CIRA ANNUAL REPORT FY 2010/2011

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE

DIRECTOR'S MESSAGE

The Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU) is one of a number of cooperative institutes (CIs) that support NOAA's mission. Although this mission continues to evolve, there continue to be strong reasons for partnering between NOAA and the fundamental research being done in the University environment. Strengthening these ties in satellite remote sensing, science algorithm and application development, education/training, regional/global weather and climate modeling, data assimilation, and data distribution technology make CIRA a valuable asset to NOAA. As the new Director of CIRA, I have put this relationship at the very top of the priority list, doing everything possible to strengthen the ties among CSU's Department of Atmospheric Science, the rest of the University and CIRA researchers. This includes a joint seminar series, shared graduate students, seed funds for joint research efforts and interactions with other Departments to lay the foundation for weather and climate science to expand into the broader human dimension. With this new emphasis, we hope not only to fulfill the promise of being the conduit for developing ground breaking research to address socially-relevant problems that face NOAA and our society today but to further help train a new work force that has a broader perspective needed for transitioning to operational stakeholders research concepts that are at the cutting edge of science.

CIRA is fortunate in that its location (proximity to a world-class Department of Atmospheric Science) and corporate culture have been able to fill its ranks with talented researchers and support staff who continue to perform at the highest possible level. There are many important accomplishments that are highlighted in this report and summarized in the executive summary. Not as obvious, but equally important, are the activities that CIRA carries out with the Department of Defense through the Center for Geosciences, the activities with the National Park Service, and the activities with NASA through the CloudSat data processing facility and OCO algorithm development. While not funded by NOAA, these activities are highly synergistic in the areas of algorithm development, modeling and data distribution. They allow CIRA researchers working on NOAA projects to have a broad pool of subject experts with whom they can consult as they develop their own projects. As we embark on a new voyage of research and discovery with our NOAA technical partners, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship among NOAA, the Department of Atmospheric Science at CSU, other Departments of the University, and the other major programs at CIRA.

Christian D. Kummerow

TABLE OF CONTENTS

VISION AND MISSION

The overarching Vision for CIRA is:

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

Expanding on this Vision, our Mission is:

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

COOPERATIVE INSTITUTE FOR RESEACH IN THE ATMOSPHERE

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

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

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

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

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

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

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

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

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

CIRA EDUCATION, TRAINING AND OUTREACH ACTIVITIES: 2010-2011

"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."

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This section describes CIRA education, training and outreach activities from April 2010 through March 2011.

A New Look for CIRA

The newly formed CIRA Marketing and Outreach team (Laura Leinen, John Forsythe, Jennifer Raab, Mary McInnis-Efaw, Maureen Murray and Karen Milberger), has created a new CIRA logo. Examples with a white or black background are shown below in Figure 1. Maureen and Karen in particular have strong expertise in graphic design and outreach built upon many years of important contributions to the GLOBE Education and Outreach program (an internationally recognized program fostering environmental literacy via K-12 curricula and activities). As the old saying goes, "a picture is worth a thousand words," and in that way our new logo attempts to communicate what CIRA does and how we do it. To this end, the logo captures CIRA's foundation as an atmospheric science research institute that emphasizes the understanding of weather and climate via numerical model development and the collection, analysis, and application of satellite remote sensing observations. Even the colors themselves (showing the glow of the horizon at dawn, transitioning to the deep blue/black of space above) were chosen to symbolize a connection between our satellite research and the dawning of new discoveries that are directed toward societal benefit.
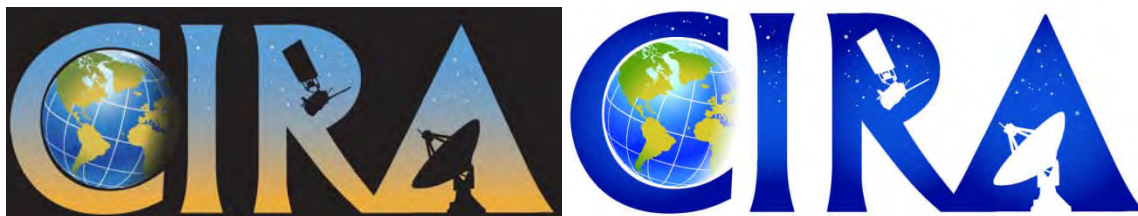

Figure 1. Examples of the new CIRA logo with various backgrounds.

New CIRA Education and Outreach Initiatives

Dr. Matt Rogers began a new position in early 2011 to work on new education and outreach initiatives, including more connections to Colorado state programs. Matt has an extensive background in education and outreach from the NASA CloudSat program. A new collaboration has begun with the Colorado Climate Center to produce a monthly distillation of regional climate information for the Colorado area, which will include an online interface. A prototype example is shown in Figure 2. CIRA Director Chris Kummerow is the main point of contact. This education and outreach effort should yield some positive interactions in 2011.
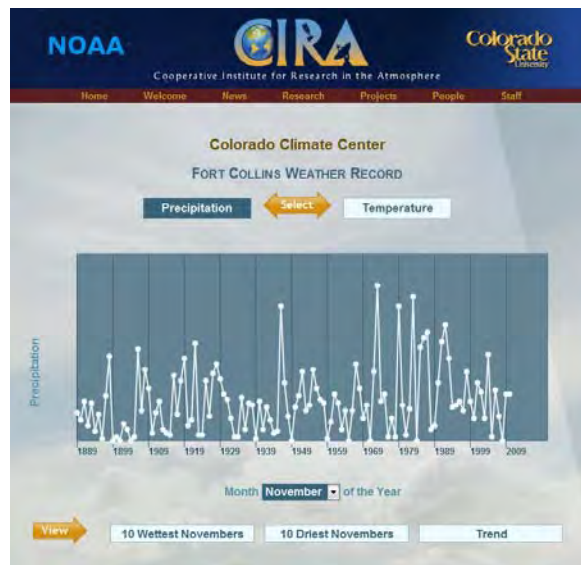
Figure 2. Prototype of Colorado climate data to be available on the new education and outreach website. Annual average precipitation in Fort Collins back into the 1880's.

A new Education and Outreach section has been added to the CIRA webpage (http://www.cira.colostate.edu/education/). This page continues to be developed by Karen Milberger, and will serve as a mechanism for improved communication to the public, as well as a place to centralize links to ongoing education, training and outreach efforts such as the VISIT program. A snapshot of the page is shown in Figure 3.

Figure 3. Early version snapshot of the new CIRA Education, Outreach and Training webpage.

CIRA Hosts 2010 NESDIS Cooperative Institute Research Symposium

CIRA hosted the 2010 Cooperative Research Program (CoRP) Science Symposium, which was held at the Hilton Ft. Collins August 10 and 11 (Figure 4). The purpose of this workshop was to highlight research and application development within NESDIS and its Cooperative Institutes. The theme of this year's symposium was "Satellite Applications to Mesoscale Meteorology and Oceanography." 37 attendees participated, including students from CIMSS, CREST, CIOSS and CIRA. The symposium provides an

opportunity for scientists at the CI's to learn about each other's activities, and for students and early career scientists to participate in a dialogue about their research with more senior scientists.

Figure 4. The NESDIS Cooperative Institute 2010 Science Symposium.

Special thanks to Dan Lindsey of the NOAA RAMM Branch for leading the organization of the symposium. Presentations and a summary of the symposium are available at:
http://rammb.cira.colostate.edu/corp/symposium/

ESRL's GSD and CIRA Contribute to "Summer School in Atmospheric Modeling"

CIRA researchers played key roles during the preparation and presentation of the first "Summer School in Atmospheric Modeling (SSAM)" sponsored by NOAA's Global Interoperability Program (GIP). This involved close collaboration between NOAA, NCAR and CSU. The vast majority of the huge effort required to make SSAM a success was carried out by GSD staff, especially Advanced Computing Section software engineers and Assimilation & Modeling Branch scientists. CIRA researchers Tom Henderson, Jeff Smith, Jacques Middlecoff and Jim Rosinski coordinated interactions with NCAR technical staff (NCAR provided the venue), prepared and gave talks during the class, and participated in technical preparations for and dry runs of practical sessions, developed a graphical user interface (FIM Portal) to simplify the running of the FIM model by students. Student feedback was positive.

CIRA Scientists Volunteer in Local Classrooms

CIRA scientists Kristi Gebhart and Bernie Connell created an after-school "weather club" for students (K-5) at Putnam Elementary School in Fort Collins. The sessions covered snow measurement, wind speed and direction, clouds, temperature, change of state, and things that spin. The students learned about weather with hands-on experiments, like using colored water to simulate warm and cold fronts. Putnam and 2 other schools received a 21st century grant for activities to support enrichment. They chose after school clubs as one of the activities. They have a coordinator who is responsible for the logistics of students and transportation. We were thankful to be able to join with them to present science through fun and engaging activities.

Louie Grasso visited Bauder Elementary School several times to teach students about meteorology, math and chemistry.

Bernie Connell gave a presentation on the GOES satellite and the characteristics of its channels to a Remote Sensing class at the Metropolitan State College of Denver on November 30. Since the Remote

Sensing class focuses mainly on earth resource topics, the students were presented with the perspective of how meteorologists view and use satellite imagery.

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

CIRA Supports the Citizen Weather Observer Program

The Citizen Weather Observer Program is a public-private partnership with three main goals: 1) to collect weather data contributed by citizens; 2) to make these data available for weather services and homeland security; and 3) to provide feedback to the data contributors so that they have the tools to check and improve their data quality. There are over 8,000 registered CWOP members worldwide. CWOP members send their weather data by internet alone or internet-wireless combination to the findU (http://www.findu.com) server and then every five minutes, the data are sent from the findU server to the NOAA MADIS server. The data undergo quality checking and then are distributed to users. There are over 500 different user organizations of the CWOP mesonet data.

Based on member input, database revisions were performed daily by CIRA researcher Randall Collander. Updates included registering new sites in the database using site location (latitude, longitude and elevation) information provided by the users and confirming site position changes using web tools. Randy interacted with users via email regarding setup and data transmission issues and aided in resolving problems and answered questions on site setup, quality control and general meteorology. Various web-based documents and databases were updated on a daily, weekly or monthly basis depending on content, and statistics and other informational graphics revised and posted. Effective March 2011, Randy will be responsible for managing the entire CWOP program.

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

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 (Figure 5). 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 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.
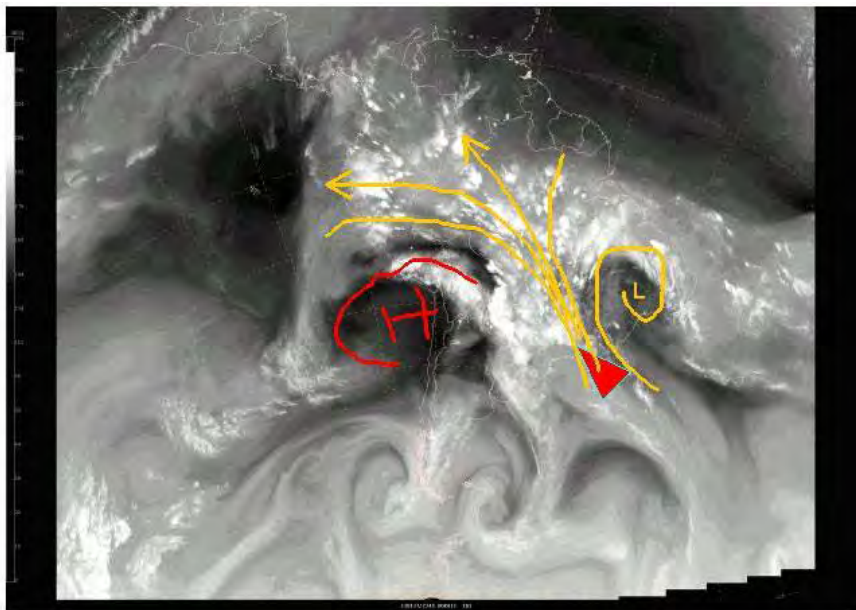
Figure 5. Screen grab during the January 2011 session of water vapor imagery over South America with annotation depicting conditions leading to heavy rains in southern Brazil.

Award-Winning CloudSat Data Processing Center Continues to Host Visitors

The CloudSat Data Processing Center (DPC) at CIRA continues to host visiting groups occasionally, at a rate of roughly three tours per month. Most of the visitors are scientists visiting CIRA or the CSU Atmospheric Science Department for related work, but non-scientist members of the public also occasionally visit. The NASA CloudSat mission will begin its sixth year of measuring Earth's clouds in 2011. All of the science data products are created and distributed through the DPC, to users worldwide. The DPC website is http://cloudsat.cira.colostate.edu.

CIRA-Developed FX-NET Supports a Variety of High-Impact Weather Needs

FX-Net is designed as an inexpensive PC workstation system for use in a variety of forecast, training, education, and research applications not requiring the full capabilities of a WFO-Advanced type system. FX-Net makes AWIPS products accessible over the Internet via high and low bandwidth communication lines. Integral to the FX-Net technology is a wavelet compression technique that can reduce and transmit product file sizes with a minimal loss of resolution.

For fire-weather users, a new version of the WRF/CHEM/SMOKE model was added to the FX-Net AWIPS servers. This is a 3km resolution version with a plume-rise algorithm that uses the NESDIS ABBA satellite fire product to initialize the smoke dispersion for the analysis and forecasts.
The Air Force One forecasters are now running multiple instances of FX-Net to support their forecasting duties.

FX-Net was used by NWS Incident Meteorologists (IMETS) in Louisiana and Mississippi during the gulf oil spill. They provided on- and off-shore forecasts during NOAA's Deep Water Horizon operations in support of the monitoring and clean-up of the oil spill.

FX-Net was also used by forecasters in support of security and facility operations for the Super Bowl.

FX-Net was used by OAR Physical Sciences Division to forecast flight tracks during the FY10 Hydro Met Testbed QPE field program.

During the week of April 19-22, 2010, CIRA researchers at the ESRL/Global Systems Division gave presentations at the National Seasonal Assessment Workshop for the Western States and Alaska about two GSD-developed tools that help fire centers prepare for and combat fires in their regions. FX-Net incorporates data compression research and Internet-based systems development into a real-time data distribution and visualization system for operational forecasters and researchers. The Gridded FX-Net aids agencies like the US Forest Service and the Bureau of Land Management to develop and execute fire potential algorithms used to create daily fire danger indices. CIRA staff provided the dozens of participants an update on the advancements of these state-of-the-art data delivery technology systems used by 11 Geographical Area Coordination Center offices. These offices that are located in the Lower 48 and Alaska are part of the National Interagency Fire Center. During the FY10/11 fire season, for example, GSD will run an experimental 3-km High-Resolution Rapid Refresh (HRRR)/Chem/Smoke model over the western US. This model will be available to the forecasters via the FX-Net system. It provides a significant improvement in the resolution of current operational models and also provides smoke plume source and extent information.

Every April, various federal and some international agencies meet with NOAA researchers at ESRL in Boulder, CO to create seasonal predictions for climate and weather as they relate to the upcoming fire season outlook for the CONUS and Alaska. By doing so, participating agencies that include the U.S. Forest Service, the Bureau of Land Management, Department of Agriculture, National Park Service, and even visiting international agencies from Canada and Mexico can plan how they will move assets and where they will locate fire fighting resources for the season.

Sher Schranz, Jebb Stewart, Evan Polster and Ning Wang lead the FX-Net Research at CIRA – Boulder Labs.

Science on a Sphere® Expands to 61 Installations Worldwide

Science on a Sphere® (SOS) creates a unique view of Earth by projecting various geophysical fields onto a six foot diameter globe. SOS® was installed at 13 more sites this year, bringing the total number of installations to 61 worldwide. In addition to the permanent sites, SOS® was exhibited in the Meteo World Pavilion at the World Expo in Shanghai, PRC. Chinese press reported that the Expo received more than 70 million visitors. SOS® was also exhibited at a large booth at the Florida State Fair in February 2011. SOS® personnel gave live 20-minute presentations to approximately 6500 fair attendees at the two-week event. CIRA staff also developed a visualization of NASA's Solar Terrestrial Relations Observatory (STEREO) data showing dramatic imagery of the sun from two observing satellites. A newly developed visualization of NOAA's FIM-Chem model was also developed, and is used to trace the presence of three aerosols from August 27, 2009 through September 7, 2009.

Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Continues to Reach New Audiences

The COCORAHS program was just awarded a NOAA Environmental Literacy Grant to continue to develop and operate this citizen scientist observer network. NOAA's Environmental Literacy Grants program is a competitive national grant program focused on creating an environmentally literate public that uses a comprehensive understanding of the role of the ocean, coasts, Great Lakes, weather and climate in the global ecosystem to make the best social and economic decisions. The program provides funding for an array of educational organizations that reach diverse audiences.

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. COCORAHS is now active in all 50 states. Data gathered by volunteers are collected via www.cocorahs.org/ (Figure 6) and made available to the public, the National Weather Service, decision makers and 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 (Figure 7). CoCoRaHS has expanded to all fifty states and now with recent grants from NOAA and NSF hopes to bolster its infrastructure through revised educational materials, Webinars, etc. and engage new unreached audiences through social networking and emerging Web 2.0 technologies over the next three years. CoCoRaHS is striving to have 30,000 - 40,000 active observers by the end of 2013 (Figure 8).
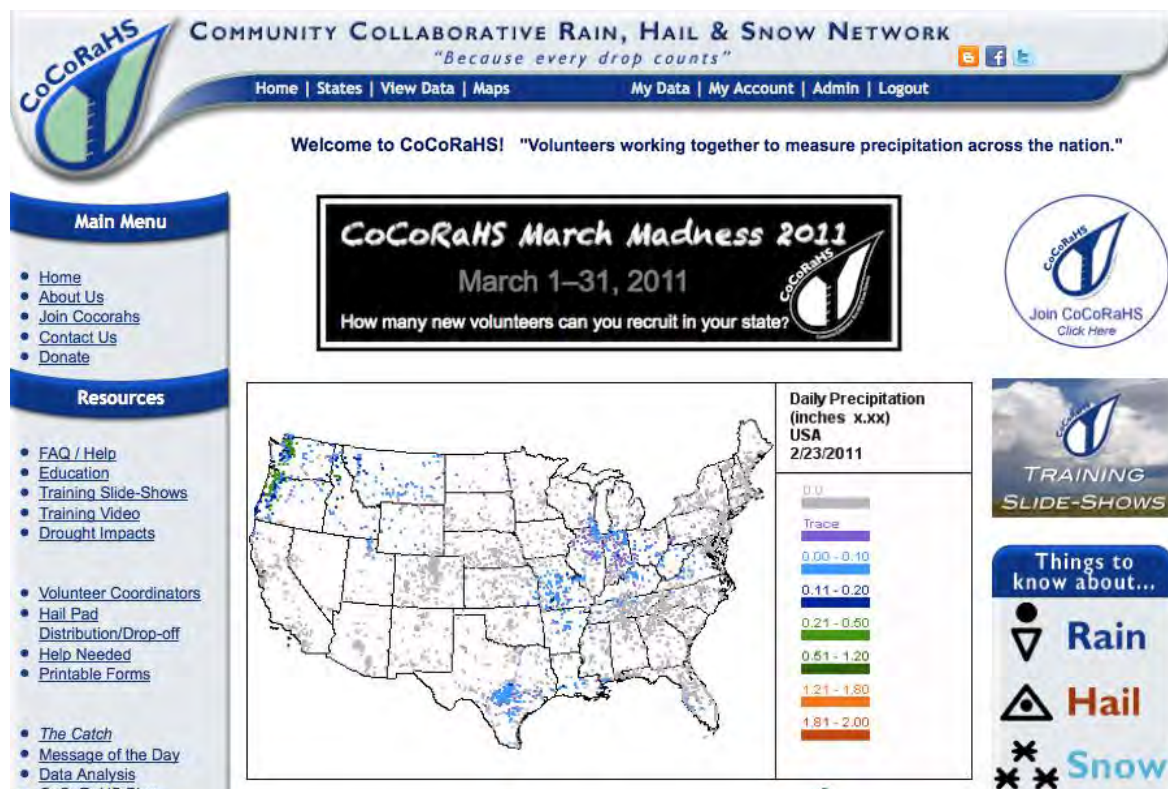

Figure 6. CoCoRaHS main webpage, http://www/cocorahs.org.

Figure 7. A very full CoCoRaHS rain gauge, courtesy Steve Kamp, Beecher, IL.

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

ESRL's Global Systems Division Hosts First LAPS Users' Workshop

ESRL's Global Systems Division hosted its first Local Analysis and Prediction System (LAPS) Users' Workshop on October 25-27, 2010 on site at NOAA Boulder. Engaging the user community in current and future LAPS developments, the workshop reviewed recent upgrades and plans regarding LAPS data assimilation, nowcasting and short-term forecasting, information technology, and user

applications/products. LAPS training opportunities, offered at follow-on meetings October 28-29, augmented the symbiotic presentations given by both developers and users.

LAPS was developed for data assimilation, nowcasting, and model initialization. Because LAPS blends a wide variety of global, national, and local datasets, its analyses can be used to initialize mesoscale forecast models. Due to its high portability and because it runs on inexpensive hardware, LAPS now has a wide variety of users including federal, state, and international agencies, private sector companies and individuals, as well as academia.

LAPS represents a valuable transfer of technology that contributes to NOAA's mission of serving society's needs for weather information. Steve Albers, Isidora Jankov and Ed Szoke are the CIRA staff in Boulder working on LAPS.

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 9) 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, Dan Lindsey, John Knaff and Mark DeMaria contribute to VISIT training. The recorded web-based training modules are taken online anytime by listening to audio playback with video.

Figure 9. VISIT allows trainers and forecasters to interact in virtual teletraining and forecasters can also use recorded training to fit their dynamic schedules.

From March 2010 through February 9, 2011, VISIT delivered 67 sessions of live teletraining to 307 participants. An additional 645 participants took the recorded web-based version of various training sessions. Since 1999, over 19,000 training certificates of completion have been awarded through VISIT.

New VISIT teletraining and modules released this year were:

--Ensemble Tropical Rainfall Potential (eTRaP)
--Synthetic Imagery in Forecasting Orographic Cirrus.
--Synthetic Imagery in Forecasting Severe Thunderstorms.

VISIT scientists traveled beyond CIRA to further educate NOAA personnel. Dan Bikos attended the AMS / NWA High Plains Conference in Dodge City, KS on August 12-13, 2010. He gave 2 oral presentations on tornado cases from this past spring in collaborative work with Jonathan Finch (NWS Dodge City, KS). Jeff Braun attended the NOAA/NWS Alaska Aviation and Volcanic Ash Workshop in Anchorage, AK on September 20-23, 2010. He gave one oral presentation on Volcanic Ash Training and Future (GOES-R) Products.

CIRA Supports Key Efforts to Prepare for GOES-R

Considerable training materials are coming out of our GOES-R Satellite Proving Ground, which serves as an interface between algorithm developers and operational users in the National Weather Service. This is an important activity for user readiness of next-generation operational systems. A variety of new and novel products, which will assist forecasters and communicate more clearly to the public are being developed. An example GeoColor product is shown in Figure 10, which shows clouds across the terminator, without the usual loss of data at sunset, and also shows land color features, snow (pink), and city lights in the nighttime portion of the image.
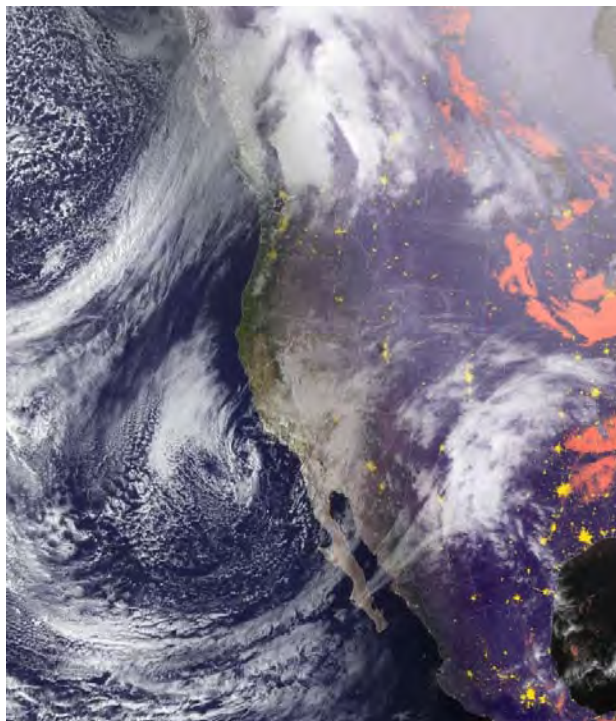

Figure 10. Example of GeoColor imagery being developed for GOES-R, by CIRA and the Naval Research Laboratory.

An extensive list with examples and documentation of GOES-R products CIRA is working on is at: http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list/.

Many of the products being demonstrated are also available in near real-time on the web: http://rammb.cira.colostate.edu/ramsdis/online/goes-r_proving_ground.asp

The CIRA Virtual Institute for Satellite Integration Training (VISIT) and Satellite Hydrology and Meteorology (SHyMet) programs, under the direction of Regional and Mesoscale Meteorology Branch (RAMMB) of NOAA/NESDIS, have a blog with a variety of educational topics. The blog is intended to open the doors of communication between the Operational, Academic and Training Meteorology communities. The blog is a valuable addition to CIRA's education and outreach mission. The VISIT blog has a feature section on the GOES-R proving ground (http://rammb.cira.colostate.edu/training/visit/blog/index.php/category/goes-r-proving-ground/). Synthetic imagery (Figure 11) is produced as CIRA, derived from the NSSL 4-km WRF-ARW model. This imagery is at 4-km resolution and at the same wavelength as GOES-R will have, therefore it is part of the GOES-R proving ground products available in real-time from CIRA.
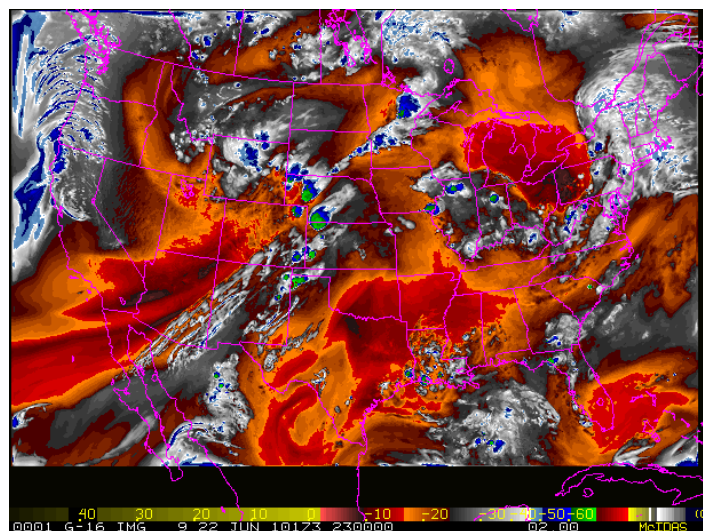

Figure 11. Synthetic water vapor imagery from the NSSL 4-km WRF-ARW model, severe weather occurred over the central US on this day, June 22, 2010.

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

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 titled "**Tropical SHyMet"** in August 2010: http://rammb.cira.colostate.edu/training/shymet/tropical_intro.asp

The Tropical track of the Satellite Hydrology and Meteorology (SHyMet) Course will cover satellite imagery interpretation and application of satellite derived products in the tropics as well as the models used at NHC for tropical cyclone forecasting. This course is administered through web-based instruction and consists of 6 hours of instructional content.
Core modules:
1. An Overview of Tropical Cyclone Track Guidance Models used by NHC.
2. An Overview of Tropical Cyclone Intensity Guidance Models used by NHC.
3. Satellite Applications for Tropical Cyclones: Dvorak Technique.
4. Basic Satellite Imagery Interpretation in the Tropics.
5. Ensemble Tropical Rainfall Potential (eTRaP).
6. ASCAT Winds.
7. Blended Total Precipitable Water (TPW) Products.

As part of the SHyMet for Forecasters course, 2 new training modules were developed in 2010:
--Regional Satellite Cloud Composites from GOES.

--Volcanic Ash Hazards.

SHyMet launched a new course titled "SHyMet: Severe Thunderstorm Forecasting" in March 2011. The Severe Thunderstorm Forecasting track of the Satellite Hydrology and Meteorology (SHyMet) Course covers how to integrate satellite imagery interpretation with other datasets in analyzing severe thunderstorm events. This course is administered through web-based instruction and consists of 7 modules (8.5 hours) of core topics and 4 modules (2.5 hours) of optional topics.
Core Courses:
--Mesoscale Analysis of Convective Weather Using GOES RSO Imagery
--Use of GOES RSO imagery with other Remote Sensor Data for Diagnosing Severe Weather across the CONUS (RSO 3)
--GOES Imagery for Forecasting and Nowcasting Severe Weather
--Water Vapor Imagery Analysis for Severe Weather Forecasting
--Synthetic Imagery in Forecasting Severe Weather
--Predicting Supercell Motion in Operations
--Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection
Optional courses:
--Monitoring Gulf Moisture Return
--The UW Convective Initiation Product
--Coastal Severe Convective Weather
--Topographically induced Convergence Zones and Severe Convective Weather

The first in the SHyMet courses was directed towards the NWS Intern and was released in 2006. The SHyMet for Interns continues to be offered (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.

CIRA Hosts CMMAP Summer Intern

Prof. Tom Vonder Haar, in conjunction with CIRA scientists Steve Fletcher, John Forsythe, and Andy Jones, hosted Erin Kashawlic in the summer of 2010 through the Center for Multiscale Modeling of Atmospheric Processes (CMMAP) summer internship program. Ms. Kashawlic studied data assimilation and presented a poster at the end of summer poster session entitled "A comparison between mixed and transform data assimilation schemes on short-, medium- and long-term forecasts". Erin is now attending graduate school in atmospheric science at Texas Tech. Another intern supported by CMMAP will be mentored by CIRA scientists in the summer of 2011.

Walking Through the Water Year: High School Students Make a TV Series About Weather and Water

CIRA contributed financially to the Colorado Climate Center's "Walking Through the Water Year" efforts and in particular a very entertaining series on water put on by high school students in the Poudre School District. The U.S. Bureau of Reclamation Eastern Bureau supported the effort for the past three years. Nolan Doesken of the Colorado Climate Center and CSU Atmospheric Science Department was the technical leader. The series aired throughout the year on public access TV channel 10 in Fort Collins. Matt Gohl was the technical contact on the Poudre School District side.

Videos of the show are available at:
http://epresence.psdschools.org/1/Page/Published/3.aspx

The topics are:
Oct. 2009 Long Term Average (focus on "Halloween Snows")
Nov. 2009 Water Diversions, Reservoirs
Dec. 2009 Upslope Concept
Jan. 2010 Air Masses and Fronts
Feb. 2011 Defining Weather vs. Climate
Mar. 2011 El Nino
April/May 2011 Streamflow
June/July 2011 Clouds
Presentations derived from this work were given to Fort Collins elementary students, for instance on March 22, 2010 on World Water Day.

National Park Service Air Quality Research and CIRA Outreach

The National Park Service CIRA outreach group has a long history of developing interpretive media to communicate air quality research and results to a diverse public. Since the early 1990s we have worked with the Cooperative Institute for Research in the Atmosphere (CIRA), and partners in the National Park Service (NPS), U.S.D.A. Forest Service, U.S. Fish and Wildlife Service (USFWS), and the Colorado State University Department of Atmospheric Sciences, to enable people to learn about the sources and effects of air pollution on natural resources. We utilize a variety of methods to communicate current research science as well as the effects of human activities on ecosystems.

Further details of CIRA NPS education and outreach are available at
http://vista.cira.colostate.edu/IMPROVE/Education/education.htm

Examples of education and outreach approaches use by the NPS group are:

--IMPROVE Calendar
Annual calendars are created in support of the national research and monitoring effort, IMPROVE (Interagency Monitoring of Protected Visual Environments). As an outreach tool, the calendar provides information about the monitoring program and provides information about monitoring protocols, supplying operators with a reliable tool for meeting data collection and equipment requirements. Individual operators are highlighted each month acknowledging the individual efforts (many of which are performed on a volunteer basis) that make the program possible. As an educational tool, the calendar provides an opportunity to summarize current research efforts, present data results and applications of IMPROVE data, identify data collection problems, and review the current status of regulatory programs.

Current and past calendars are at:http://vista.cira.colostate.edu/IMPROVE/Education/education.htm

--Interactive Media for Museums and NPS Visitor Center Displays

Of the many challenges facing developers of visitor center exhibits, usability and engagement rank high. Our projects use a virtual environment to develop an understanding and awareness of air pollution and its effects on natural resources. Content chosen is relevant to local areas and makes extensive use of rich media (graphics, animation, and video). An interactive user interface encourages exploration of many topics and activities that are designed to capture the attention of visitors who span a broad range of age and education levels. We currently have these types of exhibits running at Sequoia Kings Canyon National Park (Figure 12), the Oakland Museum of California, and Great Smoky Mountains National Park.

Figure 12. Exploring the Sequoia National Park air quality exhibit.

--Interactive Learning Station to Interpret Air Quality Monitoring

We are currently developing an interactive learning station for the Edwin B. Forsythe National Wildlife Refuge (Figure 13). The exhibit will describe the monitoring instruments and detail what pollutants are monitored, why we monitor them, what we know about current levels, and what the implications are for local ecosystems. We will connect to live visibility and ozone data for the refuge and describe how the data are applied to protect the environment and ecosystems of the refuge.

Figure 13. Interactive air quality learning exhibit.

--Video and Audio Podcasts
An audio/video podcast was produced by the NPS Air Resources Division (ARD) in cooperation with the NPS Fort Collins air quality research group at CIRA. The podcast titled "On the Air " (Figure 14), overviews air pollution issues facing national parks and is currently running on the NPS ARD Explore Air web site. There are plans to add more audio and video content to this site next year.

Figure 14. The "On the Air" podcast is available at http://www.nature.nps.gov/air/features/pod-cast/airpodcast.cfm

--Multimedia Program on Climate Change Education and Outreach

A web based multimedia program on the science of climate change is being developed as an educational tool (Figure 15).   The program will be multifunctional in that it may be used for primary and secondary education, 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.

Figure 15. The multimedia CIRA NPS climate change educational webpage.

This opening page allows exploration of a variety of topics. The participant would learn about 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. Subsequent pages allow participants to exploring more sophisticated concepts.

--Graphical Products for Public Communication
The NPS CIRA outreach group also supports the NPS Fort Collins research offices and NPS ARD outreach group with a variety of graphic products (e.g. Figure 16) including:

--Presentation graphics for meetings and technical publications

--Scientific illustrations

--Photography

--Poster creation
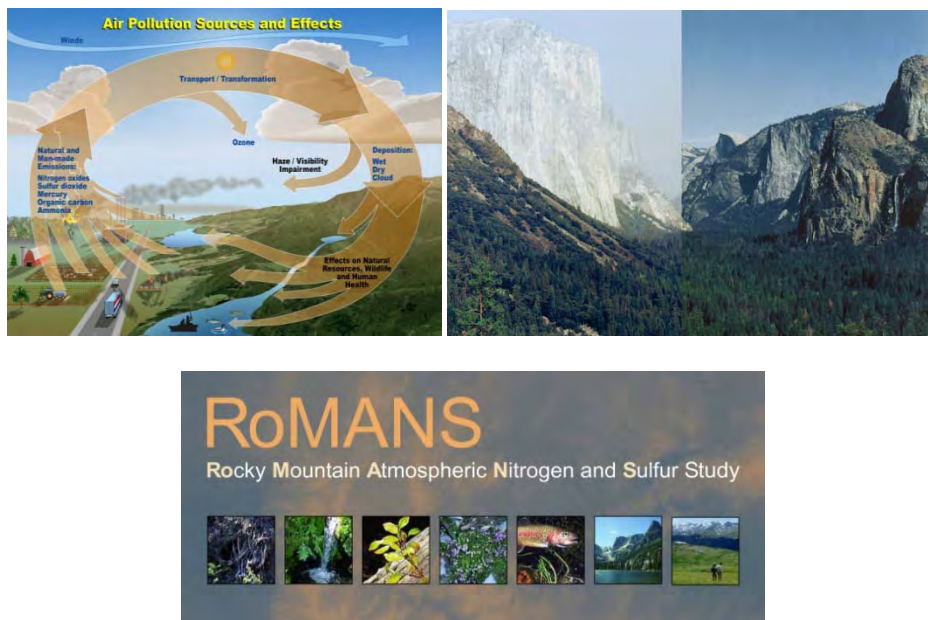
--Web graphics

--Brochures

Figure 16. Examples of NPS education and outreach: Sources of air pollution, simulated effect of haze and pollution in Yosemite NP, and the Rocky Mountain NP nitrogen and sulfur deposition study (RoMANS).

--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 (Figure 17), 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.

Figure 17. The summer Milky Way bisects the night sky over Tuolumne Meadows in Yosemite National Park, California, a location from which sky quality measurements indicate near-pristine conditions. This panoramic view of the entire sky is a mosaic of 45 individual images.

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.

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

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

Daily Weather Discussion Tradition Continues at CIRA, and Moves to Expanded Facility

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 performing the discussion. They are a great way to explore new tools and products as well as to provide the CIRA research community the practical view from the forecasters chair. During the late summer Atlantic hurricane season, the discussions are often standing room only with dozens of attendees.

The daily weather discussions will move into the new CIRA Observatorium in the spring of 2011. The Observatorium will be a multi-purpose space that is used as a weather laboratory and a convening venue for education and outreach activities. Here we will hold the daily weather briefings (and special tropical briefings during hurricane season) that provide an important connection with our Atmospheric Science Department colleagues. An exterior "bridge to the atmosphere" will extend outward from the Observatorium. Dramatic, panoramic views available from this elevated structure will provide our staff, meeting attendees, and public/student tours an ideal location to observe and reflect upon the atmosphere at work, and to match clouds they can see with features in the satellite data.

CIRA Continues AWIPS II System Implementation and Education

AWIPS II (Advanced Weather Interactive Processing System) is the future common visualization and forecast workstation for the National Weather Service. CIRA, in conjunction with the Information Systems Branch (ISB) of the Global Systems Division (GSD) developed a series of three prototypes in 2010 and one prototype in 2011 demonstrating much of the required functionality. The first prototype in 2010 was completed in May. The overall objective of this first prototype was to demonstrate a preliminary capability for AWIPS II to ingest and display model data from remote data servers. CIRA staff, working with other ISB staff, was able to leverage NextGen registry/repository technology to discover information (metadata) about remote WCS servers. They implemented a grid ingest and storage capability into AWIPS II using the EDEX (Environmental Data Exchange) plug-in capability. An interface to the Common AWIPS Visualization Environment (CAVE) was also developed by CIRA staff that enables the user to make ad-hoc requests to the remote server using web technology.

At the request of the NOAA Meteorological Development Laboratory, CIRA Researcher Ken Sperow traveled to Taiwan for a week as an Auto Now Caster (ANC) expert helping the Central Weather Bureau (CWB) understand and begin to set up the AWIPS components of ANC and the software responsible for transferring data between ANC and AWIPS. In preparation for this meeting, Ken set up the ANC bridge and AWIPS software on a development machine at the CWB and provided custom documentation. Additionally, in December 2010, Ken was asked to visit the Spokane, WA and Missoula, MT forecast offices. He briefed them on the current MDL-developed AWIPS applications in addition to planned AWIPS II work.

CIRA support for AWIPS II is provided by Joanne Edwards, James Fluke, and Ken Sperow.

New Sea Surface Temperature Quality Monitoring Website

CIRA scientist Prasanjit Dash, at NESDIS STAR in Camp Springs, MD, has developed a website of use to scientists and the public to monitor sea surface temperature (SST) products in near real-time. The SST Quality Monitor (SQUAM) is a web-based tool to diagnose and analyses satellite Sea Surface Temperature (SST) products. The website is http://www.star.nesdis.noaa.gov/sod/sst/squam/. SST is a fundamental variable which crosscuts NOAA's mission, impacting fisheries, weather forecasting and ocean health.
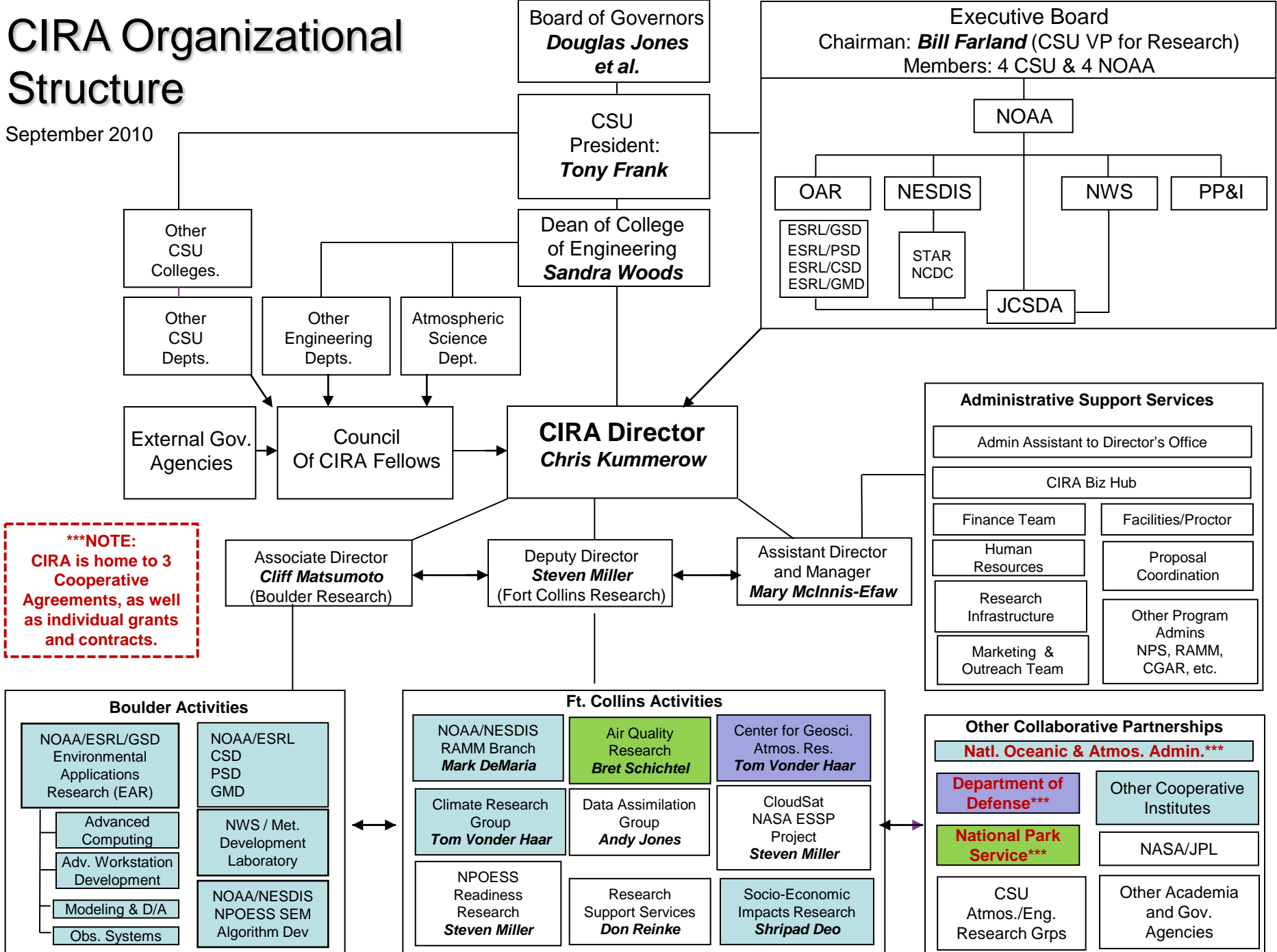
CIRA/Department of Atmospheric Science Sponsored Seminars

A complete list of seminars can be found in the Task I section.

NOAA AWARD NUMBERS

Award Number	Identifier	Project Title	Principal Investigators/ Project Directors
NA10SEC0080012	Competitive	CoCoRaHs: Capitalizing on Technological Advancements to Expand Environmental Literacy through a Successful Citizen Science Network	Chris Kummerow (Lead), Nolan Doesken
NA10OAR4310103	Competitive	Quantifying the Sources of Atmospheric Ice Nuclei from Biomass Burning Aerosols	Chris Kummerow
NA10NES4400012	Competitive	Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting	Chris Kummerow
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	Chris Kummerow (Lead), Steven Miller
NA09OAR4320074	New Cooperative Agreement	A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts	Chris Kummerow (Lead), Steven Miller

CIRA Organizational Structure

September 2010

Board of Governors
Douglas Jones et al.

Executive Board
Chairman: *Bill Farland* (CSU VP for Research)
Members: 4 CSU & 4 NOAA

CSU President: *Tony Frank*

NOAA

OAR | NESDIS | NWS | PP&I

ESRL/GSD
ESRL/PSD
ESRL/CSD
ESRL/GMD

STAR
NCDC

JCSDA

Dean of College of Engineering
Sandra Woods

Other CSU Colleges.

Other CSU Depts.

Other Engineering Depts.

Atmospheric Science Dept.

External Gov. Agencies

Council Of CIRA Fellows

CIRA Director
Chris Kummerow

***NOTE:
CIRA is home to 3 Cooperative Agreements, as well as individual grants and contracts.**

Associate Director
Cliff Matsumoto
(Boulder Research)

Deputy Director
Steven Miller
(Fort Collins Research)

Assistant Director and Manager
Mary McInnis-Efaw

Administrative Support Services

Admin Assistant to Director's Office

CIRA Biz Hub

Finance Team | Facilities/Proctor

Human Resources | Proposal Coordination

Research Infrastructure | Other Program Admins NPS, RAMM, CGAR, etc.

Marketing & Outreach Team

Boulder Activities

NOAA/ESRL/GSD Environmental Applications Research (EAR)

Advanced Computing

Adv. Workstation Development

Modeling & D/A

Obs. Systems

NOAA/ESRL CSD PSD GMD

NWS / Met. Development Laboratory

NOAA/NESDIS NPOESS SEM Algorithm Dev

Ft. Collins Activities

NOAA/NESDIS RAMM Branch
Mark DeMaria

Air Quality Research
Bret Schichtel

Center for Geosci. Atmos. Res.
Tom Vonder Haar

Climate Research Group
Tom Vonder Haar

Data Assimilation Group
Andy Jones

CloudSat NASA ESSP Project
Steven Miller

NPOESS Readiness Research
Steven Miller

Research Support Services
Don Reinke

Socio-Economic Impacts Research
Shripad Deo

Other Collaborative Partnerships

Natl. Oceanic & Atmos. Admin.***

Department of Defense*** | Other Cooperative Institutes

National Park Service*** | NASA/JPL

CSU Atmos./Eng. Research Grps | Other Academia and Gov. Agencies

CIRA BOARD, COUNCIL, FELLOWS & BOARD MEETINGS

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

Meeting of the CIRA Executive Board Held February 18, 2010
Meeting of the CIRA Executive Board scheduled for May 27, 2011

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 continues to perform basic and applied research to better utilize data from NOAA Geostationary Operational Environmental Satellite (GOES) and Polar Operational Satellites (POES). During the past year, this group has worked in diverse areas encompassing the development of GOES-based renewable (solar) energy prediction products, improved severe and tropical cyclone forecasts, as well as the initial checkout of new satellite data. During this past year, software was installed and begun running routinely for GOES-11 that uses observed cloud products coupled with the GFS forecast model to predict downwelling solar radiation at specific locations for time scales of up to three hours. GOES Imager data is also being used to along with surface observations and the NOAA/ESRL RUC model to predict the probability of severe weather in the 0-6 hour time frame, while new research was initiated that focuses on the tropical cyclone to extra-tropical cyclone transition.

- An important activity continues to be the research and development for the next generation GOES-R Risk Reduction (GOES-R3) effort.   In addition to the production, distribution, and archiving of simulated GOES-R data for the tropical Atlantic, the project has focused upon the possible improvements that the new satellite system will provide. This includes improvements in products intended to warn of tropical cyclone intensification as well as the development and demonstration of benefits in the forecast of severe as well as winter weather.   New activities are seeking the synergy of GOES-R sensors with a variety of other platforms and sensors to begin extracting the coherent environmental information that ultimately leads to revolutions in forecasting. Whether it is the synergy between GOES ABI, GLI and the water vapor from microwave imagers, or between the satellite data and forecast models, these projects have additional value in their ability to excite and entrain faculty at CSU, students and young scientists who will be trained in problems central to NOAA's mission.

- The improvement of existing products from Geostationary data as well as the development of new products is not particularly useful unless coupled with a strong program that trains forecasters to make full use of these new products. Whether it is the GOES proving ground project that has entrained new Weather Forecast Offices and now counts 10 offices as active CIRA proving ground partners, support of the Virtual Institute for Satellite Integration Training (VISIT) intended to accelerate the transfer of research results based on atmospheric remote sensing into National Weather Service (NWS) offices, or participation in the International Virtual Laboratory for training of forecasters in Latin America, CIRA remains committed to its core function of acting as a conduit for transferring state-of-the art research done in a University setting to NWS forecasters and forecast offices.

- 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 exceptionally high level this past year. CIRA researchers were immersed in every branch and virtually every project in GSD, including project leadership and integral support involving Fire Weather Modeling and Research, and the FAA and NWS NextGen, NNEW, and NEVS aviation weather programs; meteorological workstation development, including the AWIPS II Data Delivery project, FX-NET Thin Client and data compression, MADIS, and GTAS; high performance computing; and the design, development and implementation of various regional and global weather and climate models, including the RR, HRRR, WRF-Chem, FIM, and NIM as well as UAS OSSE investigations and LAPS/STMAS data assimilation systems. Under education and outreach, the SOS architecture was enhanced to run on one computer instead of five and the system was installed at 13 new sites this past year, as well as several highly publicized exhibits around the world including The Meteo World Pavilion at The World Expo in Shanghai, China from May to October.

