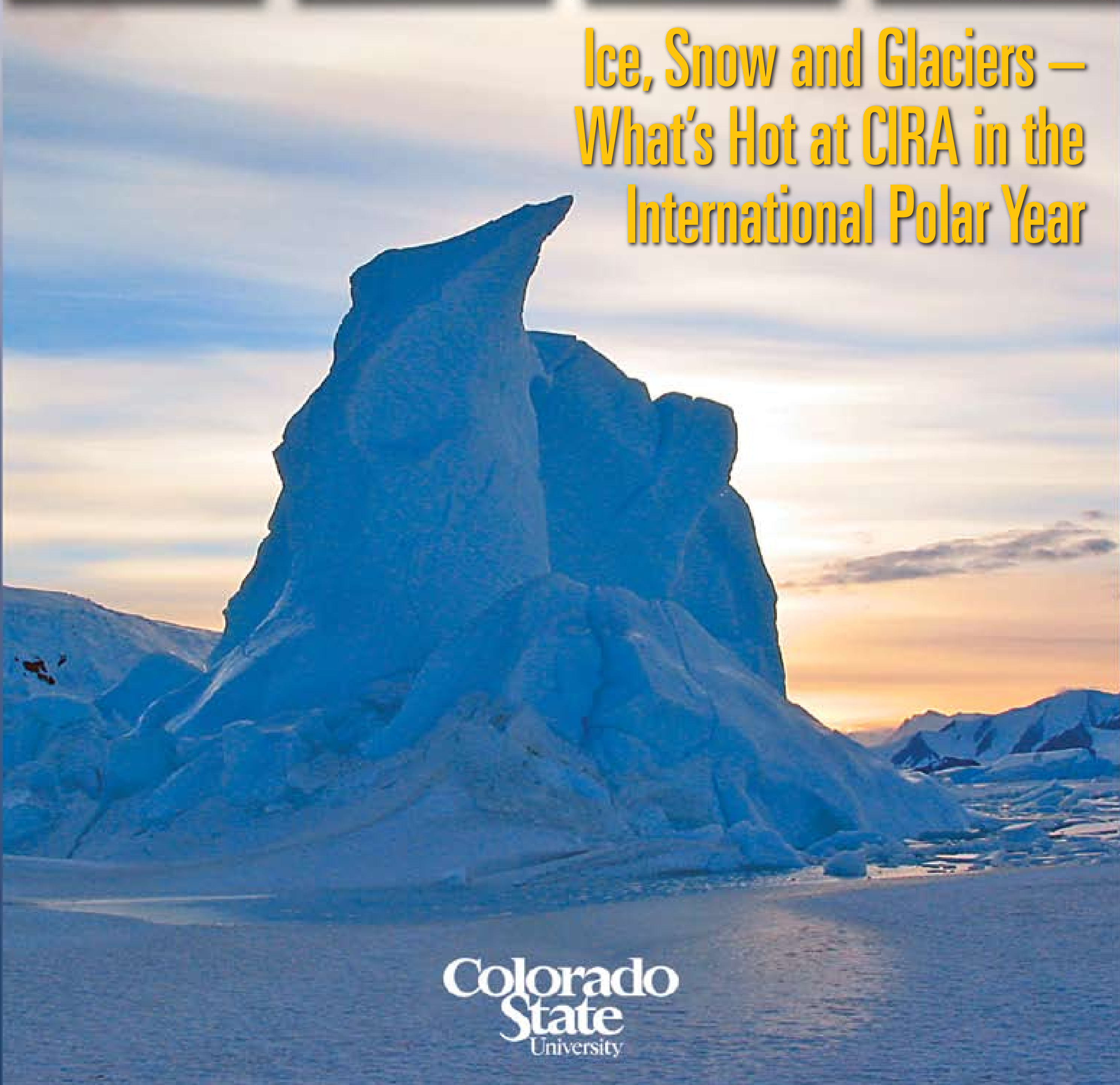
Ice, Snow and Glaciers – What's Hot at CIRA in the International Polar Year

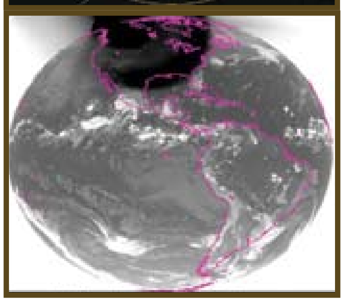


Colorado State University

VOLUME 27, SPRING 2007

CONTENTS



Photos at left, from top: Mode of travel during the Arctic Alaska traverse/expedition; Dunn Elementary students listen to Don Hillger's presentation on satellites; Mt. Augustine volcanic ash visible on radar data on the VACT system; sequences of images comparing GOES-13 to GOES-12 through eclipse.

About the cover: Photo courtesy of the U.S. Antarctic Program's Photo Library. Photograph by: Ken Ryan, National Science Foundation, November 20, 2003. A penguin-shaped iceberg trapped in sea ice at Cape Hallett, Antarctica, in northern Victoria Land.

CIRA

Cooperative Institute for Research in the Atmosphere

www.cira.colostate.edu

Magazine Staff

Mary McInnis-Efaw, Editor
Laura Grames, Assistant Editor

Design

Communications and Creative Services, Colorado State University

Technical Committee

Bernadette Connell, Doug Fox, Cliff Matsumoto, Donald Reinke

2007-2008 INTERNATIONAL POLAR YEAR

CIRA Participation in the 2007-2008 International Polar Year

by Glen E. Liston*

** Text for this article's introduction was provided by the IPY International Program Office, Cambridge, UK. (http://www.ipy.org/)*

The International Polar Year (IPY) is a large scientific program focused on the Arctic and Antarctic from March 2007 to March 2009.

IPY, organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO), is actually the fourth polar year, following those in 1882-3, 1932-3, and 1957-8. In order to have full and equal coverage of both the Arctic and the Antarctic, IPY 2007-8 covers two full annual cycles from March 2007 to March 2009 and will involve over 200 projects, with thousands of scientists from over 60 nations examining a wide range of physical, biological, and social research topics. It is also an unprecedented opportunity to demonstrate, follow, and get involved with cutting edge science in real-time.

The Urgencies of IPY

Changing Snow and Ice: IPY occurs amidst abundant evidence of changes in snow and ice: 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. Changes in snow cover, sea ice, and permafrost have immediate local consequences for terrestrial and marine ecosystems.

Global Linkages: Changes in the large ice sheets will impact global sea level, affecting coastal cities and low-lying areas. Changes in snowfall and shrinkage of glaciers will influence millions of people whose daily use of water for personal consumption or for agriculture depends on snowpack and glacial sources. Thermal degradation of permafrost will mobilize vast reserves of frozen carbon, some of which, as methane, will increase the global greenhouse effect. Changes in sea ice combined with enhanced river inputs of freshwater will lead to substantial changes in ocean circulation. Warming of polar oceans, coupled with changes in ice coverage and river run-off, will alter marine ecosystems with consequences for globally-significant fisheries.

Figure 1. Petermann Island, Antarctic Peninsula.

Discovery: For a majority of participants, IPY stimulates a sense of urgency and discovery. What secrets, what clues to the planet's past, lie under the ice? How does life survive extreme cold and long dark? What structural and physiological adaptations evolved in cold waters and propagated throughout the oceans? What marvels of photochemistry occur when spring's first light strikes winter snow? How do microbial communities in the upper ocean influence cloudiness in the atmosphere above? What subtle richness of behavior, language, and knowledge has allowed human communities to survive in the Arctic for thousands of years? Can ancient solid silent ice hold so much history and yet change so fast? IPY represents a unique opportunity to push collectively at these intellectual frontiers, to explore unseen places, to develop new concepts and theories, and to set the stage for predictions, assessments, recommendations, and future discovery through international collaboration and partnership.

IPY History

On three occasions over the past 125 years, scientists from around the world banded together to organize concentrated scientific and exploring programs in the Polar Regions. In each major thrust, or "year," scientific knowledge and geographical exploration were advanced, thereby extending understanding of many geophysical phenomena that influence nature's global systems. Each polar year was a hallmark of international cooperation in science. The

2007-2008 INTERNATIONAL POLAR YEAR

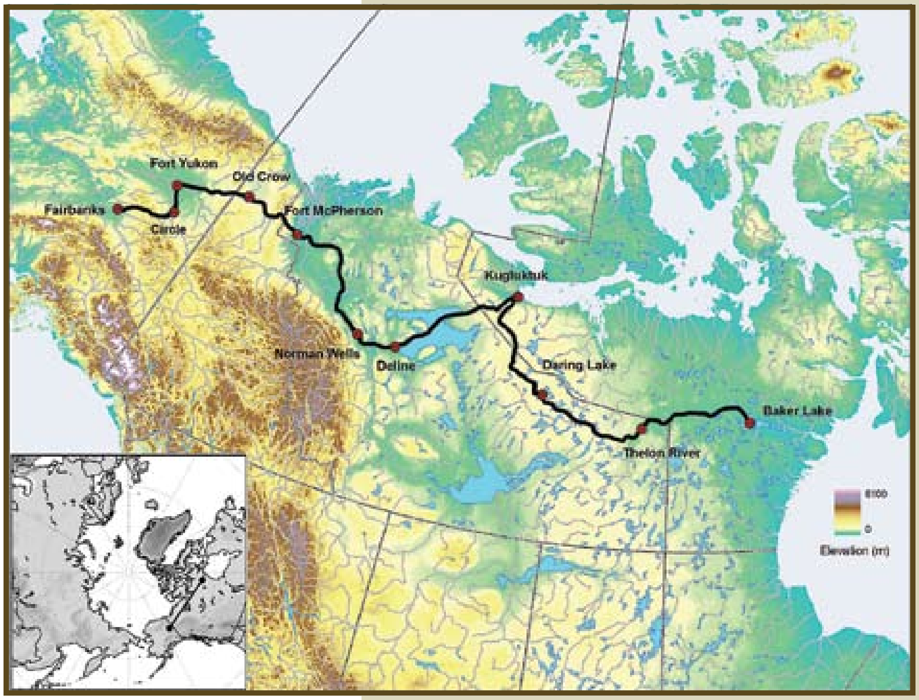


Figure 2. Canadian Arctic, Barrenlands traverse route.

experience gained by scientists and governments in international cooperation set the stage for other international scientific collaboration. International scientific cooperation also paved the way for several political accords that gained their momentum from the polar years. IPY 2007-2008 will expand upon this legacy of scientific achievement and societal benefits.

First International Polar Year (1882-1883): The idea of International Polar Years was the inspiration of the Austrian explorer and naval officer Lt. Karl Weyprecht who was a scientist and co-commander of the Austro-Hungarian Polar Expedition of 1872-74. From his experiences in the Polar Regions, Weyprecht became aware that solutions to the fundamental problems of meteorology and geophysics were most likely to be found near the Earth's poles. The key concept of the first IPY was that geophysical phenomena could not be surveyed by one nation alone; rather, an undertaking of this magnitude would require a coordinated international effort. 12 countries participated, and 15 expeditions to the poles were completed (13 to the Arctic, and 2 to the Antarctic). Beyond the advances to science and geographical exploration, a principal legacy of the First IPY was setting a precedent for international science cooperation.

NOAA has established a fascinating site where photographs and information relating to United States activities during the First IPY are available: http://www.arctic.noaa.gov/aro/ipy-1/

Second International Polar Year (1932-1933): The International Meteorological Organization proposed and promoted the Second IPY (1932–1933) as an effort to investigate the global implications of the newly discovered "Jet Stream." 40 nations participated in the Second IPY, and it heralded advances in meteorology, magnetism, atmospheric science, and in the "mapping" of ionospheric phenomena that advanced radioscience and technology. Forty permanent observation stations were established in the Arctic, creating a step-function expansion in ongoing scientific Arctic research. In Antarctica, the U.S. contribution was the second Byrd Antarctic expedition, which established a winter-long meteorological station approximately 125 miles south of Little America Station on the Ross Ice Shelf at the southern end of Roosevelt Island. This was the first research station inland from Antarctica's coast.

The International Geophysical Year (1957-58): The International Geophysical Year (IGY), 1 July 1957 to 31 December 1958, celebrated the 75th and 25th anniversaries of the First and Second IPYs. The IGY was conceived by a number of post-WWII eminent physicists, including Sydney Chapman, James Van Allen, and Lloyd Berkner, at an informal gathering in Washington, D.C., in 1950. These individuals realized the potential of the technology developed during WWII (for example, rockets and radar), and they hoped to redirect the technology and scientific momentum towards advances in research, particularly in the upper atmosphere. The IGY's research, discoveries, and vast array of synoptic observations revised or "rewrote" many notions about the Earth's geophysics. One long disputed theory, continental drift, was confirmed. A U.S. satellite discovered the Van Allen Radiation Belt encircling the Earth. Geophysical traverses over the Antarctic icecap yielded the first informed

Figure 3. Mode of travel during the traverse (Arctic Alaska).

Figure 4. Collecting snow-chemistry samples.

estimates of the total size of Antarctica's ice mass. For many disciplines, the IGY led to an increased level of research that continues to the present. The world's first satellites were launched. A notable political result founded on the IGY was ratification of the Antarctic Treaty in 1961. The scientific, institutional, and political legacies of the IGY endured for decades, many to the present day.

