CIRA

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Delving into Climate Change in Antarctica

Colorado State University

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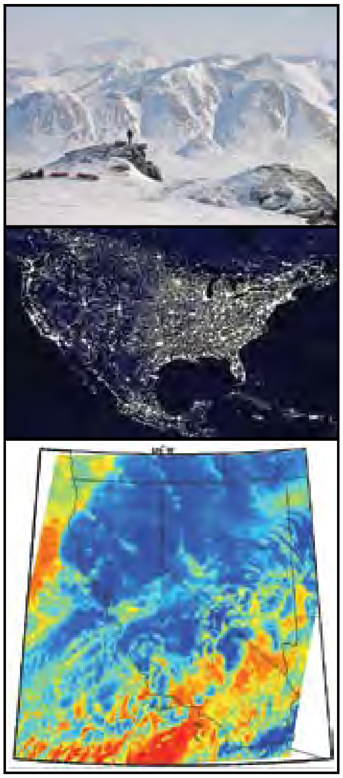

Photos above, from top:

1. An image of the south pole taken during the IPY.

2. A mosaic of night time satellite images reveals the emission of artificial light across the USA.

3. UTC 30 December 2005 observed and simulated brightness temperatures by the WRF-ARW.

About the cover: Expedition members Liston (left) and Winther (right) with Flag #24 at the 1967-1969 Plateau Station site, with 32 meter station meteorological tower in the background. (Photo: A. Muto)

CIRA

Cooperative Institute for Research in the Atmosphere

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GOES-R

GOES-R Synthetic Imagery and Fire Detection

Lewis D. Grasso, Manajit Sengupta, Donald Hillger, and Renate Brummer

Recent efforts at the Cooperative Institute for Research in the Atmosphere (CIRA) have concentrated on the development of synthetic satellite imagery. Motivation for such a system is threefold: (1) to better understand and interpret currently available satellite imagery; (2) to prepare for next generation satellite systems: such as the Geostationary Operational Environmental Satellite-R (GOES-R); and (3) to verify operational numerical weather prediction using synthetic satellite imagery.

Greenwald et al. (2002) discussed the development of an observational operator that was designed to create synthetic Geostationary Operational Environmental Satellite-9 (GOES-9) imagery. The observational operator calculates brightness temperatures from mesoscale model output. Synthetic imagery was created at five wavelengths for a scene containing a low level stratus cloud layer which occurred on 2 May 1996 over Texas and Oklahoma. Grasso and Greenwald (2004) extended the above system to an idealized thunderstorm simulation. As part of their work, the observational operator was further developed to calculate optical properties of several additional hydrometeor species: pristine ice, snow, aggregates, graupel, hail, and rain water. Grasso et al. (2008) discussed the use of a numerical cloud model in conjunction with an observational operator for future satellites. In particular, synthetic GOES-R Advanced Baseline Imager (ABI) imagery was produced for a thunderstorm event that took place over the central plains of the United States. In addition, they pointed out that synthetic imagery can be used for algorithm development. Such algorithms could be used for the detection of thin cirrus or fires.

Synthetic imagery from modeled data has also been produced by other teams. Data from the European Center for Medium Range Weather Forecasts (ECMWF) was used to produce synthetic imagery. Synthetic satellite imagery has also been used for numerical weather prediction verification. This technique has also been used to assess a parameterization scheme. Raymond and Aune (2003) have used results from the Cooperative Institute for Meteorological Satellite Studies (CIMSS) Regional Assimilation System (CRAS) model to produce synthetic imagery.

GOES-R is planned to be placed into orbit about 2015. In the infrared ranges, horizontal footprints of the ABI sensor will be near 2 km. In addition, temporal sampling of 5 minutes is planned (Schmit et al. 2005). Current GOES satellites can sample at intervals of 5 minutes – so called rapid scan operations; however, horizontal footprint sizes are near 4 km. Further, the ABI sensor will have a total of sixteen channels compared to the five channels on a current GOES imager. At CIRA we are exploring, in collaboration with other scientists at CIMSS, the use of synthetic GOES-R ABI imagery to aid in the development of fire detection algorithms.

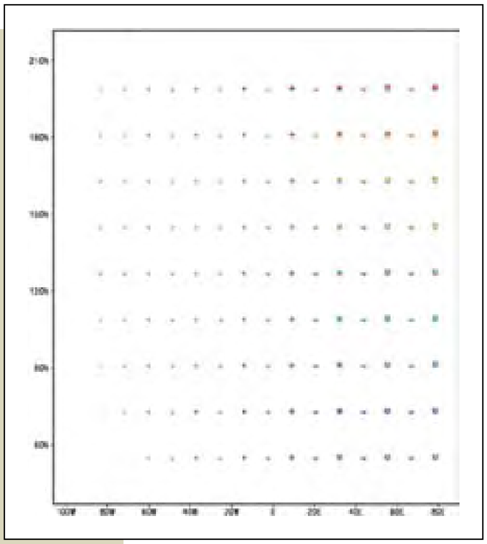

Figure 1. An array of fire pixels arranged in 15 rows and 9 columns. This data is contained in a grid with 400 m grid spacing. Fire temperatures increase from the bottom to the top while fire sizes increase from left to right.

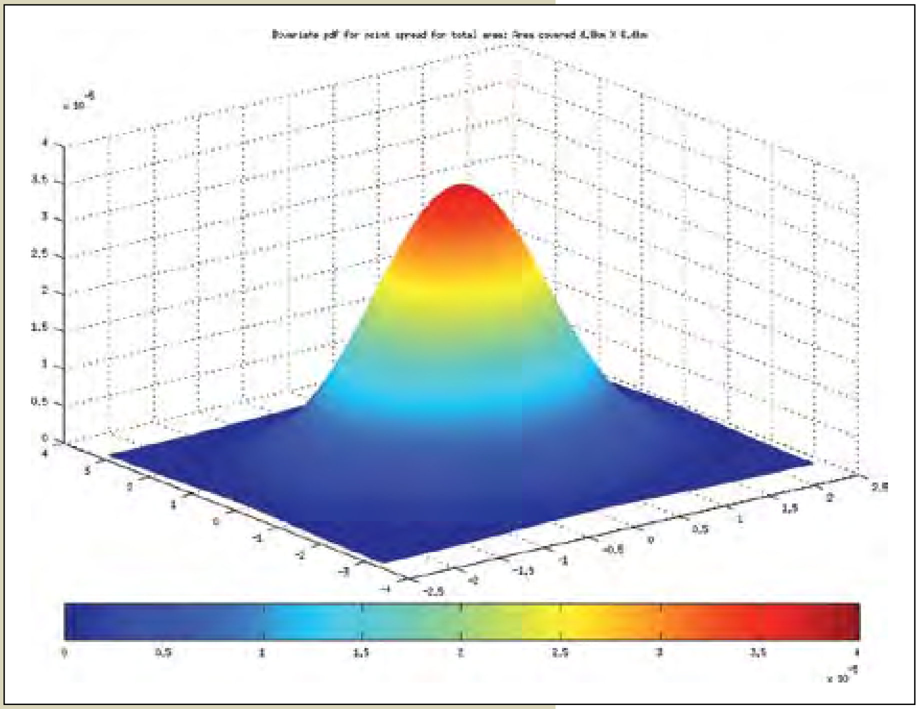

Figure 2. Three dimensional view of the point spread function used to build GOES-R ABI footprints from the 400 m data seen in Fig. 1 and other simulated data.

GOES-R

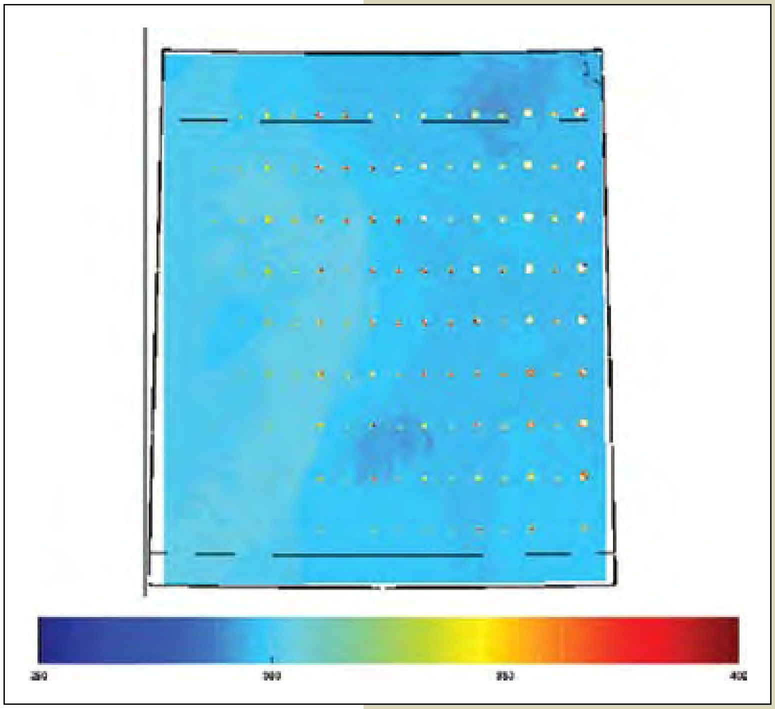

Figure 3. Synthetic GOES-R ABI 3.9 µm image built from the data shown in Fig. 1 and the point spread function shown in Fig. 2.

This collaboration will take advantage of additional ABI channels, the smaller footprint size, and higher temporal frequency as compared to the current GOES imager.

The purpose of this article is to overview the procedure that is used at CIRA to produce synthetic GOES-R ABI imagery of fires. As a first step, an idealized scene of several fires was produced (Fig. 1). This figure shows the fire hot spots embedded in a simulation over eastern Kansas. Horizontal grid spacings in Fig. 1 are 400 m in each direction. Small grid spacings were purposely chosen so that sub-pixel fires could be studied with larger footprints that make up synthetic GOES-R imagery. A point spread function (Fig. 2) is applied to the 400 m data to build the appropriate ABI footprint at a specific wavelength. Assuming GOES-R is at the same location as GOES-12, then the ABI footprint size over eastern Kansas is nearly 3.2 km in the north-south direction and 2.4 km in the east-west direction. As a result, a group of 400 m fires displayed in Fig. 1 will be sub-pixel fires in the synthetic ABI image (Fig. 3). Fire characteristics in Fig. 1 are as follows: In the southwest corner, the fires are coolest and smallest; moving to the right, all fires become larger groups of 400 m pixels; moving upward, all fires become hotter. As a consequence, the largest and hottest fires are located in the upper right portion of Fig. 1. After synthetic ABI imagery is created at 3.9, 10.35, and 11.2 µm, the resulting imagery is sent to our colleges at CIMSS. They will then apply fire algorithms to the synthetic imagery to assess the ability of the algorithms to detect the fires. This way, they always have ground truth with the data shown in Fig. 1 to evaluate their algorithms.

In an attempt to increase the complexity, our next step was to begin with GOES-12 retrieved

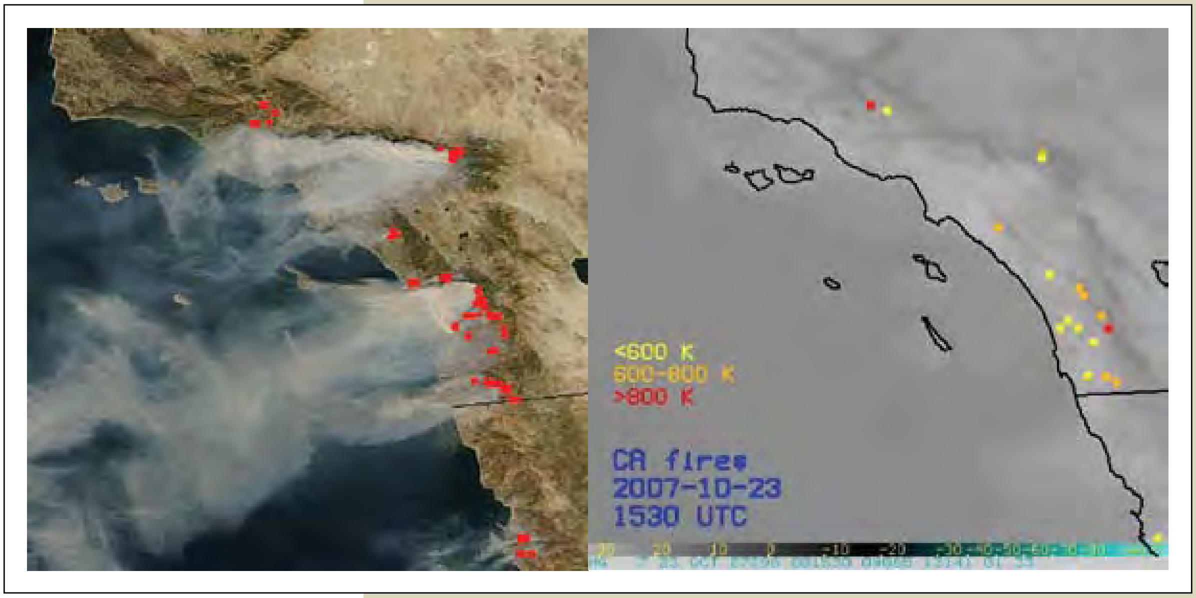

Figure 4. Example of an observed fire event which occurred in Southern California on 23 October 2007. To the left is the MODIS true color image with fire locations enhanced in red and to the right is the corresponding CIRA RAMMB synthetic image simulating a GOES-R ABI 3.9 µm band satellite image.

fire temperatures and sizes from fire cases over Central America and California. Retrieved fires were placed on a 400 m grid near the observed fire locations by using the latitude and longitudes of the retrieved fire pixels, similar to that shown in Fig. 1. Further, the point spread function was applied to the data to build ABI footprints specific to Central America and California. Because these fires were observed, as opposed to being idealized, fire temperatures were temporally variable. This allowed us to build a time sequence of ABI synthetic images over a six hour period. Like the idealized fires, this data was sent to our colleges at CIMSS to pass through their fire algorithms. Figure 4 depicts an example of an observed fire event which occurred in Southern California on 23 October 2007. To the left is the MODIS true color image with fire locations enhanced in red and to the right is the corresponding CIRA RAMMB synthetic image simulating a GOES-R ABI 3.9 µm band satellite image.