- 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). Research collaborations in Boulder continued with NESDIS/NGDC and the Space Weather Prediction Center on the USAF Defense Weather Satellite System's Space Environment Monitor (SEM) sensor algorithm development resulting from the breakup of the NPOESS program. The on-going partnership with the NWS Meteorological Development Lab continued as well with the AutoNowcast Prototype Project on convective nowcasting along with AWIPS Migration—NWS process of evolving AWIPS to an open source, service-oriented architecture.

- The multidisciplinary Center for Geosciences and Atmospheric Research (CG/AR) is in its 25th year of research on environmental issues. This Department of Defense oriented program welcomed several new graduate students into is activities in 2010. Research related to soil moisture and clouds at CG/AR exemplifies the close connection and synergy that CIRA is able to forge among its participating Centers. The soil moisture and clouds project employs sophisticated remote sensing techniques also applicable to GOES and POES retrievals while disaggregation of soil moisture and cloud products for high resolution applications uses the same data assimilation techniques being developed for NOAA. Many of the CIRA staff can, and do, move seamlessly between the two programs.

- 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 2008) continued to enjoy strong support from NASA Headquarters having successfully gone through a senior review in 2010 that extended the mission through 2012. The CloudSat program has its Data Processing Center at CIRA on behalf of NASA. The data center is widely praised for its ability to cost effectively process not only the data but to also bring in and redistribute a host of related data that represent a Cloud package rather than data from an individual sensor. As more science moves in this direction and NOAA itself begins to exploit the synergies between sensors and platforms, it will be highly beneficial for NOAA to have CIRA employees with the experience in these data systems to help guide the future.

- The NASA Orbiting Carbon Observatory (OCO) mission was cut short when it failed to reach orbit in February 2009. It has however been re-manifested for a launch in 2013. CIRA personnel, also on behalf of NASA, have lead responsibility for the satellite Level-2 algorithm development effort. This again fits well with NOAA's needs for personnel with expertise in future satellite algorithm development. The mission of OCO to measure atmospheric CO_2 and track its sources and sinks further represents an ideal opportunity for new avenues of collaboration with the NOAA Carbon Tracker 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 and Global-scale modeling Systems theme relates directly to the NOAA mission to replace the current Weather Research and Forecast (WRF) model's Rapid Update Cycle (RUC) model with the Rapid Refresh model. Considerable support is provided directly to this effort as well as high performance computing and graphical processing for the next generation Non-hydrostatic Icosaheral Model (NIM) being developed at ESRL. Applications include support for both Fire weather modeling and interfaces to aid Severe Weather/Aviation decisions.

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. The use of EnKF coupled to Gridpoint Statistical Interpolation (GSI) was implemented into the WRF-Chem model for the assimilation of ozone and particulate matter. Included in our Climate-Weather Processes theme are studies on the complex interaction between smoke and clouds as modeled via Large-Eddy Simulations (LES), participation in HMT field projects designed to gain insight into atmospheric rivers that transport so much of the water vapor needed for rainfall production, and the Community Collaborative Rain, Hail and Snow Network intended to enhance environmental Literacy through participation in Climate Monitoring and Research.

Highlighted in CIRA's *Data Distribution* theme is work with the National Weather Service (NWS) Meteorological Development Lab for migration of Autonowcaster to operations for improved convective initiation and situational awareness, multiple efforts toward improving aviation forecast support systems via the FAA and NWS NextGen and NNEW projects, preparations for the next-generation AWIPS-II interface, the Meteorological Assimilation Data Ingest System (MADIS) transition to NWS operations, and development of a novel drought early warning system. In addition to these major themes, CIRA engages in multiple education and outreach activities and strives to link weather, water, and climate research to societal impacts.
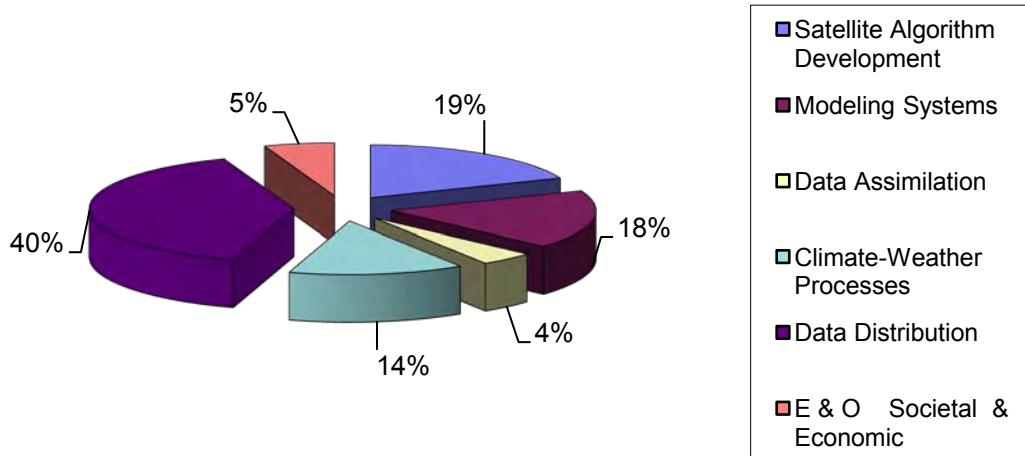
Interspersed among these major research themes are important contributions from CIRA's NESDIS Research Scientist and Postdoctoral Program in data distribution, assimilation, and satellite algorithm development. Located in Camp Springs, MD, and integrated closely with NOAA technical contacts at STAR, 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 continue to be extremely proud of this program and its direct positive impacts to NOAA research needs.

This Annual Report is the second completed under CIRA's new Cooperative Agreement with NOAA. As we continue on our voyage of research and discovery with our NOAA technical partners, we re-establish our commitment to the maintenance and growth of a strong collaborative relationship among NOAA, the 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 useful and informative, and we look forward to the challenges ahead.

NOAA TASK I EXPENSE ACTIVITY AT CIRA
APRIL 1, 2010 - MARCH 31, 2011

45%

- ■ Administration
- ■ Education and Outreach
- □ Infrastructure

51%

4%
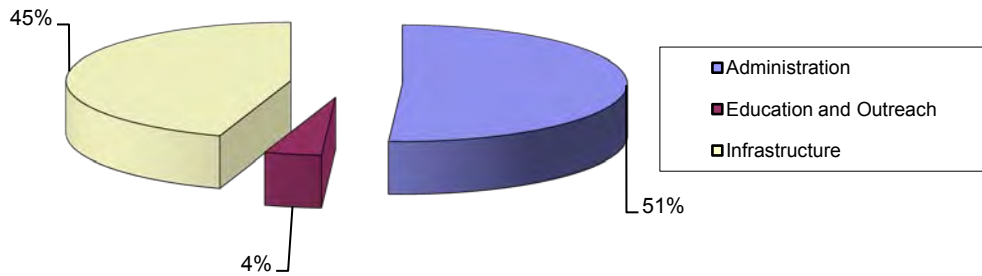
NOAA TASK II RESEARCH THEME EXPENDITURES FOR
THE PERIOD APRIL 1, 2010 - MARCH 31, 2011
$11,570,519

5%

19%

40%

18%

14%

4%

- ■ 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.

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SEMINARS SUPPORTED BY TASK I

April 1, 2010, M. Jury (Univ. of Puerto Rico Mayaguez). Caribbean climate, weather variability and interactions.

April 8, 2010, H. Coe (Univ. of Manchester). Aerosol properties and processes across Europe and their impacts: a multi-aircraft study during a European Integrated Project (EUCAARI).

April 15, 2010, G. Meehl (NCAR). Weather extremes in a changing climate.

April 21, 2010, A. Sandu (Virginia Tech). Computational tools for chemical data assimilation.

April 29, 2010, Z. Kuang (Harvard). Large-scale connectively coupled tropical transients.

May 21, 2010, M. Setvak (CHMI). Satellite observations of convective storms at the Czech Hydrometeorological Institute.

May 28, 2010, C. Balaji (Indian Institute of Technology, India). Retrieval algorithms for the Megha-Tropiques mission.

June 24, 2010, L. Bosart (State Univ. of New York). Late season tropical cyclogenesis in the Western Caribbean Sea and Gulf of Mexico: Tropical Cyclone Ida (2009).

July 16, 2010: G. Toth (Meteorological Service of Canada). A journey with the Meteorological Service of Canada.

August 20, 2010, K. Yasunaga (JAMSTEC). Do different types of equatorial waves modulate convective and stratiform precipitation differently?

August 25, 2010, K. Saito (Meteorological Research Institute). Studies at MRI toward the cloud resolving NWP.

August 26, 2010, ATS Faculty. Faculty-Intro Jamboree Part I: Overview of research areas and groups in the department.

August 31, 2010, Y. Liu (CIMSS). Preliminary results of arctic cloud macrophysical characteristics from CloudSat and CALIPSO.

September 2, 2010, R. Garcia (NCAR). Acceleration of the Brewer-Dobson circulation in a changing climate.

September 9, 2010, C. DeMott (CSU). Simulation of the Asian Monsoon in a super-parameterized AOGCM.

September 16, 2010, M. Alexander (NOAA ESRL). The impact of North Pacific atmospheric variability on ENSO via the "Seasonal Footprinting Mechanism".

September 23, 2010, J. Ham (CSU). Measuring fluxes of ammonia and other trace gases using eddy covariance and relaxed eddy accumulation.

September 30, 2010, S. Denning (CSU). My visit to the dark side: engaging climate change denial.

October 6, 2010, G. Leoncini (U.K. Met Office). Member selection for a convective scale ensemble at the UK Met Office.

October 6, 2010, Six Inuit Visitors (Nunavut, Canada). Arctic Seasons: An Inuit perspective.

October 14, 2010, M-J Kim (CIRA JCSDA). Assimilating satellite observations of clouds and precipitations in the NOAA NCEP NWP models.

October 21, 2010, W. Feltz (CIMSS). GOES-R overview of aviation and nowcasting applications: current status and a look into the future.

October 28, 2010, S. Tulich (NOAA). Tropical squall lines and convectively coupled gravity waves: why do most cloud systems move westward?

November 4, 2010, R. Neale (NCAR). Understanding and modeling the tropical atmosphere: phenomena, processes and resolution.

November 8, 2010, D. Nolan (Univ. of Miami). Fun with point-downscaling.

November 9, 2010, A.W. Omta (MIT). Antarctic temperatures and greenhouse gas concentrations throughout glacial cycles.

November 11, 2010, S. Nesbitt (Univ. of Illinois at Urbana-Champaign). Regimes of orographic precipitation in conditionally unstable flow.

November 18, 2010, R. Schumacher (Texas A&M). Ensemble-based analyses of heavy-rain-producing convective systems.

November 29, 2010, R. Bennartz (Univ. of Wisconsin-Madison). A sharper view of fuzzy objects: clouds and their role in the climate system as seen by satellites.

December 2, 2010, R. Marchand (Univ. of Washington). Evaluating clouds in climate models.

December 9, 2010, A. Heidinger (NOAA/NESDIS/STAR). Advances in infrared radiative transfer applied to the atmospheric pathfinder extended (PATMOS-x) data set.

January 20, 2011, ATS Faculty. Faculty-Intro Jamboree Part II: Overview of research areas and groups in the department.

January 25, 2011, D. Hammerling (Univ. of Michigan). Applications of spatial statistics in the geosciences.

February 3, 2011, S. Naisiri (Texas A&M). Cloud thermodynamic phase in the infrared with AIRS.

February 10, 2011, H. Masunaga (Nagoya Univ., Japan). A satellite study of the atmospheric forcing and response to moist convection.

February 17, 2011, J. de Gouw (NOAA). Aircraft measurements over the deepwater horizon oil spill: The fate of oil compounds and formation of secondary organic aerosol.

February 24, 2011, CIRA Senior Scientists. CIRA-Intro Jamboree: Overview of CIRA research areas and groups.

March 3, 2011, S. Levis (NCAR). Improved land-atmosphere fluxes from including interactive crop management in the Community Earth System Model.

March 10, 2011, P. Sardeshmukh (CIRES). Climate model misrepresentations of Tropical SSTs and their global implications.

March 10, 2011. H. Gosden (CIRA). CIRA Proving Ground Product Data Dissemination and Display at National Weather Service Forecast Offices

March 11, 2011, P. Forster (Univ. of Leeds UK). Revisiting the forcing and feedback framework of climate response.

March 24, 2011. J. Marwitz (Univ. of Wyoming). Severe Super-cooled Drizzle Drops.

March 31, 2011. P. Kushner (Univ. of Toronto). The Northern Annular Mode Response to Surface Forcing.

RESEARCH THEME REPORTS

SATELLITE ALGORITHM DEVELOPMENT, TRAINING & EDUCATION

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

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

PRINCIPAL INVESTIGATORS: Steve Miller and Renate Brummer

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

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

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

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

PROJECT ACCOMPLISHMENTS:

Interactions with Forecast Offices and National Centers. Over the past year CIRA increased their effort to work directly with partnering Weather Forecast Offices (WFO). There are now 10 WFOs nationwide which we can consider to be active CIRA proving ground partners. Depending on the WFO's individual forecast needs the, partner WFOs do receive different proving ground products from our palette of nearly 30 products.

CIRA also 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 continued between CIRA and NOAA's Storm Prediction Center (SPC) and the National Hurricane Center (NHC). New interactions began with the Ocean Prediction Center (OPC), the Hydro-meteorological Prediction Center (HPC), and the High-Latitude and Pacific Region Proving Ground team.

CIRA continued to provide NSSLWRF-based synthetic imagery and a Hail Probability Forecast product to SPC to support the Spring Experiment. The real-time production of the WRF synthetic imagery for four ABI bands continued on a daily base. Four products were developed and sent to NHC during the 2010 hurricane season. These were the Lightning-based TC Intensity Prediction (RII), the Super Rapid Scan Operations (SRSO) from GOES-15 (operated during the Science Test), ABI red-green-blue (RGB) proxy air mass and ABI proxy aerosol/dust products (derived from SEVIRI). Both of the RGB products were demonstrated through GoogleEarth.

Proving Ground Website Development. All CIRA Proving Ground training material (i.e.

product descriptions) were posted on the CIRA Proving Ground webpage. In addition, a real-time Proving Ground webpage was developed which allows the users and public to view newly developed products in real-time. By the end of this reporting period, more than 80% of the CIRA Proving Ground demonstration products can be viewed on-line, on RAMSDIS, or on AWIPS.

AWIPS Development. All new Proving Ground products were tested at CIRA's AWIPS system. Significant progress was made with feeding many more of our demonstration products to several NWS Regional Headquarters. AWIPS proving ground product installation software was developed to support CIRA's partner WFOs with making the necessary AWIPS menu adjustment. CIRA's systems team also continued their effort to stay tuned with the on-going AWIPS II development.

CIRA Proving Ground Product Development. The so-called "GeoColor" product was CIRA's first Proving Ground product to be distributed to the WFO Boulder and Cheyenne. Besides the GeoColor product, CIRA created 17 additional Proving Ground products. 90% of these products are being demonstrated in either AWIPS, N-AWIPS, GoogleEarth, RAMSDIS, or real-time on the web. For a complete list of these products see Table 1 below.
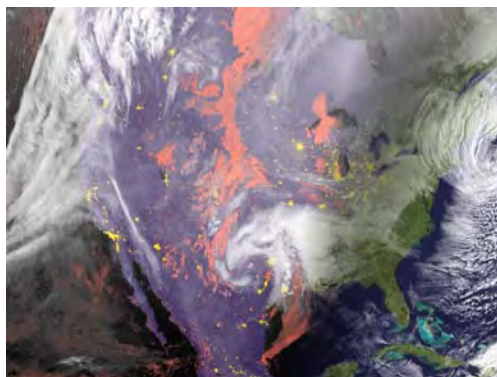

Figure 1. Example of GeoColor product for March 1, 2010 at 1315 UTC. Daytime portions of the image demonstrate a pseudo true-color capability anticipated from the ABI, and the nighttime portion of the scene demonstrates city light detection (from JPSS systems) coupled with low cloud/fog detection (red)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

Product	Satellite	GOES-R relationship
WFO Products		
GeoColor Imagery	GOES/MODIS /DMSP	New Visualization
True Color Imagery	MODIS	GOES-R, Decision Aid
Low cloud / Fog Imagery	GOES	Decision Aid
Cirrus Detection	MODIS	GOES-R, Decision Aid
Orographic Rain Index (ORI)	GOES/Radar/GFS model	GOES-R, Decision Aid
Marine Stratus Cloud Climatology	GOES	GOES-R, Decision Aid
Blowing Dust Detection (3)	GOES/MODIS	Variant of GOES-R Top 12 product
Snow/Cloud Discrimination (3)	GOES/MODIS	Variant of GOES-R Baseline
Volcanic Ash Enhancement (2)	GOES/MODIS	Variant of GOES-R Top 12 product
Vegetation (NDVI)	MODIS	GOES-R Decision Aid, new visualization
Synthetic Forecast Model Imagery	NSSL-WRF-ARW	GOES-R Decision Aid
National Center Products		
NESDIS/StAR LST	GOES	GOES-R Baseline
SPC: Hail Probability Product	GOES/RUC model	Variant of GOES-R Option2 / leveraging from GIMPAP
SPC: Synthetic Forecast Model Imagery	NSSL-WRF-ARW	GOES-R Decision Aid
NHC: Lightning-based TC Intensity Prediction (RII)	Ground-based lightning network/GFS/GOES	GOES-R3 new development
NHC: RGB Air Mass Product	MSG	GOES-R3 new development
NHC: RGB ABI Dust Product	MSG	GOES-R3 new development
NHC: Super Rapid Scan Operations (SRSO)	GOES-11, GOES-12	Training for hi-resolution imagery

Table 1. CIRA Proving Ground Products

Detailed information about each of these products can be found on our website at

http://rammb.cira.colostate.edu/research/goes-r/proving_ground/cira_product_list/ by clicking on the product name.

Figure 2. NHC Proving Ground product developer Dr. Mark DeMaria is training NHC forecaster Daniel Brown on the NHC Proving Ground RGB Airmass product.

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

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

PRINCIPAL INVESTIGATOR: Steve Miller

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

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

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

PROJECT OBJECTIVES: Over the past several years 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. Beginning in 2002, the NESDIS GIMPAP program has been supplemented with the Product System Development and Implementation (PSDI) program to provide research support for applications of satellite data that have a direct relationship with weather and climate forecasting.

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

--GOES-based renewable (solar) energy prediction products for decision makers

--Improved use of GOES tropical cyclone intensity change and formation

--Using quantitative GOES information to improve short-term severe weather forecasts

--International training

--GOES-P[15] initial checkout and data analysis/storage

PROJECT ACCOMPLISHMENTS:

GOES-based renewable (solar) energy prediction products for decision makers

GOES-derived cloud products are being used to compute parameters related to available solar irradiance at the surface, with emphasis on developing predictive capabilities at multiple time scales. The work focuses on two different time periods: short term (< 3hr) and mid- to long-term (>3 hr, to several days) prediction of cloud cover and cloud properties.

Short-term (< 3 hr) prediction of the solar irradiance (direct/diffuse components and total) is based on currently observed cloud cover, retrievals of optical/geometric cloud properties, and coupling of this information to cloud advection fields (based either on numerical weather prediction model output or feature tracking). During the past year the NOAA/NESDIS GOES Surface Insolation Project (GSIP) software was successfully installed and began running routinely for GOES-West (GOES-11) and GFS model data. Access to local surface observations and NOAA/ESRL/GSD's High Resolution Rapid Refresh forecast model were established. Look-up tables of downwelling shortwave irradiance at the surface from SBDART were constructed. Work began on modifying the GSIP code to enable higher spatial resolution insolation output fields as well as on the development of the cloud advection software with the objective to begin the evaluation part of the project.

Figure 1. The Colorado State University Foothills Campus will be used as a validation site. A 15 acre, ~2 MW solar power plant was built by Xcel Energy in 2009 and operated by Renewable Ventures.

Mid to long-term (>3 hrs to several days) prediction of cloud cover likelihood is based on satellite-derived cloud statistics conditioned on model-predicted meteorological flow regimes. Here, the hypothesis is that while models often have difficulty in producing realistic cloud cover due to complicated cloud microphysical processes that are poorly represented and unresolved sub-gridscale features (terrain-induced divergence patterns, temperature gradients, etc) that influence cloud formation., the meso/synoptic scale environmental state (described by temperature, pressure, moisture, wind etc.) predicted by numerical weather prediction models is more robust. As such, statistics on cloud coverage/properties (observed via GOES) conditioned on characteristic meteorological flow/moisture regimes (from the model) may provide improved cloud forecasting skill. This research seeks to couple these "conditional cloud regimes," when identified to a certain level of confidence, to the expected time evolution of the surface solar irradiance. In order to identify characteristic meteorological regimes for selected test locations. various meteorological data from Christman Field (1 km north of the CIRA location) was pulled from the online site and set up into formats readable by Excel, Fortran, IDL or Matlab programs. Using the solar irradiance measurements from Christman, a method to identify solar regimes was developed. It uses the average solar irradiance (as a percent of the theoretically expected value) and the standard deviation over a given four hour period (morning, mid day, evening). It produced a category for each period: clear, scattered, broken, or overcast. While this method showed promise, it was decided to do a similar classification using Principal Component Analysis of the solar irradiance data set that classifies the entire day instead of periods. This method is still in development. In addition, a GSIP cloud typing algorithm has been completed and tested. This can be used if it is decided that cloud type information will be useful to the classification process. To set up a prototype cloud cover probability product for a forecast period of 3 hr to several days a sector covering Colorado was taken from GOES West data for every daylight hour (1400-0100 UTC) during May-September 1999-2009 for imager channels 1-5. Cloud/No Cloud images for each set of images were produced using a visible background/threshold method. Algorithms and procedures using these Cloud/No Cloud images to produce cloud climatologies from different solar regimes have been developed and are ready for use. Seasonal and monthly cloud climatologies for the May-September 1999-2009 period have been produced. These will be used for comparison with solar regime cloud climatologies. Once the solar regimes have been identified, the climatologies for each regime will be produced.

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

Improved use of GOES tropical cyclone intensity change and formation

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

Tropical Cyclone (TC) forecasts affect risk mitigation activities of industry, public and governmental sectors and therefore supports directly NOAA's Weather and Water mission goals. An improved understanding of ET and RW cases will result in improved TC intensity forecasts, which is a top NOAA/DOD priority.

Using quantitative GOES information to improve short-term severe weather forecasts

The goal of this project is to extract information from GOES-derived cloud properties and use this information to make short-term predictions on convective storm evolution throughout the storm's lifecycle. GOES Imager data is being used along with fields from the SPC surface mesoanalysis and the NOAA/ESRL RUC model to predict the probability of severe weather in the 0-6 hour time frame. Cloud properties found to be correlated with severe weather are being tested using a statistical technique. In addition, we are producing a product which assists with short-term severe storm forecasting, and which generates a probability of severe wind, hail, and tornadoes in the GOES-East domain. The proposed work is building upon the pilot studies conducted with FY08-09 GIMPAP funds. This project is a collaborative effort with CIMSS.

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

International Training

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

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

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

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

Figure 2. GOES-15 Imager first full-disk visible imagery fro 06 April 2010 at 1730 UTC.
This project supports the NOAA mission goals of Climate, Weather and Water, and Commerce and Transportation. It also supports the NOAA-wide goals of Geostationary Orbiting Environmental Satellite Acquisitions (final part of Post Launch Testing) as well as Satellite Services (assure quality of data and derived products).

PROJECT TITLE: CIRA Research Collaboration with the NOAA/NESDIS NGDC for the NPOESS SEM Sensor (SEM-N Algorithm Development)

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

RESEARCH TEAM**:** Patrick Purcell, Janet Machol

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

NOAA RESEARCH TEAM**:** Janet Green, NGDC/SWPC

PROJECT OBJECTIVES:

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

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

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

PROJECT ACCOMPLISHMENTS:
The NPOESS Space Environment Monitor (SEM-N) transitioned from the NPOESS program to the USAF Defense Weather Satellite System (DWSS), a follow-on to the current Defense Meteorological Satellite Program (DMSP). The program has been re-titled Space Environment Monitor – Next (SEM-N). DWSS will manifest two SEM-N flight units for launch in approximately 2018 and 2021.

SEM-N is scheduled to fly with an orbital period of approximately 100 minutes, an altitude of approximately 830km in a Sun-synchronous orbit with a 0530 ascending node equatorial 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.

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

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

--Completion of drafts of the Algorithm Theoretical Basis Documents (ATBDs) for both algorithms.   Each document includes a description of the algorithm, the error budget, and the generation and use of proxy data for testing.
--Draft of prototype code for the EI algorithm, tested using proxy data.
--IDL code to test geometrical concepts for the AED algorithm.

2. Manage and engineer SEM-N science grade software and algorithm development.
SEM-N passed a major milestone in August 2010 with successful completion of the Preliminary Design Review (PDR). PDR marked several accomplishments including completion of draft versions of the Algorithm Theoretical Basis Documents (ATBDs), requirements refinement and flow-down from the SEM-N system level to the algorithm level, and logical (high-level) definitions of algorithm flow, interfaces and interdependencies.

Progress towards the SEM-N Critical Design Review (CDR) is well underway with completion of the software architecture for all algorithms. Detailed design of the software physical model is in progress.

Management of SEM-N Algorithm Development remains active as the program transitioned from the NPOESS Integrated Program Office (IPO) to the USAF Defense Weather Systems Directorate (DWSD) and NOAA Joint Polar Satellite System (JPSS) as per White House directive, 01 Feb 2010. Program hardware and

algorithm schedules and budgets are in work for this new phase of the program during FY11.

3. Prepare SEM-N science grade software for operational implementation at NOAA NESDIS and the Air Force Weather Agency.
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 (IIS) in Aurora, Colorado.

While the SEM-N algorithm development task is responsible developing "science-grade" code only (Raytheon's IDPS will transition this to operational code), the program office has acknowledged the need to smooth the back and forth exchange of science-grade and operational versions of SEM-N code. Transitioning operational code back to science-grade and then back to operational can be an expensive process during both the algorithm development and calibration/validation (cal/val) process.

To greatly reduce this excess cost, the NPOESS program initiated a library to emulate the IDPS operational environment, called the Algorithm Development Library (ADL). The SEM-N algorithm team has further developed a framework of adapters to ADL to allow science coders to continue to modify their code that through the adapters will "plug" directly into the operational version.
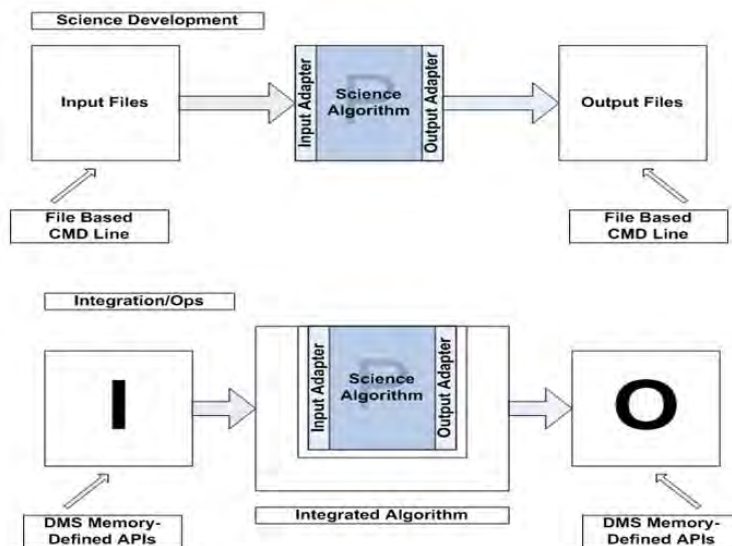

Figure 1. Input-Processing-Output (I-P-O) model for both science (top) and operational environments (bottom).

Figure 1 shows the Input-Processing-Output (I-P-O) model for both science and operational environments. The command based input statements are replaced in operations by calls to memory defined APIs to pull data from the Data Management System (DMS). The input and output adapters allow the same read/write/logging/messaging statements to exist in the science and operational versions of the code.

A prototype of this science/operational code framework has been completed on the SEM-N Suprathermal through Auroral Charged Particles (SACP) Environmental Data Record (EDR) FORTRAN code. ADL is also a major component of the JPSS algorithm development and cal/val process for the sensors manifested on the NPOESS Preparatory Project (NPP) satellite scheduled for an October 2011 launch.

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

PRINCIPAL INVESTIGATOR**:** Bernie Connell

RESEARCH TEAM**:** Hiro Gosden, Dave Watson, Mike Hiatt

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

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

PROJECT OBJECTIVES: 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.

This project supports the NOAA mission goals of Climate, Weather and Water, and Commerce and Transportation. It also supports the NOAA-wide goals of Geostationary Orbiting Environmental Satellite Acquisitions as well as Satellite Services.

PROJECT 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's 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 continues to expand an existing satellite data archive and retrieval database for the use by other CIRA researchers.

In addition, we added real-time MIRS data ingest to the online archive of polar data, and purchased hardware (10 TB NAS) for the repository. We developed a stand-alone McIDAS format data file reader consisting of user callable libraries that are independent of the McIDAS software package. The software runs under several FORTRAN compilers. This new software will be tested in-house and will then be released to other users.

Our Polar RAMSDIS system got updated to include NOAA-19 AVHRR GAC data ingest and display. Work also began on a new design for the system to work with and display data under JPSS.

All CIRA-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

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

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

NOAA RESEARCH TEAM: Mark DeMaria

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

This project supports NOAA's goals of Weather and Water, Commerce and Transportation, and Climate. Enhanced training and coordination of training accomplished under this project will prepare forecasters and managers on how to utilize imagery and products to provide improved services in these areas.

PROJECT ACCOMPLISHMENTS:

SHyMet Courses:
SHyMet launched a new course titled "Tropical SHyMet" in August 2010:
http://rammb.cira.colostate.edu/training/shymet/tropical_intro.asp

The Tropical track of the Satellite Hydrology and Meteorology (SHyMet) Course covers satellite imagery interpretation and application of satellite derived products in the tropics as well as the models used at NHC for tropical cyclone forecasting. The course is administered through web-based instruction and consists of 7 modules for a total of 6 hours of instructional content.

Modules:
--An Overview of Tropical Cyclone Track Guidance Models used by NHC.
--An Overview of Tropical Cyclone Intensity Guidance Models used by NHC.
--Satellite Applications for Tropical Cyclones: Dvorak Technique.
--Basic Satellite Imagery Interpretation in the Tropics.
--Ensemble Tropical Rainfall Potential (eTRaP).
--ASCAT Winds.
--Blended Total Precipitable Water (TPW) Products.
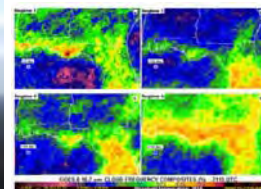
As part of the optional sessions for the SHyMet for Forecasters course, 2 new training modules were completed and added in December 2010:

--Regional Satellite Cloud Composites from GOES.
--Volcanic Ash Hazards Part 1

Additional effort was directed to Volcanic Ash Hazards Part 2 and will be made available in Spring 2011.

The most recent addition to SHyMet was during the last month of this reporting period (March 2011), and it is new course titled "Severe Thunderstorm Forecasting".

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

This course covers how to integrate satellite imagery interpretation with other datasets in analyzing severe thunderstorm events. This course is administered through web-based instruction and consists of 7 modules (8.5 hours) of core topics and 4 modules (2.5 hours) of optional topics.

Core Courses:
--Mesoscale Analysis of Convective Weather Using GOES RSO Imagery
--Use of GOES RSO imagery with other Remote Sensor Data for Diagnosing Severe Weather across the CONUS (RSO 3)

--GOES Imagery for Forecasting and Nowcasting Severe Weather
--Water Vapor Imagery Analysis for Severe Weather Forecasting
--Synthetic Imagery in Forecasting Severe Weather
--Predicting Supercell Motion in Operations
--Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection

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

The first SHyMet course was directed towards the NWS Intern and was developed during 2004-2005 (http://rammb.cira.colostate.edu/training/shymet/intern_intro.asp). It was launched in April 2006 and continues to be offered online. The content for the second course Satellite Hydrology and Meteorology for the Forecaster was developed during 2008 and 2009 (http://rammb.cira.colostate.edu/training/shymet/forecaster_intro.asp) and was offered starting in January 2010.

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

SHyMet training metrics April 1, 2010 – February 28, 2011

By Development Plans:	Registrations Apr10 – Feb11	since April 2006
SHyMet Intern	44	299
SHyMet Forecaster	30	
SHyMet Tropical	11	

By individuals sessions through NOAA's Learning Management System:

	Registrations Apr10 – Feb11	since April 2006
Intern Sessions	616	3664
Forecaster Sessions	301	
Topical Sessions	260	

PROJECT TITLE: Global Tropical Cyclone Formation Probability Product

PRINCIPAL INVESTIGATOR: John F. Dostalek

RESEARCH TEAM: Andrea Schumacher, David Watson

NOAA TECHNICAL CONTACT: Matthew Seybold, NOAA/NESDIS/OPD

NOAA RESEARCH TEAM: Mark DeMaria, John Knaff

PROJECT OBJECTIVES: The NESDIS Tropical Cyclone Formation Probability (TCFP) product uses environmental and satellite-based convective parameters to estimate the 24-hour probability of TC formation over 5 x 5 degree latitude/longitude grid boxes in the N. Atlantic, N.E. Pacific and N.W. Pacific tropical basins (Schumacher et al. 2009). The main goal of this project is to update and extend that spatial domain of the current product to better meet user needs. Project objectives include:

1) Extending the NESDIS TCFP Product to include the Indian Ocean and Southern Hemisphere,

2) Adding data from 2006 - 2008 to developmental dataset for the product,

3) Replacing the Levitus climatological SST input parameter with Reynolds weekly SST, and

4) Implementing new Global TCFP operationally at NESDIS.

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

PROJECT ACCOMPLISHMENTS: The updates listed in Objectives #1 through #3 above were completed and an experimental version of the Global TCFP product has been running at CIRA since Aug 2009. NESDIS operational systems have been under a mandatory freeze for the entirety of the report timeframe. As such, plans to install the Global TCFP on NESDIS development and operational systems (Objective #4) were put on hold until the freeze is lifted on April 15, 2011.

During this report timeframe, the experimental Global TCFP has continued to run in real-time at CIRA and its outputs have been monitored and evaluated. In addition, coordination activities continue so that the transition to pre-operations can proceed as soon as the freeze is lifted. Validation was performed for the Global TCFP for 2010 and the product once again demonstrated forecast skill in all global TC basins.

The updates listed in Objectives 1 through 3 above were completed and an experimental version of the Global TCFP product has been running at CIRA since Aug 2009.
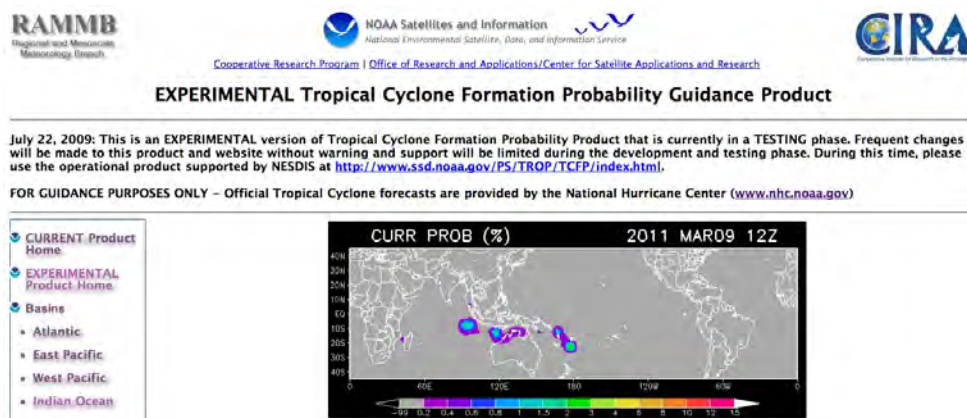

Figure 1. Screen snapshot of the experimental Global TCFP product web page that has been running at CIRA since August 2009.

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

PRINCIPAL INVESTIGATOR: John Dostalek

RESERCH TEAM: Renate Brummer

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

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

PROJECT OBJECTIVES: The overall goal of this Joint Hurricane Testbed (JHT) funded project was to improve the existing operational SHIPS rapid intensification index (RII) described in Kaplan et al. (2010) by incorporating predictors from three new sources of information: GOES infra-red (IR) imagery, total precipitable water (TPW) derived from microwave imagery, and boundary-layer predictors derived from GFS analyses. Although the proposal called for improvements to both the Atlantic and East Pacific version of the operational RII, the first year of the project was designed to focus primarily on the development and testing of the new RI predictors for the Atlantic basin version of the RII while the second year was designed to do the same for the East Pacific version. This project supports the following NOAA mission goals: Weather and Water.

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PROJECT ACCOMPLISHMENTS:

Task 1 – Predictor Selection

Predictor selection was based on the new predictors ability to significantly increase the skill of the existing operational RII (99.9% based on a two-tail Student's t-test), which has three intensity change thresholds (25 kt, 30 kt, and 35 kt change in 24 hours). In an effort to keep the number of predictors limited new predictors were used to replace existing predictors, which number eight. Based upon this criteria, three new predictors were selected to replace those in the existing operational version. The first of these three new predictors is the percentage of the area within 500 km radius 90° upshear of the storm center with TPW < 45 mm at time T=0 h. This predictor replaced the 850-700 hPa relative humidity predictor. The second new predictor

consists of the second motion relative IR principle component (front-left-to-rear-right convective asymmetry). This predictor replaces the predictor based on the percentage of pixels colder that -30C within 200 km of the storm. The final predictor added is the inner-core dry air predictor that is calculated from the GFS analyses and the current NHC intensity. This predictor replaces the ocean heat content predictor in the current scheme.

In addition to replacing the three old operational RI predictors with three new ones described above, the scaling methodology that was used for the potential intensity and persistence predictors was modified slightly since sensitivity tests showed that doing so improved the overall skill of the model for the developmental sample.

Task 2 - Preparation of Atlantic RII for real-time testing during the 2010 Hurricane Season

In preparation for testing of the experimental RII during the 2010 Hurricane Season, an offset correction was determined by comparing the NESDIS operational TPW product with the NRL TPW analyses that were used to derive the experimental Atlantic RII. This offset will be applied to the operational NESDIS TPW product that will be employed when running the experimental Atlantic RII in real-time. In addition, GOES-IR principle component analysis, TPW, and GFS boundary-layer predictors were generated for cases from the 2009 Atlantic hurricane season.

The updated 1995-2009 SHIPS developmental dataset that includes the aforementioned newly developed (TPW, GFS, GOES-IR PCs) predictors will be used to re-derive the experimental Atlantic RII for use during the upcoming 2010 Hurricane Season. In addition, a

routine will be written to compute and output the new RII results in real-time. The experimental Atlantic RII will then be run in near real-time at CIRA and the output made available to the NHC commencing at the latter part of August 2010.

Task 3 - Development of E. Pacific RI predictors and derivation of experimental E. Pacific RII

Preliminary development of RI predictors for use in the derivation of an experimental E. Pacific RII has commenced. A total of 15 new boundary-layer predictors have been generated using GFS analyses for the 1995-2008 developmental sample. Also, the formatted TPW files required to generate the E. Pacific TPW predictors have been created for the 1995-2008 developmental sample. Finally, the generation of GOES-IR imagery for the Eastern Pacific 1996 season, which previously did not exist, has begun. The complete image records for TD01, TD02, Alma, Boris, Christina, Douglas, TD06, and Elida have been created and partial records for Genevieve have also been generated. These additional cases will be employed to increase the sample of E. Pacific cases that will be used when performing the principle component analysis on the GOES-IR imagery for that basin.

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

PRINCIPAL INVESTIGATOR: Bernie Connell

RESEARCH TEAM: Luciane Veeck

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

NOAA RESEARCH TEAM: Mark DeMaria

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

--To provide high quality and up-to-date training and supporting resources on current and future meteorological and other environmental satellite systems, data, products and applications;

--To enable the regional training centers to facilitate and foster research and the development of socio-economic applications at the local level by the National Meteorological and Hydrological Services.

This project provides a person dedicated to support VL activities, to address the training needs of its evolving audience and to provide strong project coordination and management. This project directly supports NOAA commitments to WMO's Coordination Group for Meteorological Satellites (CGMS) and it supports NOAA's goals of Weather and Water, Commerce and Transportation, and Climate. Enhanced training and coordination of training accomplished under this project will prepare forecasters and managers on how to utilize imagery and products to provide services in these areas.

Figure 1. VLab logo

PROJECT ACCOMPLISHMENTS:

Activities of Luciane Veeck, Technical Support Officer:
--Monitoring CoEs' activities – Keeping in constant communication with people involved, exchanging ideas for possible VLab events and investigating the main needs and expertise of each CoE;
--Assisting in the establishment of Regional Focus Groups (RFG)
--Participation in virtual meetings and courses

25-26 May and 19-20th October VLab web meetings. The May VLab meetings had as main objective the approval of the draft agenda for the VLMG-5 meeting in Beijing. Outcomes from the ET-SUP meeting were also presented as they included a series of actions for the VLab and TSO. The October VLab meetings had as main objective the discussion of the "Aviation week" to be organized, updating information about WMO Doc 258, VLab participation at SYMET XI and actions review.

May, June, September, November: Creating Activities for Learning Meteorology (CALMET) online 2010 – the month of May focused on "Why and how to use online discussion forums", June focused on "The challenge of competency assessment in aeronautical meteorology", September focused on "Communicating and working as a virtual team", and November focused on "Experiences in new satellite training methods".

Reports
VLab report to WMO ET-SUP (15-19 March, Geneva)– A summary report of VLab activities based on the reports submitted by each CoE for the period May to December 2009, was created to be presented at the ET-SUP

VLab report to WMO CGMS-38 – A full VLab report of activities since September 2009 was compiled to be presented at the 38th meeting of CGMS (8-12 November, New Delhi, India).

Preparation of the VLab calendar of activities to be offered in the next 12 months was produced based on information collected from each CoE.

Project Presentations and Professional Meetings

27-30 April The Intergovernmental Oceanographic Commission (IOC) of UNESCO conference (IOC50) "50 Years of Education and Awareness Raising for Shaping the Future of the Oceans and Coasts" was held in St Petersburg, Russia. A presentation about the VLab programme was given

22-30 May WMO "Train the Trainer" course in Sibiu, Romania – "Train the Trainer" is a training event organized by the WMO Education and Training Program as part of a series of Regional Training Seminars for National Trainers. The TSO participated as a lecturer during the second week of the course, delivering sessions related to distance learning and teaching.

13-15 June Meeting of the "Pedagogical Assistance to Trainers" working group (PATTT WG) of the Eumetcal Program in Vienna (Austria). The working theme for the meeting was "Evaluation"

12-16 July The VLMG-5 meeting in Beijing (12-14 July), followed by the "Seminar on Training Matters" from 15 to 16 July. The TSO had responsibilities preparing for the meeting, working closely with the local organizers during the meeting, and writing up actions and recommendations of the meeting. Hands-on training sessions on the use of the VLab Moodle site and the use of ESRC were also coordinated

by the TSO during the "Seminar on Training Matters".

20-24 September A VLab poster on training and outreach was prepared for the "2010 EUMETSAT Meteorological Satellite Conference". The poster was designed by the TSO and was presented by Jose Prieto (EUMETSAT).

25-29 October "Eleventh WMO Symposium on Education and Training" A poster "Ten years of VLab - Challenges ahead of the VLab model of Education and Training" was designed by the TSO and Eduard Podgayskiy (CoE in Russia), who was presenting the poster in Indonesia.

29 November – 2 December Participation in the EUMETCAL Workshop – This workshop took place at WMO headquarters in Geneva. The TSO presented a 15 min talk on "Trainer Competencies" and also participated on the Pedagogical Assistance to Trainers (PATT) working group meeting.

Figure 2. Participants attending the 5th WMO Virtual Laboratory Management Group

Meeting held at the China Meteorological Administration Training Center in Beijing, China 12-16 July 2010. The meeting included representation from the supporting satellite operators [CMA (China), CONAE (Argentina), EUMETSAT (Europe), INPE (Brazil), JMA (Japan), NOAA/NESDIS, ROSHYDROMET (Russian Federation), and Korea)] as well as WMO training centers of excellence [Argentina, Costa Rica, Barbados, Brazil, China, Niger, Oman, Russian Federation, and South Africa].

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program - Prasanjit Dash, Research Scientist - An Improved SST Product from AVHRR/3 Sensor Flown Onboard MetOp-A

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM**:** Prasanjit Dash, Research Scientist

NOAA TECHNICAL CONTACT: Alexander Ignatov, STAR

NOAA RESEARCH TEAM: Prasanjit Dash

PROJECT OBJECTIVES: Robust SST Quality Monitor for all major Global products (polar-satellite based and level analyzed SST fields):

--SST Quality Monitor (SQUAM) – an approach towards "one-stop" shop for monitoring all major SST products
--Level-2 SQUAM
   --NESDIS AVHRR Global Area Coverage (GAC)
   --NAVOCENAO AVHRR GAC
   --NESDIS and Meteo France O&SI SAF Full Resolution Area Coverage (FRAC)
--Level-3 SQUAM (PathFinder version 5.0)
--Level-4 SQUAM (inter-compare 12 different global products and consistently validate against in situ SST)
--SST Calibration and validation
--Maintain in situ Quality Monitor (iQUAM)

PROJECT ACCOMPLISHMENTS:
(A high-level gist is available at:
http://www.star.nesdis.noaa.gov/sod/sst/squam/ squam_version.htm)

Significant improvements and additions to the Sea Surface Temperature (SST) Quality Monitor (SQUAM):
http://www.star.nesdis.noaa.gov/sod/sst/squ am/ were made (developed by the reporting administrative professional, AP, in discussions with his technical advisor, TA). The SQUAM has grown from a "NESDIS prototype for limited products" to an "international community NRT SST monitor". A number of additions, as described below, were made:

--The SQUAM structure was redesigned into three major sub-divisions: Level-2 (L2), Level-3 (L3) and Level-4 (L4). These three major sub-divisions provide the flexibility to include any SST data, appropriately – the vision is to eventually have all major global products in SQUAM analyses and provide a "central" SST monitor.

Level-2	Level-3	Level-4
AVHRR GAC NESDIS MUT (heritage) NAVO SEATEMP NESDIS ACSPO **AVHRR FRAC** NESDIS ACSPO EUMETSAT O&SI SAF **MODIS** NASA MOD28/MYD28 (coming) NESDIS ACSPO (coming) **VIIRS (proxy)** NGS/Raytheon IDPS (coming) NESDIS ACSPO (coming)	**AVHRR GAC** NODC/RSMAS PathFinder v5.0	**Bulk** Reynolds (AVHRR) : DOI_AV Reynolds (+ AMSRE-E): DOI_AA RTG high resolution: RTG_HR RTG low resolution: RTG_LR NAVO K10 NESDIS POESGOES NASA JPL 1km G1SST: G1SST **Foundation/Sub-skin** OSTIA, UK MetOffice CMC 0.2º, Environment Canada ODYSSEA, MERSEA France **Ensemble of L4 SSTs** GHRSST Median Ensemble

Level-2 SQUAM
--SQUAM continues to monitor the NESDIS AVHRR Global Area Coverage (GAC) L2 products, i.e., from the Main Unit Task (MUT) and the newer Advanced Clear-Sky Processor for Oceans (ACSPO) products (*previously reported*).

--AVHRR GAC SSTs generated by the US Naval Oceanographic Office (NAVO) were included in the SQUAM, in collaboration with the NAVO colleagues, in Mar 2010. Analyses of "NAVO SST – Level-4 SST" are made using Maps, Histograms, Time-series plots, Dependency plots, and Hovmöller diagrams. Along with the monitoring of NAVO SST products, this also helps in comparing NESDIS heritage products with NAVO products. URL: *http://www.star.nesdis.noaa.gov/sod/sst/squam/NAVO/*.
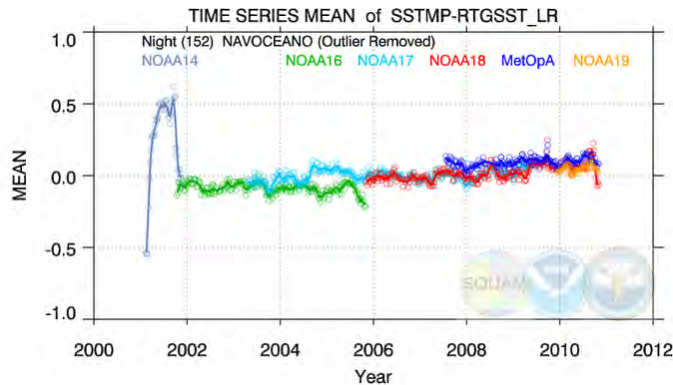

Figure 1. Mean of "Night NAVOCEANO *minus* Real Time Global (RTG) low resolution SST" for multiple platforms. More analyses are found at L2-SQUAM NAVO webpage (link provided above).