CIRA IPY Activities

CIRA is involved with three IPY projects, each relating to Arctic and/or Antarctic snow-related features and processes.

Arctic Traverse/Expedition: Five Americans and three Canadians will travel from Fairbanks, Alaska, to Hudson Bay (Baker Lake), Canada, in March and April 2007, following the Arctic Circle for much of the route. In keeping with IPY goals, this 4000 km IPY traverse will take us through dozens of historic locations, two remote diamond mines, and 11 villages where we will conduct outreach, assess change, and make snow measurements. Our mode of travel on the trip (snowmobiles) has been shown to smooth and facilitate researcher-villager interactions. In villages, we will share our science and travel experiences with school children and residents. We will carry with us posters, photos, and greetings from more than 40 classrooms participating from around the world.

We also will share our travel experiences more widely via a national web portal (http://www.barrenlands.org) and a book published after the trip. Natural system change will be assessed through: a) comparison of modern scenes with historical journals, sketches, and photographs, b) the collective observations of the traverse participants, who have a cumulative arctic experience of more than two centuries, and c) discussions with the indigenous peoples we meet en route and who take part in the journey. The snow cover measurements (depth and stratigraphy) will be the first-ever systematic measurements across the Arctic Canada Barrenlands. They will be used to improve AMSR-E satellite algorithms for snow mapping. We will also sample snow for soot, mercury, and halogens.

Figure 5. Arctic mountains (Brooks Range, Alaska).

2007-2008 INTERNATIONAL POLAR YEAR

Arctic Winter Precipitation Measurements and Modeling: Temperature and precipitation are two of the most important metrics of climate variability, yet a strong case can be made that our ability to produce accurate and reliable records of arctic precipitation is poor. The root of the problem is that for 8 to 10 months of the year, precipitation falls as a solid (snow, hail, diamond dust, sleet, and rime). Wind, drifting snow, and the propensity for snow to stick to gauges, combine to make monitoring solid precipitation a difficult task. In addition, solid precipitation accumulates and forms a long-lasting snow cover that, if anything, impacts the arctic system even more than the precipitation amount. Both snowfall and snow on the ground are changing, yet we are in a poor position to monitor these changes. Part of the problem is that winter precipitation and snow on the ground are currently monitored by two separate systems.

This project will develop a prototype international network where we will measure snowfall and snow on the ground concurrently, thereby improving our ability to monitor both. At 5 arctic sites (all identified as key locations in a pan-arctic monitoring network in the U.S., Canada, and Russia), we will augment existing meteorological and snow measuring instrumentation with solid-state snow pillows, heated plate precipitation sensors, snow fences (to capture the wind-blown flux), and eddy correlation towers for computation of sublimation. Several times a winter at the sites we will conduct ground surveys of snow cover depth, water equivalent, and other properties using tools that allow rapid collection of extensive data. These will be augmented with aerial photography and airborne remote sensing from inexpensive platforms (kites and UAVs) to visualize drift and deposition patterns. The combined suite of instruments and measurements will allow us to close the winter water balance at each site, for the first time balancing the precipitation with measured accumulation. Using a set of modeling tools (e.g., a melt model, and a transport model for blowing snow), we will (**1**) develop methods and algorithms for quality checking both meteorological and snow data by cross-comparison between sensors and instruments, (**2**) close the water balance in a way that produces more accurate values of winter precipitation and snow on the ground than are currently being collected, and (**3**) apply our methodology to historical data from the existing gauge network to produce better estimates of past trends. This effort is essential if we are to understand arctic precipitation and snow cover trends and variability.

Figure 7. Measuring snowpack properties.

Figure 6. Measuring snow depth and GPS position using automated snow probes.

Antarctic/South Pole Traverse/Expedition: One of the most pressing environmental issues of our time is the need to understand the mechanisms of current global climate change and the associated impacts on global economic and political systems. In order to predict the future with confidence, we need a clear understanding of past and present changes in the Polar Regions and the role these changes play in the global climate system. A significant portion of the fresh water on Earth exists as snow and ice in the Antarctic ice sheet. A massive, largely unexplored region, the East Antarctic ice sheet looms large in the global climate system, yet relatively little is known about its climate variability or the contribution it makes to sea level changes.

The core of this joint Norwegian - United States project involves scientific investigations along two overland traverses in East Antarctica: one going from the Norwegian Troll Station (72º S, 2º E) to the United States South Pole Station (90º S, 0º E) in 2007-2008; and a return traverse starting at South Pole Station and ending at Troll Station by a different route in 2008-2009. This project will investigate climate change in East Antarctica, with the goals of: (**1**) Understanding climate variability in Dronning Maud

Land of East Antarctica on time scales of years to centuries, (**2**) determining the surface and net mass balance of the ice sheet in this sector to understand its impact on sea level, (**3**) investigating the impact of atmospheric and oceanic variability on the chemical composition of firn and ice in the region, and (**4**) revisiting areas and sites first explored by traverses in the 1960s for detection of possible changes and to establish benchmark datasets for future research efforts.

The project includes extensive outreach to the general public both in Scandinavia and North America through the press, television, science museums, children's literature, and websites. Active knowledge sharing and collaboration between pioneers in Antarctic glaciology from Norway and the U.S., with the international group of scientists and students involved in this project, provide a unique opportunity to explore the changes that half a century have made in climate proxies from East Antarctica, scientific tools, and the culture and people of science. The project is a genuine collaboration between nations: the scientists involved have complementary expertise, and the logistics involved rely on assets unique to each nation. It is truly an endeavor that neither nation could accomplish alone, and fits nicely within IPY's framework.

Figure 9. South Pole traverse vehicle.

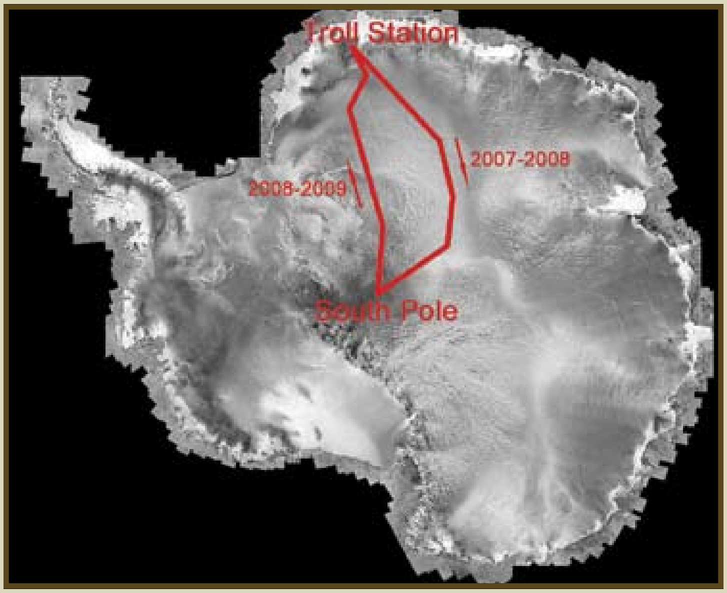


Figure 8. Antarctic, South Pole traverse route.

Figure 10. Ice core drilling for climate reconstruction.

HYDROMETEOROLOGICAL TESTBED

CIRA contributes to the Hydrometeorological Testbed

by Steve Albers, Chris Anderson, Isidora Jankov, and Ed Szoke

The Hydrometeorological Testbed (HMT) is a well-funded, multi-year project (http://hmt.noaa.gov/) designed to improve the use of research quality observations and modeling in operational forecasts of precipitation and streamflow. The first large field campaign was held December 2005 to March 2006 in the American River Basin (ARB) of the Central Sierra Mountains (Fig. 1). CIRA researchers in the Forecast Applications Branch (FAB) are an integral part of ESRL/Global Systems Division's effort to provide high-resolution model analyses and forecasts in support of field operations and NWS operational forecasting.

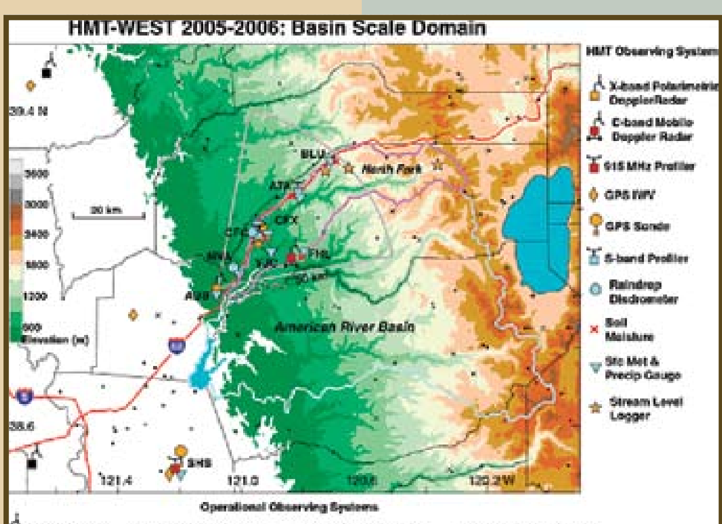


Fig 1. Basin-scale map of the first full-scale deployment of HMT-West 2006 successfully conducted December 2005 - March 2006.

LAPS Analysis

The HMT/LAPS analyses (http://laps.fsl.noaa.gov/) are used to create web graphics for nowcasting, and they provide gridded initial conditions for experimental numerical weather prediction models we are running in support of NWS weather forecast office and river forecast center operations. The analysis software assimilates a wide variety of in-situ and remotely-sensed data including GOES satellite and full volume reflectivity and velocity scans from nine WSR-88D radars. Some experimental observation systems are assimilated as well, including the 915 MHz profilers deployed in the HMT domain by ESRL/Physical Sciences Division (PSD). Several real-time hourly analyses run over the American River Basin, two running at 3-km resolution (Fig. 2a) and a third running at 1-km, were set up and improved. The surface temperature and wind fields

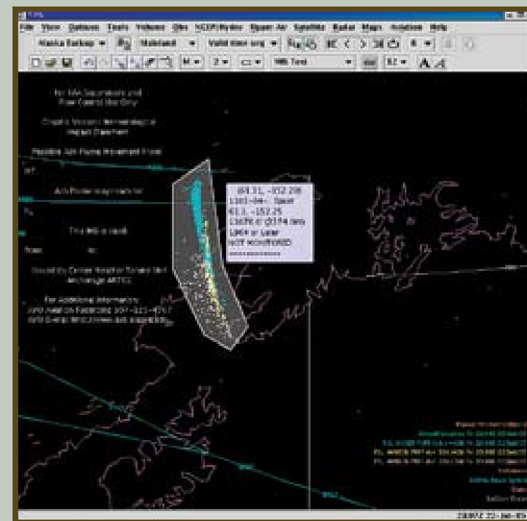


Fig 2a. LAPS hourly analysis of surface temperature and wind for the HMT domain.

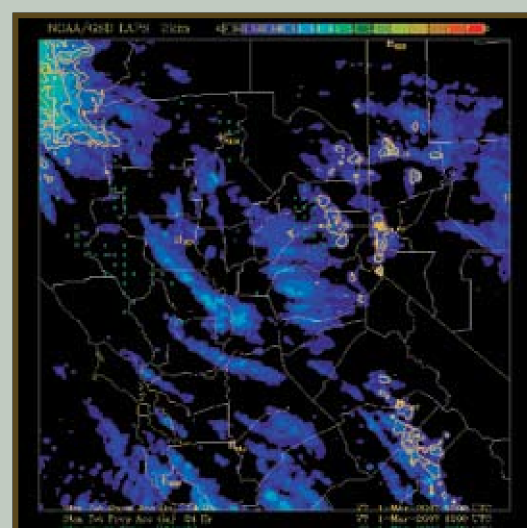


Fig 2b. LAPS analysis of 24-hr. accumulated precipitation (shaded colors), current surface precipitation type (green icons), and 24-hr. snow accumulation (orange contours).

show a wealth of detail related to the topography and land/sea boundary. In Fig. 2b, we can see where in the HMT domain the precipitation (both liquid equivalent and snowfall) has accumulated over the past day, as well as the current location and type of precipitation. This information is useful for a forecaster who may want to anticipate the evolution of precipitation over the ARB, located in the center of the domain.

Fig. 3 shows some of the hydrometeor and related fields that are used in the diabatic "hot-start" process of forecast model initialization. Cloudy and precipitating areas are dynamically included with upward vertical motion for the initial model forecast time steps. This type of plot is also useful in assessing the magnitude and depth of terrain forced upslope flow.

Model Forecasts

By the beginning of the 2005-2006 winter field campaign, a single forecast was operational. The forecast was generated by the WRF-ARW with a nest of two high resolution domains – an outer domain with 3-km grid point spacing covering northern and central California and an inner domain with 1-km grid point spacing covering only the American River Basin Domain. Soon after the beginning of the field project, an ensemble of forecasts was implemented. The ensemble was composed of MM5, WRF-ARW, and RAMS, each using the forecast domain described above. The models were initialized with the LAPS diabatic initialization fields (including wide-band radar data) and integrated to a forecast lead of 12 hours. The forecast cycle was 3 hours, producing 8 forecasts from each model per day. Late in the project, it was determined that forecast lead times of 24 hours were desirable, and the ensemble was reconfigured to contain only one forecast grid (3-km) for which forecasts to 30-hour lead times were produced. Output from each model was available via a webpage developed and maintained at NOAA/GSD.

