CIRA ANNUAL REPORT FY 2011/2012

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. Strengthening these ties 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. As the Director of CIRA, I have put this relationship at the very top of the priority list, doing everything possible to strengthen the ties among CSU's Department of Atmospheric Science, the College of Engineering, the University and CIRA researchers. This includes a joint seminar series, shared graduate students, seed funds for joint research efforts and interactions with other Departments to lay the foundation for weather and climate science to expand into the broader human dimension. With this new emphasis, we hope not only 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 but to further help train a new work force that has a broader perspective needed for transitioning to operational stakeholders research concepts that are at the cutting edge of science.

CIRA is fortunate in that its location (proximity to a world-class Department of Atmospheric Science) and corporate culture have been able to fill its ranks 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 Department of Defense through the Center for Geosciences, the activities 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 a broad pool of subject experts with whom they can consult as they develop their own projects. As we embark on a new voyage of research and discovery with our NOAA technical partners, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship among NOAA, the Department of Atmospheric Science at CSU, other Departments of the University, and the other major programs at CIRA.

Christian D. Kummerow

TABLE OF CONTENTS

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.

COOPERATIVE INSTITUTE FOR RESEACH 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: 2011-2012

"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."

This section describes CIRA education, training and outreach activities from April 2011 through March 2012.

Evolution of CIRA E&O Program

The Education and Outreach (E&O) program at CIRA evolved during 2011 with the addition of Matt Rogers (formerly the Education and Public Outreach Lead for the NASA CloudSat mission) as a part-time E&O coordinator. Part of the restructuring brought about by this addition was the formation of the CIRA Education and Outreach Committee, consisting of the designated E&O points-of-contact for each of the programs under the umbrella of CIRA, as well as members of the CIRA Marketing and Outreach team and interested CIRA researchers. Members of the CIRA E&O Committee include John Forsythe, Teresa Jiles, Karen Milberger, Maureen Murray, Noah Newman, Laura Leinen, Janice Bytheway, Kristi Gebhart, Bernie Connell, Julie Winchester, Andrea Schumacher, and Matt Rogers, along with Mary McInnis-Efaw.

An organizational plan for education and outreach activities at CIRA was also developed along a four-tiered model. A simple breakdown of the tiers is as follows:

--Tier 1 E&O activities represent mandatory public outreach tasks such as coordinating media contacts and interviews, updating the CIRA webpage and maintaining a public presence for CIRA in social media, and fielding requests for visits, etc.

--Tier 2 E&O activities represent 'pilot programs' headed by an individual E&O Committee member, and are intended to serve as rapid prototyping projects, using funding resources from CIRA to support development, with the intent of creating a number of 'shovel-ready' projects suitable for extension through funding proposals, as conditions permit. Examples include the recent CCC Climate Page, or prototyping professional development workshops for key audiences (STEM teachers, emergency managers, etc.)

Tier 2 projects also can be tied directly to individually-funded science proposals, linking the PI of each proposal to a member of the CIRA E&O Committee. Tier 2 projects can be developed and/or used to support the education and outreach needs of scientific research proposals.

--Tier 3 E&O activities will represent an evolution in Tier 2 E&O projects that have successfully applied for standalone funding projects (for example, awarding of supplementary education funding under ROSES for NASA projects.) While budget cuts have eliminated most of the standalone funds available for E&O projects for the upcoming fiscal year, continued development of Tier 2 projects will position CIRA to be competitive in this realm should standalone science E&O funding be restored. As with Tier 2 projects, a member of the CIRA E&O Committee will serve as 'PI' for Tier 3 E&O projects.

--Finally, Tier 4 E&O activities will represent a large-scale coordinated effort by the CIRA E&O staff to leverage the unique research capabilities of CIRA in supporting a national-scale education and outreach project. Opportunities to develop such a project are underway, with plans to develop the initial component of a trial Tier 4 project beginning in Fall 2012.

Transformation of the CIRA Weather Lab – Weather Briefings and More

The CIRA Collaborative Weather Lab is undergoing continued renovation and is used for an increasingly large and diverse audience. Tropical weather forecast briefs, held during the 'official' hurricane season and hosted by CIRA research staff, have been opened up to the general public, and attendance for significant storm events often fills the room to capacity. The installation of two large plasma displays connected to the AWIPS and McIDAS workstations installed in the room greatly enhances the ability of briefers to present relevant information.

In addition to the display capabilities, the planned installation of a standalone weather station and new cloud-observing webcam system on the recently completed 'atmospheric bridge' will add observational capabilities to the weather lab. Future events, including training workshops and forecast discussions in support of field experiments, are planned to utilize the capabilities of the lab.

Interaction between CIRA and other E&O Organizations – Fort Collins

In addition to the developing organizational structure of the CIRA E&O program, CIRA began to foster more solid relationships with local E&O programs in 2011.

Little Shop of Physics

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 approximately 8000 participants.

An increasing component of the Little Shop's curriculum deals with climate education; CIRA has fostered a partnership with both the demonstration and education teams with the Little Shop to develop satellite- and climate-measuring based demonstrations and educator modules for professional development workshops. As an example, for the recent Little Shop Open House, CIRA hosted a break-out room providing hands-on demonstrations of active- and passive remote sensing platforms, the electromagnetic spectrum, and cloud formation, as well as promotional material and information about CIRA.

Figure 1. CIRA personnel staff the Little Shop Open house. Approximately 1000 visitors came by the CIRA room during the event

CIRA is also working with the Little Shop to further develop the Math, Science, and Technology Day workshop hosted annually by Colorado State University to bring science education on climate-related programs to underserved Latino and Latina communities in Colorado.

Soaring Eagle Ecology Center

The Soaring Eagle Ecology Center (SEEC) is a community-led program based in Red Feather Lakes, Colorado, designed to provide that community with education programs for both K-12 and adult audiences. CIRA has provided assistance with both the K-12 and adult programs, and CIRA E&O committee members Teresa Jiles and Matt Rogers hold positions on the SEEC Advisory Committee. Activities in 2011 include a K-12 open house co-presented by CIRA and the Little Shop of Physics, and a series of adult education programs at the Red Feather Lakes Public Library including talks by CIRA researchers Matt Rogers, Bill Malm, and Colorado State Climatologist Nolan Doesken.

Poudre School District

Collaboration with the Fort Collins-based Poudre School District (PSD) bore much fruit in 2011. CIRA researcher and E&O Committee member Kristi Gebhart is a member of the District Advisory Board Science Subcommittee, and helped foster a new relationship between CIRA and PSD in the realm of science education. Aside from offering content matter experts at CIRA for school presentations, CIRA is taking the lead in assisting the district with several weather-, climate- and renewable-energy-related programs. Among these programs are a training program for 5^{th} grade teachers to address the new Colorado 5^{th}-grade standards for weather education, and supporting a renewable energy program at Fossil Ridge High School for advanced STEM students.

CIRA Weather Club

Bernie Connell and Kristi Gebhart prepared and conducted activities for an after school weather club on Mondays at Putnam Elementary (K-5) in Fort Collins. The club ran for 18 weeks during January through May 2011 and 8 weeks during September through December 2011. There were two back to back sessions each week of 45 minutes in duration for January through May 2011, while there was only one 90 minute session each week during the September through December session. Sessions covered snow, wind (speed and direction), clouds, temperature, and things that spin as well as measurements that are associated with these weather occurrences. Putnam is one of a group of 3 schools that received a 21^{st} century grant for activities to support enrichment. They chose after school clubs as one of the activities. They have a coordinator who is responsible for the logistics of students and transportation – which is great!

A talk about this effort was given at the 21st Symposium on Education at the AMS 92nd Annual Meeting in New Orleans, LA, 22-26 January 2012. The talk was in the session on K-12 and informal education and the title of the talk "Golden Words from Elementary Kids: Can I show you my observation!" reflected comments and excitement of the kids.

Figure 2. An enthusiastic student making wet and dry bulb temperature measurements during the weather club.

Finally, Jeff Braun (CIRA RAMM Branch) visited Rocky Mountain High School in Fort Collins on two separate occasions to present his “Talk about the weather”. This talk was presented to students in the Introduction to Chemistry, Physics, and Earth Sciences (ICPE) classes.

Science on a Sphere™

CIRA researchers provide technical support for SOS installation at any additional new sites that may arise. SOS™ was installed at the following sites this past year:

- Climate Institute, Acapulco, Mexico
- Aquarium of the Pacific, Long Beach, CA
- Detroit Zoological Society, Royal Oak, MI
- Beijing Huaxinchuanzi Technology Co. Ltd., Beijing, PRC
- KIGAM Geological Museum, Daejeon, Republic of Korea
- Our Planet Centre, Castries, St. Lucia
- Nurture Nature Center, Easton, PA
- Visual Climate Center, Holeby, Denmark
- Climate Institute, Texcoco, Mexico
- Climate Institute, Valle de Bravo, Mexico
- Climate Institute, Villahermosa, Mexico
- Museum of Natural History, Halifax, Nova Scotia, Canada
- Aldo Leopold Nature Center, Monona, WI
- Climate Institute, Chetumal, Mexico
- Grand Canyon Visitor Center, Grand Canyon, AZ
- China Maritime Museum, Shanghai, PRC
- St. Paul's School, Concord, NH
- Science Centre Singapore, Singapore
- Science City at Union Station, Kansas City, MO
- Climate Institute, Oaxaca, Mexico

CIRA provides technical guidance for a demonstration capability of several new features in SOS: layering, annotation, zooming, and streaming video. CIRA redesigned the core SOS display capability into an object-oriented class hierarchy as a preliminary step in implementing the new features. The initial versions of annotation, layering, and zooming were then developed as envisioned. Video streaming has proven more difficult than expected and has been deferred.

CIRA developed the initial beta version of a new SOS user interface on the iPad, iPhone and iPod Touch, to be made freely available on the Apple App Store.The user interface was further refined by other SOS team members and made available on the Apple App Store this year as the *SOS Remote* app.

Advanced High Performance Computing-ACEs

CIRA researchers serve on the GSD Program Review committee, the DTC science advisory board (SAB), and the NEIS program committee. CIRA researchers gave talks at NCAR workshops and tutorials on WRF Domain Wizard and WRF Portal. They also gave talks about GPU-related work at the NCAR Software Engineering Assembly (SEA) conference SAAHPC2011, HPC & GPU Supercomputing Group of Denver/Boulder, and the "Programming weather, climate, and earth-system models on heterogeneous multi-core platforms" symposium at NCAR.

Advanced Linux Prototype (technology transfer) ISB

The ALPS (Advanced Linux Prototype System) will continue to be the primary research system until the AWIPS II system is available. Recent addition to the ALPS system includes the display and interaction with ensemble forecast models and vertical displays of radar and model data along a non-linear path. The ALPS system was installed in Norman, OK for the Convective Initiation experiment last year. The project staff also provided the maintenance support and the system training. The CWB (Central Weather Bureau) in Taiwan expressed an interest in using the ALPS system for their operational forecast system. The ALPS project staff trained CWB staff at GSD to maintain the software and delivered the ALPS software and some test data to CWB. A trip was made to CWB to help with the initial installation and familiarize other CWB staff with the unique system features.

Citizen Weather Observer Program (CWOP)

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 over 8,000 registered CWOP members worldwide. CWOP members send their weather data by internet alone or internet-wireless combination to the findU (http://www.findu.com) server and then every five minutes, the data are sent from the findU server to the NOAA MADIS server. The data undergo quality checking and then are distributed to users. There are over 500 different user organizations of the CWOP mesonet data.

In 2011, database revisions were performed daily based upon member input. Updates included registering 2,767 new sites in the database using site location (latitude, longitude and elevation) information provided by the users and confirming 1,594 site position changes using web tools. Interactions occurred with users via email regarding setup and data transmission issues and problems resolved and questions answered on site setup, 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.

TerraViz

CIRA researchers have 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 Earth Information Services (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.

NWS Innovation Portal

Ken Sperow co-lead the Innovation Web Portal (IWP) team and independently recommended, prototyped, set up, and customized the IWP first on his laptop and then within MDL’s web infrastructure and is starting to migrate it to the NWS Internet Dissemination System (NIDS). It is envisioned that the IWP will provide NWS employees a web-enabled virtual location to collaborate and innovate. The IWP is using LifeRay’s open source java portal framework. The project passed through OSIP gate 3a this year. In support of this task, Ken attended LifeRay administrator and developer training and applied this knowledge in the creation of a NWS theme and developed a new “innovation” portlet that ties into the NWS’s 10-102 process

Ken is leading the OST Virtual Lab Working group which will be responsible for proposing and testing technical solutions in support of the Virtual Lab.

CIRA Meteorological Interpretation Blog

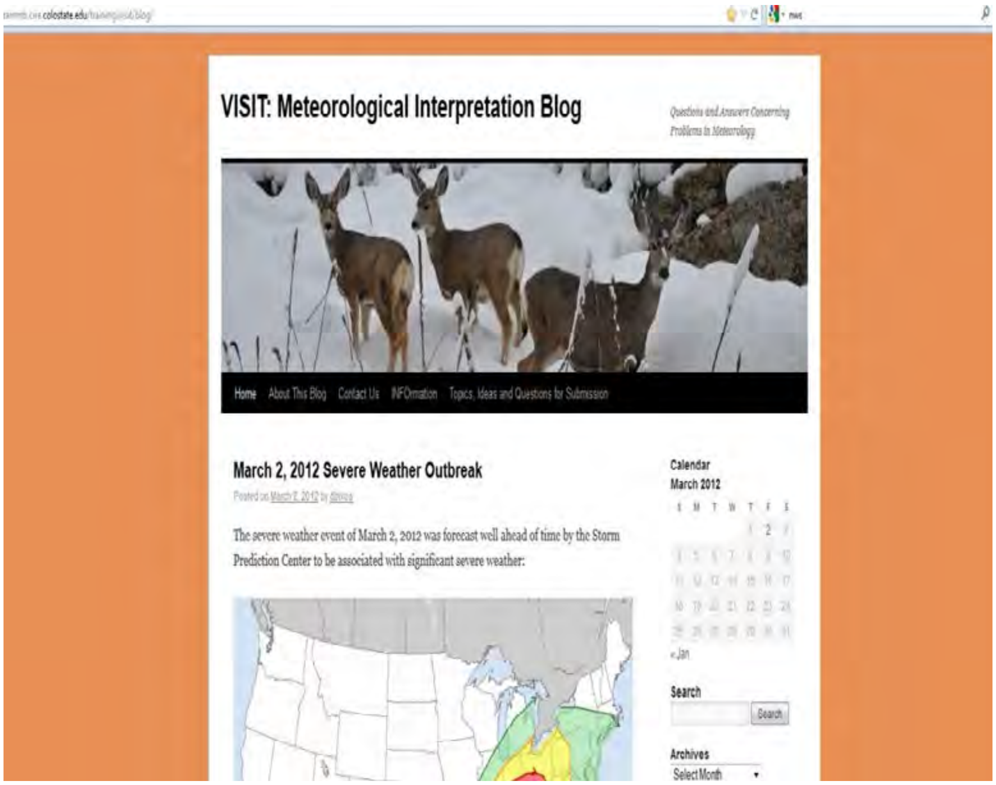


Figure 3. The CIRA Meteorological Interpretation Blog homepage

The CIRA Virtual Institute for Satellite Integration Training (VISIT) and Satellite Hydrology and Meteorology (SHyMet) programs, under the direction of Regional and Mesoscale Meteorology Branch (RAMMB) of NOAA/NESDIS, have a blog with a variety of educational topics. The blog is intended to open the doors of communication between the Operational, Academic and Training Meteorology communities. The blog is a valuable addition to CIRA's education and outreach mission. The VISIT blog has a feature section on the GOES-R proving ground, online at:

http://rammb.cira.colostate.edu/training/visit/blog/index.php/category/goes-r-proving-ground.

Synthetic imagery is produced at CIRA, derived from the NSSL 4-km WRF-ARW model. This imagery is at 4-km resolution and at the same wavelength as GOES-R will have, therefore it is part of the GOES-R proving ground products available in real-time from CIRA.

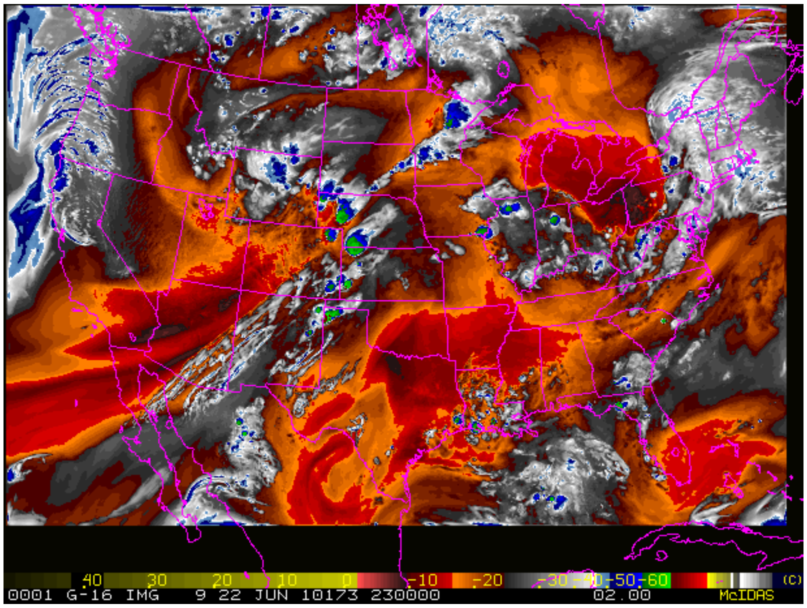


Figure 4. Synthetic water vapor imagery from the NSSL 4-km WRF-ARW model, severe weather occurred over the central US on this day, June 22, 2010.

The VISIT blog is online at http://rammb.cira.colostate.edu/training/visit/blog/.

Award-Winning CloudSat Data Processing Center Continues to Host Visitors

The CloudSat Data Processing Center (DPC) at CIRA continues to host visiting groups occasionally, at a rate of roughly three tours per month. Most of the visitors are scientists visiting CIRA or the CSU Atmospheric Science Department for related work, but non-scientist members of the public also occasionally visit. The NASA CloudSat mission will begin its seventh year of measuring Earth's clouds in 2012. All of the science data products are created and distributed through the DPC, to users worldwide.

Additionally, the DPC maintains a help desk to assist data users, averaging around 12 requests per month, as well as a CloudSat blog for users to see developments in the CloudSat mission. The DPC website is online at: http://cloudsat.cira.colostate.edu.

Satellite Hydrology and Meteorology Training (SHyMet)

SHyMet is essentially a spin-off of the VISIT program and uses aspects of the VISIT program for development and delivery of training. One of the more prominent distinctions between the two programs is 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. If a particular aspect of the topic is not represented in training materials, SHyMet will develop a module for it.

As part of the SHyMet for Forecasters course, the Volcanic Ash Hazards (Part 2) was developed in 2011.

In March 2011, SHyMet launched a course titled “SHyMet: Severe Thunderstorm Forecasting”. The Severe Thunderstorm Forecasting track of the Satellite Hydrology and Meteorology (SHyMet) Course covers how to integrate satellite imagery interpretation with other datasets in analyzing severe thunderstorm events. This course is administered through web-based instruction and consists of 7 modules (8.5 hours) of core topics and 4 modules (2.5 hours) of optional topics.

Core Courses include:
--Mesoscale Analysis of Convective Weather Using GOES RSO Imagery
--Use of GOES RSO imagery with other Remote Sensor Data for Diagnosing Severe Weather across the CONUS (RSO 3)
--GOES Imagery for Forecasting and Nowcasting Severe Weather
--Water Vapor Imagery Analysis for Severe Weather Forecasting
--Synthetic Imagery in Forecasting Severe Weather
--Predicting Supercell Motion in Operations
--Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection

Optional courses include:
--Monitoring Gulf Moisture Return
--The UW Convective Initiation Product
--Coastal Severe Convective Weather
--Topographically induced Convergence Zones and Severe Convective Weather

The first in the SHyMet courses was directed towards the NWS Intern and was released in 2006. The SHyMet for Interns continues to be offered. More information is online at:

http://rammb.cira.colostate.edu/training/shymet/intern_intro.asp

The Intern track of the Satellite Hydrology and Meteorology (SHyMet) Course covers Geostationary and Polar orbiting satellite basics (aerial coverage and image frequency), identification of atmospheric and surface phenomena, and provides examples of the integration of meteorological techniques with satellite observing capabilities. This course is administered through web-based instruction and is the equivalent of 16 hours of training.

Virtual Institute for Satellite Integration Training (VISIT)

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 (Figure 2) 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 a recorded audio / video format that plays within a web-browser and can be taken at any time. CIRA scientists Dan Bikos, Jeff Braun, Bernie Connell, Dan Lindsey, John Knaff and Mark DeMaria contribute to VISIT training. Virtually all of the training is administered through the DOC/NOAA/NWS Learning Management System (LMS), online at Learn.com.

Figure 5. VISIT allows trainers and forecasters to interact in virtual teletraining and forecasters can also use recorded training to fit their dynamic schedules.

From April 1, 2011 through February 17, 2012, VISIT delivered 33 sessions of live teletraining to 205 participants. An additional 521 participants took the recorded web-based version of various training sessions. Since 1999, over 19,000 training certificates of completion have been awarded through VISIT.

RAMMB Presentations:

* B. Connell attended the *9th International Conference on Creating Activities for Learning Meteorology, Pretoria, South Africa*, 3-8 October.

* B. Connell attended the *21st Symposium on Education and the 8th Annual Symposium on Future Operational Environmental Satellite Systems*, New Orleans, LA, 22-26 January, Amer. Meteor. Soc.

* B. Connell attended the *2011 Satellite Direct Readout Conference*, Miami, FL. 4-8 April.

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

CIRA collaborates with the World Meteorological (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 satellite imagery, and share information on global, regional, and local 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. http://rammb.cira.colostate.edu/training/rmtc/focusgroup.asp

See http://rammb.cira.colostate.edu/training/rmtc/ for more information on various RTC activities and the calendar of events.

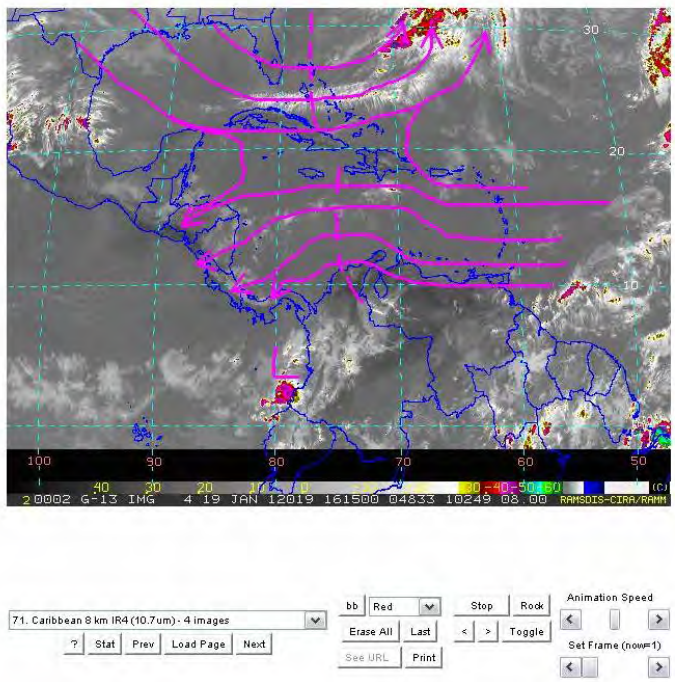


Figure 6. Screen capture during the January 2012 session showing infrared 10.7 µm over the Caribbean with annotation depicting stagnant weather conditions over the North Central Caribbean.

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 thousands of volunteers in all 50 States, with nearly 10,000 reports submitted daily. One key to the projects' success is that the data are used by the public as well as professionals including scientists and meteorologists at the National Weather Service.

Building on funding from NSF and NOAA, CoCoRaHS is working to improve the overall infrastructure of the database, allowing for future growth as well as improved mapping, graphing and data visualization capabilities. Promoting climate literacy to both formal and non-formal audiences will be achieved through many of the proposed deliverables. Volunteers learn by collecting, viewing and analyzing their own data.

In turn, they can then start to grasp the variability associated with this critical part of the water cycle, building on each day's weather to gradually create a better view of the climate. The addition of the measurement of Reference Evapotranspiration (ET) is being piloted and will hopefully provide for a better understanding of the 'invisible' part of the water cycle.

Furthermore, CoCoRaHS is implementing new and improved training materials, including animation based videos. CoCoRaHS is now hosting training webinars for both volunteers and coordinators. In an effort to promote and facilitate weather and climate literacy, CoCoRaHS is also hosting topical-based Webinars to our volunteers such as 'Identifying Clouds', 'Flash Floods' and 'Lightning'. Efforts also include participating on social media sites such as Facebook, Twitter and YouTube. Finally, a goal to expand the network and promote citizen science in the classroom is being done with a K-12 "CoCoRaHS for Schools" being piloted in Colorado. Thanks to a continuing collaboration with CIRA and the local Poudre School District television studio, the 'Walking Through the Water Year' series now consists of monthly reports from schools participating with CoCoRaHS. Each school that has a rain gauge and reports to CoCoRaHS has the opportunity to select two students to work with professionals in producing their monthly precipitation report. Episodes are aired on local TV and available on line (http://epresence.psdschools.org/4/watch/986.aspx)

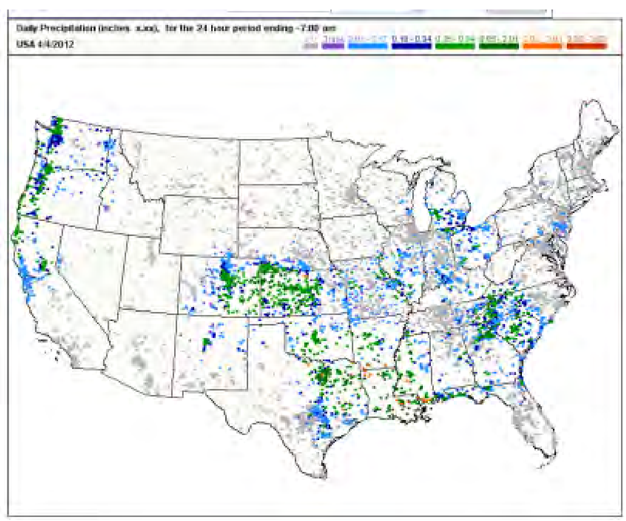


Figure 7. Nearly 10,000 reports per day are submitted to CoCoRaHs

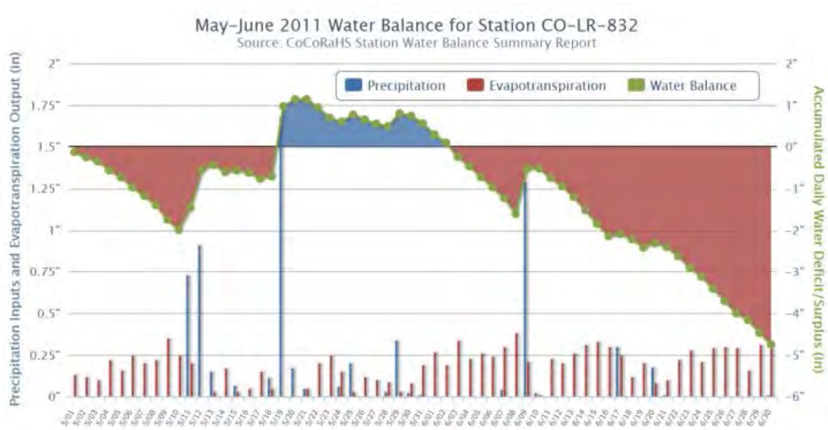


Figure 8. Evapotranspiration plots produced by CoCoRaHS help develop a better understanding of the water cycle

Figure 9. Continued training and education activities to a growing number of schools in the ‘Walking through the Water Year’ program.

National Park Service Night Skies Program Measures, Trains and Educates

The National Park Service Night Skies Program moved to CIRA in 2008. In 2011, they became part of the NPS Natural Resource Stewardship & Science, Natural Sounds and Night skies Division. The program researches and measures the night sky quality in national parks (Figure XX), 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 10. 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. We are always searching for better and unique ways to reach more audiences.

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.

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 11. 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 12. Interactive air quality exhibits

This interactive exhibit will be 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 13. 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.

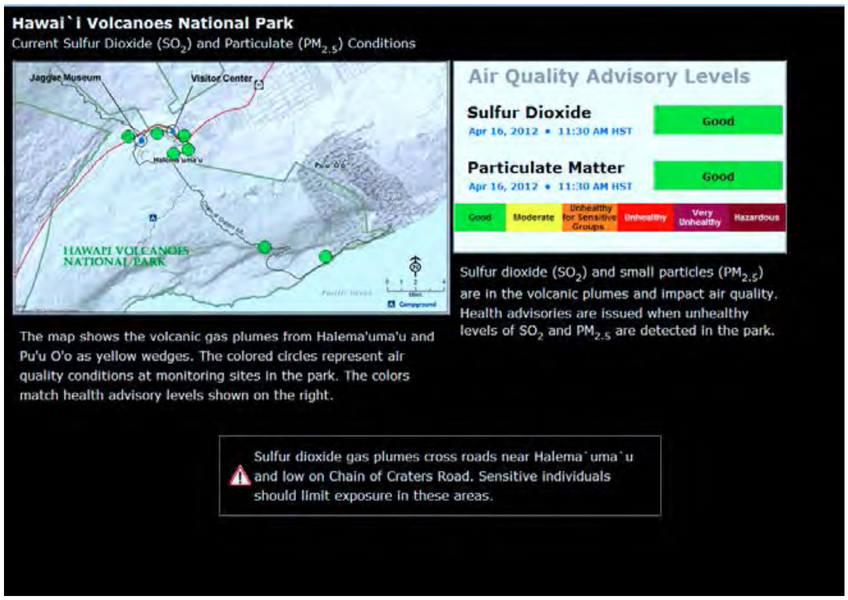


Figure 14. Air quality monitor display for Hawai'i Volcanoes National Park

Outreach Supporting Field Operations of the National Research and Monitoring Effort, IMPROVE National Air Quality Program

The IMPROVE calendar continues to be a successful outreach tool used to summarize current research efforts, present recent data summaries, identify network problems, and update the current status of regulatory programs. Distribution is 1000 calendars annually to field operators, federal, state, and local air quality managers, and researchers, and 2012 marks the 10th year of production.

Current and past calendars are available online at:

http://vista.cira.colostate.edu/IMPROVE/Education/education.htm

Figure 15. IMPROVE Calendar for 2012

Summary

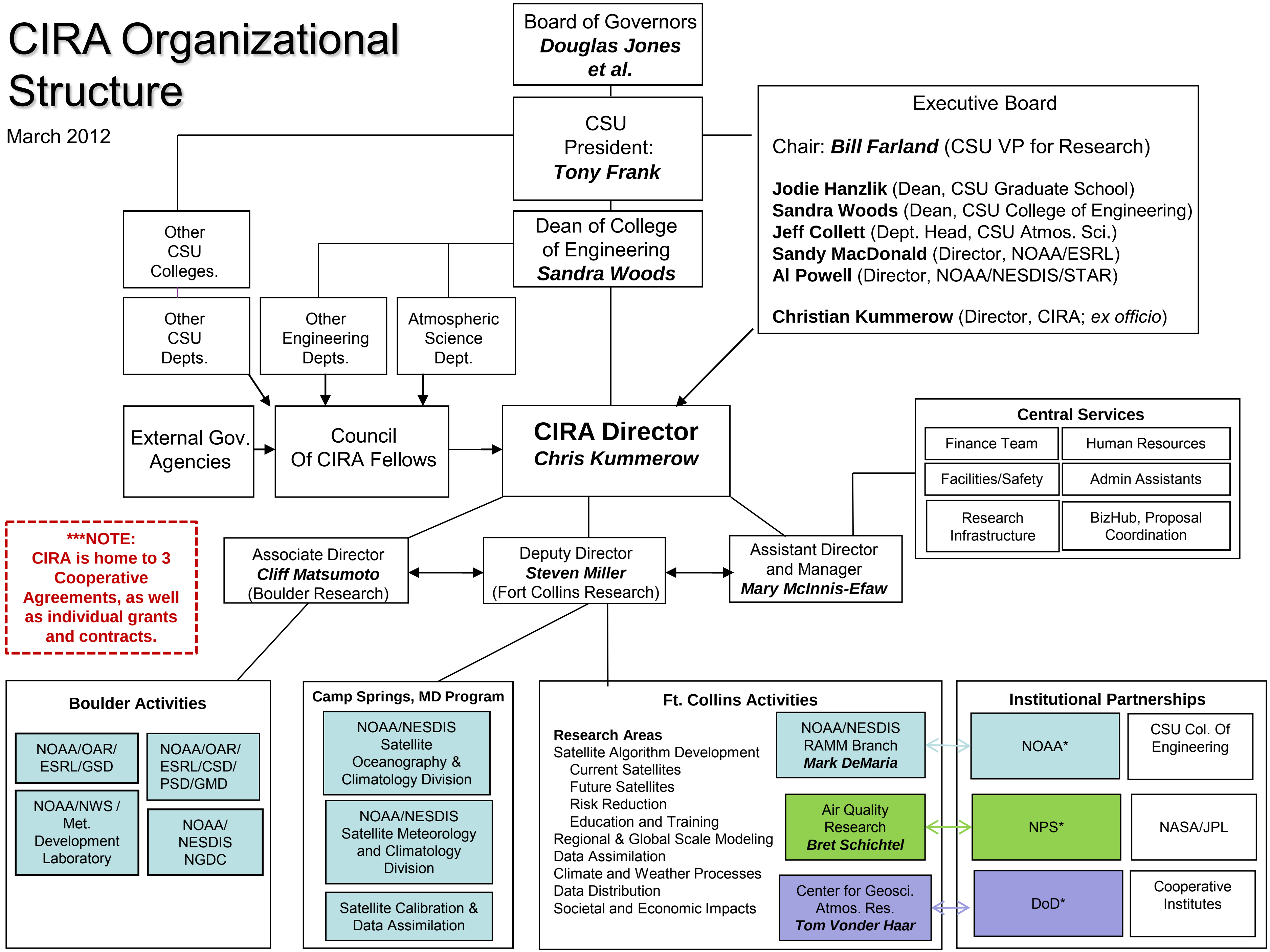
Continued development of the projects listed above, along with coordination of projects by the CIRA E&O Committee should prove to greatly enhance the ability of CIRA to conduct education and outreach activities in 2012. As science and science education becomes increasingly important in our world, positioning CIRA to be a leader in meaningful, relevant, and timely science education will benefit both NOAA and the community at large.

NOAA AWARD NUMBERS

Award Number	Identifier	Project Title	Principal Investigators/ Project Directors
NA10SEC0080012	Competitive	CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful Citizen Science Network	Chris Kummerow (Lead), Nolan Doesken
NA10OAR4310103	Competitive	Quantifying the Sources of Atmospheric Ice Nuclei from Biomass Burning Aerosols	Chris Kummerow
NA10NES4400012	Competitive	Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting	Chris Kummerow
NA08OAR4320893	Shadow Award	The Cooperative Institute for Research in the Atmosphere	Chris Kummerow (Lead), Steven Miller
NA09OAR4320074	New Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Chris Kummerow (Lead), Steven Miller
NA11OAR4310208	Competitive	Development of a Probabilistic Tropical Cyclone Prediction Scheme	Chris Kummerow
NA11OAR4310203	Competitive	Improvements in Statistical Tropical Cyclone Forecast Models	Chris Kummerow
NA11OAR4310204	Competitive	Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis	Chris Kummerow

CIRA Organizational Structure

March 2012



CIRA BOARD, COUNCIL, FELLOWS & BOARD MEETINGS

CIRA EXECUTIVE BOARD

Bill Farland, Colorado State University
Vice President for Research
Jodie Hanzlik, Colorado State University
Dean, Graduate School
Jeff Collett, Colorado State University
Department Head, Atmospheric Science
Christian Kummerow (ex officio), Colorado State University
Director, CIRA and Professor of Atmospheric Science
A.E. "Sandy" MacDonald, NOAA
Deputy Assistant Administrator for Labs/Cooperative Institutes
And Director, ESRL
Al Powell, NOAA
Director NOAA/NESDIS/STAR
Sandra Woods, Colorado State University
Dean, Engineering

CIRA COUNCIL OF FELLOWS

V. Chandrasekar, Colorado State University
Department of Electrical and Computer Engineering
Mark DeMaria, Colorado State University
Chief, NOAA RAMM Branch
Ingrid Guch, NOAA
Chief, NOAA/NESDIS/CoRP
Sonia Kreidenweis-Dandy, Colorado State University
Department of Atmospheric Science
Christian Kummerow, Colorado State University
Director, CIRA and Professor of Atmospheric Science
Marty Ralph,
Branch Chief, PSD Water Cycle Branch, NOAA/ESRL
John Schneider, NOAA
Acting Director, Global Systems Division/ESRL
Pieter Tans,
Senior Scientist, NOAA/Climate Monitoring and Diagnostics Lab
Fuzhong Weng,
Chief, NOAA/NESDIS/STAR/Satellite Calibration and Data Assimilation Branch

CIRA FELLOWS

Mahmood R. Azimi-Sadjadi, Electrical & Computer Engineering, CSU
Daniel Birkenheuer, NOAA/ESRL/GSD
V. Chandrasekar, Electrical & Computer Engineering, CSU
Jeffrey L. Collett, Jr., Atmospheric Science Department, CSU
William R. Cotton, Atmospheric Science Department, CSU
Mark DeMaria, NOAA/NESDIS/RAMMB
Scott Denning, Atmospheric Science Department, CSU
Graham Feingold, NOAA/ESRL
Douglas Fox, Senior Research Scientist Emeritus, CIRA, CSU, USDA (Retired)

Ingrid Guch, NESDIS Cooperative Research Program
Jay Ham, Soil and Crop Sciences, CSU
Richard H. Johnson, Atmospheric Science Department, CSU
Andrew Jones, Senior Research Scientist, CIRA, CSU
Pierre Y. Julien, Civil Engineering, CSU
Stanley Q. Kidder, Senior Research Scientist, CIRA, CSU
Sonia Kreidenweis, Atmospheric Science Department, CSU
Christian Kummerow, CIRA Director, Atmospheric Science Department, CSU
Glen Liston, Senior Research Scientist, CIRA, CSU
Alexander E. "Sandy" MacDonald, NOAA
Williams Malm, Senior Research Scientist, CIRA; National Park Service (retired)
Denis O'Brien, Senior Research Scientist, CIRA
Roger A. Pielke, Sr., Senior Research Scientist, CIRES, U of Colorado
James F.W. Purdom, Senior Research Scientist, CIRA, CSU
Robert Rabin, NOAA/National Severe Storms Laboratory
Marty Ralph, NOAA/ESRL
Steven A. Rutledge, Atmospheric Science Department, CSU
John Schneider, NOAA/ESRL
George Smith, Riverside Technology, Inc.
Graeme L. Stephens, JPL and Atmospheric Science Department, CSU
Pieter Tans, NOAA/CMDL
Thomas H. Vonder Haar, CIRA Director Emeritus and Atmospheric Science Department, CSU
Fuzhong, Weng, NOAA/NESDIS/STAR
Milija Zupanski, Senior Research Scientist, CIRA

Meeting of the CIRA Fellows May 11, 2011
Meeting of the CIRA Executive Board May 27, 2011

Scheduled Meetings:
Meeting of the CIRA Fellows June 15, 2012
Meeting of the CIRA Executive Board July 25, 2012

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 investigating satellite applications bearing relevance to 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. 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.

- The NOAA/NESDIS Regional and Mesoscale Meteorology Branch (RAMMB) at CIRA continued its many Geostationary Operational Environmental Satellite (GOES) research activities which consider both current and future members of this constellation. RAMMB co-led the GOES-14 Science Test to prepare this new system for operational support. New products are being developed for the next generation GOES systems (starting with GOES-R) with emphasis on severe weather and tropical cyclone forecasting. Some of these products are being demonstrated in real time for the National Weather Service (NWS) using proxy data generated from model simulations or research-grade satellite sensors. RAMMB also began new research to improve tropical cyclone forecasts as part of the NOAA Hurricane Forecast Improvement Project (HFIP) and continues to develop new applications for the National Hurricane Center (NHC) through participation in the Joint Hurricane Testbed (JHT). Two members of RAMMB (Drs. Mark DeMaria and John Knaff) were awarded the 2011 NOAA Bronze Medal for providing skillful operational hurricane intensity models as demonstrated by the NHC forecast verifications for the 2009 and 2010 seasons.

- CIRA participates actively in the GOES-R Risk Reduction activities as well as the GOES-R Satellite Proving Ground Project. The risk reduction activities cover such areas improved understanding of Tropical Cyclone Structures and Structure Changes, a blended multi-platform Tropical Cyclone Rapid Intensification Index, improved precipitation data and convective storm forecasting on the 1-6 hour horizon along with the necessary visualization and training tools to reach the forecaster of the future. The GOES-R Satellite Proving Ground is providing a new way to interface with operational end-users of satellite applications. The Proving Ground establishes a direct connection to the Advanced Weather Information Processing System (AWIPS) data display systems used in NWS Weather Forecast Offices (WFOs), and a potential conduit to all WFOs. Among the products currently being demonstrated, is a new Orographic Rain Index (ORI) tool which couples satellite-retrieved total precipitable water (TPW) information with model-predicted wind fields and high-resolution surface topography for the purpose of highlighting regions where the terrain may enhance precipitation and increase the risk of flash flooding. ORI has been used by the Hydrometeorological Prediction Center (HPC) to monitor land-falling Pacific storms along the U.S. West Coast this past fall and winter and was highlighted in several weather discussions issued to the Western Region.

- 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 continued at an exceptionally high level this past year. CIRA researchers 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), the NWS NextGen, and the Network-Enabled Verification Service (NEVS) aviation weather programs; meteorological workstation development, including the AWIPS II Data Delivery project, FX-NET Thin Client and data compression, MADIS, and GTAS; high performance computing; 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.

- As part of the NWS NextGen Program, CIRA researchers 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 prototypes, demonstrations and capability evaluations (CE's) – including the transition of technology, as required, to web-enable NOAA data providers.

- CIRA researchers have 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 Earth Information Services (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.

- Under education and outreach, the initial version of a new SOS user interface on the iPad, iPhone and iPod Touch was developed and made freely available on the Apple App Store as the *SOS Remote* app. SOS was installed at 20 new sites this past year, including Shanghai and Beijing in China, Singapore, Denmark, St. Lucia, Nova Scotia, and six locations in Mexico.

- Vital collaborations involving the other ESRL divisions continued with collaborations on atmospheric rivers and their impacts on coastal orographic precipitation enhancement (with PSD) and carbon assimilation and OSSE research (with GMD). Research collaborations with NESDIS/NGDC and the Space Weather Prediction Center on the USAF Defense Weather Satellite System's Space Environment Monitor (SEM) sensor algorithm development came to a close as a result of the breakup of the NPOESS program.

- The on-going partnership with the NWS Meteorological Development Lab continued as well with the operations and maintenance of the AutoNowcast (ANC) Project on convective nowcasting for Dallas-Ft. Worth and Melbourne, FL now transferred to a contractor. Delivery of ANC forecasts from MDL computers to Chicago was started along with the setup of ANC over a large regional domain covering the eastern half of the country. CIRA took the lead in prototyping, setting up, and customizing the NWS Innovation Web Portal (IWP) using LifeRay's open source java portal framework and is starting to migrate it to the NWS Internet Dissemination System (NIDS). It is envisioned that the IWP will provide NWS employees a web-enabled virtual location to collaborate and innovate.

- Over the past year the CIRA group working with the National Parks Service (NPS) continued its research on air quality issues in national parks. One study related to quantifying the source of atmospheric ice nuclei from biomass burning aerosols in particular highlights the leveraging abilities of CIRA. This study was made possible largely by airborne measurements supported by ongoing activities from non-NOAA measurements that provided special sampling opportunities confirming the production of ice nuclei during burning of sage-dominated biomass in Wyoming and the Sierras.

- 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 was the early work on Suomi-NPP. This satellite serves the dual purposes of providing continuity to NASA's EOS climate mission (Terra and Aqua) while also providing risk reduction and operational gap-filling to NOAA's future Joint Polar Satellite System. CIRA scientists are actively involved in many aspects of NPP including calibration, validation, and application development. Because of CIRA's involvement with CloudSat, a group of NOAA and CIRA scientists was able 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.

- The NASA Orbiting Carbon Observatory (OCO) mission, after having been remanifested by NASA after the catastrophic failure of 2009, is on target launch as early 2013. CIRA will continue to operate as a major contributor to this important and exciting mission that is designed to measure atmospheric CO2 and track its sources and sinks, and in the process presenting new avenues for collaboration with NOAA CarbonTracker activities at ESRL. In particular, a very robust interaction has occurred between the GMD Carbon Tracker activity and both the OCO Algorithm Development as well as the Carbon Modeling activity at Colorado State University that is facilitated by CIRA.

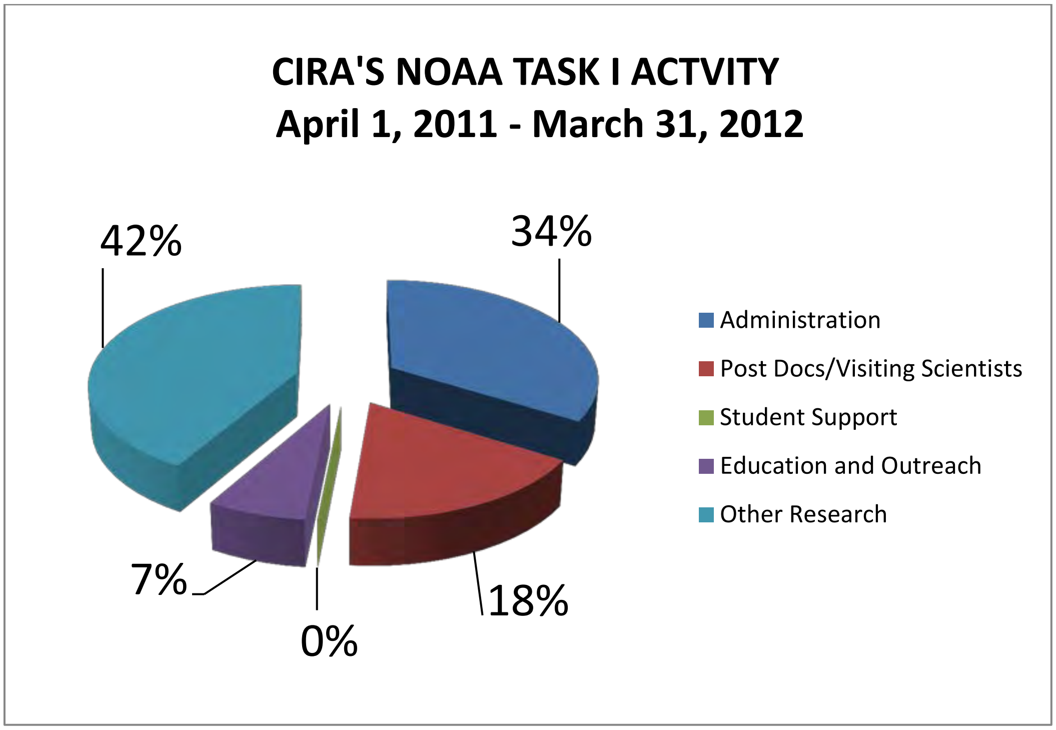
This Annual Report is broken into several chapters which represent the NOAA-defined themes of CIRA's Cooperative Institute. In our *Satellite Algorithm Development, Training and Education* theme, we describe ongoing efforts in developing applications for the current constellation of GOES sensors as well as risk-reduction for the future GOES-R satellite program, work 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. While we have recently begun adding NPP and JPSS activities, these are not yet reported in this year's accomplishments as the work has just begun. Our *Regional to Global-Scale Modeling Systems* theme focuses primarily upon 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. While other models have also been developed and highlighted in this section, noteworthy this year has been the work on the Fire Weather Modeling and Research that is likely to receive significant attention as we move into extremely dry conditions in the Mountain West.

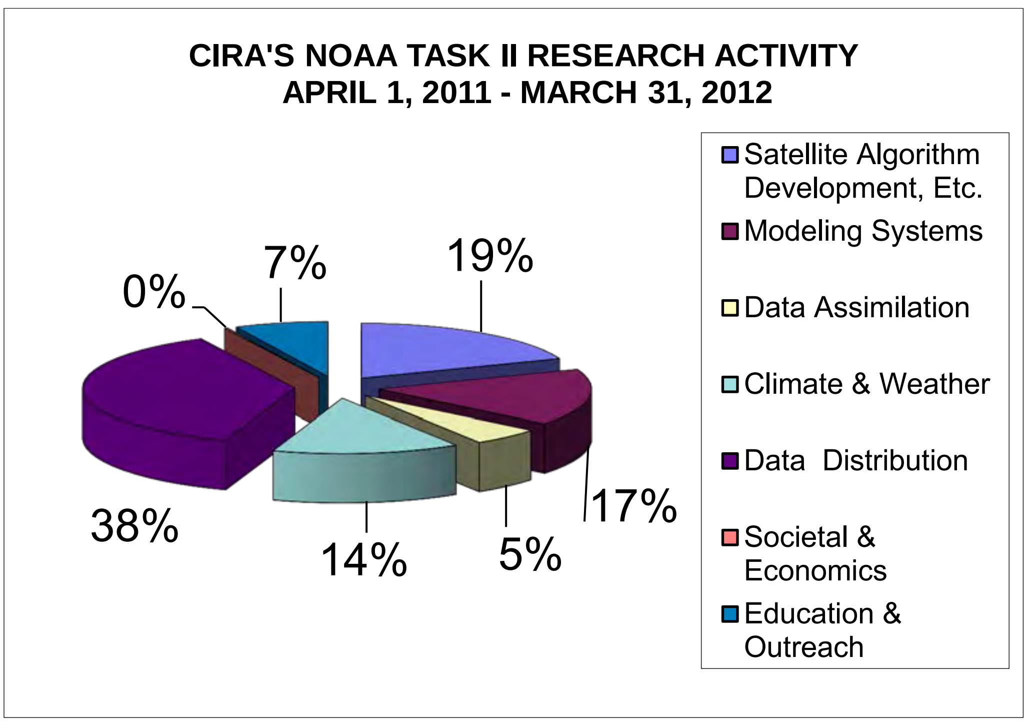
Our *Data Assimilation* theme showcases developments of Ensemble Data Assimilation for Hurricane Forecasting as well as specific applications of these techniques with GOES data. It features CO2 data assimilation within NOAA's CarbonTracker program already discussed in connection with NASA's OCO mission. It uses Ensemble Kalman Filter (EnKF) techniques coupled to Gridpoint Statistical Interpolation (GSI) implemented into the WRF-Chem model for the assimilation of ozone and particulate matter. It also features work that has just recently begun dealing with specifying error covariances for highly non Gaussian parameters such as clouds and precipitation needed to successfully assimilate these parameters. Here too, personnel and knowledge is being leveraged between work done for NOAA and work done for the Naval Research Laboratory in Monterey, CA.

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. In addition to these major themes, CIRA engages in multiple education and outreach activities and strives to link weather, water, and climate research to societal impacts.

Interspersed among these major research themes are important contributions in data distribution, assimilation, and satellite algorithm development from CIRA's NESDIS Environmental Applications Team (NEAT). Located in Camp Springs, 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. We are extremely proud of this program and its direct positive impacts to NOAA research needs.

This Annual Report is the third in a series to be completed under CIRA's Cooperative Agreement established with NOAA. As we embark on a new voyage of research and discovery with our NOAA technical partners, we reestablish our commitment to the maintenance and growth of a strong collaborative relationship between NOAA, the Atmospheric Science Department at CSU, other Departments of the University, and the other major programs at CIRA, as well as pursuing new directions of growth within our NOAA research themes. We hope that you find the contents of this report both enlightening and stimulating, and we look forward to the challenges ahead.


CIRA'S NOAA TASK I ACTVITY
April 1, 2011 - March 31, 2012
42%
34%
7%
0%
18%
Administration
Post Docs/Visiting Scientists
Student Support
Education and Outreach
Other Research


CIRA'S NOAA TASK II RESEARCH ACTIVITY
APRIL 1, 2011 - MARCH 31, 2012
0%
7%
19%
38%
14%
5%
17%
Satellite Algorithm Development, Etc.
Modeling Systems
Data Assimilation
Climate & Weather
Data Distribution
Societal & Economics
Education & Outreach

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 6, 2011, D. Thompson (CSU ATS). Understanding the Atmospheric Circulation Response to Anthropogenic Climate Change.

April 7, 2011, K. Straub (Susquehanna Univ.). MJO Initiation.

April 20, 2011, D. Jones (CSU ATS). Statistical Mechanics of Geophysical Flows.

April 21, 2011, P. Markowski (Penn State). How to Make a Tornado.

April 26, 2011, P. Forster (Univ. of Leeds, UK). The Use of Radiative Transfer in Climate Change Research and Teaching.

April 28, 2011, C. O'Dell (CSU CIRA). Probing the Earth's Carbon Cycle Through Space-Based Measurements of Atmospheric CO2.

May 4, 2011, B. Gray (CSU ATS). The Questionable Dynamics Basis of the AGW Hypothesis.

May 9, 2011, J. Abbatt (Univ. of Toronto). Studies of Oxidative Aging and CNN Properties of Organic Aerosol.

May 18, 2011, J. Dostalek (CSU CIRA). The Derivation of a Global Omega Equation.

June 1, 2011, Y. Takano (CSU ATS). Some Recent Topics from Mid-Latitude Ocean-Atmosphere Interaction.

June 29, 2011, P. Corbyn (UK). What Drives Weather and Climate and Triggers Earthquakes and Volcanoes?

July 29, 2011, W. Shi (NOAA/NESDIS/STAR/CIRA). SWIR-Based Satellite Ocean Color Remote Sensing: Algorithms and Applications.

August 4, 2011, T. Chubb (Monash Univ.). Can Precipitation Suppression due to Anthropogenic Aerosol Pollution be Detected using Back Trajectories?

August 25, 2011, T. Lane (Univ. of Melbourne). The Generation of Turbulence around Thunderstorms.

August 31, 2011, W. Han (CU). Tropical Variability Discussion Group.

September 1, 2011, G. Magnusdottir (UC Irvine). East Pacific ITCZ Variability over Three Decades of Satellite Data.

September 8, 2011, M. Assuno F. Silvia Dias (Univ. de Sao Paulo, Brazil). Surface and Aerosol Effects on Rainfall: Amazon Basin and the Megacity of Sao Paulo, Brazil.

September 13, 2011, P. Dash (NOAA/NESDIS/STAR/CIRA). The SST Quality Monitor (SQUAM).

September 15, 2011, J. Stark, P. Wolyn, N. Rydell and S. Apfel (NWS). National Weather Service Field Operations: Accomplishments, Challenges and Opportunities.

September 26, 2011, A. Robinson (Carnegie Mellon Univ.). Measurement and Simulation of Fine Particle Emissions from Combustion Systems.

September 29, 2011, A. Robock (Rutgers Univ.). Climatic Consequences of Nuclear Conflict: Nuclear Winter Still a Threat.

October 6, 2011, P. O'Gorman (MIT). Response of Precipitation to Climate Change: Theory, Simulations and Observations.

October 13, 2011, D. O'Brien (CSU/CIRA). Tiger by the Tail: Observing the Carbon Budget of Planet Earth.

October 19, 2011, L. Silvers (CSU ATS). Topographically Bound Balanced Motions.

October 20, 2011, G. Tripoli (Univ. of Wisconsin - Madison). Tropical Cyclones and their Role in Energy Transfer between the Tropics and Extra-Tropics.

November 3, 2011, D. Farmer (CSU Chemistry). The Ups and Downs of Being an Atmospheric Aerosol: Interpreting Particle Flux Measurements over Tropical and Temperate Forests.

November 9, 2011, J. Balog (Photographer). A Year in the Life of the Extreme Ice Survey and New Directions for the Future.

November 17, 2011, J. Pierce (Dalhousie Univ.). Cosmic Rays, Aerosols, Clouds and Other Adventures in Aerosol Microphysics.

November 21, 2011, X. Liang (NOAA/NESDIS/STAR/CIRA). Monitoring of IR Clear-Sky Radiances over Oceans for SST (MICROS) Readiness for NPP/VIIRS.

December 1, 2011, P. Flatau (Scripps). Observations of High Resolution Liquid Water Structure and Mid-Level Cloud Microphysics from an Advanced Pulsed Doppler Radar.

December 2, 2011, C. Siewert (Univ. of Oklahoma). The GOES-R Proving Ground at NOAA's Storm Prediction Center and Hazardous Weather Testbed.

December 6, 2011, J. Otkin (Univ. of Wisconsin – Madison, CIMSS). GOES-R ABI Proxy Radiance Dataset Generation and Data Assimilation Activities at the Cooperative Institute for Meteorological Satellite Studies (CIMSS).

February 1, 2012, P. van Delst (JCSDA). Community Radiative Transfer Model (CRTM) Development.

February 2, 2012, CSU ATS students. Dynamo Jamboree; Experiences in the Field and Preliminary Science Findings.

February 9, 2012, C. O’Dell (CSU CIRA). Towards a Better Understanding of Climate and Climate Change through Satellite Remote Sensing.

February 16, 2012, P. Di Nezio (Univ. of Hawaii/IPRC). The Response of the Tropical Pacific and ENSO to Global Warming.

February 20, 2012, M. Zelinka (Livermore National Laboratory). Progress on Diagnosing, Partitioning, and Understanding Cloud Feedbacks.

February 23, 2012, E. Barnes (Univ. of Washington). Influence of Meridional Constraints on Low-Frequency Variability and its Response to Climate Change.

February 29, 2012, G. Weller (CSU Statistics). An Investigation of the Pineapple Express Phenomenon via Bivariate Extreme Value Theory.

March 1, 2012, J. Minder (Yale Univ.). Mesoscale Controls on Mountain Climate – From Snowy Peaks to Tropical Islands.

March 8, 2012, J. Pierce (Dalhouise Univ.). The Formation and Growth of Ultrafine Atmospheric Aerosols.

March 19, 2012, E. Fischer (Harvard Univ.). Teary Eyes to Blue Skies: Using Models and Observations to Establish a Global Picture of Peroxyacetyl Nitrate (PAN).

March 22, 2012, L. Bosart (Univ. of Albany/SUNY). Impact of Tropical Cyclones and Transient Polar Disturbances on the North Pacific Subtropical Jet: Downstream Baroclinic Development and a Subsequent Intense Cyclone Event over the United States.

March 29, 2012, T. L’Ecuyer (Univ. of Wisconsin – Madison). How Well Do We Know the Earth’s Energy Budget?

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: A GOES-R Proving Ground for National Weather Service Forecaster Readiness

PRINCIPAL INVESTIGATORS: Steve Miller and Renate Brummer

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

NOAA TECHNICAL CONTACT: Ingrid Guch & Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, Donald W. Hillger, John Knaff, Dan Lindsey, Deb Molenar, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

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 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. 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.

PROJECT ACCOMPLISHMENTS:

<u>Interactions with Forecast Offices and National Centers</u>. Over the past year CIRA increased its effort to work directly with partnering Weather Forecast Offices (WFOs). There are now 17 WFOs nationwide which we can consider to be active CIRA proving ground partners. Depending on the WFO's individual forecast needs, the partner WFOs receive different proving ground products from our palette of 27 ABI proxy products.

CIRA continued to work closely with the National Weather Service Weather Forecast Offices (WFOs) in Boulder and Cheyenne by participating in their forecaster workshops, observing forecasters during their shifts, collecting forecaster feedback, inviting forecasters to Proving Ground meetings at CIRA, and supporting a close collaboration between the WFOs and CIRA's systems and algorithm development experts. The interaction with the other partnering WFOs was mostly conducted remotely. Proving Ground interactions also continued between CIRA and NOAA's Storm Prediction Center (SPC), the National Hurricane Center (NHC), the Ocean Prediction Center (OPC), the Hydrometeorological Prediction Center (HPC), the Pacific Region and the High-Latitude (Alaska region) Proving Ground team.

CIRA continued to provide NSSLWRF-based synthetic imagery and a Hail Probability Forecast product to SPC to support the Spring Experiment. The real-time production of the WRF synthetic imagery for four ABI bands continued on a daily base. Five products were developed and sent to NHC during the 2011 hurricane season. These were the Lightning-based TC Intensity Prediction (RII), the Super Rapid Scan Operations (SRSO) from GOES-15 (operated during the Science Test), ABI red-green-blue (RGB) proxy air mass and ABI proxy aerosol/dust products (derived from SEVIRI), and a new Natural Color product generated from the MODIS instrument which simulates the future Natural Color Imagery product from GOES-R. The RGB products were demonstrated on NAWIPS, the Natural Color product was available on the CIRA webpage. OPC and HPC were receiving the RGB Airmass products based on SEVIRI and based on GOES-sounder data. HPC also received the Synthetic GOES-R cloud/moisture imagery and the orographic rain index product.

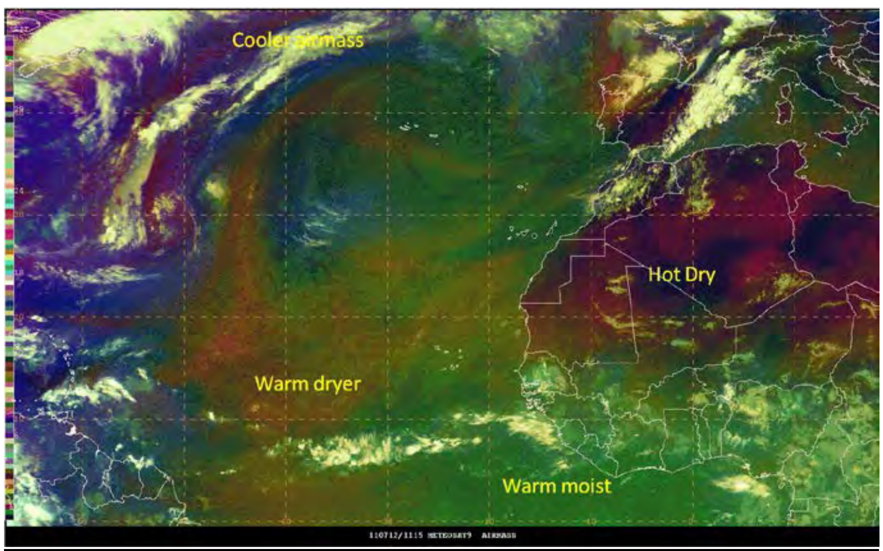


Figure 1. Air mass product example. Tropical air is displayed in green and red where the green regions have higher moisture content than the red regions. Mid-latitude air has a bluish color and areas or dark red show areas of subsidence and high ozone and PV.

Proving Ground Website Development. All CIRA Proving Ground training material (i.e. product descriptions) were posted on the CIRA Proving ground webpage. In addition, a real-time Proving Ground webpage was developed which allows the users and public to view newly developed products in real-time. More than 90% of the CIRA Proving Ground demonstration products can be viewed on-line, on RAMSDIS, or on AWIPS. A newly designed Proving Ground product table provides links to many different sources of relevant training material.

AWIPS Development. All new Proving Ground products were tested at CIRA's AWIPS system. Significant progress was made with feeding many more of our demonstration products to several NWS Regional Headquarters. CIRA continued to develop AWIPS proving ground product installation software to support CIRA's partner WFOs with making the necessary

AWIPS menu adjustment. Work continued on moving CIRA's Proving ground products into AWIPS II, which represents the next generation data display system for the NWS.

CIRA Proving Ground Product Development. CIRA continued the production and distribution of last year's Proving Ground products as well as a palette of new products. Last year's specific focus was on improving products based on forecasters' feedbacks.

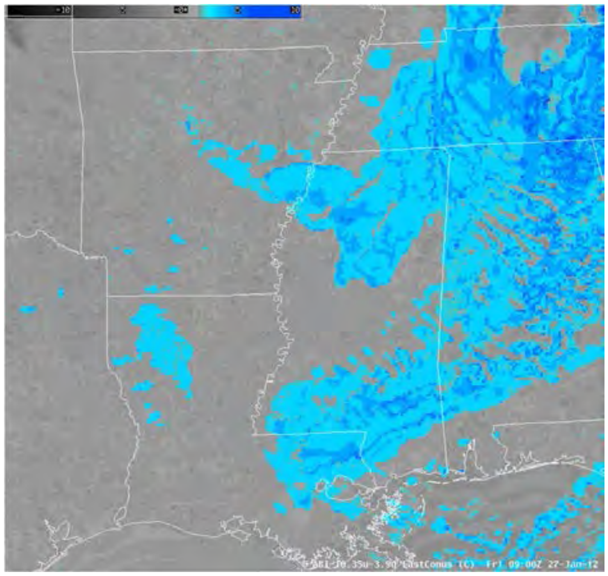


Figure 2. Synthetic 10.35-3.9 μm imagery ("fog product") based on the NSSL WRF-ARW as viewed in AWIPS. The blue pixels represent low liquid water clouds.

Figure 3. Comparison between True Color (left), the binary Cloud /Snow Discriminator product (middle), and the Cloud Layers & Snow Cover Discriminator product (right) imagery over the north-central United States as collected by NASA's MODerate-resolution Imaging Spectroradiometer (MODIS) sensor. In the Cloud Layers & Snow Cover product, white areas denote snow cover, yellow areas denote low cloud cover (liquid), orange/magenta areas denote high cloud cover (mixed/ice), and green areas denote clear sky surface.

CIRA created 27 Proving Ground products. 90% of these products are being demonstrated in either AWIPS, N-AWIPS, Google Earth, RAMSDIS, or real-time on the web. For a complete list of these products see Table 1 below.

Product	Satellite	GOES-R relationship
WFO Products		
GeoColor Imagery	GOES/MODIS /DMSP	New Visualization
True Color Imagery	MODIS	GOES-R, Decision Aid
Low cloud / Fog Imagery	GOES	Decision Aid
Cirrus Detection	MODIS	GOES-R, Decision Aid
Orographic Rain Index (ORI)	GOES/Radar/GFS model	GOES-R, Decision Aid
Marine Stratus Cloud Climatology	GOES	GOES-R, Decision Aid
Blowing Dust Detection (3)	GOES/MODIS	Variant of GOES-R Top 12 product
Snow/Cloud Discrimination (3)	GOES/MODIS	Variant of GOES-R Baseline
Volcanic Ash Enhancement (2)	GOES/MODIS	Variant of GOES-R Top 12 product
Vegetation (NDVI)	MODIS	GOES-R Decision Aid, new visualization
Synthetic Forecast Model Imagery	NSSL-WRF-ARW	GOES-R Decision Aid
National Center Products		
SPC: Hail Probability Product	GOES/RUC model	Variant of GOES-R Option2 / leveraging from GIMPAP
SPC: Synthetic Forecast Model Imagery	NSSL-WRF-ARW	GOES-R Decision Aid
NHC: Lightning-based TC Intensity Prediction (RII)	Ground-based lightning network/GFS/GOES	GOES-R3 new development
NHC: RGB Air Mass Product	MSG/ GOES-Sounder	GOES-R3 new development
NHC: RGB ABI Dust Product	MSG	GOES-R3 new development
NHC: Natural color Product	MODIS	GOES-R3 new development
NHC: Super Rapid Scan Operations (SRSO)	GOES-13, GOES-15	Training for hi-resolution imagery
HPC/OPC: RGB Airmass Product	MSG/ GOES-Sounder	GOES-R3 new development
HPC: Synthetic Cloud/Moisture Imagery	NSSL-WRF-ARW	GOES-R Decision Aid
HPC: ORI	GOES/Radar/GFS model	GOES-R, Decision Aid

Table 1. CIRA Proving Ground Products.

Detailed information about each of these products can be found on our website at http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list/ by clicking on the product name.

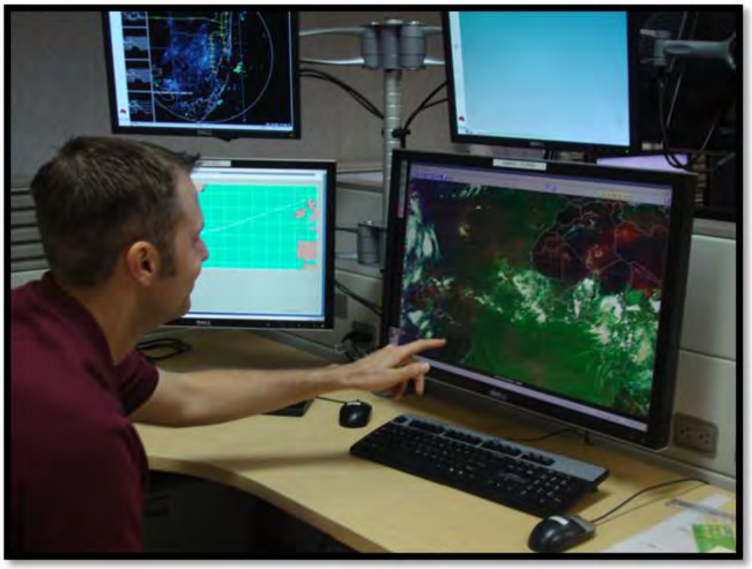


Figure 4. NHC forecaster Eric Blake is looking at CIRA's RGB Airmass product.

Training and Forecaster Feedback. The development and delivery of training material for the various satellite demonstration products remained a central component of the CIRA Proving Ground concept. Methods for the development, testing, and delivery of instructional materials and the ability to track participants, and collect and summarize course feedback material have been demonstrated in the past by the VISIT and SHyMet programs. CIRA continued to leverage these existing VISIT and SHyMet in-house capabilities which allowed us to further evaluate the one-on-one Proving Ground activities to gauge the utility of existing and new materials and improve content as required. Where appropriate, Proving Ground training content and modules were merged with current training activities to show how new capabilities will compliment and/or improve upon current product capabilities.

Forecaster feedback is crucial to the success of the GOES-R Proving Ground. Feedback was collected via forecaster comment sheets, email, blogs, actual forecast postings which mention any of the proving ground products, and verbal communication. Product descriptions were produced for user training purposes.

PROJECT TITLE: A Study of Precipitation Motion Using Model Winds

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: N/A

NOAA TECHNICAL CONTACT: Ingrid Guch, NOAA/NESDIS/STAR

NOAA RESEARCH TEAM: Not yet identified

PROJECT OBJECTIVES: We propose to study the accuracy of precipitation products, both instantaneous and accumulated, constructed by moving precipitating areas using model winds. In brief, the process we propose is as follows:

--We will use 88D radar data (Stage II and/or Stage IV) to simulate the satellite-observed rain rates. This may include a simulation of satellite footprints. It certainly will include a simulation of the satellite swath and orbital observation frequency.

--We will use GFS winds to move the rain rates to a later time, and we will accumulate the precipitation.

--We will compare the moved and accumulated precipitation with later Stage II /IV data to see how well the movement of the precipitation compares to actual.

--Real precipitating regions change with time. We will also look at whether model trends can be used to indicate an increase/decrease in precipitation during the gaps.

We expect to examine one summer's precipitation data over the CONUS. This should give us a good idea of how well precipitation estimates can be made with infrequent satellite observations.

PROJECT ACCOMPLISHMENTS: I'm trying to find time to work on this project. No money has yet been spent on it.

PROJECT TITLE: CIRA Activities and Participation in the GOES Improved Measurements and Product Assurance Plan (GIMPAP)

PRINCIPAL INVESTIGATOR: Steve Miller

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

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, Donald W. Hillger, John Knaff, Dan Lindsey, Deb Molenar, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES: Over the past several years, CIRA has performed basic and applied research to better utilize data from NOAA Geostationary Operational Environmental Satellites (GOES) and Polar Operational Environmental Satellites (POES). The NOAA/NESDIS GOES Improved Measurements Product Assurance Plan (GIMPAP) has supported CIRA research on the use of GOES data for mesoscale analysis of high-impact weather events, including severe weather and tropical cyclones. Beginning in 2002, the NESDIS GIMPAP program has been supplemented with the Product System Development and Implementation (PSDI) program to provide research support for applications of satellite data that have a direct relationship with weather and climate forecasting.

During the past year, CIRA's GIMPAP research was divided into the following five project areas:

1) GOES-based renewable (solar) energy prediction products for decision makers
2) Improved use of GOES tropical cyclone intensity change and formation
3) Using quantitative GOES information to improve short-term severe weather forecasts
4) International training
5) GOES-P[15] initial check-out and data analysis/storage

.
PROJECT ACCOMPLISHMENTS:

<u>Project 1) GOES-based renewable (solar) energy prediction products for decision makers</u>
GOES-derived cloud products from operational NESDIS algorithms are being used to compute parameters related to available solar irradiance at the surface, with emphasis on developing

predictive capabilities at multiple time scales. The work focuses on two different time periods: short term (< 3hr) and mid- to long-term (>3 hr., to several days) prediction of cloud cover and cloud properties.

Short-term (< 3 hr.) prediction of the solar irradiance (direct/diffuse components and total) is based on currently observed cloud cover, retrievals of optical/geometric cloud properties, and coupling of this information to cloud advection fields (based either on numerical weather prediction model output or feature tracking).

A simple cloud advection code was developed and tested for GOES-11 during the reporting period. Software has been written (based in the Interactive Data Language—IDL) and tested for correct operation on test cases. Upstream of this code are the operationally-run GOES Surface Insolation Project (GSIP) cloud retrievals, based on NOAA/NESDIS codes and using CIRA's EarthStation GOES E/W capture.