--AVHRR Full-Resolution Area Coverage (FRAC) 1km SSTs were included for continuous monitoring in the SQUAM. In this context, two products are analyzed together: one generated by the NESDIS ACSPO and one generate by the **EUMETSAT O&SI SAF at Meteo France**, resulting in collaboration with the French SST experts. It provides an avenue to inter-compare performances of high-density AVHRR SST data, generated independently. URL: *http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC/*.
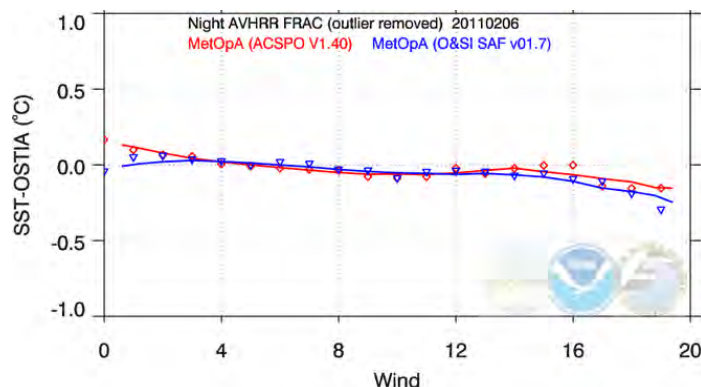

Figure 2. "AVHRR FRAC night SST – UK MetOffice OSTIA" dependency on wind speed. Such diagnostics plots (along with others) are used for continuous monitoring of performances of SST processors and products. More FRAC analyses are found at the web-link provided above.

L2-SQUAM further plans: Analysis of various L2 products has provided an easy access for checking the relative performances of various products. Also, it has opened discussions with

other experts in the U.S. (e.g., Florida State Univ. and Remote Sensing Systems) for validation of diurnal warming models. These endeavors are likely to take a few years before even being preliminarily implemented but, for the first time, have provided a unique opportunity to do such validation studies. We have received interests from external colleagues for such collaborative efforts and are in the planning phase.

Level-3 SQUAM
The level-3 products are value-added level-2 observations and under the PathFinder project

such SST data are available for a long-term AVHRR dataset (>25 years). The PathFinder (PF) data are unique in the sense that they are available for the longest time period; however, the versions are being updated with several improvements. A set-up was made in SQUAM to quantitatively evaluate the performance of updated versions, and the current PF v5.0 was thoroughly processed for detailed analyses in Sept 2010. The work has been performed in close collaboration with some of the PathFinder colleagues; namely, at NESDIS NODC and at NASA JPL.
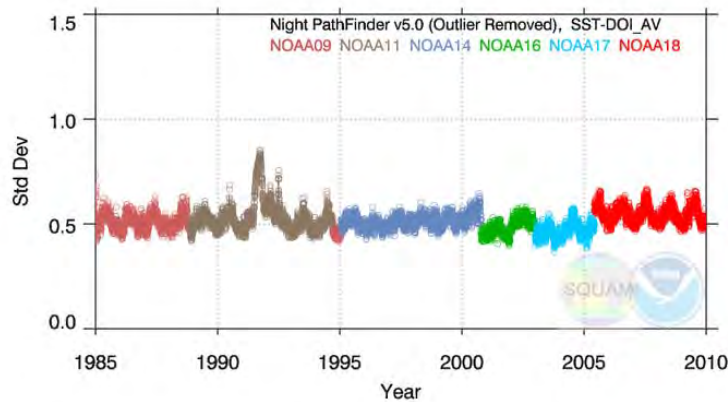
L3-SQUAM URL: *http://www.star.nesdis.noaa.gov/sod/sst/squam/PF/*.

Figure 3. Standard deviation of "PathFinder v5.0 night SST – daily OISST", for various platforms within the 25 years of data availability. While this comparison study sheds light on monitoring of L2 and L3 products, the anomalous observations may partially be due to the reference SSTs also (in this case OISST). The reference L4 SSTs are analyzed separately in another work (reported in the next section).
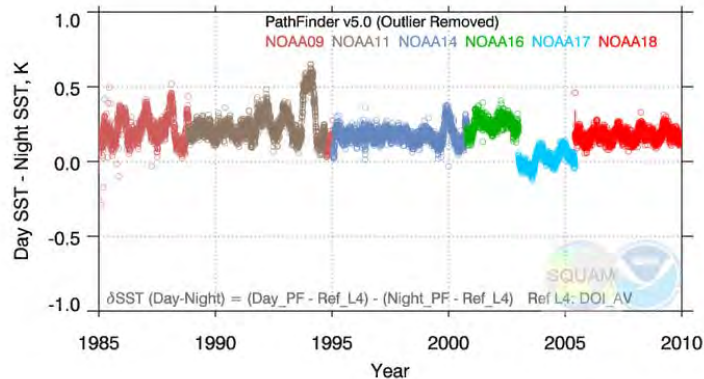

Figure 4. "Day *minus* Night" values of PathFinder v5.0 SSTs calculated by double differencing technique (for more on double differencing see Dash *et al*., 2010, J.Tech, vol 27, pp. 1899-1917). The values are less for morning platforms (e.g., NOAA-17) than for afternoon platforms. Once diurnal variation (DV) in warming is taken into account properly, these lines are expected to reconcile (future plans for validation of DV models).
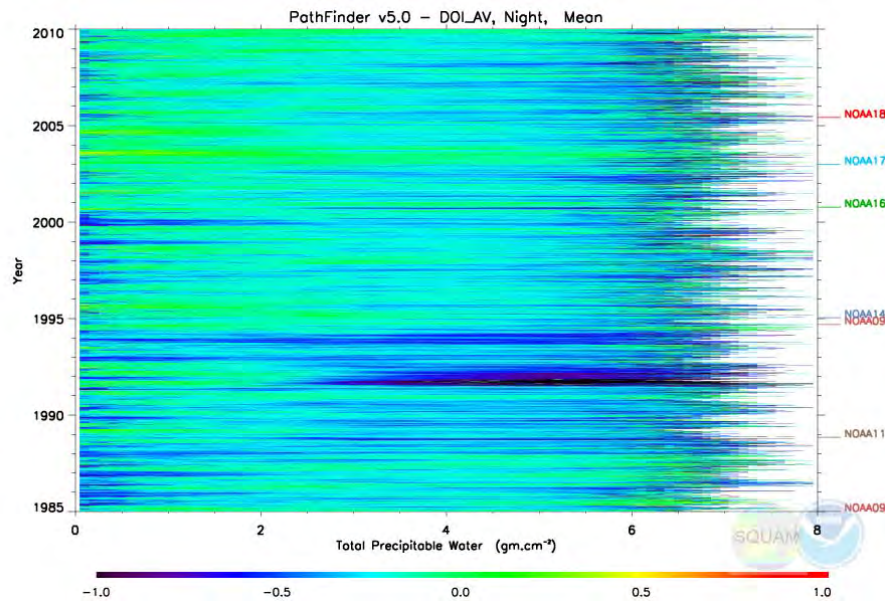
Figure 5. "PathFinder v5.0 night SST – daily OISST" dependence on total precipitable atmospheric water content. Temporal coverage of the platforms is shown to the right. Such diagnostics are used to assess algorithm performance on geophysical conditions. Also note the impact of volcanic aerosols due to Mt. Pinatubo eruption (June, 1991).

More analyses of PathFinder SST are found at the web-link.

L3-SQUAM further plans: The L3-SQUAM has provisions to include the next versions of PathFinder, when available, with a minimum effort. The AP and TA had initial discussions (NESDIS/NODC) with the colleagues responsible for the next version, *i.e.,* PF v6.0.

Level-4 SQUAM
A large number of global gridded gap-free daily SST analyses (called Level 4, or L4, analyses) are produced by various centers around the world. These products have been developed for use by a wide range of applications including climate monitoring, seasonal forecasting, weather forecasting, operational ocean forecasting as well as scientific research. Although the L4 SST production is not the primary task of our SST team, it still is used as a first guess for many of our applications; hence, it is necessary to understand the commonality and differences between these products. Hence, following this interest and request from NCEP

partners, a L4-SQUAM was set-up for inter-comparison and validation of such products.

As of this writing of this report, the following daily L4 SSTs are monitored in L4-SQUAM: two NCDC OISST, aka, Reynolds (AVHRR, AVHRR+AMSR-E), two UK Met office (OSTIA and GMPE), two NCEP RTG (high and low resolution), US NAVO K10, NESDIS POES-GOES blended, NASA JPL G1SST, Canadian Meteorological Centre's 0.2°, French IFREMER ODYSSEA, and Australian BoM GAMSSA products. All these products have been added in L4-SQUAM during different months of the reporting period. Efforts are also underway to include some of the remaining L4 products (JPL MUR, NRL NCODA, RSS IR and IR+MW, and Japanese MA MGDSST). Besides the statistical intercomparisons for available time lengths, all the L4 SSTs are also consistently validated against quality controlled *in situ* (drifters, ships, coastal and tropical moorings) data available from NESDIS *in situ* quality monitor (iQUAM); *http://www.star.nesdis.noaa.gov/sod/sst/iquam/).* L4-SQUAM URL: *http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/.*
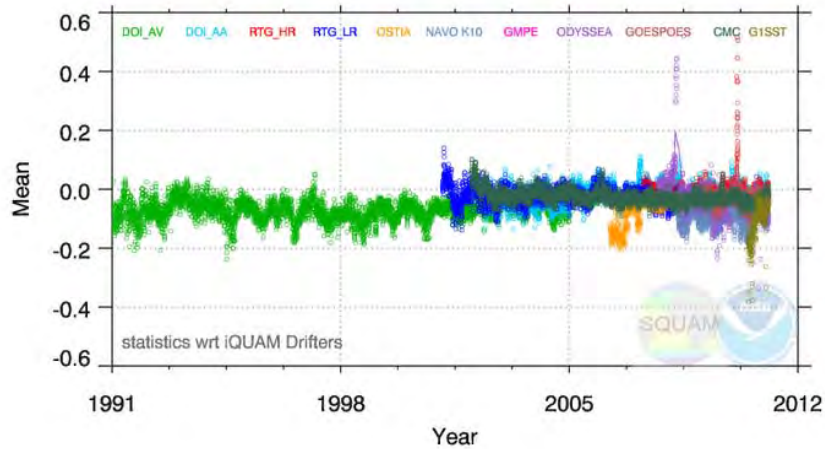
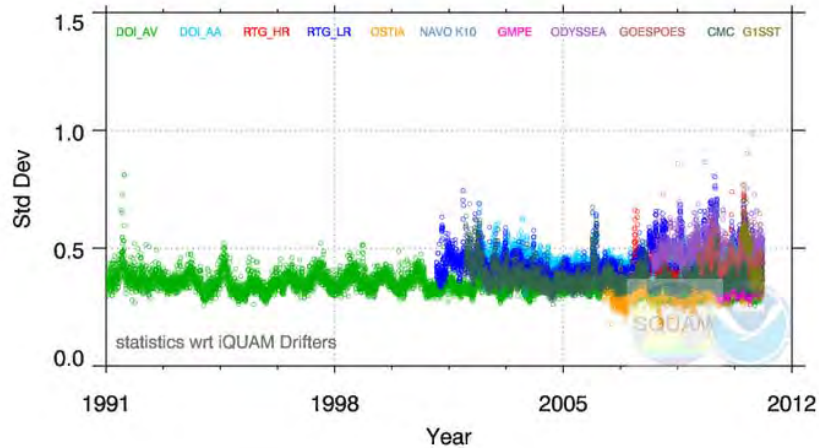Figure 6. Mean of "daily L4 SSTs – quality controlled drifters".

Figure 7. Same as Fig. 6 but for standard deviation.

The L4-SQUAM has received a positive response from the international SST community and also has been recognized as one of the main modules in the Global High Resolution SST (GHRSST) Intercomparison Technical Advisory Group (IC-TAG). We also receive and respond to external requests to incrementally add the available L4 products.
URL: *http://www.ghrsst.org/The-Inter-Calibration-TAG-%28IC-TAG%29.html*

L4-SQUAM further plans:
--Include some of the remaining L4 SSTs in the SQUAM.
--It is also critical that these results are documented in peer-reviewed papers to facilitate

the user community in understanding the subtleties in differences of these products.
--Also, currently all this processing is performed in the NESDIS/STAR research environment and an operational environment is mimicked using robust scripts. At a suitable time, the L4-SQUAM may be transferred to an operational environment (NOAA OceanWatch or OSDPD).

SST Calibration and Validation (CalVal) *(was necessary to take over after a postdoc left)*

--CalVal of NESDIS heritage Main Unit Task (MUT) SST was completely redesigned from the beginning including creation of monthly match-ups of MUT SST and iQUAM. This was required due to uncovering of an issue with the heritage

system, which was set-up a few decades ago (reported in the previous annual self-appraisal). The newer CalVal system performs both *conventional least square fit* and *robust regression* to calculate SST coefficients for both day and night equations, for all available platforms. 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. URL: *http://www.star.nesdis.noaa.gov/sod/sst/calval/MUT_IQUAM/*.

SST CalVal further plans:
--include other L2 and L3 products (as time permits- in a few years).
--It was realized that the monitoring and validation are more appropriately shown at one place, hence, the SQUAM and the Val part of CalVal will be combined under the SQUAM umbrella (already done for L4-SQUAM). (We will still maintain an internal page for extensive CalVal information). This is also helpful for NESDIS STAR visions to have a common place for all SST products.

Maintain *insitu* Quality Monitor (iQUAM) *(was necessary after a post doc left)*

Maintain seamless functioning of the in situ Quality Monitor (iQUAM), which was primarily developed by another post doc who left last year. The iQUAM provides quality controlled in situ data, required for SST validation purposes. *It is expected that the original developer may externally collaborate with STAR, after which it will be transitioned back to the original developer*. URL: *http://www.star.nesdis.noaa.gov/sod/sst/iquam/*.

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – Lide Jiang, Research Scientist

PRINCIPAL INVESTIGATOR: Steven Miller

RESEARCH TEAM: Lide Jiang

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

NOAA RESEARCH TEAM: Menghua Wang

PROJECT OBJECTIVES:

--Add VIIRS SDR import capability to MSL12 package
--Assess the capability of a bio-geo-chemical model (ChesROMS) in simulating chlorophyll concentration
--Assess tidal effect on chlorophyoll concentration and light attenuation coefficient (K490) in Chesapeake Bay, East China Sea, etc using an ocean model (ROMS).
--Assess contribution of absorbing aerosols along US east and west coasts.

PROJECT ACCOMPLISHMENTS:

--Successfully made the new MSL12 package able to read VIIRS proxy SDR and process it to get various products (nLw, chlorophyll), validated the results against MODIS-AQUA data, and documented the code changes and validation results.
--Simulated Chesapeake Bay from 2007~2010 and compared model results with remotely sensed (MODIS/Aqua) and in-situ (Chesapeake Bay Program) measurements.
--Established a high-resolution Chesapeake Bay tidal model.
--Compare MODIS/Aqua derived absorbing index (Shi & Wang 2007) with observations from AERONET.
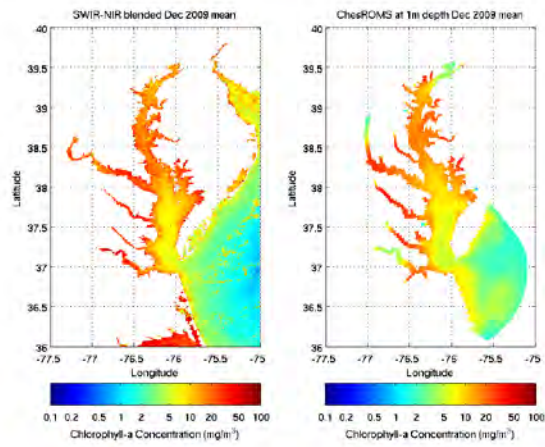
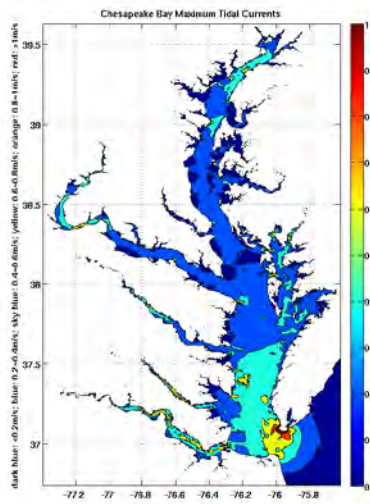Figure 1.   Comparison of chlorohpyll-a concentration between satellite derived and model simulated

Figure 2. Spatial distribution of tidal current magnitude derived from the high-resolution tidal model

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – Peter Kiss, Post Doc

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Peter Kiss, CIRA Visiting Scientist, Post Doc
Time on project: Dec 16 2010 – Feb 28 2011

NOAA Technical Contact: Alexander Ignatov, Chief, Ocean Sensors Branch, STAR/SOCD

NOAA RESEARCH TEAM: Alexander Ignatov, Chief, Ocean Sensors Branch, STAR/SOCD

PROJECT OBJECTIVES: Optimize regression Sea Surface Temperature (SST): formulations alternate to Multi-Channel SST (MCSST) and Nonlinear SST (NLSST).

PROJECT ACCOMPLISHMENTS: Various regression SST algorithms have systematically been tested on simulated (Community Radiative Transfer Model) AVHRR (Advanced Very High Resolution Radiometer) channel 4 and 5 brightness temperatures and Reynolds SST data for the period Jan 1 2011 – Jan 31 2011 from Advanced Clear Sky Processor for Oceans (ACSPO) v1.4. The results suggest that minor improvements are possible compared to the NLSST algorithm (formulation of NLSST: Le Borgne et al. Remote Sensing of Environment 115 (2011) 55-65) by incorporating water vapor

in the regression. Further minor improvements can be achieved by including a term in the regression resembling the atmospheric correction (a product of surface-air temperature difference, airmass, and total column water vapor) – compare Figures 1 and 2. The effects of uneven sampling (in parameter space) were tested; the results showed to be robust. These new algorithms however did not manage to eliminate the regional biases characteristic of regression SST algorithms. Nevertheless the results suggest that the use of atmospheric profiles and radiometric calculations in determining the regression coefficients – in addition to first guess SST and water vapor data – might lead to improved performance of regression SST algorithms.
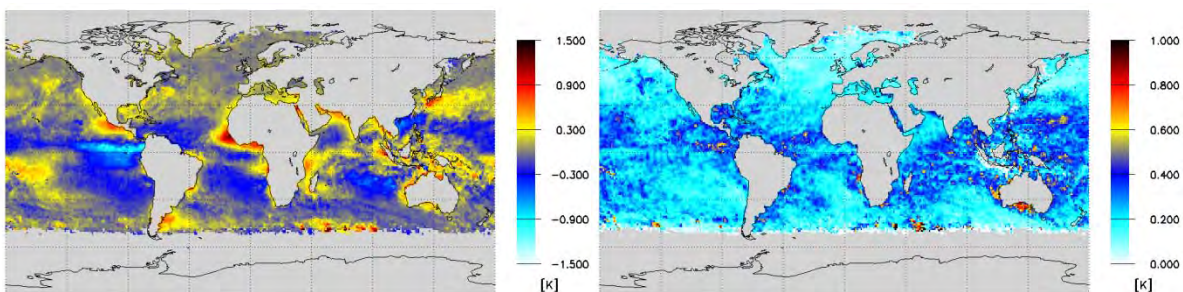

Figure 1. Bias (left) and standard deviation (right) for the NLSST regression model (7 parameters). The globally averaged root-mean-square error of the model is 0.334 K.
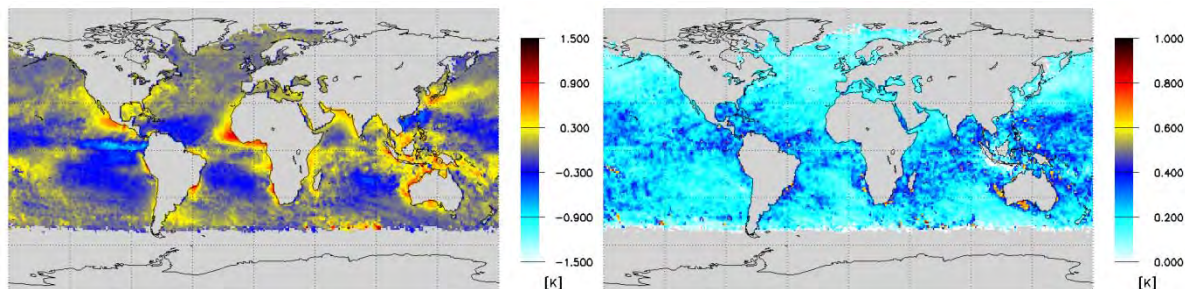
Figure 2. Bias (left) and standard deviation (right) for the 10 parameter TWTD2SST model, which uses water vapor and two terms resembling the atmospheric correction in addition to those in the NLSST model. The globally averaged root-mean-square error of the TWTD2SST model is 0.296 K.

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – XingMing Liang, Research Scientist

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Steve Miller, XingMing Liang, and Korak Saha

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Alexander Ignatov, NOAA/NESDIS/STAR; John Sapper, NOAA/NESDIS/OSDPD; Yuri Kihai, Perot System Government Services & NOAA/NESDIS; Boris Petrenko, IMSG & NOAA/NESDIS; John Stroup, IMSG & NOAA/NESDIS

PROJECT OBJECTIVES: The major objectives for 2010 were to document CRTM (Community Radiative Transfer Model) daytime performance, re-submit MICROS (Monitoring of IR Clear-sky Radiances over Oceans for SST) peer-review paper on JTECH, and develop ACSPO V1.40 and AQUAM (Aerosol Quality Monitor). The following specific tasks were accomplished toward these objectives.

PROJECT ACCOMPLISHMENTS:
--Improvement of daytime CRTM performance was documented and presented on 13th AMS Conference on Atmospheric Radiation. http://ams.confex.com/ams/13CldPhy13AtRad/techprogram/paper_170593.htm
The new proposed surface reflectance model was adopted in CRTM v2.0.

--The paper on MICROS was accepted in the Journal of Atmospheric and Oceanic Technology.

--ACSPO V1.40 was developed and documented to:
    --Update CRTM version;
    --Add OSTIA SST as an option for CRTM input in addition to Reynolds SST;
    --Reconstruct RTM model to be ready for coming CRTM parallel processing.

--The GOCART (Goddard Chemistry Aerosol Radiation and Transport) model was tested in ACSPO. The preliminary result of the simulated aerosol optical depth has been fed back to the CRTM Team and GOCART Team.

--Aerosol Quality Monitor (AQUAM) is being developed to monitor AVHRR and MODIS aerosol products. AQUAM beta version is currently under internal review. Preliminary results show that AVHRR aerosol product in ACSPO needs further quality-control.

--ACSPO V2.0 was tested out on MICROS.

--Daily Reynolds SST was added to SEVIRI-ACSPO as an option for CRTM input, in addition to weekly.

--Worked with Dr. Saha on adding SD/RSD analysis on MICROS, in addition to mean/median analysis.
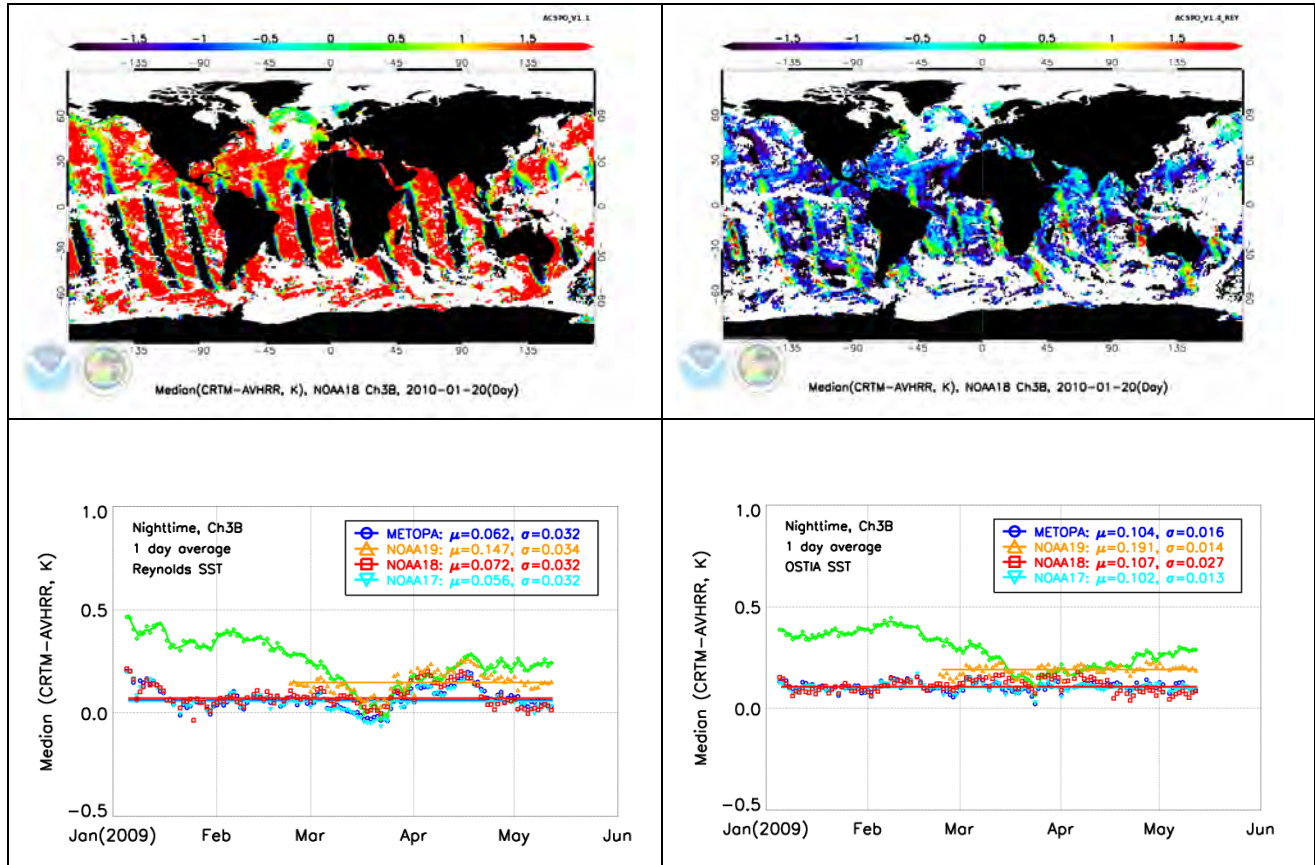
Figure 1. ACSPO V1.3 (Left panels) vs V1.40 (Right panels). Daytime M-O bias significantly reduced in ACSPO V1.40 (upper right) by using specular surface reflectance model in CRTM 2.02 instead of Lambertian in ACSPO v1.30 (upper left); The M-O variations are reduced if OSTIA SST is used as CRTM input in ACSPO V1.40 (bottom right) instead of Reynolds daily SST (bottom left) .
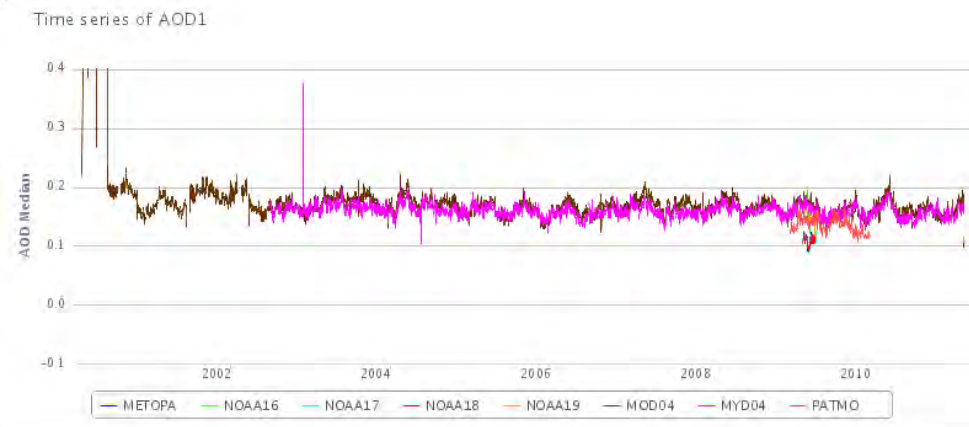
Figure 2. Time series of global median aerosol optical depth for 0.63µm; MODIS/Terra: 2000~2011; MODIS/AQUA: 2002~2011; PATMOSX: 01/2009~12/2009; Others: 03/2009~04/2009.
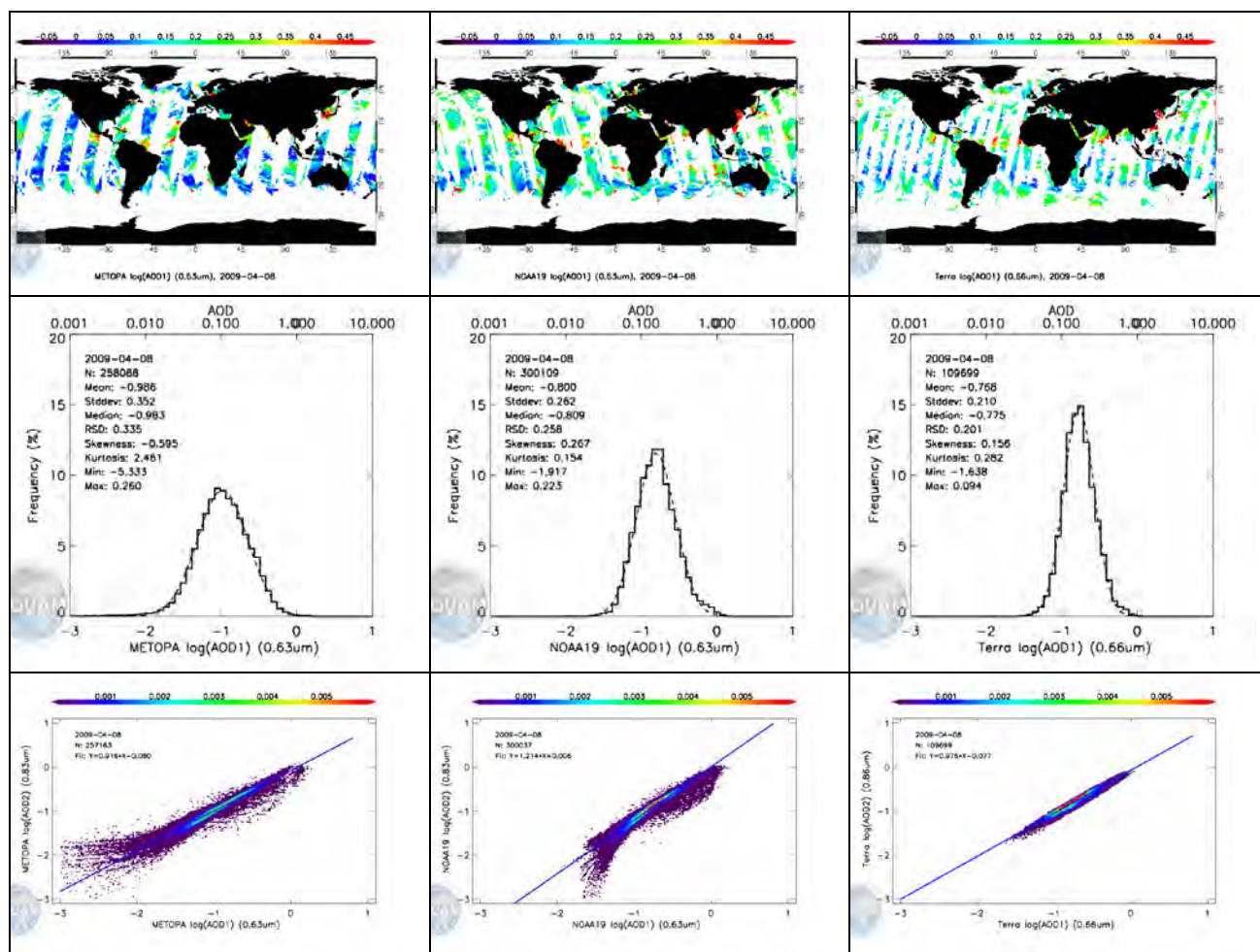
Figure 3. Global maps (upper panel), histograms (middle panel) and scattergrams (bottom panel) of aerosol optical depth (AOD) for METOPA (left panel), NOAA-19(middle panel) and MODIS/Terra (right panel). Preliminary results indicate that AVHRR AOD quality control flag need to be improved.

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – Korak Saha, Post Doc

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: XingMing Liang and Korak Saha

NOAA TECHNICAL CONTACT: Alexander Ignatov

NOAA RESEARCH TEAM: Yuri Kihai and John Stroup

PROJECT OBJECTIVES: Inclusion of Standard Deviation and Robust Standard Deviation Maps and Dependencies to the MICROS functionality

PROJECT ACCOMPLISHMENTS: Monitoring IR Clear-sky Radiances over Oceans for SST (MICROS) is an efficient diagnostic tool for
--Validating and monitoring the AVHRR Clear-sky radiances from NOAA-16, -18, -19, and MetOp-A (ACSPO main product) with Community Radiative Transfer Model (CRTM), in near-real time.
--To validate and improve the CRTM output with the help of dependency curves.
--To monitor sensor performance (cross-platform) in near-real time.

Currently there exists a fully functional MICROS functionality that uses the conventional (mean) and robust (median) statistics to achieve the aforementioned objectives. MICROS Tool is used by SST Team to improve quality of SST and clear-sky ocean radiance product; by CRTM Team to validate and improve CRTM; and Calibration Team to improve sensor calibration & cross-platform consistency.

These objectives are fulfilled by monitoring the stability and cross-platform consistency using the Model minus Observation (M-O) biases and Double-Differences(DD). These biases (M-O) in Brightness temperature (ΔT_B) and SST (ΔT_S) are monitored using

--Global maps of mean (and Median) ΔT_B and ΔT_S, 1 deg × 1deg cell
--Histograms of ΔT_B and ΔT_S along with the Gaussian distribution
--Time series of global mean bias and DD to evaluate the cross-platform consistency
--Dependencies of mean ΔT_B and ΔT_S on major geophysical parameters

In addition to the existing Mean and Median analyses the standard deviation (SD) and robust standard deviation (RSD) maps and dependencies are proposed to be added to achieve the following objectives:
--To identify regions which are more stable (Low bias and/or low variability in biases), which is essential for Sensor Calibration *etc*.
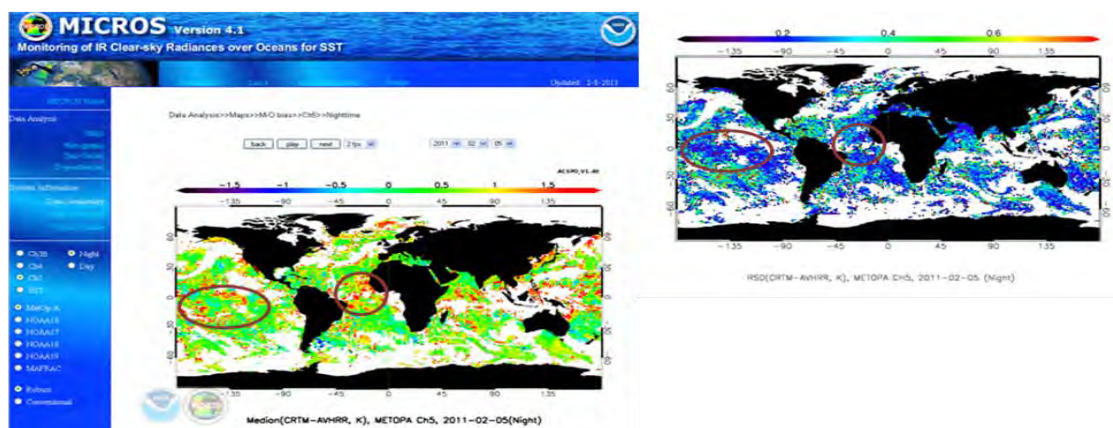--This will provide more handle to further evaluate the performance of ACSPO products

Figure 1: The median bias map for METOPA (Channel 5) in MICROS webpage on 2011-02-05 along with the robust standard deviation map

The onboard sensor calibration requires indentifying the regions with low biases and low variability in biases. An effort is made to identify such regions in global oceans. This is a challenging task as the observed in Figure 1, the region with low variability are not necessarily the region with low biases. Two such regions are encircled in the figure. This will provide an additional handle to further evaluate the performance of ACSPO products.

A dependency analysis of SD/RSD is also performed using daily ACSPO output and weekly dataset. The analysis with daily data is the form in which the current MICROS functionality works. The weekly analysis is made to cover the global oceans and reduce the noise in dataset. However, the dependency of SD/RSD to different geophysical parameters shows clear trends. Figure 2 shows as an example, the dependency plots of RSD with Latitude, Column Water Vapor, Sea-Air temperature difference, Satellite zenith angle, Reynold SST and Wind Speed respectively.
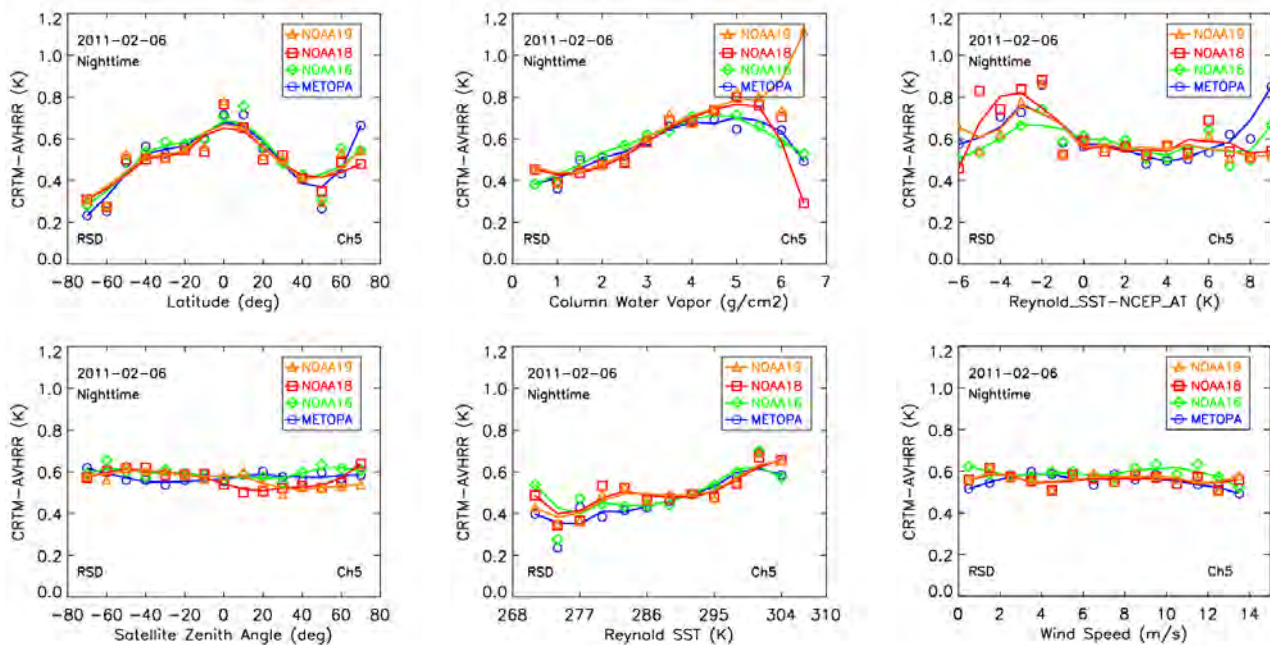
Figure 2: The dependency plots of RSD with Latitude, Column Water Vapor, Sea-Air temperature difference, Satellite zenith angle, Reynold SST and Wind Speed in Channel 5 on 2011-02-06

Cross-platform consistency in the dependencies substantiates the presence of these trends and the importance of this exercise. A clear latitudinal variation is visible for all the channels.

There is not much dependency on the parameters like wind speed and the Satellite view zenith angle. A typical trend is observed with Air-Sea Temperature difference for all the channels. Further analysis is required to understand this trend.

Dependency plots of Channel 4, and 5 shows that SD and RSD variations *w.r.t.* the water vapor variation is as expected has an increasing trend. However, in Channel 3B this variation is effected by some other components of the atmosphere (refer Figure 3).
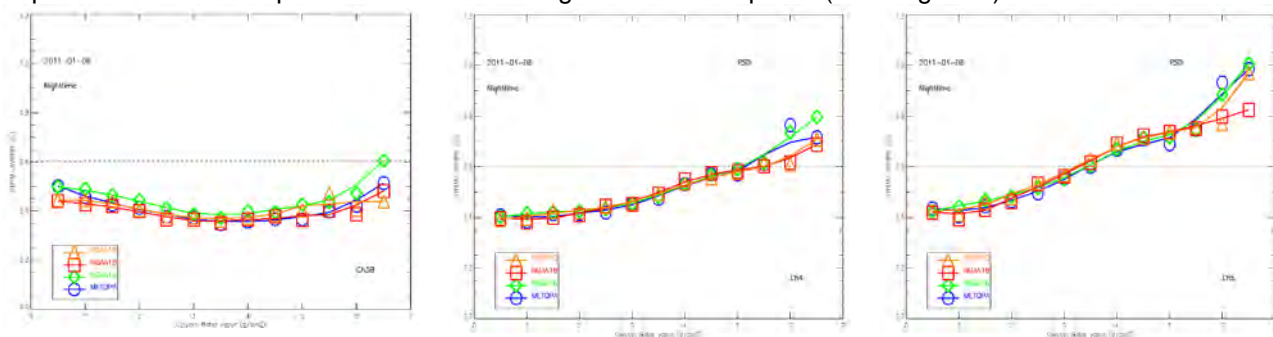
Figure 3.   The dependency plots of RSD with Column Water Vapor for Channels 3B, 4 and 5

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – Wei Shi, Research Scientist – Ocean Color Algorithm Development and Applications

PRINCIPAL INVESTIGATOR: Steve Miller

NOAA TECHNICAL CONTACT: Menghua Wang, NOAA/NESDIS

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

RESEARCH ACCOMPLISHMENTS: During this period, we have used the SWIR ocean color algorithm developed in this group to assess the ecosystem of the coastal and inland lake environment and monitor the physical, geochemical and biological processes in the coastal regions.

--Assessment of the inland water properties in Lake Taihu, China
--Satellite Ocean color algorithm refinement for highly turbid inland waters.
--Characterization of global ocean turbidity
--Ocean process study on the East China Sea plume.
--Study of asymmetrical physical and biological response to Hurricane Earl.
--Vicarious calibration study for MODIS Aqua.

PROJECT TITLE: NESDIS Research Scientist & Post Doc Program – Tong Zhu, Research Scientist– Microwave Remote Sensing of Atmospheric and Surface Parameters and Their Applications in Numerical Weather Prediction Models

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Tong Zhu: 100% FTE

NOAA TECHNICAL CONTACT: Fuzhong Weng (NOAA/NESDIS/STAR)

NOAA RESEARCH TEAM: Fuzhong Weng

PROJECT OBJECTIVES AND ACCOMPLISHMENTS:

--GOES-R Proxy Data Development:
During the past year, I worked closely with GOES-R AIT team to provide 5 new data sets as they requested. I also maintained AWG central disks and proxy data sets; provided proxy data to AWG users and answered their questions; wrote monthly report for Proxy data STAR team. Following 5 new data sets have been archived for AIT team, as well as proxy data sets generated by other proxy data groups:

 --Six weeks MODIS L1 and L2 data were collected for the time period in February, April and October 2007, and total data volume is about 3 TB. This dataset covers the MODIS Aqua and Terra data in 90°N, 145°E, and 90°S, 10°E area.

--Four months MCD43C3 land surface reflectance data for AIT and Radiance Budget Team. The MODIS Albedo product (MCD43C3) provides data describing both directional hemispherical reflectance (black-sky albedo) and bihemispherical reflectance (white-sky albedo).

--The hourly SEVIRI data for 2010 AEROSE campaign from April 26 to May 22, requested by AWG Sounding team. The data coverage is about [35N, 5S; 80W, 0], with the pixel numbers of 1620 south to 3080 north, 1820 east to 3712 west.

--MODIS Daily Surface Reflectance data for GOES-R AIT for August 24-25, 2006 and February 25-26, 2007. MOD09GA and MYD09GA data provides bands 1-7 in a daily gridded L2G product in the Sinusoidal projection, including 500-meter reflectance values and 1-kilometer observation and geolocation statistics.

 --MODIS L1B and L2 data for AIT Snow fraction test run. AIT asked for the MODIS L1B (MOD021KM, MOD03) and cloud product MOD35_L2 for the following 10 granules in year 2009. This is for v5Snow fraction test run in AIT framework function call.

--GOES-R3 GOES Imager impacts in NWP Models:

The Global Space-Based Inter-Calibration System (GSICS) calibration corrections were applied to improve the simulation of SEVIRI and GOES Imager radiances with CRTM and the assimilation in GSI/GFS forecast system. By applying GSICS calibration algorithm to correct SEVIRI and GOES-12 Imager observations biases, the impacts on GFS forecast were improved (Fig. 1 from *Zhu and Weng 2010 SPIE 7811-3 V. 6*).

Working with Mr. Greg Krasowski, we generated one week GOES-11/12 Imager full resolution BUFR data for the study of GOES Imager impacts on high resolution regional model forecast.
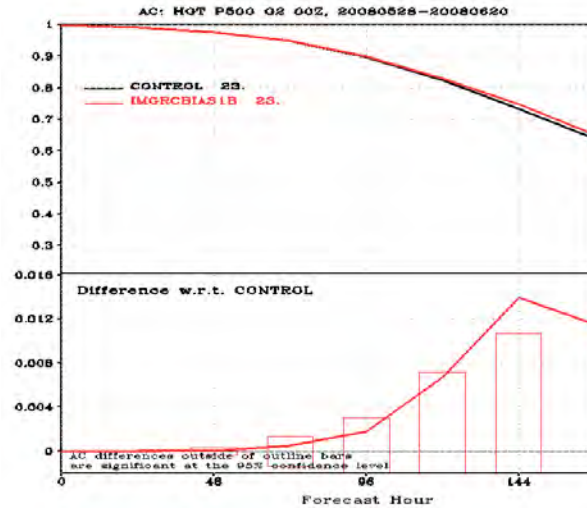
Figure 1. Globe averaged Anomaly Correlation of 500 hPa geopotential height for the impact of GOES-11 and 12 imager data after GSICS calibration correction.

Joint Global OSSE Study:
I have been working on the joint OSSE project for the past several years. Last year, I conducted simulation and validation of the synthetic satellite radiances of AMSU-A, HIRS, GOES Sounder for the Joint OSSE study. By using ECMWF land surface type and sea ice data in OSSE nature run radiance simulation with CRTM, the accuracy is improved as compared with observation. In order to add observation and representativeness errors to the simulation radiances, the operational GSI O-A/B fields have also been studied (Fig. 2 from *Zhu and Weng 2011 draft*).
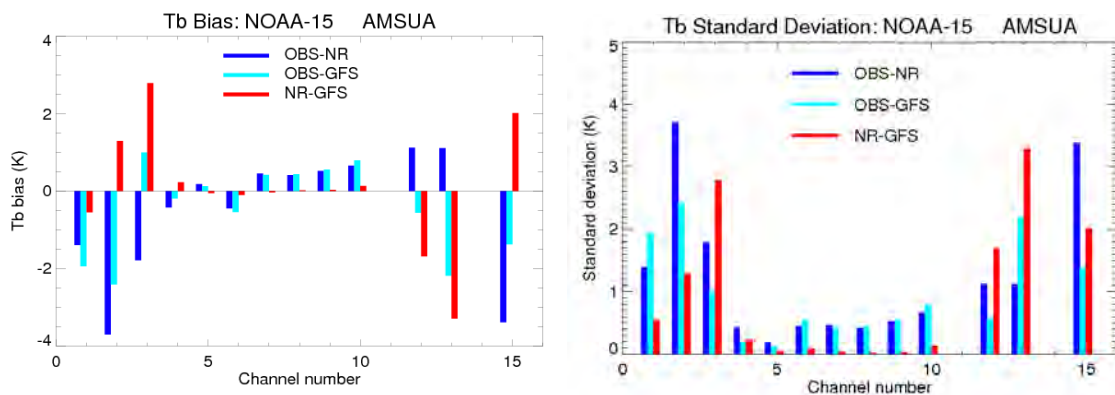
Figure 2. Biases and standard deviations of NOAA-15 AMSU-A brightness temperature among real observation, Nature Run simulation, and GFS forecast at May 2, 2005.

IR Land surface emissivity study:
A new IASI monthly land surface emissivity model was used to study its impacts on CRTM simulation and GFS forecast. First IASI emissivity was convoluted to SEVIRI bands. There were about 1% to 4% changes for emissivity at 3.9 μm and 13.4 μm over desert area after convolution. CRTM simulations of

SEVIRI radiance with IASI emissivity were improved for those surface sensitive channels, Ch4, Ch7, and Ch8. It was found that RMS errors of GFS forecast are reduced over tropical region, where more IASI land surface emissivity data was used for the SEVIRI 8 IR bands simulations (*Zhu and Weng 2011 AMS Annual Meeting*).

Development GOES-R Bias Monitoring System: To develop GOES-R Bias Monitoring System, I set up and monitor real time GSI analysis for GOES Imager data; analyze O-B biases and standard deviation; develop basic framework of GOES-R Bias Monitoring web page; provide read and plot programs for the analysis of output. The monitoring system has been working since the middle of January 2011.

