CIRA
Annual Report
2009/2010

CIRA Cooperative Institute for Research in the Atmosphere

CIRA ANNUAL REPORT FY 2009/2010

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE

Cover : Maureen Murray, CIRA

DIRECTOR'S MESSAGE

The Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU) is one of a number of co-operative institutes (CIs) that support NOAA's mission. Although this mission has evolved over time, one thing stays constant – the need to both perform ground-breaking science and transition this science to address socially-relevant problems that face NOAA and our society today. Currently NOAA is looking to strengthen its science and will look to the CIs now more than ever to help realize this new emphasis. The diverse expertise in satellite remote sensing, science algorithm and application development, education/training, regional/global weather and climate modeling, data assimilation, and data distribution technology make CIRA a valuable asset to NOAA. Our Institute serves as an instrument for transitioning research concepts that are at the cutting edge of science to operational stakeholders.

CIRA is blessed with dedicated staff and talented researchers who continue to perform at the highest possible level. There are many important accomplishments that are highlighted in this report and summarized in the executive summary. As we embark on a new voyage of research and discovery with our NOAA technical partners, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship between NOAA, the Department of Atmospheric Science at CSU, other Departments of the University, and the other major programs at CIRA as well as pursuing new directions of growth within our NOAA research themes. We hope that you find the contents of this report both enlightening and stimulating, and we look forward to broadening our outreach as we address the challenges ahead.

I am stepping down as Director toward the end of this year and want to thank all who continue to make CIRA successful. In my brief time as Director, CIRA has moved in new directions; and I have no doubt the new leadership of CIRA will be wisely chosen and will continue the tradition of excellence that has been the hallmark of CIRA since its inception 30 years ago.

Graeme L. Stephens

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VISION AND MISSION

The overarching Vision for CIRA is:

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

Expanding on this Vision, our Mission is:

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

COOPERATIVE INSTITUTE FOR RESEACH IN THE ATMOSPHERE

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

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

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

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

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

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

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

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

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

CIRA EDUCATION, TRAINING AND OUTREACH ACTIVITIES: 2009-2010

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

CIRA Scientists Share in 2009 Department of Commerce Bronze Medal

CIRA scientists Mark DeMaria and John Knaff, together with a NOAA team at the National Hurricane Center, received the 2009 Bronze Medal from the Department of Commerce. The citation reads:

"For developing, implementing, and conducting outreach for new National Hurricane Center Tropical Cyclone Surface Wind Speed Probability products."

John and Mark together with the rest of their team will receive their award from the NOAA Administrator at a ceremony in April 2010.

CIRA Launches New Meteorological Interpretation Blog

The CIRA Virtual Institute for Satellite Integration Training (VISIT) and Satellite Hydrology and Meteorology (SHyMet) programs, under the direction of Regional and Mesoscale Meteorology Branch (RAMMB) of NOAA/NESDIS, have launched a new blog with a variety of educational topics. The blog is intended to open the doors of communication between the Operational, Academic and Training Meteorology communities.

Example topics from the blog include severe thunderstorms over Arkansas on March 10, 2010, the break up of ice on Lake Erie, and smoke and fog as seen from space. The blog is a valuable addition to CIRA's education and outreach mission.

The VISIT blog has a feature section on the GOES-R proving ground: (http://rammb.cira.colostate.edu/visit/blog/index.php/category/goes-r-proving-ground/). Synthetic GOES-R Advanced Baseline Imager (ABI) imagery is shown in Figure 1.

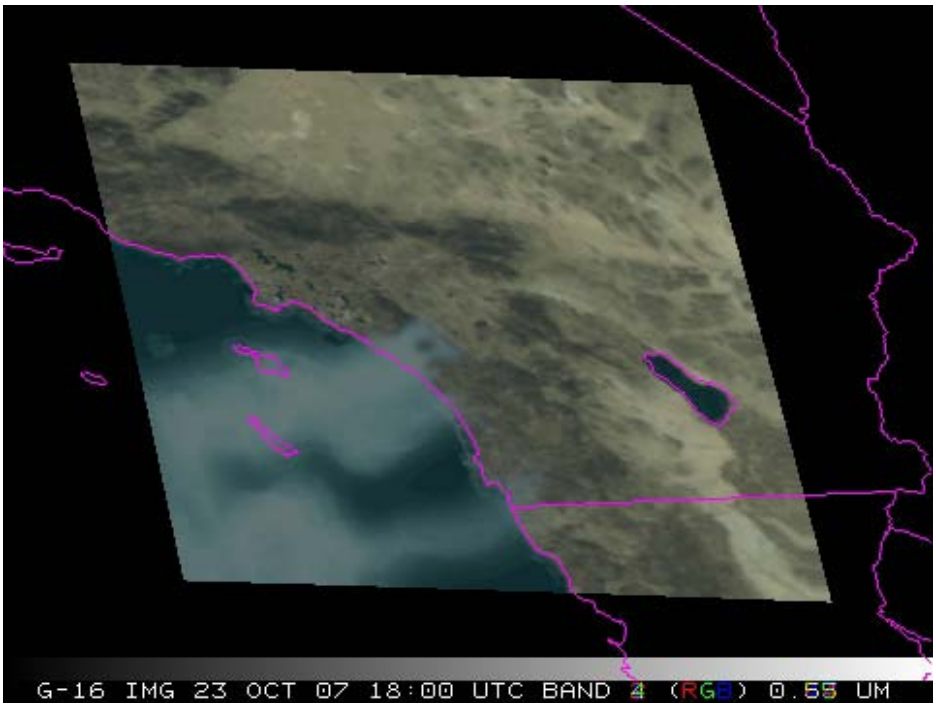


Figure 1: Synthetic GOES-R ABI color imagery over Southern California on October 23, 2007 showing smoke from a large wildfire.

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

Satellite Hydrology and Meteorology Training (SHyMet)

SHyMet is essentially a spin-off of the VISIT program and uses aspects of the VISIT program for development and delivery of training. One of the more prominent distinctions between the two programs is that VISIT focuses on individual training modules, while SHyMet organizes modules into courses. SHyMet takes a topic approach and selects content for the topic. It is able to draw on training materials not only within the VISIT program but outside the program as well. If a particular aspect of the topic is not represented in training materials, SHyMet will develop a module for it.

SHyMet launched a new course **SHyMet for Forecasters** in January 2010:
http://rammb.cira.colostate.edu/training/shymet/forecaster_intro.asp
The target audience is the forecaster, although it is open to all. This course is administered through web-based instruction and consists of 9 hours of core topics and 3 hours of optional topics.

Core modules:

1. Introduction to Remote Sensing for Hydrology
2. Interpreting Satellite Signatures (Figure 2).
3. Satellite Applications for Tropical Cyclones: Dvorak Technique
4. Aviation Hazards
5. Water Vapor Channels
6. GOES-R 101

Optional modules:

7. Regional Satellite Cloud Composites from GOES
8. Volcanic Ash Hazards

The first in the SHyMet courses was directed towards the NWS Intern and was released in 2006. The SHyMet for Interns continues to be offered: http://rammb.cira.colostate.edu/training/shymet/intern_intro.asp

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

This year also saw progress on the next 2 courses in the series: Tropical SHyMet and SHyMet for Hydrologists.

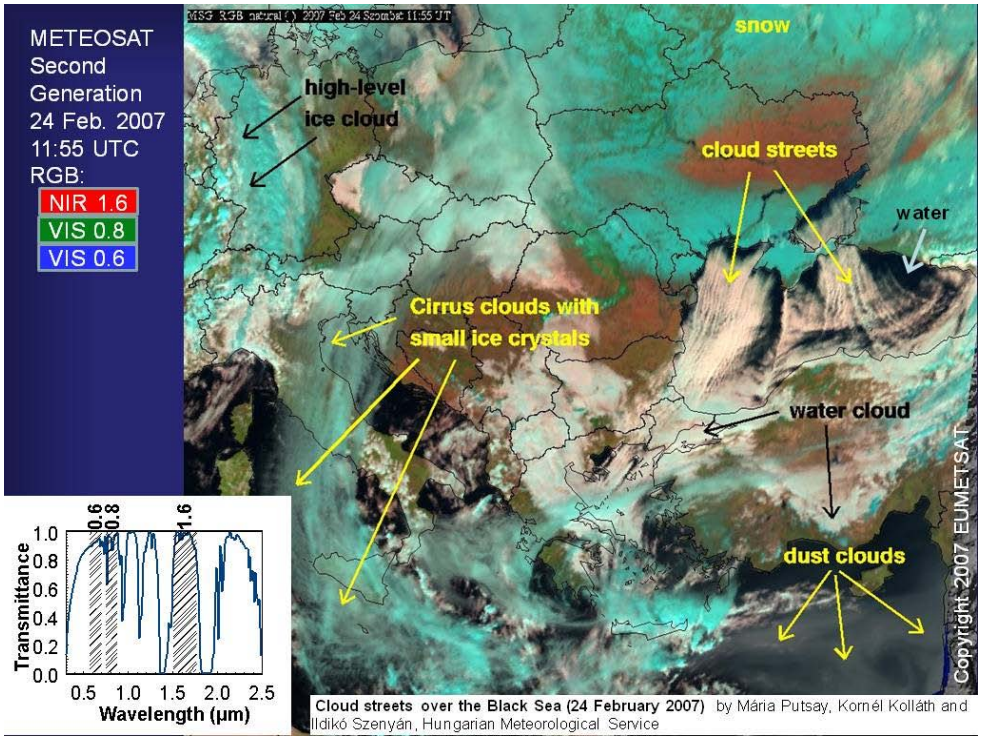


Figure 2: Example from the GOES-R 101 module in the SHyMet for Forecaster series demonstrating a Red/Green/Blue (RGB) product from METEOSAT Second Generation SEVERI visible and near infrared channels to highlight ice versus water cloud, snow versus background surface, and dust cloud.

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

CIRA collaborates with the World Meteorological (WMO) Regional Training Centers (RTC) in Costa Rica, Barbados, Argentina, and Brazil to promote satellite focused training activities. One of our most productive activities with these RTCs continues to be providing support to monthly virtual weather/satellite briefings. Our group is the WMO Focus Group of the Americas and the Caribbean, and we are a model group for other WMO countries. Participation in our monthly virtual satellite weather briefings is an easy and inexpensive way to simultaneously connect people from as many as 24 different countries, view satellite imagery, and share information on global, regional, and local weather patterns, hurricanes, severe weather, flooding, and even volcanic eruptions. Forecasters and researchers are able

to “build capacity” by being able to readily communicate with others in their discipline from different countries and discuss the impacts of their forecasts or impacts of broad reaching phenomena such as El Niño. Participants view the same imagery (geostationary and polar orbiting) using the VISITview tool (Figure 3) and utilize Yahoo Messenger for voice over the Internet.
http://rammb.cira.colostate.edu/training/rmtc/focusgroup.asp

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

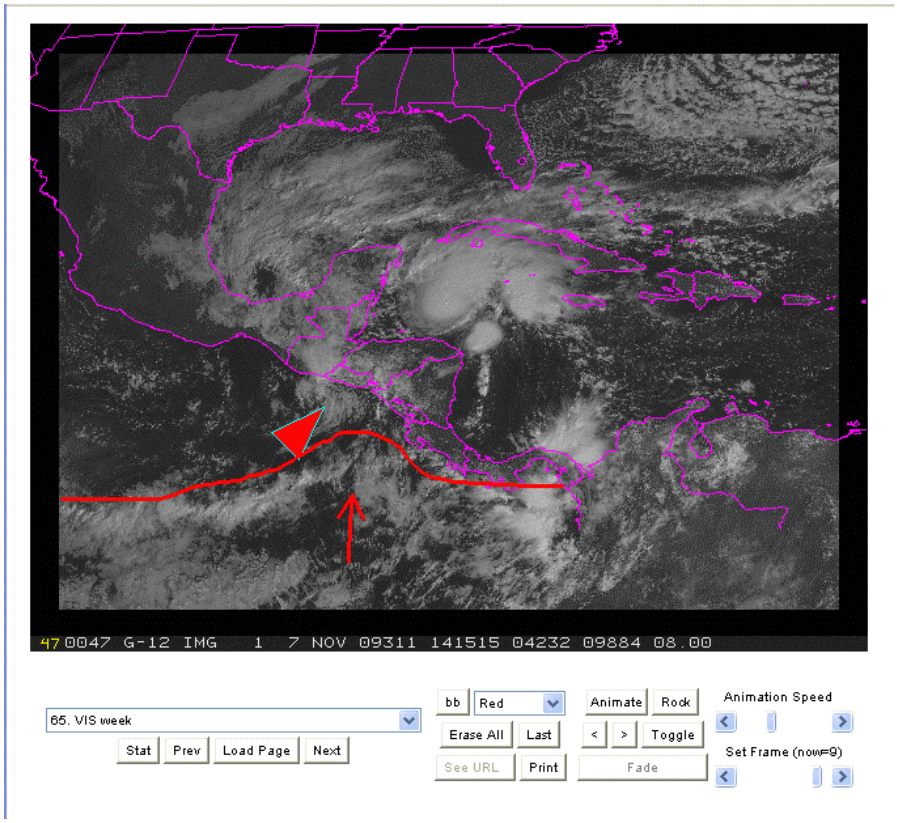


Figure 3: A screen grab showing visible imagery with annotation for 7 November 2009. The big red pointer indicates the center of the low level circulation off the coast of El Salvador. Hurricane Ida is in the Western Caribbean just north of Honduras. Late on the evening of the 7th, parts of El Salvador experienced flooding from storms that produced 355 mm (14 inches) of rain in 4 hours.

National Park Service Night Sky Program Measures, Trains and Educates

The National Park Service Night Sky Program moved to CIRA in 2008. The program researches and measures the night sky quality in national parks, advises parks about dark sky friendly lighting strategies, trains and educates park rangers about the importance of preserving dark skies, and promotes existing dark sky parks to preserve the natural night lightscape for future generations to experience. Each of these rangers will then educate thousands of park visitors on the importance of dark skies as a natural resource. Successfully trained park rangers have the potential of helping thousands of park visitors to connect with the cosmos as a natural extension of the unique park environment. Such experiences can inspire youth to pursue study in the sciences and to take a larger view of their world.

Training sessions were performed in Badlands (Figure 4) and Bryce National Parks in 2009. Training courses familiarize park rangers with the starry sky, telescope operation, night sky protection, and help them link their respective parks to the greater cosmos (Figure 5).

Figure 4: Angie Richman from the NPS Intermountain Region Office of Interpretation in Denver leads training at Badlands National Park.

Figure 5: The Milky Way loops from east to west in this full panoramic image from Death Valley's Racetrack Playa, one of the best night skies in the country.

To further help park rangers, the Night Sky Program has continued the Astronomy Volunteer In the Parks or Astro-VIP program. This program matches amateur astronomer volunteers to work in national parks. Astro-VIP's help park rangers develop and run night sky viewing programs with telescopes for park visitors. For more information see http://www.nature.nps.gov/air/lightscapes/astroVIP/index.cfm.

On September 17, during Eco Week at CSU's Pingree Park Campus for the Poudre School District Mountain Schools, Night Sky staff member Teresa Jiles presented a Sky Stories presentation under the night sky. Students learned how to use their dark adapted vision to see in the night, how to find the cardinal points using the Big Dipper, see the structure of Milky Way and hear the story of the Greek hero Perseus and see the constellations of characters involved in the night sky. Without a prior discussion of light pollution, students on their own pointed out the glow of Fort Collins light pollution dome because it disrupted their view of the rising sea monster Cetus that Perseus defeated to save the Princess Andromeda.

For more information about the Night Sky Program see http://www.nature.nps.gov/air/lightscapes.

Daily Weather Discussion Tradition Continues at CIRA

The popular Monday – Friday daily weather discussions continue at CIRA. Every day at 3 PM the CIRA RAMMB lab is used to discuss global or regional weather of interest, slanted towards a meteorological satellite perspective. Graduate students from the CSU Department of Atmospheric Science participate and often lead the daily discussions. CIRA RAMMB personnel also serve week long shifts preparing and leading the discussion. These sessions are a great way to explore new tools and products as well as to provide the CIRA research community the practical view from the forecaster's chair. During the late summer Atlantic hurricane season, the discussions are often standing room only with dozens of attendees.

Virtual Institute for Satellite Integration Training (VISIT)

The primary objective of the VISIT program is to accelerate the transfer of research results based on atmospheric remote sensing data into National Weather Service (NWS) operations. This transfer is accomplished through web-based distance learning modules developed at CIRA and delivered to NWS forecasters. There are two types of distance learning methods. The first is teletraining (Figure 6) which is a "live" training session utilizing the VISITview software and a conference call so that there is interaction between instructor and students. The second type is an audio / video playback format that plays within a web-browser. CIRA scientists Dan Bikos, Jeff Braun, Bernie Connell, John Knaff and Mark DeMaria contribute to VISIT training. The recorded web-based training modules can be taken online anytime by listening to audio playback with video.

Figure 6: VISIT allows trainers and forecasters to interact in virtual teletraining and forecasters can also use recorded training to fit their dynamic schedules.

From July 2009 through March 2010, VISIT delivered 42 sessions of live teletraining to 279 participants. An additional 191 participants utilized audio/video playbacks. Since 1999, over 19,000 training certificates of completion have been awarded through VISIT.

New VISIT teletraining and modules released this year were:

Basic Satellite Interpretation in the Tropics (teletraining):
http://rammb.cira.colostate.edu/visit/sat_tropics.html
An Overview of Tropical Cyclone Track Guidance Models used by NHC (seasonal teletraining and module)
http://rammb.cira.colostate.edu/visit/nhc_track_models.html
An Overview of Tropical Cyclone Intensity Guidance Models used by NHC (seasonal teletraining and module)
http://rammb.cira.colostate.edu/visit/nhc_intensity_models.html
For interesting weather happenings and research bits, check out the new VISIT blog:
http://rammb.cira.colostate.edu/visit/blog/

Dan Bikos of VISIT collaborated with the Warning Decision Training Branch (WDTB) in Norman, OK to assist in the development of an Advanced Warning Operations Course (AWOC) on Quasi-Linear Convective Systems (QLCS) type tornadoes that will be delivered to NWS forecast offices. Dan Bikos and Jeff Braun contributed to the development of a COMET module titled “Toward an Advanced Sounder on GOES?”.

Multimedia Training Module Created for Blended Total Precipitable Water Products

CIRA partnered with the NASA Short-term Prediction Research and Transition (SPoRT) center in Huntsville, Alabama to create a multimedia video on forecaster uses of the CIRA-developed blended total precipitable water (TPW) and anomaly product. This 30 minute video includes case studies and examples of forecaster applications and feedback. SPoRT provides the experimental version of these products to its NWS forecast office partners at the request of CIRA to evaluate their application to forecasts of precipitation and flooding potential, to tracking tropical waves, for comparing with model initialization, and to monitoring low level moisture flow. Experts from CIRA (Stan Kidder and John Forsythe) NESDIS/SAB (Sheldon Kusselson) as well as forecasters from SPoRT WFO partners have directly contributed to the content and operational case examples. This module is intended for the products directly created at CIRA, which continue to improve with additional and new TPW data sources, including adding microwave retrievals of TPW over land in 2010. The video is at http://weather.msfc.nasa.gov/sport/training/. The CIRA-developed blended TPW products became operational throughout the NWS in March 2009 and are now available via the AWIPS system. The operational blended TPW monitoring website, http://www.osdpd.noaa.gov/bTPW/ (Figure 7), presents animations of these products in near-real time.

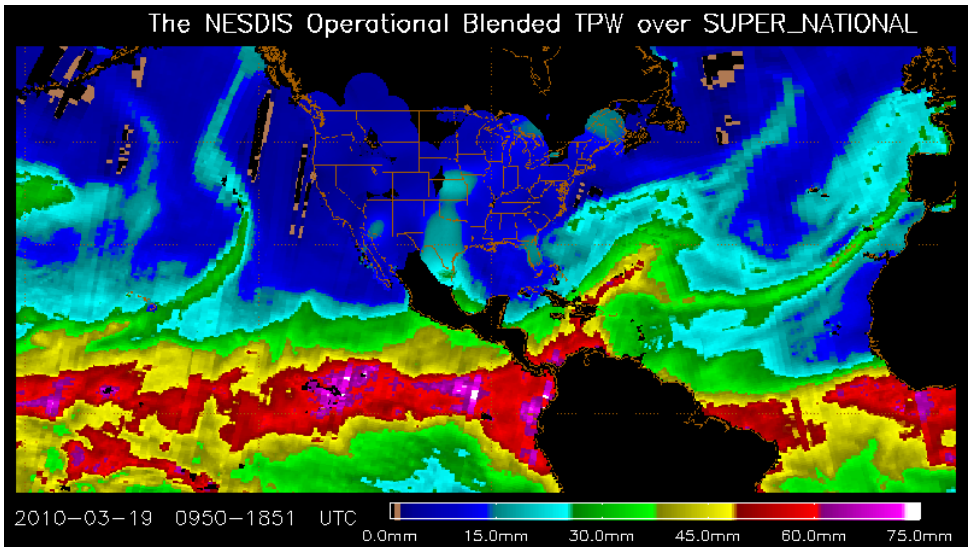


Figure 7: Example of the operational blended total precipitable water product over the CONUS from March 19, 2010 from the NESDIS website (http://www.osdpd.noaa.gov/bTPW/).

CIRA Collaborations with Local High Schools

Jeff Braun (CIRA RAMM Branch) visited Rocky Mountain High School in Fort Collins three times to present his "Talk about the weather." This talk was presented to students in the Introduction to Chemistry, Physics, and Earth Sciences (ICPE) classes.

Although no high school students were active this period in the Professional and Community Experience (PaCE) Program, CIRA expects future opportunities to materialize for high school students. The PACE program is a cooperation with the Poudre School District and allows high school students to earn school credit and learn about life in the workforce while also assisting with and being exposed to CIRA research. Typical duties include reading or backing up data or helping to write a web page.

Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Reaches Milestone of Observers in All 50 States

The Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) is headed up by the Colorado Climate Center at Colorado State University. CoCoRaHS is a large and growing collection of volunteers of all ages who help measure and report rain, hail and snow from their own homes (Figure 8). Data gathered by volunteers are collected via www.cocorahs.org/ and made available to the public, the National Weather Service, decision makers and to research scientists. Training and education is a key part of the CoCoRaHS network. All participants learn how to accurately measure and report all forms of precipitation. CoCoRaHS has expanded across the country at a rapid pace over the past few years. With the recent addition of Minnesota to the network, CoCoRaHS is now in all fifty states. COCORAHS is striving to have 20,000 active observers by the end of 2010.

Figure 8: COCORAHS observers use inexpensive but accurate equipment to measure rain, snow and hail.

CIRA National Park Service Group Develops Multimedia Program on Climate Change Education and Outreach

The United States Fish and Wildlife Service (USFWS), the National Parks and Conservation Association (NPCA), and the National Park Service (NPS) are partnering with the NPS/CIRA multimedia center to develop a multimedia outreach program on climate change education. The program is to be multifunctional in that it may be used for primary and secondary education, be presented in NPS and USFWS visitor centers, or made available for use in tourist information centers at gateway urban centers next to parks or fish and wildlife preserves. The program will be developed in a modularized fashion to facilitate evolving multiple presentations to meet a wide variety of needs. Particular consideration will be given to the sophistication and education level of the target audience and the time that a participant can reasonably be expected to interact with the program. Time factors may vary from a few minutes to hours.

Figure 9 is an example of an opening page where it is envisioned that a number of “buttons” allow exploration of many topics. In this example page the participant would learn about the effects of climate change, concepts of radiation balance, climate feedback mechanisms, and other topics. In the initial level of exploration the participant will be presented with singular concepts that start with very simple ideas. However, each page will allow the participant to continue to “tunnel” down into more and more sophisticated concepts.

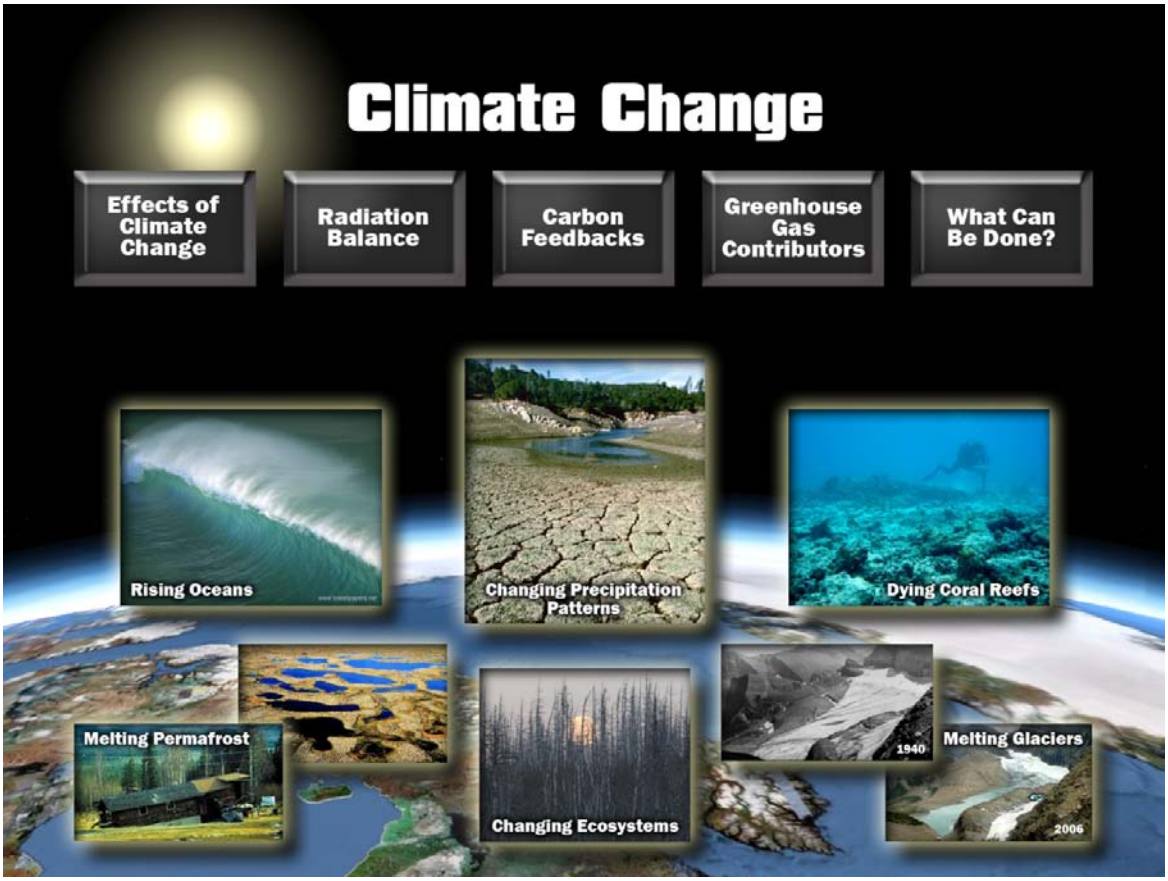


Figure 9: Example front page showing effects of climate change on various ecosystems.

For instance, under carbon cycling the participant will learn about where carbon is stored in the Earth's terrestrial and aquatic systems, how it cycles through the various systems in a very simple and graphic way, have the option to explore the chemistry of cycling between the various sources and sinks, and learn about the relative contribution of anthropogenic influences on naturally-occurring carbon cycles.

Science on a Sphere™ Showcased at UN Climate Change Conference

Science on a Sphere™ (SOS; http://sos.noaa.gov) creates a unique view of Earth by projecting various geophysical fields onto a six foot diameter globe. SOS was installed at 10 more sites this year, bringing the total number of installations to 47 worldwide (see Figure 10 for example).

In addition to these permanent sites, SOS was exhibited as the centerpiece of the US State Department's US Center at the United Nations Climate Change Conference (COP-15) in Copenhagen in December 2009. SOS inventor and CIRA Fellow Dr. Alexander MacDonald conducted an international SphereCast from the COP-15 conference. A SphereCast is an SOS presentation that is broadcast to multiple remote sites via the Internet. This was the first SphereCast originating from outside the US.

Six new visualizations of the AR4 IPCC global climate model results were created for use at the United Nations Climate Change Conference (COP15). These demonstrations illustrate surface temperature for the SRES A1B and B1 projections for the NCAR CCSM, HadCM3, and GFDL climate models.

Figure 10: Science on a Sphere™ installation at the Oregon Museum of Science and Industry.

CIRA staff at ESRL in Boulder (Mike Biere, Steve Albers, and Nikki Prive) attend SOS meetings and the SOS users workshop held in Boulder and serve on the panel discussing content creation.

GLOBE Reaches Out Through K-12 Education

The GLOBE (Global Learning and Observations to Benefit the Environment) program is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE encompasses a worldwide community of students, teachers, scientists, and citizens working together to better understand, sustain, and improve Earth's environment at local, regional, and global scales. CIRA support for GLOBE is provided by Travis Anderson, Michael Leon, Karen Milberger, Maureen Murray and David Salisbury.

"The GLOBE Earth System Science Activity Guide" was developed by GLOBE to accompany the GLOBE Earth System Poster "Exploring Connections in Year 2007" and to identify global patterns and connections in environmental data. Photographs of students were taken at Estes Park School while they participated in Earth science discovery activities. Their photographs along with a variety of relevant graphs were designed to engage students and teachers (the intended target audience) with engaging examples to enrich their experience.

GLOBE materials (posters, learning activities guide, 3-D lenticular printed card, and brochures) will be displayed at the GLOBE booth at the National Science Teachers Association meeting in Philadelphia in March 2010.

Additional graphics were created/designed, both independently and in team effort, for marketing collateral and branding for internal use and for partners. These graphics include logos, stationery, brochures, posters, and publications to NASA and the GLOBE Program Office.

GLOBE has continued to provide and maintain the design of the current web site while also producing graphics for a new Beta site. The GLOBE Program office and its partners continue to make requests for much needed updates which prompt the generation of materials and the improvement of the GLOBE user experience.

FX-NET Supports Fire Weather Forecasters and Air Force One

The FX-NET weather display provides a thin client, portable way for users to view weather data without the overhead of fixed weather displays such as AWIPS. Enhanced server systems for the FX-Net and Gridded FX-Net workstations were installed at five of the six NWS regional offices in support of the NWS Incident Meteorologists (IMET) fire weather forecasters, at 12 BLM and US Forest Service Predictive Services offices in support of fire weather forecasters, and for the support of Air Force One forecasters at Andrews AFB. Sher Schranz, Evan Polster, Jebb Stewart, and Ning Wang lead the FX-Net team at CIRA in Boulder.

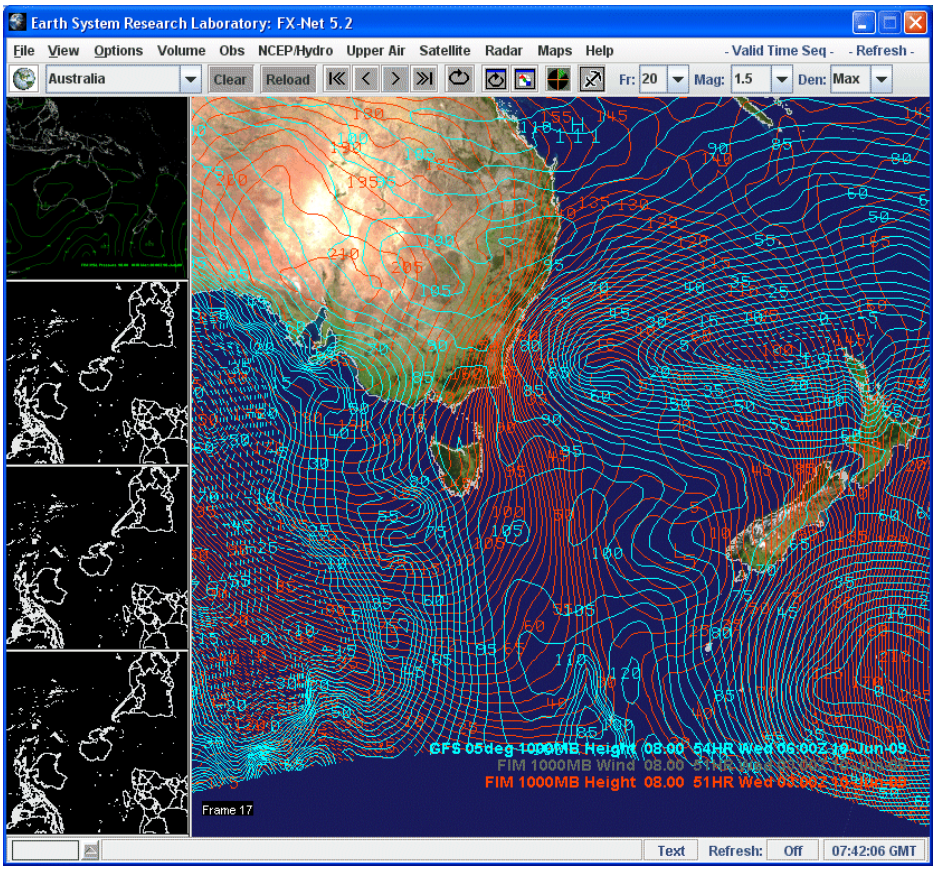


Figure 11: FX-Net for Australian Bureau of Meteorology Demonstration. Sher Shranz presented her paper, NOAA Fire Weather Research: An Integrated Fire Weather Support System, at the International Wildland Fire Conference in Sydney, Australia.

CIRA Continues to Provide Training and Support for AWIPS II

AWIPS II (Advanced Weather Interactive Processing System) is the future common visualization and forecast workstation for the National Weather Service. In continuation of the AWIPS II training conducted in previous years, and because of the new task orders, CIRA staff in conjunction with GSD's Information Systems Branch (ISB) completed the MADIS data ingest and display on AWIPS II. The plug-in to ingest a MADIS surface observation and deposit it into the PostGres database was completed. Also completed was the display plug-in to read the data from PostGres and display it on CAVE. This was a major accomplishment for CIRA since it gave CIRA developers more of an in-depth knowledge of the workings of AWIPS II. CIRA support for AWIPS II is provided by Joanne Edwards, Leigh Cheatwood-Harris, James Fluke and Ken Sperow.

The evaluation of MADIS as a viable Data Provider of surface observations was added to the Data Delivery Statement of Work. CIRA staff in conjunction with ISB developed MADIS User Scenarios for inclusion in the Data Delivery User Scenario and Use Case document. The MADIS user scenarios and use cases focus on the use of MADIS datasets to enhance forecaster situational awareness, for gridded verification and for discovering new networks. The user scenarios will be used to prototype requesting, accessing, processing and displaying MADIS datasets on AWIPS II.

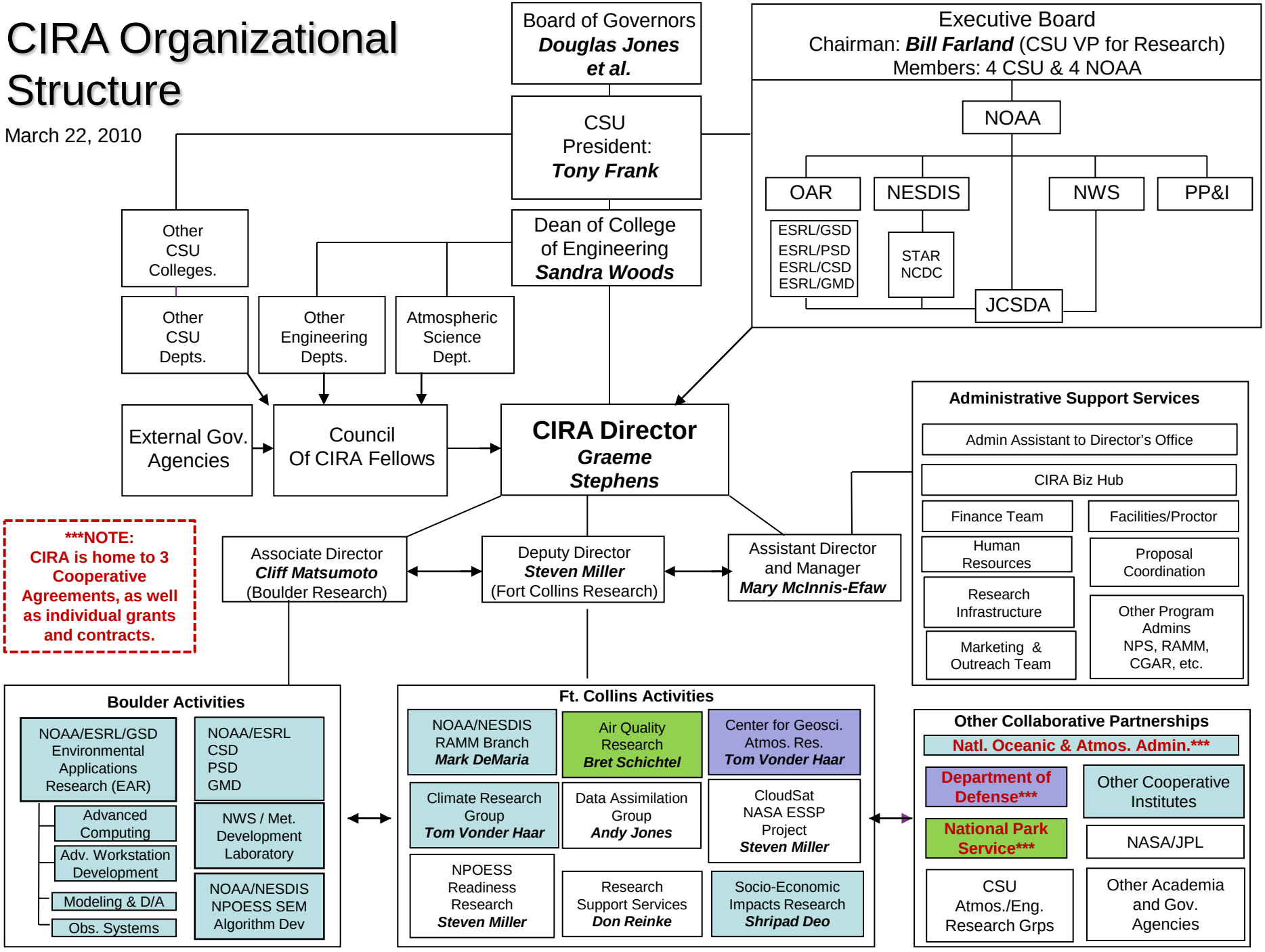
At the NWS's request, Ken Sperow created and presented a poster at the GOES User's Conference this past fall on the meteogram tool. NOAA's Meteorological Development Laboratory (MDL) also sent Ken to NWS WRHQ to understand IRIS in the context of AWIPS Migration.

NOAA AWARD NUMBERS

Award Number	Identifier	Project Title	Principal Investigators/ Project Directors
NA17RJ1228	Old Cooperative Agreement	Cooperative Institute for Research Five Year Cooperative Agreement	Graeme Stephens (Lead), Steven Miller
NA06SEC4690004	mistakenly awarded outside CA	CoCoRaHS: The Community Collaborative Rain, Hail and Snow Network - Enhancing Environmental Literacy through Participation in Climate Monitoring and Research	Nolan Doesken
NA07OAR4310263	mistakenly awarded outside CA	Monsoon Flow and its Variability during NAME: Observations and Models	Richard H. Johnson
NA07OAR4310281	mistakenly awarded outside CA	Simulation and analysis of the interaction between aerosols and clouds, precipitation and the radiation budget over the Gulf of Mexico and Houston	William Cotton
NA08OAR4320893	Shadow Award	The Cooperative Institute for Research in the Atmosphere	Graeme Stephens (Lead), Steven Miller
NA09OAR4320074	New Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Graeme Stephens (Lead), Steven Miller

CIRA Organizational Structure

March 22, 2010



CIRA FELLOWS & BOARD MEETING DATES

Mahmood R. Azimi-Sadjadi, Electrical & Computer Engineering, CSU

Daniel Birkenheuer, NOAA/ESRL/GSD

V. Chandrasekar, Electrical & Computer Engineering, CSU

Harold Cochrane, Economics, CSU (Retired)

Jeffrey L. Collett, Jr., Atmospheric Science Department, CSU

William R. Cotton, Atmospheric Science Department, CSU

Mark DeMaria, NOAA/NESDIS/RAMMB

Scott Denning, Atmospheric Science Department, CSU

Graham Feingold, NOAA/ESRL

Douglas Fox, Sr. Research Scientist Emeritus, CIRA, CSU, USDA (Retired)

Ingrid Guch, NESDIS Cooperative Research Program

Hariharan Iyer, Department of Statistics, CSU

Richard H. Johnson, Atmospheric Science Department, CSU

Pierre Y. Julien, Civil Engineering, CSU

Stanley Q. Kidder, Senior Research Scientist, CIRA, CSU

Steven E. Koch, NOAA/ESRL/GSD

Sonia Kreidenweis, Atmospheric Science Department, CSU

Christian Kummerow, Atmospheric Science Department, CSU

Alexander E. “Sandy” MacDonald, NOAA

Roger A. Pielke, Sr., Senior Research Scientist, CIRES, U of Colorado

James F.W. Purdom, Senior Research Scientist, CIRA, CSU

Steven A. Rutledge, Atmospheric Science Department, CSU

Graeme L. Stephens, CIRA Director and Atmospheric Science Department, CSU

Thomas H. Vonder Haar, CIRA and Atmospheric Science Department, CSU

Meeting of the CIRA Executive Board Held February 18, 2010

EXECUTIVE SUMMARY—Research Highlights

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

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

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

- CIRA's participation in the GOES-R Satellite Proving Ground project is providing a new way to interface with operational end-users of satellite applications. The Proving Ground establishes a direct connection to the Advanced Weather Information Processing System (AWIPS) data display systems used in NWS Weather Forecast Offices (WFOs), and a potential conduit to all WFOs. Among the products currently being demonstrated is a new Orographic Rain Index (ORI) tool which couples satellite-retrieved total precipitable water (TPW) information with model-predicted wind fields and high-resolution surface topography for the purpose of highlighting regions where the terrain may enhance precipitation and increase the risk of flash flooding. ORI has been used by the Hydrometeorological Prediction Center (HPC) to monitor land-falling Pacific storms along the U.S. West Coast this past Fall and Winter and was highlighted in several weather discussions issued to the Western Region. A strong cross-linkage between the Proving Ground and an independent research program established between CIRA and the Naval Research Laboratory has enabled the leveraging of selected applications from the *NexSat* (www.nrlmry.navy.mil/NEXSAT) program.

- Collaborations with the Global Systems Division (GSD), the Chemical Sciences Division (CSD), the Physical Sciences Division (PSD), and the Global Monitoring Division (GMD) of the NOAA Earth System Research Lab (ESRL) in Boulder continued at an unprecedented

level this past year. CIRA researchers were immersed in every branch and virtually every project in GSD, including project leadership and integral support involving the FAA and NWS NextGen, NNEW, and NEVS aviation program; meteorological workstation development, including the AWIPS II—Extended project, FX-NET, and GTAS; high performance computing; and the design, development and implementation of various regional and global weather and climate models, including the RUC, HRRR, FIM, and NIM as well as UAS OSSE investigations. Under education and outreach, the SOS architecture was enhanced to run on one computer instead of five and the system was installed at 10 new sites this past year, as well as the highly publicized centerpiece of the US State Department's US Center at the COP-15 Climate Conference in Copenhagen.

- Vital collaborations involving the other ESRL divisions continued with collaborations on clouds, aerosol, and precipitation interactions (with CSD), atmospheric rivers and their impacts on coastal orographic precipitation enhancement (with PSD), and carbon assimilation and OSSE research (with GMD). New endeavors in Boulder also included collaboration with NESDIS/NGDC and the Space Weather Prediction Center on the Joint Polar Satellite System's Space Environment Monitor (SEM) sensor algorithm development, as well as a partnership with the NWS Meteorological Development Lab and USGS on convective nowcasting and debris flow prediction.