Recently, a fire in northern California exhibited an interesting characteristic. Between 0730 and 0830 UTC on 30 July 2008, the fire hot spot flared up and dissipated. During that time period, the fire appears to have influenced the brightness temperature of several GOES-11 pixels surrounding the fire (Fig. 5). By differencing the image at two times, one can see that approximately 450 pixels (31 pixels in the east-west and 15 pixels in the north south) warmed during the flare up of the fire. Since the white pixels of the fire indicate that the sensor is saturated, current fire algorithms are unable to retrieve these fire temperatures. One question that remains unanswered is, "What caused the surrounding 450 pixels to warm?" Perhaps the signature was caused by a cloud of hot smoke under relatively calm conditions. Could the signature be a result of the optics of the telescope aboard GOES-11? We are currently exploring the idea that the signature could be a result of the diffraction of electromagnetic waves as they pass through the opening of the sensor. In addition, perhaps this effect can be used in the determination of fire temperatures that otherwise would be indeterminate due to pixel saturation.

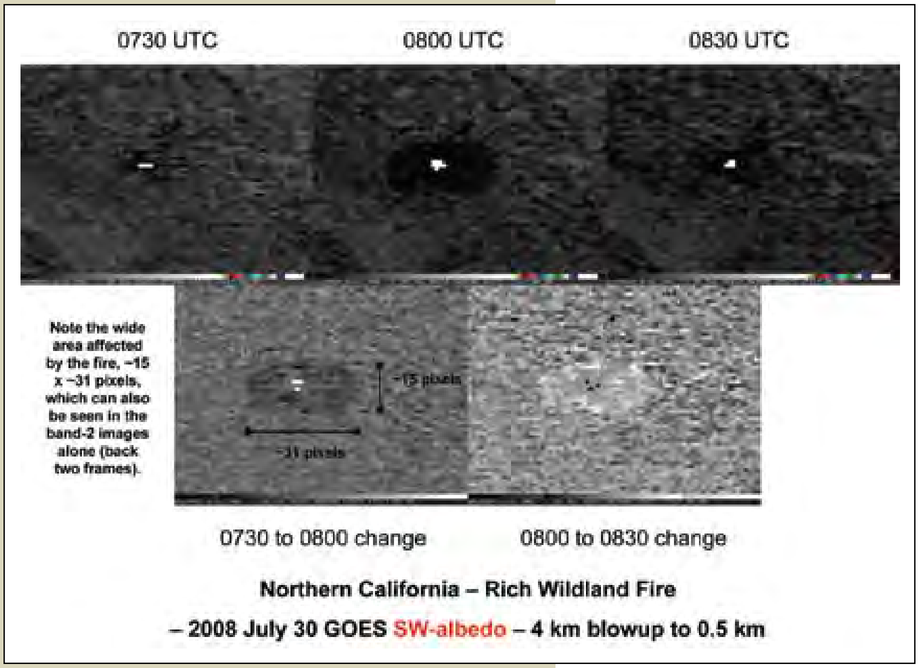

Figure 5. GOES-11 shortwave albedo images of the Rich Wildland Fire that occurred on 30 July 2008. The bottom two images show the difference between the upper three images. In particular, note the size of the area (about 450 pixels) influenced by the fire.

Due to the smaller footprint and larger temporal sampling rate of ABI, we anticipate an increased detection of fires by GOES-R. This is important for the climatology of fire activity and the associated emissions.

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IPY SOUTH POLE TRAVERSE

Norwegian-United States International Polar Year (IPY) South Pole Traverse

Dr. Glen E. Liston and Dr. Jan-Gunnar Winther

Diary Excerpt (Glen), 1 December 2007

As I lie in my small tent at -48 °C (-54 °F) near the center of Antarctica, I try to mentally force my near-frozen toes back to life. The temperatures I am experiencing now are just about equal to the mean annual Antarctic air temperature in this area; something that typically changes only slowly over the decades and centuries. I also note that one month ago I was flying, uncontrolled, 15 meters (50 feet) through the air in response to a 52 m/s (132 mph) wind gust during a storm near the Antarctic coast. I am part of a scientific research expedition traversing from the Antarctic coast to the South Pole, and this is exactly what we are here to study and understand: weather and climate variability and change on time scales of 1000 seconds (like my wind-borne flight) to 1000 years (like my cold, cold night).

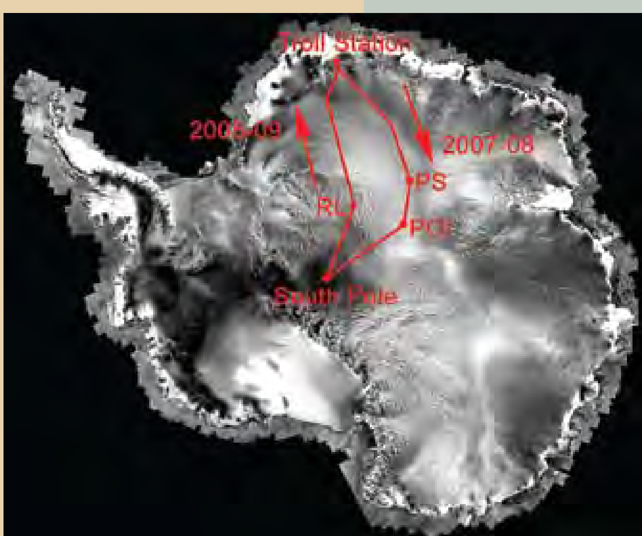


Figure 1. Antarctic traverse routes between Troll Station and the South Pole, for the two field seasons. Also shown are Plateau Station (PS), the Pole of Inaccessibility (POI), and the Recovery Lakes (RL) research site.

In 2004, under the leadership of Dr. Jan-Gunnar Winther, Director of the Norwegian Polar Institute in Tromsø, Norway, the idea of a joint Norwegian – United States, International Polar Year (IPY) scientific expedition and overland traverse to the South Pole (90º S, 0º E) was born. In the true spirit of the IPY, this effort was to be a scientific collaboration between nations, with approximately equal contributions from the two participating countries.

Three times during the past 125 years, scientists from around the world have worked together to improve our scientific understanding of the Polar Regions. This Fourth IPY (2007-2009) represents a unique opportunity for improving our understanding of the Polar Regions, particularly in light of recent concerns with global climate changes. This IPY includes a strong focus on snow and ice changes: reductions in extent and mass of glaciers and ice sheets; reductions in area, timing, and duration of snow cover; and reductions in extent and thickness of sea ice and permafrost. Through the associated changes in sea level, freshwater supplies, and air temperatures, these will all have immediate- and long-range consequences for people living on Earth.

Diary Excerpt (Glen), 8 December 2007

Temperature -46 °C (-51 °F), Chill Factor -69 °C (-92 °F). I don't know if I should tell you what happened to me today. I awoke this morning at about 5:00 a.m. to a nice little blizzard raging outside my tent; my enthusiasm for leaving my warm, cozy, sleeping bag was at an all time low. We had planned an early start, heading to our next measurement site. I took down my tent and packed up my sleeping gear, and headed off to help get the *two remaining vehicles started. We are having problems with cold fuel in the mornings, and the solution seems to be to blast the fuel filters and lines with a monster heater system. Unfortunately this is darned hard, cold work in these winds, cold, and blowing snow. About half way through the second vehicle I started getting cold ... really cold. Even when I stopped I could not get my hands warmed back up (and the rest of me wasn't getting any warmer either). This went on for a while (45 minutes?) until I realized I was in a bit of a mess. I started having hot flashes that surged through my body (a little strange while you feel like you are freezing to death) ... I felt like I was going to get sick to my stomach ... finally I staggered inside the dining module to warm up, sat in a chair in kind of a stupor, and eventually got to the point (like 30 minutes later) where I could prepare and eat something for breakfast and slowly recover and warm back up.*

We are now driving to the next site; it will take 2.5 days to get there. From my little ordeal this morning, I feel like every muscle in my body is sore; I have a horrible headache; I am having muscle cramps in my legs and feet; and sometime during all of this my left thumb split again and hurts like fire. Jan-Gunnar is driving, so I can doctor my thumb, eat and drink some more, take some 'aspirin', and get some much-needed rest. I will be okay. I remember a time during one of my Arctic traverses when I had to do something (cold, hard work) without benefit of food (like in the morning without breakfast!), and with similar consequences (I could not stay warm no matter what I tried). I will be careful not to let that happen again! I do not like the end results; my body is feeling like it was half destroyed by what I did to it this morning!

Our IPY expedition team consists of twelve hand-picked field scientists and technicians: four Americans and eight Norwegians. In late October 2007, we flew our chartered C-130 Hercules aircraft south from Cape Town, South Africa, and landed on the blue-ice runway located near Troll Station (72º S, 2º E), Norway's main Antarctic research base. Our expedition spans two austral summers (2007-2008 and 2008-2009), and takes us from Troll to the Amundsen-Scott South Pole Research Station the first season (late October through late January), and back to Troll by a different route the second season (Figure 1). Between seasons the expedition participants were flown from the South Pole, back to their home countries of Norway and the United States.

Figure 2. Crevasse detection using a vehicle-mounted radar system; Stabben is the mountain in the background, near Troll Station. (Photo: G. Liston)

Diary Excerpt (Glen), 20 December 2007

I think my toothbrush finally died this morning; it just looks all worn out. Somehow letting it freeze after every use, and using it when it is frozen and stiff, seems to be taking a toll on the bristles. I will have to dig around for one of my spares. I didn't change my underwear on Friday. I think that was a mistake, so now I have to decide whether to wait until next Friday or change them today or tomorrow (which would kind of screw up my every-3rd-Friday schedule!). I've also lost track of when I changed my socks last; and then there is the shower situation; my last one was on the 25th of October (isn't it kind of fun to think that Christmas will be my two-month no-shower anniversary ... I guess not; ... by the end of this expedition I will have gone 89 days without a shower). I suppose I could give you my theory about showers on these trips ... it goes something like this: after a few days our bodies reach some kind of equilibrium with regards to dirt, oils, and smells; and

Figure 3. Ice-core processing operations. (Photo: J.-G. Winther)

IPY SOUTH POLE TRAVERSE

Figure 4. Expedition traverse vehicles, living modules, and equipment sleds. (Photo: G. Liston)

it is our clothes that keep getting 'worse'. This is why it is so important to change your clothes every few weeks (because they basically start to rot on your body – while your body is still doing fine; or so you hope).

Our IPY expedition's primary goal is to investigate climate variability and change over the East Antarctic Ice Sheet between now and 1000 years ago. During the 2007-2008 field season, our scientific measurements included 1) drilling 700 meters (nearly half a mile) of ice cores to measure a broad range of chemical and physical properties and characteristics; 2) collecting 2500-km (1500 miles) of radar data to map snow and ice accumulation between drill sites (using 4 different ice-penetrating radar systems running continually over our route, including one specifically designed to detect crevasses [Figure 2]); 3) making detailed near-surface (top 3 meters) physical and chemical snow and ice measurements; 4) installing two automatic weather stations; 5) conducting unmanned aerial vehicle (UAV) flights and measurements; and 6) making deep-ice temperature measurements. This suite of observations will be used to gain new insights into the paleo-environments and climate change of this virtually unexplored area of Antarctica.

Figure 5. Glen's sleeping tent. (Photo: G. Liston)

Figure 6. Liston preparing to descend into the old Plateau Station. (Photo: J.-G. Winther)

Diary Excerpt (Glen), 21 December 2007

Things are going pretty well with the ice coring, although my thumbs nearly freeze every time I handle a new 1-meter (3-foot) core section that comes out of the hole (Figure 3). We are deep enough in the Ice Sheet now that the ice-core temperatures equal the mean annual air temperature of this area, about -55 °C (-67 °F), so they are darn cold to handle with lightly-gloved hands. The light gloves are required to do the note-taking and bagging of the ice cores.

While our science measurements are going wonderfully, our vehicles are having their share of problems ... this morning after 2 hours of driving, Jack (the vehicle I was driving at the time) destroyed its gear box, spewed hot oil, and promptly caught fire (or I should say the oil on the 'ground' caught fire, not the vehicle); I put the fire out by throwing snow on it – it was just a small fire. A pretty exciting morning ... one I could have done without ... one we all could have done without. Fortunately, we have one spare gear box left (a rebuilt one) to replace it with; about a 10-hour job that should be done in a few more hours. Our mechanics are amazing! We would literally be going nowhere without them.

To optimize our body's energy required to make our scientific measurements, we traveled in relative comfort (Figure 4). We used 4 tracked vehicles that pulled 3 heated modules: a dining module, a sleeping module (Glen slept in a tent; Figure 5), and a small workshop to make repairs to our scientific and mechanical equipment. These shelters were invaluable when temperature and wind conditions made working outside difficult.

During our traverse we passed through and made measurements at several interesting and historical Antarctic places, the three most notable being Plateau Station, the Pole of Inaccessibility, and the South Pole (Figure 1).

1. Plateau Station was established by the United States in 1965 and stayed open until 1969. Research at the station focused on atmospheric observations; it's location at 3620 meters (11,900 feet) on the broad crest of the East Antarctic Ice Sheet provides a climate unique for its thin air, light winds, extremely low temperatures, and short summers.

Diary Excerpt (Glen), 23 December 2007

Yesterday was amazing for us. We spent hours down (I went down 4 times) in the old Plateau Station building. It was nice to be out of the wind, but was a little cold (-51.3 °C, -61.3 °F)! We entered through a hole in one of the station observation towers, starting about 5 meters (16 feet) above the station floor (Figure 6).

I had the 'honor' of being the first one down into the station. I say 'honor' because there was some question about how safe it would be down there, with possibilities of no oxygen, poisonous gasses from old station supplies, etc. For some reason Jan-Gunnar figured I was the one expedition member they could most easily do without! Einar (our Norwegian Polar Institute 'Man of the Year') also went with me. Anyway, everything was fine, and it was nice to think that I was the first American in the station in about 40 years (it closed in 1969). Talk about stepping back in time; it was like they just walked away, leaving most everything as it was while they were living there! We saw shaving kits and toothbrushes, cupboards full of food, numerous flashlights in case of a winter power outage, chairs neatly turned over and sitting on the dining-room table, and a fully-stocked medical cabinet (Figure 7). Our visit was made particularly eerie because, at these temperatures, the moisture from your breath freezes instantly, creating an ice fog that got thicker and thicker the longer we were below the surface and in the station. But my strongest reaction was that it looked like a pretty small place for 8 people to be spending the winter!

