (^2 fit)
0 hour latitude	0 hour RH (^3 fit)
Forecast intensity	0 hour MPI
Absolute value of forecasted intensity change	0 hour heat content
Average heat content	Absolute value of forecasted intensity change
Average MPI	Average MPI
RH (Gaussian fit)	Average heat content

Table 1: The top 10 predictors for absolute error and bias.

An important but challenging intermediate step is the transformation of some of the predictor inputs into functions that do not vary linearly. For example, our previous work showed that "medium" levels of humidity are an indicator of higher forecast error, since storms in such environments can either weaken or intensify. Therefore, relative humidity and some other predictors are modified to generate maximum values for an intermediate value and minimum values for their extremes, using either a Gaussian or a polynomial function.

To date, results are moderately favorable, with some cases of fairly high correlations (R values ~ 0.6 or more). An example of very good correlation of predicted AE versus true AE is shown in Fig. 1. The general trend is for better predictions of forecast errors for the longer intervals (96h, 120h). This may be due to multiple factors, such as the accumulated effect of physical processes over time (e.g., large ocean heat content over several days), or the fact that errors are simply larger over longer forecast periods.

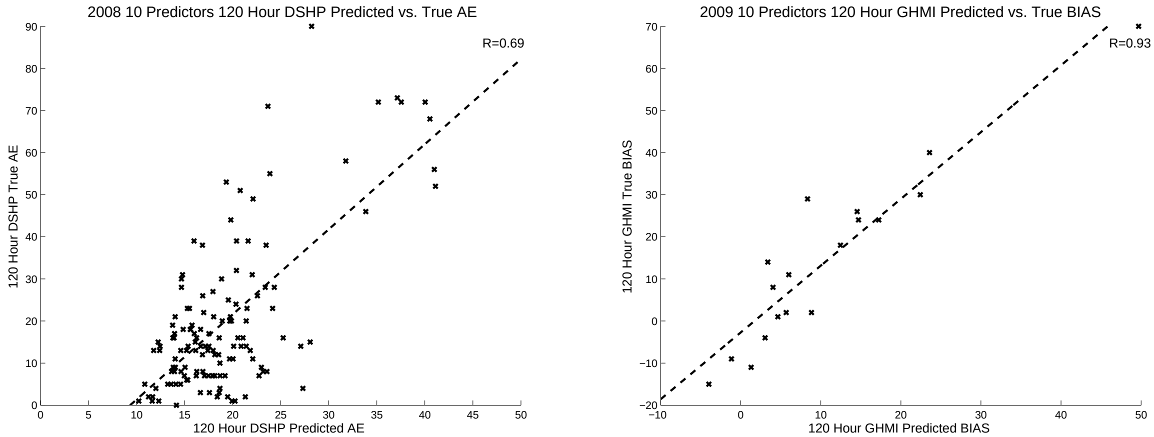

Fig 1. Predicted absolute intensity error (AE) versus true absolute error for 120 hour DSHP forecasts (left) and for bias for 120 hour GHMI forecasts (right). The dashed line indicates the least squares regression line and the R values are shown in the upper-right of each plot.

An unexpected result is that many of the predictions for bias are more accurate than the predictions of AE. The right panel of Fig. 1 shows such a case, for the 120 hour GHMI forecasts. Similarly, the skill scores (AE of the error prediction compared to the AE of using average error [from climatology] as the error prediction) are generally higher for forecasting model bias rather than for forecast error. Tables showing skill scores by hour for AE and bias are shown below.

c. Implementation for 2014

One of our goals for the first year was the implementation of a real-time (or quasi-real time) prediction system to begin assessments of the operability of the system. However, this implementation is currently underway and we expect to have the system operating in a few weeks. Of course, the part of the season that we missed will be evaluated using retrospective data.

3. Future Year 2 Efforts:

October 2014: Implementation of a real-time system that predicts absolute error (AE) and error (bias) for each of the 4 intensity forecast models, and retrospective calculations for the part of the hurricane season that has already passed.

November 2014 - December 2014: Assessment of the 2014 hurricane season results and exploration of communication methods to the forecasters (e.g., forecasts of low, medium, or high errors rather than numerical values).

January - March 2015: Development of the weighted consensus model, whereby each intensity forecast model is weighted by the inverse of its expected AE.

April – September 2015: Further refinements of the error forecasts and the weighted ensemble, implementation for the East Pacific, and delivery of the operational system.

Hours	DSHP	LGEM	HWFI	GHMI
24	5%	4%	5%	4%
36	4%	5%	6%	4%
48	7%	5%	7%	7%
60	8%	6%	4%	6%
72	6%	5%	7%	8%
84	7%	6%	8%	8%
96	4%	5%	8%	11%
108	6%	5%	5%	11%
120	6%	5%	7%	15%

Table 2: Skill scores for predictions of AE by forecast hour, using cross-validated data from 2007-2013.

Hour	DSHP	LGEM	HWFI	GHMI
24	9%	11%	11%	14%
36	10%	12%	13%	19%
48	10%	12%	14%	18%
60	11%	12%	17%	17%
72	10%	9%	20%	18%
84	11%	8%	22%	16%
96	13%	8%	24%	15%
108	14%	10%	28%	15%
120	17%	14%	32%	21%

Table 3: Skill scores for predictions of bias by forecast hour, using cross-validated data from 2007-2013.

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COMPETITIVE PROJECT TITLE: Improving CarbonTracker Flux Estimates for North America Using Carbonyl Sulfide (OCS) (NA13OAR4310080)

PRINCIPAL INVESTIGATOR(S) (CIRA/CSU PI): Ian Baker

RESEARCH TEAM: Ian Baker

NOAA TECHNICAL CONTACT: Huilin Chen (CU Office of Contracts and Grants (Randall Draper)

NOAA RESEARCH TEAM: Andrew Jacobson

PROJECT OBJECTIVES:
1: Develop and test mechanistic representations of carbonyl sulfide (OCS) within landsurface models.
2: Evaluate and quantify relationships between OCS flux and CO2 biophysics.
3: Exploit results from 1 and 2 to constrain continental-scale CO2 flux in a data-assimilation framework.

PROJECT ACCOMPLISHMENTS:

This is a new project, and work has just started. I am working on Objectives 1 and 2 currently, as well as preparing code for inclusion into a DA framework in anticipation of Objective 3.

A baseline evaluation of model behavior is necessary prior to starting the project. We have produced global simulations of surface processes using the Simple Biosphere model (SiB3; Sellers et al., 1985, 1996, Baker et al. 2003,2008) in 'offline' mode as a starting point. These simulations were forced by 1.25 x 1.0 degree Modern Era Retrospective Analysis for Research and Applications (MERRA) data, with precipitation scaled to Global Precipitation Climatology Project (GPCP; Adler et al., 2003) to minimize biases. Model phenology is determined using the Prognostic Growing Season Index (PGSI; Stockli et al., 2008, 2011) method. Mean annual Gross Primary Productivity (GPP) for years 2000-2012 is shown in Figure 1, and global uptake of carbon is estimated at around 119 GT year^{-1}. Actual global GPP is not observed directly, and simulated values can disagree by a factor of 2 or more (Huntzinger et al., 2012). However, some published estimates of global GPP based on eddy covariance flux tower observations (Jung et al., 2011) put global GPP at ~120 GT year^{-1}, which is very close to our value.

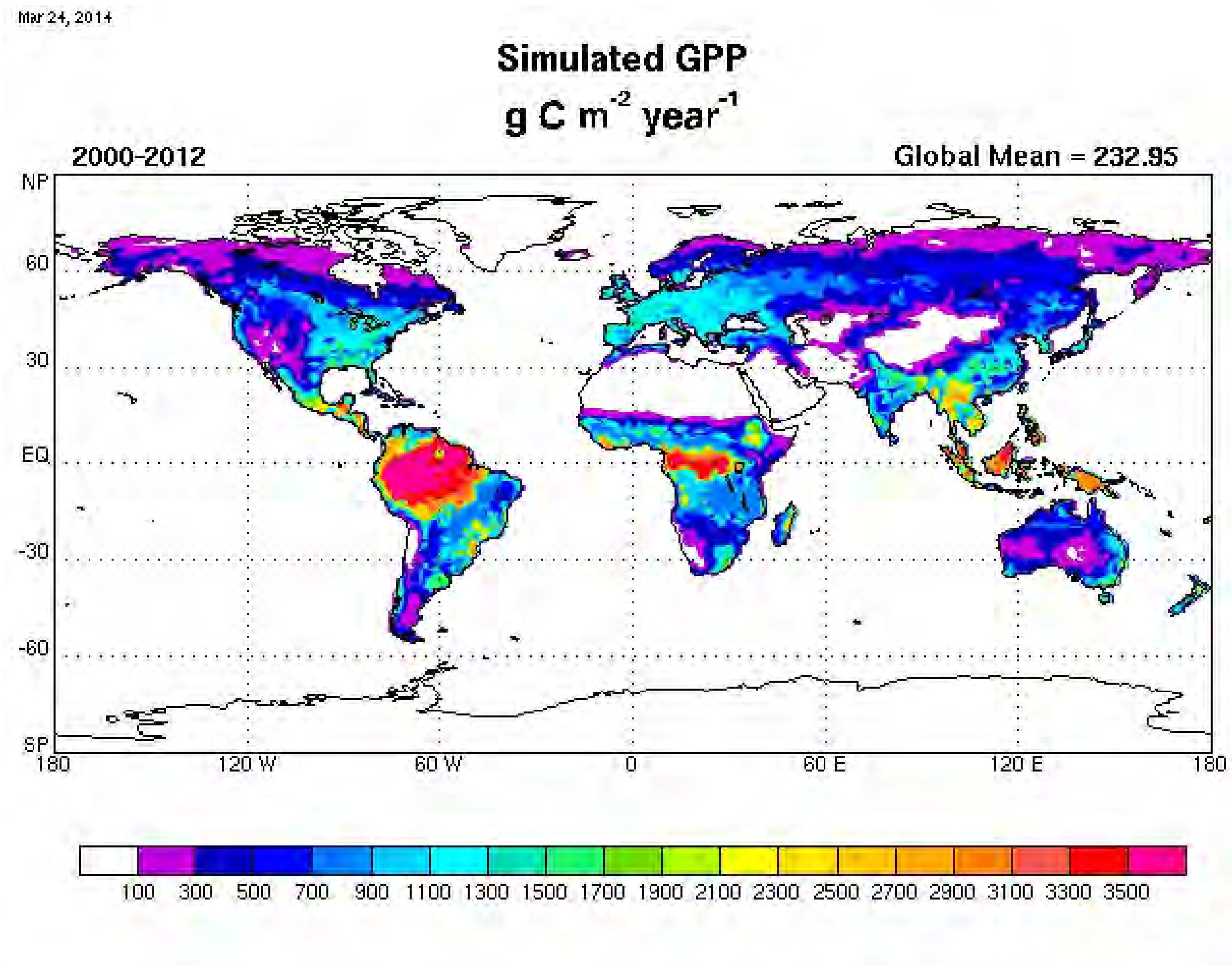

Figure 1: Mean annual GPP for years 2000-2012 in g C m^{-2} year^{-1}

We have demonstrated an ability to simulate ecosystem uptake of Carbonyl Sulfide (Berry et al., 2013). Carbonyl Sulfide (OCS) follows a pathway similar to CO_2 through stomates to the leaf interior, where it is consumed by Carbonic Anhydrase, an enzyme used to catalyze photosynthesis. Therefore, leaf uptake of OCS is demonstrates a global pattern similar to CO_2, as shown in Figure 2. However, it is worth noting that the magnitude of Sulfur uptake is by plants is several orders of magnitude less the uptake rate of CO_2.

OCS uptake by soil, while an order of magnitude less than uptake by plants, is an important process nonetheless. First, soil uptake occurs continuously, and is not-like plant uptake-occurring only during daylight hours when stomates are open. Secondly, ground uptake was previously considered a sink term only, but emerging research indicates that soil may be a source or sink term depending on temperature, moisture, and other soil characteristics. We are currently collaborating with multiple research teams to integrate their findings into our models.

Baseline simulations will provide a model 'prior' that can be used to constrain model parameters and physical processes within the North American data assimilation framework. Project collaborators at NOAA are assembling observational data and DA tools in these early stages of the project. We are ready to couple our models to theirs.

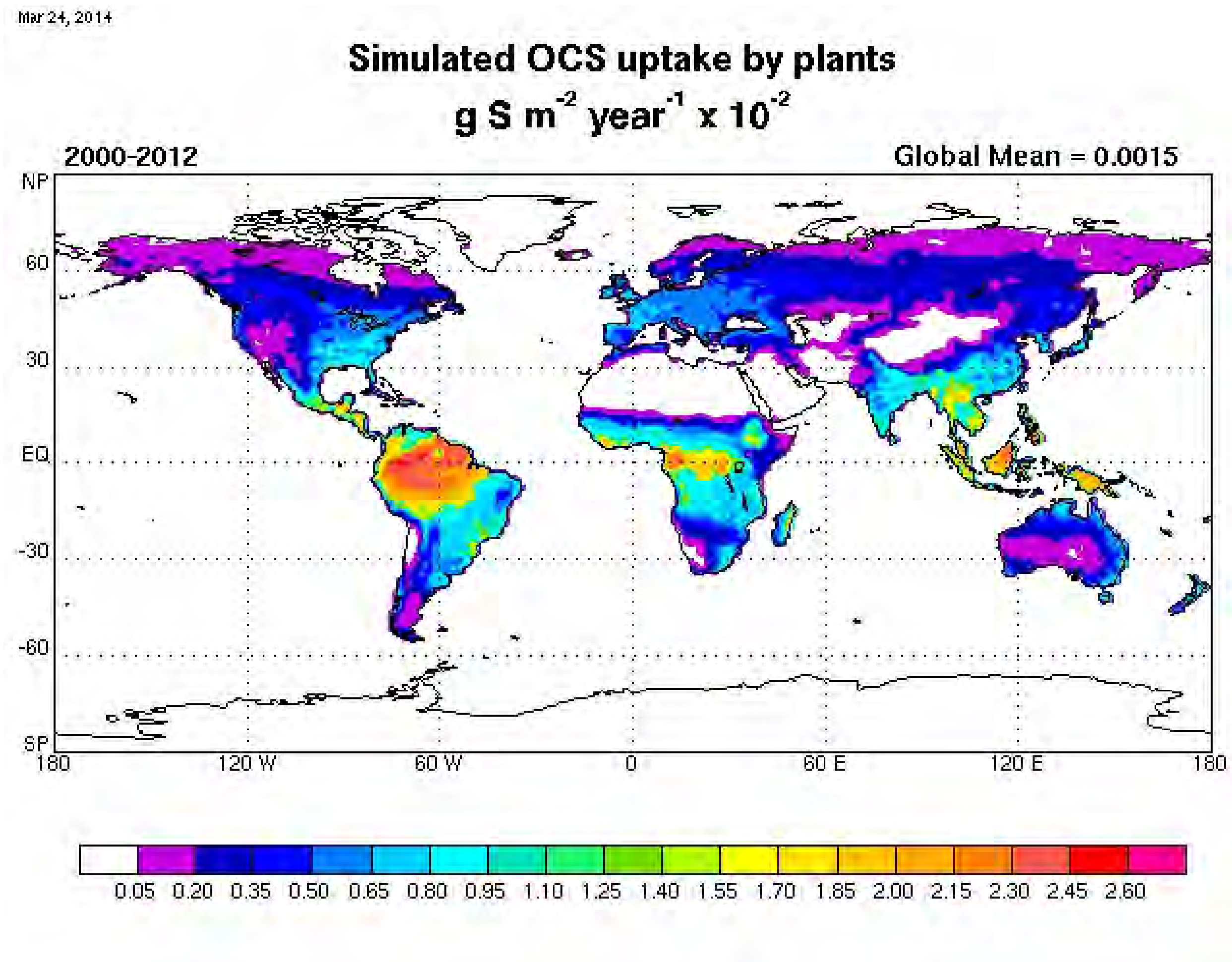

Figure 2: Global mean uptake of OCS by plants (g S m^{-2} $year^{-1}$).

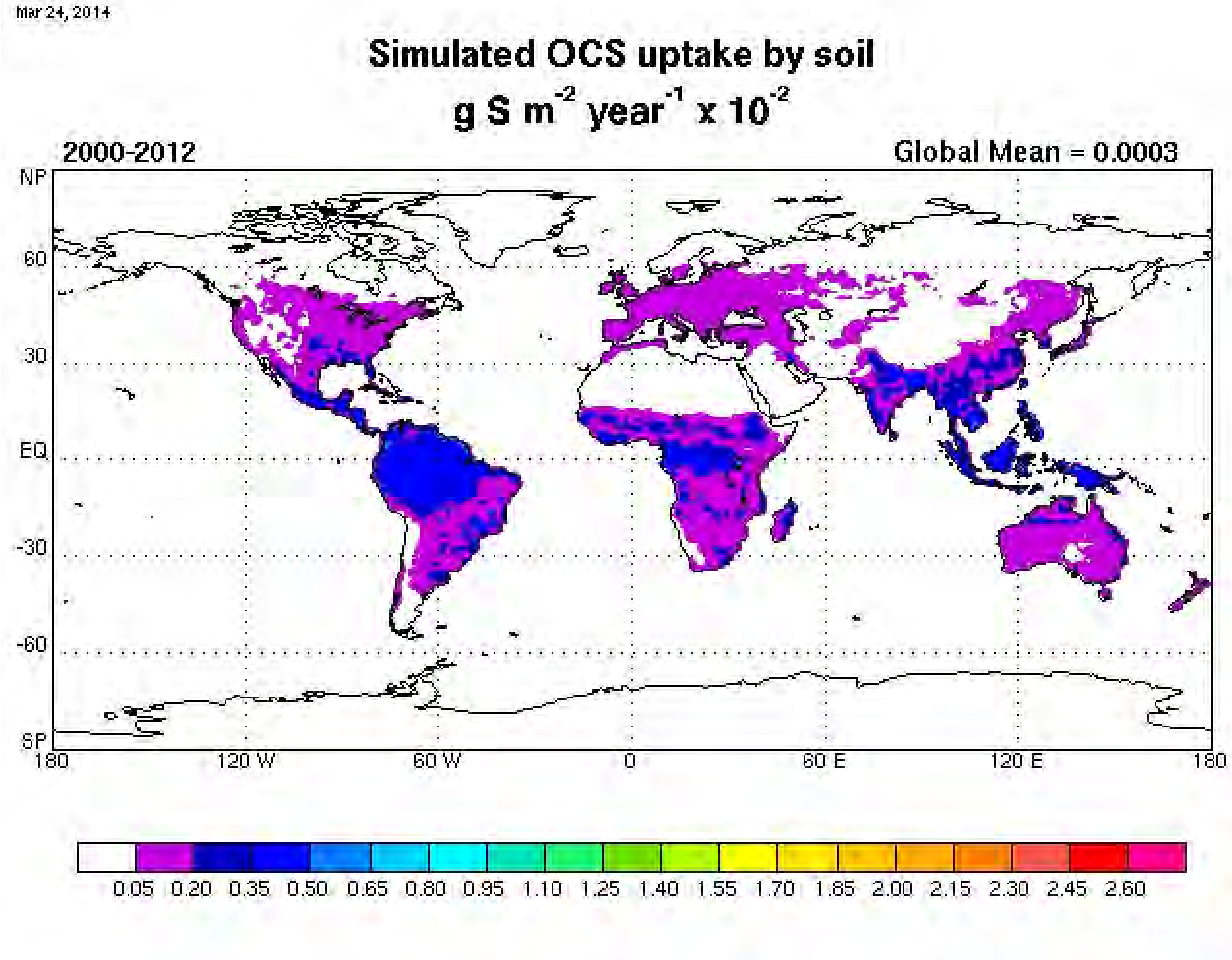

Figure 3: OCS uptake by soil (g S m^{-2} $year^{-1}$).

Next Steps:
On 19 May I met with project PI Huilin Chen and collaborator Andy Jacobson to outline project goals for the coming months. With baseline SiB simulations established, we will begin to configure model code for Huilin and his team to use for ensemble simulations and parameter estimation.

The basic premise is as follows: We will simulate regional CO2 and OCS flux in an ensemble of simulations, and these surface fluxes will be advected within a transport model (STILT) to allow comparison of CO2 and OCS concentrations with observations from towers, flasks, and aircraft. The initial ensembles will span reasonable values in parameter space for a yet-to-be determined number of critical model parameters. As the evaluation and parameter estimation process continues, PDFs of parameter values will be 'tightened' until an optimized solution in parameter space is determined. The values obtained in the regional experiment will then be utilized in a global simulation.

The regional model domain will be North America (-50 to -170 West Longitude, 10 to 80 North Latitude) as shown in Figure 4. We will prepare a simulation framework, including the following elements:

1. Surface parameter files, including information on vegetation and soil type
2. Fully spun-up carbon pools (vegetation, debris, soil) for year 2000.
3. Optimized output; As multiple ensembles will be run, we will want to streamline diagnostics. Output will be confined to CO2 and OCS fluxes on an hourly- or 3-hourly basis.

4. Parameter estimation: We will provide ‘hooks’ in the code for modifying parameter values as a means to improve model performance.
5. Grid: we will have the model set up to run on either a 1-degree or 0.5 degree grid.

Final selection of several aspects of model configuration will be determined by computing resources at PI Chen’s institution. Therefore, we will maintain flexibility in choosing the number of parameters estimated and/or grid resolution as a means to facilitate adaptability. We will address points 1-5 above in the next few months.

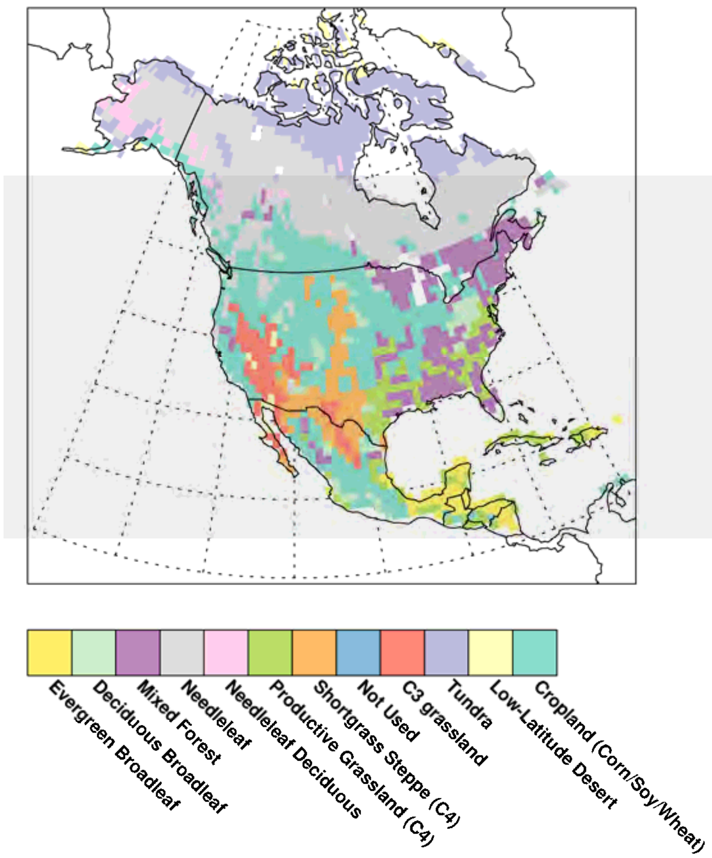

Figure 4: Model domain, showing vegetation type

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COMPETITIVE PROJECT TITLE: Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models (NA12OAR4310077)

The following is the most recent report previously submitted to the Technical Sponsor.

Project Title: Intraseasonal to Interannual Variability in the Intra-Americas Sea in Climate Models
Project Number: GC12-433 **(**NA12OAR4310077, NA13OAR4310092)
PIs: Eric D. Maloney (Colorado State University) and Shang-Ping Xie (Scripps Oceanographic Institute)
Report Type: Year 3 Report

Results and Accomplishments
The following sections list the primarily accomplishments for Year 3 by study, with the 23 publications accumulated for Years 1-3 of the project listed in the publication list at the end of the document. Unfortunately, we cannot be comprehensive given space constraints for all publications, but please contact me for more details if you are interested in anything that was missed. Again, we will concentrate on the relatively new results from this year.

North American climate in CMIP5 experiments: Assessment of 21st Century projections. (Maloney et al. 2014a)
This is the third of a three part series of review papers led by the NOAA MAPP CMIP5 Task Force on CMIP5 models and North American climate. In Part 3 of this three-part study on North American climate in Coupled Model Intercomparison project (CMIP5) models, we examine projections of 21st century climate in the RCP8.5 emission experiments. This paper summarizes and synthesizes results from several coordinated studies by the authors. Aspects of North American climate change that are examined include changes in continental-scale temperature and the hydrologic cycle, extremes events, and storm tracks, as well as regional manifestations of these climate variables. We also examine changes in eastern north Pacific and north Atlantic tropical cyclone activity and North American intraseasonal to decadal variability, including changes in teleconnections to other regions of the globe.

Projected changes are generally consistent with those previously published for CMIP3, although CMIP5 model projections differ importantly from those of CMIP3 in some aspects, including CMIP5 model agreement on increased central California precipitation. The paper also highlights uncertainties and limitations based on current results as priorities for further research. Although many projected changes in North American climate are consistent across CMIP5 models, substantial intermodel disagreement exists in other aspects. Areas of disagreement include projections of changes in snow water equivalent on a regional basis, summer Arctic sea ice extent, the magnitude and sign of regional precipitation changes, extreme heat events across the Northern U.S., and Atlantic and east Pacific tropical cyclone activity.