- The multi-disciplinary Center for Geosciences and Atmospheric Research (CG/AR) is beginning its 25th year of research on environmental issues. This Department of Defense oriented program plans to welcome several new faculty and graduate students into its activities in 2010. As another example of how CIRA is able to leverage complementary research activities, CG/AR research includes examination of data from the NASA CloudSat mission to determine our ability to extend such high vertical (but limited horizontal) resolution information into the surrounding region—a technique bearing direct relevance to the NWS NextGen aviation program in terms of improved model evaluation of cloud forecasts.

- Over the past year the CIRA group working with the National Parks Service (NPS) continued its research on air quality issues in national parks. They successfully completed the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS) that examined the causes of excess nitrogen deposition in Rocky Mountain National Park. The results are being used to support and develop nitrogen deposition mitigation strategies. Over the coming year, we will begin exploring ways in which new NOAA and National Renewable Energy Laboratory (NREL) related research at CIRA in renewable energy (solar) may leverage the wealth of *in situ* data being collected regularly by the ongoing NPS programs.

- The CloudSat mission (launched 28 April 2006) continues to enjoy strong support from NASA Headquarters, having successfully gone through its latest senior review process with a recommendation to extend mission funding through 2012. The CloudSat program, with its Data Processing Center running operationally at CIRA on behalf of NASA, has facilitated multiple research activities including both NOAA and DoD-related efforts. In early December 2009, the CloudSat spacecraft experienced a serious battery anomaly which threatened to spell the demise of the mission. Scientists at JPL, Ball Aerospace, and CIRA worked on a remedy to the complicated issues surrounding this anomaly, and the radar was turned back on to operational mode successfully in mid-January 2010.

- The NASA Orbiting Carbon Observatory (OCO) mission was cut short when it failed to reach orbit in February 2009. This dealt a heavy blow as the main algorithm development activities were led by CIRA, and satellite-based atmospheric carbon research was an important element of CIRA's re-competition proposal to NOAA. The research program was quickly reconfigured to utilize the Japanese GOSAT satellite. It was announced recently that OCO will be given a new start with a target launch in early 2013. CIRA will continue to operate as a major contributor to this important and exciting mission that is designed to measure

atmospheric CO2 and track its sources and sinks, and in the process presenting new avenues for collaboration with NOAA CarbonTracker activities at ESRL.

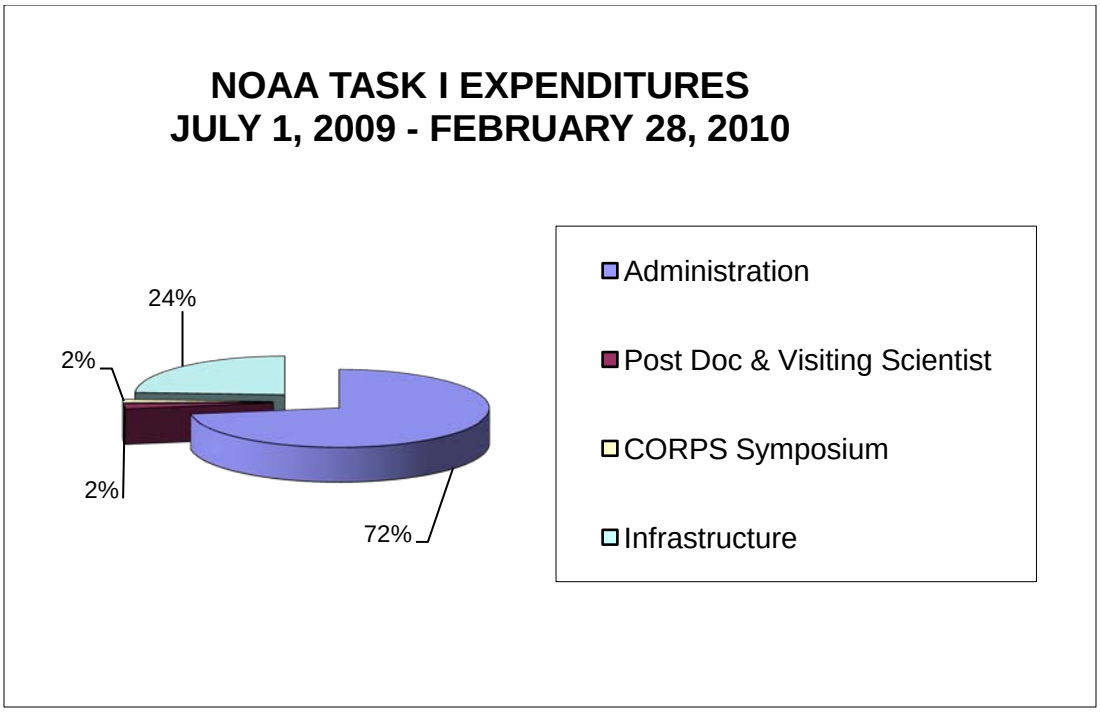
This Annual Report is broken into several chapters which represent the NOAA-defined themes of this Cooperative Institute. In our *Satellite Algorithm Development, Training and Education* theme, we describe ongoing efforts in developing applications for the current constellation of GOES sensors as well as risk-reduction for the future GOES-R satellite program, work related to estimating tropical cyclone formation probability and the cost-savings of improved track forecasting, and contributions to the VISIT and SHyMET satellite training programs. Our *Regional to Global-Scale Modeling Systems* theme includes research to improve our understanding of the magnitude of aerosol indirect effects, work with the Joint Hurricane Testbed to develop Monte-Carlo based models for probabilistic forecasting of maximum sustained wind speeds, and progress with high performance computing required to run global forecast models at increasingly higher spatial resolution.

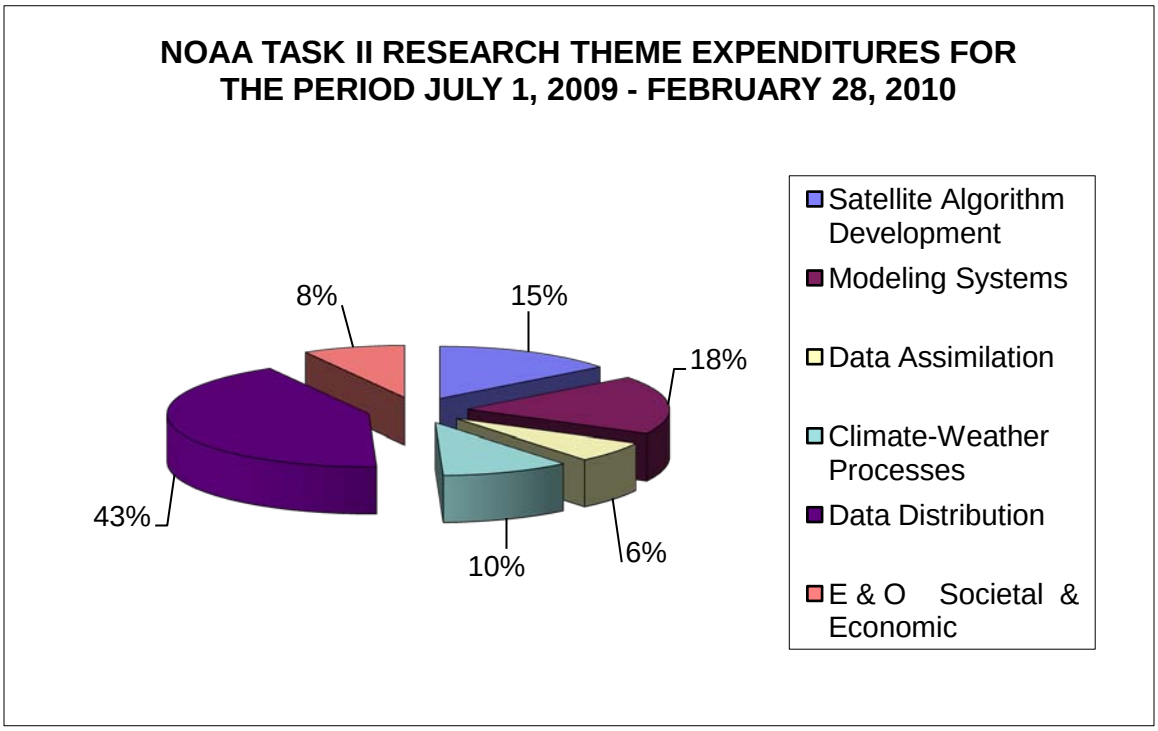
Our *Data Assimilation* theme showcases developments connected to the Hydrometeorological Testbed (HMT) program in wind profiler and GPS integrated water vapor data ingest, the use of wideband radar, balloon soundings, and Unmanned Aircraft Systems (UAS) in hurricane forecast model initialization, and the production of situation-dependent error information from Ensemble Kalman Filter data assimilation coupled to the Hurricane Weather Research Forecast (HWRF) model. Included in our *Climate-Weather Processes* theme are studies on the complex interactions between smoke and clouds as modeled via Large Eddy Simulations (LES), the development of a long-term rainfall data set from Special Sensor Microwave/Imager (SSM/I) data, and a critical assessment of the Intergovernmental Panel on Climate Change (IPCC) fourth assessment to ensure full integration of available resources, proper prioritization and physical consistency of key climate data records.

Highlighted in CIRA's *Data Distribution* theme is work with the National Weather Service (NWS) Meteorological Development Lab for flash flood monitoring and migration of Autonowcaster to operations for improved situational awareness, multiple efforts toward improving aviation forecast verification systems, preparations for the next-generation AWIPS-II interface, the Meteorological Assimilation Data Ingest System (MADIS) transition to NWS operations, and development of a novel drought early warning system. In addition to these major themes, CIRA engages in multiple education and outreach activities and strives to link weather, water, and climate research to societal impacts.

Interspersed among these major research themes are important contributions from CIRA's NESDIS postdoctoral program in data distribution, assimilation, and satellite algorithm development. Located in Camp Springs, MD, and integrated closely with NOAA technical contacts at STAR, these scientists are immersed in research ranging from refinements to the Community Radiative Transfer Model (CRTM), satellite-based sea surface temperature (SST) algorithm development, techniques for monitoring and quality control of long term SST records, and ocean color algorithm development for global climate and coastal/in-land water ecosystem monitoring. We are extremely proud of this program and its direct positive impacts to NOAA research needs.

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


NOAA TASK I EXPENDITURES
JULY 1, 2009 - FEBRUARY 28, 2010
24%
2%
2%
72%
Administration
Post Doc & Visiting Scientist
CORPS Symposium
Infrastructure


NOAA TASK II RESEARCH THEME EXPENDITURES FOR
THE PERIOD JULY 1, 2009 - FEBRUARY 28, 2010
8%
15%
18%
43%
10%
6%
Satellite Algorithm Development
Modeling Systems
Data Assimilation
Climate-Weather Processes
Data Distribution
E & O Societal & Economic

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

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

PROJECT TITLE: Task I Post Doc Scott Mackaro - The Use of Unmanned Aircraft Systems for Atmospheric Observations

PRINCIPAL RESEARCHER: Scott Mackaro and Nikki Prive`

NOAA TECHNICAL CONTACT: Yuanfu Xie, GSD/ESRL

PROJECT OBJECTIVE: To perform a regional OSSE in support of the hurricane UAS testbed in order to provide timely results for upcoming UAS missions. The Regional OSSE will use high-resolution regional models to evaluate potential hurricane intensity forecast improvements through the use of UAS observations.

ACCOMPLISHMENTS: A Nature Run has been generated for the Regional OSSE using a 3-day, 2km run of the WRF-ARW regional forecast model for Hurricane Ike. The simulated tropical cyclone undergoes a period of rapid intensification, which will be the focus of the OSSE intensity forecast studies. The HWRF model has been set up and tested for use as the forecast model for the Quick OSSE. Code for the generation of synthetic observations has been written for both the existing conventional observing network and for airborne UAS data types. Preparation of the data assimilation system for the HWRF is underway.

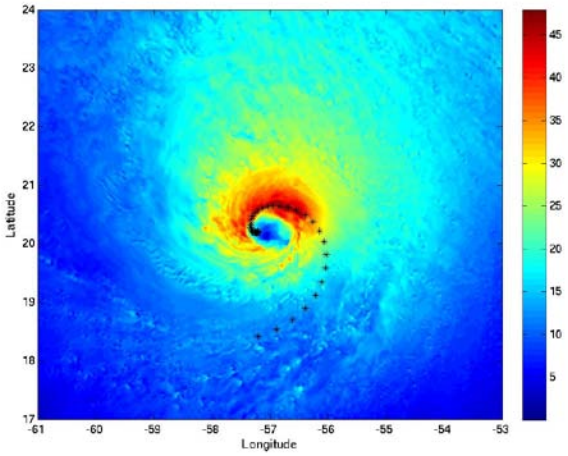


Figure 1: Quick OSSE Nature Run tropical cyclone wind speed (color, m/s) and potential low-altitude long-endurance UAS flight path (black stars).

SEMINARS SUPPORTED BY TASK I

July 16, 2009, M. Cai (Florida State Univ.). Dynamical Polar Warming Amplification and a New Climate Feedback Analysis Framework.

July 24, 2009, A. Sorooshian (CIRA). Where on Earth does Aerosol Reduce Precipitation?

July 30, 2009, W. Sun (Purdue Univ.). One Dimensional Snow-Land Surface Model and its Application.

August 6, 2009, A. Jonko (Oregon State Univ.). Effects of CO2 Forcing Magnitude on Climate Feedbacks.

August 19, 2009, A. Betts (NSSL). Idealized Model for Changes in Equilibrium Temperature and Boundary Layer Cloud Over Land in a Doubled CO2 Climate.

August 27, 2009, A. Heidinger (NOAA/NESDIS). NOAA Cloud Product Algorithm Development for the Next Generation GOES-R and NPOESS Satellite Observing Systems.

September 3, 2009, M. Glantz (Univ. of Colorado). Our War with Climate.

September 10, 2009, J. Calderazzo & S.E. Campbell (Colorado State Univ.). 100 Views of Climate Change.

September 17, 2009, T. Scambos (National Snow and Ice Data Center). Arctic Sea Ice Decline.

September 24, 2009, B. Mapes (Univ. of Miami). Studying the MJO and Tropical Waves through Data Assimilations.

October 8, 2009, W. Gray (Colorado State Univ.). A Look Back at the Changes in Meteorology (Atmospheric Science) Since the Early 1950's.

October 15, 2009, P. Durkee (Naval Post Graduate School). Multispectral Aerosol Optical Depth Retrievals from High-Resolution Satellite Imagery.

October 30, 2009, E. Tziperman (Harvard). Dinosaur Forecast: Clouds, and Other Lessons from Past Warm Climates.

November 2, 2009, B. Ruston (Naval Research Lab). Expected Impacts of NPOESS Sensors on NWP.

November 5, 2009, G. Frost (NOAA). Evaluation of U.S. NOx Emissions with Satellite-Based Observations and Model Simulations.

November 12, 2009, J. Weiss (UC Boulder). Nonequilibrium Statistical Mechanics and Climate Variability.

November 19, 2009, E. Greene (Colorado Avalanche Information Center). Understanding Avalanches: A Theoretical Framework and Practical Approach.

November 30, 2009, J. Sun (NCAR). Radar Data Assimilation for High-Resolution Models: Recent Activities at NCAR.

December 3, 2009, M. Weisman (NCAR). The 8 May 2009 "Super Derecho": A Land-Hurricane?

December 10, 2009, T. Birner (Colorado State Univ.). Stratospheric Circulation Impact on Composition and Structure of the Tropopause Region.

January 13, 2010, T. Mathewson (BLM). Fire Weather Predictive Services.

January 28, 2010, D. Estep (Univ. of Miami). Adjoint-Fueled Advances in Error Estimation for Multiscale, Multiphysics Problems.

February 4, 2010, R. Wood (Univ. of Washington). The Sensitivity of Precipitation in Low Clouds to Aerosol Perturbations.

February 8, 2010, C. Fletcher (Univ. of Toronto). Linear Interference Effects on Tropical-Extratropical Teleconnections.

February 11, 2010, K. Venayagamoorthy (Colorado State Univ.). Probing the Physics of Environmental Flows Using Numerical Simulations.

February 18, 2010, A. Clement (Univ. of Miami). Low-Level Clouds and Climate Change.

February 24, 2010, D. Zupanski (CIRA). Applications of Data Assimilation Methodologies in Wind Power Forecasting.

February 25, 2010, G. Feingold (NOAA ESRL). Aerosol Effects on Clouds and Precipitation: Buffered States, Runaway States, and Self-Organization.

March 4, 2010, S. Lovejoy (McGill Univ.). The Time-Space Cascade Structure of the Atmosphere and its Numerical Models.

March 18, 2010, S. Otsuka (Kyoto Univ.). Numerical Experiments on Thin Moist Layers in the Tropical Midtroposphere.

March 25, 2010. G. Stephens (CSU/CIRA). The Water Cycle, Moist Processes and Climate Change: What Might Be Predictable, Where Challenges Lie and What We Glean from New Earth Observations.

RESEARCH THEME REPORTS

SATELLITE ALGORITHM DEVELOPMENT, TRAINING & EDUCATION

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

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

PRINCIPAL INVESTIGATORS: Steve Miller and Renate Brummer

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: The next generation GOES environmental satellite systems, beginning with GOES-R, will contain a number of advanced instruments including the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). National Weather Service (NWS) forecasters and other operational users of satellite data must be introduced to and trained properly on these new capabilities in order to maximize the utility of GOES-R. CIRA is leveraging its existing capabilities to provide this training and experience directly to NWS forecasters through ongoing support of the NOAA 'Proving Ground' project where simulated and proxy GOES-R products are demonstrated at NWS Weather Forecast Offices (WFOs) in their native Advanced Weather Information Processing System (AWIPS) display systems.

ACCOMPLISHMENT 1: Interactions with Forecast Offices and National Centers. CIRA worked closely with the National Weather Service Weather Forecast Offices (WFO) in Boulder and Cheyenne by participating in their forecaster workshops, observing forecasters during their shifts, collecting forecaster feedback, inviting forecasters to Proving Ground meetings at CIRA, and supporting a close collaboration between the WFOs and CIRA's systems experts. Proving Ground interactions also began between CIRA and NOAA's Storm Prediction Center (SPC) and the National Hurricane Center (NHC). CIRA completed the first version of a Hail Probability Forecast product which was used during SPC's Spring Experiment 2009. The new Proving Ground collaboration with NHC began with several planning meetings. The list of NHC Proving Ground products includes an NHC lightning-based TC intensity prediction product, an NHC RGB air mass product, and an NHC RGB ABI dust product.

ACCOMPLISHMENT 2: Proving Ground Website Development. A considerable amount of effort was put into the development of CIRA Proving Ground training material (i.e. product descriptions) which was completed for most of the original CIRA Proving Ground projects. Some of the existing product descriptions were revised based on feedback from our users and liaisons. An improved CIRA product list table

was also implemented. More than 50% of the CIRA Proving Ground demonstration products can be viewed on-line, on RAMSDIS, or on AWIPS.

ACCOMPLISHMENT 3: AWIPS Development. All new Proving Ground products were tested on CIRA's AWIPS system. Significant progress was made with feeding four of these demonstration products to the NWS Central and Western Region Headquarters and with supporting WFO Boulder and Cheyenne with the necessary AWIPS menu adjustment. CIRA's systems team also made a successful effort to stay tuned with the on-going AWIPS II development.

ACCOMPLISHMENT 4: CIRA Proving Ground Product Development. The so-called "GeoColor" product was CIRA's first Proving Ground product which was distributed to run on WFO Boulder and Cheyenne AWIPS systems. GeoColor demonstrates the kind of imagery that will be possible in the GOES-R ABI era which, when combined with complementary data from other satellites, will be able to produce versions of colorful imagery without the need for some of the special blending techniques.

The Orographic Rain Index (ORI) product is another Proving Ground product developed and distributed by CIRA. The ORI is designed to indicate to forecasters where there is short-term (0-3 hours) potential for heavy orographic rain. It is based on three data sources: Blended TPW from CIRA which indicates the strength and location of atmospheric rivers impinging on the U.S. West Coast, GFS 850 mb winds which are used to advect the water vapor to a forecast time, and USGS Global 30 Arc-Second Elevation Data.

Additional CIRA Proving Ground products include a low cloud/fog product, volcanic ash products, blowing dust products, snow/cloud discrimination products, and simulated true color products. Detailed information about each of these products can be found on our website at http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list/

The CIRA team also collected forecaster feedback about the Proving Ground products. Product descriptions were produced for user training purposes. CIRA's VISIT and SHyMET experts are part of our Proving Ground team, and are being engaged in this process. New plans are in place to identify and develop case-study training examples based on the expanding and continuously updating Proving Ground product suite, as a way to educate users on capabilities (and limitations) of these products.

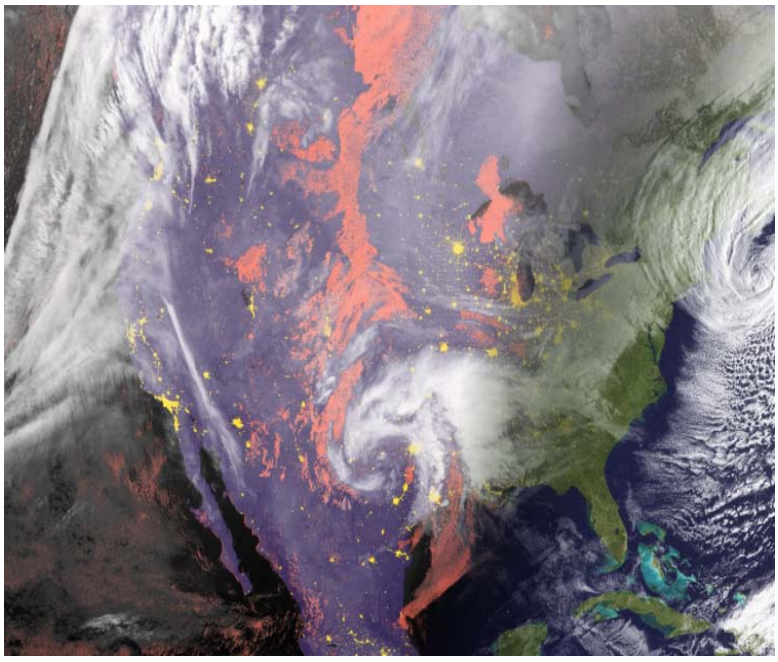


Figure 1: Example of GeoColor product for March 1, 2010 at 1315 UTC. Daytime portions of the image demonstrate a pseudo true-color capability anticipated from the ABI, and the nighttime portion of the scene demonstrates city light detection (from JPSS systems) coupled with low cloud/fog detection (red) and higher/deeper clouds in grayscale.

PROJECT TITLE: Advanced Environmental Satellite Research Support

PRINCIPAL INVESTIGATORS: Tom Vonder Haar (Jim Purdom)

NOAA TECHNICAL CONTACT:

PROJECT OBJECTIVE 1: Advancing more comprehensive utilization of satellite data;

PROJECT OBJECTIVE 2: Undertake portions of the research with this activity in a cooperative manner with national and international science groups;

PROJECT OBJECTIVE 3: Develop science requirements to help identify the role of satellites, both research and operational, within a Global Earth Observing System context;

PROJECT OBJECTIVE 4: Identify appropriate uses of satellite data for atmospheric and environmental applications based on four cornerstones of space-based remote sensing: resolution in the spatial, temporal, spectral and radiometric domains; and,

PROJECT OBJECTIVE 5: Research results will be applied to expand the use of environmental satellite data through training programs and lectures in national and international arenas.

ACCOMPLISHMENTS: Leading WMO in addressing Integrated Observing Systems, including the role of satellites in the redesign and evolution of the Global Observing System; WMO Integrated Observing Systems Planning and Implementation; Addressing merging of various WMO Observing Systems into a composite system (i.e., CBS, AREP, WyCOS, etc.); CBS Management Group; Work plan and achievements within OPAG-IOS addressed; coordinated with other CBS MG leaders on future activities; WMO Global Satellite Optimization Workshop; Represented WMO OPAG IOS interest and chaired international teleconference for ½ day portion of NRC panel on NPOESS and GOES-R mitigation; As chair OPAG-IOS advised joint meeting of ET-SAT and ET-SUP, and ET-EGOS; World Meteorological Organization (WMO) Congress and Executive Council; Advisor to NOAA DAA and US Permanent representative to WMO; Advisor and US expert on WMO CBS Observing System Activity and WMO Integrated Observing System (WIGOS) developments; Advisor and US expert on Satellite Activities; NRC Panel on a National Mesoscale Observing Network; Advise as satellite observing system capabilities and utilization expert, as well as International Observing System capabilities expert to panel; NRC Panel mitigation of removal of climate sensors from NPOESS and GOES-R; Provide input from International perspective as well as expertise on geostationary hyperspectral data; THORPEX activity includes setting goals and objectives for both space-based and in-situ observing systems to support THORPEX; THORPEX International Core Steering Committee; Expert addressing satellite related activity as well as CGMS Rapporteur to ICSC; Co-chaired THORPEX Observing System Working Group; GOES-R Risk Reduction Technical Advisory Committee and GOES-R Technical Advisory Committee and GOES-IM Product Assurance Plan Technical Advisory Committee; Provided input on GOES-R requirements based on past experience, GOS needs, and user needs (workshop on spectral coverage, three GOES configuration strategy, HES spectral coverage options, synergy with hyperspectral polar sounders and GPS OS); Helped to configure GOES R^3 and GOES-R AWG plans and participated in startup of both programs; Virtual Laboratory for Satellite Data Utilization; co-chaired five year assessment of activity within VL Management Group; planning for Earth Observing Partnership for the Americas (EOPA), renamed GEOSS Americas; planning for future Regional High Profile Training Event in the America's to assure full utilization through GEOSS Americas; Coordination Group for Meteorological Satellites (CGMS) ; Satellite Meteorology Subject matter Expert (SME) for Bulletin of American Meteorological Society

PROJECT TITLE: Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events

PRINCIPAL INVESTIGATOR: Louie Grasso

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVE: The overall goal of this project is to contribute to the reduction of time needed to fully utilize GOES-R as soon as possible after launch and to provide the necessary proxy data to the algorithm groups for testing proposed algorithms and therefore to contribute to an improved algorithm selection and algorithm refinement.

ACCOMPLISHMENTS: During the last year the CIRA GOES-R ABI synthetic imagery team focused on the development, evaluation, and testing of GOES-R Advanced Baseline Imager (ABI) fire proxy datasets. These datasets were delivered to Algorithm Working Group (AWG) fire proxy dataset teams for testing of their fire retrieval algorithm. ABI radiances and brightness temperatures for four GOES-R ABI bands (2.25 μm, 3.9 μm, 10.35 μm, 11.2 μm) were generated using the WRF-ARW model to simulate an agricultural fire event in Central America. In addition the 23 of October 2007 wildfire event of Southern California was reproduced with several improvements to the production of synthetic imagery implemented. These improvements include the use of a new lowest model layer temperature (canopy temperature) as the skin temperature. In addition a 5-minute linear interpolation of ABBA retrieved 30-min fire temperatures was introduced which replaces the formerly used 30 minutes constant fire temperature intervals. The use of MODIS 16-day albedos at 2.1 μm instead of 3.9 μm emissivities for the surface reflectance for the 2.25 μm dataset resulted in an improved 2.25 μm reflectivity dataset. A study was conducted which indicates that the use of 2.25 μm imagery in combination with 3.9 μm imagery can lead to improved fire retrievals especially for hotter fires (above 450 K). Additional fire proxy dataset work began on an agricultural fire event which occurred over north-eastern Arkansas on 5 November 2008.

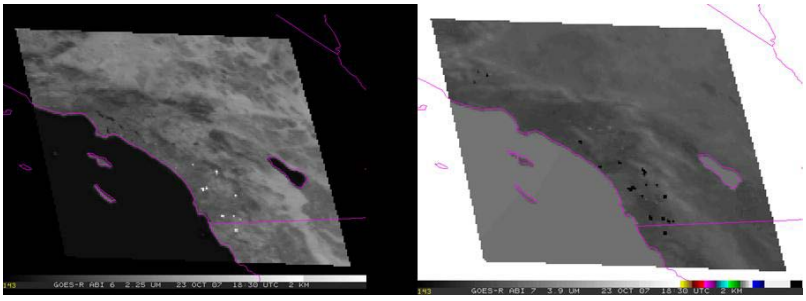


Figure 1: Synthetically produced GOES-R ABI imagery of Southern California wildfires for 23 of October 2007 at 1830 UTC. Depicted are ABI band 6 (2.25 μm) on the left and band 7 (3.9 μm) on the right.

The CIRA team also created a variety of RGB (true-color) images based on synthetic ABI data over the north-central U.S. Data was simulated through model runs and forward radiative transfer to generate simulated ABI reflectances. For comparison, RGB images were created with both "real" and "synthetic" Green components. For ABI, which won't come with a green band, a synthetic-Green image will first need to be generated and combined with the Red and Blue bands to create a synthetic-RGB image. For generating a synthetic-Green image a look-up-table (LUT) created from MODIS data was used and applied to the Red, Near-IR, and Blue bands. This technique was applied to generate RGB images of fire proxy datasets with smoke plumes. Comparisons were made between both "real" and "synthetic" images, as well as ground truth MODIS imagery.

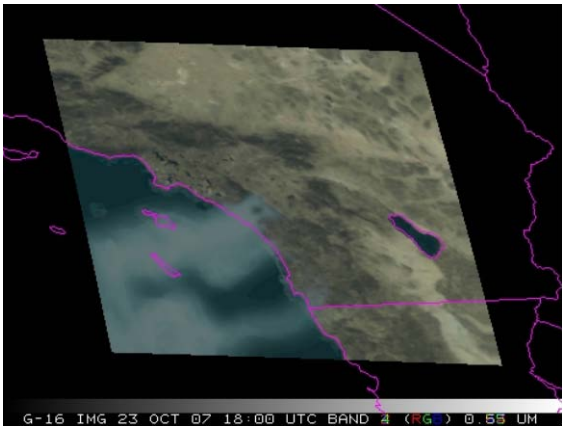


Figure 2: RGB (true-color) smoke image for the 23 October 2007 Southern California wild fire event. A Rayleigh correction has been applied to the image, to reduce atmospheric scattering and the blue bias seen in un-corrected RGB images.

PROJECT TITLE: Applications of Satellite Altimetry Data to Statistical and Simplified Dynamical Tropical Cyclone Intensity Forecast Models

PRINCIPAL INVESTIGATOR: Tom Vonder Haar

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: CIRA's role in this project is to evaluate and improve the impact of satellite altimetry in statistical tropical cyclone intensity models, and to assist with the validation of the satellite-based ocean heat content (OHC) estimates that are utilized by the statistical models.

In FY06, CIRA worked with the Naval Research Laboratory in Monterey to assess the impact of the OHC input on the Statistical Typhoon Intensity Prediction Scheme (STIPS) that is run operationally for the Joint Typhoon Warning Center in Honolulu. To increase the sample size these forecasts were continued in FY07. In FY08, the impact of the OHC was evaluated on Atlantic tropical cyclone forecasts from the Statistical Hurricane Intensity Prediction Scheme (SHIPS). Results showed that the OHC had only a very minor impact for the typical storm but a larger influence for the strongest of the tropical cyclones. The final phase of this project was to evaluate the impact on SHIPS forecasts in the eastern North Pacific and update the use of

OHC in both the Atlantic and east Pacific statistical intensity models used by the National Hurricane Center.

The physical mechanism behind the impact of the OHC is that in regions where it is large, a tropical cyclone is less likely to reduce the sea surface temperature through upwelling and mixing of cold water from beneath the surface. Another aspect of this research was to develop a more physical relationship between OHC and intensity change by investigating the ocean response to tropical cyclones. A large archive of forecast cases of the operational version of the Hurricane Weather Research and Forecast (HWRF) coupled ocean-atmosphere hurricane model was used for this purpose. A simple parameterization of SST cooling was developed. A simple method for estimating OHC from the monthly climatology and actual SST values was also developed so that the operational SHIPS forecasts can still be run when the satellite altimeter data is missing.

This research will help to improve the intensity forecasts for hurricanes that have the potential to rapidly weaken or intensify. Results show that OHC has the largest impact on very strong tropical cyclones--those that inflict the majority of the damage on coastal areas. This project has a direct connection with the public interest. Coastal evacuations and other preparations for tropical cyclones are extremely expensive, and hurricanes that undergo rapid intensity changes are the most problematic.

This research is a joint effort among several groups within NOAA, the university community, and the Department of Defense. These including the NOAA/NESDIS Office of Research and Applications, the NOAA/NCEP TPC, NOAA/OAR/AOML, The Naval Research Laboratory, The Naval Research Laboratory in Monterey, The Joint Typhoon Warning Center, Colorado State University and the University of Miami.

PROJECT ACCOMPLISHMENTS: The final phase of this project was completed during the reporting period above. An OHC archive for the eastern and central North Pacific was obtained from U. of Miami. This data was used to develop a version of SHIPS for these basins that includes OHC as a predictor. This model was implemented in NHC operations for the 2009 hurricane season. Results showed that the impact is somewhat different than in the Atlantic. In the east Pacific, the sensitivity to OHC is observed for much lower values than in the Atlantic. It is hypothesized that the larger stability values in the east Pacific ocean make it less succeptible to SST cooling so lower values of OHC have the equivalent relationship with cooling than higher values in the Atlantic.

The other accomplishment in the final year of this project was to add OHC input to the Logistic Growth Equation Model (LGEM), which is a statistical intensity prediction model similar to SHIPS. LGEM relaxes some of the constraints of the multiple linear regression formulation used in SHIPS. The version of LGEM with the OHC input was run operationally in both the Atlantic and eastern/central North Pacific basins during the 2009 hurricane season. Results for 2009 showed that LGEM was the best performing operational intensity model for the Atlantic and a combination of SHIPS at the early forecast times and LGEM at the later forecast times was best in the eastern North Pacific.

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

PRINCIPAL INVESTIGATOR: Tom Vonder Haar

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: Over the past several years the Cooperative Institute for Research in the Atmosphere (CIRA) has performed basic and applied research to better utilize data from NOAA Geostationary Operational Environmental Satellites (GOES) and Polar Operational Environmental Satellites (POES). The NOAA/NESDIS GOES Improved Measurements Product Assurance Plan, GIMPAP, has supported CIRA research on the use of GOES data for mesoscale analysis of high-impact weather events, including severe weather and tropical cyclones.

ACCOMPLISHMENT 1: Regional Cloud Climatologies. CIRA continued to generate regional cloud climatologies to aid individual NWS offices in day to day forecasts by providing additional information on local climate based on local conditions. We worked closely with Eureka's Weather Forecast Office to analyze newly generated burn-off climatologies and generated two completed sets of cloud climatologies for their area covering 2 months periods over summer 1999-2007.

ACCOMPLISHMENT 2: Severe Weather and Mesoscale Studies with GOES. Our objective was to collect satellite and model data for MCSs and to use verification statistics to improve the present MCS algorithm by making optimized use of the GOES Sounder data. Datasets from summer 2008 were collected and combined with previous years' data. Results showed that the GOES Sounder Lifted Index cannot improve the verification statistics under the current method. Instead, GOES Imager 10.7 µm data are better to characterize where MCS's and convection currently exist. For the second part of this project, we combined information from GOES imagery and RUC model output with the objective to provide short-term (0-6 hours) predictions of where severe weather is expected. A statistical analysis for severe weather reports from the summers of 2006 and 2007 was conducted. A first version of this new experimental algorithm ran in real-time during the summer of 2009 predicting the probability of severe hail within the next 1 hour (see Figure 1). The result of this forecasting project was very promising.

ACCOMPLISHMENT 3: National and International Training. CIRA continued to enhance the existing training structure for GOES. The national training was provided through the VISIT and SHyMet programs. Internationally, we collaborated closely with the WMO Virtual Lab Focus Group and we made use of their WMO Training Events. In addition, GOES-12 imagery for December 2008 through May 2009 was processed for the Regional Training Centers (RTCs) in Costa Rica and Barbados. The archives are being used to look at cloud frequency during the rainy and dry seasons and detect local variations from year to year. The archived imagery also provides access to examples for use in satellite focused training efforts.

ACCOMPLISHMENT 4: Tropical Cyclone Forecast Product Improvement with GOES. A new version of the Statistical Hurricane Intensification Prediction Scheme (SHIPS) model has been developed and an extended GOES and satellite altimeter data set was generated for the 2009 hurricane season. A traditional EOF analysis was performed using the entire CIRA/RAMMB IR archive. The Principle Components (PC) for the images have been identified and calculated for all cases. We found a slight relationship between a couple of the EOFs and intensification rates. We also redeveloped the Rapid Intensity Index (RII) coefficients for the 2009 hurricane season with the expanded GOES and OHC databases, and the OHC discriminator was included in the east Pacific version for the first time beginning in 2009. The RII code was also ported to the new NCEP IBMS for the 2009 hurricane season. A new vertical shear direction predictor was added to the SHIPS and related Logistic Growth Equation Model (LGEM). GOES and OHC predictors were added to the LGEM model for the 2009 season. The extended GOES and

OHC databases made that improvement in LGEM possible. The new versions of SHIPS and LGEM were evaluated by re-running all Atlantic and eastern Pacific forecast cases from 2006-2008 and then comparing the results with the older version of the model.

ACCOMPLISHMENT 5: Winter Weather Studies with GOES. Fourteen cases of cyclones over the Eastern Pacific from November and December 2006 were collected. The EOFs have been computed and were examined along with the principal component time series, all in relation to the time series of the central pressures of the surface lows. The analysis was restricted to deepening systems only. In addition, the principal component time series was compared to the pressure change at the storm center. For the cloud climatology study, cases of extratropical cyclones over the central and eastern U.S. with at least 4 inches of snow and obvious comma heads were examined for dynamical differences and their snowfall patterns within the comma heads. It was found that the snow swath in the comma head of a typical classic case is broad, extending throughout the comma head with localized maxima.

Results of CIRA's GIMPAP projects were presented at conferences and several manuscripts were written and sent to refereed journals.

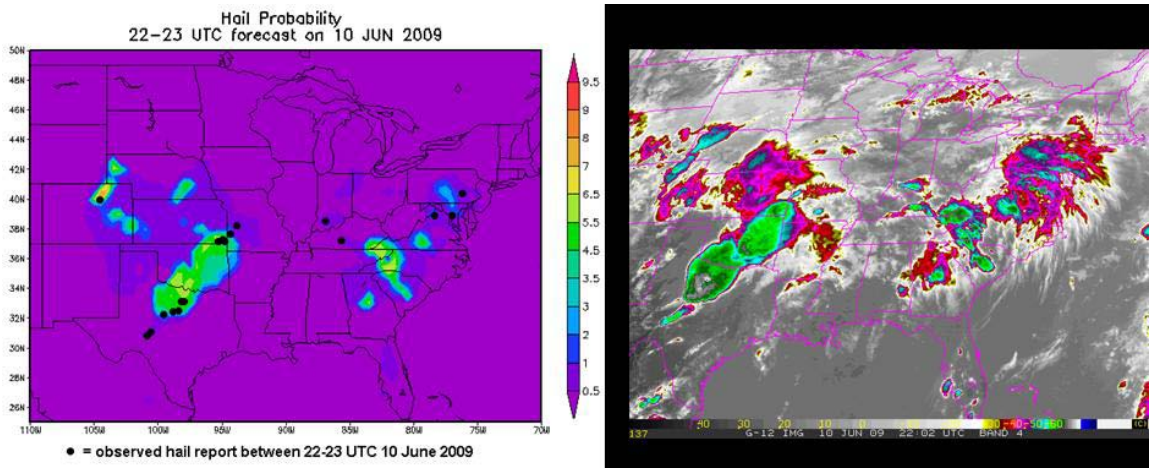


Figure 1: Left: probability of severe hail within a 0.5x0.5 degree lat/lon box between 2200 and 2300 UTC on 10 June 2009. The dots indicate observed severe hail reports between 2200 and 2300 UTC. Right: GOES 10.7 µm image from 10 June 2009 at 2200 UTC.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

PRINCIPAL RESEARCHERS: Patrick Purcell and Janet Machol

NOAA TECHNICAL CONTACT: William Denig, NGDC STP

PROJECT OBJECTIVE 1: Develop algorithms and science grade software for the NPOESS Space Environment Monitor (SEM-N).

PROJECT OBJECTIVE 2: Manage and engineer SEM-N science grade software and algorithm development.

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

ACCOMPLISHMENTS: Background: The NPOESS Space Environment Monitor (SEM-N) will fly on the first National Polar-Orbiting Operational Satellite System (NPOESS) satellite, currently scheduled for a March 2014 launch. SEM-N is scheduled to fly on the first NPOESS satellite (C1) with an orbital period of approximately 100 minutes, an altitude of approximately 830km in a Sun-synchronous orbit with a 1330 ascending node crossing time. The SEM-N sensor suite consists of three types of particle sensors covering different energy ranges. These particle sensors are based on heritage sensors currently operating on DMSP, POES, and NASA planetary missions. SEM-N will provide five environmental data records to be used by NOAA NESDIS and the Air Force Weather Agency to produce operational space weather products.

SEM-N detects energetic ions in the polar regions during solar proton events with four in-situ particle detectors which cover the higher energy ranges (10-250 MeV) of protons. The detectors will have five output channels of count rates from overlapping energy ranges of the protons. This objective is to develop an algorithm to produce an EDR of the differential flux of energetic ions by inverting the count data from the high energy detectors.

We have decided to use a simple iterative fitting method rather than a full inversion technique because there are only five particle counts representing overlapping energy regions and thus it is not possible to know the functional form of the spectra. While a true inversion code produces one functional fit for the entire energy spectrum, we are using a piecewise technique that produces four fits that step across the energy range. This piecewise technique is especially advantageous for cases where the proton energy spectrum is non-monotonic. To invert the data we first divide the particle counts into non-overlapping channels assuming piecewise power law fits for the spectrum and then perform a second iterative piecewise power law fit to the spectrum. The algorithm is a variation on one for similar detectors that will be aboard future Geostationary Operational Environmental Satellites (GOES). We have added energy-dependent detector geometric response functions and fields of view.

We are currently testing this algorithm using archived satellite data from GOES and the Polar Operational Environmental Satellite (POES). We manipulate this data to make it emulate the future NPOESS data. Further steps will be to add geometric functions to represent the non-isotropic particle distributions at lower magnetic latitudes, and to compare the results of the algorithm to those from a true inversion code.

System and Software Engineering: While the algorithm and software development for SEM-N is a small-team environment, the NPOESS ground processing system, the Interface Processing Data Segment (IDPS), is a formal development environment spanning three government agencies (DoD, DoC, and NASA) and two major contractors (Northrop Grumman Aerospace Systems and Raytheon Intelligence and Information Systems). A major challenge for the SEM-N science grade software development effort has been to integrate the level of system and software engineering formality required of the overall ground processing system with the

small SEM-N science team development environment.

To accomplish this task, the SEM-N software and project management approach was developed based on the NASA Procedural Requirements (NPR) 7150.2A. The requirements in 7150.2A are extracted from industry standards and provide NASA expertise in software engineering. SEM-N tailored these requirements to the appropriate classification of software (science and research software) to ensure successful software lifecycle development without the burden of excessive management and engineering overhead. For the current period, SEM-N has completed a software development plan that meets these goals with the assistance and expertise of the NOAA NGDC Information Technology department.

A major goal of the SEM-N System and software engineering effort is not only to develop and deliver science grade software, but also to integrate the software into the existing ground processing environment as efficiently as possible. The NPOESS ground processing segment has been developed by Raytheon Intelligence and Information Systems in Aurora, Colorado. Since the system must be in place for the NPOESS Preparatory Project satellite launch in 2011, it has already reached a high state of maturity. An overview view of IDPS is shown in Figure 1.