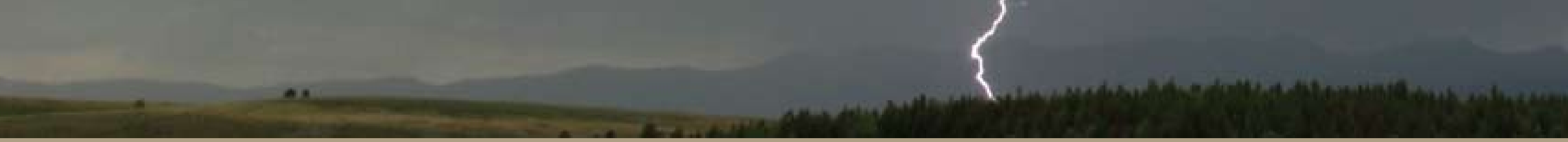
2. A "Pole of Inaccessibility" is the location on a continent that is farthest from any ocean, and thus (generally) the point most difficult to reach. In Antarctica, the Pole of Inaccessibility is located at 82° 06'S, 54° 58'E (885 km, or 532 miles, from the South Pole) and is 3730 meters (12,200 feet) above sea level. Prior to our arrival, the Pole of Inaccessibility had been visited 6 times. In 1958, a Soviet expedition left a statue of V.I. Lenin there; it is still above the surface today, stoically facing Moscow.

3. The South Pole is Earth's southern most point; it sits at an elevation of 2840 meters (9300 feet); it has a mean annual temperature of -50 °C (-58 °F) and a winter-low temperature record of -82.8 °C (-117.0 °F); at this point on Earth the sun is continually above the horizon for 6 months, then sets and is below the horizon for 6 months; and the United States has maintained a year-round research station there since 1957.

As part of this expedition, we realized our dream of a true international Antarctic science effort befitting the legacy of past IPY research projects, and setting the standard for future polar research. During Year-1 of the traverse we proudly carried Explorers Club Flag #24 (Figure 8). During Year-2 of the traverse we will travel from the South Pole back to Troll Station, continuing our field observations, including a three-week measurement campaign at the newly-discovered Recovery Lakes: a collection of lakes located at the bottom of the East Antarctic Ice Sheet (Figure 1). Additional information can be found at the expedition website http://traverse.npolar.no/, and a slide-show presentation of the expedition is available from ftp://ftp.cira.colostate.edu/liston/shows/work_trips/2007-08_South_Pole.ppt.

Figure 7. Oxygen bottle and mask in the Plateau Station lobby; presumably to help station personnel deal with the low oxygen levels at this elevation (approximately 55% of that available at sea level). (Photo: G. Liston)

Figure 8. Expedition members Liston (left) and Winther (right) with Flag #24 at the 1967-1969 Plateau Station site, with 32 meter (100 foot) station meteorological tower in the background. (Photo: A. Muto)



NIGHT SKY VISIBILITY

Investigating the Link Between Air Quality and Night Sky Visibility

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The National Park Service was created "to conserve the scenery, the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations". An element of scenery has recently come to include the view of a starry night sky. In response to the degradation of night time visibility by light pollution the National Park Service Night Sky Program was initiated to investigate the influence of artificial lights upon the nocturnal lightscape. The Night Sky Program (NSP) has developed instrumentation to inventory night sky quality which has been used at over 60 individual parks. Using Charged-Coupled Device (CCD) cameras to image the entire celestial hemisphere, a panoramic map of precise sky brightness values is generated. Since 1999 a database of over 300 photometric observations has been collected; site locations range from remote parks, protected as Class I Airsheds, to brightly lit suburban parks.

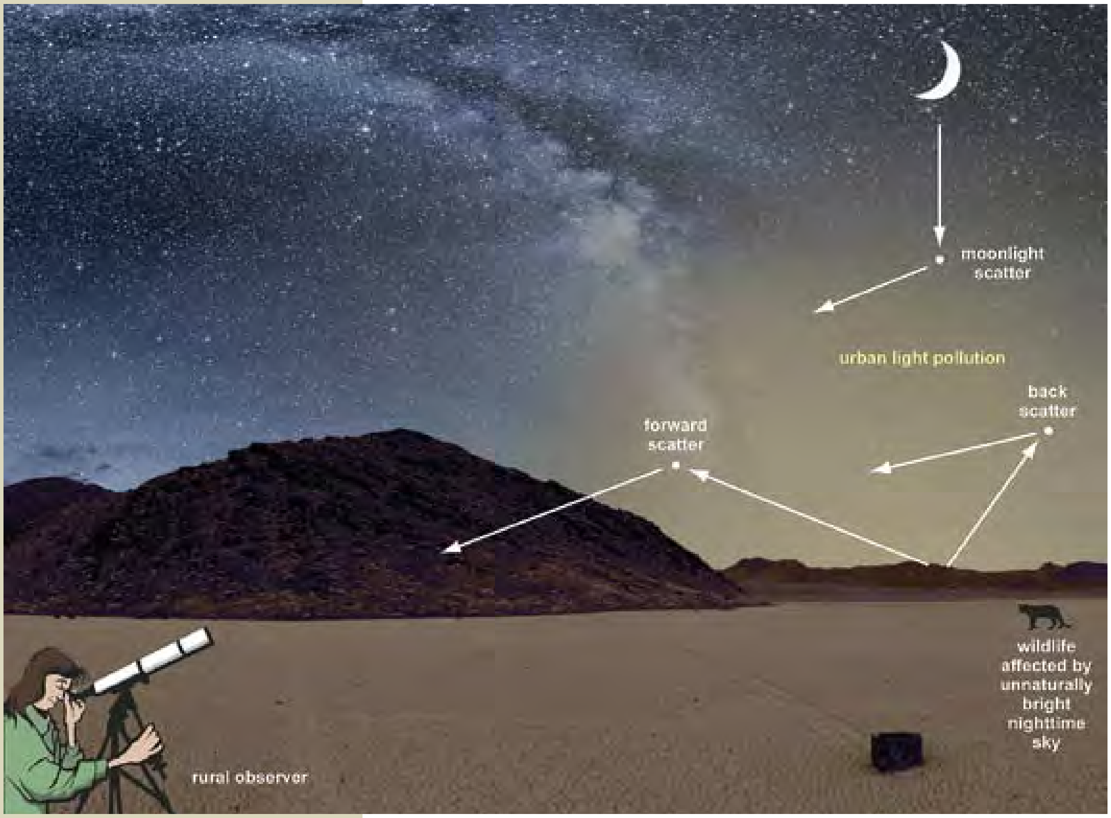


Figure 1. A night sky observer in a non-urban setting sees less of the Milky Way as the light pollution from the distant city (aka a light dome) brightens the horizon and artificial light invades nocturnal wildlife habitat.

In many data sets the NSP team has observed variation in sky brightness and the character of urban light domes from night to night. The likely cause of this variation is due to changing aerosol and particulate content in the atmosphere. The link between scattering and light pollution was characterized by Roy Garstang in 1986, however little data has been previously available to test this model. The NSP collection of all sky brightness maps provides an opportunity to test existing models. Models predicting visibility and daytime conditions have been well established and verified in publications. However, these daytime models cannot be directly applied to the night time environment for several reasons. At night, light propagates from numerous artificial light sources near ground level shining up into the atmosphere as opposed to sunlight radiating from above. Additionally, the night lightscape is 5 to 7 orders of magnitude dimmer than in the day and characterized by subtle contrast of extended features and the visibility of faint starlight against a dark background, its luminance levels near the sensitivity limit of the human eye.

In a rural or remote park setting, night sky visibility depends on how light is being scattered or absorbed through the atmosphere (Fig. 1). In a dark sky with minimal scattering aerosols, faint stars can be observed down to the horizon and diffuse features, like the Milky Way, have enough contrast to be easily seen with the naked eye. In areas such as the American Southwest, with its clear and dry conditions, the scattered light from distant cities can be seen up to 300 km away. This is frequently called a "light dome," which may be small and only extend across a few degrees of angle, or a light dome may completely dominate the celestial hemisphere. Increasing aerosols that scatter and absorb are hypothesized by some to suppress the light of distant light domes while diminishing the visibility of stars and other faint features, but amplifying the light from nearby sources. Thus there may not be a simple linear relationship between scattering, artificial light, and night sky visibility.

Urban settings typically have poor outdoor lighting, projecting a tremendous amount of light upwards into the atmosphere. This wasted light is commonly seen on satellite images at night (Fig. 2). However, increase of urban aerosols scatters this artificial light downward towards the observer, dramatically brightening the appearance of the urban night sky (Fig 3). This brightening of the sky greatly reduces the contrast between the sky background and starlight, rendering the Milky Way and other faint extended features invisible, and only allowing the light of a few bright stars and planets to be seen through the murk.

Most of the sample locations typically have good air quality and conditions optimal for photometric measures. Occasionally in these data sets, variation in absorption can be dramatically seen during episodes of wildfires, dust storms, or hazy conditions which affect light domes from surrounding cities. This provides an opportunity for insight into atmospheric science. Figure 4 shows data taken from the North Rim at the Grand Canyon on the consecutive nights of June 27 and June 28, 2008. In Figure 4a, the light dome of Las Vegas, at 271° azimuth, is clearly seen from over 285 km, despite the recent flaring of a nearby fuels reduction fire burning at 309° azimuth. The smoke from the fire is drifting to the northeast, extinguishing the light dome of Page, Arizona at 34° azimuth, 95 km and Tuba City, Arizona at 95° azimuth, 73 km. The optical depth above the observation point is 0.162, aerosol to Rayleigh scattering ratio is 4.4 and the visual range for this night is 75km. In Figure 4b, the Las Vegas light dome on the next night is greatly reduced from the smoke of the fuels reduction burn, drifting heavily to the southwest, the fire is shown at 309° azimuth and the light dome of Tuba City is barely visible at 95° azimuth. The optical depth is 0.233, aerosol to Rayleigh scattering ratio 9.4 and the visual range is 39 km.

In each NSP dataset, optical depth is calculated by measuring stellar extinction averaged over the entire sky. By using known standard stars and matching them within the data set, the observed brightness of the standard stars can be individually calibrated against their known brightness. A subset of 300 nonvariant stars picked from the Hubble Guide Star Catalogue is used for this calculation. The extinction coefficient is calculated in magnitude/airmass and then converted to the dimensionless optical depth parameter.

The NSP has begun collecting complimentary data on atmospheric conditions that may help to sort out the causal factors of night sky degradations. This includes nephelometer data captured alongside these images to determine scattering coefficient at ground level. These site-specific parameters can be combined with surrounding air quality station data to build a more comprehensive picture of atmospheric scattering.

Figure 2. A mosaic of night time satellite images reveals the emission of artificial light across the USA. Aerosols and atmospheric gases scatter a portion of this light, which is perceived by observers on the ground as light pollution. This image also provides a perspective on the scope and severity of the light pollution problem and the associated energy inefficiency.

NIGHT SKY VISIBILITY

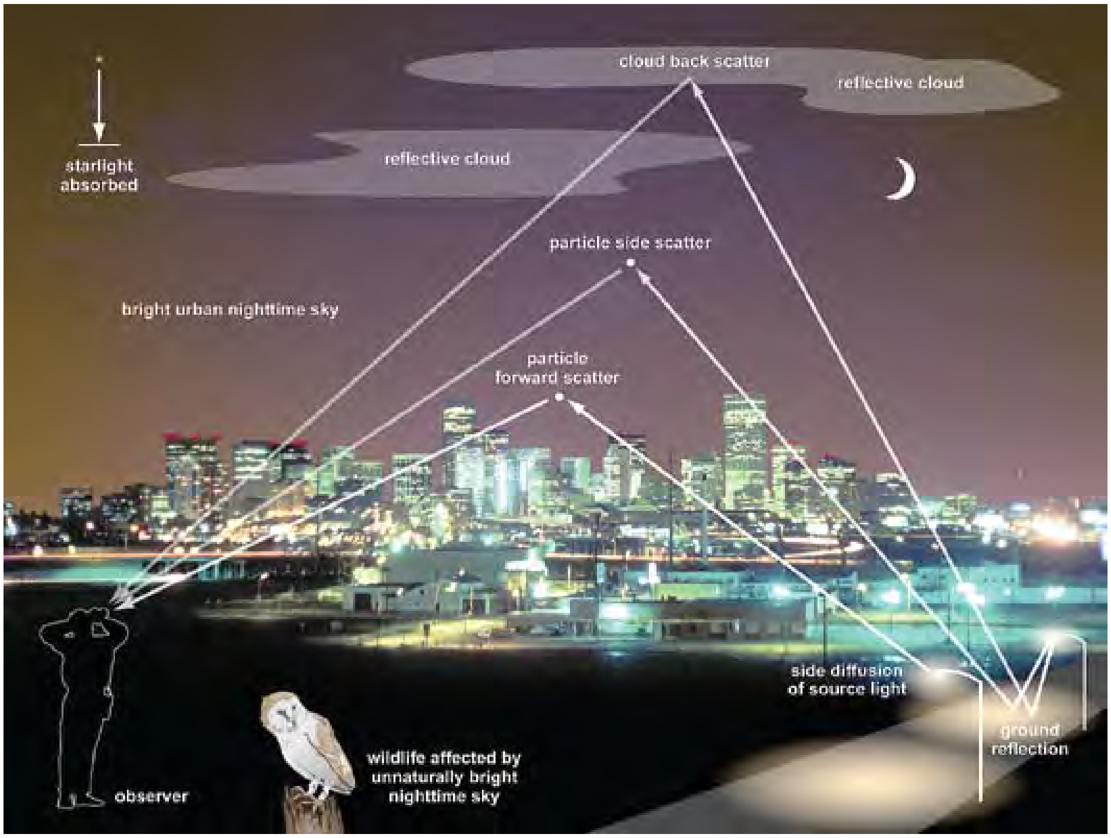
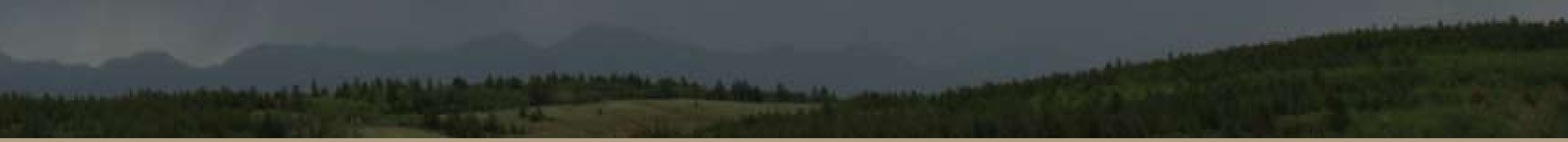


Figure 3. From a city dwellers point of view the artificial light is thrown upwards then scattered back from clouds and anthropogenic aerosols.