The first and second parts of the three part series of papers described at the top of this section are Sheffield et al. (2013 a,b), which provide an assessment of the ability of CMIP5 models to simulate current North American climate and related processes.

Gross moist stability and MJO simulation skill in three full-physics GCMs (Benedict et al. 2014).
This paper describes development of a process-oriented model diagnostic that attempts to explain why some models produce a good MJO simulation, and why others do not. Previous studies have demonstrated a link between gross moist stability (GMS) and intraseasonal variability in theoretical and reduced-complexity models. GMS essentially gives a measure of how efficiently convection discharges moisture from the column. In such simplified models, moisture modes—convectively coupled tropical disturbances that are hypothesized to be dynamical relatives of the MJO and whose formation and dynamics are closely linked to moisture perturbations—develop only when GMS is either negative or “effectively” negative when considering additional sources of moist entropy. In most cases, these simplified models use a prescribed GMS value or otherwise assume it is a temporally independent property of the simulation. Limited work has

been done to assess the GMS and its connection to intraseasonal variability in full-physics general circulation models (GCMs).

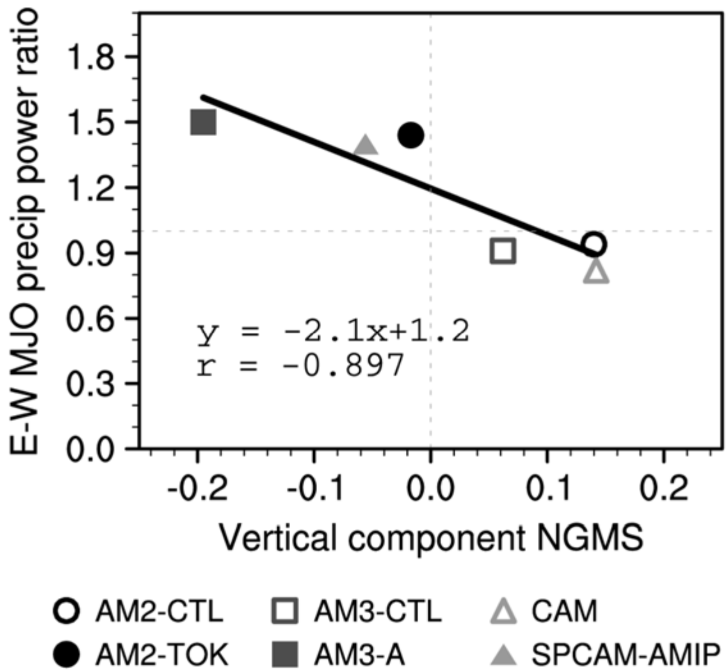

Figure 2. The relationship between October-April mean vertical component of gross moist stability and one metric of the robustness of MJO eastward propagation. The MJO metric is the ratio of eastward to westward tropical rainfall power within the MJO spectral region [periods 30-96 days, zonal wavenumbers +1 to +3 (eastward) or –1 to –3 (westward)]. Also shown are the best-fit line equation and correlation coefficient *r*.

The time-mean and intraseasonal behavior of GMS and its normalized version (NGMS) are examined in three pairs of GCMs to elucidate the possible importance of NGMS for MJO simulation. In each GCM pair, one member produces weak intraseasonal variability while the other produces stronger intraseasonal variability and robust MJO disturbances due to a change in the treatment of deep convection. A highly correlated linear relationship between time-mean NGMS and MJO simulation skill is observed, such that GCMs with less positive NGMS produce more robust MJO eastward propagation. The reduction in time-mean NGMS is primarily due to a sharp drop to negative values in the component of NGMS related to vertical advection (**Figure 2**), while the component related to horizontal advection has a less clear relationship with MJO simulation. Intraseasonal fluctuations of anomalous NGMS modulate the magnitude of background NGMS but, for the most part, do not change the sign of background NGMS. NGMS is reduced ahead of peak MJO rainfall and is increased during and after the heaviest precipitation. Total NGMS fluctuates during MJO passage but remains positive, suggesting that other sources of moist entropy are required to generate an effectively negative NGMS.

Process-oriented MJO simulation diagnostic: Moisture sensitivity of simulated convection. (Kim et al. 2014)

This paper describes further efforts to develop process-oriented diagnostics for Madden-Julian oscillation (MJO) simulations to facilitate improvements in the representation of the MJO in weather and climate models. These process-oriented diagnostics are expected to provide insights into how parameterizations of physical processes in climate models should be improved for a better MJO simulation. In this paper, we propose one such process-oriented diagnostic, which is designed to represent sensitivity of simulated convection to environmental moisture: composites of the relative humidity (RH) profile for precipitation percentiles.

The ability of the RH composite diagnostic to represent the diversity of MJO simulation skill is demonstrated using a group of climate model simulations participating in the Coupled Model Intercomparison Project Phase 3 (CMIP3) and CMIP5. A set of scalar process metrics that capture the key physical attributes of the RH diagnostic is derived and their statistical relationship with indices that quantify the fidelity of the MJO simulation is tested. We found that a process metric that represents the amount of lower-tropospheric humidity increase required for a transition from weak to strong rain regimes has a robust statistical relationship with MJO simulation skill. Our results suggest that moisture sensitivity of convection is closely related to a GCM's ability to simulate the MJO.

Process-oriented diagnosis of east Pacific warm pool intraseasonal variability (Maloney et al. 2014b).

June-October east Pacific warm pool intraseasonal variability is assessed in eight atmospheric general circulation simulations. Complex empirical orthogonal function analysis is used to document the leading mode of 30-90 day precipitation variability in the models and Tropical Rainfall Measuring Mission observations. The models exhibit a large spread in amplitude of the leading mode about the observed amplitude. Little relationship is demonstrated between amplitude of the leading mode and ability to simulate the observed propagation characteristics.

Several process-oriented diagnostics are explored that attempt to distinguish why some models produce a better representation of intraseasonal variability than others. A diagnostic based on the difference in 500-850 hPa averaged relative humidity between the top 5% and the top 10% of precipitation events exhibits a significant correlation with leading mode amplitude (**Figure 3**). Diagnostics based on the vertically-integrated moist static energy budget also demonstrate success at discriminating models with strong and weak variability. In particular, the vertical component of gross moist stability (GMS) exhibits a correlation with amplitude of -0.9, suggesting that models in which convection and associated divergent circulations are less efficient at discharging moisture from the column are more able to sustain strong intraseasonal variability. The horizontal component of GMS exhibits a significant positive correlation with amplitude. Consequences of these successful diagnostics for the dynamics of east Pacific intraseasonal variability are discussed.

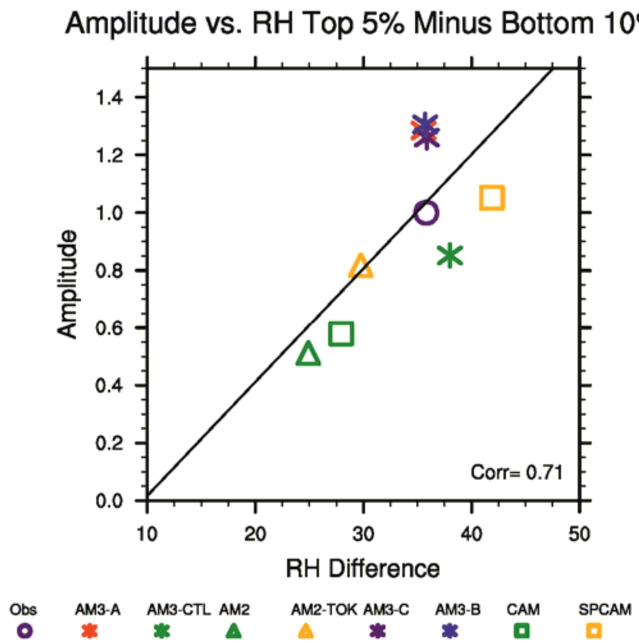

Figure 3. Amplitude of the leading CEOF mode versus the di_erence in June-October average 500-850 hPa mass weighted relative humidity between the top 5% and bottom 10% of daily averaged precipitation events . Amplitude is averaged over the domain 5N-20N, 120W-90W, and relative humidity and precipitation are considered on a point-by-point basis in the same domain. Amplitude is normalized by the TRMM amplitude. The correlation is shown in the bottom right, and the least squares regression line is also shown.

Several other diagnostics were tested including the warm pool mean surface zonal wind, the strength of surface flux feedbacks, and 500-850 hPa averaged relative humidity for the top 1% of rainfall events, but these diagnostics showed no significant relationship to leading mode amplitude. Vertical zonal wind shear does not appear to be a good predictor of model success at simulating the observed northward propagation pattern. Introduction of ocean coupling to one model with strong intraseasonal variability also did not improve the pattern of propagation.

Climate model evaluation (Li and Xie 2014)

Errors of coupled general circulation models (CGCMs) limit their utility for climate prediction and projection. Origins of and feedback for tropical biases are investigated in the historical climate simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5), together with the available Atmospheric Model Intercomparison Project (AMIP) simulations. The excessive equatorial Pacific cold tongue and double intertropical convergence zone (ITCZ) stand out as the most prominent errors of the current generation of CGCMs. The comparison of CMIP-AMIP pairs enables us to identify whether a given type of errors originates from atmospheric models. The equatorial Pacific cold tongue bias is associated with deficient precipitation and surface easterly wind bias in the western half of the basin in CGCMs, but these errors are absent in atmosphere-only models, indicating that the errors arise from the interaction with the ocean via Bjerknes feedback. For the double ITCZ problem, excessive precipitation south of the equator correlates well with excessive downward solar radiation in the Southern Hemisphere midlatitudes, an error traced back to atmospheric model simulations of cloud during austral spring and summer. This extratropical forcing of the ITCZ displacements is mediated by tropical ocean-atmosphere interaction, and is consistent with recent studies of ocean-atmospheric energy transport balance.

El Nino teleconnections in a warming climate (Zhou et al. 2014)
Atmospheric general circulation model simulations are used to investigate how ENSO-induced teleconnection patterns during boreal winter might change in response to global warming in the Pacific–North American sector. As models disagree on changes in the amplitude and spatial pattern of ENSO in response to global warming, for simplicity the same sea surface temperature (SST) pattern of ENSO is prescribed before and after the climate warming. In a warmer climate, precipitation anomalies intensify and move eastward over the equatorial Pacific during El Niño because the enhanced mean SST warming reduces the barrier to deep convection in the eastern basin. Associated with the eastward shift of tropical convective anomalies, the ENSO-forced Pacific–North American (PNA) teleconnection pattern moves eastward and intensifies under the climate warming. As a result, rainfall anomalies are expected to intensify on the west coast of North America, and the El Niño–induced surface warming to expand eastward and occupy all of northern North America.

Review of Tropical Intraseasonal Modes of the Atmosphere (Serra et al. 2014)
Tropical intraseasonal variability (TISV) of the atmosphere describes the coherent variability in basic state variables, including pressure, wind, temperature, and humidity, as well as in the physical phenomena associated with the covariability of these parameters, such as rainfall and cloudiness, over synoptic (~1,000 km, ~1–10 days) to planetary (~10,000 km, ~10–100 days) scales. In the past, the characteristics of individual TISV modes were studied separately, and much has been learned from this approach. More recent studies have increasingly focused on the multiscale nature of these modes, leading to exciting new developments in our understanding of tropical meteorology. This article reviews the most recent observations of TISV and its associated impacts on regional weather, short-term climate patterns, and atmospheric chemical transports, as well as the ability of numerical models to capture these interacting modes of variability. We also suggest where the field might focus its efforts in the future.

Convective Coupling and Moisture Organization of East Pacific Easterly Waves (Rydbeck and Maloney 2015)
Processes associated with local amplification of easterly waves (EWs) in the east Pacific warm pool are explored. Developing EWs favor convection in the southwest and northeast quadrants of the disturbance. In nascent EWs, convection favors the southwest quadrant, whereas convection in the northeast quadrant becomes increasingly prominent and southwest quadrant convection wanes as the EW lifecycle progresses. The EW moisture budget reveals that perturbation meridional winds acting on the mean meridional moisture gradient of the ITCZ produce moisture anomalies supportive of convection in the southwest quadrant early in the EW lifecycle. As EWs mature, moisture anomalies on the poleward side of the EW begin to grow and are supported by the advection of anomalous moisture by the mean zonal wind.

In southwest and northeast portions of the wave where convection anomalies are favored, lower tropospheric vorticity is generated locally through vertical stretching that supports a horizontal tilt of the wave from the southwest to the northeast. EWs with such tilts are then able to draw energy via barotropic conversion from the background cyclonic zonal wind shear present in the east Pacific. Convection anomalies associated with EWs vary strongly with changes in the background intraseasonal state. EWs during westerly and neutral intraseasonal periods are associated with robust convection anomalies. Easterly intraseasonal periods are, at times, associated with very weak EW convection anomalies due to weaker moisture and diluted CAPE variations.

NOAA MAPP CMIP5 Task Force
Eric Maloney finished his terms as co-chair, and Shang-Ping Xie finished his term as a member, of the NOAA MAPP CMIP5 Task Force. Accomplishments have included generation of a *Journal of Climate* special collection on North American Climate in CMIP5 Models, which includes the overview papers discussed in the report on Maloney et al. (2014a) above. Recent task force activities include thrusts related to 1) use of CMIP5 models to inform climate applications [see Sheffield et al. (2014) report in reference list below] and 2) process-oriented model diagnostics to inform model development and applications. Regarding point #2, we have explicitly engaged modeling centers at NCAR and GFDL with plans to incorporate some

of the process-oriented model diagnostics developed as a task force into standard model diagnostics packages used by these two modeling centers. The NOAA CMIP5 task force concluded its activities this coming Fall with a celebration at the AGU annual meeting in San Francisco.

Highlights of Accomplishments

- We strongly contributed to a *Journal of Climate* special collection on North American climate in CMIP5 models, including a lead-author comprehensive paper by the PI (Maloney) examining CMIP5 projections of North American climate.
- We developed several successful process-oriented model diagnostics that can distinguish between models with good and poor intraseasonal variability, and applied these diagnostics to several versions of the GFDL AM2 and AM3, and the NCAR CAM and SP-CAM. This analysis extended to the tropical Americas. These metrics should help inform model development.
- We have diagnosed reasons for CMIP5 model bias in the ITCZ and cold tongue regions of the Pacific, helping to inform model development
- We have contributed to the NOAA MAPP CMIP5 Task Force process-oriented model diagnostics effort, successful engaging NCAR and GFDL and making plans for incorporating our diagnostics into their standard model diagnostics packages.
- We have shown that the ENSO-forced Pacific–North American (PNA) teleconnection pattern is projected to move eastward and intensify under the climate warming, intensifying rainfall anomalies on the west coast of North America
- We have shown that convective heating helps to tilt easterly waves in the east Pacific, which then allows them to intensify in the presence of a mean sheared flow. This highlights an easterly wave generation mechanism in the east Pacific in isolation from African easterly waves.

Publications From the Project

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3) Richter, I., S.-P. Xie, A.T. Wittenberg, and Y. Masumoto, 2012: Tropical Atlantic biases and their relation to surface wind stress and terrestrial precipitation. *Clim. Dyn*., **38**, 985-1001, doi:10.1007/s00382-011-1038-9.
4) Rydbeck, R. V., 2012: *Remote versus Local Forcing of East Pacific Intraseasonal Variability.* M.S. thesis, Colorado State University, 126pp.
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PIs Contact Information

Eric D. Maloney (lead PI)
Department of Atmospheric Science
Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University
1371 Campus Delivery
Fort Collins, CO 80523-1371
Phone: (970) 491-3368
Fax: (970) 491-8449
emaloney@atmos.colostate.edu

Shang-Ping Xie (co-PI)
Scripps Institution of Oceanography
UC San Diego
9500 Gilman Drive # 0206
La Jolla CA, 92093-0206
Phone: 858-822-0053
Fax: 858-822-0302

6. Budget for the Coming Year

The budget for the coming year is unchanged from that in the submitted proposal.

7. Future Work

The work for the next year is anticipated to be the same as in the submitted proposal, with the exception that we have expanded our focus to help develop process-oriented model diagnostics that will help us to determine why some models can simulate North American climate accurately, while others cannot. Diagnostics are also being developed that inform climate applications.

COMPETITIVE PROJECT TITLE: Observational Constraints on the Mechanisms that Control Size- and Chemistry-resolved Aerosol Fluxes Over a Colorado Forest (NA14OAR4310141)

This is a new project that has not submitted a report to Grants On Line as yet.

PRINCIPAL INVESTIGATOR(S): Delphine K. Farmer/Chris Kummerow

RESEARCH TEAM: (CIRA/CSU Staff involved in the project listed in order of staffing time on project, contribution level, or other):

NOAA TECHNICAL CONTACT: Monika Kopacz, Competition Manager

NOAA RESEARCH TEAM (The equivalent of CIRA Research Team for NOAA Staff involved in the project and their affiliations):

PROJECT OBJECTIVE:

To determine the fluxes of particles in terms of both size and chemistry over a forest as a function of season

PROJECT ACCOMPLISHMENTS:

--Instrument and software development for instruments as preparation for first field deployment
--Training of students in eddy covariance flux measurement

COMPETITIVE PROJECT TITLE: Research to Advance Climate and Earth System Models Collaborative Research: A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models (NA13OAR4310103)

The following is the most recent report previously submitted to the Technical Sponsor.

A CPT for Improving Turbulence and Cloud Processes
In the NCEP Global Models

Steven K. Krueger (Lead P.I.), Peter A. Bogenschutz (P.I.), Shrinivas Moorthi (P.I.), Robert Pincus (P.I.), and David A. Randall (P.I.)

Year 1 Progress Report

Grant NA13OAR4310101

Results and Accomplishments

Each P.I. received only nominal funding ($1K) this year. As a consequence, there are no scientific results or accomplishments to report.

- Met at NCEP in Dec. 2013 (Krueger, Moorthi, Pincus, and Randall)
- Presented a MAPP Webinar in Jan. 2014
- Participated in MAPP Climate Model Development Task Force
- Interviewed postdoc candidates in March 2014 (Krueger, Moorthi, and Randall)
- Hired postdoc in April 2014 (Alexei Belochitski)
- Participated in Testbed-Proving Ground Workshop April 16-18, 2014 (SM presented a poster).

Highlights of Accomplishments

- Collaborators met at NCEP
- Presented a MAPP Webinar
- Participated in MAPP Climate Model Development Task Force
- Interviewed postdoc candidates
- Hired postdoc
- Participated in Testbed-Proving Ground Workshop

Publications from the Project
(None)

PI Contact Information

Lead P.I.:
Steven K. Krueger, Professor
Department of Atmospheric Sciences
University of Utah
135 South 1460 East, Room 819
Salt Lake City, UT 84112-0110

steven.krueger@utah.edu
phone: (801) 581-3903

P.I.:
Dr. Shrinivas Moorthi, Research Meteorologist
Global Climate and Weather Modeling Branch
Environmental Modeling Center / NCEP
5830 University Research Court - (W/NP23)
College Park MD 20740

Shrinivas.Moorthi@noaa.gov
phone: (301) 683-3718

P.I.:
Dr. Robert Pincus, Research Scientist
CIRES
University of Colorado at Boulder
Box 216 UCB
Boulder, CO 80309-0216

robert.pincus@colorado.edu
phone: (917) 464-3569

P.I.:
David A. Randall, Professor
Department of Atmospheric Science
Colorado State University
1371 Campus Delivery
Fort Collins, Colorado 80523-1371

randall@atmos.colostate.edu
phone: (970) 491-8474

P.I.:
Peter A. Bogenschutz, Project Scientist
Climate and Global Dynamics
National Center for Atmospheric Research
P.O. Box 3000
Boulder, CO 80307-3000

bogensch@ucar.edu
phone: (303) 497-1341

Budget for Coming Year

The budgets for the coming year are unchanged from those revised before the awards were made in accord with NOAA's requests.

Investigator	Institution	Budget
Krueger	Univ of Utah	$71,000
Moorthi	NCEP/NOAA	$120,000
Pincus	ESRL/NOAA	$85,000
Randall	CSU	$60,000
Bogenschutz	NCAR	$12,000

Future Work

The future work is unchanged from that in the submitted proposal, which is reproduced below. However, progress is anticipated to be significantly less rapid than originally planned due to the reduction of Moorthi's (NCEP/NOAA) budget by more than $130K, and the consequent reduction in postdocs at NCEP from two to one.

- **Year 2**

  Include new physics modules in the SCM (single-column model) based on the GFS model. Perform and compare SCM experiments with both the current operational GFS physics and new physics. Use DOE ARM[1] Program observations/analyses to initialize the SCM and to evaluate/validate the SCM performance. Select cases of special interest that ARM Program scientists have investigated before and published. Tune the physics if necessary.

  Incorporate advanced physics in the global forecast model. Perform medium-range NWP forecasts with prescribed initial conditions (from the operational GDAS). Evaluate model performs and tune the physics if necessary. Start performing AMIP-type climate tests[2] with prescribed (observed) SSTs. Depending on the results tune the model or modify the pa- rameterizations. Since the planned changes touch all aspects of the physics including SGS turbulence, cloud-radiation-microphysics interaction, and unified convection, we expect ex- tensive testing and fine tuning. If any of the physics changes show quick promise for NWP improvements, make that part available foroperational implementation, while continuing working on other parts. Strive to have each of the changes included in the GFS annual upgrade and implementation.

- **Year 3**

  Carry out fully cycled GFS parallel experiments at lower resolution (such as T382), including both analysis and forecast steps. Using NCEP/EMC/GCWMB[3] standard verification package to assess performance of the updated model compared to the operational version at that resolution. Evaluation metrics include but are not limited to anomaly correlations, RMSE, precipitation skill scores, fits to surface and rawinsonde observations, hurricane track, etc. This procedure may need to be iterated to obtain optimal performance from the new physics.

  Continue performing AMIP-type climate tests as the physics is changed. If coupling to an ocean model is available,[4] start testing with the coupled model to assess the impact of physics on long term coupled integration. If the results from any of the physics changes show promise for NWP, perform the cycled parallel test at the current (or future) operational resolution for possible operational implementation.

- **Year 4**

  Continue coupled climate forecast experiments. Examine impact of new physics on ENSO, MJO, ISO, monsoon variability, etc. Perform coupled model runs in the seasonal forecast mode: i.e., several years (~5 years) of nine-month retrospective forecasts from operational initial states starting from different seasons to assess the impact of the new coupled model on seasonal forecasting. Depending on the results, EMC may select all or parts of the physics upgrade to be considered for future CFS implementation. Likewise, we will again parallel test all or parts of physics upgrade (incorporated in the NEMS-based global model) in fully cycled mode at the anticipated resolution for future global model and make it available for operational implementation.

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[1] Atmospheric Radiation Measurement

[2] An AMIP-type climate test is a year-long forecast with observed boundary conditions of SST, snow, and sea ice fields to help identify if the updated physics has some climate bias.

[3] Global Climate and Weather Modeling Branch

[4] The current GFS is already coupled to MOM4 (GFDL's Modular Ocean Model, v. 4). However, the new GFS in the NEMS (NOAA Environmental Modeling System) infrastructure is yet to be coupled, but will be coupled to MOM5 (Modular Ocean Model, v. 5) and HYCOM (HYbrid Coordinate Ocean Model). CPC is already running the current GFS coupled to MOM4 as preliminary step toward future CFSV3.

COMPETITIVE PROJECT TITLE: Towards Assimilation of Satellite, Aircraft, and Other Upper-air CO_2 Data into CarbonTracker (NA13OAR4310077)

The following is the most recent report previously submitted to the Technical Sponsor.

PRINCIPAL INVESTIGATOR: David F. Baker

CIRA RESEARCH TEAM: Michael Trudeau, David F. Baker

NOAA TECHNICAL CONTACT: Pieter Tans, ESRL/Global Modeling Division

NOAA RESEARCH TEAM: Andrew Jacobson, CIRES/University of Colorado

PROJECT OBJECTIVES: CarbonTracker-CO_2 (CT) is a data assimilation system that estimates sources and sinks of CO_2 from atmospheric measurements, using an atmospheric transport model to link CO_2 concentrations to surface fluxes. It solves for fluxes across continental biome-sized regions over land, and basin-sized regions over the ocean, using data from NOAA/GMD's global network of *in situ* CO_2 measurement sites (flasks, tall towers, and continuous sensors). Over the past 7 years, it has been the most-used CO_2 flux product in the world. As currently configured, however, the link between surface fluxes and the down-stream effect on CO_2 concentrations is truncated after only five weeks: this is too short a time for these fluxes to mix well into the middle to upper part of the atmospheric column. As a result, CT cannot use data taken far away from the surface, such as aircraft profiles, and column-averaged CO_2 measurements from satellite and ground-based spectrometers, to provide a reliable constraint on surface fluxes: signals in the upper part of the atmospheric column are mis-attributed to near-field fluxes (those emitted within 5 weeks) rather than to the far-field fluxes that actually caused them. Given the current explosion of such data from satellites (GOSAT, OCO-2, *etc.*) and from the Total Column Carbon Observing Network (TCCON), we would like to modify CT to be able to use these data. In this project, we will experiment with lengthening the 5-week assimilation window currently used in the CT ensemble Kalman smoother (EnKS), as well as adding an "outer-loop" inversion to optimize the prior used in the EnKS at coarser scales, to minimize truncation errors from shorter window lengths in the EnKS. We will also enhance CT to solve for the surface CO_2 fluxes at higher spatial resolution when using the new high-density data. Simulation experiments will be used to accurately assess the impact of the modifications.