Forecasts from NWP models are a primary source of guidance to forecasters at forecast lead teams beyond 6 to 12 hours. NWP efforts for HMT are focused on improving precipitation forecasts in order to improve the timeliness of flash flood warnings and the accuracy of stream and river flow predictions. We have tested the utility of a number of aspects of NWP models:

- Would NWS forecasters find value in high-resolution forecasts not available from the national NWP model center?
- Would the NWP model precipitation forecast be improved by ensemble methods?
- Can the NWP ensemble provide reliable probability forecasts of precipitation?

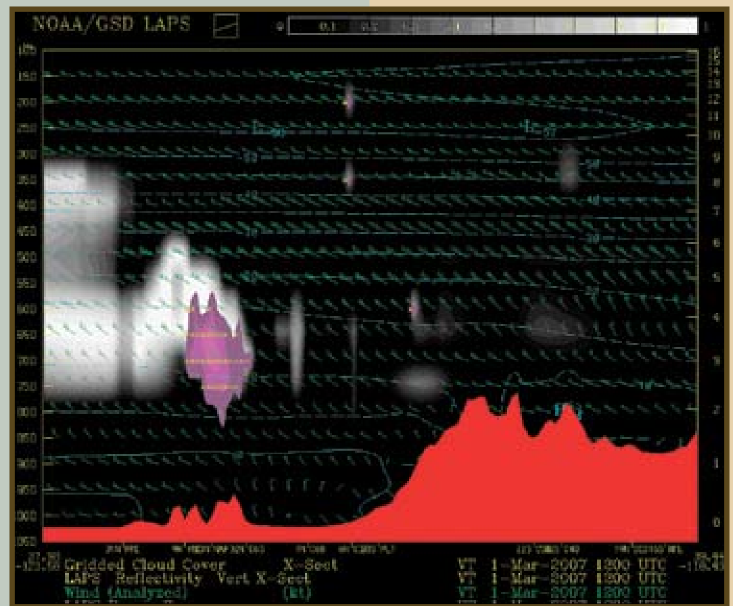


Fig 3. LAPS cross-section of clouds, radar reflectivity, and precipitation type showing mid-level precipitation moving over the California coastal range (left). The section is oriented perpendicular to the Sierra Nevada mountain range (right).

During the 2005-2006 winter field campaign, our goal was to provide a single, high-resolution NWP forecast for the forecasters in the NWS weather forecast and river forecast offices. Initial evaluations of the NWP forecast output produced high praise. Follow-up discussions with NWS forecasters helped guide the NWP model design. By late in the 2005-2006 winter field campaign, a single model with 3-km grid point spacing over a domain of 450 km X 450 km was initialized every three hours (eight times daily), providing forecasters with precipitation forecasts out to a 30-hour lead time.

Evident in Fig. 4a above are narrow regions of 24-hour precipitation accumulation exceeding 200 mm (~7.9 inches). These narrow regions correspond to peaks in the terrain. This information is

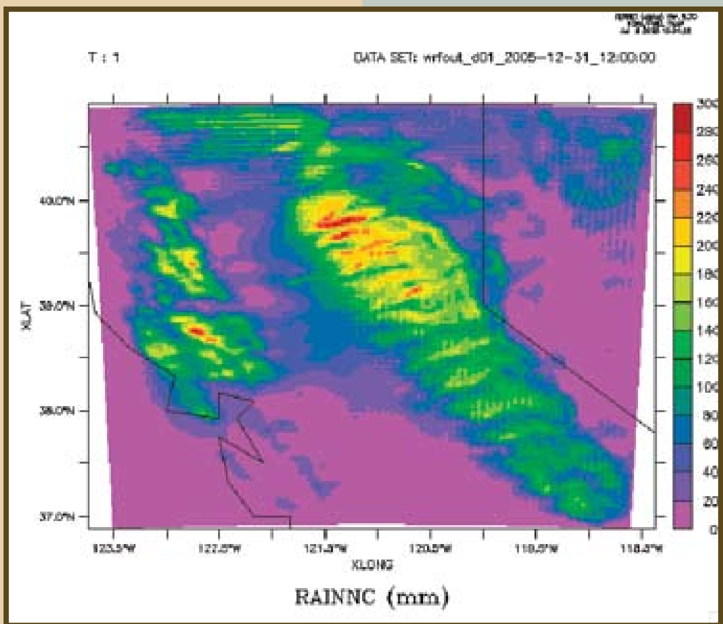


Fig 4a. An example of NWP model precipitation accumulated through the first 24 hours of the 30-hour forecast.

not available in operational forecast models with larger grid point spacing. It is also not often evident in observations, due in part to the lack of observations at the terrain peaks. We are currently collaborating with scientists from ESRL/PSD who deployed radars with the ARB to fill in the gaps for quantitative precipitation estimates with the goal of determining whether such maxima exist at the terrain peaks.

The gridded observations shown below in Fig 4b are produced by sending sparse rain gauge measurements through an interpolation routine. Thus, the spatial variability of the model runs, being unsmoothed, is much larger than observed. Nevertheless, the magnitudes of precipitation are similar. Where the observations show precipitation exceeding 6.5 inches, the model predicts 7-9 inches.

The enthusiastic response to high-resolution NWP guidance by NWS forecasters inspired our efforts to examine whether ensemble methods could improve guidance of probability of precipitation and precipitation amount. To this end, we designed an ensemble consisting of multiple NWP models and software to calibrate ensemble output with observations. A number of NWP models were considered for inclusion in the ensemble: MM5, WRF-ARW, WRF-NMM, and RAMS. The final mix of models was determined from a methodology described below (see **Ensemble Forecast Mix**).

The ensemble NWP model forecasts were implemented for the 2006-2007 winter field campaign. The ensemble consists of three configurations of the WRF-ARW and one configuration of the WRF-NMM. The forecast domain is identical to the one used during the 2005-2006 field campaign. Forecasts are initiated every 6 hours (four times daily). Ensemble data are generated on ESRL/GSD supercomputers and are delivered to the NWS weather forecast and river forecast offices via the next generation AWIPS called ALPS. The forecasters receive 30-hr. forecasts of surface and upper-air data, ensemble average precipitation, and reliable probability of precipitation exceeding certain thresholds for 6-hr. and 24-hr. accumulation periods. (A reliable probability forecast is one for which the event occurs as frequently as predicted. For example, a forecast of 10% for precipitation exceeding 2" is reliable if more than 2" of precipitation occurs during 10% of the forecasts.) Examples of the precipitation output are provided in Fig. 5.

We have explored the possibility of decreasing forecast error and forecasting the expected error with ensemble forecasts. We found little improvement in forecast error within the first 24 hours, indicating the error growth is primarily due to synoptic scale errors that aren't manifested until forecast lead times extend

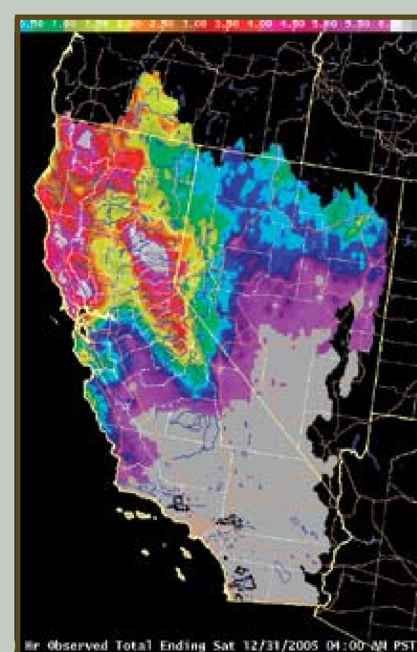


Fig. 4b. Gridded observations produced by the California Nevada River Forecast Center

beyond 24 hours. However, there is value from the ensemble in that the spread of the ensemble is correlated with the error of the ensemble mean; this suggests that it is reasonable to expect the ensemble to help predict the expected forecast error.

Ensemble Forecast Mix

The experimental ensembles were also used to evaluate a strategy to determine an optimal mix of forecast models. The results indicated that by intelligently choosing various parameterization combinations, the accuracy of the ensemble mean and the range of ensemble forecasts are both improved.

In order to improve QPF, the impact of different initial conditions and various microphysical schemes and their interactions with different PBL schemes on cold season, mainly orographically induced rainfall, was evaluated. The main focus was on the improvement of rain volume simulation over the ARB area in California. For this purpose, high resolution (3-km horizontal grid spacing, and 32 vertical levels) WRF-ARW model simulations of four HMT events were performed. For each case, four different microphysical schemes were used: Lin et al. (1983) modified by Rutledge and Hobbs (1984), Ferrier et al. (2002), WSM6 (Hong et al., 2004) and Thompson et al. (2004). For each of the four microphysics configurations, two different PBL schemes were used: the local mixing Eta PBL scheme, often referred to as Mellor-Yamada-Janjic 2.5; Janjic (2001), and the non-local mixing YSU PBL scheme (Noh et al. 2003) as an improved version of the MRF PBL scheme (Troen and Mahrt 1986). All runs were initialized with both the diabatic Local Analysis and Prediction System (LAPS) "hot-start" and 40-km Eta model analyses.

To quantify the impacts on simulated rain volume due to changes in initial conditions, microphysics, PBL schemes, as well as the interactions between the two different physical schemes (synergy), the factor separation method (Stein and Alpert, 1993) was used. For this purpose, the model run initialized with the LAPS analysis and using Lin microphysics and YSU PBL was chosen as the control configuration. By following the Hamill (1999) resampling method, statistical significance testing of all results was performed. The factor separation method results indicated that for both initializations, the largest, negative, and statistically significant impact on simulated rain volume was due to changes from Lin to Ferrier and to Thompson microphysics. In other words, the factor separation results pointed toward a statistically significant difference in performance between Lin and both Ferrier and Thompson microphysical schemes under these specific conditions. To investigate this in more detail, analyses of precipitable and cloud water tendencies over the area of interest for the four different microphysics were performed. The results showed that Lin microphysics had a tendency to convert all

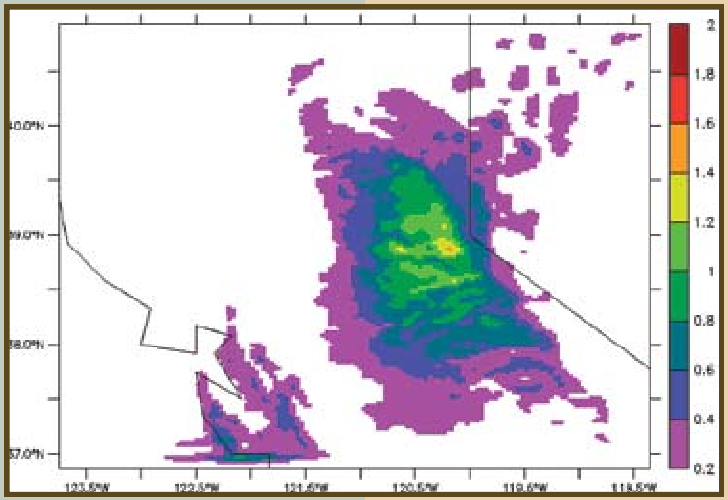


Fig 5a. Ensemble average of 6-hr. accumulation of precipitation ending at the 18-hr. lead time.

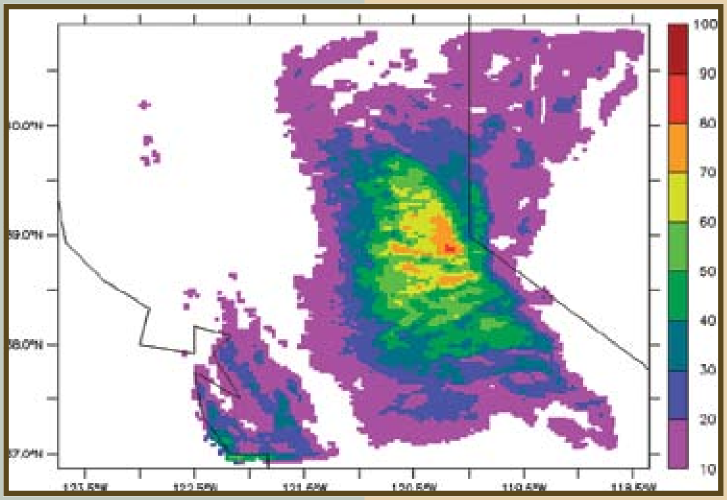


Fig 5b. Ensemble probability of 6-hr. accumulation of precipitation exceeding 0.5" ending at the 18-hr. lead time.