Figure 1 illustrates the multi-faceted design necessary to meet stringent NPOESS performance and latency requirements. SEM-N has designed requirements and software architecture to follow current IDPS paradigms in order to provide an integration effort as seamlessly as possible.

A major part of the software engineering design is to conform to the infrastructure of IDPS. Specifically, the SEM-N science grade code, in order to integrate efficiently into IDPS, will ideally use the same input/output, compiler optimization, logging and process controlling mechanisms as implemented in IDPS. To assist in this task, the NPOESS Integrated Program Office (IPO) and Northrop Grumman/Raytheon have developed the Algorithm Development Library (ADL) tool, currently undergoing testing. The goal of ADL is to allow science developers to access operational code (code that has been modified by IDPS to work within the operational system) and modify that code for re-delivery. The modified code re-delivered, instead of being science grade code that must once again be converted to operational code, would already contain the operational overhead and could then be re-integrated with much less effort than non-ADL re-delivered science grade code.

The SEM-N software development plans have folded the implementation of ADL into the lifecycle process. Continuous updates and feedback continue between the NPOESS IPO, Northrop Grumman, Raytheon and the SEM-N group to test, debug, and implement ADL for SEM-N science grade algorithms.

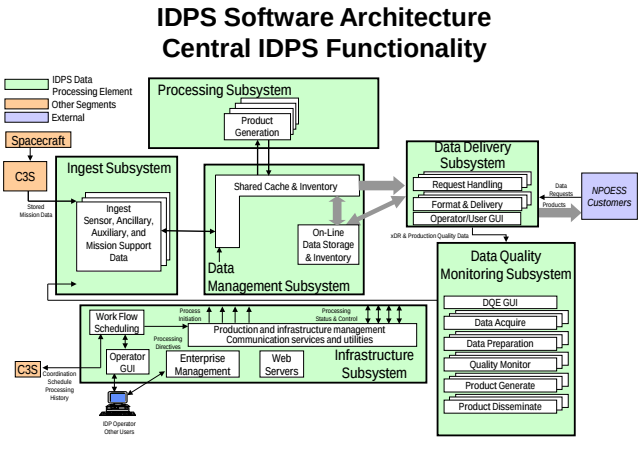


Figure 1: IDPS Software Architecture

PROJECT TITLE: Development and Evaluation of GOES and POES Products for Tropical Cyclone and Precipitation Analysis (PSDI) – Western Pacific Tropical Cyclone Formation Probabilities

PRINCIPAL INVESTIGATOR(S): Stan Kidder and Renate Brummer

NOAA TECHNICAL CONTACT: M. Seybold (OSDPD)

PROJECT OBJECTIVE: The objective of the "Development and Evaluation of GOES and POES Products for Tropical Cyclone and Precipitation Analysis (PSDI) – Western Pacific Tropical Cyclone Formation Probabilities" project is to develop a real-time, objective 24-hr Tropical Cyclone Formation Probability (TCFP) product for the Western Pacific. Specific goals are to: 1) include AMSU data from additional operational sources to existing TC intensity and wind structure algorithm, 2) extension of the NESDIS TC Formation Probability product to the N. western and central Pacific basins, and 3) to transition multi-platform TC surface wind analysis (MTC-SWA) to operations.

ACCOMPLISHMENTS: 1) Include AMSU data from additional operational sources to existing TC intensity and wind structure algorithm. The statistical temperature retrievals for the Met-Op and Aqua satellites have been developed and integrated into the program that estimates tropical cyclone intensities and wind structures. The development and implementation of the BUFR Code into the NASA Aqua AMSU antenna temperatures has been hampered by the: 1) ever changing NOAA/NCO security, 2) 64-bit binaries that are produced by the NCEP IBM. JHT servers are 32-bit, so those machines cannot read the BUFR binaries. We are pursuing other options: a) a local 64-bit machine, b) access to the IBM. We have been working closely with A. Krautkramer (NHC) on these issues. Once these issues have been addressed transition to operations will begin. IT planning information was also provided in the last year.

2) Extension of the NESDIS TC Formation Probability product to the N. western and central Pacific basins. This product was successfully transitioned to operations during the last reporting period (http://www.ssd.noaa.gov/PS/TROP/TCFP/index.html). Product validation for 2009 (Figure 1) was completed in Jan 2010 and results were presented at the Interdepartmental Hurricane Conference, 1-4 March 2010.

3) Transition multi-platform TC surface wind analysis (MTC-SWA) to operations. The code to run the MTC-SWA analysis was successfully transitioned to the pre-operational machine during 2009 and has been running in real-time since October. A real-time, java based monitoring tool has also been created requiring a slight code modification. Web page and ftp access to the data has been developed early in 2010. The web page is located at http://www.ssd.noaa.gov/PS/TROP/mtcswa.html and ftp access to the ATCF fixes are available at ftp://satepsanone.nesdis.noaa.gov/MTCSWA/ATCF_FIX/ and all the products run thus far are also available at ftp://satepsanone.nesdis.noaa.gov/MTCSWA. This product is ready for transition to operations, though work on the documentation continues. IT planning information was also provided in the last year.

Recently we were informed of a 60-day freeze on the operational machines that will likely be extended to 15 months following failure of security reviews. This situation has put the operational transition of MTC-SWA on hold until the various freezes are lifted. Impacts of a potential/imminent freeze of operations were provided to OSDPD and SAB.

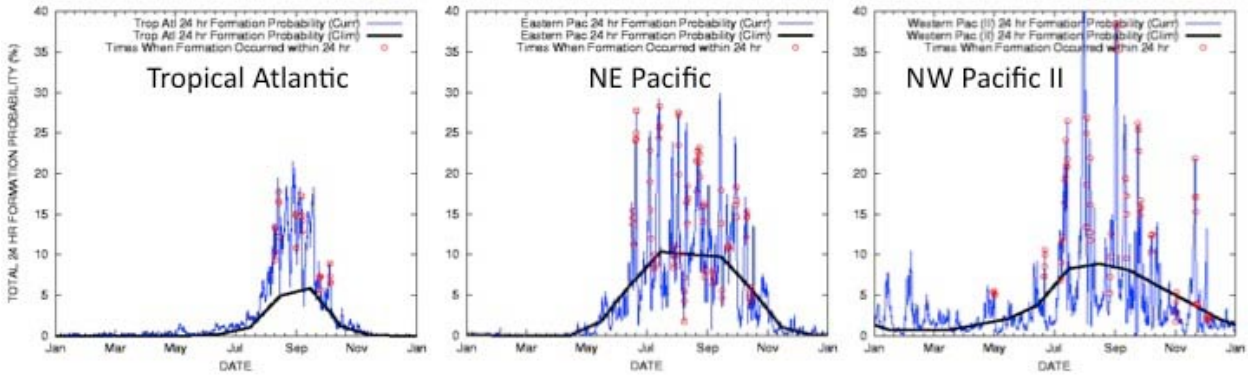


Figure 1: 2009 time series of TC formation probabilities summed over the Tropical Atlantic (left), N.E. Pacific (middle) and N.W. Pacific II (right) sub-basins. Product estimated TC formation probabilities are in blue, climatological probabilities are in black, and time periods within 24-hrs prior to TC formation are represented by open red circles.

PROJECT TITLE: Development of Polar Satellite Processing System for Research and Training

PRINCIPAL INVESTIGATOR: Bernie Connell

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVE: Through international agreements with the European Space Agency (ESA), the Met-Op polar orbiting satellite has become an important component of the global observing system. Met-Op will also provide the morning coverage that will complement the afternoon coverage provided by NOAA satellites. In addition, Met-Op contains a number of advanced instruments that are similar to those that will be available on future NOAA missions. Our project objective is to set up a processing system at CIRA for Met-Op and other polar satellite systems for research, development and training.

ACCOMPLISHMENTS: During the annual report period we continued to support and expand the product ingest for the polar satellite data processing system implemented in 2008 at the StAR Regional and Mesoscale Meteorology Branch (RAMMB) located at CIRA. We successfully implemented a routine ingest and archive process of polar data (including the newly added MIRS V.3 data) from NESDIS servers. The development of data processing software began at CIRA in 2008 and continued through the past year with the additional processing of Met-Op data sets. The Met-Op satellite contains a number of unique instruments that will be useful for development of products for mesoscale meteorology. These include the hyperspectral IASI sounder, an ocean surface wind instrument (ASCAT), and a five-channel microwave humidity sounder (MHS), which may also be available on future NOAA satellites. In addition, Met-Op includes the AVHRR-3 imager and the Advanced Microwave Sounder Unit. In cooperation with NOAA, Met-Op is in a morning orbit to complement the afternoon orbit of the NOAA satellites.

These advanced instruments have numerous applications to tropical cyclone and severe weather analysis and forecast products, and also provide subsets of what will be available on GOES-R and JPSS. Our project resulted in an expanded archive and retrieval database for use by other CIRA researchers and also supported the development of RAMMB research applications in tropical cyclone and severe weather algorithms.

Under support from another program, capabilities have been developed to generate polar satellite data from coupled numerical model/radiative transfer code. This is a very CPU intensive process, but the results are valuable for the interpretation of the Met-Op data and for product development and training. Hardware was requested to improve the ability to generate this simulated data for inclusion in the processing system.

The archived datasets will also be used for training purposes and for proxy data for JPSS and GOES-R. Improved forecaster training with advanced satellite analysis techniques developed at RAMMB/CIRA will provide better forecasts and better utilization of NOAA satellite data. The data and processing system is also available to CIRA and the Colorado State University Atmospheric Science Department for use by graduate students and other researchers.

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

PRINCIPAL INVESTIGATOR: Bernie Connell

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

OVERALL OBJECTIVE: The overall objective of the SHyMet program is to develop and deliver a comprehensive distance-learning course on satellite hydrology and meteorology. This is being done in close collaboration with experts at CIRA, the Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Cooperative Program for Operational Meteorology, Education and Training (COMET), the National Weather Service (NWS) Training Center (NWSTC), and the NWS Warning Decision Training Branch (WDTB). The challenge is to provide necessary background information to cover the many aspects of current image and product use and interpretation as well as evaluate data and products available from new satellite technologies and providing new training on the these tools to be used operationally.

PROJECT OBJECTIVE 1: Maintain, make small incremental changes as necessary and track students taking the SHyMet Intern Course (released in April 2006) http://rammb.cira.colostate.edu/training/shymet/intern_intro.asp .

PROJECT OBJECTIVE 2. Finalize modules and update web pages for the new SHyMet for Forecaster Course.

PROJECT OBJECTIVE 3. Update information on the LMS to offer and track the SHyMet for Forecaster Course and release new course.

PROJECT OBJECTIVE 4. Work closely with hydrologists and instructors at NOAA/NWS/OCWWS Training Division and COMET in Boulder to develop course outline and modules for SHyMet for Hydrologists: a) Identify target audience, b) Assist with needs assessment survey, and c) Review existing and newly developed materials.

PROJECT OBJECTIVE 5. Advertise and make SHyMet course materials available nationally and internationally to individuals outside NOAA/NWS.

PROJECT OBJECTIVE 6. Attend meteorological and educational conferences and symposiums as the opportunities arise to present materials related to SHyMet and to actively solicit training needs from the community.

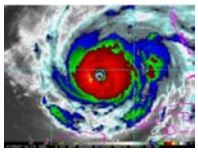
ACCOMPLISHMENT 1: SHyMet Intern tracking statistics for July 2009 - February 2010 (compared to entire period April 2006 – February 2010). Note: the metrics for the SHyMet Intern course are tracked through the expertise of the VISIT program. The course consists of 9 modules:

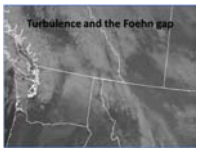
--34 new NOAA/NWS employees/participants registered at CIRA during July 2009 - Feb. 2010 (227 total for period April 2006 – February 2010)
--13 of the new (34) NOAA/NWS individuals have completed SHyMet Intern Course during July 2009- Feb. 2010. (102 total for period April 2006 – February 2010)

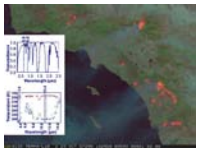
ACCOMPLISHMENTS 2 and 3: The SHyMet Forecaster course was finalized and released in January 2010.
http://rammb.cira.colostate.edu/training/shymet/forecaster_intro.asp
It consists of 6 core modules and 2 optional modules. Core courses: 1) Introduction to Remote Sensing for Hydrology; 2) Interpreting Satellite Signatures; 3) Satellite Applications for Tropical Cyclones: Dvorak Technique;
4) Aviation Hazards; 5) Water Vapor Channels;
6) GOES-R 101
Optional courses: 7) Regional Satellite Cloud Composites from GOES; 8) Volcanic Ash Hazards (Part 1)

The metrics for the course are tracked with the expertise of the VISIT program. During the past 2 months we have had 16 registrations and 3 of those individuals have already completed the course.

ACCOMPLISHMENT 4: The focus of the next SHyMet course is on Remote Sensing for Hydrology. At this point we are leaning towards 4 modules. The first two modules will set the stage for satellite applications, and the second two modules will focus on examples and applications. 1) Summary of Hydrology needs with respect to Remote Sensing; 2) Satellite Applications of QPE/QPF; 3) Feature Identification (vegetation, land use, soil moisture, flooding, ice cover); 4) Snow cover applications. In addition, with a number of new training modules developed over the last year with a Tropical theme, the team is investigating the opportunity to organize the content into a Tropical SHyMet series.





PROJECT TITLE: Global Tropical Cyclone Formation Probabilities

PRINCIPAL INVESTIGATOR: Jack Dostalek

NOAA TECHNICAL CONTACT: M. Seybold (OSDPD)

PROJECT OBJECTIVE: The objective of the "Development and Evaluation of GOES and POES Products for Tropical Cyclone and Precipitation Analysis (PSDI) – Global Tropical Cyclone Formation Probabilities" project is to develop a global, real-time, objective 24-hr Tropical Cyclone Formation Probability (TCFP) product.

PROJECT ACCOMPLISHMENTS: Product development began in May 2009. Satellite water vapor imagery was collected from Meteosat-7 and best tracks for the Indian Ocean and Southern Hemisphere were obtained from the Joint Typhoon Warning Center. The same methodology used to develop the NESDIS TCFP product for the N. Atlantic, N.E. Pacific and N.W. Pacific tropical basins was used. New algorithms were developed for the Indian Ocean and Southern Hemisphere, and the existing algorithms for the other sectors were updated with 1) 2006-2008 data and 2) Reynolds SST replacing Levitus climatological SST.

An experimental version of the Global TCFP began running in real-time at CIRA in Aug 2009. A test website was set up for monitoring of the experimental product: (http://rammb.cira.colostate.edu/projects/gparm/gparm_glob_test/index.asp). Verification of the

Global TCFP product for dependent and independent years was conducted using skill scores (Brier and ROC, with climatology as a reference) and reliability diagrams, which were presented at the Interdepartmental Hurricane Conference on 4 Mar 2010. Overall, the TCFP product has more forecast skill than the climatological reference forecast and shows predictive promise in the newest sectors (Figure 1).

In terms of development, the Global TCFP is on schedule and will be ready to transition to a NESDIS platform for a pre-operational test period this spring. However, recently we were informed of a 60-day freeze on the operational machines that will likely be extended to 15 months following failure of security reviews. This situation will put the pre-operational transition Global TCFP on hold until the various freezes are lifted. Impacts of a potential/imminent freeze of operations were provided to OSDPD and SAB.

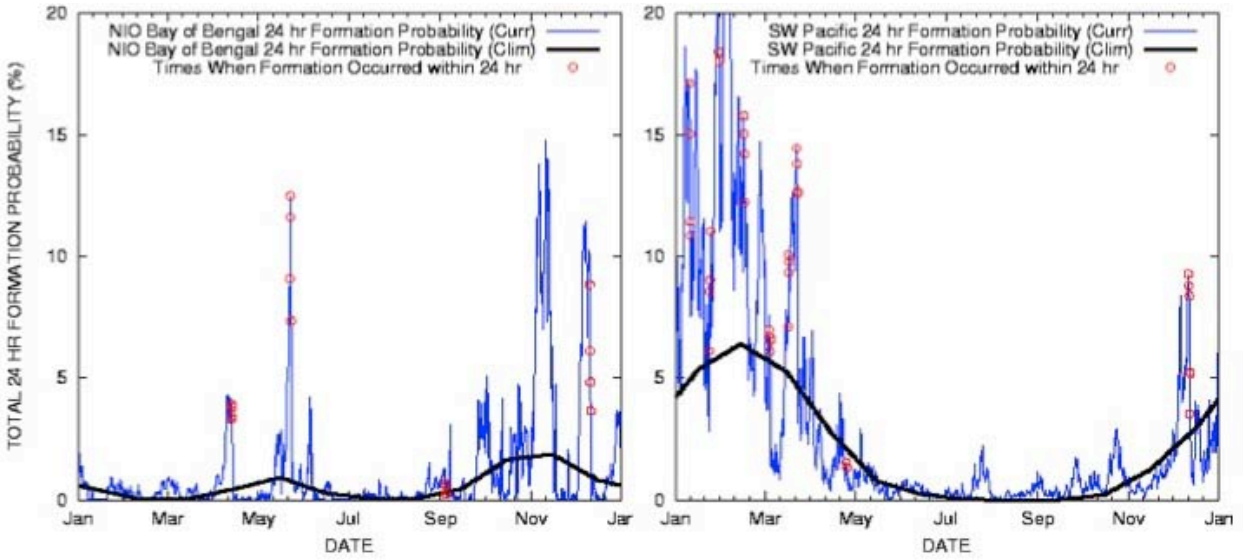


Figure 1: 2009 time series of TC formation probabilities summed over sub-basins of the Indian Ocean (left, Bay of Bengal) and Southern Hemisphere (S.W. Pacific). Product estimated TC formation probabilities are in blue, climatological probabilities are in black, and time periods within 24-hrs prior to TC formation are represented by open red circles.

PROJECT TITLE: NESDIS Post Doc Prasanjit Dash – An Improved SST Product from AVHRR/3 Sensor Flown Onboard MetOp-A

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Alexander Ignatov

PROJECT OBJECTIVES: The work by the reporting postdoc comprises two "major Systems", both of which have a number of sub-systems and objectives. Both these systems function in near real-time (NRT) with user friendly web interfaces:

--the SST Quality Monitor (SQUAM), and
--the SST calibration validation (CALVAL)

The initial set-up (technological aspects of statistical analyses and web-presentation) for the SQUAM and CALVAL prototype systems were reported in "2009 Annual Report", hence, are omitted here. Only the newer technological additions and improvements are briefed in this report, in the "Technological Additions" section.

OBJECTIVE 1: Continue maintaining and improving SQUAM for heritage Main Unit Task (MUT) Sea Surface Temperature (SST) products (all available satellites).

OBJECTIVE 2: Similar to above but for the newer Advanced Clear-Sky Processor for Oceans (ACSPO) GAC SSTs.

OBJECTIVE 3: Develop techniques and include intercomparisons of daily Level-4 (L4) analysis SST fields, compliant with the Global High-Resolution SST (GHRSST), in *SQUAM*.

OBJECTIVE 4: Develop set-up to monitor EUMETSAT O&SI SAF FRAC MetOp-2 AVHRR SST products, employing the *SQUAM* technique, in response to external request.

OBJECTIVE 5: Case study analyses of SEVIRI SST in *SQUAM*, as a preparedness for GOES-R.

OBJECTIVE 6: SST *CALVAL* for MUT.

OBJECTIVE 7: SST *CALVAL* for ACSPO.

OBJECTIVE 8: Technological improvements and additions to "*objectives 1 through 4*", for better web-presentation in the scientific community.

ACCOMPLISHMENT 1: MUT SQUAM [Status: initial objective accomplished, Phase 2 next year]. MUT SQUAM compares MUT SST products from NOAA16 through NOAA19 and MetOp-A AVHRRs, *via* SST difference maps, histograms, time-series statistics of Gaussian parameters and outlier fractions, double differences for cross-platform consistency, and geophysical dependence plots. The continuation of this work is maintained as these data are available weekly. Earlier, data from 2004-recent were processed. Now, the monitoring of data was extended back in time from 2001 to recent, and also the newer NOAA19 was added. Results are posted automatically, in NRT, at:
http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/

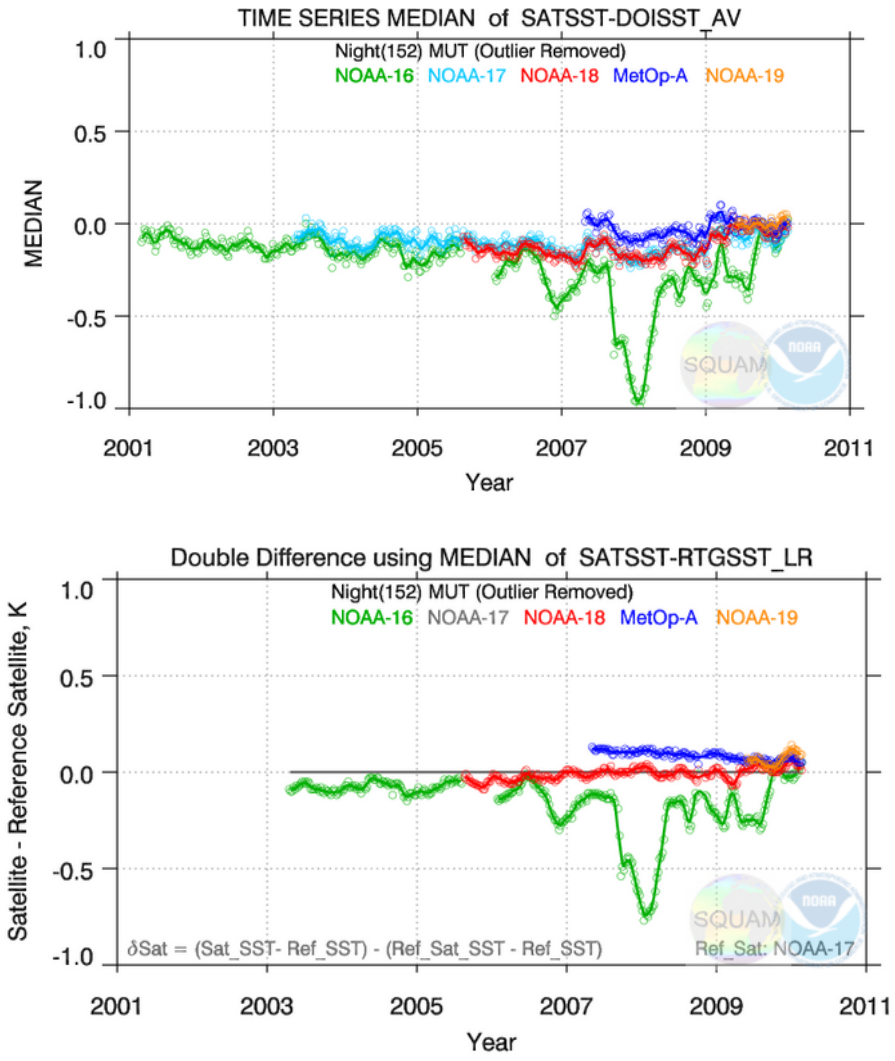


Figure 1: Median differences between nighttime MUT SST (five platforms) and daily Reynolds [upper panel]. Double differences of median (transfer standard: NOAA17 and RTG low resolution SST) for cross-platform consistency check [lower panel]. Comparisons against other L4 fields are available in the MUT SQUAM page referred above.

ACCOMPLISHMENT 2: ACSPO SQUAM [Status: initial objective accomplished]. The working aspect is similar to MUT SQUAM. The input data are in different format and available daily in GAC resolution (generated by other members of the SST team). The results are posted automatically, in NRT, at:

http://www.star.nesdis.noaa.gov/sod/sst/squam/ACSPO/ The work continues to be useful in improving the currently operational NESDIS SST system (ACSPO). There are further technical improvements compared to last year, which will be briefed later in the *"Technological Additions"* section.

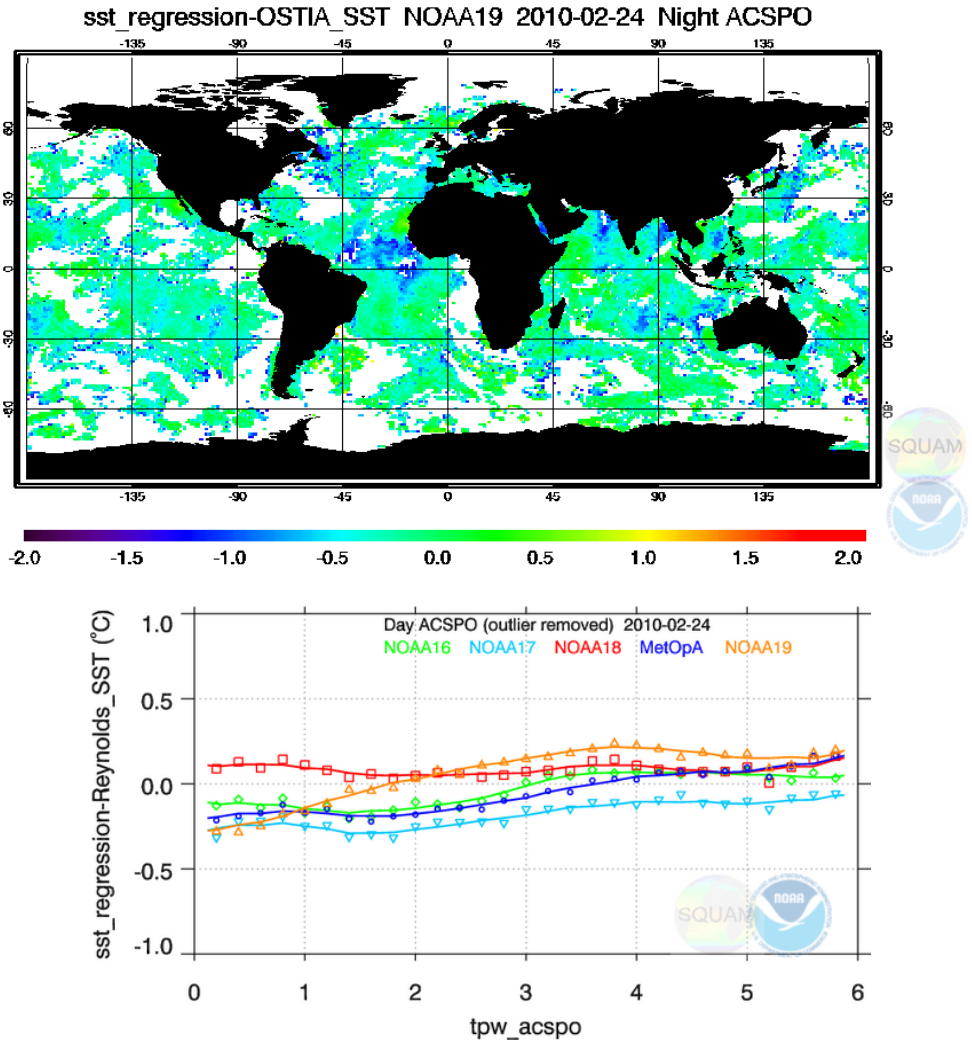


Figure 2: Example ACSPO NOAA19 nighttime SST minus OSTIA [upper panel]. Dependence of "daytime satellite SST – Reynolds SST" plotted as a function of total Column Water Content [lower panel]. Comparisons against other L4 fields and geophysical parameters are available in the ACSPO SQUAM page referenced above.

ACCOMPLISHMENT 3: L4 SQUAM [Status: prototype set, further improvements may be done]. Differences between satellite SST (T_S) and L4 fields (T_R) are analyzed in MUT and ACSPO SQUAM. Observed differences in "T_S-T_R" statistics for different T_R fields (and same T_S), however, comprehensively demonstrated significant differences between different L4 SST products, including NOAA RTG products. Then after, as a result of discussion and active coordination between NCEP and STAR SST Team, a "prototype" system was implemented for intercomparisons between the various daily L4 SST products. The diagnostics of this prototype system is available in NRT at L4-SQUAM: *http://www.star.nesdis.noaa.gov/sod/sst/squam/L4.*

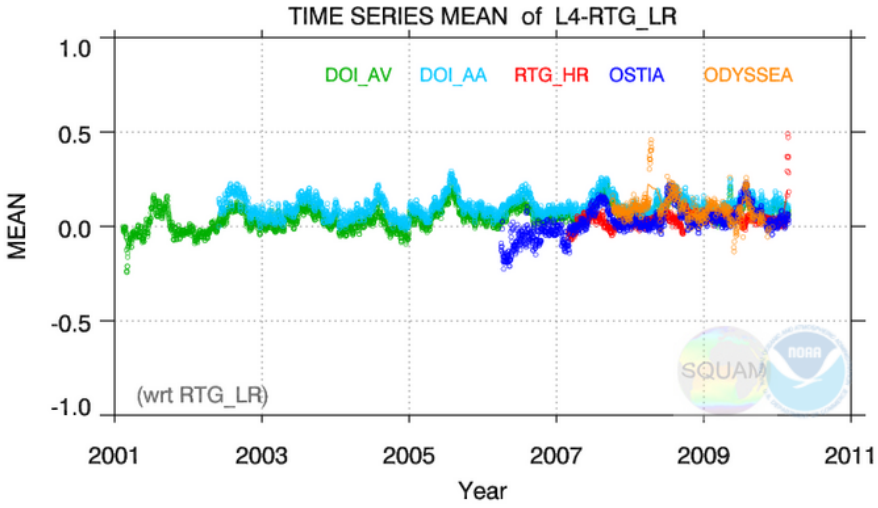
Employing the L4-SQUAM, six different daily products are intercompared (2001–recent). These products include: **two Reynolds** (AVHRR and AVHRR+AMSR-E based), **OSTIA**, **ODYSSEA**, and **two RTG** (low and high resolution).

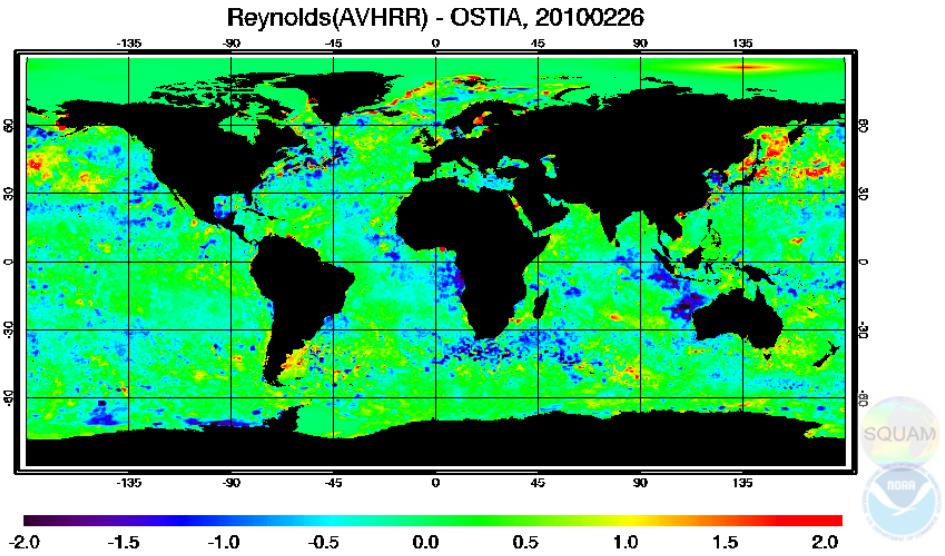
This intercomparison is also one of the high priority goals of the **GHRSST**, has been

recognized by the same, and is listed as a NESDIS system in **GHRSST IC-TAG**: *http://www.ghrsst.org/The-Inter-Calibration-TAG-(IC-TAG).html*

Comparisons are made via difference maps, histograms, time-series, and **Hovmöller** plots. The results indicate that there are high discrepancies between these fields, especially in the high-latitudes, and the L4-SQUAM is meant to assist L4 developers.

The L4-SQUAM prototype executes daily and processes data for the previous date. A "*mini funding proposal*" has also been submitted to one of the *NOAA Internal and Directive Research* funding body to further develop this prototype, with the reporting postdoc and his technical supervisor as two of the PIs, in collaboration with NCEP RTG SST developers. If accepted, this small grant will be used to further develop the L4-SQUAM, responding to the scientific community. Should it be declined, the L4-SQUAM prototype may be frozen as it is and focus will be more on the satellite observations, which will also partly decide some of the tasks for the next annual cycle.





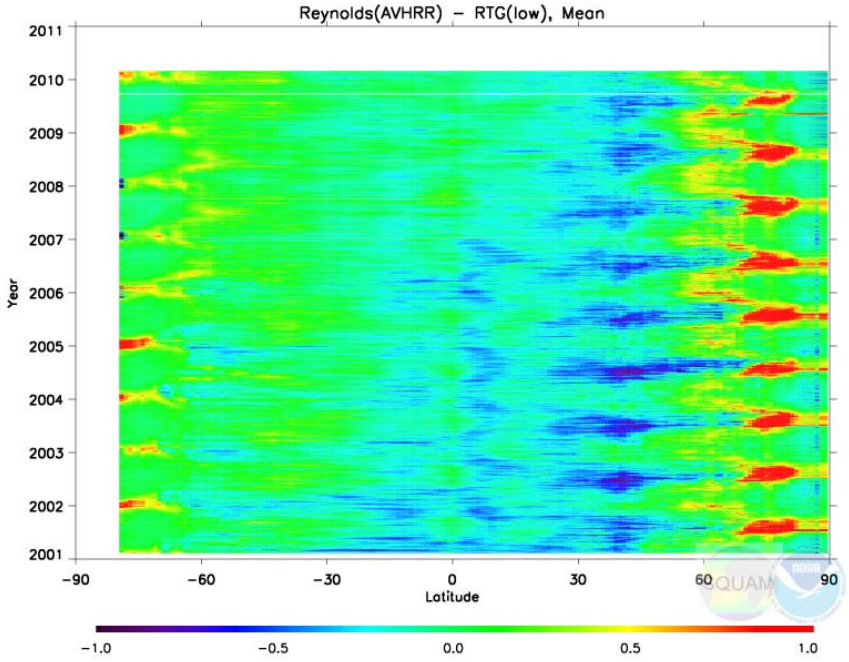


Figure 3: <u>Upper panel</u>: Global mean differences between different L4 SSTs and RTG SST. DOI_AV: daily Reynolds (AVHRR based), DOI_AA: daily Reynolds (AVHRR + AMSR-E based). Reynolds SSTs form one cluster, OSTIA and ODYSSEA follow each other closely, and RTG SSTs follow each other, although to a lesser extent. <u>Middle panel</u>: Differences between DOI_AV and OSTIA. <u>Lower panel</u>: Difference between daily Reynolds and RTG low resolution SST in time-lat Hovmöller space.

ACCOMPLISHMENT 4: <u>EUMETSAT O&SI SAF SQUAM [Status: initial objective accomplished]</u>**.** The **EUMETSAT** Satellite Application Facilities (**SAF**) are dedicated centers for generating specific satellite products. The Ocean & Sea Ice (O&SI) SAF operationally generates MetOp-2 AVHRR SSTs at Full Resolution Area Coverage (FRAC, ~1km spatial resolution). Interest was received from **O&SI SAF** (located at **Meteo France**) for SQUAM analyses of these MetOp-2 FRAC SST products. Responding to the external request, an NRT FRAC SQUAM was set up at:

http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC/

The initial set-up for O&SI SAF FRAC SQUAM is complete. However, the webpage has not been linked to publicly visible pages yet. It will be linked after receiving positive confirmation from the French colleagues. *<u>This FRAC SQUAM analyses may not be made public, in the meanwhile, and is for internal analyses, reporting, and reviewing only.</u>* Further improvements may be made in response to any external request.

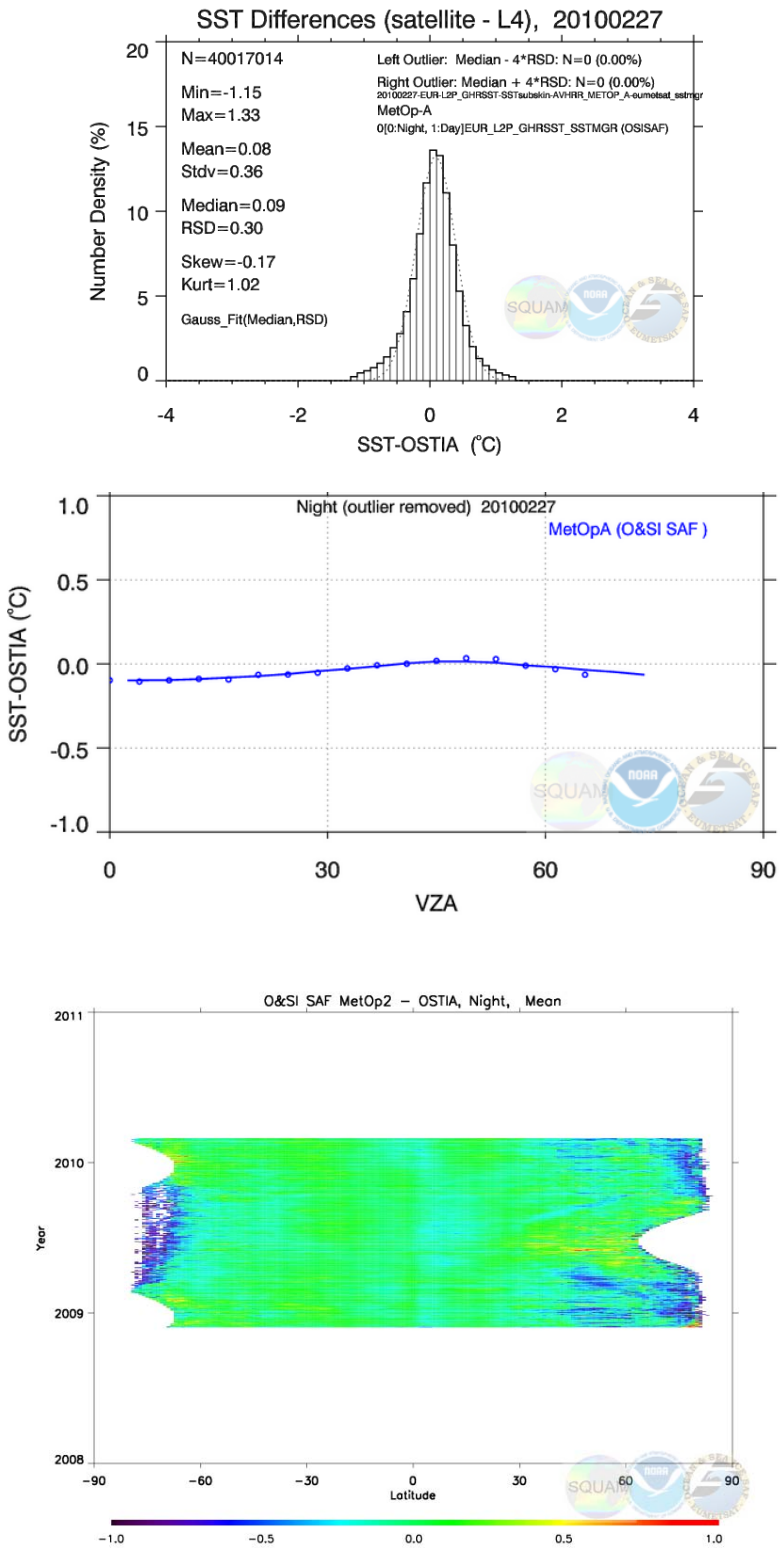


Figure 4: Example "O&SI SAF MetOp-2 FRAC SST minus OSTIA" different histogram (upper panel), dependence of the same of satellite view zenith angle (middle panel) and in time-lat Hovmöller space (lower panel). More analyses (against other time-period and reference SST filed) are available at: http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC/.

ACCOMPLISHMENT 5: Case study with SEVIRI SST for GOES-R preparedness: As a case study, SEVIRI SST (produced by other team members) data were tested with SQUAM technique, as a step towards preparedness for GOES-R data. Some of the results are available at: *http://www.star.nesdis.noaa.gov/sod/sst/squam/references.htm* (poster for GOES-R AWG & Risk Reduction Review Meetings, July 20-24 2009, Univ. of Maryland, Adelphi, MD). This may be automated for NRT monitoring, if deemed necessary, and is currently under low priority for the reporting postdoc.

The reporting postdoc also made minor contributions for GOES-R SST ATBD, in the form of copy-editing and trimming, under time pressure (not in the primary tasks).

ACCOMPLISHMENT 6: MUT CALVAL [Status: initial set-up finished, requires re-match-up]: At OSDPD (http://www.osdpd.noaa.gov), monthly match-ups (satellite SST with *in situ* SST) are generated for all available platforms. An SST calibration and validation system was established at STAR by the reporting postdoc which takes input from the OSDPD monthly match-up files (for five platforms). The tool is invoked once a month and the CalVal results are automatically made available at: *http://www.star.nesdis.noaa.gov/sod/sst/calval/MUT/*

[password protected: please send request to P. Dash or A. Ignatov, if interested]

The CalVal system performs both **conventional least square fit** and **robust regression** to calculate SST coefficients for both day and night equations. A variety of outlier removal conditions are also taken into account, in both calibration and validation modes: No removal, Mean±k×Stdv, Med±k×RSD, Med±k×MAD, where Med: median, RSD: robust standard deviation, MAD: median absolute deviation, and k = 2, 3, and 4.

Pending task due to an impending issue:
The initial set-up (IDL, shell, web presentation) has been completed. However, it appears as if the number of observations in the monthly match-up files is inconsistent in time, and it very likely has its causes in the match-up procedure (heritage system). Therefore, this CalVal has not been publicly released. The match-up process needs to be redone for verification and then the tool can be used to re-generate timeseries for web and journal publications.

Integration with other postdoc work
In the regenerated match-up, another set of *in situ* SSTs will be used which recently was generated in the scope of work of one of the CIRA/STAR postdocs (Feng Xu). It is expected that the newer *in situ* source would be more reliable as it has been rigorously quality controlled (*http://www.star.nesdis.noaa.gov/sod/sst/iquam/*).
More comprehensive results and web-presentations are planned for the next reporting period (as time permits). Some initial calibration and validation results are presented below for demonstration purposes.