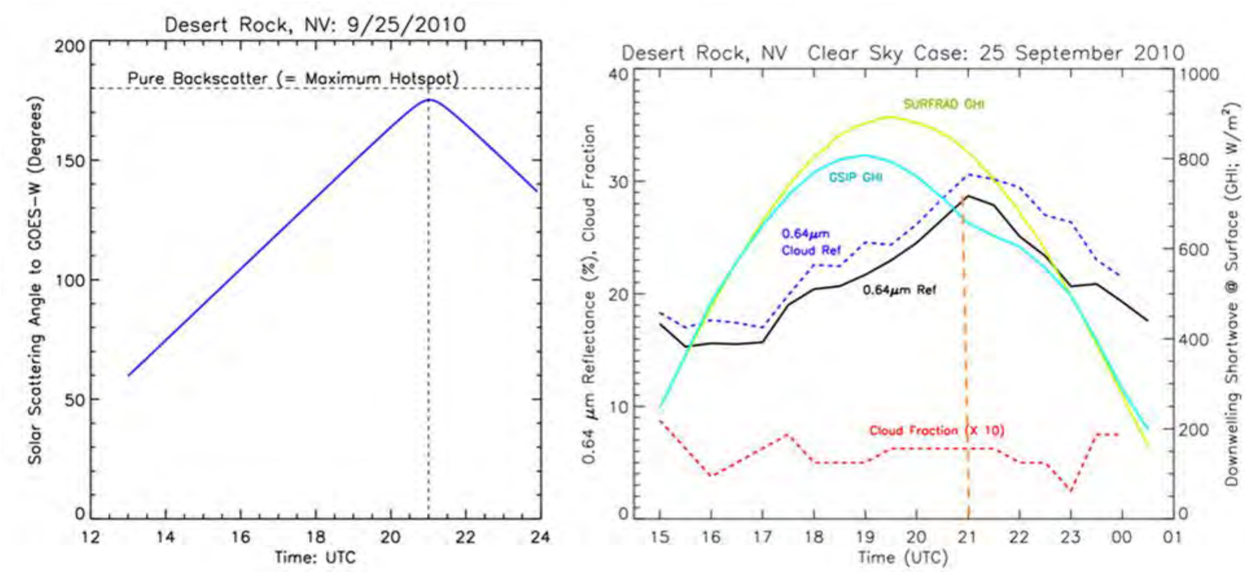


Figure 1. Sun-Satellite scattering angle (left) and measurements (right) at Desert Rock, NV, showing the effects of the opposition surge.

The initial analyses of SASRAB clear sky surface irradiances revealed an apparent anomaly in the GSIP/SASRAB-retrievals in comparison to SURFRAD observations. Upon closer inspection of this anomaly, it became apparent that the GSIP code was passing false-alarm cloudy pixels into SASRAB for certain regions. The findings point to the need for future work in mitigating this effect by i) improving the cloud mask to minimize false alarms, and ii) including a GOES cloud-cleared dark-sky albedo to pass in representative information to SASRAB. To this end, code to determine the dark-sky albedo from GOES area files has been obtained from CIMSS/SSEC and applied to local GOES datasets. The derived dark-sky composites are being applied to the latest version of the GOES/AVHRR/MODIS processing code (PATMOS-x, available online at: http://cimss.ssec.wisc.edu/patmos/). A direct comparison of SASRAB-computed GHI using both the AVHRR- and GOES-derived dark-sky databases is currently underway.

In order to evaluate techniques for cloud advection (e.g., model wind fields, atmospheric motion vectors) we have run the software described above on test cases over Colorado with an initial focus on the CSU Christman Field Weather station (although a similar analysis could be done at various SURFRAD stations, we selected the CSU site because it includes a camera that shows cloud formations and the distribution of sunlight/shadow on the surface that surrounds the field station. Different approaches to the cloud advection problem were explored and are in continued development at this time. To overcome the dispersion of contiguous clouds as a result of wind field divergence, an algorithm for physically-based cloud grouping (based on related classes and similarity of optical and geometric properties) is being examined. The cloud groups will then move as a unit, while allowing for multi-layered cloud systems to advect according to the directional shear of the environment.

Mid to long-term (>3 hrs. to several days) prediction of cloud cover likelihood is based on satellite-derived cloud statistics conditioned on model-predicted meteorological flow regimes. Work during this period has sought to characterize insolation temporal characteristics using principle component analysis (PCA). Preliminary results of the PCA suggest that the observations were simply too variable to capture via this approach. As an alternative approach, we are now exploring the application of K-mean clustering to analyze the data. First, each day was split up into three, 4 hour periods. Then using the Clear-Obs data, the mean and standard deviation was calculated for each period. Data sets containing the mean, standard deviation and the time period (1-morning, 2-midday, 3-afternoon) for each day were created. The data set was then analyzed with the K-mean function in MATLAB using various numbers of clusters ranging from 4 to 10. So far the results look promising in determining solar regimes. Future plans include trying various time scales and analyzing the data compared to cluster centers.

Until the solar regimes have been determined, the cloud climatologies for these regimes cannot be produced. However, to test the programs and process, two test regimes were considered. The first is where a previous method to determine solar regimes had indicated that the site was clear all day. For the clear case, the site shows the cloud cover percent to be less than 20%, which is significantly less than the general climatology. Overall, much of Northern Colorado is near 0%, with some higher percents in the mountains. For the overcast days, the cloud percents are much higher, with the Christman Field area showing cloud percents in the 90-95% range. This is higher than the general climatology. It is expected that similar results will be seen from the solar regime climatologies.

This project supports NOAA's mission goal to "develop and improve services for sectors such as renewable energy".

<u>Project 2) Improved use of GOES tropical cyclone intensity change and formation</u>

The objective of this project is to use GOES data and environmental conditions to improve the forecasting of tropical cyclone to extra-tropical cyclone transition (ET) as well as to improve forecasting of rapid weakening (RW) which is not associated with landfall. Research is also conducted on tropical cyclone formation, specifically on improving the probability of detection and on decreasing the false alarm ratio using GOES image processing techniques.

For the analysis of ET, a database of tropical cyclones that underwent transition to extra-tropical (ET) storms in the Atlantic, which included motion-relative infrared principle components and environmental information, was examined using linear discriminant analysis and logistic regression. Note ET rarely (1 case in 2009-2010) occurs in the East Pacific. Several predictors were linked with an increase probability of ET occurring in the next 24-h. The algorithms were tested using independent data 2009-2010 (operational SHIPS data based on analysis and forecast fields and IR PCs created in real-time) and proved skillful.

For the analysis of RW, A database of tropical cyclones that rapidly weakened (RW; 25kt decrease in 24-h) for both the Atlantic and East Pacific TC basins was examined using linear discriminant analysis and logistic regression. Several predictors were linked with an increase probability of RW. The algorithms were tested using independent data 2009-2010 (operational SHIPS data based on analysis and forecast fields and IR PCs created in real-time) and proved skillful. The logistic regression framework seemed to work best. The Brier Skill Scores and conditional Treat Scores associated with the logistic regression based results showed promise. Since rapid weakening (unlike rapid intensification) can be caused by many different factors, this problem remains challenging.

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. An improved understanding of ET and RW cases will result in improved TC intensity forecasts, which is a top NOAA/DOD priority.

Project 3) Using quantitative GOES information to improve short-term severe weather forecasts
The goal of this project is to extract information from GOES-derived cloud properties and use this information to make short-term predictions on convective storm evolution throughout the storm's lifecycle. GOES Imager data is being used along with fields from the SPC surface mesoanalysis and the NOAA/ESRL RUC model to predict the probability of severe weather in the 0-6 hour time frame. Cloud properties found to be correlated with severe weather are being tested using a statistical technique. In addition, we are producing a product which assists with short-term severe storm forecasting, and which generates a probability of severe wind, hail, and tornadoes in the GOES-East domain.

Tornadoes are too rare and depend too heavily upon low-level processes that are not captured well by either the satellite or the model fields. We believe that a similar method may be possible to predict the probability of severe wind which will be investigated in the coming year.

An experimental product was completed and continues to run. The output is being sent to the Storm Prediction Center (SPC) in Norman, OK. Since the last report, some validation work has been completed using the new version of the model and data from the summer of 2010. Since the developmental dataset consists of only a single severe weather season (including the OST data), a rigorous validation cannot be attempted. However, to provide some sense of model skill, we used a subset of the developmental dataset by selecting approximately 80% of the days, rerunning the statistics to obtain new coefficients, apply the model to the remaining 20% of independent data.

We found that the model tends to slightly over-predict probabilities in the upper end and do pretty well in the middle to lower end. Note also that 854 hail reports were associated with probability forecasts between 0 and 1%.

This project supports NOAA's Weather and Water mission goals as well as the NWS Aviation and Warn-on-Forecast goals.

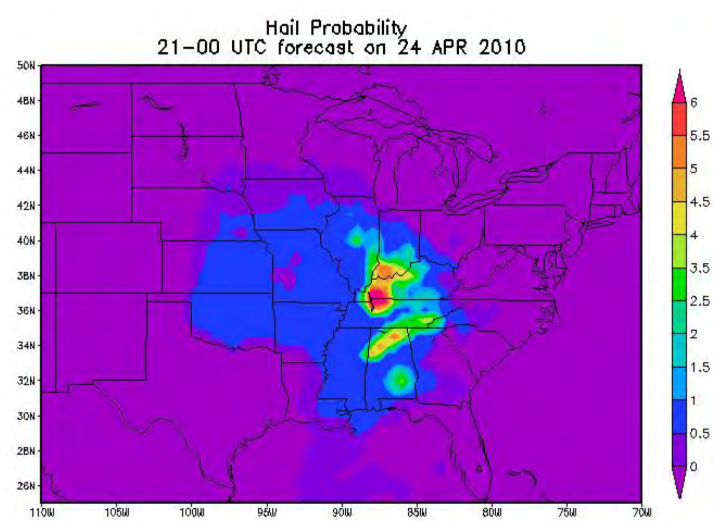


Figure 2. Example of the hail probability product from 24 April 2010 valid 21-00 UTC. The colors represent the probability (in percent) of 1 inch or greater diameter hail within a 0.5x0.5 degree lat/lon box between 21-00 UTC.

Project 4) International training

This project expands and enhances the existing training structure for GOES. The training is based on the WMO Virtual Lab (monthly regional focus group), on the WMO blended training (virtual and face to face) and on VISIT and SHyMet materials. The training project is leveraging existing US training materials. The training content promotes satellite and climatology applications.

The WMO Virtual Laboratory Regional Focus Group of the Americas and Caribbean conducted bilingual (English/Spanish) weather briefings (for March, April, June, July, August, and September 2011) through VISITview using GOES and POES satellite Imagery from CIRA (http://rammb.cira.colostate.edu/training/rmtc/focusgroup.asp) and voice via Yahoo Messenger during March and April and switching to GoToWebinar starting in June.

The Focus Group included participants from the U.S.: CIRA, NWS Training Division, the International Desk at NCEP, Territory of Puerto Rico, CSU, as well as outside the U.S.: Bahamas, Barbados, Belize, Bolivia, Brazil, Cayman Islands, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Great Britain, Guatemala, Guyana, Honduras, Panamá, St. Kitts, Trinidad and Tobago, Uruguay, and Venezuela. The participants include researchers and students as well as forecasters. Barbados has also been conducting briefings for the Eastern Caribbean to introduce forecasters in training to regional forecasters as well as stimulate discussion and collaboration. CIRA has been assisting with the logistics of the sessions and providing imagery through the RAMMB server listed above.

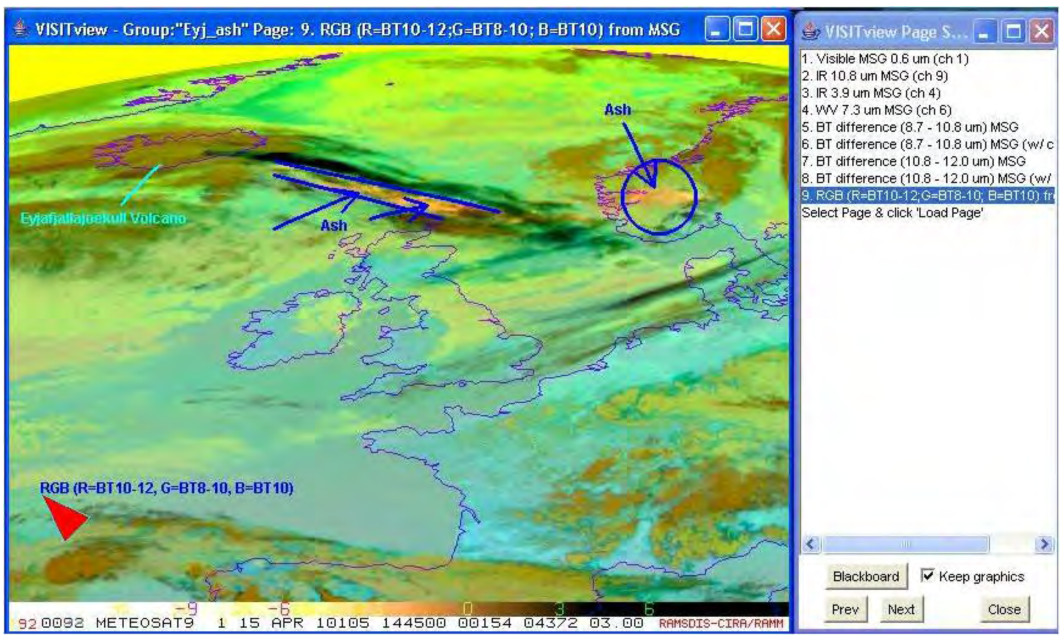


Figure 3. Volcanic ash detection using MSG RGB image combination presented at Monthly Regional Focus Group session.

This project supports the following NOAA mission goals: Weather and Water, Commerce and Transportation, Climate. Enhanced training will also prepare forecaster/manager on how to utilize imagery and products to provide services in these areas.

Project 5) GOES-P[15] initial check-out and data analysis/storage

After the successful launch of GOES-P[15] in early March, a “post-launch science check-out” was conducted in August-September 2010. GOES data are a major part NOAA’s satellite activities, and the quality of GOES data relate directly to numerous satellite products and services provided by NOAA. These data must continue to be accessed, saved and quality checked. Part of the Science Test is also an "initial product generation" from GOES-P[15] datasets. These include generation of temperature and moisture retrievals, cloud top information, DPI, winds, etc. The check-out is a critical step towards satellite operations.

During the period covered by this Annual Report, a detailed GOES 15 Science Test Technical Report was produced with the help of many CIRA and NESDIS employees.

Hillger, D.W., and T.J. Schmit, 2012: The GOES-15 Science Test: Imager and Sounder Radiance and Product Validations, *NOAA Technical Report NESDIS 141*, (November), 101 pp.

The Report is available on the GOES-15 Science Test page: http://rammb.cira.colostate.edu/projects/goes-p/

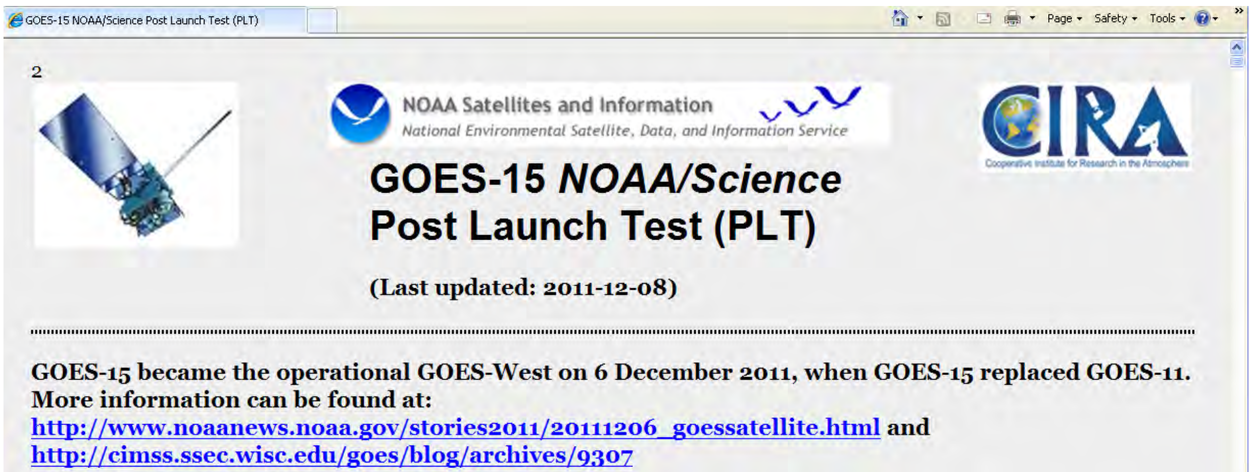


Figure 4. GOES-15 Science Test page

This project supports the NOAA mission goals of Climate, Weather and Water, and Commerce and Transportation. It also supports the NOAA-wide goals of Geostationary Orbiting Environmental Satellite Acquisitions (final part of Post Launch Testing) as well as Satellite Services (assure quality of data and derived products).

PROJECT TITLE: CIRA Research Collaboration with the NOAA/NESDIS NGDC for the NPOESS SEM Sensor Suite Algorithm Development Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Patrick Purcell, Janet Machol

NOAA TECHNICAL CONTACT: William Denig, NESDIS/NGDC/STP

NOAA RESEARCH TEAM: Janet Green, NGDC/SWPC

PROJECT OBJECTIVES:
1-Develop algorithms and science grade software for the NPOESS Space Environment Monitor (SEM-N)
2-Manage and engineer SEM-N science grade software and algorithm development.

3-Prepare SEM-N science grade software for operational implementation at NOAA NESDIS and the Air Force Weather Agency.

PROJECT ACCOMPLISHMENTS:
The NPOESS Space Environment Monitor (SEM-N) transitioned from the NPOESS program to the USAF Defense Weather Satellite System (DWSS), a follow-on to the current Defense Meteorological Satellite Program (DMSP). The program was re-titled Space Environment Monitor – Next (SEM-N).

The DWSS program was cancelled by Congress in the FY2012 budget and a DMSP follow-up program is under evaluation by the Department of Defense.

SEM-N algorithm work reached a pre-Critical Design Review stage as of the end of FY 2011 and all preliminary code and documentation was provided to the Air Force's Space and Missile Systems Center (SMC).

Objective 1. Develop algorithms and science grade software for the NPOESS Space Environment Monitor (SEM-N) Environmental Data Records (EDRs).

CIRA was responsible for development of two of the SEM-N EDRs: The Energetic Ions (EI) and the Auroral Energy Deposition (AED) algorithms. Accomplishments for the past year include:

--Updates to the Algorithm Theoretical Basis Documents (ATBDs) for both algorithms. Each document includes a description of the algorithm, the error budget, and the generation and use of proxy data for testing.

--Draft of prototype code for the EI algorithm was tested using proxy data.

--IDL code to test geometrical concepts for the AED algorithm.

Objective 2. Manage and engineer SEM-N science grade software and algorithm development.

SEM-N Algorithm Development continued refinement of requirements and system engineering related documentation and tool development (requirements, design, test) throughout the year. In addition, CIRA provided support to NOAA NGDC related to updates to Statements of Work (SOWs) and draft schedule for the DoD's implementation of the DWSS SEM-N algorithm work under various scenarios.

Objective 3. Prepare SEM-N science gradesoftware for operational implementation at NOAA NESDIS and the Air Force Weather Agency.

SEM-N prototype code, developed by the Air Force Research Lab (AFRL) for the low energy detector was successfully integrated into the JPSS/DWSS Common Ground's Algorithm Development Library (ADL). ADL is a development framework that closely mimics that of the full ground processing environment implemented and maintained by Raytheon Intelligence and Information Systems (IIS).

CIRA also developed prototype code for the low energy Raw Data Record (Level 0) to Sensor Data Record (Level 1) and successfully integrated the code into the ADL framework. This effort resulted in considerable risk reduction and would speed the integration time into the operational JPSS/DWSS ground system when delivered.

PROJECT TITLE: Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme (JHT)

PRINCIPAL INVESTIGATOR: Andrea Schumacher

RESEARCH TEAM: N/A

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES: TC genesis represents an intensity forecasting challenge and is perhaps one of the more difficult stages of the tropical cyclone lifecycle to diagnose and predict. This project seeks to combine some of the strengths of both the NHC "in-house" scheme and the NESDIS Tropical Cyclone Formation Probability (TCFP) product to develop a storm-centric scheme for objectively identifying the probability of TC genesis (within 48-hours) in the North Atlantic basin.

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: During the FY11 reporting period, CIRA was responsible for the following objectives:

--Complete identification/development of TCFP TCGI environmental predictors

A set of potential TC genesis predictors has been identified and developed for use in the TCGI (Table 1). Predictors identified for testing in this new genesis scheme were chosen based on 1) their established relevance to TC formation (i.e., successful use in other genesis prediction schemes) and 2) their ability to be computed in a disturbance-centric framework. The predictors chosen include most of those used by the NESDIS Tropical Cyclone Formation Probability (TCFP) product. In addition, a few of the predictors used in the Statistical Hurricane Intensity Prediction Scheme (SHIPS) may also be important for TC genesis and have been included in the potential predictor list for the TCGI.

Potential Predictor	Data	Source
850-200 mb vertical shear	GFS analyses	TCFP
850-mb vorticity	GFS analyses	TCFP
MSLP	GFS analyses	TCFP
Vertical instability parameter	GFS analyses	TCFP
850-mb horizontal divergence	GFS analyses	TCFP
Sea surface temperature	Reynold's weekly SST	TCFP
Latitude	Dvorak dataset	TCFP
Distance to land	Dvorak dataset	TCFP
% pixels colder than -40 C	GOES-East water vapor	TCFP
Cloud-cleared brightness temperature	GOES-East water vapor	TCFP
Climatological TC formation probability	Dvorak dataset / HURDAT / Best Track	TCFP
Distance to existing TC	Dvorak dataset / HURDAT / Best Track	TCFP
Shear direction	GFS analyses	SHIPS
Potential intensity	GFS analyses / Reynold's weekly SST	SHIPS
200-mb temperature	GFS analyses	SHIPS
700-500 mb relative humidity	GFS analyses	SHIPS
700-850 mb temperature advection	GFS analyses	SHIPS
Total Precipitable Water	Microwave Satellite-derived	SHIPS/RI Index
Dvorak T-number	Dvorak dataset	TCFP
Dvorak CI number	Dvorak dataset	TCFP

Table 1. Potential Predictor List for the TCGI.

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

PRINCIPAL INVESTIGATOR: John F. Dostalek

RESEARCH TEAM: Robert DeMaria, Kevin Micke, Kathy Fryer

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, NESDIS/RAMMB

PROJECT OBJECTIVES: The objectives of this project, which supports the NOAA mission goals of Climate, Weather, and Water, ultimately involve validating Microwave Integrated Retrieval System (MIRS) retrievals in relation to two tropical cyclone products developed at CIRA. The first product, the Multiplatform Satellite Surface Wind Analysis, uses information from 4 data sources, including microwave retrievals, to create a mid-level wind analysis using a variational approach (Knaff and DeMaria 2006). The mid-level winds are then adjusted to the surface using a single column method. The second product is a statistical intensity and wind radii estimate (Demuth et al. 2004; Demuth et al. 2006). This product uses microwave soundings to produce objective estimates of 1-min maximum sustained surface winds, minimum sea-level pressure, and the radii of 34-, 50-, and 64-kt winds in the northwest, northeast, southeast, and southwest quadrants of tropical cyclones. These two products are currently produced using microwave profiles generated from a statistical retrieval scheme over 10 years old. Intermediate validation of the MIRS retrievals will be performed by comparing them to collocated dropsondes in relation to the following:

1-Temperature
2-Relative humidity
3-Maximum Potential Intensity (MPI) of tropical cyclones (Bister and Emanuel 1998)
4-Vertical velocity produced in a simple cloud model (DeMaria 2009)

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

PROJECT ACCOMPLISHMENTS: The validation of the four intermediate values was performed by comparing the MIRS retrievals with collocated dropsondes deployed around Hurricane Irene of 2011. Figure 1 shows the bias and mean absolute error (MAE) with respect to temperature. The quality of the MIRS retrievals is consistent with the general performance of satellite soundings, performing best in the lower to middle atmosphere, with degradation near the surface and near the tropopause. Figure 2 shows the bias and MAE for the relative humidity profile. The bias is within 20% and the MAE within 30% throughout the tropopsphere. Figure 3 is a scatterplot of the calculation of the MPI for MIRS and the collocated dropsondes. Here a bias correction in temperature and relative humidity has been applied to the MIRS data. Reasonable agreement is seen, although the MIRS has a slight high bias. Figure 4 shows the vertical velocity profile which results from the mean temperature and moisture profiles of the dropsondes and three variations of the MIRS retrievals. The cyan profile is the vertical velocity profile with no bias correction, the green profile is the MIRS retrieval with only a bias correction in the moisture field, and the red profile is the MIRS retrieval with only the temperature bias correction applied. Clearly, the MIRS profile with the temperature bias correction compares best to the dropsonde profile in black. These results were presented at the AMS' 92nd Annual Meeting held in January of 2012.

In addition to the results shown above, software has been written to convert the MIRS retrievals into a format suitable for use with the Multiplatform Satellite Surface Wind Analysis and the statistical intensity and wind radii estimate.

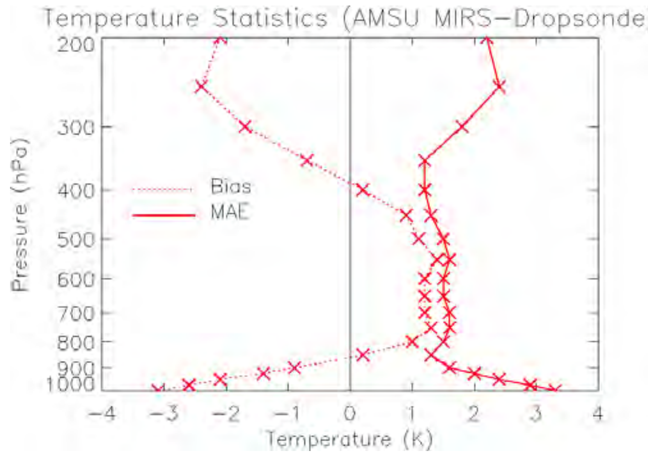


Figure 1. Bias and MAE for the comparison of temperature between MIRS profiles and collocated dropsondes in the vicinity of Hurricane Irene of 2011.

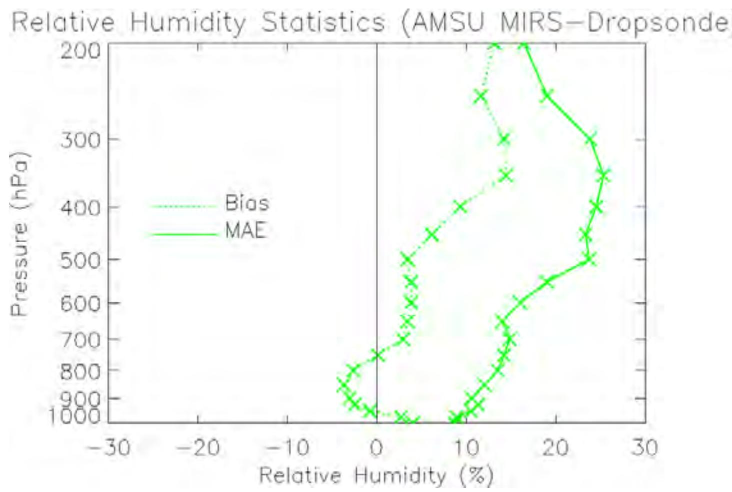


Figure 2. Bias and MAE for the comparison of relative humidity between MIRS profiles and collocated dropsondes in the vicinity of Hurricane Irene of 2011.

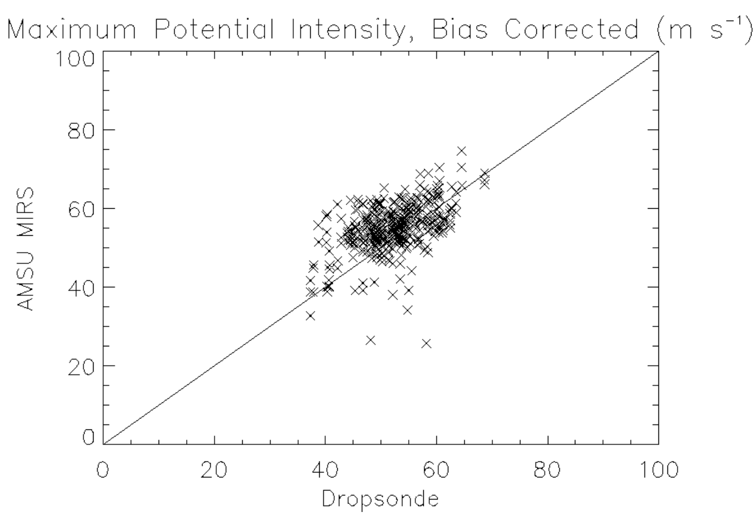


Figure 3. Scatterplot comparing the MPI as computed from bias corrected (in temperature and relative humidity) MIRS soundings vs. the collocated dropsondes in the vicinity of Hurricane Irene of 2011.

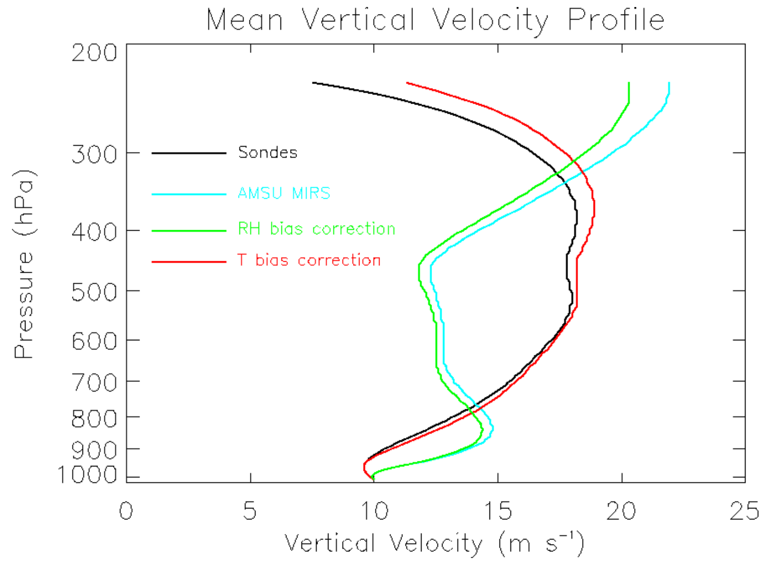


Figure 4. Mean vertical velocity profile generated from a 1-D cloud model for the dropsonde data (black), uncorrected MIRS (cyan), MIRS with a relative humidity Bias correction (green), and MIRS with a temperature bias correction (red).

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

PRINCIPAL INVESTIGATOR**:** Bernadette Connell

RESEARCH TEAM**:** Dan Bikos, Jeff Braun

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM**:** Mark DeMaria

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.

This project supports NOAA's goals of Weather and Water, Commerce and Transportation, and

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

PROJECT ACCOMPLISHMENTS:

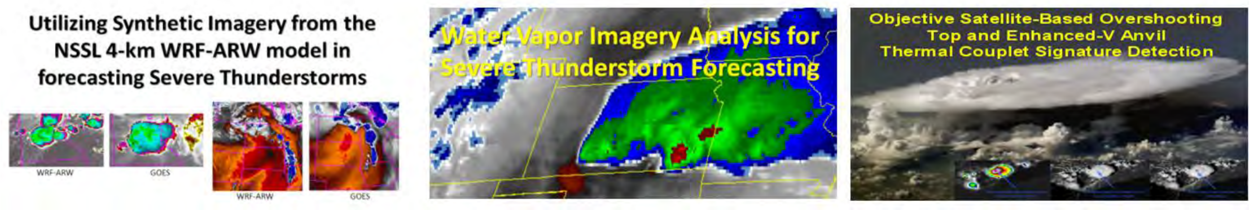


Figure 1. Selection of three different SHyMet Courses

The "Severe Thunderstorm Forecasting" Course was released in March 2011
http://rammb.cira.colostate.edu/training/shymet/severe_intro.asp
This course covers how to integrate satellite imagery interpretation with other datasets in analyzing severe thunderstorm events. This course is administered through web-based instruction and consists of 7 modules (8.5 hours) of core topics and 4 modules (2.5 hours) of optional topics.

Core Courses:
1-Mesoscale Analysis of Convective Weather Using GOES RSO Imagery
2-Use of GOES RSO imagery with other Remote Sensor Data for Diagnosing Severe Weather across the CONUS (RSO 3)
3-GOES Imagery for Forecasting and Nowcasting Severe Weather
4-Water Vapor Imagery Analysis for Severe Weather Forecasting
5-Synthetic Imagery in Forecasting Severe Weather
6-Predicting Supercell Motion in Operations
7-Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection

Optional courses:
8-Monitoring Gulf Moisture Return
9-The UW Convective Initiation Product
10-Coastal Severe Convective Weather
11-Topographically induced Convergence Zones and Severe Convective Weather

The following three courses continue to be administered:
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 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 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).

SHyMet metrics are tracked by leveraging the expertise of the VISIT program.

Course Name	2011 (NOAA) registrations	2011 (non-NOAA) registrations
Intern	36	2
Forecaster	11	3
Tropical	2	0
Severe	41	0

By individual sessions through NOAA's Learning Management System:
Registrations:

	Jan.-Dec. 2011	Since April 2006
Intern Sessions	637	4154
Forecaster Sessions	311	
Tropical Sessions	90	
Severe Thunderstorm	288	

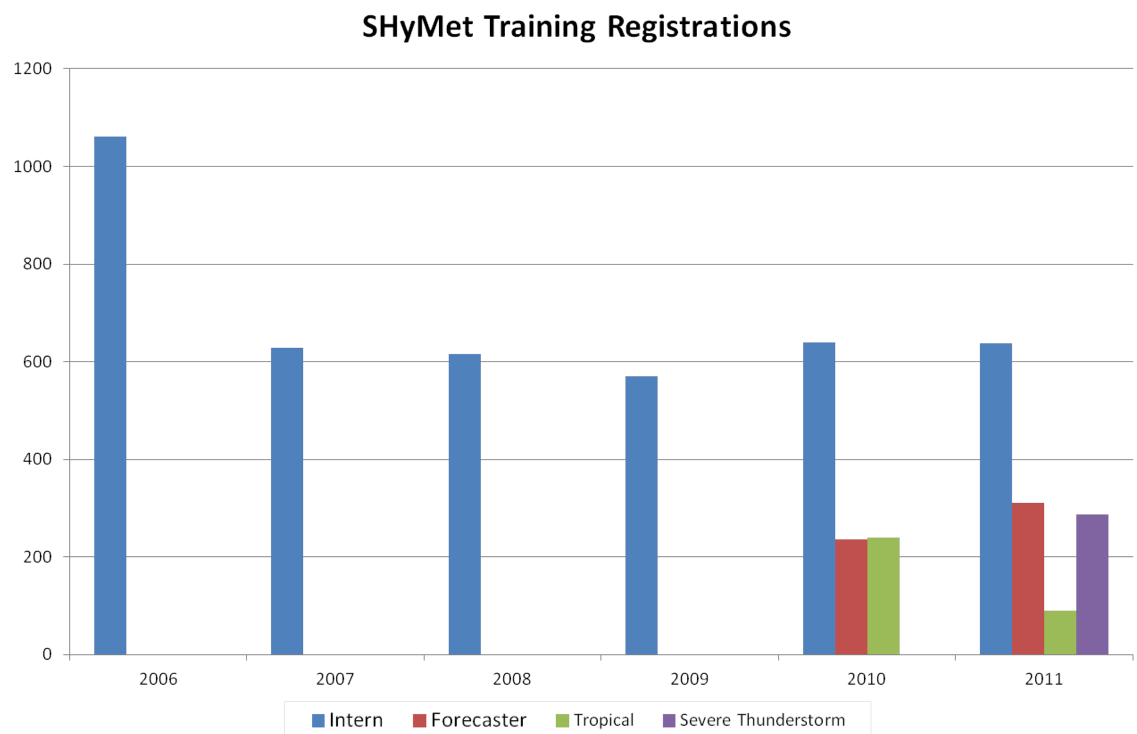


Figure 2. SHyMet registrations for total modules for the 4 courses as counted in the Commerce Learn Center Learning Management System. SHyMet Intern saw the highest number of registrations in its first year (2006). Registrations have been consistent for the Intern course over 2007-2011 reflecting the need of the target audience.

Community Outreach

J. Braun. A presentation with general guidelines to "Talk about the weather" was given on one occasion in 2011 to students of Rocky Mountain High School who attend the *Introduction to Chemistry, Physics, and Earth Sciences* (ICPE) classes.

Volunteer work supporting after-school weather club: B. Connell and K. Gebhart ran a weekly after-school weather club on Mondays for Putnam Elementary (K-5) for 7 weeks during March through May 2011 and 14 weeks during September 2011 through March 2012. There were two back to back sessions each week of 45 minutes in duration for March through May 2011, while there was only one 90 minute session each week during the September through March session. Sessions covered snow, wind (speed and direction), clouds, temperature, and things that spin as well as measurements that are associated with these weather occurrences. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!

PROJECT TITLE: GOES-O (14) Science Test and Global Tropical Cyclone Formation Probability Product

PRINCIPAL INVESTIGATOR: Andrea Schumacher

RESEARCH TEAM: Jack Dostalek, Robert DeMaria, Kevin Micke

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, John Knaff, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES: This Tropical Cyclone Formation Probability project is divided into the following three project areas:

1-Global Transition of Tropical Cyclone Forecast Products

2-48-Hour Global Tropical Cyclone Formation Probability (TCFP) Product

3-NPP Microwave Sounder-based Tropical Cyclone Products

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 1: Global Transition of Tropical Cyclone Forecast Products
The NESDIS Tropical Cyclone Formation Probability (TCFP) product uses environmental and satellite-based convective parameters to estimate the 24-hour probability of TC formation over 5 x 5 degree latitude/longitude grid boxes in the N. Atlantic, N.E. Pacific and N.W. Pacific tropical basins (Schumacher et al. 2009). The main goal of this project is to update and extend that spatial domain of the current product to better meet user needs. Project objectives for FY11 are listed below. Progress on these objectives is indicated in parentheses.

--Implementing new Global TCFP operationally at NESDIS (In progress: description below)

An experimental version of the Global TCFP product has been running at CIRA since Aug 2009. NESDIS operational systems had been under a mandatory freeze for the entirety of the last report timeframe, delaying progress on the remaining objective.

The freeze was lifted in the spring of 2011. Operational code and scripts were provided to NESDIS in summer 2011 for review. The code was approved for installation on the NESDIS development systems as soon as the backlog from the 14-month operational systems freeze allowed. The operational code is currently in the process of being installed and tested and documentation is being prepared for final implementation.

During this report timeframe, the experimental Global TCFP has continued to run in real-time at CIRA, and its outputs have been monitored and evaluated. Validation was performed for the Global TCFP for 2011; and the product once again demonstrated forecast skill in all global TC basins.

Project 2: 48-Hour Global Tropical Cyclone Formation Probability (TCFP) Product

The Global TCFP (above) was expected to be installed and running in pre-operational phase in July 2011. Although this new product will address concerns with the limited spatial domain, there remains an inconsistency between the product's temporal scale and the forecast length requirements of its end users. For example, the NHC issues 48-hr probabilistic tropical cyclone genesis forecasts in the Tropical Weather Outlook product. Also, the Joint Typhoon Warning center issues 48-hr Tropical Cyclone Formation Alerts. As such, an SPSRB user request (#1003-0003) was submitted to extend the TC formation probabilities from 24 to 48 hours in order to provide TC formation guidance that correspond with the present needs of TC forecasters. This project seeks to address this request by incorporating GFS forecast fields into the Global TCFP algorithm to extend the formation probabilities to 48 hours. Project objectives for FY11 are listed below. Progress on these objectives is indicated in parentheses.

--Begin development of 48-hour algorithm (Completed: Jul – Sep 2011)
--Complete algorithm development, begin running experimentally in real-time at CIRA (Completed: Jan – Mar 2012)
--Prepare code for operational implementation (In progress: Apr – Jun 2012)
--Perform preliminary validation (In progress: Apr – Jun 2012)

Project 3: NPP Microwave Sounder-based Tropical Cyclone Products

Recently, more powerful and flexible methods of creating vertical profiles of the atmosphere have become available, such as the Microwave Integrated Retrieval System (MIRS), NESDIS' current operational microwave retrieval system. In addition, with the launch of the NOAA Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) satellite in fall of 2011, a new microwave sensor called the Advanced Technology Microwave Sounder (ATMS) will become available. In order to continue providing the best microwave sounder-based TC intensity and structure guidance available, it is necessary to update these products (SPSRB User Request #1009-0017). This project proposes to do just that by collecting and testing MIRS-processed temperature profiles from the NPP ATMS and adapting the operational AMSU-based TC products to utilize this new data source. Project objectives for FY11 are listed below. Progress on these objectives is indicated in parentheses.

--Began adapting current AMSU TC algorithms to use MIRS AMSU retrievals (Completed: Nov 2011 – Jan 2012)

--Begin collecting ATMS radiance data (when available after NPP launch) for global tropical cyclones (Completed: Dec 2011 – Jan 2012)

--Begin collecting MIRS ATMS soundings and limb corrected ATMS brightness temperatures, for global tropical cyclones (In progress: collection of individual cases during Jan – Feb 2012, real-time data will be provided to CIRA by late Jun 2012)

PROJECT TITLE: Improvements in Statistical Tropical Cyclone Forecast Models

PRINCIPAL INVESTIGATOR: Renate Brummer

RESEARCH TEAM: Andrea Schumacher, Robert DeMaria,

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria and John Knaff, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES:
Although considerable effort is being made to improve dynamical tropical cyclone forecast models, statistical-dynamical models have generally provided the most accurate intensity predictions over the last few years. Recent

research has indicated that there is potential for further improvement of statistical-dynamical intensity forecasts. In this project, several improvements are proposed to the operational Statistical Hurricane Intensity Prediction Scheme (SHIPS) and the Logistic Growth Equation Model (LGEM). These improvements include the following: (1) Separating the persistence component of LGEM from the other inputs that are available throughout the forecast period, which allows the model to be run to any forecast length and the assimilation of the observed intensity up to the forecast time; (2) Developing versions of the SHIPS and LGEM models specifically for the Gulf of Mexico region; and (3) Improving the databases used to develop SHIPS and LGEM through use of the NCEP's new coupled reanalysis system. The project also includes a fourth task (4) to develop extended range versions of climatology and persistence models for track and intensity to be used as baselines for evaluation of other more general models beyond 5 days. A trajectory approach will be used for the new baseline models.

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

.

PROJECT ACCOMPLISHMENTS:
The accomplishments on the four main project tasks are described below.

(1) A version of LGEM has been developed where all of the inputs that are only available at t=0 have been removed (persistence and GOES variables). This change greatly reduces the number of coefficients that need to be calculated for estimating the model growth rate and allows the adjoint equation to be used to estimate the coefficients. This version can also be run to any forecast time, in preparation for developing a 7 day version of LGEM. The next step is to optimize the method for including the t=0 input into the adjoint version. This involves modifying the constant term in the equation for the growth rate. This can also be done using the adjoint version of LGEM applied to period from about 2 days before up to the start of the forecast.

(2) The development of versions of SHIPS and LGEM for the Gulf of Mexico will begin in the 2nd half of the project.

(3) The new NCEP climate reanalysis fields back to 1979 were obtained from NOAA/ESRL. The grib files have been converted to the form used by the SHIPS and LGEM diagnostic code. Although the grib files include 0.5 deg lat/lon resolution, the storage and processing requirements at that resolution are not currently feasible for SHIPS and LGEM. The new version will be developed with 1 deg lat/lon resolution, which is still a considerable improvement over the current version, which is developed from 2.5 deg lat/lon resolution reanalysis fields.

(4) Considerable progress has been made on the new baseline models. The climatological track model uses a trajectory approach (called T-CLIP), where the storm motion is determined from a time weighted average of the initial motion vector and the vertically averaged climatology flow. The weight on the initial motion vector decreases with time at a rate determined by a lag correlation analysis of a large sample of storms. The current version of T-CLIP uses a standard deep layer mean, but a version where the vertical weights depend on the intensity is being tested. The climatological intensity model also uses a trajectory type approach (called T-SHIF). The maximum wind trajectory (integration of dV/dt) is determined from the LGEM model with climatological input. If the version of T-CLIP with the variable vertical weights that are a function of intensity is successful, then T-CLIP and T-SHIF will be integrated together

PROJECT TITLE: Improvements in the Rapid Intensity Index by Incorporation of Inner-core Information

PRINCIPAL INVESTIGATOR: John Dostalek

RESEARCH TEAM: Renate Brummer

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: John Knaff, Mark DeMaria, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES: In recent years, a statistically based rapid intensification index (RII) that uses predictors from the Statistical Hurricane Intensity Prediction Scheme (SHIPS) model to estimate the likelihood of RII has been developed for operational use by forecasters at the National Hurricane Center (NHC) for systems in the Atlantic and eastern North Pacific basins. Although the index was found to exhibit some skill when verified for operational forecasts made from 2008-2010, the skill was on the low side underscoring the difficulty of predicting RI. Thus with support from the NOAA Joint Hurricane Testbed (JHT), research is conducted to try to improve the operational RII by including predictors derived from three new sources of inner-core information The first of these three new sources is the time evolution of inner-core structure as deduced using standard principle component analysis of GOES infra-red (IR) imagery while the second source is microwave-derived total precipitable water in the near storm environment. The final source is the near storm thermodynamic fields as deduced utilizing GFS temperature and moisture data.

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

PROJECT ACCOMPLISHMENTS: The results of this study indicate that the experimental RII developed using predictors derived from the aforementioned sources is generally more skillful than both climatology and the operational version (save for the 40-kt RI) in both the eastern North Pacific and Atlantic basin when verified for an independent sample of cases from 2008-2010. The finding that the largest improvements in skill (up to 8% in the Atlantic and 5 % in the eastern North Pacific) of the experimental RII over the operational version are observed for the lower RI thresholds may be due, in part, to the relatively small RI sample sizes that are available for the highest RI thresholds. It is interesting to note that an increase in skill with increasing RI threshold magnitude is observed for the eastern North Pacific RII while the opposite trend is observed for the Atlantic basin version. These opposing trends in skill as a function of RI threshold magnitude are also observed for the 2008-2010 operational RII forecasts.

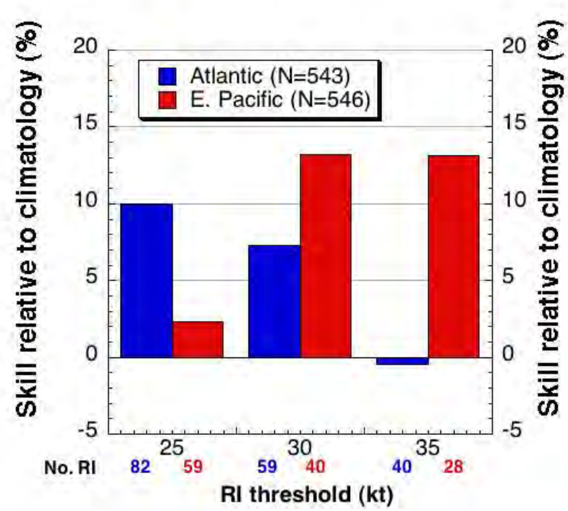


Figure 1. The skill of the 2008-2010 operational RII forecasts. The number of RI cases for each RI threshold is also provided for both the Atlantic (blue) and eastern North Pacific (red) basins.

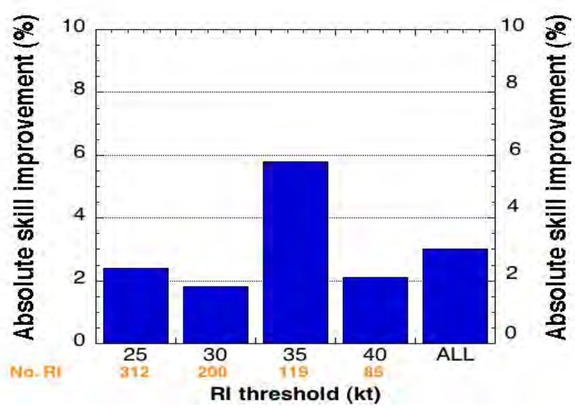


Figure 2. Improvement of the new Atlantic Experimental RII over the current operational version for the 1995-2009 dependent sample (N=2524). The number of RI cases for each RI threshold are shown in orange along the x-axis.

Figure 3. Improvement of the new eastern North Pacific Experimental RII over the current operational version for the 1995-2009 dependent sample (N=2422). The number of RI cases for each RI threshold is depicted in orange along the x-axis.

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

PRINCIPAL INVESTIGATOR: Bernadette Connell

RESEARCH TEAM: Luciane Veeck

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria

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.

This project provides a Technical Support Officer (TSO) dedicated to support VLab activities, to address the training needs of its evolving audience and to provide strong project coordination and management. This project directly supports NOAA commitments to WMO's Coordination Group for Meteorological Satellites (CGMS) and it supports NOAA's goals of Weather and Water, Commerce and Transportation, and Climate. The international activities proposed in this project also directly address the NOAA Engagement Enterprise Objective for "Full and effective use of international partnerships and policy leadership to achieve NOAA's mission objectives". 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.

PROJECT ACOMPLISHMENTS: The following coordination activities of Luciane Veeck, VLab Technical Support Officer, support the top level objectives

--Monitoring CoEs' activities – This meant constant communication with people involved, exchanging ideas for possible VLab events, updating contact's lists, and investigating the main needs and expertise of each CoE.

--Design, add content to, and maintain the new VLab central website http://vlab.wmo.int The new site went live on 2 April 2011. In order to maintain the VLab website up to date, the TSO has been uploading reports to the "Publications" area, updating information sent by CoEs' members to the "Centres of Excellence" area, adding news to the "Recent News" and VLab News" areas, and answering the queries that come through the "contacts" form in the website

--Implement and maintain the VLab calendar of events. The CoEs and the TSO enter their training events in the online calendar, which is routinely checked by the TSO for event validation. This helps track COE activity to be reported to CGMS and ET-SUP (Expert Team on Satellite Utilization and Products). To increase the visibility of the RFGs' sessions and other major events, the TSO is also emailing alerts of important dates (e.g. submission deadlines and sessions' dates) to VLab members.

--VLab Moodle - A new area was created at the VLab Moodle, called "Collaboration area for satellite courses". This area is intended to be used by VLab members and collaborators to exchange information, ideas and training materials related to the organizing of satellite courses.

-VLMG-web Meetings – Due to the global location of the VLMG members, the VLMG-web meetings occur over two days for "Western" and "Eastern" Groups. These took place on the 14th and 15th of March, the 11th and 12th of July, and the 25th and 26th of October. The organization of these meetings is the responsibility of the TSO, who books the conference system, sends the invitations, contacts presenters, prepares the agenda and slides, and offers training sessions to participants who have not yet used the Central Conference System. The agenda and action's list from each meeting can be found in the VLab Moodle site. Recorded meetings, when available, can also be downloaded from the Moodle site;

--Reports/ VLab presentations:

VLab Report to CGMS-39: Based on information collected from CoEs and activities registered in the VLab calendar, the TSO prepared the VLab annual report to CGMS covering July 2010 to August 2011. This report was presented by Volker Gärtner, VLab co-chair, at the CGMS-39 Annual Meeting, 3-7 October 2011, in St. Petersburg, Russia. The full report can be downloaded from the VLab website and Moodle site.

VLab Report to ET-SUP-6**:** The report to CGMS was used as the basis for the report submitted to the Expert Team on Satellite Utilization and Products (ET-SUP) Sixth Session (12-16 December 2011, Geneva, Switzerland). This document is available in the VLab Moodle site. An additional presentation containing a list of up-to-date VLab actions was also prepared by the TSO and presented by Volker Gärtner (VLab co-chair) at the ET-SUP-6 meeting.

VLab presentation slides: Following a WMO request, introductory slides about the VLab were prepared to be presented by Mr. Allen Huang (University of Wisconsin) during a WMO training event in Indonesia (September 2011).

VLab posters: Following a WMO request, a poster was prepared by the TSO and printed by VLab partners at JMA (Japan). This poster was presented by Dr. Jim Purdom (CIRA/CSU alumni) at the Second Asia/Oceania Meteorological Satellite Users Conference, held in Tokyo (December 2011).

Keeping continually updated regarding evolving training technologies: The TSO attended a course on the topic of moderating e-learning activities in October 2011. This course was totally online and offered by The Open University as part of continuous professional development activities.

Figure 1. Participants at the 9th International Conference on Creating Activities for Learning Meteorology (CALMet) held 3-8 October 2011 in Pretoria, South Africa. CALMet provides a forum to share experiences, expectations, and new ideas for applying emerging strategies for meteorology and hydrology in education and training. There were participants from 6 continents.

PROJECT TITLE: NESDIS Environmental Applications Team – Marouan Bouali, Post Doc

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Marouan Bouali and Alexander Ignatov

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Alexander Ignatov

PROJECT OBJECTIVES:

--Quantification of striping on level 1 clear-sky top-of-atmosphere radiances and derived ocean products
--Operational reduction of striping on level 2 SST products generated with the ACSPO

PROJECT ACCOMPLISHMENTS:

Striping is an artifact that appears on images captured by satellite sensors that combine multiple detectors and a double-sided mirror. It results from errors in the inter-detector radiometric calibration and other sources of noise such as optical/electronic cross-talk. The presence of striping on level 1 top-of-atmosphere radiances is a serious issue for ocean products such as Sea Surface Temperature (SST) because it introduces radiometric errors and obstructs the detection of thermal fronts. Although more than 30 years of research have been dedicated to the striping issue, very few techniques have been suggested to quantify the magnitude of striping on level 1 radiances and reduce operationally its impact on level 2 derived products.

Data from both Terra and Aqua MODIS thermal emissive bands used for the generation of level 2 SST products (Bands 20, 31 and 32) was analyzed to determine the degree of striping. The methodology used in this research relies on the Unidirectional Variational Destriping Model (UVDM) (Bouali and Ladjal, 2011), a recent algorithm based on advanced image processing techniques. The UVDM was shown to accurately extract striping patterns from an image, without interfering with the "true" structures contained in the original signal. Quantitative results were then compared to MODIS prelaunch specifications in terms of noise equivalent temperature difference (NEdT). Although further research is required for an unsupervised and time-efficient use of the UVDM, we found out that it constitutes a powerful tool to estimate the magnitude of stripe noise on level 1 data. Unlike most available techniques described in the literature, a major advantage of the UVDM is its ability to process highly heterogeneous images. Figure 1 shows an example of extracting striping effect from a clear-sky ocean scene of Terra MODIS band 20 using the UVDM. Once the stripe noise is isolated, an estimation of its magnitude is obtained by differencing the original and destriped cross-track profiles as shown in Figure 2. The analysis of Terra/Aqua MODIS SST bands have shown that, except for band 20, the striping in SST bands remains close to prelaunch NEdT specifications. Nonetheless, combining these bands into SST amplifies the stripe noise. Consequently, its reduction on MODIS and VIIRS level 1 radiances is an important step for the generation of improved SST products.

Future research will focus on the quantitative analysis of striping on NPP VIIRS and the development of an operational destriping algorithm to be used for near real-time processing of MODIS and VIIRS SST bands.

Results obtained so far on Terra/Aqua MODIS data will be submitted to conference and journal papers (IEEE TGRS).

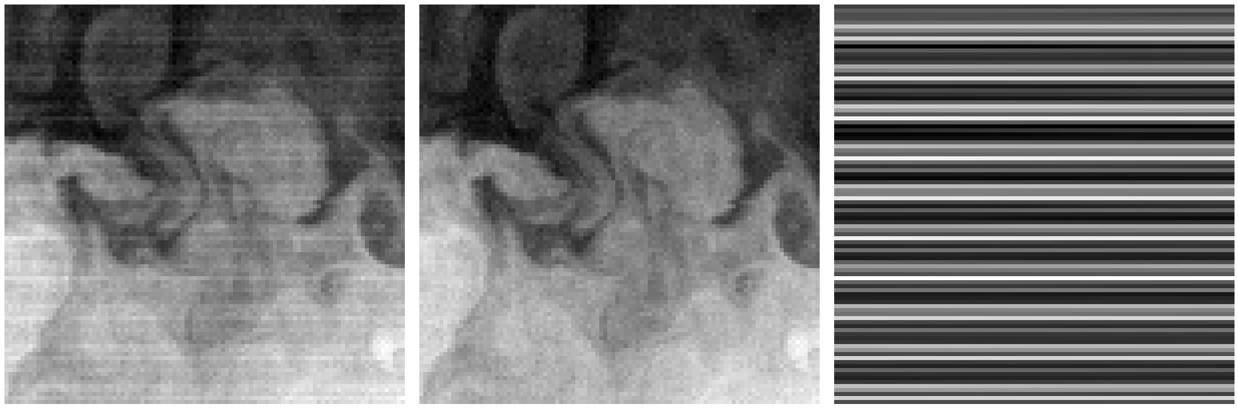


Figure 1. (left) Original image from Terra MODIS band 20 affected with stripe noise (middle) Image processed with the UVDM (right) Extracted stripe noise showing, as expected, strong anisotropic characteristics.

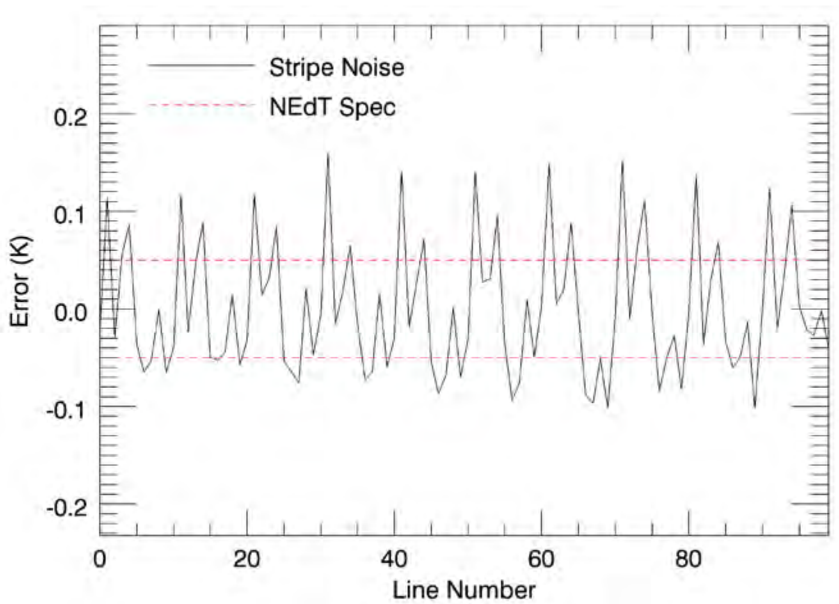


Figure 2. Cross-track profile of stripe noise extracted from a clear-sky ocean scene of Terra MODIS band 20. Errors due to striping can reach 0.15K which is three times the specified prelaunch NEdT.

PROJECT TITLE: NESDIS Environmental Applications Team –Prasanjit Dash, Research Scientist

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Prasanjit Dash (100% FTE)

NOAA TECHNICAL CONTACT: Alexander Ignatov, NESDIS/STAR, Ocean Sensors Branch

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES:

1--Continue monitoring low res. AVHRR SST products in SQUAM, generated by NAVO, heritage MUT & Advanced Clear-Sky Processor for Oceans (ACSPO).

2--Develop capabilities for monitoring High Resolution SSTs in SQUAM, e.g., ACSPO FRAC, Eumetsat FRAC, ACSPO MODIS (Terra, Aqua) and NPP Suomi.

3--Further continue intercomparisons of daily Level-4 (L4) analysis SST fields, compliant with the Global High-Resolution SST (GHRSST) and include newer products.

4--Improve capabilities for monitoring of geostationary products (SEVIRI SST) in SQUAM, as preparedness for GOES-R.

5--Maintain seamless operation of *in situ* quality monitor (iQUAM)

PROJECT ACCOMPLISHMENTS:

Among other critical tasks, most of the work performed by this AP is within the framework of SST Quality Monitor (SQUAM) which was developed, implemented, maintained and is routinely extended by the AP with the advent of newer sensors and availability of newer data. This reporting is made according to the prevailing modules of SQUAM, which monitors around 30 global Sea Surface Temperatures (SST) products. All results are reported at SQUAM URL:
http://www.star.nesdis.noaa.gov/sod/sst/squam/

The SQUAM comprises 3 main modules: Level-2 (L2-SQUAM), Level-3 (L3-SQUAM) and Level-4 (L4-SQUAM). The work was commenced with the vision to have “ALL” major global SST products monitored at one place which will serve as a “one-stop” monitor to assist both SST producers and SST users in analyzing their products and choosing the appropriate ones for their applications. The improvements in the corresponding modules, as applicable, are reported next:

1--Level-2 SQUAM.

AVHRR Global Area Coverage (GAC) SST monitoring. SQUAM continues to monitor the NESDIS AVHRR Global Area Coverage (GAC) L2 products, from the NESDIS heritage Main Unit Task (MUT), the US Naval Oceanographic Office (NAVO) and the newer Advanced Clear-Sky processor for Oceans (ACSPO) *Global Area Coverage (GAC)* products (*previously reported but site was redesigned to enhance user’s experience*). The URLs are:

NESDIS MUT: *http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/*
NAVOCEANO: *http://www.star.nesdis.noaa.gov/sod/sst/squam/NAVO/*
NESDIS ACSPO GAC: *http://www.star.nesdis.noaa.gov/sod/sst/squam/ACSPO/*

High resolution polar SST monitoring. AVHRR Full-Resolution Area Coverage (FRAC) 1km SSTs were included for continuous monitoring in the SQUAM. In this context, two products are analyzed together: one generated by the NESDIS ACSPO and one generate by the EUMETSAT O&SI SAF at Meteo France, resulting in collaboration with the French SST experts.

The L2 FRAC SSTs are compared against daily Reynolds, OSTIA and high resolution RTG, on a global domain using: SST difference *Maps*, *Histograms*, *Time series* of statistical moments, outlier information, daily *Dependence* plots (against geophysical observations) and time-series of dependence plotted in Hovmöeller space.

In addition to comparison against Level-4 products, the high resolution satellite SSTs are also validated daily against *in situ* data. Figures 1 and 2 show example illustration of high resolution SST products monitored in SQUAM.

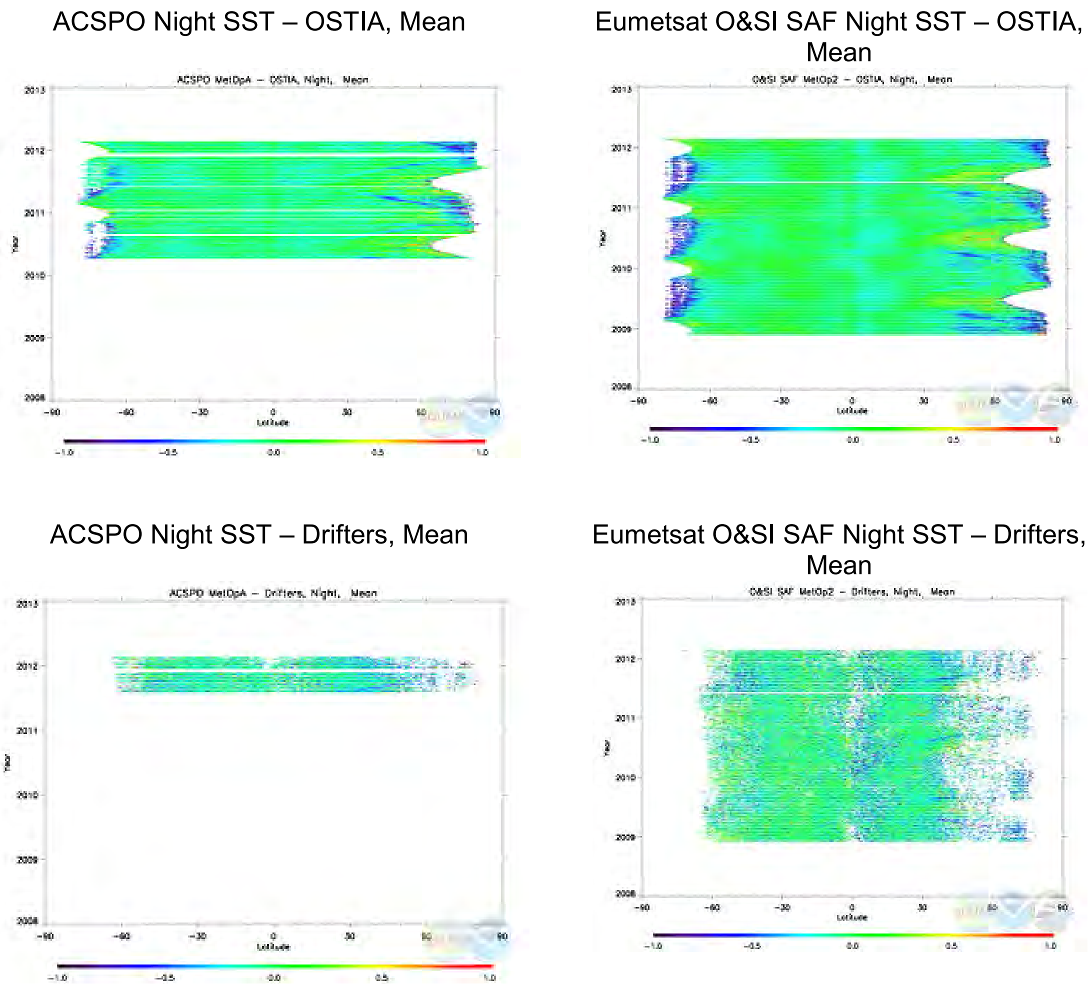


Figure 1. Mean of "satellite SST – reference SST" in Hovmöeller space. Top panels: Satellite SST – UK MetOffice OSTIA; Bottom panels: Satellite SST – Drifters; Left panels: ACSPO SST; Right-panels: O&SI SAF. [see SQUAM-HR web-page for more combinations].

Capabilities were developed to include NPP VIIRS and MODIS (Terra and Aqua) SSTs generated by ACSPO in one common SQUAM High resolution module (SQUAM-HR). The prototype was tested with proxy VIIRS data before switching to real data flow: *http://www.star.nesdis.noaa.gov/sod/sst/squam/HR/.* VIIRS data generated by the *Interface Data Processing Segment* (IDPS) is being explored.

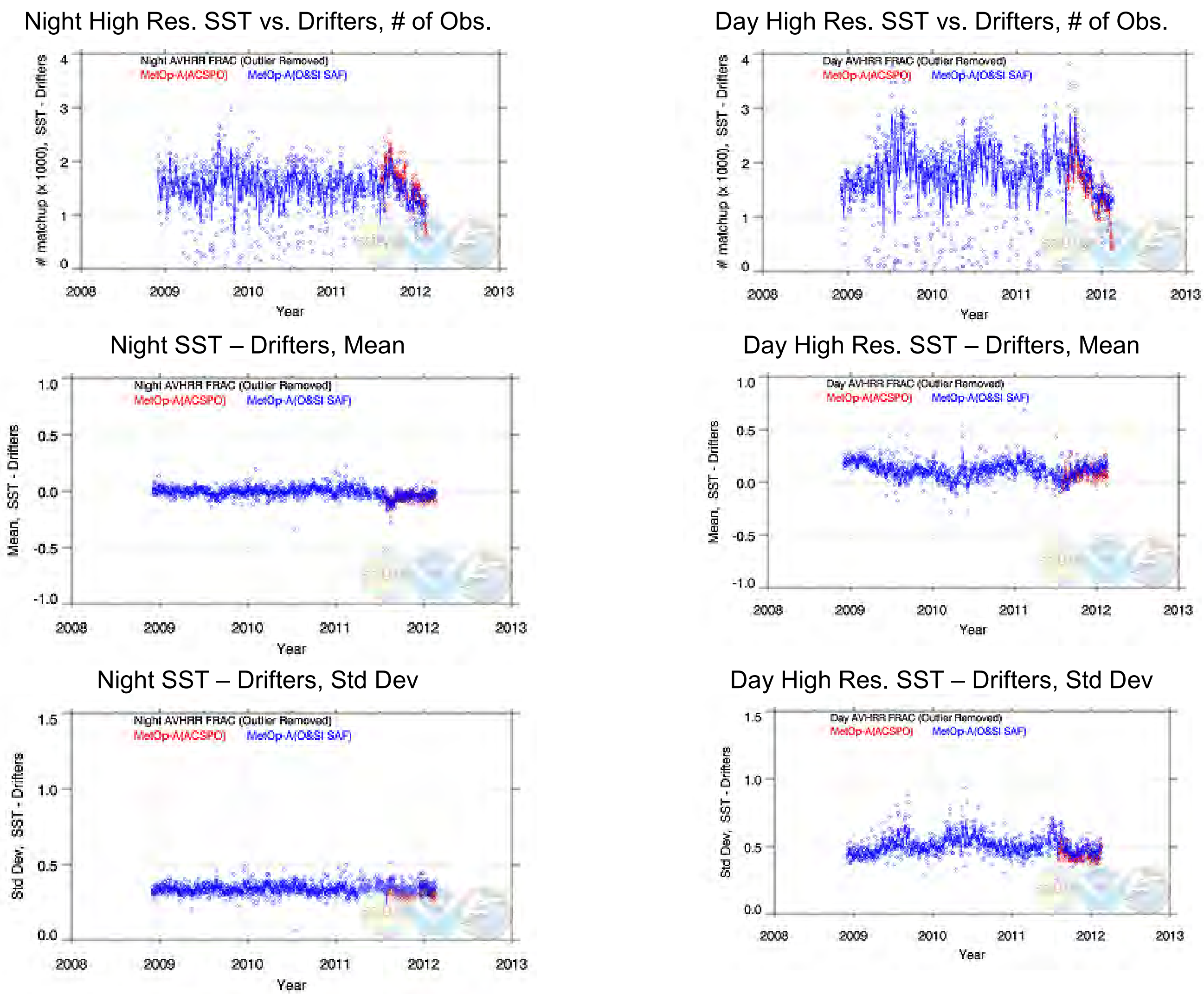


Figure 2. Daily validation of high resolution SSTs against drifters. Left panels: Night statistics; Right panels: Day statistics. Top panels: number of daily match-ups. Middle panels: Mean differences. Bottom panels: Std Dev in high resolution SSTs with respect to drifters. [see SQUAM-HR web-page for more]

Prototype for Geostationary (MSG SEVIRI) SST monitoring. A prototype was designed by the AP for monitoring of geostationary satellite SST data, as preparedness towards the GOES-R program

.

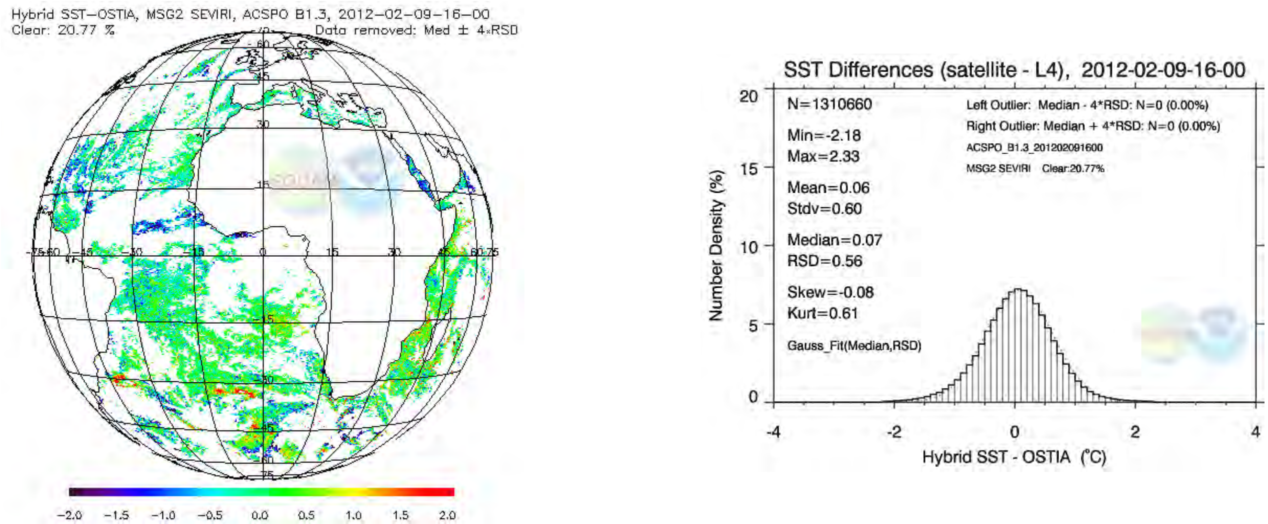


Figure 3. Example of SEVIRI monitoring. Left: SEVIRI SST - OSTIA. Right: Distribution corresponding to the left panel [for internal use only; prototype version not finalized].

L2-SQUAM further plans. Fully implement the inclusion of NPP VIIRS and MODIS SSTs (from ACSPO and IDPS) in SQUAM-HR, *i.e.*, compare against Level-4 fields and *in situ* SST and include dependence plots of standard deviations. Also, include time-series of dependences (against geophysical observations) in *Hovmöller* space. The SQUAM-HR page is aimed at becoming the community page for validation and monitoring of all major global high resolution polar SST products.

2--Level-3 SQUAM.
PathFinder v5.0 was included in L3-SQUAM, in Sep-2010 and no further addition was warranted at this point of time. (v6.0 may be considered in the future; to date, no plans).

3--Level-4 SQUAM.
Significant progress was made to the L4-SQUAM, resulting in a sizeable international collaboration (*http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/*):

--Ice-masks were applied in L4-SQUAM when ice bit-mask is available; analyses are now performed in two ways: ice included, ice excluded

--OSTIA reanalysis (1985-2007) was included (ice mask analyses pending)

--Australian BOM GAMSSA SSTs were fully included in L4-SQUAM analyses.

--L4-SQUAM has been recognized as one of the three systems in the Group for High Resolution SST (GHRSST) Inter Comparison Technical Advisory group (IC-TAG): *https://www.ghrsst.org/ghrsst-science/science-team-groups/ic-tag/*

--L4-SQUAM intercomparison community paper was submitted in DSR-II, Special issue for climate studies, in collaboration with over 20 other scientists around the world.

Currently, L4-SQUAM monitors 13 global level-4 products by cross-comparing and validating against iQUAM *in situ* data (iQUAM is explained in Section 4). Figure 4 shows example results of cross-comparison between level-4 global SST products.