Additionally, the NPS and Air Resource Specialists have begun building a radiation transfer computer model addressing night time conditions and light propagation in the urban environment (with its correspondingly higher in aerosol concentrations). Thus the project's extensive data collected at various sites and under various atmospheric conditions and depicting light sources at a range of distances provides atmospheric science an opportunity to untangle the relationship between scattering aerosols and night time visibility. The Night Sky Program located at CIRA is looking for assistance and collaborators on this project interested in adding to the body of knowledge on this topic.

The Clean Air Act provides protection for visibility, but the interpretation and implementation of this legislation has only addressed daytime visibility. The data and approach outlined here may yield evidence to show that visibility degradation per increment of air pollution is greater at night than in the day. Besides the policy ramifications, a more thorough understanding of the propagation of artificial light will help guide the protection and restoration of natural night skies (Fig 5) that piques scientific interest in youth and provides inspirational scenes in parks and backyards alike.



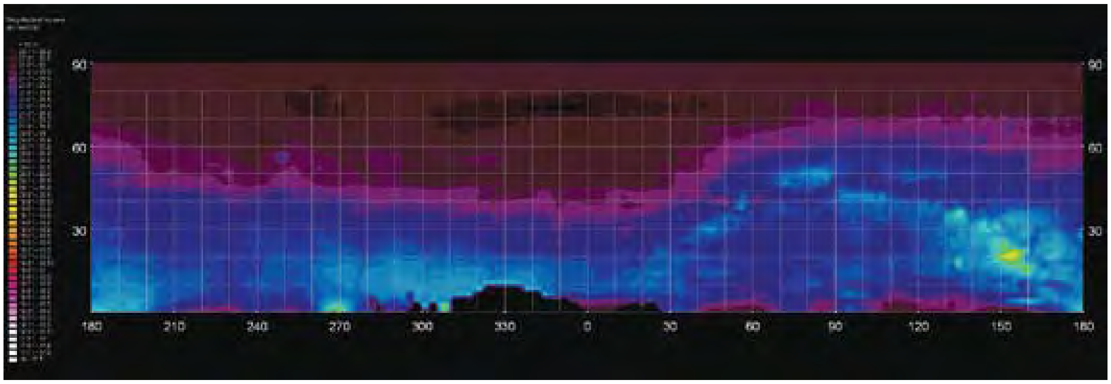


Figure 4a. National Park Service night sky brightness panoramic map in magnitude/arseconds2 at North Rim, Grand Canyon, Arizona, taken on June 27, 2008. Sky brightness is depicted in false color. The mottled arch in both images is our own galaxy seen edge on – the Milky Way.

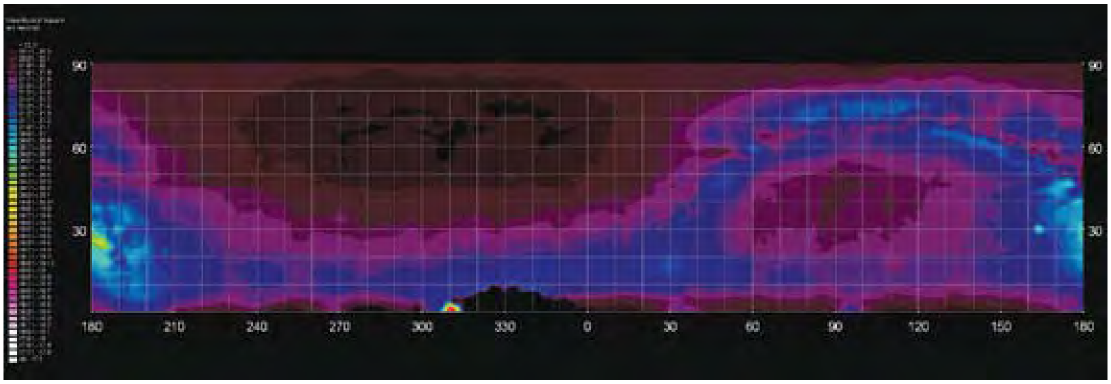
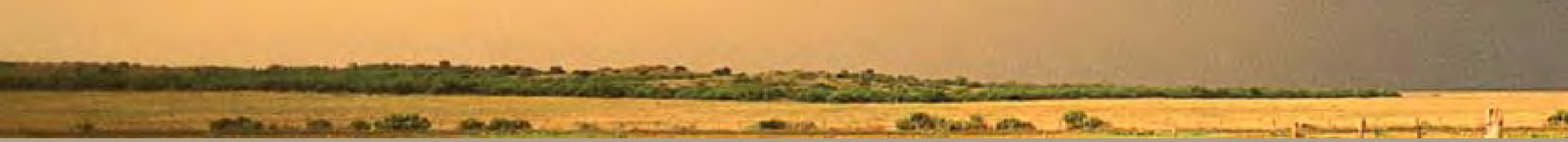


Figure 4b. The same location as image 2a, taken on the next night of June 28, 2008. Note the lack of the Las Vegas light dome at 270°.

Figure 5. A colorized image of a natural night sky above Great Basin National Park, showing the Milky Way and countless stars.



VERIFICATION OF FORECASTS

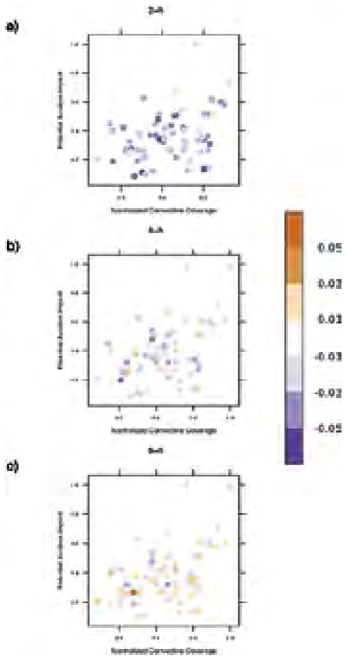


Figure 1. Difference between average CSI values for a) 2-h, b) 4-h and c) 6-h outlook period forecasts used in the ATCSCC strategic telecoms as a function of normalized convective coverage and potential aviation impact. Cool and warm colors denote the differences in performance of the forecasts. The orange colors, or positive values, indicate better performance of the primary forecast.

Verification of Aviation Weather Forecasts: Building Concepts and Systems for the Next Generation Air Transportation System

Sean Madine

According to the Federal Aviation Administration (FAA), the current air traffic system, a very important part of the national economy, will not scale to accommodate future demand in the national airspace (www.faa.gov/regulations_policies/reauthorization/). The FAA, in concert with other U.S. government organizations, has moved to transform the current management approach into the Next Generation Air Transportation System (NextGen), with planned realization in 2025. Air traffic management, when performed by either a human or a computer algorithm, requires accurate and timely forecast information about meteorological variables that impact aviation, namely convection, icing, turbulence, and visibility conditions. Verification provides information about an aviation forecast product's suitability for operations and its performance within the operational setting. CIRA researchers (Sean Madine – lead, Missy Petty, and Dan Schaffer) are working to build concepts and systems to meet the NextGen requirements for forecast verification data.

Concepts for Verification of Forecasts in NextGen

Primarily designed to bridge the gap between meteorology and air traffic management (ATM), the NextGen verification concepts adopt traditional approaches and enhance them to appropriately account for the ATM planning process. Two recent studies illustrate the enhanced verification view:

- An examination of convective forecasts used for strategic planning
- An analysis designed to measure the economic value of convective forecasts

Strategic Planning in the National Airspace

In initial investigations, the CIRA team has focused on the strategic aspect of the current planning process, which seeks, during early morning analysis, to optimize the use of the airspace for the entire day. The NextGen automated planning algorithms, dependent upon a significant strategic component, are still under development, and not yet mature enough for study. Researchers, however, anticipate that many of the lessons from current verification research will be useful for the future studies.

The Air Traffic Control System Command Center (ATCSCC) in Herndon, Virginia serves as the "central nervous system" for the management of the national airspace. Each morning, planners convene via telecom every two hours to evaluate the overall demand for airspace and potential impacts, including weather disruption, for that day. The planners consider the telecoms held at 11 GMT, 13 GMT, and 15 GMT to be the most important when dealing with convective impact, which typically occurs during the afternoon.

The ATM community has recently adopted the Weather Impacted Traffic Index (WITI) (Callaham, et al.), a measure of the overall effect of convective weather on the enroute airspace. The metric utilizes historical demand along with observed weather to give a scalar measure of impact for each hour during the day.

The CIRA team has combined these two operational aspects to produce stratified results, which provide insight into the performance of the forecasts used during the strategic planning times for days with high convective impact. An illustration of output from the analysis, which shows a combination of meteorological and air traffic information, is shown in Figure 1 (Kay, et al.).

In evaluating enroute capacity of the airspace, the ATM community needs to know the amount of convection present in the high altitude sectors used to manage traffic. Traditional verification produces metrics on a regularly spaced grid, typically the native grid of the forecast or observation field of interest. In this new approach, researchers map the forecasts and observations to the high altitude sectors, and compute metrics on the sector grid, better capturing the quality of the product with respect to operational planning. Figure 2 shows an example of the sector mapping.

Conditioning forecasts of convection for use in air traffic management: A step toward measuring economic value

Estimates of the economic value of weather forecasts for use in air traffic management (ATM) would significantly bolster current verification information, allowing for better decisions regarding the type and quality of data required for NextGen. The complexity of ATM, however, demands an approach beyond the traditional cost/loss model, which clearly fails to capture a meaningful measure of value for this domain. In an attempt to understand the economic outcome of automated ATM planning based on weather forecast information, CIRA researchers have collaborated with Boeing Corporation to examine the use of convective forecasts in a flow model.

The National Flow Model (NFM), a queue-based air traffic flow simulator, utilizes projected schedules and calibration settings from historical cases to create ATM plans based on forecast weather, and execute those plans against actual weather for a particular scenario. Importantly, it provides output that includes flight delays and cancellations, a direct measure of cost. The value of the forecast can be measured by comparing its associated cost with that of utilizing no forecast information and that of utilizing perfect knowledge of future weather.

Initial runs of the NFM, focused on five study days in the 2007 convective season, failed to provide meaningful output, primarily because the forecasts of convection indicated far too much impacted airspace. In each of the simulations, the over-forecast of hazardous weather forced the planner to essentially stop the flow of aircraft entirely. Through subjective evaluations, however, forecasters and air traffic managers have indicated that the forecasts have value for the planning process.

Motivated to understand how the forecasts might be made useful as input to the NFM, the CIRA team studied various post-processing techniques to condition the forecasts for air traffic planning. The ongoing research examines the conditioning of the forecast products and promise for measuring economic value through the outlined approach.

The Network-Enabled Verification Service (NEVS): Providing verification of weather forecast products in NextGen

As the centerpiece of all weather information in NextGen, the Weather Information Data Base (formerly known as

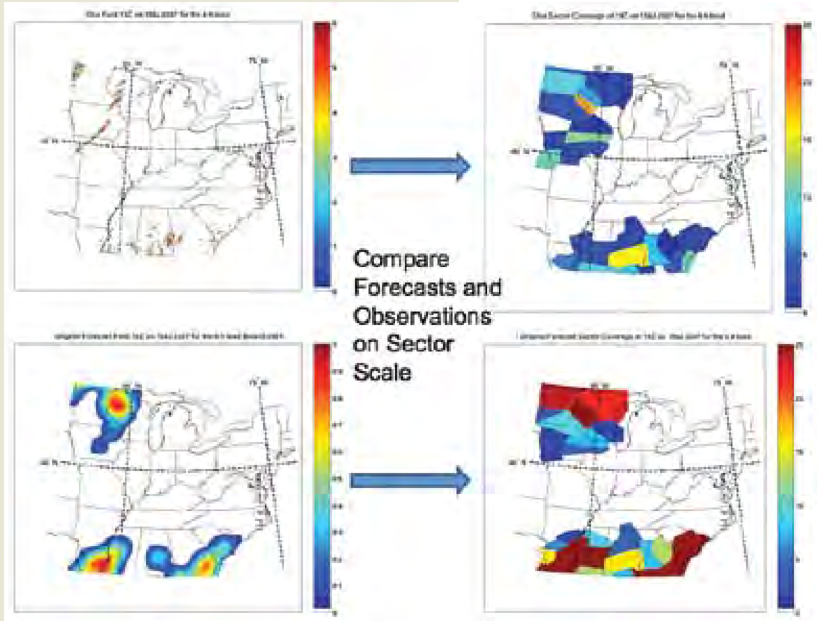
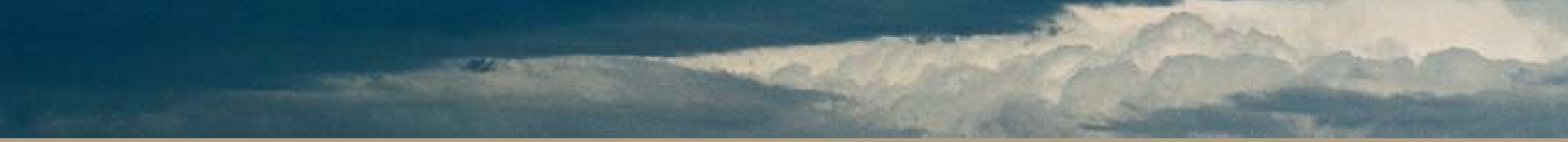


Figure 2. Depictions of gridded forecast and observation fields, with their associated sector representation. The original observation field (upper left) consisting of VIP level information is mapped to sector coverage in the upper right image. Similarly, the forecast field (lower left) comprised of probability values is mapped to sector coverage in the lower right image.