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

PRINCIPAL INVESTIGATOR: Steve Miller

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

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

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

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

CIRA's GOES-R3 and AWG work can be divided into the following ten different projects:

GOES-R3
--GOES-R Applications to Tropical Cyclone Analysis and Forecasting
--Training
--Data Assimilation: Extracting Maximum Information from the GOES-R Data
--GOES-R Severe Weather
--Winter Weather Studies with GOES-R
--New Start: Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index

AWG
--Development, Evaluation, and Testing of GOES-R ABI Fire Proxy Dataset
--AWG Critical Path - Severe Weather / Convective Initiation Product Algorithm
--Support of GOES-R Imagery/Visualization Team in RGB Applications
--AWG Critical Path - GOES-R Applications to Tropical Cyclone Analysis and Forecasting

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

PROJECT ACCOMPLISHMENTS:

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 continued to expand the ABI proxy database. Two specific datasets, MSG, and 1km IR imagery from polar satellites, were collected as part of this project. In addition to the MSG data collection over a tropical Atlantic sector during the Hurricane season, full disk and RGB imagery and RGB imagery (Air Mass, Dust, SAL) that were being generated for the GOES-R demonstration project at the National Hurricane Center, were archived. These datasets are available for future research studies.

A real-time feed of lightning data from Vaisala, established last quarter, was used for the Proving Ground Demonstration. The Vaisala GLD360, which was inter-calibrated with the

WWLLN lightning data using short period of overlap in fall/winter of 2009, was used to generate experimental Rapid Intensification Indices during the ongoing proving ground project at NHC. An example of the text output for pre-Hurricane Paula (40kt in the advisory, 50 kt in the best track) is shown in Figure 1. All of the experimental forecasts can be found at ftp://rammftp.cira.colostate.edu/demaria/NHCPG/. Verifications of these forecasts to assess the improvements due to lightning information are currently being conducted. Preliminary results show that the lightning based version had a smaller bias in 2010, but did not improve the Brier score. This may be due to the short period of overlap used to develop the correction factors to make the Vaisala data comparable to the WWLLN data. The WWLLN data from the 2010 season is being obtained to determine if the experimental algorithm would have performed better if it were run using the same data that is was developed from (the WWLLN data).

Our statistical analysis of 2003-2008 Atlantic and East Pacific tropical cyclones with SHIPS came to the result that a combination of lightning density, initial tropical cyclone intensity, and vertical windshear can significantly improve SHIPS forecasts.
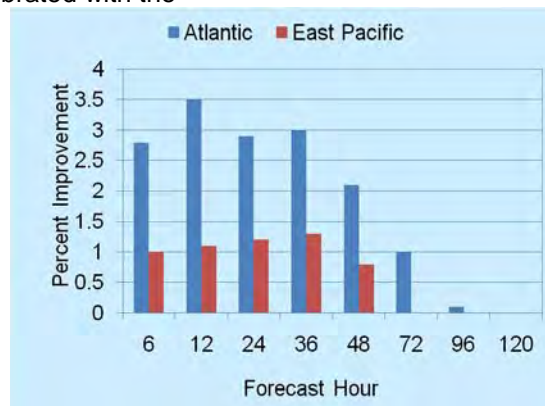
Figure 1. SHIPS forecast improvement for Atlantic and East Pacific tropical cyclones in percent for forecast hours between 6 and 120.

Much effort was put into expanding our real time demonstration web page. In addition, Google Earth loops of the Air Mass and Dust products were created for the Proving Ground demonstration. During the GOES-15 Science test project participants worked to test two operational issues. The first dealt with receiving

GOES super rapid scan (SRSO, 48 1-minute images during the science test) and continuous 5-minute data over land lines as no NHC ground station will be available at NHC. The second issue dealt with displaying high temporal resolution data in NAWIPS (the operational display software). Both tests were successful.

Google Earth loops of GOES-E imagery over the CONUS are available at http://rammb.cira.colostate.edu/products/google_earth/.

Note real-time lightning data cannot be disseminated per our agreement with Vaisala.

Manuscripts were written and submitted to refereed journals (see publication section at the end of this report). In addition, we participated in the GOES-R Proving Ground at National Hurricane Center in 2010 where our GLM and ABI RGB products were demonstrated.

Training
The GOES-R 101 module was implemented and updates were made as necessary. In addition to the new GOES-R 101 module, special training sessions highlighting imagery and products for GOES-R were conducted. GOES-R examples were also used for international focus group weather briefings.
Emphasize was put on coordination of a wide range of training activities like VISIT, SHyMet, Proving Ground, COMET, SPoRT, SRSST, WMO, and others.

This resulted in that the GOES-R 101 was included in the SHyMet for Forecaster course. The collaboration with the VISIT team resulted in a new teletraining which debuted in July which included a GOES-R example: "Water Vapor Imagery Analysis for Severe Thunderstorm Forecasting" by Dan Bikos and Dan Lindsey. One of the examples utilized 4 km cloud resolving WRF-ARW synthetic imagery to highlight what will be coming along with GOES-R. In addition, a total of 8 blog entries relating to GOES-R activities have been included in the VISIT: Meteorological Interpretation Blog (one in the last 3 months and the others since February 2010).
http://rammb.cira.colostate.edu/visit/blog/index.php/category/satellites/goes-r/ .
In collaboration with the VISIT/SHyMet team a new "Volcanic Ash Hazards (Part 1)" module was developed by Jeff Braun, et al. This module contains examples of GOES-R products from Mike Pavlonis, Steve Goodman, Don Hillger (all NOAA/NESDIS/StAR) and others. The follow-up module "Volcanic Ash Hazards (Part 2) module contains an example of synthetically produced RGB imagery of a hypothetical

volcanic eruption from the Yellowstone, Wyoming region.

The VISIT Program was utilized for training format and tracking metrics. Links to the training materials were installed on the GOES-R Home web page and Proving Ground web page to ensure broad distribution of the training materials. Presentations about the training experience were given at the WMO international satellite training event (either face to face and virtual) and at the Annual Proving Ground Meeting in Boulder at COMET in May 2010.

Data Assimilation: Extracting Maximum Information from the GOES-R Data
The main milestone of this data assimilation project was to quantify the potential impact of the GOES-R ABI data on the forecast improvements.

--Examination of the impact of assimilating synthetic GOES-R ABI radiances at 10.35 μm in cloudy conditions to evaluate the potential impact of these observations on improving model-simulated clouds is presented in Zupanski et al. (2010). In particular, we were interested in extracting maximum information from such observations by taking into account when and where this information is needed the most. The experimental results indicated that GOES-R observations could bring varying amounts of information, however depending on the choice for the control variable in data assimilation. In the examined case of the extratropical cyclone Kyrill (2007), inclusion of cloud ice into the control variable lead to a significant increase of the information content of data, eventually resulting in improved data assimilation. This suggests that it is imperative to include all radiatively active hydrometeors into the control variable for maximizing the benefits of assimilated cloudy radiances and to avoid obtaining degraded data assimilation results due to neglecting some of the important hydrometeors. On the other hand, microphysical variables to which the radiances have little sensitivity (e.g., rain or graupel) could be either included or excluded from the control variable.

Data assimilation and short term forecast results clearly indicate improvements due to assimilation of the GOES-R ABI synthetic radiance "observations", compared to the experiments without data assimilation. The results also indicated that the flow-dependent

Degrees of Freedom for Signal (DFS) information measure realistically reflect the actual forecast uncertainty, with the values of DFS being largest in the areas of large forecast errors. This confirms that the data assimilation method used in this study has the capability to maximize information content of the assimilated observations.

--Impact of assimilating the METEOSAT Second Generation (MSG) radiances has also been investigated in the same synoptic situation as above. The MSG data are typically used as proxy for future ABI radiances. The behavior of data assimilation and short term forecast is both qualitatively and quantitatively similar to the synthetic ABI case. This is a very important result as assimilation of real data is often more difficult from the data assimilation viewpoint due to approximate (i.e. unknown) observation errors. Our "non-identical twin" experiments (e.g., models used to create synthetic observations differs from the model used in data assimilation) performed in (i) suggest that the same methodology can be confidently used in other future satellite applications.

--Our related work in the Hurricane Forecasting Improvement Program (HFIP) is also contributing to better understanding of the impact of cloudy radiances in data assimilation, and thus to the future GOES-R ABI assimilation.

One of the major problems in assimilation of hurricanes is the unavailability of satellite radiance observations due to cloud clearing. As one can imagine, the near inner-core observations are mostly in cloudy conditions. However, current operational capability does not include assimilation of cloudy radiances and utilizes the cloud clearing to remove the clouds instead. In Figure5 we show the root-mean-squared (RMS) errors with respect to wind and satellite observations for several assimilation cycles in the hurricane Gustav (2008) case. This is an experiment that employs the same ensemble data assimilation system as in this project, but with the NOAA hurricane WRF model. The figure indicates a reduction of the RMS errors due to assimilation, but also shows general unavailability of satellite observations due to cloud clearing. While in Fig.5a there is a continuous availability of wind observations, in Fig.5b one can see only an intermittent availability of the Advanced Microwave Sounding Unit-B (AMSU-B) observations. Even at the times when AMSU-B observations passed the quality control, the number of observations was small. A similar situation was noted for other satellites as well. Employing cloudy radiance assimilation, developed and used in this project, would greatly improve the NOAA satellite observation database, and eventually hurricane forecasts.

(a)   (b)
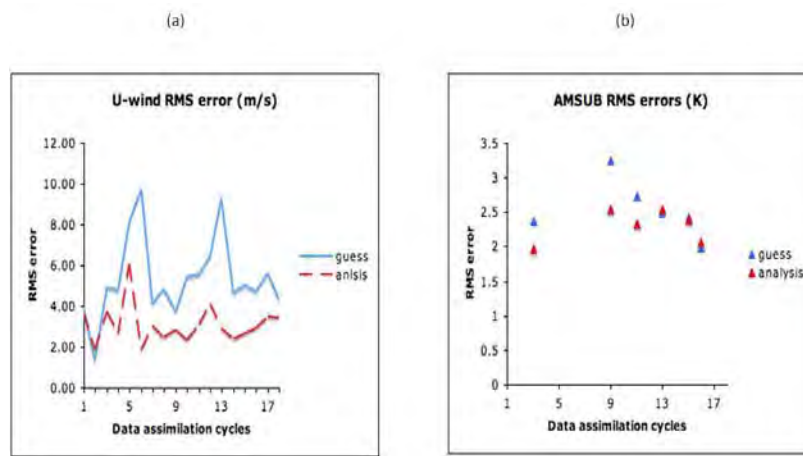
Figure 2. RMS errors with respect to observations for hurricane Gustav: (a) east-west wind component, and (b) AMSU-B satellite radiance (cloud cleared). One can notice general improvement of RMS errors due to analysis, but also that very few satellite radiance observations are available (b). The data assimilation cycle is 6 hours, and the plots describe first 18 cycles.

GOES-R Severe Weather
A manuscript entitled, "Assimilating synthetic GOES-R radiances in cloudy conditions using an ensemble-based method" was submitted to the *International Journal of Remote Sensing*. The paper was accepted for publication and is in press. This paper fulfills one of the milestones of the GOES-R Severe Weather project by demonstrating the benefit of satellite data for GOES-R Utilization.

The second milestone of this project focused on the application to a severe thunderstorm. The goal was to devise a scheme to estimate moisture depth and to use synthetic imagery to improve the particle size product. Synthetic imagery for GOES-R ABI bands 6-16 (2.25 – 13.3 µm) for a severe weather event over the mid-western United States which occurred on 27 June 2005 were generated and made available to the AWG Aviation Team. Additionally, simulated radar reflectivity and surface temperatures from the model output were made available. As a result of this work a manuscript entitled, "An Example of the use of Synthetic 3.9 µm GOES-12 Imagery for Two-Moment Microphysical Evaluation" was submitted to the *International Journal of Remote Sensing*. The paper was accepted for publication and is currently in press.
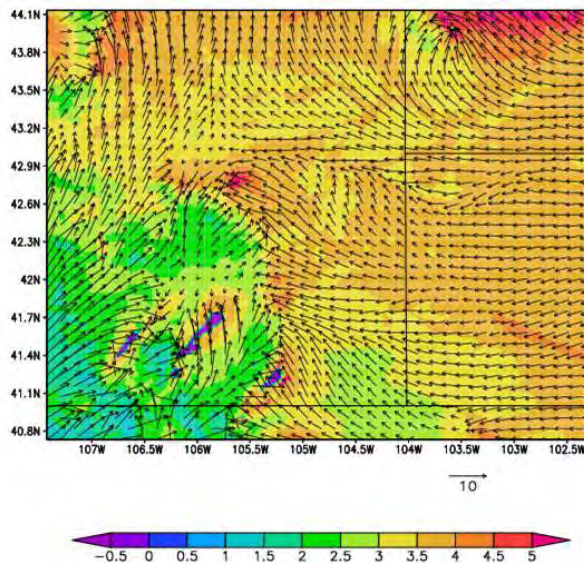
Figure 3. Simulated 10.35-12.3 µm image from the 27 June 2005 case over eastern Wyoming, along with surface wind vectors. Note that positive differences correspond to regions of surface convergence. One may use the brightness temperature difference field to predict where convective clouds are likely to form.

Winter Weather Studies with GOES-R
Virtually all wintertime, high-impact weather in the United States occurs in association with midlatitude cyclones. During this year, we continued our development of the PV/Ozone technique and the comparison of the potential vorticity fields to total ozone measurements from geostationary satellites. We also constructed cloud climatology for three season test cases and to produced cloud composites using current and new algorithms.

As part of the GOES-R Risk Reduction program, a tropopause wind product was developed.

Combining measurements from radiosondes, COSMIC, GOES, and OMI, the nondivergent wind field can be estimated at the tropopause (i.e. jet-stream level). The basis of the technique is the relationship between lower-stratospheric ozone and the vorticity at the tropopause derived by Vaughn and Price (1991). The date of the case we studied was 9 March 2009. The initial run of the technique produced reasonable results. As refinements were sought to improve the program, irregularities appeared in the ozone profiles derived from measurements taken by the Ozone Monitoring Instrument (OMI), which flies on the Aura

spacecraft. During the investigation, it was found that on 25 June 2007 the first of several row anomalies occurred which affect the ozone profiles. Figure 4 shows how much the 9 March 2009 case was affected. Plotted are the mean and the standard deviation of the total ozone (in Dobson Units) as a function of scan element. The colored (red, cyan, blue, and green) lines show the results from 9 March 2009 for 4 swaths over the United States. The black lines are from an OMI swath from 14 March 2007, before the first row anomaly occurred. Elements 13 to 21 (0-based) are definitely affected, and possibly elements 22 to 30. Since this is over half of the data, it was decided that a new study case should be chosen.
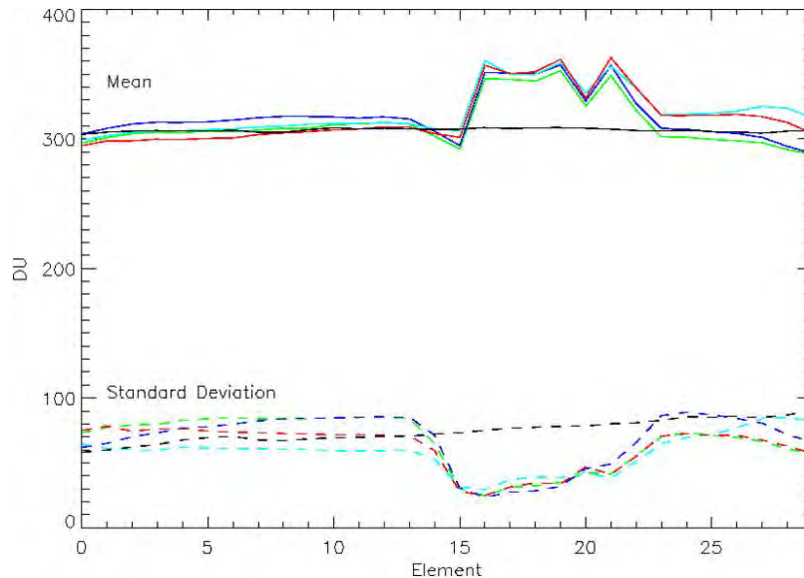
Figure 4. Affects of row anomaly on the 9 March 2009 data. Solid lines are mean total column O_3, dashed lines are standard deviation, both as a function of scan element. The colored lines are from 9 March 2009. The black lines are from a 14 March 2007 swath, before the occurrence of the first row anomaly. (Reference: Vaughn, G. and J. D. Price, 1991: On the relation between total ozone and meteorology. Quart. J. Roy. Meteor. Soc.,**117,**1281-1298.)

Our GOES-R winter weather study project also has a cloud climatology part to it. The cloud climatology project began with an analysis of a snow/cloud climatology product for a dataset from February 2007. An attempt was made to recreate the scatter plot provided in the deRuyter de Wildt at al. paper between 7.3µm and 13.4µm brightness temperature using a MSG dataset. The goal was to provide a threshold between snow and ice clouds for very cold values. Unfortunately, the data did not separate well enough between snow and ice clouds. A check of data points that must be ice cloud as oppose to snow, due to their location over the Mediterranean Sea, show these points to occur around the middle of the scatter plot. Due to this and the general disorder of the points, drawing a line for the threshold between ice cloud and snow was impossible. It is possible that our dataset did not contain enough snow points in the questionable range to show

up. Another test was required. We checked the literature to compare a MODIS snow method with the one listed in deRuyter de Wildt at al. After conducting these additional tests using our February 2007 dataset, we decided to add a 10.7 µm threshold in snow areas to weed out high, thick clouds mistaken as snow. This step was added in addition to the snow index of 1.6 µm and 0.6 µm channels and various checks from the deRuyter de Wildt at al. paper. The introduction of this new threshold corrected most of the mistaken snow areas without affecting the true snow areas.
Additional data for March 2006 and 2007 were successfully processed using the newly developed method.

New Start: Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index
To fulfill the first milestone of this project, the SHIPS database for both the Atlantic and East

Pacific was updated with IR PC predictors from 1995-2009 and lightning predictors from 2005-2009. Predictors from total precipitable water (TPW) fields were also added. The TPW and lightning predictors were made available in real time. The remaining new data source which had to be added for this project is a set of predictors from microwave imagery. The microwave dataset and predictors for the period 1995-2008 was prepared and added to the standard lsdiag files for the Atlantic and E. Pacific basins by CIMSS.

The second milestone of this project was the development of a lightning-based correction model for the Atlantic. Progress towards this goal have been steady in nature including the following accomplishments The 2009 WWLLN data were processed and calibrated for the Atlantic and East Pacific. These data have been added to the SHIPS developmental dataset (1995-2009) and are currently being examined. Results suggest that lightning information can significantly improve short-term (0-48h) intensity forecasts, but that inner core lightning activity is inversely related to intensification. Complete results of this examination were presented at the AMS Conference on Hurricanes and Tropical Meteorology. As part of this project we conducted a detailed calibration between WWLLN lightning and Vaisala GLD360 lightning datasets. A version of the rapid intensity index with the lightning data input was developed and is running in real time. In addition, a second version with TPW and new surface predictors was implemented and is running in real time. Both of these are being evaluated by NHC forecasters, and a quantitative evaluation was performed at the end of the 2010 hurricane season.

A version of the rapid intensity index with the lightning data input was run in real time for the GOES-R Proving Ground. In addition, a second version that makes use of TPW-based predictors and new surface predictors was implemented and was running in real time for a related Joint Hurricane Testbed project. Both of these are being evaluated by NHC forecasters, and a quantitative evaluation is currently being performed.

Development, Evaluation, and Testing of GOES-R ABI Fire Proxy Dataset
In support of GOES-R algorithm development, the CIRA proxy data fire team produced GOES-

R ABI proxy data sets simulating an agricultural fire event which occurred in Arkansas in November 2008.Brightness temperature fields together with radiance or reflectance were produced for three GOES-R ABI bands (3.9 μm, 10.35 μm, and 11.2 μm) at the appropriate (2 km) ABI footprint. The synthetic dataset is based on a WRF-ARW-3.0.1 forecast model. Fire location and temperatures information came from a GOES-based ABBA retrieval dataset which was created CIMSS fire proxy team. The ABBA-retrieved 30-min fire temperatures were linearly interpolated to represent 5-minute ABI data. An observational operator was run to produce the synthetic ABI imagery for the three ABI bands. In addition synthetic fire datasets for the 2.25 μm band were produced. The 2.25 μm band provides a higher dynamic range for determination of fire temperature and fire size than the other three wavelengths because of its higher fire saturation temperature. Synthetic GOES-R true color imagery was produced for individual time steps. True-color products created included cloudy scenes as well as fire hot spots with realistic smoke plumes, a volcanic ash plume, and a case study with aerosols presents.

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

AWG Critical Path - Severe Weather / Convective Initiation Product Algorithm
In support of the convective initiation product algorithm and validation activities we continued to produce simulated GOES-R ABI datasets for a severe weather case by running a cloud forecast model together with a radiative transfer model (for the upper ABI bands from 3.9 μm to 13.3 μm).

Task one of this project was to produce synthetic imagery for GOES-R ABI bands for a Severe Weather Case which occurred over Kansas on 8 May 2003. The CSU Regional Atmospheric Modeling Systems (RAMS) forecast model was used for this project.

Synthetic imagery was generated for bands 7-16. A second milestone was to provide synthetic GOES-R ABI 6.185 µm imagery for an additional severe weather case (Mid-Western United States, 27 June 2005). We also produced a datasets with zenith angles and azimuth angles for all grid points for both the 8 May 2003 and 27 June 2005 cases files. One dataset is for the GOES-8 zenith angle; while the other is GOES-8 azimuth angle. Simulated radar reflectivity and surface temperatures were generated from the RAMS forecast model output of the above case studies.

Support of GOES-R Imagery/Visualization Team in RGB Applications
The CIRA GOES-R Imagery/Visualization Team (IVT) collaborated closely with NOAA-NESDIS and UW-CIMSS scientists to support the GOES-R AWG Imagery and Visualization Team. The focus of this project was on the usage of Red/Green/Blue (RGB) color composite imagery techniques applied to multispectral ABI data as a way of highlighting specific features of the potentially complex meteorological scene. These 'value-added' imagery techniques, which can be regarded as qualitative representations of environmental information based on the same physical principles used to retrieve quantitative information, have proven extremely effective in providing forecasters with quick-look depictions of the specific information required for rapid scene characterization and short-term forecasting (nowcasting) guidance. During this reporting period the CIRA IVT team created an ATBD for the "Natural Color Image Product (NCIP)". The term "natural color image" is being used instead of "true color product" to emphasize that a synthetically generated green band is part of the RGB imagery creation. We also demonstrated our GOES-R proxy data RGB applications with NWS users via the GOES-R Satellite Proving Ground. In addition the IVT explored other colors spaces, such as Hue, Saturation, and Intensity, for analysis and pseudo-verification of RGB images.

AWG Critical Path - GOES-R Applications to Tropical Cyclone Analysis and Forecasting
Since 2006 MSG SEVERI data in a tropical subsector (1300x2000; Figure 5) has been collected from the NESDIS server (using MCIDAS imgcopy.k command). All eleven 3km-resolution, 15-minute, channels were collected, barring communication failures, and all documentation contained within the served image was preserved. The files were archived locally at CIRA. Using these archived MSG SEVERI data, imagery for the four Atlantic tropical cyclones which occurred during 2009 were extracted from DVD. The tropical cyclones used for this research study are:
Ana (August 2009), Fred (September 2009), TD8 (September 2009), and Grace (October 2009)

The goal of our project is to produce simulated 10.35um ABI imagery from the MSG imagery and supply these images along with 10.8 um MSG imagery to the AWG. To facilitate this effort software, which was capable of sectorizing the extracted MSG images was written. These sectorized images were centered on the storm of interest and reduced in size to 500x500 pixels (i.e., 1500 km x 1500 km). Positions were derived from final best track data provided by the National Hurricane Center (NHC). See Figure 2 for an example of a sectorized image of Hurricane Helene. The result was storm centered MSG imagery from which 10.35 um ABI imagery can be simulated.
The last step of our project plan task 1 was to conduct a quality control of the simulated 10.3 um ABI imagery and matching 10.8 um MSG imagery. This step involved the visual inspection of the four tropical cyclone cases and removal or correction of imagery that was not processed correctly or that the center of the cyclone was not in the imagery. After the quality control step was completed, we ended up with a total of 1983 images for the four tropical cyclones.
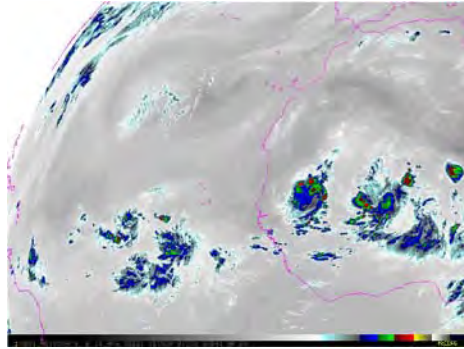
Figure 5. An example of the archived MSG sector used for this study. This example is of Channel 6 centered at 6.35 um. There are 10 other channels in the archive with an identical geographic coverage and 15-minute temporal resolution.

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

PRINCIPAL INVESTIGATOR: Andrea Schumacher

RESEARCH TEAM: Jack Dostalek, Robert DeMaria

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

NOAA RESEARCH TEAM: Mark DeMaria, NESDIS/RAMMB

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:

--To generate 3-D fields of (linear balance) omega over the Gulf Stream
--To generate fields of divergence over the Gulf Stream

The months of interest are January and February 2007.

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

PROJECT ACCOMPLISHMENTS: This project, which supports the NOAA mission goals of Climate, Weather and Water, has been ongoing. Last year, CIRA contributed by creating plots of lightning strike density from the World Wide Lightning Network and of linear balance winds derived from AMSU temperature profiles over the Gulfstream. This year two new fields corresponding to this year's project objectives were generated and shared with Dr. Chelton, both associated with the linear balance winds. The linear balance omega equation was solved, from which fields of divergence associated with the balanced flow were also be produced. The fields of tropospheric vorticity, vertical velocity, and divergence were well correlated with the SST anomalies of the Gulf Stream. The results are significant because while the interaction between the atmospheric boundary layer and the warm waters of the Gulf Stream has been recognized for decades, the extent of the

response into the troposphere had been investigated only with model analyses. The use of the data from the AMSU instrument provides observational evidence of the influence that the Gulf Stream has on the troposphere. In May of 2010, Dr. Chelton presented these results in a talk entitled "Observational Evidence of SST Influence on the Troposphere over the Gulf Stream" at the International Ocean Vector Winds Meeting in Barcelona, Spain. The summary slide of his presentation is given in Figure 1.
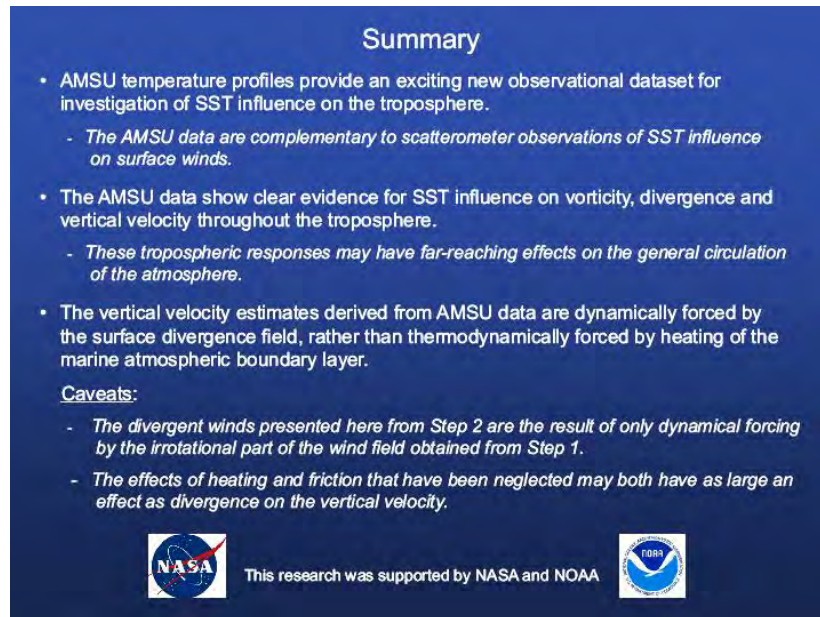
Figure 1. Summary slide from Dr. Chelton's talk "Observational Evidence of SST Influence on the Troposphere over the Gulf Stream" given at the 2010 International Ocean Vector Winds Meeting in Barcelona, Spain. The slide points out the utility of the data which CIRA provided to study the effect the Gulfstream has on the troposphere.

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

PRINCIPAL INVESTIGATOR: Tom Vonder Haar

RESEARCH TEAM: Tom Vonder Haar, Holli Knutson

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

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

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

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

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

PRINCIPAL INVESTIGATORS: Dan Bikos and Bernie Connell

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

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

NOAA RESEARCH TEAM: Mark DeMaria, Dan Lindsey, John Knaff

PROJECT OBJECTIVES: The primary objective of the VISIT program is to accelerate the transfer of research results based on atmospheric remote sensing data into National Weather Service (NWS) operations. This transfer is accomplished through web based distance learning modules developed at CIRA and delivered to NWS forecasters. There are two types of distance learning methods. The first is teletraining, which is a "live" training session utilizing the VISITview software and a conference call so that there is interaction between instructor and students. The second type is an audio / video playback format that plays within a web-browser. The later type is popular because it may be taken by a student individually whenever they choose. The combination of live teletraining and audio / video playback versions (Fig. 1) reaches out to as broad an audience as possible given the busy schedule of NWS forecasters. Over 23,000 participants have completed VISIT training since April 1999, and most student feedback suggests a direct applicability to current forecast problems. CIRA is also actively involved in tracking of participants, and the collection and

summarization of course feedback material. Because the VISIT program has been so successful within the NWS, it is being leveraged for other training activities in the US (Satellite Hydrology and Meteorology Courses (SHyMet), and the GOES-R Proving Ground) and is being utilized by the International community in training programs under the World

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

For more information on the VISIT program: http://rammb.cira.colostate.edu/visit/
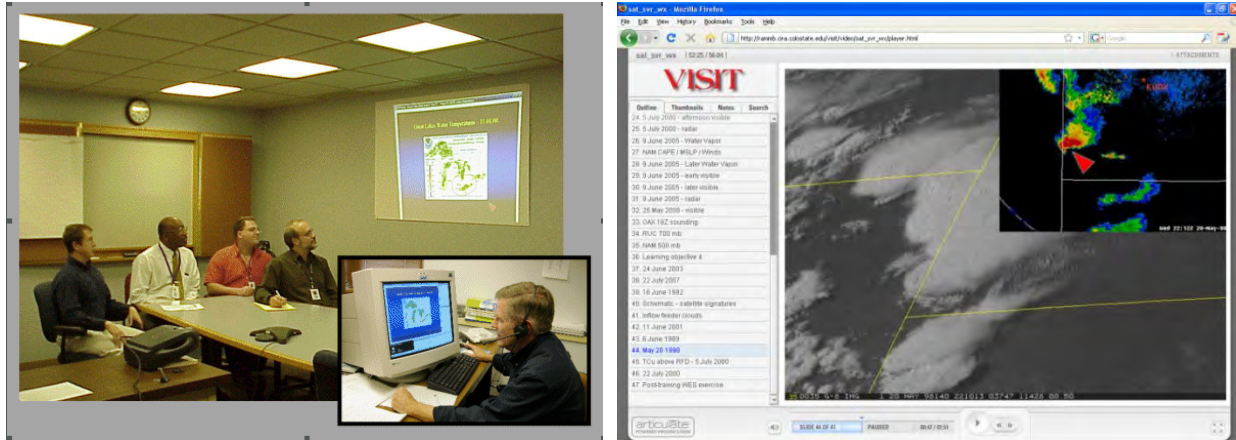
Figure 1. Live VISIT teletraining (left), and audio / video playback VISIT training module (right).

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

    --Basic Satellite Imagery Interpretation in the Tropics.
    --Water Vapor Imagery Analysis for Severe Weather Forecasting.

    --New CIRA training sessions co-developed with GOES-R project:
    • Synthetic Imagery in Forecasting Severe Weather.
    • Synthetic Imagery in Forecasting Orographic Cirrus.

    --New CIRA training sessions co-developed with SHyMet project:
    • Volcanoes and Volcanic Ash.
    • Regional Satellite Cloud Composites from GOES.

--VISIT training metrics April 1, 2010 – February 17, 2011:
    --Live teletraining: 65 sessions delivered to 300 participants.
    --Audio / video playback (through NOAA's Learning Management System as well as directly through CIRA's web interface): 592 participants.

--Collaborations on new training sessions developed outside CIRA:
    --POES and AVHRR Satellite Data in AWIPS.
    --The UW Convective Initiation Product.
    --The UW NearCasting Product
    --Morphed TPW Detection (MIMIC).
    --Objective Satellite-Based Overshooting Top and Enhanced-V Anvil Thermal Couplet Signature Detection.

--Extend the VISIT training structure and expertise to the SHyMet project. This includes web-page development, development and delivery of training content (for co-developed

training sessions, see item #1 above):

  --Delivered Tropical SHyMet course.
  --Delivered SHyMet SevereThunderstorm
   Forecasting course.

Presentations:
--D. Bikos attended the AMS / NWA High Plains Conference in Dodge City, KS on August 12-13, 2010. He gave 2 oral presentations on tornado cases from this past spring in collaborative work with Jonathan Finch (NWS Dodge City, KS).

--J. Braun attended the NOAA/NWS AlaskaAviation and Volcanic Ash Workshop in Anchorage, AK on September 20-23, 2010. He gave one oral presentation on Volcanic Ash Training and Future (GOES-R) Products.

--B. Connell attended the AMS 17th Conference on Satellite Meteorology and Oceanography in Annapolis, MD, 27-30 September 2010. The presentation "A fifteen year perspective on national and international training directed towards forecasters" was given during the Session on Training and Education for Current, New, and Future Satellite Observing Systems.

--B. Connell participated in the Eastern Region Satellite Virtual Workshop on 9 November 2010, and gave a presentation on "CIRA/RAMMB GOES-R Proving Ground Activities and NEW VISIT and SHYMET training."

--B. Connell participated in the AMS 91st Annual Meeting in Seattle, WA, 23-27 January 2011 and presented a poster on "Training for GOES-R directed towards forecasters."

New VISIT web-pages:

--The VISIT web-pages were redesigned to make them more appealing and organized for users. Since the new pages debuted in November 2010, there is an average of 25 visits per day. The visitors come from 97 countries, although 72% of the visitors are from the USA.

VISIT blog:

--Many additions (including a "new updated look") were made to the Blog over the past year. The Blog is intended to open the doors of communication between the Operational, Academic and Training Meteorology communities. Blog URL: http://rammb. cira.colostate.edu/training/visit/blog/

Community Outreach:

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

--B. Connell gave a presentation on the GOES and the characteristics of its channels to a Remote Sensing class at the Metropolitan State College of Denver on 30 November 2010.

PROJECT TITLE: Tropical Cyclone Model Diagnostics and Product Development (Hurricane Forecast Improvement Project (HFIP))

PRINCIPAL INVESTIGATOR: Wayne H. Schubert

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

NOAA TECHNICAL CONTACT: Mark DeMaria NOAA/NESDIS/STAR

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

PROJECTIVE 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. The CIRA team performed ten tasks that contribute to this HFIP effort. Details on these tasks are described in the next section.

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

PROJECT ACCOMPLISHMENTS:

Guidance on the design of annual model demonstrations
Part of HFIP includes running experimental hurricane forecast models in real time. A subset of these models was provided to the National Hurricane Center, based on past performance and diagnostic results. Guidance was provided to the HFIP management team based on the diagnostic studies performed as part of the CIRA project.

HWRF model diagnostics for cases from the 2008 and 2009 hurricane seasons
The emphasis of the CIRA diagnostic effort was on the evolution of the storm environment and its relationship to intensity and track changes. These relationships were determined from statistical analysis of large numbers of cases. Large-scale diagnostics was performed on all available runs of the operational HWRF and GFDL regional forecast models.

Creation of synthetic satellite imagery from hurricane model forecasts
One of the challenges of tropical cyclone model evaluation is the limited availability of observations, especially over the open ocean where tropical cyclones spend most of their lifetime. Determining the accuracy of model fields in the upper part of the storm is especially problematic. To address this problem, the model forecast fields are being used as input to forward radiative transfer algorithms to provide synthetic satellite imagery. These can then be compared to real satellite data (Grasso et al., 2008). This technique was applied to output from the HWRF model, with an emphasis on infrared satellite data available from the GOES satellites. The GOES data have very high temporal and spatial resolution, which makes it well-suited for model validation. The comparison of the synthetic and

real IR data was helpful to identify errors in cloud top structures, which are related to the model treatment of convective processes.

Real-time HWRF and GFDL model diagnostics during the 2010 hurricane season
The model diagnostics described in section (ii) above for the 2008 and 2009 model runs was also applied to the real-time runs of the HWRF and GFDL models during the 2010 Atlantic hurricane season. These were archived for further analysis, and a subset of these products were made available to NHC forecasters as described in more detail in section (vi) below.

Combining statistical intensity models with global track forecast models
Physically-based dynamical models provide the most accurate tropical cyclone track forecasts. However, because of the complexity of the problem, empirically-based statistical-dynamical models still provide the most accurate intensity forecasts (Franklin, 2010). The most accurate Atlantic statistical intensity model in the 2008 and 2009 hurricane seasons was the Logistic Growth Equation Model (LGEM) (DeMaria et al., 2009). In the operational version of LGEM input from the NHC official forecast track and the deterministic run of the NCEP global forecasting system (GFS) is being used. To improve the accuracy of intensity forecasts, LGEM was run for each member of a global model ensemble. The ensemble mean of the LGEM intensity forecasts was compared with the single deterministic run to evaluate the potential for improvement.

Coordinate with NHC on real-time products from HFIP models
In addition to the track and intensity forecasts from models, NHC also uses products derived from the model fields to assist with their forecasts. Many of the diagnostic products developed under previous HFIP funding have potential forecast utility, such as vertical cross sections of various quantities, and other parameters shown to have relationships with intensity change in statistical intensity models. CIRA coordinated with NHC to display a subset of the CIRA diagnostic products in real time to evaluate their forecast utility.

Develop products from ensemble tropical cyclone forecast models

There are two basic strategies for improving tropical cyclone forecast models. One is to focus on the development of the best possible deterministic forecast model. The other is to use a more probabilistic approach by considering an ensemble of forecast models with perturbed initial conditions and model physics. The HFIP program is addressing both of these approaches. One of the challenges of the ensemble approach is the development of forecast tools for NHC, which is tasked with providing a deterministic forecast of track, intensity and structure. NHC already provides a number of probabilistic products in terms of the probability of 34, 50 and 64 kt winds, in addition to a cone of uncertainty and a maximum wind probability table. Most of the NHC probabilistic products are derived from a statistically based Monte Carlo wind speed probability model (DeMaria et al. 2009), which randomly samples from the past 5 years of NHC's track and intensity error distributions. In the CIRA ensemble project, we began to adapt NHC's Monte Carlo wind speed probability model to utilize the ensemble forecasts for the dynamical models being developed under HFIP. The initial emphasis is on using the track ensembles. Using this method, the standard set of NHC probabilistic products will be generated and evaluated by comparison with the operational version of the products.

Contribute satellite observations to NOAA hurricane field program in coordination with the HFIP observations team

Another role of HFIP is to collect observations for comparison with model output. Observations from hurricane reconnaissance aircraft are routinely collected for Atlantic storms during the annual NOAA field program. CIRA collected and archived GOES satellite imagery for comparison during the 2010 field program. This data was provided to other HFIP participants for case study analysis and model verification studies via webpage. The GOES-East and GOES-West channel 3 and 4 digital datafiles for all 2010 Atlantic and East Pacific tropical cyclones will also be provided for quantative analysis.

Coordinate with the HFIP verification team on model evaluation

HFIP performs an annual verifcation of the track and intensity forecasts of the experimental and operational hurricane models. To better understand the reason for the track and intensity errors, additional model parameters were verified such as environmental wind shear, sea surface temperature and proximity to land. The work was coordinated with the HFIP verification team.

Generalize the Logistic Growth Equation Model (LGEM) to the western North Pacific

As described above, LGEM has been the most accurate intensity forecast model for Atlantic storms. A version of LGEM is also available for the eastern North Pacific. Part of HFIP includes evaluating tropical cyclone model performance in the western North Pacific, but there is not a version of LGEM available for that basin. Work began on generalizing LGEM to include that basin. The long-term goal is to implement the new code in operations of the Joint Typhoon Warning Center in Honolulu.

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

PRINCIPAL INVESTIGATOR: John F. Dostalek

RESEARCH TEAM: Robert DeMaria, Kevin Micke, Kathy Fryer

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

NOAA RESEARCH TEAM: Mark DeMaria, NESDIS/RAMMB

PROJECT OBJECTIVES: The objectives of this project, which supports the NOAA mission goals of Climate, Weather, and Water, involve comparing profiles derived from satellite data to conventional radiosonde data supplemented with GPS soundings from the NOAA Gulfstream Jet, and COSMIC retrievals (although this is a satellite retrieval, the radio occultation technique gives very high vertical resolution down to the lower troposphere). The comparison was designed to be done using NESDIS' NPROVS (NOAA PROducts Validation Systems), which was modified to process the GPS soundings. In addition to examining the basic error statistics of the temperature and moisture profiles, four features were to be evaluated:
1) The trade-wind inversion height when present
2) The tropopause height
3) The maximum potential intensity of tropical cyclones using the theory developed by Bister and Emanuel (1998)
4) A tropical convective instability parameter based on a simple Lagrangian parcel model (DeMaria 2009).

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

PROJECT ACCOMPLISHMENTS: Figure 1 shows the performance of MIRS (Microwave Integrated Retrieval System) soundings compared to 10 GPS dropsondes released from aircraft over Hurricane Ida in 2009, using NPROVS. The matchups were required to be within 100 km and ±3 hrs. The statistics of the vertical profile of temperature errors show a bias and standard deviation of 1-2K. The results of the calculation of error statistics for the moisture retrieval show, in the lower atmosphere, a mean of less than 30% with a standard deviation of less than 40%. In the middle atmosphere, the magnitude of the mean error increased with decreasing pressure to around -35% at 300 hPa. The standard deviation was more constant with

height in this portion of the atmosphere, with values around 45%. These results were shown as part of a presentation given at the NOAA/NESDIS Sounding Oversight Panel Science and User Workshop in May of 2010.

NPROVS works well for collocation and basic matchup statistics of temperature and moisture. For the evaluating items 1-4 listed above, however, the software was not able to be used directly, and the extraction of the necessary data from NPROVS proved cumbersome. The focus of this calibration/validation work has shifted, therefore, in two respects. First, only MIRS soundings will be evaluated, and second, instead of using NPROVS to evaluate the quality of the soundings, the soundings' quality will be judged according to their performance in two products produced by RAMMB.

As the successor to the Microwave Surface and Precipitation Products System, the MIRS system is NESDIS' current operational microwave retrieval package. The MIRS algorithm is a 1DVAR system which can retrieve atmospheric and surface parameters simultaneously. It was designed for use with data from a variety of microwave sensors, including AMSU-B and the Microwave Humidity Sensor, from which it can provide a vertical profile of moisture. The statistical retrieval system currently used to generate the temperature profiles for RAMMB's tropical cyclone structure products has been used for over a decade. Although it has performed well, it was designed for use only with the AMSU-A instrument, and requires additional programming if the desired AMSU data are in a format not previously used. Also because it only uses measurements from the AMSU-A instrument, it is not able to provide a vertical moisture profile. Therefore, provided they are of sufficient quality, the MIRS retrievals will replace the current microwave retrieval package used in RAMMB's products.

To assess the quality of the MIRS retrievals compared to the current procedure, the output from two RAMMB products using both methods will be compared against the "ground truth" of H* winds and best track data. The two products are:

1) The Multiplatform Satellite Surface Wind Analysis, which uses information from 4 data sources to create a mid-level wind analysis using a variational approach (Knaff and DeMaria 2006). The mid level winds are then adjusted to the surface using a single column method.

2) A statistical intensity and wind radii estimate (Demuth et al. 2004; Demuth et al. 2006). This product uses microwave soundings to produce objective estimates of 1-min maximum sustained surface winds, minimum sea-level pressure, and the radii of 34-, 50-, and 64-kt winds in the northwest, northeast, southeast, and southwest quadrants of tropical cyclones.

A proposal to conduct this research was submitted to The NESDIS/StAR Calibration and Validation Program in January 2011.

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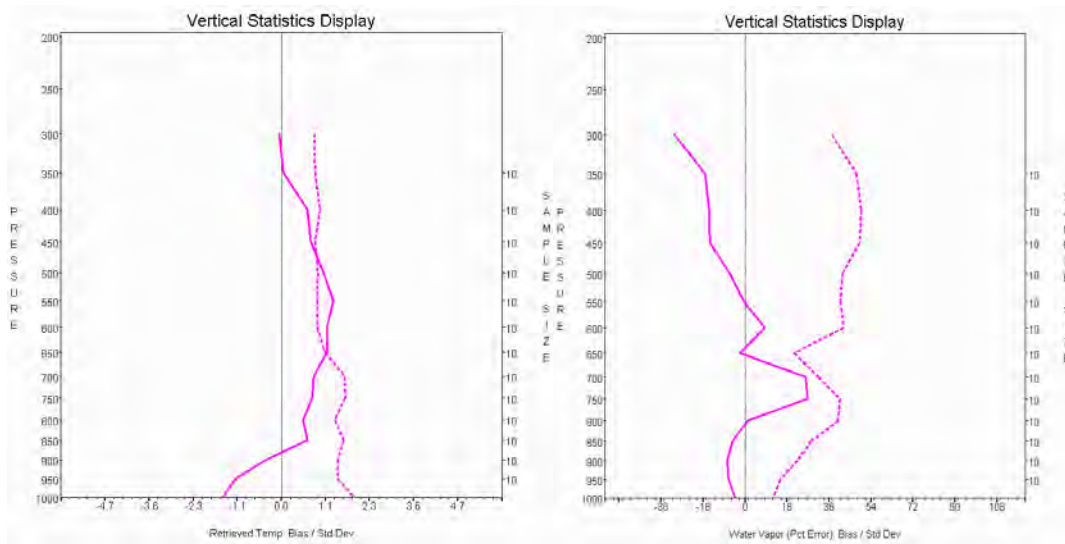
Figure 1. NPROVS output of statistical comparison of MIRS soundings with GPS dropsondes released during Hurricane Ida in 2009. Solid curves are the bias and the dashed curves are the standard deviation. The top panel contains the temperature comparison and the bottom panel contains the water vapor comparison.

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.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Kevin Brundage, Tracy Smith

NOAA TECHNICAL CONTACT: Stan Benjamin ESRL/GSD/AMB 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 2011. 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 2011, 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.

PROJECT ACCOMPLISHMENTS:
Began running Rapid Refresh (RR) system and High Resolution Rapid Refresh (HRRR) in real time on GSD's High Performance Computing System (HPCS). This implementation now uses recently introduced MOAB scheduler reservation system and the workflow manager developed at GSD.

Extended Rapid Update Cycle (RUC) forecast length running operationally at NCEP to 18 hours.

Began testing Rapid Refresh (RR) at NCEP's Environmental Modeling Center (EMC). This testing process continues and is now in the final testing phase.

Converted RR system to use a rotated lat-lon grid, to reduce low level wind forecast errors.

Please see the real time products provided at:
http://ruc.noaa.gov/rucnew/
http://rapidrefresh.noaa.gov/RR/
http://ruc.noaa.gov/hrrr/

EAR PROJECT TITLE: Advanced High Performance Computing

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

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

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

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

CIRA researchers will provide software support to ESRL scientists including software design advice and expertise on a variety of software/web/database technologies.

CIRA researchers will continue to modify the Flow-following, Finite volume Icosahedral Model (FIM) software to enhance interoperability with the National Centers for Environmental Prediction's (NCEP) National Environmental Modeling System (NEMS) architecture implemented via the ESMF and continue to collaborate closely with Tom Black and others at NCEP to further generalize the NEMS Earth System Modeling Framework (ESMF) approach so it meets requirements of NCEP models (GFS, NMMB) as well as FIM. CIRA researchers will interact with the ESMF Core development team to specify requirements for features needed by FIM, NIM, and other NOAA codes.

CIRA researchers will collaborate with LEAD researchers in the development of a Java-based graphical frontend to the WRF Pre-processing System (WPS) called WRF Domain Wizard.

CIRA researchers will continue to serve on the National Unified Operational Prediction Capability (NUOPC) Common Model Architecture (CMA) and Content Standards subcommittees.

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

PROJECT ACCOMPLISHMENTS:
CIRA researchers worked with ESRL meteorologists to improve the science driving NIM, and incorporate new methods into NIM, in a way that is structured and optimized to be efficient on the GPU, including creating the software structure to add physics as soon as it's ready. CIRA researchers parallelized NIM running on GPUs achieving, before parallel optimizations, a 15X speedup compared to parallel NIM running on CPUs.

CIRA researchers enhanced the capabilities of SMS including adding the capability for GPU parallel runs with all the data residing on the GPU where exchange does the pack and unpack on the GPU. CIRA researchers optimized SMS including reducing memory usage for large memory applications. CIRA researchers continue to assist SMS users and to find and fix bugs.

CIRA researchers worked on the optimization of several basic numerical operations in dynamic core, pre-processing and post-processing to speed up the computation and to reduce the memory consumptions. The numerical operations include least squares fitting for evaluating model variables at arbitrary locations and spherical linear interpolations for mapping model variables between different grids.

CIRA researchers upgraded grid generation software to include 2 new icosahedral grid generation schemes. CIRA researchers also upgraded the spherical interpolation scheme for FIM, and worked on new algorithms for FIM numerical computations.

CIRA researchers upgraded FIM to build and run correctly using the latest ESMF-based NEMS software infrastructure. Since this task had been intentionally delayed to allow NEMS to stabilize, the revisions to NEMS were substantial requiring significant changes to FIM code. The upgrade was accomplished without making changes to NEMS "ATM" or higher-level components. It represents a significant milestone because this is the first time a dynamical core developed by a group external to NCEP has been linked to NEMS without changing these high-level components. This success validates key NEMS design concepts and is a major step towards planned operational implementation of FIM in the NCEP multi-model global ensemble (GEFS).