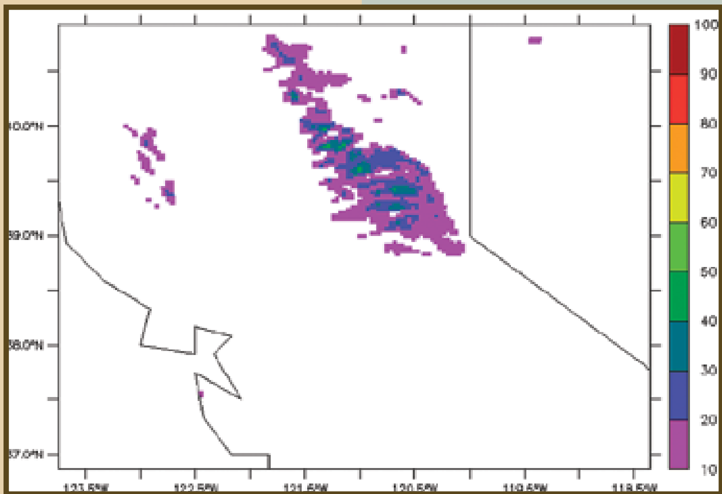


Fig 5c. Ensemble probability of 6-hr. accumulation of precipitation exceeding 1.0" ending at the 18-hr. lead time.

available precipitable water into precipitation, while both Ferrier and Thompson schemes tended to keep the majority of available precipitable water as supercooled water or snow. This was especially the case for the Ferrier microphysics. With regard to WSM6 scheme, its performance was very similar to the performance of MPL, which explains the lack of statistically significant differences of simulated rain volume between the two. It is noteworthy that the precipitable and cloud water tendencies were almost identical for the two different initial conditions. With regard to changes in initial conditions, by switching from the LAPS to the Eta analysis, the change in the PBL scheme – as well as all corresponding synergistic effects – appeared to be statistically significant.

Furthermore, the factor separation results were used to investigate if the results of the impact of different initializations and physical schemes on simulated rain volume could be used to lessen a large bias associated with the "control" configuration simulation. Using the knowledge about the magnitude and sign of the impact that different physical schemes and initial conditions had on the simulated rain volume, different combinations of model runs were created and various objective measures of the model simulations were calculated. The results showed a decrease in errors for the model combinations that were judiciously selected. Thus factor separation results were used in the design of an ensemble for QPF for the 2005-2006 HMT field experiment.

Daily Forecast Support

CIRA researchers provided real-time support to the field experiment in the form of detailed daily discussions of the precipitation forecast over the testbed. This included participation in conference calls and posting text forecasts to the HMT website.

An important part of the HMT program, as outlined at http://www.esrl.noaa.gov/psd/programs/2007/hmt/, is to assess various instrumentation, including new radar technologies, designed to better measure precipitation and determine precipitation type. The ultimate goal is to arrive at more accurate quantitative precipitation estimates (QPE) which, coupled with the advances in high-resolution numerical modeling, can lead to improved hydrologic forecasts and warnings. Additional observations during events include special radiosonde launches at frequent intervals to document the characteristics of each storm. All of these special observations require scientists to be on station for each event, but events might be widely spaced in time, so the strategy has been to make a forecast of each event and then staff accordingly, with some of the required staff having to fly in from Boulder as well as Norman, Oklahoma.

The general forecast goals are to give as much advance warning of a potential event (an "Intensive Operational Period" or IOP) as possible, with a go/no go decision needed usually no less than 24 to 48 hours in advance. The ultimate decision to call an IOP rests with the Project Director (this position rotates among several scientists within NOAA), but is of course highly influenced by the forecasters and their confidence in a potential IOP. A conference call among HMT participants occurs every day during the program at 12:30 local Mountain Time, with the initial business a forecast discussion, followed by further discussion and interpretation leading to a decision on a potential IOP. A written forecast and forecast discussion is also posted to the project webpage (at the URL noted above) near or shortly after the conference call. A preliminary version of the forecast discussion is sent to the project directors at least an hour or so ahead of the conference call for planning purposes.

CIRA researchers have been an integral part of a larger forecasting cadre that represents a cooperative effort between the National Weather Service (NWS) Weather Forecast Offices (WFO) in the HMT area, which are the Sacramento and Monterey WFOs in California and the Reno WFO in Nevada, the NOAA California-Nevada River Forecast Center in Sacramento, and the NOAA National Centers for Environmental Prediction (NCEP) Heavy Precipitation Branch. During the 2006 HMT exercise, the forecast discussion during the conference call was led by forecasters at the Sacramento WFO, with the other participants, including CIRA staff at NOAA in Boulder, free to add to the discussion at any point. Boulder forecasters were responsible for the written discussion posted to the website. This year, the decision was made to let the Boulder forecasters take the lead role during the conference call, though again, the forecast discussion typically involves input from the other participants, particularly when the weather prediction becomes less certain. Recently, a prototype AWIPS workstation was installed at the participating WFOs to allow the forecasters there to examine the output from the special model forecasts being run at GSD for the project. Also new for this season has been a more consistent participation by two NOAA forecasters from ESRL's Physical Sciences Division (formerly the Climate Diagnostics Center), who provide occasional longer range (2 to 3 week) guidance based on their analyses and interpretation of model forecasts.

CIRA and other forecasters in Boulder use a variety of information and model forecasts to make the HMT daily forecast. The standard operational models are found on AWIPS, but the web offers a look at many other models as well as ensemble model forecasts from the NCEP Global Forecast System (GFS), along with a set of ensemble forecasts from Environment Canada. Analyses of water vapor and other parameters are available from a number of other sites, with one of the favorites out of the University of Hawaii. A set of the most often used sites has been compiled onto a webpage for the project at http://laps.fsl.noaa.gov/szoke/DWB/Hydromet_Test_Bed_fcsthomepage.html. In the shorter range, of course, the forecasters utilize the various 3-km and ensemble runs initialized with LAPS and run locally at GSD that are described in this article.

Conclusion

We are currently approaching the conclusion of the 2006-2007 field experiment over the ARB in California. We look forward to conducting further analysis of the results and participating in future HMT field seasons that will cover several locations around the country, each having unique forecast challenges.

DEAR READER:

We hope you find our publication informative and interesting. We always welcome feedback and suggestions – forward your comments to us any time.

*If you no longer wish to receive the *CIRA Magazine*, kindly let us know and we will remove you from the mailing list.

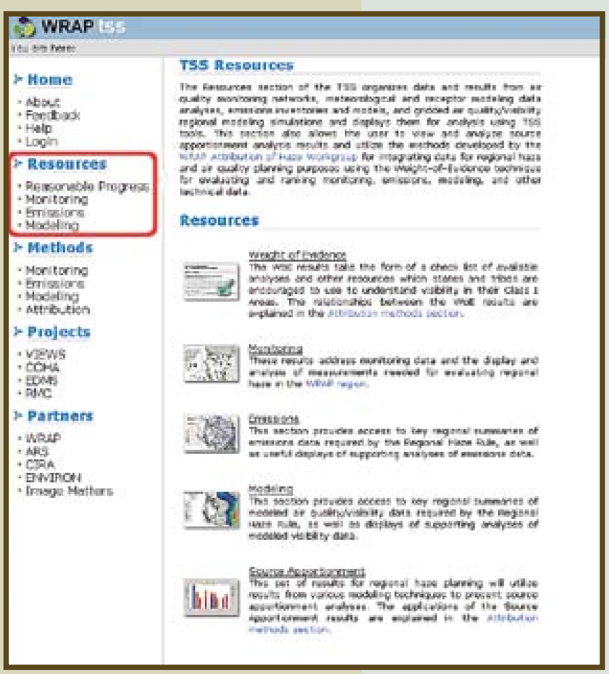
All communication may be sent to the Editor: mcinnis-efaw@cira.colostate.edu or Assistant Editor: grames@cira.colostate.edu.

CIRA

Cooperative Institute for Research in the Atmosphere

Figure 1. TSS home page

Figure 2. TSS Resources page provides summarized data results and standard displays for monitoring, emissions, and modeling analyses. The Methods menu provides summary documents fully describing all the technical methods used in monitoring, emissions, and modeling analyses. The Projects menu takes the user to the projects feeding data to the TSS; these project websites contain extremely detailed datasets and documentation.



The Western Regional Air Partnership Technical Support System

by Tom Moore, Shawn McClure and Doug Fox

Background

The Western Regional Air Partnership (WRAP) represents a history of over 15 years of collaboration on technical aspects of western air quality, specifically for analyses supporting the U.S. Environmental Protection Agency (EPA) regional haze regulations. This body of work representing well over $20 million of federal investment in data and analysis tools, underpinned by robust participation and in-kind support by States, Tribes, Federal agencies, as well as the environmental and the industrial communities. This support has established a broad basis for developing a regional understanding of air quality and future related challenges in environmental health, ecological and aesthetic protection of our natural areas and, of course, coping with a changing climate.

For the West, the WRAP has built the first regional technical support capability based on integrating the capabilities of the following data centers:

- Monitoring data analysis efforts in support of haze planning for the more than 100 federally-protected Class I visibility areas in the WRAP region, documented by the Visibility Information Exchange Web System (VIEWS), which provides on-line access to monitoring data, research results and special studies related to visibility, and WRAP's Causes of Haze Assessment project (CoHA) which presents a detailed analysis of ambient monitoring data for regional haze in the West;
- Consistent and regionally comparable emissions data for analysis and haze planning at appropriate spatial, temporal, and chemistry scales, including the:
  - Tribal Emissions Inventory Software Solution (TEISS);
  - Emissions Data Management System (EDMS), and
  - Fire Emissions Tracking System (FETS);
- Photochemical aerosol regional modeling analyses and technical assistance for haze planning and analysis of other air quality management issues, using state-of-the-science tools from the Regional Modeling Center RMC at UC Riverside, and
- Visualization and summary data analysis of regionally consistent data and information in transparent and accessible formats, to support the dissemination and understanding of policy and planning decisions by WRAP members (states, tribes, and federal land managers) in the WRAP TSS.

TSS provides a one-stop web-based resource to access and display regional haze technical data and it represents a reference location to support individual regional haze plans and the technical methodologies used in them. TSS will facilitate ongoing tracking and assessment of emissions reductions codified in the regional haze plans prepared by states, tribes, and EPA, and continue to house and deliver on-going monitoring data.

Prior to the TSS, CIRA had developed and maintains the Visibility Information Exchange Web System (VIEWS) as an online exchange of air quality data and its analysis. VIEWS is built upon a true relational database populated with a variety of data and metadata from both national and regional air quality monitoring networks. Based largely on the success of VIEWS, the WRAP, through the auspices of the Western Governors' Association, invited CIRA to participate in designing and developing the Technical Support System. Specifically, TSS supports development of Implementation Plans by state and tribal regulatory agencies required by the Regional Haze Regulations. TSS is likely to be maintained, adapted to, and serve future regional technical needs of WRAP members for air quality issues of common interest.

Overview of TSS capabilities

The TSS includes dynamic tools which are interactive and populated from queries on the database and return graphs, tables and maps, and static tools representing analyses and products that have been generated outside of the TSS all to support haze plan developers. In most cases the static tools are placeholders for future dynamic tools. Wherever possible, TSS data (graphs, tables and maps) are provided in appropriate formats for download to analysts workstations.

The TSS home page http://vista.cira.colostate.edu/tss/ presents a relatively uncluttered appearance (Figure 1) providing a left side navigation bar that addresses all of the TSS resources and a center screen tutorial on how to use the TSS and what it can do for the user. Since TSS is currently under development not all of its resources are in place. Here we will briefly illustrate some available functions under the resources menu (Figure 2).

One of the more integrated selections under Resources is the “Demonstrating Reasonable Progress” page (Figure 3) which, while still being shaped to support haze planning needs, displays an illustration of all the analyses that are likely to be included in the haze plans in late 2007. Simply, this first includes selection of the Class I area or areas of interest, then three general areas of analysis:

- Monitoring data including: identification of visibility conditions at the site for the best and worst visibility days (using regulatory specific metrics and data analysis protocols), identification of the natural background visibility at the site (the regulatory program goal is to restore natural conditions by 2064), modeled projections of visibility at the site in 2018 (based on projected growth of emissions as well as results of established control programs already established) and a determination of how much of the difference between current conditions and the future goal is reduced by 2018;
- Emissions and Source Apportionment including: emissions data and data analyses allowing investigation of specific source contribution to current and projected future visibility at the site. These tools are used to identify natural emissions sources of haze; identify federal and international emissions sources of haze; identify controllable anthropogenic emissions sources of haze; and, analyze emissions data;
- Modeling allowing determination of reasonable progress goals including the amount of improved visibility resulting from projections of emissions controls and how much more is needed to get to the 2064 goal and specific control programs established by the States (and Tribes) to accomplish reasonable progress toward the goal (these to be developed and reported back to the TSS by States and Tribes by the end of 2007.)

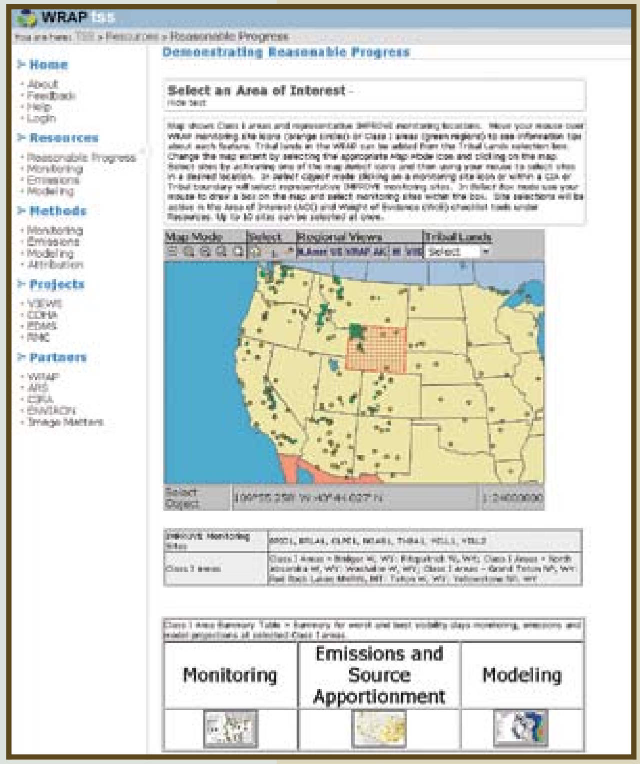


Figure 3. The working version of the “Demonstrating Reasonable Progress” page outlines the analysis steps needed for each Class I area in support of the haze plans.