PROJECT ACCOMPLISHMENTS:

To do the tests outlined in the proposal, we need a version of CarbonTracker that can run quickly (to allow runs with long assimilation windows) and can incorporate different types of upper air data. To that end, we have modified CT to compute and output two broad types of upper air measurements from modeled 3-D CO_2 fields:

1--In situ measurements at a given height or pressure, as needed for aircraft profiles. D. Baker has (in previous work) modified the PCTM code to compute the geopotential height (GPH) corresponding to a point measurement at a given height or pressure, then to interpolate between model layers to that GPH, given the surface pressure and surface elevation of the model. This GPH functionality is currently being implemented in TM5.

2--Column-integrated measurements, as from satellite or TCCON. M. Trudeau has now modified CarbonTracker to output the full vertical column $\boldsymbol{c}_{model}$ of modeled CO_2 values at a given measurement location. Column-integrated measurements $\boldsymbol{x}_+$ corresponding to these modeled values may then be computed as

$$\boldsymbol{x}_+ = \boldsymbol{x}_o + \boldsymbol{a}^T(\boldsymbol{c}_{model}-\boldsymbol{c}_o)$$

where $\boldsymbol{c}_o$ and $\boldsymbol{x}_o$ are the *a priori* CO_2 column vector and column integral assumed in the satellite or TCCON retrieval process, and $\boldsymbol{a}$ is the averaging kernel appropriate for the retrieval. Care must be taken to handle the different vertical coordinates for $\boldsymbol{c}_{model}$ versus $\boldsymbol{a}$ and $\boldsymbol{c}_o$ properly. This new capability in CT is now being tested against similar code used in Baker's PCTM model as a check.

Running CT with long assimilation windows increases its run time in proportion to the number of flux emission times estimated in the state. Solving for weekly fluxes across a year-long assimilation window (52 weeks) instead of the current 5 weeks, for example, will result in assimilations that take ~10x longer to run. To enable the runs outlined in the proposal to be run in a time-efficient manner, a coarse-resolution version of CT will be used. (We are assuming that the relationship between time truncation error and window length is not strongly dependent on the resolution used, so that the results of these coarse-resolution experiments will also apply at the finer scales currently used operationally.) One option is to run TM5 at 4°x6° (lat/lon) globally, instead of the current 2°x3° version, and with no zoom regions. Another option is to run CT driven by PCTM, at a coarsened version of the MERRA drivers. D. Baker has (in previous work) ported PCTM to NOAA's "zeus" computer, along with its MERRA 1°x1.25° driving meteorology and mixing fields. He has also set up the ability to run PCTM at coarsened resolutions of 3°x3.75° and 9°x11.25° (lat/lon). We will try running the window-lengthening experiments with TM5 at 4°x6° resolution first; if we still find significant differences at long window lengths at this resolution and need to go to longer windows, and if this takes too long to run, then we have the option of running CT with PCTM at 9°x11.25°.

The TM5 transport model used up to now has relied on the ECMWF forecast meteorology products to drive its CT inversions. However, the TM5 team in the Netherlands is no longer creating the needed TM5 winds from these analyses, but has switched to using the ECMWF ERA-Interim reanalyses. The ECMWF forecast meteorology has a higher vertical resolution and better availability, however, which makes it better suited to near real-time assimilations of vertical profile data. In order to have the needed meteorology products (winds and mixing fields) to drive TM5 for use with future satellite data, M. Trudeau has worked to establish processing of the needed products from the ECMWF forecast meteorology both at ECMWF and at the NOAA Environmental Security Computing Center (NESCC).

A. Jacobson has added the ability to use simulated rather than real measurements as input to CarbonTracker – this capability will be used in the simulation experiments outlined in the proposal to compute true estimation errors, using the known true fluxes that generated the true measurements. A. Jacobson has also modified CarbonTracker to use the new, preferred format for NOAA *in situ* data, ObsPack. This is necessary to ingest the aircraft *in situ* data used in this study.

With this progress, we are nearing the point where we can perform the window-lengthening experiments, using simulated data. We suspect that these experiments will show that lengthening the assimilation window to 6 months or more will be required to keep time truncation errors to reasonable levels, and that estimating weekly fluxes across a 6 month window (much less finer time resolutions) will be prohibitively expensive at the current 2°x3° global operational resolution. As outlined in our proposal, a more cost-effective alternative would be to perform a coarse-resolution initial inversion to optimize fluxes at longer time scales (those generally affecting the upper part of the column) and broader spatial scales, so that the prior going into the EnKS portion of CT would have smaller errors at these scales. The EnKS step would then be used to refine the finer time and space scales, using the shorter assimilation window to assign these corrections to the near-field fluxes that cause such finer-scale variability (since atmospheric mixing mixes out any such variability in the far-field fluxes).

One candidate for such an initial "outer loop" flux inversion uses additive flux basis functions derived from empirical orthogonal functions (EOFs) of land and ocean carbon models. These EOFs capture the most important modes of variability within each model, and when multiple models are used, they also capture the most important modes of across-model disagreement. The EOFs also represent interannual variability caused by anomalies like drought, heat waves, and climate modes such as El Niño. This approach has several advantages. Since the flux modes are additive, they have the ability to adjust the phasing of the annual cycle. With CT's current multiplicative scaling factor approach, the inversion is strongly tied to the phasing of the annual cycle in the prior model. EOFs are naturally ordered by spatial and temporal scale, with the most important modes expressing the largest and longest scales. This means that we can adjust the scale of flux adjustments in the inversion by changing the number of EOFs used in each region. Thus we have a means of retrieving higher-resolution flux maps in regions with more observational constraints, and lower resolutions in under-observed locations. Finally, the models also tell us how long each mode of variability should endure. The time scale associate with each EOF can be computed from the autocorrelation function of the mode's time series. This allows us to implement a "modified persistence" dynamical model for the flux adjustments, in which a mode, once "activated" by observations tends to decay back to zero magnitude at the rate predicted by models. This mechanistic approach allows us to compute an expected prior flux for each model time step. This is a vast improvement over CT's current *ad hoc* scheme, which does not account for anomaly persistence in any systematic way and has a completely informal dynamical model. The formulation of this dynamical model also gives a predictive scheme for the prior error covariance, and will allow us to more correctly estimate flux uncertainties in CarbonTracker.

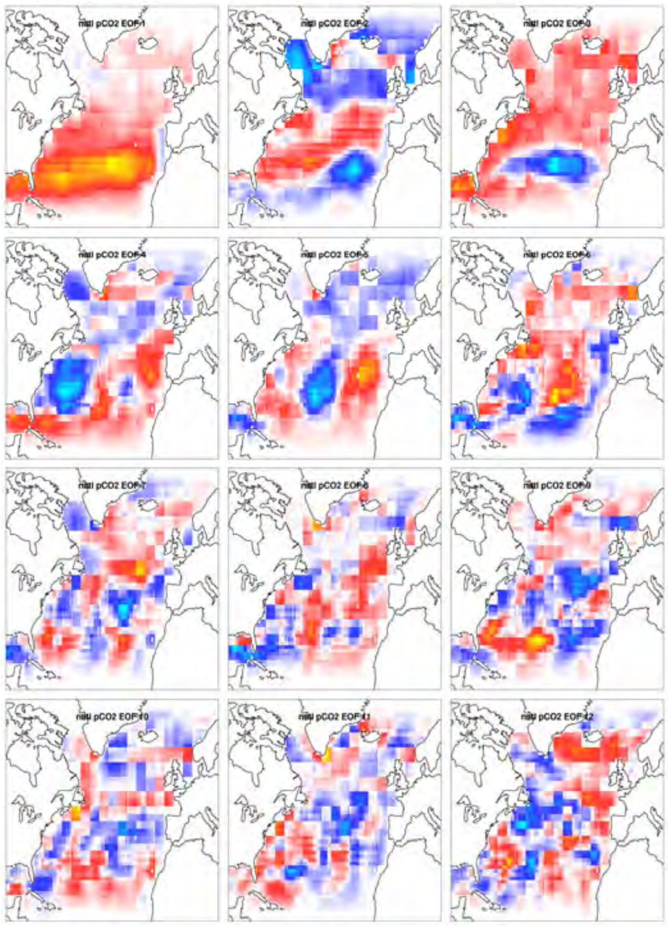

Figure 1. *Leading EOFs of flux variability in the North Atlantic ocean derived from four CMIP5 ocean carbon models.*

Significant progress has been made in preparing oceanic basis functions using this EOF-based approach. Basis functions for each of ten ocean basins were computed from a set of four CMIP5 carbon models. In Figure 1, the leading EOFs for the North Atlantic basin are shown. It can be directly observed that spatial scales are greatest for the first modes, and that these scales tend to decrease in higher-order modes. A synthetic data experiment was conducted using these basis functions, not only to test a first implementation of the modified persistence dynamical model, but also to investigate Kalman filter tuning parameters appropriate to the available pCO_2 observations. Some results from this experiment are shown in Figure 2.

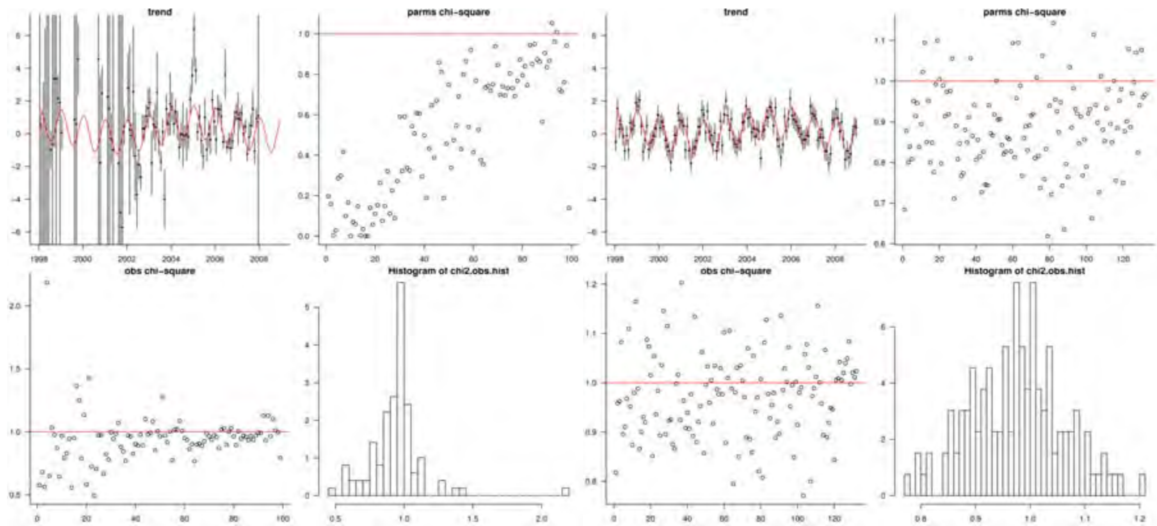

Figure 2. *Results from a synthetic data experiment investigating the tuning parameters of a Kalman filter model in the N. Atlantic Ocean using the real historical observational network (left two columns, panels a-d) and an artificial network (right two columns, panels e-h). Panels a and e: basin-wide average with truth in red, and retrieved values with 1-sigma errors in black. Panels b and f: time series of chi-squared values for parameters with goal of 1.0 in red. Panels c and g: chi-squared values for observational residuals, goal of 1.0 in red. Panels d and h: histogram of observations chi-square values.*

This synthetic data experiment was conducted using two observational networks. The first used the actual historical network from 1998-2008 in which the number of observations per month varies from zero to 600. The second uses a fixed observational network of 300 observations/ month evenly distributed throughout the basin. Both Kalman filters were successful in retrieving the imposed signal of seasonal and interannual variability within final uncertainty estimates, but diagnostics of Kalman filter performance show that the system must be adaptively tuned to available observational constraints. In particular, the chi-squared values for parameter values (Figure 2, panels b and f) and for observational residuals (Figure 2, panels c and g) show that the changing measurement density of the historical network requires a variable Kalman filter tuning. The trends in these chi-squared statistics reflect the fact that the filter was tuned to a fixed observational density. The trends are not present in the experiment using a fixed network.

Project Publications from Past Fiscal Year (including Conferences): None yet. Details on CarbonTracker-CO_2 may be found at: http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/

COMPETITIVE PROJECT TITLE: Upgrades to the Operational Monte Carlo Wind Speed Probability Program (NA13OAR4590190)

PRINCIPAL INVESTIGATORS: Andrea Schumacher

RESEARCH TEAM: Robert DeMaria and Dave Watson

NOAA TECHNICAL CONTACT: Mark DeMaria (NOAA/NWS/NHC)

NOAA RESEARCH TEAM: Mark DeMaria (NOAA/NWS/NHC)

PROJECT OBJECTIVES:

This project seeks to complete a number of upgrades to the current Monte Carlo wind speed probability model (hereafter MC model), many of which are based on NHC feedback over the past few hurricane seasons. Specific plans to improve the MC model include replacing the linear forecast interpolation scheme with a more precise spline fit scheme, applying a bias correction to the model track error statistics to provide consistency between NHC's uncertainty products, and applying a bias correction to the radii-CLIPER used by the MC model to improve the accuracy of the wind speed probabilities for exceptionally small or large (e.g. 2012's Hurricane Sandy) tropical cyclones. Additionally, several additions to the MC model will be completed such as estimates of the arrival and departure times of 34/50/64 kt winds, an integrated Goerss Predicted Consensus Error (GPCE) parameter, and wind speed probabilities beyond 5 days (proposed to 7 days). Finally, the error statistic generation code will be consolidated into a single streamlined version that will reduce the time needed to update the MC model statistics each year.

Tropical Cyclone (TC) forecasts affect risk mitigation activities of industry, public and governmental sectors and therefore supports directly NOAA's Weather and Water mission goals.

PROJECT ACCOMPLISHMENTS: Past Fiscal Year by Objective:

1--Replaced linear forecast interpolation scheme with spline fit scheme

Based on favorable testing results, the spline fit scheme developed in the last project year to replace the current linear time interpolation scheme in the MC model has been implemented in the operational version. The spline interpolation upgrade will be included in the version of the operational model running for the 2015 Atlantic and N.E. Pacific hurricane seasons. Figure 1 shows the impacts of this update on the performance of the MC model over a 3-year sample.

2--Bias correction made to MC model error statistics

The MC model uses forecast error statistics from the previous 5 years of official forecasts that do not currently exactly match the official error statistics verified by NHC. The main difference is that the MC model error statistics include some non-tropical cases (e.g., extratropical cyclones, post-tropical cyclones) that NHC does not. In order to provide consistency between NHC's uncertainty products, the MC model error statistics were adjust so they exactly match the official NHC errors reported each year in the annual Verification Reports (http://www.nhc.noaa.gov/verification/verify3.shtml?). Figure 1 shows the impacts of this update on the performance of the MC model over a 3-year sample.

3--Bias correction applied to MC model radii estimates

The current MC model uses a climatology and persistence model to estimate the 34-kt, 50-kt, and 64-kt wind radii for its realizations, which has been found to greatly over (under) estimate radii for exceptionally small (large) tropical cyclones. To address this issue, the MC model was adapted to use the official R34, R50, and R64 radii forecasts. Since official radii forecasts are only made out to 36-72 hours, radii at times after the last available radius forecast are estimated using a persistence method that relaxes back to climatology after 32 hours. Figure 1 shows the impacts of this update on the performance of the MC model over a 3-year sample.

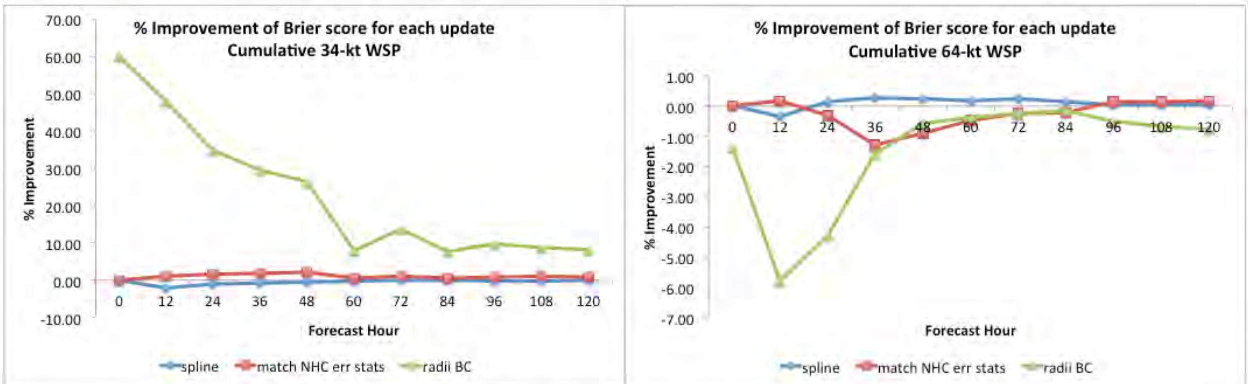

Figure 1. Improvement in Brier score for 34-kt (left) and 64-kt (right) wind speed probabilities for a sample of 2011-2013 Atlantic tropical cyclones.

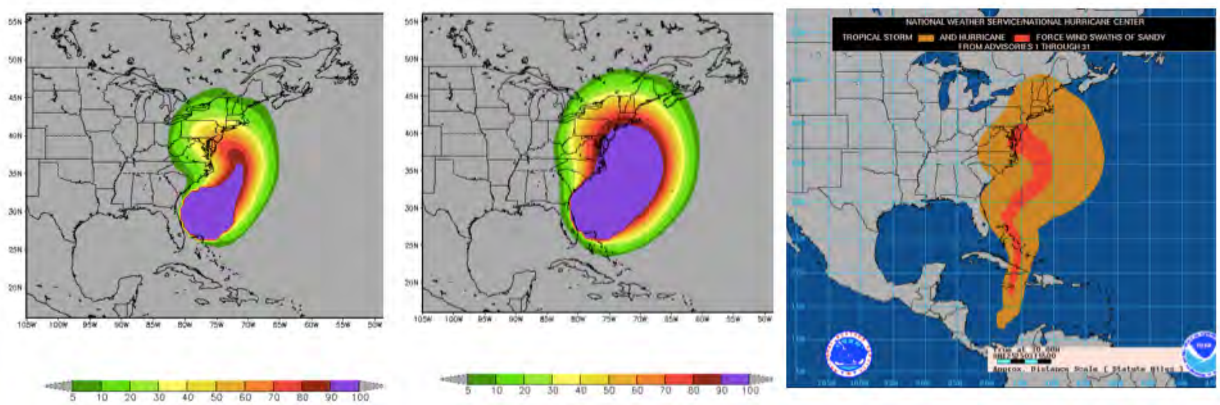

Figure 2. 34-kt wind speed probabilities for Hurricane Sandy before (left) and after (center) radii bias correction. Observed 34-kt winds are shown for comparison (right, in orange).

4--Development of time-integrated GPCE parameter:

It has been shown that past NHC track forecast errors can be separated into terciles based on their corresponding GPCE value, and that track forecast errors in the low (high) terciles tend to correspond to less (more) spread in forecast errors (DeMaria et al. 2013). This finding motivated the use of a GPCE parameter in the MC model. At present, this GPCE parameter determines the track error statistics used by the MC model to estimate wind speed probabilities, but the GPCE categories (low, medium, high) are not output directly.

It was proposed that a time integrated GPCE parameter be developed from the GPCE information used by the MC model. This information could be relayed to users through the NHC discussion product, and could potentially be used to modify the cone of uncertainty. A preliminary time integrated GPCE parameter was developed last year, and was further refined during this reporting period after discussions with NHC forecasters. The integrated GPCE parameter has been added as an option to the MC model.

5--Time of arrival/departure estimates:

Work on this update was led by NHC focal points and is near completion.

6-- Extending MC model to 7 days

Preliminary collection of the data needed to extend the MC model from 5 to 7 days has begun. This task is on track to be completed by June 2015.

7--Software updates

Once the improvements/updates in tasks 1-6 have received final approval, the MC model development code will be updated.

The following is the most recent report previously submitted to the Technical Sponsor.

NOAA Joint Hurricane Testbed (JHT)
Annual Report, Year 1

Date:	Sep 30, 2014
Reporting Period:	September 1, 2013 – August 31, 2014
Project Title:	Upgrades to the Operational Monte Carlo Wind Speed Probability Program
Principal Investigator:	Andrea Schumacher, CIRA / Colorado State University
Award Period:	September 1, 2013 – August 31, 2015

1. Long-term Objectives and Specific Plans to Achieve Them:

This project seeks to complete a number of upgrades to the current Monte Carlo wind speed probability model (hereafter MC model), many of which are based on NHC feedback over the past few hurricane seasons. Specific plans to improve the MC model include replacing the linear forecast interpolation scheme with a more precise spline fit scheme, applying a bias correction to the model track error statistics to provide consistency between NHC's uncertainty products, and applying a bias correction to the radii-CLIPER used by the MC model to improve the accuracy of the wind speed probabilities for exceptionally small or large (e.g. 2012's Hurricane Sandy) tropical cyclones. Additionally, several additions to the MC model will be completed such as estimates of the arrival and departure times of 34/50/64 kt winds, an integrated GPCE parameter, and wind speed probabilities beyond 5 days (proposed to 7 days). Finally, the error statistic generation code will be consolidated into a single streamlined version that will reduce the time needed to update the MC model statistics each year.

2. Year 1 Accomplishments:

a. Replaced linear forecast interpolation scheme with spline fit scheme

The starting point for the MC model is the NHC official track and intensity forecasts, which are available at 12 h intervals to 48 h and 24 h intervals from 48 to 120 h. A linear interpolation is used to obtain track and intensity between the forecast times. Verification statistics (DeMaria et al. 2009) show that the errors are larger for the times between the NHC forecast points, and an eastward bias is introduced for re-curving cyclones. This is especially problematic for storms close to the U.S. east coast, but just offshore, because it leads to an underestimate of the probabilities at the coast.

To correct this problem, the linear interpolation scheme was replaced with a spline fit. Figure 1 shows the Brier scores and threat scores (averaged over all probability thresholds) calculated for all 2013 Atlantic tropical cyclones. Overall, replacing the linear time interpolation scheme with a spline fit has very little impact on the basin verification statistics. The impact this fix has on wind speed probabilities can best be seen by examining the case of a tropical cyclone forecast to recurve. Figure 2 shows the difference between the forecast track and corresponding wind speed probabilities using linear interpolation (left) and the spline fit (center) for Hurricane Earl when it was forecast to recurve along the U.S. east coast. The spline fit methodology appears to be correcting the eastward bias in this case, providing a more realistic interpolated track forecast after 48 hours. The corresponding 34-kt wind speed probabilities along the North Carolina coast increase from 50-60% with the linear interpolation scheme to 70-80%.

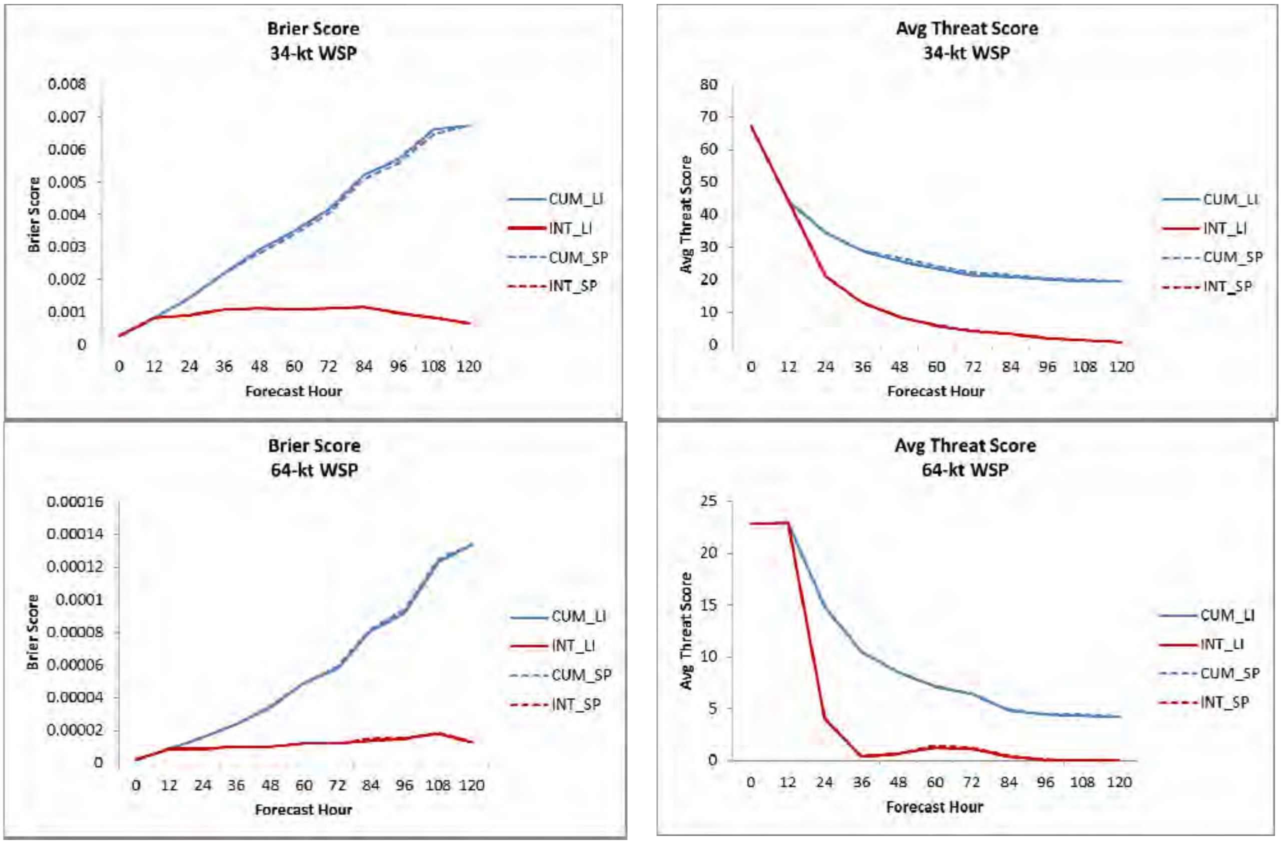

Figure 1. Brier scores for the 34-kt (left, top) and 64-kt (left, bottom) wind speed probabilities and threat scores average over all probabilities thresholds for the 34-kt (right, top) and 64-kt (right, bottom) wind speed probabilities for 2008-2012 Atlantic tropical cyclones. Verification metrics for cumulative (integrated) wind speed probabilities are shown in blue (red). Solid lines represent values using the linear interpolation scheme and dashed lines represent values using a spline fit scheme.