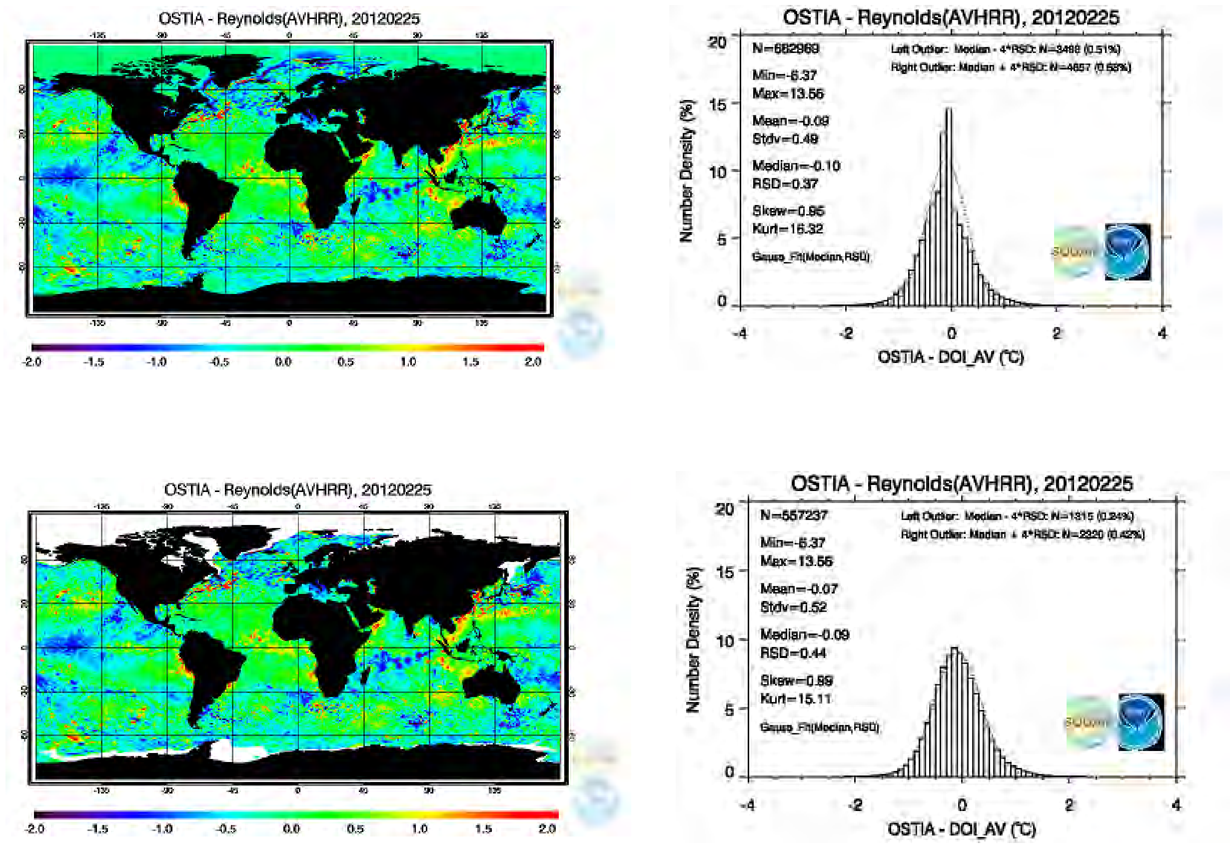


Figure 4. Example of UK MetOffice OSTIA and Reynolds OISST products. Top panels: Ice included. Bottom panels: Ice excluded. The statistical parameters annotated on the histograms are plotted as a function of time to check relative stability. [More at: *http://www.star.nesdis.noaa.gov/sod/sst/squam/L4*]

Figure 5 shows differences between RTG and NAVO K10 level SSTs, over time.

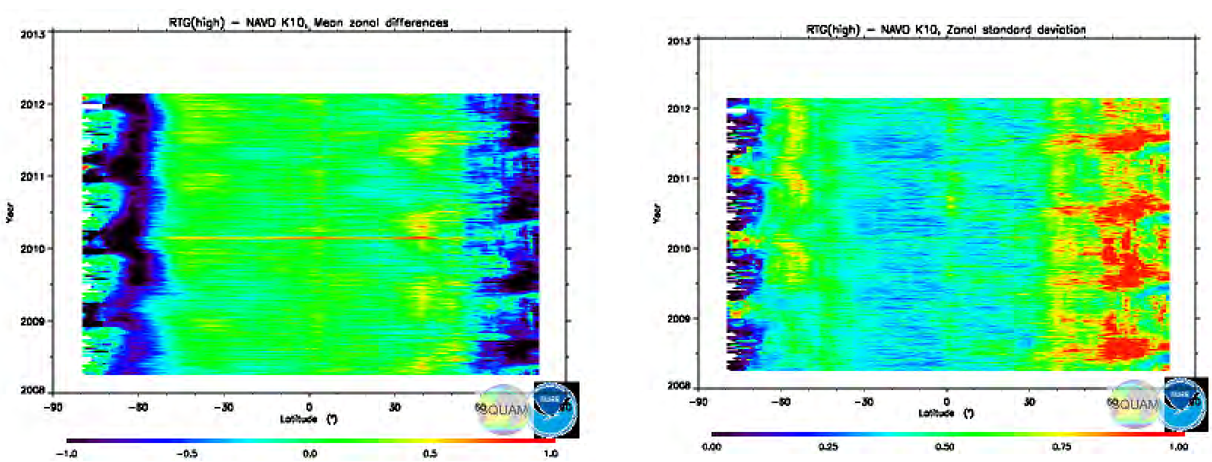


Figure 5. RTG high resolution SST – NAVO K10. Left: Mean; Right: Std Dev.

L4-SQUAM further plans. Attempt to include the remaining level-4 products: JPL MUR, Danish Met. Inst. OISST, Japanese MGDSST, RSS and NRL NCODA.

4--Maintain *in situ* Quality Monitor (iQUAM) *(was necessary after a postdoc left)*.

The AP continues to maintain seamless functioning and occasional trouble-shooting of the *in situ* Quality Monitor (iQUAM), which was earlier developed by another postdoc. The *iQUAM* provides quality controlled *in situ* data, required for SST validation purposes: *http://www.star.nesdis.noaa.gov/sod/sst/iquam/*.

PROJECT TITLE: NESDIS Environmental Applications Team – Robert Hale, Research Scientist – Satellite Land Surface Temperature Validation

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Bernie Connell, Robert Hale

NOAA TECHNICAL CONTACT**:** Yunyue Yu, Environmental Monitoring Branch, NOAA/NESDIS Center for Satellite Applications and Research (STAR)

NOAA RESEARCH TEAM**:** Yunyue Yu (STAR), Yuling Liu (STAR), Dan Tarpley (Short and Associates)

PROJECT OBJECTIVES: The objective of this project is to provide support for the validation of the future Land Surface Temperature (LST) products of the Geostationary Operational Environmental Satellite Series R (GOES-R) and Joint Polar Satellite System (JPSS) missions. A major challenge in utilizing *in situ* LST measurements for satellite-derived LST validation purposes lies in the "point" nature of ground-based LST measurements. That is, the field-of-view of the ground-based infrared thermometer or radiometer is typically much smaller than a single satellite pixel. To enable meaningful comparisons between in situ and satellite-derived LSTs, the aims of this project are twofold: 1) to characterize land surface properties in the vicinity validation sites, and 2) to develop a model for upscaling the *in situ* LST measurements to the spatial scale of a typical satellite pixel.

This project supports NOAA's goals of Weather and Water, Commerce and Transportation, and Climate.

PROJECT ACCOMPLISHMENTS: In order to develop a statistically robust model for upscaling of in situ LSTs, multiple satellite and ground-based products were acquired, aggregated, matched in time and space, and ultimately analyzed. These included over 190,000 Moderate Resolution Imaging Spectroradiometer (MODIS) and 800 Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) LST scenes. In addition, MODIS Normalized Difference Vegetation Index (NDVI) 16-day composite data were acquired for an eight-year period for each of 29 potential validation ground sites and these data were used in forming an average annual NDVI cycle dataset for each site.

The above data were utilized in developing and testing several statistically-based models for upscaling of in situ LSTs. A methodology was developed for evaluating model performance through comparison with MODIS-derived LSTs. Preliminary results indicated modest but statistically significant improvements through use of the upscaling model versus direct comparison with point measurements. Incorporation of MODIS NDVI in the model resulted in significant reduction of differences, although use of near-real-time 16-day composite data was found to be no more useful than the annual average cycle data.

In addition to the upscaling model accomplishments, analysis of National Land Cover Database (NLCD) data was completed for each of the 29 potential validation sites. This included characterization of land cover type, canopy cover, and soil imperviousness within the vicinity of the sites to aid in understanding site heterogeneity that may impact spatial variability of LST.

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

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Lide Jiang

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

NOAA RESEARCH TEAM**:** Menghua Wang

PROJECT OBJECTIVES:
--Support JPSS NPP project
--Add COMS/GOCI (Korean geostationary satellite, ocean color sensor) L1B processing capability to our NOAA MSL12 package
--Support ocean color related studies

PROJECT ACCOMPLISHMENTS**:**
--Attended GRAVITE workshops and got familiar with GRAVITE's capabilities and restrictions.
--Automated the downloading of VIIRS data from GRAVITE by GTP downloading script. Add more functionalities to the automatic downloading script to: 1) skip downloading the night-time files; 2) skip downloading duplicate files; 3) update files if the new file has the same granule time but a newer processing time
--Wrote supporting shell scripts to 1) monitor the downloaded data types and file numbers for each day; 2) organize the downloaded files according to their data type and granule time; 3) remove night-time or duplicate files already downloaded
--After NPP launch, set cron jobs to download and process VIIRS data automatically.
--Attended ADL workshops and learned to use ADL to process VIIRS SDR data into EDR data.
--Compare chlorophyll and water-leaving radiance products generated by IDPS with those generated by ADL and NOAA MSL12.
--Identified ADL's ancillary granulating issue and gained support from Paul Meade to solve the issue.
--Identified code bugs in ADL's VIIRS EDR OCC code and gained support from Raytheon to fix the bug.
--Wrote supporting shell scripts to generate the ADL inputs for the processing of specific granules.
--Successfully made the MSL12 package able to read GOCI L1B data and process it to get various products (nLw, chlorophyll), validated the results against GOCI official L2 data and MODIS data.
--Processed all GOCI data in 2011.

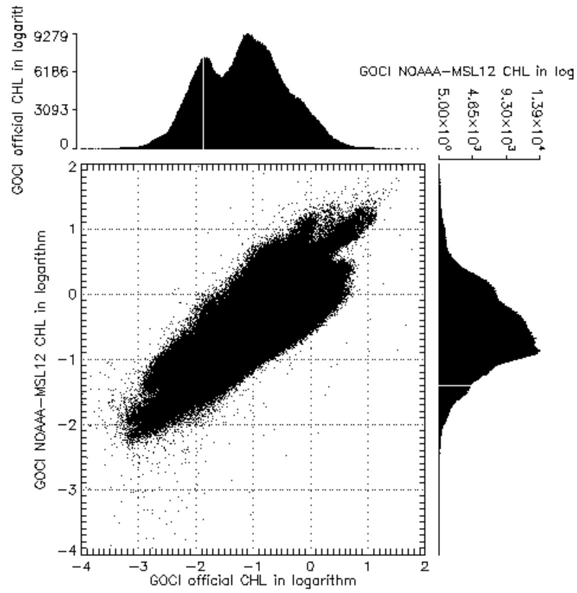


Figure 1. Comparison of chlorophyll-a concentration between GOCI official and GOCI MSL12 results

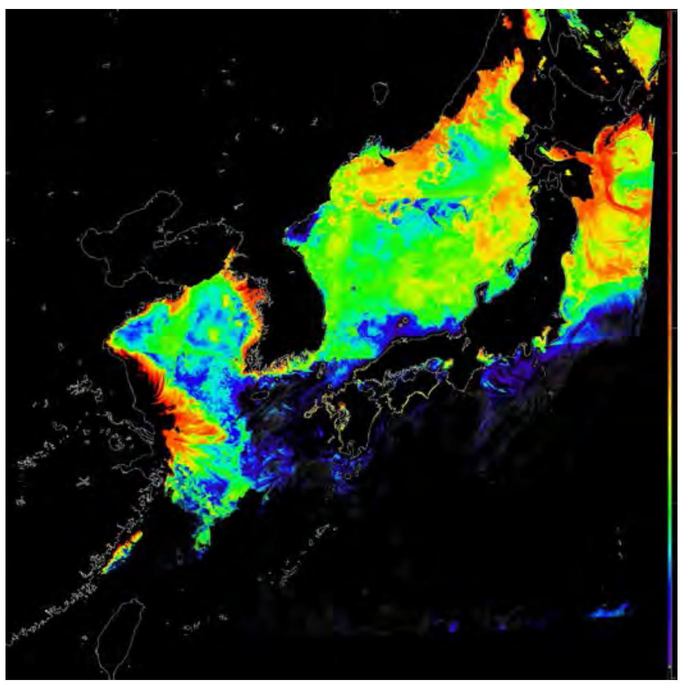


Figure 2. GOCI MSL12 results: chlorophyll concentration at 2011/04/05 16:42 UTC

PROJECT TITLE: NESDIS Environmental Applications Team – Xingming Liang, Research Scientist - Monitoring of IR Clear-Sky Radiances over Oceans for SST (MICROS), Aerosol Quality Monitor (AQUAM), and Advanced Clear-Sky Processor for Oceans (ACSPO) Development

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Xingming Liang (CIRA Technical Lead), Korak Saha

NOAA TECHNICAL CONTACT: Alexander Ignatov (NOAA/NESDIS)

NOAA RESEARCH TEAM: Alexander Ignatov, John Sapper, Boris Petrenko, Yury Kihai, John Stroup, Prasanjit Dash, and Marouan Bouali

PROJECT OBJECTIVES: Development of the Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS; http://www.star.nesdis.noaa.gov/sod/sst/micros/), which monitors "Model minus Observation" (M-O) bias of clear-sky radiances over oceans in near-real-time (NRT). It is used to diagnose SST products, validate Community Radiative Transfer Model (CRTM), and evaluate sensor radiances for stability and cross-platform consistency.

The MICROS system is widely used by three groups of users:

--SST scientists. In particular, all new versions of the Advanced Clear-Sky Processor for Oceans (ACSPO), which is operational at NESDIS and used to generate Clear Sky Ocean Radiances, SST and Aerosol products, are tested in MICROS prior to promoting them to the operations.

--CRTM developers. CRTM is used to generate model radiances in conjunction with first guess atmospheric profiles (global forecast system, GFS) and SST (e.g., Reynolds, OSTIA and other L2 or L4 SST analysis fields). Several critical improvements to CRTM and input fields were done using MICROS.

--Sensor calibration team. MICROS monitors satellite radiances for self- and cross-platform consistency, and contributes to the Global Satellite-based Satellite Inter-Calibration System (GSICS).

A persistent positive M-O is observed in MICROS. There are several factors explaining this bias, one of the most challenging being the missing aerosol in the current CRTM input. Consequently, aerosol affects SST retrievals. Removal of aerosol contaminated pixels from SST products, or aerosol correction to SST, remains one of the major challenges the SST retrieval community has been facing for several decades. The most adequate way to address that issue is based on using CRTM in conjunction with first-guess aerosol 3D fields, e.g. from The Goddard Chemistry Aerosol radiation and Transport (GOCART) or Navy Aerosol Analysis and Prediction System (NAAPS), and validate the improved 'M-O' performance using MICROS functionality. In the first step, we established Aerosol Quality Monitor (AQUAM) web-based NRT tool to check consistency between satellite and model aerosol optical depths.

The major objectives of the past fiscal year were:

1--Continued development of MICROS for SST (version 5, temporarily placed at www.star.nesdis.noaa.gov/sod/sst/micros_v5), extending its functionality to include NASA Terra/Aqua MODerate-resolution Imaging Spectroradiometer (MODIS) and NASA/NOAA Suomi National Polar-orbiting Partnership (NPP; launched 28 October 2011) Visible/Infrared Imager Radiometer Suite (VIIRS), add interactive capabilities for flexible display of multiple platforms, improve the stability of the processing and web display, add standard deviation analysis, and other functionalities including proximity to coast, bathymetry, glint angle dependencies.

2--Enhance the Aerosol Quality Monitor (AQUAM) functionality by adding self- and cross-platform consistency checks.

3--Contribute to development/testing of new versions of the Advanced Clear-Sky Processor for Oceans (ACSPO; v2.0 and v2.1).

4--Expand MICROS and AQUAM to international users by collaborating with the Global Space-based Inter-Calibration System (GSIS), Chinese Meteorological Agency (CMA) and Naval Research Laboratory (NRL).

PROJECT ACCOMPLISHMENTS:

1--Development of MICROS version 5.

--MICROS functionality extended to include MODIS onboard Terra & Aqua and VIIRS on NPP. The figure below shows time series of M-O biases for 9 platforms in MICROS v5.
--New interactive MICROS functions, including plots of time series, histograms and dependencies were included.
--A backup version of MICROS to make the near-real time MICROS more robust in the face of network issues was included.
--Extend functionality to include standard deviation analysis, and proximity to coast, bathymetry, and glint angle dependencies.

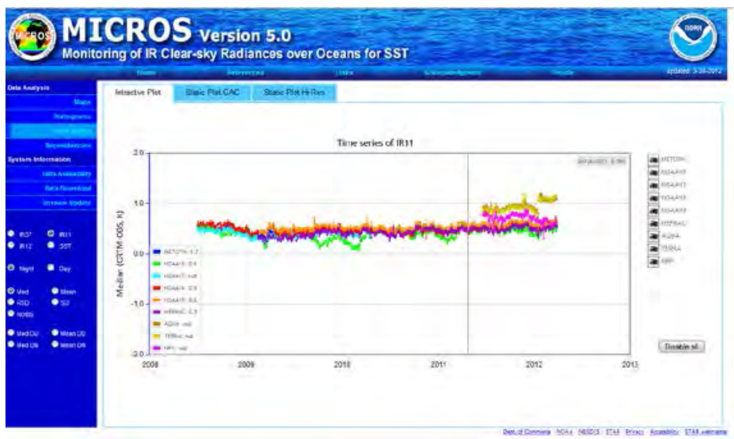


Figure 1. Time series of M-O biases for IR11 band for AVHRR/MetopA (GAC/FRAC), AVHRR/NOAA16-19(GAC), MODIS/Terra & Aqua, and VIIRS/NPP in MICROS V5 (www.star.nesdis.noaa.gov/sod/sst/micros_v5).

2--AQAUM enhancement.

--Aerosol Quality Monitor (AQUAM; http://www.star.nesdis.noaa.gov/sod/sst/aquam/) was established to check consistency between satellite and model aerosol optical depths. The figures below show a subset of the powerful array of data display and analysis capabilities that are built into AQUAM.

--AQUAM functionality was enhanced by adding self- and cross-platform consistency checks.
--New interactive functions, including plots of time series and histograms were included.
--A joint proposal with NCEP, NRL, JCSDA and NASA/GSFC was submitted to the Joint Center for Satellite Data Assimilation (JCSDA) to support this effort.

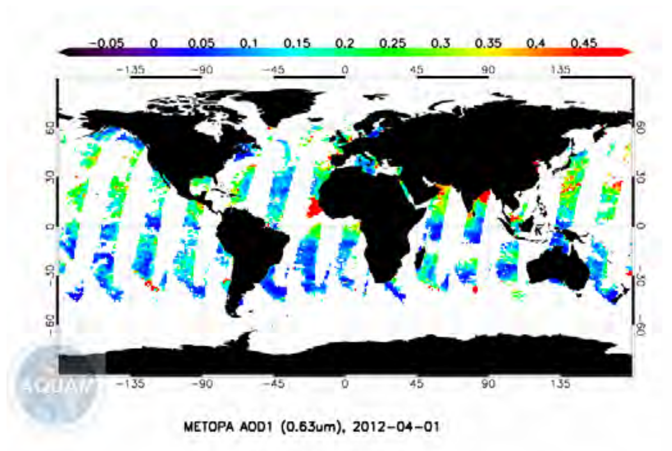


Figure 2. Aerosol Optical Depth (AOD) retrieved from the EUMETSAT MetOp-A polar orbiter satellite for data collected on 1 April 2012, as displayed in the AQUAM tool).

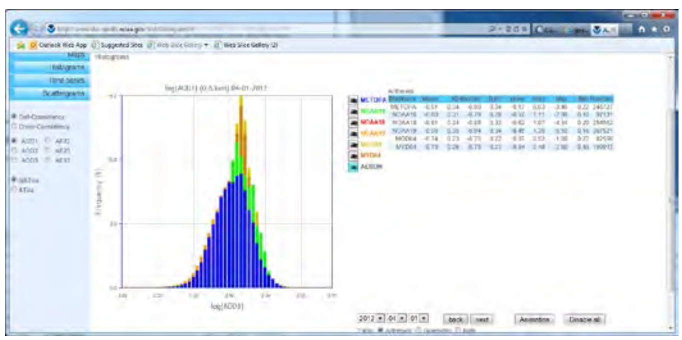


Figure 3. Example of AQUAM histogram analysis for retrieved AOD from satellites. The analysis includes an ability to dynamically interrogate and manipulate the plot.

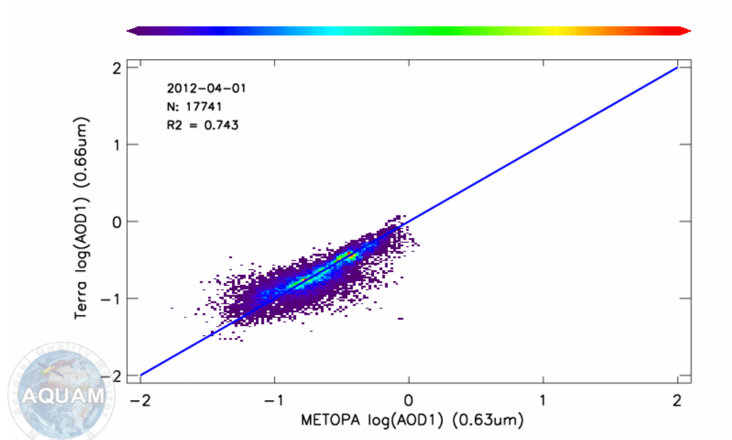


Figure 4. Example of AQUAM display of cross-sensor comparisons of AOD for Terra MODIS and MetOp-A (AVHRR) for 1 April 2012.

3--ACSPO Development.
--An initial version of ACSPO V2.0 for MODIS and VIIRS using the AVHRR cloud mask, and tested in MICROS v5.
--Worked on optimizing VIIRS processing (including code efficiency, bug fixing, and memory leak identification and correction).
--Tested the performance of ACSPO V2.0 and V2.1 within MICROS V5, providing technical feedback to the ACSPO Team.

4--Expanding MICROS and AQUAM via Extended Collaborations.
--Work to include MICROS as an integral part of the Global Space-based Inter-Calibration System (GSICS) began with a special presentation at the GSICS Annual Meeting (Beijing, 5-8 March 2012).
--MICROS extension to the Chinese Feng-Yung (FY) satellites has been discussed with the CMA and SST Teams, and an invited talk will be coordinated with CMA on this topic.
--A joint proposal between the STAR/CIRA SST Team, the JCSDA Community Radiative Transfer Model (CRTM) Team, and the Naval Research Laboratory was submitted
--Oral talk on AQUAM was presented at NASA/GSFC.

PROJECT TITLE: NESDIS Environmental Applications Team – Korak Saha, Post Doc

PRINCIPAL INVESTIGATOR: Steve Miller

Research Team: Korak Saha, Xingming Liang

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Yuri Kihai, John Stroup

PROJECT OBJECTIVES:

--Inclusion of Standard Deviation Maps and Dependencies for the NPP-VIIRS, AQUA and TERRA-MODIS in MICROS

--Selecting a first-guess sea surface temperature as input to forward model

PROJECT ACCOMPLISHMENTS:

--1(a) Inclusion of Standard Deviation Maps for the NPP-VIIRS, AQUA and TERRA-MODIS in MICROS

Monitoring of IR Clear-Sky Radiances over Oceans for SST (MICROS) is a Web-based tool (http://www.star.nesdis.noaa.gov/sod/sst/micros/) to monitor model minus observation (M-O) biases in clear-sky brightness temperatures (BTs) and sea surface temperatures (SSTs) produced by the Advanced Clear-Sky Processor for Oceans (ACSPO) system developed at NESDIS. The fast Community Radiative Transfer Model (CRTM) is implemented to simulate clear-sky BTs, using Reynolds Optimum Interpolation Sea Surface Temperature (OISST) and NCEP/GFS atmospheric profiles as inputs. The simulated BTs are used for detecting clouds, retrieving physical SSTs, monitoring sensor performance and validating CRTM. The key MICROS objectives are to fully understand and reconcile the measured and simulated BTs, and to minimize cross-platform biases through improvements to ACSPO algorithms, CRTM and its inputs, satellite radiances, and skin-bulk and diurnal SST modeling.

Until recently, MICROS monitored M-O difference statistics in three AVHRR bands centered at 3.7, 11, and 12 *μm* for five satellites, NOAA-16, -17, 18, -19 and MetOp-A, using the Global Maps, histograms and dependencies of these M-O differences on various physical parameters. MICROS functionality has been extended to additionally monitor clear-sky ocean radiances in AVHRR-like bands of two MODIS instruments onboard Terra and Aqua, and recently launched NPP-VIIRS data. NPP/VIIRS clear-sky radiances are added in MICROS since sensor data became available (01-22-2012). As an example the Global map of the standard deviation of M-O difference for the NPP-VIIRS band centered at 3.7 *μm* is shown in Figure 1.

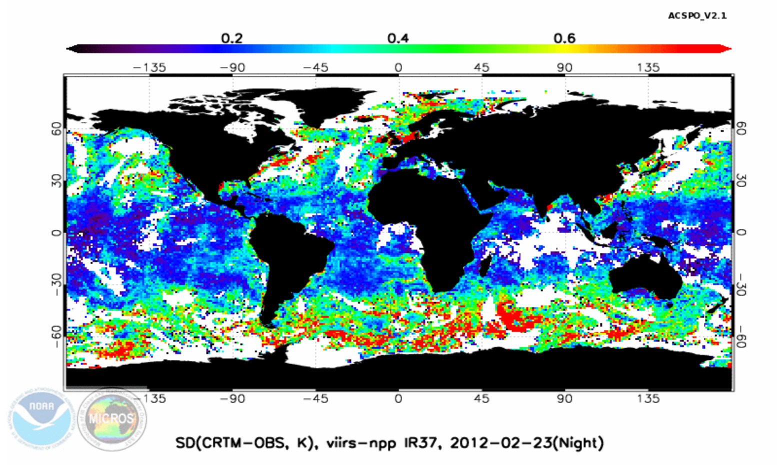


Figure 1. The standard deviation map for NPP-VIIRS (Channel 3.7) in MICROS webpage on 2012-02-23

--1(b) New Dependencies added in MICROS

New dependency plots of the mean/median, standard deviation/robust standard deviation of the M-O differences against Glint angle, Solar Zenith Angle, Bathymetry and Proximity to coast, were added in MICROS. As an example the dependencies for mean and standard deviation of M-O differences on proximity to land are shown in Figure 2. Analysis of their stability in time is underway.

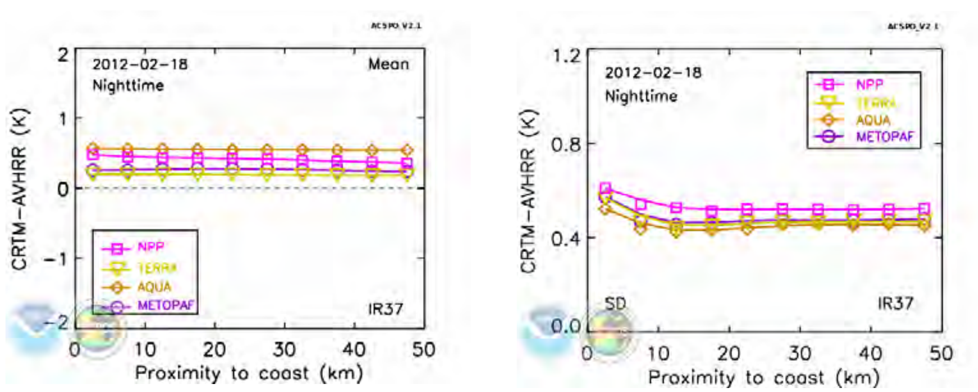


Figure 2. Mean M-O dependencies with the Glint angle, Solar Zenith angle, Bathymetry and Proximity to coast

--2. Selecting a first-guess sea surface temperature as input to forward model in infrared bands

Eleven different gap-free gridded L4 SST fields have been tested for their potential use as a first-guess in ACSPO. The testing is performed by comparing these L4 products with ACSPO L2 SST products ($\Delta T_{L4-L2}=T_{L4}-T_{L2}$) and ranking them using several specially introduced metrics.

The temporal evolution of the global mean ΔT_{L4-L2} ($\mu_{\Delta\varepsilon}$) is plotted in Figure 3 (a) and their root mean square variability ($\sigma_{\Delta\varepsilon}$) in Figure 3(b). In this study the mean and standard deviation of $\mu_{\Delta\varepsilon}$ ($\mu(\mu_{\Delta\varepsilon})$ and $\sigma(\mu_{\Delta\varepsilon})$) and $\sigma_{\Delta\varepsilon}$ ($\mu(\sigma_{\Delta\varepsilon})$ and $\sigma(\sigma_{\Delta\varepsilon})$) are the metrics used to identify the L4 SST which acts as a better first-guess. Apart from that the temporal variability of the Double Difference ($\Delta T_{L4-M2} - \Delta T_{L4-SAT(18/19)}$) is used as another metrics for this purpose. $\Delta T_{L4-M2} - \Delta T_{L4-SAT(18/19)}$ is plotted for both NOAA-18 and NOAA-19 satellites in Figure 4 (a-b).

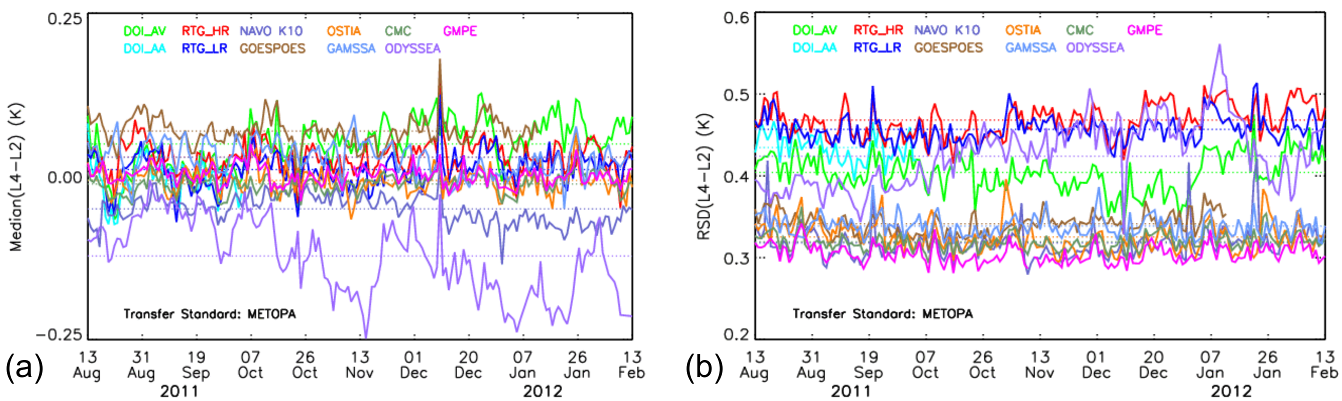


Figure 3. (a) The time series of global median ($\mu_{\Delta\varepsilon}$) for ΔT_{L4L2}, with L2 SST derived from Metop-A GAC data; (b) The time series of global robust standard deviation ($\sigma_{\Delta\varepsilon}$) for ΔT_{L4L2}

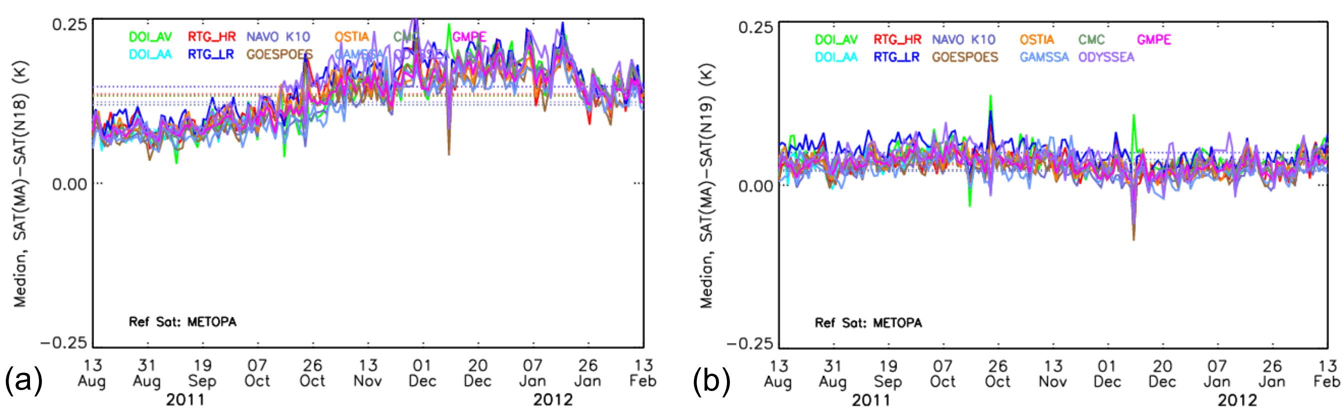


Figure 4. A time series of double differences [$(T_{L4}-T_{L2,MA}) - (T_{L4}-T_{L2,SAT})$] with different L4 SST fields as transfer standard (T_{L4}), Metop-A as reference ($T_{L2,MA}$), for two platforms (a) NOAA-18 and (b) NOAA-19

It is generally observed from the T_{L4}-T_{L2} comparison analysis that the GMPE, CMC 0.2^o and UKMO OSTIA provide an improved combination of metrics and thus serve as a more consistent first-guess SST field for ACSPO

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, Research Scientist

NOAA TECHNICAL CONTACT: Menghua Wang

NOAA RESEARCH TEAM: Wei Shi and Menghua Wang

PROJECT OBJECTIVES:
--Development of new ocean color algorithm
--Application of satellite ocean color for coastal and in-land water ecosystem monitoring.

PROJECT ACCOMPLISHMENTS:
During this period, we have used the SWIR_NIR ocean color algorithm developed in this group to assess the ecosystem of the coastal and inland lake environment and monitor the physical, geochemical and biological processes in the coastal regions.
--Assessment of environmental changes from the Tonga volcano eruption in the southern tropical Pacific
--Study of asymmetrical physical and biological responses to Hurricane Earl
--Study of spring-neap tidal effects on satellite ocean color observations in the Bohai Sea, Yellow Sea, and East China Sea.
--Ocean color atmospheric correction using near-infrared bands for highly turbid regions.
--Sea ice remote sensing with MODIS observations

Excerpts from Project Publications:
Title: Spring-neap tidal effects on satellite ocean color observations in the Bohai Sea, Yellow Sea, and East China Sea.
Author(s): Shi, Wei; Wang, Menghua; Jiang, Lide
Journal of Geophysical Research-Oceans, Volume: 116, 2011, DOI: 10.1029/2011JC007234
Abstract: Eight-year ocean color observations between 2002 and 2009 from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Aqua satellite are used to quantitatively assess the spring-neap tidal effects on variability of ocean optical and biogeochemical properties in the Bohai Sea, Yellow Sea, and East China Sea. We demonstrate that spring-neap tidal variation is one of important ocean processes that drive both the synoptic-scale and mesoscale changes of the ocean optical, biological, and biogeochemical properties in the coastal region. Normalized water-leaving radiance spectra (nLw(λ)), water diffuse attenuation coefficient at the wavelength of 490 nm (Kd(490)), and total suspended matter (TSM) concentration show significant spring-neap variations in the coastal region within a lunar cycle of 29.53 days. In the open ocean, however, spring-neap tidal effects on ocean color data are negligible. The entire areal coverage of the turbid waters (Kd(490) > 0.3 m-1) showing significant spring-neap tidal variations is similar to 4-5 x 105 km2. Similar coverage of moderately turbid waters (0.1 < Kd(490) <= 0.3 m-1) is also impacted by the spring-neap tides. The magnitude of the spring-neap tidal effects on the variations of the satellite ocean color properties, e. g., Kd(490) and TSM, is in the same order as the seasonal variations in the coastal region. Highest Kd(490) and largest turbid water coverage lag the new moon (or full moon) about 2-3 days, while the lowest Kd(490) and smallest turbid water coverage are also similar to 2-3 days behind the one-quarter (or three-quarter) moon. This is attributed to the seawater inertia and the friction against the seabed as well as the sediment resuspension process.

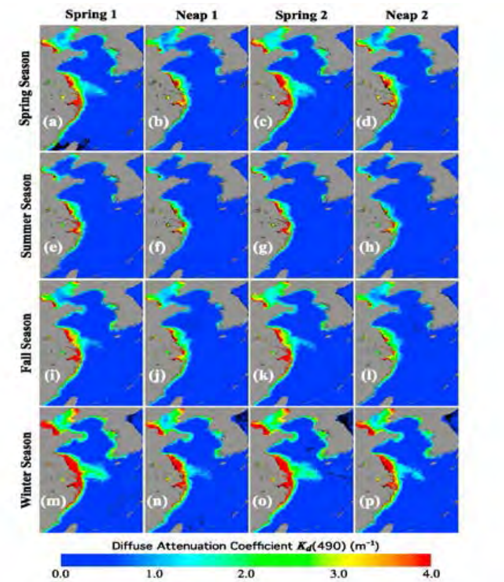


Figure 1. Seasonal variations of K_d (490) for the four different moon phases in the season of (a-d) spring, (e-h) summer, (i-l) fall, and (j-m) winter.

Title: Satellite observations of asymmetrical physical and biological responses to Hurricane Earl Author(s): Shi, W; Wang, MH *Geophysical Research Letters*, Volume: 38, 2011, DOI: 10.1029/2010GL046574.

Abstract: Asymmetrical physical and biological responses to Hurricane Earl in 2010 are revealed with a combined data set of the Moderate Resolution Imaging Spectroradiometer (MODIS) ocean color and Advanced Microwave Scanning Radiometer EOS (AMSR-E) SST observations onboard the satellite Aqua. Hurricane Earl induced broad SST drops and elevated chlorophyll-a concentrations along its track. The ocean's physical and biological responses are notably right-biased when the hurricane passed along the U. S. East Coast. In the ranges within 100 km off the track, the SST dropped 1.85 °C and 1.23 °C on the right and left sides, respectively. On the other hand, the ratios of the chlorophyll-a concentration before and after the passage of Hurricane Earl are 2.04 on the right side and 1.33 on the left. In addition to the satellite-observed sea surface changes, temperature and salinity profiles of an Argo float on Earl's track show the ocean's physical response occurred mostly within the mixed layer and thermocline in the upper 70 m water column.

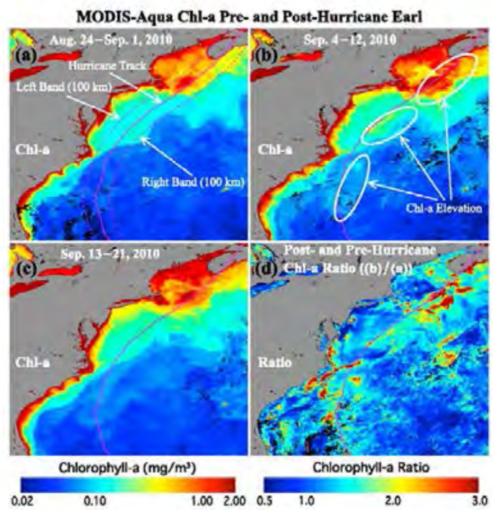


Figure 2. Chlorophyll-a concentration distributions derived from MODIS-Aqua observations (a) before Hurricane Earl between August 24 and September 1, (b) after Hurricane Earl between September 4 and September 12, (c) after Hurricane Earl between September 13 and September 21, and (d) chlorophyll-a ratio between post-hurricane chlorophyll-a (September 4–12) and pre-hurricane chlorophyll-a (August 24–September 1). The hurricane track is overlaid in each image. Dash lines parallel to the hurricane track in panel (a) mark the 100 km bands to the hurricane's left and right sides. In panel (b), regions of notable chlorophyll-a elevation are outlined in white.

Title: Ocean sand ridge signatures in the Bohai Sea observed by satellite ocean color and synthetic aperture radar measurements
Author(s): Shi, Wei; Wang, Menghua; Li, Xiaofeng; et al.
Source: Remote Sensing of Environment Volume: 115 Issue: 8 Pages: 1926-1934, 2011.
Abstract: Satellite measurements from Synthetic Aperture Radar (SAR) and the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Aqua platform are used to study the ocean sand ridges in the eastern Bohai Sea in China. Even though the imaging mechanisms for SAR and MODIS-Aqua remote sensing are different, the sand ridges are shown to have exactly the same patterns in images from both sensors. Therefore, the location, extension and coverage of the ocean sand ridges can be detected and cross-examined by both SAR and MODIS-Aqua observations. Satellite images show quite different sand ridge distribution pattern from the published bathymetry map (based on in situ data) that shows six sand ridges in the area. 10 finger-shaped sand ridges are identified from satellite observations. The tidal-current/sand-ridge interaction driven physical and optical changes are assessed and evaluated. The existence of sand ridges causes enhanced water diffuse attenuation coefficient Kd(490) and elevated normalized water-leaving radiance at the red and near-infrared (NIR) wavelengths. The sea surface over the sand ridges experiences significant seasonal variability of water turbidity and shows remarkable differences from nearby ocean regions. During winter, Kd(490) values are about 2-3 m-1 over the ridges, while the maximum Kd(490) in the neighboring oceans is approximately 1.5 m-1. In summer, the enhancement of the sea surface turbidity is less significant than that which occurs in winter.

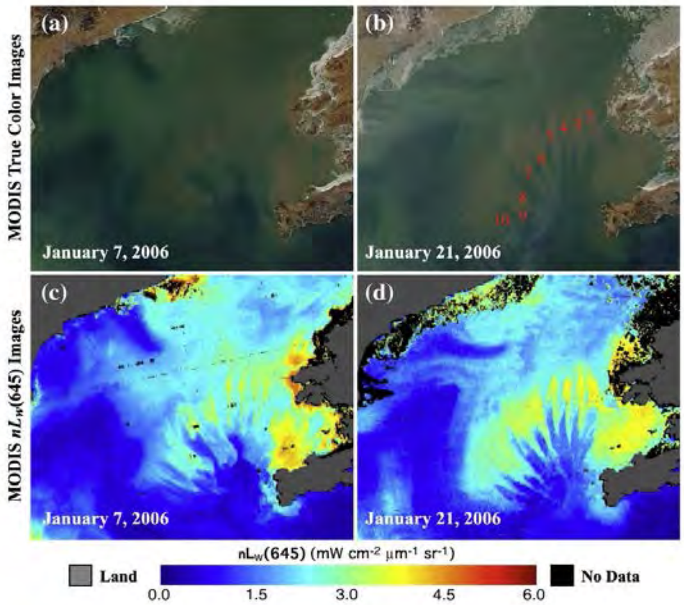


Figure 3. Two cases of the clear-scene MODIS-Aqua observations of sand ridges for (a) and (b) true color images on January 6 and 21, 2006, respectively, and (c) and (d) the corresponding spatial patterns of *nLw*(645) on January 6 and 21, 2006, respectively.

Title: Satellite observations of environmental changes from the Tonga volcano eruption in the southern tropical Pacific Author(s): Shi, W.; Wang, M. *International Journal of Remote Sensing,* Volume: 32 Issue: 20 Pages: 5785–5796, 2011.

Abstract: Satellite measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua were used to study changes of the ocean and atmosphere following the eruption of a submarine volcano in March 2009 in the southern tropical Pacific. Significant increase of water turbidity was observed in an area of similar to 368 km2 near the location of the eruption due to the deposition of volcanic ash. In the ocean region close to the volcanic eruption, the diffuse attenuation coefficient at a wavelength of 490 nm, Kd(490), increased from similar to 0.025 to 0.16 m-1 before and after the volcanic eruption. Within two weeks of the event, the coverage of the ash-laden waters decreased to similar to 30 km2, and after four weeks the satellite-measured marine environment parameters returned back to the pre-eruption condition. The normalized water-leaving reflectance spectra, derived from the combined near-infrared (NIR) and shortwave infrared (SWIR) atmospheric correction algorithm for the ash-laden water, show some unique optical features, different from those of the sediment-dominated turbid waters, river plume waters or other productive waters. No significant sea surface temperature (SST) change was detected from satellite measurements near the eruption site. Volcanic ash plumes in the atmosphere were observed moving north-eastward following the ocean winds on 18 March 2009. The aerosol optical thickness increased from 0.06 on the previous day to 0.25 at a location similar to 60 km north-east of the volcanic eruption site.

Title: Atmospheric correction using near-infrared bands for satellite ocean color data processing in the turbid western Pacific region Author(s): Wang, Menghua; Shi, Wei; Jiang, Lide
Optics Express, Volume: 20 Issue: 2 Pages: 741-753, 2012

Abstract: A regional near-infrared (NIR) ocean normalized water-leaving radiance (nLw(λ)) model is proposed for atmospheric correction for ocean color data processing in the western Pacific region, including the Bohai Sea, Yellow Sea, and East China Sea. Our motivation for this work is to derive ocean color products in the highly turbid western Pacific region using the Geostationary Ocean Color Imager (GOCI) onboard South Korean Communication, Ocean, and Meteorological Satellite (COMS). GOCI has eight spectral bands from 412 to 865 nm but does not have shortwave infrared (SWIR) bands that are needed for satellite ocean color remote sensing in the turbid ocean region. Based on a regional empirical relationship between the NIR nLw(λ) and diffuse attenuation coefficient at 490 nm (Kd(490)), which is derived from the long-term measurements with the Moderate-resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite, an iterative scheme with the NIR-based atmospheric correction algorithm has been developed. Results from MODIS-Aqua measurements show that ocean color products in the region derived from the new proposed NIR-corrected atmospheric correction algorithm match well with those from the SWIR atmospheric correction algorithm. Thus, the proposed new atmospheric correction method provides an alternative for ocean color data processing for GOCI (and other ocean color satellite sensors without SWIR bands) in the turbid ocean regions of the Bohai Sea, Yellow Sea, and East China Sea, although the SWIR-based atmospheric correction approach is still much preferred. The proposed atmospheric correction methodology can also be applied to other turbid coastal regions.

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:

--Processing and validation/evaluation of the JPSS VIIRS data
--Processing and Validation/evaluation of the Geostationary Ocean Color Imager (GOCI) data
--Development of bio-optical and biogeochemical algorithms for the satellite ocean color data use in the coastal waters

PROJECT ACCOMPLISHMENTS:

--The two VIIRS data sets from IDPS-EDR and NOAA-MSL12 processing have been being processed over the various ocean waters (Hawaii region, South Pacific Gyre, US east coast, Yellow & East China seas, and Mediterranean Sea). In situ bio-optical data were compared for validation of the VIIRS data in various regions.
--The first geostationary ocean color imager (GOCI) data in 2011, derived using a new atmospheric correction algorithm, were processed and compared with in-situ bio-optical data.
--Regional algorithms of total suspended sediments in the Chesapeake Bay and of turbidity in China's Lake Taihu have been developed. The results were submitted to internal scientific journals.

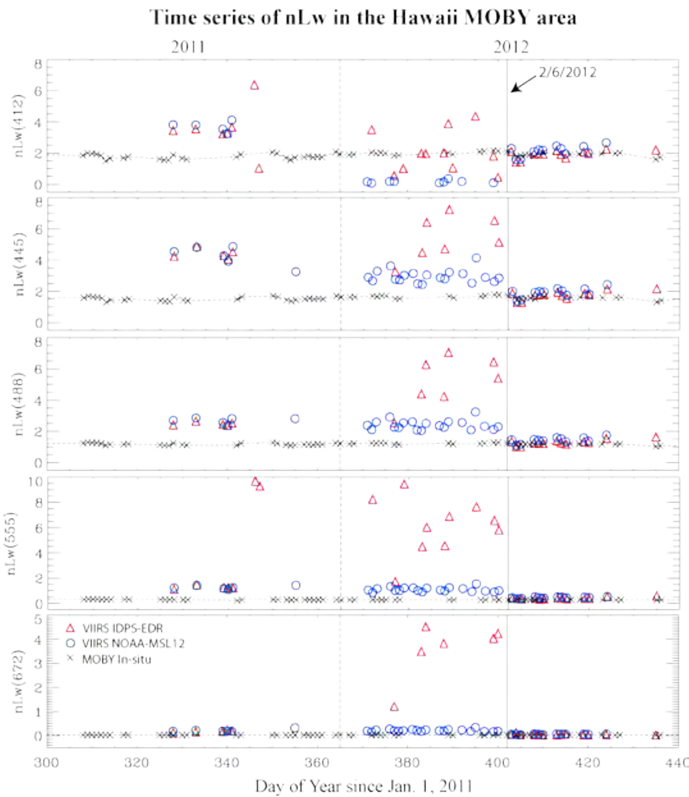


Figure 1. Time series of the normalized water-leaving radiances ($nL_w(\lambda)$, where λ=412, 445, 488, 555, and 672 nm) from the VIIRS IDPS-EDR, VIIRS NOAA-MSL12, and in-situ measurements.

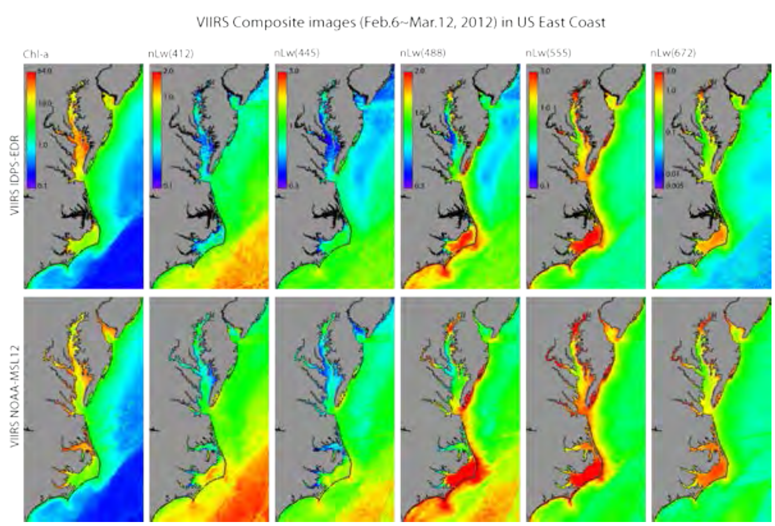


Figure 2. Composite images (Feb. 6 ~ Mar. 12, 2011) of VIIRS IDPS-EDR and NOAA-MSL12 in the US East coast.

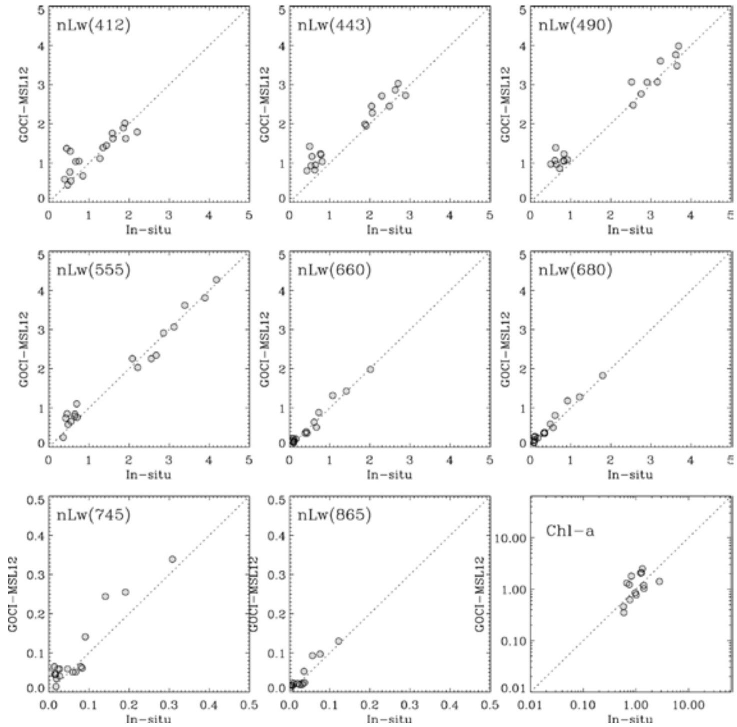


Figure 3. Matchup comparisons between in-situ and GOCI normalized water-leaving radiances and chlorophyll-a data.

PROJECT TITLE: NESDIS Environmental Applications Team – Sirish Uprety, Research Associate – Vicarious Calibration of Imaging Radiometers

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Sirish Uprety, Research Associate

NOAA TECHNICAL CONTACT: Changyong Cao, NOAA/NESDIS/STAR

NOAA RESEARCH TEAM: Sirish Uprety and Changyong Cao

PROJECT OBJECTIVE: To identify, characterize and compare stable calibration targets in terms of radiometric, spectral and spatial aspects in order to reduce the uncertainty in measurement of Imaging Radiometers

PROJECT ACCOMPLISHMENTS:
EO-1 Hyperion observations were used to analyze the spectral characteristics of different types of calibration targets such as Desert sites (such as Libya NOAA site, Sonoran Desert and Dunhuang Desert), Antarctica Dome C site, Deep Convective Clouds and Moon. One of the key hyper-spectral analysis is that it not only

helps calibration scientists to understand the spectral characteristics but also helps to analyze the spectrally induced bias between multiple instruments contributed due to the spectral differences of the targets and the differences in the spectral response functions of the instrument themselves. Radiometric biases between AVHRR, MODIS and NPP/VIIRS at all above targets were computed using EO-1 Hyperion observations. The study can be a major contribution to reduce the uncertainty in cross calibration and establish the radiometric consistency among satellite instruments.

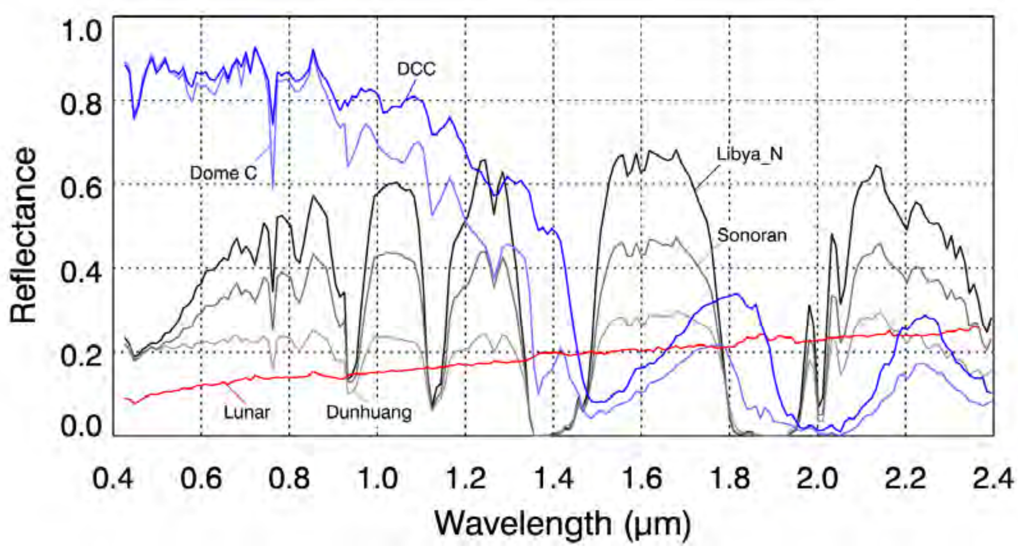


Figure 1. Libya-NOAA site, Lunar, Deep Convective Cloud, Dome C, Sonoran Desert, and Dunhuang Desert Top of the Atmosphere (TOA) reflectance retrieved from Hyperion

PROJECT TITLE: NESDIS Environmental Applications Team – Tong Zhu, Research Scientist - Microwave Remote Sensing of Atmospheric and Surface Parameters and Their Applications in Numerical Weather Prediction Models

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Tong Zhu: 100% FTE

NOAA TECHNICAL CONTACT: Fuzhong Weng, NOAA/NESDIS/STAR

NOAA RESEARCH TEAM: Fuzhong Weng

PROJECT OBJECTIVES:

--GOES-R Proxy Data Development:
During the past year, I helped STAR government PI to do the management of this project. I worked closely with GOES-R AWG/AIT team to provide new data sets as they requested. I also maintained AWG central disks and proxy data sets; provided proxy data to

AWG users and answered their questions; wrote monthly report for Proxy data team.

--GOES-R3, IR Land surface emissivity study: Two new emissivity models were connected with CRTM model. The first one is the NASA/LARC IR land emissivity model retrieved from IASI observation and the second one is UW-RTTOV IR emissivity module. I analyzed the two new emissivity data sets, and performed impact study on CRTM simulation and GFS forecast. It was found that the major difference and variance of the two emissivity models are over desert regions, where UW emissivity is smaller than IASI emissivity for about 0.01 – 0.02. Two seasons (spring and winter) one-month GSi/GFS impact study were conducted by using the new emissivity models. The total assimilated observation numbers for IR sensors are increased, and there is very little change of the assimilation numbers for microwave sensors. There is small positive impact on GFS forecast when using IASI emissivity model in spring time, and small positive impact in winter time when using UW emissivity model. GSI analysis with UW-RTTOV emissivity model leads to warm temperature and dry moisture fields over desert regions at lower atmospheric levels as compared with using LARC IASI emissivity model (see Figure 1).

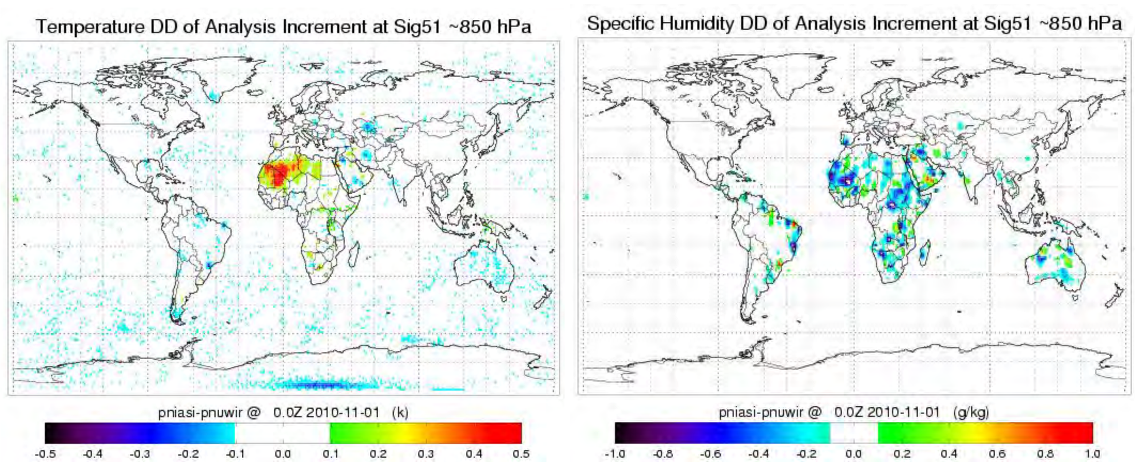


Figure 1. Analysis increments difference between experiments with IASI emissivity and UWIR emissivity over sig-L51 (~850-hPa) at 0000 UTC Mar 11, 2011 for (a) temperature, (b) specific humidity fields.

--Joint Global OSSE Study:
I have been working on the joint OSSE project for several years. Last year, I conducted simulation and validation of the synthetic satellite radiances of AMSU-A, HIRS, GOES Sounder for the Joint OSSE study. I also produced one month synthetic radiance simulation for ATMS sensor by using ECMWF Nature Run as into data.

--Analysis ATMS Observations:
After the launch of NPP satellite on October 28, 2011, I began to analyze the ATMS observation data. I found there are cross track biases for ATMS three surface channels, Ch-1, 2 and 16, which are similar to that of AMSU-A. A theoretic is used to simulate the bias. The result indicates that there is about 1 to 2 degree polarization misalignment for ATMS antenna.

PROJECT TITLE: Research and Development for GOES-R Risk Reduction (GOES-R3) for Mesoscale Weather Analysis and Forecasting; and Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events (AWG)

PRINCIPAL INVESTIGATOR: Steve Miller

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

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, Donald W. Hillger, John Knaff, Dan Lindsey, Deb Molenar, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

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 work done in the areas of GOES-R Risk Reduction (R3) and GOES-R Algorithm Working Group (AWG). 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. CIRA's GOES-R3 and AWG work can be divided into the following nine different projects:

<u>GOES-R3 Research Areas</u>
1--Data Assimilation: Utility of GOES-R Geostationary Lightning Mapper (GLM) using Hybrid Variational-Ensemble Data Assimilation in Regional Applications.
2--Severe Weather: Convective Storm Forecasting 1-6 Hours Prior to Initiation.
3--Training: National and International Training Development, Delivery, and Distribution
4--Tropical Cyclones: Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes.
5--A Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index.
6--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
7--Precipitation: Improvements to QPE using GOES Visible ABI and Model Data.

<u>AWG Research Areas</u>
8--GOES–R Proxy Data Application: Development, Evaluation, and Testing.
9--Support of GOES-R Imagery/Visualization Team in RGB Applications.

These projects support the following NOAA mission goals: Weather and Water, Commerce and Transportation, Climate. Enhanced training will also prepare forecaster/manager on how to utilize satellite imagery and products to provide services in these areas.

PROJECT ACCOMPLISHMENTS:

<u>1--Data Assimilation: Utility of GOES-R Geostationary Lightning Mapper (GLM) using hybrid variational-ensemble data assimilation in regional applications</u>

For this data assimilation work we used the NOAA operational modeling system, the

Weather Research and Forecasting Nonhydrostatic Mesoscale Model (WRF-NMM). The WRF-NMM system was interfaced with our Maximum Likelihood Ensemble Filter MLEF. We began to assimilate the NOAA operational observations (NOOBS). In a related NOAA project we have assimilated AMSU-A cloudy microwave radiances, shown in Fig 1. The results indicate a positive impact of assimilating microwave radiances, in both intensity and location of the storm.

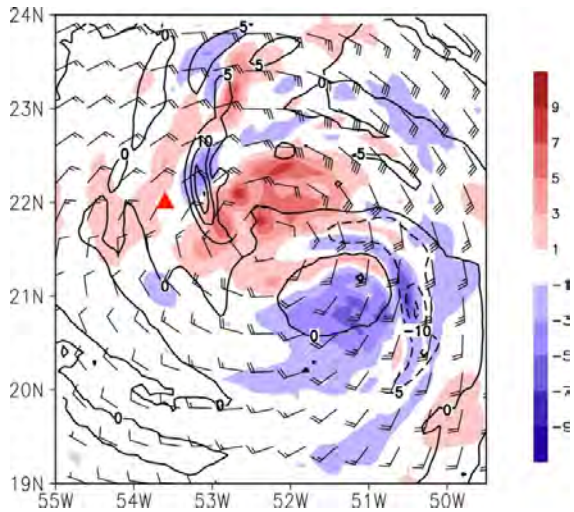


Figure 1. Assimilation of Advanced Microwave Sounding Unit-A (AMSU-A) all-sky satellite radiances into the NOAA Hurricane-WRF (HWRF) modeling system with prototype hybrid variational-ensemble data assimilation system (HVEDAS). Shown is the difference between the HVEDAS and NOOBS.

Upon completion of this task, we began work on an initial evaluation of the system in application to severe weather and constructed benchmark experiments (without lightning data). Work also began work on the development and adaptation of the forward observational operator for lightning data and made initial evaluations. The observational operator based on the link between maximum vertical velocity and lightning flash rate was developed. At the end of this reporting period, the lightning observational operator was ready for testing in stand-alone mode, the final step before proceeding to its application in a complete data assimilation system.

<u>2--Severe Weather: Convective Storm Forecasting 1-6 Hours Prior to Initiation. (CIRA/CIMSS project)</u>

As part of the "Severe Weather Convective Storm Forecasting" project, CIRA performed simulations with the Weather Research and Forecasting (WRF) forecast model combined with CIRA's radiative transfer model (RTM). We collected MeteoSat Second Generation (MSG) proxy data, collected non-satellite Convective Initiation (CI) predictors, and began to investigate how the split window difference (i.e., the 11 - 12 μm brightness temperatures) can be modified to account for varying low-level temperature lapse rates. To do so, we collected MSG data throughout the summer of 2011. Since MSG has bands near 11 and 12 μm, a split window difference can be calculated as a proxy for the ABI's 10.35-12.3 μm. The case study chosen for analysis was: 21 May 2011; a day that featured a relatively large area of clear skies across the Central Plains and a number of unique convective initiation events across Texas, Oklahoma and Kansas. To match the time resolution of the Advanced Baseline Imagery (ABI), NOAA's National Severe Storms Laboratory (NSSL) agreed to re-run their 4-km Advanced Research WRF model (WRF-ARW) for this day, saving the output every 5 minutes. That data was sent to CIRA and to the Cooperative Institute for Meteorological Satellite Studies (CIMSS), from which synthetic ABI imagery for bands 7-16 was generated. Selected loops from that synthetic imagery output can be viewed here:

http://rammb.cira.colostate.edu/dev/lindsey/loops/ (scroll down to “21 May 2011 Case Study)

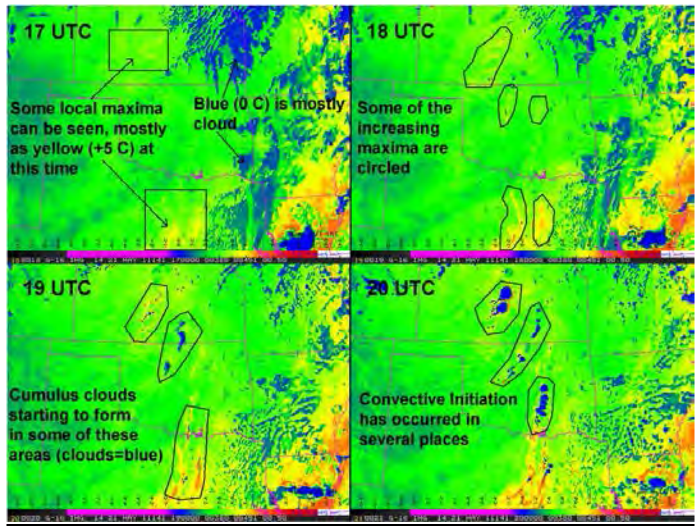


Figure 2. Simulated 10.35 – 12.3 μm from the 17-20-hour forecast from the 21 May 2011 WRF-ARW forecast. Green to yellow to red shows increasing positive values of the split window difference, indicative of a moistening pre-storm environment, and clouds are generally blue.

Results from these simulations show local maxima in the split window difference 2-3 hours prior to convective initiation, suggesting possible pre-storm environment predictive aid.

3--Training: National and International Training Development, Delivery, and Distribution

In collaboration with the Virtual Institute for Satellite Integration Training (VISIT) team, we revised the web content on GOES-R Satellite Proving Ground pages with focus on the GOES-R Product List. In close collaboration with the CIMSS training team an agreement was reached such that CIRA and CIMSS tables display similar content while retaining information needed for researchers, developers and users. Highlights include links to relevant training, contacts, and user feedback. The new “Usage” column provides a means to organize products into topic areas for a Satellite Hydro-Meteorology (SHyMet) GOES-R course. CIRA’s updated page can be viewed at: http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list/

The training team also worked on analysis of training trends for World Meteorological Organization (WMO) Focus Group training trends. The WMO Focus Group of the Americas and the Caribbean started in March 2004. It was launched through the cooperative efforts of CIRA, the National Weather Service (NWS) Training Division, the International Desk at the National Centers for Environmental Predictions (NCEP), the University of Costa Rica, the Caribbean Institute of Meteorology and Hydrology, and CIMSS. We recently started looking at participation trends – by individuals, and by country.

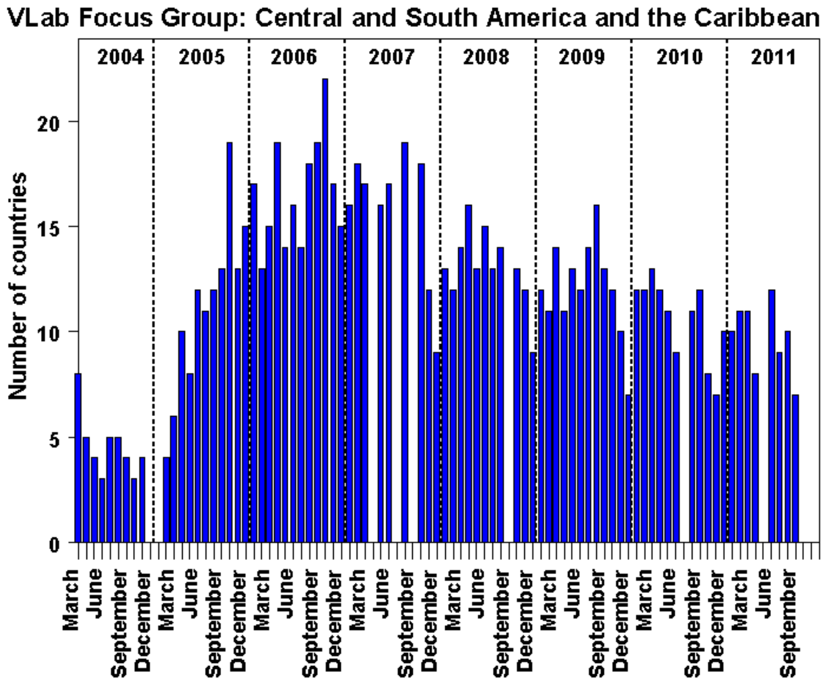


Figure 3. Graph showing the number of Central and South American and Caribbean countries that have participated in the WMO Virtual Laboratory for Education and Training Matters in Satellite Meteorology (VLab) monthly virtual focus group sessions since the inception of the focus group in March 2004 through December 2011.

Figure 3 gives a first look at country participation. Information is being further analyzed to determine successes of the focus group and how to continue with activities in the future. A presentation "What drives online participation patterns for a focus group?" is being prepared for the 9th International Conference on Creating Activities for Learning Meteorology (CALMet). CALMet is being held 3-8 October 2011 at the University of Pretoria in South Africa. Funding for the trip is being provided by WMO and another CIRA project "Support of NOAA's commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory". CALMet has been a forum to share experiences, expectations, and new ideas for applying emerging strategies for meteorology and hydrology in education and training. The conference provides opportunities for learning from others who work both within and outside these disciplines, from professionals who all face similar challenges and share a similar passion for improving their practice. The theme of the conference falls along the work of the World Meteorological Organization's Virtual Laboratory for Education and Training Matters in Satellite Meteorology (VLab). VLab members have recognized the scope and benefits of PG activities and have already proposed an action to "Write general guidelines for a transition plan to support user readiness for new satellite generations". CIRA serves on this action committee. A draft of guidelines was presented to VLAB management group members for their review and comments in October 2011.

4--Tropical Cyclones: Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes

The first task of this tropical cyclone (TC) project concentrated on the creation of a Radius of Maximum Wind (RMW) climatology. These climatologies were created using the extended best track and ATCF aircraft storm position fixes. In addition, we also decoded the aircraft flight-level data 1995-present. This data allowed for the analysis of the wind field and an independent (from those reported in the extended best track and the fix data) and objective determination of RMW. Tropical cyclone aircraft reconnaissance data from 1995-2010 came in a variety of different ASCII formats, temporal resolution (30 Hz ,10 Hz, 1 Hz) and included different data types (flight-level and SFMR). CIRA successfully completed the conversion of all existing post season and real-time (HDOBS) aircraft reconnaissance data to a simple and standardized ASCII format.

Task 2 of this project focused on a satellite-based TC size database and algorithm development. Using the Atlantic and East Pacific storms contained in the CIRA Infrared (IR) TC image archive and a size parameters derived from the Global Forecast System (GFS) analysis (i.e., the tangential wind at r=500 km or VT500), an objective method for estimating tropical cyclone size based on a single IR image, storm position and storm intensity has been developed. Results show that 35% GFS-based VT500 could be explained using information contained in the imagery along with latitude an intensity, but 13% more than could be explained by latitude and intensity alone. The fit to the GFS-based VT500 was lower than was initially expected, However upon examination of individual cases, it was clear that this objective method was doing a good job of detecting size changes in TCs, which suggests that the GFS-based VT500 metric contains not only contributions of the storm circulation size, but also an environmental contribution from winds that surround the storm.

The VT500 predicted from the imagery can be normalized by the climatological expected VT500 as a function of latitude and intensity, similar to Knaff and Zehr (2007). Doing so creates a nearly normal distribution of TC size. One can then examine small (<-0.67 σ), average and large (> 0.67 σ) TC composites as a function of three separate intensities as shown in Figure 2. These purely objective TC size measurements, which appear to remove the more random environmental contributions to VT500, will be used to investigate purported size relationships with the environmental moisture variations in the next several quarters.

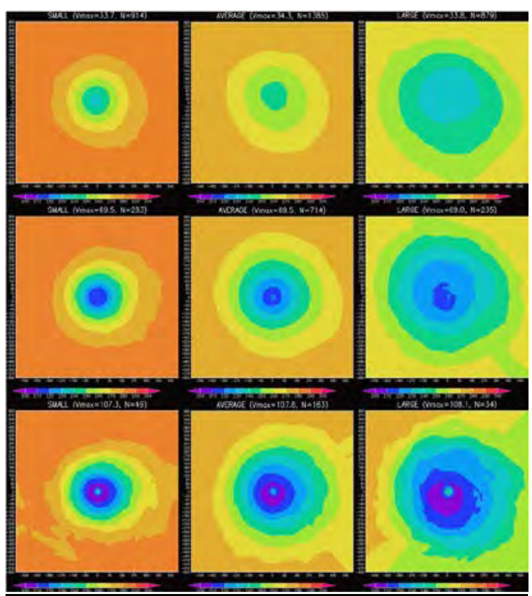


Figure 4. Composite average brightness temperatures within 600 km of the center of east Pacific and Atlantic tropical cyclones. These are motion relative composites with the TCs moving toward the top of the page. First, second and third rows show composites that have intensities between 29 and 44 knots, 64 and 76 knots and 102 and 114 knots. The columns represent the smallest 25%, average sized, and the largest 25% in our sample, going left to right. Titles provide statistics for each panel and the temperature scales are identical for all panels.

After the completion of the reformatting of the aircraft data, we commenced work on the analyses to estimate the flight-level radii of maximum winds from those data.