VERIFICATION OF FORECASTS

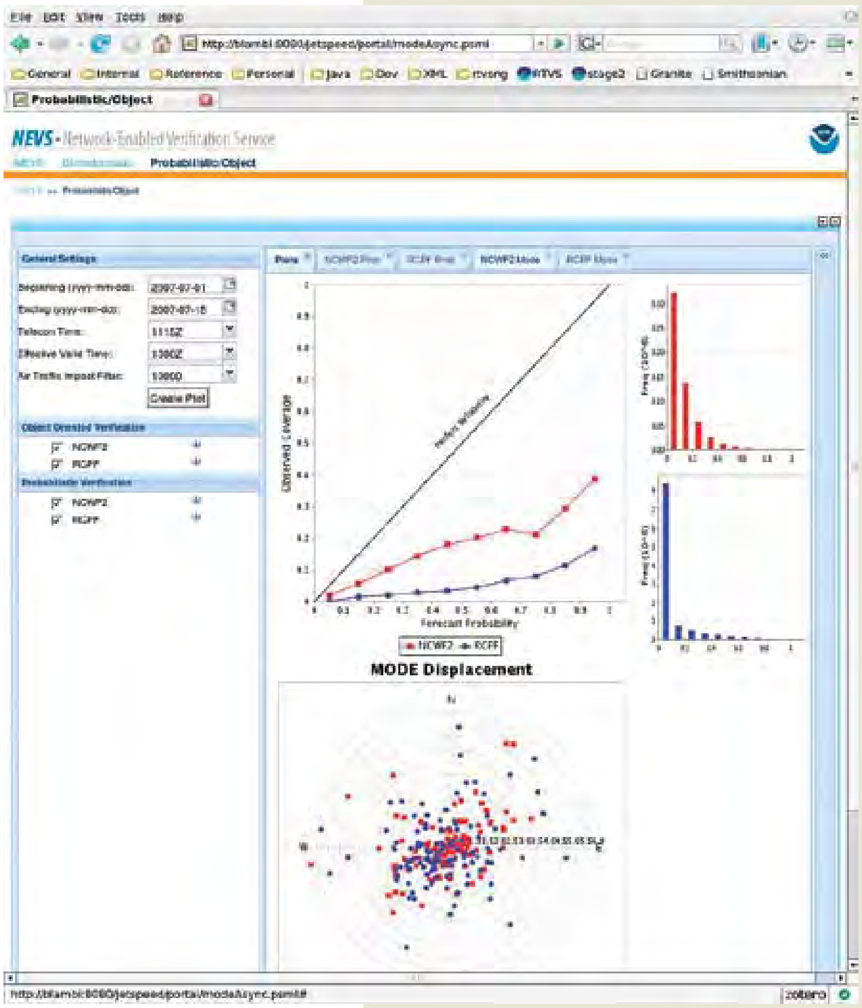


Figure 3. Web interface and output for verification information about two experimental probabilistic convective products in use during the 2007 convective season. Meteorological metrics are stratified by an air traffic impact measure, WITI. (MODE displacement data courtesy of National Center for Atmospheric Research – Research Applications Laboratory.)

the 4-D Data Cube) will contain verification information about the forecasts utilized by the ATM algorithms. Traditional approaches to the development of verification software have yielded effective solutions for agile, focused analysis. However, a new approach is necessary to create verification software sufficient for the NextGen operational setting, a complex, service-oriented architecture (SOA) comprised of weather and air traffic management components. In response to this need, the CIRA researchers have collaborated with other groups at NOAA's Earth System Research Laboratory (NOAA/ESRL) to develop a proof-of-concept version of the Network-Enabled Verification Service (NEVS).

In addition to supporting the transition of experimental forecast products to operations, NEVS will provide verification data for other NextGen requirements, including assessment of the performance of forecasts in the Single Authoritative Source (SAS). The flexible framework upon which NEVS is built allows verification information created by any components of the Weather Information Data Base to be published and integrated into one service, enabling NEVS to act as the SAS of verification. Critical to this role is the ability to integrate non-meteorological information provided by other services within the software architecture. NEVS contains a wide array of verification approaches and metrics. Beyond the standard dichotomous and probabilistic measures, it provides object-based analysis, computation of non-parametric confidence intervals on statistics, and evaluation of forecasts on air traffic sector grids.

NextGen will demand automated access to verification information; however, the near-term NEVS effort must support human access as well. Figure 3 depicts the type of output available through the proof-of-concept web interface.

Planned for release in late 2008, the next version of NEVS will illustrate new capabilities based on forecasts for the 2008 convective season. NEVS will also contribute to the 2012 Initial Operating Capability (IOC), a critical milestone for NextGen.

References

Callaham, M., DeArmon, J., Cooper, A., Goodfriend, J., Moch-Mooney, D., and Solomos, G., 2001: Assessing NAS Performance: Normalizing for the Effects of Weather. 4th USA/Europe Air Traffic Management R&D Symposium, Santa Fe, NM.

Kay, M.P., S. Madine, J.L. Mahoney, and J.E. Hart, 2007: 2007 Convective Forecast Scientific Evaluation. Prepared for the FAA System Operations Group.

NASA Group Achievement Award

Don Hillger was part of a Group Achievement Award presented to the GOES-N Series Team by the National Aeronautics and Space Administration (NASA) in April. The award was recognition "for providing the next generation of advanced weather satellites, a service essential to the Nation." Hillger coordinated the GOES-13 Science Test, which occurred at the end of Post Launch Testing for GOES-13 in December 2006, and was assisted by many other scientists who analyzed the data from GOES-13, whose efforts were complied into *NOAA Technical Report NESDIS 125*, available at http://rammb.cira.colostate.edu/projects/goes_n/.

GSD Certificate of Appreciation

The following CIRA researchers (along with their federal colleagues) were recognized with a Certificate of Appreciation at the GSD "Town Hall" meeting on April 16 for their contributions to the integrated demonstration of GSD global modeling (Flow-following finite-volume Icosahedral Model – FIM), supercomputing, data management, and information systems efforts for Mary Glackin (NOAA Deputy Under Secretary for Oceans and Atmosphere) during her visit to ESRL on March 6.

- Setting Up Real-Time FIM Runs on wJet and Getting Output on/public in a Timely Manner – Bob Lipschutz (Coordination of Team Activities), Paul Hamer, Patrick Hildreth, and Chris MacDermaid
- FIM Code Management with Subversion and GForge/Allowing Well-Controlled Frequent Changes to FIM from Developers – Tom Henderson and Richard Ryan
- Actual Code Developers for FIM Model and Post-Processing/Many Key Changes Over a Three-Week Period – Jacques Middlecoff and Ning Wang
- FIM Display Capabilities on Science On a Sphere® – Steve Albers, Mike Biere, and Jebb Stewart
- FIM Display Capabilities Using ALPS – Tom Kent
- FIM Display Capabilities for Hall Display – Kevin Brundage and Brian Jamison

NASA Honor Award to Graeme Stephens and Phil Partain

Graeme Stephens received an Exceptional Public Service Medal at an award ceremony

held at JPL July 23, 2008. He was honored for his exceptional scientific leadership of the CloudSat Project and for his visionary promotion of combined active and passive measurements for atmospheric science. This is a prestigious NASA award that is presented to a number of carefully selected individuals and teams who have distinguished themselves by making outstanding contributions to the NASA mission.

Phil Partain also received an Exceptional Public Service Medal for his unique contributions to the CloudSat mission. Phil began his association with the CloudSat mission in 2000, when he was assigned to develop the Level 2 science data processing infrastructure for the CloudSat data processing center. Phil combined an existing university prototype with numerous innovations of his own to develop an advanced Level 2 processing system that

has been recognized as state of the art by experts from JPL, GSFC, and LaRC.

IRC Gold Medal to Graeme Stephens

The IAMAS International Radiation Commission (IRC) selected Graeme Stephens as the awardee of an IRC Gold Medal. This medal is given to a world's key scientist who made a great contribution to the radiation community. Graeme was invited to speak at the International Radiation Symposium 2008 and receive his pure gold medal at that time.

2008 OAR Outstanding Scientific Paper Award

"A measure of the effectiveness of a research organization is the number and quality of its scientific publications. The Outstanding Scientific Paper Awards were established to recognize the NOAA Office of Oceanic and Atmospheric Research (OAR) Federal employees, and Cooperative Institute (CI) scientists associated with OAR who published outstanding scientific peer-reviewed research papers, review papers, books, monographs, and chapters of books that have contributed to or contain the results of research sponsored by OAR.

I would like to congratulate you on the excellent science conducted by ESRL GSD and notably acknowledge the work of Tracy Lorraine Smith, Stanley G. Benjamin, Seth I. Gutman, and Susan Sahm on the "Short-range Forecast Impact from Assimilation of GPS-IPW Observations into the Rapid Update Cycle", Monthly Weather Review, Vol. 135, C03S90, doi: 10.1175/MWR3436.1. This paper was deemed to be one of the most original, important, useful, and best written, by a team of reviewers and has been awarded the 2008 OAR Outstanding Scientific Paper Award. We received many excellent papers this year and congratulate your Laboratory and the work of your scientists on their efforts towards this accomplishment."

– Richard Spinrad

"Congratulations to Tracy Smith, Stan Benjamin, Seth Gutman, and Susan Sahm of GSD for having been awarded the 2008 OAR Outstanding Scientific Paper Award. This is one of three papers that we submitted for consideration, and two of the three were awarded to GSD scientists. This is truly a remarkable achievement for GSD!"

– Steve Koch

This paper describes the results of experiments on the improvement of weather model forecasts using GPS integrated precipitable water (GPS-IPW). It uses an innovative evaluation technique, and is particularly broad in the duration of the study. The Rapid Update Cycle (RUC) hourly data assimilation has already had huge operational significance, and this paper clearly shows that RUC forecasts are improved by assimilation of GPS-IPW observations. This impact of GPS-IPW observations in the RUC is extensive, affecting guidance for forecasters from the National Weather Service forecast offices who use the RUC routinely for short-range guidance, and also for forecasters from the NOAA Storm Prediction Center producing severe weather watches and NOAA Aviation Weather Center for making aviation weather advisories. The published results of this paper have been instrumental in considering NOAA adoption of GPS-IPW observations.

2008 CIRA Research Initiative Award Winners

Paul Hamer

Paul, an employee of CIRA in Boulder, has been instrumental in developing and supporting the Object Data System (ODS) software architecture that underlies the success of the Central Facility data system of the NOAA ESRL Global Systems Division (GSD). As

a result of Paul's work, the ODS methods routinely and reliably accommodate ingest data formats such as GOES GVAR, WSR-88D Level-II, GRIB Edition-1 and -2, BUFR and ASCII. Paul's leadership in developing ODS has provided GSD with an asset that is the foundation upon which many of GSD's successful projects rely.

Jeff Smith

Jeff, an employee of CIRA in Boulder, has significantly impacted the Global Systems Division in respect to web applications, web services, and java programming. He led the design and development of Weather Research and Forecast Domain Wizard, (a graphical tool used to define the spatial domain needed to run the new WRF Pre-processor System), he helped to design and develop the WRF Portal (a java application which allows users to develop, configure, run, and monitor the execution of complex WRF model workflows), he developed a java training course for the ESRL staff, and he won a web award for his work on Data Locator (a web services based data access and display capability, which was an integral part of exploratory work on the Open Geospatial Consortium Web Coverage Service).

Andrea Schumacher

Andrea, an employee of CIRA in Fort Collins, worked as part of a NESDIS team on the development and transition of a new operational NESDIS product for estimating the probability of tropical cyclone formation. Andrea took the lead on generalizing the product to include the central and western north Pacific, and at present the final product is in the final stages of transition to NESDIS opera-

tions. The NOAA members of the NESDIS team on which Andrea worked, received the NOAA Bronze Medal for their work. (Unfortunately Andrea could not receive this same honor because she was not an employee of NOAA.)

Thank You to those who nominated individuals for consideration and to the members of the committee who reviewed the nominations!

May 2008 Team Member of the Month – Chris MacDermaid, Information & Technology Services

Chris MacDermaid is ITS' nomination for GSD's Team Member of the Month for May 2008. He is recognized for his dedication to providing outstanding customer support as well as his exceptional skills and knowledge of data systems.

Chris leads the Data Systems Group (DSG) within ITS. His group works with GRIB, BUFR, GVAR, METAR and other data. Some of the projects supported by Chris' group are MADIS, FSL to GSD Web project, ATAMS, RUC, WRF and FIM.

September 2008 Team Member of the Month – Isidora Jankov, Forecast Applications Branch

Dr. Jankov has been a member of FAB for the last three years. After receiving her Ph.D. in 2006 at Iowa State University, Isidora joined the staff as a CIRA-supported postdoctoral associate. In October of 2007, she was hired as a CIRA Scientist.

Isidora has made valuable contributions to the International H2O project and the Hydometeorological Testbed project in ensemble design and optimization. During her tenure at ESRL, she has published numerous papers as primary and co-author. With the recent departure of Dr. Chris Anderson to Iowa State University, Dr. Jankov has taken on the important role of primary modeler for the branch including configuring the realtime system for this year's HMT and California Department of Water Resources Projects.

Dr. Jankov has strong collaborations with other CIRA and CIRES research efforts. She is an absolutely indispensable member of FAB.