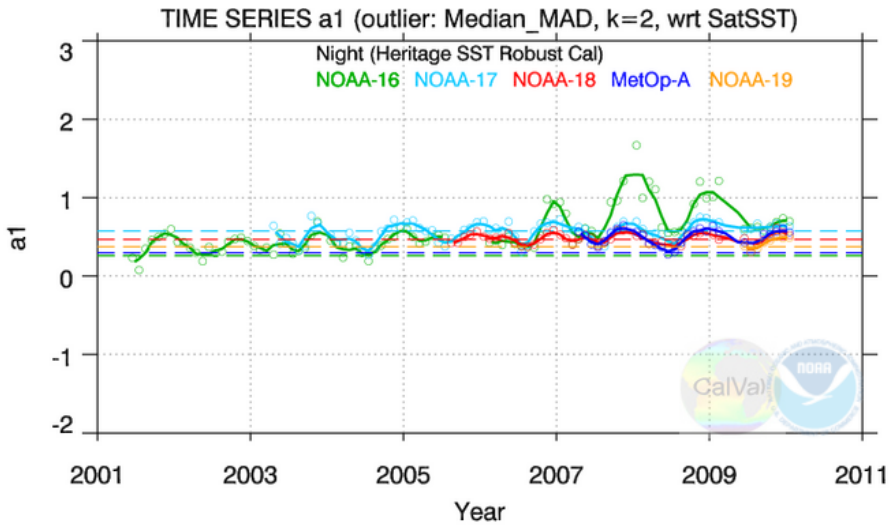


*Figure 5: Example timeseries of coefficient "a1" in night SST equation, using robust regression, where, SST=a0+a1*T4+a2*T3+a3*T5+a4*(T3-T5)*(secθ-1)+a5*(secθ-1). Other coefficients, both for day and night, are available at: http://www.star.nesdis.noaa.gov/sod/sst/calval/MUT/ [Calibration mode of CalVal].*

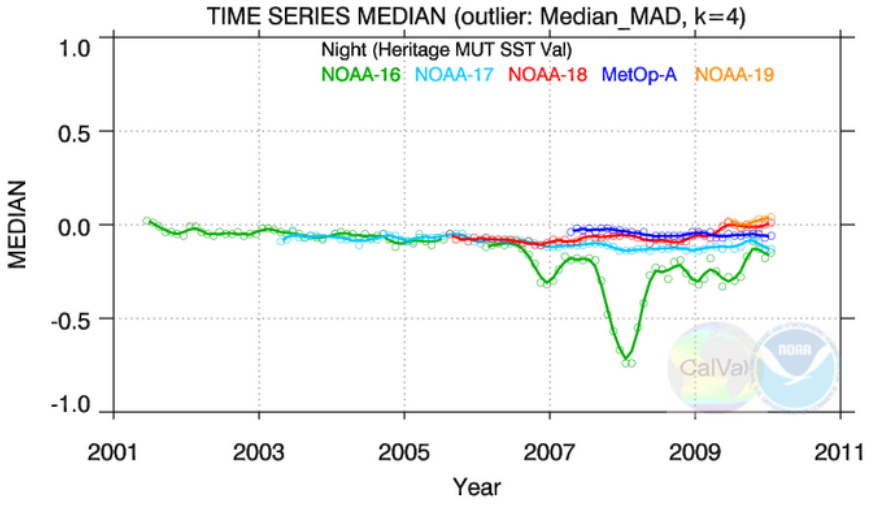
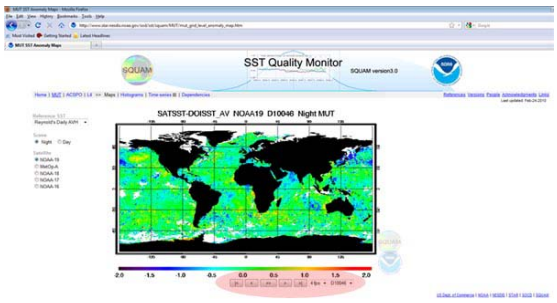


Figure 6: Median biases in night SST (five platforms), against in situ data. Other statistical parameters for day and night are available at CalVal webpage [Validation mode of CalVal]. Also, compare in situ validation (this figure) with validation against L4 SST (Fig 7 upper panel) for assessing efficacy of the SQUAM system.

ACCOMPLISHMENT 7: <u>ACSPO CALVAL [Status: initial set-up finished, requires improvement]</u>. ACSPO CalVal system has been initially established and runs on daily data as well as a monthly moving window. Although the initial system is finished, further work is required for seamless CalVal of ACSPO GAC data. There are some inconsistencies from the prior step's data input, which needs to be handled. *Http:www.star.nesdis.noaa.gov/sod/sst/calval/ACSPO/* [password protected: Please send request to P. Dash or A. Ignatov, if interested] Results of this work may be reported in the next term.

ACCOMPLISHMENT 8: Technological improvements and additions for Objectives 1 to 4. A decent amount of effort was put into improving the usability of the web pages and the diagnostics. A brief summary is provided below.

--Date playbars were added for Maps, Histograms, and Dependence plots for both MUT and ACSPO. Earlier, it showed only recent files; and the history was in the form of animated graphics. The newer edition provides access to individual files. Example:
http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/mut_grid_level_anomaly_map.htm



--Dependence plots were improved, overlaying multiple platforms together. (*cf.*, Figure 2) More examples for MUT and ACSPO, for various geophysical parameters, are at:
http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/mut_grid_level_anomaly_trends.htm &
http://www.star.nesdis.noaa.gov/sod/sst/squam/ACSPO/acspo_grid_level_anomaly_trends.htm

--Hovmöller plots were implemented for daily update (where applicable):
http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/l4_delsst_hovmoller.htm

--An interactive technique for time series plots was also implemented for MUT SQUAM, ACSPO SQUAM, and L4 SQUAM, in addition to static plots. Interactive plots allow the user to better analyze the results, with a variety of options. *E.g.*, users can turn on or off the desired platforms and focus on their specific interest.

Time series interactive plots:
http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/mut_pixel_level_timeseries_ia.htm
http://www.star.nesdis.noaa.gov/sod/sst/squam/ACSPO/acspo_pixel_level_timeseries_ia.htm

Double differences interactive plots:
http://www.star.nesdis.noaa.gov/sod/sst/squam/MUT/mut_dd_satellite_ia.htm
http://www.star.nesdis.noaa.gov/sod/sst/squam/ACSPO/acspo_dd_satellite_ia.htm

L4 SQUAM interactive plots (Internet explorer not recommended):
http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/l4_delsst_timeseries_ia.htm

Scientific outlook and future work based on the accomplished objectives:

--Maintain and improve the systems developed so far (~20% FTE)

--Develop new SQUAM subsystem for NAVOCEANO data (~8% FTE)

--Develop new SQUAM subsystem for ACSPO FRAC data (generated by other members) and compare with EUMETSAT O&SI SAF FRAC data (~12% FTE)

--Observed cross-platform inconsistencies in time series plots (*e.g.*, Figure 1) are deemed to be due to at least two reasons:

Not accounting for diurnal variation (DV) in L4 reference SST fields

Calibration issues in the AVHRR IR sensors

A future research effort will include exploring a DV model to adjust the L4 SSTs and also use better calibrated brightness temperatures to generate SST (if available to be leveraged from other work), for reconciling the platforms. (~25% FTE)

--Upgrade L4 SQUAM if the applied project proposal is accepted, *e.g.*, add more L4 fields and statistical techniques. (~20% FTE)

--Work towards publications/reports/abstracts. (~15% FTE)
========== Total = 100% FTE

Extra (priorities may be re-arranged on the go and some may remain pending):

--Work towards improving the SST CalVal system. (~25% FTE)

--Learn to maintain iQUAM work of leaving postdoc (Feng Xu). (~10% FTE)

--Coordinate *vide* SQUAM: O&SI SAF, GHRSST, RSS, NESDIS, NCEP, NAVO (~2%FTE)

--Conferences/meetings of interest, as applicable (~3% FTE)

--Information content analysis for SST algorithm evaluation (~10% FTE)
========== Extra = 50% FTE

PROJECT TITLE: NESDIS Post Doc Xing Ming Liang

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Alexander Ignatov, NOAA/NESDIS/STAR

PROJECT OBJECTIVES: Monitoring IR Clear-Sky Radiances over Ocean for SST (MICROS, www.star.nesdis.noaa.gov/sod/sst/micros), an online near-real time tool was established to monitor global Model minus Observation (M-O) bias for AVHRR Ch3B, Ch4, Ch5 onboard NOAA-16,-17,-18,-19 and MetopA, and SST bias as well. MICROS version 1.0 has been launched at STAR since July 2008 and was updated to Ver 2.0 at the end of 2008.

The major objectives for 2009 were to enhance and document MICROS, and validate CRTM daytime performance. The following specific tasks were accomplished toward these objectives.

ACCOMPLISHMENT 1: MICROS was updated from Ver 2.0 to Ver 4.0, including:

Ver 2.1: Reynolds Ver 2.0 Daily SST replaced Ver 1.0 as CRTM input.

Ver 3.0: Added NOAA-19 processing; Added Robust Statistics (in addition to conventional statistics); and Added global maps for environmental and geophysical parameters.

Ver 4.0: Added MetOp-A FRAC data with the same functionality as GAC.

ACCOMPLISHMENT 2: A peer-reviewed paper on MICROS is under review by Dr. A. Ignatov;

ACCOMPLISHMENT 3: A proposal about CRTM validation in MICROS was submitted to NOAA/NESDIS (NOAA-NESDIS-NESDISPO-2010-2001902);

ACCOMPLISHMENT 4: A collaboration project about extending MICROS functionality for sensor calibration has been established with the sensor calibration team;

ACCOMPLISHMENT 5: MICROS was presented on the AMS2009, CALCON2009, GHRSST2009, GOES-R/AWG2009 and NPOESS-CAL/VAL2009, in cooperation with Dr. A. Ignatov.

ACCOMPLISHMENT 6: An instantaneous reflectance model has been tested instead of the current CRTM (version 1.2) solar reflectance. The new solar reflectance model dramatically improved global M-O bias, and it has been verified to be a physical consideration for solar reflectance and will be adopted in CRTM v2.0.

ACCOMPLISHMENT 7: The fact that a significant cold M-O bias (~-2 K) was observed in the SEVIRI IR 3.9 band was investigated with

the CRTM Team. Initial analyses suggest that this bias may be largely due to the 26 levels of GFS data used as CRTM input. This number of layers in the current atmospheric profiles may not be sufficient to adequately model the wide window band with the current CRTM.

PROJECT TITLE: NESDIS Post Doc Wei Shi – Ocean Color Algorithm Development and Application

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Menghua Wang, NOAA/NESDIS

PROJECT OBJECTIVE: Development of new ocean color algorithm for global climate study and coastal and in-land water ecosystem monitoring.

PROJECT ACCOMPLISHMENTS: SWIR atmospheric correction algorithm developed by Wang and Shi for ocean color remote sensing has extensive application in the coastal regions and in-land waters. During this period, we have refined this algorithm and evaluated the accuracy of the ocean color retrievals and improved the ability to monitor the physical, geochemical and biological processes in the coastal region.

--Assessment of the Ocean Black Pixel Assumption for the MODIS SWIR Bands
--Algorithm development for Detection of Ice and Mixed Ice-Water Pixels for MODIS Ocean Color Data Processing.
--Validation and Assessment Study for the SWIR and NIR- SWIR Atmospheric Correction Algorithm with in-site data.
--Application to the Observations of Flood-Driven Mississippi River Plume in the Spring 2008.
--Application to the Assessments of Green Macroalgae Blooms in the Yellow Sea during the Spring and Summer of 2008.

PROJECT TITLE: NESDIS Post Doc Feng Xu

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Alexander Ignatov, NOAA/NESDIS/STAR

PROJECT OBJECTIVE 1: Evaluation of in situ SST for satellite calibration and validation

--Explores major existing in situ SST data sets, such as NCEP GTS, ICOADS and FNMOC. Cross-evaluate these data sets and determine their relative value for SST Cal/Val tasks;

--Evaluate the quality control (QC) information available on these data sets;

--Compare in situ SSTs from ships, drifters, and tropical and coastal moorings among these data sets. Explore the potential of ship data for Cal/Val, particularly in the early 1980s, when ships were the major source of in situ data;

--Further analyze the four types of in situ measurements in terms of their coverage and systematic and random errors.

PROJECT OBJECTIVE 2: Quality control of in situ SST

--Implement advanced QC algorithm from meteorological community (Bayesian-based) for *in situ* data;

--Evaluate the performance of QC algorithm and demonstrate its efficacy;

--Establish operational QC system in near real time;

--Establish online monitoring and feedback system of *in situ* SST statistics.

ACCOMPLISHMENT 1: Evaluation of in situ SST for satellite calibration and validation

Three in situ data sets from the NCEP GTS, the ICOADS release 2.4, and the US GODAE/FNMOC were analyzed.

A manuscript "Evaluation of in situ SSTs for use in the calibration and validation of satellite retrievals" was submitted to JGR for peer-reviewed publication.

ACCOMPLISHMENT 2: Quality control of in situ SST

A sophisticated QC algorithm was implemented at NESDIS and operationally run in near real time using NCEP GTS data. In addition to basic screenings (duplicate removal, plausibility, platform track and SST spike checks), the algorithm also includes two advanced checks for consistency with the external reference field, and cross-platform consistency, based on Bayesian theory.

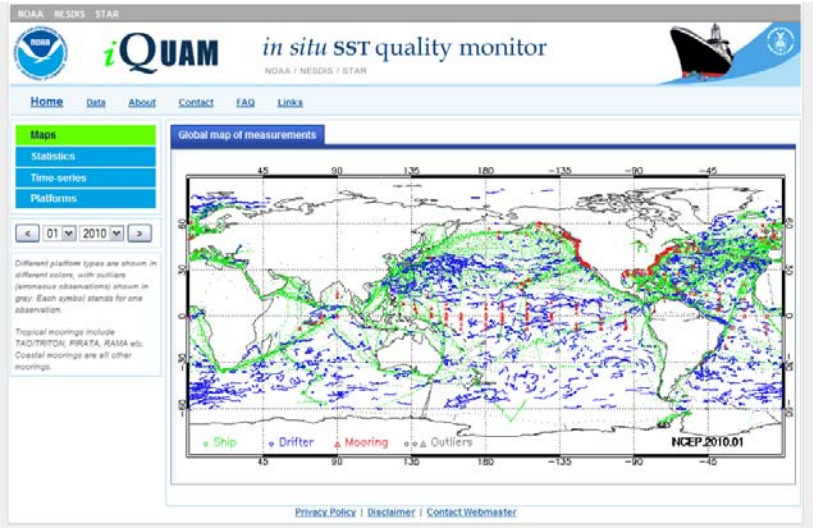
The efficacy of the QC algorithm was tested by adding simulated errors and climate signals on the top of "error-free" (QCed) *in situ* data, and estimating whether the QC algorithm can capture errors and preserve the climate signals.

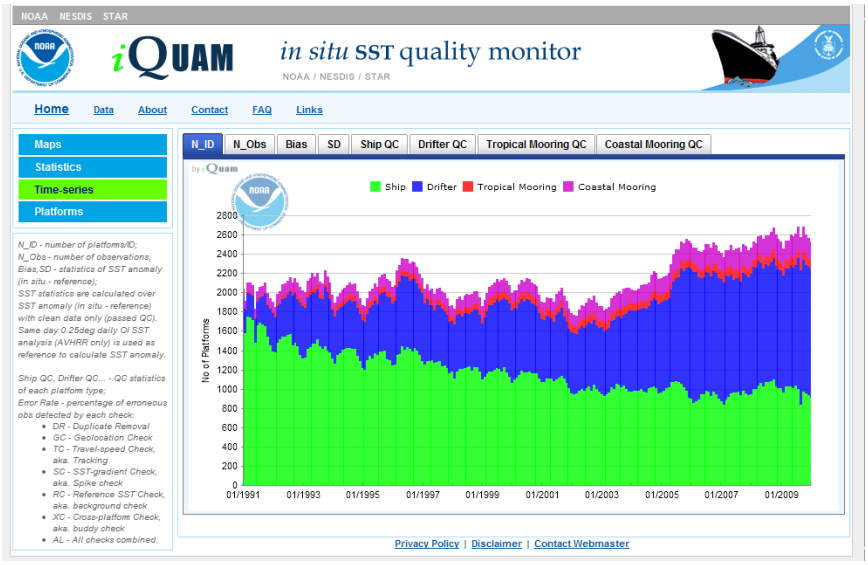
An online *in situ* quality monitor (*iQuam*; www.star.nesdis.noaa.gov/sod/sst/iquam/) was set up to serve the QCed *in situ* SSTs to external users for the use in satellite Cal/Val. The *iQuam* also displays in near real time maps and basic "*in situ* minus reference" SST statistics stratified by four *in situ* platform types (drifters, ships, tropical and coastal moorings). The user also has a choice to monitor individual *in situ* platforms.

A manuscript "Quality control and monitoring of *in situ* sea surface temperature measurements" is in preparation for peer-reviewed publication.

The *iQuam* was presented at the 90th AMS Annual Meeting, the AGU Ocean Science Meeting and the MyOcean & STVAL Meeting.

Some screenshots of iQuam web pages are shown below:




NOAA NESDIS STAR
iQUAM
in situ SST quality monitor
NOAA / NESDIS / STAR
Home
Data
About
Contact
FAQ
Links
Maps
Statistics
Time-series
Platforms
N_ID
N_Obs
Bias
SD
Ship QC
Drifter QC
Tropical Mooring QC
Coastal Mooring QC
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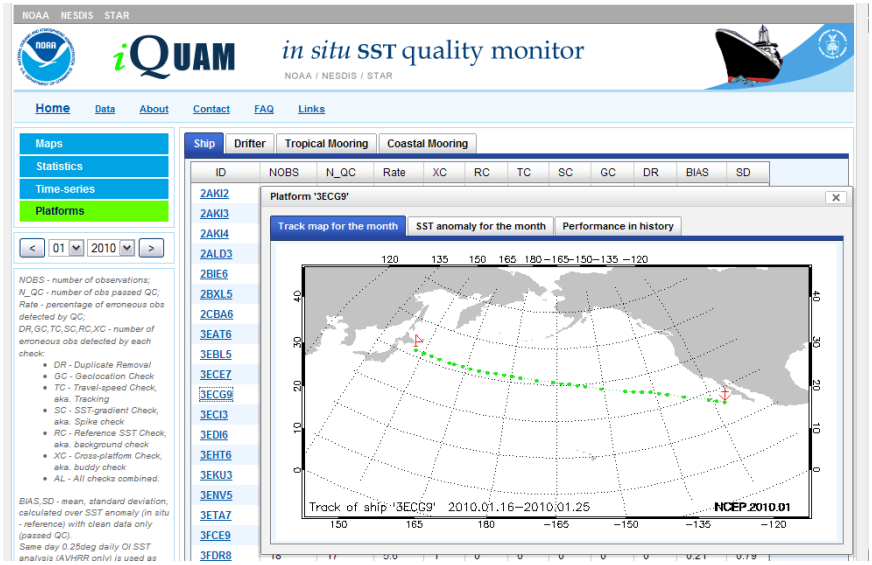
Privacy Policy
Disclaimer
Contact Webmaster


NOAA NESDIS STAR
iQUAM
in situ SST quality monitor
NOAA / NESDIS / STAR
Home
Data
About
Contact
FAQ
Links
Maps
Statistics
Time-series
Platforms
Ship
Drifter
Tropical Mooring
Coastal Mooring
ID
NOBS
N_QC
Rate
XC
RC
TC
SC
GC
DR
BIAS
SD
Platform '3ECG9'
Track map for the month
SST anomaly for the month
Performance in history
Track of ship '3ECG9' 2010.01.16–2010.01.25
NCEP 2010.01

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

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVE: The next generation GOES satellites (beginning with GOES-R) will include the Advanced Baseline Imager (ABI) with vastly improved spectral, spatial and temporal resolution relative to the current GOES I-M series satellites. It will also include a lightning mapper which, together with the ABI, offers the potential to significantly improve the analysis and forecasts of tropical storms. The main objective of CIRA's GOES-R Risk Reduction science studies is to reduce the time needed to fully utilize GOES-R as soon as possible after launch.

ACCOMPLISHMENT 1: GOES-R Applications to Tropical Cyclone Analysis and Forecasting**.** As part of the GOES-R Applications to Tropical Cyclone Analysis and Forecasting project, the CIRA team expanded the ABI proxy database for tropical cyclones over the Atlantic by adding additional MSG data, simulated ABI data from MSG, soundings from the AMSU instrument, AIRS soundings, and COSMIC soundings. In addition, IASI soundings were added to the database and a 1km IR archive (MODIS and AVHRR) of global tropical cyclones was set up. The analysis of the World Wide Lightning Location Network (WWLLN) data for the period of 2003-2008 which started in the previous year was continued through this reporting period. For specific environmental wind shear condition, a positive correlation between lightning and intensification could be found (see Figure 1). We also evaluated the GOES-R impact on forecast algorithms (SHIPS, Rapid Intensity Index) and began to demonstrate our experimental GOES-R products on a real time web site.

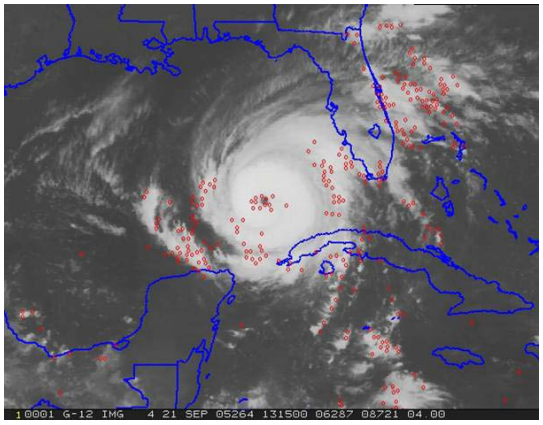


Figure 1: 6-hour lightning strikes (red circles) starting at 12 UTC on 21 September 2005 on a GOES IR image for Hurricane Rita.

ACCOMPLISHMENT 2: Training**.** The training team completed the first production of a "GOES-R 101" training module as part of the SHyMet for Forecasters series. This module focuses on highlighting imagery and products for GOES-R (see Figure 2). A comprehensive overview of the new GOES-R sensors including solar, GLM, Auxiliary Services and the ABI is contained in this module.

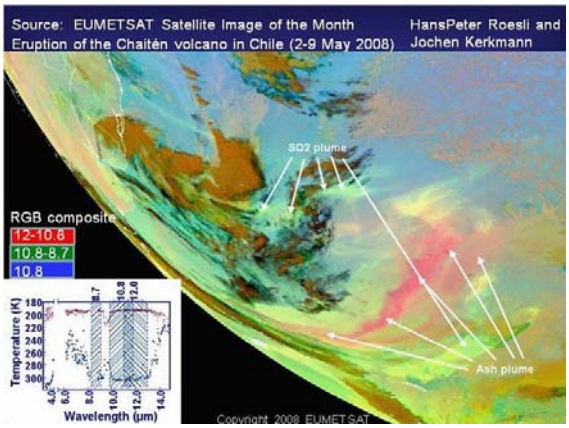


Figure 2: This sample image from the new GOES-R training module demonstrates the use of RGB image combinations and the addition of a new channel near 8.7 µm to aid in the detection of volcanic ash and SO2 using a EUMETSAT image of the Chaitén Volcano in Chile in May 2008.

ACCOMPLISHMENT 3: Data Assimilation Project. CIRA's data assimilation team continued to prove that the use of the GOES-R data can be improved by extracting maximum information. As part of this project the WRF-MLEF algorithm was updated with the capability to assimilate MSG radiance data through the use of the JCSDA CRTM forward operator. These data assimilation experiments were performed by assimilating real MSG radiances at 10.80 µm. An evaluation of the algorithm's ability to extract maximum information from the data through the use of various information measures was performed. The data assimilation efforts focused on the case of the extra-tropical cyclone Kyrill (Feb 2008). A comparison of the assimilation results of synthetic ABI 10.35 µm radiances and real MSG 10.80 µm radiances was conducted.

ACCOMPLISHMENT 4: GOES-R Severe Weather Project. The GOES-R severe weather project produced a high-resolution numerical model forecast of a severe thunderstorm event which occurred over the Mid-western united States on 27 June 2005. Synthetic GOES-R ABI imagery was generated for the upper 11 ABI bands (2.25 µm to 13.3 µm). A manuscript was produced which discusses the benefit of synthetic imagery of numerical model output.

ACCOMPLISHMENT 5: GOES-R Winter Weather Studies and Cloud Climatologies**.** The development of the PV/Ozone technique was continued under the winter weather studies with the GOES-R project. Three options for combining the COSMIC potential vorticity with geostationary data were considered: the GOES sounder total ozone, the GOES water vapor imagery (used by tropopause fold algorithm), and the airmass RGB product used by MSG satellites. The study will continue using one of these methods. The cloud climatology project produced a new set of cloud composites by using a new algorithm. The new cloud detection algorithm is based on the de Ruyter de Wildt

method combined with our existing algorithm. It uses the 0.64μm, 0.8μm, and 1.6 μm channels from MSG to better distinguish snow from cloud. A new set of cloud composites was successfully produced for the test case of January 2007.

Results of CIRA's GOES-R3 projects were presented at conferences and several manuscripts were written and sent to refereed journals.

PROJECT TITLE: Satellite Analysis of the Influence of the Gulf Stream on the Troposphere: Convective Response

PRINCIPAL INVESTIGATOR: Andrea Schumacher

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: This project is a collaborative effort between CIRA and CIOSS, with Dudley Chelton of CIOSS as the overall Principal Investigator. CIRA's contribution to the research is given by the following objectives:
1) Analyze the lightning strike density over the Gulf Stream
2) Generate wind fields over the Gulf Stream from temperature retrievals generated from AMSU radiances.

The period of study chosen was January and February 2007.

PROJECT ACCOMPLISHMENTS: Both objectives were met for this period. Data from the World Wide Lightning Network (WWLN) were compiled and plots of lightning-strike density overlaid onto sea-surface temperature were provided to Dudley Chelton. As an example, the plot for January 2007 is shown in Figure 1. The figure shows that the temperatures along the Gulf Stream are positively correlated to lightning-strike densities.

The second objective was to generate wind retrievals derived from satellite measurements, again looking for a correlation with the sea-surface temperature along the Gulf Stream. Wind fields were generated from the satellite retrievals of temperature by assuming hydrostatic and linear balance. Plots of vorticity were overlaid onto sea-surface temperature and provided to Dudley Chelton. Figure 2 is the 850-hPa vorticity and sea-surface temperature plot from January 2007. As with the lightning-strike density, good correlation is seen between vorticity and sea-surface temperature.

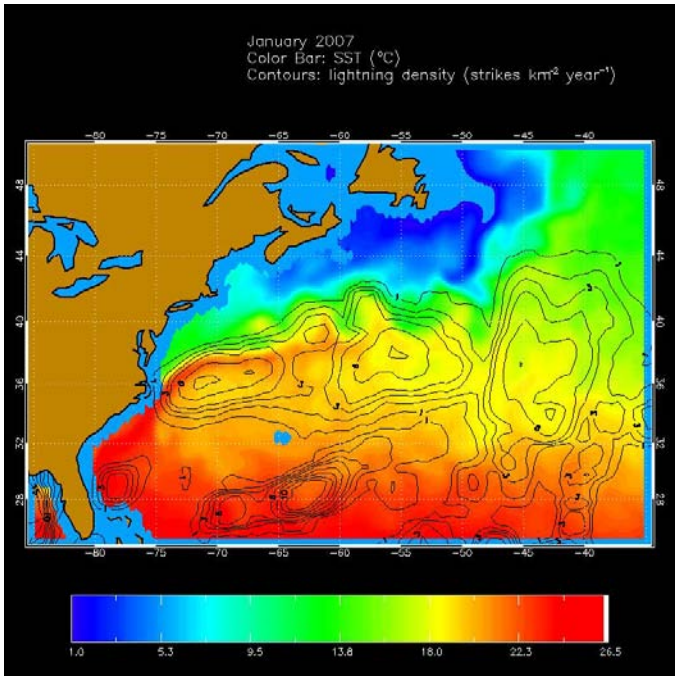


Figure 1: Lightning strike density (WWLN) and sea-surface temperature for January 2007.

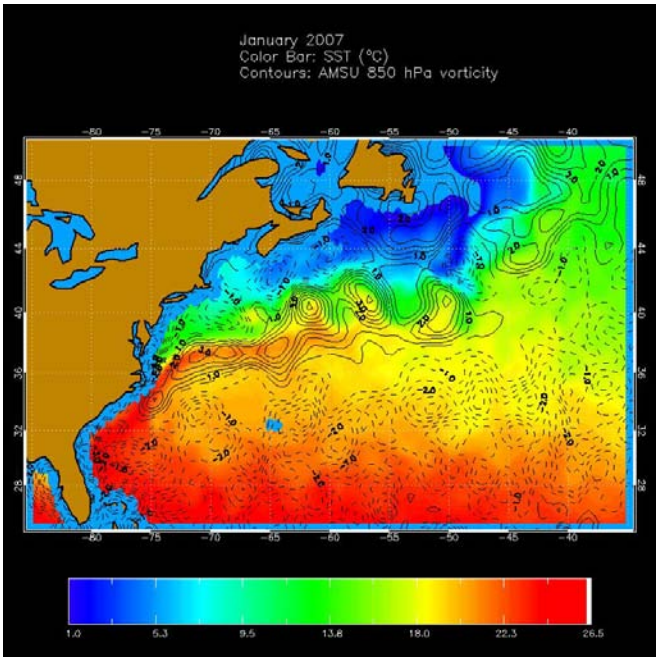


Figure 2: 850-hPa, linear-balance relative vorticity ($x10^{-5}$ s^{-1}) and sea-surface temperature for January 2007.

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

PRINCIPAL INVESTIGATORS: Dan Bikos and Bernie Connell

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: The primary objective of the VISIT program is to accelerate the transfer of research results based on atmospheric remote sensing data into National Weather Service (NWS) operations. This transfer is accomplished through web based distance learning modules developed at CIRA and delivered to NWS forecasters. There are two types of distance learning methods. The first is teletraining, which is a "live" training session utilizing the VISITview software and a conference call so that there is interaction between instructor and students. The second type is an audio / video playback format that plays within a web-browser. The latter type is popular because it may be taken by a student individually whenever they choose. The combination of live teletraining and audio / video playback versions (Fig. 1) reaches out to as broad an audience as possible given the busy schedule of NWS forecasters. Over 19,000 training certificates of completion have been awarded since April 1999, and most student feedback suggests a direct applicability to current forecast problems. CIRA is also actively involved in tracking of participants, and the collection and summarization of course feedback material. Because the VISIT program has been so successful within the NWS, it is being leveraged for other training activities in the US (Satellite Hydrology and Meteorology Courses (SHyMet), and the GOES-R Proving Ground) and is being utilized in by the International community in training programs under the World Meteorological Organization (WMO)

For more information on the VISIT program, see http://rammb.cira.colostate.edu/visit

PROJECT ACCOMPLISHMENTS: New training sessions developed at CIRA (includes sessions co-developed with partners and subject matter experts):

--Basic Satellite Interpretation in the Tropics by D. Bikos.
--Aviation Hazards
--An Overview of Tropical Cyclone Track Guidance Models used by NHC
--An Overview of Tropical Cyclone Intensity Guidance Models used by NHC

VISIT training metrics July 1, 2009 – March 8, 2010:
--Live teletraining: 42 sessions delivered to 279 participants.
--Audio / video playback (through NOAA's learning management system as well as directly through CIRA's web interface): 191 participants.

Collaborations on new training sessions developed outside CIRA:
--D. Bikos collaborated with the Warning Decision Training Branch (WDTB) in Norman, OK to assist in the development of an Advanced Warning Operations Course (AWOC) on Quasi-Linear Convective Systems (QLCS) type tornadoes that will be delivered to NWS forecast offices.
--D. Bikos and J. Braun contributed to the development of a COMET module titled "Toward an Advanced Sounder on GOES?". Patrick Dills (COMET) conducted phone interviews with Bikos and Braun which were used as content in the module.
--AWIPS OB9 Blended TPW Products
--ASCAT Winds

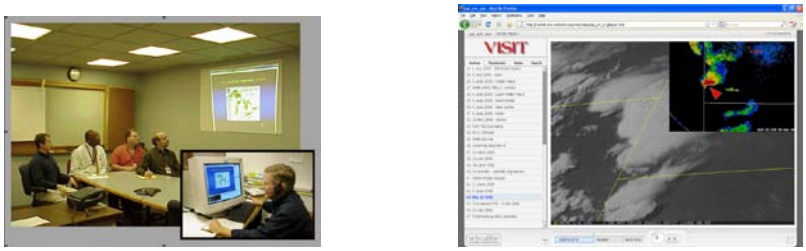


Figure 1: Live VISIT teletraining (left), and audio / video playback VISIT training module (right).

PROJECT TITLE: Tropical Cyclone Model Diagnostics and Product Development

PRINCIPAL INVESTIGATOR: Wayne Schubert

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: The National Oceanic and Atmospheric Administration (NOAA) recently initiated the Hurricane Forecast Improvement Project (HFIP) to reduce the errors in tropical cyclone track and intensity forecasts. This reduction will be accomplished through improved coupled ocean-atmosphere numerical hurricane models, better use of observations through advanced data assimilation techniques and ensemble forecasts. Model diagnostic techniques will also be developed to determine the sources of model errors and guide future improvements. CIRA's objectives are to perform five tasks that contribute to this HFIP effort. These include (i) application of large-scale diagnostics to the operational Hurricane Weather Research and Forecast (HWRF) model, (ii) evaluation of the impact of forecast improvements on Hurricane Watches and Warnings, (iii) evaluation of the HyCOM ocean model forecasts through comparison with satellite retrievals, (iv) development of forecast applications of ensemble predictions, and (v) examination of cloud top structure in relation to tropical cyclone formation.

ACCOMPLISHMENTS: 1) Application of large-scale diagnostics to the operational Hurricane Weather Research and Forecast (HWRF) model. The forecast fields from the operational HWRF model runs were used as input to diagnostic software similar to that developed for the Statistical Hurricane Intensity Prediction Scheme (SHIPS). Both the Atlantic and east Pacific storm cases were considered, and the underlying relationships between the large-scale and the HWRF intensity changes were compared to observed relationships. This work is helping to uncover biases in the model intensity predictions.

2) Evaluation of the impact of forecast improvements on Hurricane Watches and Warnings. A recent study by Mainelli et al (2008) showed that the National Hurricane Center's wind speed probability model can be used to provide the link between forecast error distributions and Hurricane Warnings. This relationship is being used to evaluate the impact of reductions in track and intensity errors to Hurricane Warnings and societal benefits. The underlying probability distributions in the wind speed model was modified in a manner consistent with the HFIP forecast goals to determine the resulting reductions in the size and duration of the warnings. Results show that if the HFIP goals are achieved, considerable reductions in the size and duration of hurricane warnings would be possible. Figure 1 shows an estimate of the reduction in the size of the hurricane warnings per storm based on the 5 and 10 year HFIP error reduction goals, and a rough estimate of the corresponding cost savings per storm.

3) Evaluation of the HyCOM ocean model forecasts through comparison with satellite retrievals. In this task, the satellite altimetry based ocean heat content OHC product is being used to evaluate the Hybrid Coordinate Ocean Model HyCOM model coupled to the HWRF atmospheric model. Basic diagnostics have been performed to determine the ability of HyCOM to simulate the OHC and sea surface temperature evolution in tropical cyclone forecasts, and to provide feedback to model developers. Emphasis is on a case study of Hurricane Ike from the 2008 hurricane season.

4) Development of forecast applications of ensemble predictions. In this ensemble project, we adapted NHC's Monte Carlo wind speed probability model to utilize the ensemble forecasts for the dynamical models being developed under HFIP. The initial emphasis was on using the track ensembles. Using this method, the standard set of NHC probabilistic products was generated and evaluated by comparison with the operational version of the products.

5) Examination of cloud top structure in relation to tropical cyclone formation. This part of the project was performed by the University of Arizona. A method has been developed using GOES satellite infrared images with a temporal

resolution of 30 minutes that analyzes the symmetry of tropical cloud formations in order to predict their intensity (Piñeros et al. 2008). The 2004 and 2005 North Atlantic hurricane seasons were processed and the ability of the technique to identify developing cloud clusters was assessed by identifying any points in the image where the variance dropped below some pre-determined threshold (Piñeros et al. 2009). Work began on expanding the database of analyzed storms to include the 2006 – 2008 Atlantic hurricane seasons and to determine appropriate thresholds for using the method as a 48-hour predictor of TC genesis.

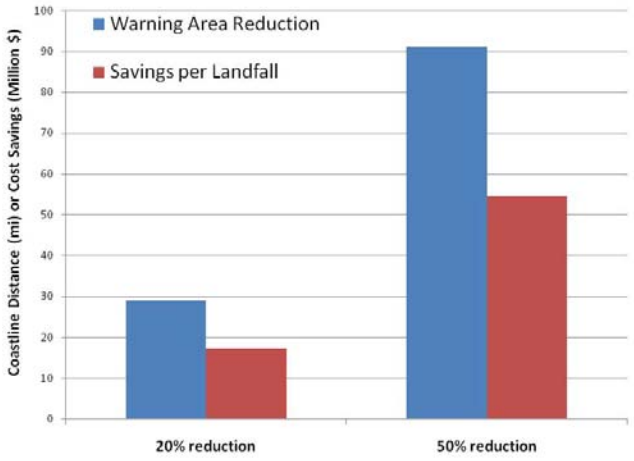


Figure 1: The estimated reduction in the size of the warning area and possible cost savings per storm for a 20% and 50% reduction in tropical cyclone track forecast errors

PROJECT TITLE: Validation of Satellite-based Thermodynamic Retrievals in the Tropics

PRINCIPAL INVESTIGATOR: Jack Dostalek

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVE: The overall objective of this project is to assess the quality of atmospheric retrievals derived from satellite measurements over the tropical Atlantic as compared to the GFS model analysis, using radiosondes and dropsondes as ground truth. In addition to computing basic error statistics, the assessment will involve comparing the retrievals to the analysis in four specific areas:
1) The height of the tropopause
2) The height of the trade-wind inversion
3) The computing of a tropical convective instability parameter
4) The computing of the maximum potential intensity a tropical cyclone can achieve.
In examining these 4 areas, it can be determined whether it is better to use the GFS or satellite soundings in the tropical cyclone analysis and forecast algorithms maintained at CIRA. Also, feedback from this research will be provided to the groups developing and improving the satellite retrieval algorithms.

ACCOMPLISHMENTS: This past year we had several accomplishments which will contribute to the completion of the 4 objectives listed above. First, since the installation of the NPROVS (NOAA Product Validation System) system at CIRA in May 2009, we have been familiarizing ourselves with its capabilities. Developed by NESDIS, NPROVS provides global collocations among various satellite retrievals and radiosondes. It also computes basic statistics regarding the performance of the soundings compared to the radiosondes. Second, we worked on understanding the structure of the NPROVS input files in case we need to manipulate these files for our specific purposes. Third, we chose a case study with which to begin our investigation – Hurricane Ida of 4-11 November 2009. Fourth, as a result of our desire to include dropsondes from Ida in the analysis, the NPROVS system was upgraded to include dropsonde data. In all of these areas we worked closely with NESDIS researchers. Finally, the convective instability parameter code was run with a sample collocation of radiosonde data from Antigua, a MIRS profile, and an IASI profile. Figure 1 shows the three soundings and Figure 2 shows the resultant vertical velocity profiles from using the convective instability code. Although the average temperature and dewpoint temperature errors of the two satellite soundings relative to the radiosonde sounding (Fig. 2) are fairly small (about 0.5 K), the behaviors in the parcel model are very different. Similar to its use in statistical intensity prediction models, the parcel is initialized at the surface with a 10 m s^{-1} updraft and a temperature equal to the observed sea surface temperature. The buoyancy is determined by the difference between the parcel virtual temperature and that of the environment (from the sounding). For the radiosonde sounding, the parcel becomes buoyant at about 1 km, reaches a maximum vertical velocity of about 25 m s^{-1} at 8.5 km, and eventually rises to a little above 13 km. For the satellite soundings, the dry bias in the MIRS sounding and the enhanced low-level stability in the IASI sounding prevent the parcel from reaching its level of free convection, and neither parcel rises above 2 km. These dramatic differences illustrate the need for very accurate temperature and moisture profiles when trying to assess convective instability in the tropics.

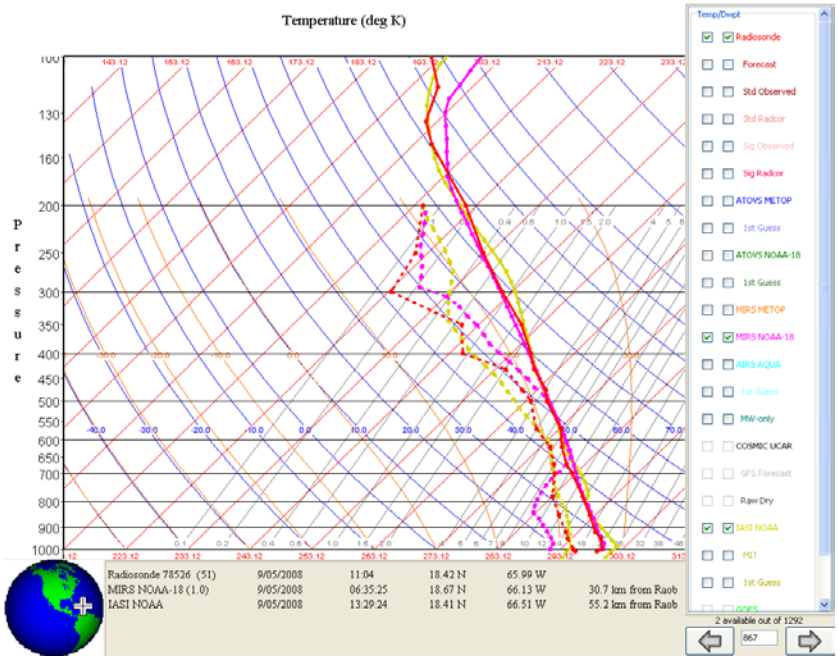


Figure 1: Comparison among the 1200 UTC radiosonde (red) from the island of Antigua and the collocated MIRS (NOAA-18, dark pink) and IASI (Met-Op, yellow) retrievals for 5 September 2008. Temperature retrievals are solid, dewpoint temperature retrievals are dashed. The plots are from the NPROVS system.

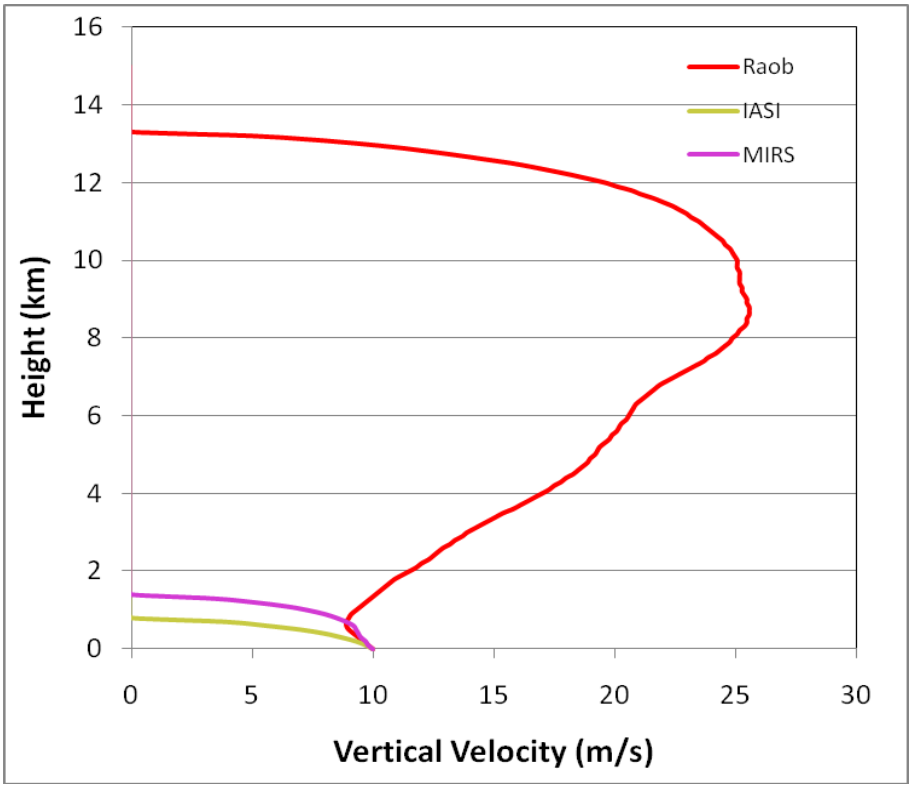


Figure 2: Vertical velocity profiles of a parcel lifted from the surface at an initial upwards velocity of 10 m s^{-1} in an environment with temperature and moisture profiles estimated from radiosondes (red), and IASI (yellow) and MIRS (purple) satellite retrievals. The soundings are near the Caribbean island of Antigua at about 12 UTC on September 5, 2008. Hurricane Ike was to the north of Antigua at this time. The parcel is initialized with the observed sea surface temperature and relative humidity from the environmental sounding. The velocity profile is determined from a Lagrangian parcel model, which includes the effects of entrainment, condensate weight and the ice phase.