CIRA researchers played key roles during the preparation and presentation of the first "Summer School in Atmospheric Modeling" sponsored by NOAA's Global Interoperability Program (GIP). This involved close collaboration with NCAR and CSU. The vast majority of the huge effort required to make SSAM a success was carried out by GSD staff, especially ACS software engineers and AMB scientists. CIRA researchers coordinated interactions with NCAR technical staff (NCAR provided the venue), prepared and gave talks during the class, and participated in technical preparations for and dry runs of practical sessions, and developed a graphical user interface (FIM Portal) to simplify the running of the FIM model by students. Student feedback was positive.

CIRA researchers authored an article on GIM Tool, a Google Earth based tool for visualizing global icosahedral datasets, published in the Spring 2010 issue of the CIRA Magazine.

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

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

CIRA researchers continued collaborating with NCEP, Navy, NCAR, and NASA to define aspects of a Common Modeling Architecture (CMA) for the National Unified Operational Prediction Capability (NUOPC). The primary objective of the NUOPC's CMA is to reduce long-term costs of integrating and sharing software between the nation's three operational global weather prediction centers, AFWA, FNMOC, and NCEP. They also served on the NUOPC Content Standards Committee (CSC) to define meta-data conventions to be shared by operational NWP models.

CIRA researchers began investigating fault-tolerant communication mechanisms and execution modes with the goal of recommending a solution that addresses crucial reliability problems in planned operational NWP ensembles and can be integrated into the Earth System Modeling Framework (ESMF). Initial use cases and prototypes were created and CIRA researchers have provided them to the MPI-3 standardization effort to help guide their work to create portable low-level support for fault-tolerant inter-process communication. This work was supported by a seed grant from the GSD Director's Office and we plan to complete this work under GIP support in FY11.

CIRA researchers ported FIM to ORNL's "jaguar" (Cray), MacOS (Apple), and NCEP's development machine "vapor" (IBM AIX). An initial round of performance tuning was then completed on "vapor" yielding a 2x performance improvement.

CIRA researchers assisted GSD scientists with initial efforts to couple FIM to ocean (HYCOM), physics (Grell parameterizations from WRF), and atmospheric chemistry. This work leveraged other funding sources and does not yet use NEMS.

CIRA researchers continued to improve software engineering processes for FIM and NIM. To ease porting and maintenance of FIM, CIRA researchers restructured and modernized the FIM build automation. The FIM build can now run in parallel on multi-core nodes greatly

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

CIRA researchers had ongoing interactions with the ESMF core development team, reporting bugs, requesting new features, and providing suggestions and advice regarding development directions and priorities.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Brian Jamison

NOAA TECHNICAL CONTACT: Steve Koch, NOAA/OAR/ESRL/GSD/DO

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.

PROJECT ACCOMPLISHMENTS: A web site for display of FIM model output http://fim.noaa.gov/FIMscp/ was updated and currently has 28 products available in 8 regions for perusal with 6-hourly forecasts going out to 10 days. Also available are GFS model forecast plots, FIMX (a version with chemistry, for which 7 more products are available for viewing), and FIMY (another test version of the FIM). Difference plots are generated as well and are available. The FIMX provided some insight on the spread and forecast spread of volcanic ash during the Icelandic eruptions during April 2010 (one of the few products available for this purpose, see Figure 1).
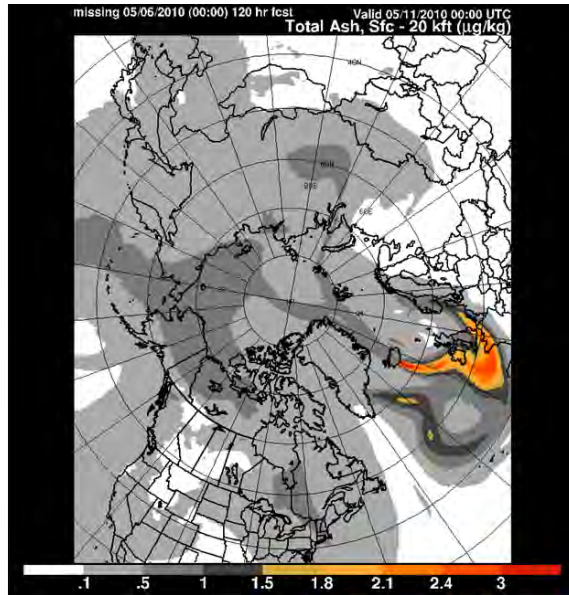
Figure 1. An example plot of Total Ash from the FIM model with chemistry. Large concentrations can be seen coming from an active volcano in Iceland.

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

EAR PROJECT TITLE: Fire Weather Modeling and Research

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

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

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

NOAA RESEARCH TEAM: Yuanfu Xie (GSD/FAB), Paul Schultz (GSD/FAB), Steven Peckham (CIRES/CU), Ruddy Mell (NIST)

PROJECT OBJECTIVES:
--Coordinate NOAA/NIST coupled fire weather/fire behavior modeling activities. NOAA has provided funding for fire weather modeling for FY10. Sher Schranz is the ESRL/GSD Program Manager.

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

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

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

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

PROJECT ACCOMPLISHMENTS:
--Closely coordinated coupling weather and fire models' research direction and progress with Dr. Mell and Dr. Peckham.

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

Sher Schranz was assigned by the new NOAA Strategy Execution and Evaluation (SEE) office as a Subject Matter Expert (SME) for fire weather observations and field evaluations. As the NOAA SME, Sher completed two evaluations of NSF fire weather-related proposals, one USFS field study proposal and contributed to formal NWS UAS (Unmanned Aircraft Systems), and SEE requirements documents. She is also on the Science Advisory Board for the NOAA UAS program for Fire Weather Observations.

--A new version of the experimental GSD 3km WRF/Smoke model was integrated into the FX-Net system for use by fire weather forecasters during the FY10 fire weather season. No formal assessment was conducted. Field study proposals resulted in adding 2 Unmanned Aircraft Systems to the CU/NIST observing systems suite; however no formal field studies were funded.

--The first annual Fire Weather Research Meeting with US Forest Service, OAR and NWS researchers was held in September, 2010. Another meeting is planned for FY11. The NOAA-USFS Collaborative Fire Weather Research MOU was drafted by the USFS and Sher Schranz. The Document will be signed by the NOAA/OAR AA.

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

--Model downscaling research and the use of ensemble models for fire weather operations was conducted with Hongli Jiang as the Principal Scientist. Objectives of this work were:

   --To use the dynamical downscaling method to provide high-resolution wind information to the office of NWS's Incident Meteorologists (IMETs) working at wildfires.
   --To explore a Fire Weather Index Calculation using ensemble model output.

Research Conducted:
--Wildfire behavior is extremely sensitive to wind variations on the scale of 100 meters and 10 minutes, or less, in some cases. Today's NWS forecast model of highest resolution (Rapid Updated Cycle, RUC) provides forecasts at the scale of 10,000 meters and 1 hour. High-resolution wind direction and speed is crucial information for Incident Meteorologists (IMETs) working at wildfires. We have been developing and testing the Space-Time Multi-scale Analysis System (STMAS) dynamical downscaling method which is designed to improve forecasts and analysis and meets NOAA goals. A testing case is selected from a wildfire that erupted near the Four-mile canyon, Boulder Colorado on September 6, 2010. Using the initially available observational data during the fire, we use the WRF-ARW output as the background fields to start the downscaling method. Results show that with realistic terrain, some reasonable wind structures are generated. Figure 1 shows the observational network including terrain height in green contour and wind for the Boulder area. There are only a few surface stations covering the rural area of CO, west of Boulder. Figure 2 shows the results of downscaling method providing high-resolution wind information for the same time as shown in Figure 1. Strong wind is produced over the steep terrain region over the western half of the domain where observation is scarce. This simple example illustrates the great potential of downscaling method for generating realistic wind structures using high-resolution terrain.
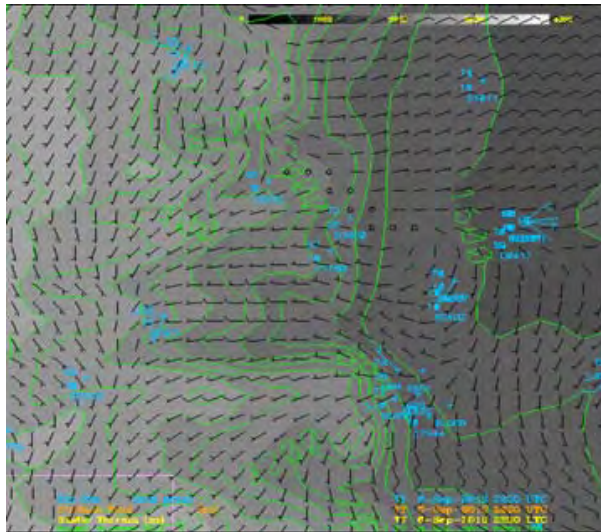
Figure 1. Surface observation network from Boulder to its west. There are only a few surface stations covering the area where the terrain is steep and the Four Mile Canyon Fire is located. Plotted is the terrain in green contour with label, and blue indicates the observational stations for September 6, 2010 at 2200UTC.
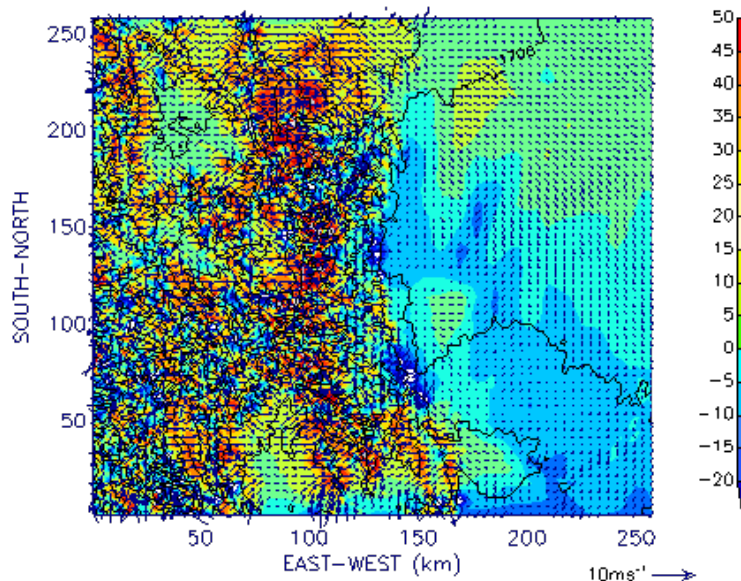
Figure 2. Surface wind from Downscaling output for the Four Mile Canyon Fire on September 6, 2010, at 22UTC. Color bar indicates the horizontal wind component in m/s. Darker blue indicates strong gusts from the East and darker red indicates westerly flow. These winds are in 1km resolution. Strong wind is produced in the steep terrain region over the western half of the domain. The Four Mile Canyon is located near the center of the domain (Lat: 40.0156, long: -105.3243).

--Research Conducted

The LAPS/Kelsch Fire Danger Index is based mainly on surface RH, Temperature, and Wind speed. RH and wind have the most weight with temperature having a lesser weight for this index that ranges from 0 to 20. Snow cover, elevation, and land fraction are given secondary consideration. High elevations, assumed to be above the treeline, are given a lower maximum value of 10. The index value of 0-5 is considered low, 5-15 is moderate, and any value greater than 15 is considered very high danger. For example, the index was 15 during the 2010 Boulder, CO Four Mile Canyon fire. The following is a brief explanation of the Index:

	4<wsd<8	8<wsd<12	12<wsd<15	15<wsd<18	18<wsd<21	21<wsd<24	Wsp>24
50%<RH<60%	8	9	10	11	12	13	14
41%<RH<50%	9	10	11	12	13	14	15
33%<RH<41%	10	11	12	13	14	15	16
25%<RH<33%	11	12	13	14	15	16	17
17%<RH<25%	12	13	14	15	16	17	18
9%<RH<17%	13	14	15	16	17	18	19
RH<9%	14	15	16	17	18	19	20

Table 1. Wsp: wind speed in mph. Note that temperature and soil moisture are also counted in fire index calculations. The above is done under extreme dry and hot conditions with soil moisture about 20 % and temperature warmer than 95 F. For temperature between 86 F and 95 F, the indices will be reduced by 1. For temperature ranging between 77F and 86F, the indices will be lowered by 2. If soil moisture increases to 35%, the indices will be reduced by 1. If soil moisture increases to 50%, the indices will be reduced by 2. If ground has 25 % snow cover, the index will be reduced by 5.

EAR PROJECT TITLE: LAPS/WRF Modeling Activities

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Steve Albers, Isidora Jankov

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

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

PROJECT OBJECTIVES:

Hurricane Forecast Improvement Program

Global Systems Division (GSD) and FAB have been involved in three different HFIP efforts. These efforts are linked to data assimilation, numerical modeling and statistical post-processing. Isidora Jankov is leading the numerical modeling effort for this multi-year project. The effort addresses testing/comparison of different ensemble configurations and determining the optimal ensemble strategy for regional ensembles, including initial condition perturbations and lateral boundary conditions.

Milestones and deliverables for this particular task are as follows:
--Milestone: Test "cycling" initial perturbation approach for TC five-day forecasts.
Deliverable: Compare skill statistics of TC track and intensity forecasts with "cycling" approach versus traditional (e.g. interpolated global analysis) initialization approach for a sample of storms.
--Milestone: Compare "cycling" results to regional EnKF results.
Deliverable: Compare statistics of ensembles performance when using EnKF and "cycled" initial conditions.
--Milestone: Test performance of various dynamic cores/physical parameterizations using cycling method.
Deliverable: Compare results from various dynamic cores (e.g. HWRF, HWRFX, WRF-ARW) and/or various physical parameterizations (e.g. microphysics). For this purpose, traditional measures (e.g. TC track and intensity) will be evaluated in addition to QPF associated with a sample of TCs. Possible focus area will be on TC's landfall to benefit from observations available over land (e.g. radar data).
-- Milestone: Assess uncertainty related to both initial conditions and model uncertainty by evaluating total error variance.
Deliverable: Improved suite of model(s) and/or initial condition perturbations for TC ensemble applications.

PROJECT ACCOMPLISHMENTS:
This is a new project in the developing stage and more on progress will be reported next year.

DTC Ensemble Testbed (DET)
As operational centers move towards ensemble-based probabilistic forecasting, it is important that the DTC expands its effort into this area in order to continue to serve as a bridge between research and operations. To accomplish this, the DTC mesoscale Ensemble testbed was established in 2010. The main purpose of DET is to provide an environment in which extensive testing and evaluation of ensemble-related techniques can be performed and results provided to the operational centers. Also, the DET will help NCEP in design and testing of the next generation SREF. This is a multi-year project.
The DET infrastructure consists of six modules:

--Ensemble configuration (defines membership and horizontal/vertical resolution of members, such that the different models and/or different configurations of the same model can be included)
--Initial/Lateral Boundary perturbations (provides the ability to represent uncertainty in initial conditions based on a variety of techniques)
--Model perturbations (provides the ability to represent mode-related uncertainty based on a variety of techniques)
--Statistical post-processing
--Product generation
--Verification.

PROJECT ACCOMPLISHMENTS:
Isidora Jankov is the lead for efforts related to modules 2 and 3 and works collaboratively with Linda Wharton on module 1. In August 2010, the first DET workshop took place in Boulder. At the meeting, some preliminary results related to module 2 were presented.

Convective Initiation- NextGen
There is a possibility that FAB will be funded for exciting research related to convective initiation (CI) in relation to the NextGen project. The proposal from the FAB includes data assimilation and ensemble modeling aspects. For this purpose, numerical modeling experiment will be designed as follows: Simulations will be performed for five selected events. The CONUS ensemble will be used to drive a 10-20-member ensemble of WRF with a 3 km grid. This high-resolution model will cover the Eastern U.S. ("golden triangle"). Ensemble members will be embedded into the coarser resolution CONUS ensemble and will include different cores and physics. Initial perturbations will be dynamically downscaled from the CONUS ensemble to capture analysis uncertainties on the finer scales. For each case, the model will be started every hour and run for 6-8 hours. For critical periods of convective initiation, the ensemble may be initialized every 15 minutes to assess the lead-time at which convective initiation can be captured. Ensemble outputs will be used to generate probabilistic products. The combination of high-resolution ensemble and rapid refresh will provide a level of guidance that is not currently available. The products from these simulations will be archived for use during the displaced real-time demonstration with forecasters. These predictions will be compared with current operational products. Steve Albers will lead analysis-related activities while Isidora Jankov will lead the modeling effort.

PROJECT ACCOMPLISHMENTS:
This is a new project awaiting funding.

Hazardous Weather Testbed
At FAB, two domains will be set up for the HWT demonstration, one is a relatively larger domain that is the same as the CAPS domain and the other is the smaller 1km inner nest. This inner domain can be dynamically selected through our website covering hazardous weather areas. We propose the following for deterministic control run and ensemble runs:

Domain	Forecast	Resolution	Frequency	Forecast length
CAPS	Deterministic	2.5km	3-6 hour	12 hour
CAPS	Ensemble	7.5km	6 hour	12-18 hour
Inner	Deterministic	1km	15 minute	1-2 hour
Inner	Ensemble	2.5km	6 hour	6 hour

We list these as the candidates for the HWT demo and hope to discuss with NSSL on how to coordinate, as NSSL will set up LAPS/WRF run as well.
The important features of these runs are:
--3km DA using LAPS
--fine scale ensembles
--timely analysis and forecasts (15 minute analysis and forecast cycle for the deterministic runs).

A STMAS surface analysis will be sent to HWT for evaluation. It provides a 2-km analysis over 15 minute cycles over the CONUS grid. A new version of the STMAS surface is nearing the end of its development and testing, which includes:
--multivariate analysis;
--incorporation of topography
--background flow dependency
--use of simple surface constraints.
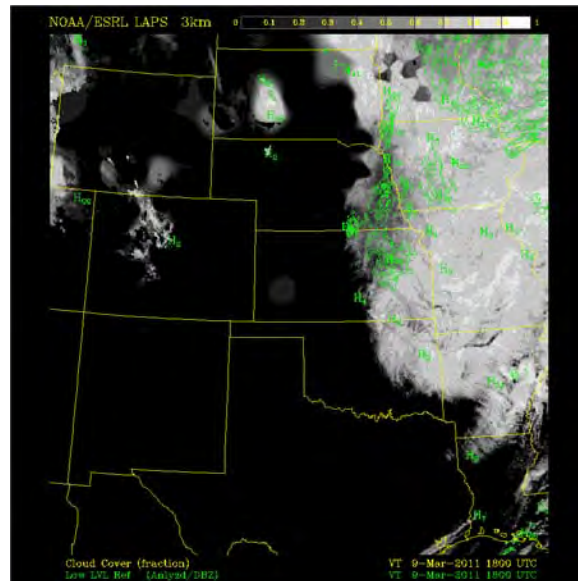
Figure 1. LAPS cloud analysis over the domain used for the Hazardous Weather Testbed (HWT) experiment.

PROJECT ACCOMPLISHMENTS:
This is a new project in the developing stage and more on progress will be reported next year.

PROJECT TITLE: Severe Weather/Aviation Impact from Hyperspectral Assimilation

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Haidao Lin

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

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

Research Conducted (Accomplishments) Past Fiscal Year by Objective:
Since the start of this project in August 2010, several tasks have been completed to incorporate Atmospheric Infrared Sounder (AIRS) single field of view (SFOV) retrieved soundings into a retrospective test run of the Rapid Refresh (RR) and to evaluate the impact of these data on RR forecast skill. First, codes and scripts were written to read the AIRS SFOV temperature and water vapor data and to append them to the appropriate prepbufr observation data files for use in the RR data assimilation system. Next, the AIRS SFOV

retrieved soundings were compared with neighboring (in space and time) radiosondes to assess difference patterns (especially biases).

Results indicated that the AIRS SFOV retrieved temperatures tended to be colder than the corresponding radiosonde temperatures. This pattern was also evident in the analysis increments (A-B) in regions dominated by the SFOV observations (see Figure 1 for sample analysis increments with and without inclusion of the SFOV data). Following this observation assessment, retrospective control (use of all conventional observations) and radiosonde denial experiments were completed to validate performance of the retrospective system. Verification of these experiments against radiosondes yielded expected forecast error scores for the control and expected forecast skill degradation for the radiosonde denial experiment.
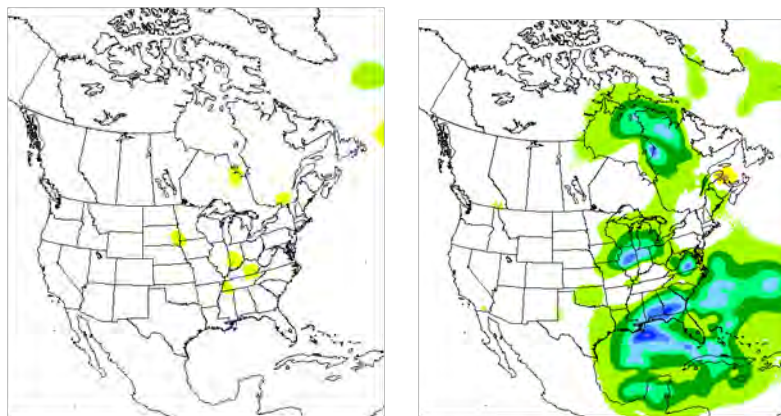
Figures 1a. and b. 500 mb temperature analysis increment for (1a) the control run (without AIRS soundings) and (1b) the experiment assimilating all available AIRS temperature soundings at 0600 UTC 8 May 2010.

Next, a series of 9-day RR retrospective experiments was performed to test the forecast impact from the AIRS SFOV data. Initial experiments have focused on use of only the

retrieved temperature data. Assimilation of all the temperature profile data resulted in somewhat degraded forecast skill. Subsequent

experiments, in which SFOV data were not used at low (>800 mb) and high (<400 mb) levels improved results, as did doubling the assumed observation error variance and thinning the SFOV observation in both the horizontal and vertical dimensions. Inclusion of all of these modifications has yielded modest forecast skill improvement at some levels, as shown in Figure 2. Additional work is ongoing to assimilate the water vapor data and to further evaluate analysis innovation (O-B) patterns in order to obtain objective criteria for more selective SFOV

data quality control. This should lead to further forecast improvements from assimilation of these data.

Complementary work has focused on direct radiance assimilation at the mesoscale, in particular evaluating the satellite bias-corrections within GSI for the RR. Results from the SFOV assimilation work were presented at the High Impact Weather working group meeting in Norman, OK in Feb. 2011.
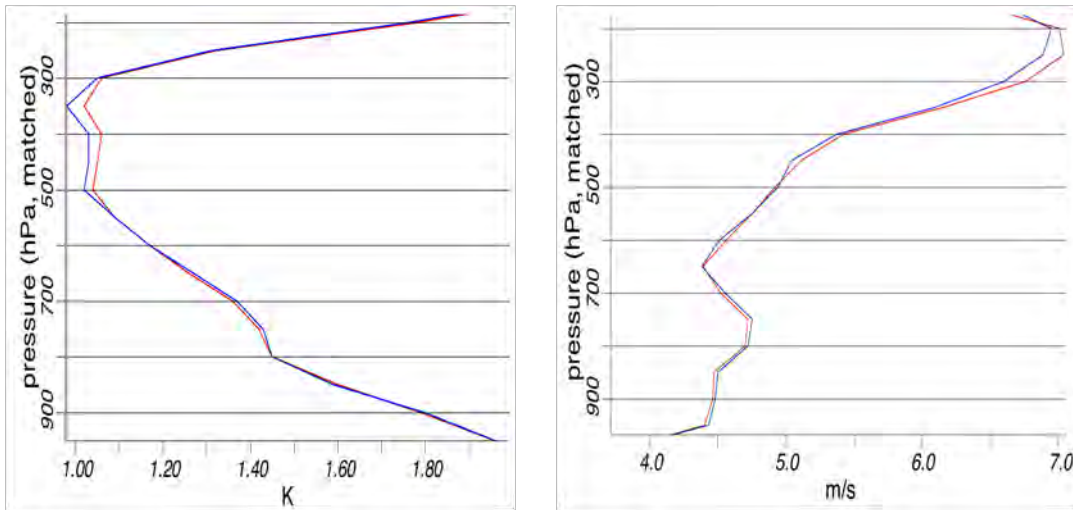
Figures 2a. 12-h forecast temperature profile RMS errors (vs radiosonde) and 2b. 12-h forecast vector wind profile RSM errors for the control run (red, without AIRS data) and the experiment using the AIRS temperature soundings (blue, 60 km horizontal, 50 mb vertical thinning, doubling the assumed observation errors).

PROJECT TITLE: Teaching Modeling at Universities

PRINCIPAL INVESTIGATOR: David Randall

RESEARCH TEAM: Don Dazlich, David Randall, Kelley Wittmeyer

NOAA TECHNICAL CONTACT: Allan Schmidt, OAR Cooperative Institutes Office (CIPO)

NOAA RESEARCH TEAM: None

PROJECT OBJECTIVES: Develop and make available course materials that can be used to train graduate students to understand, create, modify, and apply global atmosphere and ocean models. Both numerical methods and physical parameterizations will be covered**.**

PROJECT ACCOMPLISHMENTS**:**
--Summer School on Atmospheric Modeling. Most of our Year 1 funding was used to develop and conduct a Summer School on Atmospheric Modeling (SSAM) which was held in Boulder, Colorado on July 19-21, 2010. For 2010, the focus of SSAM was FIM, a Flow-Following, Finite-Volume, Icosahedral Model developed at NOAA's Earth System Research Laboratory (ESRL).

The presentations and other course materials are available at http://wrfportal.org/FIMPortal.html. Twenty-file students participated; a list of students is available upon request. Demand exceeded supply: Some students who applied for the course could not be accommodated due to space limitations which were announced in advance. When the Summer School ended, the students provided written feedback on the design and conduct of the course. The

feedback was strongly positive. Copies of the students' comments are available on request.

SSAM was made possible through the efforts of ESRL scientists whose participation was authorized by ESRL Director Alexander MacDonald. Dr. MacDonald also gave one of the opening lectures of the Summer School.

In addition, SSAM received support from NCAR. This included a significant amount of computing time as well as use of meeting space at NCAR's Foothills Laboratory.

--Class Materials on Global Atmospheric Modeling. David Randall is currently nearing completion of a book with the working title "Atmospheric Processes in Climate," to be published by Princeton University Press. The book is aimed at undergraduates. It should appear in late 2011 or early 2012.

In addition, Randall taught a graduate-level class during the Fall Semester of 2010 entitled "Introduction to General Circulation Modeling." The materials used for this class are being used as the basis for a second book to be completed during 2012.

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.

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PROJECT TITLE: Ensemble Data Assimilation for Hurricane Forecasting

PRINCIPAL INVESTIGATOR: Milija Zupanski

RESEARCH TEAM: Min-Jeong Kim, CIRA and JCSDA, Man Zhang, CIRA, Karina Apodaca, CIRA

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

NOAA RESEARCH TEAM: Stephen Lord, NCEP/EMC, John Derber, NCEP/EMC, Jim Purser, SAIC and NCEP/EMC

PROJECT OBJECTIVES:

--Perform diagnostics of the cross-covariances from the evolved ensembles for improving the situation dependent background errors (SDBE) covariance modeling in GSI for hurricanes

--In synergy with the JCSDA/EMC development of forward operators for cloudy radiances, begin work on utilizing and evaluating cloudy radiances in hurricane situations with ensemble data assimilation (EnsDA).

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

PROJECT ACCOMPLISHMENTS:

--We performed numerous single-observation experiments to evaluate the structure of SDBE from EnsDA. An example of analysis response to a single specific humidity (q) observation at 850 hPa is shown in Fig.1. The structure indicates flow-dependent character of the errors. For example, the q response (Fig.1a) is stretched in the direction of wind, and wind response indicates a surface convergence (Figs.1b,c).
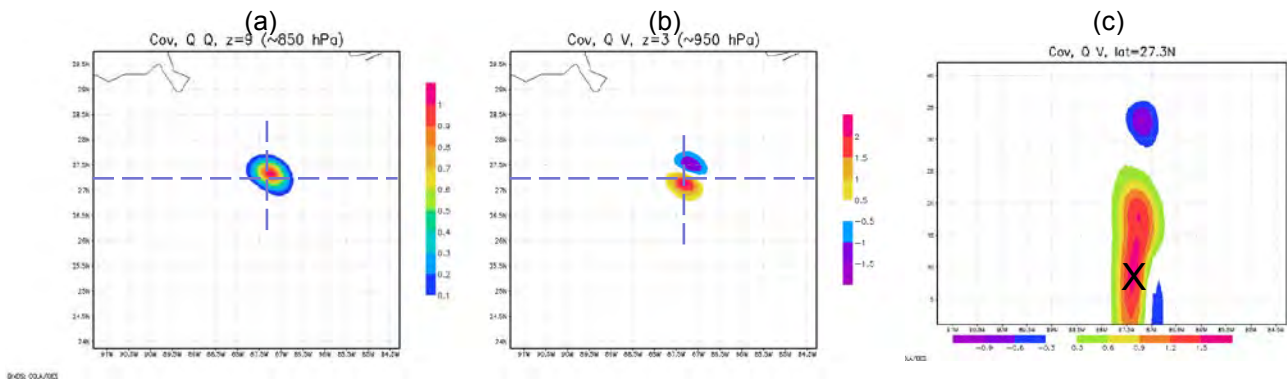
Figure 1. An average analysis response to a single specific humidity observation at 850 hPa, located northwest of the center of the hurricane Gustav (2008): (a) specific humidity at 850 hPa, (b) north-south wind at 950 hPa, and (c) vertical cross-section of north-south wind. Included are 10 data assimilation cycles, with 6 hour from 10 data assimilation cycle is 6 hours.

--We adopted the development by M-J Kim for global data assimilation and implemented microwave cloudy radiance assimilation in the regional HWRF-EnsDA system. Since the HWRF microphysics produces only a total column of all water phases, the approach involves a separation of liquid and ice. Also, all components of the HWRF-EnsDA system have been updated: GSI, CRTM and HWRF.

--Cloud microphysical variables have been included in HWRF-EnsDA. Their impact is being evaluated.

EAR PROJECT TITLE: Chemical Data Assimilation

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Mariusz Pagowski

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

NOAA RESEARCH TEAM: Georg Grell (CIRES), Stuart McKeen (ESRL/CSD), Steven Peckham (CIRES)

PROJECT OBJECTIVES: Further development of data assimilation system for WRF-Chem and CMAQ using GSI and Ensemble Kalman Filter (funding from OAR)

Further development of data assimilation system for WRF-Chem over Rapid Refresh domain (funding from AFWA)
PROJECT ACCOMPLISHMENTS:
A paper submitted to the Quarterly Journal of the Royal Meteorological Society (QJRMS) on chemical data assimilation of ozone and particulate matter has been published in October 2010. A follow-up publication on frequency of the assimilation cycle is being prepared. Statistics illustrating performance of WRF-Chem forecasts with and without assimilation for six-hourly assimilation cycle for ozone and particulate matter are shown in Figures 1 and 2, respectively.
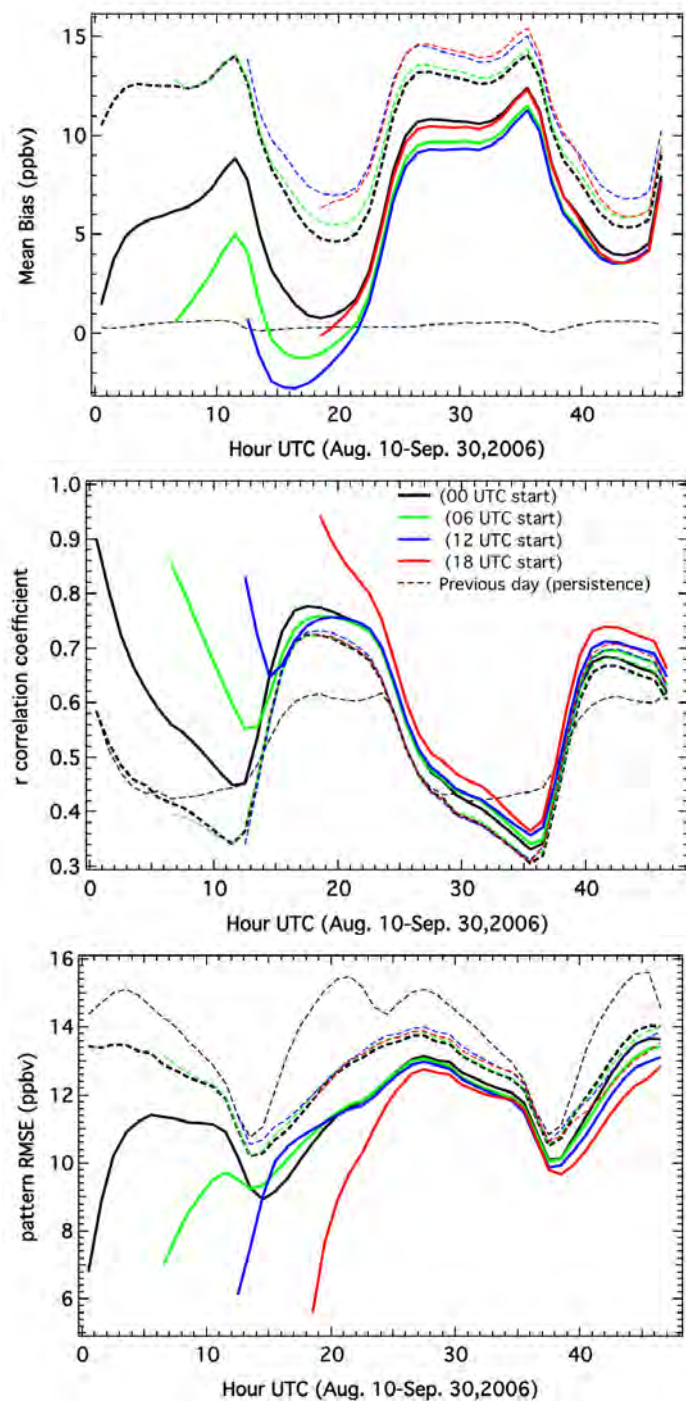
Figure 1 a, b, c. Time series of mean bias (1a), pattern root mean square root error (1b), and correlation of ozone forecasts with and without assimilation (1c).
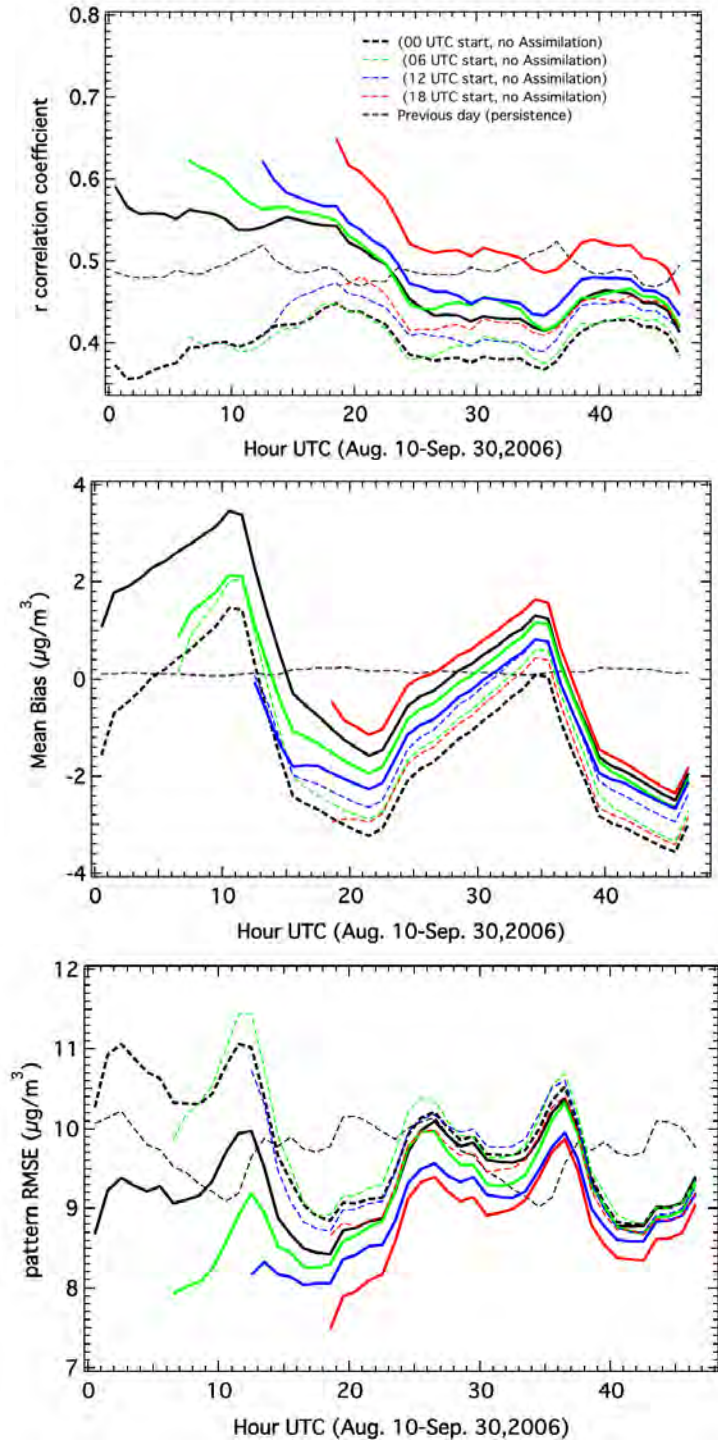
Figure 2 a, b, c. Time series of mean bias (2a), pattern root mean square root error (2b), and correlation of particulate matter forecasts with and without assimilation (2c).

Background error statistics for particulate matter have been derived for WRF-Chem over the Rapid Refresh domain covering the entire North America. Forecasts with the assimilation of this species are running in real-time.

Simulations to assess impact of assimilation of ozone soundings and measurements from commercial aircraft on forecasts of ozone were performed for summer of 2006. Evaluation of the results is under way and will be presented at EGU conference in April 2011.

Assimilation of particulate matter using Gridpoint Statistical Interpolation (GSI) and Community Multiscale Air Quality (CMAQ) model as a background has been implemented on request from NCEP. The developed code has been accepted into the GSI repository and, upon successful evaluation of CMAQ forecasts by NCEP, will be used for national forecasting of particulate matter.

EAR PROJECT TITLE: Local Analysis and Prediction System

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Steve Albers, Isidora Jankov, Ed Szoke

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

PROJECT OBJECTIVES: The Local Analysis and Prediction System (LAPS) integrates data from virtually every meteorological observation system into a very high-resolution gridded framework centered on a forecast office's domain of responsibility. Thus, the data from local mesonetworks of surface observing systems, Doppler radars, satellites, wind and temperature (RASS) profilers (404 and boundary-layer 915 MHz), radiometric profilers, as well as aircraft are incorporated every hour into a three-dimensional grid covering a 1040km by 1240km area. New analysis techniques such as Space and Time Multiscale Analysis System (STMAS) are being developed within the LAPS umbrella. LAPS has analysis and prediction components. The prediction component is being configured using various mesoscale models that are initialized with LAPS or STMAS analyses and run to provide short-term forecasts. Ensemble-based forecasts using multiple models and initialization methods, with verification are also produced.

LAPS (increasingly including the new STMAS analysis package) is run in real-time at ESRL/GSD for many domains including one

centered on the Denver, CO Weather Forecast Office. LAPS has also been ported to many locations (~150 worldwide), including universities such as Univ. of Oklahoma ("OLAPS"), and Univ. of North Dakota. LAPS is running on-site at each National Weather Service Forecast Office (WFO) as an integral part of AWIPS. LAPS software is also being implemented at various U.S. government agencies such as Federal Highways Administration (MDSS), Range Standardization and Automation (RSA) at the U.S. Space Centers, National Ocean Service, U.S. Forest Service, and for international government weather bureaus such as China, Italy, Taiwan, Finland, and Korea.

Research objectives related to LAPS continue 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.

It is worth noting that LAPS and WRF improvements frequently have cross-cutting

benefits that leverage towards many of the supported research projects (both within and external to NOAA) described later in this report. Funding has materialized for certain projects

PROJECT ACCOMPLISHMENTS: Within the Forecast Applications Branch (FAB), CIRA researchers continue to play a leading role in development and implementation of meteorological analyses (e.g. wind, clouds, temperature, and precipitation), data ingest, and auxiliary processing, and web displays within the Local Analysis and Prediction System (LAPS). This includes overall management of the configuration, updates, and distribution of the LAPS (and STMAS) systems. These systems are widely used at hundreds of institutions within the U.S. and around the world for weather analysis and forecasting purposes. One of the

since the Statement of Work was formulated; LAPS/STMAS improvements benefiting these projects are included in this section.

highlights for the year was the inaugural LAPS workshop principally organized by Steve Albers to motivate and lead the coordination of new ideas for development in LAPS and STMAS. A regular series of LAPS / STMAS meetings within FAB also takes place.

For LAPS and STMAS, we worked to improve the analyses in the following areas:
--First Guess Processing
--Observational Data Sets
--Surface Observations
--Upper Air Observations
--Surface Analysis
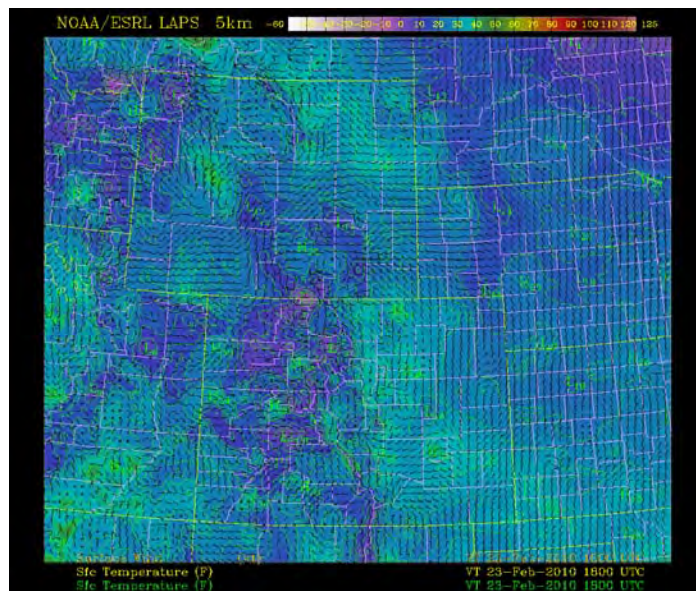
Figure 1. LAPS surface temperature and wind on the 5-km Colorado domain

Radar Processing
Routines were added to read and pre-process the netCDF volume radar data that is now being generated by GSD's central facility. Results are now close to the older tilt files. This is a key development in having a portable radar ingest interface for Precision Wind and other users.

Wind / Temperature Analyses
The wind analysis now runs faster with high-resolution domains having numerous Doppler radar data as the single-Doppler passes now have a smaller radius of influence.

Working with Jacques Middlecoff of the HPCC group, MPI changes to parallelize key portions

of the wind analysis are now in place. This is now running in real-time on our JET Linux cluster. Related script refinements were made to have more flexibility and efficiency when we run the parallelized analysis on JET, including during the transition from the WJET to HJET clusters.

The LAPS wind analysis now pares down the multiple-Doppler radial velocity observations further to help it run faster. This also includes using multi-Doppler obs only at smaller scales within the multi-scale Barnes analysis.

Multi-Doppler wind vectors now work properly with 4 radars, thanks to a change submitted by METEOCAT.

We now use a thinner boundary layer at night in the temperature analysis to restrict the depth of nocturnal inversions. This may help with radiometer comparisons.

Radiometer temperature profiles now get used in the lowest 1km for the traditional LAPS temperature analysis.

Cloud / Precipitation Analyses
Computation of downward short wave analysis field was added based on simple model that includes clear sky solar radiation, cloud fraction, cloud analysis metadata, and snow cover. This analysis is statistically compared with global insolation observations. The statistics include things such as overall bias/rms/correlation as well as sensitivity of the observed radiation (normalized with clear sky values) to variations in cloud cover. This is a key development in support of renewable energy efforts.

The cloud analysis now makes some use of the surface-based Lifted Condensation Level (LCL) to help define cloud base.

Cloud analysis issues impacting about 10% of Linux runs were fixed. This should help both in-house runs and external ones like at the Norman, OK WFO. A separate cloud analysis issue discovered by the Finnish Meteorological Institute when we have more than 41 vertical levels has been fixed.

The radar reflectivity access routine should work now using sparse (non-filled) arrays for STMAS. The "Kessler" option for precipitating rain and snow now has correct units.

Cloud-top determination improvements from METEOCAT were incorporated into the software. Cloud layer input to the surface obs ingest and cloud analysis is now working with the new virtual server LINUX OS. Cloud analysis METAR & PIREP "sounding" routines were moved to library so they could be used in STMAS.

Cloud analysis QC was improved based on runs from Ben Baranowski at the NWS.

Cloud Type and Precipitation Type are now written into separate files. Other steps were taken to separate cloud & precipitation type calculations in the software. Eventually, we can move the cloud type into the cloud analysis so it can be effectively used by the humidity code, though for now it is still in the derived products program.

The derived products program efficiency was improved (helping Global LAPS).

Improvements were made for blended gauge/radar precipitation analysis. A regression routine added to precipitation accumulation analysis to give a new option for correcting radar/first guess derived precipitation with rain gauges. Here the applied bias becomes a function of precipitation rate.

The Stage IV precipitation remapping routine is now a bit more generic.

LAPS Model Initialization/Post Processing
The LAPS model post-processing scripts that are set up in cron now run better for the various WRF model cases. A related test script now works better and can be set up automatically via the LAPS configuration.

LFMPOST now handles zero radar reflectivity more consistently for various microphysical options. LAPS Fire weather now gets calculated in LFMPOST by default.

The use of surface balance fields in model initialization can now be controlled via namelist.

WRF support for downward solar radiation and outgoing longwave radiation (OLR) has been added to LFMPOST. This will help with visualizing and verifying solar radiation forecasts. OLR images should be a reasonably

good proxy for infrared satellite imagery in visualizing model forecasts of clouds.
We now define areas below sea level as land for masking purposes in calculating upslope moisture flux. Subroutine calling bugs were fixed.

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.
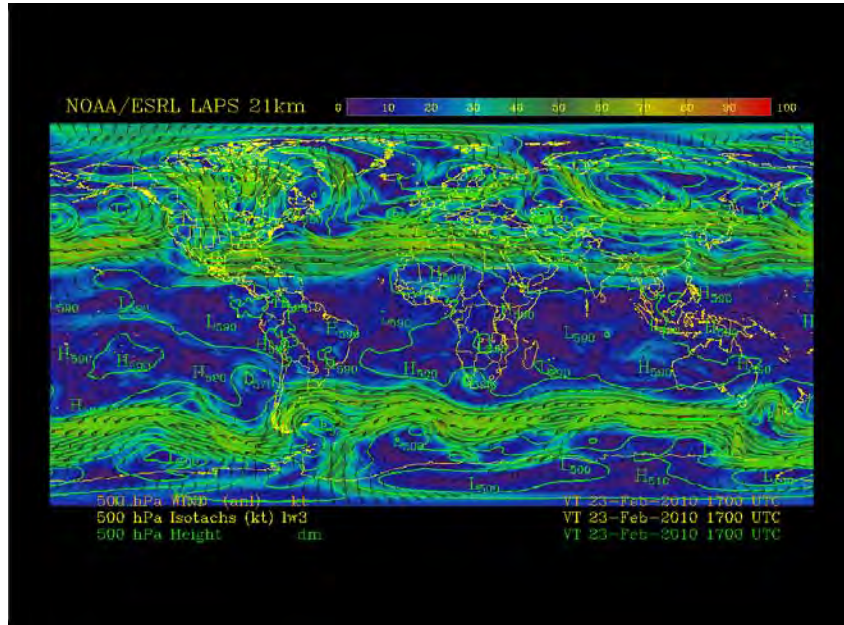
Figure 2. Analyzed 500mb height and wind on the GLAPS 21-km global domain

Research continues with both real-time and retrospective LAPS runs with the Mauna Kea Weather Center (University of Hawaii).

A paper was published with an Italian Climate agency on use of Meteosat Second Generation satellite data in LAPS.

WWW LAPS Interface
Web pages were significantly improved for plotting analysis and forecast fields for LAPS including STMAS. The "on-the-fly" page has additional available fields and improved animation capability.

Range Standardization and Automation (RSA) Project
NOAA/CIRA funding was unavailable so only minimal work was done during this period

Model Ensembles and Ensemble Post Processing
Ensemble forecast system testing and implementation continued in support of the Hydrometeorological Testbed and the project

supported by California's Department of Water Resources.

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 has been run over the much larger domain covering basically the whole west coast this season. The increase in the integration domain resulted in coarsening horizontal grid spacing from

5 to10km. As during the last season, the output from this run was used as input to a moisture flux tool developed by colleagues from PSD.

Taiwan Central Weather Bureau (CWB)
CIRA proposed to continue its long-term scientific collaboration with the Taiwan Central Weather Bureau (CWB) to update the LAPS/STMAS analyses and hot-start forecast software at the CWB. CIRA also proposed to study improvements to analysis techniques, diabatic initialization and balance package, WRF model initialization, as well as model forecast verification. We continued to operate real-time LAPS and STMAS runs both at GSD and at the CWB. Our achievements for this project compare favorably with the goals projected in the statement of work, given the available funding.