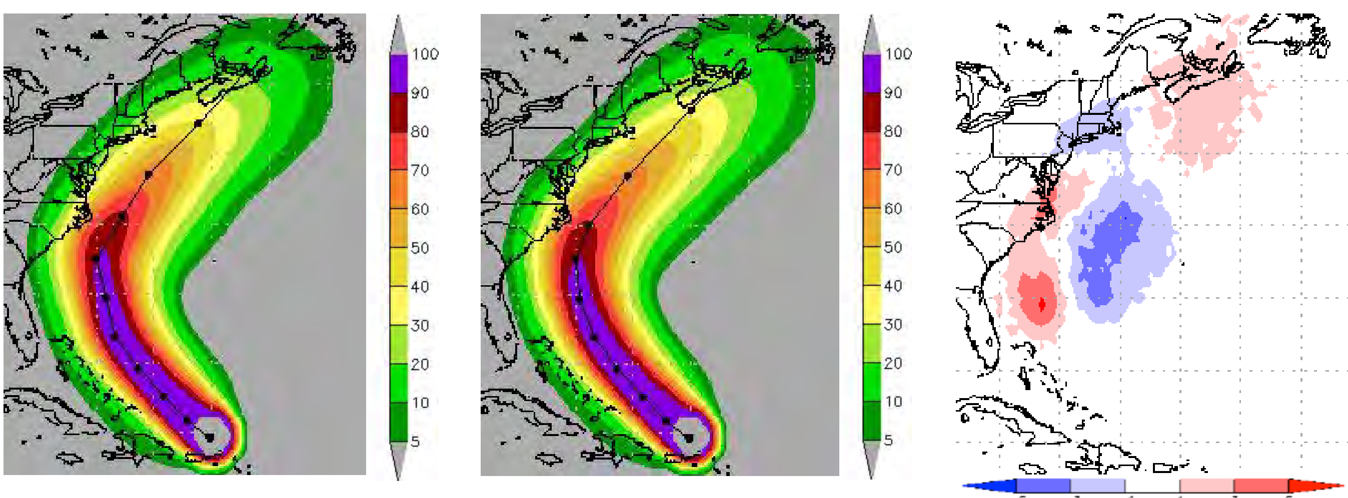

Figure 2. 34-kt wind speed probabilities using linear interpolation (left), spline fit (center), and difference plot (spline - linear, right) for Hurricane Earl on 31 Aug 2010 0000 UTC.

b. Development of an integrated GPCE parameter

It has been shown that past NHC track forecast errors can be separated into terciles based on their corresponding GPCE value, and that track forecast errors in the low (high) terciles tend to correspond to less (more) spread in forecast errors (DeMaria et al. 2013). This finding motivated the use of a GPCE parameter in the MC model. At present, this GPCE parameter determines the track error statistics used by the MC model to estimate wind speed probabilities, but the GPCE categories (low, medium, high) are not output directly.

It was proposed that a time integrated GPCE parameter be developed from the GPCE information used by the MC model. This information could be relayed to users through the NHC discussion product, and could potentially be used to modify the cone of uncertainty. A preliminary time integrated GPCE parameter has been developed using the following methodology; 1) GPCE values at each forecast time from 12h to 120h is normalized by their standard deviation and 2) 12h to 120h normalized GPCE values are averaged. This methodology provides a single GPCE parameter for each 120h track forecast that characterizes the overall uncertainty of that forecast. The same methodology was applied to NHC track forecast errors from 2008-2012. The time integrated forecast errors corresponding to the three time integrated GPCE terciles are shown in Figure 3. Similar to the findings for GPCE values at each forecast time, the low (high) integrated GPCE tercile tends to correspond to less (more) spread in integrated forecast errors. A recent meeting with NHC point of contact Dan Brown, Mark DeMaria, and James Franklin brought forth some useful ideas with respect to how this upgrade can be made to best fit the needs of the NHC forecasters, including creating separate integrated GPCE parameters for the early (1-2 days) and later (3-5 days) parts of the track forecast and looking at bins other than terciles to increase the separation in forecast errors between the low and high GPCE bin. Testing continues to determine the optimal weighting scheme for providing the most separation in integrated forecast errors.

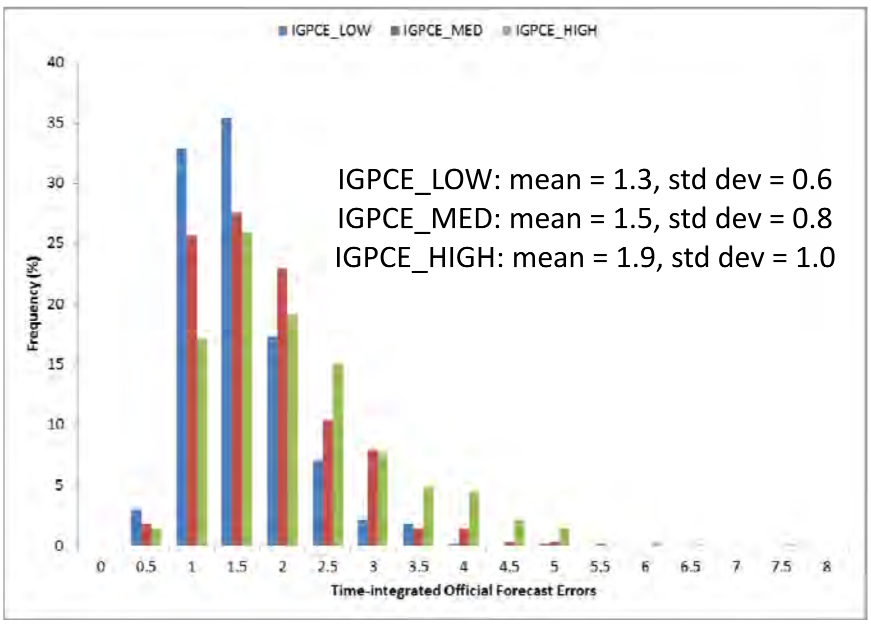

Figure 3. Integrated forecast error distributions corresponding to the low, medium, and high integrated GPCE parameter terciles for all 2008-2012 NHC Atlantic tropical cyclone forecasts.

c. MC model error statistics adjusted to be consistent with official error statistics

It was proposed that the MC model error statistics be adjusted to match those of NHC. This task was completed by 1) removing extratropical cases from the MC model error statistics and 2) applying a bias correction to account for bias introduced by the serial correlation of errors. Figure 4 shows the distributions of the current and bias-corrected along and cross track error distributions for 2009-2013. In general, this correction does not significantly change the wind speed probability values, yet it will allow for consistency between NHC uncertainty products.

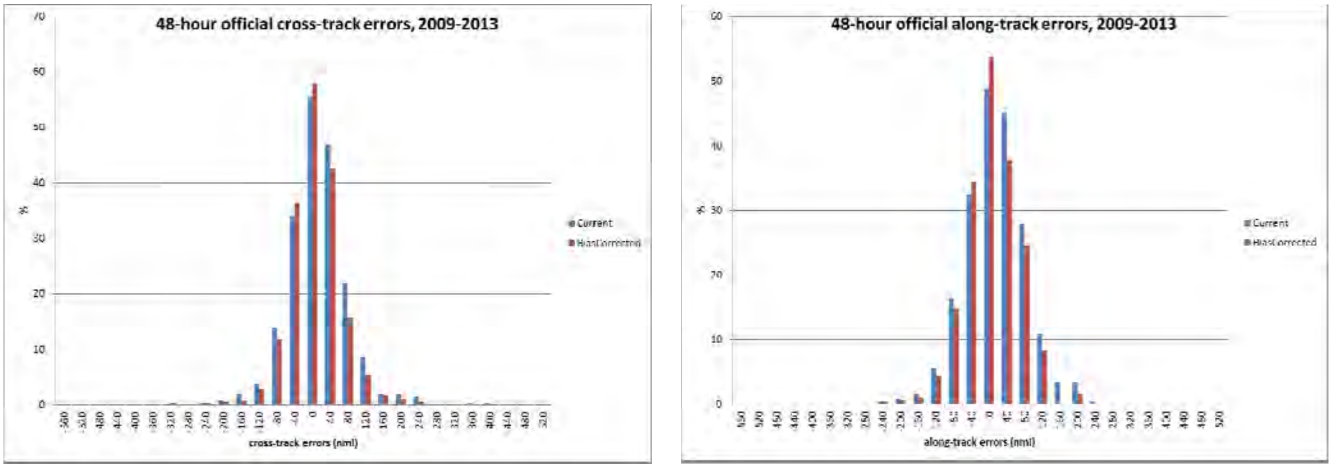

Figure 4. Current (blue) and bias-corrected (red) 2009-2013 official 48-h cross (left) and along (right) track errors.

d. Bias correction of radii-CLIPER

Work continues on the development of a procedure to bias correct the MC model radii-CLIPER model using NHC forecast 34, 50, and 64-kt wind radii forecasts in order to reduce wind speed probability biases in tropical cyclones that are significantly smaller or larger than climatology. NHC radii forecast data has been collected and preliminary work has begun to determine the best methodology for using radii forecasts to bias correct radii CLIPER. However, the optimal methodology for completing this bias correction has yet to be determined and work will continue on this upgrade into the beginning of year 2.

e. Experimental version of the MC model was developed and is currently running in parallel at CIRA

After consulting with NHC TSB staff, it was decided that the experimental MC model developed in Y1 be run in quasi-real-time at CIRA during the 2014 Atlantic and N.E. Pacific hurricane seasons. Currently 2 experimental versions of the MC model, v1.1 and v1.2, are running at CIRA that incorporate upgrades *a* and *c*, respectively. Additionally, an experimental version of the MC model that uses the operational algorithm is being run for comparison. Model output wind speed probability plots and difference plots are posted on the RAMMB website (http://rammb.cira.colostate.edu/realtime_data/nhc/mc_model/) in near-real-time.

3. Year 2 Milestones (through mid-year):

Sep 2014 -	Begin parallel runs during 2014 season and monitor results during the season
Nov 2014 -	Complete development of MC model code to calculate estimates of the arrival/departure of 34-, 50-, and 64-kt winds
Jan 2015 -	Evaluate parallel runs from 2014 season and make any necessary adjustments to the experimental model
Feb 2015 -	Create developmental dataset of 7-day forecasts (NHC for 2012, GFS tracks and new trajectory-CLIPER intensity prior to 2012)

COMPETITIVE PROJECT TITLE: Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-resolving Refined Local Mesh to Study MJO Initiation (NA13OAR4310163)

The following is the most recent report previously submitted to the Technical Sponsor.

Project Title: Use of the Ocean-Land-Atmosphere Model (OLAM) with Cloud System-Resolving Refined Local Mesh to Study MJO Initiation
Project Number: NA13OAR4310163
PIs: Eric D. Maloney and William Cotton (Colorado State University) and Robert Walko (University of Miami)
Report Type: Year 2 Report

Results and Accomplishments
The following sections list the primarily accomplishments for Year 2. All publications from this project are listed at the end of this report.

The Moist Static Energy Budget in Climate Model Hindcasts during DYNAMO (Hannah and Maloney 2014)

The Dynamics of the MJO (DYNAMO) field campaign took place in the Indian Ocean during boreal fall and winter of 2011-2012 to collect observations of Madden-Julian Oscillation (MJO) initiation. Hindcast experiments are conducted with an atmospheric general circulation model with varying values of a dilute CAPE entrainment rate parameter for the first two MJO events of DYNAMO from 01 October – 15 December 2011. Higher entrainment rates better reproduce MJO precipitation and zonal wind (**Figure 1**), with RMM skill up to 20 days. Simulations with lower entrainment rapidly diverge from observations with no coherent MJO convective signal after 5 days, and no MJO predictive skill beyond 12 days.

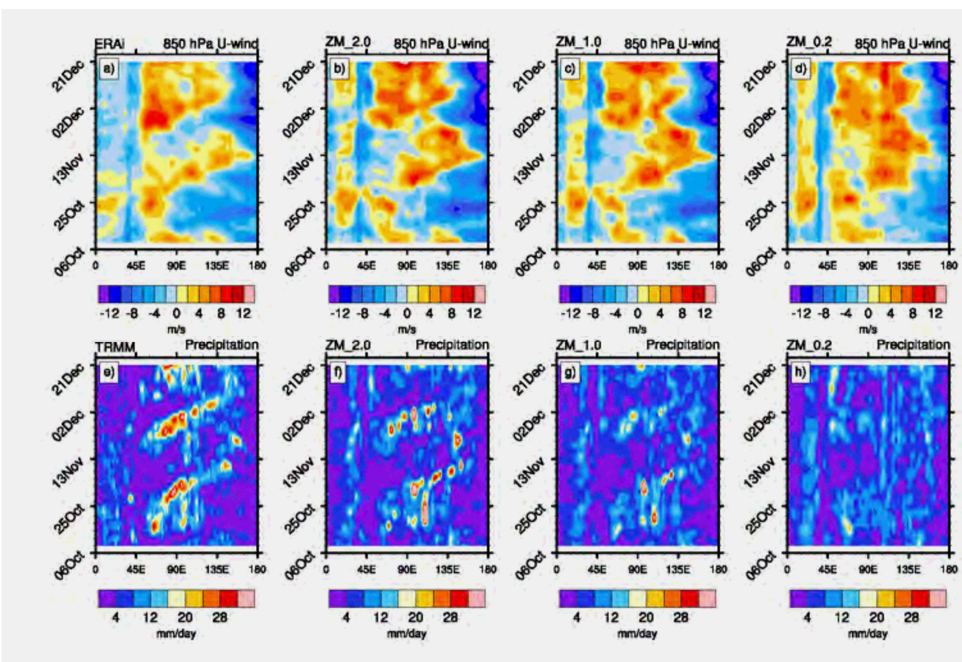

Figure 1. Hovmöller diagram of equatorial 850 hPa wind (a-d) and precipitation (e-h) averaged from 5°S-5°N for 05-09 day lead times. The entrainment rates for the simulations decrease toward the right.

Analysis of the tropical Indian Ocean column moist static energy (MSE) budget reveals that the simulations with superior MJO performance exhibit a mean positive MSE tendency by vertical advection; inconsistent with reanalysis that indicates a weak negative tendency. All simulations have weaker mean MSE source tendency and significantly weaker cloud-radiative feedbacks (**Figure 2**). The vertical gross moist stability (VGMS) is used to interpret these MSE budget results in a normalized framework relevant to moisture mode theory. VGMS in the high

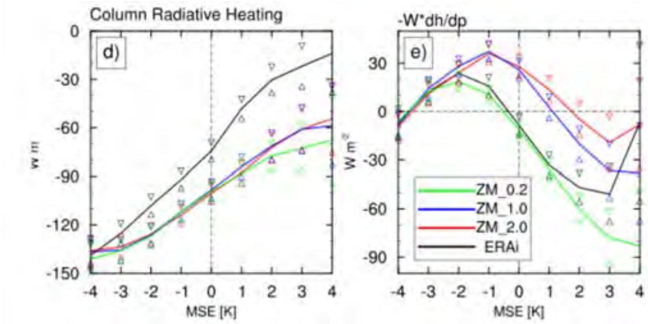

Figure 2. Average column radiative heating and vertical MSE advection binned by the MSE anomaly for 00-04 day lead times over the equatorial Indian Ocean (10°S-10°N; 60-90°E) for model simulations with different entrainment rate and ERAi. Error bound estimates are indicated by triangle markers and were calculated using a Student's *t*-statistic.

entrainment runs is far too low compared to ERAi, indicating that it cannot be used in isolation as a measure of model success in producing a realistic MJO hindcast, contrary to previous studies. However, effective VGMS that includes radiative feedbacks is similar among the high entrainment runs and ERAi (**Figure 3**). We conclude that the MJO is erroneously improved by increasing the entrainment parameter because moistening by vertical MSE advection compensates for the overly weak cloud radiative feedbacks.

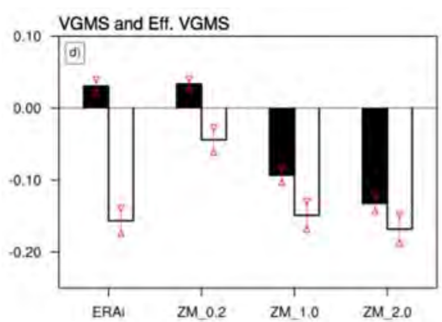

Figure 3. The VGMS (black bars) and effective VGMS for ERA-I and the models with different entrainment parameters. 95% confidence limits on the VGMS and effective VGMS are calculated and shown as error bars.

Consequences of Systematic Model Drift in DYNAMO MJO Hindcasts with SP-CAM and CAM5 (Hannah et al. 2015).

Hindcast simulations of MJO events during the Dynamics of the MJO (DYNAMO) field campaign are conducted with two models, one with conventional parameterization (CAM5) and a comparable model that utilizes super-parameterization (SP-CAM). SP-CAM is shown to produce a qualitatively better reproduction of the fluctuations of precipitation and low-level zonal wind associated with the first two DYNAMO MJO events compared to CAM5 (**Figure 4**). Interestingly, skill metrics using the real-time multivariate MJO index (RMM) suggest the opposite conclusion, that CAM5 has more skill than SP-CAM. This inconsistency can be

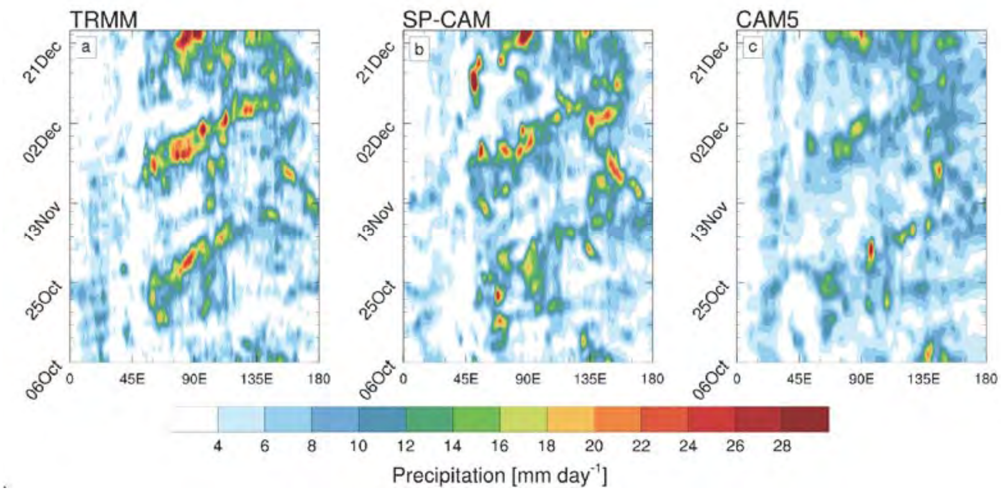

Figure 4. Hovmöller diagram of equatorial precipitation averaged from 5°S-5°N for 05-09 day lead times.

explained by a systematic increase of RMM amplitude with lead-time, which results from a drift of the large-scale wind field in SP-CAM that projects strongly onto the RMM index (**Figure 5**).
CAM5 hindcasts exhibit a contraction of the moisture distribution, in which extreme wet and dry conditions become less frequent with lead-time. SP-CAM hindcasts better reproduce the observed moisture distribution, but also have stronger drift patterns of moisture budget terms, such as an increase in drying by meridional advection in SP-CAM. This advection tendency in SP-CAM appears to be associated with enhanced off-equatorial synoptic eddy activity with lead-time. Systematic drift moisture tendencies in SP-CAM are of similar magnitude to intraseasonal moisture tendencies, and therefore are important for understanding MJO predictability.

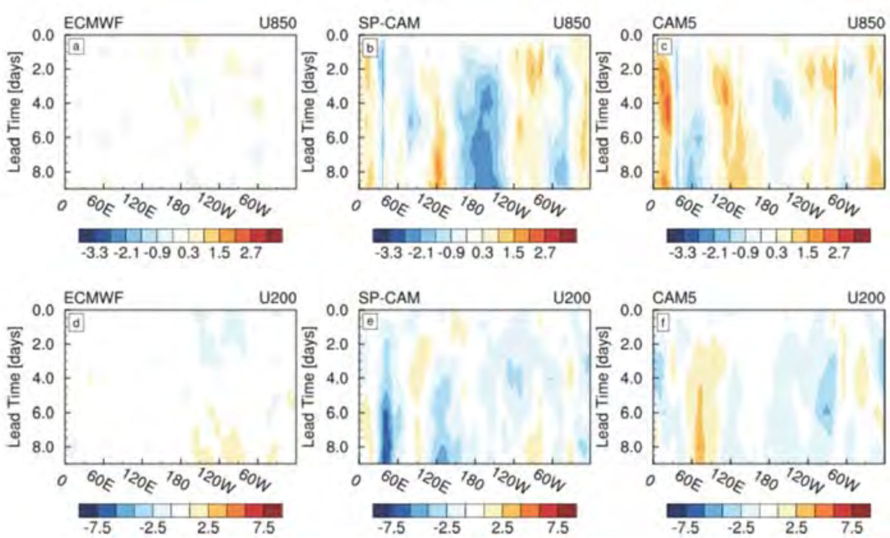

Figure 5. Hovmöller diagrams of the systematic drift over the DYNAMO period as a function of time since hindcast initialization (see text) in the wind fields used in the RMM index in ERAi, SP-CAM, and CAM5. Data was equatorial averaged from 15°S-15°N, consistent with the RMM index.