5--A Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index

As part of the "Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index" project, storm relative IR predictors were collected in real-time during the 2011 hurricane season. The IR imagery from invest systems and numbered systems have been combined. The goal is to reprocess the storm relative predictors once the final best tracks are available. The experimental Rapid Intensification Index (RII) and RIC (lightning corrected) that were produced during the season were made available at ftp://rammftp.cira.colostate.edu/demaria/nhcpg

In order to adapt the RIC algorithms to the western North Pacific, Western Pacific version of SHIPS and LGEM have been developed. These are being tested on cases from the 2008-2011 typhoon seasons. Preliminary results show that both the SHIPS and LGEM models have greater skill in the West Pacific than current models, but the LGEM model has a slight low bias. Once this test is completed, the Rapid Intensity Change algorithm will be adapted, tested and disseminated to the Joint Typhoon Warning Center (JTWC). The code will also be supplied to the Navy Research Laboratory in Monterey.

6--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 is a collaboration project between three cooperative institutes: the Center for Analysis and Prediction of Storms (CAPS; University of Oklahoma [OU]), CIMSS, and CIRA. The project employs 4-km Storm-Scale Ensemble Forecasts (SSEFs) produced by CAPS for the NOAA Hazardous Weather Testbed (HWT) Spring Experiments. Utilizing national supercomputing resources, synthetic imagery is being generated in real-time, for several infrared channels from 10-15 ensemble members, at hourly intervals. Three radiative transfer model packages are being employed in the project. They include 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 will be 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 will be sought so as to provide insights for improving the CRTM system, which is part of the operational data assimilation systems at NCEP.

During this reporting period the CIRA component of this project focused on the enhancement of the CIRA RTM package to ensure compatibility with the microphysics used in the SSEF members. The test the packages used sample output from the spring 2010 CAPS SSEF. In addition, CIRA wrote software to generate synthetic ABI and GOES infrared brightness temperatures within the existing CAPS ensemble post-processing system.

7--Precipitation: Improvements to QPE using GOES visible ABI and model data

This precipitation project involves collaboration 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 by terrain and/or overshooting the precipitation of distant storms. 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 were made using high resolution cloud structure from the GOES visible imagery (daytime) estimates of cloud top phase and particle size, and moisture and wind fields from numerical weather model and model+satellite "blended" datasets. Preliminary work at the

National Severe Storms Laboratory (NSSL) indicated that a simple technique to identify fine-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 to provide cloud-top effective radius retrievals for selected case studies. The GOES cloud liquid water particle size retrieval algorithm was modified and made to run on real-time GOES data. Output was provided via McIDAS ADDE server to NSSL.

8--AWG: Development, Evaluation, and Testing of GOES-R ABI Fire Proxy Dataset

In support of GOES-R algorithm development, the CIRA proxy data fire team produced GOES-R ABI proxy data sets simulating a strong Texas Panhandle wildfire which occurred on 27 February 2011 (see Figure 5 below). During this event we observed the individual fire hot spots moving relatively fast eastbound (due to strong westerly winds). This rapidly spreading fire added an interesting new component to our proxy dataset (fire pixels moving in space and flickering in time).

Brightness temperature datasets together with radiance or reflectance were produced for four GOES-R ABI bands (2.25 μm, 3.9 μm, 10.35 μm, and 11.2 μm) at the appropriate (2 km) ABI footprint as well as for GOES-13 at 3.9 μm. These synthetic measurements form the base input to GOES-R fire retrieval algorithms currently in development.

CIRA's synthetic dataset is based on a WRF-ARW forecast model. Fire location and temperatures information come from a GOES-based ABBA retrieval dataset which was created CIMSS fire proxy team. The ABBA-retrieved fire temperatures were linearly interpolated to represent 5-minute ABI data. An observational operator was run to produce the synthetic imagery. The 2.25 μm band provides a higher dynamic range for determination of fire temperature and fire size than the other three wavelengths because of its higher fire saturation temperature. Synthetic GOES-R true color imagery was produced for individual time steps. True-color products created included fire hot spots with a realistic smoke plume evolving over time.

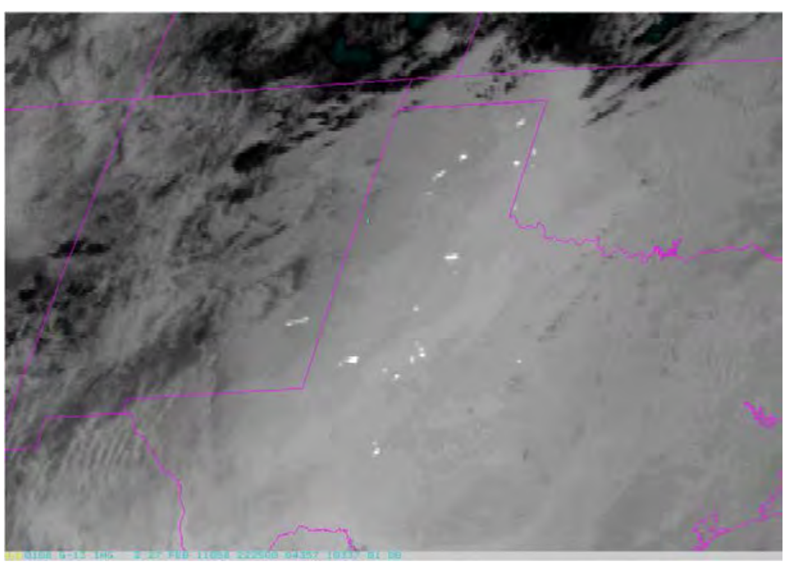


Figure 5. GOES-13 image depicting the 27 Feb 2011 wild fires over the Texas Panhandle

The CIRA-produced high quality synthetic GOES-R fire proxy datasets serve in support of the test procedures of the fire detection algorithms for ABI. The research results regarding the use of the 2.25 μm ABI band for fire retrieval could possibly result in an improvement of fire retrievals once GOES-R is launched. Finally, high quality imagery in the 3 visible bands will lead to development of better imaging and visualization capacity for new shortwave bands on GOES-R ABI.

9--Support of GOES-R Imagery/Visualization Team in RGB Applications

The CIRA Team collaborated closely with NOAA-NESDIS and CIMSS scientists to support the continued development of an Algorithm Theoretical Basis Document (ATBD) for imagery and visualization applications using the GOES-R Advanced Baseline Imager (ABI). This project focused on the usage of Red/Green/Blue (RGB) color composite imagery techniques applied to multispectral ABI data as a way of highlighting specific features of the potentially complex meteorological scene. These 'value-added' imagery techniques have proven extremely effective in providing forecasters with quick-look depictions of the specific information required for rapid scene characterization and short-term forecasting (nowcasting) guidance. During the annual report period CIRA developed "Natural Color Capabilities" for the ABI, conducted research toward the demonstration of new and improved products and datasets for product development, created datasets for smoke and trace gas detection in fire scenarios, displayed new products real-time on the RAMMB home page, and leveraged the GOES-R Satellite Proving Ground for RGB application demonstration.

PROJECT TITLE: Scientific Support to the GOES-R Algorithm Review Board

PRINCIPAL INVESTIGATOR: Thomas H. Vonder Haar

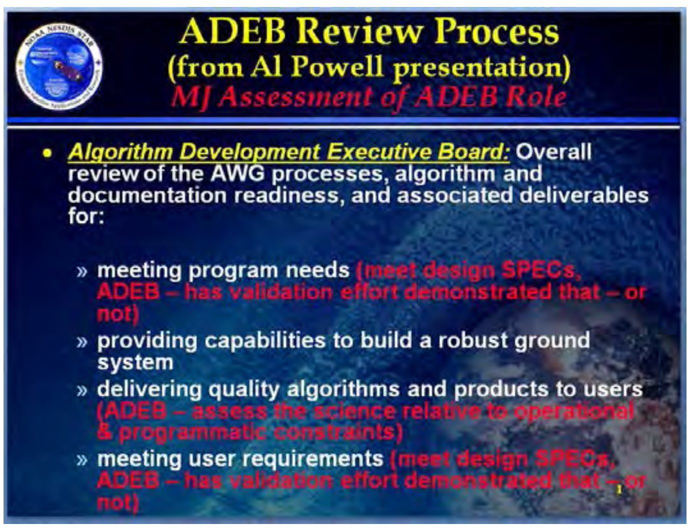
Research Team: Tom Vonder Haar, Holli Knutson

NOAA TECHNICAL CONTACT: Steve Goodman, GOES-R Project Scientist

NOAA RESEARCH TEAM: Very large NOAA Program led by Mr. Greg Mandt

PROJECT OBJECTIVES: Serve as a Member of the GOES-R Algorithm Development Executive Board (ADEB)

PROJECT ACCOMPLISHMENTS:
Objectives for ADEB include those noted in the graphic below by Mike Johnson, our Coordinator. We reviewed all GOES-R algorithm status reports, ATBD's and peer reviews of algorithms against those objectives and against both heritage and state-of-the science performance. (Review results are listed in the ADEB reports to the GOES-R Project Office, NESDIS, NOAA).



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

PRINCIPAL INVESTIGATORS: Dan Bikos and Bernadette Connell

RESEARCH TEAM: Jeff Braun, Kevin Micke, Laurel Kessler, Kathy Fryer.

NOAA TECHNICAL CONTACT: Ingrid Guch and Philip Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria, Dan Lindsey

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 later 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 (Figure 1) reaches out to as broad an audience as possible given the busy schedule of NWS forecasters. Over 23,000 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: http://rammb.cira.colostate.edu/visit/

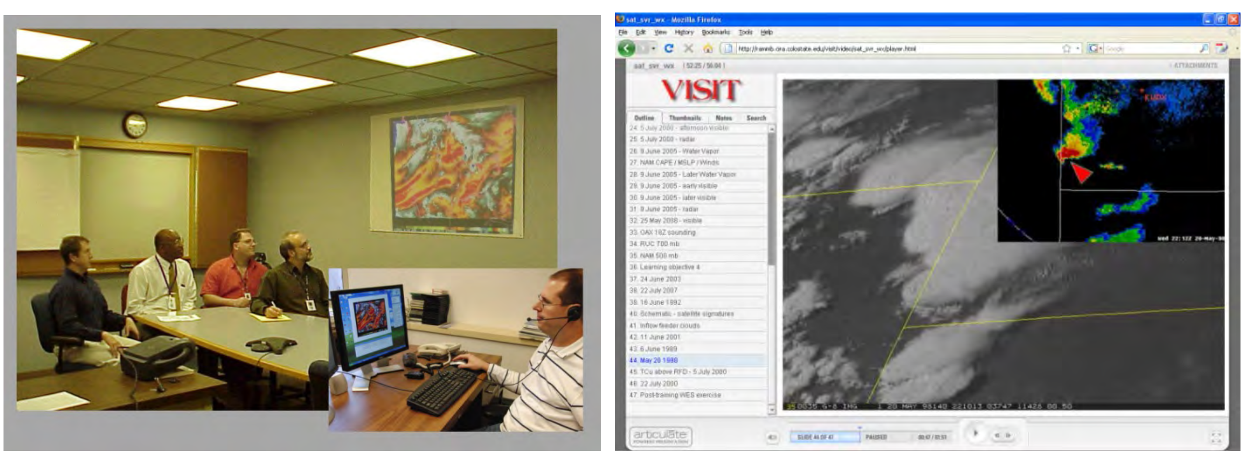


Figure 1. Live VISIT teletraining (left), and audio / video playback VISIT training module (right).

PROJECT ACCOMPLISHMENTS:

1--VISIT training metrics April 1, 2011 – February 17, 2012:
--Live teletraining: 33 sessions delivered to 205 participants.
--Audio / video playback (through NOAA's Learning Management System as well as directly through CIRA's web interface): 521 participants.

2--Training sessions:
--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".
--Support for new training session led by Scott Lindstrom (CIMSS) – "Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection".
--Support for new training session led by Ross Van Til (FDTB) – "GOES-15 Becomes GOES-West".

3--The "Utilizing Synthetic Imagery from the NSSL 4 km WRF-ARW model in Forecasting Severe Thunderstorms" training session was delivered to the entire staff of the Storm Prediction Center (27 participants) in preparation for the upcoming severe weather season. This was accomplished via 5 teletraining sessions in February through early March 2011.

4--VISIT blog:
--Many additions were made to the Blog over the past year. 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/

5--Community Outreach:
--J. Braun. A presentation with general guidelines to "Talk about the weather" was given on one occasion in 2011 to students of Rocky Mountain High School who attend the *Introduction to Chemistry, Physics, and Earth Sciences* (ICPE) classes.

--Volunteer work supporting after-school weather club: B. Connell and K. Gebhart ran a weekly after-school weather club on Mondays for Putnam Elementary (K-5) for 7 weeks during March through May 2011 and 8 weeks during September through December 2011. There were two back to back sessions each week of 45 minutes in duration for March through May 2011, while there was only one 90 minute session each week during the September through December session. Sessions covered snow, wind (speed and direction), clouds, temperature, and things that spin as well as measurements that are associated with these weather occurrences. Putnam has a coordinator who is responsible for matching students with clubs, assigning classrooms, providing snacks, and providing transportation – which is great!

PROJECT TITLE: Tropical Cyclone Model Diagnostics and Product Development

PRINCIPAL INVESTIGATOR: Wayne H. Schubert

RESEARCH TEAM: Kate Musgrave, Brian McNoldy, Louie Grasso, Robert DeMaria, Kathy Fryer

NOAA TECHNICAL CONTACT: Mark DeMaria NOAA/NESDIS/RAMMB

NOAA RESEARCH TEAM: John Knaff, Mark DeMaria., CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

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.

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

PROJECT ACCOMPLISHMENTS:

<u>1--Forward radiative transfer model development</u>
One of the challenges of model evaluation is the limited availability of observations, especially over the open ocean where tropical cyclones spend most of their lifetime. Determining the accuracy of model fields in the upper part of the storm is especially problematic. To address this problem, the model forecast fields were used as input to forward radiative transfer algorithms to provide synthetic satellite imagery. These were then compared to real satellite data (Grasso et al., 2008). This technique was applied to output from the HWRF model, with an emphasis on infrared satellite data available from the GOES satellites. The GOES data have very high temporal and spatial resolution, which makes it well-suited for model validation. The comparison of the synthetic and real IR data was used to identify errors in cloud top structures, which are related to the model treatment of convective processes. General comparison code and IR databases was provided to other groups within HFIP for additional model verification.

<u>2--Statistical post-processing</u>
Physically-based dynamical models provide the most accurate tropical cyclone track forecasts. However, because of the complexity of the problem, empirically-based statistical-dynamical models still provide the most accurate intensity forecasts (Franklin, 2010). The most accurate Atlantic statistical intensity models in the 2008-2010 hurricane seasons were the Logistic Growth Equation Model (LGEM) (DeMaria et al., 2009) and the Statistical Hurricane Intensity Prediction Scheme (SHIPS). The operational versions of LGEM and SHIPS were run using input from the NHC official forecast track and the deterministic run of the NCEP global forecasting system (GFS). To improve the accuracy of intensity forecasts, LGEM and SHIPS were run with input from additional regional and global models. The ensemble mean of the LGEM and SHIPS intensity forecasts was compared with the single deterministic run to evaluate the potential for improvement. This capability was demonstrated in near real time during the 2011 hurricane season with very encouraging results.

<u>3--Model diagnostic code development</u>
Work continued on the development of diagnostic code, with emphasis on the HWRF and GFDL regional hurricane models. The emphasis was on parameters related to the storm environment, and a version was provided to the NCEP Environmental Modeling Center to assist with the model inter-comparison and pre-season testing and evaluation of the HWRF model.

<u>4--Improved model diagnostic studies</u>
To enhance the code in item (iii) above, research was performed to develop new capabilities for model diagnostics. These studies included adapting the balance model theory and vortex structure evaluation capabilities, using the vortex profile originally developed by Holland (1980).

<u>5--Tasks related to the CIRA part of the National Oceanographic Partnership Program (NOPP)</u>
The HFIP is working closely with NOPP on the development of improved hurricane forecasts. As part of that coordination, the statistical models SHIPS and LGEM were adapted to run in the western North Pacific. New predictors from a new high resolution ocean analysis system were tested along with those from balance model theory with input from aircraft and microwave satellite imagery. The satellite imagery was used to estimate the convective heating field, which is the forcing function for the balance model geopotential tendency equation (Vigh and Schubert 2009).

<u>6-- Ensemble product development</u>
There are two basic strategies for improving tropical cyclone forecast models. One is to focus on the development of the best possible deterministic forecast model. The other is to use a more probabilistic approach by considering an ensemble of forecast models with perturbed initial conditions and model physics. The HFIP program is addressing both of these approaches. One of the challenges of the ensemble approach is the development of forecast tools for NHC, which is tasked with

providing a deterministic forecast of track, intensity and structure. NHC already provides a number of probabilistic products in terms of the probability of 34, 50 and 64 kt winds, in addition to a cone of uncertainty and a maximum wind probability table. Most of the NHC probabilistic products are derived from a statistically based Monte Carlo wind speed probability model (DeMaria et al. 2009), which randomly samples from the past 5 years of NHC's track and intensity error distributions. In this CIRA ensemble project, we adapted NHC's Monte Carlo wind speed probability model to utilize the ensemble forecasts for the dynamical models being developed under HFIP. The initial emphasis was on using the track ensembles. Using this method, the standard set of NHC probabilistic products was generated and evaluated by comparison with the operational version of the products. This capability will be demonstrated in real time during the 2012 hurricane season.

7--Analyze Atmospheric Motion Vector (AMV) experiments

As described in the introduction, one of the primary HFIP tasks is to improve hurricane model forecasts through better data assimilation. NCEP/EMC was testing the assimilation of various new data types in the HWRF, including AMW. Although this is a not a primary task for CIRA, AMV datasets were collected during the 2010 and 2011 seasons to assist with this evaluation and made available to other groups within HFIP.

8--Comparison of simulated and real microwave imagery

In item (i) above, real and simulated IR imagery from GOES was being compared. Several HFIP groups including NCEP/EMC and OAR/AOML were developing similar capabilities for microwave imagery. CIRA coordinated with these groups on the comparison of the real and simulated imagery in several case studies. This comparison provided insight in the ability to initialize and simulate the inner core convective structure of the storm.

9--Make satellite data available to other teams

CIRA collected a wide variety of satellite data and products in storm relative coordinates for global tropical cyclones. This data was provided to other HFIP teams to assist with their model evaluation and verification activities.

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 - Advanced High Performance Computing

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Tom Henderson, Jeff Smith, Jacques Middlecoff, Ning Wang, Jim Rosinski, George Carr, Jr.

NOAA TECHNICAL CONTACT: Mark Govett, OAR/ESRL/GSD/ACE

PROJECT OBJECTIVES: CIRA researchers will collaborate with ESRL meteorologists with 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). CIRA researchers will provide software support to ESRL scientists including software design advice and expertise on a variety of software/web/database technologies. CIRA researchers will continue to modify the Flow-following, Finite volume Icosahedral Model (FIM) software to enhance interoperability with 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. CIRA researchers will interact with the ESMF Core development team to specify requirements for features needed by FIM, NIM, and other NOAA codes. CIRA researchers will continue to serve on the National Unified Operational Prediction Capability (NUOPC) Common Model Architecture (CMA) and Content Standards subcommittees. CIRA researchers will continue to 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.

CIRA researchers will collaborate with the Developmental Testbed Center Ensemble Team (DET) to modify WRF Portal to support running complex WRF ensembles on the GSD Jet and TACC Ranger supercomputers. They will also continue to develop, improve, and support WRF Portal, FIM Portal, and WRF Domain Wizard. CIRA researchers will 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), perform load tests, generate graphs and reports, and enable guided ad-hoc querying of these web services. CIRA researchers will serve on the GSD program review committee and the NOAA Earth Information Service (NEIS) committee (a project listed in NOAA’s 2011 Annual Guidance Memorandum as a priority for NOAA). CIRA researchers will 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.

PROJECT ACCOMPLISHMENTS: CIRA researchers worked with ESRL meteorologists to improve the science driving NIM, and incorporate new methods into NIM, in a way that is structured and optimized to be efficient on the GPU, including GFS physics and GRIMS physics. With Dr. Bao, CIRA researchers incorporated GFS physics into NIM. CIRA researchers merged Dr. Jin Lee's new aqua planet dynamics, including the new GRIMS physics, into the existing well-structured and parallelized software resulting in a parallel aqua planet NIM with the runtime choice of either GFS or GRIMS physics. The new aqua planet dynamics was ported to the GPU and software structure was put in place that allows the dynamics to run on the GPU while physics runs on the CPU. CIRA researchers optimized serial and parallel NIM on the GPU. CIRA researchers also used NIM as a test case to investigate the stability and features of new commercial GPU compilers from CAPS and Portland Group. Many compiler bugs and limitations were found and fed back to the vendors yielding improved products that better address our needs.
CIRA researchers enhanced the capabilities of SMS including updating to cuda 3.0 for the GPU and optimizing the GPU message passing interface by adding pinned memory and "zero copy." CIRA researchers also extended SMS implementation of communications for icosahedral grids to support mixed precision (REAL*4 and REAL*8). CIRA researchers continue to assist SMS users and to find and fix bugs.

CIRA researchers worked on the optimization of several basic numerical operations in the dynamics, pre-processing and post-processing of the model to speed up computation, reduce memory consumption, and improve robustness of numerical computations. The algorithmic work includes the creation of a new scheme for spherical linear interpolation for scalar and vector variables.

To study the spectral properties of data sets from the global model, CIRA researchers created a set of utilities that perform spherical spectral analysis on global model data over the icosahedral grid. The utility package also implements several common numerical operators in the spherical spectral domain.

CIRA researchers upgraded grid generation software to include two new icosahedral grid generation schemes. CIRA researcher also integrated the two new schemes into the current FIM grid generation package to allow them to work with mixed bi-section / tri-section subdivisions.

CIRA researchers upgraded FIM to build and run correctly using the latest ESMF-based NEMS software infrastructure, upgraded FIM to ESMF 3.1.0rp2, ported FIM to cirrus/stratus, integrated FIM code and build automation into the latest NEMS framework, added FIM system tests to the NEMS test suite, and committed to the NEMS trunk. This satisfies a key milestone for transition of FIM into operations. CIRA researchers authored an article on GIM Tool, a Google Earth-based tool for visualizing global icosahedral datasets, published in the Spring 2010 issue of CIRA Magazine.

CIRA researchers created Domain Wizard for LAPS (Local Analysis and Prediction System), a tool for initializing domains used by LAPS. They also added HWRF (Hurricane WRF) support in Domain Wizard by supporting the import of hurricane tcvitals files and automatically creating HWRF domains for them.

CIRA researchers continued development of WRF Portal, implementing advanced workflow management features, limited ensemble support, and improved workflow monitoring, error reporting and visualization capabilities.

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—AFWA, FNMOC, and NCEP. They also served on the NUOPC Content Standards Committee (CSC) to define meta-data conventions to be shared by operational NWP models.

CIRA researchers continued investigating fault-tolerant communication mechanisms and execution modes with the goal of recommending a solution that addresses crucial reliability problems in planned operational NWP ensembles and can be integrated into the Earth System Modeling Framework (ESMF). Use cases and prototypes were refined and delivered to the ESMF core team for integration into the ESMF.

CIRA researchers provided FIM grid details to Bob Oehmke on the ESMF core team so ESMF can be extended to support icosahedral grids used by FIM and NIM.

CIRA researchers ported FIM to NOAA's new “gaia” supercomputer.

CIRA researchers assisted GSD scientists with initial efforts to couple FIM to ocean (HYCOM), physics (Grell parameterizations from WRF), and atmospheric chemistry.

CIRA researchers created an offline program to convert FIM data sets to NetCDF following the Climate and Forecast Meta-data Conventions. NetCDF files produced by this program can be automatically read and plotted by a variety of open-source graphics programs.

CIRA researchers continued to improve software engineering processes for FIM and NIM. To ease porting and maintenance of FIM, CIRA researchers restructured and modernized the FIM build automation. The FIM build can now run in parallel on multi-core nodes greatly speeding build time. System-specific build-time settings have been factored out into separate "macro" files allowing easier modification and creation of future ports. In addition, automatic generation of file dependencies was expanded to reduce our recurring maintenance costs. CIRA researchers also enhanced FIM portability by redesigning FIM initialization procedure to use industry-standard MPI calls in place of site-specific system software to assign MPI tasks to cores at run-time. And CIRA researchers helped construct a FIM benchmark (including SMS) for distribution to vendors during the NOAA "Site-B" procurement, verifying its correct execution on jet (GSD), jaguar (ORNL Cray), and various AIX platforms at NCEP and NCAR

CIRA researchers have collaborated with CIRES researchers to co-develop a prototype of TerraViz, a 3D spinning globe application that was funded via Directors Discretionary Funds (DDF) by GSD Director, John Schneider, and supported by ESRL Director, Sandy MacDonald. TerraViz will be the visualization front end of the new NOAA Earth Information Service (NEIS). CIRA researchers co-authored a DDF proposal for creating 3D visualization capabilities for the FIM and NIM models, and this proposal was also funded by John Schneider. This work has been combined with TerraViz.

CIRA researchers won a GSD Web Award for work on the (NextGen) NNEW Testbed website, adding a number of new features including the ability to perform ad hoc queries against various OGC web feature services (WFS) and web coverage services (WCS) and dynamically convert the responses into maps and charts that are displayed within the web application. They gave a talk on the project at the AMS meeting in New Orleans and assisted in the annual FAA Capability Evaluation tests at the FAA Tech Center.

CIRA researchers collaborated with the Developmental Testbed Center Ensemble Team (DET) to port complex WRF workflows from Jet to the Texas Advanced Computing Center (TACC) to run on their supercomputer, Ranger. They also improved WRF Domain Wizard by adding some new features, including doubling the resolution of the global maps and also led the development of FIM/WRF Portal, adding a new ensemble “wizard” screen to facilitate creating ensemble workflows (also used by DET).

CIRA researchers serve on the GSD Program Review committee, the DTC science advisory board (SAB), and the NEIS program committee. CIRA researchers gave talks at NCAR workshops and tutorials on WRF Domain Wizard and WRF Portal. They also gave talks about GPU-related work at the NCAR Software Engineering Assembly (SEA) conference SAAHPC2011, HPC & GPU Supercomputing Group of Denver/Boulder, and the "Programming weather, climate, and earth-system models on heterogeneous multi-core platforms" symposium at NCAR.

PROJECT TITLE: EAR - Fire Weather Modeling and Research

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sher Schranz, Hongli Jiang, Steve Albers, Isidora Jankov

NOAA TECHNICAL CONTACT: Zoltan Toth, OAR/ESRL/GSD/FAB

NOAA RESEARCH TEAM: Yuanfu Xie OAR/ESRL/GSD/FAB, Steven Peckham, CIRES/CU, Ruddy Mell, NIST

PROJECT OBJECTIVES:
1) Coordinate NOAA/NIST coupled fire weather/fire behavior modeling activities. NOAA has provided funding for fire weather modeling for FY11. Sher Schranz is the ESRL/GSD Program Manager.

2) Coordinate ingest of experimental models into operational systems. Coordinate collaborative field studies.

3) Coordinate fire weather modeling and decision support tools research with NWS, University, US Forest Service and BLM fire weather researchers and users.

4) Formally respond to the NOAA Science Advisory Board's Fire Weather Research 'A Burning Agenda' report and recommendations.

5) Conduct model downscaling research, investigate the use of high resolution ensemble models in US Forest Service operations, and develop web interface tools for model initiation and data delivery.

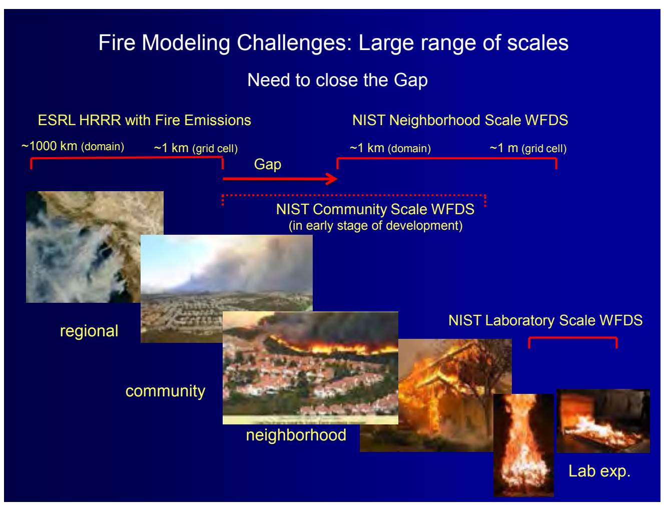


Figure 1. Fire Weather Research

PROJECT ACCOMPLISHMENTS:
1) Closely coordinated coupling weather and fire models' research direction and progress with Dr. Hongli Jiang and Dr. Peckham.

Provided the CIRA and NOAA research teams with research focus and program direction based on the NOAA Science Advisory Board recommendations and collaboration with the NWS and US Forest Service.

Sher Schranz was assigned by the new NOAA Strategy Execution and Evaluation (SEE) office as a Subject Matter Expert (SME) for fire weather observations and field evaluations. As the NOAA SEE SME, Sher completed an evaluation of NSF fire weather-related proposals, one UAS fire weather sensor SBIR proposal, and SEE requirements documents. She is also on the Science Advisory Board for the NOAA UAS program for Fire Weather Observations.

2) A new version of the experimental GSD 3km WRF/Smoke model was integrated into the FX-Net system for use by fire weather forecasters during the FY11 fire weather season. No formal assessment was conducted.

3) Multiple meetings and telecons were held in FY11 in support of the NOAA-USFS Collaborative Fire Weather Research MOU. Collaborative working groups and research teams were developed to create 2 year and 5-year research goals. The 2-year plans identified funding required, but no funding sources have been identified.

4) An SAB recommendations progress report was developed by the NWS fire weather program office and the CIRA team and briefed to the NWS, OAR and USFS directors.

5) Model downscaling research and the use of ensemble models for fire weather operations was conducted with Hongli Jiang as the Principal Investigator. Objectives of this work are to use the dynamical downscaling method to provide high-resolution wind information to the office of NWS's Incident Meteorologists (IMETs) working at wildfires.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Brian Jamison

NOAA TECHNICAL CONTACT: Stan Benjamin OAR/ESRL/GSD/AMB

PROJECT OBJECTIVES: Tasks for this project include: generating graphics of output fields, creation and management of websites for display of those graphics, and creation and management of graphics for hallway public displays, including software for automatic real-time updates.

PROJECT ACCOMPLISHMENTS: A website for display of FIM model output http://fim.noaa.gov/FIMscp/ was updated and currently has 37 products available in 9 regions for perusal with 6-hourly forecasts going out to 14 days. Also available are GFS model forecast plots, FIMX (a version with chemistry, for which 7 more products are available for viewing), FIMY and FIMZ (other test versions of the FIM). Difference plots are generated and are available, as are plots of forecast error. A special version of the FIMX was set up to include estimated Cesium emissions from the damaged Japan nuclear reactor to provide some insight on advection of these emissions.

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.

PROJECT TITLE: EAR - LAPS/WRF Modeling Activities

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Steve Albers, Isidora Jankov, Hongli Jiang

NOAA TECHNICAL CONTACT: Zoltan Toth, OAR/ESRL/GSD/FAB

NOAA RESEARCH TEAM: Linda Wharton, OAR/ESRL/GSD/FAB

PROJECT OBJECTIVES: CIRA proposes to provide expertise to develop and deploy LAPS and the WRF for additional applications, including Renewable Energy, Fire Weather, Homeland Security, hurricane model initialization, etc., as newly funded projects and other initiatives arise. Improvements in model initialization and cycled runs will be explored.

PROJECT ACCOMPLISHMENTS:
Convective Initiation- NextGen. There is a possibility that FAB will be funded for exciting research related to convective initiation (CI) in relation to the NextGen project. The proposal from the FAB includes data assimilation and ensemble modeling aspects. For this purpose numerical modeling experiment was designed as follows:

Simulations were performed in real-time during a two-week intensive operational period in the summer. The CONUS ensemble will be used to drive a 10-20-member ensemble of WRF with a 3 km grid. This high-resolution model will cover the Eastern U.S. ("golden triangle"). Ensemble members will be embedded into the coarser resolution CONUS ensemble and will include different cores and physics. Initial perturbations will be dynamically downscaled from the CONUS ensemble to capture analysis uncertainties on the finer scales. For each case, the model will be started every hour and run for 6-8 hours. The combination of high resolution, ensemble, and rapid refresh provides a level of guidance that is not currently available. These predictions will be compared with current operational products. Steve Albers led analysis-related activities while Isidora Jankov led the modeling effort.

Hazardous Weather Testbed. At FAB, two domains were set up for the HWT demonstration—one is a relatively larger domain that is the same as CAPS domain and the other is the smaller 1km inner nest. We set up the following for deterministic control run and ensemble runs:

Domain	Forecast	Resolution	Frequency	Forecast length
CAPS	Deterministic	2.5km	3-6 hour	12 hour
CAPS	Ensemble	7.5km	6 hour	12-18 hour
CAPS (LAPS / STMAS)	Deterministic	3km	6 hour	12 hour
Inner	Deterministic	1km	15 minute	1-2 hour
Inner	Ensemble	3.0km	6 hour	6 hour

Table 1

We list these as a summary for the HWT demo for 2011 and hope to discuss how to continue this in 2012 with NSSL. The purpose of this run is to evaluate and improve the performance of STMAS for 2012 and beyond.

The important features of these runs are:
--3km DA using LAPS
--Fine-scale ensembles
--The timely analysis and forecasts (15-minute analysis and forecast cycle for the deterministic runs).

A STMAS surface analysis was sent to HWT for evaluation. It provides a 2-km analysis over 15-minute cycles over the CONUS grid. A new version of the STMAS surface is nearing the end of development and testing, which is:
--Multivariate analysis
--Topography incorporated
--Background flow dependent
--Simple surface constraints used

Real-time verification was developed and made available online so we can look at the quality of radar reflectivity and other forecasts.

PROJECT TITLE: EAR - Nonhydrostatic Icosahedral Model (NIM)

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

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

NOAA TECHNICAL CONTACT**:** Jin Luen Lee, OAR/ESRL/GSD/OD

NOAA RESEARCH TEAM**:** Jian-Wen Bao, CIRES, Mark Govett, OAR/ESRL/GSD/ACE

PROJECT OBJECTIVES:
--Development of Nonhydrostatic Icosahedral Model (NIM) for kilometer-scale resolution on multiple graphical processing units
--Explicit prediction of small-scale weather systems such as topographic precipitation as well as convective macro-phenomenon like the MJO
--Diagnosing and resolving atmospheric phenomenon using the NIM modeling system

PROJECT ACCOMPLISHMENTS:
--Implementation of NCEP GFS physics option for sequential and parallel processing
--Implementation of three microphysics schemes for moisture processes (WSM1, WSM3, and WSM5)
--Build-up of the interface between dynamics and physics for the aqua-planet simulation and restart run
--Energy budget studies for PBL and radiation
--Set-up of physics parameterizations and symmetric ozone and solar zenith angle for aqua-planet long-term integration
--Development of a new grid generation package for super-high resolution icosahedral-hexagonal grid to carry out grid computation, visualization, and statistic gathering tasks.
--Development of a spherical spectral analysis package for spectral analysis of the model data on icosahedral grid.
--Development of an extensive debugging and diagnostic package for NIM model output analysis and visualization
--Completion of integration of the software packages and libraries by individual developers to create the first version of the model in preparation for the real-data run.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Kevin Brundage, Tracy Smith

NOAA TECHNICAL CONTACT: Stan Benjamin ESRL/GSD/AMB

PROJECT OBJECTIVES: The primary focus of the GSD Assimilation and Modeling Branch 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. The RAP is intended to replace the operational Rapid Update Cycle (RUC), which runs operationally at the NOAA/NWS National Centers for Environmental Prediction (NCEP) in the spring of 2012 (currently scheduled to replace the RUC on March 20, 2012). 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.

CIRA staff is also involved in development and support of the Finite-volume Flow-following Icosahedral global NWP model (FIM). The FIM model utilizes a unique combination of horizontal grid structure based on icosahedral decomposition, an adaptive hybrid isentropic-sigma vertical structure and finite-volume horizontal transport mechanism. The innovative combination of grid structure, dynamics and physics parameterization shows a great deal of promise for both medium (3-5 days) and long range (months-years) weather and climate forecasts. Collaborative efforts are currently underway to couple an ocean model with the atmospheric component.

PROJECT ACCOMPLISHMENTS: While the implementation of the RAP at NCEP was delayed due to availability of resources, the system has been running in NCEP's Environmental Modeling Center (EMC) in a near real-time mode for several months. This system has now passed NCEP's acceptance tests and is awaiting deployment on their operational system by the end of March 2012. This WRF-based model provides enhanced resolution and has proven to improve forecasts of winds aloft and precipitation, two critical elements required by aviation forecasters.

The global FIM model provided experimental guidance at the National Hurricane Center as part of the NOAA Hurricane Forecast Improvement Project (HFIP) during the 2011 hurricane season. Storm track data generated by the FIM provided predicted hurricane tracks as part of this important experiment. Experience gained from this active season provided important feedback used to improve the model physics utilized in this model.

In addition to the important model development work conducted during 2011, CIRA personnel also provided benchmarking and consulting support in the selection of new computational facilities intended to support all of NOAA's R&D efforts. This 382 Tflop high performance computing system was installed at the NOAA Environmental Security Computing Center (NESCC) in late 2011 and is currently in the final acceptance testing period. This system provides over 27,600 computational cores to support the R&D efforts throughout NOAA.

Please see the real time products and additional information available at:

http://ruc.noaa.gov/rucnew/
http://rapidrefresh.noaa.gov/RR/
http://ruc.noaa.gov/hrrr/
http://fim.noaa.gov

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Brian Jamison

NOAA TECHNICAL CONTACT: Steven Weygandt, OAR/ESRL/GSD/AMB

PROJECT OBJECTIVES: Tasks for this project include: Creation and management of automated scripts that generate real-time graphics of output fields, management of web-sites for display of those graphics, and management of graphics for hallway public displays.

Each of the web pages for RR http://rapidrefresh.noaa.gov/, HRRR http://rapidrefresh.noaa.gov/hrrrconus/ , and RUC http://ruc.noaa.gov/rucnew/ have been refined with better graphics, new fields, and more subdomains. The NCEP versions of the RR and RUC have also been included, and difference plots are available.

A webpage with sounding plots http://rapidrefresh.noaa.gov/soundings/ has been added for the local HRRR, RR and RUC models at 98 current NWS radiosonde observation locations. Soundings are plotted on the skew-T graph with inset hodographs and index values (see Figure 1.)

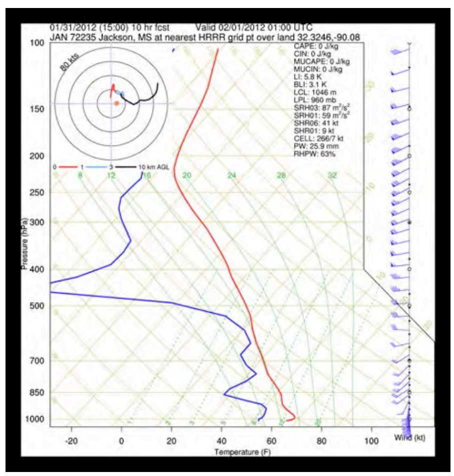


Figure 1. Sounding Plot from the HRRR at Jackson, MS.

Cross section plotting capabililty has been developed for the RUC, RR, and HRRR (currently not available on the web). The cross sections can be height or pressure based, are defined using latitude-longitude pairs, and can be height limited, allowing for analysis of more detail in the lower troposphere. An inset map on the display shows a plan view location of the section.

Many improvements and some new products were added to the RR and HRRR suite, including convective initiation, convective activity, lightning threat, and time-lagged ensemble plots of updraft helicity and composite reflectivity.

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.

PROJECT TITLE: Severe Weather/Aviation Impact from Hyperspectral Assimilation

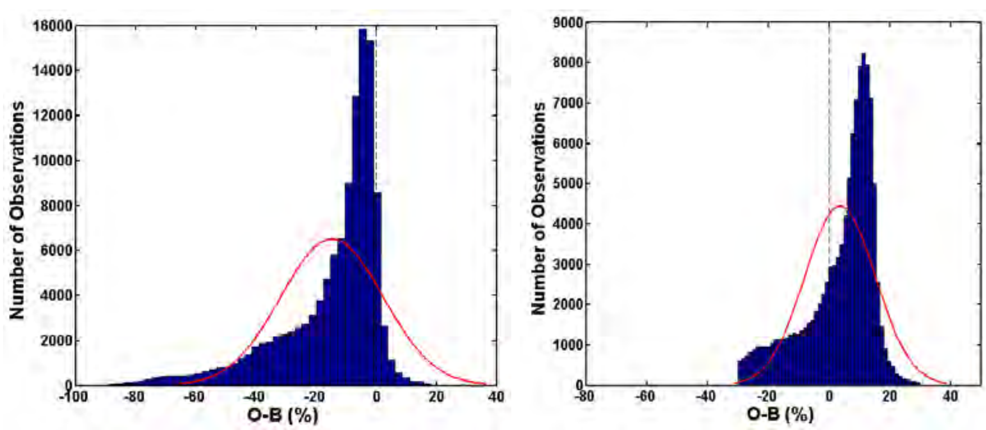
PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Haidao Lin, PhD

NOAA TECHNICAL CONTACT: Steven Weygandt OAR/ESRL/GSD/AMB

PROJECT OBJECTIVES: Investigate the impact from satellite hyperspectral data to severe storms in the Rapid Refresh and increase the accuracy of short range mesoscale model forecast for severe weather by the assimilation of satellite data into the Rapid Refresh.

PROJECT ACCOMPLISHMENTS: In the last year, several steps have been taken to improve forecast skill in the Rapid Refresh (RAP) mesoscale modeling system by incorporating AIRS single field of view (SFOV) retrieved soundings into the RAP assimilation system. First, a moisture bias issue with the SFOV observations was identified and evaluated compared with the RAP background. It was found that SFOV moisture has a noticeable dry bias compared with the background (Figure 1a). This dry bias was also corroborated by comparisons against nearby radiosonde observations. Second, a simple bias correction scheme with +15% (normalized by the background saturation specific humidity) bias correction was applied to the moisture data (Figure 1b).



1(a) 1(b)

Figure 1. Histogram of AIRA SFOV moisture innovations (specific humidity O-B normalized by Background saturation specific humidity) (1) before and (b) after bias correction.

The moisture bias correction procedure reduced the moisture bias for both the analysis and 12-h forecast compared with the experiment without moisture bias correction (Figure 2). Also, the temperature, moisture, and wind forecast skill during the 9-day retrospective period was improved after the moisture bias correction (Figure 3).

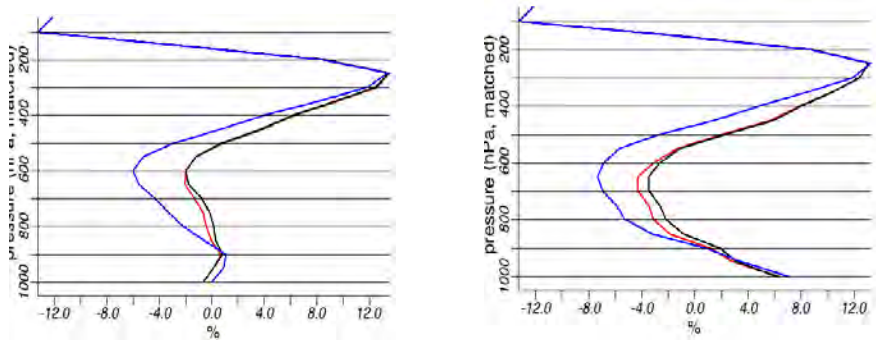


Figure 2. (left) 0-h analysis and (right) 12-h forecast relative humidity bias for control run (black, no SFOV data), SFOV moisture data without bias correction (blue) and SFOV moisture data with bias correction.

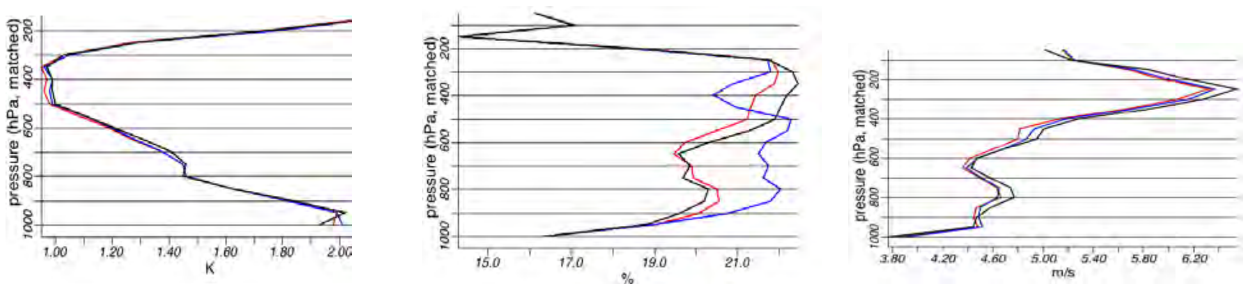
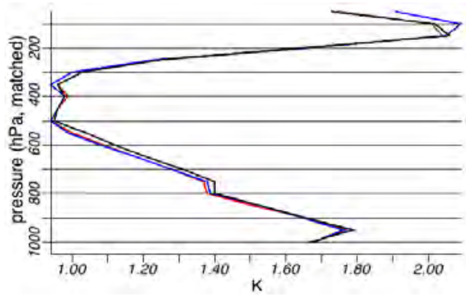


Figure 3. (a) 12-h forecast temperature profile RMS errors (against radiosonde), (b) 12-h forecast relative humidity profile RMS errors, and (c) 12-h forecast vector wind profile RMS errors for the control run (black, without AIRS data), the experiment using the AIRS moisture soundings without bias correction (blue), and the experiment using AIRS moisture soundings with bias correction (red).

Third, a temperature bias correction procedure has been started, focused on correcting the complicated diurnal bias patterns documented in the mean O-B difference (with some accounting for the bias of the analysis relative to the radiosonde observed estimates). Currently, more robust temperature and moisture bias correction schemes are under investigation with a goal of improving forecast skill especially for severe weather. Complementary work has focused on direct radiance assimilation, in particular evaluating AIRS channel selection for RAP based on Jacobian and adjoint sensitivity study. A set of 68 AIRS channels has been selected as the preliminary test for the AIRS channel selection in RAP. It is shown that after removing some upper-level temperature channels, for which adverse effects were from the Jacobian, the 6-h temperature forecast skill in the upper level has been improved as well as the moisture forecast skill compared with using the 120 GDAS channel set (Figure 4). Results from the SFOV assimilation and radiance assimilation work were presented at the 92th AMS annual meeting in New Oreland, LA in January 2012 and the Warn-on-Forecast and High Impact Weather Working Group Meeting in Norman, OK in February 2012.



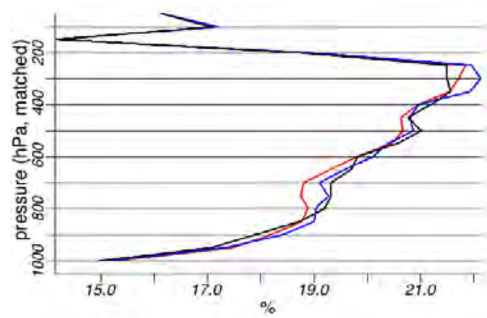


Figure 4. (left) 6-h forecast temperature profile RMS errors (against radiosonde), (right) 6-h forecast relative humidity profile RMS errors control run (black, without AIRS data), the experiment using the AIRS radiance with 120 GDAS channel set (blue), and the experiment using AIRS radiance data with the 68 selected channel set (red).

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: Earth System Research Lab/Global Monitoring Division Carbon Tracker Modeler and Software Developer

PRINCIPAL INVESTIGATOR: David Baker

RESEARCH TEAM: Michael Trudeau, Christopher O'Dell, David Baker

NOAA TECHNICAL CONTACT: Pieter Tans, NOAA/ESRL/GMD

NOAA RESEARCH TEAM: Andrew Jacobson, CIRES/NOAA

PROJECT OBJECTIVES: Help the CarbonTracker team at NOAA to:

--Develop a CarbonTracker software framework that facilitates comparisons of different methods
--Implement, test and modify various community packages for global modeling
--Optimize software on high-performance computing systems
--Diagnose and resolve problems in the CarbonTracker modeling scheme, including models, interfaces, and post-processing
--Prepare, run, and verify annual CarbonTracker release fluxes and case studies
--Publish results in peer-reviewed literature and present at professional conferences

PROJECT ACCOMPLISHMENTS: Since starting on this project last summer, Mike Trudeau has contributed in two main ways to the 2011/2012 release of CarbonTracker (CT). First, he has developed a new flux emission package for the TM5 transport model that will be used in the new modular CT framework both to get CO_2 fluxes into the model and to output the fluxes for documentation purposes. This coding effort has been described as "…the most complex programming challenge … yet encountered in the lifetime of CT." Second, Mike has worked with colleagues in Europe to pre-process ECMWF forecast model output to produce the meteorology variables needed to drive the TM5 model. As this product was no longer produced in the needed format by ECMWF as part of their routine operations, this work was critical for use of TM5 in CT.

As the annual CT release is now finishing up, Mike has shifted his focus to running the TM5 model driven by fluxes produced by the CIRA team (Baker). This will generate one of a suite of four forward model CO_2 runs produced by cross-mixing two sets of CO_2 fluxes (CIRA and CT) with two transport models (CT's TM5 and CIRA's PCTM). The spread of CO_2 concentrations across this suite will be used to quantify model error in the CO_2 flux estimation problem.

No publications, but Mike Trudeau did travel to the Netherlands, to attend a recent TM5 meeting, where he worked on the ECMWF driver issue, as well as familiarized himself with CT run scripts developed by our European CarbonTracker colleagues.

PROJECT TITLE: Ensemble Data Assimilation for Hurricane Forecasting

PRINCIPAL INVESTIGATOR: Milija Zupanski

RESEARCH TEAM: Man Zhang, CIRA, Karina Apodaca, CIRA

NOAA TECHNICAL CONTACTS: Stephen Lord, NCEP/EMC; Bill Lapenta, NCEP/EMC

NOAA RESEARCH TEAM: Stephen Lord, NCEP/EMC

PROJECT OBJECTIVES:
1--In synergy with the JCSDA/EMC development of forward operators for cloudy radiances, evaluate all-sky radiance assimilation in hurricane inner core using ensemble data assimilation (EnsDA).

2--Conduct preliminary HWRF-EnsDA experiments with cloud microphysics control variables in selected hurricane cases.

PROJECT ACCOMPLISHMENTS:
The NOAA HWRF modeling system interfaced with EnsDA has been used to assimilate AMSR-E all-sky satellite radiances in hurricane inner core. A typical experiment setup includes 32 ensemble members and a 6-hour assimilation interval. The system has been evaluated in the Hurricane Danielle (2010) case. Note that the current operational HWRF system does not assimilate data in hurricane inner core. Main accomplishments are:

1) Assimilation of satellite radiances in inner core is beneficial, 2) Assimilation of all-sky radiances adds more observations compared to cloud-cleared radiances, and 3) All-sky radiance assimilation further improves the inner core structure, eventually improving the forecasted hurricane intensity.

To illustrate the improvement of hurricane intensity, we conducted cycling data assimilation experiments for 60-hours. The hurricane intensity forecast (Figure 1) shows a clear improvement over current operational setup in last several cycles, after the EnsDA system warm-up period.

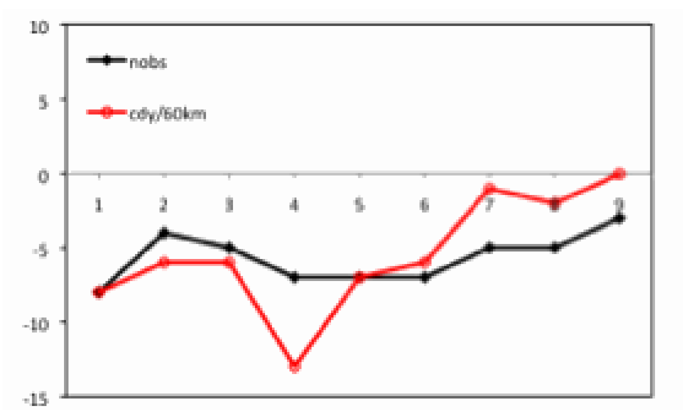


Figure 1. Hurricane intensity (hPa) for Danielle (2010). Black line is control experiment and red line represents results of all-sky radiance assimilation for the inner nest of HWRF.

PROJECT TITLE: EAR - Assimilation of Surface $PM_{2.5}$ Observations using GSI and EnKF with WRF-Chem

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Mariusz Pagowski

NOAA TECHNICAL CONTACT: John Brown, OAR/ESRL/GSD/AMB

NOAA RESEARCH TEAM: Georg Grell, CIRES

PROJECT OBJECTIVES: Implementation of EnKF for air quality prediction.

During the past year, we implemented assimilation of surface $PM_{2.5}$ using WRF-Chem air quality model and Ensemble Kalman Filter. This work builds on results of our previous assimilation studies with GSI. Original EnKF code was obtained from Jeff Whitaker (PSD, NOAA/ESRL) and modified to accommodate aerosols. The work was presented at the Third International Workshop on Air Quality Research Forecasting, Potomac, MD (available on-line).

PROJECT ACCOMPLISHMENTS:
GSI vs. EnKF. GSI is a 3D-VAR method that uses static background error statistics usually derived from climatology such as the NMC method (48-hr fcst – 24-hr fcst); subsequently, a variational problem is solved to obtain optimal solution given model and observation errors. In EnKF, state dependent model errors are obtained from an ensemble of simulations; next, an optimal solution is obtained using Kalman filter equations. Such approach has significantly higher computational cost because of the need for multiple ensemble forecasts but potentially can provide better estimates of model errors.

Experiment Outline. Observations of hourly concentrations of surface $PM_{2.5}$ are obtained from AIRNow network which provides measurements in a timely manner suitable for real-time forecasting and model evaluation. The map of stations is shown in Figure 1. Modeling domain covers the continental US with a 60-km grid (Figure 2) and extends to 50 mb using 40 vertically stretched layers.

Figure 1. Real-time AIRNow $PM_{2.5}$ measurements network

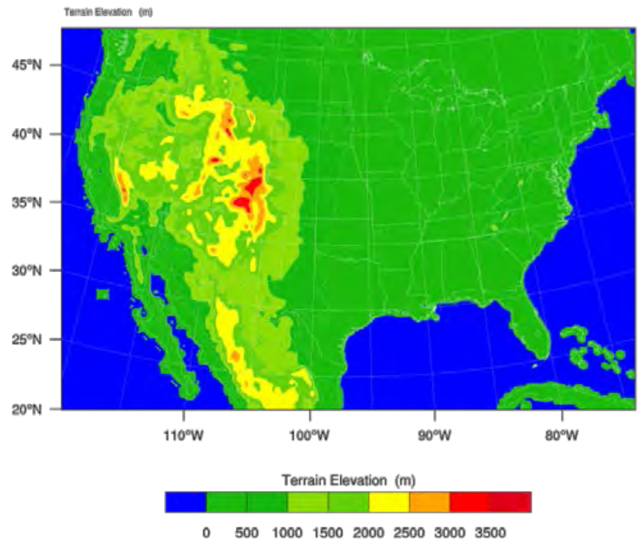


Figure 2. Modeling Domain.

Simulations are performed for a period of 6 weeks beginning at the end of May 2010. Because of computational constraints, WRF-Chem simulations use GOCART aerosol module. Simultaneous assimilation of meteorology and $PM_{2.5}$ is applied every six hours with one-hour window for observations. Background error statistics for GSI assimilation were obtained as described in Pagowski et al. (2010) and are shown in Figure 3.

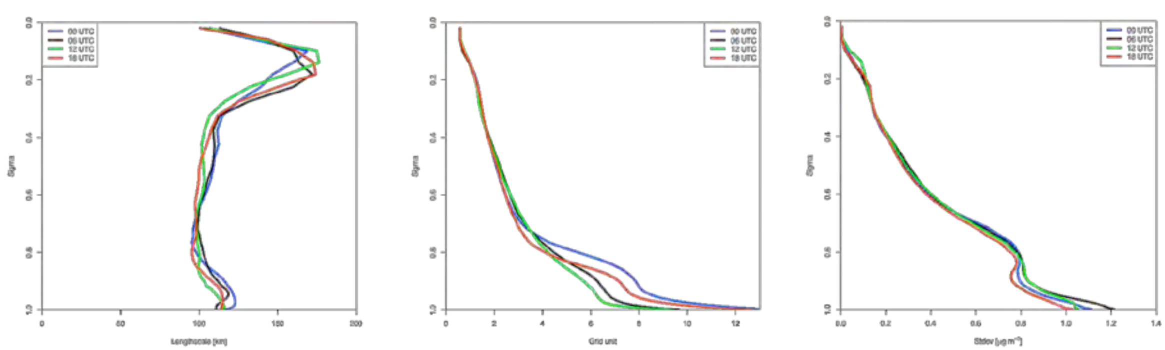


Figure 3. (a) Horizontal error length scales, (b) vertical error length scales, (c) standard error deviation for 00z, 06z, 12z, and 18z.

For EnKF application perturbations to meteorology are obtained from these statistics. From experimentation, it became obvious that meteorological perturbations are insufficient to obtain desired spread of ensemble predictions of $PM_{2.5}$ concentrations. Therefore, a method was devised to parameterize error of emission sources. First, a spatial scale of surface emissions of aerosol species was calculated. Since temporal factors of similar emission sources do not vary broadly, it can be assumed with a reasonable accuracy that such scale is temporarily invariant and that errors in emissions are correlated at the same spatial scale as emissions. This approach can be further refined to account for spatial variability of emission sources using wavelet approach and might be pursued in the future. Examples of perturbations to surface emissions of unspecified $PM_{2.5}$ are shown in Figure 4. Alternatively, emissions can be parameterized as a red noise process and modeled as a state variable. EnKF simulations comprised 50 ensembles.

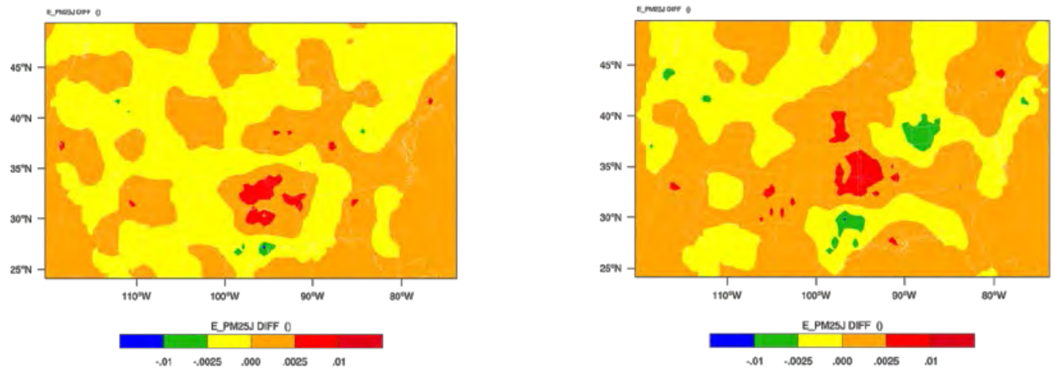


Figure 4. Sample perturbations to surface emissions of unspecified $PM_{2.5}$

Evaluation. Standard evaluation statistics of model and assimilation performance are given in Figures 5, 6, and 7. Biases for free-running model (NoDA, only with meteorological assimilation), GSI and different flavors of EnKF are shown in Figure 5.

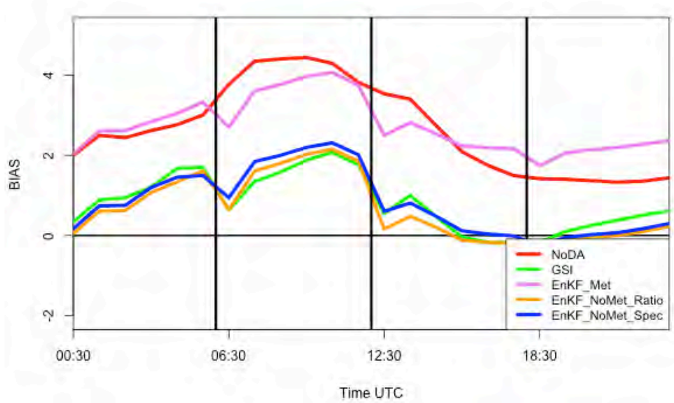


Figure 5. Time series of bias for different simulations.

In the figure, EnKF_Met denotes simulations where all observations, meteorology and $PM_{2.5}$ are allowed to affect all state variables; EnKF_No_Met_Ratio and EnKF_No_Met_Spec denote simulations where meteorological observations do not affect $PM_{2.5}$ and vice versa. In addition, for EnKF_No_Met_Ratio, ratio of the mass of aerosol species to the total $PM_{2.5}$ is invariant during the assimilation ($PM_{2.5}$ is a state variable); for EnKF_No_Met_Spec, aerosol species are state variables. Pattern RMSE and spatial correlation for the above simulations are shown in Figures 6 and 7, respectively.

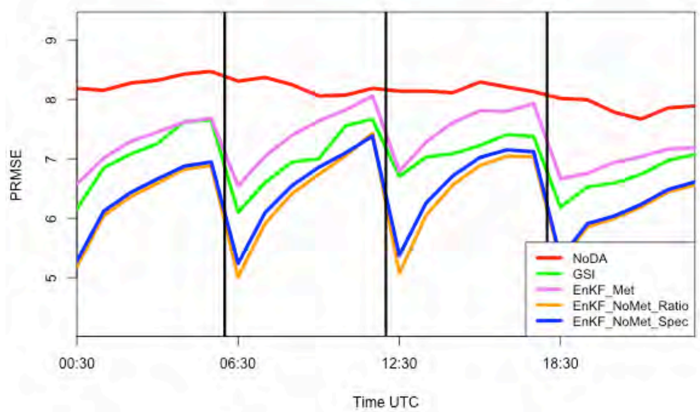


Figure 6. As Figure 5 but for pattern RMSE

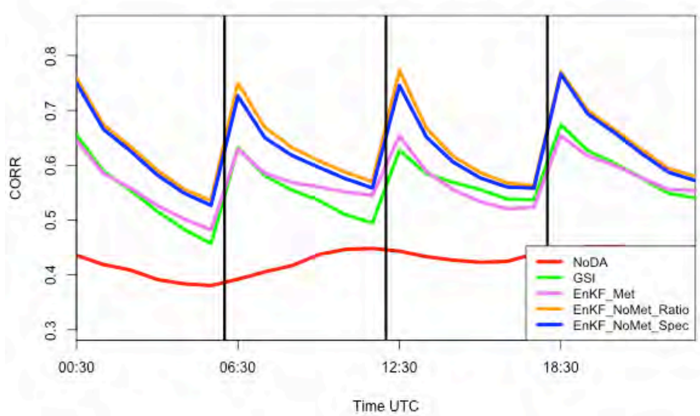


Figure 7. As Figure 5 but for correlation

In our opinion, verification statistics demonstrate superiority of EnKF assimilations over 3D-VAR. There is no apparent advantage of EnKF_No_Met_Spec vs. EnKF_No_Met_Ratio because of the lack of observations of aerosol species suitable for assimilation. Results are still being analyzed. More comprehensive analysis will be presented in a manuscript in preparation.

PROJECT TITLE: EAR - Local Analysis and Prediction System

PRINCIPAL INVESTIGATOR Cliff Matsumoto

RESEARCH TEAM: Steve Albers, Isidora Jankov, Ed Szoke

NOAA TECHNICAL CONTACT: Zoltan Toth, OAR/ESRL/GSD/FAB

PROJECT OBJECTIVES: Research objectives related to LAPS continues to be the improvement and enhancement of the system 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 various issues associated with model initialization and cycling process and to, hopefully, improve these processes.

Study improvements to analysis techniques, diabatic initialization and balance package, WRF model initialization, as well as model forecast verification at the Taiwan Central Weather Bureau.

Continue long-term collaboration with GSD to have LAPS / STMAS software running in the National Weather Service 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 but similar effort, 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.

Research Conducted Past Fiscal Year by Objective:
Within the Forecast Applications Branch (FAB), 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 Local Analysis and Prediction System (LAPS). This includes overall management of the configuration, updates, and distribution of the LAPS (including STMAS) system. We are now planning for a 2012 LAPS workshop that Steve Albers will be organizing. We've thus been highly motivated to lead the coordination of new ideas for development in LAPS including STMAS. We also organize a regular series of LAPS / STMAS meetings within FAB.
For LAPS and STMAS, we worked to improve the analyses in the following areas:
--First Guess Processing
--Observational Data Sets
--Surface Observations
--Upper Air Observations
--Surface Analysis
--Radar Processing
--Wind/Temperature Analyses
--Cloud / Precipitation Analyses
--LAPS/STMAS Model Initialization/Post Processing
--General Software Improvements & Portability
--LAPS Implementation

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

A high-resolution 1-km LAPS 3D analysis was set up to run with a 15-min cycle. A global analysis is also being run.

A paper was published with Radiometrics Corporation on using LAPS with radiometer data.

<u>WWW LAPS Interface</u>. Webpages were significantly improved for plotting analysis and forecast fields for LAPS including STMAS. The "on-the-fly" page has additional available fields and improved animation capability. Our achievements for this project compare favorably with the goals projected in the statement of work.

<u>STMAS-3D Development and Improvements</u>. As the STMAS analysis is embedded within the overall LAPS software package, most of the improvements mentioned regarding LAPS have

a direct benefit to STMAS. There are some items we can highlight here with respect to the STMAS-3D analysis development. One principal area is the variational cloud analysis where some preliminary cost function routines were developed to help improve the fit to visible and 11-micron IR satellite imagery.

We are also running a hybrid system with STMAS-3D where analysis modules from both the new STMAS software are combined with some from "traditional" LAPS. This provides an ideal testing platform as we phase in STMAS variational improvements.

Range Standardization and Automation (RSA) Project. Only minimal work was done during this period, though NOAA is still pursuing the long-term plan to convert from the MM5 to the WRF model in the RSA system.

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 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.

A model run with an hourly cycle and 12-hr forecast length this season has been run over a large domain covering basically the entire West Coast. The increase in the integration domain resulted in coarsening horizontal grid spacing from 5 to 10 km. Ensemble mean products were developed for the HMT experiment. As during the earlier seasons, the output from this run was used as input to a moisture flux tool developed by colleagues from PSD.

An ensemble, similar to the HMT setup, was run for the Hazardous Weather Testbed (HWT) Spring 2011 experiment.

Taiwan Central Weather Bureau (CWB). We continued to operate real-time LAPS and STMAS runs both at GSD and at the CWB. We added the model run with 6-hour cycle and 12-hr forecast for CWB domain. Our achievements for this project compare favorably with the goals projected in the statement of work, given the available funding. We have accomplished additional task compared to the objectives since Hongli Jiang joined the team.

NWS Interaction.

a)-- AWIPS and AWIPS-II

We continue a long-term effort to have LAPS software running in the National Weather Service WFOs (on AWIPS) for evaluation and use by operational forecasters. Discussions are being held about ongoing efforts to upgrade LAPS and introduce STMAS in both AWIPS and the new AWIPS-II workstations running in National Weather Service WFOs. A high resolution (5-km horizontal grid spacing) WRF-ARW model run is available four times per day for operational use by the local NWS office in Boulder.

b)-EFF Activities

We continued our interaction with the local NWS WFO in Boulder located within the David Skaggs Research Center. This includes Ed Szoke working forecast shifts at the Boulder WFO. The interaction helps to provide better forecaster feedback on other projects that Ed is involved with outside of LAPS, including the GOES-R Proving Ground project and evaluating the FIM model. Several CIRA researchers also take part in presenting and producing weather briefings. We have begun to have better participation from other researchers within ESRL but outside of GSD following a new initiative to increase Weather Briefing awareness. We are looking for improved support of the weather briefing from various levels of management. Unlike some times in the past, funding is non-existent at present.

Hydrometeorological Testbed (HMT) / California Department of Water Resources (DWR). At the end of the 2010 HMT season, a decision was made to continue the ensemble runs throughout the year to provide modeling support in decision making for fire weather in the State of California. For the past several years, the ensemble modeling effort has been led by Isidora Jankov while the corresponding LAPS and post processing activities have been led by Steve Albers.

Ensemble forecast system testing and improvement continues. The focus of the last two seasons has been on testing a new approach to initial condition perturbations for limited area ensemble. Recently, initial condition “cycling” technique has been implemented for testing as a part of the HMT real-time ensemble prediction system. The “cycling” technique preserves information from the higher-resolution model run and complements the coarser-resolution information provided by the output from a global modeling system (e.g. GFS). At the start of cycling, higher-resolution limited area model is initialized with output from a global forecasting system interpolated to the fine regional grid. At the following analysis time, the difference between limited area model and global system’s forecasts interpolated to the fine grid, valid at the same time, is added to the current interpolated global analysis, which is then used to initialize the subsequent regional model run. In this way, higher-resolution information is cycled and preserved. Additional adjustments to the approach, such as centering perturbations on a high-resolution analysis, will be explored. Preliminary tests showed very promising results.

In the past year, the HMT-related research, performed in collaboration with several CIRA scientists resulted in a publication available via online release in JHM.

Investigative Modeling Research. Hurricane initialization studies with LAPS / STMAS / GSI (funding was unavailable for this effort during 2011).

Finnish Meteorological Institute (FMI). We continued to work with the FMI on various LAPS topics including the use of radar data and the model first guess in the LAPS analyses. Improved methods of using rain gauge to refine radar-estimated rainfall are being investigated.

Windsor Tornado Case Study. We are collaborating with Radiometrics Corporation, UCAR, and others to study the analysis and short-range forecasting of the May 2008 Windsor, CO tornado. This includes gathering the real-time LAPS analyses, as well as all available in-situ and remotely sensed observational data for rerunning LAPS and STMAS, together with WRF forecasts. There is a CIRA-managed special project dedicated to continued research on this topic. For this project, we ran short-term 1-hour and 3-hour LAPS/WRF forecasts of the Windsor Tornado. We made careful comparisons of model runs initialized from both LAPS and STMAS analyses. Resolutions ranged from 5km down to 800m. We also performed some data denial experiments for the LAPS humidity analysis with and without radiometer data.

Radiometrics Corporation is experimenting with using LAPS soundings as input to a forward model. The forward modeled brightness temperatures are then compared with radiometer measurements in several frequency bands. Results show reasonable consistency, though with a bias at one of the highest frequency bands. Meanwhile STMAS is being run at a higher resolution (81 vertical levels) to improve depiction of the boundary layer. We identified some issues with model initialization of boundary layer humidity that will be investigated. We are also improving several aspects of the hot-start by looking at 1-minute WRF output. This helps in our forecasts of radar reflectivity, clouds, and solar radiation.

Department of Homeland Security (DHS). We set up and continued to monitor LAPS analysis runs to support the initial Dallas-Ft. Worth implementation of the Geo-Targeted Alert System (GTAS). Doppler radars from 5 sites near DFW are included. The LAPS analysis is then used to initialize the outer nest of a high resolution (4.5 km) WRF-NMM model run. The outer nest provides boundary conditions for the inner nest having 1.5 km horizontal grid spacing. The same configuration has been used for several additional sites recently added to the GTAS project since last year. These additional sites include Seattle, Melbourne, FL, and the Kansas City area. Currently, for the two new locations, only WRF-NMM model runs are performed in real-time. The production of the corresponding real-time LAPS analysis in the proper location is in process. The model output is used as an input to the HYSPLIT dispersion model as well as for a display on AWIPS workstation.

Renewable Energy. We have been collaborating with Precision Wind and CIRA Fort Collins for radar data and wind forecasts. This project, entitled "Ensemble Data Assimilation Research for Wind Forecasting" involves collaboration with PI Dr. Zupanski and Co-PI Dr. Miller in the capacity of Senior Consultant in tasks that involve utilization of radar, wind energy, and other data into the Maximum

Likelihood Ensemble Filter (MLEF) ensemble system. As part of this, we are working with Precision Wind to install the LAPS/STMAS system including access to model first guess, in-situ observations, and Doppler radar data.

We've also been attending ESRL Renewable Energy meetings convened by Melinda Marquis. Based on this, we've informally been doing (and presenting) some experiments with verifying analyses and forecasts of solar radiation. The recent MOU signed between NOAA and DOE for renewable energy should help provide impetus to this research. There is an associated discussion specifically on solar energy that has been going on between NOAA and DOE for a while. We are assisting with the planning process on how to fill in gaps in capability on both the ESRL and NOAA levels. Our modeling efforts are being well received by the group and they have great potential to help NOAA provide improved analyses and short-term forecasts of solar radiation. This is leading to some improvements to the cloud analysis in LAPS and STMAS. We co-authored an article on solar radiation forecasting with this group and presented a poster on solar forecasting at the AGU conference in December 2011. This meeting group is also interested in our high-resolution wind forecasts.

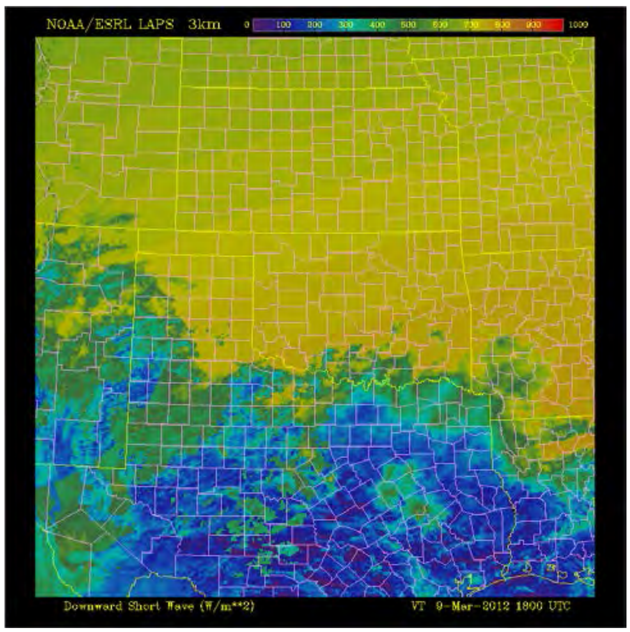


Figure 1. LAPS solar radiation analysis over the domain used for the Hazardous Weather Testbed (HWT) experiment.