REGIONAL TO GLOBAL SCALE MODELING SYSTEMS

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

PROJECT TITLE: Analysis of Clouds, Radiation and Aerosols from Surface Measurements and Modeling Studies

PRINCIPAL INVESTIGATORS: Cliff Matsumoto and Shelby Frisch

NOAA TECHNICAL CONTACT:

PROJECT OBJECTIVES: The effect of aerosols on cloud microphysical and radiative properties (the indirect effect") has the greatest uncertainty of all known climate forcing mechanisms. Increases in aerosol concentrations result in higher concentrations of cloud condensation nuclei (CCN), increased cloud droplet concentrations, and smaller droplet sizes. A possible secondary effect is the suppression of rainfall. Together, these effects generate more reflective clouds which, in theory, create a radiative forcing estimated on the global scale to range from 0.0 Wm-2 to -4.8 Wm-2.

While there is ample evidence that an increase in aerosol tends to decrease cloud drop size and increase cloud reflectance, many questions remain concerning the degree to which this occurs, the most important controlling parameters, and the measurement requirements for these parameters. For example, although the concept of the first indirect effect posed by Twomey (1974) clearly states that the comparison be made between clouds having the same liquid water content, many studies have ignored this requirement. Therefore, it is unclear whether drop sizes are smaller because of higher CCN concentrations or because of lower condensed water (Schwartz et al., 2002). Other important questions include the relative importance of cloud dynamics (particularly updraft velocity), aerosol composition, and aerosol size distribution (Feingold, 2003).

Although it is clear that aerosol effects on clouds extend to cloud lifetime, precipitation (Warner, 1968; Albrecht, 1989), and cloud dynamics, an understanding of the magnitude of the first indirect effect is in and of itself a worthy goal.

ACCOMPLISHMENTS: We have set up a synchronized data set of pertinent cloud and aerosol microphysical properties at a temporal resolution of 20s. Aerosol fields measured at coarser temporal resolution have been interpolated to 20s recognizing that aerosol temporal changes are much slower than cloud temporal changes. We demonstrate that although the various measures of aerosol effects on cloud microphysics are consistent, they are likely too low. This inference is based on theoretical analysis of cloud modeling (Feingold 2003). Radiative transfer modeling also demonstrates that uncertainties in these measures will translate to large uncertainties in radiative forcing estimates. This is a continuation of our study with the data from Pt. Reyes, CA.

In addition to a Department of Energy presentation on "Measures of aerosol-cloud interactions and their uncertainties: A case study from the AMF Pt. Reyes deployment," a JGR journal publication and a conference poster presented at a 2009 DOE/ARM meeting (see Figure 1) provide results from this study.

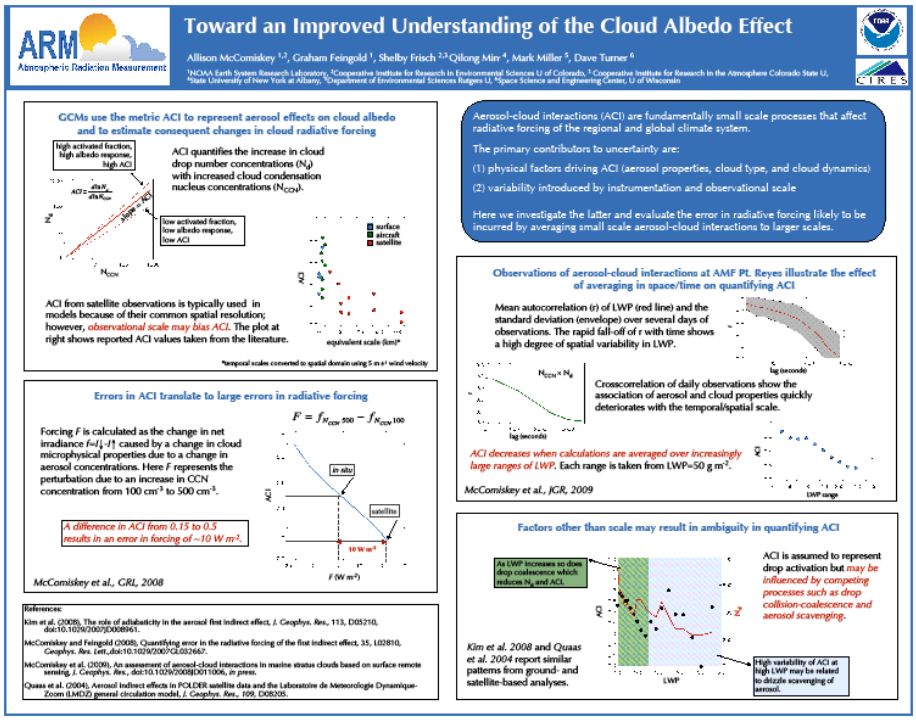


Figure 1: DOE/ARM Conference Poster Presentation on an Improved Understanding of the Cloud Albedo Effect

EAR – Research Collaborations With ESRL/GSD Assimilation and Modeling Branch

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

PRINCIPAL RESEARCHERS: Kevin Brundage and Tracy Smith

NOAA TECHNICAL CONTACT: Stan Benjamin, ESRL/GSD/AMB Chief

PROJECT OBJECTIVES: The primary focus of the GSD Assimilation and Modeling Branch is the refinement and enhancement of the Rapid Refresh, High Resolution Rapid Refresh (RR and HRRR) and development of the Weather Research and Forecast (WRF) model. The RR is intended to replace the operational Rapid Update Cycle (RUC), which runs operationally at the NOAA/NWS National Centers for Environmental Prediction (NCEP), in the fall of 2010. In addition to refinement and enhancements of the RR and HRRR, CIRA researchers collaborate on the development of the Weather Research and Forecast (WRF) model used by CIRA and GSD researchers. During 2010, we intend to continue the development work on the Weather Research and Forecast (WRF) and Rapid Refresh models used by CIRA researchers and to improve the required visualization techniques for the RR and HRRR fields. Additionally, CIRA researchers continue to work on applications of the RUC and RR to forecast problems, including investigations into the use of model time-lagged ensembles to improve the accuracy and provide certainty estimates for short-range forecasts, in particular QPF and wind energy.

ACCOMPLISHMENTS: During the past year, the RR and HRRR, and wrfRR were implemented quasi-operationally on ESRL's Jet HPCC systems. These real-time runs provide scientists with critical feedback and verification information necessary to tune model specific parameterizations. Additional information and results from these real-time model runs are available on the internet at: http://rapidrefresh.noaa.gov and http://ruc.noaa.gov/hrrr.

The NOAA/ORLN climate research procurement is currently soliciting bids from potential providers and is expected to award a contract later this year. Benchmarks provided by GSD/CIRA personnel provide a critical performance gauge used in the evaluation of these proposed HPC systems. Similar benchmarks are currently in development and will be used in the evaluation of the weather forecasting research procurement which will be awarded during 2011.

EAR – Research Collaborations with ESRL/GSD Aviation Branch

PROJECT TITLE: Advanced High-performance Computing

PRINCIPAL RESEARCHERS: Tom Henderson, Jacques Middlecoff, Jeff Smith, and Ning Wang

NOAA TECHNICAL CONTACT: Mark Govett, ESRL/GSD/AB

PROJECT OBJECTIVES: To run the NIM at sub 5km global resolution which requires accelerator technology. CIRA researchers will also collaborate with ESRL scientists on NIM research in the area of grid generation and optimization, pre- and post processing, and development of numerical algorithms.

Develop and enhance the software suite known as the Scalable Modeling System (SMS).

To support ESRL scientists with their codes and be available to provide design advice and expertise on a variety of software/web/database technologies for incorporation into the Lab's various research endeavors.

Continue to modify the Flow-following, Finite-volume Icosahedral Model (FIM) software to enhance interoperability with NCEP's NEMS architecture implemented via the ESMF.

Continue to collaborate closely with Tom Black and others at NCEP to further generalize the NEMS ESMF approach so it meets requirements of NCEP models (GFS, NMMB) as well as FIM.

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

Collaborate with LEAD researchers in the development of a Java-based graphical front end to the WRF Pre-processing System (WPS) called WRF Domain Wizard.

Serve on the National Unified Operational Prediction Capability (NUOPC) interim committee on Common Model Architecture (CMA).

Continue to fine-tune software engineering processes used during FIM development, ensuring that these processes remain suitable for a candidate production NWP code.

Optimize run-time performance as needed and incorporate new features such as the ongoing integration of WRF-CHEM and WRF-ARW physics into FIM.

ACCOMPLISHMENTS: CIRA researchers restructured and optimized NIM to be efficient on the GPU. CIRA researchers were part of a team that ported NIM to the GPU resulting in a 34X speedup compared to the CPU. CIRA researchers investigated the IBM Cell

technology but found that it did not meet our needs.

CIRA researchers developed a NNEW Testbed website which runs functional and performance tests against the NNEW WFS (Web Feature Service) and dynamically graphs the results on a web page. NNEW is part of the Nextgen project.

CIRA researchers upgraded FIM to interoperate with NEMS revision 3038. This major upgrade required retro-fitting our older GFS physics component to work with the newer NEMS version.

CIRA researchers collaborated with NCEP developers to improve several aspects of NEMS. A key accomplishment was design of new flexibility required to avoid duplicate storage of model state arrays and refactoring to remove large sections of duplicated set-up code. Also identified a key deficiency regarding fault-tolerance of forecast ensembles and proposed a solution. This deficiency may preclude operational implementation of NEMS if not corrected.

CIRA researchers continued to interact with the ESMF core team on a variety of technical issues. We hope that ESMF will eventually support our proposed solution to the fault-tolerance deficiencies of NEMS and have begun discussions on this topic.

CIRA researchers added important new features to the portal and to WRF Domain Wizard. These features include adding support for Hurricane WRF (HWRF), support for Geo Target Alert System (GTAS) and GLAPS domains, a namelist.input editor with validation checking, a non-linear vertical grid stretcher (in collaboration with LEAD researchers), and additional workflow management enhancements to support running the FIM model.

CIRA researchers continued to serve on the CMA of the NUOPC. Phase I has been completed with creation of a set of recommendations. These recommendations have been accepted and funding approved for a second phase which has just begun. CIRA researchers will also serve on the new Content Standards Committee (CSC) which was created following Phase-I recommendations.

CIRA researchers have continued to improve software engineering processes for FIM and NIM. FIM build and run automation has been improved and simplified. The FIM test suite has been extended to include wfm and COMPARE_VAR and other cases. FIM and NIM I/O have been extracted and combined into a separate repository that is now shared between both models.

CIRA researchers employed cloud computing (Amazon EC2) to develop a prototype (called GIMTool) that enables Finite-volume Icosahedral Model (FIM) researchers to navigate and visualize the output from their global FIM runs in a web page utilizing the Google Earth browser plugin.

EAR – Research Collaborations With the ESRL/GSD Office of the Director

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

PRINCIPAL RESEARCHER: Brian Jamison

NOAA TECHNICAL CONTACT: Steve Koch, ESRL/GSD

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

ACCOMPLISHMENTS: Interpolation routines were developed that generate FIM output on a

0.5 degree latitude and longitude grid. These output fields can then be plotted using standard contouring packages. The NCAR Graphics Command Language (NCL) is the primary tool used for real-time graphics generation.

A web site for display of FIM model output was updated and currently has 27 products available for perusal with 3-hourly forecasts going out to 10 days (http://fim.noaa.gov/FIMscp). Additionally, the web site features the ability to loop any of these fields throughout the forecast periods.

Test versions of the FIM model were run on the Texas Advanced Computing Center (TACC) computer, which generated output at about 10 km resolution. Separate web pages were created for FIM output from the TACC runs. Hurricane tracking software was used on the FIM output, providing FIM-produced forecasts of projected hurricane paths. These runs feature ensemble members of hurricane tracks, which have provided some very promising results.

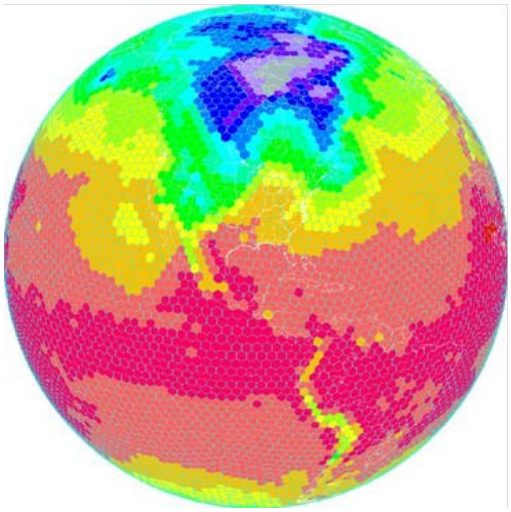


Figure 1: An example of the icosahedral grid with FIM model temperature plotted (provided by Ning Wang)

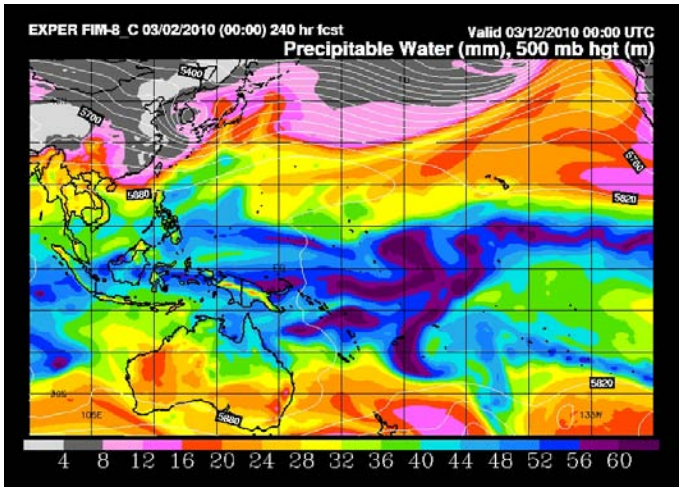


Figure 2: A 240-hour FIM forecast of precipitable water over the Western Pacific with 500 mb height contours overlaid

PROJECT TITLE: Evaluation of Hurricane Mitigation Hypotheses Through an Interactive Program of Observational Analyses and Numerical Simulation

PRINCIPAL INVESTIGATOR: William R. Cotton

NOAA TECHNICAL CONTACT:

PROJECT OBJECTIVE 1: Development of a Prognostic Scheme for Sea-salt Sources

PROJECT OBJECTIVE 2: Implementation of Scavenging Aerosol Sinks

PROJECT OBJECTIVE 3: Exploration of Methods to Mitigate the Intensity of Tropical Storms

ACCOMPLISHMENT 1: We developed a prognostic scheme to take into account sea-salt surface sources based on a set of diagnostic (empirical) formulae (O' Dowd, 1999). The scheme used a Newtonian relaxation technique and it is able to predict the generation of sea-salt particles in three size ranges: the film, jet, and spume sea-salt modes. These modes have been added to our research version of RAMS as full prognostic variables, and therefore they are advected, diffused and have sources and sinks. The film and jet modes have also been interfaced with the microphysical modules to act as cloud condensation nuclei (CCN) and giant CCN, respectively. These schemes were tested in an interactive-nested-multi-grid framework and used for hurricane studies.

ACCOMPLISHMENT 2: We added separate routines to consider the scavenging of sea-salt particles by rain and drizzle drops. Scavenging efficiencies are *no*t averaged and are considered dependent on the drop sizes for both precipitating liquid species and therefore the process is "weighted" by the corresponding size distributions. These routines (separately) compute scavenging the scavenging of CCN, GCCN as well as the film, jet, and spume sea-salt modes by drizzle and raindrops spectra. To reduce the uncertainty linked to drop-particle collision efficiencies; we based the scheme on empirical data (Chate et al., 2007 and personal communication) linking scavenging coefficients to rainfall rates at every model grid cell (computed from the drizzle and raindrop spectra). As in the previous case, the model improvements were tested in an interactive-nested-multi-grid framework and used for hurricane studies.

ACCOMPLISHMENT 3: The development of methods to mitigate storm intensity has regained interest after the devastating 2005 United States hurricane season. Some recent studies suggest some new strategies (e.g., Rosenfeld et al., 2007; Cotton et al, 2007) that involve enhancing the CCN concentrations in the outer rainband region. Increasing CCN concentrations would cause a reduced collision and coalescence, resulting in more supercooled liquid water to be transported aloft which then freezes and enhances convection via enhanced latent heat or freezing. The intensified convection would condense more water ultimately enhancing precipitation in the outer rainbands. Enhanced evaporative cooling from the increased precipitation in the outer rainbands would produce stronger and more widespread areal cold pools which block the flow of energy into the storm core, ultimately inhibiting the intensification of the TC.

We designed a series of simulations for which the time of the "virtual flights" as well as the aerosol release rates are varied. RAMS@CSU was configured to have three two-way interactive nested grids. All runs consider a spin-up time of 36 hours and after that time, seeding is considered. A code that simulates the flight of a plane is used to increase the CCN concentrations as an aircraft flies. We performed various runs considering virtual flights at an altitude slightly lower than cloud base and at several seeding times (every three hours). In addition, the aerosol release rates were also varied. All sensitivity experiments considered an aircraft speed of 150m/s and flight times ranging from 10 to 30 min, increasing as the tropical cyclone develops.

Results, although preliminary show a significant sensitivity to both the seeding time and the aerosol release rates. Supporting the aforementioned hypotheses, seeding flights

increased the quantities of supercooled liquid water, peak updrafts, and decreased the temperature of the cold pool and, more importantly, the peak surface winds. As an illustration, Fig. 1 compares the distribution of surface winds simulated for the free run (control) and several virtual seeding flights. Two papers are under elaboration.

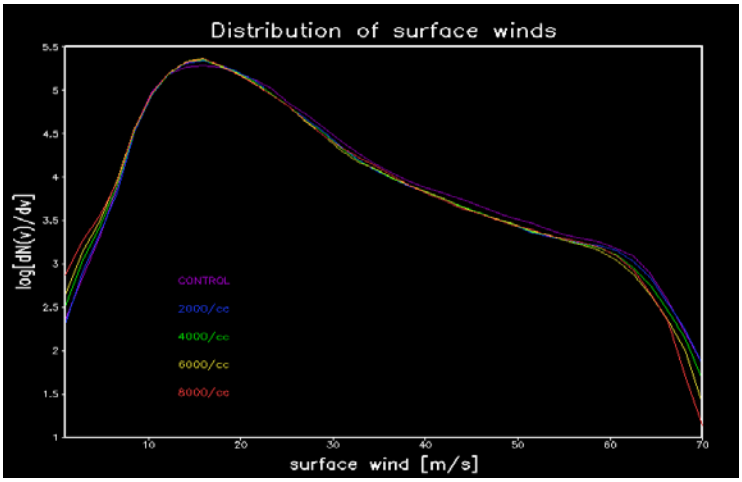


Fig 1: Surface wind distributions for run with and without seeding flights.

PROJECT TITLE: Joint Hurricane Testbed – An Improved Wind Probability Estimation Program

PRINCIPAL INVESTIGATOR: Stanley Q. Kidder

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: A program for estimating the probability of occurrence of 34, 50 and 64 kt winds was developed under an earlier Joint Hurricane Testbed (JHT) project. At that time we utilized a Monte Carlo (MC) method to combine the uncertainty in the track, intensity and wind structure forecasts. This current project focused on three tasks to improve the existing probability program:
1) Refining the MC wind probability estimates by making the underlying track error distributions a function of the forecast uncertainty.
2) Improving the timeliness of the MC model by optimizing and modifying the code.
3) Generalizing the code that calculates the track and intensity error distributions for the MC model to also update the “stand-alone” intensity probability product utilized by NHC.

ACCOMPLISHMENT 1: Refining the MC wind probability estimates. We incorporated a real-time tool into the MC model which quantitatively estimates the track forecast uncertainty (the Goerss Predicted Consensus Error, GPCE). Given that the NHC track errors generally are larger when the GPCE values are larger, the MC probability model was modified to track error distributions that depend on the GPCE value. When the GPCE category is high, the wind probability distributions tend to spread out, with lower probabilities along the track and higher probabilities farther from the track. The opposite is true when the GPCE category is low. For medium GPCE values, the probabilities vary only slightly relative to the version where the full distributions are used. To implement this information into our MC probability model, we

used the NHC track errors from the previous five years and divided these into terciles (low, medium and high) based on the corresponding GPCE values. The code also accounts for cases where the GPCE tercile changes with time along the forecast track as well as for those cases when the GPCE value is missing. For the latter, the track error distributions for the full 5-year sample were used. The result of this code refinement increased the MC wind probabilities along the track by more than 10% and the values away from the track decreased by more than 7%. The new model was tested on 169 cases from the 2008 Atlantic season that were within about 1000 km of the U.S. coast. For the quantitative comparison of the operational and GPCE versions of the model, the 2008 cases were also run for the contiguous U.S. and Caribbean coastal breakpoints, similar to those used in the NHC operational test product. The Brier Score and Threat Score were used to evaluate the new model for those cases most relevant to U.S. watches and warnings, and over a more focused region. Both measures showed that the GPCE version of the model ended up being an improvement over the operational version.

ACCOMPLISHMENT 2: Improving the timeliness of the MC model. Work on optimizing and modifying the code of the MC model was successfully completed and resulted in a speed-up by a factor of six of the MC model running time. The optimized code was tested and showed to provide identical results. The new code was implemented on the NCEP IBM.

ACCOMPLISHMENT 3: Generalizing the code that calculates the track and intensity error distributions. Our final project objective was to provide NHC with a modified version of the code that returned all of the information for the wind speed probability table. The error distributions used in the code were brought up-to-date and the new version of this product was extended to match NHC's official 120 hr forecasts periods. This code was provided to C. Lauer from NHC prior to the start of the 2008 hurricane season, and was run for the 2008 and 2009 hurricane seasons.

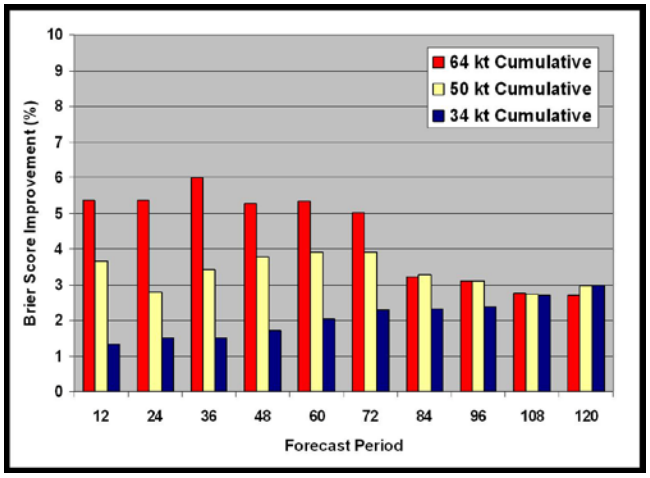


Figure 1: The improvement in the Brier Score of the 34, 50 and 64 kt wind probabilities of the GPCE version of the MC model relative to the operational version. The sample includes 169 Atlantic cases from 2008 that were within 1000 km from land, and the probabilities were calculated at 257 breakpoints along the U.S. Gulf and east coasts and the Caribbean.

PROJECT TITLE: Monsoon Flow and Its Variability During NAME: Observations and Models

PRINCIPAL INVESTIGATOR(S): Richard H. Johnson

NOAA TECHNICAL CONTACT: Jin Huang

PROJECT OBJECTIVE: To improve understanding of the North American Monsoon and its variability on multiple spatial and temporal scales. Data from the 2004 North American Monsoon Experiment (NAME) will be used to accomplish this goal.

ACCOMPLISHMENT: Research has been completed on the diurnal cycle of convection, correction of sounding humidity biases, and the dynamics of upper-level inverted troughs during NAME. The research involves diagnostic analyses of NAME sounding data.

PROJECT TITLE: Simulation and Analysis of the Interaction Between Aerosols and Clouds, Precipitation and the Radiation Budget Over the Gulf of Mexico and Houston

PRINCIPAL INVESTIGATOR: William R. Cotton

NOAA TECHNICAL CONTACT:

PROJECT OBJECTIVE: Sensitivity of Aerosol Indirect Effects to Instability.

ACCOMPLISHMENT: In a first stage we had analyzed the effect of growth of the Houston metropolitan area on the intensity of convection and precipitation using a vase study. The studies we performed during the last fiscal year were a follow-up to our previous study based on the case study.

Using RAMS coupled to the Town Energy Budget (TEB) urban model, we had examined the impact of urban growth on convection using NLCD corresponding to the years 1992, 2001 and 2006. We analyzed the impact on two distinct groups of simulated (and observed) convective cells that developed on August 24, 2000. The first group of storms located southeast of the city and the second, occurred north of the city (downwind). For the first group, the effects of land-use on convection and precipitation were dramatic and mainly linked to a monotonic increase in the intensity of the sea breeze due to the urban land-use change. The total volume of precipitation increased monotonically when increased city size was considered. Conversely, the storm that developed north of the city was significantly perturbed by the enhanced concentrations of aerosols from the urban sources.

We design a new series of sensitivity experiments focused on considering not only urban sources of varied intensities but also the convective instability conditions, performing a large number of multi-grid simulations (over a hundred). In agreement with previous studies, enhancing CCN concentrations reduced the size of the liquid droplets, reduced collection, and increased the amount of supercooled liquid content. Therefore, convective cells were intensified by enhanced latent heat or freezing. *However*, the effect on precipitation was *not* monotonic because as CCN concentrations are increased to large amounts, the efficiency of droplet collection and ice-phase riming is greatly reduced. As a result a large fraction of condensate is transported aloft as pristine ice crystals rather than forming large precipitation particles. In addition, the enhanced concentration of (smaller) pristine ice crystals transported to higher levels of the storm enhances the optical thickness, area coverage

and life time of cirrus-anvil clouds. In summary, aerosol pollution can intensify convective cells downwind of the city due to additional latent heat release, but while modest increases in pollution can increase precipitation, large amounts of aerosol pollution can reduce precipitation.

We examined how variations in convective instability can modify the relative importance of these two opposing effects on precipitation for sea-breeze-induced storms over an urban complex. The main conclusions can be summarized as follows:

--Pollution can significantly intensify downwind convective cells (+12% in max accumulations); however the effect on integral precipitation values is less important.

--In agreement with previous studies, [CCN] ↑ reduce the size of the droplets and the collision efficiencies increasing the amount of SC liquid content and enhancing latent heat release.

--*But*, the effect of pollution is *not* monotonic.

--Further enhancing [CCN] generates smaller SC droplets less efficient to form large precipitation particles, and more likely to be transported aloft as pristine ice crystals.

--For a given level of pollution, precipitation is more likely to be enhanced in events characterized by higher instability.

DATA ASSIMILATION

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

EAR – Research Collaborations With ESRL/GSD Assimilation and Modeling Branch

PROJECT TITLE: Chemical Data Assimilation

PRINCIPAL SCIENTIST: Mariusz Pagowski

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

PROJECT OBJECTIVE 1: Development of data assimilation system for WRF-Chem.

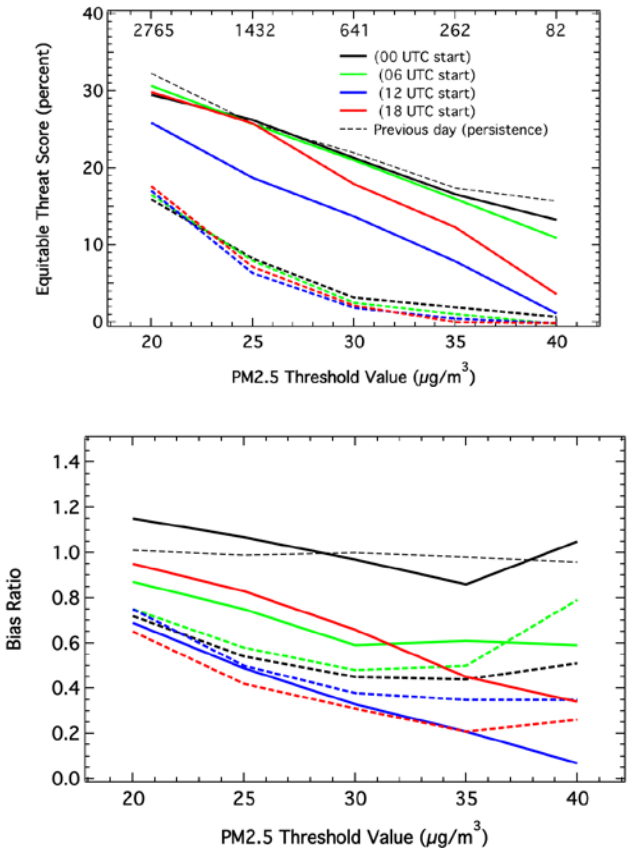
PROJECT OBJECTIVE 2: Development of aerosol assimilation for Rapid Refresh domain.

PROJECT OBJECTIVE 3: Assessment of the effect of assimilation of ozone vertical soundings and on-board commercial aircraft measurements on ozone/aerosol forecasts.

ACCOMPLISHMENT 1: A paper submitted for QJRMS required revision and new simulations. Revision has been submitted and the paper is still in review. 6-hourly assimilation cycle of surface ozone and aerosols has been implemented and evaluated. The results show that improvement in forecast skill is particularly significant for aerosol prediction. Equitable threat score and bias ratio for control forecasts (dashed) and with assimilation are shown in Figures 1 and 2. A publication is being prepared and will be ready for submission once the paper for QJRMS is accepted. Also, simultaneous meteorological and chemical assimilation with GSI has been implemented. The assimilation includes interdependence between temperature and streamfunction and ozone/aerosols. Results are being evaluated. GSI code with added chemistry has been forwarded to Air Resources Laboratory with the purpose to use it for real-time air quality forecasting at NCEP.

ACCOMPLISHMENT 2: Error correlation lengthscales and variances are being derived using aerosol forecasts over Rapid Refresh domain. These statistics will be used for real-time forecasts of aerosol concentration over RR domain.

ACCOMPLISHMENT 3: Forecasts of RAQMS global chemical model are being used to provide lateral boundary conditions for WRF-Chem over the continental US domain. WRF-Chem has been run in the same configuration for July 2008 to derive background error correlation lengthscales and variances. With these background error statistics and RAQMS lateral boundary conditions, an assimilation cycle was run for August 2006. In the assimilation, surface observations of ozone and aerosols are used. After obtaining commercial aircraft measurements and ozone soundings, a data assimilation cycle will be executed to assess if soundings and aircraft data contribute to the improvement of air quality forecast skill.



Figures 1 and 2: Equitable threat score and bias ratio for control forecasts (dashed) and with assimilation.

EAR – Research Collaborations With ESRL/GSD Forecast Applications Branch

PROJECT TITLE: Hydrometeorological Testbed (HMT)/California Department of Water Resources (DWR)

PRINCIPAL RESEARCHERS: Steve Albers and Isidora Jankov

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

PROJECTIVE OBJECTIVE: The Hydrometeorological testbed (HMT) is a well-funded, multi-year project (hmt.noaa.gov) designed to improve the use of research quality observations and modeling in operational forecasts of precipitation and streamflow.

ACCOMPLISHMENTS: LAPS analyses were set up for this winter season's Hydrometeorological Testbed (HMT) domains over the West Coast. This includes a 9km/3km nest for precipitation prediction and a 10km domain covering a wider area helping to support water vapor flux calculations. Improvements were made to model forecast post-processing.

A subroutine was written to emulate what the PSD flux-tool does except we now calculate it over the 2-D LAPS grid instead of just a few locations. This upslope component of the moisture flux is being calculated within the LAPS analyses and forecasts. Upslope moisture flux is calculated as plain moisture flux over ocean areas and can be displayed on our website. The controlling layer is set to 750-1250m. We are also looking at moisture flux on other domains (including global) to see the large-scale evolution of atmospheric rivers and other storm types.

A study performed in collaboration with several scientists from NOAA/PSD (Jian-Wen Bao, Paul Neiman and Allen White) and CIRES (Huiling Yuan) focused on a detailed analysis of a high-resolution numerical model with various microphysics and its performance in cases of atmospheric river events has been published in Journal of Hydrometeorology.

An additional evaluation of the WRF-ARW model performance when using various microphysics was assessed by producing synthetic satellite imagery and using an objective measure of difference in various microphysics compared to observations. This research was performed in collaboration with a group of CIRA scientists. Results from this study were used in preparation of a manuscript that has been recently submitted for review to Journal of Hydrometeorology.

An additional activity of Isidora Jankov consisted of taking part in a team effort to test a newly developed observations-based forecast model verification tool by a group of PSD scientists for atmospheric rivers and their impacts on coastal orographic precipitation enhancement. The tool focuses on water vapor flux as a major determinant of orographic precipitation. The water vapor transport is estimated by using wind profilers and GPS-met (Integrated Water Vapor) IWV data. For this purpose, LAPS analysis and hourly reinitialized 12-hr model simulations of ten events characterized by significant precipitations have been performed. The data from this experiment are currently undergoing a statistical analysis and the team is working on preparation of a manuscript for submission to a peer reviewed scientific journal.

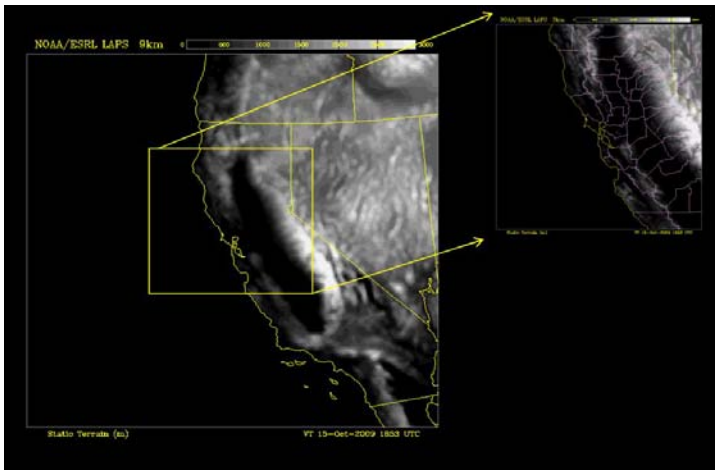


Figure 1a: Nested integration domain for the HMT/DWR experiment during the 2009-2010 winter season.

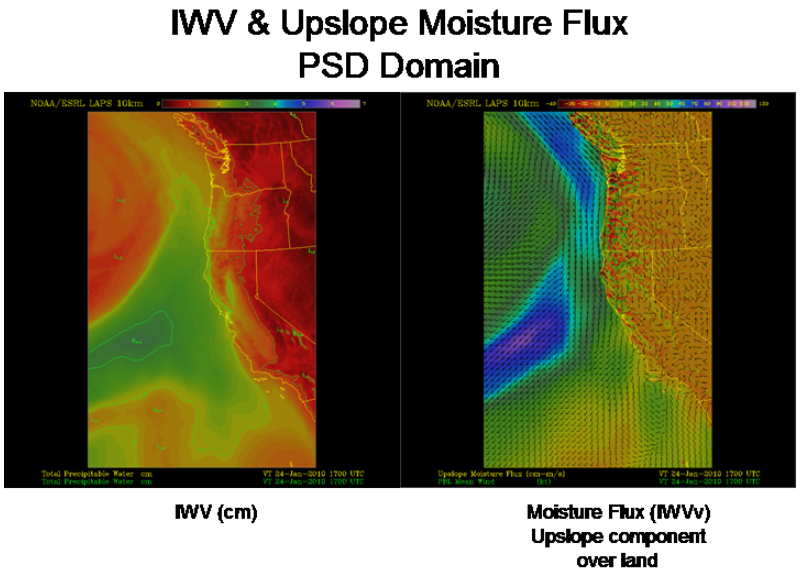


Figure 1b: Vertically integrated water vapor and the corresponding moisture flux with the upslope component over land for the HMT/DWR 2009-2010 winter season experiment.

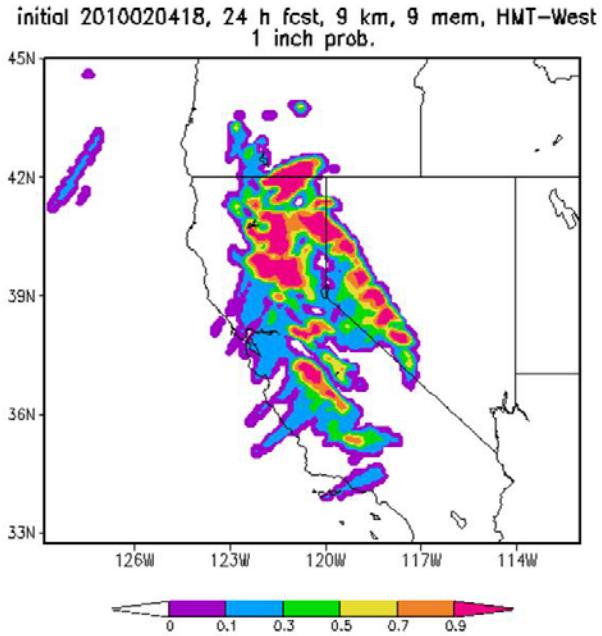


Figure 1c: Probabilistic Quantitative Precipitation Forecast (PQPF) for 1 in. threshold derived from the HMT/DWR ensemble forecasts.

EAR – Research Collaborations With ESRL/GSD Forecast Applications Branch

PROJECT TITLE: Investigative Modeling Research

PRINCIPAL RESEARCHERS: Steve Albers and Isidora Jankov

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

PROJECT OBJECTIVE 1: NSF Model Microphysics Study

PROJECT OBJECTIVE 2: Hurricane Initialization Studies with LAPS/STMAS/GSI

PROJECT ACCOMPLISHMENTS: NSF model microphysics study. Steve Albers and Isidora Jankov continue to work in collaboration with Tomislava Vukicevic and a PhD student Marcus van-Lier Walqui on an NSF grant. During the second year of the project in terms of the code development endeavor, a version of the SynPolRad model software allowing production of synthetic polarimetric reflectivity and associated parameters has been employed by CSU/CIRA personnel with help from Marcus van Lier-Valqui. The software has been implemented as a post-processing part within the LAPS framework. In addition, two different options for synthetic reflectivity calculation ('Kessler'and 'RAMS') have been added to the same framework.

Analysis and model simulations of two IHOP events have been performed. The selected events occurred on June 13th and June 16th of 2002. At the simulations initial time 00UTC, both events were characterized by multiple convective cells near the northern Oklahoma border. The convective cells organized relatively quickly into well-defined squall lines while moving from north-west to south-east over the state of Oklahoma. For both cases, the simulations were performed for the 6-hour period with very high spatial (2-km horizontal grid spacing and 53 vertical levels) and temporal (15-minute) resolutions. The simulations included use of three different microphysics schemes available in the WRF-ARW code. The model output has been post processed by using two choices (mentioned above) for synthetic reflectivity calculations (SynPolRad option is still under testing). This resulted in a matrix of six solutions (three microphysics schemes and two different reflectivity calculation options) for each of the two events. For both events, LAPS analysis was produced for the same spatial and temporal resolutions as the simulations. For this purpose, all available observations including both 2D and 3D radar data reflectivity, radial velocities, other in-situ and remotely sensed data were used. The six various options of the synthetic reflectivity have been objectively compared to the LAPS radar reflectivity analysis using our locally developed verification software. This comprises histograms, contingency tables and various skill scores. We are currently performing an assessment of the results so far obtained. The latest interim results and associated discussion will be included in the official report to the NSF submitted March 1, 2010.

As mentioned above, the Synthetic polarimetric radar "SynPolRad" software package is now an option for the model post-processed reflectivity fields. Other reflectivity options include "Kessler" and "RAMS". The model post-processing software also includes derived polarimetric radar variables (ZDR and LDR). Along with this, the polarimetric radar software interface was integrated more closely into the LAPS environment and has improved microphysical inputs for ice. Thus, we can post-process model forecast output for both conventional and polarimetric radar reflectivity parameters. LAPS precipitating hydrometeor analyses now have an option to use the "Kessler" relationship to radar reflectivity. This is the inverse of what the model post-processing does with Kessler for rain and Rogers & Yau for snow/ice.

Hurricane initialization studies with LAPS / STMAS / GSI. We gave a presentation at the GSD technical review on hurricane research efforts within FAB. Additional wideband radars were set up along the Gulf Coast for the Caribbean and WISDOM balloon LAPS & STMAS analysis runs. The domain localization procedure now tells us which radars are near the ocean as that is helpful in setting up hurricane runs. WISDOM balloon observations should now show up in the LAPS "what-got-in"

outputs for wind and temperature, including verification statistics. Preliminary work was done for accessing airborne Doppler radial velocity data in the native radial (non-analyzed) format. Default dimensions of observations were increased helping our large hurricane domain STMAS runs.

Several WISDOM balloon launch events were tracked using LAPS and STMAS. Improvements were made for plotting WISDOM balloons with the LAPS NCAR graphics program. Additional station QC climatological and standard deviation checks can now be turned on and off via name list, helping particularly for surface observations in the vicinity of hurricanes.

Recently, a proposal of activities related to hurricane analysis and forecasting was submitted to the HFIP program. Seven out of nine proposed ideas have been implemented into the program milestones. It remains to be seen how many of these ideas will be funded. CIRA researches will be heavily involved in this project supporting the development of hurricane data assimilation as well as development and setting of an ensemble system for hurricane forecasting.

EAR – Research Collaborations with ESRL/GSD Forecast Applications Branch

PROJECT TITLE: Local Analysis and Prediction System (LAPS)

PRINCIPAL RESEARCHERS: Steve Albers, Isidora Jankov, and Ed Szoke

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

PROJECT OBJECTIVES: Research objectives related to LAPS continues to be the improvement and enhancement of the system in providing real-time, three-dimensional, local-scale analyses and short-range forecasts for domestic and foreign operational weather offices, facilities, and aviation and other field operations.

PROJECT ACCOMPLISHMENTS: First Guess Processing. The program option for utilizing surface fields (versus 3D) from the model first guess will now attempt this for a wider variety of models when we interpolate to the LAPS surface grid. Associated changes improve first guess interpolation from the Finnish Meteorological Institute.

Observational Data Sets. Improvements were made in LAPS to analyze observations from new types of instruments and new data formats, thus expanding the envelope of meteorological data environments that we can operate in with our ever growing set of users.

Surface Observations. New MADIS networks were added while our subjective QC blacklist was updated. A QC check was added for solar radiation.

Upper Air Observations. Surface observations can now be extracted from satellite soundings. Support was added for radiometer cloud base and temperature. Temperature and relative humidity now accompany WISDOM balloon wind data.

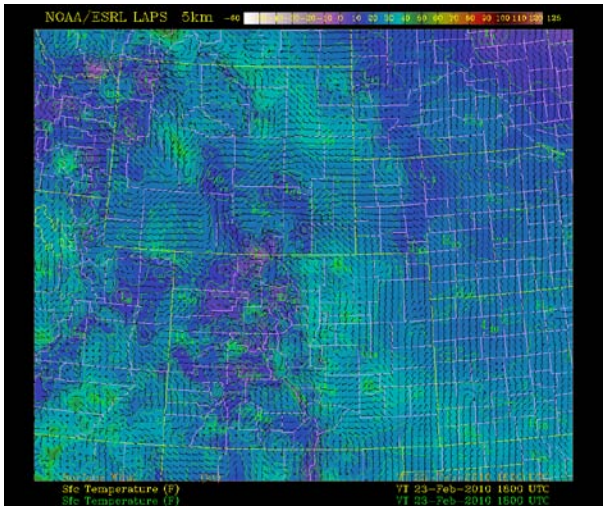


Figure 1: LAPS surface temperature and wind on the 5-km Colorado domain.

Surface Analysis. GPS surface observation access was made more flexible to work with the users' particular timing, supporting research done with the University of Hawaii. Surface "station" pressure analysis was improved to use the more accurate reduced pressure field in its calculation.