Selecting an area of interest is the first step in any TSS analysis. The site selection panel, shown in Figure 3, documents the location(s) selected. Under the Emissions and Source Apportionment selection, there is a tool that presents results of the apportionment that the regional air quality modeling attributed to different source types (point sources, area sources, mobile sources, etc.) in different regions. Figure 4 illustrates the type of results that can be generated, in this case looking at Yellowstone National Park in 2018. The graphic illustrates that significant contributions to the particulate

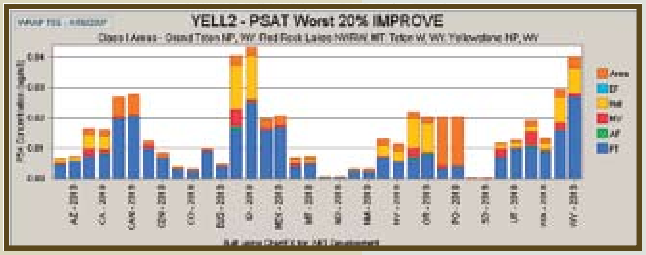
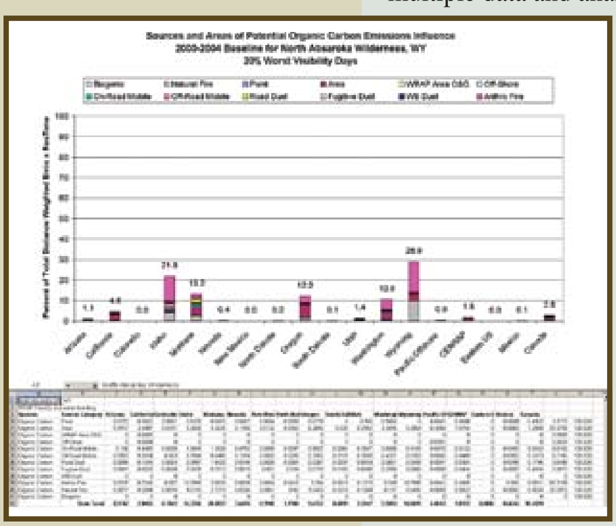


Figure 4. This source attribution tool provides a chart display and associated data table depicting 3-D photochemical aerosol tracer modeling results, depicting the contribution of source categories and regions at each Class I area, and the change in modeled planning scenarios over time with control measures included.

Figure 5. This chart provides a simple multiplicative product of air mass residence time arriving at a Class I area during the 2000-04 time period (weighted for transport distance) multiplied by the gridded emissions inventory data from the same time period and future emissions scenarios, so that haze planners can evaluate and uniformly rank the magnitude of potential emissions sources and contributions, as well as identify regions for prioritized analysis.



sulfate at Yellowstone National Park on the worst visibility days in 2018 comes from sources located in Idaho and in the Eastern U.S., quantifying for haze planning purposes the contribution of source types, as well as the inter-State and regional scale of this issue, for the purpose of assisting planners in defining the nature and geographic scope of consultation needed with other regulatory agencies.

Finally, Figure 5 presents another type of analysis that can be accomplished with the TSS. This chart and its associated data table (not included) illustrate an index based on combining air mass residence time for air masses arriving at a Class I area during the 2000-04 time period (weighted for transport distance) multiplied by the gridded emissions inventory data from the same time period and also for future emissions scenarios, so that haze planners can evaluate and uniformly rank the magnitude of potential emissions sources and contributions, as well as identify regions for prioritized analysis.

Summary

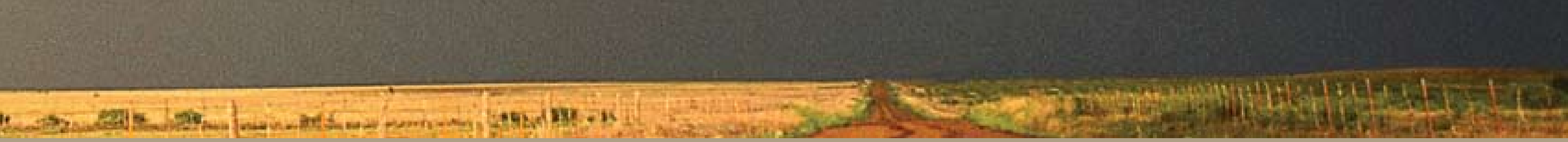
The TSS is a prototype decision support system designed to facilitate the browsing, assembling, formatting and downloading of multiple data and analysis products in a geographically referenced manner for general users. While it will specifically assist western air quality managers and planners in accomplishing their responsibilities under the regional haze regulation, in general it has a much broader potential.

TSS illustrates the power of a well designed, truly relational database and emerging web tools for manipulating and working with the database. In the existing case, the TSS has a vast array of observational data and associated metadata loaded. It also includes gridded model inputs and outputs for a large regional domain. The power of the TSS is that it provides the user an opportunity to cut and slice the data and the model results in multiple different dimensions.

In the future, we anticipate expanding the TSS geographically to include the entire U.S. Equally important, we can foresee applications to a broader set of air issues. Air pollution sources will remain a concern for many years. While the haze regulations have charted a course of action to achieve pristine air quality, there are many diversions and detours that will be encountered along the way. One of the likely outcomes of the haze plans will be more scrutiny of fires and dust. In the case of fires, there are significant efforts underway to account for the differences between those that are of natural origin and those that are human influenced. For dust, the same efforts are possible in the future. New more stringent ambient air quality standards for fine particulates and ozone are likely, increasing the importance of regional analysis. Increased concerns about long distance transport of particulates, particularly intercontinental transport from Asia of chemically diverse aerosols will become more significant in the next few years. Finally, as efforts are initiated to cope with the growing challenges of Climate Change, emissions of greenhouse gases and their control are likely targets for TSS-like decision support systems.

Acknowledgement

The TSS is a team effort. The organization and presentation of the TSS is largely the work of Joe Adlhoch of ARS, Inc. The vast majority of the tools on the TSS were developed by Rodger Ames (formerly at CIRA) currently with the Department of Atmospheric Sciences, CSU. All of the modeling data and its presentation layers were developed from the WRAP Regional Modeling Center by Gerry Mansell of ENVIRON, Inc.



FIRST GRADERS VISIT CIRA

Dunn Elementary First Graders Visit CIRA

By David Cismoski

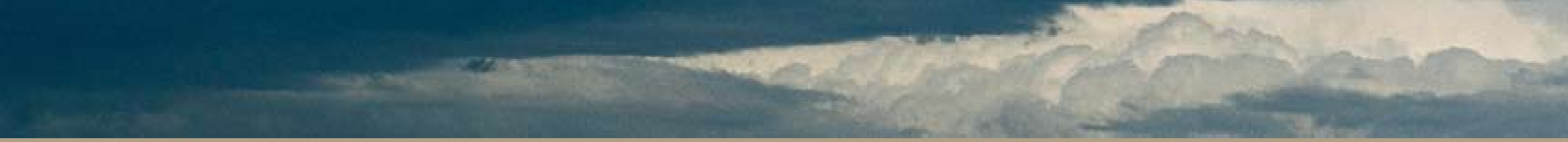
On February 7, 2007, with sunny skies and unseasonably warm temperatures, nearly 70 first graders from Dunn Elementary, an IB (International Baccalaureate) World School, visited CIRA. Accompanied by 20 teachers and parents, the kids, with notepads in hand, were ready to go. They had been studying clouds in their classes and were especially interested in both how clouds form and the types of clouds that they saw in the sky.

The trip was organized by Mrs. Jamie Romero and hosted by CIRA's Education and Outreach Coordinator David Cismoski (aka Ski). Assisting him in this endeavor were Ms. Holli Knutson, Mr. Don Reinke, Mr. Don Hillger, and two very observant photographers. This large group was split into two sections with Ski leading one and Holli the other. As one group listened to Mr. Reinke show the launch of the CloudSat spacecraft and explain its mission to profile clouds, the second group watched an animation on the types of clouds in the atmosphere and discussed how clouds are formed. After about 15 minutes, Holli's group went to the CIRA computer lab where Mr. Hillger showed real-time computer images prepared from data being transmitted from various satellites. Meanwhile, Ski's group went to hear Mr. Reinke's second presentation. In one hour, both groups were able to listen to three presentations and ask many questions, some of which showed the imagination that first graders have: Why doesn't the CloudSat satellite get pulled into a "black hole"? And, does the satellite ever see any aliens? A follow-up packet of thank you letters received from the kids indicated to us that the visit and presentations were a great success.

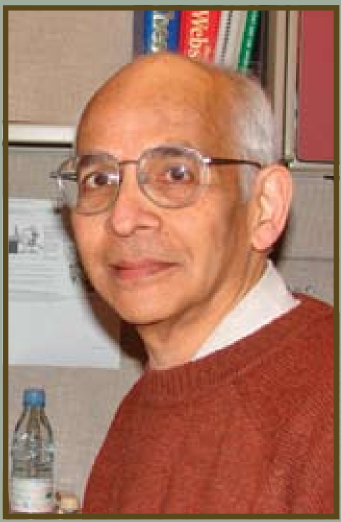
Dunn Elementary students listen to Don Hillger's presentation on satellites.

Far left: Students learn about clouds from Ski.

Left: First graders diligently taking notes.



CIRA COMMUNIQUÉ



Dr. Shripad Deo

Jeff Smith

Dr. Shripad Deo Wins Regional Excellence Award

Dr. Shripad Deo, a CIRA Research Associate based in Kansas City, Mo., with our National Weather Service Central Region Headquarters colleagues, was recently recognized with a Regional Excellence Award. The focus of Dr. Deo's research has been in trying to help the NWS communicate with the public more clearly and effectively. In this project, the goal was to develop a web portal that would allow the lay public access to NWS information without overwhelming them. With help from the webmaster, the project was completed in June of 2006.

"Mr. Shripad D. Deo is recognized for his outstanding efforts in working with the Central Region group that constructed and implemented a simple and user-friendly regional climate services resource website for non-technical users of climate data and information. The website is planned as a portal to provide training and answers to climate questions for academia and media. Plain text on the site explains to users what is available and where to find it in four main areas of Outlooks, Resources, Information, and Science and Education. Mr. Deo's outstanding efforts and dedication contributed directly to successful completion of the National Weather Service's mission to save lives and property damage through public education."

On the web: http://www.crh.noaa.gov/climate/

Best New Site by Jeff Smith

CIRA Research Associate Jeff Smith was recognized at the NOAA/Global Systems Division (GSD) Christmas party this past December (2006) with a web award for "Best New Site." Jeff's creation, called "JavaZone" was created as a supplement to Jeff's Java class for the Earth Systems Research Laboratory (NOAA) in Boulder, Colo. However, it has taken on a life of its own and become a valuable resource for many GSD developers. The site is fun, clever, and user-friendly. Power Point training slides, Java programming exercises, downloads, links, and a "fun stuff" category are all provided on the site. Jeff's well-designed and well-coded site is GSD's Best New Site of 2006.

On the web: http://www-ad.fsl.noaa.gov/ac/javazone/

Gold Medal and Paper of the Year Awards for Tracy Smith

The ESRL/Global Systems Division's GPS-Met team received the 2006 Department of Commerce Gold Medal for its development of Global Positioning System (GPS) meteorology, a new low cost, upper-air observing system that uses GPS to continuously measure the total amount of water vapor in the atmosphere.

Tracy Smith

Although only Federal employees are eligible for this award, CIRA Research Associate Tracy Smith was a key member of the team that successfully demonstrated new applications for GPS meteorology that are essential to NOAA's Integrated Earth Observing System/Global Earth Observing System of Systems. Their efforts have advanced weather forecasting, climate monitoring, and atmospheric research by providing a new way to monitor atmospheric water vapor.

Tracy and Kevin Brundage were also coauthors on a paper selected as one of the 2005 OAR Outstanding Scientific Paper Awards announced in June. The award-winning paper, "An Hourly Assimilation-Forecast Cycle: The RUC," was published in *Monthly Weather Review*. This paper describes the analysis system utilized within the Rapid Update Cycle (RUC) and discusses some issues associated with high-frequency data assimilation cycling. The RUC is an operational NCEP weather forecast system Tracy helped develop as part of the GSD Assimilation and Modeling Branch.