Science on a Sphere™. CIRA staff continued maintaining real-time weather models (Global LAPS, FIM, GFS) on SOS. Other real-time datasets we developed and continue to maintain include global weather satellite, earthquakes, and solar extreme ultraviolet images from the STEREO spacecraft. With the library of solar system datasets, improvements were made to the maps of Mercury and Titania. We continued to develop a FIM-Chem global aerosol animation for SOS with plans to run this daily to provide real-time updates to all SOS sites.

GLOBE / VAST. We are developing a project managed by the ESRL Director called Vegetation and Surface Tracker (VAST), an endeavor that requires developing a global school-based network with a protocol to use GPS and digital imagery to document vegetation and surface observing points around the globe. The ultimate goal of VAST is to develop this global surface network to obtain the required density of surface measurements for satellite ground truth.

We have been providing strategic and technical guidance to the various participants in this program, including NOAA, GLOBE, and the University of Colorado. We also participated in a webinar that helped to discuss the program with school teachers around the country.

FIM evaluation. FIM model development has continued with several model variations now being run. Ed Szoke's role continues to be to help evaluate and compare the various FIM forecasts, both amongst the variations of the FIM model as well as between the FIM and the operational models such as the GFS and ECMWF. This is largely done through a subjective evaluation effort using case studies of significant weather events and complements the objective verification activities that are underway within the FIM group. Ed also examines areas where various model issues arise, including behavior in forecasting hurricanes. One of the long-term goals is for the FIM to become part of the North American Ensemble Forecast System (NAEFS), which is apparently getting closer to being a reality. Ed Szoke gave a talk on the FIM at the AMS Annual Meeting in Seattle in January 2011, and also wrote a paper with the title of "FIM performance for some of the major events of the 2009-2010 winter season".

GOES-R Proving Ground. Work continued with the CIRA group involved in the GOES-R Proving Ground activities at a 20% level. A big part of this effort is to work closely with the Boulder NWS Weather Forecast Office (WFO), and this includes supporting Ed Szoke's shift work at that office. The other WFO we are working closest with is at Cheyenne, Wyoming, but we are also working with an expanding number of WFOs including as far to the east as Buffalo, New York, and continue to add sites along the West Coast as well and most recently in Southern Region in Texas. Ed Szoke's effort includes up to twice yearly presentations and updates of GOES-R Proving Ground activities with the two WFOs through their forecaster workshops, communication and training for the various WFOs and developing and assisting in training information for our CIRA GOES-R Proving Ground products, as well as garnering feedback on the products from all the WFOs. In addition to presentations at the Boulder forecaster workshops, Ed presented a poster with an accompanying paper on our activities at the AMS Annual Meeting in Seattle in January 2011 at the 7th Annual Symposium on Future Operational Environmental Satellite Systems, titled "An overview of CIRA's contribution to the GOES-R Proving Ground".

PROJECT TITLE: NESDIS Environmental Applications Team – Yong Chen, Research Scientist

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Yong Chen

NOAA TECHNICAL CONTACT: Fuzhong Weng, NESDIS/STAR

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES
--Develop and validate the CRTM for visible, infrared, and microwave under various atmospheric (clear, aerosol, and cloudy sky) and surface conditions. Integrate new radiative transfer components into CRTM.
--Tests of CRTM in satellite data assimilation system GSI (Grid Statistical Interpolation).

PROJECT ACCOMPLISHMENTS:
--Completed CRTM transmittance coefficients for US and foreign satellite sensors, for example, Kalpana (India satellite) imager (vhrr_kalpana1), COMS (Korean satellite) imager (mi-l_coms, mi-m_coms), and FY3B (Chinese satellite) iras, mwri, mwhs, mwts.

--Completed CRTM transmittance for visible sensors (ODAS coefficients only), including imager of GOES-11, GOES-12, GOES-13, GOES-14, GOES-15, mt2, viirs-i_npp, viirs-m_npp. Collaborate with AER to address the LBLRTM model problem in order to generate ODPS coefficients, LBLRTM continues output error message to generate water vapor continua beyond 25500 cm^{-1}.

--Completed HIRS transmittance coefficients bases on shifted SRFs for hirs2 on NOAA10, NOAA11, NOAA12, and NOAA14, hirs3 on NOAA15, NOAA16, and NOAA17, hirs4 on NOAA18, NOAA19 and Metop-a from U of Wisconsin/SSEC/CIMSS.

--Completed and update CRTM transmittance for new sensors and existing sensors for MTEOP-B sensors (IASI, AVHRR3, HIRS4, AMSUA, and MHS), and foreign satellite (French) Megha-Tropiques microwave sensors (MADRAS and SAPHIR).

--Completed CRTM transmittance for visible channels, including IRAS on FY3A and FY3B; MI on COMS; SNDR on GOES-08 to GOES-15; MODIS on AQUA and TERRA.

--Completed CRTM coefficients for ABI on GOES-R, IMGR on GOES-14 and GOES-15 are updated based on the newest updated sensor response functions.

--Developed a new CRTM interface for using land surface emissivity databases and tested the impact on AMUSA data assimilation in GSI. Land surface emissivity databases provide the emissivity based on input time, latitude, and longitude, such as TELSEM (A Tool to Estimated Land Surface Emissivities at Microwave frequencies), CNRM (French CNRM Microwave Atlas), and UWIREMIS. The land emissivity can be calculated before calling CRTM main module (such as CRTM_Forward, CRTM_K_Matrix), and passed to CRTM through Options structure. It is the most convenient way to take advantage of existing land surface emissivity database and using their own reading codes instead of taking a lot of effects to implement and integrate into CRTM. The parallel experiments were setup to test the impact of the microwave land surface emissivity databases, and new physical model in CRTM on GFS compared to the CRTM v2.0.2 default model (referred as NESDIS). The experiments are running from July 1 2010 to July 31, 2010 for GFS version r11574 (with update and improved surface skin temperature) and GSI version r13012 with resolution of T382. Global statistics of O-B in terms of number assimilated observations, bias, and standard deviation over land for all experiments during the one month period for the 6 AMSUA channels are summarized in Figure 1. The details are documented in a paper draft to be submitted to TGRS.

--Published a paper in Journal Atmospheric and Oceanic Technology. Paper titled: “Community Radiative Transfer Model for Stratospheric Sounding Unit channels”, by Yong Chen, Yong Han, Quanhua Liu, Paul Van Delst, and Fuzhong Weng has recently been published (*J. Atmos. Oceanic. Technol., 28,* 767-778, doi: 10.1175/2010JECHA1509.1 2011).

--Two papers have been accepted by JGR-atmosphere and JTECH. One is for Planck weighted transmittance and correction of solar reflection for broadband infrared satellite channels, and the other is for CRTM validation and the comparison of ODPS and ODAS in CRTM v2.0.2 for AVHRR sensors. Shown in Figure 2 are the brightness temperature bias and standard deviation as a function of satellite zenith angle for AVHRR channel 3, 4 and 5. Note that ODAS_W is the ODAS transmittance algorithm with Wu-Smith emissivity model, ODPS_W is the ODPS transmittance algorithm with Wu-Smith emissivity model, and ODPS_N is ODPS transmittance algorithm with Nalli model.

--Worked on the impact of CO_2 amount on NLTE results. NLTE (non-local thermodynamic equilibrium) model in CRTM shows that there is -0.45 K difference between CRTM and AIRS observation at 2360.16 cm^{-1} over night time. I had tested the uncertainty in the CO_2 volume mixing ratio contribution to the difference. The CO_2 profile in the NLTE training set (UMBC 48 profile) is same for all the profiles, with surface concentration at 380.165 ppmv. The CRTM NLTE model, which computes the NLTE and LTE radiance differences, was trained with the LBLRTM/NLTE v11.7. The radiance difference from the NLTE model was then added to the LTE radiance, which was computed with CRTM v2.0.2 (with default CO_2 amount 384 ppmv, trained with LBLRTM v11.3. The CRTM-obs differences in the region above 2400 cm^{-1} would be smaller if CRTM is trained with LBLRTM v11.7. The improvement from LBLRTM v11.3 to v11.7 is ~0.15 K at the region. To test the CO2 amount impact on the NLTE results, I rerun the LBLRTM v11.7 with the NLTE turned on by using different CO_2 amount in the training profiles (ranging from 380.165 (1- 5%) to 380.165 (1+5%) ppmv and changing from profile 1 to profile 48) and compared to the fix amount by running the LBLRTM v11.7 for zenith angle 0 for AIRS NLTE channels. For the fix CO_2 amount, the NLTE daytime brightness temperature (BT), Delta_BT (NLTE-LTE) for profiles 1, 25, and 48 are shown in Figure 1a, and the impact of CO2 amount on daytime AIRS NLTE channel BTs compared to the fix CO_2 amount is shown in Figure 1b. For CO2 amount changing of ~20 ppmv, the NLTE daytime different is ~0.3 K from 2300 cm^{-1} to 2400 cm^{-1}, could not explain the ~1.5 K difference shown in Yong Han's NLTE study. The larger difference in daytime is not coming from the CO_2 amount using in the CRTM calculation, it should be something else, and this need to be further investigated.

--Developed an aircraft version of CRTM. In order to extend CRTM validation efforts and expand CRTM validity further to cloudy and rainy conditions, in particular using airborne campaigns targeting cloudy and precipitating cases, an aircraft version of CRTM is developed. When a user specifies the flight pressure level through Option structure passed to CRTM main module, CRTM can output the radiance (brightness temperature) at that level. Effects have been made to collect the aircraft experimental data and used in CRTM validation. The CRTM coefficients for passive Microwave sensor HAMSR (High Altitude MMIC Sounding Radiometer, 25 sounder channels at 60, 118, and 183 GHz) have been generated.

--Generated the SSMIS F20 Zeeman TauCoeff. The Zeeman TauCoeff file for SSMIS F20 is missing from the CRTM coefficients. It is not included in CRTM release package. To generate the SSMIS F20 Zeeman TauCoeff files, based on Yong Han's previous work, I have done follows: Check the Rosenkranz Zeeman LBL source codes into repository; Check the source codes to compute SSMIS channel transmittance into repository; Check the scripts to generate the LBL transmittance profiles into repository; Check the training source codes and scripts into repository. The Zeeman TauCoeff files (ODPS) in formats of Big_Endian, Little_Endian, and netCDF for SSMIS F20 have been created based on above source codes and shell scripts.

--Generated MODIS CRTM coefficient files based on shifted SRF data for Aqua and Terra.

--Tested channel selection capability in GSI for IASI 616 channels. Same results are obtained for the two different settings. This capability allows user to run CRTM more efficient if they want just a few channels for a particular sensor, especially for hyper-spectral IR sensors such as IASI, AIRS, and CrIS.

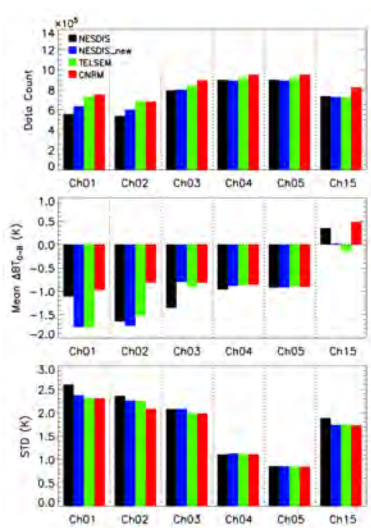


Figure 1. Assimilated AMSUA data count, bias and standard deviation over land in GDAS for the experiment period from July 1 to July 31 2010.

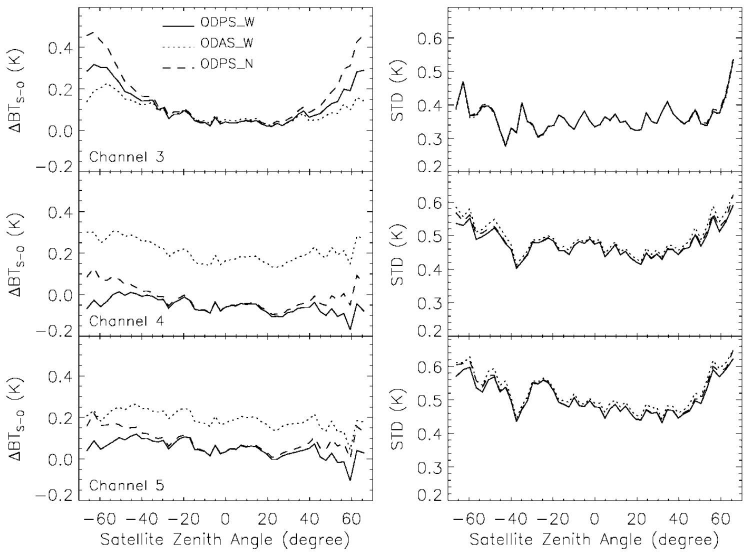


Figure 2. Brightness temperature bias (left) and standard deviation (right) as a function of satellite zenith angle for CRTM simulation compared to observation.

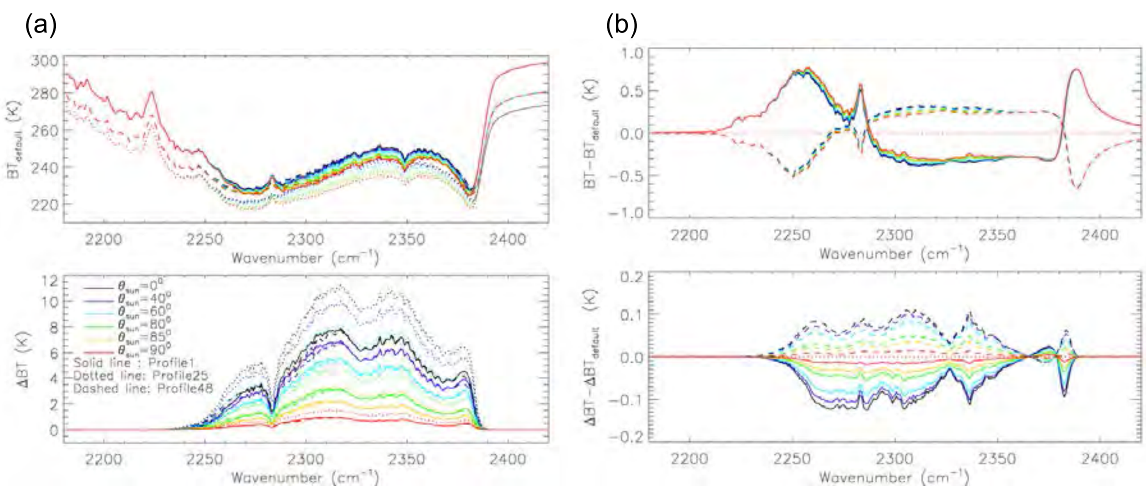


Figure 3. (a) AIRS NLTE daytime brightness temperature, and difference for fix CO2 amount, and (b) the impact of CO2 amount on daytime AIRS NLTE channel BTs compared to the fix CO_2 amount.

PROJECT TITLE: NESDIS Environmental Applications Team – Min-Jeong Kim, Post Doc - Implementation of Cloudy Radiance Data Assimilation in the NCEP NWP Models.

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Min-Jeong Kim

NOAA TECHNICAL CONTACT: John Derber, NOAA/NCEP

NOAA RESEARCH TEAM: Yanqiu Zhu (NOAA/NCEP), Emily Liu (NOAA/NCEP), Andrew Collard (NOAA/NCEP), Will McCarty (NASA/GSFC)

PROJECT OBJECTIVES:
--Developing the cloud radiance data assimilation components in the NCEP data assimilation system.
--Implementing cloud affected microwave radiance data assimilation in NCEP Global Data Assimilation System (GDAS) in operational mode.

PROJECT ACCOMPLISHMENTS:

The capability to assimilate AMSU-A cloudy radiance data has been added to GDAS system, and it is available for other GSI scientists through the GSI subversion repository. The new components listed below are currently being tested in clear + non-precipitating cloudy sky conditions. Further improvements especially in moisture control variables and the background error covariance are in progress.

The following components have been developed to date (Table 1):

1)--Observation operator: The observation operator to simulate radiance data in the GSI has been extended to include cloud and precipitation affected radiance data. (a) Cloud water mixing ratio profiles from the GFS model 06 hr forecast have been added to first guess fields, (b) estimated changes in and sensitivity to clouds and precipitation are estimated from the GFS physics using the tangent linear and adjoint models (c) cloud water has been split into cloud liquid water and cloud ice water following GFS model physics and (d) temporal and spatial interpolations have been applied to these cloud water first guess fields along with other first guess variables. (e) Cloud liquid and cloud ice water content profiles, cloud effective radius, and size distribution have been estimated and (f) set up as inputs for the CRTM to calculate cloudy radiances.

2)--Observation error model: An observation error model for AMSU-A radiance data applicable both in clear and non-precipitating cloudy sky conditions has been built in the GSI. The observation error model has been calculated using the symmetric error model (Geer and Bauer 2010) method. Radiance data in precipitating cloudy sky conditions include a scattering signal which makes optimization in assimilation systems more complicated because of difficulties in forward calculations, and observation and background error estimation. Therefore, non-precipitating cloudy radiance data in the GSI will be tested and implemented first and precipitating cloudy radiance data will be addressed second.

3)--New quality control processes: New quality control to include cloudy radiance data while screening radiance data with scattering signals has been built in GSI (See Table 1). These new quality control checks allow inclusion of AMSU-A radiance data in non-precipitating cloudy sky conditions. A new gross check for AMSU-A data utilizes the observation error estimated in non-precipitating cloudy sky conditions.

4)--Additional moisture control variable: Cloud water has been included as an additional moisture control variable for AMSU-A radiance data assimilation. Different choices for moisture control variables are currently being tested.

Figure 1 demonstrates that adding these new components to the GSI analysis system and using them to assimilate AMSU-A cloudy radiance observations increases/decreases clouds in the first-guess cloud field in the right places.

Table 1. Summary of the changes made to assimilate cloud affected AMSU-A radiances in GSI.

	Operational GSI	New GSI
FW operator & first guess fields	Do not include cloud	Include clouds for Tb and Jacobean calculations
Usage of AMSU-A radiance data	Clear sky over land and ocean	Clear sky over land and ocean + non-precipitating cloudy sky over the ocean
Observation error	Statistics based on clear sky conditions	Statistics based in clear and cloudy sky conditions
Control variable	T, q, ozone profiles, sfc P, u, v Not including cloud water	T, q ozone profiles, sfc P, u, v + cloud water
Background error covariance	T, q, ozone profiles, sfc P, u, v from NMC method	T, q, ozone profiles, sfc P, u, v + cloud water from NMC method
Quality control	-Screen out cloudy data -Gross check: $\frac{\lvert Tb_{obs} - Tb_{FG} \rvert}{\sigma_{clear\ sky}} > 3$	-Keep cloudy data unless cloud liquid water path > 0.5 kg/m2 - Gross check: $\frac{\lvert Tb_{obs} - Tb_{FG} \rvert}{\sigma_{cloudy\ sky}} > 3$

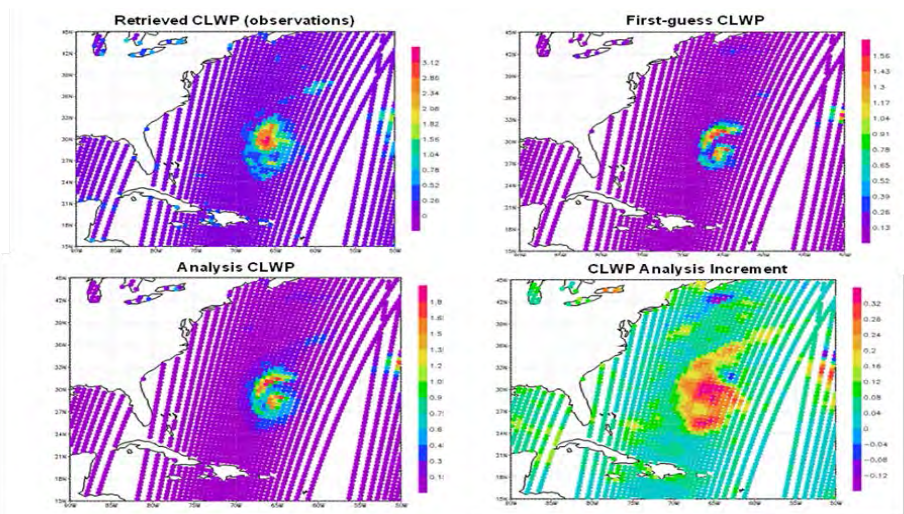


Figure 1. Cloud water paths (a) retrieved from AMSU-A observations, (b) calculated with first-guess (i.e. GFS model 6hr forecast) cloud water mixing ratio profiles, (c) calculated with analysis cloud water mixing ratio profiles after including AMSU-A cloudy radiance observations in GSI assimilation system, and (d) cloud water path increments , that is, (c)-(b). This figure demonstrates that GSI analysis system increases/decreases clouds in the first-guess cloud field in the right places by including AMSU-A cloudy radiance observations during Hurricane Igor (09/19/2010).

5)--Adjoint models for moisture physics schemes: Tangent linear (TL) and adjoint (AD) models (needed for the variational assimilation of the cloud and precipitation data) for GFS moisture physics schemes have been developed.

(a) GFS large scale condensation scheme : TL and AD models have been completed.

(b) New GFS sub-grid deep convection scheme: TL model has been completed. Updating AD model codes is in progress. (GFS recently replaced the old convection schemes with new convection schemes so that changes in AD code had to be made as well.)

(c) GFS Precipitation scheme: TL and AD models have been completed.

(d) These TL and AD models of the full GFS moisture physics will be included in the minimization for the following purposes: (a) to obtain derived cloud increments from total condensate for each hydrometer required by the observation operator; (b) to ensure that increments among control/state variables are more physically constrained and balanced (multivariate relationship). The inclusion of TL and AD models of moisture physics in the minimization should lead to a better initial conditions for the subsequent forecasts

(e) Currently collaborating with Daryl Kleist of EMC to include these moisture physics models in the strong constraint to improve analysis fields near the tropics and collaborating with Miodrag Rancic (EMC) to include these moisture physics TL and AD models in GSI 4D-Var system.

6)--Testing total moisture as a control variable: The capability of using total water as an alternative choice for the control variable is currently being developed in the GSI. As a first step, the capability to assimilate cloudy radiance data using total water (=q+ql+qi) as a control variable has been developed with simplified moisture physics in the minimization. Here q, ql, and qi are water vapor, cloud liquid water, and cloud ice water, respectively.

Using total water as a control variable in the analysis has several benefits: (a) the error distribution of total water is more Gaussian than cloud water alone. If the error distribution of the control variable is not Gaussian, the minimization would not be optimal. (b) The background error for total water is much easier to characterize than cloud water since the total water field is more smooth and continuous.
(c) In addition, the choice of total water has the advantages of reducing the dimension of the control vector, enforcing an implicit correlation between humidity and water condensates, including a super-saturation constraint. However, there are some drawbacks in using total water in the analysis. It is necessary to separate the increment of total water into increments of water vapor and clouds in the minimization because observations provide sensitivity information on water vapor and hydrometeors separately. Moisture physics and their TL and AD models are required to split sensitivity to total water into water vapor and cloud water contributions. Therefore, analysis results become sensitive to the validity/performance of the moisture parameterizations used.

To find the best form of total water to use, 60 pairs of 24 and 48-hour forecast from the GFS were used to study the error distribution of total water in various formats (the NMC method). The background errors are directly related to the forecast differences in that if the forecast differences are Gaussian, so are the background errors. Figure 2 shows the probability density function (PDF) of forecast differences for normalized total water mixing ratio and normalized total relative humidity, respectively. The black solid curve is the PDF for a Gaussian distribution. It is obvious that the forecast difference of the normalized total relative humidity exhibits near-Gaussian behavior (Figure 2a), whereas the distribution of the normalized total water mixing ratio is not very similar to the Gaussion PDF (Figure 2b). Therefore, the normalized total relative humidity is the one selected to test in cloudy radiance assimilation in GSI.

To use normalized total relative humidity as the control variable in the analysis, moisture physics need to be included to split the total increment into a water vapor increment and a cloud water increment in the minimization. A simplified moisture physics scheme for the splitting based on relative humidity thresholds has been tested in the GSI. The simplified version is implemented as a place holder in the minimization for a more sophisticated moisture physics scheme that is consistent with the one in GFS forecast model in the future.

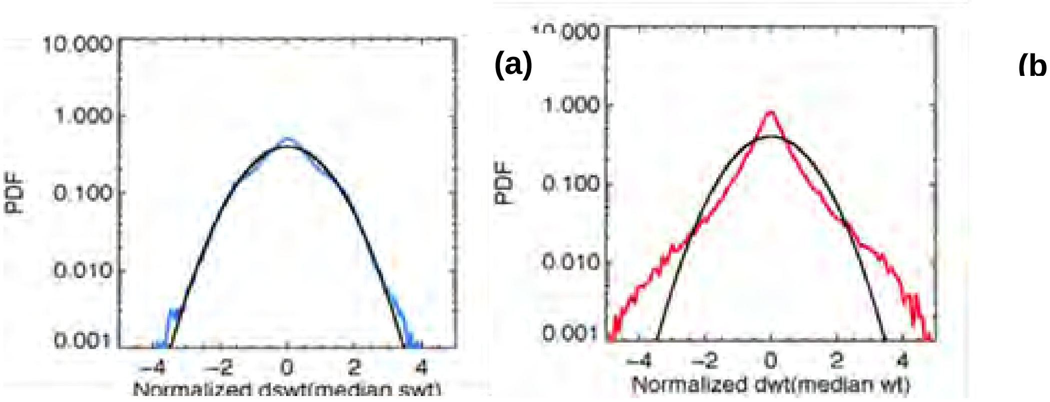


Figure 2. The probability density function (PDF) of forecast differences at approximately 850 hPa. The blue curve is the PDF of forecast differences for normalized total relative humidity (a). The red curve shows the PDF of forecast differences for normalized total water mixing ratio (b). For comparison, a Gaussian (black curve) PDF is also shown on both plots.

7)--Comparisons of several choices of moisture control variable: GDAS experiments coordinated to study the impact of various choices of control variable for cloudy radiance assimilation have been performed for preliminary assessment (Table 2).

The control run shows the results from the current operational GSI which assimilates only clear sky radiance data from AMSU-A with other satellite and conventional data. The EXP1, EXP2, and EXP3 experiments include AMSU-A cloudy radiance data in addition to the data used in the control run. EXP1 uses cloud water and humidity as two separate control variables. EXP2 uses only humidity as a control variable but updates the cloud fields using updated humidity and dynamic fields from the moisture physics in the outer-loop to calculate cloudy radiances to update the radiance departures. Currently, the ECMWF has been using the EXP2 approach in its operational all-sky radiance assimilation system. EXP3 assimilates cloudy radiances from AMSU-A using normalized total relative humidity as a control variable and the simplified moisture physics in the minimization. Because the error distribution of cloud water is non-Gaussian, using cloud water itself as a control variable (i.e. EXP1) does not guarantee the optimized analysis results. Testing another form of cloud water such as q/(qsN) (See Table 2), which shows a more Gaussian error distribution, is in progress as EXP4 and similar efforts are currently underway at ECMWF (Holm and Gong, 2010) .

In this preliminary assessment, the cloudy AMSU-A data were only assimilated over the ocean between latitudes 60 degree north and south. Polar regions were excluded due to uncertainties in predicting sea ice location, skin temperature, and surface emissivity. Experiments will be performed repeatedly for evaluation as the proposed implementations progress.

Table 2. Summary of GDAS experiments with various configurations for moisture control variables.

	Moisture input for observation operator (CRTM)	Moisture Control variable
Operational (Control)	q	q
Approach 1 (Exp1)	q, ql, qi	q, cw(=ql+qi)
Approach 2 (Exp2)	q, ql, qi, rain, snow	q
Approach 3 (Exp3) (In progress by Emily Liu)	q, ql, qi	Normalized Total Relative Humidity (RH Total=ql+qi+cw)
Approach 4 (Exp4) (In progress by Min-Jeong)	q, ql, qi	Different forms of cw (e.g. cw/qs, cw/N where N is cloud coverage and qs is saturated mixing ratio)

Figures 3-6 compare the cloud analysis increments and relative humidity analysis from the Control, EXP1, EXP2, and EXP3 approaches. As shown in Figure 3, cloud field changes little even where relative humidity fields change significantly after assimilating data in the operational GSI system. When using cloud water mixing ratio as a moisture control variable (EXP1), cloud fields change significantly especially in the region where relative humidity is high, as shown in Figure 4. For EXP2, Figure 5 also shows that cloud fields change significantly especially in the region with high analysis relative humidity but a much smaller area is covered by clouds compared with results from EXP1, shown in Figure 4. The EXP2 approach can be more beneficial for GFS forecast spin up because moisture fields are constrained by GFS moisture physics. For EXP 3, it is found that the clouds in the background were modified by the cloudy AMSU-A data mostly in the troposphere between latitudes 60 degree north and south. Even though cloudy AMSU-A radiances were not assimilated in polar regions, significant change in clouds were found. In polar regions, clouds were mostly modified by the moisture physics through temperature and pressure increments since the moisture physics linked the cloud increments with those from temperature and pressure (Figure 6). The assimilation of cloudy AMSU-A overall added clouds in the system, and change in clouds were fairly localized.

Currently, to evaluate analysis results from different approaches, comparisons of impacts on GFS model forecast skill scores and on HWRF hurricane forecasts are in progress. In addition, various cloud validation metrics are under development to evaluate the cloud fields from this initial assessment. The proposed metrics include radiance data from selected channels from AIRS, HIRS, AVHRR, and SEVIRI. Lidar data from Calipso and radar data from CloudSat will be used to validate clouds in areas of interest.

8)--Including cloudy radiance data assimilation components in the GSI regional analysis: Since the GSI is a unified global/regional system, changes made to the system can often be applied without too much change to both regional and global applications. The capability of assimilating AMSU-A cloudy radiance has been added to the NDAS for regional analysis in GSI, in which the sum of the cloud liquid water and cloud ice was used as the cloud control variable. The background error variance of the cloud variable was developed. Preliminary tests indicated that the use of the cloudy radiance data modified the cloud field as expected.

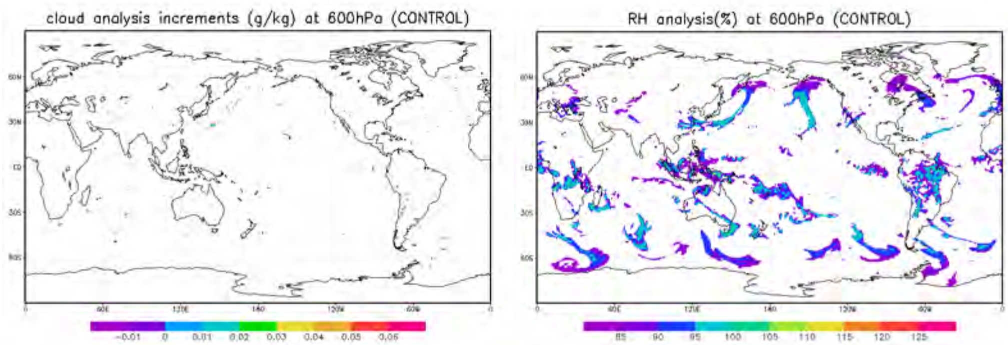


Figure 3. Cloud water mixing ratio analysis increment (left, g/kg) and relative humidity increments (right, %) at 600hPa from "Control" run (See Table 1). This is the GSI in operational system assimilating only clear sky AMSU-A radiance data.

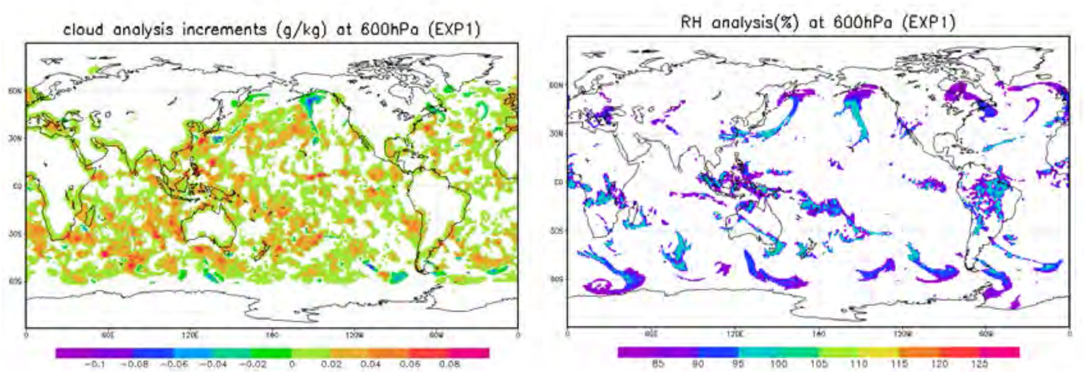


Figure 4. Cloud water mixing ratio analysis increment (left, g/kg) and relative humidity (right, %) analysis at 600hPa from "EXP1" run (See Table 1). Cloud water mixing ratio is used as a control variable for the optimization in GSI.

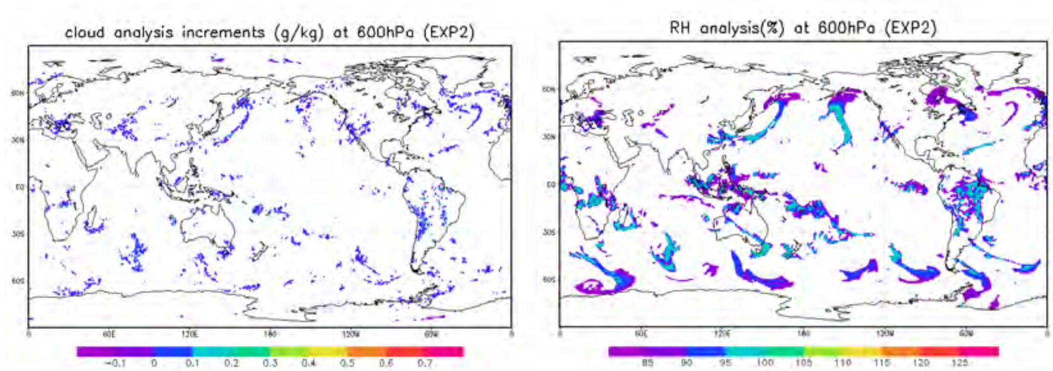


Figure 5. Cloud water mixing ratio analysis increment (left, g/kg) and (b) relative humidity increment (right, %) at 600hPa from the "EXP2" run (See Table 1). Cloud water mixing ratio is NOT a control variable for the minimization in GSI. Cloud fields are updated in the outer loop by GFS moisture physics schemes using updated humidity and dynamic fields as inputs.

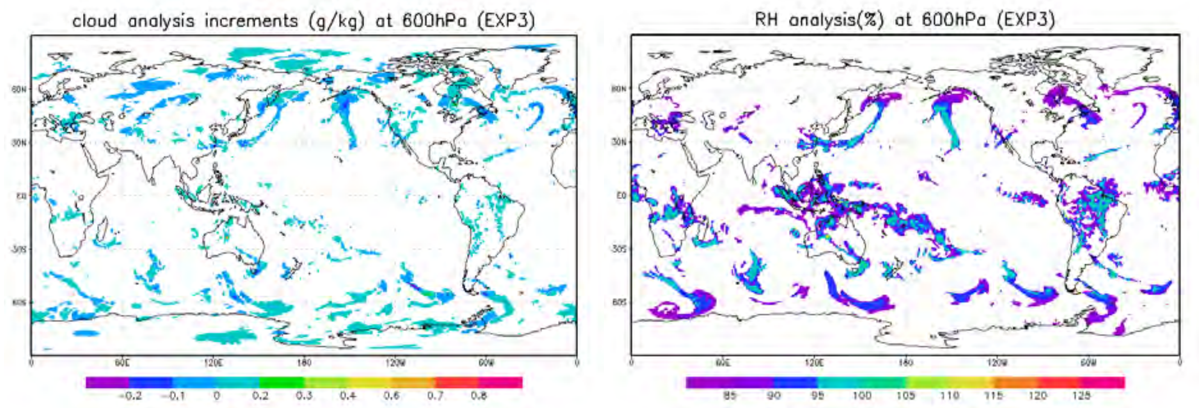


Figure 6. Cloud water mixing ratio analysis increment (left, g/kg) and (b) relative humidity increment (right,%) at 600hPa from the "EXP3" run (See Table 1). EXP3 is an experiment for assimilating cloudy radiances from AMSU-A using normalized total relative humidity as control variable and the simplified moisture physics in the minimization.

PROJECT TITLE: Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting

PRINCIPAL INVESTIGATOR: Milija Zupanski

RESEARCH TEAM: Man Zhang, CIRA, Karina Apodaca, CIRA, Louis Grasso, CIRA

NOAA TECHNICAL CONTACT: Sid Boukabara, NOAA/NESDIS/JCSDA

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES:
--Combine all components into a single ensemble-based data assimilation system and conduct benchmark experiments (without lightning data).

--Evaluate the impact of GOES-R ABI proxy data in TC application.

--Evaluate the impact of IR sounder proxy data in clear skies in TC application. Temporal impact of advanced sounding product on hurricane forecast will be conducted by including AIRS alone, and by combining AIRS and IASI, respectively.

--Submit manuscript(s) for publication in peer-reviewed scientific journals. Present the results on the webpage and at the conferences/ workshops on this subject.

PROJECT ACCOMPLISHMENTS:
--We upgraded the GSI-CRTM code to include observation operator for regional assimilation of MSG SEVIRI radiances. Most of the time spent on this task focused on transforming MSG SEVIRI data from ASCII format to BUFR format. Since NOAA operations utilize BUFR format, we transform MSG SEVIRI ASCII data to BUFR, and then use the GSI and CRTM to read and process these data.

--The full spatial resolution advanced sounding product in clear and some cloudy skies, and error characterization, were completed by our collaborators on this project from CIMSS at Univ. Wisconsin. We have available full spatial resolution AIRS sounding product files that we can use for hurricane Fred (2010). These observations have also been transferred to BUFR format, and added to the PREPBUFR file.

--We developed the full HWRF-based ensemble data assimilation system that can assimilate all-sky radiances. Since the structure of tropical cyclone (TC) is best seen by microwave (MW) spectrum we also add the AMSU-A all-sky MW radiance assimilation to the system. The assimilation of all-sky MW satellite radiances greatly improves the structure of the inner core, as seen from Figure 1.

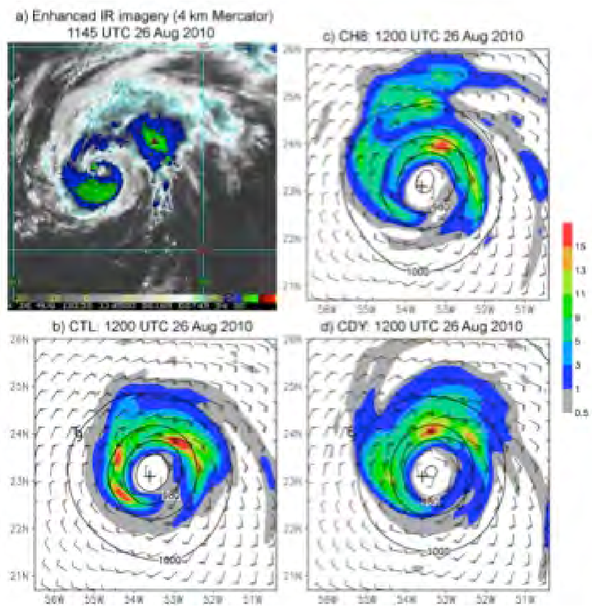


Figure 1. Results of assimilating all-sky AMSU-A radiances with NOAA operational HWRF system for hurricane Danielle (2010): (a) IR imagery used for verification, (b) Control experiment (Current operational HWRF-GSI setup), (c) Assimilation of AMSU-A with relaxed quality control, and (d) Assimilation of AMSU-A with quality control used in GSI.

--The results have been presented at the 9th JCSDA Workshop on Satellite Data Assimilation May 24-25, 2011 held at University of Maryland, College Park. A manuscript entitled "Direct Assimilation of all-sky AMSU-A Radiances in TC inner core: Hurricane Danielle (2010)" by Man Zhang, Milija Zupanski, Min-Jeong Kim, and John Knaff has been prepared for publication in Monthly Weather Review.

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: Application of Joint Polar Satellite System (JPSS) Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Kate Musgrave, Andrea Schumacher, Rober DeMaria, Hiro Gosden, Dave Watson, Kevin Micke, Renate Brummer, Kathy Fryer

NOAA TECHNICAL CONTACT: Ingrid Guch and Phil Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Mark DeMaria and John Knaff, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

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 tropical cyclone tracks and intensities. During the annual report period, we began with the development of two tropical cyclone applications of JPSS data. The first uses the imager and sounder data for improving the center location of tropical cyclones, which is the starting point for tropical cyclone forecasts. We began working on methods to use multi-spectral imagery from VIIRS, including the low-light imager, in combination with sounder data for this purpose. The second is to use temperature and moisture retrievals from ATMS and CrIS in the near storm environment to improve intensity forecasting. The objective is to incorporate this new information into an existing operational statistical-dynamical intensity forecast model to improve its performance. Once completed, these new products will be made 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. If the evaluation is positive, or points toward issues that can be adequately addressed via operational/developer interactions, the products can be transitioned to NHC and JTWC operations.

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/DoD priority.

PROJECT ACCOMPLISHMENTS:

--Developed database of AMSU temperature retrievals from the existing operational product.
--Developed database of MIRS temperature and moisture retrieval for global tropical cyclones.
--Developed database of MODIS, AVHRR and DMSP OLS data. Use storm relative coordinates to account for time differences.
--Initial development began on the creation of a center fixing routine with surface pressure from AMSU, AVHRR, MODIS.

--Began testing of maximum potential intensity estimate with MIRS retrievals for improved LGEM.
--AMSU data from Hurricane Irene during the 2011 season are being used as an initial case study to evaluate the utility of MIRS retrievals for hurricane intensity forecasting.
--MIRS retrievals from the newly available ATMS data were obtained for an Indian Ocean tropical cyclone. This case is being used for a preliminary comparison with the AMSU retrievals

Results of this research are being presented at annual conferences in partnership and coordination with the greater JPSS/VIIRS Calibration/Validation Team.

PROJECT TITLE: CoCoRaHS: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful Citizen Science Network

PRINCIPAL INVESTIGATOR: Nolan J. Doesken

RESEARCH TEAM: Noah Newman, Julian Turner, Henry Reges, Zachary Schwalbe, Nolan Doesken

NOAA TECHNICAL CONTACT: Sarah Schoedinger, Office of Education

NOAA RESEARCH TEAM: Jay Lawrimore, DOC NOAA, Douglas R. Kluck, NOAA National Weather Service; NOAA ESRL Global Systems Div., NOAA NWS National Operational Hydrologic Remote Sensing Center (Carrie Olheiser, Anne Sawyer, John Halquist)

PROJECT OBJECTIVES:
This is a multi-faceted nationwide engagement project intended to involve the public in climate monitoring (measuring rain, hail and snow). Through participation of thousands of volunteers in the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS http://www.cocorahs.org), it is our intent to enhance several aspects of public climate literacy including but not limited to the role and importance of observations and monitoring, seasons, climate variability, and the function and importance of the water cycle.

In the past year we have focused on utilizing social networking, data visualization, and webinar technology to improve the "CoCoRaHS experience" for our volunteers and to move our volunteers beyond being only data collectors to also being data analysts. Through the use of communications technology we hope to not only improve the experience of current volunteers to help retain them in the project but also to make the project more appealing to younger and more diverse populations.

Two other important efforts were proposed to more deeply engage some of our volunteer participants: 1) The addition of the measurement and analysis of evapotranspiration and, 2) collaboration with the PRISM Climate group at Oregon State University to help put local current observations of precipitation into a visually interpretable spatial and temporal context

PROJECT ACCOMPLISHMENTS:
We have continued to successfully manage and grow a very large nationwide network of "Citizen Scientists" collecting daily research-quality precipitation data. The number of active (reporting at least a few times per year) volunteers remains close to 15,000 while the number of reliable daily observers inches closer and closer to 10,000.

During the past year we introduced and continue to expand the use of Facebook and Twitter with about 1/6 of our active volunteers choosing to participate in this additional way.

During the last few months we have begun utilizing Webinars as a means of delivering training and education to growing numbers of volunteers. We began the WxTalk webinar series with special presentations from a diverse set of weather and climate experts. We began with attendance of less than 100 but by March we needed to expand our attendance capabilities to allow up to 500 simultaneous participants. The WxTalk Webinar series is just gaining momentum. At least one "class" per month is scheduled for the next year with topics ranging from hurricanes and tornadoes to atmospheric optics, aurora borealis, lightning and much more.

In an effort to appeal to wider audiences, we are putting more and more resources on YouTube, established our own YouTube CoCoRaHS channel and are utilizing animation to simplify content while also adding interest and humor

http://www.youtube.com/playlist?list=PLBD28578BA99D402A&feature=plcp

Water year summary reporting capabilities were greatly enhanced this year to better utilize, display and share data from each and every station that participated (water year is defined as October – September). See example below of some of the enhanced features that were developed this past year.

The PRISM Climate group at Oregon State University is a subcontractor on this project and has completed a fantastic interface that will allow CoCoRaHS volunteers to access and view enhanced precipitation maps for specific dates and periods and also to see time series of historical precipitation estimated for any gridcell location on the U.S. maps. We have not yet completed the interface on our end to provide access to these features, but that will be coming soon.

A "new" mapping system was deployed giving any users of the CoCoRaHS system the option of using our traditional static maps (county, state, or nation) or to now begin using a mapping system similar to Google that allows panning, zooming, and point clicking. Many more improvements are planned for the next year, but the current system is functional at a state-level or smaller.

During the summer of 2011, the ETgage was pilot tested by several volunteers across the country to see if this instrument could be used as a source of low-cost evapotranspiration data. More testing is needed, but results were sufficient that we will begin promoting the ETgage more widely beginning in April 2012. Several new reports and summaries were developed to accommodate this new data stream

The staff on the CoCoRaHS project (listed above) continues to work closely with David Heil and Associates completing a "front end" evaluation of the current CoCoRaHS activities and gathering data that will be used in more comprehensive formative and summative evaluations. New survey tools are being developed that will hopefully make it easier to quantify the nature and depth of science learning that participants are achieving while involved in CoCoRaHS.

Perhaps the best aspect of all is the fact that the data being collected each and every day are being used by weather forecasters, climatologists, hydrologists, utilities, businesses, researchers and teachers all across the country every day. Rarely does a week go by that we don't learn of new groups or organizations that are coming to appreciate and use the timely and reliable precipitation data provided by CoCoRaHS. We continue to enjoy mutually beneficial partnerships with the National Weather Service and increasingly with the U.S. Dept. of Agriculture. In May 2012, CoCoRaHS even helped facilitate a national coordination meeting including state emergency management officials, FEMA and other federal agencies related to the use of volunteer-collected snowfall data for county-level disaster declarations.

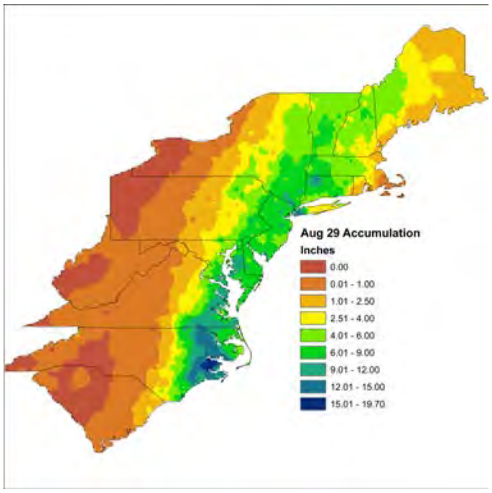


Figure 1. Hurricane Irene Precipitation Map from CoCoRaHS

Figure 2. CoCoRaHS Water Year Summary for CoCoRaHS Station

PROJECT TITLE: Design, Development, Evaluation, Integration and Deployment of New Weather Radar Technology

PRINCIPAL INVESTIGATOR: V. Chandrasekar

RESEARCH TEAM: Francesc Junyent

NOAA TECHNICAL CONTACT: Allen White

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES:

--Evaluate operational status and capabilities of existing NOAA X-band radar system
--Propose upgrade path
--Implement upgrades

PROJECT ACCOMPLISHMENTS:

<u>Evaluate operational status and capabilities of existing NOAA X-band radar system</u>
--Assembled existing radar unit as originally configured
--Operated and tested existing radar unit as originally configured as means to familiarize with the radar system
--Identified and replaced faulty components (main power supply, high-voltage switching tube, miscellaneous circuit components)
--Replaced existing transmitter klystron with high-power magnetron
--Evaluated and characterized transmitter performance
--Tested all available magnetron units for new transmitter
--Repaired second timing circuit unit to generate long pulses
--Updated transmitter supply and beam monitoring circuits to work with new magnetron transmitter
--Evaluated and documented performance of high-power X-band switches for alternate transmission mode

Propose upgrade path

--Evaluated cost and engineering aspects of upgrading the following radar subsystems:

- --Antenna
- --Transmitter
- --Duplexer
- --Receiver

--Prepared document with requirements gathered from NOAA stakeholders, proposed engineering upgrades and designs addressing those requirements, and associated costs

--Attended meeting to present and discuss upgrading options

Implement upgrades

--Prepared detailed system design of chosen upgrades

--Prepared detailed specification for antenna bid

--Prepared bill of materials for purchase of rest of components

PROJECT TITLE: Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis

PRINCIPAL INVESTIGATOR: Renate Brummer,

RESEARCH TEAM: Andrea Schumacher, Robert DeMaria,

NOAA TECHNICAL CONTACT: Ingrid Guch and Phil Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: John Knaff and Mark DeMaria, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

PROJECT OBJECTIVES: 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 by providing useful information for a variety of operational products.

In this project we endeavor to create a real-time and fully automated surface wind analysis system at NHC by combining accepted operational wind reduction procedures and a comparably simple variational data analysis methodology (Knaff et al. 2011). Specifically, this project will make use of the Franklin et al (2003) flight-level to surface wind reduction findings along with current operational procedures and the automated analysis and quality control (QC) procedures used in the Multi-platform tropical cyclone surface wind analyses (MTCSWA; Knaff et al. 2011). The aircraft reconnaissance wind data (flight-level and SFMR), and the MTCSWA satellite-based MTCSWA will be used. The MTCSWA will serve as a first guess field with very low weighting and the aircraft-based data will be composited over a finite period of time and analyzed. The analysis will be performed on a polar grid at the surface level. The proposed wind analysis will run at NHC and make use of the local data stream and JHT servers. The resulting two-dimensional wind analysis will produce 1-min sustained winds valid for 10 meter (m) marine exposure with sufficient resolution to properly capture the radii of maximum winds. The polar grid resolution and domain size will be consistent with the resolution of the aircraft reconnaissance data and the needs of the forecasters.

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

.

PROJECT ACCOMPLISHMENTS: The accomplishments on the four main project tasks are described below.

--Desired analysis properties were determined through discussion with NHC project advisors. The basic questions of when the analysis would be run, how datasets would be weighted and the flight-level-to-surface wind reductions that would be used were determined for the initial analysis attempts.

Analysis timing: Analyses would be triggered at 30 minutes prior to synoptic time (T), at T and again at T+1:30. This would fit the Hurricane Specialist's potential need; namely, generation of the TC Bogus/TC vitals/request for model guidance at T-:30 and T and just prior to releasing the advisory package.

Flight-level-to-surface reduction factors (FLTSRF): Here Franklin et al. (2003) is used as guidance, where eyewall FLTSRF would be used within twice the radius of maximum wind (RMW) and outer vortex FLTSRF would be used outside four times RMW and a linearly weighting of eyewall and outer vortex FLTSRF would be used for 2RMW < r < 4RMW. In addition the FLTSRF would be a function of storm direction reduction factors (i.e., left quadrants would be 4% higher than the right quadrants). This 4% will be maintained in the outer vortex. Finally it was agreed that convective FLTSRF would be used throughout, thus producing conservatively high surface wind estimates.

Data weights for the variational analysis: It was decided that the data weights for the flight-level winds and the SFMR surface wind estimates would be a function of the magnitude of the flight-level winds. SFMR would be preferentially weighted when the flight-level winds exceeded hurricane strength and flight-level winds would be preferentially weighted when the flight-level winds were less than 50-kt. Again more equal weighting will be used when the flight-level winds are between 50 and 64 kt.

Inflow angles: A consensus was reached that 20 degree inflow seemed reasonable.

--Scripts and programs to combine aircraft center fixes, operational best tracks and OFCI/OFCL were created. These take into account whether the analysis is run at T-:30, T, or T+1:30. Points from the CARQ lines and the latest available official forecast and all of the aircraft center fixes in the fdecks are sorted and provided to the analysis software. These files (*.inp) are the starting point for each analysis.

--Scripts and programs were developed to ingest real-time aircraft flight-level, and SFMR datasets. GPS sonde decoders are under development.

--The design of the local data ingest (i.e. aircraft from NHC, MTCSWA from NESDIS, a/f decks from NHC) and analysis has begun. Aircraft, ATCF, and MTCSWA datasets are being mirrored locally and the *.inp files will be generated automatically at T-:30, T and T+1:30, when Atlantic and East Pacific storms become active. An Example Wind analysis is shown in Figure 1 for Hurricane Irene, 24 August 2011 at 12 UTC.

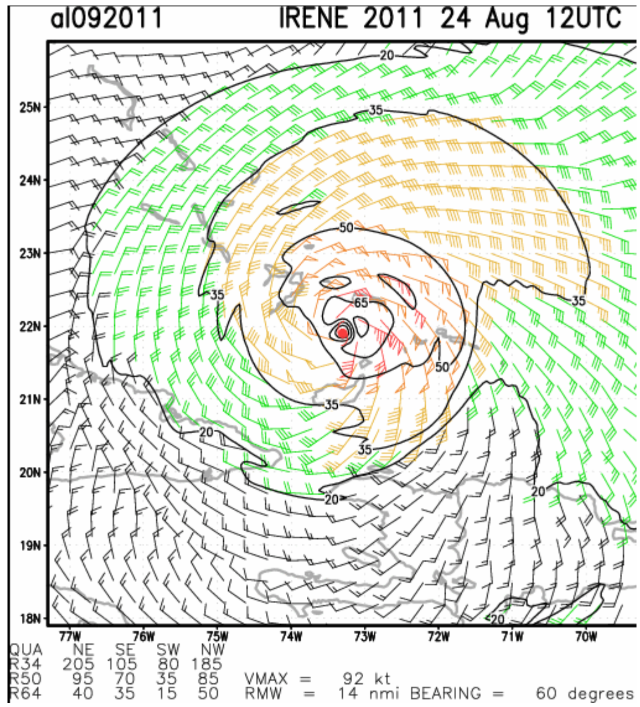


Figure 1. Surface wind analysis based on aircraft reconnaissance collected from 06 UTC to 15 UTC on 24 August 2011. The data are composited in a motion relative framework following the storm track and the analysis is valid at 12 UTC. The table at the bottom provides statistics associated with the vortex.

PROJECT TITLE: eTRaP Upgrade – SSMIS, GOES CONUS Hydro-Estimator (HE)

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: N/A

NOAA TECHNICAL CONTACT: Liqun Ma, NESDIS/OSPO

NOAA RESEARCH TEAM: Bob Kuligowski (NESDIS/STAR), Sheldon Kusselson (NESDIS/OSPO/SAB), Michael Turk (NESDIS/OSPO/SAB), Limin Zhao (NESDIS/OSPO), and others

PROJECT OBJECTIVES:
--Ingest SSMIS data and GOES HE data, calculate the appropriate weights, and produce the eTRaP product including the new data.
--Complete calibration of eTRaP PoPs.

PROJECT ACCOMPLISHMENTS:
--Acquired computer account at STAR
--Installed and ran the eTRaP program.
--Produced a calibration report by comparing eTRaPs with Stage IV radar data
--Experimented with a 40 km radius-of-influence eTRaP (see Figure 1)

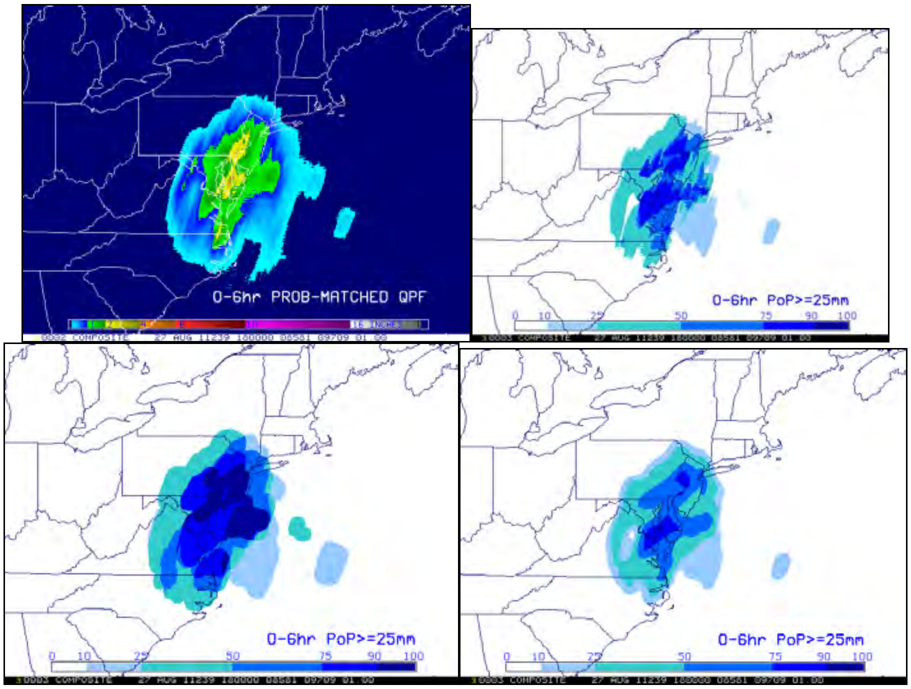


Figure 1. Three ways to calculate probability. (top left) eTRaP-generated 0-6 hr QPF; (top right) 0-6 hr PoP calculated at each point (this is currently operational, see http://www.ssd.noaa.gov/PS/TROP/etrap.html); (bottom left) 0-6 hr PoP calculated within 40 km of each point; (bottom right) 0-6 hr PoP calculated as the fraction of pixels within 40 km which exceed the 25 mm threshold. All from Hurricane Irene on 27 August 2011 at 1800 UTC. We are currently working with forecasters to determine which is the most useful to them in their work.

PROJECT TITLE: HMT Field Coordinator Position in NOAA ESRL Physical Sciences Division

PRINCIPAL INVESTIGATOR: V. Chandrasekar

RESEARCH TEAM: Sanhun Lim (CIRA) – 60%

NOAA TECHNICAL CONTACT: Timothy Schneider and Marty Ralph, Water Cycle Branch, NOAA Physical Sciences Division

NOAA RESEARCH TEAM: This project includes the vast majority of staff in the NOAA Water Cycle Branch. The affiliations are a combination of CIRA, CIRES and federal employees

PROJECT OBJECTIVES: Coordination, implementation, and supervision of field experiments for the Hydrometeorology Testbed (HMT).

PROJECT ACCOMPLISHMENTS:
--Coordinated periodic telecons to summarize HMT-related research;
--Worked with NOAA staff to plan and implement the HMT-West 2012 field season in California;
--Developed a plan for the quantitative precipitation estimation (QPE) major activity area in HMT;
--Conducted research on QPE with NOAA PSD, NWS, and NCAR colleagues;
--Developed a Science Implementation Plan for HMT-SE; and
--Presented HMT QPE findings at AGU Annual Meeting (San Francisco)

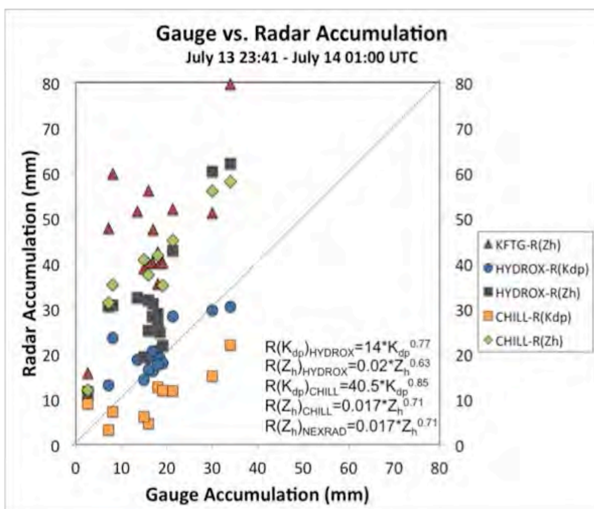


Figure 1. Comparison of radar and gauge rainfall accumulations for a flash flood event in Fourmile Canyon, Colorado during July 2011.

PROJECT TITLE: POES-GOES Blended Hydrometeorological Products

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: John Forsythe, Andy Jones

NOAA TECHNICAL CONTACT: Limin Zhao, NESDIS/OSDPD

NOAA RESEARCH TEAM: Limin Zhao (NESDIS/OSDPD), Sheldon Kusselson (NESDIS/OSDPD), John Paquette (NESDIS/OSDPD), Ralph Ferraro (NESDIS/STAR), and others

PROJECT OBJECTIVES:
-- Write the code to ingest ATMS/NPP data into DPEAS for Blended TPW and Blended RR
--Deliver the Blended RR code and Enhanced Blended TPW code (developed last year)

PROJECT ACCOMPLISHMENTS:
--We have developed the ATMS code. We now await the operational implementation of the ATMS data so that we can test its inclusion in Blended TPW and Blended RR. This is to be accomplished in next year's work.
--The Blended RR (Fig. 1) and Enhanced Blended TPW codes were delivered. We are now working on the ATBDs and other required documents.
--We worked with University of Michigan colleagues on ways to blend TPW observations using universal kriging.
--We also implemented a fix for MIRS data which was causing artifacts in the Blended TPW loops.

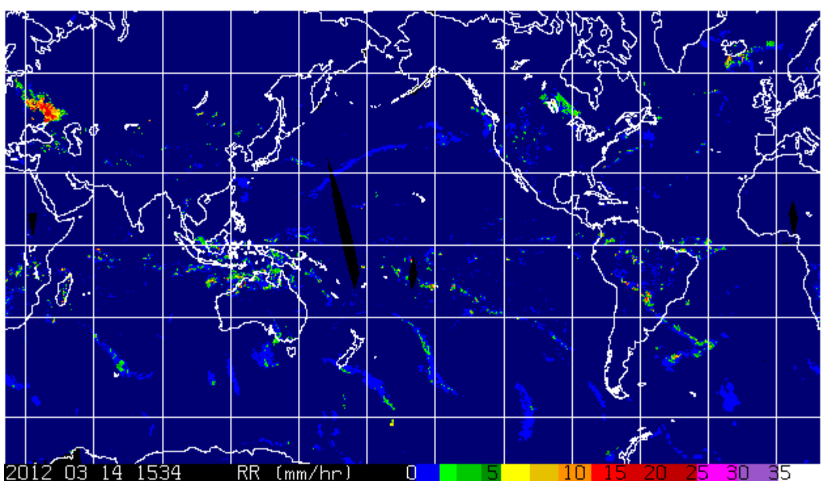


Figure 1. Blended Rain Rate on 14 March 2012 at 1543 UTC. Image retrieved from http://cat.cira.colostate.edu.

PROJECT TITLE: Quantifying the Source of Atmospheric Ice Nuclei from Biomass Burning Aerosols

PRINCIPAL INVESTIGATOR: Paul J. DeMott

CO-PRINCIPAL INVESTIGATORS: Anthony J. Prenni, Amy P. Sullivan

RESEARCH TEAM:

NOAA TECHNICAL CONTACT:

NOAA RESEARCH TEAM:

The goals and objectives for the work underway are focused around identifying the contributions of biomass burning of forests, grasslands and other biomass combustion as sources for atmospheric ice nuclei (IN), to discern the nature of these IN, their association to other aerosol properties, their temporal transformations, and to quantify these results for use in numerical models:

PROJECT OBJECTIVES:

--Perform sampling of IN from controlled burns of Western and Southeastern U.S. forest and grassland fuels.

--Perform sampling of IN within wildfire smoke plumes of opportunity.

--Explore the impact of atmospheric processing on biomass smokes

--Explore relations between IN number concentrations and other aerosol properties

--Parameterize ice nucleation results for use in numerical modeling studies.

PROJECT ACCOMPLISHMENTS:
The previous annual report summarized the following activities, methods, and results in great detail. A brief synopsis is given here for framing progress made during Year 2. During Year 1, significant progress was made on Objectives 1, 2, and 4, plans were made for additional field deployments during year 2, conference presentations were made, a first publication draft was begun, and retention of new personnel was undertaken.

Experimental protocols and logistics for measurements of biomass burning aerosols in the ambient atmosphere were established in Year 1. Measurements were conducted using the CSU air quality laboratory, a custom designed panel truck vehicle, along with portable generators for locating downwind of the parked vehicle during sampling. Measurements of IN number concentrations were made using the Colorado State University (CSU) continuous flow diffusion chamber (CFDC) (Rogers et al. 2001, Eidhammer et al. 2010). Simultaneous measurements included condensation nuclei (CN), particle size distributions, PM2.5 mass, and PM2.5 chemical composition. Attempt was made to associate similar measurements in both background and smoke-affected air in every case. Measurements were made from seven fires in Colorado and Wyoming, and one case of intense smoke from long range transport. The first annual report includes a map of fire locations and a table of fire characteristics. While prescribed burn sampling was proposed to dominate Year 1 activities, weather conditions limited such sampling, so opportunities were sought to sample smoke from wildland fires, in advance of such a planned focus during Year 3.

Results from Year 1 were:
--New evidence was obtained for biomass burning particles as a source for ice nuclei. Airborne measurements during projects supported under other agency funding and with different foci provided special sampling opportunities confirming the production of ice nuclei during burning of sage-dominated biomass in Wyoming and slash pile biomass in the Sierra's. Some of these results were incorporated into the draft of our first study publication (Prenni et al. 2012).

--Ice nucleation efficiency of biomass burning particles from prescribed burns was quantified. Prescribed burns in coordination with the U.S. Forest Service in Colorado allowed for quantifying IN production from such fires and relation to other aerosol properties. The number of IN clearly increase in the presence of smoke near prescribed fire sources, although the fraction of total particles (CN) which nucleate ice is usually less than found in background air. Also, the ice nucleating fractions of all particles were lower than estimated as needed for fires to have a large impact on regional IN budgets [Petters et al., 2009], suggesting primarily local influence. Firming this conclusion will require more careful consideration of fire size, duration, and dispersion characteristics. Relations to other aerosol properties, such as concentrations of large aerosol particles (DeMott et al. 2010) were clearly noted and will be applied toward parameterizing IN from biomass burning for use in numerical model simulations.

--Larger, more intense wildfires were found to exhibit regional impacts on ice nuclei populations. Sampling of four wildfires sized small to very large, at distances of several to nearly 1000 miles indicated IN number concentrations exceeding the background atmosphere and IN fractions of total aerosol at least equivalent to the background atmosphere, implying high occurrence of regional impacts on IN feeding clouds.

--Smoldering wildfires were observed to be associated with lower IN production efficiency. For the same fire and IN activation conditions (T, RH), primarily smoldering fire conditions were associated with lowered efficiency of generating ice nuclei in comparison to flaming conditions as determined by visual and bulk chemical analyses.

--Chemical marker studies added to growing database of such fire data from the laboratory and the atmosphere.

--Student and postdoctoral recruiting and training were advanced, conference presentations made. Three different postdoctoral scientists assisted with measurements at times, and a new M.S. student was targeted for Summer 2011 acceptance.

--Presentations and publications: Dr. Prenni presented results at the International Aerosol Conference in Helsinki in August 2010. A short abstract was published.

Year 2 Activities

The research results described from Year 1 have been consolidated into a first project publication that is in the final stages for submission, tentatively March 1, to Geophysical Research Letters (Prenni et al. 2012).

New research during Year 2 centered on objectives 1, 4 and 5. Following the proposed research plan, prescribed burn sampling was planned and executed at the Joseph W. Jones Ecological Research Center (http://www.jonesctr.org/) near Newton, GA during March 2011. Equipment was transported using the CSU Air Quality mobile laboratory to the site. Four large burns were sampled and one day was devoted to background sampling only. Fuels included wiregrass, pine needles, small shrubs, and longleaf pine trees typical of the large regions burned in the SE United States in springtime. Measurements included ice nuclei number concentration over a broad temperature range, ice nuclei chemical composition measurements (via post-analysis of TEM grid collections of IN), aerosol size distribution, total aerosol chemistry (as described in the Year 1 report), and total aerosol mass measurements (new TEOM device purchased to supplement existing EBAMS). Total chemistry and mass measurements were collected at near-fire and background sites on every day of the study. The entire suite of measurements will become a standard suite for all future sampling periods, including the smoke processing studies that will be conducted as part of the next series of prescribed burn sampling in Colorado. We made additional measurements at Sheep Creek during prescribed burns in summer 2011. Unfortunately, due to the relatively jarring drive to the remote sampling location of these burns, the CFDC developed a leak prior to the measurements, and the resulting IN data quality is poor. Nevertheless, this sampling period did provide additional bulk chemical data for comparison to earlier measurements. Finally, the newly purchased TEOM failed during measurements in Year 2. This instrument took several weeks to fix, but is ready for additional measurements in 2012. .

The primary foci for new measurements during Year 2 was determination of IN temperature spectra, and identification of the source physical and chemical characteristics of ice nuclei found in biomass burning plumes. Besides TEM analyses and correlations of IN to bulk smoke chemistry, additional exploratory measurements were made to identify the organic and biological contributions to ice nuclei in the smoke plumes. This was done in collaboration with University of Wyoming colleagues Thomas Hill and Gary Franc who participate with us on the NSF-funded study “Collaborative Research: Laboratory and Ground-Based Studies Addressing Unresolved Aspects of Atmospheric Ice Nucleation.” That project has a special focus on methods to identify biological ice nuclei. Additional filters were collected in Georgia for rinsing and then testing the freezing of small volume suspensions as a function of temperature, followed by application of the methods of Vali (1971) to determine atmospheric number concentrations of IN. Heat treatments are then applied to liquid droplet populations to determine the proportion of IN that are inorganic versus organic, and separate untreated volumes are put through quantitive polymerase chain reaction (qPCR) analyses using special primers to quantify number concentrations of known biological ice nucleating bacteria (Garcia et al. 2012).

Selected Year 2 Results

--A large and diverse data set was obtained for targeted analyses of IN sources from the Longleaf Pine ecosystem of the SE United States. This data set will serve as the focus for a Master’s thesis and the basis for at least two additional publications. All data have undergone initial processing and quality control, including ice nuclei concentrations, IN TEM grid analyses of elemental compositions and morphology, bulk aerosol compositions, size distributions, and mass concentrations. The diversity of temporal sampling conditions during the prescribed burns is evident in Figure 1. Such images were collected throughout the sampling periods and will assist in further categorization of the smoke and fire character at different times. Additional information graciously provided by the Jones Center scientists included meteorological data, total burn area, total fuel mass per area, and GIS data on both soil and biomass types in each of the burn areas that were an average 500 acres in size.

--IN temperature spectra were obtained for aerosols lofted by prescribed fires for the first time. An example of ice nuclei temperature spectra on one burn day are shown in Figure 2. While variability is evident even for 10 minute sample intervals, clear elevation of local IN concentrations was observed in the vicinity of the fires by up to 100 times above the background conditions for this region and time of year. While these measurements were performed at relatively close ranges of a few hundred to a few kilometers distance, elevation of concentrated plumes were observed on many occasions, clearly reaching to cloud levels. There is widespread use of prescribed burning in this region of the United States during springtime, so the possibility for regional impacts on the ice phase properties of clouds is an issue that can be explored using our data.

--The ice nucleating efficiencies of biomass burning aerosols of the basic type investigated are grossly over-predicted by a recent generalized relation between global atmospheric IN number concentrations, cloud temperature, and aerosol concentrations larger than 0.5 □m. DeMott et al. (2010) used observational data from a variety of field campaigns to recommend such a relationship for use in predicting IN number concentrations active in mixed-phase clouds within global climate models. This relation provided an explicit link to aerosol variability while greatly reducing the uncertainty in predicting IN concentrations versus temperature, but it was hypothesized that specific dependence of ice nuclei on source chemical composition might be responsible for unexplained remaining variations in space and time. Data shown in Figure 3 demonstrate nearly an order of magnitude lowered efficiency of IN in the particles released from the burn on March 11 compared to values predicted for the background global atmosphere under similar perturbations to aerosol concentrations larger than 0.5 μm. Nevertheless, inference could be made that for this particular burn and for the temperature regime isolated in this plot, specific relation of the ice nuclei concentrations to an aerosol parameter such as the concentrations larger than a certain size could be used to parameterize some amount of the variation noted. Remaining variations in this case may reflect actual variations in fire conditions and their impact on the particle chemical and surface properties as they affect ice nucleation. Thus, basic source functions for IN from fires should be possible, but there remain complexities to be explored.

--IN chemical speciation during burns reveals a diversity of sources from soil particles, unknown organic species with varied origins, and soot, the proportions of which appear to depend on combustion conditions. A first example of such results is shown from segments of one burn day in Figure 4. First categorization of the ice nuclei on the basis of elemental compositions and morphology indicated the dominance of carbonaceous types during burns in general. These C-dominated types varied from highly organic types with inorganic inclusions attributed by Stith et al. (2011) to a biomass combustion source, to a range of unknown and apparently solid organics, some showing the morphology of plant fragments, to soot particle agglomerates. This is the first confirmation that soot particles acting as ice nuclei are produced from biomass combustion. While this type has not been found to be abundant among atmospheric ice nuclei on the basis of general collections of this type in the free troposphere, it will be important to document its frequency of occurrence in the broader data set and the conditions under which it is favored for formation. In this regard, it was surprising on March 11 to find that soot IN were not associated with close flaming combustion, but appeared during smoldering and aged-smoke phases of the fire. Finally, the appearance of mineral and soil IN was maximized during the nearby flaming phase, as might have been expected in correlation to soil surface perturbation.