Objective Diagnostics and the Madden-Julian Oscillation. Part I: Methodology (Wolding and Maloney 2015a)

Graduate student Brandon Wolding developed advanced MJO diagnostics that provided substantial insight into the nature of MJO events during DYNAMO and the ability of conventional MJO indices such as those of Wheeler and Hendon to successfully characterize the nature of the MJO. Diagnostics obtained as an extension of empirical orthogonal function (EOF) analysis are shown to address many disadvantages of using EOF-based indices to assess the state of the Madden-Julian Oscillation (MJO). The Realtime Multivariate MJO (RMM) index and the Filtered MJO OLR (FMO) index are used to demonstrate these diagnostics. General characteristics of the indices, such as the geographical regions that most heavily in each index,

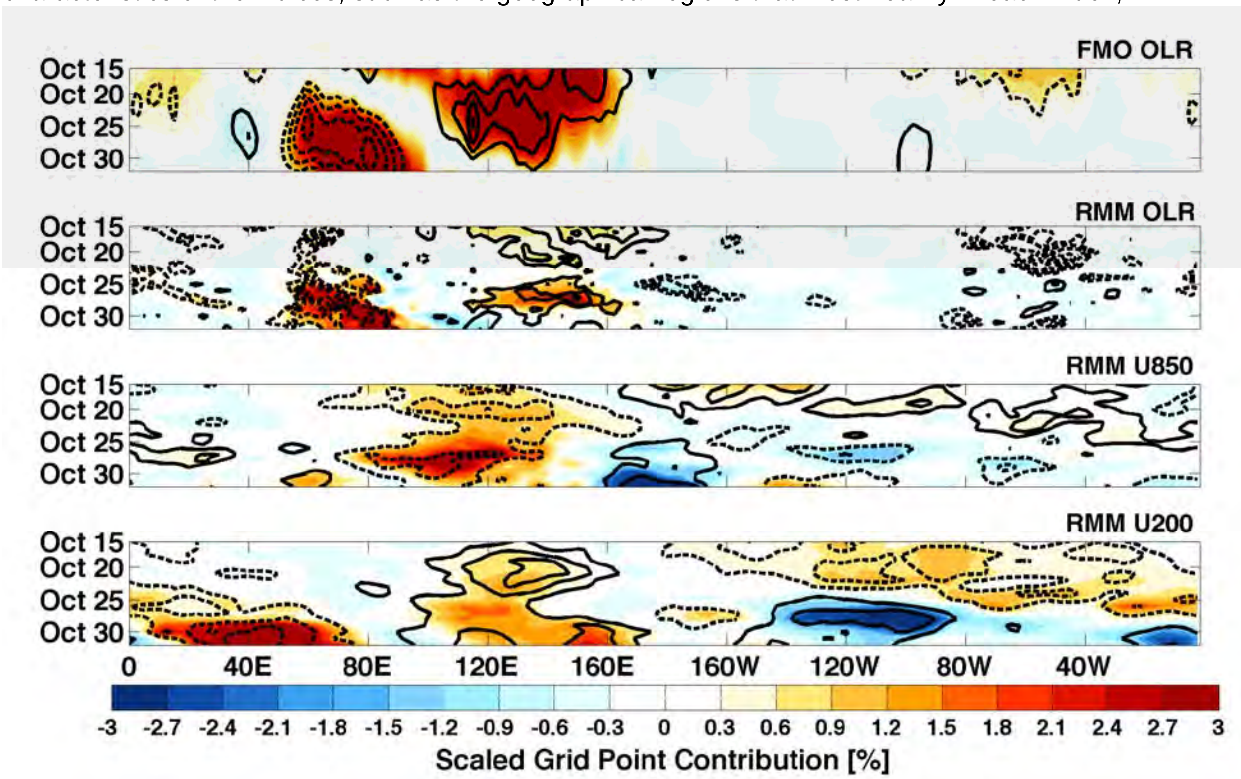

Figure 6. OLR, U850, and U200 anomalies (contours) averaged from 15N-15S and corresponding scaled grid point contribution (shading) for the RMM and FMO index from October 15-31. Positive (negative) anomalies are given by solid (dashed) contours. In the top panel, OLR has been bandpass filtered to 20-96 days. Contours for the filtered OLR, unfiltered OLR, U850, and U200 anomalies are, respectively, as follows: every 5 W/m^2 beginning at 10 W/m^2 , every 10 W/m^2 beginning at 20 W/m^2, every 2 m/s beginning at 2 m/s , every 5 m/s beginning at 5 m/s.

are assessed using the diagnostics. The diagnostics also identify how a given field at various geographical locations, influences the index value at a given time. Termination (as defined by the RMM index) of the October 2011 MJO event that occurred during the Cooperative Indian Ocean Experiment on Intraseasonal Variability in the Year 2011(CINDY) Dynamics of the MJO (DYNAMO) field campaign is shown to have resulted from changes in zonal wind anomalies at 200 hPa over the eastern Pacific Ocean, despite the onset of enhanced convection in the Indian Ocean and the persistence of favorable lower and upper level zonal wind anomalies near this region (**Figure 6**). The diagnostics objectively identify, for each specific geographical location, the index phase where the largest MJO-related anomalies in a given field are likely to be observed. This allows for the geographical variability of anomalous conditions associated with the MJO to be easily assessed throughout its lifecycle. In Part II of this study (see below), unique physical insight into the moist static energy and moisture budgets of the MJO is obtained from the application of diagnostics introduced here.

Objective Diagnostics and the Madden-Julian Oscillation. Part II: Application to Moist Static Energy and Moisture Budgets (Wolding and Maloney 2015b)

This study investigates processes controlling moisture variations associated with the MJO by assessing budgets of moist static energy (MSE) and moisture. The net effect of vertical moisture advection and cloud processes was found to be a modest positive feedback to column moisture anomalies during both enhanced and suppressed phases of the MJO. This positive feedback is regionally strengthened by anomalous surface fluxes of latent heat. The modulation of synoptic scale eddy mixing acts as a negative feedback to column moisture anomalies, while anomalous winds acting against the mean state moisture gradient aid in their eastward propagation. Objective methods developed in Part I of this study were used to investigate the geographical variability of these process, showing that they act in a systematic fashion across the Indian Ocean and oceanic regions of the Maritime Continent.

The ability to approximately close the MSE budget serves an important role in constraining the moisture budget, whose residual is several times larger than the total and horizontal advective moisture tendencies. Comparison with TRMM precipitation anomalies suggests that the moisture budget residual results from an underestimation by ERAi of variations in both total precipitation and vertical moisture advection associated with the MJO. The robustness of the primary results of this study was assessed by calculating various processes using both MSE and moisture budgets with various treatments of their respective budget residuals. Depending on the method of calculation, the net effect of anomalous vertical moisture advection and cloud processes can appear strongest in the early, mid or later portions of the suppressed and enhanced phases. This corresponds to aiding the growth column moisture anomalies, enhancing column moisture anomalies when they are largest, or maintaining column moisture anomalies against dissipation respectively. No method of calculation indicates that these processes result in a discharge of column moisture anomalies. The results of this study support the concept of the MJO as a moisture-mode.

OLAM simulations of the DYNAMO events

We have continuing to experiment with hindcast experiments during three events in the DYNAMO period using OLAM, including simulations with different nested mesh sizes, resolutions, and nudging strategies. Basic comparison of the fidelity of the OLAM performance relative to observations in humidity, temperature, winds, moist static energy, and precipitation has been conducted, and indicates a substantial sensitivity to the domain configuration that will help inform subsequent runs. **Figure 7** shows the results of nudged OLAM runs in the MSE anomaly field, demonstrating an ability to successfully simulate the first two DYNAMO MJO events. We are currently in the process of generating a moist static energy budget for OLAM that can be used as a diagnostic tool for understanding the physics of the MJO initiation process in the model. OLAM has been a bit more challenging to work with than anticipated, given the irregular grid topology and unfriendliness of the output protocol, especially when running the model in a parallel framework. However, we have overcome these challenges and are in the process of demonstrating the power of this model for understanding MJO initiation. Gustavo Carrio here at CSU has been instrumental in helping to overcome these challenges, including reconfiguring OLAM to run on systems such as Yellowstone in Wyoming.

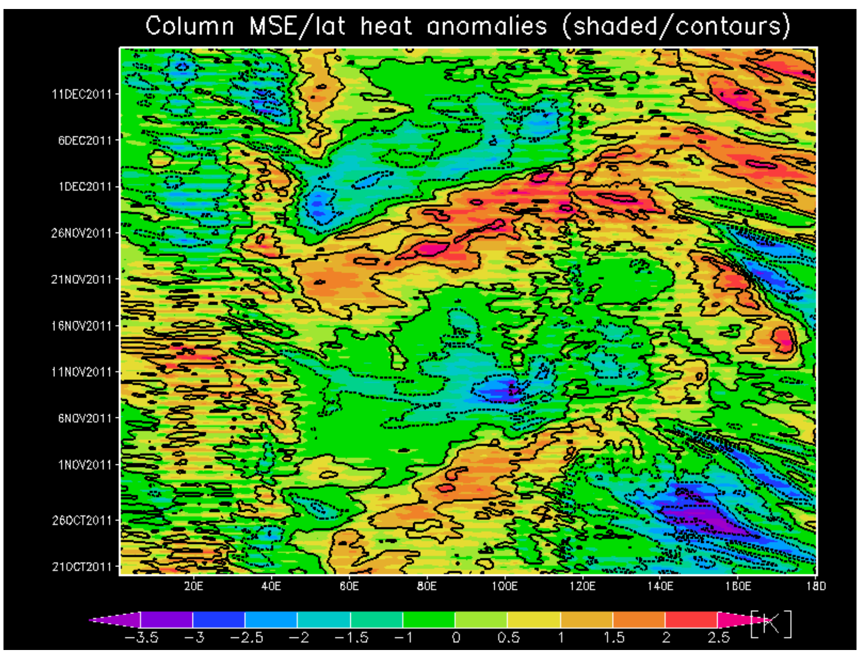

Figure 7. Column-integrated MSE anomalies (shaded) and latent heat anomalies (contour) in nudged OLAM experiments during the DYNAMO experiment.

Highlights of Accomplishments

- We showed the MJO hindcasts during the DYNAMO period could be improved through increasing convective entrainment.
- We showed that with increased entrainment, the NCAR CAM5 appears to produce a good MJO for the wrong reasons, with enhanced vertical advection compensating for too weak of cloud-radiative feedbacks. This highlights areas of improvement for climate models.
- The SP-CAM produces an improved representation of the MJO relative to the NCAR CAM during the DYNAMO period, although the SP-CAM exhibits a poorer MJO skill score based on RMSE since SP-CAM mean state drift projects strongly onto the MJO indices used to assess skill.
- The SP-CAM produces too strong of a simulation of vertical MSE advection relative to ERA-I that helps to destabilize the MJO, associated with too bottom-heavy of a diabatic heating profile.
- Advanced MJO diagnostics were developed that showed the RMM index to be dominated by east Pacific 200 hPa zonal wind variability during the October DYNAMO event that erroneously suggested a weakening of the event at the end of October.
- Objective diagnostics of the DYNAMO and broader region indicate that the MJO is destabilized by radiative feedbacks, and propagated by horizontal advection.
- Initial OLAM simulations were conducted that showed great success at reproducing the October and November DYNAMO MJO events. We have optimized the model and its output for use on parallel machines such as Yellowstone.

Publications From the Project

Hannah, W. M., and E. D. Maloney, 2014: The Moist Static Energy Budget in NCAR CAM5 Hindcasts during DYNAMO. *J. Adv. Modeling Earth Sys*., **6**, doi:10.1002/2013MS000272.

Hannah, W. M., E. D. Maloney, and M. Pritchard, 2015: Consequences of Systematic Model Drift in DYNAMO MJO Hindcasts with SP-CAM and CAM5. J. Adv. Modeling. Earth Sys., accepted pending revision.

Wolding, B. O., and E. D. Maloney, 2015: Objective Diagnostics and the Madden-Julian Oscillation. Part I: Methodology. *J. Climate*, in press.

Wolding, B. O., and E. D. Maloney, 2015: Objective Diagnostics and the Madden-Julian Oscillation. Part II: Application to Moist Static Energy and Moisture Budgets. *J. Climate*, accepted pending revision.

PIs Contact Information

Eric D. Maloney (lead PI)
Department of Atmospheric Science
Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University
1371 Campus Delivery
Fort Collins, CO 80523-1371
Phone: (970) 491-3368
Fax: (970) 491-8449
emaloney@atmos.colostate.edu

William Cotton (co-PI)
Department of Atmospheric Science
Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University
1371 Campus Delivery
Fort Collins, CO 80523-1371
Phone: (970) 491-8593
Fax: (970) 491-8449

Robert Walko (co-PI)
Rosenstiel School of Marine and Atmospheric Science,
University of Miami,
4600 Rickenbacker Causeway,
Miami, FL 33149-1031.
Phone: (305) 421-4621

SANDY COMPETITIVE PROJECT TITLE: S1 - CIRA Assimilation of Moisture and Precipitation Observations in Cloudy Regions of Hurricane Inner Core Environments to Improve Hurricane Intensity, Structure and Precipitation (NA14OAR4830122)

This is a new project

PRINCIPAL INVESTIGATOR(S): Christian Kummerow and Milija Zupanski

RESEARCH TEAM: Ting-Chi Wu, Karina Apodaca, Louis Grasso

NOAA TECHNICAL CONTACT: Vijay Tallapragada (NCEP/EMC)

NOAA RESEARCH TEAM: Mark DeMaria NCEP/NHC), Richard J. Pasch (NCEP/NHC), Sid Boukabara (NESDIS/STAR)

PROJECT OBJECTIVE(S):

1--adopt and optimize a regional ensemble-based data assimilation algorithm for assimilation of satellite moisture-affected radiances and custom GPM rainfall product,
2--develop this capability for the NOAA operational HWRF system for assimilation in the core, and near-core environment, and
3--evaluate the impact of these products on the analysis and prediction of hurricane intensity, structure, and precipitation

PROJECT ACCOMPLISHMENTS: (Research Conducted) Past Fiscal Year by Objective:

(1a) Implemented and tested the NOAA operational Hurricane WRF (HWRF) coupled atmosphere-ocean modeling system
(1b) Evaluated the Gridpoint Statistical Interpolation (GSI) hybrid data assimilation algorithm within HWRF

(2a) tested the capability of HWRF to use GSI with assimilation of clear-sky satellite radiances in inner-most domain (3 km – resolution)
(2b) developed and tested the HWRF-GSI capability to assimilate hurricane-customized GPM retrievals

(3a) Conducted preliminary evaluation of the HWRF-GSI system for hurricane Leslie (2012)

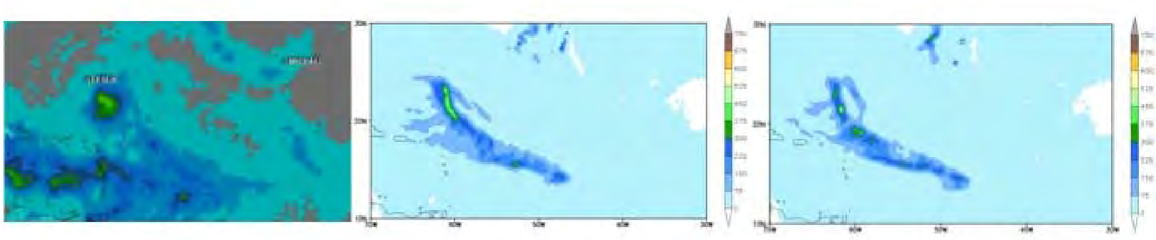

Figure 1. 102-hour accumulated precipitation (mm) for domain-3 of HWRF valid 4 Sep 2012 at 0600 UTC: (a) Verification from TRMM, (b) HWRF forecast using NOAA operational setup (without assimilating any satellite data), and (c) HWRF forecast with assimilation of additional clear-sky radiances. Both forecasts show a lack of skill, suggesting a potential for improvements by customized data assimilation of satellite precipitation information.

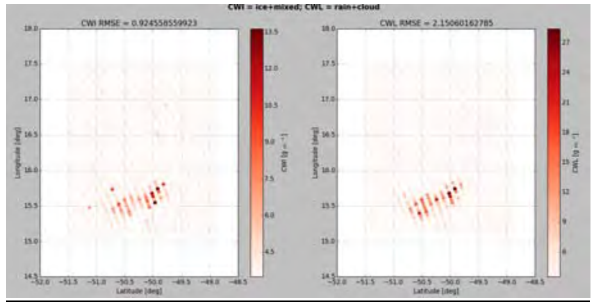

Figure 2. The spatial distribution of CWI (cloud water ice) and CWL (cloud water liquid) (kg/m^3) GPM observations in the innermost nest of HWRF.

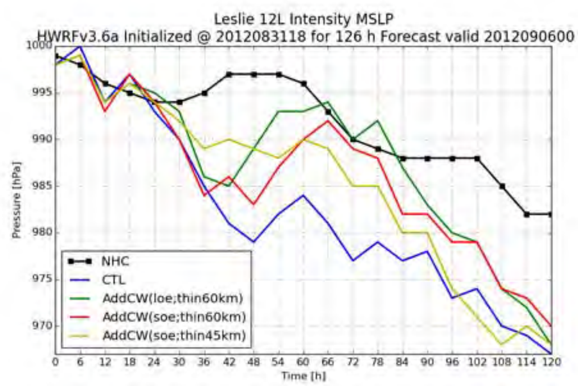

Figure 3. Intensity forecast (MSLP) of hurricane Leslie, valid from 1800 UTC on 31 Aug 2012 until 0600 UTC on 6 Sep 2012. The NHC verification is shown in black, while the forecast using NOAA operational setup (CTL) is shown in blue. Several forecasts after assimilating GPM retrievals of cloud ice and liquid are shown in green (60 km thinning, large observation error), yellow (45 km thinning, small observation error) and red (60 km thinning, small observation errors). There is clearly a positive impact of data assimilation in all experiments initiated after the assimilation of GPM data.

Project Publications from Past Fiscal Year (including Conferences): None (project started July 1, 2015)

SANDY COMPETITIVE PROJECT TITLE: S2--CIRA - Distance Learning Materials on Blended Numerical Guidance Products (NA14NWS4830020)

The following is the most recent report previously submitted to the Technical Advisor.

CIRA - Distance Learning Materials on Blended Numerical Guidance Products
Reporting Period: 1 October – 31 December 2014

2--Introduction

2-1 Short Description of CIRA and its Core Activities

The Cooperative Institute for Research in the Atmosphere (CIRA) is an interdisciplinary research institute in the College of Engineering at Colorado State University. While the headquarters are located on the Foothills Campus of CSU in Fort Collins, CO, CIRA has employees at the Earth Systems Research Laboratory (ESRL) in Boulder, CO, the Aviation Weather Testbed in Kansas City, MO and at the National Environmental Satellite, Data, and Information Service (NESDIS) Center for Satellite Applications and Research in College Park, MD.

CIRA has five broad research themes and two cross-cutting programmatic disciplines: 1) Satellite Algorithm Development, Training and Education; 2) Regional to Global Scale Modeling Systems; 3) Data Assimilation; 4) Climate-Weather Processes; and 5) Data Distribution. The 2 areas of cross-cutting activity at CIRA are: 1) Assessing the Value of NOAA Research via Societal/Economic Impact Studies, and 2) Promoting Education and Outreach on Behalf of NOAA and the University.

2-2 Description of how CIRA is Managed, including Mission and Vision Statements

The CI Director is responsible for the overall strategic direction and mission of the Institute. The Deputy Director position is maintained at a half-time level, with the balance devoted to immersion in research activities. In addition to interactions with funding agencies and University leadership, the

Director and Deputy are principal points of contact to collaborators and potential partners on behalf of the Institute. An Assistant Director is dedicated to handling as much of the administrative load on behalf of the Director and Deputy as possible. CIRA also receives oversight from both an Executive Board and Council of Fellows.

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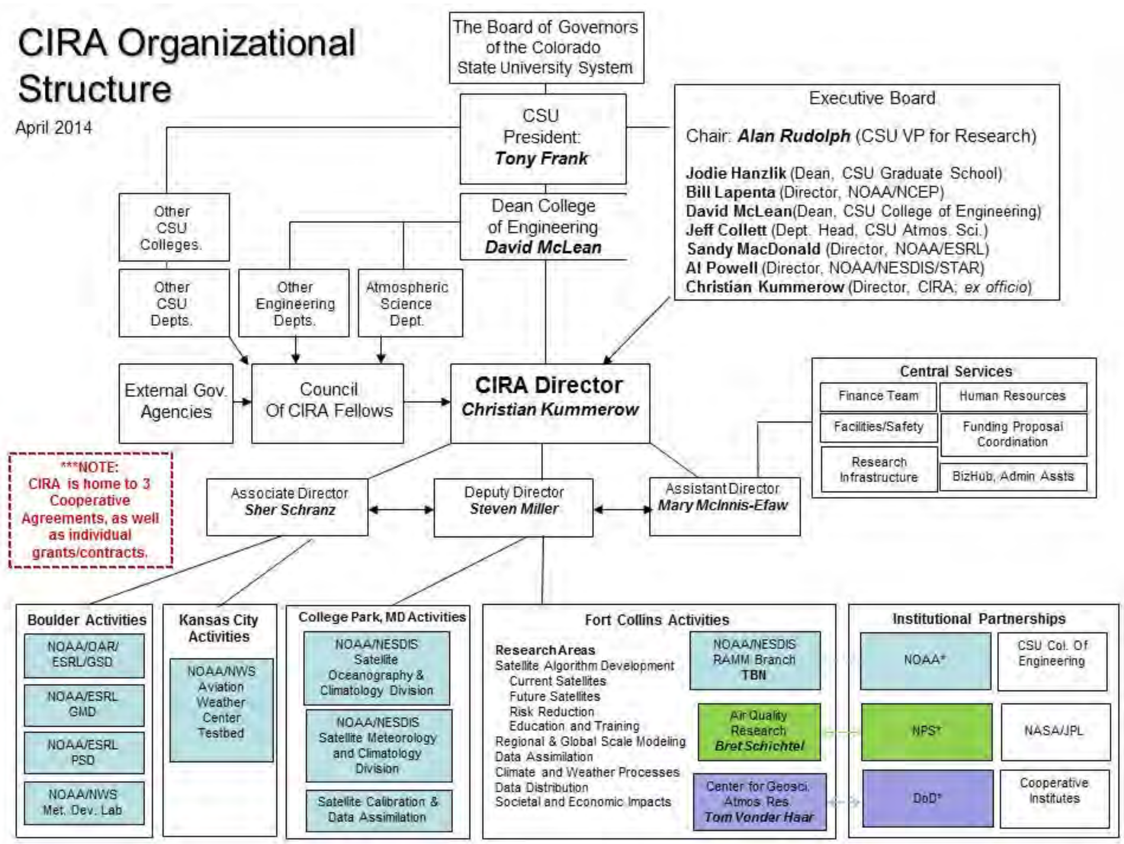
2-3 CIRA Organizational Structure



2-4 Executive Summaries of CIRA Banner Research Activities and Results from 2014

The GOES Improvement and Product Application Program (GIMPAP) has six concurrent research areas that span the gamut of applications from: (1) Combining Probabilistic and Deterministic Statistical Tropical Cyclone Intensity Forecast Models; (2) Developing GOES-Based Tropical Cyclone Recurvature Tools; (3) WFR Cloud Moisture Verification with GOES; (4) Advancing GOES Cloud and Surface Irradiance Products for Applications to Short-Term Solar Energy Forecasting; (5) Enhanced Downslope windstorm Prediction with GOES Warning Indicators; and (6) Probabilistic Nearcasting of Severe Convection. The Nearcasting of severe convection in particular, has made important strides in the research and shows greater lead times than the NWS severe thunderstorm/tornado warnings in a median sense. Coupled with continued education and training activities such as CIRA's participation in the Virtual Institute for Satellite Integration Training (VISIT), the value of existing data is still being exploited to its fullest.

CIRA participates actively in the GOES-R and JPSS Risk Reduction activities as well as the GOES-R Satellite Proving Ground project. The risk reduction activities for GOES-R focus on CIRA-developed techniques to simulate GOES-R data from high resolution forecast models to help understand the system and its capabilities. Also focused on GOES are substantial activities related to the Algorithm Working Groups where CIRA projects focus on Data Assimilation, Severe Storm Near-casting; Tropical Cyclone track and intensity analysis and data user preparation. This of course is coupled to proving ground activities described in the report to prepare forecasters in the field for these new products. An area of great excitement continues to be the work being done with the Day/Night band of Suomi-NPP in preparation for JPSS. Not only is detection of smoke, dust, and fog possible at night, but results appear far better than originally anticipated. Immediate applications such as ash monitoring from Alaska volcanoes is underway as detailed in the detailed project reports. The VIIRS Sensor is also being used extensively for more established applications related to Sea Surface Temperature and Ocean Color products produced by CIRA Research Scientists working directly with NOAA STAR employees in College Park, MD. Perhaps not evident when evaluating a single proposal, however, is the synergy that CIRA provides across projects through its internal communications and collaborations. A careful review of all the activities related to satellite algorithm development, training and education and training, however, clearly reveals these synergies and the benefits that these create on behalf of NOAA.

Collaborations with the Global Systems Division (GSD), the Physical Sciences Division (PSD), and the Global Monitoring Division (GMD) of the NOAA Earth System Research Lab (ESRL) in Boulder were productive in both continuing and new research areas. CIRA researchers either led or were immersed in every branch and virtually every project in GSD. Project leadership and integral support were provided for: Fire Weather Modeling and Research, the FAA NextGen Network-Enabled Weather (NNEW—now known as CSS-Wx), the NWS NextGen, and Aviation Weather Forecast Evaluation programs; meteorological workstation development, including the AWIPS II Extended Tasks for both Collaboration and Hazard Services, FX-NET Thin Client, AWIPS II Thin Client, and MADIS; high performance computing (especially related to GPU processing); and the design, development and implementation of various regional and global weather and climate models, including the RR, HRRR, WRF-Chem, FIM, and NIM as well as the LAPS/STMAS data assimilation systems and ensemble model post-processing and technology leadership in the Science on a Sphere (SOS®) program and the new NOAA Environmental Information System (NEIS) project. NOAA testbed research resulted in improvements to the ensemble models in the Hydrometeorological

Testbed (HMT), downscaled additions to the CONUS Experimental Warning Program (EWP) domain in the Hazardous Weather Testbed (HWT) and changes to the SREF configuration in the Developmental Test Center (DTC) Ensemble Testbed.

3--Funded Project

3-1 Award Number: NA14NWS4830020

3-2 Project Title: CIRA - Distance Learning Materials on Blended Numerical Guidance Products

3-3 PIs Bernadette Connell, Chris Kummerow

3-4 NOAA Sponsor: Hurricane Sandy Supplemental Funding for NOAA

3-5 NOAA Sponsoring Organization : National Weather Service (NWS)

3-6 Reporting Period: 1 October – 31 December 2014

3-7 Description of Task I activities

Blended numerical guidance products are being developed and generated centrally in the NCEP Production Suite. This new guidance requires training to ensure successful implementation, and CIRA and COMET will work together to ensure the training developed under this funding meets the needs of operational forecasters in preparing them to respond to high-impact events such as Hurricane/Post-Tropical Cyclone Sandy. Topics of high priority for training include component gridded products, statistical techniques, and product verification. CIRA will work with the COMET Program, taking advantage of the program's extensive experience pairing instructional design, graphic artist and multimedia programming expertise with scientific experts to develop and deliver three online learning modules. The training developed will incorporate data provided by CIRA and the expertise of CIRA scientists to ensure the technical content of the training.

The training will incorporate the latest information on blended numerical guidance and will be made available as asynchronous distance learning modules available through the COMET MetEd Website

The objectives for this project include:

--***Publish blended numerical guidance module (Sep 2015)
--Publish Component Gridded Products module (Dec 2015)
--Publish Statistical Techniques module (Mar 2016)
--Publish Product Verification module (Jun 2016)
--Final Report (Aug 2016)

** The NWS contact (Tony Mostek) requested that this deliverable be moved from the other proposal (NA14NWS4830018 CIRA - Distance Learning Materials on Tropical Storm Forecasting and Threats) to here to be tracked in tandem with the activity in this proposal.