Radar Processing. In the radar remapping program elevation angle handling was generalized to help with radars pointing below the horizon, benefiting the Mauna-Kea Weather Center test radar on Mt. Haleakala.

Wind / Temperature Analyses. A more generic mean layer wind routine was developed for use in upslope moisture flux and other future uses.

Stability Indices. CAPE and other related indices can now be calculated at very high altitudes to support the Global LAPS (G-LAPS).

Cloud / Precipitation Analyses. Flexibility was improved in selecting radar, rain gauge, and model first guess options for the precipitation accumulation analysis. Rain gauge/radar pair information was improved. These changes benefit our study of precipitation representativeness. A new radar utility library has a "Kessler" microphysics to radar reflectivity forward model for use in STMAS.

STMAS Development and real-time evaluation efforts. We continued with Space-time Mesoscale Analysis System (STMAS) ports to NWS Southern Region Headquarters and MIT/LL where background model ingest was tested. We submitted a journal article on STMAS as co-author.
Preliminary changes were made to allow a sigma-height grid in the background model interpolation program (LGA) via a reorganization and enhancement of vertical interpolation routines.

Progress was made on getting TDWR radar data into a format that can be used by STMAS and LAPS. The 3-D to surface field interpolation routine is now available in the library for STMAS use. The NetCDF file for STMAS-2D has been updated so we can output relative humidity and mixing ratio variables.

The duplicate observation names check can now be turned off via namelist to support reading in multiple surface observations in the time window for STMAS, particularly when reading ASOS data. Fixes to satellite ingest handling and precipitation accumulations were made to benefit various STMAS runs.

The STMAS variation of LAPS is running in real-time at a 5 km horizontal grid resolution on the LAPS ROC (Colorado) domain. As development continues on STMAS and changes are made to improve the analysis, an important step is to evaluate the quality of the analyses. Ed Szoke has been involved in this part of the STMAS project, with an emphasis on examining case studies of features such as frontal

passages. STMAS analyses were compared with observations as well as analyses from the traditional LAPS and RTMA (Real-Time Mesoscale Analysis). RTMA is the current NWS analysis package that is available on AWIPS.

This subjective evaluation effort has proven useful in identifying areas where the STMAS analysis can be improved. Much was learned about the quality control of observations.

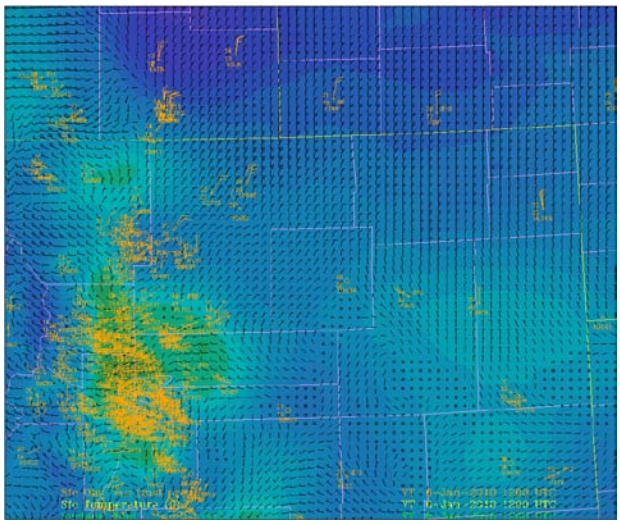


Figure 2: STMAS analysis of wind (barbs) and temperature (image) overlaid with observations for a cold front moving southward through northeastern Colorado at 1200 UTC on 6 January 2010. The analysis agreed fairly well with the observations for this case.

General Software Improvements & Portability. LAPS software documentation, logging, observation reporting, and error checking were improved, while obsolete code was removed. Software was revised to be more understandable. FORTRAN code was made more efficient. Scripts were made more robust and streamlined to be more user-friendly. More variables were initialized and declared properly for improved 64-bit portability. Observation reporting was improved. Physical constants were streamlined.

We maintain the LAPS software distribution and the associated web site. A high resolution 1-km LAPS 3D analysis was set up to run with a 15-min cycle. A global analysis is also being run.

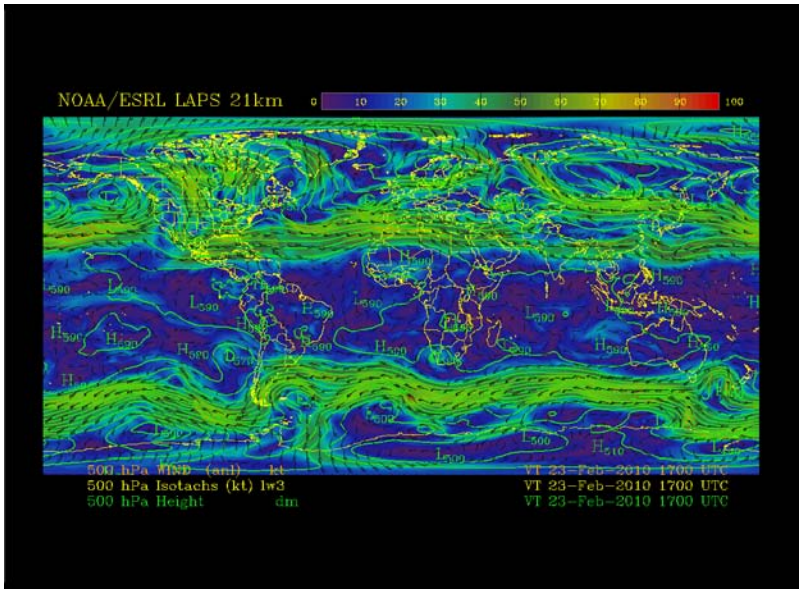


Figure 3: Analyzed 500mb height and wind on the GLAPS 21-km global domain.

LAPS Implementation & Collaborations. Research continues with both real-time and retrospective LAPS runs with the Mauna Kea Weather Center (University of Hawaii). The recent focus includes using retrospective satellite imagery and GPS data in the analyses. A paper was submitted with an Italian Climate agency on use of Meteosat Second Generation satellite data in LAPS. We attended workshops at NCAR on cloud analysis and ensembles. Initial planning was conducted for a LAPS workshop.

WWW LAPS Interface. Observation plots were added for integrated water vapor, 3-D dewpoint and specific humidity. They were improved for surface obs, WISDOM balloons and ACARS.

Several fields were added such as altimeter setting, 3D dewpoint, and balanced specific humidity. Graphics were improved for snow accumulation, balanced divergence/vorticity, 3-D specific humidity, microphysical variables, and surface mixing ratio. Color tables and labels were improved.

The "on-the-fly" page has additional available fields and improved animation capability. Sounding plots and forecast (pre-generated) web graphic scripts are now more user friendly.

We set up and continued to monitor LAPS analysis runs to support the initial Dallas-Ft. Worth implementation of the Geo-Targeted Alert System (GTAS). Doppler radars from 5 sites near DFW were included. The LAPS analysis is then used to initialize the outer nest of a high resolution (4.5 km) WRF-NMM model run. The outer nest provides boundary conditions for the inner nest having 1.5 km horizontal grid spacing. The same configuration has been used for two new sites added to the GTAS project since last year. The two additional sites include Seattle and Kansas City area. Currently, for the two new locations, only WRF-NMM model runs are performed in real-time. The production of the corresponding real-time LAPS analysis in the proper location is in process. For this purpose, an effort was made to add LAPS to the WRF domain wizard in collaboration with CIRA associate Jeff Smith. The model output is used as an input to the HYSPLIT dispersion model as well as for a display on AWIPS work stations.

We are considering adding new domains such as in New York. We are also working with Ed Tollerud to ensure the LAPS analyses are properly archived for verification purposes (along with the WRF forecasts).

ATMET/AFTAC. We are continuing with a reorganization of LAPS top level routines to support a single executable compilation and runtime option. Surface analysis routines were renamed to avoid duplication in the single executable version of LAPS.

FMI. We continued to work with the FMI on various LAPS topics including the use of radar data and the model first guess in the LAPS analyses.

Precision Wind. Preliminary discussions were held with CIRA & Precision Wind personnel about using LAPS & STMAS analyses to interface with the MLEF and WRF modeling being done at CIRA. The goal is to support wind energy operations with improved wind forecasts. An initial focus will be assimilating Doppler radar data and using this in LAPS analyses as well as with forward modeling in STMAS and/or MLEF.

EAR – Research Collaborations with ESRL/GSD Forecast Applications Branch

PROJECT TITLE: Model Ensembles and Ensemble Post Processing

PRINCIPAL RESEARCHERS: Steve Albers and Isidora Jankov

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

PROJECT OBJECTIVE: Ensemble forecast system testing and implementation continued in support of the Hydrometeorological Testbed and the project supported by California's Department of Water Resources.

ACCOMPLISHMENTS: Prior to the current season's experiment, significant changes in ensemble forecasting system have been made. Last year's integration domain, with 9-km grid spacing, has been extended westward and a high resolution (3-km grid spacing) nest has been added over central California. The forecast length of 120 hours has been kept the same for the outer nest while the inner nest forecasts have been produced for the 12-hour period. The ensemble design in terms of dynamic cores and physics stayed the same as previous years (3 WRF-ARW runs with various microphysics and one WRF-NMM run). The additional variety has been added by using the GFS ensemble members to provide lateral boundary conditions for the HMT/DWR ensemble members.

Last year's model run with an hourly cycle and 12 hr forecast length this season has been run over the much larger domain covering basically the entire West Coast. The increase in the integration domain resulted in coarsening horizontal grid spacing from 5 to 10 km. As during the last season, the output from this run was used as input to a moisture flux tool developed by colleagues from PSD.

EAR – Research Collaborations With ESRL/GSD Forecast Applications Branch

PROJECT TITLE: Range Standardization and Automation (RSA) Project

PRINCIPAL RESEARCHERS: Steve Albers and Isidora Jankov

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

PROJECT OBJECTIVES: In the early 2000s, the Air Force initiated the RSA program to modernize and standardize the command and control infrastructure of the two U.S. Space Launch facilities (ranges) located at Vandenberg AFB, California and Cape Canaveral Air Station, Florida. In cooperation with Lockheed Martin Mission Systems (and now ITT) staff serving as system integrator, ESRL/GSD developed and installed an integrated local data assimilation and forecasting system at the Western and Eastern Ranges with capabilities to incorporate local meteorological sensor data. Upgrades, enhancements and maintenance to the system continue.

ACCOMPLISHMENTS: We are maintaining the LAPS analysis on a shadow system at ESRL in preparation for delivery of a new LAPS/WRF software package to the ranges. The first challenge in implementing the WRF code on a computer that match the configuration with the contractors has been to compile the code using the pgi compiler. Preliminary tests have been conducted in collaboration with WRF support at NCAR. So far, the code has not compiled successfully. The next step will be to compile the code with a different compiler (e.g. gfortran or ifort) that will be installed on both local and contractor's machines.

EAR – Research Collaborations with the ESRL/GSD Office of the Director

PROJECT TITLE: The Use of Unmanned Aircraft Systems for Atmospheric Observations

PRINCIPAL RESEARCHER: Nikki Prive

NOAA TECHNICAL CONTACT: Yuanfu Xie, ESRL/GSD

PROJECTIVE OBJECTIVES: To develop a concept of operations for a global network of Unmanned Aircraft Systems (UAS) for the purpose of improving atmospheric observations for climate and weather over data-poor regions. The observational goals and viability of such a network will be determined by using Observing System Simulation Experiments (OSSE) for contributions to operational weather forecasting; and through analysis of existing climate data for contributions to climate research. A "full" OSSE using global forecast models will be performed to investigate potential hurricane track forecast improvements through the use of UAS observations.

A simplified form called a "Quick" OSSE will be performed in support of the hurricane UAS testbed in order to provide timely results for upcoming UAS missions. The Quick OSSE will use high-resolution regional models to evaluate potential hurricane intensity forecast improvements through the use of UAS observations.

ACCOMPLISHMENTS: Calibration of the global OSSE is nearly complete. All synthetic conventional observations have been calibrated using data denial experiments with the GFS/GSI forecast model and data assimilation package. Complete calibration of the synthetic radiance observations is expected by April 2010. Two tropical cyclones in the Nature Run have been selected for OSSE case studies of UAS observation impact on track forecasts. Initial forecasts using synthetic observations have

been performed for one of the two tropical cyclones. Further evaluation of atmospheric wave behavior in the Nature Run in comparison to reanalysis has been performed and is being readied for publication.

A Nature Run has been generated for the Quick OSSE using a 3-day, 2km run of the WRF-ARW regional forecast model for Hurricane Ike. The simulated tropical cyclone undergoes a period of rapid intensification which will be the focus of the OSSE intensity forecast studies. The HWRF model has been set up and tested for use as the forecast model for the Quick OSSE. Code for the generation of synthetic observations has been written for both the existing conventional observing network and for airborne UAS data types. Preparation of the data assimilation system for the HWRF is underway.

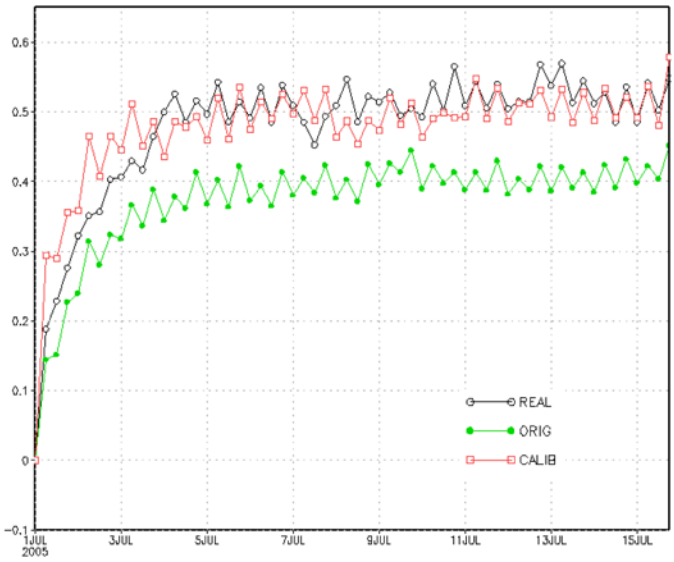


Figure 1: Global mean root-mean-square analysis impact for temperature shows successful calibration of synthetic aircraft observations. The uncalibrated synthetic observations (green) have too little impact in data denial experiments using GFS/GSI. The calibrated synthetic aircraft observations (red) have similar analysis impact to real aircraft observations (black).

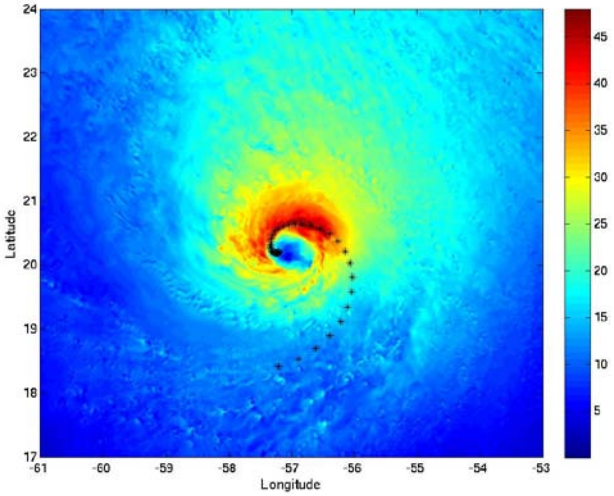


Figure 2: Quick OSSE Nature Run tropical cyclone wind speed (color, M/s) and potential low-altitude long-endurance UAS flight path (black stars).

PROJECT TITLE: Ensemble Data Assimilation for Hurricane Forecasting

PRINCIPAL INVESTIGATOR: Milija Zupanski

NOAA TECHNICAL CONTACT: Stephen Lord, NCEP/EMC

PROJECT OBJECTIVES: Produce situation-dependent forecast error covariances from an ensemble Kalman filter (EnKF) data assimilation with hurricane WRF (HWRF) model. Make those error covariances available to NCEP/EMC researchers for further improvement of NOAA operational data assimilation system (GSI) for hurricane forecasting.

PROJECT ACCOMPLISHMENTS: The EnKF system was interfaced with HWRF model and NOAA operational observations to produce situation-dependent forecast error covariances for use by GSI. The accomplished research stages are:

1) Interface between EnKF and HWRF
The interface was developed by utilizing several components of the HWRF system infrastructure to: set-up hurricane case, initiate all models, access global model files and observation files, and execute the forecast.

2) Interface between EnKF and GSI
The forward component of the GSI operator is used to access observations in EnKF system. This enables the EnKF-HWRF system to have observation error characteristics and quality control from GSI.

3) Evaluation of the EnKF-HWRF system
The EnKF-HWRF system has been evaluated on a hurricane Gustav (2008) case. Several aspects of the system have been investigated in detail, such as cost function decrease, ch-square test, and root-mean-squared (RMS) errors with respect to observations. All tests indicated that the EnKF-HWRF system is performing well, with improved measures.

4) Production of situation-dependent forecast error covariances from EnKF-WRF
A set of EnKF-HWRF data assimilation cycles from a hurricane Gustav has been performed, showing improvements due to assimilation of observations in the larger domain and in the moving nest.

PROJECT TITLE: NESDIS Post Doc Yong Chen

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Fuzhong Weng, NESDIS/STAR

PROJECT OBJECTIVE 1: Develop and validate the CRTM for visible, infrared, and microwave under various atmospheric (clear, aerosol, and cloudy sky) and surface conditions. Integrate new radiative transfer components into CRTM.

PROJECT OBJECTIVE 2: Tests of CRTM in satellite data assimilation system GSI (Grid Statistical Interpolation).

ACCOMPLISHMENTS: The new transmittance model ODPS (Optical Depth in Pressure Space) has been implemented into CRTM version 2. The ODPS model can have up to six user input variable absorbers (H_2O, CO_2, O_3, N_2O, CO and CH_4), while the operational Compact-OPTRAN in current CRTM only allows two variable absorbers (H_2O and O_3). Several important features are included in the ODPS model: (1) the CO_2 now is a user input variable absorber, it can be a profile or single value (same value at all height); (2) for hyper-spectral sensor, the input variable absorbers can be the same as broadband IR, all other gases are treated as dry

(fixed) gases; (3) using Compact-OPTRAN concept to treat water line transmittance if the fitting error for this component meets prescribed conditions compared to ODPS standard water line training error, in this way the water vapor Jacobian smoothness will remain; (4) water vapor continual transmittance is treated separately. The ODPS also considers the Earth curvature effect by adding altitude dependence to the zenith angle profiles.

--Comprehensive study of water vapor Jacobian for different transmittance models in CRTM. The results are included in a paper accepted by Journal of Geophysical Research and titled "On Water Vapor Jacobian in Fast Radiative Transfer Model" by Yong Chen, Yong Han, Paul Van Delst, and Fuzhong Weng. The paper summarizes the recent results in the improvement of the atmospheric transmittance module in the Community Radiative Transfer Model (CRTM), with an emphasis on the water vapor Jacobians. Three water vapor transmittance regression methods (labeled with A, B and C, respectively) are discussed, which differ primarily in vertical coordinates and the application of constraints to smooth vertical structures of the regression coefficients. Method A computes optical depth profiles at fixed pressure levels, while method B at fixed levels of the integrated absorber amount. Method C is a derived version of method B with an addition that a polynomial function is applied to the regression coefficients to improve the water vapor Jacobians. Inter-comparisons of the three methods were performed. The results were compiled for Method A and Method C for water vapor line absorption only while keeping the other components the same under the CRTM framework. In the infrared (IR), the temperature and water vapor Jacobian goodness of fit measure (*M*) values are less than 15 for both Method A and C and sufficient for NWP application, except for some dry atmospheric profiles (see Fig. 1). For the cold and dry atmospheric profiles, Method C can significantly improve water vapor Jacobian profile and remove the unphysical kinks (oscillations) that appear in Method A. The improved water vapor Jacobian profile results in the improved temperature Jacobian. For the microwave (MW) channels, the overall water vapor Jacobian *M* values using Method A are better than those using Method C, especially for warm and wet atmospheric profiles.

--Testing the CRTM_v2.0 in GSI. Experiments had been set up for three different runs: control run (currently operational GSI with CRTM_v1.1), ODAS run (with ODAS transmittance coefficients), and ODPS run (with ODPS transmittance coefficients). It is shown that the impacts are positive in terms of GFS ACC at 1000 hPa (see Fig. 2). Much of this positive impact is probably attributed to the improvements in surface emissivity components and the new treatments of water vapor optical parameters in the pressure coordinate.

--Improving the fast radiative transfer model for the Stratospheric Sounding Unit (SSU) after a study of the sensor's spectral response functions and sensitivities to the variations of atmospheric CO_2 and O_3 concentration. The model is implemented in CRTM version 2, to be released in the first Quarter of 2010. The study revealed that the spectral resolution for SRF calculations in developing the previous model was coarse for channel 3, which could result in 0.6 K brightness temperature errors on average. The resolution has been increased for the improved model and the errors are reduced to a negligible level. The study also revealed that channel 1 is sensitive to O_3 and all three channels are sensitive to the CO_2 variations occurring in the atmosphere. Unlike the previous model, CO_2 and O_3 are now treated as variable gases and their concentrations can be specified by the users. The results of the study are included in a paper which is being prepared and intended to submit to Journal of Geophysical Research (Atmosphere) in 2010.

--Simulated CrIS buffer data are testing in GSI system. In those buffer data, there are 300 arbitrary selected (every 4 channels) CrIS channels. It is shown that the overall CrIS simulated data quality is good compared to AIRS (IASI) observations.

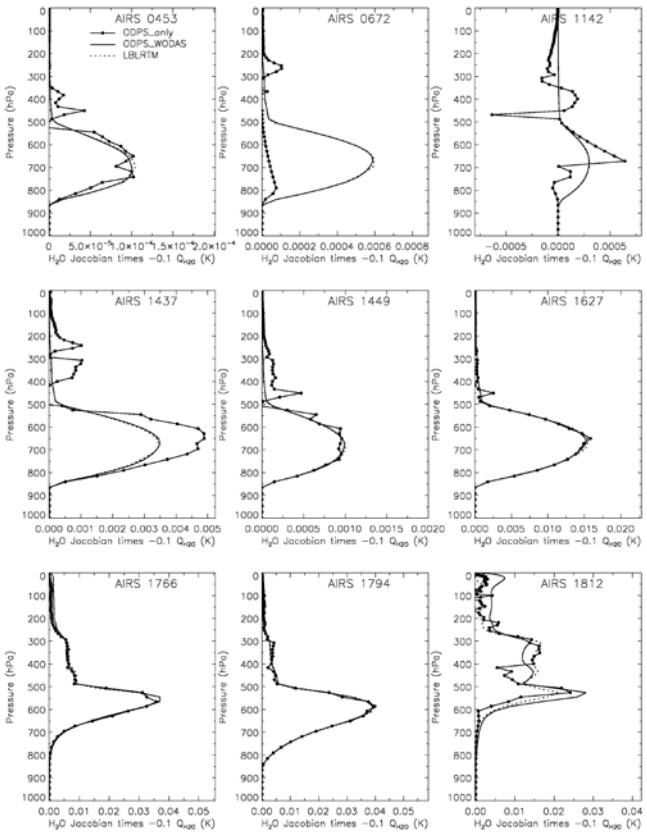


Figure 1: AIRS 9 channels water Jacobian profiles for the IR models for ODPS_only (Method A), ODPS_WODAS (Method C), and LBLRTM applied to UMBC atmospheric profile 7.

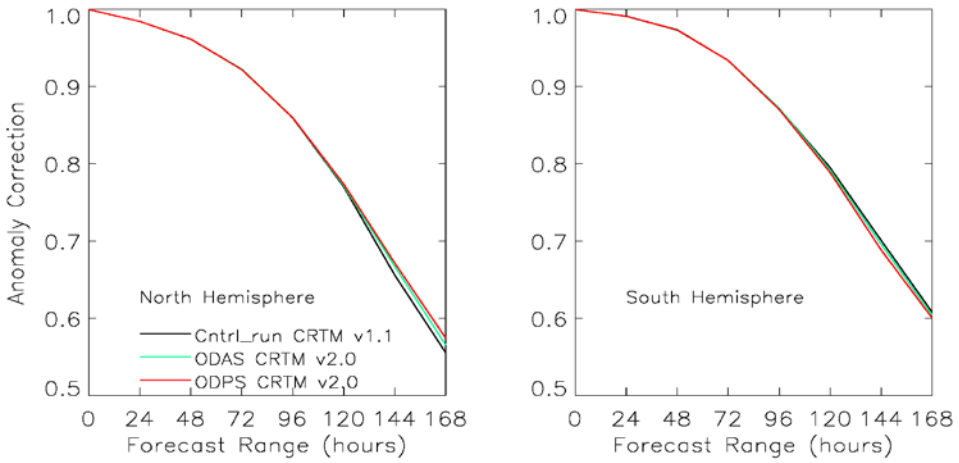


Figure 2: 1000 hPa geopotential height anomaly correlations 20N-80N waves 1-20 on 14 June 2009-16 August 2009.

CLIMATE-WEATHER PROCESSES

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

PROJECT TITLE: CoCoRaHS: The Community Collaborative Rain, Hail and Snow Network—Enhancing Environmental Literacy Through Participation in Climate Monitoring and Research

PRINCIPAL INVESTIGATOR: Nolan J. Doesken

NOAA TECHNICAL CONTACT: Sarah Schoedinger, NOAA Office of Education

PROJECT OBJECTIVES: The primary objective of this project is to enhance public awareness and environmental literacy through active participation in backyard monitoring of precipitation. During the period July 1, 2009 – March 31, 2010, the CoCoRaHS team at Colorado State University exceeded the ultimate goal of this project by registering all remaining states. By December 2009 all 50 states had a local CoCoRaHS volunteer leadership team in place and at least a few volunteers signed up and collecting data. The majority of states now have extensive statewide volunteer networks. The final state added to the program was Minnesota. Well over 20,000 volunteers have signed up since the project began. By the end of 2009 over 14,000 volunteers had sent in at least one precipitation report in the previous year. In September, a new record was set with more than 9,000 precipitation reports submitted on several individual days.

Special emphasis on providing volunteer training for the measurement and reporting of snow was required this past winter due to the numerous and large snow storms that tracked across the southern U.S.

PROJECT ACCOMPLISHMENTS: A comprehensive on-line survey was circulated to CoCoRaHS participants during September. Over 7,000 volunteers completed this lengthy survey providing the CoCoRaHS team with important feedback on the demographics of CoCoRaHS participants, their motivation and quality of experience, barriers to participation, what they are learning, and improvements they would like to see. This information will be used to plan next steps for CoCoRaHS and to establish objectives for future proposals. PhD candidates from Rutgers University and the University of Michigan both worked with the CoCoRaHS team in processing and interpreting results.

The project is currently proceeding with a no-cost extension and will end later in 2010. The last remaining funds from this grant were spent in February 2010. To keep the momentum going, the CoCoRaHS team engaged in a public fund raising campaign in December and January. Staff also began redirecting efforts including working on a mutually beneficial project funded by the National Drought Mitigation Center (NDMC) to add a capability to CoCoRaHS so that participants can submit drought impact reports through CoCoRaHS and these reports then go directly to NDMC. This will complement NOAA's current commitment to drought monitoring.

PROJECT TITLE: Development of an Improved Climate Rainfall Dataset from SSM/I

PRINCIPAL INVESTIGATORS: Christian Kummerow and Wesley Berg

NOAA TECHNICAL CONTACT: Chris Miller, Program Manager, Climate Change Data and Detection Program, NOAA Climate Program Office.

PROJECT OBJECTIVE 1: Implement GPROF-2008 for SSM/I. This involves the development of specific rainfall databases and procedures, which are consistent with funded efforts to produce rainfall products from TMI and AMSR-E.

ACCOMPLISHMENT 1: GPROF 2008 has been implemented for SSM/I. Rainfall estimates for the period from December 1997 through 2009 have been computed. Current efforts are focused on identifying and correcting issues with the current retrieval before the final rainfall product is produced.

PROJECT OBJECTIVE 2: Investigate the sensitivity of the SSM/I rainfall products to Tb variability:

1) Across DMSP platforms using F13 as the calibration standard

2) Across radiometer platforms using TMI as the calibration standard

ACCOMPLISHMENT 2: Calibration of the SSM/I sensors is ongoing at this time. While efforts to calibrate the SSM/I TBs using TMI as a reference standard have been done, we are currently working to investigate calibration offsets in SSM/I TBs prior to the launch of TMI in December of 1997 using in-situ ocean buoy wind data. While significant progress has been made, differences between wind speed based calibration efforts and the TMI reference calibration are currently being investigated.

PROJECT OBJECTIVE 3: Investigate the impact of changes in rainfall associated with the diurnal cycle over the tropics using TMI. Since TMI processes throughout the diurnal cycle, the 8+ years of available data can be used to determine the impact of diurnal variations on the different overpass times of the multiple sun-synchronous DMSP satellites within the tropics. Changes in the local observing times of the DMSP satellites due to orbit drift will also be addressed.

ACCOMPLISHMENT 3: The investigation of diurnal cycle impacts is ongoing.

PROJECT OBJECTIVE 4: Produce and distribute daily and monthly gridded SSM/I rainfall products for the period of record. We will distribute the data via both ftp and from our current website (http://rain.atmos.colostate.edu/RAINMAP) In addition, we will work with the community (i.e. GPCP, CPC, and other potential users) to develop a mechanism for long-term distribution of the data though NCDC and/or other data archive centers.

ACCOMPLISHMENT 4: As mentioned above, we have produced daily and monthly rainfall products from the SSM/I sensors for the period from December 1997 through 2009. While the current products are a beta test version which has yet to be finalized, they are publically available online (http://rain.atmos.colostate.edu/RAINMAP08). There are currently both daily and monthly gridded data files containing surface precipitation, total precipitable water, surface wind speed, SST from Reynolds, and cloud, rain, and ice water path estimates. The digital gridded data files are available for download from F11, F13, F14, and F15 along with prerendered images and the capability for users to create custom plots of any of the variables listed above.

PROJECT OBJECTIVE 5: Create a composite monthly climate rainfall product from the available SSM/I data. We will apply the results from our investigation of diurnal cycle impacts on the sun-synchronous sampling of the DMSP sensors to account for sampling-related climate biases.

ACCOMPLISHMENT 5: The creation of a composite monthly climate rainfall product will be done once the algorithm and calibration are finalized and the final products are computed.

PROJECT TITLE: Investigation of Smoke Aerosol-cloud Interactions Using Large Eddy Simulations

PRINCIPAL INVESTIGATORS: Hongli Jiang and Cliff Matsumoto

NOAA TECHNICAL CONTACT: Graham Feingold, ESRL/CSD

PROJECT OBJECTIVE: To understand climate variability and change in order to enhance society's ability to plan and respond to climate forcing.

PROJECT ACCOMPLISHMENT 1: Using large eddy simulation of clouds observed during the Rain in Cumulus over the Ocean (RICO) experiment, macro and microphysical controls on shallow cumulus convection are explored. Hundreds of individual clouds are tracked, and rain rates are expressed in terms of power-law functions of cloud liquid water path, drop concentration and cloud lifetime. Research has shown, as expected, that liquid water path has a stronger influence (by a factor of about 2) on the ability of a cloud to precipitate than does drop concentration. The inclusion of cloud lifetime into the expressions greatly improves the integrated rainfall estimates and results in robust estimates that should be suitable for use in large-scale models. Results are generalized by exploring relationships between the recently proposed concept of precipitation susceptibility (the sensitivity of rain rate to a microphysical perturbation) and precipitation efficiency (the ratio of rain volume to water condensed), with our results falling within the parameters of other studies (Jiang et al. 2009, 2010).

PROJECT ACCOMPLISHMENT 2: Dr. Jiang has collaborated with Wayne Angevine (NOAA, CSD) to evaluate the performance of a mass-flux based cloud parameterization developed by Angevine against the LES output. A comparison focused on microphysical and dynamical variables such as cloud fraction, cloud top/base height, updraft velocity, and moisture and temperature fluxes. The paper describing the comparison results has been accepted for publication in *Monthly Weather Review* (Angevine et al., 2010).

PROJECT TITLE: IPCC Studies for Climate Observations

PRINCIPAL INVESTIGATORS: Tom Vonder Haar and John Forsythe

NOAA TECHNICAL CONTACT: John Bates, NCDC Remote Sensing Applications Division

PROJECT OBJECTIVE 1: Examine the IPCC Fourth Assessment (AR4) in regard to short-term and long-term priorities for Climate Data Records (CDRs) targeted to reduce the wide range of climate scenarios provided by current climate models.

PROJECT OBJECTIVE 2: Examine the current state of climate-related observations reported in the AR4 together with related science and technical information to recommend priorities for key CDR and Scientific Data Stewardship (SDS) actions. The recent list of about 20 CDRs noted in the NOAA-NASA report to OSTP will be used.

PROJECT OBJECTIVE 3: Involve in our studies both well-known experts in the CDR area as well as a few young scientists who have chosen to enter the climate observation field with their new ideas.

ACCOMPLISHMENTS: While IPCC AR4 uses a variety of CDRs, the records themselves are produced independently and often without

regard to physical linkage. A physically consistent production approach to these records is suggested as a future NOAA contribution of value to the IPCC assessment process.

The CDR and Essential Climate Variable (ECV) maturity matrix concept developed by NCDC is useful. A portrayal of this in the next IPCC assessment would be welcome.

The Arctic is a region of utmost importance, but data quality and access to data are still problematic. Opportunities for Scientific data stewardship abound. NOAA is to be applauded for outreach and science efforts to increase awareness of Arctic climate.

Regional climate studies and data stewardship, particularly in areas of high gradients in precipitation which have a large societal impact, are valuable and could serve as a future focus area for NOAA. This aligns with regional climate modeling efforts.

There are untapped satellite datasets relevant to IPCC. While the IPCC AR4 discusses upper tropospheric humidity in a proxy manner using High Resolution Infrared Sounder (HIRS) data (AR4, Ch. 3, P. 274), the 183 GHz measurement archive (and accompanying channels near 90 and 150 GHz) dating back to 1993 could provide a more direct attack. NOAA should encourage stewardship and application of the underused, multisensory 183 GHz satellite record.

As a contribution to such a data set, Special Sensor Microwave / Temperature-2 (SSM/T-2) (a microwave moisture sounder) data from 1993-1995 were rescued from the archives at CIRA and were provided to NCDC.

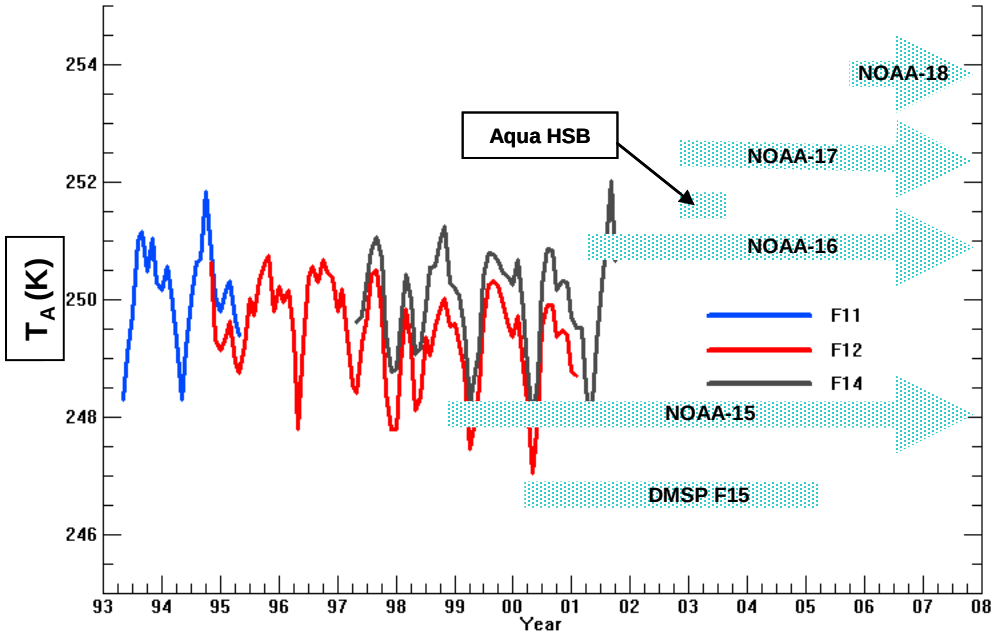


Figure 1: Time series of satellites with 183 GHz measurements. The monthly mean antenna temperature from 10º N to 10º S for the 183 ± 1 GHz channel on the SSM/T-2 instrument at near-nadir for the F11, F12 and F14 spacecraft is shown (blue, red, and gray lines). Periods of coverage for the SSM/T-2 on F15 and the AMSU-B sensors, as well as the short-lived but valuable HSB instrument on Aqua are also shown. CIRA rescued the F11 SSM/T-2 data (blue line) and delivered this data to NCDC for future stewardship.

PROJECT TITLE: POES-GOES Blended Hydrometeorological Products

PRINCIPAL INVESTIGATOR: Stan Kidder

NOAA TECHNICAL CONTACT: Limin Zhao, NESDIS/OSDPD

PROJECT OBJECTIVES: In the previous fiscal year, we developed a system to blend Total Precipitable Water retrievals from NOAA and DMSP microwave measurements in to a unified, global product. This system was transitioned to NOAA in March, 2009 (http://www.osdpd.noaa.gov/bTPW/).

This fiscal year we were to accomplish two objectives:

--Develop a blended rain rate system, following the design of the blended TPW system we developed last year.

--Develop the capability to use the new MIRS (Microwave Integrated Retrieval System, see http://mirs.nesdis.noaa.gov/) retrievals in either the blended TPW product or in the blended rain rate product.

ACCOMPLISHMENTS: Both objectives were achieved. A module for ingesting MIRS retrievals was written and tested in DPEAS (Data Processing and Error Analysis System), which forms the basis of the blending system. Modules were written to construct blended rain rate (see Fig. 1). The process runs hourly at CIRA (http://cat.cira.colostate.edu, click on Blended Rain Rate). The system was not installed at NESDIS/OSDPD due to a variety of problems, including the NESDIS approval process and a change of contractors in Washington. This transition will be accomplished in the next fiscal year.

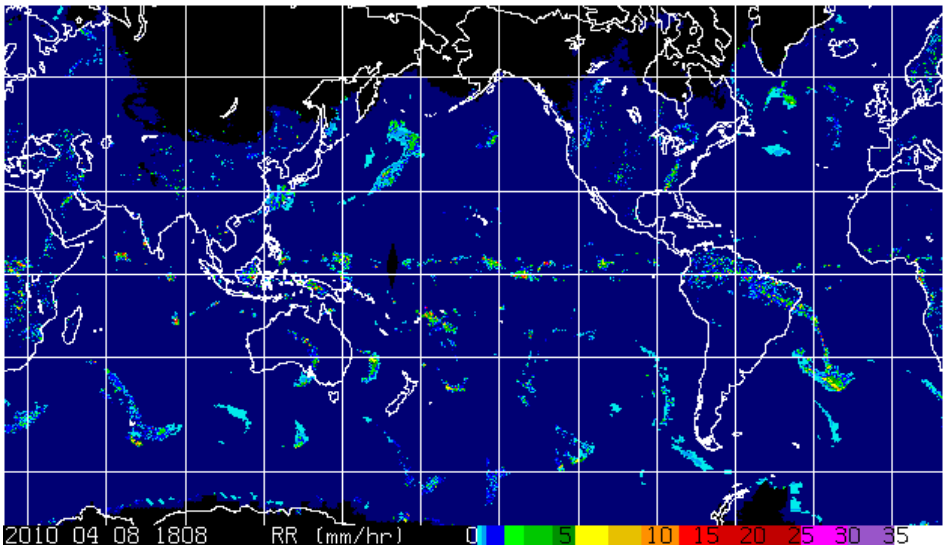


Figure 1: Blended Rain Rate constructed from AMSU-B observations from the NOAA 15, 16, and 17 satellites and from MHS observations from the NOAA 18, and 19 satellites and MetOp-A.

DATA DISTRIBUTION

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

PROJECT TITLE: Continuation of the CIRA Research Collaboration with the NWS Meteorological Development Lab

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

PRINCIPAL RESEARCHER: Scott O'Donnell

NOAA TECHNICAL CONTACT: Stephan Smith, NWS/MDL/DAB

PROJECT OBJECTIVE: Flash Flood Monitoring Program (FFMP). The Flash Flood Monitoring Program (FFMP) attempts to fill the gap between the RFC-provided Flash Flood Guidance products issued several times each day and the operational forecaster needs during high-intensity, short duration rainfall events, which are responsible for most of the flash floods occurring within the 0-3 hr time range.

ACCOMPLISHMENT: In the past year, the system for delivering internet available precipitation data to the USGS to support their debris flow forecasts from Southern California burned areas was expanded to provide data from the local NWS's precipitation database. Software was designed and implemented to retrieve once each hour the rainfall observations from every reporting gage during the past two hours, using one hour accumulation duration at each station. This software was installed and successfully tested at the LOX WFO to verify correct application setup and configuration.

PROJECT OBJECTIVE: AutoNowcaster (ANC). The general project objective is to migrate the improvements in situational awareness provided by NCAR's Autonowcaster to the NWS forecast workstation, AWIPS.

ACCOMPLISHMENT: This year, the project expanded its role to ingesting and generating the ANC data sets, while assuming the role of providing real-time data to each installation.

During the past year, the Autonowcaster team has acquired and installed the NCAR Autonowcaster software on two, independent, dedicated systems at MDL. This was done to gain experience with the Autonowcaster installation, ANC algorithms, and data management techniques required to generate the entire suite of products required to allow ANC convection forecasts. Migration of ANC data production and dissemination to the NWS was the primary goal. For several months, MDL has been producing the ANC product suite in preparation to begin serving the two prototype WFO installations. In February, 2010, MDL began serving Autonowcaster data to the Dallas-Fort Worth ANC installation using the MDL generated data.

The Autonowcaster team expanded the ANC installations by adding an Autonowcaster installation at the Melbourne, Florida NWS Weather Forecast Office (MLB WFO). This new installation will also be served using data generated at MDL. At that time, MDL will be providing ANC products in real-time to both offices, FWD and MLB, relieving NCAR of this operational responsibility.

This year, five new grids have been added to the suite of Autonowcaster grids already ingested every 5-6 minutes without impact to the ingest system. The new grids are a convection

forecast probability grid, two initiation likelihood grids and two verification grids.

One of the Initiation grids is generated by the Autonowcaster without the benefit of human interaction. This allows an assessment of 'improvement' added by the forecaster in the Initiation forecast. The other Initiation grid is an 'experimental' grid, which allows ingest and display of 'new' experimental products. This grid is intended to change periodically as new initiation algorithms are being tested. The Verification grids compare the current convective conditions with those forecasted earlier. The two Verification grids compare Convective Initiation Likelihood with and without forecaster input. These grids will help objectively evaluate the forecaster's ability to improve the Autonowcaster forecasts. The verification scale depicts hits, missed events, false alarms, and corrects 'no forecast convection' to quickly ascertain forecasting skill.

When adding these grids to the ingest system, the existing code was extensively refactored to improve performance, to simplify the process of adding new grids to the ANC data ingest data, and to allow installation of the software at an arbitrary location.
An example of an improvement is the software was generalized to store gridded data based on the lesser of either the size of the Autonowcaster domain or of the netcdf defined grid. This makes the code much more robust (less likely to crash) and allows the ingest application to be used at new locations without modification.

These improvements provide a 'standard' ANC data ingest processing system. This has resulted in a generalized installation which can now be applied to any location with relatively few modifications, generally limited to configuration files.