Award winning ATS alumni and former CIRA-supported student, Tom Peterson, has accomplished much in recent years

- *NOAA Administrator's Award* "for outstanding leadership in and dedication to developing U.S. CCSP Synthesis & Assessment Products integrating climate research for decision support," with Harold E. Brooks, Roger Pulwarty, Ronald J. Stouffer, Thomas L. Delworth, Robert S. Webb, Douglas Marcy, Robb Wright, Neil Christerson, Adrienne Sutton, Thomas Knutson and Kent Laborde.
- United States Department of Commerce *Gold Medal* Award for Scientific/Engineering Achievement "for improving the understanding of observed climate change and causes by showing that global average atmospheric warming is similar to surface warming" with Thomas R. Karl, Christopher D. Miller, Venkatachalam Ramaswamy, John R. Lanzante, Dian J. Seidel, Russell S. Vose and Richard William Reynolds.
- United States Department of Commerce *Bronze Medal* Award for Superior Federal Service "for developing research-quality radiosonde atmospheric temperature datasets for reliably monitoring climate variations and change," with Imke Durre, Melissa Free, John Lanzante, Jay Lawrimore, and Dian Seidel, 2007.
- United States Department of Commerce *Bronze Medal* Award for Superior Federal Service "for innovative research which led to the production of a unique blended (satellite and ground based) global surface temperature data set," with Alan Basist, Norm Grody and Claude Williams, 2001.
- United States Department of Commerce *Bronze Medal* Award for Superior Federal Service in 1996 "for developing revolutionary new climatological baseline data sets and statistical techniques that reveal accurate long-term climatic trends," with David Easterling.

WRF-ARW EVALUATION

An Evaluation of Various WRF-ARW Microphysics Using Simulated GOES Imagery for an Atmospheric River Event Affecting the California Coast

Isidora Jankov[1], Manajit Sengupta[2], Louis Grasso[2], Daniel Coleman[2], Dusanka Zupanski[2], Milija Zupanski[2], Daniel Lindsey[3], and Renate Brummer[2]

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Affiliated with NOAA/ESRL/ Global Systems Division
[2] Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, CO
[3] NOAA/NESDIS/STAR/RAMMB CIRA/Colorado State University, Fort Collins, CO

Significant precipitation events in California during the winter season are often caused by land-falling "atmospheric rivers" associated with extratropical cyclones from the Pacific Ocean. Atmospheric rivers are elongated regions of enhanced water vapor over the Pacific and Atlantic oceans that can extend from the tropics and subtropics into the extratropics and are readily identifiable using Special Sensor Microwave/Imager (SSM/I) polar-orbiting satellite imagery (Fig. 1). High values of integrated water vapor (IWV) are advected within the warm sector of extratropical cyclones, immediately ahead of polar cold fronts. When an atmospheric river makes landfall on the coast of California, the northwest to southeast orientation of the high terrain produces orographic lifting. As a result, sustained precipitation is typically enhanced and modified by the complex terrain. This has major hydrological consequences. In addition, due to the terrain steepness and soil characteristics in the area, flash flooding and landslides can occur. The importance of gaining an understanding of how forecast models deal with this kind of meteorological event is amplified by the fact that land-falling atmospheric rivers represent a major water source for California's large population.

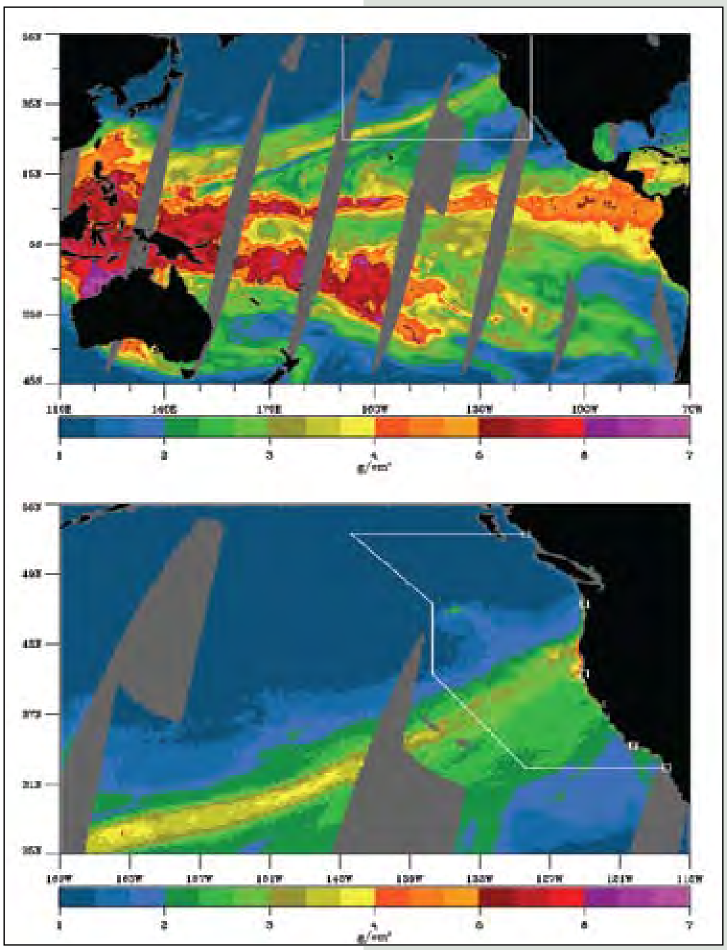


Figure 1. SSM/I images for December 30, 2005 at 00 UTC.

For this type of event, previous studies have shown a large sensitivity of simulated precipitation amounts to the choice of microphysical schemes used in numerical models for weather prediction. The main focus of this research is to assess the differences in performance of various microphysics within Weather Research and Forecasting (WRF) numerical model with Advanced Research WRF (ARW) dynamic core by evaluating simulated brightness temperatures, as opposed to simulated rain. This will be performed by statistically comparing simulated brightness temperatures from various microphysical schemes with GOES-10 observations at 10.7 micrometers. For this purpose, an atmospheric river event that occurred on 30 December 2005 was simulated using four different microphysical schemes (Lin, WSM6, Thompson and Schultz). Synthetic imagery for the simulation was created and scenes from the simulations were statistically compared with observations using a histogram-based technique.

Observational Analysis of the 30 December 2005 atmospheric river event

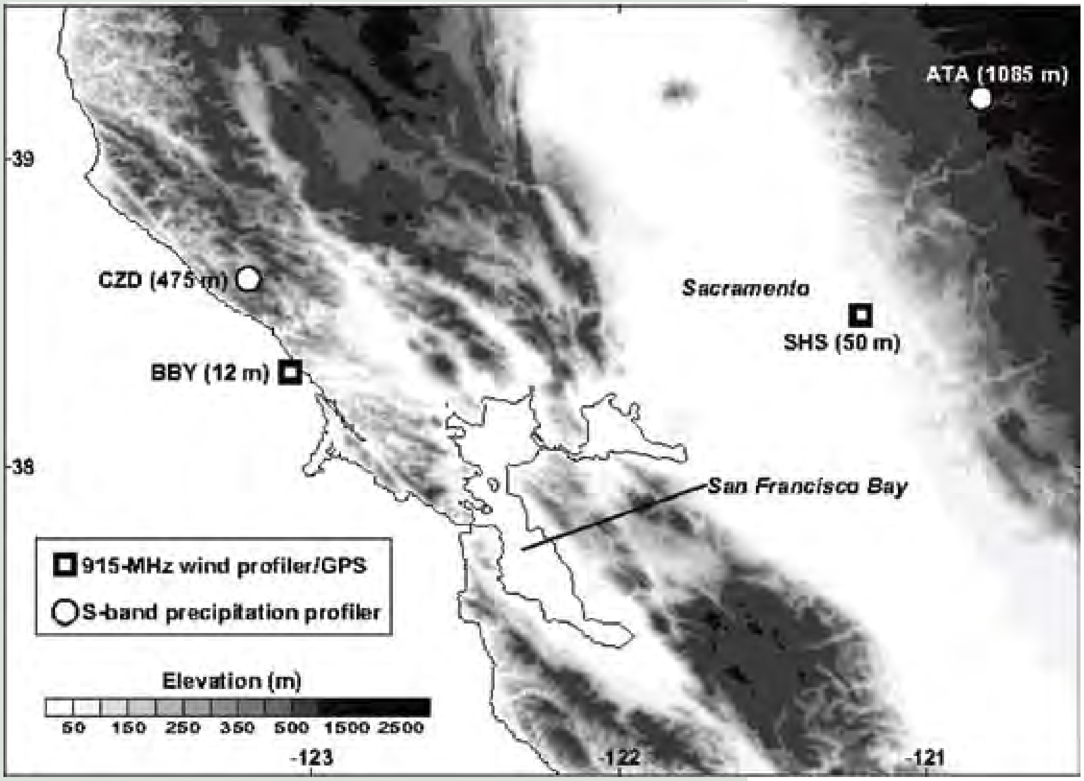
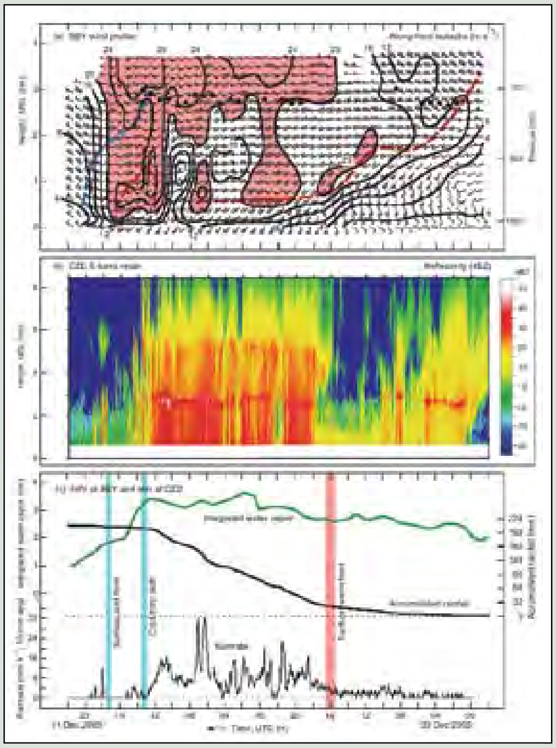


Figure 2. Terrain base map of Northern California, with the wind profiler sites shown at Bodega Bay (BBY) and Sloughhouse (SHS), and the S-band radar sites shown at Cazadero (CZD) and Alta (ATA). Station elevations are shown in parentheses.

Relevant mesoscale attributes for the storm were evaluated based on observations from 915-MHz wind profilers, vertically pointing S-band radars and collocated Global Positioning Systems (GPS) water-vapor sensors, and surface meteorological instrumentation in two key domains: the coastal region northwest of San Francisco and the interior east of Sacramento (Fig. 2). The instrumentation in the coastal region included a wind profiler and GPS device on the coast at Bodega Bay (BBY) and S-band radar in the coastal mountains at Cazadero (CZD). The interior region featured a wind profiler and GPS in the Central Valley at Sloughhouse (SHS) and S-band radar in the Sierra foothills at Alta (ATA). The elevations of these fours sights are 12, 475, 50, and 1085 m, respectively. Finally, all sites were equipped with tipping-bucket rain gauges and towers that recorded standard meteorological surface data every 2 minutes.

The 30-31 December 2005 event was characterized by rain amounts in excess of 200 mm in the mountainous terrain at each S-band radar site. A time-height section of hourly wind profiles and along-front isotachs along the coast at BBY (Fig. 3a) shows the temporal descent of warm-frontal shear (highlighted by a descending axis of thermal-wind-derived warm advection) from roughly 3 km MSL at 22 UTC 29 December to near the surface at 16 UTC 30 December. This was followed by enhanced southwesterly flow and multiple low-level jets (LLJs) in the warm sector. The Integrated Water Vapor (IWV) at BBY attained maximum values between 2.5 and 3.5 cm (Fig. 3c) in the strong warm-sector flow: these values are characteristic of atmospheric rivers. Because the flow is perpendicular to the mountain barrier at CZD (Fig. 4c), it is likely that orographic processes enhanced the rainfall intensity. A cold-frontal passage aloft was captured by the BBY profiler at around 13 UTC 31 December, as evidenced by the commencement and subsequent descent of thermal-wind-derived cold advection and an abrupt decrease in IWV and rain intensity. Four hours later, a robust, surface-based cold front accompanied by a 3-km-deep wind shift from southwesterly to northwesterly flow crossed the profiler. A brief spike in precipitation and a second stepwise decrease in IWV were observed with this front. Concurrent S-band radar observations at CZD (Fig. 3b) documented mostly non-bright band (NBB) rain during the

WRF-ARW EVALUATION



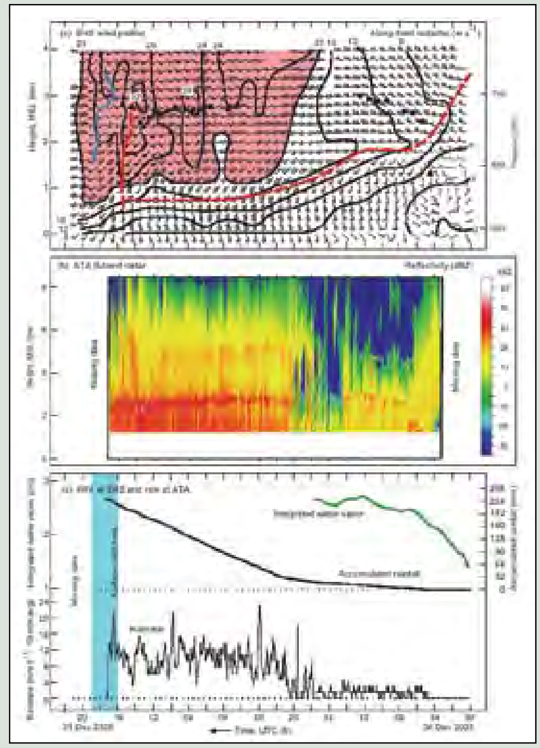


Figure 3. Time series of observations from BBY and CZD between 22 UTC 29 December and 22 UTC 31 December 2005. (a) Time-height section of hourly-averaged wind profiles (wind flags 25 m s-1; barbs = 5 m s-1; half-barbs = 2.5 m s-1), along-front isotachs (directed from 230°; red shading >20 m s-1), bright band melting-level height (bold black dots), and axes of maximum thermal wind-derived warm and cold advection (red and blue dashed lines, respectively), from the wind profiler at BBY. (b) Time-height section of ~1.5-min radar reflectivity (dBZ) from the S-band radar at CZD. (c) Time-series traces of 30-min IWV (cm; green) from the GPS sensor at BBY and 2-min rain accumulation (mm) and rain rate (RR = mm h-1; 10-min averaging period) data recorded at the rain gauge at CZD. The red- and blue-shaded bars in the bottom panel denote warm- and cold-frontal transitions, respectively.