--Drop freezing studies of collected aerosols (not shown) support the majority contribution of organic ice nuclei produced from these prescribed fires, especially at activation temperatures warmer than -20°C. As the filter collections at Jones Center were done value added and on short notice, the filter media employed (nylon) was not the same as employed in NSF studies (polycarbonate nucleopore). A consequence was the apparent (visual) inefficiency of efforts to completely remove the carbonaceous material into DI water. We will therefore seek to further refine this method during future burns to improve confidence in directly comparing CFDC and drop freezing derived IN number concentration estimates.

Year 2 Education and Training

Student Christina McCluskey began her M.S. studies in Fall 2011 and is focusing her research on the data collected during the Georgia campaign. Dr. Sonia Kreidenweis serves as Ms. McCluskey's academic supervisor and Dr. DeMott will mentor her research and serve on her thesis committee. Despite a full first-year class load, Christina is actively working on analysis toward her thesis preparation and a second reviewed publication that she will lead. Three postdoctoral scientists have worked on the project at times, including Dr. Ryan Sullivan, Dr. Gavin McMeeking, and Dr. Yutaka Tobo. Dr. Sullivan has accepted a faculty position at Carnegie Mellon University. Dr. McMeeking, who participated in instrument setup and data collection in Georgia, has transitioned to a research scientist position. He will take over a modest number of Dr. Prenni's responsibilities on this project during the last year of the study due to Dr. Prenni's transitioning to a position of responsibility for measurements on National Parks Service related research studies. Dr. Yury Desyaterik, a research scientist, assisted Dr. Amy Sullivan for aerosol chemistry measurements during prescribed burns.

Research results from this study were presented in multiple scientific forums during the past year, where NOAA funding on this grant was acknowledged. Web sites are noted where abstracts or presentations may be found. A first publication is ready for submission for peer review.

Activities Planned Through Year 3

Progress will continue on all project objectives in Year 3:

--Analyses of the Georgia fire data sets will continue to provide more comprehensive results of the types shown in Figures 2 to 4 in this report for the entire range of conditions encountered during the study. Specific aerosol physical and chemical impacts on ice nuclei activation characteristics will be explored, including relation on a fire by fire basis to the bulk chemical compositions (see tabulated data of the type given in the last report).

--Parameterizations of ice nuclei number concentrations on the basis of completed analyses will be recommended for use in exploring the local and regional cold cloud impacts of fires in the SE and Western U.S. We have access to a cloud resolving model for possible sensitivity studies as part of separate funding, and we will make our research results available to other modeling research groups.

--Chemical marker data for fires will be integrated into broader assessments being performed by Dr. Amy Sullivan.

--New prescribed burn sampling opportunities will be sought in both Colorado and the Southeast U.S. A special case being sought for sampling during 2012 is sawgrass burning along coastal Florida. This species provides a link to the biomass type exhibiting the highest ice nucleation efficiency in our prior laboratory studies (Petters et al. 2009). Additionally, we will integrate aging methods into new burns.

--Additional wildfire sampling opportunities will be taken advantage of within the Colorado region. We especially still desire to locate within regions where wildfires are producing strongly elevated mass and number concentrations of particles.

--A second major publication will be drafted for tentative submission during summer 2012. A third publication integrating new measurements in 2012 will be prepared prior to the end of the research grant.

--A final report will be prepared and submitted at the end of the study, and consideration will be given toward proposal of new research studies that might advance the knowledge gained in this study.

Figure 1. Near-vicinity flaming (March 11) versus later smoldering combustion (March 11) during prescribed burning in Longleaf Pine ecosystem of SW Georgia.

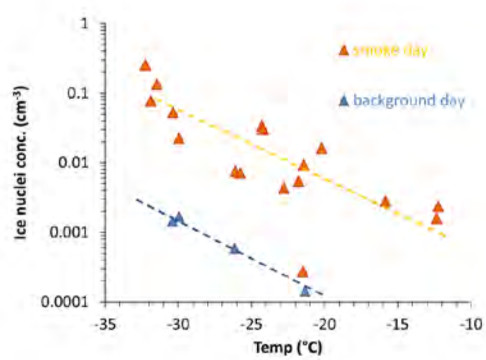


Figure 2. Period (5-15 minute) average ice nuclei concentrations measured on a fire day (3/15/11) versus a background sampling period (3/9/11) deemed to be characteristic of most background periods on the basis of bulk chemical composition data collected daily

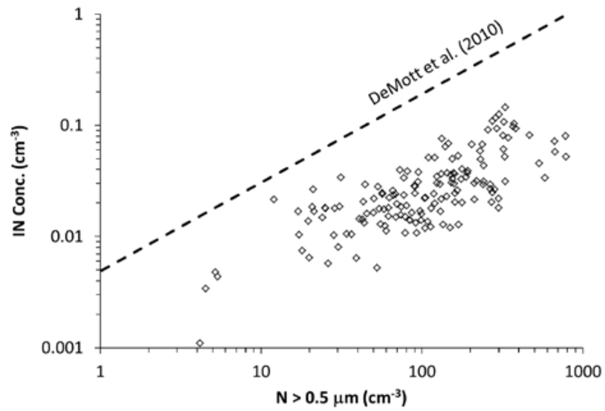


Figure 3. Relation between IN concentrations (all at -30°C) and aerosol concentrations larger than 0.5 µm for 30 s intervals during smoke sampling on March 11, 2011. Comparison is made to global background IN predicted based on the observationally-based parameterization given in DeMott et al. (2010). These data demonstrate the relative inefficiency of the fire-produced IN from this ecosystem.

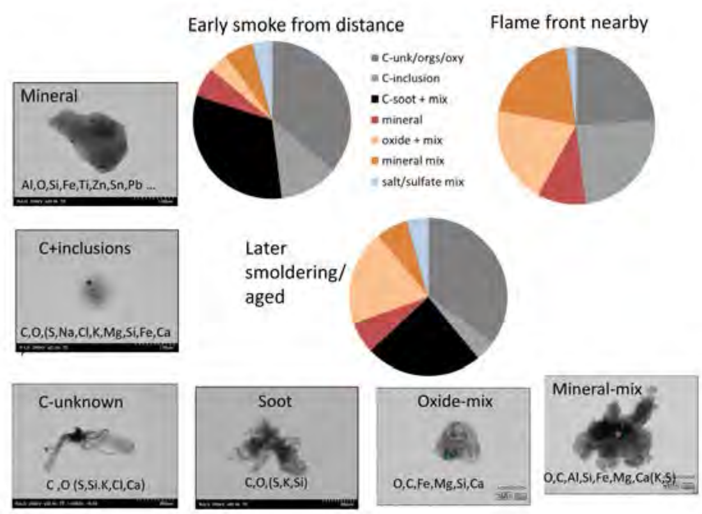


Figure 4. Ice nuclei particle types, with examples of their respective morphologies and elemental compositions observed during three subsequent hour-long periods on March 11, 2011. The flame front and later smoldering periods are shown in Figure 1.

PROJECT TITLE: Quantitative Precipitation Estimation (QPE)

PRINCIPAL INVESTIGATOR: V. Chandrasekar

RESEARCH TEAM: Sanghun Lim

NOAA TECHNICAL CONTACT:

NOAA RESEARCH TEAM:

PROJECT OBJECTIVE:
QPE in the NOAA's West Hydrometeorology Testbed (HMT-West)

PROJECT ACCOMPLISHMENTS:

--Relative bias estimation of HMT-West radars
--Hydrometeor classification
--New Kdp retrieval algorithm
--Evaluation of QPE based on new Kdp

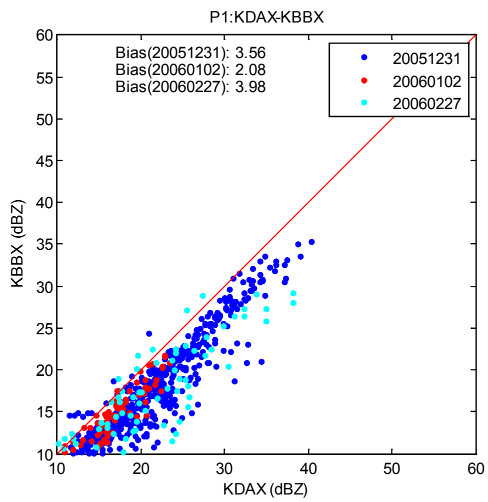


Figure 1. Bias Comparison

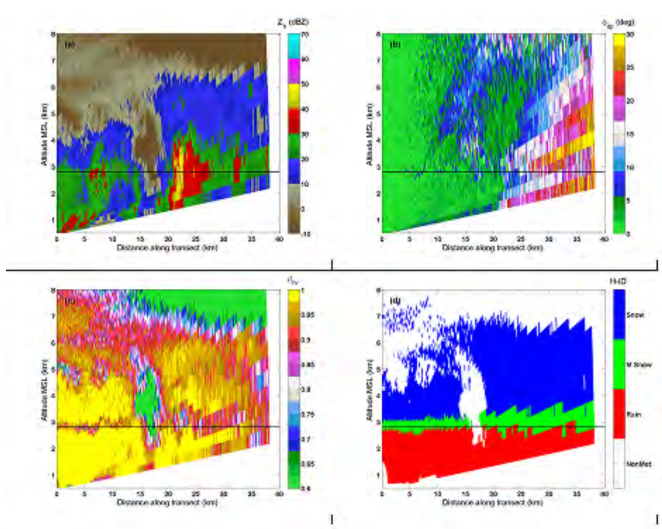


Figure 2. Classification

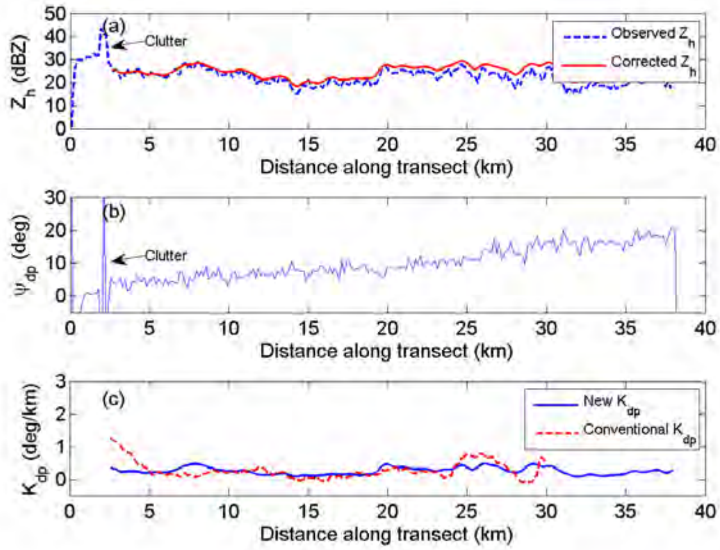


Figure 3. New Kdp

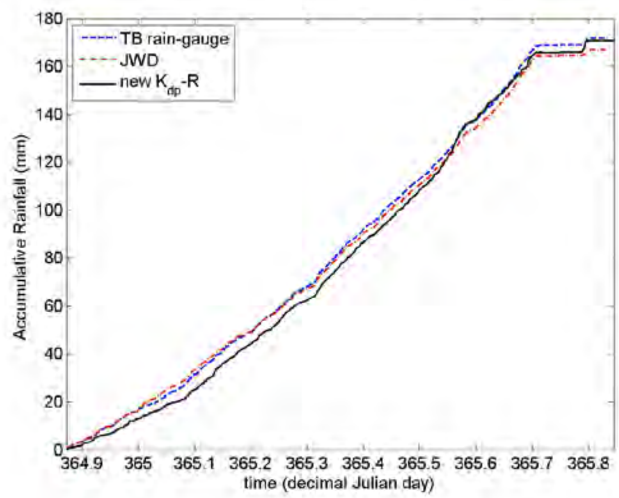


Figure 4. QPE

PROJECT TITLE: Science and Management Support for NPP VIIRS EDR Imagery Algorithm and Validation Activities and 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: Ingrid Guch and Phil Hoffman, NOAA/OAR Cooperative Institute Program

NOAA RESEARCH TEAM: Don Hillger, John Knaff, Dan Lindsey, Mark DeMaria, CIRA/Regional and Mesoscale Meteorology (RAMM) Branch

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 Imager/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) which 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).

These VIIRS calibration/validation projects directly address NOAA's Weather and Water goal which seeks to serve society's needs for weather and water information. This research 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.

CIRA's research can be divided in into a) VIIRS Imagery Algorithm and Validation Activities and b) VIIRS Cloud Base Height (CBH) and Cloud Cover/Layers (CCL) Validation.

PROJECT ACCOMPLISHMENTS:
Project I: VIIRS Imagery Algorithm and Validation Activities
--A large amount of VIIRS proxy data was collected and archived. Display/visualization tools (such as McIDAS-V) were successfully prepared and enabled. These tools were ready to be used immediately after the VIIRS post-launch checkout phase. VIIRS imagery and products on tropical cyclones, dust enhancement, aerosols, and snow, were created and shared with NESDIS management. VIIRS imagery was depicted on the Imagery Team Website, CIRA's NPP Blog, and occasionally on the NESDIS and StAR pages.

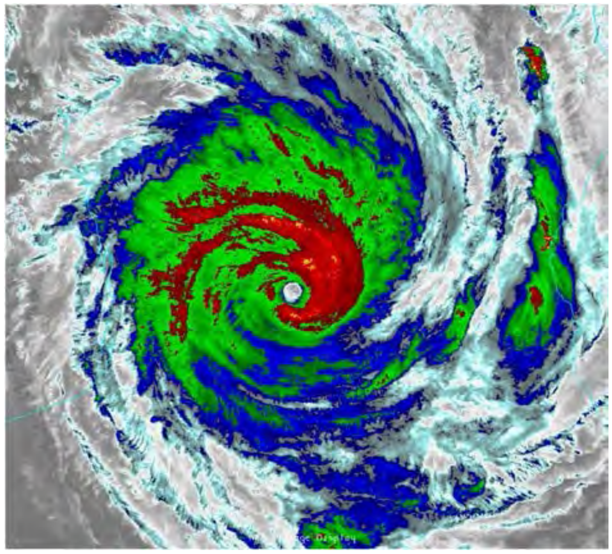


Figure 1. VIIRS I-band-5 at 375m of Tropical Cyclone Funso in the SW Indian Ocean on 25 Jan 2012.

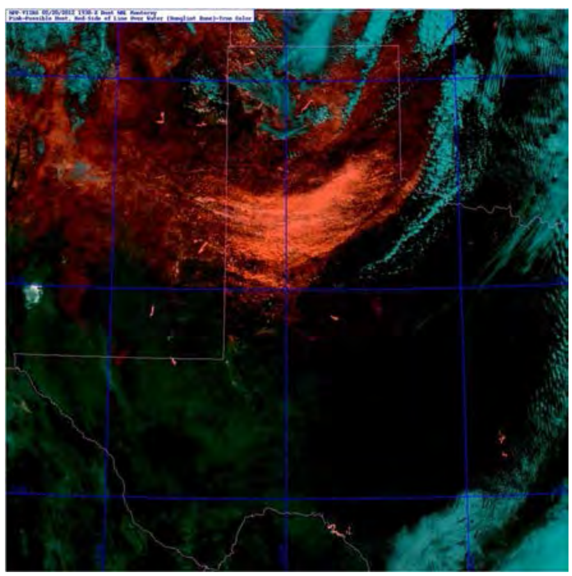


Figure 2. VIIRS imagery with dust enhancement (red) depicting a strong dust storm over the Texas Panhandle on 20 February 2012 at 1940 UTC

--Preparations were made so that CIRA was able to receive and display (in near real-time) the Imagery EDRs and SDRs from available sources (GRAVITE and PEATE).

--Activities with other VIIRS EDR and SDR team members were coordinated to accomplish the checkout of imagery and image product quality. Weekly telecons were conducted to discuss the quality of the imagery, including such things as: data access, image quality, image and data processing problems, and discrepancy reporting. CIRA scientists participated in the identification of bad and duplicate imagery EDR granules with “missing triangles” of data. These examples were supplied to the IDPS team, who subsequently identified the issues and corrections are pending.

Project II: VIIRS Cloud Base Height and Cloud Cover/Layers Validation
--Information on ARM validation and tools were developed for predicting overpass times at these sites. In addition, tools for predicting co-location between the CloudSat and Suomi NPP satellites were developed and automated. Given CloudSat's current orbit outside of the A-Train, the two satellites converge every 2-3 days. Plans are for CloudSat to rejoin the A-Train in mid-2012.

--Code to account for parallax effects in CloudSat/NPP pixel matching was written.

--Work began 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. Since the EDRs are aggregated from the Intermediate Products (IPs), the latter are the initial focus of this cal/val effort as they are available at the native sensor resolution of VIIRS M-bands.

--Because CloudSat data are currently available, it is not yet necessary to enlist a combination of ground-based radar (e.g., W-band), lidar, and ceilometers measurements as available from the ARM sites. These point sources will not provide statistically robust cal/val results and require additional assumptions that make this validation source less ideal.

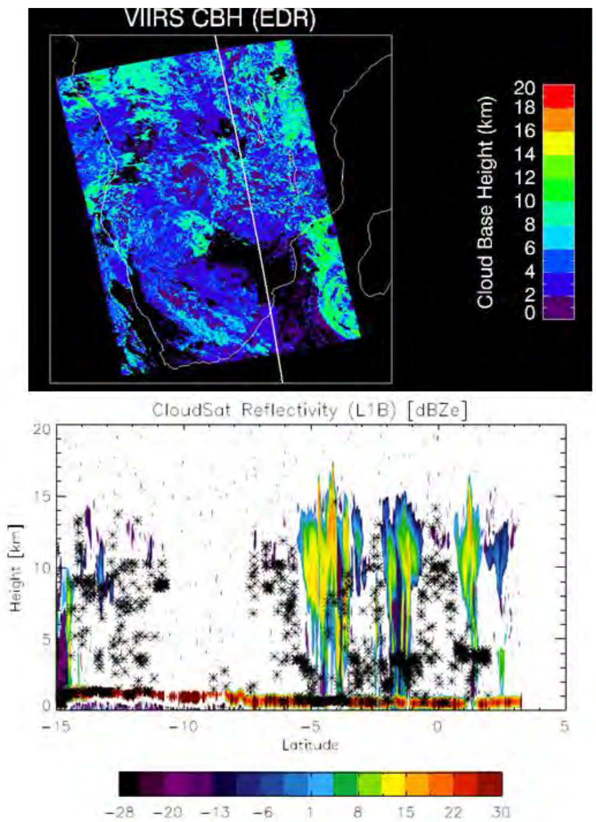


Figure 3. "Sample matchup between VIIRS-retrieved Cloud Base Heights (asterisks) and CloudSat radar reflectivity profile (color, in dBZ) for 17 Feb 2012 at ~1150 UTC."

Results of this research are being presented at annual conferences in partnership and coordination with the greater JPSS/VIIRS Calibration/Validation Team.

PROJECT TITLE: Simulation and Analysis of the Interaction between Aerosols and Clouds, Precipitation and the Radiation Budget over the Gulf of Mexico and Houston

PRINCIPAL INVESTIGATORS: William R. Cotton and Gustavo Carrió

RESEARCH TEAM:

NOAA TECHNICAL CONTACT: Kea Duckenfield

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES: Our project targets two of the NOAA's Atmospheric Composition and Climate (ACC) program objectives: i) "research targeting processes or measurements germane to atmospheric composition that contribute to substantial uncertainty in simulations of aerosol/climate interactions" and ii) "analysis and interpretation of data from the GoMACCS 2006 field campaign".

PROJECT ACCOMPLISHMENTS: We analyzed the effect of the growth of the Houston metropolitan area on the intensity of convection and precipitation, focusing on events triggered by the seabreeze circulation. Our analyses have been performed in four distinct phases. The activities and foci of the studies corresponding to those phases can be summarized as follows:

1--Landuse. A series of multigrid simulations were performed using the Regional Atmospheric Modeling System developed at CSU (RAMS@CSU) and a seabreeze-induced case study (August 24, 2000) as a benchmark. The 1992, 2001, 2006 high resolution (30m) National Land Cover Data (NLCD) were used for an objective experimental design of the landuse sensitivity experiments. These datasets were used for the initialization of the two finest grids, enhancing the representation of the land surface heterogeneities with respect to the default RAMS@CSU land use dataset with a pixel size of 1 km. More importantly, the use of these three satellite datasets for the City of Houston allowed a realistic experimental design for sensitivity runs varying the city size and subgrid area fractions. The Town Energy Budget (TEB) urban model was coupled to the newest version of RAMS@CSU. The coupled model was adapted to run in parallel to maximize the full potential of our computing resources. The model was validated against radar data for the case study and the impact of the landuse change on precipitation characteristics was examined. These simulations indicated an important impact of the growth of the metropolitan complex on both, locally accumulated precipitation and spatially integrated values.

2-- Indirect effects of urban pollution. We examined the indirect effects of urban pollution considering urban sources. The intensity of the urban sources was linked to the subgrid urban area fractions derived from satellite data. We performed three series of simulations varying the intensity of the urban sources for the 1992, 2001, and 2006 satellite NLCD datasets. We focused on individual convective cells simulated downwind of the city for which greater amounts of liquid water being thrust aloft into supercooled levels freezes releasing greater amounts of latent heat of freezing invigorating the convection. In that sense, results were consistent with previous studies; however, the response was nonmonotonic.

3--Dependence of the indirect effects on instability. Motivated by the interesting nonmonotonic precipitation response to pollution in phase 2, we designed a new sensitivity experiment to identify the cause of this behavior and analyze how it varies for more or less unstable environments. It consisted of large number (over 100) of multigrid simulations varying both the intensity of the urban CCN source and the convective instability (10 pollution levels and 11 CAPE values). These experiments were performed for the city size linked to the case study (2001) and were initialized modifying its initial fields to vary the CAPE values. This nonmonotonic response was linked to a reduction in the efficiency of riming of ice particles when aerosol concentrations were further enhanced. Therefore, a greater fraction of the icephase condensed water mass is transported out of the storm as pristine ice crystals instead of being transferred to precipitating water species.

4--<u>Aerosol direct effects</u>***.*** Finally, the fourth series of simulations focused on direct (radiative) impact of urban pollution on precipitation, and on the comparison of the various aforementioned effects. We ran numerical experiments considering both indirect and direct effects, only microphysically or radiatively active aerosols, and a run with no urban sources. Our result indicate a non-negligible radiative impact, although less important that the indirect effect and landuse forcing.

<u>General Simulation Conditions</u>
--Model configuration. These mesoscale sensitivity experiments were performed using RAMS@CSU with three two way interactive nested grids with 42 vertical levels and horizontal grid spacing of 15, 3.75, and 0.75 km. The corresponding domain sizes were 1065 X 915km, 382.5 X 382.5km, and 151.5 X 151.5km, respectively, and the grids were centered over the City of Houston. Grids 1 and 2 were used.

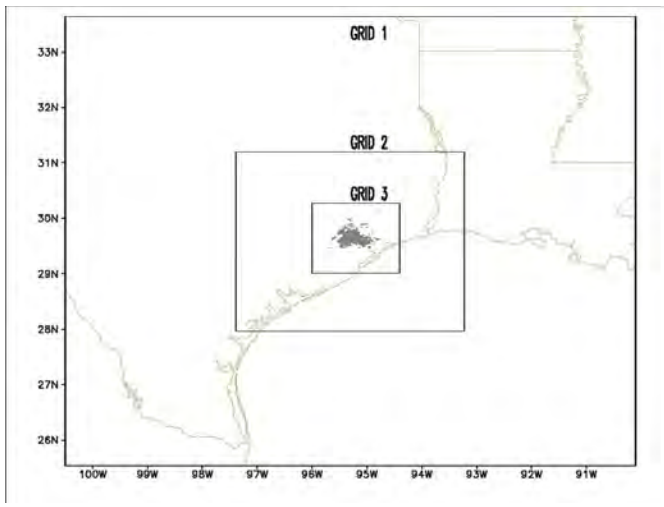


Figure 1. Grid configuration. The center of all grids coincides with the location of the city. The shaded area represents the city of Houston

The vertical grid was stretched using 75m spacing at the finest levels to provide better resolution within the first 1.5 km, and the model top extended to approximately 20 km above ground level. Simulations in phases 1, 2, and 4 were heterogeneously initialized with 40 km ETA data from 24 July 2000 at 00:00 UTC and the simulation period was 24h. For the initialization of phase 3 run, the initial temperature field corresponding to the case study was modified to consider environments with different convective instability. We added or subtracted constant values to the temperature vertical profiles of the finest grid (grid 3) approximately between cloud base and 10000 m in such a way that the convective available potential energy (CAPE) varied between 400 and 1600 Jkg1. In most cases CAPE was varied at 100 Jkg1 intervals, however, we considered 50 Jkg1 intervals for some urban aerosol intensities. Those temperature differences were smoothed out within grid 2 to avoid numerical discontinuities.

<u>Land use and urban CCN sources</u>***.***
The RAMS@CSU code has been modified to initialize the different grids with NLCD data. These data (available at a pixel size of ~30 m) allowed a much better representation of the land surface heterogeneities and the subgrid area fractions of the various landuse categories considered by the model. We considered numerical experiments using the 1992, 2001, and 2006 landuse satellite data sets as well as a *NO CITY* run. The latter corresponds to the satellite data closest to the case used for this study (2001), but the urban subgrid patches

were replaced by the predominant landuse categories in the city surroundings. We also considered a series of numerical experiments varying the intensity of CCN sources linked to the urban area (no sensitivity runs have been performed varying GCCN). To choose CCN concentrations representative of a highly polluted day, we analyzed two aerosol data sets documented during the Texas Air Quality Study / Gulf of Mexico Atmospheric Composition and Climate Study (TexAQSGoMACCS), and CCN measurements on the CIRPAS Twin Otter and NOAA P3 and the data collected by the Ronald H. Brown ship. These 1min temporal series of condensation nuclei (CN) concentrations, CCN/CN ratios, and the corresponding supersaturations were processed for the entire period to make the concentrations consistent with what "CCN" means for the activation routine in RAMS@CSU (i.e., the haze particles or maximum concentration of cloud droplets that can be activated). Peak CCN concentrations exceeded 25000 cm3; however, we eventually used lower CCN concentrations. A series of preliminary tests indicated that increasing the latter above 4000 cm3 did not produce a significant impact on the results. City CCN sources were considered by nudging these high concentrations at the first model level above the ground multiplied by the subgrid urban fraction of the corresponding grid cell. In addition to high CCN concentrations over the city, we initialized the surroundings and the gulf area with more moderate and "cleaner" CCN values, respectively. In all cases, we considered urban sources linked to the CCN concentrations between 0 and 4000cm3. These values correspond to the maximum values (entirely urban grid cell) that were used to nudge the first model level to consider CCN sources. All runs focused on effects of urban CCN enhancement and therefore, GCCN concentrations were homogeneously initialized in an identical manner for all runs. For that purpose, we chose the values of the seasalt jet mode (approximately 2 m m in diameter) predicted by O'Dowd formulae when using the wind speed over the gulf at the time of initialization. For these studies, we used the binemulating bulk microphysical model that predicts both the mass mixing ratio and number concentrations of the hydrometeor species (cloud droplet, drizzle drops, rain, pristine ice, aggregates, snow, graupel, and hail) CCN, GCCN and IFN concentrations were also considered as prognostic variables.

Concluding Remarks. We examined the effect of Houston's urban growth on convection/ precipitation isolating the urban pollution aerosol direct and indirect effects and landuse change impact.

In summary, when considering "larger cities" we simulated:
--Higher precipitation rates over the finest grid, the NO CITY run exhibits a maximum much later.
--The precipitation rates and accumulated values over urban cells showed lower but positive differences.
--The intensity of the sea breeze increased.
--Total volume of precipitation (finest grid) increased monotonically 9, 11, and 26% (over NOCITY) for 1992, 2001, and 2006, respectively,
--LWPs and updraft maxima did not change significantly,
--Conversely, the integral value of condensate and maximum downdrafts increased. The latter result is liked to the larger area coverage of the storm.

While "more polluted cities" resulted in:
--Positive differences in LWC maxima and differences up to 9% for supercooled water mass.
--Small differences in the total precipitated volume for both the entire domain and the city
-- However, there is a significant increase in the accumulated precipitation linked to the most intense cells downwind of the city.
--Accumulated precipitation maxima exhibited a nonmonotonic impact.

When considering more or less unstable environments:
--Again, a nonmonotonic response of accumulated precipitation maxima (independent of the value of CAPE).
--It first increases from the clean city run to a certain level of particulate pollution and then decreases when considering more intense urban sources.
--Updraft maxima altitude, integral mass of supercooled water, and precipitation efficiency also exhibited a nonmonotonic behavior.
--Further enhancing urban aerosol concentrations reduces the efficiencies of riming processes, responsible for the rapid transfer of the SC liquid water to the ice phase and larger amounts of condensate were transported upwards into the storm anvil.

--For more unstable environments, the peak values of these quantities corresponded to higher levels of pollution. Larger overall upward fluxes and therefore more intense CCN sources are required to produce equivalent micro and macrophysical effects.

--The increase of the particulate pollution is more likely to selectively enhance precipitation of convective events characterized by higher instability.

And, for radiative effects of urban pollution:
--Surface cooling produces a small although nonnegligible reduction of convective instability, intensity of the seabreeze, and precipitation.
--Results suggest that the radiative effect is less important than the indirect effect for seabreeze-induced storms over Houston, which in turn, is less important than the landuse effects.

PROJECT TITLE: Summer School on Atmospheric Modeling

PRINCIPAL INVESTIGATOR: David Randall

RESEARCH TEAM:

NOAA TECHNICAL CONTACT:

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES AND ACCOMPLISHMENTS:
1—Summer School on Atmospheric Modeling

Most of our Year 1 funding was used to develop and conduct a Summer School on Atmospheric Modeling (SSAM), which was held in Boulder Colorado on July 19-21, 2010. For 2010, the focus of SSAM was FIM, a Flow-Following, Finite-Volume, Icosahedral Model developed at NOAA's Earth System Research Laboratory (ESRL).

The program for the Summer School is shown in Table 1. The presentations and other course materials are available at http://wrfportal.org/FIMPortal.html.

Twenty-five students participated; a list of the students is available upon request. Demand exceeded supply: Some students who applied for the course could not be accommodated due to space limitations, which were announced in advance. When the Summer School ended, the students provided written feedback on the design and conduct of the course. The feedback was strongly positive. Copies of the students' comments are available on request.

SSAM was made possible through the efforts of ESRL scientists, whose participation was authorized by ESRL Director Alexander MacDonald. Dr. MacDonald also gave one of the opening lectures of the Summer School. A letter to Dr. MacDonald is attached to this report.

In addition, SSAM received support from NCAR. This included a significant amount of computing time, as well as use of meeting space at NCAR's Foothills Laboratory.

2--Class Materials on Global Atmospheric Modeling

David Randall is currently nearing completion of a book with the working title "Atmospheric Processes in Climate," to be published by Princeton University Press. The book is aimed at undergraduates. It should appear in late 2011 or early 2012. In addition, Randall taught a graduate-level class during the fall semester of 2010 entitled "Introduction to General Circulation Modeling." The materials used for this class are being used as the basis for a second book, to be completed during 2012.

Summer School in Atmospheric Modeling (SSAM)

Time	Monday 7/19/10	Tuesday 7/20/10	Wednesday 7/21/10
9:00	Welcome, Introduction, and FIM Overview -- David Randall, Alexander MacDonald, Steve Koch, Jin Lee, Rainer Bleck	Parameterizations -- Jongil Han and Jian-Wen Bao	Geodesic numerics 2 -- Jin Lee
10:00	BREAK	BREAK	BREAK
10:15	Geodesic numerics 1 -- David Randall, Jin Lee	FIM as a numerical weather prediction tool -- Stan Benjamin, Jin Lee	Vertical discretization -- Rainer Bleck, Stan Benjamin
11:15	Hybrid vertical coordinates -- Rainer Bleck, Stan Benjamin	Computational issues – Jin Lee, Tom Henderson	Overview of some research issues -- David Randall
12:00	LUNCH	LUNCH	LUNCH
13:30	Hands-on with FIM Basic mechanics of running the model -- Brandon Lynge, Jeff Smith, and Jim Rosinski,	Hands-on with FIM Case 1 (winter) – Stan Benjamin, Jim Rosinski, Brandon, Lynge, and Jeff Smith	Hands-on with FIM Case 2 (summer) -- Jin Lee, Jian-Wen Bao, Jim Rosinski, Susan Sahm, Brandon Lynge, and Jeff Smith
15:45	BREAK	BREAK	BREAK
16:00	Introduction to FIM diagnostics -- Ning Wang, Phillip Pegion and Jin Lee	Where FIM stands as a candidate model for operational NWP -- Stan Benjamin	Closing session and feedback from students -- David Randall, Jin Lee, Rainer Bleck
17:00	Adjourn for the day	Adjourn for the day	Summer school ends

PROJECT TITLE: The Role of the Colorado Climate Center in a Meaningful Drought Early Warning System for the Upper Colorado Basin

PRINCIPAL INVESTIGATOR: Nolan Doesken

RESEARCH TEAM: Becky Smith

NOAA TECHNICAL CONTACT: Allan.Schmidt@noaa.gov; OAR Cooperative Institutes Office (CIPO)

NOAA RESEARCH TEAM: Roger Pulwarty, Jim Verdin, Lisa Darby, Chad NcNutt (NIDIS program office, Boulder CO)

PROJECT OBJECTIVES:
--To complete a thorough data inventory of all water variables over the Upper Colorado River Basin.
--To obtain a better understanding of the water balance and its seasonal and inter-annual variability for the Upper Colorado River Basin.
--To identify the relationship between the hydroclimate of the Upper Colorado River Basin and large-scale climate variability.

PROJECT ACCOMPLISHMENTS: We are now in the final phases of this initial NIDIS Upper Colorado River Basin Pilot project contract. The intensive drought monitoring efforts and the production of weekly webinars and narrative coordinated summaries that began last year are continuing but are now being supported by phase two NOAA NIDIS funding. The work described here is the ongoing focused research being conducted by Becky Smith in pursuit of her PhD.

Data Inventory. In order to better understand the climate variability and water availability in the Upper Colorado River Basin, a thorough inventory of all data products available over the basin was conducted. *In-situ* observations include NWS COOP precipitation observations, SNOTEL precipitation and snow water equivalent observations, reservoir storage volumes from the U.S. Bureau of Reclamation, and USGS streamflow measurements. Because of the sparseness of *in-situ* data in the region, gridded products are also analyzed. Reanalysis data from NCEP, NASA, and ECMWF provide precipitation, evaporation, specific humidity and wind estimates. Satellite data also provide useful information—the GRACE satellite mission provides monthly changes in terrestrial water storage over basin scales; snow water equivalent estimates are available from AMSR-E on the AQUA satellite; satellite observations combined with empirical models were also used to estimate evapotranspiration over the basin.

The water balance of the Upper Colorado River Basin. Calculations of the surface and atmospheric water budgets were completed using the entire suite of available *in-situ*, reanalysis, and satellite data over the basin. A comparison of the different products show which data are better representatives for the basin and which best capture the seasonal and inter-annual variability. Results have been written in a first draft of a paper that will soon be submitted for publication.

Relationship between local hydroclimate and large-scale climate variability. A first step at attempting to better predict the seasonal water supply of the basin first requires an understanding of the relationships between the local climate variables in the basin and large-scale climate variability (e.g. ENSO, PDO). Maximum and minimum temperature and precipitation observations (using COOP and SNOTEL data) for 30 years were gridded and averaged (precipitation was volume totaled) for one sub-basin in the Upper Colorado River Basin. This time series was then correlated with gridded sea surface temperature data and an EOF analysis was performed to find what large-scale climate indices are closely related to the variability in the sub-basin. These first steps were presented at the AMS Annual Conference in January.

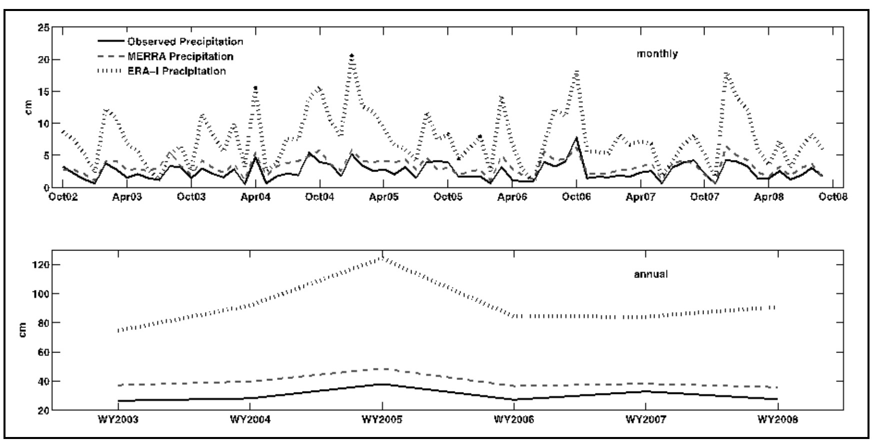


Figure 1. A comparison of observed precipitation with MERRA and ERA-I reanalysis precipitation over the basin.

PROJECT TITLE: Variability in Snow Sublimation Across Basin Scale Systems

PRINCIPAL INVESTIGATOR: Nolan Doesken

RESEARCH TEAM: Morgan Phillips, Nolan Doesken

NOAA TECHNICAL CONTACT: OAR Cooperative Institutes Program Office (CIPO), Kristee Hall, kristee.hall@noaa.gov

NOAA RESEARCH TEAM: Chad McNutt

PROJECT OBJECTIVES AND ACCOMPLISHMENTS:

--Identify past and current research on sublimation pertaining to the Upper Colorado River Basin

While numerous studies on the general topic of sublimation exist, there are very few that consider its effects at watershed scale or focus specifically on the Upper Colorado Basin in particular. This task remains ongoing as new material comes to light during research.

-- Data availability for use in a regional scale study

As anticipated the availability of high temporal resolution surface data within the Upper Colorado River Basin is sparse, with most data coming from either Remotely Automated Weather Stations (RAWS), Snowpack Telemetry (SNOTEL) or a limited number of privately operated mesonets.

Given the sparse coverage of surface observations, access to gridded analysis from numerical weather models has been obtained to supplement the limited number of observations. These data sets have proved somewhat difficult to obtain, and developing the software necessary to do so has been a major focus of the project.

--Methodologies for estimating sublimation

Given the large spatial scale and complex topography in the region of interest, a gridded numerical model (SnowModel) has been employed to provide quantitative estimates of surface sublimation. This particular model is favored because it explicitly defines sublimation that occurs from blowing snow, which has been shown to be a major component of sublimation (MacDonald et al., 2010). In addition SnowModel has been well documented in numerous research papers (Liston et al., 1995, 1998, 2002, 2006, 2007, 2008) providing both verification and validation of the model in several different scenarios.

Significant time was devoted to obtaining and installing SnowModel during the initial phase of the project. This process involved learning how to run a moderate sized FORTRAN 77 program in a UNIX environment, while at the same time developing methods to ingest meteorological forcing data from various sources into the model. A working version of SnowModel is now operational and is awaiting the data assimilation phase to proceed.

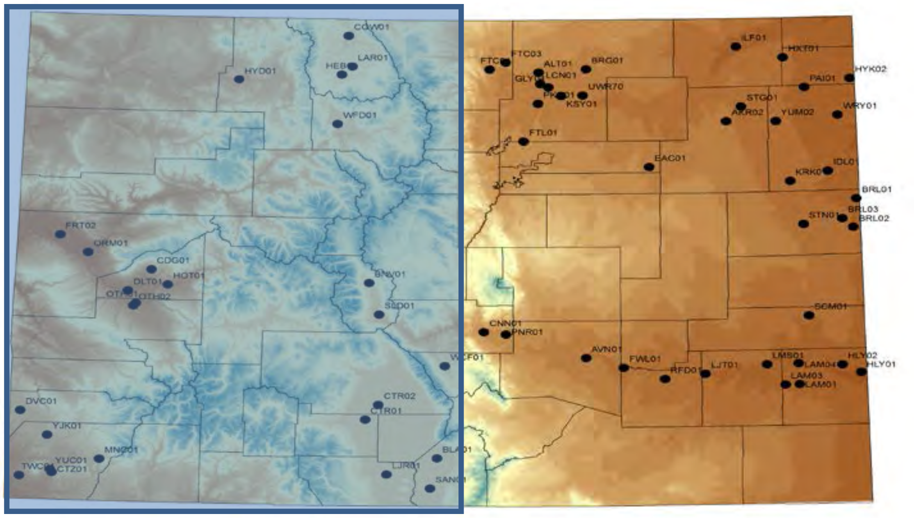


Figure 1. Proposed model domain (shaded) and locations of candidate input weather stations (CoagMet) not included in gridded model analysis (not pictured).

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 Autonowcaster and AWIPS II Projects

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

PRINCIPAL RESEARCHER: Scott O'Donnell

NOAA TECHNICALCONTACT: Stephan Smith, NWS/OSD/MDL

PROJECT OBJECTIVES:
1--The AutoNowcast (ANC) Prototype Project - ANC is a suite of automated applications developed by NCAR Research Applications Laboratory (RAL) that produce 0- to 1-hour predictor fields of storm initiation, growth, and decay. The long-term objective of this project is to transfer the ANC software into NWS operations with the goals of providing short-term forecast guidance, area weather updates, and use of the ANC-generated forecasts by meteorologists at the Center Weather Service Units (CWSUs).

This project can be broken down into two pieces: 1) Providing ANC data to NWS WFO forecasters within the Two-Dimensional Display (D-2D) and developing interactive tools within D-2D so that these forecasters can provide feedback to the ANC system; and 2) set up and run the complete ANC system on NWS hardware at the Meteorological Development Laboratory (MDL). The main objectives of this project are to: 1) conduct proof of concept experiments within WFOs using the tools and data we provide, and 2) better understand the configuration, architecture, and customization of the ANC system with the intention of streamlining the system for operational use.

2--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.

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, 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.) which are new to MDL and the NWS. In order for MDL to be in a position to add value, they need people that have a working understanding of these technologies.

3--NWS Innovation Web Portal (IWP) and Virtual Lab - The NWS is creating a new portal to foster innovation and science sharing among the NWS community as well as providing a centralized innovation repository. The IWP is intended to be part of the Virtual Lab that OST is in the process of developing, which is intended to foster development from anywhere and move development into the cloud.

PROJECT ACCOMPLISHMENTS:
1--The AutoNowcast (ANC) Prototype Project
--In support of continuing to transfer knowledge pertaining to NCAR's Auto-Nowcast (ANC)

system from NCAR to MDL and providing expertise on MDL's running ANC instances, Ken Sperow finished spinning up a new contractor on the workings and maintenance of ANC.

--Delivery of ANC forecasts from MDL computers to Chicago was started. Ken also assisted in setting up ANC over a large regional domain covering the eastern half of the country. New AWIPS package for Chicago was also developed and updates to MLB and COMET were provided. Travel was conducted to Chicago in August to help train the forecasters on the use of ANC in AWIPS.

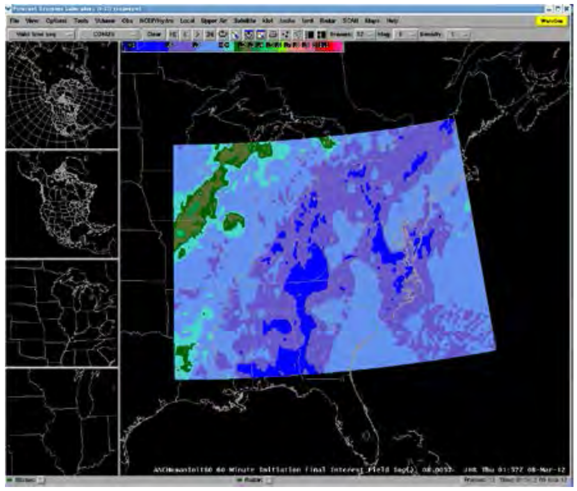


Figure 1. Diagram showing ANC's Golden Triangle domain.

--Ken provided consulting support in transferring the ANC AWIPS tools to the AWIPS II framework.

--Ken continued to provide ANC AWIPS updates to the Melbourne WFO as well as the Chicago WFO, where ANC was installed this past year. Travel occurred to Chicago to meet with the WFO and CWSU to spin up the project.

--Ken continued working with NSSL and the MDL ANC team to set up automated ANC tuning techniques. Paper entitled "Tuning AutoNowcaster Automatically" was co-authored that has been submitted and accepted into *Weather and Forecasting*.

2--AWIPS II
--Ken Sperow represented MDL along with two other MDL senior employees on the AWIPS II Software Development Planning team this year. He continued to provide AWIPS II support to MDL developers and to install new releases of the AWIPS II software on his system for testing and knowledge transfer activities. Ken is the OSIP lead and developer of a meteogram tool being developed within AWIPS II.

--Ken served as the IrisDB tiger team lead. He provided recommendations with guidance from the team on how the NWS could potentially integrate Iris capabilities into AWIPS II.

3--NWS Innovation Portal
--Ken Sperow co-lead the Innovation Web Portal (IWP) team and independently recommended, prototyped, set up, and customized the IWP first on his laptop and then within MDL's web infrastructure and is starting to migrate it to the NWS Internet Dissemination System (NIDS). It is envisioned that the IWP will provide NWS employees a web-enabled virtual location to collaborate and innovate. The IWP is using LifeRay's open source java portal framework. The project passed through OSIP Gate 3a this year. In support of this task, Ken attended LifeRay administrator and developer training and applied this knowledge in the creation of a NWS theme and developed a new "innovation" portlet that ties into the NWS's 10-102 process

--Ken is leading the OST Virtual Lab Working group which will be responsible for proposing and testing technical solutions in support of the Virtual Lab.

4--NWS Technical leadership
--Ken Sperow served as a member of MDL's Configuration Control Board (CCB), the body responsible for reviewing requests for change to MDL's IT infrastructure.

--He served as the lead of the Innovation Advisory Board Database Repository Tiger Team responsible for coming up with technical recommendations.

Ken was asked by the NextGen Weather Program Manager to conduct an assessment of the NEVS project. He researched NEVS and provided a report to the NextGen Weather Program Manager as requested. The report was well received.

PROJECT TITLE: Effective Collaborative NIDIS Drought Monitoring and Early Warning in the Upper Colorado Basin

PRINCIPAL INVESTIGATOR: Nolan Doesken

RESEARCH TEAM: Nolan Doesken, Zachary Schwalbe, Wendy Ryan, Henry Reges

NOAA TECHNICAL CONTACT: Allan Schmidt, OAR Cooperative Institutes Office

NOAA RESEARCH TEAM: Roger Pulwarty, Jim Verdin, Lisa Darby, Chad NcNutt, NIDIS program office, Boulder CO

PROJECT OBJECTIVES:
1--Develop and improve drought monitoring webinars for the purpose of providing timely status reports and drought early warning information for stakeholders and information providers and also to coordinate input for the USDM weekly update cycle

2--Expand active participation and strategically engage multiagency expertise from Utah and Wyoming to improve the quality and cross-border consistency of USDM products
.
3 --Expand the current scope of this drought monitoring and early warning effort to begin to address the Tribal information and communications needs of the highly climate sensitive Four Corners Region.

4--Systematically conduct formative and summative evaluation with emphasis on stakeholder impact and changes in confidence and use of drought products and information over time

RESEARCH ACCOMPLISHMENTS: We are still in the first year of this 3-year project but considerable progress is being made. Recent (late winter 2012) dryness over much of the Upper Colorado River Basin in combination with ongoing lower than average storage in Lake Powell is currently putting this project to the test.

The following work has been accomplished and is currently underway aligned with the stated objectives above.

1--We are maintaining proactive involvement in coordinated drought monitoring on a weekly basis – working directly each week with the US Drought Monitor author, representatives of regional NWS Forecast Offices, the Colorado Basin River Forecast Center, the Colorado Water Conservation Board and several other federal, state and local entities. Beginning in late January 2012, we began doing weekly webinars presenting current updates to precipitation, snowpack, stream flow, reservoir levels, water demand and forecasted weather. We defer to CBRFC at the beginning of each month when they lead regional Upper Colorado River Basin streamflow forecast webinars.

http://ccc.atmos.colostate.edu/drought_webinar.php

There is considerable stakeholder interest in seasonal prediction with lead times as great as 2 years. Klaus Wolter continues to provide seasonal prediction support, based particularly on his research on ENSO impacts. He provides periodic briefs through our webinars and weekly climate narratives.

Integration of remote sensing products to complement surface observations continues and will be emphasized during the 2012 growing season

Documentation of drought impacts continues to be a challenge. We are currently assembling a statewide drought impact detection network consisting of local experts with land-management or engagement responsibilities such as Extension personnel and Conservation District staff. We also continue to develop and utilize evapotranspiration products and services based on available CoAgMet data.

We are working in collaboration with Riverside Technology, recipient of a recent Small Business Innovation grant from NOAA, to better automate the development of routine data analysis products for drought monitoring.

2--Our contribution to enhanced and effective drought monitoring in the Upper Colorado River Basin has been limited in Utah and Southwest Wyoming by not having enough “boots on the ground” in those states. We have made progress in recent months in Utah with the help of Western Water Assessment’s Climate Services liaison. We have added several dozen Utah contacts to our NIDIS Pilot communications e-mail list and now routinely have Utah participation in our weekly webinars. More progress is still needed in the Green River Basin of Southwestern Wyoming as they do not have a similar liaison with the Western Water Assessment.

3--We are just beginning to develop strategies to assist in drought preparedness for Tribes in the Four Corners Region. We met with Dan Ferguson of CLIMAS at the Univ. of Arizona and have also discussed potential tribal partnerships with Dr. Nancy Selover at Arizona State University. Nolan Doesken will be giving a presentation to water managers in the Four Corners Region of Colorado. Wendy Ryan has been in contact with Margaret Hiza Redsteer (USGS) regarding helping with a network of automated weather stations in NE Arizona. At this point, we are just getting started on this objective.

4--A very important long-term objective of this project is quantifying the effects of enhanced drought monitoring and early warning on stakeholders drought knowledge, readiness and responses. A questionnaire for stakeholders has been prepared but has not yet been circulated. Nolan Doesken continues to regularly meet with stakeholders and assess their information needs and desires. Further and more objective documentation is clearly needed and will be a priority for the coming year.

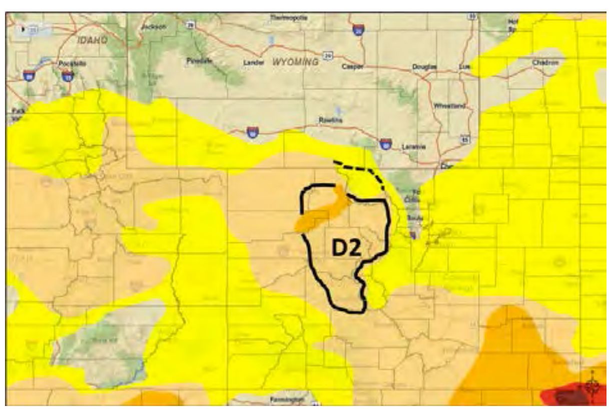


Figure 1. U.S. Drought Monitor (USDM) image showing draft map valid April 3, 2012. Sketch lines show recommended changes to the U.S. Drought Monitor map based on group discussion that are part of the weekly NIDIS UCRB Pilot Project webinars. These recommendations are then forwarded up to the USDM author for consideration in the national update.

PROJECT TITLE: EAR Aviation Weather Forecast Evaluation

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Melissa Petty, Sean Madine, Paul Hamer, Daniel Schaffer

NOAA TECHNICAL CONTACT: Jennifer Mahoney, OAR/ESRL/GSD/ACE/FIQAS

NOAA RESEARCH TEAM: CIRES: Steve Lack, Geary Layne, Mike Kay, Matt Wandishin, Brian Pettegrew, Andy Loughe, Joan Hart

PROJECT OBJECTIVES:
--Provide project management support for independent assessments of the quality and skill of aviation weather forecast products transitioning to FAA or NWS operations

--Continuation of the development of the Network Enabled Verification Service (NEVS), which is intended for transition to the National Weather Service (NWS) as an operational system.

PROJECT ACCOMPLISHMENTS: Project management support was provided to three primary assessment projects this year.
--Evaluation of the Graphical Turbulence Guidance (GTG) products: Original plans to evaluate the GTG Version 3 and GTG Nowcast Version 1 were postponed due to the more immediate need to evaluate an interim version of the GTG forecast product. GTG Version 2.5 was necessitated by the replacement of the algorithm's underlying model, the Rapid Update Cycle (RUC), with the WRF Rapid Refresh (RR). The GTG2.5 assessment was completed in September, with assessment results presented to the Technical Review Panel tasked with the approval of GTG 2.5 as a replacement to the current operational GTG product.
--Evaluation of the Current Icing Potential (CIP) and Forecast Icing Potential (FIP) Products: Similar to that of GTG, plans to evaluate the CIP and FIP Initial Operating Capability (IOC) versions were postponed to evaluate interim versions necessitated by the replacement of the RUC, the underlying model of these algorithms, with the WRF RR. The assessment of the CIP and FIP WRF RR versions was completed in November, with assessment results presented to a Technical Review Panel tasked with the approval of the CIP and FIP WRF RR versions as a replacement to the current operational CIP and FIP products.
--Evaluation of the Consolidated Storm Prediction for Aviation (CoSPA) Algorithm: Two assessments of this convective forecast product occurred this year: One in the winter months to evaluate its performance as a winter product, and one to assess its performance during the convective season. The winter assessment was completed with results presented to FAA management in July. The summer assessment evaluated the performance of the product June-September and was completed in December. Results were presented to FAA management in early February 2012, along with a comprehensive written report of the results of both assessments to be completed March 2012.

The evaluation of the National Ceiling and Visibility Forecast originally planned for 2011 did not occur and is postponed indefinitely due to changes in product development plans.

Network Enabled Verification Service (NEVS) development. As an operational NWS system, NEVS is intended to provide automated verification of operational aviation weather forecasts in real time to support decision-making processes in the aviation community. NEVS will provide this functionality while being technologically aligned with the NextGen architecture and information delivery mechanisms required of a subsystem of the NextGen 4D Weather Data Cube.

The objectives for NEVS work in 2011 were to:
--In coordination with the NWS, complete stage 3 of the Operations and Services Improvements Process (OSIP), a formal NWS Solution Management process to facilitate the transition of NEVS to NWS operations
--Complete the engineering for the first version of NEVS to provide automated verification and visualization of results for Turbulence and Icing forecast products.

Work on this project was placed on hold at the request of the NWS effective June 1 due to budgetary issues, so the objectives were only partially realized. Accomplishments are summarized below.

OSIP Stage 3. Documentation required for the completion of Stage 3 was developed and scheduled for review and approval at the Stage 3 decision point known as Gate 3. Specifically, the required Business Case Analysis was completed and approved via Gate 3a, and the Technical Requirements document and Operational Development Plan were under final internal review and scheduled for Gate 3b approval when the project was placed on hold.

Engineering. The NEVS architecture is composed of three primary service components:
--Production: Responsible for ingest and storage of raw forecast and observation data and the production of verification results from this data.
--Integration: Responsible for storage of verification results and air traffic data, and provides capabilities to integrate verification data with air traffic information and operational decision criteria.
--Presentation: Provides network-enabled capabilities to retrieve verification results from the Integration Layer, via a web application or web services

Figure 1 is a diagram of the NEVS architecture.

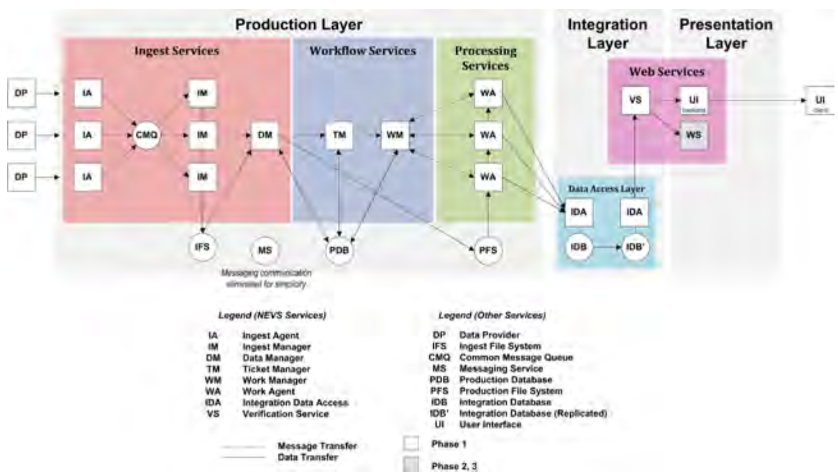


Figure 1. NEVS Architecture, including the components within the Production, Integration, and Presentation components. A messaging system is used for communication between services within the system. Individual "Agents" serve as workers within the service areas.

Progress was made in the development of the infrastructure for the Production and Integration components needed for the first version of NEVS: Specifically, ingest, workflow, and processing services within the Production component, and the database layer and supporting querying capabilities for the Integration Layer. Additionally, a functional requirements document defining the Turbulence and Icing capabilities was completed. Remaining work required to complete this first version of NEVS would primarily be focused on the infrastructure of the Presentation Layer followed by domain-specific implementation and configuration across all three components for Turbulence and Icing capabilities.

Although development for NEVS was put on hold, the framework established through NEVS development was leveraged in the development of other verification technologies: Specifically, the first prototype of the Verification, Requirements and Monitoring Capability (VRMC) was completed in September. The VRMC is an FAA-sponsored development intended to provide technological support to FIQAS assessments and provide a means to monitor aviation weather forecast performance through on-line historical baselines. The September prototype incorporated the data used in the GTG 2.5 assessment and made it available for further analysis via a web application. Future developments include extensions of the prototype to support subsequent Turbulence assessments, including GTG 3. The VRMC prototype can be found at http://esrl.noaa.gov/fiqas/tech/vrmc/turb/

PROJECT TITLE: EAR Advanced Weather Interactive Processing System II (AWIPS) Data Delivery Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Joanne Edwards, James Fluke, Daniel Schaffer

NOAA TECHNICAL CONTACT: Woody Roberts, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: With AWIPS II rapidly approaching deployment, the National Weather Service has identified a need to extend AWIPS II capabilities in order to handle the demand for more and larger datasets. With the current distribution network at near capacity, a Data Delivery mechanism is envisioned by the NWS to include the following capabilities:

--Data registry services that will provide a means to publish data sources and metadata information and allow for the introduction of new data services
--Data discovery services that will provide for a system that can discover datasets and necessary associated metadata
--Smart push/pull technologies that will provide the means to subset the data by user selectable field value, time, space, parameters, etc. Such dataset filtering would be done on an ad-hoc user-request basis or in a pre-defined way.

The system must be robust addressing the following challenges:
--It must satisfy fault tolerance requirements including recovery from software, hardware, and network failures.
--It must satisfy quality-of-service (QOS) requirements including data access reliability and latency.
--It must include monitoring services to support fault detection and diagnosis.
--It must support security provisions, such as user access and authentication

The emphasis must shift away from a broadcast system where all the data are pushed to the field offices toward the concept where the data providers and data consumers exchange only necessary information.

The primary goal of GSD is to develop a prototype data delivery system for eventual use in AWIPS II. The idea is to develop a system that will enable access to data regardless of its location. In other words, to enable access to data that does not reside locally.

PROJECT ACCOMPLISHMENTS: CIRA, in conjunction with the Information Systems Branch (ISB) of the Global Systems Division (GSD) developed four prototypes in 2011, each one enhancing the capabilities of the previous one. The following capabilities were added:

--A client broker capability that enables asynchronous message passing between the Common AWIPS Visualization Environment (CAVE) plugins and the web clients. A message passing capability call Apache QPID was researched and prototyped, enabling requests to be sent out to the data providers, and data or metadata returned, asynchronously.
--The request GUI was upgraded to enable users to request data by data type, e.g., model or observation, model such as HRRR and description or parameter. The information presented to the user in a tree-type structure was taken from a tree structure containing metadata that was implemented by CIRA staff. This information was obtained from remote registry/repositories and data providers and resides locally in order to enhance performance.
--New datasets from the HRRR model, NOMADS OPeNDAP Grads system and CUAHSI WaterML systems were also added.

CIRA staff, in conjunction with other Cooperative Institute staff, researched the addition of these new data datasets and implemented the capability to request, ingest and display these datasets.

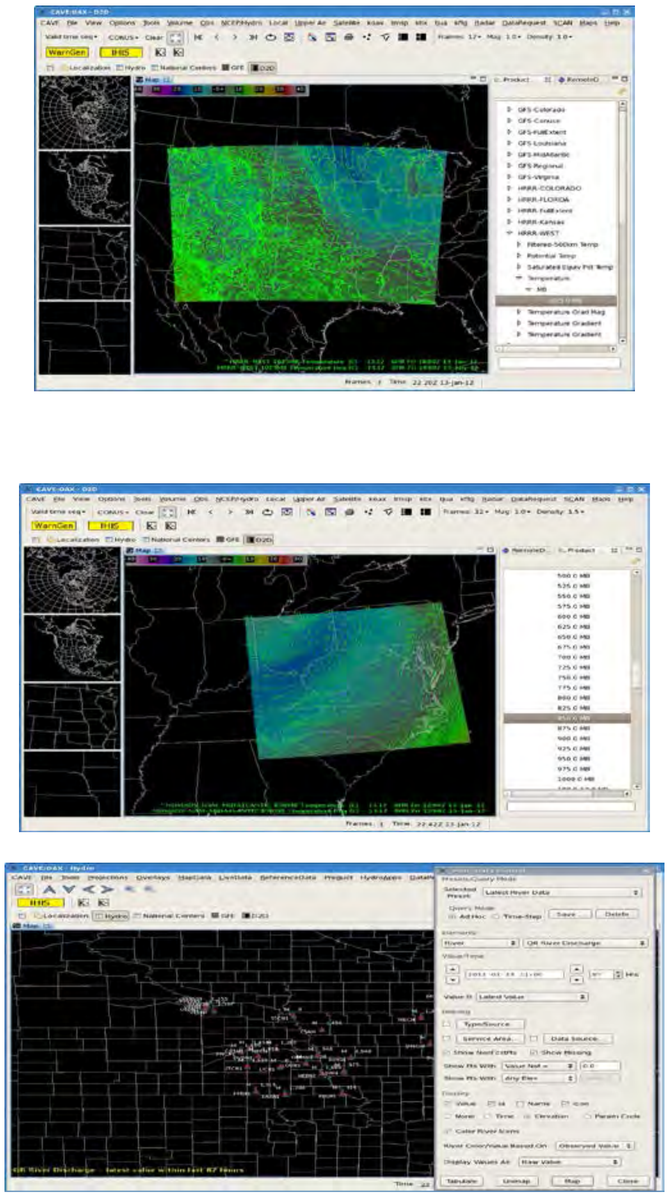


Figure 1. Some examples of datasets and the CUAHSI hydro system.

Due to funding shortfalls at the NWS, this project was cut from the 2012 budget and all CIRA research activities ceased in March.

PROJECT TITLE: EAR AWIPS II Extended – Collaboration

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: U Herb Grote, Daniel Schaffer

NOAA TECHNICAL CONTACT: Woody Roberts, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: The NWS has identified a need for new tools to provide for more effective real-time collaboration between NWS operational units to allow for collaboration earlier in the forecast process than is possible today. There is also a need for more effective collaboration between NWS forecasters and partners such as emergency managers in support of their decision-making processes especially with respect to high impact events. GSD has been instrumental in developing prototypes to satisfy the requirements.

PROJECT ACCOMPLISHMENTS: Over the past reporting period, CIRA staff has worked with other ISB staff to enhance the external collaboration tool. The objective of this tool is to provide the capability for an external user, such as a fire weather manager, to follow a briefing conducted by a moderator. CIRA staff added the capability for the moderator to direct the data browser to animate images in tandem with what was happening on the forecasters GUI. CIRA staff also developed a RESTful web service approach to caching images on the client instead of on the server. This capability is being tested with an android client application giving users the capability to store images on their on display system.

PROJECT TITLE: EAR Advanced Weather Display Systems

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Herb Grote, James Ramer, James Fluke, Daniel Shaffer

NOAA TECHNICAL CONTACT: Woody Roberts, OAR/ESRL/GSD/ISB

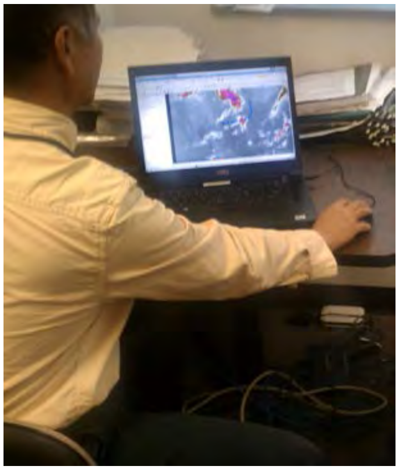
PROJECT OBJECTIVE: The objective of this project is to develop advanced features for an interactive weather forecasting workstation. The project will explore new capabilities such as inter-office and external collaboration, web graphic generation, and innovative approaches for viewing model data.

PROJECT ACCOMPLISHMENTS:
Inter-office collaboration. The goal of this specific project is to provide a system capability that allows operational forecasters to see each other's workstation screens during collaboration. The primary constraints are the low available bandwidth of the AWIPS Wide Area Network (WAN) and the firewalls to the external networks. The software also had to run on Linux machines. Three different approaches consisting of conferencing software, desktop-sharing utilities, and a custom-built AWIPS II collaboration plug-in were evaluated. The top contenders for collaboration software included BigBlueButton, WebHuddle, and vnc (virtual network computing). All candidate software was evaluated for the required functionality and performance in a controlled environment and also on the operational NWS network. The most promising software was the vnc remote desktop software and the custom CAVE plug-in, both of which provided the critical functionality and provided reasonable performance. Subsequent tests performed with operational forecasters indicated that vnc did not adequately support frame animation and did not retain the full set of colors for images. The CAVE plug-in remained the sole contender. All test results were documented and delivered to the NWS. The operational design and implementation has been turned over to the AWIPS II contractor.

External Collaboration. The goal of the external collaboration is to facilitate the collaboration between operational forecasters using the AWIPS II workstation and external decision makers, such as emergency managers. Since external decision makers do not have access to AWIPS II, the CAVE plug-in approach was not a viable solution. One of the challenges for external collaboration is the requirement for bidirectional communications through the AWIPS firewall. Various approaches for external collaboration were investigated. They included the StormCenter EVCM (Environmental Collaboration Module) and the RENSI collaboration software. The AWIPS II CAVE display was exported as a KMZ file to several external EVCM clients. Only unidirectional communications from AWIPS II to these systems was possible and tested. Preliminary tests were conducted to explore the use of ssh tunneling to facilitate bidirectional communications through the firewall. A custom software solution is being developed to test this approach with external decision makers.

Web Graphic Generation. The FXC software has been used extensively by the NWS forecast offices to generate graphical weather forecasts for the web. This software was dependent on AWIPS I and had to be migrated to AWIPS II in order for forecasters to continue to generate these graphics. The software was successfully migrated to AWIPS II and has been installed on AWIPS II workstations at several forecast offices. The Boulder forecast office is now using it routinely for all of their web graphics. The project staff will continue to update the documentation, support new installations, and train forecasters in the use of the new software.

Advanced Linux Prototype (technology transfer). The ALPS (Advanced Linux Prototype System) will continue to be the primary research system until the AWIPS II system is available. Recent addition to the ALPS system includes the display and interaction with ensemble forecast models and vertical displays of radar and model data along a non-linear path. The ALPS system was installed in Norman, OK for the Convective Initiation Experiment last year. The project staff also provided the maintenance support and the system training. The CWB (Central Weather Bureau) in Taiwan expressed an interest in using the ALPS system for their operational forecast system. The ALPS project staff trained CWB staff at GSD to maintain the software and delivered the ALPS software and some test data to CWB. A trip was made to CWB to help with the initial installation and familiarize other CWB staff with the unique system features



Figures 1 and 2. Real-time Collaboration on the AWIPS II/CAVE workstation.

PROJECT TITLE: EAR Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Tom Kent

NOAA TECHNICAL CONTACT: Greg Pratt, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: MADIS is dedicated toward making value-added data available from GSD for the purpose of improving weather forecasting by providing support for data assimilation, numerical weather prediction, and other hydro-meteorological operations. MADIS hit a huge milestone in September 2010 by reaching Initial Operating Capability (IOC). The objectives are:
--To continue to add new functionality and data sources to MADIS.
--To provide support to the user community
--To augment existing networks

PROJECT ACCOMPLISHMENTS:
1--Addition of New Networks
CIRA developers, in conjunction with ISB, added new networks to the MADIS system. This involved coordination with the data providers on items such as data delivery communications mechanisms, data formats, data content and frequency, and metadata.

2--MADIS Support
Over the past reporting period, CIRA staff played a key role in providing support such as handling user problems, data archive requests, firewall issues, LDM set-up, password resets and a host of other issues.

3--MADIS Upgrades
CIRA staff continued work on the Mobile Platform Environmental Data (MoPED). Due to the success of the 2010 trial, the number of sensors was increased to 200 in 2011. CIRA staff set up a web-based client to grab the data from web servers that had been fed the sensor data.

Work continued on the National Mesonet with updates being made to the ingest of sensorML data and data from three climate networks – the Climate Reference Network (CRN), the Historical Climate Network (HCN), and the New England Pilot Project (NEPP).

PROJECT TITLE: EAR Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Randall Collander, Tom Kent

NOAA TECHNICAL CONTACT: Greg Pratt, OAR/ESRL/GSD/ISB

NOAA RESEARCH TEAM: Leon Benjamin, CIRES; Gopa Padmanabhan, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: Aid efficiency in transitioning MADIS processing from ESRL/GSD to National Weather Service operations, as follows: Diagnose and resolve data distribution outages through examination of raw data feeds, processing code and interaction with data providers; introduce mesonet observations from additional data providers into the MADIS processing and distribution system; document technical setup parameters specific to each mesonet and provider to aid MADIS personnel in diagnosing and resolving output file anomalies and data ingest and distribution errors.

The current implementation of the MADIS at ESRL/GSD makes integrated data available in real-time with interoperable formats to hundreds of users in the weather and climate enterprise for the purpose of improving weather forecasting by providing support for data assimilation, numerical weather prediction, climate applications, and other hydrometeorological applications. The transfer will be accomplished through the testing of software presently in use at GSD on National Centers for Environmental Prediction (NCEP) computing systems, as well as development of additional software required for adapting to compute architecture differences.

PROJECT ACCOMPLISHMENTS: During this period, software was developed to add data from additional surface mesonets and the data integrated into local processing in preparation for transitioning to NCEP operations. Data distribution outages were investigated and resolved promptly, and issues noted by data providers and other users were similarly handled. Mesonet-specific documentation was prepared for the AK-MESO, AIRNow and AFA, AKDOT, APG, APRSWXNET, ARLFRD, AWS, AWX, CAIC, CA-Hydro-Snow, and GLDNWS mesonets. The documents outline the entire process from raw data ingest to processed data distribution, providing the location of data in the MADIS processing system, the names of processing scripts and output files, descriptive parameter and station listing files, and contact information.

PROJECT TITLE: EAR Citizen Weather Observer Program (CWOP)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Randall Collander

NOAA TECHNICAL CONTACT: Bobby Kelley, OAR/ESRL/GSD/OD

PROJECT OBJECTIVE: Administer the CWOP through database updates (adding new stations, removing stations no longer reporting data, and maintaining accurate site location information), interact with CWOP members (answering questions and discussing suggestions, and investigating data ingest and dissemination issues), refreshing related webpages and documents, verify 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 Citizen Weather Observer Program is a public-private partnership with 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 over 8,000 registered CWOP members worldwide. CWOP members send their weather data by internet alone or internet-wireless combination to the findU (http://www.findu.com) server and then every five minutes, the data are sent from the findU server to the NOAA MADIS server. The data undergo quality checking and then are distributed to users. There are over 500 different user organizations of the CWOP mesonet data.

PROJECT ACCOMPLISHMENTS: Database revisions were performed daily based upon member input. Updates included registering 2,767 new sites in the database using site location (latitude, longitude and elevation) information provided by the users and confirming 1,594 site position changes using web tools. Interactions occurred with users via email regarding setup and data transmission issues and problems resolved and questions answered on site setup, 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.

PROJECT TITLE: EAR Geo-Targeted Alerting System (GTAS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Leigh Cheatwood-Harris, James Ramer

NOAA TECHNICAL CONTACT: Greg Pratt, OAR/ESRL/GSD/ISB

NOAA RESEARCH TEAM: Susan Williams, OAR/ESRL/GSD /ISB

PROJECT OBJECTIVES: The GTAS project is a prototype implementation of the latest developments in plume modeling, high-resolution weather models, and network enabled operations. One of the prime objectives of the GTAS project is to meet the Federal Emergency Management Agency's (FEMA) requirements to provide air dispersion and toxic plume information along with NOAA meteorological and environmental data to state and local emergency management agencies. GTAS is to build upon established relationships between local NWS WFOs and local Emergency Operations Centers (EOCs) by providing shared situational awareness of vital data, so that emergency manages can quickly determine the impact and provide mitigation and response plans to the public and other local and state EOCs.

PROJECT ACCOMPLISHMENTS: The biggest users of GTAS are the emergency managers. They need to be trained on the system in order for them to be more effective in responding to emergency situations. CIRA staff continued to work diligently to update training plans for the users and continued updates to the on-line questionnaire. CIRA staff also took a lead role in providing on-site training at the Weather Forecast Offices (WFOs) and Emergency Operations Centers (EOCs) across the Nation. Other work included maintenance of GTAS Users' Guide. Due to funding shortfalls, this project was discontinued.

PROJECT TITLE: EAR Integrated Hazard Information Services (IHIS)

PRINCIAPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Daniel Schaffer, Joanne Wade, James Ramer, James Fluke

NOAA TECHNICAL CONTACT: Tracy Hansen, OAR/ESRL/GSD/ISB

NOAA RESEARCH TEAM: Joe Wakefield, OAR/ESRL/GSD/ISB, Susan Williams, OAR/ ESRL/GSD/ISB, Tom Filliaggi, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: The IHIS project is a spin-off of the Next Generation Warning Tool (NGWT). Its purpose is to combine existing warning tools used in the current AWIPS by forecasters into a newly defined warning system. The warning systems include WarnGen, Graphical Hazards Generator (GHG), and RiverPro. It is envisioned that this new system will comprise a flexible, extensible framework which can accommodate not only the existing capabilities of AWIPS but also allow for creation of new, state-of-the-art products and tools. The IHIS project has been renamed Hazard Services.