NWS Interaction
a) AWIPS and AWIPS-II
We continue a long-term effort to have LAPS software running in the National Weather Service WFO's (on AWIPS) for evaluation and use by operational forecasters. Discussions are being held about future plans to upgrade LAPS and introduce STMAS in both AWIPS and the new AWIPS-II workstations running in National Weather Service WFOs. A high resolution (5 km horizontal grid spacing) WRF-ARW model run is available four times per day for operational use by the local NWS office in Boulder. In addition, Isidora Jankov was invited to discuss options for setting up a high resolution model for numerical prediction supporting convective weather forecasting at the NWS in Omaha.

b) EFF Activities
We continued our interaction with the local National Weather Service (NWS) Weather Forecast Office (WFO) in Boulder, located within the David Skaggs Research Center.
This includes Ed Szoke working forecast shifts at the Boulder WFO. The interaction helps to provide better forecaster feedback on other projects that Ed is involved with outside of LAPS, including the GOES-R Proving Ground project and evaluating the FIM model. There are also occasional cooperative research projects, some resulting in co-authored conference papers. Additionally, one of the Boulder forecasters does periodic weather briefings as a part of the long-running Daily Weather Briefing program, which involves a 30-minute weather briefing held on every workday at 11:00 A.M in GSD. Several CIRA researchers also take part in presenting and producing weather briefings. We have also begun to have better participation from other researchers within ESRL but outside of GSD following a new initiative to increase Weather Briefing awareness.

Hydrometeorological Testbed (HMT) / California Department of Water Resources (DWR)
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. Three large field campaigns were held in December through March of the past five winter seasons in California. CIRA staff in the Forecast Applications Branch (FAB) are an integral part of ESRL/GSD's effort to provide high-resolution model analyses and forecasts, as well as forecast interpretation by meteorologists, in support of field operations and NWS operational forecasting. Starting in 2010, a second area in the Eastern U.S. will be the focus of the HMT experiment in which CIRA staff will be heavily involved.

For the past five years, FAB has been actively participating in the HMT experiment. The main role of FAB in the HMT has been to design an ensemble system for real-time precipitation forecasting and to support this real-time system during the experiment. In addition, FAB collaborated with PSD colleagues on addressing various research questions related to "atmospheric rivers". These collaborations resulted in six per-reviewed publications and many conference presentations at national and international meetings.

At the end of the last HMT season (March 2010), a decision was made to continue the ensemble runs throughout the year to provide modeling support in decision making for fire weather in the state of California. For the past three years, the ensemble modeling effort has been led by Isidora Jankov while the corresponding LAPS and post-processing activities have been led by Steve Albers.

Ensemble forecast system testing and improvement continues. The focus of the upcoming season will be on testing new approach to initial condition perturbations for limited area ensemble. Recently, initial condition

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

In the past year the HMT related research, performed in collaboration with several CIRA scientists, resulted in a publication accepted by the Journal of Hydrometeorology.

Investigative Modeling Research
--NSF Model Microphysics Study
--Hurricane Initialization Studies with LAPS/STMAS/GSI

-- NSF Model Microphysics Study. Steve Albers and Isidora Jankov continued to work in collaboration with Tomislava Vukicevic and a PhD student Marcus van-Lier Walqui on an NSF granted project. Synthetic polarimetric radar, 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. Results obtained from this study have been reported to NSF and will be used for an official journal publication in near future.

--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 obs 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 obs 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 has been 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 researchers 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.

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

Windsor Tornado Case Study:
We are collaborating with Radiometrics Corporation, UCAR, and others to study the analysis and short-range forecasting of the May 2008 Windsor, CO tornado. This includes gathering the real-time LAPS analyses, as well as all available in-situ and remotely sensed observational data for rerunning LAPS and STMAS, together with WRF forecasts. There is a CIRA/Fort Collins-managed special project dedicated to continued research on this topic.

For this project, we ran short-term 1-hour and 3-hour LAPS/WRF forecasts of the Windsor

Tornado. We made careful comparisons of model runs initialized from both LAPS and STMAS analyses. Resolutions ranged from 5km down to 800m. We also did some data denial experiments for the LAPS humidity analysis with and without radiometer data.

Radiometrics Corporation is experimenting with using LAPS soundings as input to a forward model. The forward modeled brightness temperatures are then compared with radiometer measurements in several frequency bands. Results show reasonable consistency, though with a bias at one of the highest frequency bands. Meanwhile, STMAS is being run at a higher resolution (81 vertical levels) to improve depiction of the boundary layer. We identified some issues with model initialization of boundary layer humidity that will be investigated.

Potential vorticity has been added as a new field for diagnosing frontal structure and boundary layer vorticity. This helped us to diagnose and fix some issues with the LAPS balance package.

Department of Homeland Security (DHS)
We set up and continued to monitor LAPS analysis runs to support the initial Dallas-Ft. Worth implementation of the Geo-Targeted Alert System (GTAS). Doppler radars from 5 sites near DFW 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 areas. 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 those in New York.

Renewable Energy
We have been collaborating with Precision Wind and CIRA Fort Collins for radar data and wind forecasts. This project entitled "Ensemble Data Assimilation Research for Wind Forecasting" involves collaboration with PI Dr. Zupanski and Co-PI Dr. Miller in the capacity of a Senior Consultant in tasks that involve utilization of radar, wind energy, and other data into the Maximum Likelihood Ensemble Filter (MLEF) ensemble system.
We have been working with Precision Wind to install the LAPS/STMAS system, including access of model first guess, in-situ observations, and Doppler radar data.

We have also been attending ESRL Renewable Energy meetings convened by Melinda Marquis in response to the recent MOU signed between NOAA and DOE for renewable energy research. There is an associated discussion specifically on solar energy that has been going on between NOAA and DOE for a while and we are assisting with the planning process on how to fill in gaps in capability on both the ESRL and NOAA levels.

In connection with the ESRL renewable energy meetings, we have informally been conducting (and presenting) some experiments with verifying analyses and forecasts of solar radiation. Our modeling efforts are being well received by the group and they have great potential to help NOAA provide improved analyses and short-term forecasts of solar radiation. This meeting group is also interested in our high-resolution wind forecasts.

Science On a Sphere (SOS)
CIRA staff continued to maintain real-time weather models (Global LAPS, FIM, GFS) on SOS. Other real-time datasets that have been developed and maintained include global weather satellite, earthquakes, and solar extreme ultraviolet images from the STEREO spacecraft. For global weather satellite, a new version was added that shows infra-red temperature more clearly to help interpret diurnal changes in surface temperature.

Imagery from the Cassini spacecraft was used to update the maps for Saturn's satellites Mimas and Dione.

We developed a FIM-Chem global aerosol animation for SOS that was prominently shown as part of the ESRL/GSD Physical Sciences Review.
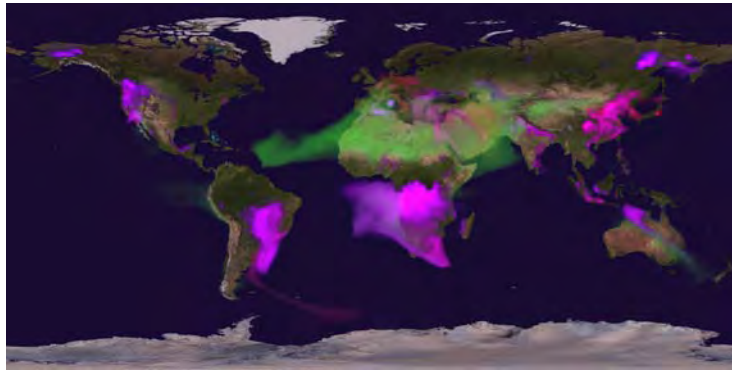
Figure 3. Global Fim-Chem Aerosol forecast as displayed on SOS

GLOBE/VAST

We are collaborating on a project managed by the ESRL Director called Vegetation and Surface Tracker (VAST), an endeavor that requires developing a global school-based network with a protocol to use GPS and digital imagery to document vegetation and surface observing points around the globe. The ultimate goal of VAST is to develop this global surface network to obtain the required density of surface measurements for satellite ground truth. These measurements would consist primarily of digital images (photographs) of the vegetation at the respective geographic locations. The existing GLOBE network is ideal and a great opportunity for young students to support NOAA research by improving our national and global land cover databases.

As background, a major limitation of the current generation of Earth System Models is their very crude and static vegetation. A global observing system is needed that will diagnose the CHANGING biosphere, and connect it to the physical simulation of the biosphere in the models. The GLOBE schools could be the (on-the-ground) global observing system needed for diagnosing the changing biosphere. Current Advanced Earth System Models have atmospheres based on the global atmospheric observing system, oceans based on the global ocean observing system and similar capabilities for other components such as ice and land surface. The global biosphere is the most complex and difficult part of Earth System Models. We need to improve our understanding of it but are hampered by the least capable observing system. Like the other earth system components, the biosphere observing system must be based on a COMBINATION of satellite sensors and in situ surface sensors. We are proposing to develop and implement the surface ground truth needed to track global vegetation, especially as it changes due to a changing climate. Digital imagery could be obtained from GLOBE student's cell phones or digital cameras, and their data once on line becomes an ingestible data source that we can use at NOAA.

Steve Albers has been working with Sara Summers (NOAA/OAR/ESRL/GSD/OD) to provide strategic and technical guidance to the various participants in this program, including NOAA, GLOBE, and the University of Colorado.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Nikki Privé, Scott Mackaro

NOAA TECHNICAL CONTACT: Yuanfu Xie, ESRL/GSD/FAB

PROJECT OBJECTIVES:
Develop a concept of operations for a global network of Unmanned Aircraft Systems (UAS) for the purpose of improving atmospheric observations of 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.

PROJECT ACCOMPLISHMENTS:
Evaluation and calibration of the global OSSE was completed. Preliminary experiments were conducted to investigate the impact of a high-altitude UAS with dropsonde deployment capabilities on track forecasts for an Atlantic hurricane. Significant improvements in hurricane track forecasts were observed for circumnavigational flight paths (Figures 1, 2, Table 1). The results of these experiments were delivered to the NOAA UAS Program in the form of an official report. Code was developed to generate synthetic observations for the WISDOM balloon project. Ongoing experiments are continuing for evaluation of UAS impact on hurricane track forecasts for multiple tropical cyclones and mission scenarios. A manuscript for publication in a scientific journal detailing the setup and evaluation of the OSSE is in preparation.

The regional "Quick OSSE" was set up and tested with synthetic observations. Problems with the data assimilation system prevented use of the regional OSSE for experiments. Collaboration with AOML is ongoing to develop a "full" regional OSSE for studies of hurricane intensity forecasting.
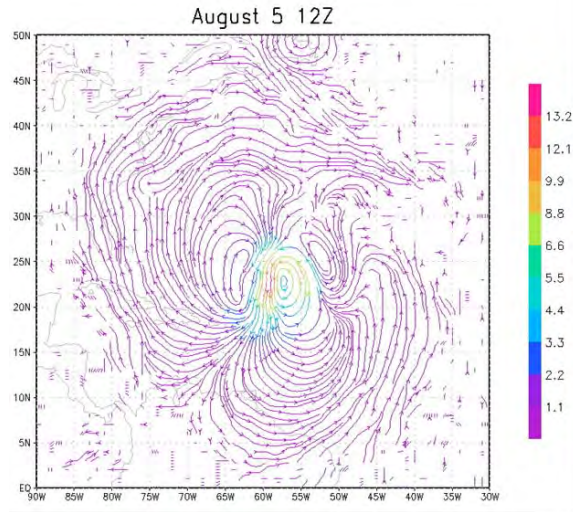
Figure 1.   500 mb streamfunction difference, Analysis with UAS dropsonde observations versus control analysis, 12Z 5 August. Color indicates windspeed difference, m/s.
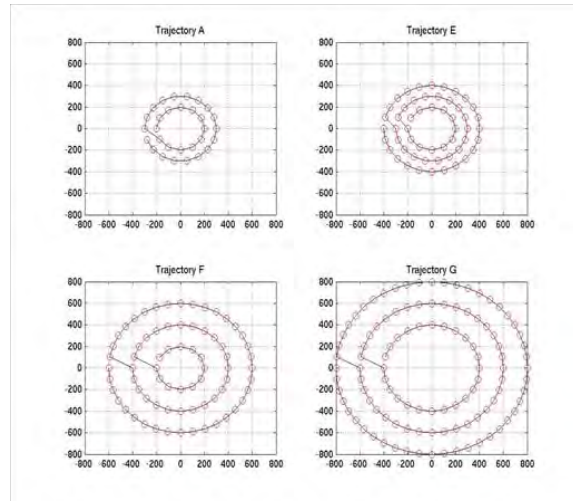
Figure 2. Circumnavigation flight path scenarios for high-altitude UAS. Red circles indicate location of dropsonde releases.

	Analysis	24 hr	48 hr	72 hr	96 hr	120 hr
Control	108	127	170	264	367	692
Trajectory AA	67	92	171	210	347	635
Trajectory AAA	67	92	171	210	347	635
Trajectory EE	67	84	134	174	288	456
Trajectory F	70	30	127	164	293	405
Trajectory FF	24	52	169	186	285	571
Trajectory G	103	38	121	183	293	445

Table 1. 12Z 5 August track forecast errors for various trajectory scenarios and control, km.

PROJECT TITLE: NESDIS Research Scientist and Post Doc Program – Yong Chen, Research Scientist

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Yong Chen

NOAA TECHNICAL CONTACT: Fuzhong Weng, NESDIS/STAR

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

PROJECT ACCOMPLISHMENTS:
--The assimilation of the CrIS "observation" (proxy) data in NCEP Global Data Assimilation System GSI was prepared and tested. Input/output interface for reading CrIS BUFR in GSI has been implemented. The ingestion of simulated NPP CrIS Bufr data in NCEP GFS has been completed. The assimilated channel error covariance was calculated based on the instrument noises and RT model forward errors. The scan angle bias was also be calculated by processing the diagnostic files for 4-6 weeks in the testing run.
--Tests CRTM with different surface emissivity models in GSI. (For microwave sea surface emissivity models: fastem1 and fastem3; and for IR land surface emissivity: NPOESS, AIRS retrieval emissivity dataset, and MODIS-derived IR Emissivity from University Wisconsin (UWIREMIS)). Based on the experiments, we found that fastem1 is better than fastem3 (fastem3 has very large positive biases for AMSUA surface channels). The UWIREMIS has slight positive impacts at winter North hemisphere and summer South hemisphere.
--An improved Stratospheric Sounding Unit (SSU) model implemented into CRTM version 2. The improved SSU fast model treats the CO_2 and O_3 as variable gases, uses the SRFs with an increased spectral resolution, and considers the earth curvature effects by varying the zenith angle with height. In addition to these improvements, the model also takes into account the variations of the SRFs due to the CO_2 cell pressure variations same as the previous SSU model. This fast radiative transfer model can be used to assimilate the SSU measurements in operational systems for reanalysis. There are large brightness temperature gap between observation and model simulation using the available cell pressures for NOAA-7 channel 2 after June 1983. Linear fittings of this channel's cell pressures based on previous cell leaking behaviors have been studied, and results show that the new cell pressures are reasonable. These improvements are documented in a peer reviewed publications (Chen et al., 2010).
--Paper published in JGR-atmosphere: Paper titled "On Water Vapor Jacobian in Fast Radiative Transfer Model" by Yong Chen, Yong Han, Paul Van Delst, and Fuzhong Weng has recently been published in Journal of Geophysical Research (J. Geophys. Res., 115, D12303, doi:10.1029/2009JD013379). The paper summarizes the results in the improvement of the atmospheric transmittance module in the Community Radiative Transfer Model (CRTM), with an emphasis on the water vapor Jacobians. The improved water vapor Jacobian profile results in the improved temperature Jacobian.
--Performed control GSI run and experimental GSI run using CRTM release v2.0.2. CRTM v2.0.2 includes a new transmittance model ODPS, surface BRDF for solar-affected shortwave IR channels, and specular sea surface reflection as opposed to Lambertian sea surface reflection. For the GSI experiment, there was significant positive impact in the Southern Hemisphere. The positive impact is due to the update to specular sea surface reflection. The fitting statistics for ODPS are better than for ODAS.
--Worked on Planck weighted transmittance and correction of solar reflection for broadband infrared satellite channels. Three methods for calculating Line-by-Line Radiative Transfer Model (LBLRTM) derived level-to-space channel transmittances are applied to generate transmittance coefficients that relate

atmospheric conditions to optical properties for the Community Radiative Transfer Model (CRTM). In this study we generate transmittance coefficients for four infrared channels chosen from sensors that are currently supported by the CRTM and one hypothetical channel. The three methods are referred to as Planck-Weighted Transmittance 1 (PW1), Planck-Weighted Transmittance 2 (PW2) and Non Planck-Weighted Transmittance (ORD). For channels with broad SRFs, we show that the ORD method is less accurate than methods PW2 and PW1. Additionally, we show that the PW1 method is more accurate than the PW2 method, and that the difference in accuracy between PW1 and PW2 increases with the optical thickness of the atmospheric layers (see Fig.1). Based on these simulations and comparisons, when the band correction is larger (greater than 1), PW1 method should be used to take account of the Planck radiance variation with the transmittance within the band spectral. When considering the solar contribution in daytime, correction of the solar reflection has been made for near infrared broadband channels (~3.7 µm) when using PW1

transmittance. The solar transmittance is predicted by using explanatory variables as PW1 transmittance, secant of zenith angle, and surface temperature. With the correction, the error reduces to more reasonable level (see Fig. 2). 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 2011.

--For CRTM validation, working on the comparison of ODPS and ODAS in CRTM v2.0.2, especially for AVHRR sensors. Recently, the discrepancy of CRTM performance between ODPS and ODAS has been studied and the reasons have been found.

--Training codes for ODAS and ODPS are in CRTM public access repository.

--Support completion of the CRTM version 2 release.

--Complete CRTM transmittance coefficients for GOES-15 imager and sounder, GMI on GPM for both ODPS and ODAS; coefficients for hyper-spectral sensors, AIRS, IASI, and CrIS for ODPS with 6 absorber variables.
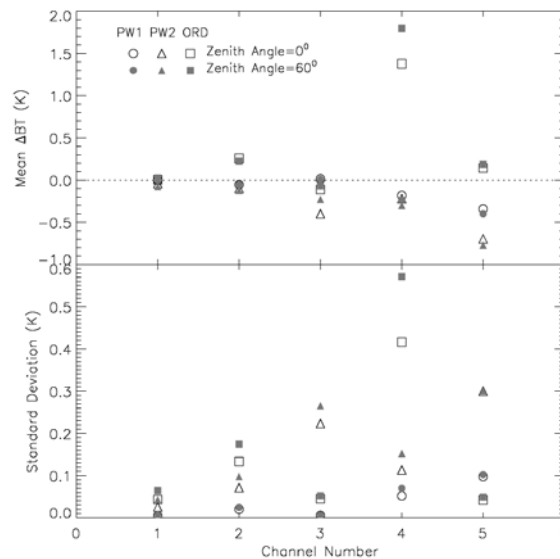
Figure 1. Mean brightness temperature differences and standard deviation for approximation methods PW1, PW2, and ORD compared to LBL results for UMBC 48 diverse atmospheric profiles at nadir.
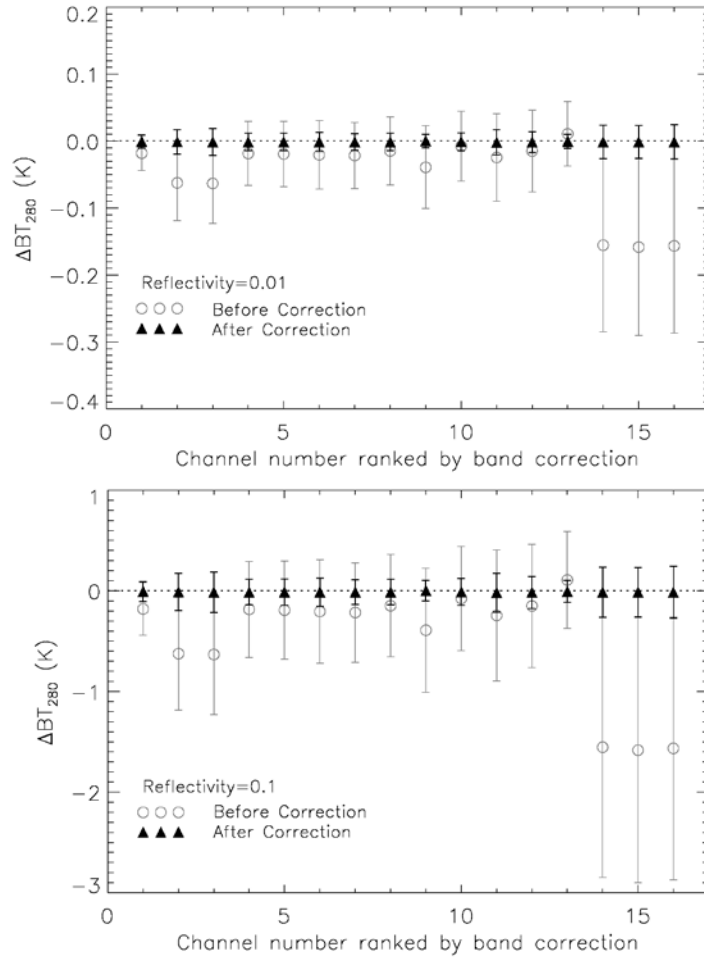
Figure 2. Statistics for solar reflection before and after correction for reflectivity 0.01 (top) and 0.1 (bottom). The symbol open circles and solid triangles are biases for before correction and after correction, respectively. The standard deviations are also shown with vertical bar.

PROJECT TITLE: NESDIS Research Scientist and Post Doc Program – Min-Jeong Kim, Research Scientist - Assimilating Cloudy Radiance Observations in NCEP GDAS

PRINCIPAL INVESTIGATOR: Steve Miller

RESEARCH TEAM: Min-Jeong Kim

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

PROJECT OBJECTIVES:
--Developing the cloudy radiance data assimilation system for NOAA NCEP Global Data Assimilation System (GDAS)

--Evaluating impacts of including microwave cloudy radiance observations in NWP system through data assimilation

PROJECT ACCOMPLISHMENTS:

--Added NCEP GFS convective schemes into the moisture physics package for data assimilation.
--Applied this full moisture package to the strong background constraint in GDAS to improve the use of constraint in the region where moist processes are important.
--Modified data thinning and quality control processes for AMSU-A in GDAS so that cloudy radiance observations can be kept instead of being screened out.

--Observation error covariance for each channel depending on cloud amount has been estimated.
--Modified bias correction and new quality control schemes have been developed.
--Background error covariance for cloud water condensate has been examined.

The following figures show that cloud analysis got closer to the observations after assimilating AMSU-A cloudy radiances over the ocean.
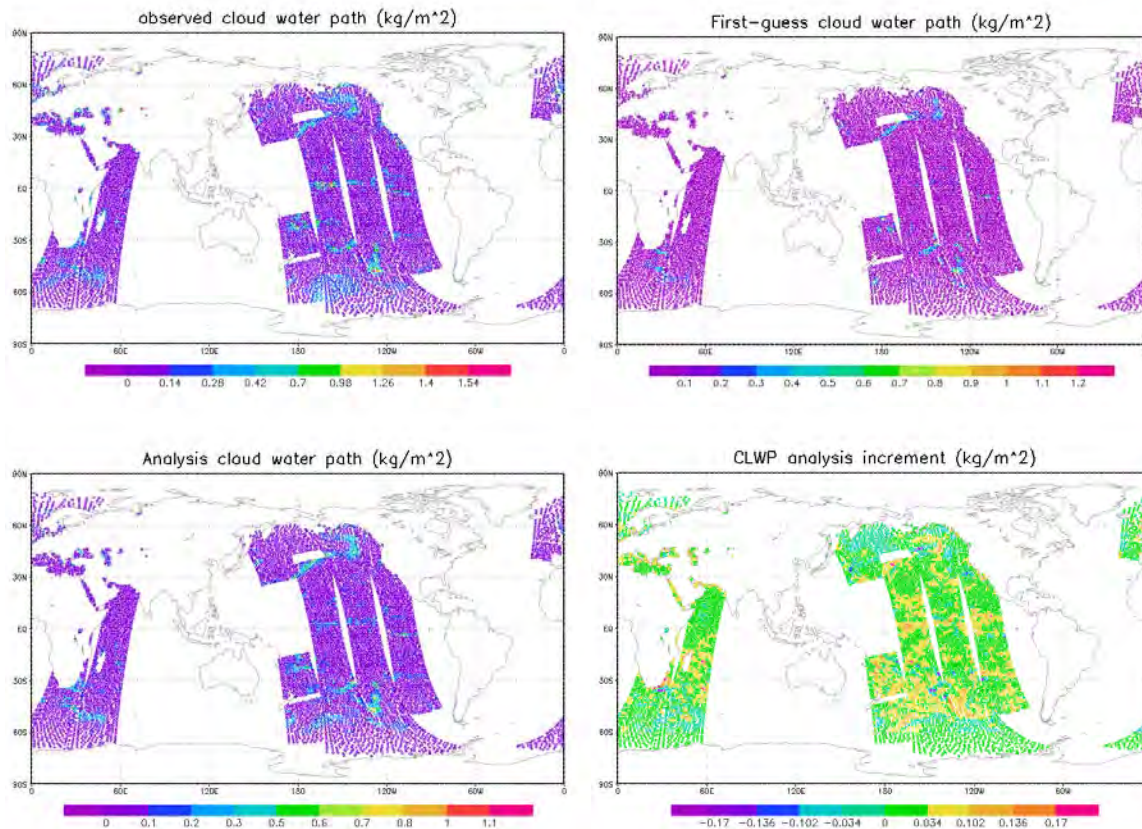
observed cloud water path (kg/m^2)

First-guess cloud water path (kg/m^2)

Analysis cloud water path (kg/m^2)

CLWP analysis increment (kg/m^2)

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.

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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

RESEARCH TEAM: Henry Reges, Julian Turner, Zach Schwalbe, Nolan Doesken

NOAA TECHNICAL CONTACT: Sarah Schoedinger, NOAA Office of Education

NOAA RESEARCH TEAM: We do not have a NOAA research team. This project has benefited from a very strong nationwide NOAA collaboration team made up primarily of staff of many of the nation's National Weather Service forecast offices who have and still are serving as local/regional coordinators for the Community Collaborative Rain, Hail and Snow Network.

PROJECT OBJECTIVES: Increase environmental understanding and literacy by engaging people of all ages in observing the weather and climate about them and specifically taking backyard measurements of precipitation (rain, hail and snow). Through the collective small efforts of thousands of volunteers, we are able to track and study precipitation patterns. By providing direct access to precipitation maps and analyses, we will help to engage volunteers in exploring the complex and highly variable precipitation patterns that are a part of our climate system.

PROJECT ACCOMPLISHMENTS: This project was extended through September 2010 by a no-cost extension. This past year was mostly a period of finishing up a few unfinished items such as "Climate Information for Master Gardeners" and organizing and providing better access to instructional resources that were developed during the past 4 years. More time

was also spent interpreting results from the participant survey conducted late in 2009. Over 7000 CoCoRaHS volunteers completed a lengthy on-line survey that included questions about demographics, motivations for participating in CoCoRaHS, barriers to participation, educational impacts, and many questions about the various elements of CoCoRaHS and how they are or are not utilized by participants. The overall findings of the Survey along with a compilation of project outputs and outcomes were summarized in the project final report submitted in December 2010 to the NOAA Office of Education. These findings became the foundation for a new proposal submitted in 2010 focusing on improving the cyber-infrastructure of CoCoRaHS to help reach broader and younger audiences, to help sustain longer-term citizen participation, and to more deeply involve participants as climate analysts, not just data gatherers.

Figure 1. The "Climate Resources for Master Gardeners" is a slide show developed for leaders of Master Gardener state and county organizations across the county. The Power Point presentation can be used in its entirety or sections can be borrowed and customized for local needs. This resource includes descriptions and links to many sources of local climate data for the nation that may be especially useful for gardeners and also for professional agricultural applications.

CoCoRaHS continued to add hundreds more volunteers during the past year. Daily participation in precipitation measurement grew to occasionally more than 9000 per day during the summer of 2010. Nearly 15,000 individuals, families and schools reported at least a few measurements during the past year. For the first time, a program was written to produce comprehensive water year precipitation summaries (Oct 1, 2009 - Sept. 30, 2010) for every reporting station. http://www.cocorahs.org/content.aspx?page=WaterYear2010 This feature was greatly appreciated by CoCoRaHS volunteers.

Education has been a major focus of this project, but the extensive data set that has now been collected of rain, hail and snow data has grown to become the largest readily-available source of daily precipitation data for the nation. The data are routinely and, in most cases, automatically being ingested into a variety of NOAA and non-NOAA products and information including the popular "Daily Precipitation Estimates" http://water.weather.gov/precip/. A data collection feature added in 2010 was the "Drought Impact Report" providing volunteers the opportunity to describe quantitatively and qualitatively the impact that abnormally dry conditions are having on their own lives or that of their communities. These reports are automatically ingested into the Drought Monitoring processes and products of the National Drought Mitigation Center

Figure 2. Example drought impact report form and instructions developed to help participants provide local descriptions of how abnormally dry conditions are affecting their communities.

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

PRINCIPAL INVESTIGATOR: Robert Cifelli

RESEARCH TEAM: Sanhun Linn (CIRA) – 60%. This project includes the vast majority of staff in the NOAA Water Cycle Branch. The affiliations are a combination of CIRES and federal employees.

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

PROJECT OBJECTIVE: Coordinate implementation and operation of field experiments for the Hydrometeorology Testbed (HMT).

PROJECT ACCOMPLISHMENTS:
--Coordinated monthly telcons to summarize HMT-related research;
--Worked with the HMT Project Manager to plan the HMT annual meeting – presented HMT findings on quantitative precipitation estimation (QPE);
--Planned and worked with NOAA staff to conduct the HMT-West 2011 field season in California;

--Conducted research on QPE with NWS staff
--Served as Operations Director during the 2011 field season;
--Worked with the HMT Project Manager and NASA GPM partners to develop science objectives and instrument deployment strategy for HMT-SE;
--Worked with HMT Project Manager, University of Washington, and NASA GPM partners to develop a white paper for upcoming field campaign in Olympic Range (OLYMPEX) that will include HMT activities;
--Hired a staff member (Sanghun Lim) to work on QPE research
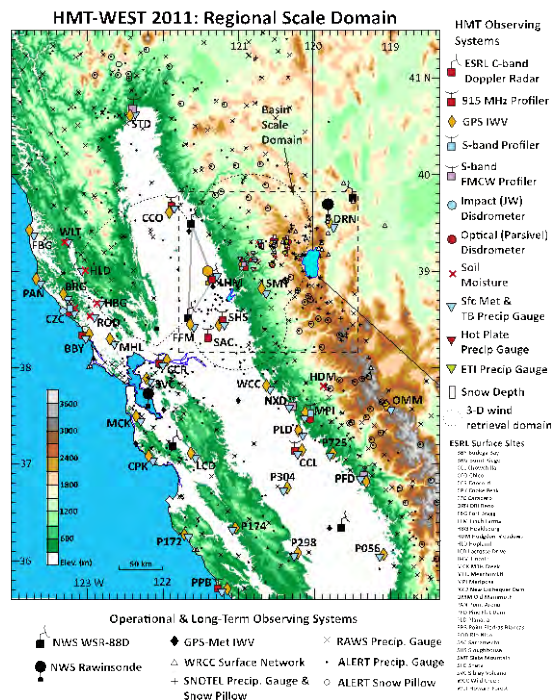
Figure 1. Regional-scale map of HMT-West instrumentation for 2011 field season

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Hongli Jiang

NOAA TECHNICAL CONTACT: Graham Feingold, NOAA/OAR/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 ACCOMPLISHMENTS:
We conducted large-eddy simulations of warm, trade wind cumulus clouds for a range of aerosol conditions with a focus on precipitating clouds. Individual clouds are tracked over the course of their lifetimes. Precipitation rate decreases progressively as aerosol increases. For larger, precipitating clouds, the polluted clouds have

longer lifetimes because of precipitation suppression. For clean aerosol conditions, there is good agreement between the average model precipitation rate and that calculated based on observed radar reflectivity Z and precipitation rate R relationships. Precipitation rate can be expressed as a power-law function of liquid water path (LWP) and N_d, to reasonable accuracy. The respective powers for LWP and N_d are of similar magnitude compared to those based on observational studies of stratocumulus clouds. The time-integrated precipitation rate represented by a power-law function of LWP, N_d,

and cloud lifetime is much more reliably predicted than is R expressed in terms of LWP and N_d alone. The precipitation susceptibility (S_0) that quantifies the sensitivity of precipitation to changes in N_d depends strongly on LWP and exhibits non-monotonic behavior with a maximum at intermediate LWP values. We further explored the relationship between S_0 and precipitation efficiency. These results provide trade cumulus cloud population statistics, as well as relationships between microphysical and macrophysical properties and precipitation that can be used in larger-scale models.

PROJECT TITLE: POES-GOES Blended Hydrometeorological Products

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: John Forsythe, Andy Jones

NOAA TECHNICAL CONTACT: Limin Zhao (NESDIS/OSDPD)

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

PROJECT OBJECTIVES:
--Include MIRS retrievals of TPW over land in Blended TPW
--Develop an improved Blended TPW product for the CONUS and adjacent waters which better blends GOES PW, GPS TPW, and MIRS TPW
--Transition Blended Rain Rate (developed last year) into Operations after the IT Freeze is lifted.

PROJECT ACCOMPLISHMENTS:
--The MIRS data have been ingested and blended (see http://cat.cira.colostate.edu, and Fig. 1, below). This code is ready to be implemented in the Operational Blended TPW system that runs at OSDPD
--The product has been created and is available on the Web at http://amsu.cira.colostate.edu/bTPW (see Fig. 2, below). The blending algorithm is being finalized as is the production code to be transitioned into operations.
--Still waiting for the IT Freeze to be lifted.
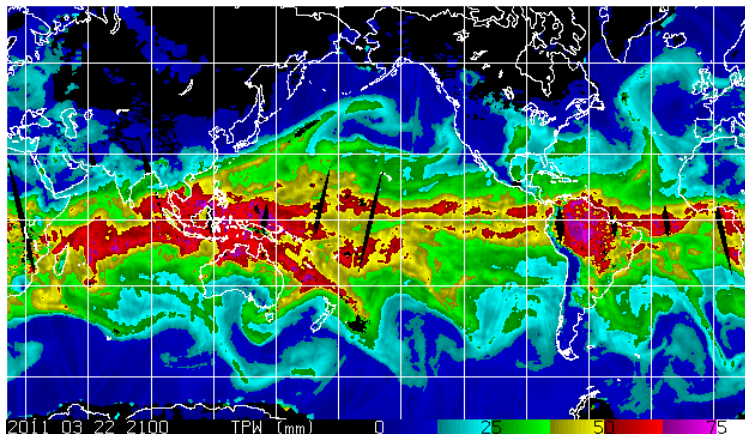
Figure 1. Blended TPW including MIRS TPW over land (except where the land is ice or snow covered). For comparison, see the current Operational Blended TPW, which has TPW over land only over the CONUS (http://www.osdpd.noaa.gov/bTPW).
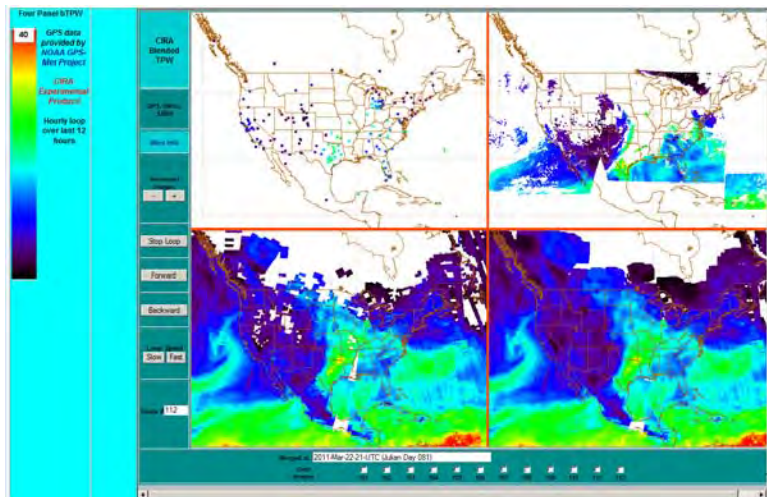
Figure 2. Upper left: GPS TPW; upper right: GOES PW, lower left: MIRS TPW; lower right Blended TPW. This product is produced hourly at CIRA. Watch the loop at http://amsu.cira.colostate.edu/bTPW.

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

PRINCIPAL INVESTIGATOR: Nolan Doesken

RESEARCH TEAM: Becky Smith, Wendy Ryan, Nolan Doesken, Morgan Phillips, Zach Schwalbe, Henry Reges, Noah Newman

NOAA TECHNICAL CONTACT: Alan Schmidt, OAR Cooperative Institutes Office (CIPO)

NOAA RESEARCH TEAM: Roger Pulwarty, Jim Verdin, Lisa Darby, Chad McNutt (NIDIS program office, Boulder, CO)

PROJECT OBJECTIVES: To assess drought monitoring gaps, drought indicators and drought triggers currently identified by water users, water managers and other resource managers in the Upper Colorado River Basin and areas that derive their water supply from this region.

To work with the National Integrated Drought Information System staff and partners to improve drought early warning in the Upper Colorado River Basin.

To evaluate if drought monitoring and prediction is improving as a result of the NIDIS Upper Colorado River Basin pilot project and if this is measurably beneficial to stakeholders in the basin.

PROJECT ACCOMPLISHMENTS: During the April 2010 - March 2011 time period, the project team continued to improve the form, format and delivery for weekly spring/early summer drought monitoring webinars. These 20-30 minute webinars were designed to provide reliable and timely updates on climate and water supply during the critical spring months when water supply and water demand change most quickly. In lieu of or in addition to skillful seasonal climate and water supply forecasts, these weekly status reports provide assurance that drought won't develop unexpectedly. The webinars were first started in March 2010 and continued through mid June 2010. The 2010 water year was a very interesting year with abundant snow and generous soil moisture east of the Continental Divide, while the main stem headwaters of the Colorado River experienced a very dry winter. Late spring weather patterns changed and brought cool and wet weather to northern Colorado and southern Wyoming followed by a rapid warm up and then widespread rains in mid June resulting in unexpected high water and flood conditions that had not been anticipated. Then the late summer turned very dry with a rapid return to baseflow conditions and peak demand for irrigation water delayed to late August and September in many areas.

Based on feedback from participants, we streamlined graphics and shortened the presentations making sure that each briefing was no more than 20 minutes. We included more detailed reservoir climatology information. The USGS took the lead in providing the weekly updates on streamflow. We then dedicated the last 10 minutes of each webinar to a detailed discussion of the US Drought Monitor and changes that we thought were appropriate for the Upper Basin and surrounding areas. The USDM author often participated in this discussion.

Webinars were held infrequently after June, but we then introduced a weekly narrative and graphical water supply assessment report circulated first among a small group of about 20 water and climate experts in and near the basin including all National Weather Service Forecast Offices. Then, after obtaining local input, the assessment would be e-mailed to the USDM weekly author, updated to the Colorado Climate Center website

(http://climate.colostate.edu/drought_webinar.php) and circulated to a list of nearly 200 interested organizations and individuals with interests in water from the Upper Colorado. Users were particularly interested in access to long range winter season forecasts beginning as early as late July and August of the previous summer. We worked with NIDIS and the Western Water Assessment and eventually secured a commitment of support to engage Klaus Wolter in twice-annual seasonal climate predictions for the basin. Webinar attendance most weeks is modest -- 15-20 participants -- but in weeks where seasonal forecasts are featured, attendance is much higher. NIDIS Pilot Project webinars were also coordinated with the NWS Colorado Basin River Forecast Center who delivers monthly webinars during the spring and a water year wrap up webinar in the fall.

During this time period we reached a preliminary conclusion that our efforts were well spent and, perhaps, best spent, improving the accuracy, resolution and agreement of the USDM maps for our region. This was in contrast to our original intent of developing a basin specific independent drought monitor for the Upper Colorado River Basin. Since reaching that decision our efforts have been focused towards USDM improvement. That said, we realize that a single-map 5-category representation of drought conditions is inherently difficult and perhaps impossible in a region where surface water supplies come primarily from mountain snowpack while most low elevation areas are watered by direct natural precipitation. We will continue to battle with this dilemma in the final year of this project.

Available drought monitoring and seasonal prediction information is becoming readily accessible for interested citizens and decision makers. Now the question is, what are we doing of benefit and use to decision makers? We began developing a stakeholder engagement questionnaire to try to get at some of this information. The questionnaire is now being refined and will be circulated to dozens of participants and stakeholders later this summer following the peak runoff season.

We are also undertaking additional research through this project. During this time period, Becky Smith, who is pursuing her PhD, refined

her research goals and held her preliminary exam in February 2011. Her research will be focusing on climate predictability in the Upper Colorado River Basin. Morgan Phillips started his pursuit of an M.S. in Atmospheric Science focusing on estimating spatial patterns and interannual variability in snowpack sublimation over the Upper Colorado River Basin. Currently he is focusing on course work as a first semester graduate student, but research will begin this summer. Becky also has conducted analysis of the water balance of the mainstem Colorado River Upper Basin including an analysis of total-basin water from the GRACE satellite mission.
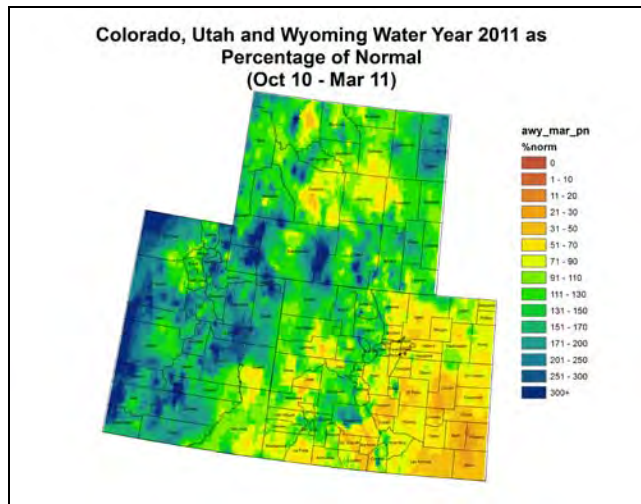
Figure 1. Colorado Climate Center customized precipitation maps for the Upper Colorado River Basin and surrounding portions of Utah, Wyoming and Colorado. These maps are updated weekly and help guide weekly discussions of emerging or improving drought conditions.
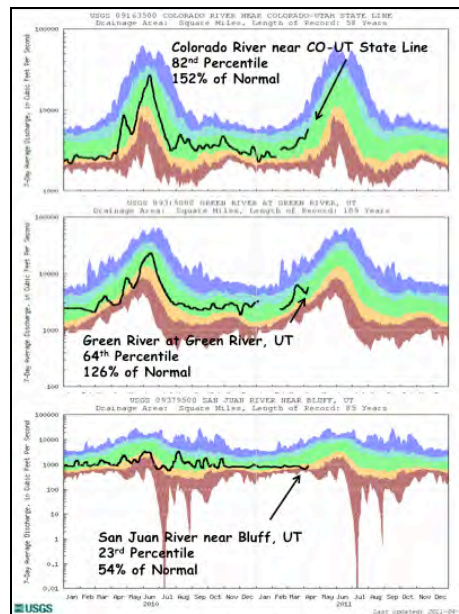
Figure 2. Example of USGS streamflow input to weekly webinars.
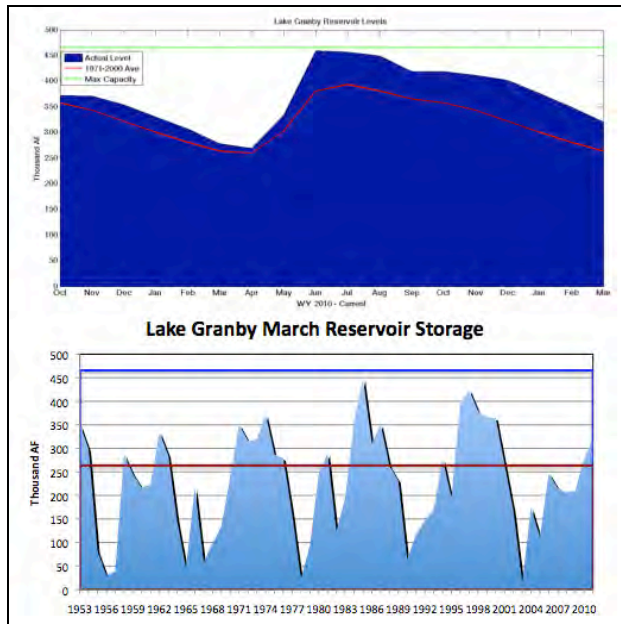
Figure 3. Example reservoir climatology designed to give a better historic perspective on seasonal cycles and interannual variability in storage for key large reservoirs in the Upper Colorado River Basin.
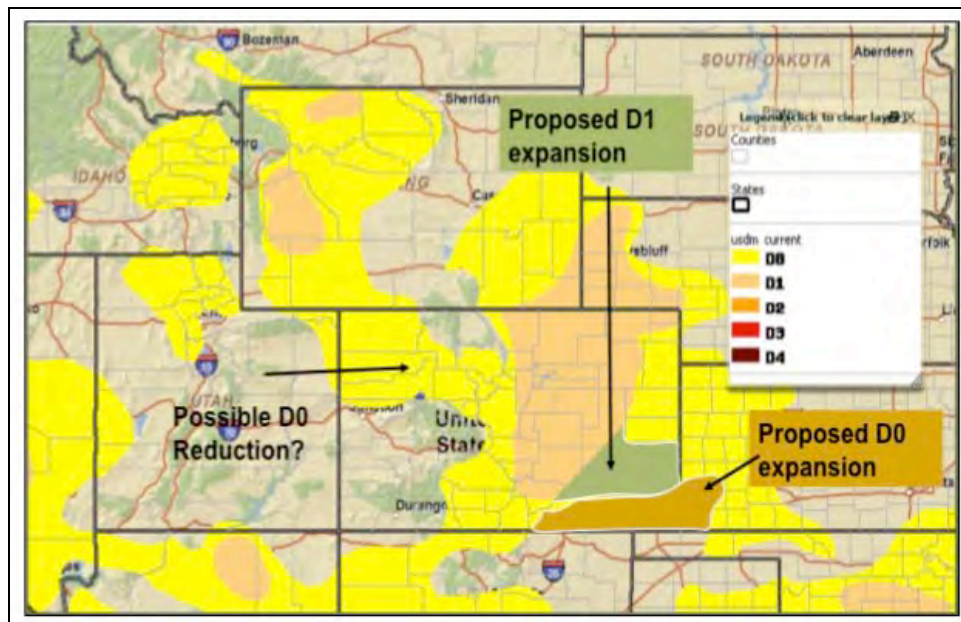
Figure 4. Example graphic used to discuss and refine drought categorization.

PROJECT TITLE: Upgrade to eTRaP—Probability Calibrations

PRINCIPAL INVESTIGATOR: Stan Kidder

RESEARCH TEAM: N/A

NOAA TECHNICAL CONTACT: Liqun Ma (NESDIS/OSDPD)

NOAA RESEARCH TEAM: Liqun Ma (NESDIS/OSDPD), Bob Kuligowski (NESDIS/STAR), Matt Seybold (NESDIS/OSDPD), Beth Ebert (Australian Bureau of Meteorology)

PROJECT OBJECTIVE: Recalibrate the eTRaP rainfall probabilities so that they are more useful to forecasters

PROJECT ACCOMPLISHMENTS: I spent most of the year and about half of the money trying to get started on this project, which began with Beth Ebert in Australia. I am currently working on getting a computer account which will allow me to run Beth's code and do the proposed recalibration of the product.

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.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

PRINCIPAL RESEARCHER: Scott O'Donnell

NOAA TECHNICALCONTACT: Stephan Smith, NWS/MDL/DAB

PROJECT OBJECTIVE: <u>Flash Flood Monitoring Program (FFMP)</u>. 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: <u>AutoNowcaster (ANC)</u>. 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 PROJECT TITLE: Rapid Update Cycle (RUC) Rapid Refresh (RR) and High-Resolution Rapid Refresh (HRRR) Models Project

PRINCIPAL INVESTIGATOR**:** Cliff Matsumoto

RESEARCH TEAM**:** Brian Jamison

NOAA TECHNICALCONTACT: Steve Weygandt, NOAA/OAR/ESRL/GSD/AMB

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

PROJECT ACCOMPLISHMENTS:
A new RUC web page http://ruc.noaa.gov/rucnew/ was developed in the same fashion as the RR and HRRR pages are currently. This includes output from the RUC backup, RUC developmental, and difference plots (including difference plots for analysis – background, and digital filter initialization (DFI) – analysis). Seven

subdomains showing more detail are also available.

A version of the RR has been installed at NCEP and graphics for the CONUS domain, including differences from the GSD version, have been added to the RR website http://rapidrefresh.noaa.gov/.

Software was modified to accommodate the RR coordinate system change to a rotated latitude-longitude format.