EAR – Research Collaborations with ESRL/GSD Assimilation and Modeling Branch

PROJECT TITLE: Rapid Refresh (RR) and High-Resolution Rapid Refresh (HRRR) Model Project

PRINCIPAL RESEARCHER: Brian Jamison

NOAA TECHNICAL CONTACT: Steve Weygandt, ESRL/GSD/AMB

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

ACCOMPLISHMENTS: Many improvements were made to the initial web pages, including adding zoomed subdomains: five for the RR (including Alaska), and six for the HRRR. These subdomains not only allow for more detail in the contoured variables, but also in the mapping, providing county level detail in the subdomains for the HRRR. A number of new products were also added, including: 1 km agl reflectivity, max reflectivity, most unstable CAPE, mixed CAPE, LCL, 0-1 km shear, 0-6 km shear, max updraft helicity, max 10m wind, mean vertical velocity, max updraft, max downdraft, 0-1 km storm relative helicity, 0-3 km storm relative helicity, and best lifted index. These images proved very useful during the convective active weather period, and several of them were collected by the Vortex2 project for their field catalog.

New plotting scripts and new web pages for three more versions of the RR were also developed: one with chemistry, a parallel version, and a cold-start version. Difference plots for each of those with the primary version are also available.

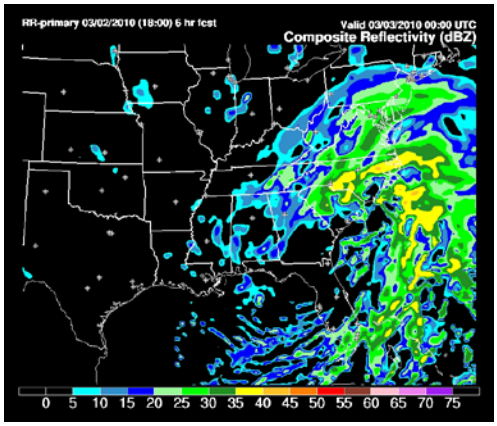


Figure 1: A 6-hour Forecast of Composite Reflectivity from the Southeast Quadrant of the Primary RR.

EAR – Research Collaborations with ESRL/GSD Assimilation and Modeling Branch

PROJECT TITLE: Tropospheric Airborne Meteorological Data Reporting (TAMDAR) Project

PRINCIPAL RESEARCHER: Brian Jamison

NOAA TECHNICAL CONTACT: Bill Moninger, ESRL/GSD/AMB

PROJECT OBJECTIVES: Tasks primarily involve examining the data for quality, and investigating the impact of the data on weather model forecasts. For these tasks, retrospective runs of the Rapid Update Cycle (RUC) 20 km model were performed.

ACCOMPISHMENTS: Retrospective runs of the RUC for the period of August 15-25, 2007 were necessary in order to determine the effect of adjustments to the model and/or the input data. This time period was selected primarily due to its substantial convective activity. When the model code was moved to a different computer, some repeated runs were necessary to compare with previous runs and verify continuity. Runs for this period include:

--a baseline run using all data with no alterations in parameters, for which successive runs will be compared to determine impacts
--a run with all aircraft data removed.
--a run with all aircraft data removed except TAMDAR data.
--a run without using the cloud analysis.
--a run without using pseudo observations in the boundary layer.

To fulfill a final requirement from the project, a run with no other aircraft data except TAMDAR data needed to be performed for the earlier winter retro period in 2006. The 2006 data were restored and output was with the previous output to prepare for this run. Runs for this period include:

--a run with all data, to be compared with the previous run and verify continuity.
--a run with TAMDAR data removed.
--a run with all aircraft data removed.
--a run with all aircraft data removed except TAMDAR data.

Analyzing the retrospective run results greatly increased our knowledge of the relative value of each of the contributing data sets, and gave a good perspective of the relative impact of the TAMDAR data. Feedback to AirDat (the designers of the TAMDAR sensors) has proven very worthwhile.

EAR – Research Collaborations with ESRL/GSD Aviation Branch

PROJECT TITLE: Aviation Forecast Verification

PRINCIPAL RESEARCHER: Sean Madine
OTHER CIRA TEAM MEMBERS: Melissa Petty, Daniel Schaffer

NOAA TECHNICAL CONTACT: Jennifer Mahoney, ESRL/GSD/AB/FVS

PROJECT OBJECTIVES: Evaluation of FAA-Developed National Ceiling and Visibility Analysis (NCVA).

--Engineering Research for the Network-Enabled Verification Service (NEVS).
--Evaluation of FAA-Developed Consolidated Storm Prediction for Aviation (CoSPA).

ACCOMPLISHMENTS: Evaluation of FAA-Developed National Ceiling and Visibility Analysis (NCVA)
CIRA researchers significantly contributed to a formal quality assessment of the National Ceiling and Visibility Analysis product (NCVA), a gridded analysis that evaluates reported ceiling and visibility information for the purpose of improving the flight planning process. On behalf of the Federal Aviation Administration's Aviation Weather Research Program and in support of an Aviation Weather Technology Transfer (AWTT) D4 (operational) decision point, this study was carried out to examine the following:

Overall, the study found that the NCVA could add significant value to the planning process compared with the baseline analysis (NN-A) by more effectively detecting IFR events and reducing risk throughout the airspace (NCVA Probability of Detection of 0.71 vs. 0.60 for the NN-A), and by more effectively reducing false alarms of IFR events, resulting in more efficient use of the airspace (NCVA False Alarm Ratio of 0.25 vs. 0.39 for the NN-A), with a lower False Alarm Ratio being more favorable.

Engineering Research for the Network-Enabled Verification Service (NEVS)
The NextGen 4-D Weather Single Authoritative Source (SAS) will require an ongoing evaluation of weather data quality, with emphasis on the air traffic planning processes and the impact weather has on safety and efficiency. The Network Enabled Verification Service (NEVS), currently under development with collaborative input from CIRA researchers, will fulfill this SAS requirement, incorporating innovative user-specific verification concepts with an operationally robust engineering solution.

The complex data analysis provided by NEVS has forced a break from the traditional stovepipe architectures found in most legacy verification systems. The NEVS architecture, adopting an approach compatible with the NextGen Network Enabled Weather (NNEW) Service Oriented Architecture (SOA), defines three distinct layers: production, integration, and analysis. The integration layer, built on a relational data model, enables dynamic data mapping driven by the user problem domain and sophisticated data joining. This unique aspect of NEVS allows data analysis across traditional weather and ATM boundaries.

Efforts this year culminated with a prototype of NEVS, geared primarily to verification of convective products for the strategic planning process in the national airspace. The figure below illustrates the type of output available from NEVS.

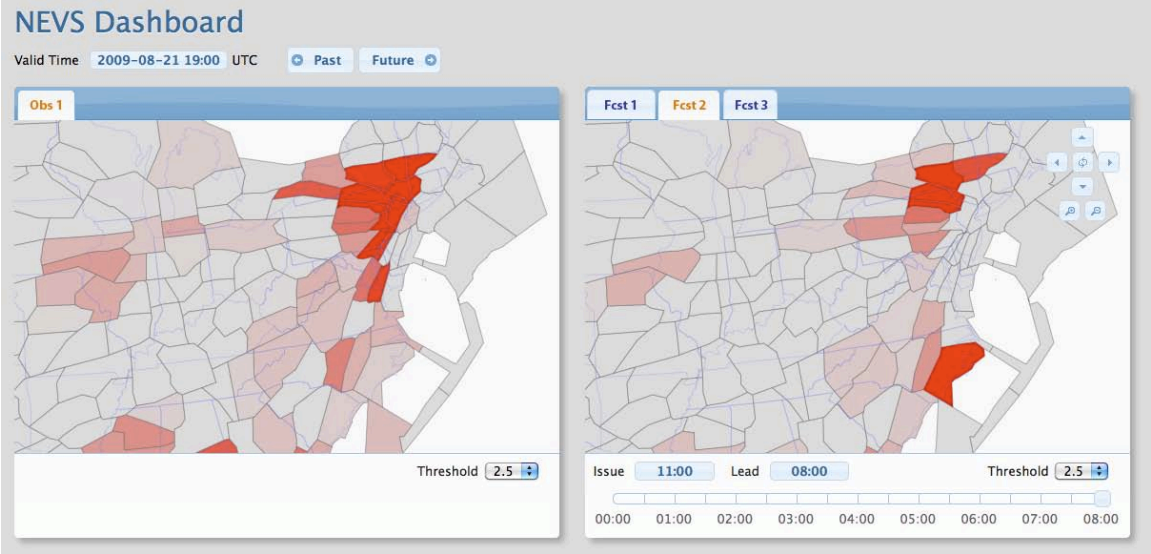


Figure 1: Depiction of high-altitude sector capacity as measured by an algorithm being considered for future air traffic management. The forecast, with an 8-hour lead time, is shown on the right, with the observed field on the left. In addition to the images, NEVS provides aggregate statistics of performance using this measure.

Evaluation of FAA-Developed Consolidated Storm Prediction for Aviation (CoSPA).
As input to upper level FAA management regarding a convection forecast for NextGen, CIRA researchers performed a study of the Consolidated Storm Prediction for Aviation (CoSPA) during the 2009 convective season. The analysis, designed to measure the performance of CoSPA in the context of strategic planning in the national airspace, provided decision-makers with overall benchmarks and diagnostic information to determine how the CoSPA research should proceed and transition to operations.

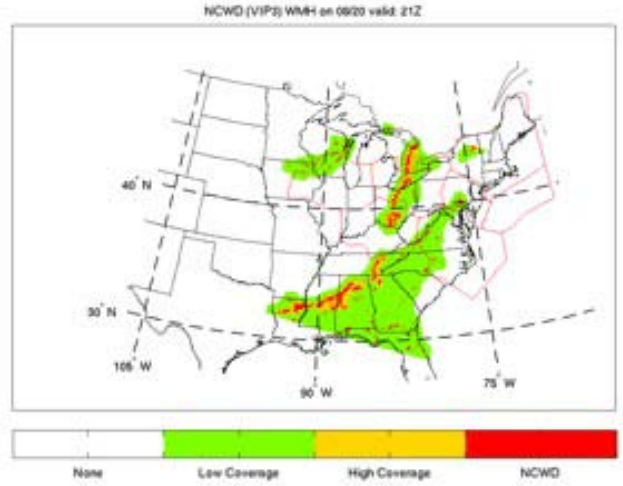


Figure 2: Depiction of observed convective hazard for 21Z on 20 August 2009. The red areas show intensity of VIP 3 or higher. The green and yellow colors designate areas of low and high coverage clustering, respectively.

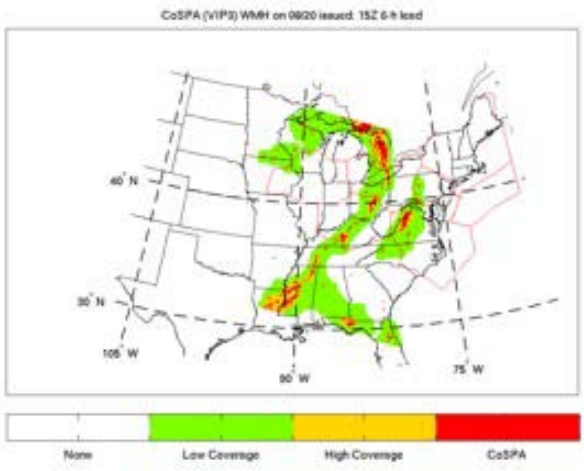


Figure 3: Same as Figure 2, but for the CoSPA forecast issued at 15Z, valid at 21Z.

EAR – Reserch Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: AWIPS II – Data Delivery Project

PRINCIPAL RESEARCHERS: Joanne Edwards and James Fluke

NOAA TECHNICAL CONTACT: Woody Roberts, ESRL/GSD/ISB

PROJECT OBJECTIVES: With AWIPS II rapidly approaching deployment, the National Weather Service has identified the necessity to extend AWIPS II capabilities in order to handle the demand for more and larger datasets. With the current distribution network at near capacity, a Data Delivery mechanism is envisioned by the NWS to include the following capabilities:

--Data registry services that will provide a means to publish data sources and metadata information and allow for the introduction of new data services.

--Data discovery services that will provide for a system that can discover datasets and necessary associated metadata.

--Smart push/pull technologies that will provide the means to subset the data by user selectable field value, time, space, parameters, etc. Such dataset filtering would be done on an ad-hoc user-request basis or in a pre-defined way.

The system must be robust addressing the following challenges:

--It must satisfy fault tolerance requirements including recovery from software, hardware and network failures.

--It must satisfy quality-of-service (QOS) requirements including data access reliability and latency.

--It must include monitoring services to support fault detection and diagnosis.

--It must support security provisions, such as user access and authentication.

The emphasis must shift away from a broadcast system where all the data are pushed to the field

offices toward the concept where the data providers and data consumers exchange only necessary information.

The primary goal of GSD is to develop a prototype data delivery system for eventual use in AWIPS II. The idea is to develop a system that will enable access to data irrespective of its location. In other words, to enable access to data that does not reside locally.

ACCOMPLISHMENTS: CIRA, in conjunction with the Information Systems Branch (ISB) of the Global Systems Division (GSD) evaluated different technologies that would provide data and services via the world-wide web to its clients. Three technologies evaluated for providing access to gridded data were the NOAA Meteorological Access and Distribution System (NOMADS), Web Coverage Services (WCS) and the Joint Metoc Broker Language (JMBL). These technologies were evaluated and comparisons made based on a list of system requirements. The results were reported in a Technology Evaluation report and presented to the NWS.

The three prototype systems enabled ad-hoc requests to be made to the NOMADS server, the AFWA JMBL server, and the NCAR WCS server, motherlode. The prototype systems used web HTTP requests to make the requests and to bring in the resultant datasets. The WCS request yielded a display product on the AWIPS II Common AWIPS Visualization Environment (CAVE) Graphical User Interface (GUI). The other requests primarily focused on request and product storage, as the products were not in a format that is currently handled by AWIPS II. Subsequent prototype systems will be developed to handle new data formats. Continued prototype work in the first quarter of 2010 includes accessing the NextGen Registry/Repository for discovering new datasets and services. The web technology of choice will be WCS.

Research was also conducted to obtain information on how clients would utilize such a system. CIRA staff, in conjunction with ISB led a team to generate Data Delivery user scenarios and use cases for eventual generation of OSIP requirements. Valuable information was obtained not only from forecasters at the BOU forecast office but also from other meteorologists within GSD. A User Scenario and Use Case document was generated and handed over to the NWS. This document is a work-in-progress.

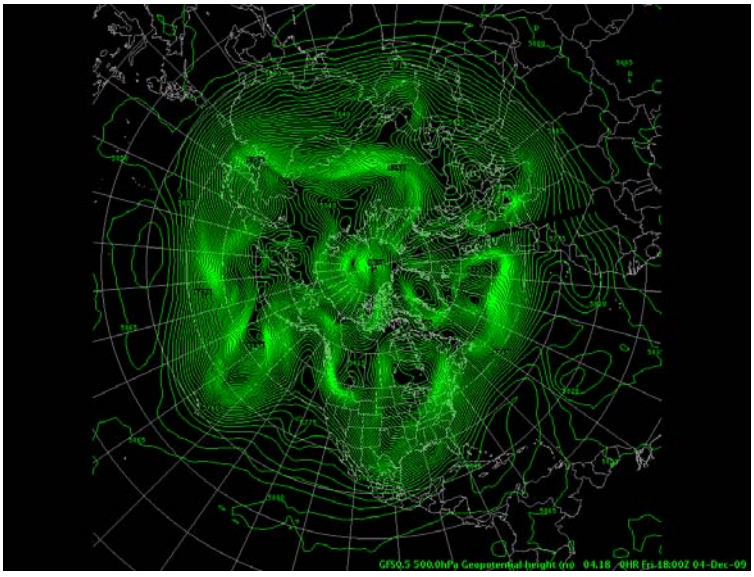


Figure 1: A screen-shot of the display of one of the global datasets requested from the NOMADS server and displayed on CAVE. CIRA developers did not generate the image, but provided the data ingest that fed data to CAVE.

EAR – Research Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: AWIPS II – Independent Validation and Verification (IV&V) and System Development

PRINCIPAL RESEARCHERS: Joanne Edwards, Leigh Cheatwood-Harris and Jim Fluke

NOAA TECHNICAL CONTACT: Woody Roberts, ESRL/GSD/ISB

PROJECT OBJECTIVE 1: The objective of the Independent Validation and Verification is for the government to perform evaluations of the phases of AWIPS II independently of Raytheon, which is developing the system. The IV&V consists of running and/or developing test cases in order to verify that certain functionality exists, and generating trouble tickets if a problem exists.

PROJECT OBJECTIVE 2: The objective of the system development was to develop hands-on knowledge of AWIPS II.

ACCOMPLISHMENTS: As part of the continuing AWIPS II Independent Validation and Verification, CIRA staff in conjunction with ISB conducted and participated in the testing and evaluation of AWIPS II task order 11 (TO11). With each new version or slice of TO11, CIRA staff installed the new version of AWIPS II. Once installation was complete, CIRA staff participated in the evaluation and validation. The work was later handed off to GSD federal employees to continue with the testing and evaluation.

In continuation of the AWIPS II training conducted in previous years, and because of the new task orders, CIRA staff in conjunction with ISB completed the MADIS data ingest and display on AWIPS II. The plug-in to ingest a MADIS surface observation and deposit it into the PostGres database was completed. Also completed was the display plug-in to read the data from PostGres and display it on CAVE. This was a major accomplishment for CIRA since it gave CIRA developers more of an in-depth knowledge of the workings of AWIPS II.

EAR – Research Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: Exploratory Workstation Development

PRINCIPAL RESEARCHERS: U. Herb Grote and Jim Ramer

NOAA TECHNICAL CONTACT: Woody Roberts, ESRL/GSD/ISB

PROJECT OBJECTIVES: The long-term objective is to develop forecast workstations with advanced interactive display capabilities that include inter-office collaboration to improve operational forecast products. The ability to collaborate is of special importance in certain applications. For example, to prepare a consistent forecast, such as prediction of a large severe weather event or dispersion of a toxic chemical, all participants must share a common situational awareness. All participants must have access to the identical data sets and be able to display the data in the same manner. This facilitates the exchange of ideas and allows forecasters and users to get a similar understanding of the weather event. To support this, the display system must be able to display a diverse set of real-time meteorological data, allow users to graphically annotate the display, and include a text chat capability. The system also needs to be able to run dispersion models to help predict movement of volcanic ash, smoke, or toxic chemicals, and must have an alert capability that can interface with available dissemination technologies.

ACCOMPLISHMENTS: AWIPS II Extended – Collaboration. The collaboration activity for the AWIPS II program consisted of two elements. The first element of this task was to define user requirements for collaboration and to identify technical issues with implementing these requirements in AWIPS II. Several NWS offices were visited and asked to provide operational scenarios that employed collaboration. The scenarios were analyzed and a limited number of system use cases were generated from these scenarios. The scenarios and use cases, along with a system evaluation, were then described in a document that provides the basis for the collaboration requirements. The system evaluation found that a significant number of additional features needed to be implemented in AWIPS II to support the collaboration capabilities required by the use cases. Also, no commercial software was found to exist that supports the full NWS data conferencing requirements. The second task element was to evaluate one of the untried use cases in the document using a simple prototype: Two forecast offices created an estimate of the QPF (Quantitative Precipitation Forecast) for their respective area with little coordination and posted it to a common server. The resulting QPF values are shown by the combined grids in Figure 1 (left image). Next, they used a collaboration tool to coordinate the QPF for the combined area, and using the collaborated graphic of the QPF as a template re-adjusted their individual QPFs. The joined QPF grids before and after are shown in Figure 1. The result shows the potential for improving grid continuity across forecast area boundaries through graphic collaboration. Additional work is required to perform a more thorough evaluation and to determine how to integrate this capability effectively into the daily operations. The task included development of the prototype.

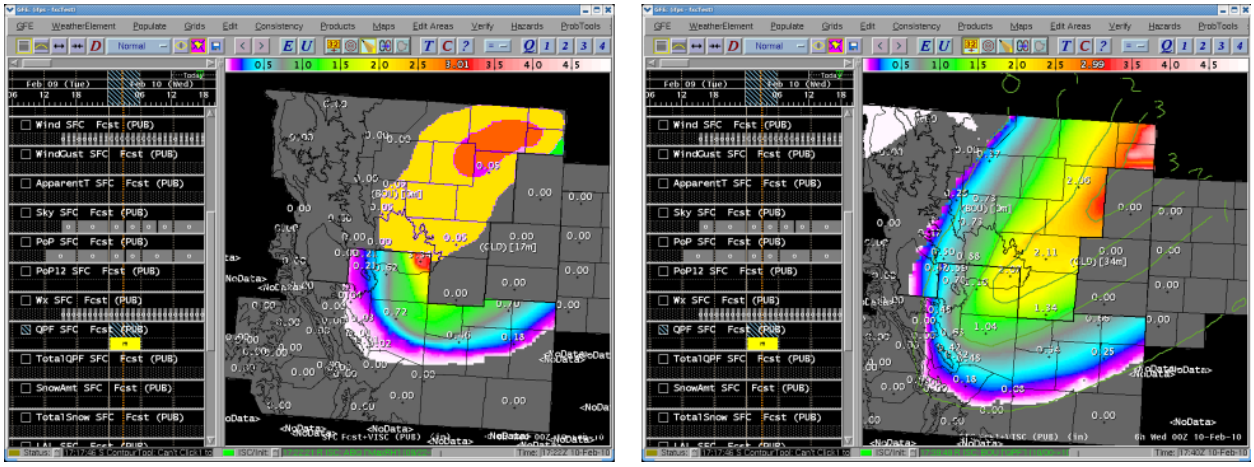


Figure 1: Adjacent QPF grids before and after collaboration.

Geo-Targeted Alerting System (GTAS). The GTAS project is designed to develop an advanced warning system that can rapidly and precisely warn and provide safety information and instructions to the public in case of a life-threatening toxic release. GTAS systems were installed at the NWS Southern Region Headquarter in Fort Worth, Texas, the adjacent weather forecast office and the Emergency Operations Center. All users were trained on the system. Since then, changes have been made to the GTAS system to improve the flexibility and speed with which GIS shapefiles are displayed. Also, to allow collaborators to refer to information that is not directly available from the GTAS menu, the system now has the ability to "cut-and-paste" information from other windows into the GTAS display. A major development effort was the use of the public internet port to connect a client to a GTAS server. Prior to this, special communications ports needed to be opened and configured to reach the GTAS server. An initial version of the new software is being tested and is expected to be ready for operational testing by the middle of 2010.

EAR – Research Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: MADIS – Meteorological Assimilation Data Ingest System

PRINCIPAL RESEARCHERS: Joanne Edwards, Leigh Cheatwood-Harris and Tom Kent

NOAA TECHNICAL CONTACT: Patty Miller, ESRL/GSD/ISB

PROJECT OBJECTIVE 1: To continue the transition of MADIS to NWS operations at NWS operational facilities that have the necessary infrastructure to operate and maintain the system during 24-hour by 7-day operations; also to maintain continuity of data streams and services before, during and after the transition; and to pre-plan for product improvements and technology infusion.

PROJECT OBJECTIVE 2: To complete the evaluation of the JMBL web technology for providing surface observations to MADIS users.

PROJECT OBJECTIVE 3: To evaluate technologies for adding MADIS observations to the Data Delivery system, as MADIS is slated to be one of the NextGen data providers to the Weather Information Database (WIDB).

ACCOMPLISHMENTS: MADIS Transition. As part of the MADIS transition, CIRA developers in conjunction with ISB completed the very important task of transitioning MADIS to NWS operations. Two major areas of the MADIS transition were accomplished during this reporting period:

LDAD C++ Software Port to AIX. This involved taking the LDAD software that decodes incoming mesonet data by using multiple scripts to pre-process the data and get it into a standard CSV format which is then processed and stored into NetCDF. The big challenge of this was to build the software as 32-bit code running on a 64 bit AIX NCEP machine. Other challenges arose in syncing up COTS software libraries such as (NetCDF, UdUnits, xsltproc, and perl modules) that were compatible with our 32 bit software on the 64 bit machine. This is a very important port without which none of the mesonet data ingest would be possible.

Climate Networks. New England Pilot Project stations (NEPP), Historical Climate Network Modernization (HCN), and Climate Reference Network (CRN) surface providers were also transitioned. These sensors offer real-time temp and precipitation values every 5 minutes, are sent in XML and decoded and stored into NetCDF files. CIRA developers, in conjunction with ISB completed the NEPP/HCN/CRN product decoding and storage before handing the software over for transition to NWS operations.

JMBL. The evaluation of JMBL as a technology to provide surface observations to MADIS users was completed. The JMBL server was enhanced to provide data in CF-compliant NetCDF format if the response file was greater than 3 million bytes. This was done in accordance with JMBL documentation. The user is presented with an XML response file containing the location of the NetCDF file, thus enabling the user to get on to the web site and download the file. For AWIPS users, the NetCDF file was modified to include AWIPS I inventory information. CIRA developers also provided documentation evaluating JMBL as a viable technology, and outlining the variances between JMBL and MADIS.

MADIS and Data Delivery. The evaluation of MADIS as a viable Data Provider of surface observations was added to the Data Delivery Statement of Work (SOW). CIRA staff in conjunction with ISB developed MADIS User Scenarios for inclusion in the Data Delivery User Scenario and Use Case document. The MADIS user scenarios and use cases focus on the use of MADIS datasets to enhance forecaster situational awareness, for gridded verification and for discovering new networks. The user scenarios will be used to prototype requesting, accessing, processing and displaying MADIS datasets on AWIPS II.

EAR – Research Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL RESEARCHER: Randall Collander

NOAA TECHNICAL CONTACT: Patty Miller, ESRL/GSD/ISB

PROJECT OBJECTIVE: Transition MADIS processing from ESRL/GSD to National Weather Service operations.

PROJECT ACCOMPLISHMENTS: During this period, a number of data subsets were exported from GSD and preliminary testing conducted on the NCEP supercomputer. These data types included rawinsonde, snowfall, satellite-derived winds, and radiometer. In each case, software was adapted for computer architecture differences (compiled executables and file structure), and then tested from raw input to processed output using saved test cases in order to demonstrate proper function of all software executables and scripts. Accomplishing this transition also required learning a new data format (BUFR) and creation of software to translate from this raw format into the standard format expected by the bulk of the MADIS processing software, allowing for efficient transition by reducing the number of scripts and other code that needed to be modified.

Software to add data from additional sources (surface mesonets) was also developed and will be integrated into the transitioned software set.

EAR –Research Collaborations With the ESRL/GSD Information Systems Branch

PROJECT TITLE: Weather In-situ Deployment Optimization Method (WISDOM)

PRINCIPAL RESEARCHER: Randall Collander

NOAA TECHNICAL CONTACT: Patty Miller/OAR/ESRL/GSD

PROJECT OBJECTIVE: Improve the 3- to 7-day predictions of Atlantic hurricane track and intensity by deploying specialized balloons into important data sparse regions of the atmosphere. The long term goal is to saturate data void regions for every major storm with several hundred balloons to measurably improve the 3- to 7-day hurricane forecast. Observations from these data void areas will significantly improve the 24 hour forecast, saving lives and property, conserve energy, and potentially save millions of dollars.

PROJECT ACCOMPLISHMENTS: Prior to the 2009 hurricane season, a robust system of 3 computers was assembled and tasked with ingesting numerical model output grids from 3 independent models: the Global Forecast System (GFS) at both 1-degree and 0.5-degree resolution and the Finite-volume Icosahedral Model (FIM). The two WISDOM-dedicated machines and a third backup processor were programmed enabling each machine to perform processing for one of the models with the ability to process either of the other two models. This resulted in efficient completion of trajectory predictions in a timely manner that met the needs of project forecasters in decisions regarding deployment of field teams. This setup also provided redundancy necessary for uninterrupted processing in the event of failure by any one of the systems.

Trajectory prediction software originally written to utilize gridded wind data from the 1-degree resolution Global Forecast System (GFS) model was modified to use gridded wind data from the 0.5-degree resolution GFS and the 0.5-degree

resolution Finite-volume Icosahedral Model (FIM). Use of these finer spatial resolution models in trajectory prediction is estimated to produce more accurate predictions of balloon motion after launch and aided in launch decision making.

Successful field team deployments and balloon launches occurred in September, October and early November and observations from these balloons was ingested into numerical models at GSD and the effect seen in comparison runs of the model that did and did not include the WISDOM wind observations.

EAR – Research Collaborations with ESRL/GSD Information and Technology Services

PROJECT TITLE: Aviation Initiative Demonstration (FXC AI)

PRINCIPAL RESEARCHER: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus, NOAA/ESRL/GSD/AB

PROJECT OBJECTIVES: Consistent with the FAA's Air Traffic Organization's (ATO) philosophy to review, upgrade, and create efficiencies in various functions, in January 2006, the National Weather Service (NWS) Corporate Board agreed to prototype the FXC AI system to demonstrate a more effective and efficient forecast process to support Air Route Traffic Control Center (ARTCC) operations.

ACCOMPLISHMENTS: A core server and client systems are still in use and were supported throughout the year. The AI system continues to be used at the Leesburg, Virginia Center Weather Service Unit (CWSU) for its daily weather briefings to the Traffic Managers.

The focus this year has been to secure funding for continued maintenance and support. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. Currently, the plan is to maintain these systems until the capability and requirements that were implemented are available and replaced by AWIPS II extended clients. As of Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) is being drafted in order to specify the funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSU's occurs.

This is really good news and is an example of the AI project research being transferred to operations. The remaining work on these projects is the planning, documentation, implementation, and final transition of the maintenance and support of these systems to the GSD's Systems Support Group.

EAR – Research Collaborations with ESRL/GSD Information and Technology Services

PROJECT TITLE: Federal Aviation Administration (FAA) Prototyping and Aviation Collaboration (PACE) Effort – Traffic Management Unit (TMU) Project

PRINCIPAL RESEARCHER: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus, NOAA/ESRL/GSD/AB

PROJECT OBJECTIVES: The TMU project, staged at this facility, is researching the weather information needs and developing innovative software technology used to directly provide weather support for the ARTCC Traffic Management Unit (TMU). A major objective is to investigate aviation data sets and forecast products specifically tailored for the ARTCC air traffic weather forecasting environment among operational weather forecasting facilities and to investigate the utilization of collaborative weather forecasting.

ACCOMPLISHMENTS: The focus this year has been to secure funding for continued maintenance and support of this project. It is important to mention that these systems are still in full use at the Fort Worth Center Weather Service Unit (CWSU) for the daily weather briefings to the Traffic Managers. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. Currently, the plan is to maintain these systems until the capability and requirements that were implemented for the projects are available and replaced by AWIPS II extended clients. As of Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) is being drafted in order to specify the funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSU's occurs.

This is good news and is an example of the TMU project research being transferred to operations. The remaining work on these projects is the planning, documentation, implementation, and final transition of the maintenance and support of these systems to the GSD's Systems Support Group.

There were no specific deliverables made this year and effort was concentrated on the software/systems, support and maintenance, and funding agreements. Work was started on proposed TMU Fort Worth Enhancements, which was to include the addition of CIWS Data, additional Radar Sites and the development of a Traffic Managers BriefEE Client. The Fort Worth enhancements were ultimately postponed due to the departure of the Federal Manager, my Family Medical Leave, and then usurped by NNEW NEWT priorities. At this point, I'm not certain if these enhancements will still be included or developed in to the baseline project software. This is a management decision.

The two images below show current impact with no Forecaster Edits. ZFW TRACON departure gates are displaying green (no impact) and yellow (partial impact).

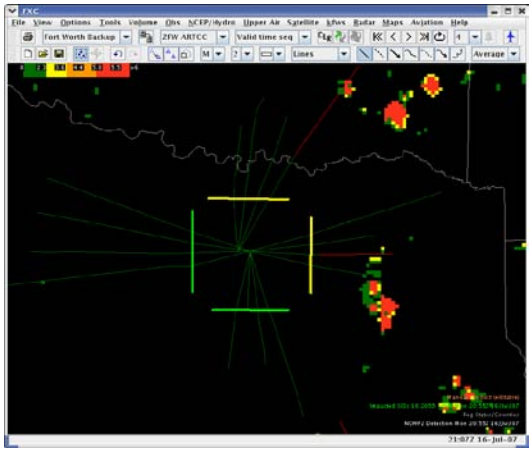


Figure 1: Forecaster FXC tool showing current ZFW TRACO.

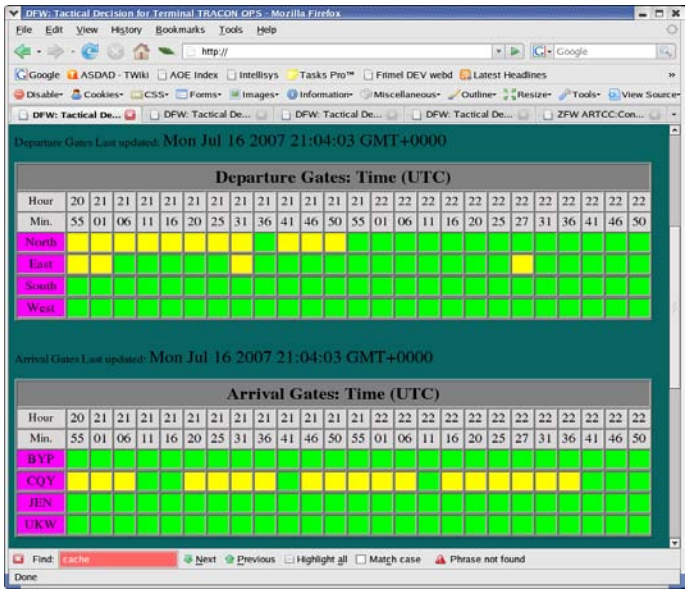


Figure 2: Traffic Manager (WIDA) Web Display showing concurrent Red-light/Green-light Departure Gate Impact information.

EAR – Research Collaborations with ESRL/GSD Information and Technology Services

PROJECT TITLE: FXC NextGen Network Enabled Weather (NNEW) Demonstration

PRINCIPAL RESEARCHER: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus, NOAA/ESRL/GSD/AB

PROJECT OBJECTIVES: --A nationally consistent weather picture for all data (obs, analysis, and forecast).

--A Single Authoritative Source and a virtual repository of data (no single physical database, computer or location).
--A conceptually unified data source distribution among multiple physical locations and providers.
--Integration of weather information into the operational decision making processes.

ACCOMPLISHMENTS: During this research period, the ASDAD intent was to develop and refine the NextGen Evaluation Weather Tool (NEWT) proposal and to begin implementation. The basic proposal of NEWT was to utilize FXC/AWIPS to provide a visual and statistical means to compare the NNEW NextGen 4D weather cube data delivery services with an NWS Operational System for Performance and Latency Monitoring. The concept was never directly funded by the FAA, and was considered outside the scope of NNEW requirements (NNEW scope is more focused on data delivery NOT client side testing and displays). The requirement and necessity of such utility is still under debate and may come to fruition as the realization of such needs become apparent as NNEW Services are implemented. With that said, NEWT was shelved. Also, a primary concern with NEWT was its startup tie and overhead to the legacy AWIPS system.

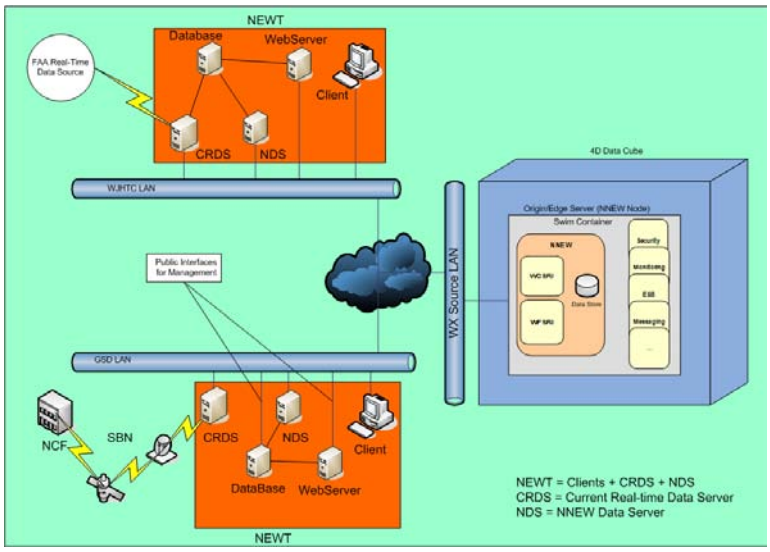


Figure 1: The notional architecture of NEWT.

EAR – Research Collaborations with ESRL/GSD Information & Technology Services

PROJECT TITLE: Meteorological Data Acquisition Systems

PRINCIPAL RESEARCHERS: Chris MacDermaid and Robert Lipschutz

OTHER TEAM MEMBERS: Leslie Ewy, Paul Hamer, Patrick Hildreth, Glen Pankow, Richard Ryan, MarySue Schultz, Amenda Stanley, Jennifer Valdez

NOAA TECHNICAL CONTACT: Pam Weber, ESRL/GSD/ITS

PROJECT OBJECTIVE: Implement a scalable Data Cluster for GSD.

ACCOMPLISHMENTS: Within the NOAA Earth System Research Laboratory (ESRL), the Global Systems Division (GSD) develops weather information systems, weather forecast models, and other applications in support of the National Weather Service, the Federal Aviation Administration, and other agencies. Well-known GSD products include the Rapid Update Cycle (RUC) model, the Local Analysis and Prediction System (LAPS), the Meteorological Assimilation Data Ingest System (MADIS), and Science on a Sphere® (SOS). A common feature of these and other GSD projects is that they require observational and model data provided by acquisition systems running within GSD's Central Facility (CF). The CF systems, created by CIRA developers in the Data Systems Group (DSG) of the Information and Technology Services (ITS) branch handle some 800 GBytes of incoming data per day as they acquire, decode, store, and distribute the needed data sets for GSD scientists and their collaborators.

To substantially improve GSD's Central Facility data systems, the DSG CIRA team embarked on a development project to design, assemble and configure a new six-host clustered data system. This new system, dubbed the DSG Cluster (DC) replaced a collection of aging Linux High-Availability (HA) pairs and stand-alone platforms. The DC is a scalable Linux cluster that now offers high throughput performance as well as excellent reliability, resource utilization and configurability.

To achieve these goals, we implemented the DC with these key software components, depicted in Figure 1:

--the **CentOS** Enterprise Linux operating system,
--the **Red Hat Cluster Suite** for managing cluster-wide application services and failovers,
--Sun Grid Engine (SGE) for job activation and load balancing,
--fcron for cluster-wide time-based job triggering,
--Unidata's Local Data Manager (LDM) for data transport and event-based job triggering, and
--Open-E storage software for controlling the NFS-mounted back-end Data Storage Server (DSS) RAID disk system.

Within the framework provided by these software elements, the Object Data System (ODS) applications developed by CIRA's Paul Hamer are responsible for such data processing tasks as converting GOES GVAR satellite data, Gridded Binary (GRIB) model data, WSR-88D Level-II radar data, and a variety of point observation data types into the netCDF formats needed by GSD user applications. Minimal changes to the existing ODS software were needed to accommodate the cluster architecture. In addition, two new scripts were developed to provide common methods for submitting jobs to the SGE job queue from LDM (pqact) and fcron, while several old scripts were extended to include a cluster-wide locking mechanism to avoid concurrent instances of some jobs.

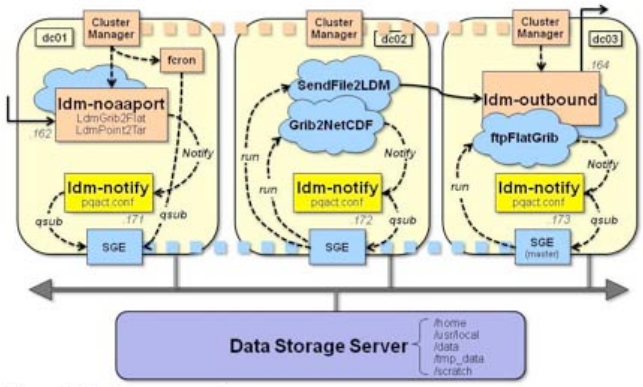


Figure 1. Cluster components.

Figure 1: Cluster Components.

EAR – Research Collaborations with ESRL/GSD Information & Technology Services

PROJECT TITLE: NextGen Network-Enabled Weather (NNEW) Program

PRINCIPAL RESEARCHER: Chris MacDermaid

OTHER CIRA TEAM MEMBERS: MarySue Schultz, Michael Leon

NOAA TECHNICAL CONTACT: Lynn Sherretz, ESRL/GSD/AB

PROJECT OBJECTIVE: Participate in the FY09 NNEW Demonstration at the Federal Aviation Administration's (FAA) William J. Huges Technical Center (WJHTC).

ACCOMPLISHMENTS: The NNEW Program is tasked with creating an infrastructure that will allow users of the United States' national airspace system — from air traffic controllers to National Weather Service (NWS) employees — to access a single, nationwide picture of the weather. This infrastructure, the 4-D Wx Data Cube, will disseminate up-to-the-minute weather information synthesized from tens of thousands of data sources, providing its users with a single, authoritative source of weather observation and forecasting data.

On September 16, 2009, we participated in the joint FAA and NWS demonstration at the WHJTC. From the Global Systems Division's Central Facility, we served the Rapid Refresh version of the Weather Research and Forecast (WRF-RR) model using an OGC (Open Geospatial Consortium) WFS (Web Coverage Service) and served MDCRS (Meteorological Data Collection and Reporting System) aviation weather report data using an OGC WFS (Web Feature Service). The demonstration was successful. These following comments are from the Joint Planning and Development Office press release.[1]

"Tom Ryan, FAA's NextGen Network-Enabled Weather Program Manager, was impressed with the teamwork between the agencies. 'While the FAA led this demonstration effort, we could not have accomplished all of this without a successful partnership with our NWS team members.'"

"Jason Tuell, Meteorological Services Division Chief for NWS, was very satisfied with the results of the demonstration. According to Tuell, 'This marks a critical milestone in the NWS-FAA integrated plan on building the NextGen Four-Dimensional (4-D) Weather Data Cube. We've demonstrated the principles of interagency data sharing, which is one of the core requirements of the Cube.'"

[1] NextGen Joint Planning and Development Office. Retrieved February 26, 2010 from http://www.jpdo.gov/newsArticle.asp?id=124

EAR – Research Collaborations with ESRL/GSD Information and Technology Services

PROJECT TITLE: Volcanic Ash Coordination Tool Project (FXC VACT)

PRINCIPAL RESEARCHER: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus, NOAA/ESRL/GSD/AB

PROJECT OBJECTIVES: 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, 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.

ACCOMPLISHMENTS: At the end of June 2007, the FXC VACT Project team was notified of a budget and funding shortfall. As a result, priorities shifted to mothballing the FXC VACT Project to a functional/stable release and all systems were migrated to a minimum environment topology for continued operational support. Additionally, this framework provided a minimally functional development and support environment based on the projected demands and resources. The decision to keep the project afloat was based on the high value and the potential for resurrecting this project in the future. A core server and client system are still in use with software maintenance and system support being provided throughout the year.

As of March 2009, the federal manager of this project left to work for another branch within GSD. The focus this year has been to secure funding for continued maintenance and support. The reason these systems have continued to be maintained and supported is a testimony to the project success and utility by the end users. Currently, the plan is to maintain these systems until the capability and requirements that were implemented are available and replaced by AWIPS II extended clients. As of Feb 2010, a Letter of Agreement between GSD and the NWS Office of Climate, Water, and Weather Services (OCWWS) is being drafted in order to specify the funding and understanding to support and maintain these systems until the transition to AWIPS II extended clients for the CWSU's occurs.

The primary remaining work on these projects is the planning, documentation, implementation, and final transition of the maintenance and support of these systems to the GSD's Systems Support Group.