On the web: the website for GPS-Met is http://gpsmet.noaa.gov/jsp/index.jsp and for the RUC (now known as Rapid Refresh) is http://rapidrefresh.noaa.gov/

A copy of the MWR paper can be found at: http://www-frd.fsl.noaa.gov/pub/papers/Benjamin2004c/j.pdf

GSD Team Member of the Month: Evan Polster

Another CIRA researcher co-located at the federal lab in Boulder was also honored with an award. Evan Polster was named GSD's December 2006 Team Member of the Month. Evan serves as the Technology Outreach Branch programmer Analyst for the FX-Net Technology. He was recognized for his outstanding efforts in furthering the FX-Net activities including: contributing innovative ideas on improving recent FX-Net Client updates; working hard to meet many development and software release deadlines; maintaining the Starteam software version control system and the FX-Net group Wiki site; and providing Java development leadership.

On the web: http://www-tod.fsl.noaa.gov/fxnet.html

Sher Schranz and Jebb Stewart Honored for FX-Net Project

At the annual NWS Incident Meteorologist (IMET) Workshop in Boise, Idaho, during the week of March 12, 2007, the National Weather Service Director, Brig. General D.L. Johnson, USAF (Ret.), presented 'Certificates of Recognition' to two members of the FX-Net project team. Sher Schranz, Project Manager, and Jebb Stewart, Development Lead, received the award.

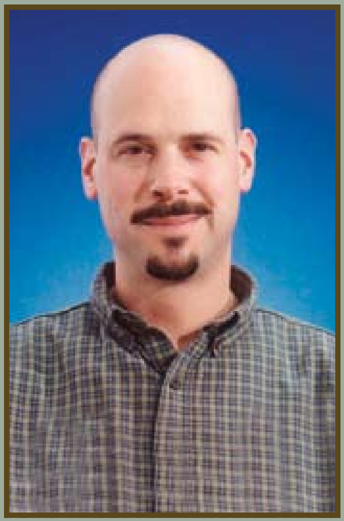
"In Recognition of your leadership to ensure operational excellence via innovative development and maintenance of critical software for our IMETS."

The National Weather Service has implemented an All Hazards Onsite Meteorological Support System to provide data and communications to the NWS Incident Meterologists (IMETS) at remote locations. The core component of the system is the NOAA ESRL/GSD's FX-NET system. FX-NET provides AWIPS-like displays on the IMET laptop while retrieving real-time atmospheric data from remote data servers. FX-NET has been deployed to hundreds of fires during the last four fire weather seasons, and to other events such as Katrina clean-up support, oil spills and national political conventions. FX-Net delivers high-resolution satellite, radar, observational and weather prediction model data utilizing unique compression technology and state of the art, cross-platform display software.

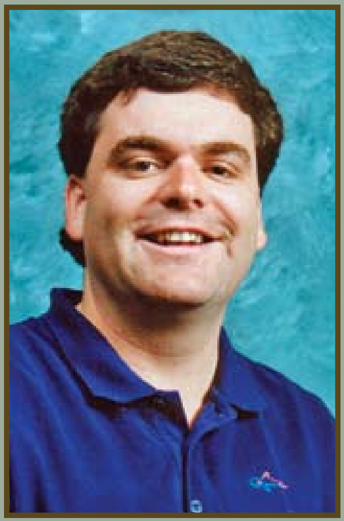
Sher Schranz and Jebb Stewart

Tom Kent Selected as GSD Team Member of the Month

Tom Kent at the ESRL/Global Systems Division Information Systems Branch/Data Access and QC Section was selected as the GSD Team Member of the Month for April 2007. Tom was a key player in the just completed HydroMeteorological Testbed (HMT) activity. Tom is the expert on decoding, storing, and displaying grids on AWIPS. For HMT, a new concept of pulling grids from a remote location for display on the HMT enabled workstations was tested and Tom was the principal developer/implementer of this new "data pull" approach to grids on the advanced AWIPS system.



Evan Polster



Tom Kent

The Volcanic Ash Coordination Tool (VACT) Project

by Jim Frimel and Cliff Matsumoto

After the 2001 eruption of Mt. Cleveland in the Aleutian Islands of Alaska, inconsistent weather advisory products were generated for the adjacent Flight Information Regions. In response, NOAA's Earth System Research Lab/Global Systems Division (ESRL/GSD) and CIRA engineers have been researching collaborative approaches for generating Volcanic Ash Advisories at the Anchorage Volcanic Ash Advisory Center (VAAC), Alaska Volcano Observatory (AVO), and Anchorage Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU). The Volcanic Ash Coordination Tool (VACT) is under development and will be deployed at each of these operational units to simultaneously view identical displays and collaborate weather information in near real-time to help create a suite of fully consistent advisories and forecasts for volcanic ash.

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 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. Efforts are focused on integrating the latest advancements in volcanic ash detection and dispersion from the research community and 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 is an experimental client/server-based application utilizing the Internet and is based on the FX-Collaborate (FXC) system architecture. The 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 system. The software used to acquire, distribute, and provide the required datasets for FXC is the AWIPS Linux data ingest and display system. The FXC and AWIPS software is being extended and enhanced for the VACT project. The FXC software allows for the remote access and display of AWIPS datasets 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 system allows users at different sites and with different expertise to simultaneously view identical displays of volcanic ash and other related datasets (i.e. shared situational awareness) and collaborate in near real-time. The expertise from all participating agencies is used to determine the location, extent, and movement of ash, thereby allowing for more consistent and accurate ash advisories. 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.

An initial design of a Graphical User Interface for running the Puff-UAF dispersion model (Puff-UAF obtained from the Geophysical Institute at the University of Alaska-Fairbanks) from the VACT system has been completed. One of the goals in developing the Puff-UAF interface for the VACT system was to implement the existing capabilities as well as extending this functionality and leveraging the strengths of the VACT system. The capabilities implemented within the VACT system include the following: ability to change parameters, start parameter/value checking, select English or Metric units, and generate output against multiple models. From the VACT Puff-UAF GUI, each of the participating agencies has the ability to independently run the Puff model and generate/store their own model output. Each organization's model runs are available for viewing and sharing with each of the participating agencies. Puff is currently producing output based on the GFSGBL (NCEP's global GFS

In February 2007, the Federal government members of the VACT development team were awarded the **2006 U.S. Department of Commerce Bronze Medal** "for developing the Volcanic Ash Collaboration Tool, a new tool which provides forecasting capabilities during volcanic eruptions and is essential to preventing volcanic ash damage to lives and property." The Bronze Medal is the highest honor award that can be granted by the U.S. Undersecretary of Commerce for Oceans and Atmosphere. The entire project team is comprised of:

ESRL/GSD Aviation Branch/Development and Deployment Section – Greg Pratt, Lynn Sherretz, Jim Frimel (CIRA), Young Chun (CIRA), and Chris Masters (Contractor)

NWS Alaska – Tony Hall, Kristine Nelson, Jeffrey Osiensky, Christopher Strager and Craig Bauer

USGS AVO – Dave Schneider and Rick Wessels model) and the UKMET grids, with NAM40 (NCEP's regional North American 40km model) in the works.

Additional enhancements and capabilities added to the VACT system included the ability to display the Alaska HIPS Imagery satellite data at its distributed high resolution. Also, a map overlay that can be queried to display volcano information updated from the Smithsonian Institute's volcano database has been implemented. Other map additions to the software include updates to the navigational aides and NOPAC North Pacific Route Systems maps. Further data enhancements include the addition of Russian, Japanese, and Chinese RAOBS, specific radar data and sites for VACT, and the high-resolution grids for that region. An additional tool was developed to assist the forecaster in generating predefined text for the Meteorological Impact Statement (MIS) from the Alaska Center Weather Service Unit.

Figure 2 provides a glimpse of how the VACT system may assist aviation forecasters in achieving the goal of generating fully consistent, accurate and timely volcanic ash advisories and forecasts. The ability to run Puff-UAF iteratively over a volcanic ash event in order to match the model output with the initial plume may also assist forecasters in predicting ash movement more accurately. By coupling dispersion model output displays with the VACT's strengths and capabilities of collaborative sharing, overlaying weather information, aviation information, and tools for generating volcanic ash advisories and forecasts, the VACT system will hopefully provide assistance for improving the safety, efficiency and quality of air traffic operations within International and the National Airspace System (NAS).

On May 25, 2005, a successful operational exercise to test the functionality and utility of the VACT system in Alaska with GSD, the Alaska Aviation Weather Unit, Alaska Volcano Observatory, and the Anchorage Center Weather Service Unit was performed. The test and meetings that followed enabled the participants to exercise the VACT system in a simulated operational situation. Additionally, the simulation provided the following opportunity: familiarize users with system capabilities; develop collaboration strategies and protocols for operations; gather feedback on new needs, limitations and requirements; and identify the immediate and potential benefits of the VACT system to operations.

During 2005-2006, the VACT system was providing support of volcanic eruptions for the Anchorage VAAC. The system was used in operations during the January 2006 eruptions of Mt. Augustine and for other volcanic events along the Aleutian chain and the Kamchatka peninsula.

Following are some examples of volcanic eruptions with images and agency feedback on the use of the VACT system in operations.

Mt. Sheveluch	September 22, 2005
Mt. Cleveland	October 7, 2005
Mt. Katmai	November 3, 2005
Mt. Augustine	January 11 thru February 6, 2006

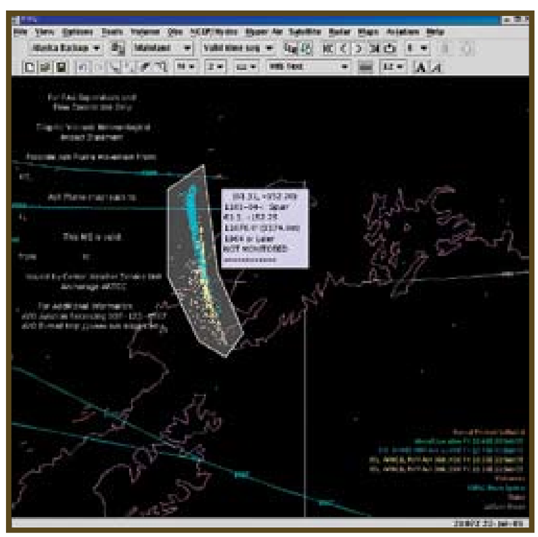


Fig. 2. Example of some enhancements to the VACT display, including MIS template text, aircraft location data, NOPAC routes, and GIS volcano query of Mt. Spurr.

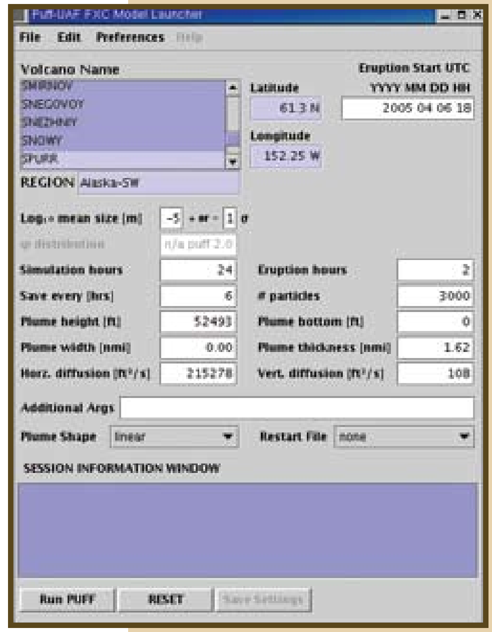


Fig. 1. View of the Puff-UAF Model Launcher interface.

VOLCANIC ASH COORDINATION TOOL

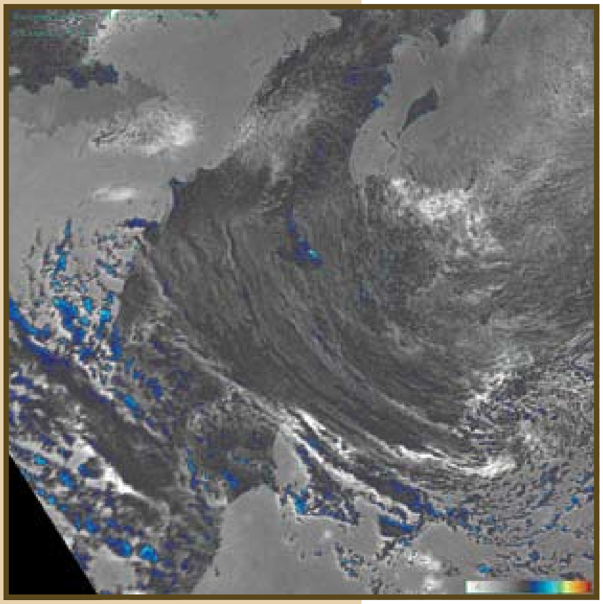


Fig. 3. September 22, 2005, eruption of Mt. Sheveluch, Kamchatka, Russia. AVO satellite image captured ash cloud with AVHRR IR 4/5 enhanced.

Mt. Sheveluch September 22, 2005

The VACT project participants collaborated on their own to monitor the Sheveluch eruption on September 22, 2005 at 05:15 ZULU. The AVO initiated a collaborative effort with the CWSU and AAWU when AVO noticed that if the Kamchatkan Volcanic Eruption Response Team (KVERT) was wrong with their height estimate, the volcanic ash from the eruption could disperse into jet route areas. AVO was able to determine this by using the PUFF model runs from the VACT system.