Cross section plotting capabililty has been developed for the RUC, RR, and HRRR (currently not available on the web). The cross sections can be height or pressure based, are

defined using latitude-longitude pairs, and can be height limited, allowing for analysis of more detail in the lower troposphere. An inset map shows the location of the section (see Figure 1).
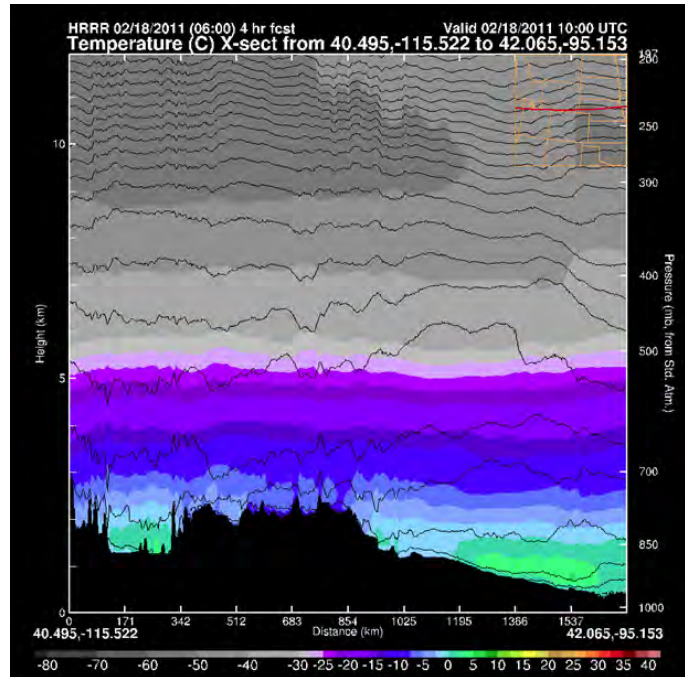
Figure 1.

New graphics were developed for thunderstorm probability and potential echo top products as part of the RUC Convective Probability Forecast (RCPF). These are currently on the web site http://ruc.noaa.gov/rcpf/.

A developmental version of the HRRR was installed at GSD and routines to develop graphics for that model were created and images were added to the HRRR web site http://rapidrefresh.noaa.gov/hrrrconus/.

Many improvements and some new products were added to the RR and HRRR suite, including relative humidity with respect to precipitable water and 2m agl potential temperature.

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

EAR PROJECT TITLE: Aviation Weather Forecast Evaluation

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sean Madine, Melissa Petty, Paul Hamer, Daniel Schaffer

NOAA TECHNICAL CONTACT: Jennifer Mahoney, NOAA/OAR/ESRL/GSD/ACE/FIQAS Section Chief

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

PROJECT ACCOMPLISHMENTS:
Engineering Research for the Network-Enabled Verification Service (NEVS)
The NextGen 4D Weather Data Cube's 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 an experimental version of NEVS, built to participate in the 4D Weather Data Cube Capability Evaluation (CE) held September 13-17, 2010 at the FAA's William J. Hughes Technical Center. Below is a diagram reflecting the planned ingest of data for the Capability Evaluation.   The overall goal was for NEVS to ingest forecasts of convection using a Web Feature Service (WFS) and a Web Coverage Service (WCS) via the Internet and NOAANet.
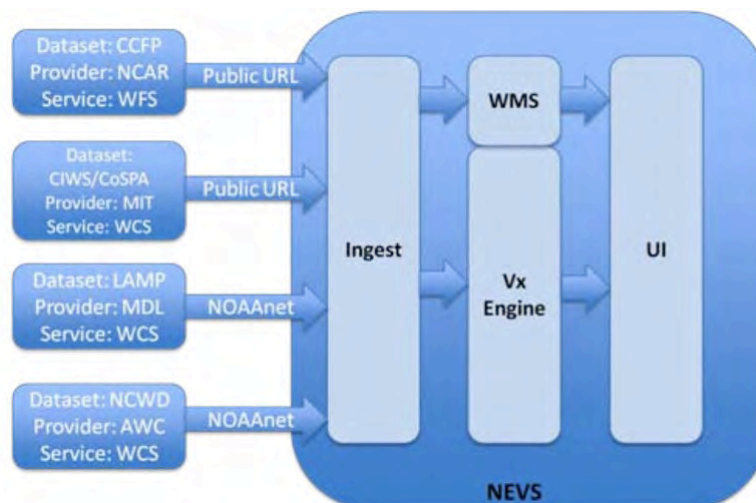
Figure 1. Planned demonstration ingesting the Collaborative Convective Forecast Product (CCFP) and CoSPA using WFS and WCS, respectively, via Internet, and the Local Aviation MOS Product (LAMP) and National Convective Weather Detection (NCWD) using WCS via NOAANet.

NEVS successfully supported the 2010 CE during the formal exercise by demonstrating access to the data, utilizing the data discovery aspects of the 4D Weather Cube, and retrieving relevant metadata via the WCS and WFS.

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 2010 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.

The study summarized convective forecasts evaluated in an operational context for the 2010 convective season: (1) Consolidated Storm Prediction for Aviation (CoSPA); and (2) Localized Aviation MOS Program/Collaborative Convective Forecast Product Hybrid (LAMP CCFP Hybrid, LCH). CIRA researchers worked collaboratively to determine the value of these forecasts for the two- to eight-hour lead time as it pertains to strategic Traffic Flow Management (TFM). The current operational convective forecast, CCFP, was used to define the baseline of performance against which experimental products were compared.

The assessment framework for this report adopted concepts from the Joint Planning and Development Office (JPDO) Air Traffic

Management (ATM) Weather Integration Plan as a description of the planning process, acknowledging that the current process is difficult to define and is much more organic. To determine indicators of forecast value, the study focused on two areas of investigation within the planning process: *weather* and *weather translation*. As the baseline forecast for the study, CCFP was treated in the analysis in two different ways: by straightforward definition, and calibrated based on its operational performance over recent years.

Primary themes in the Weather Assessment:
--Direct analysis of CCFP, CoSPA, and LCH in the context of strategic planning, including stratifications for planning times with emphasis on issuances before convective initiation.
--Comparison of CoSPA and the LAMP Thunderstorm Product as supplements to CCFP; forecast relationship outlined in the Concept of Use for the Operational Evaluation.
--Diagnostic comparisons of CoSPA and the underlying High-Resolution Rapid Refresh (HRRR) model forecasts.

Primary themes in the Weather Translation Assessment:
--Direct analysis of CCFP, CoSPA, and LCH in the context of strategic planning, including stratifications for planning times with emphasis on issuances before convective initiation.
--Diagnostic comparisons of CoSPA and the underlying HRRR model forecasts.

As part of the investigation, seasonal convective climatology was examined. Results are depicted in Figures 2 and 3 below.
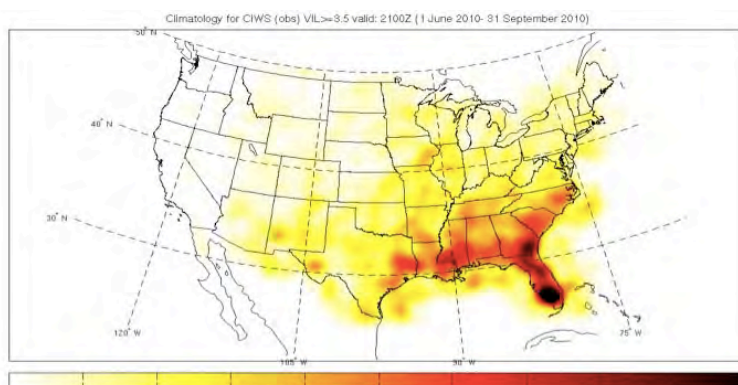
Figure 2. Climatology of CIWS VIL analysis at a threshold of VIP-level 3 valid at 21Z each day from 1 June 2010 through 30 September 2010. Higher values (darker colors) indicate more occurrence of convective weather.
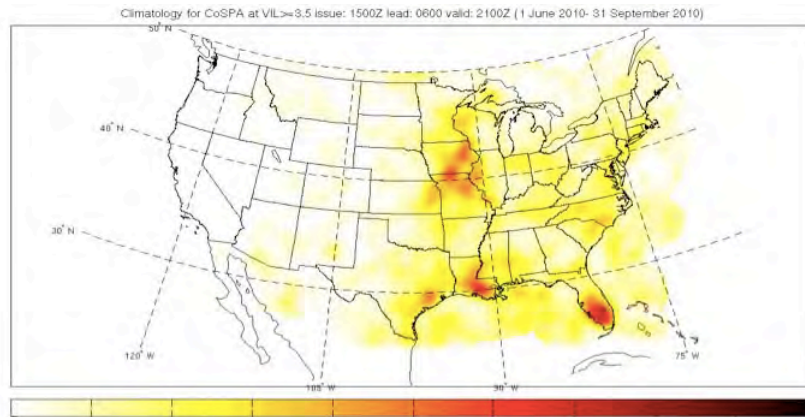
Figure 3. Climatology of CoSPA forecast (15Z issuance, 6-h lead time) at a threshold of VIP-level 3 valid at 21Z each day from 1 June 2010 through 30 September 2010. Higher values (darker colors) indicate more occurrence of forecast convection.

EAR PROJECT TITLE: Advanced Weather Interactive Processing System II (AWIPS) Data Delivery Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Joanne Edwards, James Fluke

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

PROJECT OBJECTIVES: With AWIPS II rapidly approaching deployment, the National Weather Service has identified a need to extend AWIPS II capabilities in order to handle the demand for more and larger datasets. With the current distribution network at near capacity, a Data Delivery mechanism is envisioned by the NWS to include the following capabilities:
--Data registry services that will provide a means to publish data sources and metadata information and allow for the introduction of new data services
--Data discovery services that will provide for a system that can discover datasets and necessary associated metadata
--Smart push/pull technologies that will provide the means to subset the data by user selectable field value, time, space, parameters, etc. Such

dataset filtering would be done on an ad-hoc user-request basis or in a pre-defined way.

The system must be robust addressing the following challenges:
--It must satisfy fault tolerance requirements including recovery from software, hardware, and network failures.
--It must satisfy quality-of-service (QOS) requirements including data access reliability and latency.
--It must include monitoring services to support fault detection and diagnosis.
--It must support security provisions, such as user access and authentication

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

offices toward the concept where the data providers and data consumers exchange only necessary information. The primary goal of GSD is to develop a prototype data delivery system for eventual use in AWIPS II. The idea is to develop a system that will enable access to data regardless of its location. In other words, to enable access to data that does not reside locally.

PROJECT ACCOMPLISHMENTS: CIRA, in conjunction with the Information Systems Branch (ISB) of the Global Systems Division (GSD) developed a series of three prototypes in 2010 and one prototype in 2011 demonstrating much of the required functionality. The first prototype in 2010 was completed in May. The overall objective of this first prototype was to demonstrate a preliminary capability for AWIPS II to ingest and display model data from remote data servers. CIRA staff, working with other ISB staff, was able to leverage NextGen registry/repository technology to discover information (metadata) about remote WCS servers. They implemented a grid ingest and storage capability into AWIPS II using the EDEX (Environmental Data Exchange) plug-in capability. An interface to the Common AWIPS Visualization Environment (CAVE) was also developed by CIRA staff that enables the user to make ad-hoc requests to the remote server using web technology.

The second prototype, which was completed in September 2010, featured the addition of observation data to the Data Delivery system. CIRA staff continued to leverage NextGen capability by utilizing the Web Feature Service (WFS) Reference Implementation (RI) and Joint METOC Broker Language (JMBL) clients to request METAR and MADIS datasets, respectively, from WFSRI servers and the JMBL

MADIS server, and ingest into AWIPS II. Three MADIS networks were used – Climate Reference Network (CRN), Mesonet and METARS. The JMBL web capability was used since these datasets were not yet available via the WFSRI servers. CIRA staff added two new EDEX plugins - one to ingest observation data in the Weather Exchange Model (WXXM) format, and the other to handle MADIS data in NetCDF-3 format.

The third and final prototype for 2010 was completed in December. This prototype featured new Graphical User Interface (GUI) capabilities on CAVE. These features include a first cut at dynamic menu creation, provide the user with a robust interface to request data on pre-defined domains, and to do some temporal sub-setting. A subscription capability was also introduced for gridded datasets from Web Coverage Service (WCS) Reference Implementation (RI) servers. CIRA staff worked with ISB to provide an updated interface capability with the CAVE plug-in. The interface provides a high-level mechanism for CAVE to interface to the remote servers.

The first prototype for 2011 was completed on March 1. This prototype features a more dynamic WFS subscription capability and an even more robust GUI. The GUI provides a sub-set manager that handles spatial and temporal sub-setting and provides the user with options to do spatial sub-setting. The GUI provides the user with the option to select predefined areas, to enter a latitude/longitude extent, or to draw a bounding box around the area of interest. CIRA staff worked with ISB staff to develop a more robust WFSRI client that would generate requests on-the-fly instead of reading requests from a file. CIRA staff augmented the CAVE interface to enable the WFSRI subscription.
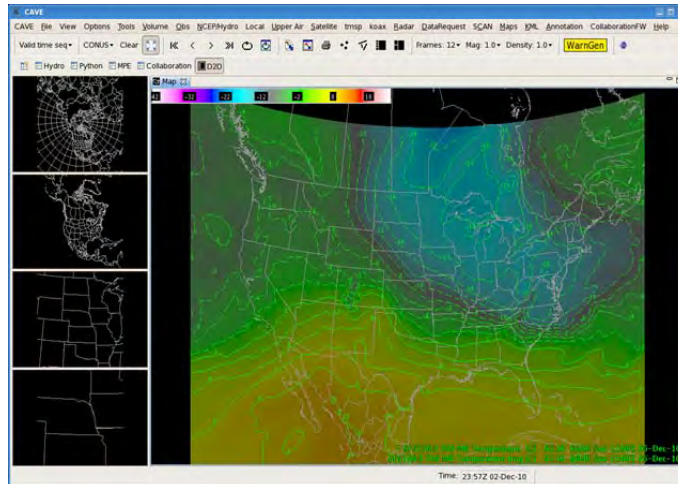
Figure 1.   A display of the GFS temperature grid requested from one of the NextGen WCSRI servers on the CAVE GUI.
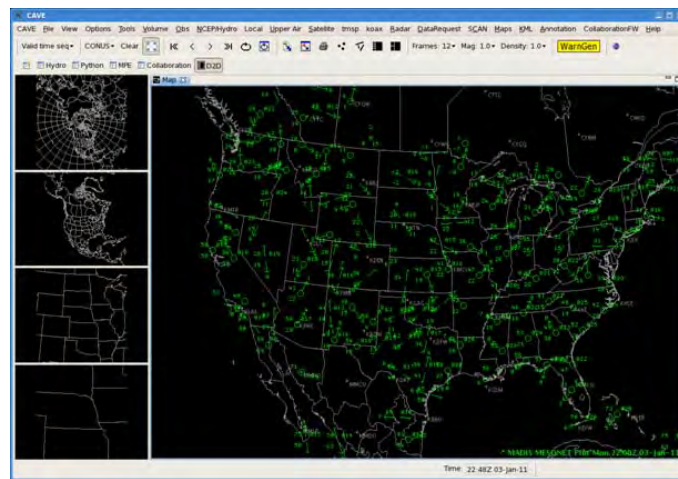
Figure 2.   MADIS mesonet data from the JMBL-MADIS server displayed on the CONUS scale on the CAVE GUI.

EAR PROJECT TITLE: Exploratory Workstation Development

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: U. Herb Grote, James Ramer

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

PROJECT OBJECTIVE: The objective of this project is to develop a weather forecast workstation with advanced interactive display capabilities that includes inter-office collaboration. To maintain spatial consistency of operational forecasts, adjacent forecast offices must have access to identical data sets and be able to view the data in the same manner. This

allows forecasters and users to obtain a similar understanding of the weather event and allow them to create consistent forecasts. To achieve effective inter-office collaboration, the workstation must display a diverse set of real-time meteorological data, allow users to graphically annotate the display, and provide a text chat capability in real-time. The system also needs to be able to run dispersion models to help predict movement of volcanic ash, smoke, or toxic chemicals, and include an alert capability that can interface with available dissemination technologies.

AWIPS II Extended - Collaboration
Several options were explored for implementing a real-time collaboration capability in AWIPS II. These included open source conferencing software packages, custom software development, and system tools that support desktop sharing. A collaboration server was set up to evaluate two of the open source conferencing software packages. The tests involved local and remote users and explored collaboration functionality and quality of the shared displays. It also became apparent additional test were required to evaluate performance, particularly over low bandwidth network links. Several network shaping tools were used to characterize the collaboration response at different network speeds. All of the collaboration tools use various performance optimization techniques such as image compression, partial screen refresh, and pixel depth reduction. The custom collaboration capability takes advantage of the fact that similar data bases exists at forecast offices and simple control instructions such as "load" can produce shared display. This approach also allows image animation and rapid zoom and pan. Graphic annotations are shared as graphic instructions instead of image pixel transfers. A comprehensive annotation capability that

included weather symbols and features was added to the collaboration software.

FXC Migration to AWIPS II
The FXC system provides capabilities ranging from accessing remote weather displays to performing real-time collaboration, delivering remote weather briefings, supporting extensive weather graphic annotation, creating slide presentations, and running applications like dispersion models. Most of the NWS forecast offices use FXC primarily to generate graphics for their web pages (i.e. "Graphicast" and "Weather Story"). To provide this limited capability when AWIPS II is introduced into the offices, only a subset of the FXC capabilities have been implemented in the AWIPS II Common AWIPS Visualization Environment (CAVE) as an "annotation plug-in".

The annotation plug-in creates a separate drawing layer on top of the CAVE display. This allows the forecaster to use the basic CAVE features to load and manipulate real-time weather data, and launch the annotation plug-in when the user wants to annotate the display. In AWIPS II, a software application that implements a specific set of operational requirements in the display window is called a "perspectives". The annotation capability is available to all CAVE perspectives. Also, annotations created in one perspective can easily be displayed in another. The same drawing features found in FXC have been implemented in the plug-in. In the D2D perspective (see figure 1), the drawing can be swapped into one of the side small panes. The drawing must be returned to the large pane to perform any editing. Several offices have tested the new software in their AWIPS II environment. The FXC annotation plug-in will officially be made available to forecast offices as a local application.
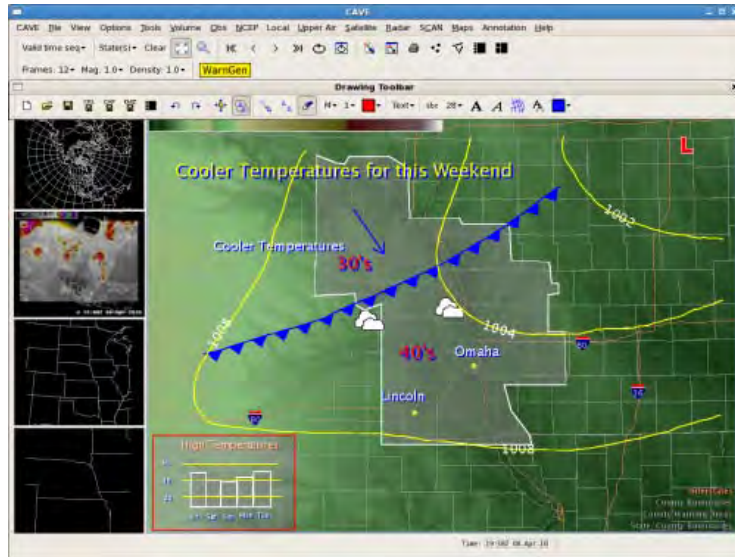
Figure 1. The FXC Annotation Capability on AWIPS II

EAR PROJECT TITLE: Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Joanne Edwards, Tom Kent

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

NOAA RESEARCH TEAM: Michael Barth, OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: MADIS is dedicated toward making value-added data available from GSD for the purpose of improving weather forecasting by providing support for data assimilation, numerical weather prediction, and other hydro-meteorological operations. MADIS hit a huge milestone in September 2010 by reaching Initial Operating Capability (IOC). The objectives for the previous reporting period were:

--To complete the transition of MADIS to NWS operations at the National Centers for Environmental Prediction (NCEP) and to get MADIS to Initial Operating Capability (IOC)
--To continue to add new functionality and data sources to MADIS.

--To continue to explore ways of getting MADIS observations to the Data Delivery system since MADIS is slated to be one of the NextGen data providers to the Weather Information Database (WIDB).

PROJECT ACCOMPLISHMENTS:
--MADIS Transition
As part of the MADIS transition, CIRA developers in conjunction with ISB worked diligently toward completing 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-preprocess 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. Many 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. This work was begun in 2009 and completed in 2010.

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. Work has continued as new stations are added to the network.

--New MADIS Functionality and Data
Over the past reporting period, a new capability was added to MADIS—the Sensor Model Language (SensorML) Metadata standard that all national mesonets are beginning to use. This metadata is in an XML format and contains information about all of the stations within a given mesonet network. This information includes everything from station names, locations, meteorological parameter sensor

inputs and outputs and units, maintenance dates and procedures, to various vegetation obstructions around the sensors. CIRA staff developed numerous scripts to download the data from a web page, parse the XML, decode the data values, and store the values into NetCDF. CIRA staff also developed a tool that is used by the end-users to view the NetCDF data in a concise format, sorted by network.

Another new data source that was added to MADIS in the previous reporting period is the Mobile Platform Environmental Data (MoPED). The MoPED project involves putting sensors on buses and having the sensors transmit data every 10 seconds to a web server. CIRA staff was responsible for writing numerous scripts to interface with the web server, parse/decode the XML data, and store the data into NetCDF.

Since these datasets are so new, CIRA staff also played a key role in helping the NWS contractors debug the system. It is anticipated that due to the success of this project, several thousand more sensors will be added in 2011.

--MADIS and Data Delivery
The evaluation of MADIS as a viable Data Provider of surface observations was added to the AWIPS II Data Delivery Statement of Work (SOW) in 2009. CIRA staff in conjunction with ISB added MADIS to the Data Delivery system during the second Data Delivery prototype development that concluded in September 2010. MADIS data were added via the MADIS Joint Metoc Broker Language (JMBL) server that was developed in 2008/2009. The addition of this capability enables users to request data from three MADIS networks—CRN, METARS and Mesonet—and display the data on to the AWIPS II GUI. CIRA staff and other MADIS staff in ISB were also successful in setting up a subscription capability for requesting MADIS data from a remote WFSRI server.

EAR PROJECT TITLE: Meteorological Assimilation Data Ingest System (MADIS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Randall Collander, Tom Kent

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

NOAA RESEARCH TEAM: Leon Benjamin, CIRES; Michael Barth, Federal

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

The current implementation of the Meteorological Assimilation Data Ingest System (MADIS) at ESRL/GSD makes integrated data available in real-time, with interoperable formats, to hundreds of users in the weather and climate enterprise for the purpose of improving weather forecasting by providing support for data assimilation, numerical weather prediction, climate applications, and other hydrometeorological applications. The transfer will be accomplished through the testing of software presently in use at GSD on National Centers for Environmental Prediction (NCEP) computing systems, as well as development of additional software required for adapting to computer architecture differences.

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 creation of software to translate from the BUFR raw data 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 locally and will be integrated into the transitioned software set at a future date.

EAR PROJECT TITLE: Geo-Targeted Alerting System (GTAS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Leigh Cheatwood-Harris

NOAA TECHNICAL CONTACT: Greg Pratt, NOAA/OAR/ESRL/GSD/ISB

NOAA RESEARCH TEAM: Rich Jesuroga ESRL/GSD/ISB, Greg Pratt ESRL/GSD /ISB, Susan Williams ESRL/GSD /ISB, Linda Wharton ESRL/GSD /FAB

PROJECT OBJECTIVES: The GTAS project is a prototype implementation of the latest developments in plume modeling, high resolution weather models, and network enabled operations. One of the prime objectives of the GTAS project is to meet the Federal Emergency Management Agency's (FEMA) requirements to provide air dispersion and toxic plume information along with NOAA meteorological and environmental data to state and local emergency

management agencies. GTAS is to build upon established relationships between local NWS WFOs and local Emergency Operations Centers (EOCs) by providing shared situational awareness of vital data, so that emergency managers can quickly determine the impact and provide mitigation and response plans to the public and other local and state EOCs.

PROJECT ACCOMPLISHMENTS: The biggest users of GTAS are emergency managers. They need to be trained on the system in order for them to be more effective in responding to emergency situations. CIRA staff worked diligently to generate training plans for users, and began development of videos and on-line questionnaires to be used in generating more effective training plans. CIRA staff also took a lead role in developing the GTAS HySPLIT interface, which allows users to run plume models for toxic releases given chemical and location characteristics. This work was built on top of work that was done in the previous year and required research into the Tcl/Tk scripting language that was used to develop this capability.

EAR PROJECT TITLE: Integrated Hazard Information Services (IHIS)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Leigh Cheatwood-Harris

NOAA TECHNICAL CONTACT: Tracy Hansen, NOAA/OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: The IHIS project is a spin-off of the Next Generation Warning Tool (NGWT). Its purpose is to combine existing warning tools used in the current AWIPS by forecasters into a new, defined warning system. It is envisioned that this new system will comprise a flexible, extensible framework which can accommodate not only the existing capabilities of AWIPS but also allow for creation of new, state-of-the-art products and tools.

PROJECT ACCOMPLISHMENTS: CIRA staff was instrumental in setting up GTAS-like GIS shapefiles for IHIS. In order to accomplish this, CIRA staff collaborated with the IHIS developers. The inclusion of this capability decreased duplication efforts as the work had been done previously for GTAS.

EAR PROJECT TITLE: NextGen Aviation Project - IC4D and Auto-Nowcaster

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Leigh Cheatwood-Harris

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

PROJECT OBJECTIVES: The NextGen Aviation project is a project that will enhance NWS Aviation responsibilities. Its goal is to provide new capabilities that make air transportation safer and more reliable while improving the capacity of the National Airspace System (NAS) and reducing aviation's impact on the environment.

In order to meet the NextGen weather functional and performance requirements, significant changes to model resolution, both temporal and spatial, are expected. If human forecasters are to add value to this type of frequently updated, high resolution model data, today's forecast techniques and methodologies must change. The National Weather Service, in conjunction with their research partners, are exploring and developing processes in which a human forecaster is "over the loop" (HOTL), adjusting model output as needed and then using the new data for various forecast products.

Two HOTL processes are currently being tested by the NWS:
--Interactive Calibration of Aviation Grids in 4 Dimensions (IC4D)—allows forecasters to adjust gridded output of fully automated aviation

forecast products using a software suite compatible to existing NWS tools.
--Auto-Nowcaster—NWS forecasters attempt to improve the consistency, reliability, and accuracy of 0-2 hour automated convective forecast products.

PROJECT ACCOMPLISHMENTS:
CIRA staff continued testing of the IC4D software on local workstations and creating online evaluation surveys for the Auto-Nowcaster. After completing the Auto-Nowcaster surveys and obtaining feedback from the users, the information was compiled into a "Catalog of Responses" report. This report is accessible for the users and management to review. In return, this helps them plan the action steps to take in the future.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Tom Kent

NOAA TECHNICAL CONTACT: Russell Chadwick, NOAA/OAR/ESRL/GSD/ISB

PROJECT OBJECTIVES: The WISDOM project has a goal of improving the 3- to 7-day predictions of hurricane track and intensity. It is a joint project between NOAA and Department of Homeland Security (DHS) and is aimed at saving millions of dollars in regards to evacuations and storm preparations. It is envisioned that this will be done by providing users with the capability to better pinpoint a smaller target area for hurricane landfall. To achieve this goal, a set of balloons (as many as 200) are launched from various sites surrounding the hurricane from 4 to 7 days before landfall. These are "super-pressure" balloons that will rise rapidly to a specified altitude. Balloons are sent to different altitudes

and then float at that fixed altitude for several days, sending measured meteorological data as well as latitude/longitude information to a receiver every few minutes.

PROJECT ACCOMPLISHMENTS: CIRA staff continued to work on this project which was developed during the previous reporting period. Most of the software was still valid during this period, and some testing was done of the communications from the sites of the balloon launches. This involved some minor changes to the software as well as coordinating with other IT people at remote sites. Some optimizing of the code was also done to optimize data flow when processing different XML data formats.

EAR PROJECT TITLE: QC Procedures for Application to US Operational and Real-time Mesonetwork Precipitation Observations

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Randall Collander

NOAA TECHNICAL CONTACT: Edward Tollerud, NOAA/OAR/ESRL/GSD/FAB

PROJECT OBJECTIVES: Adapt and extend existing quality control procedures designed to screen existing hourly gage precipitation network gage observations (primarily HADS and ASOS) to gage observations from several additional regional mesonetworks processed by MADIS.

Experience with the HADS/ASOS (Hydrometeorological Automated Data System/Automated Surface Observing System) system suggests that many of the problems it is designed to mitigate probably also exist in the other mesonetworks accessed by the Meteorological Assimilation Data Ingest System (MADIS). However, these other mesonetworks will undoubtedly also be susceptible to serious problems that are not of significance in the HADS/ASOS reports. Addressing these new problems will necessitate an expanded set of screening algorithms.

Besides the obvious usefulness of quality dense, short-term gage reports for display and other applications, these recently acquired reports also potentially represent a critically important addition to the HADS/ASOS screening by providing a regionally rich set of comparison observations for neighbor checks and hence more robust data screening. For users such as the GSD Real-Time Verification System (RTVS), this increase can significantly improve the prospects for verification of model predictions within western United States regions where the HADS are scarce.

PROJECT ACCOMPLISHMENTS: NOAA/CIRA funding unavailable for work during this period.

EAR PROJECT TITLE: Balloon-borne Atmospheric Sampling

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Randall Collander

NOAA TECHNICAL CONTACT: Russ Chadwick, NOAA/OAR/ESRL/GSD/DO

PROJECT OBJECTIVES: Continue research activities drawing upon extensive experience with design and implementation of balloon vehicles and balloon-based instrument payloads. This objective will be applied to two sub-projects:

--The AirCore™ method for obtaining vertical atmospheric profiles of trace gases designed by scientists in the ESRL Global Monitoring Division. The basic concept is that a very long coil of tubing, open on one end, is taken to high altitude and allowed to descend back to earth, establishing a concentration profile of stable gases in the tubing that can be read using a gas analyzer.

--The Ultra-Light Dropsonde System (ULDS). A dropsonde weighing approximately 38 grams has been developed for deployment from Remotely-Operated Aircraft (ROA) and other applications including fire weather. Laboratory testing is necessary to assess instrument robustness under extreme temperature and altitude conditions, with field testing (via balloon) required to verify communications and the effect of atmospheric exposure on packaging, instrumentation and batteries.

PROJECT ACCOMPLISHMENTS: NOAA/CIRA funding unavailable for work during this period.

EAR PROJECT TITLE: Aviation Initiative Demonstration (FXC AI)

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus OAR/ESRL/GSD/ACE Chief

PROJECT OBJECTIVES: Consistent with the FAA's Air Traffic Organization's (ATO) philosophy to review, upgrade, and create efficiencies in various functions, 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 in January 2006.

The FXC Aviation Demonstration was a short-term effort that took place from July through September of 2006. It was a rapid response development and prototyping effort with an extremely demanding schedule. This effort was in support of a NWS proposal for transforming the agency's aviation weather service program to meet the FAA requirements of reducing costs and enhancing services. The initiative focuses on services provided by NWS Center Weather Service Units (CWSU).

The participants in the demonstration were the Leesburg, Virginia CWSU and the Sterling, Virginia Weather Forecast Office (WFO). System and server support was from Boulder's ESRL/Global Systems Division. The purpose of the FXC Aviation Initiative was to demonstrate the capability to perform collaboration between the CWSU and the WFO to produce new forecast and decision aid products that translate weather impact on en-route and terminal air operations and that provide common situational awareness to all prototype participants; additionally to demonstrate the capability of the WFO to remotely support ARTCC weather information requirements when the CWSU is unavailable.

During the summer of 2006, CIRA researchers in the Global Systems Division's Aviation Branch, along with FXC engineers from the Information Systems Branch, concentrated its efforts on Aviation Initiative development. This development was based on the Earth System Research Laboratory technologies and services being developed by CIRA engineers at the Prototyping Aviation Collaborative Effort (PACE) facility at the Fort Worth ARTCC. For a description of PACE and related FXC Development, refer to the FXC TMU project description. The FX-Collaborate (FXC) software, developed at the ESRL was the major software system used in the AI Demonstration. The FXC AI offers on-demand services, remote briefing capabilities, new graphical products, and tactical decision aids.
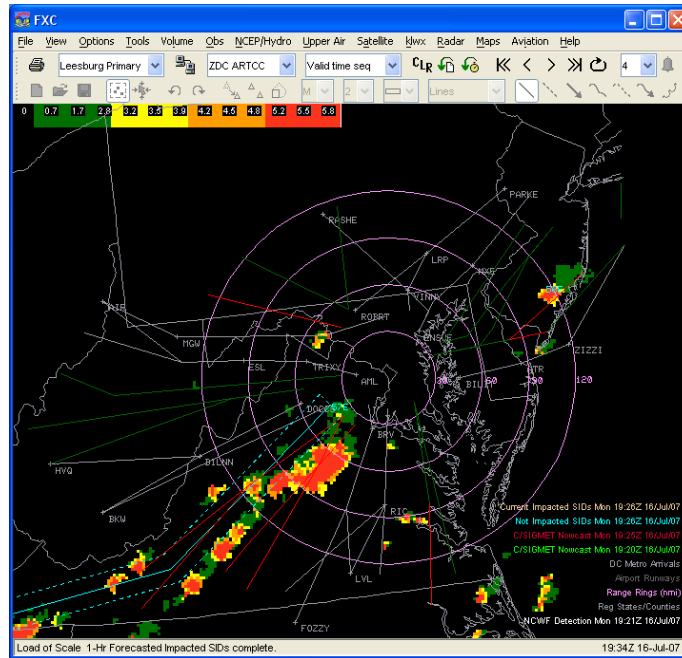
Figure 1. View of the FXC AI BriefEE display with map enhancements and impacted DC Metro departure routes.

PROJECT ACCOMPLISHMENTS: Over the research period, no new research or development was directly applied to any AI Project work. There were no deliverables made this year. However, it is important to mention that 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 CWSU for its daily weather briefings to the Traffic Managers.

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.

This is really good news and is evidence 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.

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus NOAA/OAR/ESRL/GSD/ACE Chief

PROJECT OBJECTIVES: PACE is an operational test area located within the Fort Worth Air Route Traffic Control Center's CWSU for developing innovative science and software technology used to directly provide weather support for the ARTCC Traffic Management Unit (TMU).
The TMU project, staged at this facility, is researching the weather information needs and developing innovative software technology used to directly provide weather support for the ARTCC TMU. A major objective is to investigate aviation data sets and forecast products specifically tailored for the ARTCC air traffic weather forecasting environment among operational weather forecasting facilities and to investigate the utilization of collaborative weather forecasting.

The objectives came from the necessity to research and investigate software tools and data products for minimizing adverse weather disruptions in air traffic operations within the National Airspace System (NAS). Requirements and needs can be found in the study performed by FAA ARS-100 on "Decision-Based Weather Needs for the Air Route Traffic Control Center (ARTCC) Traffic Management Unit".

The FX-Collaborate (FXC) software, developed at NOAA's Earth System Research Lab in the Global Systems Division's Information Systems Branch, is a major component of the TMU project. The major system used to acquire, distribute, create and provide the required data sets for FXC is the AWIPS Linux data ingest and display system. The FXC and AWIPS software is being tailored, modified, extended, enhanced, and utilized in the TMU project. The FXC software allows for the remote access and display of AWIPS data sets over the Internet, a collaboration capability among participants at physically different locations, and the ability to utilize tools to aid in discussing forecasts. Additionally, the TMU project relies on the

AWIPS system for generating the content available on the TMU Project TCHP and ADA web site.

The TMU Project is comprised of a suite of systems that consists of a database to house tactical decision aids, a web presence to display this content to traffic managers, and a FXC TMU system capable of overriding the impact information. The FXC TMU end-to-end capability allows forecasters to edit and override aviation route impacts. The override information is propagated back through the system and made available to update AWIPS, FXC, and the TMU Web Content displays. The initial design and structure of the decision aids relational database was populated with map background information for the ZFW arrival/departures, high-use jet routes, and TRACON arrival/departure gates. Following were changes to the AWIPS impact decoders to create impact information based on the NCWF2 data sets that would then be stored in the database and server side processing and generation of the web content generation.

A goal of the TMU web site is to consolidate all tactical aviation weather hazards information into a suite of products for presentation to TMU decision-makers in an easily understood format (A, GO-NO-GO, approach to air traffic route and flow information). What is important to understand about the Weather Information Decision Aids (WIDA) web content page is that it is a complete end-to-end system, not just a simple web display that provides useful information assisting in tactical and strategic decision making. It is an extremely complex suit of systems that involves AWIPS, FXC, content generation for the web, and a database backend. This is an end-to-end decision aid tool centered on the forecaster in the loop concept for helping to keep and create a more consistent, relevant, and accurate WIDA product available for TMU managers. The consistency

and power comes from the fact that all these systems are now tied and share the same data source.

The two images below show current impact with no Forecaster Edits. ZFW TRACON departure gates are displaying green (no impact) and yellow (partial impact).
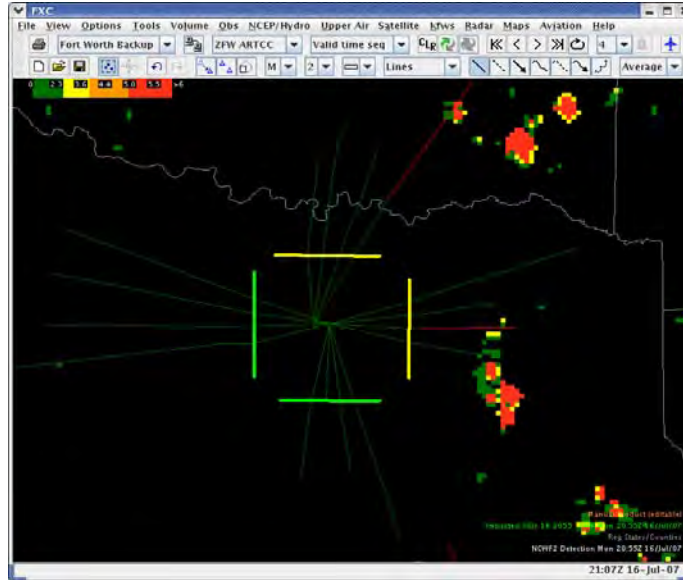
Figure 1. Forecaster FXC tool showing current ZFW TRACON Departure Gate impacts with NCWF2.
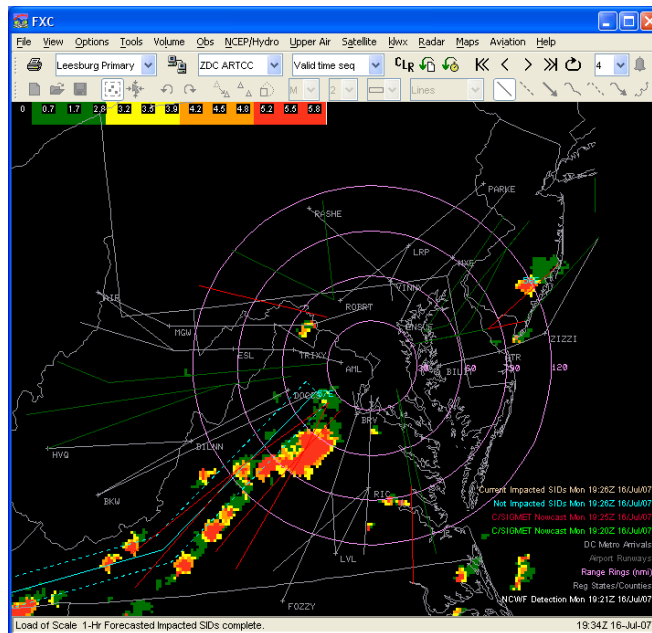
Figure 2. Traffic Manager (WIDA) Web Display showing concurrent Red-light/Green-light Departure Gate Impact information.

PROJECT ACCOMPLISHMENTS: As of May 2007, the TMU project has been operating in software/system maintenance and support mode since the project research funding had ended. As of March 2009, the 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 of this project. It is important to mention that these systems are still in full use at the Fort Worth 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 February 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 CWSUs occurs.

This is really good news and serves 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.

EAR PROJECT TITLE: Meteorological Data Acquisition Systems

PRINCIPAL INVESTIGATORS: Cliff Matsumoto

RESEARCH TEAM: Chris MacDermaid and Robert Lipschutz, Leslie Ewy, Paul Hamer, Patrick Hildreth, Glen Pankow, Randy Pierce, Richard Ryan, MarySue Schultz, Amenda Stanley, Jennifer Valdez

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

PROJECT OBJECTIVES: Manage the Global Systems Division (GSD) Central Facility Data Acquisition and Distribution Systems

PROJECT ACCOMPLISHMENTS: The GSD Central Facility comprises a number of real-time systems for the acquisition, processing, and distribution of meteorological data sets used by GSD researchers and developers, as well as numerous external NOAA offices and other agencies. These systems range from a single-purpose ingestor of data from the National Weather Service's NOAAPORT satellite feed to a six-host high performance cluster. Based on requirements from GSD users, the Facility handles an ever-growing data load, now over 1 TB of data each day—up some 25% over the past year.

A wide variety of new data sets were added to the Facility over the year in support of such GSD projects as Rapid Refresh (RR), High Resolution Rapid Refresh (HRRR), Local Analysis and Prediction System (LAPS), Network-Enabled Verification System (NEVS), the Hurricane Forecast Improvement Project (HFIP), and the Hydrometerology Testbed (HMT).

In addition to simply acquiring new data sets, software was developed to decode and process new data types, including data from meteorological towers and from wind farm nacelle anemometers. We also created new software to handle Graphical AIRMET (G-AIRMET) data from NOAA's Aviation Weather Center (AWC) and continued to transition legacy software to the Central Facility's Object Data System (ODS) framework.

Finally, in collaboration with GSD Systems Administrators, several legacy systems were decommissioned and replaced by new platforms. Most notably, GSD's computer responsible for ftp services was upgraded to a scalable three-host farm arrangement that is expected to provide ample capacity and expandability for GSD's foreseeable data distribution needs. In addition, GSD's three end-of-life Local Data Manager (LDM) servers were replaced by a new set of higher capacity servers, enabling distribution of larger data sets including 2-D HRRR model data.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Christopher MacDermaid**,** Michael Leon, MarySue Schultz, Michael Turpin, Jim Frimel, Patrick Hildreth, Glen Pankow, Jeff Smith, Sher Schranz

NOAA TECHNICAL CONTACT: Lynn Sherretz, NOAA/OAR/ESRL/GSD/ACE Branch

PROJECT OBJECTIVES: Participation in the fiscal year 2010 Capabilities Evaluation (CE) at the Federal Aviation Administration's William J Hughes Technical Center (WJHTC)

PROJECT ACCOMPLISHMENTS: The purpose of the FAA's NNEW program is to provide common, universal access to aviation weather data. The goals of this program include providing network-enabled weather information services, disseminating weather information to transportation decision makers and National Air Space (NAS) users, laying the foundation for access to the "common weather picture", and providing for the extraction of weather information by user-specified criteria (e.g., along a flight path).

As of January 2011, the NNEW program has completed the FAA's Investment Analysis Readiness Decision (IARD) and has been transitioned from the FAA's AJP (Operations Planning Services, Air Traffic Organization) to the FAA's AJW (Technical Operation Services, Air Traffic Organization). IOC (Initial Operating Capability) is scheduled for 2015.

FY10 Capability Evaluation
In September of 2010 the Federal Aviation Administration (FAA), in close collaboration with the National Weather Service (NWS) and a host of other organizations including CIRA researchers, put on an event to showcase the capabilities of NNEW software and services.

The CIRA research team helped to ensure the successful delivery of aviation weather data via software developed by the National Center for Atmospheric Research (NCAR) and Massachusetts Institute of Technology (MIT)/ Lincoln Laboratory. Much preparation was necessary at the William J Hughes Technical Center to lay out the infrastructure, connectivity, and security needed to integrate all of the participating entities. CIRA researchers assisted with the coordination, setup and troubleshooting involved with getting all of the CE participants to successfully provide their data to the (WJHTC) for this high profile demonstration. CIRA researchers also provided data and performed automated testing related to the functionality of the Web Feature Service Reference Implementation (WFSRI). In the end, the FY10 CE was deemed a success by program management from both the FAA and the NWS. This testing utilized the GSD R&D Testing Environment.

GSD R&D Test Environment
As the development of the NNEW WFSRI, Web Coverage Service Reference Implementation (WCSRI) and Registry/Repository (Reg/Rep) proceeds and new versions are released, testing of these system components needs to occur periodically to ensure that the requirements are still being met and that the end-to-end system functions efficiently and correctly. CIRA researchers have developed an R&D test environment comprised of implementations of

the WFSRI, WCSRI and RegRep to support the functional, integration, and performance testing required to accomplish these goals. CIRA researchers are in an ideal position to contribute to this testing with expertise in weather data decoding and distribution. Figure 1 is a diagram of the GSD R&D Test Environment network topology.

Further, CIRA researchers have developed a web application (the GSD NNEW Testing Portal) that facilitates running tests on the NNEW software. Test results and additional diagnostics are displayed in the form of graphs and are recorded in a central database for additional analysis. The Testing Portal was used for functional testing of the WFSRI during the FY10 CE and received positive feedback for its utility as an automated testing service for the WFSRI.
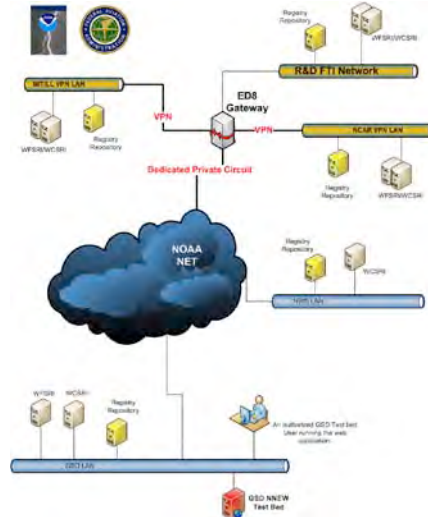
Figure 1. GSD R&D Test Environment Network Topology

EAR PROJECT TITLE: FXC Volcanic Ash Coordination Tool, VACT

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jim Frimel

NOAA TECHNICAL CONTACT: Michael Kraus NOAA/OAR/ESRL/GSD/ACE Chief

PROJECT OBJECTIVES: The FXC VACT project is an experimental client/server based application utilizing the Internet and is based on the FX-Collaborate (FXC) system architecture. The participating agencies are currently the National Weather Service Alaska Region Headquarters (NWSARH), Anchorage Volcanic Ash Advisory Center (VAAC), Alaska Volcano Observatory (AVO), and the Anchorage Air Route Traffic Control Center, Center Weather Service Unit (CWSU).

The FX-Collaborate (FXC) software, developed at NOAA's Earth System Research Lab in the Global Systems Division's Information Systems Branch, is a major component of the FXC VACT project. The major system used to acquire, distribute, create and provide the required data sets for FXC is the AWIPS Linux data ingest and display system. The FXC and AWIPS software is being tailored, modified, extended, enhanced, and utilized in the FXC VACT project. The FXC

software allows for the remote access and display of AWIPS data sets over the Internet, a collaboration capability among participants at physically different locations, and the ability to utilize tools to aid in discussing forecasts

The FXC VACT project is a research and development effort in direct response to investigating the collaborative approaches and needs of agencies involved in generating Volcanic Ash Advisories. The FXC Volcanic Ash Coordination Tool is being tested at each of these operational sites to investigate forecaster productivity tools and collaboration capabilities in response to aviation hazards posed by volcanic eruptions. The system is designed to help locate and determine the extent and movement of volcanic ash so that more accurate, timely, consistent, and relevant ash dispersion and ash fallout watches, warnings, and forecasts can be issued. These watches, warnings, and forecasts can be disseminated using current approaches and standards (societal impact statements) but will also be tailored for end user needs in the form of societal impact graphics (i.e. jet routes or runways turning red when ash is present). Graphics tailored to aviation needs focus on making the National Airspace System (NAS) safer and more efficient during a volcanic ash event. Efforts are focused on integrating the latest advancements in volcanic ash detection and dispersion from the research community, allowing users to overlay and manipulate this information in real-time; developing tools to generate end user impact statements and graphics; and disseminating the impact

statements in a timely fashion so that hazard mitigation plans can be activated.

The VACT system allows users at different sites and with different expertise to simultaneously view identical displays of volcanic ash and other related data sets (i.e. shared situational awareness) and collaborate in near real-time. The expertise from all participating agencies is used in the determination of location, extent, and movement allowing for forecasts of fallout and dispersion to be consistent and more accurate. Relevant data on local agency systems and on the Internet can be pulled into the VACT system during collaborative sessions among the agencies to help in the analysis phase of an event. Societal impact forecasts can be disseminated faster through the development of a smart-system, which will automatically center on the area of eruption and display or highlight all key data sets for the volcanic ash event. Users of the VACT system aren't tasked with determining which data is relevant and can focus their attention on location, extent, dispersion, and societal impact. Societal impact statements can be disseminated following current standards and practices or by interactive briefings tailored to meet the needs of the end user (i.e. the public, emergency managers, FAA, airlines, armed services, state agencies, etc.). All volcanic ash events are captured and archived to help improve detection and dispersion methodologies, train new users on VACT functionality, detect and eliminate problems with multiple agencies collaborating in real-time on volcanic ash events, and improve dissemination techniques.
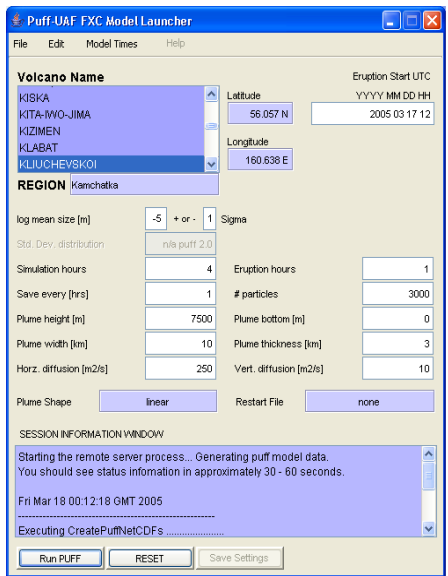
Figure 1. The FXC VACT PUFF Interface.
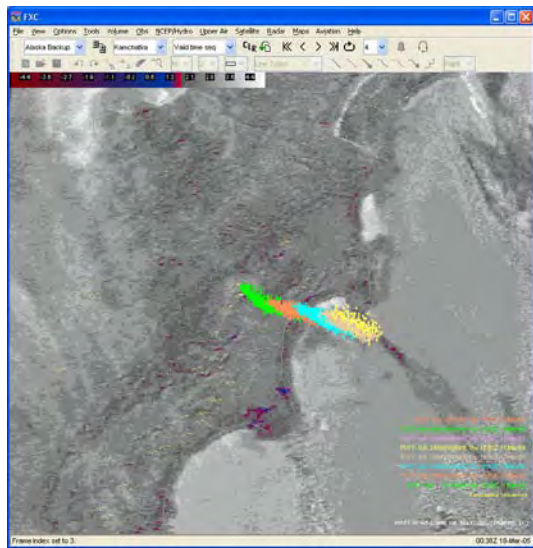
Figure 2. Example output from running the PUFF model over the 17 March 2005 eruption of Kliuchevskoi.