EAR – Research Collaborations with ESRL/GSD Technology Outreach Branch

PROJECT TITLE: FX-Net Forecaster Workstation Project

PRINCIPAL RESEARCHER: Sher Schranz

OTHER CIRA TEAM MEMBERS: Jebb Stewart, Evan Polster, and Ning Wang

NOAA TECHNICAL CONTACT: Bill Bendel, ESRL/GSD/TOB

PROJECT OBJECTIVE 1: Enhance performance and reliability of FX-Net Thin Client and server system software and hardware.

PROJECT OBJECTIVE 2: Refactor Wavelet Compression software.

PROJECT OBJECTIVE 3: Install upgraded systems at operational sites.

PROJECT OBJECTIVE 4: Evaluate the AWIPS II thin client capability for the NWS AWIPS Program Office.

PROJECT OBJECTIVE 5: Develop documentation for NWS Operational System Improvement Process for the FX-Net system's NWS transition to operations.

ACCOMPLISHMENT 1: Reduced the amount of hardware required for a research and development environment by successfully supporting multiple FX-Net file systems and client versions on a single set of AWIPS data servers.

ACCOMPLISHMENT 2: Wavelet compression software redesign was completed and performance and precision testing has begun. When fully tested, this software will be used in the next version of the FX-Net system, the AWIPS II Thin Client and the Gridded FX-Net System.

ACCOMPLISHMENT 3: Enhanced server systems were installed at five of the six NWS regional offices in support of the NWS Incident Meteorologists (IMET) fire weather forecasters, at 12 BLM and US Forest Service Predictive Services offices in support of fire weather forecasters, and for the support of Air Force One forecasters at Andrews AFB.

ACCOMPLISHMENT 4: Installed the AWIPS II software deliveries. Provided documentation to the NWS on the Common AWIPS Visualization Environment (CAVE)Thin Client capability.

ACCOMPLISHMENT 5: Developed general requirements, use cases, system descriptions and performance parameters for the NWS's FX-Net Thin Client technology transition to operations OSIP Gate 2 document.

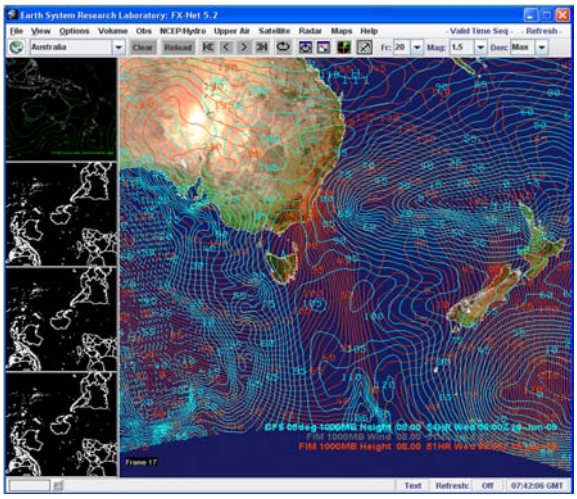


Figure 1: FX-Net for Australian Bureau of Meteorology Demonstration.

EAR – Research Collaborations With ESRL/GSD Technology Outreach Branch

PROJECT TITLE: IPCC Climate Model Demonstrations for Science on a Sphere

PRINCIPAL RESEARCHER: Nikki Prive

NOAA TECHNICAL CONTACT: David Himes, ESRL/GSD/TOB

PROJECT OBJECTIVES: The objective of this project is to illustrate current climate model results for public outreach using Science on a Sphere™ to increase understanding of climate change science.

ACCOMPLISHMENTS: Six new visualizations of the AR4 IPCC global climate model results were created for use at the United Nations Climate Change Conference (COP15). These demonstrations illustrate surface temperature for the SRES A1B and B1 projections for the NCAR CCSM, HadCM3, and GFDL climate models.

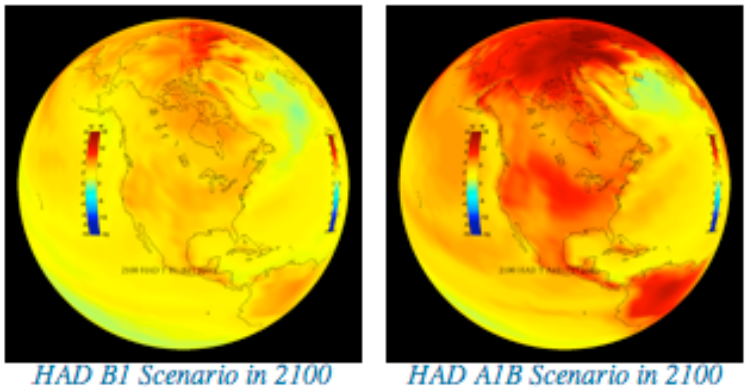


Figure 1: Illustration of snapshots from two new SOS IPCC demonstrations.

EAR – Research Collaborations With ESRL/GSD Technology Outreach Branch

PROJECT TITLE: Science on a Sphere (SOS) Development

PRINCIPAL RESEARCHER: Michael Biere

NOAA TECHNICAL CONTACT: William B. Bendel ESRL/GSD

PROJECT OBJECTIVES: The Science on a Sphere™ Development project addresses NOAA's cross-cutting priority of promoting environmental literacy.

The major research and development task for the project in FY 2010 is to reduce the hardware complexity of the SOS system. Currently, six workstation-class computers (including one spare) are required for the SOS system. The architecture is around five years old at this time, and with increasing computer performance levels, we believe it is realistic to reduce that number to two or three computers (including one

spare). That will require some significant changes to the SOS software, which currently expects only one video output per computer. To achieve optimum video performance, we will continue the design direction of moving more processing from the CPU to the GPU (the graphics card).

Provide technical support for SOS installations at additional new sites.

Continue support of SphereCasting (SOS remote presentations via the Internet).

ACCOMPLISHMENTS: As planned, the SOS system architecture was successfully modified to run on one computer with two high-performance graphics cards instead of the five computers originally required. This is now the new standard SOS architecture being installed at all new sites, and is a major enhancement to the reliability and simplicity of the system.

SOS was installed at the following 10 sites this year:
--Oregon Museum of Science and Industry, Portland, OR
--Heureka, The Finnish Science Centere, Vantaa, Finland
--Houston Museum of Natural Science, Houston, TX
--Discovery Science Center, Santa Ana, CA
--Challenger Learning Center, Atwater, CA
--Natural History Museum, Mexico City, Mexico
--US Astronaut Hall of Fame, Titusville, FL
--China Beijiko Meteorological Museum, Nanjing, PRC
--Cite de l'espace, Toulouse, France
--Denver Museum of Nature & Science, Denver, CO

In addition to these permanent sites, SOS was exhibited as the centerpiece of the US State Department's US Center at the COP-15 climate conference in Copenhagen.

We conducted our first international SphereCast, by SOS inventor Dr. Alexander MacDonald, from the COP-15 conference. A SphereCast is an SOS presentation that is broadcast to multiple remote sites via the Internet. This was the first SphereCast originating from outside the US.

CIRA staff continued to maintain realtime weather models (Global LAPS, FIM, GFS) on SOS. Real-time sea surface temperature analyses from Fleet Numerical Weather Center were reworked to conform to their new website imagery. A set of "seismic rings" was created in the correct spherical projection for an earthquake/tsunami animation being developed with NGDC.

The map of Saturn's moon Enceladus was updated with images from a recent flyby of the Cassini spacecraft. Imagery from the Cassini spacecraft was also used to update the maps for Saturn's satellites Dione and Iapetus. An example for Iapetus is depicted in Figure 2.

We maintained real-time earthquakes and a library of planetary datasets. The map of Mercury was updated using the data from the third MESSENGER spacecraft flyby. We helped with a National Geographic crew filming a documentary on interplanetary travel.

CIRA staff attended SOS meetings and the SOS users workshop in Boulder. We served on the panel discussing content creation.

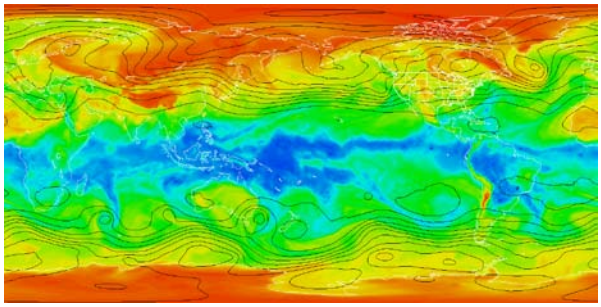


Figure 1: Global GFS analysis of precipitable water (image) and 500mb height contours on January 18, 2010 at 1200 UTC.

Figure 2: Cylindrical map of Saturn's satellite Iapetus as updated using recent Cassini spacecraft imagery.

PROJECT TITLE: Further Expansion of CIRA Research Collaboration with the NWS Meteorological Development Lab

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

PRINCIPAL RESERCHER: Ken Sperow

NOAA TECHNICAL CONTACT: Stephan Smith, NWS/OSD/MDL

PROJECT OBJECTIVE 1: The AutoNowcast (ANC) Prototype Project **.** ANC is a suite of automated applications developed by NCAR Research Applications Laboratory (RAL) that produce 0- to 1-hour predictor fields of storm initiation, growth, and decay. The long-term objective of this project is to transfer the ANC software into NWS operations with the goals of providing short-term forecast guidance, area weather updates, and use of the ANC generated forecasts by meteorologists at the Center Weather Service Units (CWSUs).

This project can be broken down into two pieces: 1) Providing ANC data to NWS WFO forecasters within the Two-Dimensional Display (D-2D) and developing interactive tools within D-2D enabling forecasters to provide feedback to the ANC system; and 2) setup and run the complete ANC system on NWS hardware at the Meteorological Development Laboratory (MDL). The main objectives of this project are: 1) conduct proof of concept experiments within WFOs using the tools and data we provide, and 2) to better understand the configuration, architecture, and customization of the ANC system with the intention of streamlining the system for operational use.

ACCOMPLISHMENT: The AutoNowcast (ANC) Prototype Project. The ANC prototype is up and running at the FWD WFO and has been for several years now. This year we expanded the experiment to include an additional WFO, Melbourne (MLB), Florida. The NWS sent the ANC team members to MLB to meet with the MLB staff so we better understood the unique characteristics of convective initiation in Florida. This year, Ken Sperow delivered updated ANC packages to FWD in support of new operational versions of AWIPS (OB9.1, OB9.2). Additionally, the team developed, tested, and made available to the WFO a MLB specific AWIPS package.

Using the ANC production system running at MDL that Ken built and configured, MDL is now delivering forecast data to the FWD WFO. Additionally, the NWS purchased new servers for a Melbourne instance of ANC based on my

hardware recommendations and specifications. Using the knowledge gained in streamlining the FWD ANC instance and plans Ken put together with NCAR last year, he set up test and production instances of ANC for MLB.

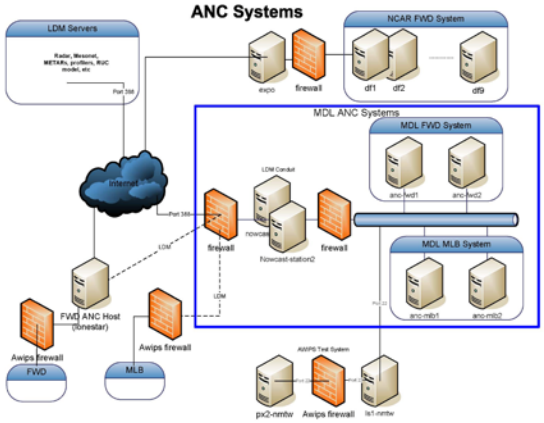


Figure 1: Diagram showing the ANC cluster at MDL illustrating the development, test, and production systems.

PROJECT OBJECTIVE 2: AWIPS Migration. The NWS is in the process of evolving AWIPS to an open source, service oriented architecture (SOA). The major objective of this project is to provide the functionality of AWIPS build OB9 in this new SOA infrastructure.

MDL is not directly responsible for the migration of its applications from AWIPS to AWIPS Migration; this is the responsibility of Raytheon, the prime contractor. However, MDL will be overseeing the migration of its current applications, developing new applications in the new framework, and enhancing existing applications beyond OB9, which falls outside the scope of Raytheon's migration.

AWIPS Migration uses many technologies (JAVA, Mule, Hibernate, JavaScript, JMS, JMX, etc.) which are new to MDL and the NWS. In order for MDL to be in a position to add value, they need people that have a working understanding of these technologies.

ACCOMPLISHMENT: As a member of the AWIPS Migration Independent Validation and Verification (IV&V) group, the AWIPS Performance team, and the Architecture board, Ken is actively engaged in the AWIPS Migration community. He continued to provide AWIPS Migration support to MDL developers and to install new releases of the AWIPS Migration software on his system for testing and knowledge transfer activities. He is the OSIP lead and developer of a meteogram tool being prototyped within AWIPS Migration. At the NWS's request, he created and presented a poster at the GOES User's Conference this past fall on the meteogram tool. MDL also sent him to NWS WRHQ to understand IRIS in the context of AWIPS Migration.

PROJECT OBJECTIVE 3: AWIPS Data Visualization and Monitoring System for Operational Records (ADVISOR). ADVISOR will be an AWIPS monitoring and display tool designed to aid forecasters in decision-making. The objective of this project is to design and develop a powerful decision assistance framework within AWIPS Migration.

ACCOMPLISHMENT: This past fall, the ADVISOR project successfully passed through gate 1 of the NWS OSIP process. As a team member, Ken is helping to push the project into a prototyping phase, so the team better understands the design and implementation of the AWIPS Migration framework in which the ADVISOR application will be developed. This coming year, we need to complete the OO design and start more in-depth prototyping.

PROJECT TITLE: The Role of the Colorado Climate Center in a Meaningful Drought Early Warning System for the Upper Colorado Basin

PRINCIPAL INVESTIGATOR Nolan Doesken

NOAA TECHNICAL CONTACT: Chad McNutt, Roger Pulwarty, Jim Verdin, NOAA/NIDIS Program Office

PROJECT OBJECTIVE 1: Conduct assessment of drought indicators and triggers in the upper basin in Colorado and how they could be incorporated and communicated in an Upper Colorado River Basin "Drought Monitor" product.

PROJECT OBJECTIVE 2: Development of "The Upper Colorado Drought Monitor" and the "Upper Basin Drought Portal Community"

ACCOMPLISHMENTS: This project began during the summer of 2009 and continues at this time. The early phase of this work involved meeting with many water users, water owners, water managers and watershed protection groups in the Upper Colorado River Basin in Colorado. Interviews were conducted to discuss drought concerns and information needs. Specific quantitative information was solicited about points at which shortages in snowpack, precipitation, streamflow and/or reservoir storage become problematic. A common reply from many sectors there was "drought is not a big problem until it lasts at least 3 years". That reply is a result of the fact that the mainstem of the Upper Colorado River Basin in Colorado has several large reservoirs containing multiyear storage. Examples of organizations that were interviewed included U.S. Bureau of Reclamation, Colorado Division of Wildlife, Colorado Division of Water Resources, NW Council of Governments, Ground County Water Information Network, Colorado River Water Conservation District, Excel Energy, ski resort operators, U.S. Bureau of Land Management, Denver Water, Northern Colorado Water Conservancy District, and others. Concerns of both reduced water quality and quantity were discussed. Information from these interviews is still being assembled. Monitoring gaps were also assessed to help determine what additional climate and monitoring is needed to better track water supplies from this sensitive area.

Becky Smith joined this project in August 2009 as a Graduate Research Assistant supported by this project and advised by Dr. Chris Kummerow. She has done very useful water balance assessments and reservoir climatologies as a foundation to help understand drought and water balance in the Upper Colorado.

Starting in February 2010, we began producing weekly "Webinars" to address the second objective. The goal is to move towards a drought early warning system for the basin by first improving the scale and timeliness of monitoring. A basin specific "Drought Monitor" can provide much better local information on each component of the water balance and can serve as a companion to the U.S. Drought monitor (www.drought.gov). The spring months, March –June are especially critical for water supplies in this region. Detailed weekly assessments of precipitation, snow accumulation, stream flow and reservoir levels are being conducted, are open to participation from any stakeholders and are posted for online viewing. http://ccc.atmos.colostate.edu/drought_webinar.php Experience gained from this process will guide monitoring, drought assessment and drought predict efforts later in the project.

PROJECT TITLE: Transitioning ISCCP GOES-West Processing from CIRA to NCDC

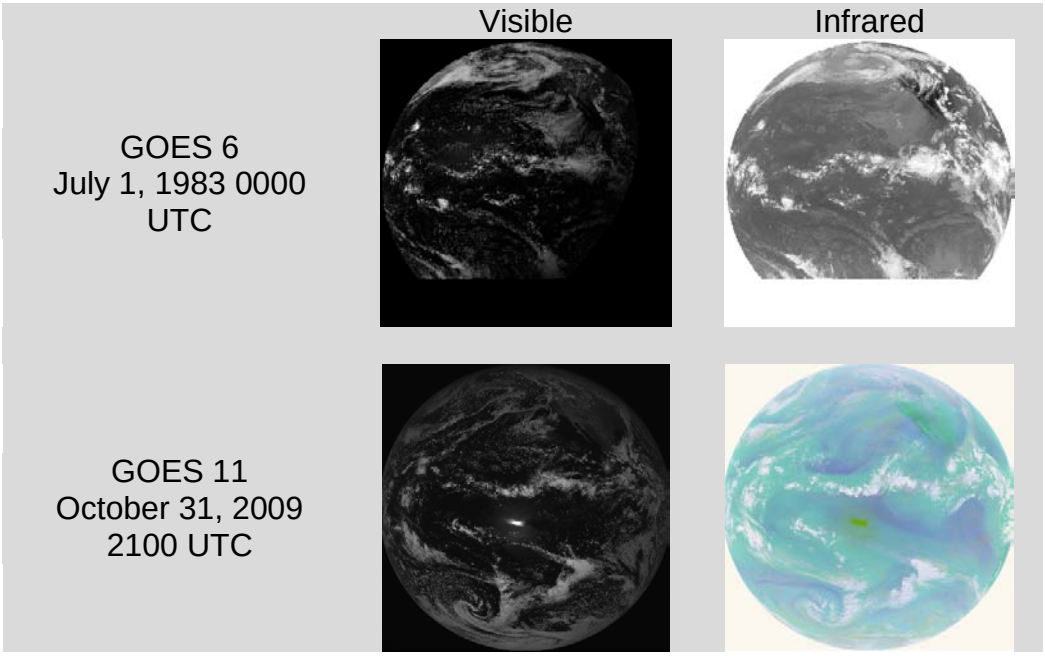
PRINCIPAL INVESTIGATOR: Stan Kidder

NOAA TECHNICAL CONTACT: Ken Knapp/NCDC

PROJECT OBJECTIVE: Transition ISCCP GOES West sector processing code written at CIRA to NCDC.

ACCOMPLISHMENT: The objective was accomplished. On 1 November 2009, NCDC replaced CIRA as the ISCCP GOES West Sector Processing Center. NCDC also plans to use the code for GOES East sector processing.

This project brings to an end data collection which stared July 1, 1983. Here are images of the first and last data collected:



PROJECT TITLE: Weather Satellite Data and Analysis Equipment and Support for Research Activities

PRINCIPAL INVESTIGATORS: Graeme Stephens & Michael Hiatt

NOAA TECHNICAL CONTACT: Deb Molenar and Don Hillger

PROJECT OBJECTIVES: The funds from this award are used to cover Colorado State University (CSU) costs incurred in supporting the joint research activities between National Environmental Satellite, Data and Information Service (NESDIS) Regional Mesoscale Meteorology (RAMM) Team and CSU/CIRA scientists and graduate students. This research collaboration is to improve the CIRA satellite Earthstation and infrastructure.
This segment of research funding provides support to the CSU and NESDIS research scientists using the multi-million dollar CSU satellite Earthstation and its associated processing and data handling activities. Due to continuing new technical developments in weather satellites and the instrumentation on the satellites, CIRA uses the proposed funds to keep our high-tech, cutting edge satellite receiving capabilities up to date to support the researchers.

The Earthstation and infrastructure also support the daily weather briefings and discussions with many participants including students. This provides the opportunity for RAMM Team researchers to test and demonstrate new applied research products for NOAA centers and forecasters.

ACCOMPLISHMENTS:

Terascan System: Ingest Hardware

Data Archive Room: Air Conditioning, Storage Racks, UPS Power.

Archive Improvements: DVD Writer, RAID6 Storage Units.

Earthstation: GOES Receiver, Update to McIDAS Format, 2 New GOES 3.4M Antennas.

Personnel Salary: Part time coverage for Engineer, Software Developer, and Student Hourly.

AWARDS

Alan Berman Research Publication Award
The paper "Stratospheric Impact of the Chisholm Pyrocumulonimbus Eruption: Part 1. Earth-viewing Satellite Perspective," by M. Fromm (NRL) et al., for which **Dan Lindsey** is a co-author, has been selected to receive an Alan Berman Research Publication Award at the Naval Research Laboratory.

GSD Team Member of the Month (August 2009)
Randy Collander and Tom Ken were part of a team that was awarded the August GSD Team Member of the Month Award for their work on MADIS**:** The Meteorological Assimilation Data Ingest System. FSL's MADIS Project makes integrated, quality-controlled observations available to the meteorological community. More information on MADIS can be found here:
http://www-sdd.fsl.noaa.gov/MADIS_Overview/MADIS_Overview.html

U.S.-Norway Research Collaborations Strengthen
A recent initiative from U.S. Secretary of State, Hillary Clinton, and Norwegian Minister of Foreign Affairs, Jonas Gahr Støre, aims to strengthen U.S.-Norwegian collaboration in polar research with a special focus on Svalbard, Norway. Their initiative which identified key scientific questions that should be given priority was presented and discussed at the 50-year Anniversar of the Joint Arctic Council and Antarctic Treaty Consultative Meeting in Washington, D.C. in April 2009.

Among the list of suggested Norway-U.S. research collaborations was a merging of CIRA snow, weather, and climate modeling tools with Norway's field observations in Svalbard, Norway (the high Arctic). For the past 15 years, under the leadership of Dr. Glen Liston, scientists at CIRA/Colorado State University have been developing regional climate modeling tools to simulate the evolution and changes occurring within Arctic systems. These tools include atmospheric models, hydrologic models, ecosystem models, and data assimilation models. In addition, they have developed a nested modeling structure that is able to simulate the feedbacks and interactions among the key climate systems and the associated physical and biological climate system variables. Development of a regional climate model for Svalbard would be an excellent tool for climate-change researchers and managers interested in understanding an Arctic "hot spot," i.e., an Arctic region where the climate is changing very fast.

CIRA Student, Darren Van Cleave, Honored at the AMS Numerical Weather Prediction Conference
At the conference in Omaha, NE there were student awards given in four categories among 42 competitors:
(1) PhD Student Oral Presentation (18 competitors),
(2) PhD Student Poster Presentation (7 competitors),
(3) M.S./B.S. Student Oral Presentation (8 competitors), and
(4) M.S./B.S. Student Poster Presentation (9 competitors).

Darren tied for first place in Category 4 with his poster "Relating Snowfall Patterns Over the Central and Eastern US to Infrared Imagery of Extratropical Cyclone Comma Heads."

All students who presented at the conference have much of which to be proud; they and their faculty advisors have done a superb job and helped to advance our science and nurture our future research pioneers.

The Prestigious NOAA Bronze Medal Award
CIRA is proud to acknowledge two of its on-site NOAA collaborators (and CSU alums!), John Knaff and Mark DeMaria, who were recently honored with the 2009 NOAA Bronze Medal. Also, three staff members from our Boulder CIRA team were celebrated as collaborators on Bronze-Medal winning teams. Read below for all the details!

The NOAA Bronze Medal is the highest honorary award granted to NOAA employees by a head of an operating unit or Secretarial Officer or equivalent. It is defined as superior performance characterized by outstanding or significant contributions which have increased the efficiency and effectiveness of the operating unit. All of the esteemed award recipients were honored at a ceremony held on Tuesday, April 27th in the NOAA Auditorium in Silver Spring, Maryland.

Mark and John are both members of NOAA's RAMMBranch: The Regional and Mesoscale Meteorology Branch (RAMMB) of NOAA/NESDIS, which is co-located at CIRA. Mark is the Branch head, and John is both a former CIRA employee and now RAMMB team member. RAMMB conducts research on the use of satellite data to improve analysis, forecasts and warnings for regional and mesoscale meteorological events. The work honored with the award focused on developing, implementing, and conducting outreach for the new National Hurricane Center Tropical Cyclone Surface Wind Speed Probability products. The entire winning team is listed below:

Mark DeMaria
John Knaff
Alison Krautkramer
Chris Lauer
Chris Sisko
Richard Knabb
Chris Juckins
Timothy Schott
Michelle Mainelli
Edward Rappaport

Since the Bronze Medal can only be awarded to NOAA employees, CIRA issues its own citations for employees who collaborated on winning teams, including a one-time special cash award for each CIRA winner. Among the CIRA staff associated with Bronze Medal winning teams are **Isidora Jankov, Kevin Brundage** and **Bob Lipschutz.**

Isidora served as a key contributor in the NOAA/Earth System Research Lab joint PSD-GSD (Physical Sciences Division-Global Systems Division) effort to develop the atmospheric river moisture flux tool. The tool combines observations and numerical model output so that atmospheric river conditions can be documented and monitored. Atmospheric rivers help scientists identify conditions which often lead to excessive precipitation. Isadora handled the modeling component of the project herself which included both developing a strategy for submitting specialized WRF model runs and delivering timely model results that could be used in the tool on an hourly basis. Her work and commitment to the effort helped to strengthen the collaboration of all the scientists from GSD, PSD and CIRA in working on HMT-related research. Congratulations and thank you to Isidora!

Kevin Brundage and Bob Lipschutz both collaborated with colleagues from NOAA's Earth System Research Lab Global Systems Division and the National Weather Service to develop the first NWS/NCEP (National Centers for Environmental Prediction) operational radar reflectivity assimilation technique to improve convective storm forecasting for the real-time RUC (Rapid Update Cycle) model. The RUC is an integrated high-frequency model/assimilation system.

Operational assimilation of radar reflectivity data was thought to be unachievable for many years until the award-winning team developed a very effective technique that did not increase computational resources and was then successfully implemented at NCEP. Kevin did the scripting to add the radar assimilation to the real-time RUC where the testing occurred as well as additional scripting to improve the radar

assimilation with initialization files. Bob set up the real-time transfer of reflectivity mosaic files from NSSL to ESRL for real-time testing and evaluation. Both of their contributions were important components to the overall effort. Congratulations and thank you to Kevin and Bob!

Reflections on 50 years of Earth Observation: Drs Kidder and Vonder Haar Featured in *Science* Magazine

From their long and distinguished vantage point, **Dr. Stan Kidder and** CIRA Director Emeritus **Prof. Tom Vonder Haar** took to the pages of *Science* magazine recently to describe the evolution of space-based Earth observation. In their article appearing in the February 26th issue Kidder and Vonder Haar wrote, "The first 50 years of space-based Earth observation progressed from crude observation to scientific understanding to stewardship of the atmosphere and of Earth. The new observations will result in many scientific insights and should help humanity to weather what could be the worst of global warming and other environmental problems."

As a core mission of our Institute, this unique overview of how satellite observations have changed atmospheric science is a true must-read. The full article is available here:

http://www.sciencemag.org/cgi/content/full/327/5969/1085

AutoNowcaster Team Wins Recognition of Excellence -- January 2010

Two more CIRA employees were honored for their work in collaboration with NOAA research teams. The Meteorological Development Laboratory Recognition of Excellence Award was recently given to the NWS AutoNowcaster Demonstration Team. Team Members include: **Scott O'Donnell and Ken Sperow**, both of CIRA, as well as Steve Olson, Curt Neidhart (OST/PPD), Chris Adams, and Mamoudou Ba.

The team was recognized for the successful implementation of the NCAR AutoNowcaster system within AWIPS to provide real-time thunderstorm nowcasts at National Weather Service Forecast Offices in Dallas-Fort Worth and Melbourne, Florida in support of NextGen. Congratulations to Scott and Ken!

NOAA/GSD Team Member of the Month – October 2009

Technology Outreach Branch Chief Bill Bendel presented CIRA's own **Ning Wang** with the NOAA/GSD Team Member of the Month award last fall.

Ning Wang received this acknowledgement in recognition for outstanding contributions to the Flow-following Finite-volume Icosahedral Model (FIM) and Flow-following Non-Hydrostatic Icosahedral Model (NIM) work and for continuing support of the compression algorithms for FX-Net activities. In particular, Dr. Bendel cited the following achievements:

- implementation of the FIM – Icosahedral Grid Meta System and the FIM pre- and post-processing subroutines;
- improvement of FIM and NIM efficiency and accuracy through research on geometric optimization schemes; and
- continued support of the FX-Net Project through the optimizing of wavelet compression algorithms.

Gavin Roy NSF Fellowship

Prof. Tom Vonder Haar, CIRA's Director Emeritus, is pleased to announce that one of his upcoming graduate advisees in the Department of Atmospheric Sciences has won an NSF Fellowship award. Gavin Roy will be starting at CSU this August and will be working on and supported through funding from the Center for Geosciences/Atmospheric Research, one of CIRA's main cooperative agreements. Gavin submitted what amounts to a mock grant proposal, along with a stack of other documents to the NSF

Graduate Research Fellowship Program and succeeded in winning one of these coveted awards despite rigorous competition that numbered well over 400 other applicants. There were five award winners in the field of "Geosciences - Dynamic Meteorology," and Gavin was the only undergraduate meteorology student to receive an award. The fellowship covers 3 years of funding: $10,000 of tuition per year, a $30,000 stipend per year, and a one-time international travel allowance of $1000.

The Fellowship seeks to identify and reward individuals who are anticipated to become knowledge experts in their field of study. They are further expected to become individuals who can contribute to research, teaching, and innovations in science and engineering. As the NSF website cites: "These individuals are crucial to maintaining and advancing the Nation's technological infrastructure and national security as well as contributing to the economic well-being of society at large."

The Department and CIRA is looking forward to working with such a talented young man this fall. Congratulations to Gavin!

CIRA Employee Promotion News
Our Human Resources Manager, Linn Barrett, recently announced a bevy of newly-promoted CIRA employees. All of the CIRA team wishes to acknowledge the following employees for their outstanding efforts which have earned them each a promotion. Please offer your congratulations to:

Robert DeMaria
Robert was promoted to Research Associate II on July 1, 2009. He has provided valuable computer programming support to RAMMB by collaborating with scientists and team members in support of the GOES-R Risk Reduction, GOES-R Algorithm Working Group, and the Joint Hurricane Testbed. Robert has been with RAMMB for almost 9 years--starting out initially as a high school PACE student. It has been exciting to watch him grow through his education, interactions with others, and application of acquired knowledge.

Christopher Hiemstra
Dr. Hiemstra was promoted to Research Scientist/Scholar III on July 1, 2009. He is an integral member of CIRA's snow hydrology and snow-vegetation-atmosphere research team. His work focuses on understanding atmosphere, snow, and vegetation interactions and how land-cover variations influence weather, climate, and ecosystem structure and function. He is actively involved with leading field-measurement efforts in the Arctic and middle latitudes and assisting with development of improved snow-vegetation-atmosphere interaction models. His work includes using a combination of field measurements, remote-sensing observations, and physically-based models to improve our understanding of the associated system components and how they relate to each other.

Isidora Jankov
Dr. Jankov was promoted to Research Scientist/Scholar II on July 1, 2009. She transitioned to a Research Scientist over 2 years ago following a 2-year stint as a CIRA Postdoc. Her wide range of independent and specialized research efforts include high-resolution model ensemble used for experimental deterministic and probabilistic precipitation forecasts.

Andrew Jones
Dr. Jones was promoted to Senior Research Scientist/Scholar on July 1, 2009. As the new Deputy Director of CIRA's Center for Geosciences/Atmospheric Sciences (CG/AR), he is responsible for presenting program overviews to DoD leadership, developing new project initiatives within the program, and providing overall technical leadership to the staff. Dr. Jones also actively aids graduate students and postdoctoral fellows with their research and frequently presents technical lectures in local classes.

Nan McClurg
Nan was promoted to Research Associate III on July 1, 2009. She has been the manager of the GLOBE Help Desk ever since the Program's transfer to the UCAR/CSU partnership in 2003. She has also provided outstanding support to the Program as its North American Regional Desk Officer over the past 6 years.

Ning Wang
Dr. Wang was promoted to Research Associate IV on July 1, 2009. He has been with CIRA for nearly 14 years. During this time, he has contributed unique and indispensable expertise as a PhD mathematician to several high-profile research projects, including his wavelet transform data compression algorithms for the FX-Net project and, more recently, his grid generation and other pre- and post-processing techniques for the ESRL global Flow-following finite volume Icosahedral global Model (FIM).

Min-Jeong Kim
Dr. Kim was promoted to Research Scientist/Scholar II on January 1, 2010. She works as a member of the GOES-R Proxy Data Team and as a member of the Joint Center for Satellite Data Assimilation (JCSDA) scientists located at NOAA/NESDIS in Maryland. She is currently leading a project to assimilate satellite cloudy radiance observations in the NCEP Global Data Assimilation System and to improve the numerical model predictions for severe weather. Steve Miller is her supervisor and Fuzhong Weng is her technical advisor.

Wei Shi
Dr. Shi was promoted to Research Scientist/Scholar II on January 1, 2010. Previously, Dr. Shi worked for CIRA as a Postdoctoral Fellow located at the Center for SaTellite Applications and Research (STAR) of NOAA/NESDIS in Camp Springs, Maryland. From his duty station in Maryland, Dr. Shi aids development and validation of the new atmospheric correction algorithm for deriving accurate ocean optical and biological products in coastal regions. In addition, he uses the improved ocean color product data for various applications such as studies for Hurricane Katrina-induced phytoplankton bloom, ecosystem responses to the Cyclone Nargis in the Gulf of Martaban, flood-driven Mississippi River plume in the spring of 2008, monitoring green macroalgae bloom in the Yellow Sea, etc. Steve Miller is his supervisor and Menghua Wang is his technical advisor.

Colorado State University Service Milestone Awards:

Travis Andersen - 10 years of service
Linn Barrett - 10 years of service
Daniel Bikos - 10 years of service
Kevin Brundage - 15 years of service
Scott Copeland - 15 years of service
Laura Fowler - 20 years of service
Paul Hamer - 10 years of service
Jeffrey Lemke - 15 years of service
Chungu Lu - 20 years of service
Mary McInnis-Efaw - 10 years of service
Evan Poster - 10 years of service
Dale Reinke - 20 years of service
Daniel Schaffer - 10 years of service
David Watson - 20 years of service
Loretta Wilson - 25 years of service

CIRA EMPLOYEE MATRIX

Employees who received 50% support or more		Degree			
Category	Number	Doctorate	Masters	Bachelors	Non-Degreed
Research Scientists	13	13	0	0	0
Visiting Scientists	1	1	0	0	0
Postdoctoral Fellows	6	6	0	0	0
Research Support Staff*	59	6	20	25	8
Administrative Personnel	5	1	2	2	0
Total	84	27	22	27	8

Employees who received less than 50% support		Degree				
	Number	Doctorate	Masters	Bachelors	Associates	Non-Degreed
	50	16	10	14	2	8

Supported Students		Degree		
Category	Number	Doctorate	Masters	Bachelors
Undergraduate	1	0	0	0
Graduate	15	0	5	10
Total	16	0	5	10

Employees located at NOAA Laboratories		GSD	MDL	CSD	NGDC
Total	46	41	2	1	2

Obtained NOAA Employment within the last year	
Total	0

*Equivalent to Research Associate in CIRA/CSU parlance

PUBLICATIONS - NOAA-FUNDED PROJECTS

Angevine, W. M., H. Jiang, and T. Mauritsen, 2010: Performance of an eddy diffusivity – mass flux scheme for shallow cumulus boundary layers. Mon. Wea. Rev., in press.

Biere, M., S. Albers, 2009: Science On a Sphere Update – New Sites and New Visualizations, *CIRA Mag.*, 32, 15-16.

Carrió, Cotton, W. R., 2010: Effects of the Urban growth of Houston on convection and precipitation. Part I: The August 2000 case. Atmospheric Research (accepted Dec 2009, in press).

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(pdf file available at: http://www.star.nesdis.noaa.gov/sod/sst/squam/references.htm)

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PRESENTATIONS - NOAA-FUNDED PROJECTS

Benjamin, S. G., W. R. Moninger, B. D. Jamison, and S. R. Sahm, 2009: Relative Short-Range Forecast Impact in Summer and Windter from Aircraft Profiler, Rawinsonde, VAD, GPS-PW, METAR, and Mesonet Observations for Hourly Assimilation into the RUC. Presented at *13th Conference on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface (IOAS-AOLS)*, Phoenix, AZ, Amer. Meteor. Soc.

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Braun, J. A presentation with general guidelines to “Talk about the weather” was given on three separate occasions in 2009 to students of Rocky Mountain High School who attend the *Introduction to Chemistry, Physics, and Earth Sciences* (ICPE) classes.

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Ignatov *et al*., 2009: The SST Quality Monitor (SQUAM). GHRSST users conference, May-June 2009, Santa Rosa, CA, *Presented by: Alexander Ignatov, STAR scientist* (ppt and extended abstract at: http://www.star.nesdis.noaa.gov/sod/sst/squam/references.htm)

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Rodriguez, M. A. 2009. Regional air quality simulation of the Rocky Mountain Atmospheric Nitrogen and Sulfur study (RoMANS): Model diagnosis using integrated process analysis. Presented at the 25th Annual Clean Air Conference, Estes Park, September.

Rodriguez, M. A., Barna, M. G., and Moore, T. 2010. Regional impacts of oil and gas development in the western United States. Presented at the American Association for Aerosol Research international specialty conference: Air Pollution and Health: Bridging the Gap from Sources to Health Outcomes, San Diego, March 22-26.

Schichtel, B. A., Malm, W. C., Collett, J. L., Jr., Sullivan, A. P., Patterson, L. A., and Holden, A. S. 2009. Estimating the contribution of smoke and its source regions to fine particulate matter using a hybrid receptor model. Presented at the American Association of Aerosol Research 28th Annual Conference, Minneapolis, October 26-30.

Seaman, C., 2010: Impact of Cloud-Affected Infrared Satellite Observations on a Cloud-Free Initial Model State, Annual Review of the DoD Center for Geosciences/Atmospheric Research at Colorado State University, Fort Collins, Colorado, March 30.

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Zhang, S.Q., A.Y. Hou, X. Lin, D. Zupanski, M. Zupanski, S.H. Cheung, 2009: Progress in precipitation assimilation at GSFC. *PMM Science Team Meeting*, 26-29 October, Salt Lake City, UT.

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PUBLICATIONS MATRIX

Peer-Reviewed

Institute Lead Author						NOAA Lead Author						Other Lead Author					
2004	2005	2006	2007-08	2008-09	2009-10	2004	2005	2006	2007-08	2008-09	2009-10	2004	2005	2006	2007-08	2008-09	2009-10
29	70	42	46	37	24	20	14	30	26	21	17	40	25	71	80	35	31
82	128	40	6	58	6	48	52	91	2	34	0	53	46	64	5	49	5

NOAA PROJECTS BY TITLE

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NOAA PROJECT THEME MATRIX

Title	Project#	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
A GOES-R Proving Ground for National Weather Service Forecaster Readiness	5-31240	Miller	x						
Advanced Environmental Satellite Research Support	5-31203	Vonder Haar	x						
Analysis of Clouds, Radiation and Aerosols from Surface Measurements and Modeling Studies	5-31218	Matsumoto, Frisch		x					
Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events	5-31214	Grasso	x						
Applications of Satellite Altimetry Data to Statistical and Simplified Dynamical Tropical Cyclone Intensity Forecast Models	5-31201	Vonder Haar	x						
CIRA Activities and Participation in the GOES Improved Measurements and Product Assurance Plan (GIMPAP) and in the Product System Development and Implementation (PSDI) Program	5-31222	Vonder Haar (DeMaria)	x						
CIRA Research Collaboration with the NOAA/NESDIS NGDC for the NPOESS SEM Sensor	5-312510	Matsumoto	x						

NOAA PROJECT THEME MATRIX

Title	Project#	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
CoCoRaHS: The Community Collaborative Rain, Hail and Snow Network--Enhancing environmental literacy through participation in climate monitoring and research	5-31227	Doesken							x
Continuation of the CIRA Research Collaboration with the NWS Meteorological Development Lab	5-31209	Matsumoto					x		
Development and Evaluation of GOES and POES Products for Tropical Cyclone and Precipitation Analysis: Western Pacific Tropical Cyclone Formation Probabilities	5-31225	Kidder, Brummer	x						
Development of a Polar Satellite Processing System for Research and Training	5-31239	Connell	x						x
Development of an Improved Climate Rainfall Dataset from SSM/I	5-31232 (1245)	Kummerow				x			
Ensemble Data Assimilation for Hurricane Forecasting	5-31111	M.Zupanski			x				
Environmental Applications Research (EAR)	5-31144	Matsumoto		x	x	x	x		x
Further Expansion of CIRA Research Collaboration with the NWS Meteorological Development Lab	5-31237	Matsumoto					x		

NOAA PROJECT THEME MATRIX

Title	Project#	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Getting Ready for NOAA's Advanced Remote Sensing Programs A Satellite Hydro-Meteorology (SHyMet) Training and Education Proposal	5-31202	Connell	x						
Global Tropical Cyclone Formation Probabilities	5-31249	Dostalek	x						
Investigation of Smoke Aerosol-cloud Interactions Using Large Eddy Simulations	5-31198	Matsumoto, Jiang		x		x			
IPCC Studies for Climate Observations	5-31228	Vonder Haar, Forsythe				x			
Joint Hurricane Testbed: An Improved Wind Probability Estimation Program	5-31236 (1244)	Kidder		x					
Monsoon Flow and Its Variability During NAME: Observations and Models	5-31235	Johnson		x		x			
NESDIS Postdoctoral Program	5-31208	Miller	X	X		X			
Chen, Yong					x				
Dash, Prasanjit			x				x		
Liang, XingMing			x				x		

NOAA PROJECT THEME MATRIX

Title	Project#	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Shi, Wei			x						
Xu, Feng			x				x		
POES-GOES Blended Hydrometeorological Products	5-31238	Kidder, Jones, Forsythe			x	x	x		
Research and Development for GOES-R Risk Reduction for Mesoscale Weather Analysis and Forecasting and Analysis of Simulated Radiance Fields for GOES-R ABI Bands for Mesoscale Weather and Hazard Events	5-31194	Miller	x						
Satellite Analysis of the Influence of the Gulf Stream on the Troposphere: Convective Response	5-31243	Schumacher	x						
Simulation and Analysis of the Interaction Between Aerosols and Clouds, Precipitation and the Radiation Budget Over the Gulf of Mexico and Houston	5-31231	Cotton		x					
Support of the Virtual Institute for Satellite Integration Training (VISIT)	5-31206	Connell, Bikos	x						x
Task I - A Cooperative Institute to Investigate Satellite Applications for Regional/Global-scale Forecasts	5-31107	Stephens					x	x	x

NOAA PROJECT THEME MATRIX

Title	Project#	PI	Satellite Algorithm Development, Training and Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Eduation and Outreach
Mackaro, Scott (Post Doc)									
The Role of the Colorado Climate Center in a Meaningful Drought Early Warning System for the Upper Colorado Basin	5-311120	Doesken				x	x	x	x
Transitioning ISCCP GOES-West Processing from CIRA to NCDC	5-31241	Kidder	x				x		
Tropical Cyclone Model Diagnostics and Product Development	5-31207	Schubert	x						
Validation of Satellite-Based Thermodynamic Retrievals in the Tropics	5-31242	Dostalek	x						
Weather Satellite Data and Analysis Equipment and Support for Research Activities	5-31152	Stephens, Hiatt					x		