The objective relevant to this reporting period includes:
Sep-Oct 2014: Develop project plans and design instructional components.

3-8 The related NOAA Strategic Goal(s): Weather Ready Nation

3-9 Detailed description of the research that was conducted during the reporting period, including progress to date with respect to originally proposed objectives and schedule

The subcontract to do collaborative work with COMET partners was put in place in early October and the development of project plans commenced shortly after.
A staff needs analysis was completed.

Note that the NWS contact, Tony Mostek, requested that the deliverable:
"Publish blended numerical guidance module (Sep 2015)" be moved from the proposal (NA14NWS4830018 CIRA - Distance Learning Materials on Tropical Storm Forecasting and Threats) to here to be tracked in tandem with the activity in this proposal.

SANDY COMPETITIVE PROJECT TITLE: S3--CIRA - Distance Learning Materials on Tropical Storm Forecasting and Threats (NA14NWS4830018

The following is the most recent report previously submitted to the Technical Sponsor.

CIRA - Distance Learning Materials on Tropical Storm Forecasting and Threats

Reporting Period: 1 October – 31 December 2014

1--Table of Content

2--Introduction

2-1 Short Description of CIRA and its Core Activities

The Cooperative Institute for Research in the Atmosphere (CIRA) is an interdisciplinary research institute in the College of Engineering at Colorado State University. While the headquarters are located on the Foothills Campus of CSU in Fort Collins, CO, CIRA has employees at the Earth Systems Research Laboratory (ESRL) in Boulder, CO, the Aviation Weather Testbed in Kansas City, MO and at the National Environmental Satellite, Data, and Information Service (NESDIS) Center for Satellite Applications and Research in College Park, MD.

CIRA has five broad research themes and two cross-cutting programmatic disciplines: 1) Satellite Algorithm Development, Training and Education; 2) Regional to Global Scale Modeling Systems; 3) Data Assimilation; 4) Climate-Weather Processes; and 5) Data Distribution. The 2 areas of cross-cutting activity at CIRA are: 1) Assessing the Value of NOAA Research via Societal/Economic Impact Studies, and 2) Promoting Education and Outreach on Behalf of NOAA and the University.

2-2 Description of how CIRA is Managed, including Mission and Vision Statements

The CI Director is responsible for the overall strategic direction and mission of the Institute. The Deputy Director position is maintained at a half-time level, with the balance devoted to immersion in research activities. In addition to interactions with funding agencies and University leadership, the Director and Deputy are principal points of contact to collaborators and potential partners on behalf of the Institute. An Assistant Director is dedicated to handling as much of the administrative load on behalf of the Director and Deputy as possible. CIRA also receives oversight from both an Executive Board and Council of Fellows.

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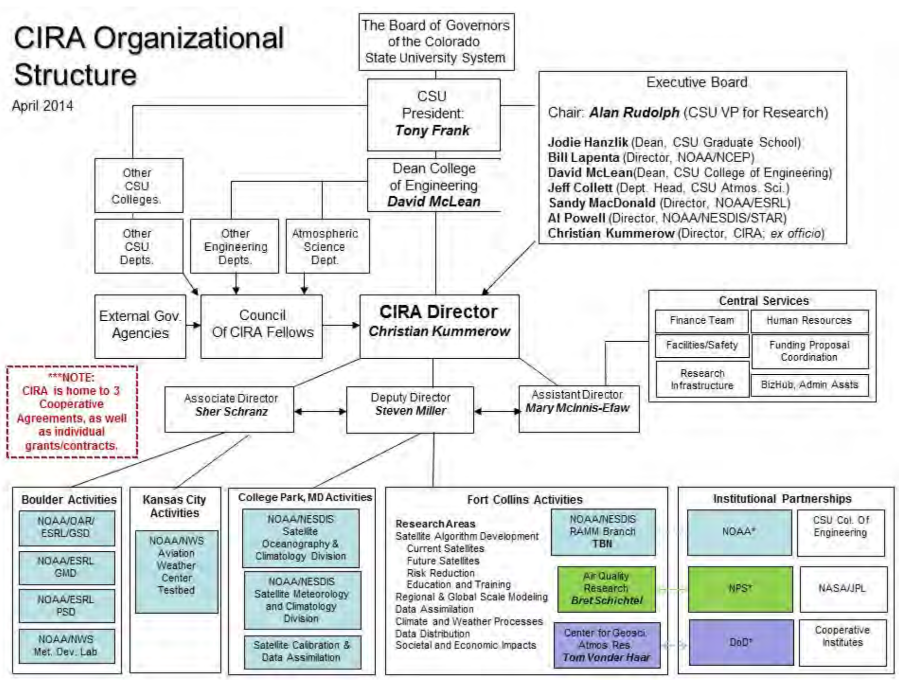

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3-1 Award Number: NA14NWS4830018

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3-3 PIs Bernadette Connell, Chris Kummerow

3-4 NOAA Sponsor: Hurricane Sandy Supplemental Funding for NOAA

3-5 NOAA Sponsoring Organization : National Weather Service (NWS)

3-6 Reporting Period: 1 October – 31 December 2014

3-7 Description of Task I activities

The National Weather Service Training Division (NWSTD) has a priority need for education and training materials that will fill critical gaps identified through the service assessment that was completed after the Hurricane/Post-Tropical Cyclone Sandy event, which was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season as well as the second-costliest hurricane in United States history. In the service assessment of Hurricane/Post-Tropical Cyclone Sandy, NOAA/NWS customers and constituents identified that the highest priority need is for improved high-resolution storm surge forecasting and communication. Findings included that a better understanding of the impacts of surge, the resulting coastal inundation, and how best to communicate the associated threats is needed for this diverse audience. Topics supporting these needs include coastal inundation science and forecasting as well as hazards, terminology, interpretation, and NWS products related to storm surge.

In addition, training on assessing tropical cyclone threats and communicating their risks and impacts was identified as a need for operational forecasters to help them better respond to high impact events, such as Sandy. In support of effective application of numerical weather prediction models in forecasting tropical cyclones, updates to the Operational Models Matrix training will be covered. Annual updates to existing training on hurricane intensity and track forecasts as well as training demonstrating the utility of AMDAR datasets in analysis and forecasting hazards are also included.

NOAA's NWS and NESDIS have historically supported training through both the Virtual Institute for Satellite Integration Training (VISIT) and Satellite Hydrology and Meteorology (SHyMet) programs at CIRA and the COMET program at UCAR in Boulder. A varied approach to training is needed to address different users with various learning needs and preferred means of learning as well as ranges in user abilities from the intern to the expert. Broad types of training utilized include: 15-30 minute just in time training, real-time access to experts, and an online library of supporting resources that include short and as well as extensive coverage of the topics. The CIRA and COMET programs have a combination of these types of training and both programs utilize subject matter experts to provide content for modules and to review final training materials. The long and successful working relationship between CIRA and COMET as well as the strengths of each organization, will provide distance learning materials that will enhance the opportunities to inform the community and strongly support the activities under this funding.

The objectives for this project include:

--Conduct virtual VISIT satellite chat highlighting an NHC expert and post recording on the VISIT site (Oct 2014)
--Publish AMDAR training materials related to the benefits of incorporating these data into storm forecasting on the COMET MetEd Website(Dec 2014)
--Storm Surge Module (May 2015)
--Updates to and teletraining delivery of 2 Tropical Cyclone modules on Hurricane intensity and track model guidance. (Jul 2015)
--Deliver teletraining and publish recording on VISIT website on “Evaluating Subjective Uncertainty Estimates in National Hurricane Center Forecast Discussions” (August 2015)
--Publish six short and highly-focused training modules on Tropical Cyclone Forecasting and Threats on the COMET MetEd Website(Sep 2015)
--Updates to the COMET MetEd Operational Models Matrix (Sep 2015)
--***Publish module on blended numerical guidance on the MetEd Website(Sep 2015)
--Conduct virtual VISIT satellite chat highlighting an NHC expert and post recording on the VISIT site (Oct 2015)
--Updates to and teletraining delivery of 2 Tropical Cyclone modules on Hurricane intensity and track model guidance. (Jul 2016)
--Quarterly reports (Sept 2014-Aug 2016)
--Write final report (Aug 2016)

*** The NWS contact (Tony Mostek) requested that this deliverable be moved from here to the proposal (NA14NWS4830020 CIRA - Distance Learning Materials on Blended Numerical Guidance Products) to be tracked in tandem with the activity in that proposal.

The objectives relevant to this reporting period include:
Sep 2014-Sep 2015: Collect data and develop case study
Sep -Oct 2014: Post examples of tropical cyclone products along with interpretation on the VISIT Blog.
Sep – Oct 2014: Host NHC expert on one of the monthly virtual VISIT satellite chat sessions
Dec 2014: Publish AMDAR training materials related to the benefits of incorporating these data into storm forecasting on the COMET MetEd Website

3-8 The related NOAA Strategic Goal(s): Weather Ready Nation

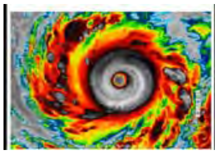
3-9 Detailed description of the research that was conducted during the reporting period, including progress to date with respect to originally proposed objectives and schedule

The subcontract to do collaborative work with COMET partners was put in place by early October. Project planning commenced shortly after.

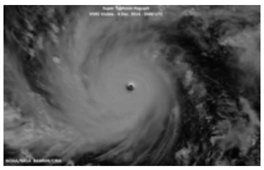
An additional full time employee, Vanessa Vicente, was hired through CIRA/CSU to work on activities in this project. Her start date was October 1, 2014

We had the opportunity to add on to the first completed project objective:

--Conduct a virtual VISIT satellite chat. This chat highlighted imagery used for tropical applications:



Dr. John Knaff (CIRA) discussed applications of VIIRS imagery for Super-typhoon Vongfong at the October 15 virtual VISIT chat session. The session was delivered using GoToWebinar software. The recording of the session can be found here:
http://rammb.cira.colostate.edu/training/visit/satellite_chat/20141015/



In support of the objective to post examples related to tropical cyclone products, Kate Musgrave (CIRA) wrote a VISIT blog entry on Typhoon Hagapit.
The entry can be viewed here:

http://rammb.cira.colostate.edu/training/visit/blog/index.php/2014/12/05/typhoon-hagupit/

The AMDAR module objective: *Introduction to Aircraft Meteorological Data Relay (AMDAR)* was published on MetEd:

https://www.meted.ucar.edu/training_module.php?id=1114
Introduction to Aircraft Meteorological Data Relay (AMDAR) provides national meteorological services worldwide, airlines, and aviation organizations with information about the World Meteorological Organization (WMO) aircraft-based observing system. The audience includes meteorological service managers and providers, observational development groups, the aviation industry, and others interested in benefiting from an aircraft-based observing system in their region. Aspects demonstrating the utility of AMDAR datasets in analysis and forecasting hazards are also included.

Progress on the Storm Surge module:

--Introduction to TC Storm Surge (60%)
--Forecasting Storm Surge and Storm Surge Products (30%)
--An Update to the NOAA/NWS Storm Surge Program (20%)

SANDY COMPETITIVE PROJECT TITLE: S4--CIRA Support to Monte Carlo Model-based Wind Arrival and Departure Estimates (NA14NWS4830056)

PRINCIPAL INVESTIGATOR: Andrea Schumacher

RESEARCH TEAM: John Forsythe

NOAA TECHNICAL CONTACT: Mark DeMaria (NOAA/NWS/NHC)

NOAA RESEARCH TEAM: Mark DeMaria (NOAA/NWS/NHC)

PROJECT OBJECTIVES:

The goal of this project is to develop a new product that will run in conjunction with the Monte Carlo wind speed probability model (MC model) that estimates the arrival and departure of 34, 50, and 64-kt winds. A similar application that estimates the arrival and departure of 34, 50, and 64-kt winds at a user-specified point (Figure 1) is currently available in Hurricane Landfall Probability Application (HuLPA). NHC feedback has indicated that this information would be extremely useful for emergency managers. The HURREVAC program used by emergency managers provides time of arrival information based on the NHC deterministic forecast, but does not provide the range of possibilities that is available from the MC model. Although HuLPA can provide this same information in a post-processing step, it would be very inefficient to generate these values for a wide range of coastal points or grid one at a time. This project proposes incorporating the timing information currently available in post-processing with HuLPA into the operational MC model. Including this timing information as part of the MC model would set the stage for development of future landfall timing products from NHC.

PROJECT ACCOMPLISHMENTS: Past Fiscal Year by Objective:

Scientists have integrated the code elements that determine the arrival and departure times of 34, 50, and 64-knot winds from the Hurricane Landfall Probability Applications (HuLPA) program into the MC model and conducted initial testing. Figure 1 shows an example of the time of arrival estimates for 34-kt (tropical storm force) winds for Hurricane Ike on 18 September 2008 at 18 UTC based on the 10th percentile of realizations. Time of arrival and departure estimates are now provided by the MC model for numerous percentiles in a format compatible with the GIS graphical display used by the National Hurricane Center. Work continues on updating the MC model code to Fortran 90 and optimizing this updated MC model for operations.

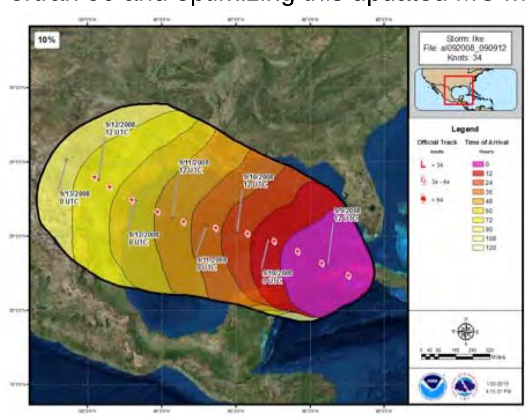


Figure 1. Time of arrival estimates (based on 10th percentile) for Hurricane Ike on 18 September 2008 at 18 UTC generated by the newly upgraded MC model. Image courtesy of Casey Ogden, NHC.

SANDY COMPETITIVE PROJECT TITLE: S5--ESRL/GSD Participation in the Establishment of a NOAA Lab Activity for OSSEs (NA14OAR4830110)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 –December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Hongli Wang

NOAA Technical Contact: Jennifer Mahoney (OAR/ESRL/OD) (formerly Yuanfu Xie))

NOAA Research Team: Zoltan Toth (OAR/ESRL/GSD/OD), Lidia Cucurull (CIRES)

Project Objective

CIRA's will participate in collaborative NOAA research with the Earth System Research Lab/Global Systems Division (GSD) and the Atlantic Oceanographic and Meteorological Laboratory (AOML) for establishment of a system for the quantitative assessment of observing systems in order to enable the most cost-effective decisions relating to NOAA's operational aircraft reconnaissance missions. The capability to be established will include the potential to conduct numerical experiments to quantitatively assess the value of either existing or future observing systems. Currently, the ability to conduct "real data" Observing System Experiments (OSE) is widely distributed throughout many organizations, while the ability to conduct realistic assessments for future observing systems through Observing System Simulation Experiments (OSSE) is more limited. This project extends capability beyond this limit

Research Tasks

The primary activity to be performed in this proposal with the Sandy Supplemental funding will be the development of a new global OSSE system capability to perform realistic quantitative assessments related to NOAA's operational aircraft reconnaissance missions.

Outcomes

Year 1
CIRA will incorporate ensemble-based adaptive observational technology into NOAA's joint global OSSE infrastructure in preparation for OSSE experiments in support of NOAA operational aircraft reconnaissance missions

--Generate a set of ensemble forecasts for the joint OSSE nature runs, ECMWF T511 and the possible high resolution new nature runs from GMAO or ECMWF;
--Implement the Ensemble Transform (ET) or Ensemble Transform sensitivity (ETS) adaptive observation technique into the joint OSSE system;
--For a hurricane case in a nature run, test scripts for identifying targeted observation regions.

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 31 2014

1--I summarized the work on validation of the GEOS-5 Nature Run (G5NR) and estimation of NCEP GFS model predictability using G5NR initial conditions and submitted two posters to the AMS 2015 annual conference.
2--The proposed ETS algorithm was investigated for a hurricane Irene (2011) using ensemble produced by ECMWF. Results showed that the ETS algorithm produced almost the same targeting region to the ET algorithm for this hurricane case.

SANDY COMPETITIVE PROJECT: S6--Evaluation of Earth Networks Total Lightning Products for NWS Warning Services in the Hazardous Weather Testbed (NA14OAR4830114)

Project Reporting Period: Quarterly Progress Report, Performance Period: Oct 1, 2014 –December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Jim Ramer

NOAA Technical Contact: Woody Roberts (OAR/ESRL/GSD)

NOAA Research Team: Woody Roberts (OAR/ESRL/GSD)

Project Objective

Working at OAR's Global Systems Division, CIRA will collaborate with both Federal and the University of Oklahoma's Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) staff at NOAA's National Severe Storms Laboratory (NSSL) in the performance of this proposal. Earth Networks (ENI), a private weather enterprise, has indicated the potential for their total lightning data and "Dangerous Thunderstorm Alerts" to increase lead time over current National Weather Service (NWS) severe weather and tornado warnings, while maintaining a similar probability of detection and false alarm ratio. This project will implement the Earth Networks data and products into the NWS operational AWIPS software and then test both the feasibility of use in warning operations as well as the impact on warnings issued by NWS forecasters in the Hazardous Weather Testbed in Norman, OK. The final goal of this project is to make recommendations on possible product improvements and determine whether Earth Networks' products should become part of the operational product streams available to NWS offices nationally.

Research Tasks

Total lightning activity has been shown to act as a precursor or signal of severe weather potential (e.g., Goodman et al. 1988, Schultz et al. 2011) due to the inherent link between storm electrification and updraft size and strength (e.g., Saunders et al. 2006, MacGorman et al. 2008, Calhoun et al. 2013a). In addition to the detection of total lightning (in-cloud and cloud-to-ground) flash rates, Earth Networks Incorporated (ENI) has developed Dangerous Thunderstorm Alerts (DTAs) based on a proprietary storm tracking and lightning flash rate threshold algorithm (Earth Networks, 2013). These DTAs are meant to indicate an increased potential for dangerous conditions, similar to the goal of real time Lightning Jump Algorithms currently being developed and tested for NWS implementation (e.g., Calhoun et al. 2013b).

Currently, ENI produces DTAs for storms across the continental United States (CONUS) and adjacent coastal and land areas at 1 min intervals, though they are only updated at 15 min intervals for private customers (Earth Networks, 2013). These DTAs are a combination of a cluster identification and tracking algorithm as well as a threshold of the total lightning flash rate (i.e., 25 flashes per minute). Operationally, for NWS forecasters, the DTA is currently displayed in real time outside the NWS operational Advanced Weather Interactive Processing System (AWIPS) software using the StreamerRT web application. The DTA display includes a polygon box specifying the location and forecast threat area as well as the cluster identification, past track, and time series of the cluster flash rate.

Preliminary examination of the performance of the DTA provided by ENI for five separate days during 2013 depicted an increased lead time (between 3 to 27 min over NWS warnings) and similar probability of detection (60-90%) to NWS warnings on the same dates. Additionally, a more comprehensive analysis performed by ENI of all tornadic events from 2011 (NOAA Storm Event Database) indicates a median DTA lead time of 27 minutes versus an NWS median lead time of 18 minutes. In order to determine if the DTAs could lead to improved forecasts and warnings during NWS operations, a controlled experiment similar to Heinselman et al. (2012) will be completed within NOAA's Hazardous Weather Testbed (HWT). This displaced real-time experiment will allow for multiple forecasters of varying levels of expertise to complete multiple warning scenarios in order to produce repeatable results, across a number of scenarios, and reduce the influence of singular forecaster expertise on the verification statistics.   The second year will focus on real time forecaster use and evaluation in the HWT during the Spring Experiment.

Objectives

Outcomes Year 1: HWT Evaluation
Initial development and production of both the raw Earth Networks flash locations and the ENI DTA system inside of the AWIPS2 platform will be led by CIRA working at the OAR/Global Systems Division (GSD) and coordinating with the HWT activities at the National Severe Storms Laboratory (NSSL). Included in this initial development is the implementation of point locations for the ENI identified flashes, to be displayed as point locations at 1 min update rates (similar to currently available CG data from the National Lightning Detection Network, NLDN).   Secondarily, will be the inclusion of ENI total lightning products associated with the DTA including the DTA polygon, cluster identification and past track.

Following CIRA development and implementation of the ENI products into AWIPS2, forecaster evaluation of the ENI products will be completed in the HWT. The HWT experiment will consist of approximately 15 forecasters, with each participating in the evaluation for three-to-four days. Each forecaster will complete six-to-ten different scenarios within AWIPS2 using WarnGen to issue warnings in displaced real time. The scenarios will range in intensity from high impact tornadic events to marginally severe events and include a variety of geographic locations. One third of the forecasters will work a "control" event for each scenario, operating under current radar products only while the other two thirds will work the event with the addition of ENI Total Lightning Data and/or algorithms. For example, fifteen forecasters will each issue warnings for a given County Warning Area for a severe weather event, 5 will be working without access to any ENI data, 5 will have access to the raw ENI flash data in addition to what is provided for the control and 5 will have access to the ENI flash data and radar data, but will also be provided the DTA system including cluster analysis, past track, and cell statistics. Determination of which forecaster will work the control versus the additional DTA will be random with no forecaster completing all control or DTA scenarios. Forecaster experience and expertise will range from "Journeyman" through "Lead," from all regions of the US.   Following each event, a detailed interview will be completed with each forecaster to determine how and why he or she integrated the ENI data and DTAs into their warning decision process if it was available during that event.

In addition to forecaster use and evaluation, verification statistics of the DTA versus standard NWS warnings will be evaluated for a large, continuous sample of across the CONUS coverage of the ENI. These statistics will use primarily storm data for verification and include lead time, probability of detection, false alarm ratio, and skill scores and be compared with statistics provided by ENI.

Accomplishments for Performance Period: July 1, 2014 – Sept, 30 2014

AWIPS II Platform Development:
Completed implementing experimental plan-view displays of lightning 'Cell' information and DTA polygons for AWIPS-II (much of the work was performed in the previous quarter). This implementation involved encoding the displays into Redbook graphics. This choice was made because it minimized development time and the amount of changes necessary to the core A-II display software. The Redbook implementation is nothing one would want to use for a production implementation for ENI derived lightning products, but is was sufficient to enable the conduction of the forecaster evaluation exercise that was performed by HWT staff in Norman in during July 2014. This exercise was conducted using review cases, with the primary goal of determining what contribution ENI lightning data and derived products could make to the accuracy and lead time for severe convective warnings.

Evaluation:
Meetings were held to plan the next phase of the evaluation activity. A meeting with all collaborators from CIMMS, NSSL and the NWS is planned for November, 2014.

Accomplishments for Performance Period: Oct 1, 2014 – Dec 31, 2014:

AWIPS II Platform Development:

Successfully prototyped time series displays of lightning 'Cell' information AWIPS-II. There is still some work to do on the time series displays. The time series displays, along with the plan-view displays previously developed, will be used in a real-time forecaster evaluation exercise to be conducted at the HWT in Norman during the Spring of 2015.

Evaluation:
A day and a half long workshop was conducted in Boulder Nov 12 and 13. Collaborators from CIMMS, NSSL and the NWS were present along with GSD staff. Results of the forecaster evaluation exercise were presented. One major takeaway of the exercise evaluation is that earlier evaluations of the utility of the DTAs overstated their skill in forecasting severe convection, primarily because the DTAs have very high false alarm rates.

SANDY COMPETITIVE PROJECT TITLE: S7--Incorporating the GOES-R Geostationary Lightning Mapper Assimilation into the GSI for Use in the NCEP Global System (NA14NWS4830034)

PRINCIPAL INVESTIGATOR(S): Milija Zupanski

RESEARCH TEAM: Karina Apodaca

NOAA TECHNICAL CONTACT: John Derber (NCEP/EMC)

NOAA RESEARCH TEAM: Milija Zupanski, Karina Apodaca

PROJECT OBJECTIVE(S):

These are the objectives for the 2-year length of this project:
1--adopt and optimize the GLM lightning observation operator that is suited for NOAA global forecasting and data assimilation system,
2--incorporate the lightning observation operator in GSI, and
3--evaluate the impact of assimilating GLM lightning observations.

PROJECT ACCOMPLISHMENTS:

Partial completion of each of the three 2-year objectives
1a--GLM lightning observation operator based on the maximum vertical updraft recursion adopted and installed
1b--Pre-processing program for basic quality control and transformation of GLM lightning strikes observations to lightning flash rates developed and installed

2--Incorporation of GLM lightning observations in GSI: (a) Conversion of ascii input lightning observations file to BUFR format completed, (b) Developed of new setup light .f90 code that calculates the nonlinear and tangent linear observation operator, (c) Developed new intjo.f90 program that handles the adjoint and tangent linear calculations in GSI

3--Started evaluating the impact of GLM lightning observations in regional WRF model before continuing with the GFS model, in case of the East Pacific tropical cyclone Ivo (2013).