PROJECT ACCOMPLISHMENTS:
CIRA staff has been working in conjunction with other ISB staff to prepare the Hazard Services

system for Initial Operating Capability (IOC). CIRA staff has been researching a number of areas related to the Data Transformation Framework for Hazard Services. These areas include:

--Implementation of a national database to hold hazard information. The databases being researched are MongoDB and CouchDB. These databases are being compared to answer a number of questions such as reliability, security, scalability, ease of use and deployment. The databases are termed NoSQL because the implementations do not use the SQL query language.

--Analyzing the different approaches taken by the text product generation tools such as WarnGen (AWIPS I), Velocity WarnGen (AWIPS II), the Graphical Hazards Generator (GHG), RiverPro and the product generation tool (PGEN) developed by NCAR for AWIPS II. These text product generation tools are being analyzed to determine how well they could be integrated into a single application.

--Generating user stories for new recommenders for Hazard Services. The user stories drive requirements and are used to test the implementations. CIRA staff has written a number of stories, one of which is a convective hazard story which describes in detail the process to follow when forecasting a tornado.

PROJECT TITLE: EAR Aviation Tools: Aviation Initiative (AI) Project

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

RESEARCH TEAM**:** Jim Frimel

NOAA TECHNICAL CONTACT**:** Dr. Lynn Sherretz, OAR/ESRL/GSD/ACE

NOAA RESEARCH TEAM**:** Riverside Technology: Chris Masters, Kelli Werlinich, David Hagerty, Gregg Phillips

PROJECT OBJECTIVES: Consistent with the FAA's Air Traffic Organization's (ATO) philosophy to review, upgrade, and create efficiencies in various functions, in January 2006, the National Weather Service (NWS) Corporate Board agreed to prototype the FXC AI system to demonstrate a more effective and efficient forecast process to support Air Route Traffic Control Center (ARTCC) operations.

The Aviation Initiative was a short-term effort that took place from July through September of 2006. It was a rapid response development and prototyping effort with an extremely demanding schedule. This effort was in support of a NWS proposal for transforming the agency's aviation weather service program to meet the FAA requirements of reducing costs and enhancing services. The initiative focuses on services provided by NWS Center Weather Service Units (CWSU).

The participants in the demonstration were the Leesburg, Virginia CWSU and the Sterling, Virginia Weather Forecast Office (WFO). System and server support was from Boulder's ESRL/Global Systems Division. The purpose of the FXC Aviation Initiative was to demonstrate the capability to perform collaboration between the CWSU and the WFO to produce new forecast and decision aid products that translate weather impact on en-route and terminal air operations and that provide common situational awareness to all prototype participants; additionally to demonstrate the capability of the WFO to remotely support ARTCC weather information requirements when the CWSU is unavailable.

During the summer of 2006, CIRA researchers in the Global Systems Division's Aviation Branch, along with FXC engineers from the Information Systems Branch, concentrated its efforts on Aviation Initiative development. This development was based on the Earth System Research Laboratory (ESRL) technologies and services being developed by CIRA engineers at the Prototyping Aviation Collaborative Effort

(PACE) facility at the Fort Worth ARTCC. For a description of PACE and related FXC Development, refer to the FXC TMU project description. The FX-Collaborate (FXC) software developed at NOAA's ESRL was the major software system used in the Aviation Initiative demonstration. The FXC Aviation Initiative offers on-demand services, remote briefing capabilities, new graphical products, and tactical decision aids.

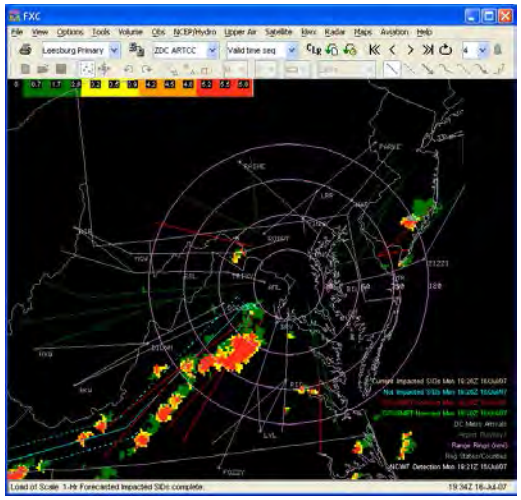


Figure 1. View of the FXC AI Brief EE display with map enhancements and impacted DC Metro departure routes.

As of May 2007, the AI project has been operating in software/system maintenance and support mode since the project research funding had ended. As of March 2009, the original federal manager of this project left to work for another branch within GSD. In Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) was drafted in order to specify some funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSUs occurs.

PROJECT ACCOMPLISHMENTS:
The SOW for this year was to transition the Aviation Tools software/systems support to the Systems Support Group (SSG http://esrl.noaa.gov/gsd/its/ssg/) in the ITS branch of GSD. The SSG is functionally equipped and designated to provide system support services and monitoring for numerous systems and facilities throughout GSD. The current plan is for SSG to support and maintain the ASDAD systems until the Aviation Tools capabilities and requirements that were developed are implemented and replaced by the AWIPS II extended tasks.

This year, we have achieved and are officially running the legacy software and systems in production; and they are being supported by the ITS SSG.

The majority of work over the past year has been related to: Setting up the hardware and systems for the maintenance and support environment; porting the ASDAD's Legacy AWIPS software to a new Operating System; and implementing required modifications to the FXC and AWIPS software code base to run in the new systems maintenance environment.

In order to deliver this stable production release with respect to just the AWIPS/FXC code base, we had implemented approximately 60 changes and issues throughout the integration and deployment cycle of the servers and clients from May through July. Also worth noting is the implementation of the maintenance environment which has been reduced to a fraction of the previous development environment, providing more cost saving.

The majority of the transition has been completed this year. However, there are still remaining tasks, important priorities, and decisions that need to be made by management. However, the reality is that the project has been underfunded for the required support and maintenance necessary to keep the hardware, software and services running. As such, we have run out of funds to fully complete the transition and continue to provide support and maintenance.

Without the necessary resources (time and money), we are again limited by how long we can sustain the current hardware, software, and systems. All these components are once again approaching, and in some cases exceeding, their life expectancy.

As of January 2012, management is looking into various plans and strategies in order to keep the services running until the transition to AWIPS II extended tasks and clients that meet the Aviation Tools requirements are delivered. As of February 2012, one aspect of funding fallout has been the de-commissioning of the NCWF2 Product generation from the Aviation Weather Center. In general, we are on standby and at a crossroads, waiting for funds and on management for a decision regarding the next step, a plan and strategy.

It is important to mention that these systems are still in full use at the Leesburg, Virginia CWSU for the daily weather briefings to the Traffic Managers. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. This is a noteworthy example of the AI project research being transferred to operations.

Project Website:
http://www.esrl.noaa.gov/gsd/ab/asdad/

PROJECT TITLE: EAR Federal Aviation Administration (FAA) Prototyping and Aviation Collaboration (PACE) Effort – Traffic Management Unit (TMU) Project

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

RESEARCH TEAM**:** Jim Frimel

NOAA TECHNICAL CONTACT**:** Lynn Sherretz, OAR/ESRL/GSD/ACE

NOAA RESEARCH TEAM**:** Riverside Technology: Chris Masters, Kelli Werlinich, David Hagerty, Gregg Phillips

PROJECT OBJECTIVES: Prototyping and Aviation Collaboration Effort (PACE) is an operational test area located within the Fort Worth Air Route Traffic Control Center's (ARTCC) CWSU for developing innovative science and software technology used to directly provide weather support for the ARTCC Traffic Management Unit (TMU).

The TMU project, staged at this facility, is researching the weather information needs and developing innovative software technology used to directly provide weather support for the ARTCC TMU. A major objective is to investigate aviation data sets and forecast products specifically tailored for the ARTCC air traffic weather forecasting environment among operational weather forecasting facilities and to investigate the utilization of collaborative weather forecasting.

The objectives came from the necessity to research and investigate software tools and data products for minimizing adverse weather disruptions in air traffic operations within the National Airspace System (NAS). Requirements and needs can be found in the study performed by FAA ARS-100 on “Decision-Based Weather Needs for the Air Route Traffic Control Center (ARTCC) Traffic Management Unit”.

The TMU project is currently using convective weather products to address the weather information needs of the TMU relating to weather-related hazards impacting air traffic, originally planned to be followed by icing, turbulence, and ceiling/visibility. Each phase will address the tactical (0-1 hour) and the strategic (2-6 hour) application of the above products to help the TMU decision maker in directing air traffic into and out of the ARTCC airspace. All phases will be subjected to the iterative process of defining, developing, demonstrating, and evaluating the weather related hazard graphic and its presentation to the Traffic Manager.

The FX-Collaborate (FXC) software, developed at NOAA's Earth System Research Lab at the Global Systems Division's Information Systems Branch, is a major component of the TMU project. The major system used to acquire, distribute, create and provide the required data sets for FXC is the AWIPS Linux data ingest and display system. The FXC and AWIPS software is being tailored, modified, extended, enhanced, and utilized in the TMU project. The FXC software allows for the remote access and display of AWIPS data sets over the Internet, a collaboration capability among participants at physically different locations, remote weather briefings and the ability to utilize tools to aid in discussing forecasts. Additionally, the TMU project relies on the AWIPS system for generating the content available on the TMU Project TCHP and ADA web site.

The TMU Project is comprised of a suite of systems that consists of a database to house tactical decision aids, a web presence to display this content to traffic managers, and a FXC TMU system capable of overriding the impact information. The FXC TMU end-to-end capability allows forecasters to edit and override aviation route impacts. The override information is propagated back through the system and made available to update AWIPS, FXC, and the TMU Web Content displays. The initial design and structure of the decision aids relational database was populated with map background information for the ZFW arrival/departures, high-use jet routes, and TRACON arrival/departure gates. Following were changes to the AWIPS impact decoders to create impact information based on the NCWF2 data sets that would then be stored in the database and server side processing and generation of the web content generation.

A goal of the TMU web site is to consolidate all tactical aviation weather hazards information into a suite of products for presentation to TMU decision-makers in an easily understood format (A, GO-NO-GO, approach to air traffic route and flow information). What is important to understand about the Weather Information Decision Aids (WIDA) web content page is that it is a complete end-to-end system, not just a simple web display that provides useful information assisting in tactical and strategic decision making. It is an extremely complex suit of systems that involves AWIPS, FXC, content generation for the web, and a database backend. This is an end-to-end decision aid tool centered on the forecaster in the loop concept for helping to keep and create a more consistent, relevant, and accurate Weather Information Decision Aid (WIDA) product available for TMU managers. The consistency and power comes from the fact that all these systems are now tied and share the same data source.

The two images below show current impact with no Forecaster Edits. ZFW TRACON departure gates are displaying green (no impact) and yellow (partial impact).

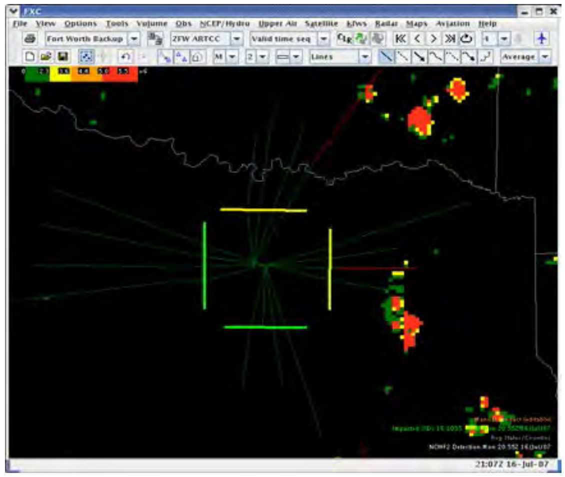


Figure 1. Forecaster FXC tool showing current ZFW TRACON Departure Gate impacts with NCWF2.

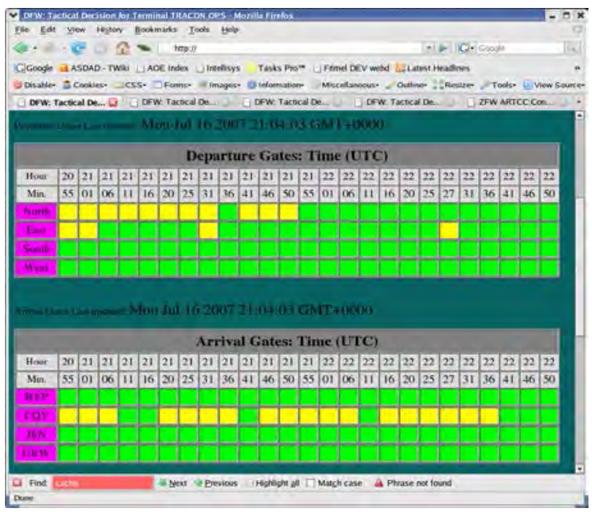


Figure 2. Traffic Manager (WIDA) Web Display showing concurrent Red-light/Green-light Departure Gate Impact information.

As of May 2007, the TMU project has been operating in software/system maintenance and support mode since the project research funding had ended. As of March 2009, the original federal manager of this project left to work for another branch within GSD. In Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) was drafted in order to specify some funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSUs occurs.

PROJECT ACCOMPLISHMENTS:
The SOW for this year was to transition the Aviation Tools software/systems support to the Systems Support Group (SSG http://esrl.noaa.gov/gsd/its/ssg/) in the ITS branch of GSD. The SSG is functionally equipped and designated to provide system support services and monitoring for numerous systems and facilities throughout GSD. The current plan is for SSG to support and maintain the ASDAD systems until the Aviation Tools capabilities and requirements that were developed are implemented and replaced by the AWIPS II extended tasks.

This year, we have achieved and are officially running the legacy software and systems in production and they are being supported by the ITS SSG.

The majority of work over the past year has been related to: Setting up the hardware and systems for the maintenance and support environment; porting the ASDAD's Legacy AWIPS software to a new Operating System; and implementing required modifications to the FXC and AWIPS software code base to run in the new systems maintenance environment.

In order to deliver this stable production release with respect to just the AWIPS/FXC code base, we had implemented approximately 60 changes and issues throughout the integration and deployment cycle of the servers and clients from May through July. Also worth noting is the implementation of the maintenance environment which has been reduced to a fraction of the previous development environment, providing more cost saving.

The majority of the transition has been completed this year. However, there are still remaining tasks, important priorities, and decisions that need to be made by management. However, the reality is that the project has been under-funded for the required support and maintenance necessary to keep the hardware, software and services running. As such, we have run out of funds to fully complete the transition and continue to provide support and maintenance.

Without the necessary resources (time and money), we are again limited by how long we can sustain the current hardware, software, and systems. All these components are once again approaching, and in some cases exceeding, their Life Expectancy.

As of January 2012, management is looking into various plans and strategies in order to keep the services running until the transition to AWIPS II extended tasks and clients that meet the Aviation Tools requirements are delivered. As of February 2012, one aspect of funding fallout has been the de-commissioning of the NCWF2 Product generation from the Aviation Weather Center. This product was a key dataset of the Fort Worth Decision Support Tools developed by GSD. As of March 2012, we are waiting on a decision if we will be decommissioning all hardware and services related to the Decision Support Tools or possibly migrating the tools to another product such as CIWS. As such, the possible TMU research and development related to using CIWS data, adding additional radar sites, and implementing a BriefEE Client has been indefinitely postponed. In general, we are on standby and at a crossroads, waiting for funds and on management for a decision regarding the next step, a plan and strategy.

It is important to mention that these systems are still in full use at the Fort Worth Center Weather Service Unit (CWSU) for the daily weather briefings to the Traffic Managers. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. This is a noteworthy example of the TMU project research being transferred to operations.

Project Website:
http://www.esrl.noaa.gov/gsd/ab/asdad/

PROJECT TITLE: EAR Aviation Tools: Volcanic Ash Coordination Tool (VACT) Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jim Frimel

NOAA TECHNICAL CONTACT: Lynn Sherretz, OAR/ESRL/GSD/ACE

NOAA RESEARCH TEAM: Riverside Technology: Chris Masters, Kelli Werlinich, David Hagerty, Gregg Phillips

PROJECT OBJECTIVES: The VACT project is an experimental client/server based application utilizing the Internet and is based on the FX-Collaborate (FXC) system architecture. The participating agencies are currently the National Weather Service Alaska Region Headquarters (NWSARH), Anchorage Volcanic Ash Advisory Center (VAAC), Alaska Volcano Observatory (AVO), and the Anchorage Air Route Traffic Control Center, Center Weather Service Unit (CWSU).

The FX-Collaborate (FXC) software developed at NOAA's Earth System Research Lab in the Global Systems Division's Information Systems Branch is a major component of the VACT project. The major system used to acquire, distribute, create and provide the required data sets for FXC is the AWIPS Linux data ingest and display system. The FXC and AWIPS software is being tailored, modified, extended, enhanced, and utilized in the VACT project. The FXC software allows for the remote access and display of AWIPS data sets over the Internet, a collaboration capability among participants at physically different locations, and the ability to utilize tools to aid in discussing forecasts

The VACT project is a research and development effort in direct response to investigating the collaborative approaches and needs of agencies involved in generating Volcanic Ash Advisories. The Volcanic Ash Coordination Tool is being tested at each of these operational sites to investigate forecaster productivity tools and collaboration capabilities in response to aviation hazards posed by volcanic eruptions. The system is designed to help locate and determine the extent and movement of volcanic ash so that more accurate, timely, consistent, and relevant ash dispersion and ash fallout watches, warnings, and forecasts can be issued. These watches, warnings, and forecasts can be disseminated using current approaches and standards (societal impact statements) but will also be tailored for end user needs in the form of societal impact graphics (i.e. jet routes or runways turning red when ash is present). Graphics tailored to aviation needs focus on making the National Airspace System (NAS) safer and more efficient during a volcanic ash event. Efforts are focused on integrating the latest advancements in volcanic ash detection and dispersion from the research community, allowing users to overlay and manipulate this information in real-time; developing tools to generate end user impact statements and graphics; and disseminating the impact statements in a timely fashion so that hazard mitigation plans can be activated.

The VACT system allows users at different sites and with different expertise to simultaneously view identical displays of volcanic ash and other related data sets (i.e. shared situational awareness) and collaborate in near real-time. The expertise from all participating agencies is used in the determination of location, extent, and movement allowing for forecasts of fallout and dispersion to be consistent and more accurate. Relevant data on local agency systems and on the Internet can be pulled into the VACT system during collaborative sessions among the agencies to help in the analysis phase of an event. Societal impact forecasts can be disseminated faster through the development of a smart-system, which will automatically center on the area of eruption and display or highlight all key data sets for the volcanic ash event. Users of the VACT system aren't tasked with determining which data is relevant and can focus their attention on location, extent, dispersion, and societal impact. Societal impact statements can be disseminated following current standards and practices or by interactive briefings tailored to meet the needs of the end user (i.e. the public, emergency managers, FAA, airlines, armed services, state agencies, etc.). All volcanic ash events are captured and archived to help improve detection and dispersion methodologies, train new users on VACT functionality, detect and eliminate problems with multiple agencies collaborating in real-time on volcanic ash events, and improve dissemination techniques.

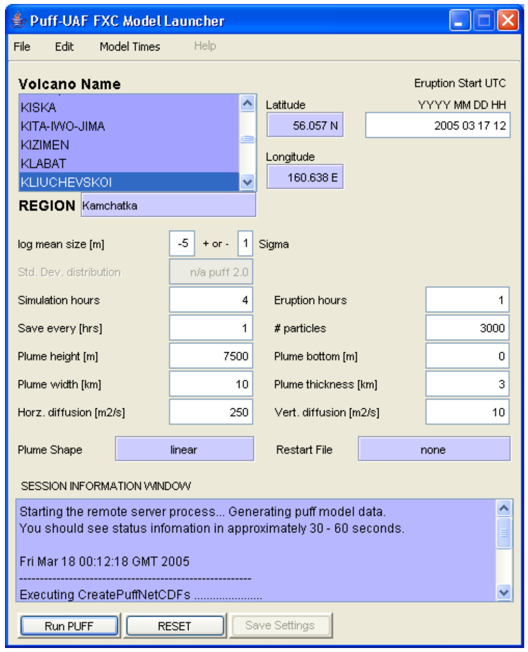


Figure 1. Shows the VACT PUFF Interface.

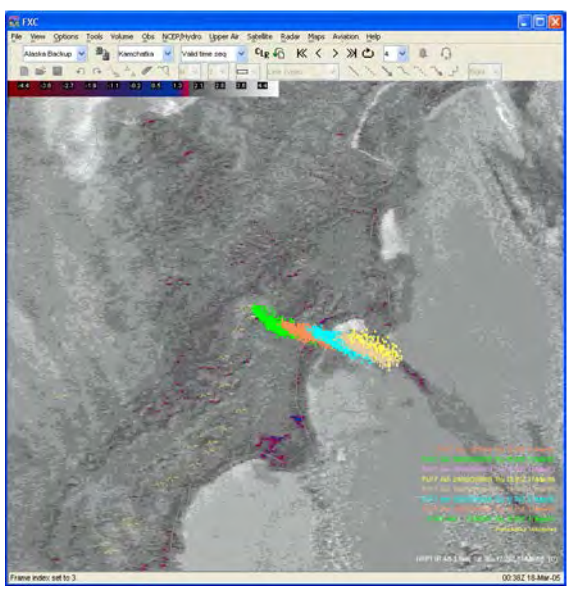


Figure 2. Shows example output from running the PUFF model over the 17 March 2005 eruption of Kliuchevskoi.

As of May 2007, the VACT project has been operating in software/system maintenance and support mode since the project research funding had ended. As of March 2009, the original federal manager of this project left to work for another branch within GSD. In Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) was drafted in order to specify some funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSUs occurs.

PROJECT ACCOMPISHMENTS: The SOW for this year was to transition the Aviation Tools software/systems support to the Systems Support Group (SSG http://esrl.noaa.gov/gsd/its/ssg/) in the ITS branch of GSD. The SSG is functionally equipped and designated to provide system support services and monitoring for numerous systems and facilities throughout GSD. The current plan is for SSG to support and maintain the ASDAD systems until the Aviation Tools capabilities and requirements that were developed, are implemented and replaced by the AWIPS II extended tasks.

This year, we have achieved and are officially running the legacy software and systems in production, and they are being supported by the ITS SSG.

The majority of work over the past year has been related to: Setting up the hardware and systems for the maintenance and support environment; porting the ASDAD's Legacy AWIPS software to a new Operating System; and implementing required modifications to the FXC and AWIPS software code base to run in the new systems maintenance environment.

In order to deliver this stable production release with respect to just the AWIPS/FXC code base, we had implemented approximately 60 changes and issues throughout the integration and deployment cycle of the servers and clients from May through July. Also worth noting is the implementation of the maintenance environment which has been reduced to a fraction of the previous development environment, providing more cost saving.

The majority of the transition has been completed this year. However, there are still remaining tasks, important priorities, and decisions that need to be made by management. However, the reality is that the project has been under funded for the required support and maintenance necessary to keep the hardware, software and services running. As such, we have run out of funds to fully complete the transition and continue to provide support and maintenance.

Without the necessary resources (time and money), we are again limited by how long we can sustain the current hardware, software, and systems. All these components are once again approaching, and in some cases exceeding, their Life Expectancy.

As of January 2012, management is looking into various plans and strategies in order to keep the services running until the transition to AWIPS II extended tasks and clients that meet the Aviation Tools requirements are delivered. In general, we are on standby and at a crossroads waiting for funds and on management for a decision regarding the next step, a plan and strategy.

It is important to mention that the VACT core server and client systems were supported throughout the year. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. This is a noteworthy example of the VACT project research being transferred to operations.

Project Website:
http://www.esrl.noaa.gov/gsd/ab/asdad/

PROJECT TITLE: EAR Research Collaboration with Information and Technology Services

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM**:** Leslie Ewy, Patrick Hildreth, Robert Lipschutz, Chris MacDermaid, Glen Pankow, Randy Pierce, Richard Ryan, MarySue Schultz, Amenda Stanley, Jennifer Valdez

NOAA TECHNICAL CONTACT**:** Scott Nahman, OAR/ESRL/GSD/ITS

NOAA RESERCH TEAM**:** Judy Henderson, OAR/ESRL/GSD; Chris Masters, Cherokee Services; Alex Mendoza, Cherokee Services

PROJECT OBJECTIVES: Information and Technology Services (ITS) develops and maintains systems that acquire, process, store, and distribute global meteorological data in support of weather model and application R&D projects throughout GSD. CIRA staff collaborates with ITS and other GSD staff to design and implement solutions that meet the specified requirements. CIRA also develops methods to provide and maintain user access to the NOAA R&D High Performance Computing System's (RDHPCS) Hierarchical Storage Management System (HSMS), and develops and maintains the GSD web site.

PROJECT ACCOMPLISHMENTS:
Projects on which CIRA staff collaborated this year include:
--WFIP (Wind Forecast Improvement Project) - WFIP activities included coordinating with researchers on acquiring and processing new data sets that are intended to assist wind energy forecasting, developing data translation software, configuring data transport, and managing data access for numerous external project collaborators. Figure 1 illustrates the WFIP data flow.

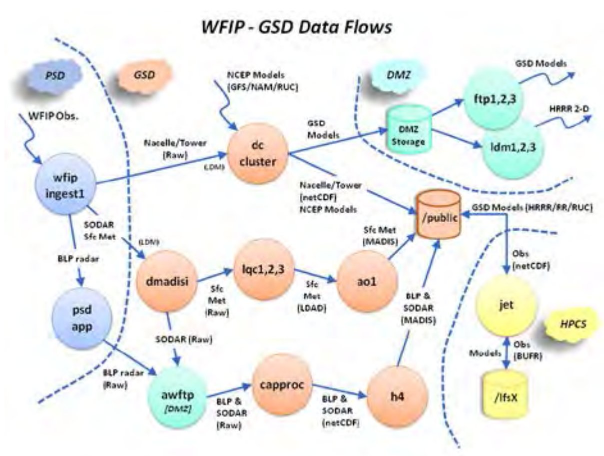


Figure 1. WFIP data flow

--NOAA Earth Information Service (NEIS) - the NEIS demonstration program involved developing a web service that could gather NOAA dataset metadata for subsequent access by an advanced global data viewer system.
--NextGen Network Enabled Weather (NNEW) - worked with the NNEW collaborators in GSD, NCAR, and MIT/Lincoln Lab on the 4D Weather Cube.

--Director's Discretionary Fund (DDF) Aircraft Meteorological Data Relay (AMDAR) WXXM project - as a demonstration of WXXM utility, a WXXM AMDAR schema was developed, and a java application was written to encode AMDAR temperature observations and quality control information following the WXXM specification.

--GLD360 Lightning Data - a new data acquisition subsystem was developed to receive, decode, and store global lightning data from the Vaisala GLD360 service for assimilation into GSD's Rapid Refresh weather model.
--Data Tracker / Central Product Metadata service - the Data Tracker, which is in integration testing, will collect and provide efficient database query access to data file metadata, thereby off-loading costly access to the GSD central storage system; the related Central Product Metadata service, now being designed and prototyped, will allow users to discover data holdings within GSD.
--RDHPCS HSMS - CIRA staff collaborated with NOAA RDHPCS staff to maintain user access to the HSMS, and began designing methods to support supercomputer users at the NOAA Environmental Security Computing Center (NESCC) facility.
--GSD Webmaster - activities included redesigning the GSD Intranet website and developing a number of forms for use within GSD.

PROJECT TITLE: EAR NextGen Network Enabled Weather (NNEW) Program

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jim Frimel, Patrick Hildreth, Michael Leon, Chris MacDermaid, Glen Pankow, Jeff Smith, Sher Schranz, MarySue Schultz, Amenda Stanley, Jebb Stewart, Mike Turpin

NOAA TECHNICAL CONTACT: Dr. Lynn Sherretz, OAR/ESRL/GSD/ACE

NOAA TEAM: James Schroeter, Cherokee Services

PROJECT OBJECTIVES:
--Advancements to the NextGen Testing Portal
--Participation in the Fiscal Year 2011 Capabilities Evaluation (CE) at the Federal Aviation Administration's William J Hughes Technical Center (WJHTC)
--Quality of Service Research

PROJECT ACCOMPLISHMENTS:
The purpose of the FAA's NNEW program is to provide common, universal access to aviation weather data. The goals of this program include providing network-enabled weather information services, disseminating weather information to transportation decision makers and National Air Space (NAS) users, laying the foundation for access to the "common weather picture", and providing for the extraction of weather information by user-specified criteria (e.g., along a flight path)

NextGen Testing Portal. There were several advancements in the Testing Portal last year: new functional tests for WFS, WCS, and RegRep services, improved reporting, new load testing capabilities including the ability to run custom queries and dynamically see results plotted on the screen in real time, and a WCS ad hoc query editor that helps users find the desired coverages, fields, and times and also guides them in constructing an xml query to submit to the WCS. The Java code backing this ad hoc editor converted NetCDF output from the WCS into GeoTIFF and jpeg images suitable for web display; this code was shared with the NCAR WFS developers to help them improve the next version of their WFS.

Participation in the FY 2011 Capability Evaluation (CE) at the Federal Aviation Administration's William J Hughes Technical Center (WJHTC). In October 2011, the FAA and the National Weather Service (NWS) conducted a Capability Evaluation at the WJHTC to demonstrate the benefits and assess the performance of the NNEW infrastructure. The CIRA research team implemented the NNEW services (WFS, WCS and RegRep) in the GSD R&D Testing Environment, providing data for many of the CE demonstrations. CIRA staff assisted with the coordination, setup and troubleshooting involved with building and configuring the WJHTC Evaluation Environment and enabling other CE participants to provide data for this high profile demonstration. CIRA researchers extended the functional and load testing capabilities of the NextGen Testing Portal, integrated NNEW data with a variety of display technologies including iPad and Android, and demonstrated these testing and display capabilities to FAA and NWS management at the CE. CIRA was responsible for writing a report that provided a summary of the CE proceedings and recommended areas for future research.

Quality of Service Research. One of the GSD deliverables for NNEW this past year was a QoS report on the NNEW services. This QoS report was limited to evaluating risk areas that would affect user satisfaction such as performance with the idea being that the test results provide information that can be used to determine if NextGen service level and performance requirements are being met.

The QoS testing was isolated to measuring the processing time taken by the WFS and WCS reference implementation software at the GSD, NCAR and FAA Tech Center test environments. Multiple test configurations were run for each service, which included geographic subsetting and running parallel requests. In the case of the WFS, it was discovered that there was a relationship between the number of features available and the RI response time; however we did not discover the same relationship between file size and RI processing time in the case of the WCS.

These tests were only beginning to look at what could be analyzed. Examples of further work would focus on increasing the number and diversity of tests, bypassing the caching of results, expanding the test areas to include a larger number of clients, finding points of failure after sufficient stress testing, and developing performance tests that measure CPU, disk and memory usage.

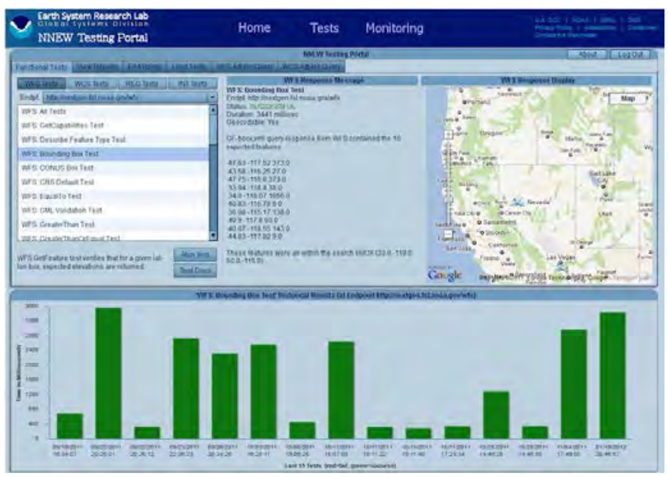


Figure 1. NNEW Testing Portal

PROJECT TITLE: EAR FX-Net Forecaster Workstation Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sher Schranz, Jebb Stewart, Evan Polster, Ning Wang

NOAA TECHNICAL CONTACT: William Bendel, OAR/ESRL/GSD/TOB

PROJECT OBJECTIVES: The purpose of the AWIPS Thin Client project is to develop and deploy an integrated thin client solution that will satisfy the NWS enterprise requirements for remote access to baseline AWIPS-II capabilities. Included in this project is the effort to transition from maintenance and support of the FX-Net thin client workstation to the delivery of the AWIPS II Common AWIPS Visualization Environment (CAVE) thin client workstation.

The FX-Net Thin Client has been supporting NWS Incident Meteorologists, USFS Predictive Services Fire Weather Forecasters, NOAA Research field studies, university meteorological education programs and the US Air Force's Air Force One weather forecasting operations. FX-Net continued to support these programs in FY11.

The CIRA team's objective is to continue supporting FX-Net while conducting research and development to add FX-Net functionality to the AWIPS II CAVE and to port the remote CAVE code to the Windows OS platform.

1) Maintain NWS and US Forest Service FX-Net AWIPS Servers
2) Develop software to add experimental fire weather data distribution to FX-Net users.
3) Test and evaluate the Windows port of the CAVE Thin Client software developed by Raytheon.
4) Research and develop AWIPS II CAVE Thin Client plug-ins to add full FX-Net functionality to the AWIPS II CAVE Thin Client.

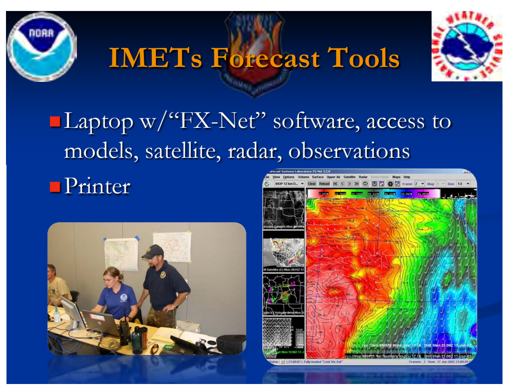


Figure 1. NWS Incident Meteorologist using FX-Net at the Four-Mile Canyon Fire, September 2010.

PROJECT ACCOMPLISHMENTS:
1--Upgraded all servers with latest security, OS patching and AWIPS software bug fixes. Provided the software to all NWS Regional HQ offices and to the USFS National Interagency Fire Center for use by fire weather and hazards forecasters.

2--New Models:
Added a new version of WRF/Chem/Smoke model to FX-Net servers.

Evaluated the experimental NCEP Fire Weather high-resolution model grids in order to make them available to the FX-Net AWIPS servers. Software is being developed to modify AWIPS file server processes.

3--AWIPS II CAVE Test and Evaluation:
Completed and integrated plug-ins for the AWIPS II CAVE system. The Markers, KML Import and KML Export, and Shaped File Import capabilities were integrated into the Linux

version of the CAVE Thin Client. Conducted extensive testing of the developmental Windows CAVE.

4--AWIPS II Research and Development: Prototyped a new Tool Layer capability for the CAVE environment that can be used by CAVE developers to provide a set of functions and libraries that will make cross-perspective development more transparent. The first prototype was the Feature Set Viewer. This capability allows users to load different data types and normalize their look and related metadata for visualizing in CAVE.

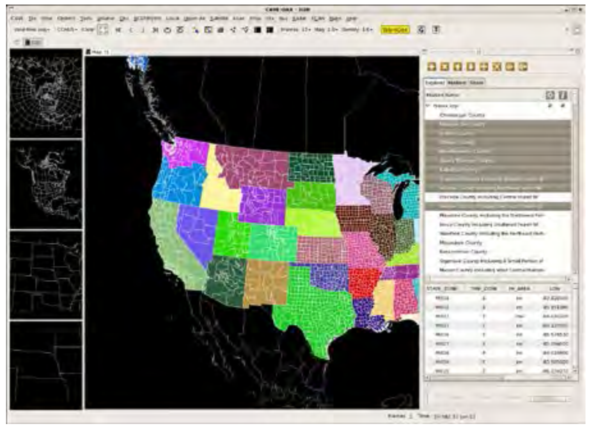


Figure 2. Feature Set Viewer. CAVE displaying Fire Weather Zones (ingested using Shape File Plug-in) with multiple geometries. Note the related meta-data from all geometries are displayed in the table to the right.

Project Publications from Past Fiscal Year:
NWS OSIP, Gate Three, stage Two; CONOPS ORD (https://osip.nws.noaa.gov/osip) OSIP ID: 09-015

PROJECT TITLE: EAR GRIDDED FX-Net Forecaster Workstation Project

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

RESEARCH TEAM**:** Sher Schranz, Jebb Stewart, Evan Polster, Ning Wang

NOAA TECHNICAL CONTACT**:** William Bendel, OAR/ESRL/GSD/TOB

PROJECT OBJECTIVE: Maintain existing system capabilities for USFS, BLM and Dept. of Agriculture National Interagency Fire Center (NIFC) Predictive Services Fire Weather forecasters.

PROJECT ACCOMPLISHMENTS:
Upgraded software and deployed to 6 Geographical Area Coordination Centers (GACCs). Systems were successfully used by GACC Fire Weather Predictive Services forecasters during the FY 11 fire weather season.

The GETWI application is supporting GACC offices across the US.

Began development of new 5-year MOU with NIFC. The new MOU will include plans for transitioning the NIFC systems from AWIPS I technology to AWIPS II technology.

PROJECT TITLE: EAR Wavelet Data Compression Research and Applications

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Ning Wang, Jebb Stewart, Sher Schranz

NOAA TECHNICAL CONTACT: William Bendel, OAR/ESRL/GSD/TOB

PROJECT OBJECTIVES:
1--Enhance performance and efficiency of the compression software
2--Enhance the functionalities of the compression software to deal with data sets with various topologies and formats.
3--Evaluate the impact of the lossy data computation to the data sets which will be used in further numerical computations.

PROJECT ACCOMPLISHMENTS:
1--Continuous progress has been made on enhancing the Wavelet Data Compression in 2011. Improvements in the technology were developed for its computation efficiency, flexibility, and robustness. In particular, the software has been improved to handle super high-resolution data sets with very complex regions of missing values.
2--Demonstration software has been created to allow potential users to conduct data compression experiments on their data sets to experience how their data set volume can benefit from this state-of-the-art data compression technique.
3--Some further experiments have been conducted to assess the feasibility of compressing model data that are archived for future numerical processing. A winter case and a summer hurricane case were put into the test, and their results are being summarized and will be presented to the geoscience and data compression communities.

A new experiment was carried out during 2011 to test the feasibility of using wavelet compressed, high-resolution, satellite images in data assimilation. The wavelet data compression technique was developed to use Regions Of Interest (ROI) to enhance the simple 'thinning' technique currently used in the processing of satellite images for data assimilation. The preliminary experiment yields some interesting and promising results. However, we are still in a rather early stage of the research. To integrate the technique to the operational data assimilation process, several numerical and algorithmic problems will be solved in FY12.

PROJECT TITLE: EAR National Weather Service NextGen 4D Data Cube

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jebb Stewart, MarySue Schultz, Patrick Hildreth, Mike Turpin, Amenda Stanley, Sher Schranz, Chris MacDermaid

NOAA TECHNICAL CONTACT: Lynn Sherretz, OAR/ESRL/GSD/ACE

PROJECT OBJECTIVES:
1--Conduct 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. The GSD Director has appointed Sher Schranz as the Deputy Program Manager for the ESRL/GSD projects. Members of the FX-Net team will conduct research projects as a part of this program in the FY11/12 federal fiscal year.

2--Support NWS 4D Data Cube prototypes, demonstrations and capability evaluations (CEs) – including the transition of technology, as required, to web-enable NOAA data providers.

3--Support Program Manager and develop program plans, personnel resource allocations and budgets for research and development projects.

4--CIRA is now a member of the Open Geospatial Consortium and as a part of this project is an active member of the working groups and committee that develop standards for the web services and web-enabled data formats, such as WXXM.

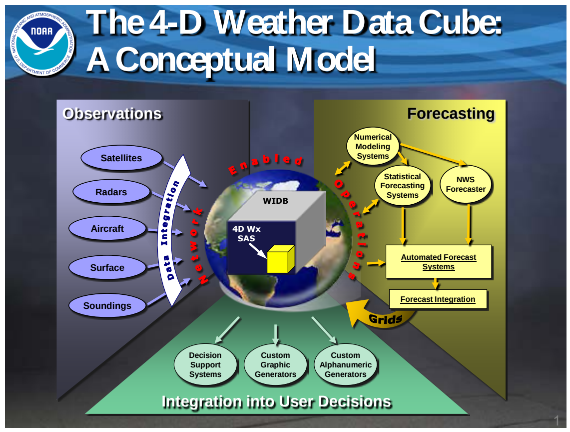


Figure 1. NextGen 4D Weather Cube

PROJECT ACCOMPLISHMENTS:
1--The research and development team transitioned the Testing Portal service to the National Weather Service's NET web environment. The NWS is using the NET to support the FAA Capabilities Evaluations (CEs). The WCS and WFS web services are also being ported to the NWS NET. Configuration Management and web services installation documentation was developed for the NWS NextGen program to enable the NWS to install the services on other NWS data provider's systems.

Web Coverage Service (WCS) software has been installed in the Aviation Weather Testbed (AWT) in Kansas City, KS. The Boulder/CIRA NextGen team works very closely with the AWT on testing and evaluating web services for aviation weather forecast processes. A new member of the CIRA team began working at the AWT in January. This position will greatly enhance our collaborations with this important NWS weather testbed.

2--The team developed test plans and test cases used during the October 2011 Capabilities Evaluation (CE). Prototype demonstrations were shown to NWS NextGen program management and to NOAA data providers. Virtual machines were developed to provide Web Coverage services to the NWS Aviation Weather Center, Meteorological Development Lab, NCEP and NSSL. An iPad application was developed to demonstrate the use of a Wed Mapping Service's (WMS) ability to overlay WCS and WFS data.

The CIRA NextGen team was essential to the success of the October CE as they provided security, networking, software development and real-time data feed support to the FAA's Technical Center prior to, and during, the real-time event.

3--Program management spreadsheets were developed to track research and development progress and budget. Regular developer and program management meetings are held with researchers from GSD, CIRA, and the NWS NextGen Program Office.

Team members are participating in research planning for a Convective Initiation demonstration to take place in FY12 and FY13. Members are also participating with the NWS and other OAR labs in Technology Innovation research planning and are contributing to the development of NWS Science and Technology roadmaps.

PROJECT TITLE: EAR Science on a Sphere (SOS) Development

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Michael Biere, Steve Albers

NOAA TECHNICAL CONTACT: William Bendel, OAR/ESRL/GSD/TOB

PROJECT OBJECTIVES: The Science on a Sphere® Development project addresses NOAA's cross-cutting priority of promoting environmental literacy.

The NOAA Science on a Sphere® (SOS) project displays and animates global data sets in a spatially accurate and visually compelling way, on a 6-foot spherical screen. CIRA provides key technical support to the project, particularly research into effective user interfaces for the system, new visualization techniques, and new data sets.

PROJECT ACCOMPLISHMENTS:
Objective: CIRA staff will continue to develop and enhance near real-time global data sets for SOS museum sites.

Status: A flexible label generator program was developed that compensates for the distortion introduced by the spherical display transformation used in SOS. This label generator was used to create approximately 20 data set overlays, labeling the principal features of many of our planetary data sets.

Objective: CIRA researchers will be providing technical support for SOS installation at any additional new sites that may arise.

Status: SOS was installed at the following sites this past year:

Climate Institute, Acapulco, Mexico
Aquarium of the Pacific, Long Beach, CA
Detroit Zoological Society, Royal Oak, MI
Beijing Huaxinchuanzi Technology Co. Ltd., Beijing, PRC
KIGAM Geological Museum, Daejeon, Republic of Korea
Our Planet Centre, Castries, St. Lucia
Nurture Nature Center, Easton, PA
Visual Climate Center, Holeby, Denmark
Climate Institute, Texcoco, Mexico
Climate Institute, Valle de Bravo, Mexico
Climate Institute, Villahermosa, Mexico
Museum of Natural History, Halifax, Nova Scotia, Canada
Aldo Leopold Nature Center, Monona, WI
Climate Institute, Chetumal, Mexico
Grand Canyon Visitor Center, Grand Canyon, AZ
China Maritime Museum, Shanghai, PRC
St. Paul's School, Concord, NH
Science Centre Singapore, Singapore
Science City at Union Station, Kansas City, MO
Climate Institute, Oaxaca, Mexico

Objective: CIRA will provide technical guidance for a demonstration capability of several new features in SOS: layering, annotation, zooming, and streaming video.

Status: CIRA redesigned the core SOS display capability into an object-oriented class hierarchy as a preliminary step in implementing the new features. The initial versions of annotation, layering, and zooming were then developed as envisioned. Video streaming has proven more difficult than expected and has been deferred.

Objective: CIRA will develop the initial version of a new SOS user interface on the iPad, iPhone and iPod Touch, to be made freely available on the Apple App Store.

Status: CIRA developed the initial beta version of this interface. The user interface was further refined by other SOS team members and made available on the Apple App Store this year as the *SOS Remote* app.

Figure 1. CIRA developed the initial version of the SOS Remote app for iPad. After beta testing and graphical polishing, the version shown here was published to the Apple App Store. The app allows data set selection and interactive control of SOS.

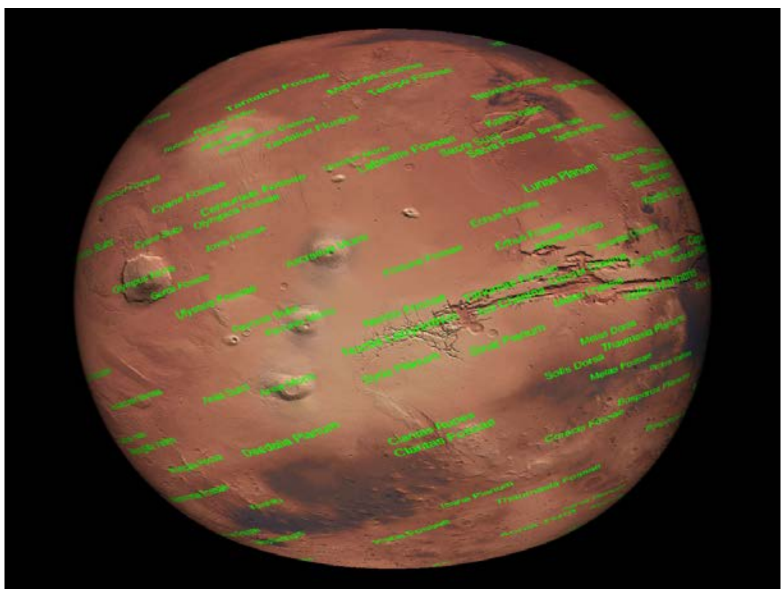


Figure 2. Label overlays were developed by CIRA for many of the SOS astronomical data set. Shown here for Mars, the labels can be interactively toggled on and off with the layer capability that CIRA added to SOS this year.

PROJECT TITLE: Legacy Atmospheric Sounding Data Set Project

PRINCIPAL INVESTIGATOR: Richard H. Johnson

RESEARCH TEAM: Richard H. Johnson (CSU), Paul E. Ciesielski (CSU), Steven F. Williams (NCAR)

NOAA TECHNICAL CONTACT: Chris Miller, Climate Change and Data Detection

NOAA RESEARCH TEAM: None

PROJECT OBJECTIVE: The identification, recovery, cataloguing, and central archiving of sounding data from field campaigns going back to the 1950s.

PROJECT ACCOMPLISHMENTS:
--Identification of past field campaigns for which central collections of sounding data do not exist
--Visit to NCDC to evaluate their inventory and retrieve relevant data
--Preparation of website for Legacy Project – http://www.eol.ucar.edu/projects/legacy
--Preparation of two articles for Bulletin of AMS (Ciesielski et al. 2012; Johnson et al. 2012)

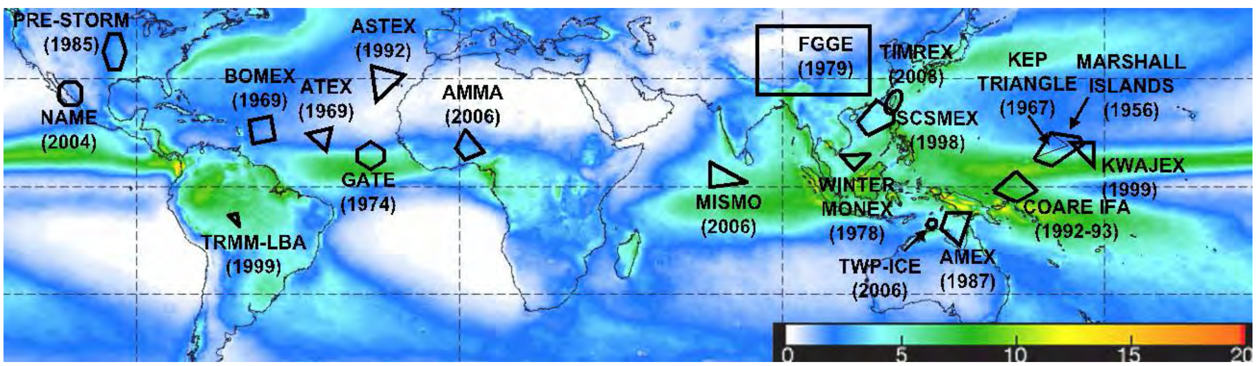


Figure 1. Sounding networks for several major field campaigns superimposed on the annual-mean TRMM 3B43 rainfall (mm/day) for the period 1998-2008.

PROJECT TITLE: Research Collaboration with the Aviation Weather Testbed

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sher Schranz, Benjamin Schwedler

NOAA TECHNICAL CONTACT: NWS/AWC, David Bright

PROJECT OBJECTIVES: CIRA staff will assist the NOAA NextGen Weather Program and the Aviation Weather Testbed in Kansas City, MO with developing, testing, and transitioning promising aviation weather research to operations in the National Weather Service.

Responsibilities include the following tasks:

--Coordinate activities between the NextGen Weather Program and the Aviation Weather Testbed
--Develop a thorough understanding of NWS aviation services and work with the NWS NextGen Program, the Aviation Weather Center, and the NWS Aviation Services Branch to propose, develop, and evaluate forecast processes which meet NextGen requirements while remaining operationally viable
--Conduct applied operational research to assist the AWC in achieving the meteorological and air traffic requirements for the Next Generation Air Transportation System (NextGen)
--Evaluate and implement new forecast techniques and aviation impact diagnostics using observations and models, particularly emerging high-resolution models and ensemble forecast systems
--Serve as a liaison between operational forecasters, the Aviation Weather Testbed, and NWS headquarters to facilitate coordinated communication and a common vision
--Represent the Aviation Weather Testbed by contributing to formal scientific publications and attending off-site conferences, symposia, and aviation weather related outreach events
--Other support activities as deemed appropriate by the NextGen Program and the Aviation Weather Testbed

PROJECT ACCOMPLISHMENTS:
Ben Schwedler was hired on January 17, 2012 for this new role and is busy familiarizing himself with his responsibilities and the Aviation Weather Center/Testbed environment. He visited CIRA and the NOAA Earth System Research Lab/Global Systems Division in mid-February to better understand the goals and objectives of the GOES-R Proving Grounds Project and the GSD deliverables in support of the NWS NextGen program.

PROJECT TITLE: Weather Satellite Data and Analysis Equipment and Support for Research Activities

PRINCIPAL INVESTIGATORS: Chris Kummerow / Michael Hiatt

RESEARCH TEAM: Michael Hiatt

NOAA TECHNICAL CONTACT:

NOAA RESEARCH TEAM:

PROJECT OBJECTIVES:
--Earthstation: Operations and maintenance for antennas, telemetry, ingest, processing, and archive
--Data Collection and Distribution: All GOES, MSG2, and 26 project products
--Data Archive: DVD media and online RAID storage
--Personnel Salary: Part time coverage for one Electrical Engineer

PROJECT ACCOMPLISHMENTS:
--All data sets collected, processed, cataloged, distributed, and archived at 99.9% level. Online archive spans from 1992-2012 with approximately 300TB online data.
--7M Antenna feed assembly cleaned. Some waveguide parts replaced.
--7 RAID units added for additional storage.
--3 DVD writers replaced.
--2 ingest servers replaced.
--3 processing servers upgraded.

AWARDS

CIRA Director, Prof. Christian Kummerow, named a Fellow of the American Meteorological Society
The focus of Prof. Kummerow's research is global and regional climate change through the use of satellite data. As his colleague in the Department of Atmospheric Science, Dr. Richard Johnson, stated in the nomination document: "Chris has achieved international recognition for his research in atmospheric radiative transfer and remote sensing of precipitation. He is probably the world's leader right now in passive microwave remote sensing of precipitation." The AMS chooses Fellows via nomination by a current member, and the honor belongs to an elite group of researchers who strive for excellence and the pursuit of knowledge and practice in the atmospheric sciences. "I feel deeply honored that the AMS was willing to recognize my work in atmospheric science," Kummerow said. "It is in fact quite humbling when you see some of the really great scientists in the field before me."

Nolan Doesken received the Colorado Foundation for Water Education's 2011 President's Award
Nolan Doesken, Colorado's State Climatologist and a CIRA Principal Investigator, was recently honored for his tireless efforts on behalf of educating the public on water issues. Nolan's work is legendary in Colorado as he is responsible for establishing the Community Collaborative Rain, Hail and Snow Network ("CoCoRaHS"). This citizen network began in the state but has since expanded into a nation-wide effort engaging people in collecting measurements of precipitation right in their backyards. All of this data helps to inform our understanding of weather and longer term climate issues. Nolan was honored at a reception at NCAR on April 8, 2011. CIRA is a long-time supporter of the CoCoRaHS effort and we are proud of Nolan's well-deserved recognition!

The Prestigious NOAA Bronze Medal Award
CIRA is proud to acknowledge two of its on-site NOAA collaborators (and CSU alums), John Knaff and Mark DeMaria, who were recently honored with the 2011 NOAA Bronze Medal.

The NOAA Bronze Medal is the highest honorary award granted to NOAA employees by a head of an operating unit or Secretarial Officer or equivalent. It is defined as superior performance characterized by outstanding or significant contributions which have increased the efficiency and effectiveness of the operating unit.

Mark and John are both members of NOAA's RAMM Branch: The Regional and Mesoscale Meteorology Branch (RAMMB) of NOAA/NESDIS, which is co-located at CIRA. Mark is the Branch Chief, and John is both a former CIRA employee and now RAMMB team member. RAMMB conducts research on the use of satellite data to improve analysis, forecasts and warnings for regional and mesoscale meteorological events. The work honored with the award focused on providing skillful operational hurricane intensity models as demonstrated by the NHC forecast verifications for the 2009 and 2010 Seasons,

The DeMaria group consisted of: Mark DeMaria, John Knaff and John Kaplan.

CIRA Fellow, Sonia Kreidenweis, recognized with two recent fellowships
Professor of Atmospheric Science and CIRA Fellow, Dr. Sonia Kreidenweis, has been recognized with two recent fellowships. At the American Association for Aerosol Research 29th Annual Conference this past October, Dr. Kreidenweis received one of only 2 openings to become an elected Fellow. A few short months later, she was recognized a second time by the American Meteorological Society as an elected Fellow during the 91st Annual Meeting in Seattle this past January. CIRA is privileged to have Dr. Kreidenweis serve on its own Council of Fellows where her well-regarded expertise on the nature and behavior of particulate matter in the atmosphere and its effects on climate and visibility contribute greatly to CIRA science.

CIRA Fellow, Pieter Tans, received Revelle Medal at AGU
Dr. Pieter Tans, a new CIRA Fellow, was recently awarded the Revelle Medal in acknowledgement for his work in understanding Earth's carbon cycle. The ceremony took place during the fall meeting of the American Geophysical Union in San Francisco. Dr. Tans works in the Earth System Research Lab in Boulder where many CIRA staff are collocated to work with NOAA scientists on research topics of mutual interest. Dr. Tans' findings have advanced our understanding of the global carbon cycle and climate change. He is best known for his discovery that the carbon dioxide released by burning fossil fuels which is not accounted for in the ocean and atmosphere can be found stored in the land ecosystems of the Northern Hemisphere. He was further recognized for his invention of a formula now used throughout the scientific community as well as his founding role in the Carbon Tracker system — which calculates carbon dioxide uptake and release over time.

NASA Exceptional Public Service Medal - Dale Reinke
For exceptional and sustained contributions to the CloudSat Mission in the development of the CloudSat Data Ingest and Processing System.

June 2011 GSD Team Member of the Month - Melissa Petty
Missy's work as deputy program manager for the Forecast Impact and Quality Assessment (FIQAS) Section of ACE is outstanding. She provides excellent project management for many of the section's scientific assessments through extensive coordination with external sponsors, such as the FAA, and hands-on direction of the scientific team. She is able to communicate complicated abstract concepts to programmatic audiences through clearly written documents and program plans. For example, she recently completed two extensive documents for the Network-Enabled Verification Service (NEVS): the Concept of Operations, and Technical Requirements. These documents have laid the foundation for a NEVS transition to the NWS as well as the foundation for a verification capability supporting automated operational decision-making. Missy is the lead for the FIQAS Computer Resource Committee and the OSIP process for the NEVS transition, both of which are extensions to her main responsibilities. Her contributions to the FIQAS Program have been exceptional!

May 2011 GSD Team Member of the Month - Leigh Cheatwood-Harris
In her multiple roles, Leigh made very significant contributions in several areas related to the Geo-Targeting Alert System (GTAS) and the Next Generation Aviation Transportation System (NextGen). For GTAS, she developed a GIS database to provide street-level mapping capabilities that are vital for decision support. The resulting GTAS system is assisting the Federal Emergency Management Agency's (FEMA's) requirements to provide air dispersion and toxic plume information along with NOAA environmental data to state and local emergency management agencies. Additionally, she provides training and evaluation for forecasters and emergency managers on GTAS at locations around the U.S., resulting in strengthened relationships between local NWS Weather Forecast Offices and Emergency Operation Centers through shared situational awareness of vital data. Leigh also compiled NextGen evaluations of the Auto-Nowcaster tool, which provides automated, short-term forecasts to detect and warn of high-impact weather events associated with thunderstorms.

April 2011 GSD Team Member of the Month - Bob Lipschutz
Over the past year, Bob has done an excellent job serving as the Central Facility production control manager. In this role, he keeps the Data Systems Group processing cluster functioning as a highly-reliable data delivery service for GSD. Bob has also stepped up to lead the Data Storage Study Group. This group is tasked with a top to bottom review of GSD's storage capability while identifying future needs and recommending optimization strategies. Bob is also leading ITS's contribution to the Wind Forecast Improvement Project (WFIP) by assisting with the required storage needs for this project. Bob provides valuable support for the Hydrometeorology Testbed, as well as many other projects and programs, and his outstanding support and contributions have led to the success of many programs.

CIRA 2011 Research and Service Initiative Awards:

Prasanjit Dash - Together with Dr. Xingming Liang, for development of the SST Quality Monitor (SQUAM) near-real time monitoring system, which complements Dr. Liang's Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS) monitoring system and provides online access of these important analysis tools for the research community.

Xingming Liang - Together with Dr. Prasanjit Dash, for development of the Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS) near-real time monitoring system, which complements Dr. Dash's SST Quality Monitor (SQUAM) monitoring system and provides online access of these important analysis tools for the research community.

Wei Shi - For innovative use of shortwave infrared (SWIR) bands on NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor for the purpose of deriving more accurate ocean color data products in the challenging coastal zones, as well as demonstrating the many practical applications of these improved ocean color products.

Colorado State University Service Milestone Awards:

Helene Bennett – 20 years
Derek Day – 20 years
Joanne DiVico – 30 years
Leslie Ewy – 15 years
Andrew Jones – 25 years
Kevin Micke – 10 years
Lance Noble – 25 years
Mariusz Pagowski – 10 years
Glen Pankow – 15 years
Donald Reinke – 25 years
Karll Renken – 15 years
Richard Ryan – 10 years
Curtis Seaman – 10 years
Amenda Stanley – 15 years

PUBLICATIONS MATRIX

	Institute Lead Author							NOAA Lead Author							Other Lead Author						
	2005	2006	2007-08	2008-09	2009-10	2010-11	2011-12	2005	2006	2007-08	2008-09	2009-10	2010-11	2011-12	2005	2006	2007-08	2008-09	2009-10	2010-11	2011-12
Peer-Reviewed	70	42	46	37	24	24	21	14	30	26	21	17	16	23	25	71	80	35	31	20	29
Non Peer-Reviewed	128	40	6	58	6	45	71	52	91	2	34	0	33	70	46	64	5	49	5	20	35

PUBLICATIONS & PRESENTATIONS

PUBLICATIONS

(All publications fall under Award Number NA090AR4320074 unless otherwise noted)

A GOES-R Proving Ground for National Weather Service Forecaster Readiness

Bikos, Dan, Daniel Lindsey; Jason Otkin; Justin Sieglaff; Louie Grasso; Chris Siewert; James Correia; Michael Coniglio; Robert Rabin; Jack Kain; Scott Dembek, 2011: Synthetic Satellite Imagery For Real-Time High Resolution Model Evaluation. Weather and Forecasting. [Accepted]

DeMaria, Mark,2012: Tropical Cyclone Lightning and Rapid Intensity Change. Monthly Weather Review. [Accepted]

Goodman, Steven J., James Gurka; Mark DeMaria; Gary Jedlovec; Timothy Schmit; Chris Siewert; Anthony Mostek; Wayne Feltz; Jordan Gerth; Renate Brummer; Steven Miller; Bonnie Reed; Richard Reynolds, 2012: The GOES-R Proving Ground: Accelerating User Readiness for the Next Generation Geostationary Environmental Satellite. BAMS (accepted Feb 2012)

Grasso, L.D., D.T. Lindsey, 2011: An Example of the use of Synthetic 3.9 µm GOES-12 Imagery for Two-Moment Microphysical Evaluation. International Journal of Remote Sensing. 32:8, 2337.

Hillger, D.W., L.D. Grasso, S. Miller, R. Brummer, and R. DeMaria, 2011: Synthetic advanced baseline imager true-color imagery. J. Appl. Remote Sens. (JARS) 5, 053520 (2011), DOI:10.1117/1.3576112

Knaff, J.A., C.R. Sampson, P. J. Fitzpatrick, Y. Jin, and C.M. Hill, 2011: Simple Diagnosis of Tropical Cyclone Structure via Pressure Gradients. Weather and Forecasting. 26:6, 1020-1031. DOI: 10.1175/WAF-D-11-00013.

Advanced Applications of the Monte Carlo Wind Probability Model (Shadow Award No. NA080AR4320893)

Santos, P., M. DeMaria, and D. Sharp, 2010: The determination of optimal thresholds of tropical cyclone incremental wind speed probabilities to support expressions of uncertainty within text forecasts: An update. Extended Abstract, 20th Conference on Probability and Statistics in the Atmospheric Sciences, Amer. Meteor. Soc., Atlanta, GA. <Available from http://ams.confex.com/ams/90annual/techprogram/paper_160384.htm>

Tsai, H., K. Lu, N. Hsu, A. Chia, M. DeMaria, 2011: An Application of the Monte Carlo Method: Tropical Cyclone Strike Probabilities. *Atmospheric Sciences*, 39:3, 269-288.

CIRA Activities and Participation in GIMPAP

Goni, G.J., J.A. Knaff, and I-I Lin, 2011: TC heat potential (TCHP) [in “State of the Climate in 2010”]. Bull. Amer. Meteor. Soc.,92:6, S132-S134.

Hillger, D.W., and T.J. Schmit, 2012: The GOES-15 Science Test: Imager and Sounder Radiance and Product Validations, NOAA Technical Report NESDIS 141, (November), 101 pp. The Report is available on the GOES-15 Science Test page: http://rammb.cira.colostate.edu/projects/goes-p/

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 Applied Meteorology and Climatology. 50:10, 2149-2166. doi: 10.1175/2011JAMC2673.1

Miller, S. D., D. Chand, C. L. Combs, M. Sengupta, and A. K. Heidinger, 2011: Toward Evaluating Short-Term Predictions of Solar Irradiance at the Surface: Persistence, Satellite-Based Trajectory and Numerical Weather Prediction Models. Proc. ASES, 151

Sampson, C.R., J. Kaplan, J.A. Knaff, M. DeMaria, and C. Sisko, 2011: A deterministic rapid intensification aid. Wea. Forecasting, 26:4, 579-585.

CIRA Research Collaboration with the NOAA/NESDIS NGDC for the NPOESS SEM Senor Suite Algorithm Development Project

Machol, J. L., J. C. Green, R. J. Redmon, R. A. Viereck, and P. T. Newell, 2012.: Evaluation of OVATION Prime as a Forecast Model for Visible Aurorae, Space Weather, In Press, doi:10.1029/2011SW000746.

Machol, J. L., J.C. Green, J.V. Rodriguez, T.G. Onsager, W.F. Denig, and P.N. Purcell, 2012: New Operational Algorithms for Charged Particle Data from Low-Altitude Polar-Orbiting Satellites. , Proc .92nd Annual Meeting of the American Meteorological New Orleans, LA, American Meteorological Society.

Machol, J. L., J.C. Green, R.J. Redmon, R.A. Viereck, and P.T. Newell, 2011: Evaluation of Ovation Prime as a Forecast Model for Visible Aurorae. Proc. Fall Meeting 2011, San Francisco, CA, American Geophysical Union.

CIRA Research Collaborations with the NWS Meteorological Development Lab on Autonowcaster and AWIPS II Projects

Lakshmanan, V., J.Crockett, K. Sperow, M. Ba, and L. Xin, 2012: Tuning AutoNowcaster automatically. Wea. For. , submitted.

CoCoRaHS (Award No. NA10SEC0080012)

Doesken, Nolan and Henry Reges. “Creating a Volunteer Observing Network.” World Meteorological Organization Bulletin. Vol. 60 (1) - 2011: 48-52. Print.

Data Fusion to Determine North American Sources and Sinks of Carbon Dioxide at High Spatial and Temporal Resolution from 2004 to 2008 (Shadow Award No. NA080AR4320074)

Baker, I. T., Denning, A. S. and Stockli, R. (2010), North American gross primary productivity: regional characterization and interannual variability. Tellus B, 62: 533–549. doi: 10.1111/j.1600-0889.2010.00492.x

Lauvaux, T., Schuh, A. E., Uliasz, M., Richardson, S., Miles, N., Andrews, A. E., Sweeney, C., Diaz, L. I., Martins, D., Shepson, P. B., and Davis, K. J.: Constraining the CO_2 budget of the corn belt: exploring uncertainties from the assumptions in a mesoscale inverse system, Atmos. Chem. Phys. Discuss., 11, 20855-20898, doi:10.5194/acpd-11-20855-2011, 2011.

Schuh, A. E., A. S. Denning, M. Uliasz, K. D. Corbin, 2009. Seeing the Forest through the Trees: Recovering large scale carbon flux biases in the midst of small scale variability. Jour. Geophys. Res., doi:10.1029/2008JG000842.

Schuh, A. E., A. S. Denning, K. D. Corbin, I. T. Baker, M. Uliasz, N. Parazoo, A. E. Andrews, and D. E. J. Worthy, 2010. A regional high-resolution carbon flux inversion of North America for 2004. Biogeosciences, 7, 1625–1644

Schuh, A. E., Lauvaux, T., West, Tristram, Uliasz, M., Lokupitiya, E., Andrews, A., Cooley, D., Denning, S., Davis, K., Ogle, S. Evaluating atmospheric CO2 inversions at multiple scales over a highly-inventoried agricultural landscape In prep for Global Change Biology, March 6, 2012

Uliasz, M. et al Title In prep for AGU Monograph Series

Ensemble Data Assimilation for Hurricane Forecasting

Zhang, M., M. Zupanski, and M.-J. Kim, 2011: All-sky AMSU-A Radiance EnsDA Study of hurricane Danielle (2010). 9th JCSDA Workshop on Satellite Data Assimilation, University of Maryland, College Park, May 24-25, 2011.

Zhang, M., M. Zupanski, M.-J. Kim, and J. Knaff, 2012: Direct Assimilation of all-sky AMSU-A Radiances in TC inner core: Hurricane Danielle (2010). To be submitted to Mon. Wea. Rev.

Environmental Applications Research

Benjamin, S. G., R. Bleck, J. M. Brown, S. Sun, J. W. Bao, S. Sahm, M. Fiorino and T. Henderson, 2011: Progress in development of the flow-following finite-volume icosahedral model (FIM) toward improving NCEP global ensemble forecasts and toward a chemistry-coupled global model research capability. Proc. 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans and Land Surface (IOAS-AOLS), Seattle, WA, American Meteorological Society.

Cimini D., E. Campos, R. Ware, S. Albers, G. Giuliani, J. Oreamuno, P. Joe, S. Koch, S. Cober, and E. R. Westwater, 2011: Thermodynamic atmospheric profiling during the 2010 Winter Olympics using ground-based microwave radiometry. IEEE Trans. Geosci. Rem. Sens., 49, no. 12, 4959-4969.

Henderson, T., J. Middlecoff, M. Govett and P. Madden, 2011: Experience applying Fortran GPU compilers to numerical weather prediction. Proc. 2011 Symposium on Application Accelerators in High Performance Computing, National Center for Supercomputing Applications, Knoxville, TN, University of Illinois at Urbana-Champaign.

Jankov, I., S. C. Albers, H. Yuan, L. S. Wharton, Z. Toth, T. L. Schneider, A. B. White and F. M. Ralph, 2011: Ensemble prediction system development for hydrometeorological testbed (HMT) application. Proc. 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, Seattle, WA, American Meteorological Society.

Jankov, I., L. D. Grasso, M. Sengupta, P. J. Neiman, D. Zupanski, M. Zupanski, D. Lindsey, D. W. Hillger, D. L. Birkenheuer, R. Brummer, H. Yuan, 2011: An evaluation of five WRF-ARW microphysics schemes using synthetic GOES imagery for an atmospheric river event affecting the California coast. Journal of Hydrometeorology, In Press. [Early Online Release at http://journals.ametsoc.org/doi/pdf/10.1175/2010JHM1282.1].

Jiang, H. and Y. Xie, 2012: A multiscale dynamic downscaling technique for application in geoscience and weather forecast. Proc. 21st conference on probability and statistics, New Orleans, LA, American Meteorological Society.

Jiang, H., Y. Xie, J. H. Teng, F. Moeng, and S. Schranz, 2011: A multiscale dynamic downscaling technique for application in fire weather. Proc. Ninth Symposium on Fire and Forest Meteorology, Palm Springs, CA, American Meteorological Society.

Lack, S.A., G. J. Layne, M. P. Kay, M. A. Petty, and J. L. Mahoney, 2012: Relating a convective translation metric to convective impact. Preprints, Third Aviation, Range and Aerospace Meteorology Special Symposium on Weather-Air Traffic Management Integration, New Orleans, LA, Amer. Meteor. Soc.

Lack, S.A., G.J. Layne, M.P. Kay, S. Madine, M.A. Petty, and J.L. Mahoney, 2011: Quality assessment techniques for evaluating convective weather products used for air traffic management strategic planning. Preprints, 15th Conference on Aviation, Range, and Aerospace Meteorology, Los Angeles, CA, Amer. Meteor. Soc.

Lack, S.A., M.S. Wandishin, M.A. Petty, and J.L. Mahoney, 2011: AutoNowcaster Pilot Evaluation Study. Submitted to the National Weather Service Aviation Services Branch.

Lack, S., G. Layne, S. Madine and J. Mahoney,2011:Quality Assessment of CoSPA. NOAA Technical Report, 34 pp.

MacDermaid, C., and G. Pankow 2011: Trade-offs involved when representing weather and/or aviation data in WXXM formats. Proc. Air Transportation Information Exchange Conference, Silver Spring, MD, Federal Aviation Administration.

Mahoney, J., S. Madine, M. Petty, C. Grzywinski and J. L. Vavra, 2011: The Network Enabled Verification Service (NEVS): A bridge between weather and ATM weather integration. Proc. Second Aviation, Range and Aerospace Meteorology Special Symposium on Weather-Air Traffic Management Integration, Seattle, WA, American Meteorological Society.

Marquis, M., S. C. Albers and E. C. Weatherhead, 2011: For better integration, improve the forecast. Solar Today, 25, 52-53.

Pagowski, M., and G. A. Grell, 2011: Experiments with assimilation of surface PM2.5 observations using GSI and EnKF with WRF-Chem during summer 2010. Proc. International Workshop on Air Quality Research Forecasting, Potomac, MD, National Oceanic and Atmospheric Administration.

Pagowski, M., G. A. Grell and S. A. McKeen, 2011: Impact of assimilation of ozone soundings and aircraft measurements on forecasting surface ozone in the USA. Proc. General Assembly, Vienna, Austria, European Geosciences Union.

Pagowski, M., S. E. Peckham, G. A. Grell, and S. A. McKeen, 2011: 3DVAR chemical data assimilation in WRF/Chem forecasts during CalNEX.13th Conference on Atmospheric Chemistry, Seattle, WA, American Meteorological Society.

Peckham, S. , G. Grell, S. Freitas, M. Stuefer, S McKeen, T. Smirnova, S. Benjamin, K. Largo, S. Schranz, 2011: Progress made toward including wildfires in real-time cloud resolving forecasts. Proc. Ninth Symposium on Fire and Forest Meteorology, Palm Springs, CA, American Meteorological Society.

Smith, J. S., M. Leon, M. Turpin, S. Schranz, J. Q. Stewart, and L. Sherretz 2012: Update on NextGen 4-D weather data cube development and tools for content developers. Proc. 27th Int. Conf. on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, New Orleans, LA, American Meteorological Society.

Stewart, J. Q., M. Leon, C. MacDermaid, M. Schultz, S. Schranz, and L. Sherretz 2012: NextGen testing portal. Proc. 27th Int. Conf. on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, New Orleans, LA, American Meteorological Society.

Stewart, J. Q., M. Leon, C. MacDermaid, M. Schultz and L. Sherretz, 2011: NextGen 4-D weather data cube development and tools for content developers. Proc. 27th Conference on Interactive Information Processing Systems (IIPS), Seattle, WA, American Meteorological Society.