Figure 4. As in Fig. 3, except for SHS and ATA, respectively, between 00 UTC December and 21 UTC 31 December 2005.

warm-frontal descent and a mix of NBB and bright band (BB) rain in the warm sector. The precipitation immediately preceding the cold frontal passage, which represented a period of enhanced and deep mesoscale forcing, exhibited the strongest BB characteristics during the event.

This event was also well documented along the windward slope of the Sierras at SHS and ATA (Fig. 4), although the meteorological transitions here were not nearly as well-defined as along the coast (Fig. 3). This difference arose due to the presence of deep, blocked flow along the windward slope of the tall Sierras but not along the windward slope of the much shallower coastal mountains. Most notably, the terrain-parallel or blocking component (i.e., the south-southeasterly component) of the flow at SHS was much deeper at SHS than at BBY. Because the deeper-blocked flow at SHS tended to mask the transient meteorological features during this event, it was crucial to analyze these interior observations within the context of what was analyzed along the coast at BBY and CZD.

Simulated brightness temperatures of various WRF-ARW microphysical algorithms

As previously mentioned, the WRF-ARW simulations of the 30 December 2005 event were carried out by using four different microphysical algorithms. The integrations were performed over a 48-hour period and contained two grids, one of which was nested. Grid spacings for both of these grids were 20 km and 4 km, respectively. The grid spacing of 4 km for the inner grid was chosen to match the approximate footprint of GOES-10. For the statistical analysis 15-minute model output was used. To compute the brightness temperature, an observational operator developed at CIRA was utilized. The three main components of the operator are gas extinction model, hydrometeor optical property models and radiative transfer models. Gas extinction

was computed using optical transmittance code, called OPTRAN. Modified anomalous diffraction theory was used to compute hydrometeor optical properties. The gaseous extinction and hydrometeor properties were fed into a radiative transfer model which computes brightness temperatures. The four microphysical schemes used in this study only predict the mass mixing ratio for each hydrometeor. The observational operator requires not only mass mixing ratio, but also number concentration. As a result, particle number concentrations were specified. Brightness temperatures for simulations using various microphysics algorithms were calculated and statistically compared with observations using a histogram-based technique.

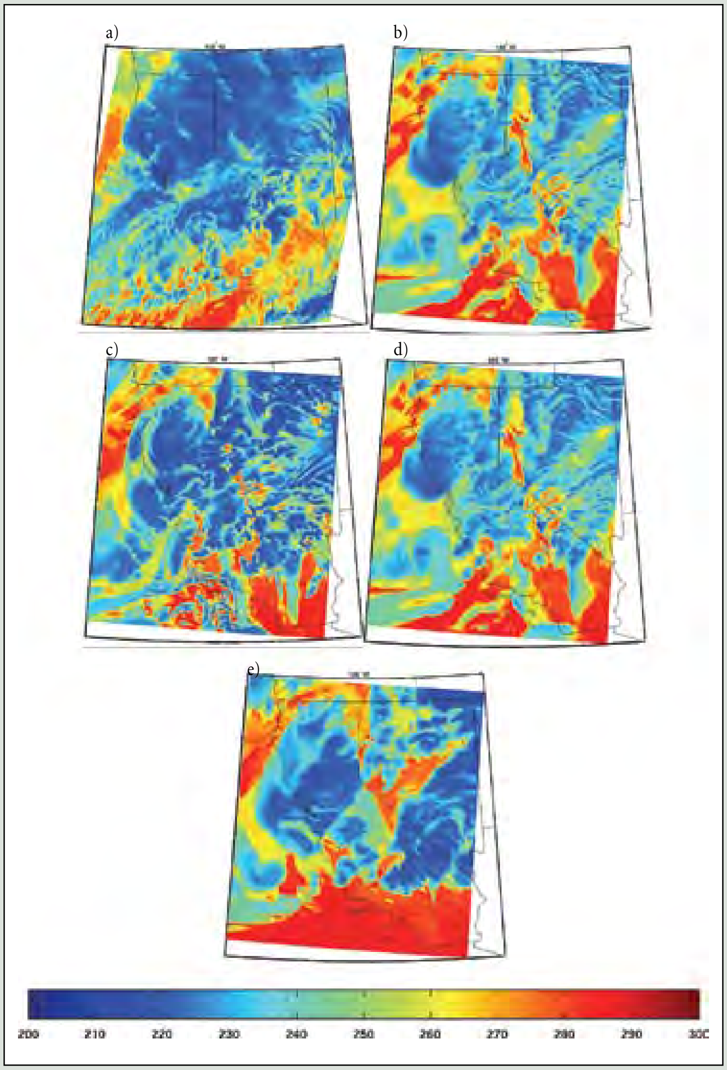


Figure 5. UTC 30 December 2005 a) observed and simulated brightness temperatures by the WRF-ARW model using b) Lin, c) WSM6, d) Thompson and e) Schultz microphysical algorithms.

Figure 5 shows observed brightness temperature and brightness temperatures simulated by four different model configurations valid at 31 December 2005 at 00 UTC. At this time over the northeastern part of the domain, generally covered with clouds, all model configurations (Figs. 5b-e) resulted in brightness temperatures to a greater or a lesser extent warmer compared to the observations (Fig. 5a). In terms of the southern part of the domain, or more precisely over the southeastern corner of the domain, the model simulations were generally characterized by larger areas of higher values of brightness temperatures compared to the observations. This was especially true for the model runs using Thompson and Schultz microphysics. Probability of occurrence of certain brightness temperatures in GOES-10 10.7 μm observed data are presented as a histogram in Fig. 6. The corresponding histograms for each of the different model configurations are presented in Fig. 7. The histogram containing observations indicates two maxima in probability of occurrence with the primary maximum centered on ~220 K and the secondary on ~260 K. Generally, all model simulations depicted the primary maximum well (Figs. 7a-d) with the model simulation using WSM6 microphysics demonstrating the closest resemblance to the observations. The secondary

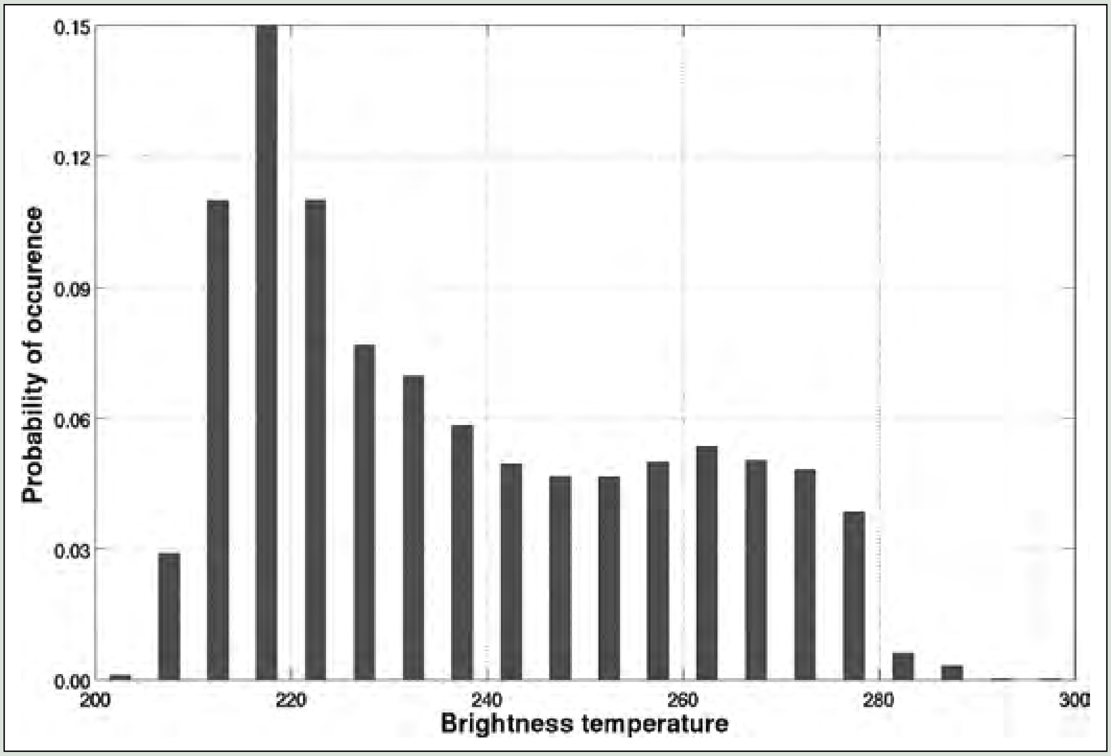


Figure 6. A histogram of the probability of occurrence of observed GOES-10 brightness temperatures.

maximum was, in general, overestimated by all model configurations except for the model simulation using Lin microphysics (Fig. 7a) which performed somewhat better than other simulations when compared to observations.

Lastly, Fig. 8 shows GOES-10 10.7 µm 24-hour observed brightness temperature plotted versus brightness temperatures simulated by various model configurations. It can be seen that for lower values of brightness temperatures (~220 K – 230 K) all model configurations showed generally good agreement with the observations. The same was true for high values of brightness temperatures (~ 260 K), while for the range of brightness temperatures from 230 K to 260 K a presence of moderate to large bias was detected for model runs using Schultz and Thompson microphysical algorithms. This warm bias in the brightness temperature may indicate that the two schemes had fewer high clouds and more mid-level clouds than observed.

Overall, the results demonstrate potential of the statistical method utilized in the present study in evaluation of performance of various microphysical algorithms. This type of analysis could be very useful for better understanding and improvement of existing microphysical schemes, which will be part of future studies.

Acknowledgement

The authors would like to thank Paul Neiman for his help with mesoscale analysis of the event used in the present study.

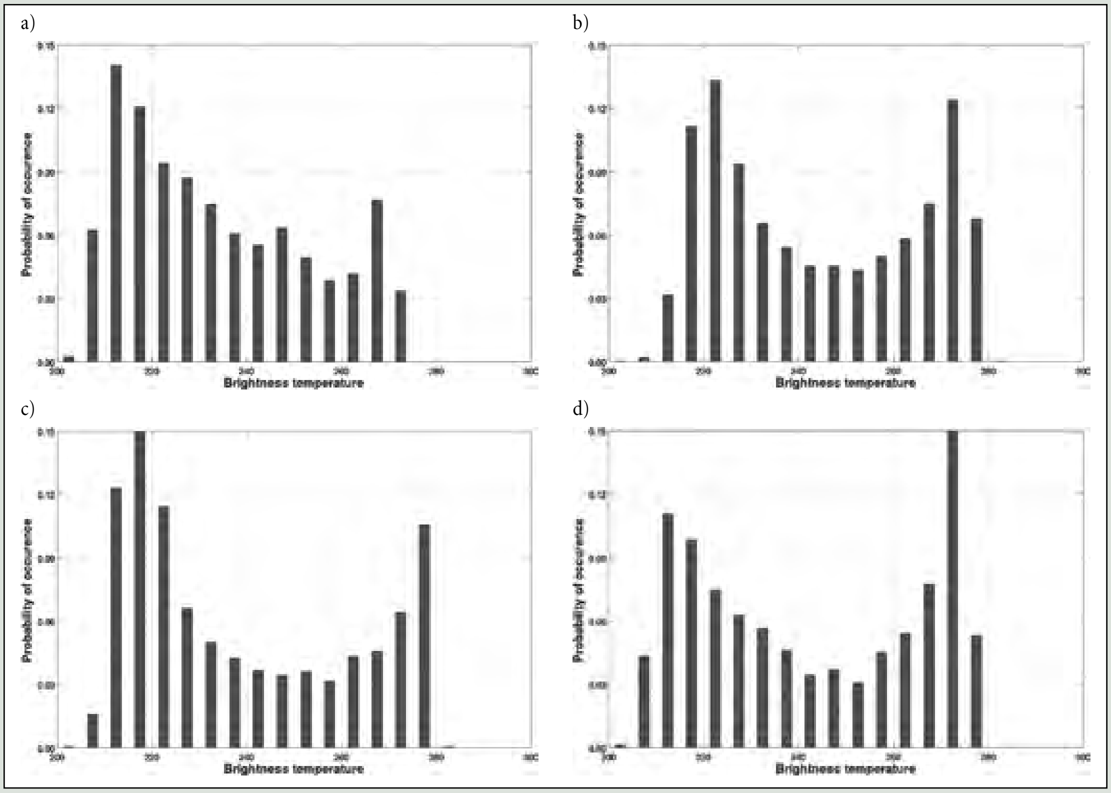


Figure 7. As in Fig. 6 except for simulated brightness temperatures from the a) Lin, b) WSM6, c) Thompson, and d) Schultz microphysical algorithms.