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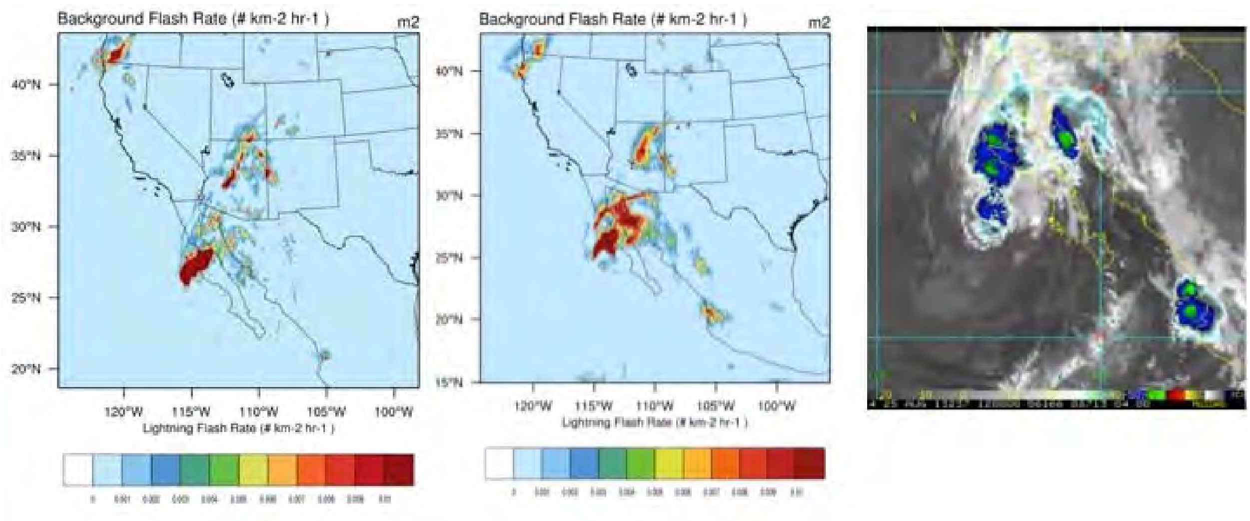


Figure 1. A 3-hour forecast of lightning flash rate (strikes/km2/hr) valid 25 AUG 2013 1200 UTC: (a) after assimilating GSI observations only, (b) after assimilating GSI and WWLLN lightning observations, and (c) verification from a GOES-R infrared image.

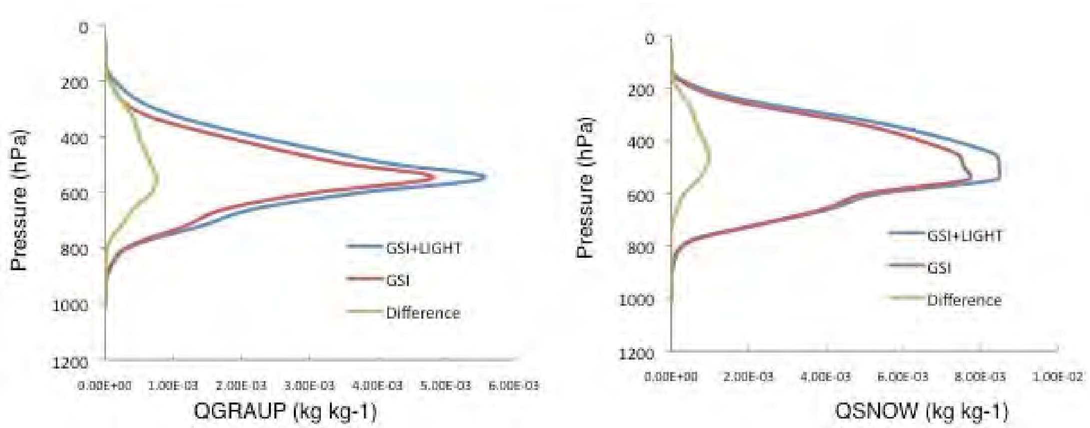


Figure 2. Horizontally averaged vertical profiles of cloud hydrometeors for tropical cyclone Ivo (2013). The GSI experiment (red) refers to assimilating only GSI observations), and the GSI+LIGHT experiment refers to assimilating additional lightning observations. The lightning data assimilation impact shows an increase of cloud hydrometeors at 500-600 hPa layer, implying a potentially stronger precipitation.

Project Publications from Past Fiscal Year (including Conferences): None (project started July 1, 2014)

SANDY COMPETITIVE PROJECT: S8--MADIS Transition to NWS Operations (NA14NWS4830009)

Project Reporting Period: Quarterly Progress Report, Performance Period: Oct 1, 2014 – December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Tom Kent

NOAA Technical Contact: Greg Pratt (OAR/ESRL/GSD)

NOAA Research Team: Greg Pratt (OAR/ESRL/GSD)

Project Objective

The Meteorological Assimilation Data Ingest System (MADIS) provides a framework for easily extending NOAA's observational data capabilities. MADIS does this by leveraging partnerships with international agencies, federal, state, and local agencies (e.g. state Departments of Transportation), universities, volunteer networks, and the private sector (e.g. airlines, railroads) and integrating observations from their stations with those of NOAA to provide a finer density, higher frequency observational database. Through these partnerships, MADIS provides NOAA with an additional 13 million observations a day from 66,127 non-NOAA stations received from over 160 providers. These observations are Quality Controlled and made available to the greater meteorological community in standardized formats. MADIS observations are used throughout the weather research and operational communities in the data assimilation phase and verification of weather forecast models. MADIS attained Initial Operating Capability (IOC) at National Weather Service (NWS) in September 2010 with backup systems running at the Earth System Research Laboratory. Due to funding shortfalls, MADIS has failed to reach Final Operating Capability (FOC) at NWS.

MADIS IOC is defined as operational MADIS services running at NWS and backup MADIS services running at Global Systems Division (GSD). The operational MADIS system is a distributed system with the NWS Telecommunications Operations Center (TOC) providing MADIS ingest and distribution services and the NWS' National Center of Environmental Protection (NCEP) Central Operations (NCO) providing MADIS processing services. The MADIS operational backup system runs at GSD and is a centralized system, meaning MADIS ingest, processing, and distribution services are provided by GSD.

MADIS FOC is defined as centralized MADIS operational services being provided by the NWS Integrated Dissemination Program (IDP) (Figure 1 below). MADIS' primary operational systems will run at the IDP's College Park facility and backup operational systems will run at the IDP's Boulder facility. Both facilities will be hosted and maintained by NCEP NCO personnel. MADIS data will be archived at the National Environmental Satellite, Data, and Information Service (NESDIS) National Climate Data Center (NCDC).

Research Tasks

This proposed SOW is intended to cover all the tasks/activities required to move MADIS from IOC to FOC. The following major tasks have been identified in order to complete the transition:

1--MADIS primary and backup operational ingest services moved to NCO IDP systems at College Park and Boulder facilities.
2--MADIS primary and backup operational distribution services moved to NCO IDP systems at College Park and Boulder facilities.
3--MADIS primary and backup operational processing services moved to NCO IDP systems at College Park and Boulder facilities.
4--MADIS Data Recovery (MDR) moved to NCO IDP systems at College Park and Boulder facilities.
5--Cooperative Agency Profiler (CAP) dialers moved to NCO IDP systems at College Park and Boulder facilities.
6--MADIS user distribution services for data, graphics, and system information moved to the MADIS distribution system at the NCO IDP College Park or Boulder facility.

7--MADIS archive moved to NCDC and updatable by the MADIS distribution system at the NCO IDP College Park or Boulder facility.
8--MADIS tier I and tier II support provided by NWS NCO.
Support FOC testing.

Objectives

Tasks, milestones, and deliverables proposed for this SOW are presented below. Milestones and deliverables are subject to change and dependent upon any modifications to technical direction that may be required by the funding sponsor.

Task	Milestone	Deliverable
(1a) Move MADIS primary ingest to NCO IDP blade server at College Park.	6/30/2014	Primary MADIS ingest system running on blade servers at NCO IDP College Park facility.
(2a) Move MADIS primary distribution services to NCO IDP blade server at College Park.	7/15/2014	Primary MADIS distribution system running on blade servers at NCO IDP College Park facility.
(3a) Move MADIS primary processing to NCO IDP blade server at College Park.	8/15/2014	Primary MADIS processing system running on bladed servers at NCO IDP College Park facility.
(1b) Support move of MADIS backup ingest system to NCO blade server at Boulder.	10/15/2015	Backup MADIS ingest system running on blade servers at NCO IDP Boulder facility.
(4a) Move MADIS data recovery system to NCO blade server at College Park.	9/30/2014	Primary MADIS data recovery system running on blade servers at NCO IDP College Park facility.
(2b) Support move of MADIS backup distribution system to NCO blade server at Boulder facility.	11/30/2015	Backup MADIS distribution system running on blade servers at NCO IDP Boulder facility.
(5) Move CAP dialers to NCO IDP facility.	9/30/2014	CAP dialers running at NCO IDP facility.
(3b) Support move of MADIS backup processing to NCO IDP blade server at Boulder facility.	3/31/2016	Backup MADIS processing system running on blade servers at NCO IDP Boulder facility.
(6) Move MADIS user distribution services for data, graphics, and information services to NCO IDP primary and backup blade	10/30/2014	Ability for MADIS users to request data, graphics, or general MADIS information from NCO IDP primary and backup servers located at College Park facility.

servers at College Park facility.		
(4b) Support move of MADIS Data Recovery system to NCO blade server at Boulder.	10/30/2015	Backup MADIS data recovery system running at NWS IDP Boulder facility.
(8) Transfer all Tier I & II support to NCO personnel.	11/29/2014	Tier I & II Support Transferred to NWS NCO IDP operational support team.
(7) Move MADIS data archive to NCDC.	11/29/2014	Archive running at NCDC.
(9) Support NWS MADIS operational testing.	12/31/2014	Support NWS operational testing as required.

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 30 2014

Task numbers above completed for this quarter include:
6--Move MADIS user distribution services for data, graphics, and information services to NCO IDP primary and backup blade servers at College Park facility.
7--Move MADIS data archive to NCDC.
8--Transfer all Tier I & II support to NCO personnel.
9--Support NWS MADIS operational testing.

SANDY COMPETITIVE PROJECT: S9--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Ensemble Statistical Post-Processing (NA14OAR4830111)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU PI: Sher Schranz

CIRA CSU CO-PI: Isidora Jankov

NOAA Technical Contact: Tim Schneider (OAR/ESRL/GSD)

NOAA Research Team:
- Stan Benjamin (OAR/ESRL/GSD/EMB)
- Georg Grell (OAR/ESRL/GSD/EMB)
- Tom Hamill (OAR/ESRL/PSD)
- Yujian Zhu (NWS/NCEP/ClimateTestbed)
- Steve Weygandt (OAR/ESRL/GSD/EMB)
- Jeff Whitaker (OAR/ESRL/PSD)
- Jin Huang (NWS/NCEP)
- S. "Gopal" Gopalakrishnan (OAR/AOML)
- Vijay Tallapragada (NWS/NCEP/EMC)
- Mark Govett (OAR/ESRL/GSD/ATO)
- Jin Lee (OAR/ESRL/GSD/EMB)
- S-J Lin (OAR/GFDL)
- Scott Gregory (CIRES)

Project Objective

The HIWPP Test Program is a part of the broader HIWPP plan to focus, accelerate and enhance a number of ongoing R&D efforts to help achieve several of these objectives using "Hurricane Sandy Supplemental Funding. The objective is to create a framework for model development that allows developers and trusted partners alike to access, process, visualize and analyze large volumes of gridded earth system data—in particular, gridded high-resolution NWP model forecasts. Thus, a key component of HIWPP will be the development of a capability for testing and evaluating the accuracy of global NWP systems and ultimately for running mature systems in near real-time. This research capability will complement the capabilities now present at the operational centers by allowing for more extensive testing of new technologies and models that may be a large departure from the current operational system. It will also allow for more community involvement in the development, testing, and evaluation process.

Having a reliable and skillful forecast, especially in the case of high-impact weather events such as Hurricane Sandy, would facilitate better decision-making resulting in saving lives and minimizing property loss. For more accurate, longer lead-time forecasts, it is necessary to use global modeling systems. In recent years, ensemble-forecasting techniques have been increasingly used. Early into the ensemble-forecasting era, ensemble mean values were found to estimate the verifying state (usually large-scale circulations) better than the forecast from a single ensemble member. Ensembles also are advantageous because they supply probabilistic forecast information which may be of more value to users than a single deterministic forecast. The ensemble dispersion gives an estimate of forecast uncertainty.

Research Tasks

To assist model evaluation, the test program will develop and implement statistical tools to compare, quantify, and evaluate the performance of the new prediction system relative to operational global prediction systems. This includes creating improved output of forecaster-oriented metrics and indices useful for medium and extended range timescales. Additional outputs will provide assessments of forecast uncertainty, particularly for medium and longer-range ensemble products. Routine verification of the ensemble guidance, both individual model components and the multi-model product, will be made readily available. The verification will include standard metrics (anomaly correlations, RMS errors, error statistics currently computed by NWS, etc.) and ensemble verification of regular and high-impact forecasts (e.g., heavy precipitation, hurricane track and intensity, etc.)

The main goal of this task is to statistically combine information from a mini-ensemble consisting of three deterministic, hydrostatic, high-resolution global models and coarser resolution global ensembles to produce the best estimate of surface temperature, wind, precipitation, and 500-mb anomaly correlation. The models of interest are the 13km, 15km, and 20 km deterministic runs from the GFS, FIM, and NAVGEM global models, respectively, and corresponding coarser resolution ensembles (10-20 members). For this purpose, more sophisticated and innovative statistical approaches will be explored. The goal is to provide the best estimate of model skill, especially for the aforementioned variables. The product will be produced in a real-time experimental mode and delivered to HIWPP trusted partners for evaluation and feedback.

Outcomes Year 1:

1--Test and evaluate various statistical techniques for ensemble post-processing with a goal of having the best estimate of surface temperature, wind, precipitation, and 500mb anomaly correlation. Some of the techniques under consideration are time weighted ensemble mean, weather and climatological regime dependent weighted ensemble mean, Bayesian Model Averaging (BMA), self-organizing maps, field alignment, Bayesian Processor for Ensemble (BPE). Initially, focus will be on simpler approaches; it is likely that for the preliminary testing, currently available data (coarser version of both models and corresponding ensembles) will be used. The next set of testing would include retrospective data when they become available.

2--Code development for implementation of promising technique(s) into real-time forecasts and testing the code with whatever preliminary high-resolution model data are available.

Accomplishments for Performance Period: October 1, 2014 – December 31, 2014

In the final quarter of the calendar year of 2014, the HIWPP statistical post-processing task delivered the Production Version 1.0 of Statistical Post Processing (V1.0_SPP). Based on the results of analysis performed on surface temperature and wind (T2m and U/V 10m), geopotential height at 500mb (Z500), and 6 hour accumulated precipitation with two models, V1.0_SPP includes model weighting at each grid point that is inversely proportional to the Mean Absolute Error at the point in 30 days of training data. The other major result desired from the statistical post-processing task is a probability distribution of the forecast. To this end, also included in the output of the production code is the standard deviation of the weighted forecast error in the training period at each grid point for T2m, U/V10m, and Z500, variables currently assumed to be distributed normally. For precipitation, the probability of exceeding 1mm, 5mm and 10mm of precipitation are provided, based on an exponential distribution using the reciprocal of the weighted mean quantitative precipitation forecast (QPF) in the exponent. The performance of the weighted mean versus the arithmetic mean of the models for the period from December 24, 2014 thru January 7, 2015 is shown below, figure (1). These are consistent with the results from sample data analyzed prior to the development of the production code and are therefore considered representative of the general performance of the weighting algorithm.

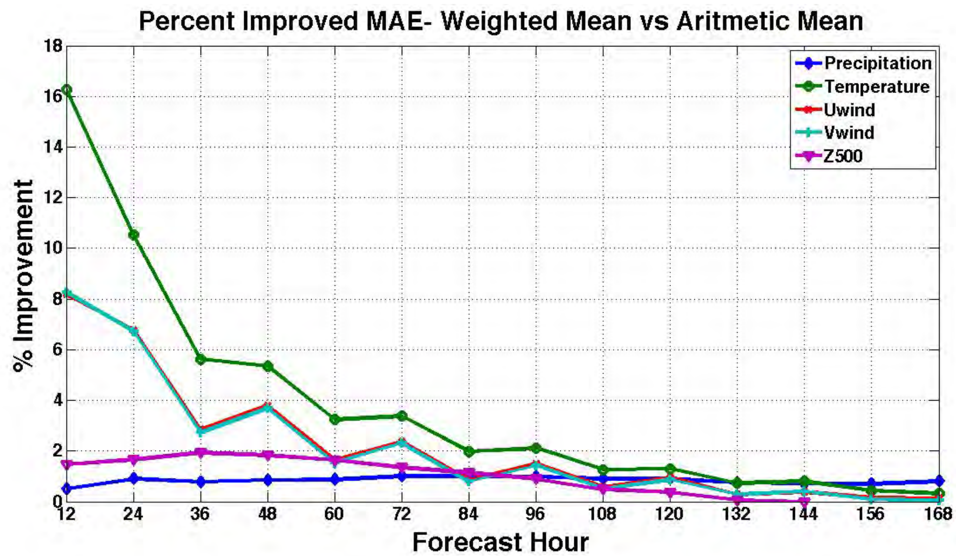


Figure 5: Weighted Mean Forecast Performance

The production code was monitored for stability and additional code was added to perform conversions of output from netcdf to grib1 for verification, and to grib 2 for users who prefer it.

SANDY COMPETITIVE PROJECT: S10--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Fine-Grain Computing (NA14OAR4830112)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Tom Henderson

NOAA Technical Contact: Mark Govett (OAR/ESRL/GSD)

CIRA Research Team: Jacques Middlecoff, Jim Rosinski

Project Objective

The HIWPP Test Program is a part of the broader HIWPP plan to focus, accelerate and enhance a number of ongoing R&D efforts to help achieve several of these objectives using "Hurricane Sandy Supplemental Funding. The objective is to create a framework for model development that allows developers and trusted partners alike to access, process, visualize and analyze large volumes of gridded earth system data—in particular, gridded high-resolution NWP model forecasts. Thus, a key component of HIWPP will be the development of a capability for testing and evaluating the accuracy of global NWP systems and ultimately for running mature systems in near real-time. This research capability will complement the capabilities now present at the operational centers by allowing for more extensive testing of new technologies and models that may be a large departure from the current operational system. It will also allow for more community involvement in the development, testing, and evaluation process.

To meet a key HIWPP goal of developing and running global non-hydrostatic models at cloud-permitting 3-4 km horizontal resolution, a new generation of high-performance computing called Massively Parallel Fine Grain (MPGF) must be used. MPFG computing falls into two general categories: Graphics Processing Units (GPUs) from NVIDIA and AMD and Many Integrated Core (MIC or Xeon Phi) offered by Intel. These chips are ten to fifty times more powerful than CPUs. Rather than 12-16 powerful cores found in CPUs, they rely on hundreds to thousands of simple compute cores to execute calculations simultaneously. To effectively use MPFG computing, model codes must be adapted, parallelized, and optimized to achieve high performance.

Research Tasks

In order to use the high degree of parallelism available in MPFG, model codes must be adapted and parallelized for high performance. MPFG parallelization will proceed in three stages:

First, code will be analyzed and modified as needed to expose loop level parallelism and data organization will be improved to optimize memory accesses, reduce branching, and other optimizations. Every attempt will be made to demonstrate there are no changes in model results, but we anticipate some algorithmic changes may prove beneficial. All changes will be reviewed for clarity and accuracy by the modelers before being accepted. These optimizations have proven beneficial to both CPU and MPFG systems.

Second, industry-standard openMP and openACC directives will be inserted into the Fortran codes for MIC and GPU parallelization. The openMP standard is used with Intel's MIC system, while the openACC standard is used with the PGI, Cray and CAPS compilers for the GPU systems. The Non-hydrostatic Icosahedral Model (NIM) and Flow-following finite volume Icosahedral Model (FIM) currently use a compiler developed at ESRL called F2C-ACC. This compiler was developed before commercial Fortran GPU compilers were available and it continues to be used to run FIM and NIM to demonstrate performance results and to push for improvements in the openACC compilers. F2C-ACC and openACC directives are very similar so code conversion can easily be done once commercial compilers are ready. ESRL continues to evaluate the openACC compilers and collaborate with vendors on improvements to meet GSD's modeling needs.

Model optimization and scaling to thousands of Fine-Grain nodes will be the focus of the final stage in parallelization for MPFG. Thorough evaluation of initial performance via testing and profiling will help determine bottlenecks, communications optimizations, and I/O improvements. Given that NOAA will not have a large MPFG system until FY15, testing will be done on the MIC-based Texas Advanced Computing Center (TACC) and NVIDIA-based Titan systems at Oak Ridge National Laboratory (ORNL) as resources permit.

CIRA researchers will support the above parallelization efforts. In addition, CIRA researchers will explore performance profiling tools and debuggers for the GPU and MIC to support model development, parallelization and optimization efforts.

Objectives

Outcomes Year 1
--Performance analysis and tuning of NIM model dynamics, and selection of physics routines

Accomplishments for Performance Period: October 1, 2014 – December, 31 2014

CIRA researchers continued work on MPFG optimizations for Intel Xeon (CPU) and Xeon Phi (MIC) architectures using NIM coupled to WRF physics packages shared with NCAR's atmospheric component of the Model for Prediction Across Scales (MPAS). CIRA researchers continued to tune performance of WSM6 microphysics on Xeon and Xeon Phi and refined new techniques that improved performance over previous methods while allowing modified source code to remain much closer to the original WRF version. CIRA researchers extended these techniques to the RRTMG long wave radiation package used by WRF, MPAS, NIM, and many other NWP models. CIRA researchers attended a week-long Intel “dungeon” at Intel HQ. This was an unprecedented opportunity to work closely with Intel compiler and hardware experts. New techniques were identified and feedback provided to Intel. Using a combination of techniques, CIRA researchers were able to speed up WSM6 by 30% and RRTMG-LW by over 20% on Xeon, and even more on Xeon Phi. CIRA researchers demonstrated that these techniques provide similar benefits on both Intel and Cray compilers. Cray joined Intel in providing access to an in-house system with their latest software and hardware. CIRA researchers also continued ongoing collaboration with NCEP's John Michalakes, reducing R&D costs by coordinating our MPFG efforts.

CIRA researchers continued to tune FIM dynamics performance on Intel Xeon Phi. This work was performed in close collaboration with Intel experts who provided suggestions during weekly telecons. CIRA researchers also improved threading of MPI communications, threaded inter-grid interpolations performed during FIM model start-up, and further tuned performance of NIM dynamics routines.

CIRA researchers continued to optimize MPI communications in the Scalable Modeling System to improve performance on both NVIDIA GPU and Intel Xeon Phi architectures. SMS provides distributed-memory parallelism for both the FIM and NIM NWP models. SMS halo exchange time was reduced by adding the capability for overlapping communication with model calculations. CIRA researchers begtan work to further reduce SMS halo exchange time by taking advantage of the flexible column storage order enabled by use of indirect addressing to eliminate the pack-unpack step usually required with MPI communications. This is a novel approach and should improve performance especially on MPFG architectures where pack-unpack is a key bottleneck.

This work has consistently improved performance on traditional CPUs as well as on GPUs and Xeon Phi. Performance improvements have already been incorporated into some production codes. No matter how the hardware architecture races turn out, NOAA will continue to benefit from MPFG performance improvements on existing machines.

CIRA researchers presented results of these ongoing efforts at the 16th ECMWF Workshop on High-Performance Computing in Meteorology (http://www.ecmwf.int/sites/default/files/HPC-WS-Rosinski.pdf. http://www.ecmwf.int/sites/default/files/HPC-WS-Henderson.pdf) and at the 2014 ESPC-AOLI meeting (https://www.earthsystemcog.org/site_media/projects/espc-aoli/AOLI_2014_Henderson.ppt).

SANDY COMPETITIVE PROJECT: S11--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Real-Time IT Operations (NA14OAR4830109)

Project Reporting Period: Quarterly Report for Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU PI: Sher Schranz

CIRA/CSU CO-PI: Bonny Strong

NOAA Technical Contact: Tim Schneider (OAR/ESRL/GSD/EMB)

NOAA Research Team:

- Stan Benjamin (OAR/ESRL/GSD/EMB)
- Georg Grell (OAR/ESRL/GSD/EMB)
- Tom Hamill (OAR/ESRL/PSD)
- Yujian Zhu (NWS/NCEP/ClimateTestbed)
- Steve Weygandt (OAR/ESRL/GSD/EMB)
- Jeff Whitaker (OAR/ESRL/PSD)
- Jin Huang (NWS/NCEP)
- S. "Gopal" Gopalakrishnan (OAR/AOML)
- Vijay Tallapragada (NWS/NCEP/EMC)
- Mark Govett (OAR/ESRL/GSD/ATO)
- Jin Lee (OAR/ESRL/GSD/EMB)
- S-J Lin (OAR/GFDL)

Project Objective

The HIWPP Test Program is a part of the broader HIWPP plan to focus, accelerate and enhance a number of ongoing R&D efforts to help achieve several of these objectives using "Hurricane Sandy Supplemental Funding. The objective is to create a framework for model development that allows developers and trusted partners alike to access, process, visualize and analyze large volumes of gridded earth system data—in particular, gridded high-resolution NWP model forecasts. Thus, a key component of HIWPP will be the development of a capability for testing and evaluating the accuracy of global NWP systems and ultimately for running mature systems in near real-time. This research capability will complement the capabilities now present at the operational centers by allowing for more extensive testing of new technologies and models that may be a large departure from the current operational system. It will also allow for more community involvement in the development, testing, and evaluation process. Another key part of this new capability will be a system to enable real-time access of global-scale and regionally sub-setted model data to a diverse community of users. This system will build upon the prototype NOAA Earth Information System (NEIS) developing advanced dynamic visualization and analytics in addition to on-demand access and integration of experimental global-scale models and other earth system data.