Stewart, J. Q., M. Leon, C. MacDermaid, M. Schultz, and L. Sherretz, 2012: Update on Nextgen 4-D Weather Data Cube development and tools for content developers. Proc 28th International Conference on Interactive Information Systems (IIPS) for Meteorology, New Orleans, LA, Amer. Meteor. Soc., CD-ROM, 7A.4.

Szoke, E. J., S. C. Albers, Y. Xie, L. Wharton, R. Glancy, E. Thaler, D. Barjenbruch, B. Meier and Z. Toth, 2011: A comparison of several analysis schemes in their ability to diagnose boundaries. Proc. 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, Seattle, WA, Amer. Meteor. Soc.

Szoke, E., S. G. Benjamin, J. M. Brown, M. Fiorino, B. D. Jamison, W. Moninger and S. Sahm, 2011: FIM Performance for some of the major events of the 2009-2010 winter season. Proc. 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans and Land Surface (IOAS-AOLS), Seattle, WA, American Meteorological Society.

Szoke, E., R. Brummer, H. Gosden, S. D. Miller, M. DeMaria and D. A. Molenar, 2011: An overview of CIRA's contribution to the GOES-R Proving Ground. Proc. Seventh Annual Symposium on Future Operational Environmental Satellite Systems, Seattle, WA, American Meteorological Society

Tollerud, E. I., T. L. Jensen, I. Jankov, H. Yuan, J. H. Gotway and P. Oldenburg, 2011: The performance of high-resolution WRF ensemble QPF during heavy winter precipitation events in California. Proc. 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, Seattle, WA, American Meteorological Society.

Toth, Z., S. C. Albers, and Y. Xie, 2012: Analysis of fine scale weather phenomena. Bull. Amer. Meteor. Soc., 93, 3 pp.

Toth, Z., B. G. Brown, I. Jankov, T. L. Jensen, H. Yuan, E. I. Tollerud, L. S. Wharton, P. McCaslin, B. Kuo, L. Nance and S. E. Koch, 2011: The DTC Ensemble Testbed: A new testing and evaluation facility for mesoscale ensembles. Proc. 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, Seattle, WA, American Meteorological Society.

Wade, G. J., J. Fluke, B. Lawrence, D. Schaffer, 2012: AWIPS II Data Delivery Paradigm – A new approach to data acquisition. Proc 28^{th} IIPS, New Orleans, LA, American Meteorological Association.

Wandishin, M.S., B.P. Pettegrew, M.A. Petty, and J.L. Mahoney, 2011: Quality Assessment Report: Graphical Turbulence Guidance, Version 2.5. NOAA Technical Memorandum OAR GSD-39, 44pp.

Wang, N. and J. L. Li, 2011: Geometric properties of the icosahedral-hexagonal grid on the two-sphere. SIAM J. Sci. Comput. 33(5), 2536-2559.

Yuan, H., Y. Xie, S. C. Albers and I. Jankov, 2011: Impacts of the STMAS cycling data assimilation system on improving severe weather forecasting. Proc. 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans and Land Surface (IOAS-AOLS), Seattle, WA, American Meteorological Society.

Future Changes of the Southern Ocean CO2 Fluxes (Shadow Award No. NA080AR4320893)

Jones D.C., T. Ito and N.S. Lovenduski, (2011), “The transient response of the Southern Ocean pycnocline to changing atmospheric winds”, Geophysical Research Letters, 38, L15604, doi:10.1029/2011GL048145

Lenton, A., B. Tilbrook, M. Alvarez, D. Bakker, M. Hoppema, C. LoMonaco, N. Lovenduski, R. Matear, B. McNeil, N. Metzl, P. Monteir, C. Sweeney, in preparation: Southern Ocean regional carbon cycle assessment. Biogeosciences.

Lovenduski, N. S., T. Ito, and D. C. Jones, in preparation: Pre-industrial carbon in the eddying Southern Ocean. Biogeosciences.

Lovenduski, N. S., M. C. Long, P. Gent, and K. Lindsay, 2012 in preparation: Southern Ocean meridional overturning and air-sea CO2 flux variability in the Community Earth System Model. Geophysical Research Letters.

Sweeney, C., T. Guilderson, T. Takahashi, T. Newberger, K. Rodgers, S. E. Mikaloff Fletcher, N. S. Lovenduski, and C. Le Quéré, 2012 in preparation: Surface ocean pCO2 and radiocarbon observations provide evidence of increased vertical mixing south of the Antarctic Polar front. Geophysical Research Letters.

Woloszyn M., M. Mazloff, T. Ito (2011), "Development and evaluation of a high resolution Southern Ocean carbon cycle model", Ocean Modeling, 39(1-2), pp. 170-182

HMT Field Coordinator

Lim, S., R. Cifelli, V. Chandrasekar and S. Y. Matrosov, 2012: Classification, Specific Differential Phase Retrieval, and Rainfall Estimation for X-band Dual-Polarization Weather Radar: Application in HMT. J. Atmos. Oceanic Technol., in preparation.

Matrosov, S.Y., R. Cifelli, and D. Gochis, 2012: High Resolution Measurements of Heavy Convective Rainfall in Flood-Prone Areas Using an X-Band Polarimetric Radar. J. Atmos. Oceanic Technol., in review.

Improvements in the Rapid Intensity Index by Incorporation of Inner-core Information

DeMaria, M., J.A Knaff, M J. Brennan, J.L. Beven, R T. DeMaria, A B. Schumacher, J. Kaplan, and N.W.S. Demetriades, 2011: Tropical cyclone rapid intensity change forecasting using lightning data during the 2010 GOES-R Proving Ground at the National Hurricane Center. AMS Fifth Conference on the Meteorological Applications of Lightning Data, 23-27 January, Seattle, WA.

Sampson, C.R., J. Kaplan, J.A. Knaff, M. DeMaria, and C. Sisko, 2011: A deterministic rapid intensification aid. Wea. Forecasting, 26:4, 579-585.

Legacy Atmospheric Sounding Data Set Project

Ciesielski, P. E., P. T. Haertel, R. H. Johnson, J. Wang and S. M. Loehrer, 2012: Developing high-quality field program sounding datasets. Bull. Amer. Meteor. Soc. (in press)

Ciesielski, P.E., Johnson, R.H., S.F. Williams, and S.M. Loehrer, 2011: Field campaign atmospheric sounding legacy data sets. AMS Annual Meeting, Seattle, WA. 25 Jan 2011.

Johnson, R. H., S. F. Williams, and P. E. Ciesielski, 2012: Legacy atmospheric sounding data set project. Bull. Amer. Meteor. Soc., 93, 14-17.

NESDIS Environmental Applications Team (NEAT)

Bauer, P., T. Auligne, W.Bell, A. Geer, V. Guidard, S. Heilliette, M. Kazumori, , Min-Jeong Kim, E. Liu, A. P. McNally, B. Macpherson, R. Renshaw, and L. Riishojgaard 2011: Status of satellite cloud and precipitation assimilation at operational NWP centres, Quar. Jou. Roy. Meteor. Soc. 137, 1934-1951

Cao, Changyong,k Sirish Uprety, Xi Shao and Petya Campbell, 2012: Hyperion characterization of calibration/validation targets in support of the operational calibration of NOAA satellite imaging radiometers VIIRS and AVHRR (submitted).

Chen, Y., Y. Han, Q. Liu, P. van Delst, and F. Weng, Community Radiative Transfer Model for Stratospheric Sounding Unit channels, J. Atmos. Oceanic. Technol., 28, 767-778, doi: 10.1175/2010JECHA1509.1 (2011).

Chen, Y., Y. Han, and F. Weng, Comparison of two transmittance algorithms in the Community Radiative Transfer Model: Application to AVHRR, J. Geophys. Res., 2011JD016656, in press (2012). http://www.agu.org/journals/jd/papersinpress.shtml#id2011JD016656

Chen, Y., F. Weng, Y. Han, and Q. Liu, Planck weighted transmittance and correction of solar reflection for broadband infrared satellite channels, J. Atmos. Oceanic. Technol., doi:10.1175/JTECH-D-11-00102.1, in press (2012). http://journals.ametsoc.org/doi/pdf/10.1175/JTECH-D-11-00102.1

Dash, P., Ignatov, A., Martin, M., Donlon, C., Brasnett, B., Reynolds, R. W., Banzon, V., Beggs, H., Cayula, J.-F., Chao, Y., Grumbine, R., Maturi, E., Harris, A., Mittaz, J., Sapper, J., Chin, T. M., Vazquez, J., Armstrong, E. M., Gentemann, C., Cummings, J., Piollé, J.-F., Autret, E., Roberts-Jones, J., Isizaki, S., Høyer, J. L., Poulter, D., Group for High Resolution SST (GHRSST) Analysis Fields Inter Comparisons: Part 2. Near real-time web-based Level 4 SST Quality Monitor (L4-SQUAM), 2011. Recommended for publication in special issue of DSR-II

Gallo, K., R. Hale, D. Tarpley, and Y. Yu. 2011. Evaluation of the relationship between air and land surface temperature under clear and cloudy sky conditions. Journal of Applied Meteorology and Climatology, doi: 10.1175/2010JAMC2460.1.

Gallo, K., G. Stensaas, G. Chander, Y. Yu, M. Goldberg, R. Hale, and D. Tarpley. 2011. Development of a multi-satellite validation system for NOAA/GOES-R ABI land surface products. 2011 NOAA STAR GOES-R AWG Annual Review, Fort Collins, Colorado, June 14-16.

Hale, R. C., K. P. Gallo, D. Tarpley, and Y. Yu. 2011. Characterization of in situ locations for calibration/validation of satellite-derived land surface temperature data. Remote Sensing Letters, 2: 41-50.

Kim, Min-Jeong 2012: Effective Refractive Indices of Partially Melted Snow Particles for Microwave Remote Sensing of Frozen Precipitation. J. Geophy. Res. (Submitted)

Kim, Min-Jeong 2012: Implementation of cloudy radiance data assimilation in the NCEP NWP Models. International TOVS Study Conference (ITSC), 21-27 March 2012, Toulouse, France

Lavanant, L., N. Fourrie, A.Gambacorta, G. Grieco, S. Heilliette, F. Hilton, Min-Jeong Kim, A. P. McNally, H. Nishihata, E. G. Pavelin, F. Rabier 2011: Comparison of cloud products within IASI footprints for the assimilation of cloudy radiances. Quart. Journal. Royal. Meteor. 137, 1988-2003

Liang, X. and A. Ignatov, 2011: Monitoring of IR clear-sky radiances over oceans for SST (MICROS). J. Atmos. Ocean. Tech., 28, 1228-1242.

Martin, M., Dash, P., Ignatov, A., Donlon, C., Kaplan, A., Grumbine, R., Brasnett, B., McKenzie, B., Cayula, J.-F., Chao, Y., Beggs, H., Maturi, E., Gentemann, C., Cummings, J., Banzon, V., Ishizaki, S., Autret, E. , Group for High Resolution SST (GHRSST) Analysis Fields Inter Comparisons: Part 1. A multi-product ensemble of sea surface temperature analyses, 2011. Recommended for publication in special issue of DSR-II

Masutani, M., L. P. Riishojgaard, J. S. Woollen, Z. Ma, T. Zhu, and Y. Xie, 2012: Internationally Collaborative Joint OSSEs – Progress at NOAA. The 8th Annual Symposium on Future Operational Environmental Satellite Systems, 92st AMS, New Orleans, LA.

Masutani, M., L. P. Riishojgaard, J. S. Woollen, Z. Ma, Y. Xie, and T. Zhu, 2012: Joint OSSEs At NOAA, Evaluation of DWL, JPSS, and DWSS. The 8th Annual Symposium on Future Operational Environmental Satellite Systems

Saha, K., et al., 2012: Selecting a first-guess SST as input to forward model. (To be submitted to JGR).

Shi, W. and M.H. Wang, Satellite observations of asymmetrical physical and biological responses to Hurricane Earl, Geophysical Research Letters, Volume: 38, 2011, DOI: 10.1029/2010GL046574.

Shi, Wei; M. Wang, and L. Jiang. Spring-neap tidal effects on satellite ocean color observations in the Bohai Sea, Yellow Sea, and East China Sea. Journal of Geophysical Research-Oceans, Volume: 116, 2011, DOI: 10.1029/2011JC007234

Shi, Wei, M. Wang and X. Li. Ocean sand ridge signatures in the Bohai Sea observed by satellite ocean color and synthetic aperture radar measurements. Remote Sensing of Environment Volume: 115 Issue: 8 Pages: 1926-1934, 2011

Shi, W., and M. Wang. Satellite observations of environmental changes from the Tonga volcano eruption in the southern tropical Pacific. M. International Journal of Remote Sensing, Volume: 32 Issue: 20 Pages: 5785–5796, 2011.

Wang, X-L., Y. Yu, H. Xu, D. Tarpley, and R. Hale. 2011. Developing tools for LST validation and deep-dive analysis. 2011 NOAA STAR GOES-R AWG Annual Review, Fort Collins, Colorado, June 14-16.

Wang, M.,W. Shi, and L. Jiang (2012): Atmospheric correction using near-infrared bands for satellite ocean color data processing in the turbid western Pacific ocean region, Optical Express, 20(2), 741-753

Yu, Y., H. Xu, L. Wang, D. Tarpley, K. Vinnikov, and R. Hale. 2011. Validation of the land surface temperature algorithm for the U.S. GOES-R mission. 2011 NOAA STAR GOES-R AWG Annual Review, Fort Collins, Colorado, June 14-16.

Zhu, T. and F. Weng, 2012: Synthetic radiance simulation and evaluation for a Joint OSSE. J. Geophys. Res., (submitted).

Zhu, T. and F. Weng, 2012: Evaluation of IR Land Surface Emissivity Model Impacts on GFS. The 8th Annual Symposium on Future Operational Environmental Satellite Systems, 92st AMS, New Orleans, LA.

POES-GOES Blended Hydrometeorological Products

Kusselson, S., L. Zhao, S. Kidder, J. Forsythe, A. Jones, and R. Kuligowski, 2011: The Tennessee floods of May 2010: A satellite perspective. 36th Annual Meeting, National Weather Association, Birmingham, AL, 20 October.

Shiga, Y. P., D. Hammerling, S. Kidder, and J. Forsythe, 2012: Mapping total precipitable water over North America by blending GOES Sounder, GPS, and MIRS observations. 16th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS). American Meteorological Society, New Orleans, LA, 25 January.

Quantifying the Sources of Atmospheric Ice Nuclei from Biomass Burning Aerosols

(Award No. NA10OAR4310103)

DeMott, P. J., 2011: Progress and needs for in-situ measurements of atmospheric ice nuclei sources, DOE ASR Fall Working Group Meeting, September 12 – 14, 2011, Annapolis, MD (http://asr.science.energy.gov/meetings/fall-working-groups/presentations).

DeMott, P. J., 2011: Insights into the roles of different aerosol types as ice nuclei (Invited), Gordon Research Conference on Atmospheric Chemistry, July 27, 2011, Mt. Snow, VT.

DeMott, P. J., A. J. Prenni, A. P. Sullivan, G. R. McMeeking, G. D. Franc, T. C. Hill, J. Anderson, Y. Desyaterik, R. C. Sullivan, and S. M. Kreidenweis, 2011: Investigations of Atmospheric Ice Nuclei Produced from Biomass Burning , American Association for Aerosol Research Annual Meeting, Abstract 9F.1, October 6, 2011, Orlando, FL (http://aaar.conference2011.org/content/program).

DeMott, P. J., R. C Sullivan, G. R. McMeeking, A. J Prenni1, T. C. Hill, G. D. Franc, A. P. Sullivan, E. Garcia, Y. Tobo, K. A Prather, K. Suski, A. Cazorla, J. R. Anderson, S. M. Kreidenweis, 2011: Recent Field Measurements of Ice Nuclei Concentration Relation to Aerosol Properties (Invited), Abstract A21E-01, 2011 AGU Fall Meeting, December, 6-10, 2011, San Francisco, CA (http://fallmeeting.agu.org/2011/fall-meeting-2011-program-book/).

Prenni, A. J., P. J. DeMott, A. P. Sullivan, R. C. Sullivan and S. M. Kreidenweis, 2010: Quantifying the Sources of Atmospheric Ice Nuclei from Biomass Burning Aerosols, International Aerosol Conference 2010, Helsinki, FI, 29 August – 3 September (www.iac2010.fi/).

Prenni, A. J., P. J. DeMott, A. P. Sullivan, R. C. Sullivan, and S. M. Kreidenweis, 2012: Biomass burning as a potential source for atmospheric ice nuclei: Western wildfires and prescribed burns. To be submitted March 1 to Geophys. Res. Lett.

Quantitative Precipitation Estimation

Chandrasekar V., S. Lim and R. Cifelli, 2011: Principles and practical implementation for high resolution multi-sensor QPE, AGU Fall Meeting 2011, San Francisco, CA, American Geophysical Union.

Lim, S., V. Chandrasekar, R. Cifelli, S. Matrosov and Tim Schneider, 2011: QPE in the Hydrometeorology Testbed: Methodologies and Challenges in Complex Terrain, 35th Conference on Radar Meteorology, Pittsburgh, PA**,** American Meteorological Society

Lim, S., R. Cifelli, V. Chandrasekar and S. Y. Matrosov, Classification, Specific Differential Phase Retrieval, and Rainfall Estimation for X-band Dual-Polarization Weather Radar: Application in HMT, (in submission)

Remote Versus Local Forcing of Intraseasonal Variability in the IAS Region: Consequences for Prediction (Shadow Award No. NA080AR4320893)

Alaka, G. J., and E. D. Maloney, 2012: The Madden Julian oscillation influence on upstream African easterly wave precursor disturbances during boreal summer. *J. Climate*, in press.

Rydbeck, A., 2012: *Remote Versus Local Controls of East Pacific Intraseasonal Variability.* M.S. Thesis, Colorado State University, 104pp.

Shaman, J., and E. D. Maloney, 2012: Shortcomings in climate model simulations of the ENSO-Atlantic hurricane teleconnection. *Climate Dynamics*, in press.

Slade, S. A., 2012: *A Statistical Prediction Model for East Pacific and Atlantic Tropical Cyclone Genesis.* M.S. Thesis, Colorado State University, 95pp.

Small, R. J., S.-P. Xie, E. D. Maloney, S. P. deSzoeke, and T. Miyama, 2011: Intraseasonal Variability in the far-east Pacific: Investigation of the role of air-sea coupling in a regional coupled model. *Clim. Dyn*., **36**, 867–890, DOI 10.1007/s00382-010-0786-2.

Van Roekel, L. P., and E. D. Maloney, 2012: Mixed layer modeling in the east Pacific warm pool during 2002. *Climate Dynamics,* in press.

Younger, K., E. D. Maloney, and R. McCrary, 2012: Modeling the West African Monsoon and the Formation of African Easterly Waves. *Papers, 92nd AMS Annual Meeting, 24th Conference on Climate Variability and Change*, 22-26 January, 2012, New Orleans, LA.

Yu, W., W. Han, D. Gochis, E.D Maloney, and S.-P. Xie, 2011: Observations of eastward propagation of atmospheric intraseasonal oscillations from the Pacific to the Atlantic. *J. Geophys. Res.*, **116**, D02101, doi:10.1029/2010JD014336.

Research and Development for GOES-R Risk Reduction

Apodaca, K., M. Zupanski, J.A. Knaff, and L.D. Grasso, 2011: Assimilation of MSG-SEVIRI cloudy radiances into MLEF-HWRF as a GOES-R ABI proxy. JCSDA 9th Workshop on Satellite Data Assimilation, 24-25 May, College Park, Maryland.

Bikos, D., D. Lindsey, J. Otkin, J. Sieglaff, L. Grasso, C. Siewert, J. Correia, M. Coniglio, R. Rabin, J. Kain, and S. Dembek, 2011: Synthetic Satellite Imagery For Real-Time High Resolution Model Evaluation. Weather and Forecasting. [Accepted]

Connell, B.H., D. Bikos, J. Braun, A.S. Bachmeier, S. Lindstrom, A. Mostek, M. Davison, K.A. Caesar, V. Castro, L.Veeck, M. DeMaria, and T.J. Schmit, 2012: Satellite Training Activities: VISIT, SHyMet and WMO VLab Focus Group. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

Csiszar, I., C.D. Barnet, R. Ferraro, L.E. Flynn, A.K. Heidinger, D.W. Hillger, A.Ignatov, J.Key, S.Kondragunta, I.Laszlo, and M.Wang, 2012: Overview of NPP/JPSS Environmental Data Products and Algorithm Development. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

DeMaria, M., J.A. Knaff, A.B. Schumacher, J.F. Dostalek and R. DeMaria, 2012: Applications of ATMS/CrIS Soundings to Tropical Cyclone Analysis and Forecasting. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

DeMaria, M. 2012: Tropical Cyclone Lightning and Rapid Intensity Change. Monthly Weather Review. [Accepted]

Grasso, L.D., D.T. Lindsey, 2011: An Example of the use of Synthetic 3.9 µm GOES-12 Imagery for Two-Moment Microphysical Evaluation. International Journal of Remote Sensing. 32:8, 2337.

Gurka, J.J., S. Goodman, T.J. Schmit, M. DeMaria, A. Mostek, C.W. Siewert, and B. Reed, 2012: The GOES-R Proving Ground: 2012 Update. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January 2012, New Orleans, LA.

Hillger, D.W., T.J. Kopp, 2012: First Images and Products From VIIRS on NPP. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

Hillger, D.W., and T. Schmit, 2012: GOES Science Tests: Results for the Last Two of the Current GOES Series. 18th Conference on Satellite Meteorology, Oceanography and Climatology / First Joint AMS-Asia Satellite Meteorology Conference. 22-26 January, New Orleans, LA.

Hillger, D.W., L.D. Grasso, S. Miller, R. Brummer, and R. DeMaria, 2011: Synthetic advanced baseline imager true-color imagery. J. Appl. Remote Sens. (JARS) 5, 053520 (2011), DOI:10.1117/1.3576112

Hillger, D.W., and S.D. Miller, 2011: GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document (ATBD) For Natural (aka True) Color Imagery Product (NCIP), NOAA/NESDIS/STAR, (April), 28 pp.

Hillger, D.W., and T.J. Schmit, 2011: The GOES-15 Science Test: Imager and Sounder Radiance and Product Validations, NOAA Technical Report NESDIS 141, (November), 101 pp.

Hillger, D.W., and T. Schmit, 2012: GOES Science Tests: Results for the Last Two of the Current GOES Series. 18th Conference on Satellite Meteorology, Oceanography and Climatology / First Joint AMS-Asia Satellite Meteorology Conference. 22-26 January, New Orleans, LA.

Jankov I., L.D. Grasso, M. Sengupta, P.J. Neiman, D. Zupanski, M. Zupanski, D.T. Lindsey, and R.L. Brummer, 2011: An Evaluation of Five WRF-ARW Microphysics Schemes Using Synthetic GOES Imagery for an Atmospheric River Event Affecting the California Coast. Journal of Hydrometeorology. 618-633.

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 Applied Meteorology and Climatology. 50:10, 2149-2166. doi: 10.1175/2011JAMC2673.1

Knaff, J.A., C.R. Sampson, P. J. Fitzpatrick, Y. Jin, and C.M. Hill, 2011: Simple Diagnosis of Tropical Cyclone Structure via Pressure Gradients. Weather and Forecasting. 26:6, 1020-1031. DOI: 10.1175/WAF-D-11-00013.1.

Lindsey, D.T., and L.D. Grasso, 2012: Predicting where convective clouds will form with the GOES-R ABI. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

Lindsey, D.T., T. Schmit, W. MacKenzie, L.D. Grasso, M. Gunshor, C. Jewett, 2012: The 10.35 micrometer band: A more appropriate window band for GOES-R ABI than 11.2?. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January, New Orleans, LA.

Mecikalski, J.R., D.T. Lindsey, C.S. Velden, B.L. Vant-Hull, and R.M. Rabin, 2012: Convective Storm Forecasting 1-6 Hours Prior to Initiation AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January 2012, New Orleans, LA.

Miller, S. D., C. C. Schmidt, T. J. Schmit, and D. W. Hillger, 2011: A case for natural colour imagery from geostationary satellites, and an approximation for the GOES-R ABI. Int. J. Rem. Sensing, 33(13), 3999-4028, doi 10.1080/01431161.2011.637529.

Molthan, A., K. Fuell, H. Oswald, and J.A. Knaff, 2012: Development of RGB Composite Imagery for Operational Weather Forecasting Applications. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January 2012, New Orleans, LA.

Reed, B., M. DeMaria, S.J. Goodman, J. Gurka, D. Reynolds, and C.W. Siewert, 2012: GOES-R Proving Ground - Demonstrating GOES-R Products in 2011. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January 2012, New Orleans, LA.

Reynolds, D., M. DeMaria, S.J. Goodman, M.W. Johnson, and B. Reed, 2012: Data Fusion Demonstrations At the GOES-R Proving Ground Using Satellites, in-Situ Data and Weather Forecast Models. AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems, 22-26 January 2012, New Orleans, LA.

Zupanski, D., M. Zupanski, L.D. Grasso, R.L. Brummer, I. Jankov, D.T. Lindsey, M. Sengupta and M. DeMaria, 2011: Assimilating synthetic GOES-R radiances in cloudy conditions using an ensemble-based method. International Journal of Remote Sensing. Online: DOI:10.1080/01431161.2011.572094

Scientific Support to the GOES-R Algorithm Review Board

Vonder Haar, T.H. Co-Author of ADEB Publications (see GOES-R Project Office, Dr. Steve Goodman, Project Scientist)

Severe Weather/Aviation Impact from Hyperspectral Assimilation

Lin, H., S. S. Weygandt, M. Hu, S.G. Benjamin, and P. Hofmann, 2012: Preliminary Results From Assimilation of AIRS Radiance Data in the Rapid Refresh Model System. *Proc. 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction*, New Orleans, LA, American Meteorological Society.

Lin, H., S. S. Weygandt, S. G. Benjamin, M. Hu, P. Hofmann, J. Li, and T. J. Schmit, 2012: Assimilation of AIRS SFOV Retrieval Profiles in the Rapid Refresh Model System: Assimilation Modifications to Maximize Forecast Improvement. *Poster, Warn-on-Forecast and High Impact Weather Working Group*, Norman, OK, National Oceanic and Atmospheric Administration.

Simulation and Analysis of the Interaction Between Aerosols and Clouds, Precipitation and the Radiation Budget Over the Gulf of Mexico and Houston

Carrió, Cotton, W. R., Cheng, 2010: Effects of the Urban growth of Houston on convection and precipitation. Part I: the August 2000 case. *Atmos. Res.*, 96, 560-574.

Carrió G.G., Cotton, W. R., 2011: Effects of the Urban growth of Houston on convection and precipitation. Part II: Their dependence on instability. Atmospheric Research (conditionally accepted, in final revision).

Support of the Virtual Institute

Bikos, D., Lindsey, D.T., Otkin, J., Sieglaff, J., Grasso, L., Siewert, C., Correia Jr., J., Coniglio, M., Rabin, R., Kain, J.S., and S. Dembek, 2011: Synthetic Satellite Imagery For Real-Time High Resolution Model Evaluation. *Wea. Forecasting*. doi: 10.1175/WAF-D-11-00130.1, in press.

The Madden-Julian Oscillation: Model Development and Diagnosis of Mechanisms

(Shadow Award No. NA080AR4320074)

Benedict, J. J., and D. A. Randall, 2011: Impacts of idealized air-sea coupling on Madden-Julian Oscillation structure in the super-parameterized CAM *J. Atmos. Sci.*, **68**, 1990–2008

Benedict, J. J., A. H. Sobel, E. D. Maloney, D. M. Frierson, and L. J. Donner, 2012: Tropical intraseasonal variability in Version 3 of the GFDL Atmosphere Model*. J. Climate*, submitted.

Benedict, J. J., A. H. Sobel, E. D. Maloney, D. M. Frierson, and L. Donner, 2011: Assessment of tropical intraseasonal variability in versions 2 and 3 of the GFDL atmosphere model. *Papers, 18th Conference on Atmospheric and Oceanic Fluid Dynamics*, 12-17 June, 2011, Spokane, WA.

Goswami, B. B., N. J. Mani, P. Mukhopadhyay, D. Waliser, J. Benedict, E. Maloney, M. Khairoutdinov, and B. N. Goswami, 2011: Monsoon intraseasonal oscillations as simulated by the superparameterized Community Atmospheric Model. *J. Geophys. Res*., **116**, D22104, doi:10.1029/2011JD015948.

Hannah, W. M., and E. D. Maloney, 2011: The role of moisture-convection feedbacks in simulating the Madden-Julian oscillation. *J. Climate*, 24, 2754-2770.

Kim, D., A. H. Sobel, E. D. Maloney, D. M. W. Frierson, and I.-S. Kang, 2011: A systematic relationship between intraseasonal variability and mean state bias*. J. Climate*, 24, 5506-5520.

Kim, D., A. H. Sobel, E. D. Maloney, D. M. Frierson, and I. S. Kang, 2011: A systematic relationship between intraseasonal variability and mean state bias in AGCM simulations. *Papers, 18th Conference on Atmospheric and Oceanic Fluid Dynamics*, 12-17 June, 2011, Spokane, WA.

Landu, K., and E. D. Maloney, 2011: Understanding intraseasonal variability in an aquaplanet GCM. *J. Meteor. Soc. Japan*, 89, 195-210, doi:10.2151/jmsj.2011-302.

Maloney, E. D., A. Sobel, K. Landu, M. Khairoutdinov, 2011: Exploring the Dynamics of the Madden-Julian Oscillation with a Hierarchy of Atmospheric Models. *Abstracts, 2011 IUGG Assembly*, 28 June-7 July, 2011, Melbourne, Australia (invited).

Sobel, A. H., and E. D. Maloney, 2012: An idealized semi-empirical framework for modeling the Madden-Julian oscillation, in press.

Sobel, A. H., and E. D. Maloney, 2011: A simple semi-empirical MJO model. *Papers, 18th Conference on Atmospheric and Oceanic Fluid Dynamics*, 12-17 June, 2011, Spokane, WA.

The Role of the Colorado Climate Center in a Meaningful Drought Early Warning System for the Upper Colorado Basin

Smith, Rebecca A., N.J. Doesken and C. Kummerow. 19th Conference on Applied Climatology, July 18 – 20, 2011, Asheville, NC, "A comparison of *in-situ*, reanalysis, and satellite water data over the Upper Colorado River Basin." Abstract and Recording: http://ams.confex.com/ams/19Applied/webprogram/Paper190427.html

Smith, Rebecca A., N.J. Doesken and C,. Kummerow. 26th Conference on Hydrology, January 22 – 26, 2012, New Orleans, LA. "Large-scale Climate Variability and Local Hydroclimate Relationships Used as Drivers in a Hydrologic Model to Predict the Hydrology of the Upper Colorado River Basin." Abstract and Recording: http://ams.confex.com/ams/92Annual/webprogram/Paper196899.html

Tropical Cyclone Model Diagnostics

Knaff, J.A., C.R. Sampson, P. J. Fitzpatrick, Y. Jin, and C.M. Hill, 2011: Simple Diagnosis of Tropical Cyclone Structure via Pressure Gradients. *Weather and Forecastin*g. 26:6, 1020-1031. DOI: 10.1175/WAF-D-11-00013.1

Sampson, C.R., J. Kaplan, J.A. Knaff, M. DeMaria, and C. Sisko, 2011: A deterministic rapid intensification aid. *Wea. Forecasting*, 26:4, 579-585.

Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting

(Award No. NA10NES4400012)

Apodaca, K., M. Zupanski, J. A. Knaff, and L. D. Grasso, 2011: Assimilation of MSG SEVIRI all-sky IR Radiances into MLEF-HWRF as a GOES-R ABI Proxy. *9th JCSDA Workshop on Satellite Data Assimilation*, University of Maryland, College Park, May 24-25, 2011.

Zhang, M., M. Zupanski, and M.-J. Kim, 2011: All-sky AMSU-A Radiance EnsDA Study of hurricane Danielle (2010). *9th JCSDA Workshop on Satellite Data Assimilation*, University of Maryland, College Park, May 24-25, 2011.

Zhang, M., M. Zupanski, M.-J. Kim, and J. Knaff, 2012: Direct Assimilation of all-sky AMSU-A Radiances in TC inner core: Hurricane Danielle (2010). To be submitted to *Mon. Wea. Rev*.

Zupanski, M., 2011: Utility of GOES-R Instruments for Data Assimilation and Forecasting. *9th JCSDA Workshop on Satellite Data Assimilation*, University of Maryland, College Park, May 24-25, 2011.

Zupanski, M., 2012: All-sky satellite radiance data assimilation: Methodology and Challenges. Invited book chapter for *Data Assimilation for Atmospheric, Oceanic, and Hydrologic Applications*, S.-K. Park and L. Xu, Eds, Springer-Verlag Berlin, In review..

PRESENTATIONS

(All presentations fall under Award Number NA090AR4320074 unless otherwise noted)

A Goes-R Proving Ground

Connell, B.H., D. Bikos, J. Braun, A.S. Bachmeier, S. Lindstrom, A. Mostek, M. Davison, K.A. Caesar, V. Castro, L.Veeck, M. DeMaria, and T.J. Schmit, 2012: Satellite Training Activities: VISIT, SHyMet and WMO VLab Focus Group. *AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems*. 22-26 January, New Orleans, LA.

Gurka, J.J., S. Goodman, T.J. Schmit, M. DeMaria, A. Mostek, C.W. Siewert, and B. Reed, 2012: The GOES-R Proving Ground: 2012 Update. *8th Annual Symposium on Future Operational Environmental Satellite Systems,* 22-26 January 2012, New Orleans, LA.

Hillger, D.W., T.J. Kopp, 2012: First Images and Products From VIIRS on NPP. *AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems,* 22-26 January, New Orleans, LA.

Lindsey, D.T., and L.D. Grasso, 2012: Predicting where convective clouds will form with the GOES-R ABI. *AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems*. 22-26 January, New Orleans, LA.

Lindsey, D.T., T. Schmit, W. MacKenzie, L.D. Grasso, M. Gunshor, C. Jewett, 2012: The 10.35 micrometer band: A more appropriate window band for GOES-R ABI than 11.2?. *AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems.* 22-26 January, New Orleans, LA.

Lindsey, D.T., 2011: Simulated Satellite Imagery: A New Tool for Real-Time Model Evaluation, *National Weather Association (NWA) annual meeting and the GOES User's Conference (GUC)* Oct. 17-21, Birmingham, AL.

Lindsey, D.T., 2011: GOES-R Proving Ground Product Development at CIRA, *National Weather Association (NWA) annual meeting and the GOES User's Conference (GUC)* Oct. 17-21, Birmingham, AL.

Mecikalski, J.R., D.T. Lindsey, C.S. Velden, B.L. Vant-Hull, and R.M. Rabin, 2012: Convective Storm Forecasting 1-6 Hours Prior to Initiation. *8th Annual Symposium on Future Operational Environmental Satellite Systems*, 22-26 January 2012, New Orleans, LA.

Molthan, A., K. Fuell, H. Oswald, and J.A. Knaff, 2012: Development of RGB Composite Imagery for Operational Weather Forecasting Applications. *AMS Eighth Annual Symposium on Future Operational Environmental Satellite Systems*, 22-26 January 2012, New Orleans, LA.

Reed, B., M. DeMaria, S.J. Goodman, J. Gurka, D. Reynolds, and C.W. Siewert, 2012: GOES-R Proving Ground - Demonstrating GOES-R Products in 2011. *8th Annual Symposium on Future Operational Environmental Satellite Systems*, 22-26 January 2012, New Orleans, LA.

Reynolds, D., M. DeMaria, S.J. Goodman, M.W. Johnson, and B. Reed, 2012: Data Fusion Demonstrations At the GOES-R Proving Ground Using Satellites, *in-Situ* Data and Weather Forecast Models. *8th Annual Symposium on Future Operational Environmental Satellite Systems*, 22-26 January 2012, New Orleans,

CIRA Activities and Participation in GIMPAP

Knaff, John, 2011: "New Tropical Cyclone Intensity Forecast Tools for the Western North Pacific". Joint Typhoon Warning Center. September 13, 2011.

Knaff, John, 2011: "Overview of CIRA and NESDIS Global TC Services", , WMO Southern Hemisphere TC Workshop, Melbourne, Australia (via remote webinar), 14 September 2011.

Data Fusion to Determine North American Sources and Sinks of Carbon Dioxide at High Spatial and Temporal Resolution from 2004 to 2008 (Shadow Award)

Andrews, A. E. et al. Evaluation of Lagrangian Particle Dispersion Models using Radiocarbon and Carbon Dioxide Measurements, AGU Chapman Conference on Advances in Lagrangian Modeling of the Atomsphere, Grindelwald, Switzerland, 9 – 14 October 2011

Andrews, Arlyn Elizabeth, Gabrielle Petron, Trudeau Michael, Sharon Gourdji, Kim Mueller, Anna M. Michalak, Thomas Lauvaux, **Andrew Schuh**, Marek Uliasz, Aditsuda Jamroensan, Charles Stanier, Gregory Carmichael, Comparison of Atmospheric Transport Models for the Mid-Continent Intensive Synthesis Study, 3rd NACP All-Investigators Meeting New Orleans 2011

Breidt, F.J., Cooley, D.S., Thurier, Q, Wang, Y. , Schuh, A.E., Denning, A., Davis, K.J., West, T.O., Ogle, S.M. Reconciliation of Carbon Dioxide Flux Estimates from Atmospheric Inversions and Inventories in the Mid-Continent Intensive, Oral Presentation at 2009 AGU Fall Meeting

Davis, K J et al. Greenhouse gas emissions derived from regional measurement networks and atmospheric inversions: Results from the MCI and INFLUX experiments, Oral Presentation at 2010 AGU Fall Meeting

Ogle, S.M., Cooley, D.S., Schuh A.E., Denning, A. Davis, K.J., West, T.O., Breidt, F.J. Comparison of Regional Carbon Dioxide Fluxes from Atmospheric Inversions and Inventories in the Mid-Continent Intensive, Poster Presentation at 2009 AGU Fall Meeting

Schuh, A.E., Lauvaux, T., West, T.O., Uliasz, M., Mueller, K.L., Davis, K.J., Ogle, S.M. Evaluating atmospheric CO2 inversions at multiple scales over a highly-inventoried agricultural landscape AGU 2011 Fall Meeting

Schuh A.E., Lauvaux, A.E., West, T.O., Davis, K.J., Denning, A.S., Ogle, S. Evaluating atmospheric CO2 inversions from multiple scales over a highly-inventoried agricultural landscape, 2011 NASA CC&E Joint Science

Schuh, A.E., Thomas Lauvaux, Stephen M Ogle, Kenneth J. Davis, Scott Denning, Dan Cooley, F. Jay Breidt, Natasha Miles, Scott Richardson, Liza Ivelisse Diaz, Marek Uliasz, Andy Jacobson, Kim Mueller, Sharon Gourdji, Arlyn Elizabeth Andrews, Tristram O. West Contrasting atmospheric CO2 inversion results at a regional scale over the highly-inventoried area of the Mid Continental Intensive., 3rd NACP All-Investigators Meeting New Orleans 2011

Schuh, A. E., Ogle, S M, Davis K J, Denning A, Lauvaux, T., Miles, N L, Richardson, S., Jacobson, A R, Andrews, A E, Uliasz, M, Diaz L I, West, T. O., Cooley, D. S. Top-down bottom-up comparisons of the Mid-Continental Intensive (MCI) Region. (Invited) Oral Presentation at 2010 AGU Fall Meeting

Schuh, A.E., Denning, A., Ogle, S.M., Corbin, K., Uliasz, M, Davis, K.J., Lauvaux, T, Miles, N, Andrews, A.E., Petron, G., Huntzinger, D.N. Atmospheric CO2 Inversions of the Mid-Continental Intensive (MCI) Region (Invited). Oral Presentation at 2009 AGU Fall Meeting

Schuh, A.E., et al. Resolving CO2 Flux Estimates from Atmospheric Inversions and Inventories in the Mid-Continent Region. Oral Presentation at 2009 ICDC8, Jena Germany.

Uliasz, M., Schuh, A.E. Influence of Uncertainty in Atmospheric Transport Modeling on Regional and Continental Scale Inversions AGU 2011 Fall Meeting

Uliasz, M, Schuh, A E and Denning, A Regional Modeling Support for Planning Airborne Campaigns to Observe CO2 and Other Trace Gases Poster Presentation at 2010 AGU Fall Meeting

Uliasz, M., Schuh, A.E. Implementation of Lagrangian Particle Dispersion Model for CO2 studies in a Continental Scale, Poster Presentation at 2009 AGU Fall Meeting

West, T.O., Bandaru, V., Brandt, C.C., Schuh, A.E., Gurney, K.R., Heath, L.S., Izaurralde, R.C., Liu, S., Li, Z., Ogle, S.M. Estimating Carbon Dioxide Fluxes from Sources and Sinks in the Mid-Continent Intensive using Inventories and Satellite Remote Sensing, Poster Presentation at 2009 AGU Fall Meeting

Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme
(Award No. NA220AR4310208)

Dunion, J., 2012: Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme, *66th Interdepartmental Hurricane Conference*, 5-8 Mar 2012, Charleston, SC.

Development of a Real-time Automated Tropical Cyclone Surface Wind Analysis
(Award No. NA110AR4310204)

Knaff, J. A., M. DeMaria, R. Brummer, C. Landsea, and J. Franklin, 2012: Development of a Real-Time Automated Tropical Cyclone Surface Wind Analysis: A Year 1 Joint Hurricane Testbed Project Update. *66th Interdepartmental Hurricane Conference*, March 6- 9, Charleston, SC.

Effective Collaborative NIDIS Drought Monitoring and Early Warning in the Upper Colorado Basin

NIDIS Upper Colorado River Basin Pilot Project", Wendy Ryan, Nolan Doesken and Becky Smith. US Drought Monitor Forum, George Mason University, Farifax, Virgina. April 13-15, 2011.

Future Changes of the Southern Ocean CO2 Fluxes (Shadow Award No. NA080AR4320074)

Ito, T. and N.S. Lovenduski, May 2011: An Eddy-Permitting Simulation of the Southern Ocean Ecosystem and Biogeochemistry, Proceedings of the American Meteorological Society 11th Conference on Polar Meteorology and Oceanography, Boston, MA.

Jones, D.C., T. Ito, and N.S. Lovenduski, June 2011: Multi-Decadal Adjustment of the Buoyancy and Eddy Fields in an Idealized Model of the Southern Ocean, Proceedings of the American Meteorological Society 18th Conference on Atmospheric and Oceanic Fluid Dynamics, Spokane, WA.

Jones, D.C., T. Ito, and N.S. Lovenduski, June 2011: Putting time limits on the eddy saturation hypothesis, Southern Ocean Climate Process Team Meeting, Princeton University, Princeton, NJ.

Lovenduski, N.S., November 2010: Recent Changes in Southern Ocean Biogeochemistry, Climate and Global Dynamics Division, National Center for Atmospheric Research, Boulder, CO. also at the Department of Atmospheric and Oceanic Sciences, University of Colorado at Boulder, Boulder, CO., Program on Climate Change, University of Washington, Seattle, WA.

Lovenduski, N.S., June 2011: Air-sea Carbon Dioxide Exchange, Ocean Ecologies and their Physical Habitats in a Changing Climate Workshop, Mathematical Biosciences Institute, Columbus, OH.

Lovenduski, N.S., July 2011: Carbon as Velcro: Connecting physical climate variability and biogeochemical dynamics in the Southern Ocean, Ocean Carbon and Biogeochemistry Summer Workshop, Woods Hole Oceanographic Institution, Woods Hole, MA.

Sweeney, C., and N.S. Lovenduski, June 2011: Detecting Southern Overturning Circulation, Southern Ocean Climate Process Team Meeting, Princeton University, Princeton, NJ.

Getting Ready for SHyMet

Connell, B., Bikos, D., Braun, J., Bachmeier, S., Lindstrom, S., Mostek, A., Davison, M., Caesar, K., Castro, V., Veeck, L., DeMaria, M., and Schmitt, T., 2012: Satellite Training Activities: VISIT, SHyMet and WMO VLabFocus Group, *8th Annual Symposium on Future Operational Environmental Satellite Systems*, New Orleans, LA., 22-26 January, Amer. Meteor. Soc. Poster

Connell, B. H., and Gebhart, K., 2012: Golden Words from elementary kids: Can I show you my observation! *21st Symposium on Education*, New Orleans, LA, 22-26 January, Amer. Meteor. Soc. Presentation

Connell, B. H., Veeck, L., Davison, M., Mostek, T., Caesar, K. A., and Castro, V., 2011: What drives online participation patterns for a focus group? *9th International Conference on Creating Activities for Learning Meteorology, Pretoria, South Africa*, 3-8 October. Presentation

Connell, B.H., and many others, 2011: CIRA Proving Ground Activities, *2011 Satellite Direct Readout Conference*, Miami, FL. 4-8 April. Presentation

Connell, B. H., and many others, 2011: Satellite Training Activities: VISIT, SHyMet, and WMO VLab Focus Group, *2011 Satellite Direct Readout Conference,* Miami, FL. 4-8 April. Presentation

GOES-0 (14) Science Test and Global Tropical Cyclone Formation Probability Product

Schumacher, A., M. DeMaria, L. Zhao and T. Schott, 2011: NPP Microwave Sounder-based Tropical Cyclone Products, *65th Interdepartmental Hurricane Conference*, 28 Feb – 3 Mar 2011, Miami, FL.

Improvements in Statistical Tropical Cyclone Forecast Models (Award No. NA110AR4310203)

M. DeMaria, R. Brummer, J. Knaff, M. Brennan, C. Landsea, A. Schumacher, 2012: Improvements in Statistical Tropical Cyclone Forecast Models: A Year 1 Joint Hurricane Testbed Project Update. *66th Interdepartmental Hurricane Conference*, 6- 8 March, Charleston, SC.

Improvements in the Rapid Intensity

Results of CIRA's JHT rapid intensity index project were presented at conferences and published.

In Support of NOAA's Commitment – Virtual Lab

Connell, B., Bikos, D., Braun, J., Bachmeier, S., Lindstrom, S., Mostek, A., Davison, M., Caesar, K., Castro, V., Veeck, L., DeMaria, M., and Schmitt, T., 2012: Satellite Training Activities: VISIT, SHyMet and WMO VLab Focus Group, *8th Annual Symposium on Future Operational Environmental Satellite Systems*, New Orleans, LA., 22-26 January, Amer. Meteor. Soc. Poster

Connell, B. H., Veeck, L., Davison, M., Mostek, T., Caesar, K. A., and Castro, V., 2011: What drives online participation patterns for a focus group? *9th International Conference on Creating Activities for Learning Meteorology, Pretoria, South Africa*, 3-8 October. Presentation

Connell, B. H., and many others, 2011: Satellite Training Activities: VISIT, SHyMet, and WMO VLab Focus Group, *2011 Satellite Direct Readout Conference,* Miami, FL. 4-8 April. Presentation

Connell, B. H., Caesar, K. A., Veeck, L., and Mostek, A., 2011: WMO CGMS VLab: What is it? Lessons over 15 years and opportunities for the future, *2011 Satellite Direct Readout Conference,* Miami, FL., 4-8 April. Poster

Veeck, L., and Connell, B., 2011: Benefits and problems of Online Learning Communities: the case of VLab Regional Focus Groups. *9th International Conference on Creating Activities for Learning Meteorology, Pretoria, South Africa*, 3-8 October. Presentation

NESDIS Environmental Applications Team

Chen Y., F. Weng, Y. Han, P. Van Delst, Q. Liu, and D. Groff, Updates to the JCSDA Community Radiative Transfer Model (CRTM), *The 92th American Meteorological Society Annual Meeting,* 22-26, January, 2012, New Orleans, LA. (Oral)

Chen Y., and F. Weng, Community Radiative Transfer Model (CRTM), 10-16, December, 2011, China Meteorological Administration Training Center, Beijing, China. (Invited lecture)

Chen Y., and F. Weng, Impact of microwave land emissivity information on satellite data assimilation, *ITSC 3rd Workshop on Remote Sensing and Modeling of Surface Properties*, 18-20 October, 2011, Beijing, China. (Oral)

Chen Y., Y. Han, F. Weng, Q. Liu, and P. Van Delst, Two Transmittance Models Comparison in CRTM for AVHRR, *JCSDA 9th Workshop on Satellite Data Assimilation*, 24-25, May, 2011, College Park, MD. (Poster)

Han, Y., Y. Chen, and P. Van Delst, CRTM NLTE module: Development and implementation for CRTM Version 2.1, *JCSDA 9th Workshop on Satellite Data Assimilation*, 24-25, May, 2011, College Park, MD. (Oral)

Ignatov, A., X. Liang, P. Dash, and F. Xu, 2011: Monitoring SST and Clear-Sky Radiances for GOES-R. Annual Mtg, Ft Collins, CO, 13-15 June 2011 (oral).

Laing, Xingming. AQUAM poster presented at GRC 2011 Conference (July 2011)

Laing, Xingming. MICROS invited seminar presented at CIRA, as part of Award ceremony.(Nob 2011)

Laing, Xingming. AQUAM poster presented at AGU Fall 2011 Conference (Dec 2011).

Laing, Xingming. AQUAM poster presented at IAMA 2011 Conference (Dec 2011).

Laing, Xingming. AQUAM oral presentation presented at NASA/GSFC (Feb 2012).

Saha, Korak. Selecting a first-guess SST as input to ACSPO," for Oral presentation to be presented 25 Apr 2012. This conference is part of SPIE Defense, Security, and Sensing which will be held 23-27 April 2012 in Baltimore, Maryland United States.

Research and Development for GOES-R

Connell, B., 2011: What drives online participation patterns for a focus group. *9th International Conference on Creating Activities for Learning Meteorology (CALMet),* 3-8 October, Pretoria, South Africa.

Connell, B., presented a poster entitled "WMO CGMS VLab: What is it? Lessons over 15 years and opportunities for the future." at the *NOAA Satellite Direct Readout Conferenc*e in Miami April 4-8.

DeMaria, M., 2011: Improving Tropical Cyclone Intensity Forecast Models with Theoretically-Based Statistical Models. NOPP Review, 24 February, Miami, FL.

DeMaria, M., 2011: Tropical Cyclone Rapid Intensity Change Forecasting Using Lightning Data During the 2010 GOES-R Proving Ground at the National Hurricane Center. *AMS Meteorological Applications of Lightning Data Conference.* 23-27 January, Seattle, WA.

DeMaria, M., 2011: Use of proxy GOES-R Geostationary Lightning Mapper (GLM) for the prediction of tropical cyclone rapid intensification during the Proving Ground at the National Hurricane Center. *Southern Thunder Workshop*, 11-14 July, Norman, OK.

DeMaria, M., and J.A. Knaff, 2011: TC rapid intensity forecasting. GOES-R Risk Reduction Annual Review, September.

DeMaria, M., A.B, Schumacher, J. A. Knaff, and R.L. Brummer, 2012: Improvements in Statistical Tropical Cyclone Forecast Models: A Year 1 Joint Hurricane Testbed Project Update. *66th Interdepartmental Hurricane Conference,*, March 5-8, Charleston, SC.

Hillger, D.W., 2011: GOES-R ABI True-Color Capability. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

Hillger, D.W., 2011: NOAA Science Test results from the GOES-14 and 15 Imager and Sounder. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

Hillger, D.W., 2011: An Overview of True-Color Imagery Products from Space: ATS-3 to GOES-R*. 8th Annual CoRP Science Symposium*. Asheville, NC, 17-18 August.

Kaplan, J., J. Cione, M. DeMaria, J.A. Knaff, J. Dunion, J. Solbrig, J. Hawkins, T. Lee, E. Kalina, J. Zhang, J.F. Dostalek, and P. Leighton, 2011: Enhancements to the SHIPS Rapid Intensification Index. *65th Interdepartmental Hurricane Conference,* 28 February – 3 March, Miami, FL.

Knaff, J.A., M. DeMaria, J. Kaplan, C.M. Rozoff, J. Kossin, and C.S. Velden, 2011: Improvements to statistical intensity forecasts. *65th Interdepartmental Hurricane Conference,* 28 February – 3 March, Miami, FL.

Lindsey, D.T., 2011: Simulated Satellite Imagery: A New Tool for Real-Time Model Evaluation, *National Weather Association (NWA) annual meeting and the GOES User's Conference (GUC)* Oct. 17-21, Birmingham, AL.

Lindsey, D.T., 2011: GOES-R Applications to Severe Weather (lecture and lab session). COMET-sponsored instructor's course, August, Boulder, CO.

Rozoff, C.M., J. Kossin, C. Velden, A. Wimmers, M. Kieper, J. Kaplan, J.A. Knaff, and M. DeMaria, 2011: Improvements in the Statistical Prediction of Tropical Cyclone Rapid Intensification. *65th Interdepartmental Hurricane Conference,* 28 February – 3 March, Miami, FL.

Schumacher, A.B., M. DeMaria and J.A. Knaff, 2011: Another Look at Maximum Potential Intensity Estimates for Tropical Cyclones, *NOAA/NESDIS CoRP Science Symposium*, 17-18 Aug 2011, Asheville, NC.

Schumacher, A.B.,, M. DeMaria, J.A. Knaff, 2011: Another Look at Maximum Potential Intensity of Tropical Cyclones, *Tropical Cyclone Mini-Workshop,* 16 November, CIRA.

Setvak, M., A. Sokol, D.T. Lindsey, K. Bedka, P. Wang, J. Stastka, and Z. Charvat, 2011: Remote Sensing of Convective Storms: A-Train Observations of Storm Tops, *European Conference of Severe Storms,* October, Palma de Mallorca, Spain.

Science and Management Support for NPP VIIRS EDR Imagery Algorithm

Hillger, D.W., and T.J. Kopp, 2012: First images and products from VIIRS on NPP, *8th Symposium on Future Operational Environmental Satellite Systems*, AMS, New Orleans, 22-26 Jan 2012..

S.Miller, T. F. Lee, C. Elvidge, and J. D. Hawkins, 2012: Dramatic Improvements to Nighttime Imaging with the VIIRS DAY/Night Band. 92nd Annual AMS Conference, New Orleans, 22-26 Jan 2012.

Severe Weather/Aviation Impact from Hyperspectral Assimilation

Lin, H., S. S. Weygandt, S. G. Benjamin, M. Hu, P. Hofmann, J. Li, and T. J. Schmit, 2012: Assimilation of AIRS SFOV Retrieval Profiles in the Rapid Refresh Model System: Assimilation Modifications to Maximize Forecast Improvement. *Poster, Warn-on-Forecast and High Impact Weather Working Group*, Norman, OK, National Oceanic and Atmospheric Administration.

Simulation and Analysis of the Interaction Between Aerosols and Clouds, Precipitation and the Radiation Budget Over the Gulf of Mexico and Houston

Carrió, G. G., and W. R. Cotton: *Direct and indirect effects of urban pollution and landuse change impacts: A comparison*. 91st Annual Meeting, Seattle, 23–27 January 2011 (talk).

Carrió, G. *G., and W. R. Cotton: Aerosol Pollution Impacts over an Urban Complex. 13th Conference on Cloud Physics/13th Conference on Atmospheric Radiation 28 June–2 July 2010, Portland.*

Carrió, G. G. and W. R. Cotton, 2009: Urban landuse and pollution impacts onmesoscale circulations and convection over Houston, 13th AMS Conference on Mesoscale Processes, Salt Lake City, 16—20 August 2009 (11.1).

Carrió, G. G. and W. R. Cotton, 2009: Seebreeze induced convection over Houston: Sensitivity of aerosol indirect effects on instability, AGU fall meeting, San Francisco, 1418 December 2009 (A44B05

Support of the Virtual Institute

Connell, B., Bikos, D., Braun, J., Bachmeier, S., Lindstrom, S., Mostek, A., Davison, M., Caesar, K., Castro, V., Veeck, L., DeMaria, M., and Schmitt, T., 2012: Satellite Training Activities: VISIT, SHyMet and WMO VLab Focus Group, *8th Annual Symposium on Future Operational Environmental Satellite Systems*, New Orleans, LA., 22-26 January, Amer. Meteor. Soc. Poster

Connell, B. H., and Gebhart, K., 2012: Golden Words from elementary kids: Can I show you my observation! *21st Symposium on Education*, New Orleans, LA, 22-26 January, Amer. Meteor. Soc. Presentation

Connell, B. H., Veeck, L., Davison, M., Mostek, T., Caesar, K. A., and Castro, V., 2011: What drives online participation patterns for a focus group? *9th International Conference on Creating Activities for Learning Meteorology, Pretoria, South Africa*, 3-8 October. Presentation

Connell, B.H., and many others, 2011: CIRA Proving Ground Activities, *2011 Satellite Direct Readout Conference*, Miami, FL. 4-8 April. Presentation

Connell, B. H., and many others, 2011: Satellite Training Activities: VISIT, SHyMet, and WMO VLab Focus Group, *2011 Satellite Direct Readout Conference,* Miami, FL. 4-8 April. Presentation

Tropical Cyclone Model Diagnostics

DeMaria, M., 2011: Tropical cyclone environmental model diagnostics. HFIP Annual Review, Nov. 7-9, 2011, Miami, FL.

DeMaria, M., 2011: Tropical cyclone rapid intensity forecasting. Lightning workshop, Sept 19-20, 2011, Huntsville, AL.

DeMaria, M., 2011: New tropical cyclone intensity forecast tools for the western North Pacific. Off-CONUS Proving Ground workshop, July 27-29, 2011, Juneau, AK.

DeMaria, M., 2011: Hurricane model diagnostics: Synoptic to cloud scale. HWRF Tutorial Workshop, April 26, 2011, Boulder, CO.

Hogsett, W., and M. DeMaria, 2011: Applications Development and Diagnostics Team progress report. HFIP Annual Review, Nov. 7-9, 2011, Miami, FL.

Knaff, J.A., M. DeMaria, J. Kaplan, C. M. Rozoff, J. Kossin, and C.S. Velden, 2011: Improvements to statistical intensity forecasts. *65th Interdepartmental Hurricane Conference*, 28 February – 3 March, Miami, FL.

Knaff, J.A., 2011: New Tropical Cyclone Intensity Forecast Tools for the Western North Pacific. Joint Typhoon Warning Center Seminar. September 13.

CIRA EMPLOYEE MATRIX

Employees who received 50% support or more		Degree			
Category	Number	Doctorate	Masters	Bachelors	Non-Degreed
Research Scientists	18	18	0	0	0
Visiting Scientists	0	0	0	0	0
Postdoctoral Fellows	7	7	0	0	0
Research Support Staff*	55	4	26	25	0
Administrative Personnel	4	1	2	1	0
Total	84	30	28	26	0

Employees who received less than 50% support	Degree				
Number	Doctorate	Masters	Bachelors	Associates	Non-Degreed
60	20	13	17	1	9

Students who received less than 50% support		Degree		
Category	Number	Doctorate	Masters	Bachelors
Undergraduate	0	0	0	0
Graduate	12	1	6	5
Total	12	1	6	5

Employees located at NOAA Laboratories		GSD	MDL	PSD	GMD	NGDC
Total	56	48	1	1	4	2

Obtained NOAA Employment within the last year	
Total	0

***Equivalent to Research Associate in CIRA/CSU parlance**

NOAA PROJECTS BY TITLE

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
A Fundamental Climate Data Record of SSM/I, SSMIS and Future Microwave Imagers	NOAA Shadow	5-312660	Kummerow				x			
A Global High-Resolution Fossil Fuel CO2 Inventory Built from Assimilation of In situ…	NASA	5-355320	Baker		x		x			
A GOES-R Proving Ground for National Weather Service Forecaster Readiness	NOAA	5-312570	Miller, Brummer	x						
A Multisensor 4-D Blended Water Vapor Product for Weather Forecasting	NASA	5-319490	Kidder, Fosythe, Jones				x			
A Study of Precipitation Motion Using Model Winds	NOAA	5-311250	Kidder	x						
Advanced Applications of the Monte Carlo Wind Probability Model	NOAA Shadow	5-312610	Kidder				x			
AFWA Coupled Assimilation and Prediction System Development at CIRA	UCAR/NCAR	5-319380	Jones, Fletcher	x	x	x	x			
Application of "A-Train" Satellite Observations to Support Decision Support Systems for Operational Aviation Weather Products (NASA)	NASA	5-319070	Miller	x						
Application of JPSS Imagers and Sounders to Tropical Cyclone Track and Intensity Forecasting	NOAA	5-311270	Miller				x			
Assistance for Instrument Development to Measure the Relationship of Air Quality with Night Sky Visibility	NPS	5-341840	Hand			x				
Assistance for Night Sky Visibility Data Collection, Analysis and Presentation and Web-based Environmental Database Supporting Air Resource Management	NPS	5-317040	Hand					x		

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Assistance for Visibility Data Analysis and Image Display Techniques	NPS	5-341070	Hand		x			x		
CIRA Activities and Participation in the GOES Improved Measurements and Product Assurance Plan (GIMPAP)	NOAA	5-311190	Miller	x						
CIRA Data Processing Center Support for the CloudSat Mission	JPL	5-339760	Miller					x		
CIRA Research Collaboration with the NOAA/NESDIS/NGDC for the NPOESS SEM Sensor Algorithm Development Project	NOAA	5-312510	Matsumoto	x						
CIRA Research Collaboration with the NWS Meteorological Development Lab on AutoNowcaster and AWIPSII Projects	NOAA	5-311150	Matsumoto					x		
CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy Through a Successful Citizen Science Network	NOAA	5-311010	Doesken							x
Co-instructor for the COMET 2011 Summer Course for University Faculty	UCAR/NCAR	5-371050	Kidder					x		
Collaborative Research: A Prototye Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net)	NSF	5-331160	Liston, Hiemstra				x			
Collaborative Research - AON: A Snow Observing Network to Detect Arctic Climate Change - SnowNet II	NSF	5-338800	Liston, Hiemstra				x			
Collaborative Research: Linking Inuit Knowledge and Synoptic- to Local-scale Meteorology to Investigate Changing Winds and Human Impacts at Clyde River, Nunavut	NSF	5-336100	Liston				x			

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Collaborative Research: Norwegian-United States IPY Scientific Transverse: Climate Variability and Glaciology	NSF	5-330420	Liston				x			
Data Fusion to Determine North American Sources and Sinks of Carbon Dioxide at High Spatial and Temporal Resolution from 2004 to 2008	NOAA Shadow	5-312470	Denning		x		x			
Data Warehouse for Air Quality Modeling in the Oil and Gas Region of Wyoming, Utah, and Colorado	NPS	5-341820	McClure			x		x		
Defining Subgrid Snow Distributions Within NASA Remote Sensing Products & Models	NASA	5-319550	Liston, Hiemstra			x				
Deriving Mutually-consistent Carbon-water Fluxes at the Regional Scale from Observations by Using a…	NSF	5-333370	Lu				x			
Design, Development, Evaluation, Integration and Deployment of New Weather Radar Technology	NOAA	5-312770	Chandra V.				x			
Development of an Improved Climate Rainfall Data set from SSM/I	NOAA Shadow	5-312450	Kummerow				x			
Development of a Probabilistic Tropical Cyclone Prediction Scheme	NOAA	5-312890	Schumacher	x						
Development of a Real-Time Automated Tropical Cyclone Surface Wind Analysis	NOAA	5-312850	Brummer				x			
Development of Short-term Solar Forecasting Methods	NREL	5-339460	Miller	x						
DoD Center for Geosciences/Atmospheric Research at CSU	DoD		Vonder Haar	x		x	x	x		

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Downscaling NCEP Global Climate Forecast System (CFS) Seasonal Predictions for Hydrologic Applictions Using Regional Atmospheric Modeling System (RAMS) (CU/CIRES)	CU/ CIRES	5-311130	Lu		x	x	x			
Earth System Research Lab/Global Monitoring DivisionCcarbon Tracker Modeler and Software Developer	NOAA	5-312760	Baker			x				
Effective Collaborative NIDIS Drought Monitoring and Early Warning in the Upper Colorado River Basin	NOAA	5-311280	Doesken				x	x	x	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	5-319010	McClure			x		x		
Ensemble Data Assimilation for Hurricane Forecasting	NOAA	5-311110	Zupanski, M			x				
Ensemble Data Assimilation for Nonlinear and Nondifferentiable Problems in Geosciences	NSF	5-331190	Zupanski, Zupanski			x				
Ensemble-based Assimilation and Downscaling of the GPM-like Satellite Precipitation Information	NASA	5-365100	Zupanski, D.			x				
Environmental Applications Research	NOAA	5-312500	Matsumoto		x	x	x	x		x
eTRaP Upgrade – SSMIS, GOES CONUS Hydro-Estimator (HE)	NOAA	5-311200	Kidder	x			x			
Feature-based Validation of MIRS Soundings for Tropical Cyclone Analysis and Forecasting	NOAA	5-311160	Dostalek	x						

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Fine-resolution CO2 Flux Estimates from AIRS and GOSAT CO2 Retrievals: Data Validation and Assimilation	NASA	5-319030	Baker	x	x	x				
Future Changes of the Southern Ocean CO2 Fluxes	NOAA Shadow	5-312630	Ito		x		x			
Getting Ready for NOAA's Advanced Remote Sensing Programs A Satellite Hydro-Meteorology (SHyMet) Training and Education Proposal	NOAA	5-312540	Connell	x						
GOES-O (14) Science Test and Global Tropical Cyclone Formation Probability Product	NOAA	5-312490	Dostalek	x				x		
HMT Field Coordinator Position in NOAA ESRL Physical Sciences Division	NOAA	5-312720	Chandra V.				x	x		
Improvements in Statistical Tropical Cyclone Forecast Models	NOAA	5-312780	Brummer	x						
Improvements in the Rapid Intensity Index by Incorporation of Inner-core Information	NOAA	5-312530	Dostalek	x						
Improving an Air Quality Decision Support System Through the Integration of Satellite Data with Ground-based, Modeled, and Emissions Data	NASA	5-327240	McClure			x		x		
Improving the Representation of Global Snow Cover, Snow Water Equivalent, and Snow Albedo…	NASA	5-365070	Fletcher			x				
In Support of NOAA's Commitment to the Coordination Group for Meteorological Satellites: Enhancing the International Virtual Laboratory	NOAA	5-312680	Connell	x						x
Legacy Atmospheric Sounding Data Set Project	NOAA	5-312750	Johnson					x		x
NEAT Expanded: Multi-sensor Calibration/Validation	NOAA	5-311260	Miller	x						

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
NEAT Expanded: VIIRS Ocean Color	NOAA	5-311290	Miller	x						
NEAT: Environmental Applications Team	NOAA	5-311080	Miller	x	x		x			
NRA/NASA Modeling, Analysis and Prediction	NASA	5-365990	O'Brien	x						
OCO Atmospheric CO2 Observations from Space (ACOS) Task	JPL	5-339920	O'Brien	x						
Orbiting Carbon Observatory (OCO-2) Task	JPL	5-319950	O'Dell	x						
POES-GOES Blended Hydrometeorological Products	NOAA	5-311180	Kidder, Jones, Forsythe			x	x	x		
Quantifying the Source of Atmospheric Ice Nuclei from the Biomass Burning Aerosols	NOAA	5-312700	DeMott				x			
Quantitative Precipitation Estimation (QPE)	NOAA	5-312260	Chandra V.				x			
Remote Versus Local Forcing of Intraseasonal Variability in the IAS Region: Consequences for Prediction	NOAA Shadow	5-312620	Maloney		x		x			
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	NOAA	5-312740	Miller	x						
Research Collaboration with the Aviation Weather Testbed in Support of the NWS NextGen Weather Program	NOAA	5-311040	Matsumoto		x	x		x		
Satellite Meteorological Application Research, Development and Technical Support	NRL	5-372130	Miller	x						
Science and Management Support for NPP VIIRS EDR Imagery Algorithm and Validation Activities and NPP VIIRS Cloud Validation	NOAA	5-311240	Miller				x			

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Scientific Support to the GOES-R Algorithm Review Board	NOAA	5-312640	Vonder Haar	x						
SEMAP - Southeastern Modeling, Analysis, and Planning Project	GIT	5-347810	McClure					x		
Severe Weather/Aviation Impact from Hyperspace Assimilation	NOAA	5-312710	Matsumoto		x	x				
Simulation and Analysis of the Interaction Between Aerosols and Clouds, Precipitation…	NOAA	5-312310	Cotton				x			
Summer School on Atmospheric Modeling	NOAA	5-311100	Randall							x
Support of the Virtual Institute for Satellite Integration Training (VISIT)	NOAA	5-312560	Bikos, Connell	x						
The Madden-Julian Oscillation: Model Development and Diagnosis of Mechanisms	NOAA Shadow	5-312600	Maloney		x		x			
The Role of Atmospheric Water Content in Climate and Climate Change	NASA	5-319200	Miller					x		
The Role of the CCC in a Meaningful Drought Early Warning System for the Upper Colorado Basin	NOAA	5-311120	Doesken				x	x	x	x
The Role of the Vertical Distribution of Clouds in the Atmospheric Energetics	NASA	5-319310	Vonder Haar				x			
Tropical Cyclone Model Diagnostics and Product Development	NOAA	5-312070	Schubert		x					
Using a Regional-scale Model to Analyze the Scale Dependence of Convection, Cloud Microphysics, and Fractional Cloudiness	NSF	5-335670	Miller		x					
Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting	NOAA	5-311210	Zupanski, M, Zupanski, D.,Grasso			x				
Variability in Snow Sublimation Across Basin Scale Systems	NOAA	5-311090	Doesken				x			

2011-2012 NOAA AND OTHER FUNDING PROJECT THEME MATRIX

TITLE	Agency	Project #	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Weather Satellite Data and Analysis Equipment and Support for Research Activities	NOAA	5-312580	Kummerow					x		
Web-based Environmental Database Supporting Air Resource Management in National Park and Forest Service Lands	NPS	5-341970	Hand			x		x		

PI	Title	Lead NOAA Collaborator	Awarding Agency	Total Funding Amount
Lu	Downscaling NCEP Global Climate Forecast System (CFS) Seasonal Predictions for Hydrologic Applications Using Regional Atmospheric Modeling System (RAMS)	(NOAA-funded CPPA Program)	University of Colorado, CIRES	$116,644
Vonder Haar	Five Year Cooperative Agreement for Center for Geosciences/ Atmospheric Research	No (Mark DeMaria, RAMMB Co-advises a post doc on one project	Department of Defense	$2,363,000
McClure	SEMAP-Southeastern Modeling, Analysis, and Planning Project	No	GIT	$53,900
Miller	CIRA Data Processing Center Support for the CloudSat Mission	No	JPL	$90,348
O'Dell	Orbiting Carbon Observatory (OCO) Atmospheric CO_2 Observations from Space (ACOS) Task	No	JPL	$550,000
O'Dell	Orbiting Carbon Observatory (OCO-2) Task	No	JPL	$300,000
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	NASA	$37,268
Kidder, Forsythe, Jones	A Multisensor 4-D Blended Water Vapor Product for Weather Forecasting	Working with Sat Anal. Branch	NASA	$41,161
Miller	Application of 'A-Train' Satellite Observations to Support Decision Support Systems for Operational Aviation Weather Products	No	NASA	$75,000
Liston, Hiemstra	Defining Subgrid Snow Distributions Within NASA Remote Sensing Products and Models	No	NASA	$142,206
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-like Satellite Precipitation Information	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

McClure	Improving an Air Quality Decision Support System Through the Integration of Satellite Data with Ground-based, Modeled, and Emissions Data	No	NASA	$107,475
Fletcher, Liston	Improving the Representation of Global Snow Cover, Snow Water Equivalent, and Snow Albedo in Climate Models by Applying EOS Tera and Aqua Observations	No	NASA	$124,972
O'Brien	NRA/NASA-Modeling, Analysis and Prediction	Collaborated with Pieter Tans, Kenneth Masarie, Lori Bruhwiler, Arlyn Andrews	NASA	$472,344
Miller	The Role of Atmospheric Water Content in Climate and Climate Change	No	NASA	$53,290
Vonder Haar	The Role of the Vertical Distribution of Clouds in the Atmospheric Energetics	No	NASA	$32,713
Hand	Assistance for Instrument Development to Measure the Relationship of Air Quality with Night Sky Visibility	No	NPS	$160,872
Hand	Assistance for Night Sky Visibility Data Collection, Analysis and Presentation and Web-based Environmental Database Supporting Air Resource Management in National Park and Forest Service Lands	No	NPS	$339,999
Hand	Assistance for Visibility Data Analysis and Image Display Techniques	No	NPS	$314,412
McClure	Data Warehouse for Air Quality Modeling in the Oil and Gas Regions of Wyoming, Utah, and Colorado	No	NPS	$215,850
Hand	Web-based Environmental Database Supporting Air Resource Management in National Park and Forest Service Lands	No	NPS	$90,000
Miller	Development of Short-term Solar Forecasting Methods	Stan Benjamin ESRL; Andy Heidinger/Istvan Laszlo NESDIS collaborators	NREL	$150,000
Miller	Satellite Meteorological Application Research, Development, and Technical Support	No	NRL	$223,000
Liston, Hiemstra	Collaborative Research: AON A Snow Observing Network to Detect Arctic ClimateCchange-Snow Net II	No	NSF	$409,463
Liston, Hiemstra	Collaborative Research: A Prototype Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net)	No	NSF	$78,000

Liston	Collaborative Research: Norwegian-United States IPY Scientific Transverse: Climate Variability and Glaciology	No	NSF	$53,347
Liston	Collaborative Research: Linking Inuit Knowledge and Local-scale Environmental Modeling to Evaluate the Impacts of Changing Weather on Human Activities at Clyde River, Nunavut	No	NSF	$136,036
Lu	Deriving Mutually-consistent Carbon-Water Fluxes at the Regional Scale from Observations by Using a Coupled Biosphere-Atmosphere Model	No	NSF	$191,043
Zupanski, Zupanski	Ensemble Data Assimilation for Nonlinear and Nondifferentiable Problems in Geosciences	No	NSF	$399,056
Miller	Using a Regional-scale Model to Analyze the Scale Dependence of Convection, Cloud Microphysics, and Fractional Cloudiness	No	NSF	$111,283
Jones, Fletcher	AFWA Coupled Assimilation and Prediction System Development at CIRA	No	UCAR/NCAR	$49,630
Kidder	Co-instructor for the COMET 2011 Summer Course for University Faculty	NOAA funds supplied through COMET (GOES, Steve Goodman)	UCAR/NCAR	$7,660