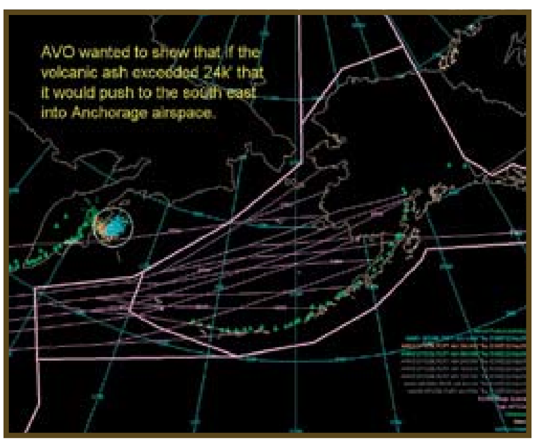


Fig. 4. September 22, 2005, eruption of Mt. Sheveluch, Kamchatka, Russia on the VACT system with GFSGBL Puff-UAF Model output and possible ash dispersion in a jet route above 24,000 feet.

Mt. Cleveland October 7, 2005

Figure 5 and Figure 6 are from the October 7, 2005, Mt. Cleveland eruptions and is another example of AVO images and VACT data used during collaboration. Participants were able to run the dispersion model, which overlaid nicely on the satellite imagery and provided assistance in determining the forecast that was issued.

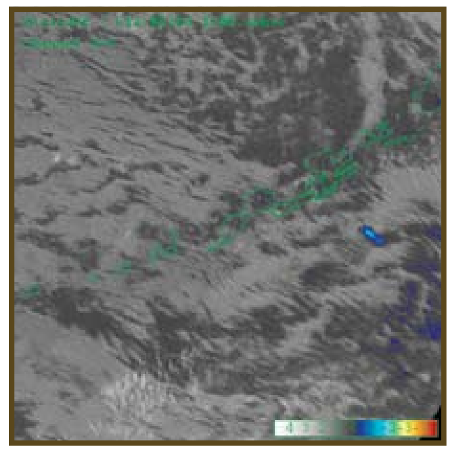


Fig. 5. October 7, 2005, eruption of Mt. Cleveland. AVO satellite image captured ash cloud with AVHRR IR 4/5 enhanced.

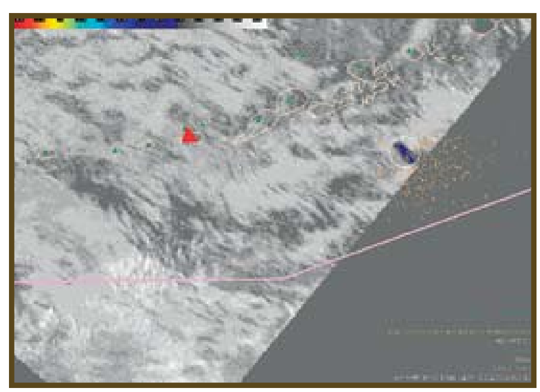


Fig. 6. October 7, 2005, eruption of Mt. Cleveland on the VACT system with GFSGBL Puff-UAF Model output, highlighted and overlaid on HRPT IR 4/5 satellite imagery.

Mt. Katmai
November 3, 2005

Figure 7 and Figure 8 show the November 3, 2005, Mt. Katmai wind-blown ash event detected by satellite and the VACT data used during collaboration.

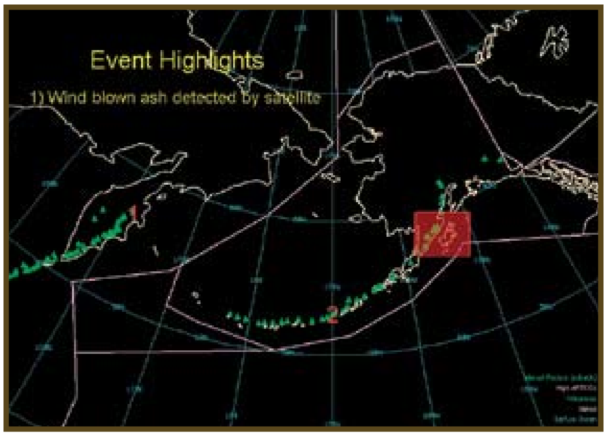


Fig. 7. November 3, 2005, Mt. Katmai wind-blown ash region on the VACT system.

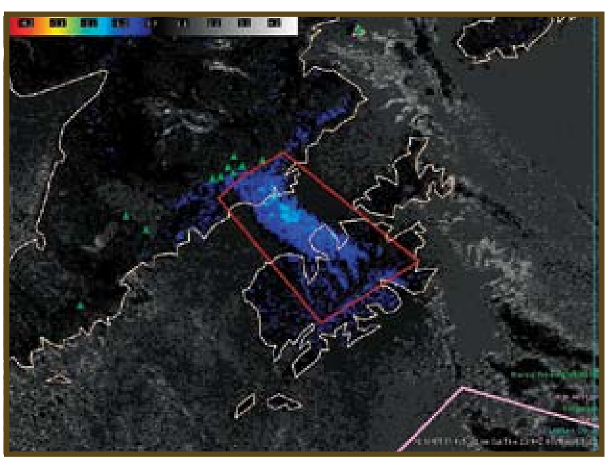


Fig. 8. November 3, 2005, Mt. Katmai wind-blown ash event with satellite data on the VACT system.

Mt. Augustine
January 11 thru February 6, 2006

Figures 9, 10, and 11 show the January 2006 eruption of Mt. Augustine in the Cook Inlet of Alaska on the VACT system. Some of the highlights of this event include volcanic ash visible in satellite data and radar data; Puff-UAF dispersion model output was consistent with the satellite data and the Alaska participants used the VACT system before briefing state agencies.

Due to the January 2006 activity of Mt. Augustine in the Cook Inlet of Alaska and a successful operational exercise, the VACT Project was a highly visible effort during 2006 and received numerous rewarding recognition within the NWS, the FAA, and NOAA. Two examples are cited below:

The Director of NWS AK Region, Laura Furgione, stated that

"VACT enables more timely and accurate forecasts from a coordinated multi-agency response, allowing operational scientists in USGS and NWS to collaborate in real time with shared situational awareness. VACT was operationally tested during the 2006 eruptions of Augustine Volcano that caused ash to fall in several communities, many airline flights to be canceled, and military aircraft to be redeployed. AK Volcano Observatory (USGS) scientists repeatedly expressed gratitude for VACT because it facilitated coordination."

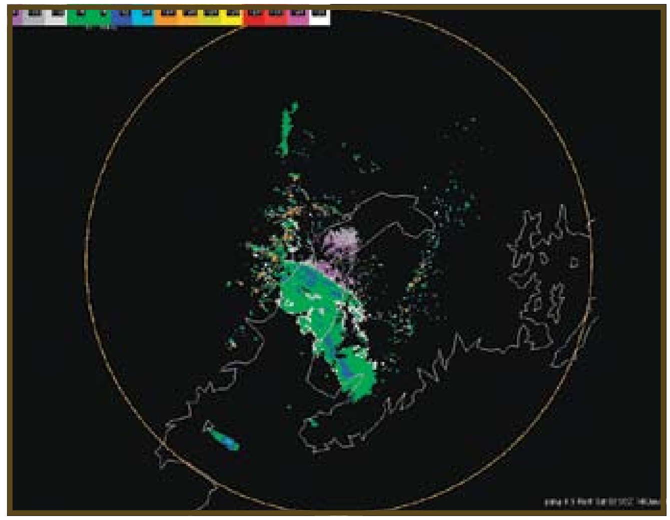
Under Secretary VADM Conrad C. Lautenbacher, Jr. also provided laudatory feedback as part of his January 2006 Weekly NOAA News. Following is an excerpt of his message:

VOLCANIC ASH COORDINATION TOOL

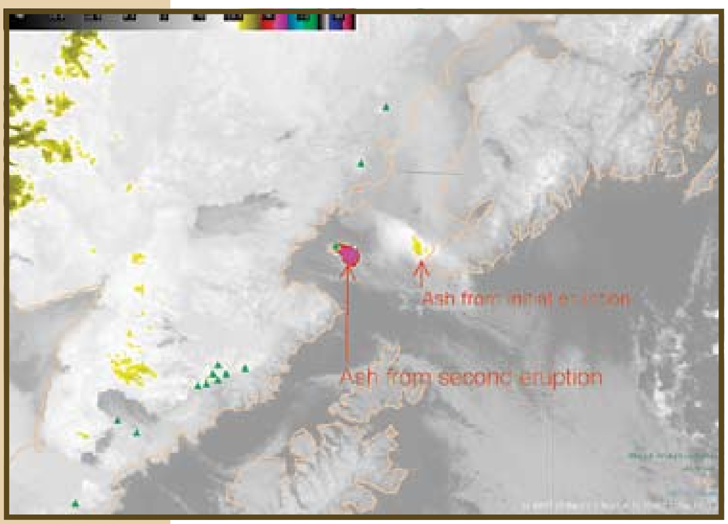
"On January 11, when Augustine Volcano erupted to 30,000 feet, NOAA's Alaska Aviation Weather Unit/Volcanic Ash Advisory Center in Anchorage signaled that the eruption had occurred. The Anchorage Weather Forecast Office issued Marine and Public Ashfall Advisories soon after. The Federal Aviation Administration put NOAA's information to work, giving air traffic managers and controllers a heads-up to ensure airspace safety around the volcano and along the forecast trajectory of the ash plume. The volcano's eruption had already automatically alerted the West Coast and Alaska Tsunami Warning Center of seismic activity. Since January 11, there have been seven more eruptions, including an eruption to 45,000 feet on January 17.

"An Experimental Volcanic Ash Collaboration Tool, developed by NOAA Research's Global Systems Division, was used in real-time by NOAA and U.S. Geological Survey staff to evaluate the location, extent, and movement of ash. This one-stop site has become a popular resource for local, state, and federal officials and the media. My thanks to the VACT development team. . ."

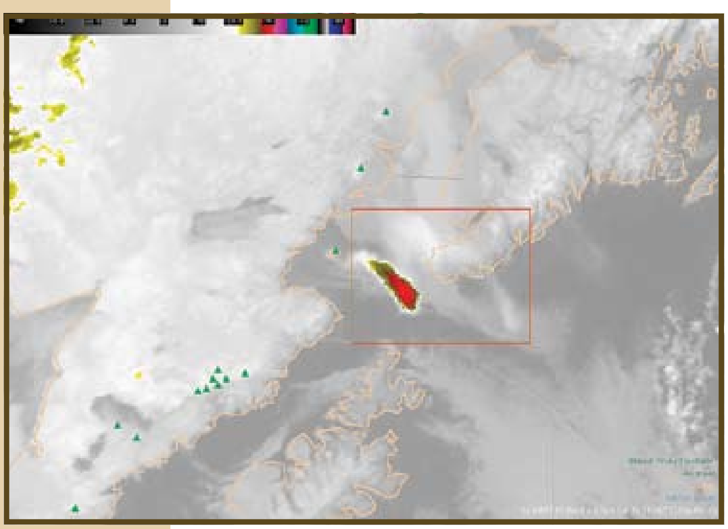
An initial build of the Volcanic Ash Coordination Tool, first envisioned shortly after the eruption of Mt. Cleveland in 2001, was installed in Spring, 2003 at the Anchorage VAAC, AVO, and CWSU. The prototype system was modified and enhanced with subsequent builds over the following years. Although further enhancements will continue, the project team proudly views the current operational version as having successfully met the goal of designing and developing a tool that allows for the coordination, collaboration and generation of volcanic ash products that are consistent among all agencies involved in the detection and dissemination of volcanic ash warnings. The Department of Commerce Bronze Medal is a fitting recognition of the VACT development team's accomplishments.



(At right) Fig. 9. January 14, 2006, Mt. Augustine volcanic ash visible on radar data on the VACT system.



(Below, top) Fig. 10. January 13, 2006, Mt. Augustine volcanic ash visible on satellite data on the VACT system.



(Below, bottom) Fig. 11. January 13, 2006, Mt. Augustine volcanic ash visible on satellite data on the VACT system.

GOES-13 SCIENCE TEST

The GOES-13 Science Test

by Don Hillger

GOES-N/O/P series

The latest Geostationary Operational Environmental Satellite (GOES), GOES-N, was launched on 24 May 2006, and reached geostationary orbit at 89.5°W on 4 June 2006 to become GOES-13. It was later moved to 105ºW for the Science Test and eventual storage. GOES-13 has Imager and Sounder instruments similar to those on GOES-8/12, but is on a different spacecraft bus (Figure 1). The new bus for GOES-N/O/P allows improvements both to image navigation and registration, as well as the radiometrics. Also, by supplying data through the eclipse, when the satellite passes into the shadow of the earth, the GOES-N/O/P system addresses related outages during eclipses in both the spring and fall seasons. Operation through eclipse is now possible due to larger spacecraft batteries.