Research Tasks

The HIWPP Test Program will build upon the NEIS and create the test program architecture and methods to permit advanced users to access the experimental, quasi-real-time model output and will develop capabilities for interactive visualization of model output using existing structures that are readily available when possible. Real-Time IT Operations task is the foundation of the Test Program and facilitates the testing and evaluation of experimental global NWP systems. A significant portion of this task is the overall management of the Test Program to ensure each subtask is meeting its milestones and deliverables towards the overall success of the HIWPP. The other significant portion of this task is to provide, monitor, and support an IT infrastructure for the distribution, testing and evaluation of data related to the HIWPP program. This task will leverage the existing IT infrastructure and personnel available at the ESRL/GSD. While this infrastructure supports the existing data needs, research and development are required to improve and enhance these capabilities to support the next generation large volume global prediction systems data needed by other Test Program tasks.

More specifically, the Real-Time IT Operations project will strive to meet the following goals in support of the Test Program:
1--Management of the Test Program to ensure each subtask is meeting its milestones and deliverables.
2--Provide enhanced real-time IT infrastructure for the testing and evaluation of next generation global NWP systems.
3--Provide community environment to allow a diverse group of users to be more involved in the development, testing, and evaluation process of the HIWPP program.
4--Monitor real-time IT infrastructure ensuring services, systems and data are accessible to the participating community.
5--Provide support and responses to the HIWPP program partners and community of users.

Objectives

Outcomes Year 1:
1--Develop enhanced system architecture.
2--Start and complete storage hardware procurement and initiate installation.
3--Plan in place to acquire all HIWPP required data in GSD's Central Facility
4--Establish POCs between HIWPP data partners.
5--Set up community portal, support infrastructure and procedures for the group.
6--Ensure data from HIWPP partners is flowing and available on Real-Time IT Operations infrastructure in GSD's Central Facility.
7--Complete installation and testing of Enhanced IT Infrastructure.

Outcomes Year 2:
1--Create development plan in response to feedback from Test Program users, if necessary.
2--Begin and deliver any necessary changes to the community portal, real-time monitoring or Enhanced IT Infrastructure.
3--Deliver final Enhanced IT Infrastructure.
4--Create and deliver final task report.

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 31 2014

Test Program Sub-Project
The Test Program sub-project consists of four tasks:
--Statistical Post-Processing
--Visualization and analysis via NEIS
--Verification
--Real-time IT Operations

All 4 tasks work with output from the hydrostatic modeling task. Due to delays in availability of real-time hydrostatic model output, some work planned for year 1 for the Test Program continued into year 2 as real-time model data became available.
Major accomplishments of the Test Program during this period include:
--Follow-on from the major hardware purchases and installations during the July-Sep time period to monitor and resolve some remaining serious issues with storage hardware.
--The Statistical Post-Processing task completed code improvements in the product created during year 1, and insured the code was modular and maintainable. In parallel, research began on new experimental products to be implemented for year 2.
--The NEIS team completed version 1 of NEIS by Oct 1, 2014. During this past quarter they continued work on some bug fixes and code changes that were required as model data became more reliably available. They also began work on new features to be implemented in year 2 of the project.
--The verification team completed deployment of a new initial verification system based on NCEP's current vsdb-based system, for both retrospective and real-time runs of the 3 high-resolution hydrostatic models. In parallel, work has proceeded on the intermediate system based on MySQL with integrated capabilities based on systems now in use at NCEP and ESRL.
--Flow of model data was implemented with the new hardware to make hydrostatic model data available in real-time for NEIS, real-time data distribution, verification, and input to the statistical post-processing system.

--Policies and plans for engagement with the external weather enterprise, now named the HIWPP Open Data Initiative, were completed and submitted for review.

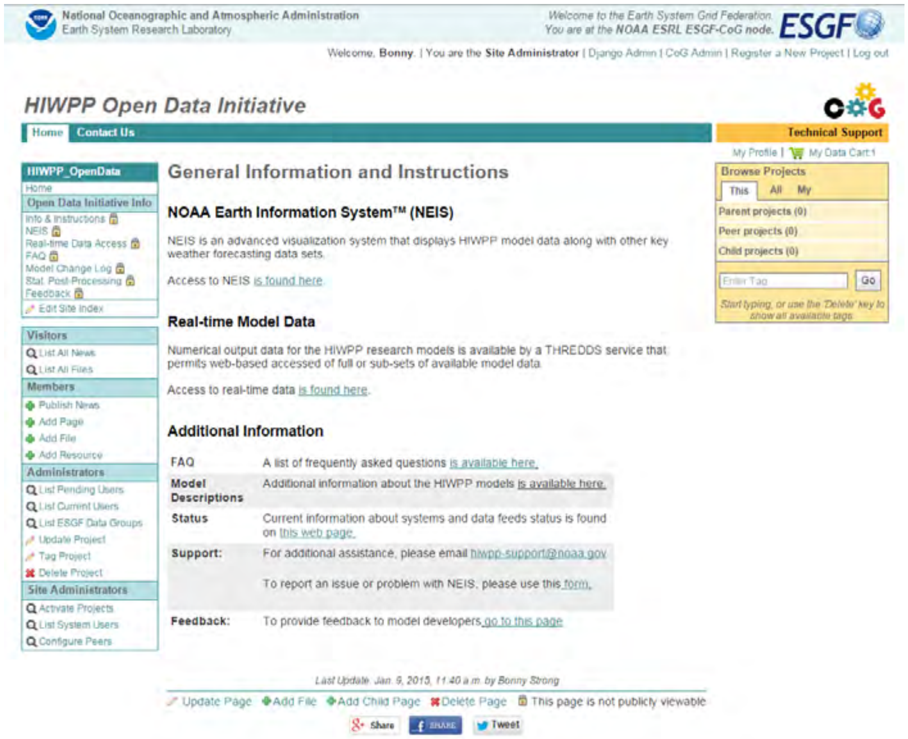
Real-time IT Operations
The Real-time IT Operations task incorporates several sub-tasks, including:
1--Collect model data into a central location, where it is available for post-processing, visualization, and verification
2--Acquire additional data needed for verification and visualization
3--Distribute model data to HIWPP to public data users as part of the HIWPP Open Data Initiative
4--Provide tools and infrastructure to support the Open Data Initiative
5--Provide and support a community portal for communication and collaboration of all HIWPP project members
6--Provide documentation, monitoring, and support for real-time data operations.

During this quarter, critical hardware was ready for use, and implementation of software modules and configurations was implemented to ensure flow of model data as was needed to support the other Test Program tasks. Infrastructure analysis and deployment, such as deployment of virtual machines for various components and resolution of firewall and security issues was completed. The issue of authentication for external users of HIWPP data was addressed, and a solution was found using an OpenID implementation provided by the Earth System Grid Federation (ESGF) installation at ESRL.

A major focus during this quarter has been the Open Data Initiative, the HIWPP initiative for engaging with the external weather enterprise (public, private, and academic sectors) in a real-time research mode. Policies for this initiative were defined and reviewed with NOAA legal and policy teams, and presented to the Executive Oversight Board for final approval. The policy was then submitted for approval in the command chain of both NWS and OAR.

Tools for the implementation of the finalized Open Data Initiative policy were also evaluated and deployed. This included mechanisms for distribution of NEIS software, for access to real-time data, for means of communication and support with users, and mechanisms for Open Data Initiative participants to provide feedback to model developers. By December, 2014, the system was in place with initial testing completed, ready to begin Beta testing with external users, once official approvals have been received.

An example from one of the Open Data Initiative user pages is shown below.


National Oceanographic and Atmospheric Administration
Earth System Research Laboratory
Welcome to the Earth System Grid Federation
You are at the NOAA ESRL ESGF-CoG node.
ESGF
Welcome, Bonny. | You are the Site Administrator | Django Admin | CoG Admin | Register a New Project | Log out
HIWPP Open Data Initiative
Home
Contact Us
Technical Support
General Information and Instructions
NOAA Earth Information System™ (NEIS)
NEIS is an advanced visualization system that displays HIWPP model data along with other key weather forecasting data sets.
Access to NEIS is found here
Real-time Model Data
Numerical output data for the HIWPP research models is available by a THREDDS service that permits web-based accessed of full or sub-sets of available model data.
Access to real-time data is found here.
Additional Information
FAQ
A list of frequently asked questions is available here.
Model Descriptions
Additional information about the HIWPP models is available here.
Status
Current information about systems and data feeds status is found on this web page.
Support:
For additional assistance, please email hiwpp-support@noaa.gov
To report an issue or problem with NEIS, please use this form.
Feedback:
To provide feedback to model developers go to this page
Last Update: Jan. 9, 2015, 11:40 a.m. by Bonny Strong
Update Page
Add File
Add Child Page
Delete Page
This page is not publicly viewable
HIWPP_OpenData
Open Data Initiative Info
Visitors
Members
Administrators
Site Administrators
Browse Projects
Parent projects (0)
Peer projects (0)
Child projects (0)
Go
Share
Tweet

SANDY COMPETITIVE PROJECT: S12--NOAA's High Impact Weather Prediction Project (HIWPP) Test Program—Visualization and Extraction via NEIS (NA14OAR4830113)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Jebb Stewart

NOAA Technical Contact: Tim Schneider (OAR/ESRL/GSD)

NOAA Research Team: Tracy Hansen (OAR/ESRL/GSD), Eric Hackathorn (OAR/ESRL/GSD)

Project Objective

The HIWPP Test Program is a part of the broader HIWPP plan to focus, accelerate and enhance a number of ongoing R&D efforts to help achieve several of these objectives using "Hurricane Sandy Supplemental Funding. The objective is to create a framework for model development that allows developers and trusted partners alike to access, process, visualize and analyze large volumes of gridded earth system data—in particular, gridded high-resolution NWP model forecasts. Thus, a key component of HIWPP will be the development of a capability for testing and evaluating the accuracy of global NWP systems and ultimately for running mature systems in near real-time. This research capability will complement the capabilities now present at the operational centers by allowing for more extensive testing of new technologies and models that may be a large departure from the current operational system. It will also allow for more community involvement in the development, testing, and evaluation process.

Essential to this new capability will be a system that will enable real-time access to global-scale and regionally sub-setted model data for a diverse community of users. This system will build upon the prototype NOAA Earth Information System (NEIS) developing advanced dynamic visualization and analytics in addition to on-demand access and integration of experimental global-scale models and other earth system data.

Research Tasks

The proposed research effort falls under 5 general tasks/activities:
1--An advanced visualization system based on prototype NEIS with the capabilities for real-time, on-demand access, visualization and integration of time- and space-matched earth system data as well as basic processing and analytic capability including ensemble means, differencing, probability, etc.
2--Data availability through NEIS for at least the last 24 hours for the following parameters:
a--HIWPP hydrostatic experimental deterministic global predictions
b--HIWPP hydrostatic experimental ensemble global predictions
c--HIWPP verification data
d--Global operational models
e--Global satellite observations
f--Global air and surface observations
3--Services enabling the ability to extract full and subset (regional, level, field) to a diverse community of users.
4--Biannual software and technology demonstrations
5--Development Report (description of technology, design and related decisions and reasoning)

Objectives

Outcomes Year 1:
1--Evaluate various encoding techniques for server-side visualization and data transmission.
2--Develop system architecture and identify/procure required hardware.
3--Begin visualization and extraction development based on NEIS prototype.
4--Begin basic service-based processing development.

5--Demonstrate preliminary NEIS data access and visualization capabilities.
6--Link visualization and extraction hardware to real-time IT operations tasks infrastructure and verification data services.
7--Deliver NEIS client with capability of research-grade real-time access and visualization of global model data with integration of time- and space-matched earth information data.

Accomplishments for Performance Period: Oct, 01 2014 – Dec, 31 2014:

Objective 1:
Continued research for optimal data transmission encoding technique. For imagery related data. Zipped DDS images have best result for transmission size, speed of decompression, and reading data directly to GPU for visualization

Objective 2:
Completed by September 30th, 2014.

Objective 3:
Ongoing development and improvement to existing real-time research data ingest system. Adding new data sets such including high resolution GFS data, and second run of high resolution FIM data from Jet supercomputer. Additionally added point data ingest and visualization capability for METAR and RAOB data.

Objective 4:
Ongoing development to fine tune service based processing development. Making it easier to work with data not in a common projection or grid size. Common projection and grid size needed for comparisons.

Objective 5:
Demonstrated NEIS/TerraViz technologies at Meteorology Technology Expo in Brussels, Belgium October 21st - 23rd and at the American Geophysical Union Fall 2014 conference in San Francisco, CA December 15-19th.

Objective 7:
Updated NEIS Visualization client made available to CIRA staff and other preliminary testers in mid-October. Additionally the latest visualization client as of December 15th, 2014 will be used for the first release as part of the HIWPP Open Data Initiative program launching in January 2015.

SANDY COMPETITIVE PROJECT: S13--NOAA's Observing System Experiments and Observing System Simulation Experiments in Support of the SHOUT Program - Development and Testing of Sampling Strategies for Unmanned Aerial Systems (NA14OAR4830167)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Hongli Wang

NOAA Technical Contact: Lidia Cucurull (CIRES) (formerly Yuanfu Xie))

NOAA Research Team: Zoltan Toth (OAR/ESRL/GSD/OD)

Project Objective

Environmental data from satellites have become critically important to the delivery of accurate weather forecasts for the nation. This criticality has become so significant that potential gap in satellite environmental observations are expected to diminish the quality of the nation's events. The National Weather Service (NWS) is now assimilating vertical atmospheric temperature and moisture profiles from the National Polar-orbiting Partnership (NPP) satellite into the NWS operational global forecast models. Thus, any future problems with NPP data (JPSS) will create vulnerability for the nation's weather services. To offset this threat, the U.S. Congress included $111M in the Disaster Relief Appropriations (DRA) Act of 2013 to test observing gaps. One of the options funded by DRA Act is the development and testing of targeted observations project using unmanned aircraft systems (UAS) to collect vertical atmospheric observations and other crucial environmental information to assist weather predictions of high impact weather.

This option is feasible because NASA and NOAA have demonstrated that Global Hawk UAS can overfly storms in the Atlantic, Pacific, and Arctic Oceans and deliver real-time vertical atmospheric profiles and environmental data. NASA Global Hawk UAS payloads have included infrared and microwave sounders similar to the Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) flown on NPP and currently assimilated operationally by the NWS. Other new observing capabilities are being designed to observe vertical wind profiles from UAS. Although environmental data collected by UAS cannot completely replace the global coverage of satellite data, the long endurance and long range of a Global Hawk UAS does provide new capabilities to reach and stay with high impact oceanic weather events.

The NOAA UAS Program has designed a project focused on "Sensing Hazards with Operational Unmanned Technology" (SHOUT) to quantify the influence of UAS environmental data to high impact weather prediction and assess the operational effectiveness of UAS environmental data to high impact weather prediction and assess the operational effectiveness of UAS to help mitigate the risk of satellite observing gaps.

In order to quantitatively evaluate the benefits of UAS data on mitigating a satellite gap, both Observing System Experiments (OSEs) and Observing System Simulations Experiments (OSSEs) are necessary. OSEs allow the evaluation of real data but cannot be use to analyze the impact of future observing systems. On the other hand, OSSEs provide a rigorous, cost-effective approach to evaluate the potential impact of new observing systems and alternate deployments of existing systems, and to optimize observing strategies. They are also used to prepare for the assimilation of new types of data, and to optimize the assimilation of existing data. OSSEs are an extension of OSEs, which use data denial experiments to determine the impact of existing observing systems. Atmospheric OSSEs determine the impact of new systems by performing data denial experiments that assimilate synthetic observations simulated from a realistic Nature Run (NR) stipulated to represent the "true" atmosphere.

For the OSSEs to produce accurate quantitative results, all of the components of the OSSE system must be realistic. This means that (1) the nature run, that is used to represent the atmosphere, should be generated by a state of the art numerical model, (2) there should be realistic differences between the nature run model and the model used for assimilation and forecasting, (3) the assimilation methodology must conform to current or future practices, (4) observations should be simulated with realistic coverage and accuracy, and (5) the entire OSSE system must be validated to ensure that the accuracy of analyses and forecasts, and the impact of existing observing systems in the OSSE are comparable to the accuracies and impacts of the same observing systems in the real world.

Under the SHOUT project, OSE and OSSE experiments will be performed to evaluate the impact of current and potential environmental observations on the Global Hawk to mitigate a potential gap in satellite data. In support of these experiments, strategies will be developed for flights of the Global Hawk that will be directed to appropriate locations for execution of the OSSE and OSE experiments. Therefore, four different tasks are proposed. In each task, milestones are listed from the starting date of the award (DOA).

Research Tasks

The goal of this program is to develop and test various flight pattern sampling strategies to provide guidance for Unmanned Aerial Systems (UAS) deployment for 4 experiments including: Quick global OSSE, ET-based OSSE (ensemble transform based sensitivity (ETS) algorithm to specify adaptive regions for the UAS deployment), and a TSD-based ("Threat - Sensitivity – Deployment) OSSE, and for two real-time field campaigns in 2015 and 2016. The research will measure impacts of observations from the Unmanned Aerial Systems (UAS) on numerical weather prediction. The proposed work will be coordinated with the work outlined in the CIRES' Contribution to the Observing System Experiments and Observing System Simulation Experiments in support of the SHOUT Program proposal.

Outcomes

Support to the Quick Global Observing System Simulation Experiments (OSSE): Develop and test sampling strategy
--Assess analysis error compared to nature run.
--Design UAS flights based to sample areas with largest analysis error.
--Deliver flight pattern to Quick Global OSSE (Task 1) (DOA+2 months)

Support to the ET-based OSSE
--Test UAS flight design methodology in OSSE.
--Identify "threat cases" based probabilistic information from ~3-day lead-time operational global ensemble forecasts.
--Develop fully automated ETS algorithm to determine sensitive regions at ~12-hour lead-time for forecast threat cases.
--Prepare automated UAS deployment (flight track design) algorithm based on automated ET sensitivity.
--Deliver flight pattern to ET-based OSSE (DOA+10 months)

Support to the TSD-based ("Threat - Sensitivity - Deployment - TSD") OSSE
--Test "Threat - Sensitivity - Deployment - TSD" sampling strategy in OSSE.
--Improve targeting observation scheme based on quick OSSE results
--Provide guidance for UAS deployment during 2015 field campaign using ETS targeting scheme. Prepare initial observing system experiment (OSE) evaluation report on ETS based targeting observation scheme for dropsonde data.
--Improve TSD strategy based on experience in quick OSSE, 2015 field campaign, and full OSSE.
--Deliver flight pattern to TSD-based OSSE (DOA + 28 months)

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 31 2014

In the performance period, we focused on the following tasks:
--Design UAS flights based to sample areas with largest analysis error
--Deliver flight pattern to Quick Global OSSE
--Test UAS flight design methodology in OSSE

1--Design and deliver flight pattern
Analysis error variances were estimated by comparing analyses to the ECMWF (T511) nature run during 2-17 August 2015. Based on the maximum range that the UAS can reach and the spatial distribution of analysis error variances, targeted regions for the UAS were identified. Moreover, we produced simulated dropsonde observations in the targeted regions, and tested the impact of dropsonde data on analysis in sensitivity experiments. Analyses from control and sensitivity experiments were delivered to Quick Global OSSE team for further investigation.

2--Test UAS flight design methodology in OSSE
We investigated the difference between the proposed ETS algorithm and the original ET algorithm. Two cases including the hurricane Irene (2011) and a rainfall case were tested. Results showed that the ETS algorithm produced a very similar targeted region to the ET algorithm. However, ETS reduced computation time 60-80%.

SANDY COMPETITIVE PROJECT: S14--Sensing Hazards with Operational Unmanned Technology (SHOUT) - Data Management and Visualization (NA14OAR4830166)

Project Reporting Period: Quarterly Progress Report, Performance Period: October 1, 2014 – December 31, 2014

CIRA/CSU Principal Investigator: Sher Schranz

CIRA/CSU CO-PI: Jebb Stewart

NOAA Technical Contact: Robbie Hood (OAR/UAS) Program Manager

NOAA Research Team: Greg Pratt (OAR/ESRL), JC Coffey (OAR/US), Gary Wick (NOAA/ESRL)

Project Objective

The SHOUT Program is a part of the broader plan to focus, accelerate and enhance a number of ongoing R&D efforts to help achieve several of these objectives using “Hurricane Sandy” Supplemental Funding. The overall goal of the SHOUT project is to demonstrate and test a prototype concept of operations for unmanned observing technology that could be used to mitigate the risk of diminished high impact weather forecasts and warnings in the case of polar-orbiting satellite observing gaps.

Effective information planning and management will be critical to fully evaluating the potential of unmanned technology to successfully mitigate the loss of satellite information for weather prediction of high impact events. SHOUT project funding will be used to develop a strategic plan, demonstrate, and test a concept of operations for effectively and efficiently delivering SHOUT gap filling data for real-time operations, near-real time use, and for future use. This task will not build a duplicate information delivery and archival system but will be a systems engineering effort to address how to use current NOAA information management systems most effectively given the data volume and latency of Global Hawk observations. The technology readiness of Global Hawk data communication and payload systems must be evaluated for real-time utilization by operational weather prediction models and forecasters. Of particular importance to this task is the consideration of how UAS observations will be incorporated into operational data assimilation procedures in the event of an actual satellite observing gap.

The development of a SHOUT information management strategic plan will be performed by Cooperative Institute for Research in the Atmosphere (CIRA) working collaboratively with the Cooperative Institute for Research in Environmental Sciences (CIRES) and NOAA building on experience in researching and developing NOAA meteorological information management systems. It is expected the team will also work collaboratively with existing NOAA information management teams to develop and demonstrate real-time data delivery, visualization, and archival for the UAS observations. An emphasis will be placed on leveraging current work but providing additional resources so the UAS observations will be managed and utilized in parallel with other data sets and not sequentially after other data sets. These tasks will include the development and implementation of the SHOUT information management requirements.

Research Tasks

The proposed research effort falls under 4 general tasks/activities:
1--UAS data Lifecycle management-- Management and maintenance of data through various stages of the data lifecycle from data creation, real-time delivery for modelling assimilation and visualization, accessible storage for use in other tools and applications, and eventual archival for long-term preservation.
2--Research and investigation of existing visualization tools, providing guidance and recommendations going forward for real-time UAS data visualization within three (3) distinct realms: Real Time Mission Monitoring, Real Time Data Visualization for operational users, and Scientific visualization for data analysis, comparison and impacts. Each visualization system will allow users to integrate other earth system data synchronized in both time and space. Initial candidates will include existing NASA Mission Tools Suites, NOAA AWIPS II, and the NOAA Earth Information System (NEIS).

3--Development of real-time data visualization tools resulting from output of task 2.
4--Development and implementation of tools aiding UAS data discovery and accessibility to meet NOAA data management requirements.

Milestones Year 1:
1--Develop SHOUT data lifecycle management plan.
2--Evaluate existing visualization tools and capabilities for use in three visualization realms described above.
3--Develop recommendations for system architecture and implementation plan for UAS data visualization for three realms described above.
4--Develop recommendations for UAS data visualization for operational NWS forecasters.
5--Develop data discovery and accessibility architecture and implementation plan.
6--Implementation and delivery of initial data lifecycle management for one UAS instrumentation package, making data available for real-time model assimilation and visualization and data archival.
7--Initial proof of concept visualization development for one UAS instrumentation package.
8--Implementation and delivery of initial visualization system Real Time Mission Monitoring

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 31 2014

Table 1: Year 1 -Tasks/Milestones/Deliverables

Task	**Milestone**	**Deliverable**
1. Work with NOAA and CIRES to develop data lifecycle management plan.	02/28/2015	SHOUT Data Lifecycle plan for UAS instrumentation packages.
2. Evaluate existing visualization tools.	3/31/2015	Recommendations for which tool to use for each visualization realm.
3. Develop recommendations for system architecture and implementation plan for UAS data visualization for each realm.	6/30/2015	System architecture and implementation plan for visualization of each realm.
4. Develop recommendations for UAS data visualization for operational NWS forecasters.	6/30/2015	UAS data visualization system architecture and implementation plan for NWS forecasters.
5. Develop data discovery and accessibility architecture and implementation plan.	6/30/2015	Plan for data discovery and accessibility architecture for UAS instrumentation package data.
6. Implementation and delivery of initial data lifecycle management for one UAS instrumentation package.	6/30/2015	One UAS instrumentation package data set ingested, available for visualization, and discoverable, for all SHOUT flights.
7.Initial proof of concept visualization development for one UAS instrumentation package.	6/30/2105	Proof of concept display reading data from UAS data lifecycle implementation.
8.Implementation and delivery of initial visualization system Real Time Mission Monitoring	6/30/2016	Initial Real Time Mission monitoring visualization tools.

Accomplishments for Performance Period: Oct 1, 2014 – Dec, 31 2014
--Meetings with Gary Wick continuing conversation on data life cycle and visualization planning.
--Presented visualization demonstration for SHOUT workshop with NOAA, CIRES and CIRA team members on 11.21.2014. Year 1 milestone 1.