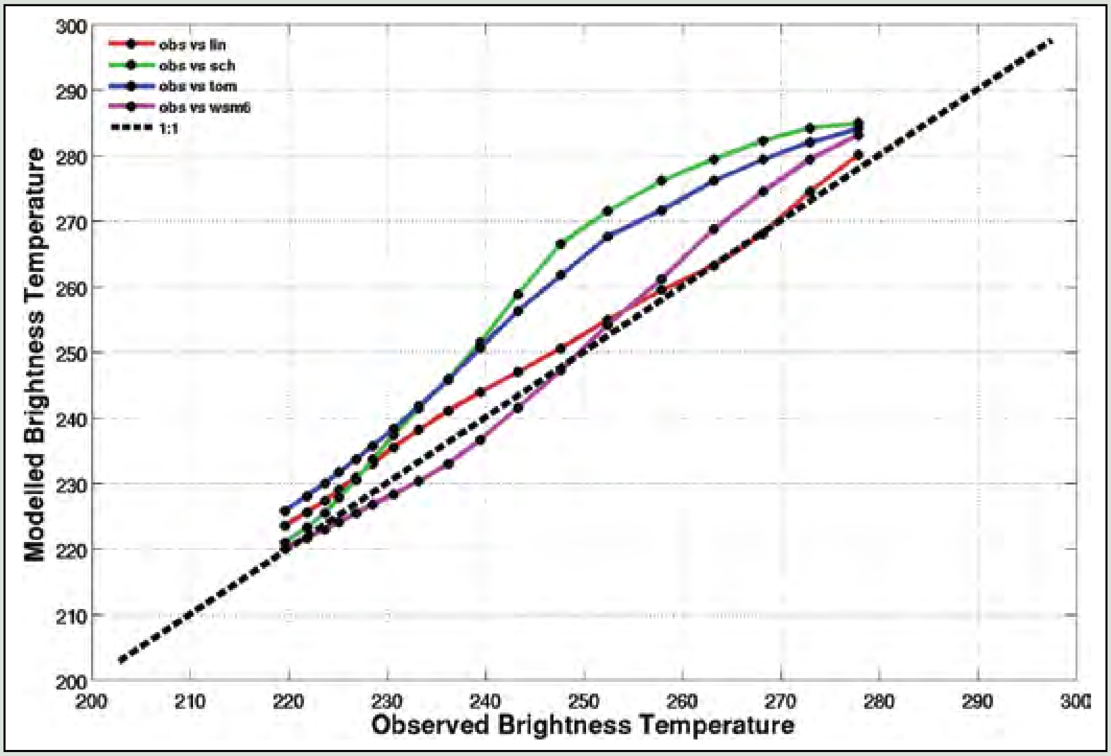


Figure 8. GOES 10 10.7 µm 24-hour percentiles of observed versus simulated brightness temperatures.

FOUNDING DIRECTOR

Thomas H. Vonder Haar
CIRA Founding Director

CIRA...From a Vision to Reality...

In the late 1970s, Tom Vonder Haar had a vision of a center for interdisciplinary research. In September 1980, that vision became a reality when the Cooperative Institute for Research in the Atmosphere at Colorado State University opened its doors.

Since that day, CIRA has grown into a prestigious research institute currently employing more than 130 people. This, of course, would not have been possible without the orchestration of our Founding Director and the cooperation among NOAA, CSU and our research partners.

Thank you, Tom, for the opportunity you afforded us over the past 28 years.

Graeme Stephens presents Tom Vonder Haar with a token of CIRA's appreciation for his dedicated leadership over the past 28 years.

Department of Atmospheric Science Head, Richard Johnson, speaks of Tom's time at CIRA.

The faces of CIRA.

CloudSat Views Double Intertropical Convergence Zone

Heather Quantz

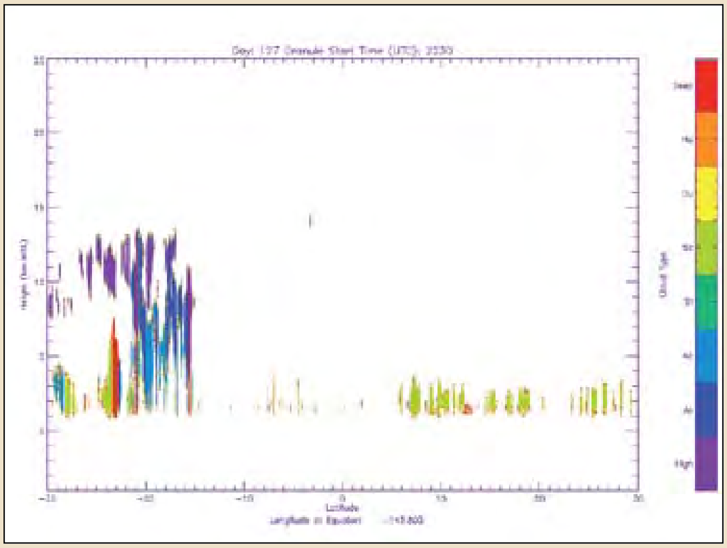


Figure 1. Cloudsat cloud classification, May 7, 2007

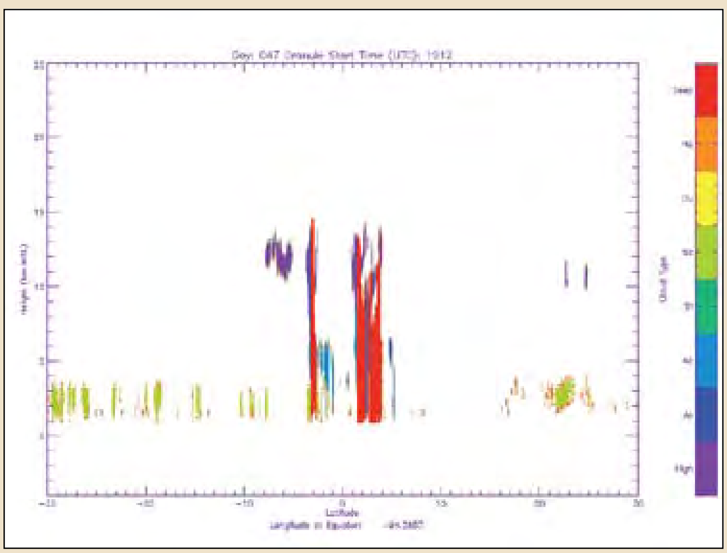


Figure 2. CloudSat cloud classification, February 16, 2007

During the boreal spring of 2007, CloudSat made numerous passes over the Eastern Pacific, often catching glimpses of the Double Intertropical Convergence Zone (DITCZ) in its path. An exploratory study of this poorly understood phenomenon makes use of these overpasses to document the existence, duration, and vertical cloud structure of the DITCZ between February 15 and May 15.

The preliminary results offer a novel look at the vertical structure of the branches of the DITCZ. Four example cases of the cloud types within the branches are shown in the figures 1-4, which were derived from the CloudSat 2B-CLDCLASS product. Figure 1 depicts the zone late in the season on May 7 when there is no apparent DITCZ. Figure 2 provides an example of a case where both branches of the DITCZ are present, but the northern branch is markedly stronger than its counterpart. This case is especially interesting because it is from a pass that took place on February 16, almost a month before most previous studies begin their DITCZ documentation. Figure 3 similarly shows a case where both branches are seen, but in this case from March 26, the southern branch is noticeably stronger. Finally, Figure 4 shows an example of a case from March 4 in which both branches are present and, at least visually during this pass, equal in strength. The corresponding GOES visible satellite image to Figure 4 is shown in Figure 5 for comparison.

In further study, February 15-May 15 of 2008 will be similarly processed and the data from both years will be examined to provide comparisons and to perform a small-scale statistical analysis over the entire time period. Additionally, sea surface temperature (SST) and other data will be added to the analyses in order to see any correlation between the convection or lack thereof and the SST maxima, wind variations, and related factors.

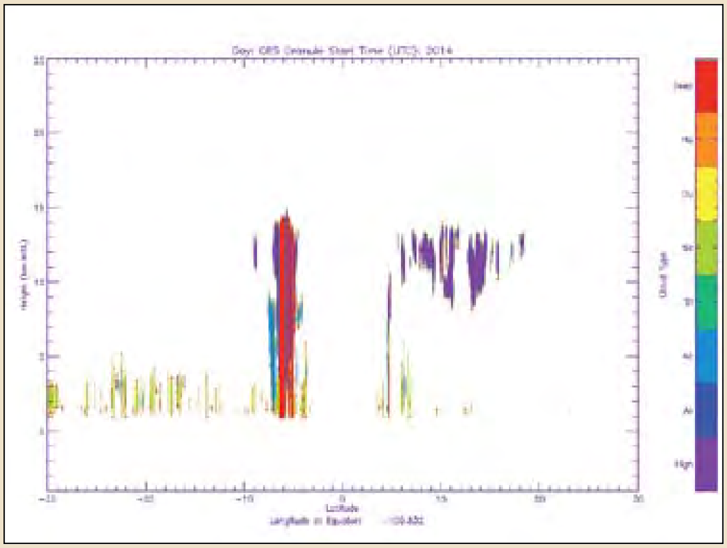


Figure 3. CloudSat cloud classification, March 26, 2007

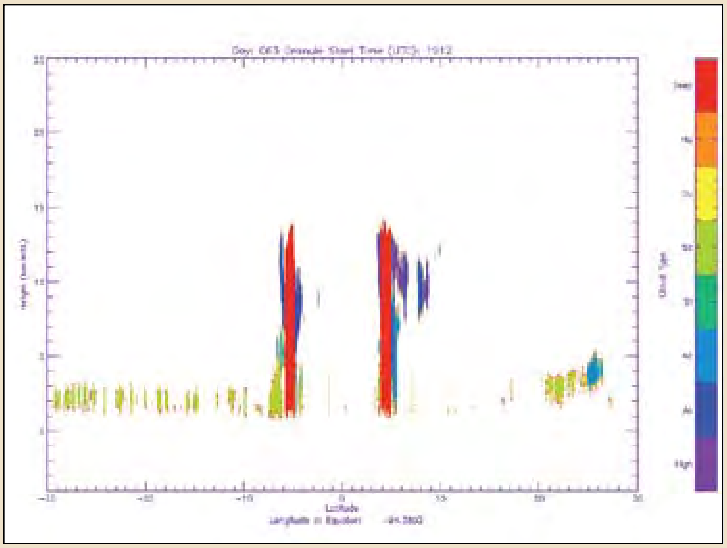


Figure 4. CloudSat cloud classification, March 4, 2007

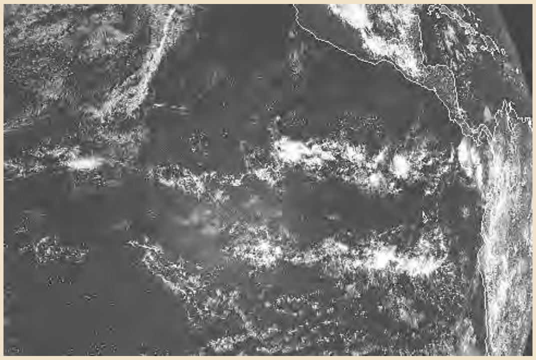


Figure 5. GOES visible satellite image, March 4, 2007

CREST VISITORS

CREST Students Visit CIRA

John Forsythe

On August 14-15, five students from NOAA's Cooperative Remote Sensing Science and Technology Center (CREST) visited CIRA as part of the NESDIS cooperative institute student exchange program. This summer program provides an opportunity for students at the NESDIS cooperative institutes to visit other cooperative institutes and related NOAA facilities. Julia He, Marzieh Azarderakhsh, Hamidreza Nourouzi, Javier Mendez-Rodriguez and Melvin Cardona-Soto from CREST visited CIRA and met with a variety of CIRA scientists. John Forsythe hosted the students.

The students are all working on their Masters and Ph.D. degrees at CREST. Julia He is working on GOES aerosol retrievals over land. Marzieh Azarderakhsh is studying the variability of the hydrologic cycle and surface flooding over the Amazon and Africa. Hamidreza Nourouzi's research aims to better characterize microwave land surface emissivity so that passive microwave satellite data can be exploited more fully. Javier Mendez-Rodriguez operates a lidar at the University of Mayaguez in Puerto Rico and is studying aerosol properties. Melvin Cardona-Soto is examining improvements to precipitation retrievals from GOES over Puerto Rico, where the heritage hydroestimator technique performs poorly with warm rain processes.

Several CIRA and CSU Department of Atmospheric scientists discussed their work with the students and provided ideas for their research. Topics covered included data assimilation and non-Gaussian variables, the CloudSat Data Processing Center, National Park Service aerosol measurement programs, applications of the GOES satellite, microwave radiative transfer, blended water vapor products, and climate research on water vapor. A tour of the atmospheric chemistry laboratories in the Department of Atmospheric Science provided an exciting look at how aerosol properties are measured. A lunchtime session with the Vonder Haar group students allowed the CREST students to discuss similarities and differences in student life. CIRA Deputy Director Steve Miller gave a lunchtime presentation to the student group on his discovery of large areas of bioluminescence ("milky seas") from

Caption: CREST students (left to right) Julia He, Marzieh Azarderakhsh, Hamidreza Nourouzi, Javier Mendez-Rodriguez and Melvin Cardona-Soto visited CIRA in August to meet CIRA scientists and learn about CIRA research.

space, which carried the inspirational message that completely new discoveries can still be made with remote sensing.

The students attended the daily satellite-focused weather discussions at CIRA (CIRA Newsletter, Spring 2006) and were interested in starting such a discussion at CREST. The student exchange program is a valuable mechanism for students from across the NOAA cooperative institutes to broaden their understanding of the field and to receive expert advice on their research.

Thanks to all of those at CIRA/ATS who generously took time to discuss their research with the visiting students! Many thanks to CIRA scientists Doug Braun, Dan Bikos, Stan Kidder, Steve Fletcher, Milija Zupanski, Don Reinke, Bret Schichtel, Jenny Hand, Steve Miller and Don Hillger. The assistance of Chris Kummerow, Wes Berg and Tristan L'Ecuyer of the CSU Department of Atmospheric Science along with graduate students Kelley Johnson and Laurie Mack from Sonia Kreidenweis' group is greatly appreciated. Kathy Fryer and Holli Knutson of CIRA were instrumental in organizing travel and logistics.

CIRA Mission

The mission of the Institute is to conduct research in the atmospheric sciences of mutual benefit to NOAA, the University, the state, and the nation. The Institute strives to provide a center for cooperation in specified research program areas by scientists, staff, and students and to enhance the training of atmospheric scientists. Special effort is directed toward the transition of research results into practical applications in the weather and climate areas. In addition, multidisciplinary research programs are emphasized, and all university and NOAA organizational elements are invited to participate in CIRA's atmospheric research programs.

The Institute's research is concentrated in several theme areas that include global and regional climate, local and mesoscale weather forecasting and evaluation, applied cloud physics, applications of satellite observations, air quality and visibility, and societal and economic impacts, along with cross-cutting research areas of numerical modeling and education, training, and outreach. In addition to CIRA's relationship with NOAA, the National Park Service also has an ongoing cooperation in air quality and visibility research that involves scientists from numerous disciplines, and the Center for Geosciences/Atmospheric Research based at CIRA is a long-term program sponsored by the Department of Defense.

Cooperative Institute for Research in the Atmosphere

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