All of the enhancements to operational imagery expected from GOES-13 were monitored during the NOAA post-launch Science Test. The Science Tests come after the spacecraft and ground system engineering tests that must take place first, so the Science Tests do not occur until several months after launch. The GOES-13 test period occupied three weeks in December of 2006. Similar Science Tests have been part of the post-launch checkout since at least GOES-10 and have become a formal part of every new GOES launch. These testing periods allow a number of groups within NOAA/NESDIS and its Cooperative Institutes to take part in the satellite check-out. NOAA scientists have the opportunity to control the satellite imaging schedule, to provide radiance measurements to be validated, as well as to generate products from the radiances. Special GOES-13 datasets were collected for analysis not possible during normal GOES operations; for lunar calibration; and for emulation of GOES-R 2-km data through spatial over-sampling. These post-launch check-out periods are essential to the subsequent operational use of the satellite assets.

As with any GOES check-out, there are several goals for the Science Test. First, the quality of the GOES-13 data is investigated. This is accomplished by a comparison with data from other satellites and by calculating the signal-to-noise ratio. The second goal is to generate products from the GOES-13 data stream and compare them with those produced from other satellites. These products may include several Imager and Sounder products: visible and shortwave albedo, land skin temperatures, temperature/moisture retrievals, total precipitable water, lifted index, cloud-top pressure, atmospheric motion vectors, and sea-surface temperatures. The third goal is to investigate the impact of any instrument and spacecraft changes. For GOES-13, the better navigation, improved calibration, and the operation-through-eclipse periods were investigated. In addition, rapid-scan images of severe weather cases were investigated as part of GOES-R Risk Reduction activities.

GOES-13 Imaging Schedules

The satellite operations for the Science Tests included choices of image sectors and the timing of those sectors. Choices ranged from operational-type schedules to super-rapid-interval (rapid-scan) imagery both at 1-minute and at 30-second intervals. 30-second rapid-scan imagery has not been taken since 1996 with data from GOES-8, and then only for a short period. Otherwise rapid-scan imagery is important for operational use in severe weather and hurricane situations.

The proposed tests were invoked on a daily basis, depending on the occurrence of various weather events. The default schedule was the emulation of current GOES operations, either GOES-east or GOES-west, with some time for each. Those emulations allow products generated from GOES-13 to be compared to products from the current GOES. The schedules for more rapid collection of data (both 1-minute and 30-second interval) coincided with severe weather events, or were for comparison with data from ground-

Figure 1: GOES-N spacecraft. (Image courtesy of NASA.)

Figure 2: GOES-13 visible (0.7 µm) image at 1801 UTC on 22 June 2006, the first image captured at CIRA's satellite ground station.

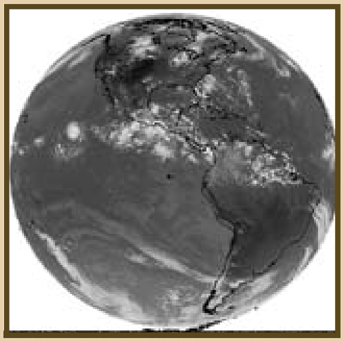


Figure 3: GOES-13 band-4 (10.7 µm) longwave window image at 1800 UTC on 20 July 2006.

GOES-13 SCIENCE TEST

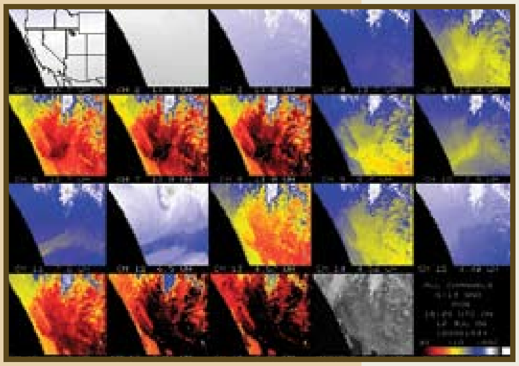


Figure 4: Composite of the GOES-13 Sounder images for all 19 bands for a sector over the western U.S. (Data ingested by the University of Wisconsin/ SSEC Data Center)

based lightning detection networks. Five-minute interval images were also collected to emulate the timing of future GOES-R operational imagery.

Science Test Results

GOES-13 data have been sent to ground stations in GVAR (GOES Variable) format through most of the engineering tests starting immediately after launch, before the beginning of the formal Science Test period in December. Preliminary analysis of that early data are included as part of the Science Test.

On 22 June 2006 the first GOES-13 full-disk visible (0.7 µm) image was captured at 1730 UTC. Figure 2 shows the 1801 UTC visible image captured at CIRA's satellite ground station. The first Sounder visible images were also captured on that date as well, but were not calibrated and appeared quite dark on first viewing.

On 12 July 2006 the first preliminary, un-calibrated GOES-13 full-disk infrared images were captured at 1820 UTC. Some issues were noted with those images, which were later corrected. Then on 20 July the first GOES-13 calibrated full-disk infrared images were captured at 1800 UTC. The band-4 (10.7 µm) longwave window band image is shown in Figure 3.

Figure 4, courtesy of the Cooperative Institute for Meteorological Satellites Studies (CIMSS), shows a composite of the GOES-13 Sounder images for all 19 bands for a sector over the western U.S. The images in all bands compared well, in a qualitative sense, with those from the GOES-11 Sounder (not shown). The GOES-13 radiance images are also visually less noisy than either GOES-11 or GOES-10 Sounder data. For example, note the clean band-15 panel.

There were expected radiometric improvements with the GOES-13 instruments (Imager and Sounder), since they utilized a colder patch (hot blackbody) temperature. Using GOES-13 data that arrived during the engineering tests, a preliminary analysis of the noise level of the data was performed. Both GOES-13 and current operational GOES data were analyzed for the same dates and times. The results are shown in Figure 5, which is a comparison of GOES-13 noise to GOES-12. The improvements are given as noise ratios, with the results ranging from an almost even comparison for band-3 (6.5 µm), to an improvement by a factor of 2 for band-4 (10.7 µm), by a factor of 2.5 for band-2 (3.9 µm), and by a factor of 3 for band-6 (13.3 µm). (There is no band-5, since the addition of band-6 and removal of band-5 to the GOES-12 Imager.) Later, a more extensive analysis of both Imager and Sounder noise verified the initial noise results for the Imager. The analysis also confirmed that the GOES-13 Sounder noise appears to be lower than previous GOES in the longwave IR bands in particular, while other bands have noise similar to GOES-12. But noise in all bands is much lower than instrument specifications.

Estimates of detector-to-detector striping in the GOES-13 infrared images were also made. There is a potential reduction in detector-to-detector striping to be achieved through increasing the Imager scan-mirror dwell time on the blackbody from 0.2 seconds to 2 seconds. The results of the striping analysis for the GOES-13 Imager, except for water-vapor band-3, were comparable to those from GOES-12 (not shown). For the Sounder, striping was not surprisingly found to be much larger for earth-only measurements (because of the larger signal and correlated striping) compared to space-only measurements. However, for earth-only measurements, striping is much larger (on the order of a factor of 2) for the west limb vs. the east limb. Investigation into this anomalous behavior is ongoing.

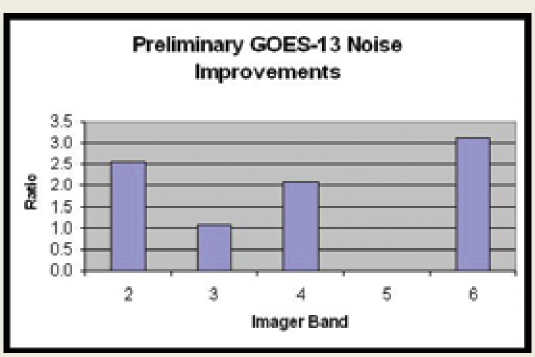


Figure 5: First estimates of noise for the GOES-13 Imager, as compared to the operational GOES-12 Imager. (Figure courtesy of Tim Schmit, NOAA/ NESDIS/ASPB)

In September 2006, GOES-13 went into eclipse operations. Previous GOES were not able to collect imagery in these circumstances. However GOES-13 has larger batteries that allow it to collect imagery through eclipse conditions. Figure 6 contains sequences of images from both GOES-13 and GOES-12, showing the gaps that exist in the images from each satellite. Whereas there is one large gap, of about 3 hours, in the current GOES imagery (as shown by the GOES-12 example on top) there are two shorter gaps in the GOES-13 imagery as shown in the bottom part of the figure. Those two gaps are caused by Keep Out Zones (KOZ), when there is potential for contamination of the images from the sun within view on either side of the earth.

An example of solar contamination in a GOES-13 image collected in an otherwise KOZ is shown in Figure 7. To avoid this possibility, a KOZ is needed, since the radiation affects some bands and areas of the full-disk view from GOES. It's possible that imagery can be collected from portions of the full disk away from the side of the earth where the sun may be found. This too is under further investigation.

There were also improvements in both the navigation and registration on GOES-13. The navigation was improved thanks to the use of star trackers (as opposed to the current method of edge-of-earth sensors). In general, the navigation (at nadir) was expected to go from between 4-6 km with previous Imagers, to less than 2 km with those on the GOES-N/O/P satellites. Both within-frame and frame-to-frame registration were also improved. These improvements are hard to visualize in static imagery, so readers are encouraged to view the improved navigation results on the GOES-13 Science Test website (http://rammb.cira.colostate.edu/projects/goes_n/).

Additional results of the GOES-13 Science Test will be forthcoming, particularly with respect to image products generated from both the Imager and Sounder instruments. Some of those products are generated at CIRA, other products by CIRA's sister-organization, CIMSS, and yet other products by the NOAA/NESDIS Satellite Applications Branch.

The Future of GOES-13

CIRA, as well as other groups participating in the Science Tests, collected and archived the GOES-13 Science Test data. The NOAA Science Post Launch Test (PLT) website continues to be updated as new results are processed and collected. The test results, which are the combined efforts of a number of groups within NOAA/NESDIS and its Cooperative Institutes, will also be distributed as a new *NOAA/NESDIS Technical Report*, similar to the report produced for GOES-12 (Hillger et al 2003). That GOES-13 report should be available in about 6 months.

GOES-13 is now in storage mode awaiting future use. Current plans call for GOES-13 not to become operational until it would replace either GOES-11 (currently GOES-west) or GOES-12 (currently GOES-east), whichever is first to fail or run out of station-keeping fuel. At the time of writing, CIRA is collecting imagery from both GOES-11 and 12, as well as GOES-10, which is imaging over South America.

Reference

Hillger, D.W., T.J. Schmit, and J.M. Daniels, 2003: Imager and Sounder Radiance and Product Validations for the GOES-12 Science Test, *NOAA Technical Report NESDIS 115*, U.S. Department of Commerce, Washington DC, 70 pages.

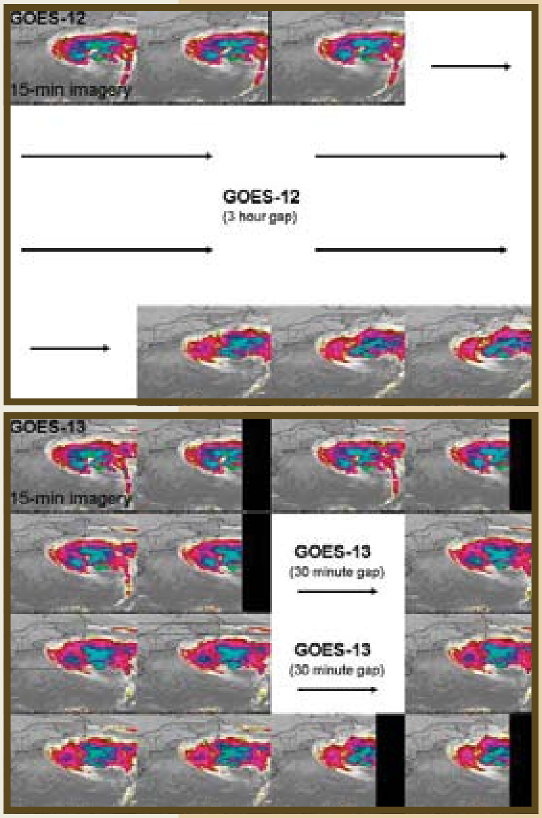


Figure 6: Sequences of images comparing GOES-13 to GOES-12 through eclipse. Rather than one long gap while the sun is behind the earth, there are two gaps when the sun is within view on each side of the earth.

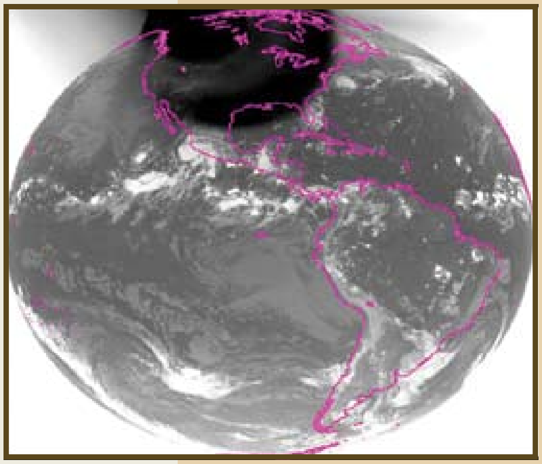


Figure 7: An example of stray solar radiation from the sun next to the earth just before the "eclipse" of GOES-13.

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

College of Engineering – Foothills Campus, Colorado State University
1375 Campus Delivery, Fort Collins, CO 80523-1375
(970) 491-8448

www.cira.colostate.edu

If you know of someone who would also like to receive the CIRA Newsletter, or if there are corrections to your address, please notify us.

Colorado State University