PROJECT 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.

This is really good news and shows an example of the FXC VACT project research being transferred to operations. 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 PROJECT TITLE: FX-Net Forecaster Workstation Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sher Schranz, Jebb Stewart, Evan Polster, Ning Wang

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

PROJECT OBJECTIVES: The purpose of the AWIPS Thin Client project is to develop and deploy an integrated thin client solution that will satisfy the NWS enterprise requirements for remote access to baseline AWIPS-II capabilities. Included in this project is the effort to transition from maintenance and support of the FX-Net thin client workstation to the delivery of the AWIPS II Common AWIPS Visualization Environment (CAVE) thin client workstation.

The CIRA team's objective is to continue supporting FX-Net while conducting research and development to make CAVE a remote, thin client.
Project goals for the past year include:
--Upgrade NWS and US Forest Service FX-Net AWIPS Servers
--Provide systems support and experimental fire weather data distribution to FX-Net users.
--Prototype an AWIPS II thin client capability for the NWS AWIPS Program Office.
--Develop AWIPS II CAVE Thin Client plug-ins and support contractor development

PROJECT ACCOMPLISHMENTS:
--The FX-Net AWIPS servers were upgraded to Linux v. 5 and the AWIPS software to v. 9.1. The latest security updates were also applied. Most of the NWS regional servers have been upgraded to these versions. Alaska and Eastern region are in process.

--For fire-weather users, a new version of the WRF/CHEM/SMOKE model was added to the FX-Net AWIPS servers. This is a 3km resolution version with a plume-rise algorithm that uses the NESDIS ABBA satellite fire product to initialize the smoke dispersion for the analysis and forecasts.

The Air Force One forecasters are now running multiple instances of FX-Net to support their forecasting duties.

FX-Net was used by NWS IMETS in Louisiana and Mississippi during the gulf oil spill. They provided on and off-shore forecasts during NOAA's Deep Water Horizon operations in support of the monitoring and clean-up of the oil spill.

FX-Net was also used by forecasters in support of security and facility operations for the Super Bowl.

FX-Net was used by OAR Physical Sciences Division to forecast flight tracks during the FY10 Hydromet Testbed QPE field program.

--Three prototypes of potential AWIPS II CAVE Thin Clients were built and demonstrated to the NWS. A detailed Analysis report was submitted to the NWS AWIPS II Program Office providing a detailed analysis of the current CAVE remote client, an analysis of potential development

directions and recommendations for the development of the optimal AWIPS II CAVE Thin Client. The FX-Net Team's analysis and recommendations were accepted by the NWS Program Office. The implementation of the FX-Net team's recommendations will be executed by the AWIPS II contractor, with architecture and testing support provided by the FX-Net development team.

--Investigated and prototyped AWIPS II CAVE-compliant "Markers" and "KML Export" plug-in. This will be tested with the first version of the CAVE Thin Client from the AWIPS II contractor.
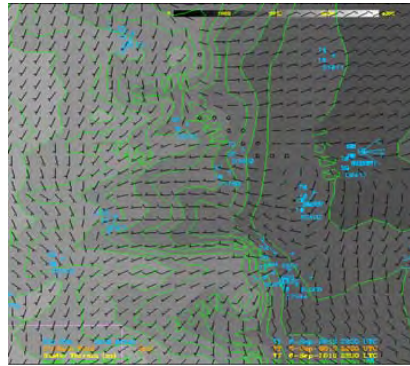
Figure 1. KML Plugin – CAVE Product
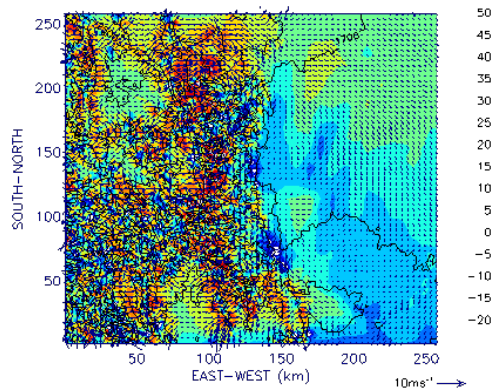
Figure 2. KML Plugin – CAVE Product Exported and Viewed in Google Earth

EAR PROJECT TITLE: GRIDDED FX-Net Forecaster Workstation Project

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Sher Schranz, Jebb Stewart, Evan Polster, Ning Wang

NOAA TECHNICAL CONTACT**:** Bill Bendel, NOAA/OAR/ESRL/GSD/TOB Chief

PROJECT OBJECTIVES: Maintain existing system capabilities for USFS, BLM and Dept of Agriculture.

PROJECT ACCOMPLISHMENTS: Upgraded hardware deployed to 6 Geographical Area Coordination Centers (GACCs). Systems were successfully used by GACC Fire Weather

Predictive Services forecasters during the FY 10 fire weather season.

The GETWI application was deployed to one additional GACC office in FY10. The system continues to support the FY09 offices.

The Fire Weather Forecast group from British Columbia, Canada - FOR:EX is evaluating the Gridded FX-Net system for possible use in their operations.

EAR PROJECT TITLE: Wavelet Data Compression Research and Applications

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Ning Wang, Jebb Stewart, Sher Schranz

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

PROJECT OBJECTIVES:
--Enhance performance and efficiency of the compression software.
--Enhance the functionalities of the compression software to deal with data sets with various topologies and formats.
--Evaluate the impact of the lossy data computation to the data sets which will be used in further numerical computations.

PROJECT ACCOMPLISHMENTS:
--Progress has been made to enhance the Wavelet Data Compression in 2010. The data compression software has been updated and is more flexible in dealing with different data sets and more efficient in the use of computing resources. A new type of data compression evaluation has been conducted to assess the feasibility of compressing model data that are archived for further numerical processes.

A major function added to the software package is the program that compresses icosahedral grid data sets. The pre-process software transforms and organizes the data in unstructured icosahedral grid to a set of data in Cartesian grid that maintains a good correlation between adjacent grid points. Experiments have shown that the software package performs well in compressing the data sets produced by icosahedral grid global model.

Several experiments have been conducted using the compression software to evaluate the feasibility of compressing gridded weather model data. The data sets include global model data and European regional model data in Cartesian coordinate, and global model data in icosahedral grid.

--Data compression evaluation for Germany BGIO model data sets.
Two types of model output data were tested for BGIO to evaluate the performance of the wavelet compression package: one for a hydrostatic global model (720 x 361 horizontal resolution) and the other for a non-hydrostatic regional model (665 x 657 horizontal resolution). Both data sets are currently coded in GRIB format. Each GRIB file contains 4-5 vertical levels and 3-4 forecast times and has a 2:1 compression ratio in terms of raw data size.

Following the precision requirement for GRIB data format, we achieved the following compression:

For the global model:

Temperature: upper level ~37:1; lower level ~30:1;

Relative Humidity: upper level ~15:1, lower level ~ 12:1;

U, v component of wind: upper level ~ 14:1, lower level ~ 12:1;

For the regional model, we have achieved an average of 56:1 compression.

The experiment results show that, with the same compression accuracy, the wavelet data compression package can achieve significantly

better compressions compared to GRIB coding format.

--Data compression experiment with global icosahedral grid model data sets.
A new experiment has been carried out during 2010 to test the feasibility of compressing the data sets from global models using icosahedral grid mesh for various archiving purposes. The experiment was conducted on FIM[1], an icosahedral grid global model developed by the NOAA Earth System Research Laboratory. For the experiment, the model ran at 60 km horizontal resolution and 64 vertical levels. Each field has roughly 42 MB of data. The wind components u and v fields at the initial time were compressed with a specified accuracy and then decompressed and restored. The model ran to 72 hours with both original u, v fields and restored u, v fields as its initial condition.

The preliminary results from the experiment show that model predictability is not impacted by the slight accuracy loss due to the compression to the initial condition. We specified the compression accuracy to be 0.05 m/s and with which we achieved an approximately 10:1 compression ratio. Figure 1 depicts the 72 hours u, v fields forecast by the model. The upper two images are the model forecast with original uncompressed initial fields and the bottom two images the same forecast with compressed initial fields. The experiment results were reported at the 2010 AGU Fall Meeting. Further experiments are to be conducted in the near future to obtain more complete and detailed conclusions.
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Figure 1: The 72 hour forecast of u (left) and v (right) component, at potential temperature 273 degree. Upper: ordinary run, bottom: experimental run with compressed u, v initial condition

EAR PROJECT TITLE: National Weather Service NextGen 4D Data Cube

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Jebb Stewart, MarySue Schultz, Patrick Hildreth, Mike Turpin, Amenda Stanley, Sher Schranz, Chris MacDermaid

NOAA TECHNICAL CONTACT: Lynn Sherretz, NOAA/OAR/ESRL/GSD/ACE Branch

PROJECT OBJECTIVES:
--Conduct research into the technology and science of populating a four dimensional airspace with atmospheric data, extraction methodologies, distribution formats and input mechanisms to be used by aviation decision support systems. The GSD Director has appointed Sher Schranz as the Deputy Program Manager for the ESRL/GSD projects. Members of the FX-Net team will conduct research projects as a part of this program in the FY10/11 federal fiscal year.

--Support NWS 4D Data Cube prototypes, demonstrations and evaluations – including the coordination required to web-enable NOAA data providers.

--Support Program Manager and develop program plans, personnel resource allocations and budgets for research and development projects.

PROJECT ACCOMPLISHMENTS:
--Program coordination and roles and responsibilities documentation was developed for use by the GSD Division Director, Program Manager and Deputy Program Manager. Attended program development and research meetings with OAR, NESDIS, NWS, FAA, MIT and NCAR development partners.

--The team developed test plans and test cases used during the September 2010 Capabilities Evaluation (CE). Prototype demonstrations were shown to NWS NextGen Program Management and to NOAA data providers. Virtual Machines were developed to provide Web Coverage services to the NWS Aviation Weather Center, Meteorological Development Lab, NCEP and NSSL. The team then supported these groups while they populated their Virtual Machines with model, radar and aviation weather forecast data.

The CIRA NextGen team was essential to the success of the September CE as they provided security, networking, software development and real-time data feed support to the FAA's Technical Center prior to, and during the real-time event.

--Program management spreadsheets were developed to track research and development progress and budget. Regular developer and program management meetings are held with researchers from GSD, CIRA, and the NWS NextGen Program Office.

Team members are participating in research planning for a Convective Initiation demonstration to take place in FY12 and FY13. Members are also participating with the NWS and other OAR labs in Technology Innovation research planning and are contributing to the development of NWS Science and Technology roadmaps.

EAR PROJECT TITLE: Science on a Sphere® (SOS) Development

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Michael Biere, Steve Albers

NOAA TECHNICAL CONTACT: William B. Bendel, NOAA/OAR/ESRL/GSD/TOB Chief

NOAA RESEARCH TEAM: David Himes OAR/ESRL/GSD/TOB, William B. Bendel OAR/ESRL/GSD/TOB

PROJECT OBJECTIVES: The Science on a Sphere® Development project addresses NOAA's cross-cutting priority of promoting environmental literacy. The NOAA Science on a Sphere® (SOS) project displays and animates global data sets in a spatially accurate and visually compelling way on a 6-foot spherical screen. CIRA provides key technical support to the project, particularly research into effective user interfaces for the system, new visualization techniques, and new data sets.
Project objectives include:
--CIRA staff will continue to develop and enhance near real-time global data sets for SOS museum sites.
--CIRA researchers will be providing technical support for SOS® installation at any additional new sites that may arise.
--CIRA plans to continue support of the SOS® museum sites via our on-line Web Forum, as well as ongoing telephone and email support.
--CIRA staff will continue to enhance and debug the SOS® software.

PROJECT ACCOMPLISHMENTS:
--CIRA staff will continue to develop and enhance near real-time global data sets for SOS® museum sites.
CIRA staff developed a visualization of NASA's Solar Terrestrial Relations Observatory (STEREO) data showing dramatic imagery of the sun from two observing satellites. A newly developed visualization of NOAA's FIM-Chem model was also developed, and is used to trace the presence of three aerosols from August 27, 2009 through September 7, 2009.

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

--Point Reyes National Seashore, CA
--Central Weather Bureau, Taipei, Taiwan
--Bay Education Center, Rockport, TX
--Climate Institute, Cuernavaca, Mexico
--Pacific Science Center, Seattle, WA
--Danville Science Center, Danville, VA
--Science Museum, London, UK
--Climate Institute, Chilpancingo, Mexico
--Climate Institute, Atlacomulco, Mexico
--Climate Institute, Metepec, Mexico
--Climate Institute, Casa de la Tierra, Veracruz, Mexico
--Climate Institute, Planetario de Morelia, Morelia, Mexico
--Science Museum of Virginia, Richmond, VA

--CIRA will continue support of the SOS® museum sites via our on-line Web Forum, as well as ongoing telephone and email support. CIRA staff provided technical support to the network of existing SOS® sites.

--CIRA staff will continue to enhance and debug the SOS® software.
We developed a "distributor" version of SOS® that requires an encrypted key file mapped to specific hardware in order to operate the system. We added an "orient" command to the control interface, allowing external controllers to easily position the sphere in a known orientation. We enhanced the PIP (picture in a picture) capability of SOS® by allowing animation sequences of overlays with transparent backgrounds. We extended the PIP capability and the external control interface by adding named PIPs that can be manipulated after their creation. In addition we implemented numerous minor bug fixes and performance enhancements in the system.

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

PRINCIPAL INVESTIGATOR: Cliff Matsumoto

RESEARCH TEAM: Kenneth Sperow

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

PROJECT OBJECTIVES**:**
--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: Providing ANC data to NWS WFO forecasters within the Two-Dimensional Display (D-2D) and developing interactive tools within D-2D so that these forecasters can provide feedback to the ANC system as well as set up and run the complete ANC system on NWS hardware at the Meteorological Development Laboratory (MDL).

The main objectives of this project are: 1) to 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.

--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.

--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.

PROJECT ACCOMPLISHMENTS:
--The AutoNowcast (ANC) Prototype Project

The ANC prototype at the FWD WFO wrapped up this year. This past Spring, there was a 5-week intensive testing period conducted at FWD that was supported. The prototyping continues at WFO, Melbourne (MLB), Florida. The NWS sent ANC team members to MLB to train the MLB staff on the use of ANC AWIPS tools.

Using the ANC production system running at MDL built and configured by Ken Sperow, MDL is now delivering forecast data to the MLB WFO.

The ANC team started working this past year with NSSL to set up semi-automatic tuning of ANC's fuzzy logic engine that is used to generate convective initiation forecasts.

At the request of MDL, Ken Sperow traveled to Taiwan for a week as an ANC expert helping the Central Weather Bureau (CWB) understand and begin to set up the AWIPS components of ANC and the software responsible for transferring data between ANC and AWIPS. In preparation for this meeting, Ken set up the ANC bridge and AWIPS software on a development machine at the CWB and provided custom documentation.

MLB ANC Data Flow -
ANC to AWIPS

nowcast-station
@MDL   SRH   ldad@ls2   ldad@px2

LDM   →   LDM   →   LDM   newLDADdata   →   listener   Ldad_AncPrep   NcarDataIngest
                                           Notification   rocessor.pl

                                           FULL FILENAME: FULL FILENAME:
                                           /data/incoming   /data/fxa/LDAD/tmp

                                                                                    FULL FILENAME:
                                                                                    /data/fxa/tmp/other/ANC/

                                                                                    FULL FILENAME:
                                                                                    /data/fxa/Grid/TDL/netCDF/ANC (grids)
                                                                                    /data/fxa/workFiles/autonowcaster (xml)
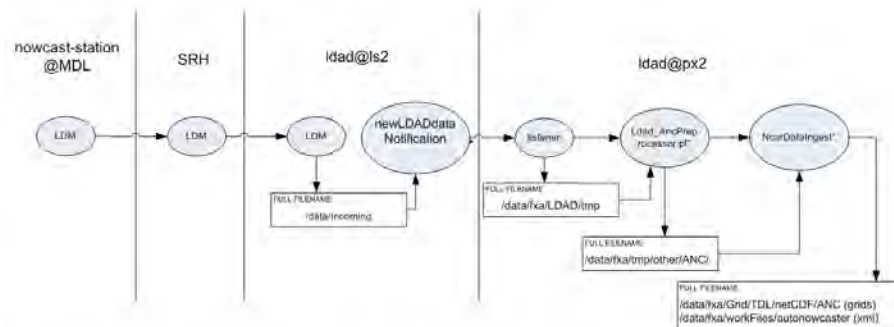
Details:

MDV and xml data is generated on anc-mlb1 or anc-mlb2 and uploaded to LDM using the EXP feed type with product IDs following the format:
NWS.MDL.ANC.<site>.<type>.<product>.YYYYMMDD_HHMM

where   'site' is the ANC site (e.g. FWD or MLB)
        'type' is the product data type (e.g. mdv or xml)
        'product' is the product type (e.g. boundary, polygon, regime, gandi60, cronusinit60, adjoint, etc.).

Data flows from anc-mlb# machines to ls2 via LDM (nowcast-station -> SRH -> ls2).

- Datasets that are uploaded are configured in ldad@anc-mlb1:$HOME/etc/input.py. directoryMonitor.py uploads the data as soon as it is written to disk.
- Currently we are transferring cronusInit60, humanInit60, cronusGrow60, gandi60, verify60, verifyNH60, NRLCloudClass, cronusLtgPof and adjoint MDV files, as well
as the boundary and polygon trigger files.
- Data files are written out to disk in /data/incoming via LDM (pqact.conf).
- newLDADdataNotification scans the /data/incoming directory every 20 seconds. newLDADdataNotification notifies listener running on px2, which then scp's the data
from ls2 to px2 and starts Ldad_AncPreprocessor.pl on px2 which copies the data to the correct location and sends a notification to the notification server.
- The NcarDataIngest process receives the notification picks up the files and converts MDV files to AWIPS netcdf files.

AWIPS Migration

--Ken was asked to represent MDL with two other MDL senior employees on the AWIPS II Software Development Planning. He continued to provide AWIPS migration support to MDL developers and to install new releases of the AWIPS Migration software on the system for testing and knowledge transfer activities. Ken is the OSIP lead and developer of a meteogram tool being prototyped within AWIPS Migration.

--At the NWS's request, he represented MDL and CIRA at several workshops this past year:
    --Attended an IHIS workshop at GSD in early June.
    --In October, he traveled to NWS headquarters to attend a developer coordination meeting hosted and led by MDL.

--Additionally, in December, Ken was asked to visit the Spokane, WA and Missoula, MT forecast offices. He briefed them on the current MDL developed AWIPS applications in addition to planned AWIPS II work.

--AWIPS Data Visualization and Monitoring System for Operational Records (ADVISOR)

This past year, Ken was asked to lead the ADVISOR project, which is comprised of 3 additional senior government employees. Most of the energy this past year was spent spinning up on AWIPS II framework and starting to prototype ADVISOR within this framework. This coming year, they will complete the OO design and finish the prototyping. Additionally, they intend to go through GATE II of OSIP.

PROJECT TITLE Legacy Atmospheric Sounding Data Set Project

PRINCIPAL INVESTIGATOR: Richard Johnson

RESEARCH TEAM: Paul E. Ciesielski

NOAA TECHNICALCONTACT: Chris Miller, NOAA CPO

PROJECT OBJECTIVES: A collaborative effort involving the Earth Observing Laboratory at the National Center for Atmospheric Research and the Department of Atmospheric Science at Colorado State University is underway to identify, inventory, recover, restore, place into a common format, and develop a central archive for sounding data from historical field programs such as ATEX, BOMEX, GATE, MONEX, and others.   The project involves a data stewardship effort to:

--Identify past field programs for which central collections of sounding data do not exist,

--Track down existing holdings of sounding data for those field programs, to the extent they exist, at centers, laboratories, and universities,

--Extract sounding data that are found from old storage media (i.e., 9-track tapes, printouts, etc.), and place into a consistent, common digital format,

--Carry out standard quality control of the sounding data including objective gross limit and vertical consistency checks, and

--Prepare a catalog and a central, publicly accessible archive of the sounding data (probably at NCAR and/or NCDC).

PROJECT ACCOMPLISHMENTS:
--A survey of atmospheric sounding data set holdings from past national and international field programs was carried out by CSU and NCAR. Old data tapes from a number of past field programs have been identified at CSU (WMONEX, TAMEX, PRE-STORM) and have found to be still readable. Other data holdings at NCAR and NCDC have been identified.

--An inventory of past field campaigns going back to the 1950s is being developed and PIs and other contacts from these campaigns are being identified.

--Websites for each of the field campaigns are being created, which will be populated with links to the sounding data as they become available.

--A presentation on this project is being prepared for the 27th Conference on Interactive Information Processing Systems on 25 January 2011 at the AMS Annual Meeting.

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

PRINCIPAL INVESTIGATORS: Chris Kummerow/Michael Hiatt

RESEARCH TEAM: Michael Hiatt, Steve Finley, Student Hourly

NOAA TECHNICAL CONTACT**:**

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.

PROJECT ACCOMPLISHMENTS:

--All data sets collected, processed, and archived at 99.9% level. Archive is both online RAID storage and DVD backups.
--GOES receiver repaired
--7m antenna feed waveguide repaired
--6 RAID units added for additional storage
--2 DVD writers replaced

AWARDS

Michael Leon Team Member of the Month in November 2010
Michael Leon of the Aviation, Computing, and Evaluation (ACE) Branch is GSD's Team Member of the Month for November 2010. Michael is the Technical Lead for the NextGen Network-Enabled Weather (NNEW) program which is developing state-of-the-art data handling capability based on standard data formats and standard data services as specified by the Open Geospatial Consortium (OGC). Michael led the GSD team (members named below) in preparing for and participating in the FAA/NWS IT Capabilities Evaluation (CE), held in September at the FAA Technical Center. The effort included working closely with NWS AWC and MDL, NSSL, NCAR, MIT/LL, and FAA Technical Center. The GSD team performed outstandingly and contributed greatly to the success of the CE. The CE was a highly-visible joint FAA/NWS effort and was the first major accomplishment of the NextGen Weather Working Group--and the first major accomplishment of the entire NextGen Program.

CIRA team members included Mike Turpin, Mary Sue Schultz, Amenda Stanley, Bob Lipschutz, Paul Hamer, Patrick Hildreth, Jim Frimel, Sher Schranz, Jebb Stewart, Jeff Smith, Chris MacDermaid, and Glen Pankow. Other team members include Lynn Sherretz, James Schroeter, Shannon Johnston, Chris Masters, and Steve Ennis

CIRA Fellow & Council Member Dr. Steven Koch has been selected Director of the National Severe Storms Laboratory in Norman, OK.

ATS Student Awards
2010 winners of two annual ATS student awards - The Herbert Riehl Memorial Award and Alumni Award: Rachel Storer (Riehl Award), Daniel Ward (Alumni Award). These awards were presented at the annual Herbert Riehl Reception on May 6.

June 2010 GSD Team Member of the Month – Steve Albers
The nomination from Forecast Applications Branch Chief Zoltan Toth:

"The Forecast Applications Branch nominates Steve Albers for the GSD June 2010 Team Member of the Month. Steve is a solid performer all the time. His contributions in the past half year to achieving FAB and GSD goals were especially noteworthy. Beyond the scheduled LAPS science and technical upgrades, Steve initiated the transition of the regular LAPS analysis and forecast runs to the more reliable Virtual Machine framework, which is now almost complete. Jointly with Isidora Jankov and others, Steve had major contributions to the success of HMT-10 forecast season, recognized by a DOC Gold Medal. The continual improvements to the cloud and microphysics initialization scheme keeps LAPS among the top schemes for warn-on-forecast applications. Steve is always looking for opportunities for further improvements. His current work with Isidora on convective-scale analysis and forecasting for the HWT domain will offer further insight into how convective processes can be best initialized for NWP applications."

CIRA Research Initiative Award

The Team of Steve Albers and Isidora Jankov **-** This honor acknowledges contributions to Numerical Weather Prediction (NWP) forecasting—and more specifically research which focuses on the initialization of fine scale numerical models in GSD's Local Analysis and Prediction System (LAPS) and research efforts aimed at improved physical parameterization schemes and ensemble forecast techniques in NWP.

Dale Reinke **-** This honor acknowledges contributions to the CloudSat Program and, specifically, design, development and implementation of what could be considered the most significant piece of software for the CloudSat ground data processing system – the Science and Engineering Data Ingest and Processing System. Development and implementation of the Data Distribution sub-system is also being recognized.

<u>Laura Leinen</u> **–** This honor is for leadership of CIRA's Biz Hub and its efforts to better serve CIRA's research activities by performing a multitude of administrative tasks for the CIRA Community as well as duties as the editor of the CIRA Magazine and organization of monthly confabs. Most noteworthy is the efficiency and willingness to work long hours to ensure the timely submission of numerous research proposals (especially ones requiring short turn-around time).

CIRA Employee Promotion News

<u>David Baker</u>
Dr. Baker, who had been a Postdoctoral Fellow with CIRA in Fort Collins, transitioned into a Research Scientist II position in March 2010. He works on quantifying sources and sinks of CO_2 using 4D-variational assimilation of in-situ measurements of CO_2 concentration from flasks and aircraft, as well as the new data streams of column averaged CO_2 concentration from satellites such as Japan's Greenhouse gases Observing SATellite (GOSAT) and NASA's rebuild of its Orbiting Carbon Observatory (OCO-2). David works closely with NOAA's ESRL in Boulder to adapt his models so that they can be used with Carbon Tracker, a modeling tool for both scientific research and policy development. His supervisor is Denis O'Brien.

<u>Helene Bennett</u>
Helene was promoted to Program Assistant II within the State Classified system in February 2010. This promotion was very much overdue given the breadth of responsibilities Helene manages for the NPS Cooperative Agreement within CIRA. Helene has a proven record of reliable, accurate, and timely service for the NPS team as she covers accounting, purchasing, travel and general admin duties for the group. Her supervisor is Mary McInnis-Efaw.

<u>Yong Chen</u>
Dr. Chen transitioned into a Research Scientist/Scholar I position in March 2010. Formerly a Postdoctoral Fellow, he works as a member of the Community Radiative Transfer Model (CRTM) team and as a member of the Joint Center for Satellite Data Assimilation (JCSDA) at the NESDIS Center for Satellite Application and Research (STAR) in Camp Springs, Maryland. His main tasks include testing the impacts of CRTM in the NWP system, and developing new modules to improve the CRTM performance. Steve Miller is his supervisor and Fuzhong Weng is his Technical Advisor.

<u>Cindy Combs</u>
Cindy was promoted to Research Associate IV in August 2010. She has been working for CIRA since 1991 and is one of CIRA's most experienced RA's in the field of satellite data processing. Cindy has been accepting an increasing role in the coordination with National Weather Service offices in Cheyenne, WY and Eureka, CA to implement her climatology products as part of the "NESDIS/NWS Satellite Proving Ground."   Several of her other recent projects include cloud liquid water and soil moisture work with Dr. Andy Jones (for CG/AR), and work on the determination of "lunar availability" for Dr. Steve Miller.

<u>Prasanjit Dash</u>
Dr. Dash transitioned into a Research Scientist/Scholar II position in March 2010. Formerly a Postdoctoral Fellow, he works with the Sea Surface Temperature (SST) Team at the NESDIS Center for Satellite Application and Research (STAR) in Camp Springs, MD. He is responsible for the Cal/Val and long-term monitoring of satellite SST products for stability, self- and cross-platform consistency. His most recent accomplishment is the development of the online web-based tool, SST Quality Monitor (SQUAM) http://www.star.nesdis.noaa.gov/sod/sst/squam/. The SQUAM monitors satellite SSTs with respect to several global analyses SSTs (including Reynolds, RTG, OSTIA, and ODYSSEA) from NOAA-16, -17, -18, -19, and MetOp-A. The SQUAM tool proved instrumental for quick near-real time diagnostics of the satellite SST products, and identifying root-causes of the anomalies (related to SST algorithm, cloud leakage, or sensor performance). Prasanjit is closely involved with the NPOESS Cal/Val Project and with the International Group for High-Resolution SST Team. His supervisor is Steve Miller and his Technical Advisor is Alexander Ignatov.

Steve Finley
Steve was promoted to Research Associate III in March 2010. Formerly a Research Associate for the Department of Atmospheric Science (1990-1997) and most recently a non-student hourly employee, he provides Linux IT support and Linux cluster support to CIRA in Fort Collins. Steve holds a B.S. in Meteorology and an M.S. in Agricultural Meteorology from Iowa State University, but has largely been employed as a scientific computing systems engineer, in support of operational projects for NASA, the FAA, and the DoD. Most recently he was employed by a local start-up company, Privacy Networks, along with other former Atmos and CIRA folks. His supervisor is Michael Hiatt.

Steven Fletcher
Dr. Fletcher was promoted to Research Scientist III in February 2011. He has been with CIRA in Fort Collins for 7 years in the CIRA data assimilation working groups, and has served as a mentor for several students who conduct work using data assimilation methods. Steve has in-depth experience with both ensemble and variational data assimilation systems, and has recently coordinated an International workshop on cloud data assimilation and served as a convener of special sessions on nonlinear and non-Gaussian data assimilation at the AGU Fall meetings. His work involves data assimilation of clouds, water vapor, and surface snow cover and snow water equivalent.

John Forsythe
John was promoted to Research Associate IV in August 2010. He has worked in several areas of Satellite Meteorology for the Center for Geosciences and NOAA and NASA projects. John's current research focuses upon long-term global water vapor data sets for climate studies and water vapor and cloud products for forecaster aids.

Lewis Grasso
Dr. Grasso was promoted to Research Scientist III in August 2010. Louie joined CIRA 21 years ago and has been an integral member of the CIRA/RAMMB team since. His expertise is in the areas of numerical forecast modeling, radiative transfer modeling, and satellite imagery. Most of his work is focusing on GOES-R Risk Reduction studies of mesoscale severe weather events.

Thomas Henderson
Tom was promoted to Research Associate IV in August 2010. He has been with CIRA for 3 years and as a lead Senior Software Engineer, he is now responsible for leading the software development of a uniquely new global numerical prediction model referred to as the Flow-following finite volume Icosahedral Model (FIM). Tom leads the efforts to address the reliability, portability, interoperability, efficiency, and performance of the FIM. Tom has also assumed supervisory responsibilities for two new staff members hired to assist him with modeling infrastructure and interoperability activities.

Michael Leon
Michael was promoted to Research Associate IV in February 2011. He has been with CIRA for nearly 8 years, initially with the NASA-sponsored GLOBE international science education program. A year ago, he was competitively selected to fill the position of Technical Lead for the FAA-funded NextGen Neb-Enabled Weather Program. After successfully leading GSD's contributions in a major FAA test and evaluation activity for NNEW, he now has the additional and increased role of senior project management of this high-visibility, cross-agency program.

XingMing Liang
Dr. Liang transitioned into a Research Scientist/Scholar II position in February 2010. Formerly a Postdoctoral Fellow, he is a member of the Sea Surface Temperature (SST) Team at the NESDIS Center for Satellite Application and Research (STAR) in Camp Springs, Maryland. He joined the SST Team in February 2007 as a CIRA Postdoctoral Fellow. XingMing is responsible for implementation and validation of the Community Radiative Transfer Model (CRTM) in the newly developed NESDIS Advanced Clear-Sky Processor for Oceans (ACSPO) system. His most recent accomplishment is the development of the online web-based tool, Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS)

. The MICROS monitors Model (CRTM) minus Observation (AVHRR) biases for three AVHRR IR channels, from five platforms including NOAA-16, -17, -18, -19, and MetOp-A. MICROS proved critically important for a number of applications, including monitoring performance and improvements in ACSPO products, validation of CRTM, and Cal/Val of satellite radiances. XingMing is closely involved with NPOESS Cal/Val and GOES-R SST Development Projects. His supervisor is Steve Miller and his Technical Advisor is Alexander Ignatov.

Chris MacDermaid

Chris was promoted to Senior Research Associate in April 2010. He is the senior project manager and technical lead of the 11-person Data Systems Group within Information & Technology Services at the NOAA Earth System Research Lab Global Systems Division in Boulder. DSG is responsible for developing and configuring the computer systems for acquiring, processing, storing, and distributing approximately 500 GB of conventional and advanced meteorological data per day. Chris also assumed the technical lead role for GSD on the FAA NNEW (NextGen Network Enabled Weather) program to evaluate, identify and develop web-enabled data services to integrate into the FAA's NextGen testbed at the FAA Tech Center in Atlantic City, NJ. Cliff Matsumoto is his supervisor.

Sean Madine

Sean was promoted to Senior Research Associate in April 2010. He is the deputy Program Manager for the Forecast Verification Section at the NOAA ESRL/GSD in Boulder and the Project Lead for Network Enabled Verification Service (NEVS), a key NextGen innovative technology that will form the bridge between weather forecasts and the integration of those forecasts into FAA operations. Sean is also the Project and Scientific Lead for in-depth and complex evaluations of several weather products used in aviation operations such as the National Ceiling and Visibility Analysis, Consolidated Storm Prediction for Aviation, Collaborative Convective Forecast Product/Localized Aviation MOS Product, and the World Area Forecast Center Global Icing Product. His supervisor is Cliff Matsumoto.

Christopher O'Dell

Chris was promoted to Research Scientist/Scholar III in April 2010. He is the PI for the Atmospheric CO_2 Observations from Space (ACOS) project at CSU, and he leads the L2 algorithm team for OCO-2, which is the successor to the ill-fated Orbiting Carbon Observatory that failed to reach orbit in February 2009. The L2 team, with members at CSU, JPL and the University of Leicester, aims to deliver column-averaged concentrations of CO_2 to the international carbon cycle community in order to quantify regional sources and sinks of CO_2. This task is particularly challenging because the accuracy of the CO_2 measurements from space must be better than 0.5%, a stringent requirement rarely obtained in remote sensing measurements. Thus, Chris is leading an enterprise with elements of risk but enormous potential. Denis O'Brien is his supervisor.

Mariusz Pagowski

Mariusz was promoted to Research Scientist/Scholar III in April 2010. He is an integral and key member of the Air Quality group in the GSD Assimilation and Modeling Branch involved in the development of WRF-Chem (Weather Research and Forecasting—Chemistry), a meteorological and chemical data assimilation and modeling system with the purpose of improving forecasts of concentrations of chemical species. Biogenic and anthropogenic emissions, deposition, convective and turbulent chemical transport, photolysis, and advective chemical transport are all treated simultaneously with the meteorology. WRF-Chem model has the capability to simulate the coupling between dynamics, radiation, and chemistry and the implementation of the assimilation cycle for daily air quality forecasts over the continental US is anticipated very soon. His supervisor is Cliff Matsumoto.

Patrick Purcell

Patrick was promoted to Research Associate IV in February 2011. He has been with CIRA in Boulder for 1 1/2 years collaborating with the National Geophysical Data Center in Boulder as the Algorithm Technical Lead and senior system and software engineer for the NPOESS Space Environment Monitor project. With the recent Presidential decision to split the NPOESS program into separate NOAA and DoD programs, he now has the added responsibility to support the DoD Defense Weather Satellite Program as the Project Manager including all aspects of project management while investigating optimum

collaboration with the NASA/NOAA Joint Polar Satellite System under a dual-hatted structure in a more formal development environment.

Jennifer Raab

Jennifer joined CIRA in Boulder in January 2009 as a State Classified Administrative Assistant. Effective in November 2010, her position was reclassified and converted to an Administrative Professional Research Coordinator with increased responsibilities involving additional outreach, budget, and administration tasks. Her supervisor is Cliff Matsumoto.

Donald Reinke

Donald was promoted to Senior Research Associate in February 2011, and he is the Operations Manager to the CloudSat Data Processing Center (DPC) at CIRA in Fort Collins—a program that has been ongoing for the past decade and which has recently grown in its scope (additional processing requirements) and size (additional staffing). Don serves as lead to all DPC operations from ingest of raw data, to processing these data into science products, to making the results accessible to the science community. Running the DPC, which serves in a 24/7 capacity, is a non-trivial task that involves a sophisticated infrastructure and a carefully engineered sequence of ingest, processing, and distribution. NASA makes tremendous investments (tens of millions) in data processing for support of various satellite missions. Compared to these other missions, NASA realizes an order of magnitude savings on its CloudSat mission run through the DPC. The scope of the DPC and the role of the Operations Manager in particular, are anticipated to grow over the coming years as CIRA pursues many new opportunities both with NASA and other agencies. These additional activities will add several layers of complexity to the DPC and an expanded role for Don in juggling these responsibilities.

Sher Schranz

Sher was promoted to Senior Research Associate in April 2010. She is a senior program manager leading a number of research projects at the NOAA ESRL/GSD in Boulder. She leads a team of researchers and software developers in the design, development, testing, deployment, and operational support for the NWS- and BLM-sponsored FX-Net, Gridded GX-Net, and Fire Weather projects. Sher recently began acting as the Deputy Program Manager for the ESRL NWS NextGen and NNEW programs and is responsible for developing the research program proposals, budgets, project management and research plans for the program components such as IT, NWP models, verification and guidance algorithms, and forecast analysis research and development. Cliff Matsumoto is her supervisor

Jeffrey Smith

Jeff was promoted to Research Associate IV in February 2011. He has been with CIRA for 6 years as the resident expert on web portal development at the ESRL Global Systems Division. He was recently designated as the Project Manager for the NextGen NNEW portal development program. In addition to his technical lead responsibilities, he will now be responsible for all aspects of managing the project with internal and external modeling groups.

Kenneth Sperow

Ken was promoted to Research Associate IV in August 2010. He has been with CIRA for 3 years and with the success of implementing the NCAR Autonowcaster prototype at the Dallas-Fort Worth weather forecast office that he led for the past 3 years, the research partnership between CIRA and NWS/MDL has been expanded to a new 4-year funded proposal. Ken provides project leadership and expertise in a wide range of technical areas including configuration management, hardware and software configuration and tuning, software design and development, and application of new technologies and languages aligned with other NWS projects.

Jebb Stewart

Jebb was promoted to Research Associate IV in August 2010. As a hybrid developer, he is an essential team member, technical lead and system architect for a number of weather forecasting and atmospheric data services projects. Jebb's scientific background has enhanced the development of critical systems used by NWS Incident Meteorologists when they travel to fires in support of fire fighting operations, post-disaster emergency response support and special venues, like the Olympics. He is the ESRL architect

and lead developer for the NextGen 4D Weather Cube which will serve the FAA's new generation flight systems with targeted weather information, and will be a key component of the enhanced NWS Weather Forecast Office of the future. Jebb interfaces with researchers and operations meteorologists and systems developers from the NOAA, US Forest Service, the BLM, EPA and the private sector to maintain a cutting edge approach to the design and implementation of these critical systems.

Jennifer Valdez
Jennifer was promoted to Research Associate III in February 2011.   She has worked since 2007 for CIRA in Boulder as the Earth System Research Laboratory Global Systems Division (ESRL/GSD) Web Master. In this role, Jennifer is involved with many of GSD's projects including NOAA's R&D High-Performance Computing System, the Integrated Hazard Information Service, the Real-time Verification System, and the Weather In-Situ Deployment Optimization Method project. Jennifer also serves in a leadership role in GSD's Work Place Advisory Committee and has recently mentored a student intern from the Hispanic Association of Colleges and Universities.

Milija Zupanski
Dr. Zupanski was promoted to Senior Research Scientist in August 2010. He leads CIRA's Data Assimilation Team and works on theoretical and practical development of data assimilation methodologies, with an emphasis on assimilation of satellite sensors and other nonlinear observations into various meteorological models. This also includes development of new methods and algorithms that serve as an improvement to data assimilation.   Dr. Zupanski has also assumed the role of lead liaison to the emerging wind energy industry

Colorado State University Service Milestone Awards

Steven Albers - 20 years
Michael Biere - 10 years
Robert Cifelli - 10 years
Bernadette Connell - 15 years
Robert DeMaria - 10 years
Hiroyuki Gosden - 15 years
Lewis Grasso - 20 years
Hongli Jiang - 15 years
Robert Lipschutz - 15 years
Glen Liston - 15 years
Jacques Middlecoff - 10 years
James Ramer - 20 years
Sherri Schranz - 10 years
Tracy Smith - 20 years
Julie Winchester - 20 years

CIRA EMPLOYEE MATRIX

Employees who received 50% support or more		Degree			
Category	Number	Doctorate	Masters	Bachelors	Non-Degreed
Research Scientists	16	16	0	0	0
Visiting Scientists	0	0	0	0	0
Postdoctoral Fellows	5	5	0	0	0
Research Support Staff*	62	5	24	27	6
Administrative Personnel	5	1	2	2	0
Total	88	27	26	29	6

Employees who received less than 50% support		Degree				
	Number	Doctorate	Masters	Bachelors	Associates	Non-Degreed
	54	18	13	13	1	9

Supported Students		Degree		
Category	Number	Doctorate	Masters	Bachelors
Undergraduate	4	0	0	4
Graduate	11	0	11	0
Total	15	0	11	4

Employees located at NOAA Laboratories		GSD	MDL	PSD	GMD
Total	51	46	2	2	1

Obtained NOAA Employment within the last year	
Total	0

*Equivalent to Research Associate in CIRA/CSU parlance

PUBLICATIONS & PRESENTATIONS

PUBLICATIONS

CIRA Activities and Participation in GIMPAP

Goni, G.J., J.A. Knaff, and I-I Lin, 2010: TC heat potential (TCHP). Bull. Amer. Meteor. Soc., 91:6, S99-S100.

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Environmental Applications Research

Benjamin, S. G., B. D. Jamison, W. Moninger, S. Sahm, B. E. Schwartz, and T. W. Schlatter, 2010: Relative short-range forecast impact from aircraft, profiler, radiosonde, VAD, GPS-PW, METAR and mesonet observations within hourly assimilation in the RUC. *Mon. Wea. Rev.,* 138, 1319-1343.

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NWS OSIP, Gate Three, stage one; CONOPS ORD https://osip.nws.noaa.gov/osip OSIP ID: 09-015

NWS OSIP, Gate Two, Requirements, https://osip.nws.noaa.gov/osip,

OSIP ID: 08-012

Pagowski, M., G.A. Grell, S.A. McKeen, S.E. Peckham, and D. Devenyi, 2010: Three-dimensional variational data assimilation of ozone and fine particulate matter observations. Some results using the Weather Research and Forecasting – Chemistry model and Gridpoint Statistical Interpolation. *QJRM*, 136, pp 2013-2024.

Saide, P.E., G.R. Carmichael, S.N. Spak, L. Gallardo, A.E. Osses, M.A.Mena-Carrasco, and M. Pagowski, 2011: Forecasting urban PM10 and PM2.5 pollution episodes in very stable nocturnal conditions and complex terrain using WRF-Chem CO tracer model. *Atmos. Environ*., in press.

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Bauer, P., T. Auligne, W.Bell, A. Geer, V. Guidard, S. Heilliette, M. Kazumori, M.-J. Kim, E. Liu, A. P. McNally, B. Macpherson, R. Renshaw, and L. Riishojgaard 2011: Status of satellite cloud and precipitation assimilation at operational NWP centres, *Quar. Jou. Roy. Meteor. Soc.* (Submitted)

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Saha, Suranjana, , Shrinivas Moorthi , Hua-Lu Pan, Xingren Wu, Jiande Wang, Sudhir Nadiga, Patri ck Tripp , Robert Kistler, John Woollen, David Behringer, Haixia Liu, Diane Stokes, Robert Grumbine, George Gayno, Jun Wang, Yu-Tai Hou, Hui-ya Chuang, Hann-Ming H. Juang, Joe Sela, Mark Iredell , Russ Treadon, Daryl Kleist, Paul Van Delst, Dennis Keyser, John Derber, Michael Ek, Jesse Meng, Helin Wei, Rongqian Yang, Stephen Lord, Huug van den Dool, Arun Kumar, Wanqiu Wang, Craig Long, Muthuvel Chelliah, Yan Xue, Boyin Huang, Jae-Kyung Schemm , Wesley Ebisuzaki, Roger Lin, Pingping Xie, Mingyue Chen, Shuntai Zhou, Wayne Higgins, Cheng-Zhi Zou, Quanhua Liu, **Yong Chen**, Yong Han, Lidia Cucurull , Richard W. Reynolds, Glenn Rutledge, and Mitch Goldberg,. The NCEP Climate Forecast System Reanalysis. *Bull. Amer. Meteor. Soc.*, **91**, 1015–1057. doi: 10.1175/2010BAMS3001.1 (2010).

Shi W., M. Wang, X. Li and W. Pichel, Ocean Sand Ridge Signatures in the Bohai Sea Observed by Satellite Ocean Color and Synthetic Aperture Radar Measurements, *Remote Sens. Environ.,* in press.

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Wang, M., W. Shi, and J. Tang, Water property monitoring and assessment for China's inland Lake Taihufrom MODIS-Aqua measurements, *Remote Sens. Environ.*, 115, 841-845, 2011.

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Setvak, M., D.T. Lindsey, R.M. Rabin, P.K. Wang, and A. Demeterova, 2010: Possible moisture plume above a deep convective storm on 28 June 2005 in MSG-1 imagery. *Wea. Rev*.

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Schumacher, Russ S., Daniel T. Lindsey, Andrea B. Schumacher, Jeff Braun, Steven D. Miller, Julie L. Demuth, 2010: Multidisciplinary Analysis of an Unusual Tornado: Meteorology, Climatology, and the Communication and Interpretation of Warnings. *Weather and Forecasting*, 25, 1412–1429.

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PRESENTATIONS

A Goes-R Proving Ground

Connell, B.H., D. Bikos, J. Braun, A. S. Bachmeier, S. S. Lindstrom, A. Mostek, M. DeMaria, and T. J. Schmit, 2011: Training for GOES-R directed towards forecasters. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*, 23-27 January, Seattle, WA.

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Grasso, L.D., R. Brummer, R. DeMaria, D. Lindsey, and D. Hillger, 2010: GOES-R Activities at CIRA. *14th Great Divide Weather Workshop*, 2-4 November, Billings, MT

Gurka, J.J., S.J. Goodman, T.J. Schmit, A. Mostek, S.D. Miller, A.S. Bachmeier, M. DeMaria, and B. Reed, 2011: GOES-R proving ground: plans for 2011 and beyond.*AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

Gurka, J.J., S.J. Goodman, T.J. Schmit, C. Siewart, J.L. Bevin and M. DeMaria, 2010: GOES-R proving ground plans for the 2010 hurricane season at the National Hurricane Center (NHC) and the Storm Prediction Center (SPC) spring experiment. *17th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis MD

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Lindsey, D.T., L.D. Grasso, D. Bikos, J. Sieglaff, J. Otkin, R. Rabin, J. Kain, 2010: Simulating GOES-R Satellite Imagery from WRF Output. *25th AMS Conference on Severe Local Storms*. October 11-15, Denver, CO

Lindsey, D.T., 2010: "Simulating satellite imagery from high-resolution WRF output: A method for cloud verification? Invited talk at a model verification workshop, 3 November, NCAR, Boulder, CO.

Miller, S., 2010: Proving Ground Activities and Plans at CIRA. *Proving Ground Annual Meeting UCAR/COMET,* 18-19 May 2010, Boulder, CO

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Szoke, E.J., R.L. Brummer, H. Gosden, S.D. Miller, M. DeMaria, and D.A. Molenar, 2011: An overview of CIRA's contribution to the GOES-R Proving Ground. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

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Knaff J. A., and M. DeMaria, 2010: Rapid Weakening of Non-Landfalling Atlantic Tropical Cyclones. Interdepartmental Hurricane Conference, Savannah, GA, 1– 4 March

Knaff, J.A., and B.A. Harper, 2010: Tropical cyclone surface wind structure and wind-pressure relationships. Keynote #3, WMO International Workshop on Tropical Cyclones – VII, La Reunion, France, 15-20 November

Connell, B., 2010: A fifteen year perspective on national and international training directed towards forecasters. AMS 17th Conference on Satellite Meteorology and Oceanography in Annapolis, MD, 27-30 September 2010.

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Ware, R., D. Cimini, G. Guiliani, E. Campos, J. Oreamuno, K.P. Joe, S. Cober, S. Albers, S. Koch, and E. Westwater, 2010: Thermodynamic Profiling at the Alpine Venue of the 2010 Winter Olympics. *Proc. Technical Conference on Meteorological and Environmental Instruments and Methods of Observation,* Helsinki, Finland, World Meteorological Organization.

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Connell, B.H., D. Bikos, J. Braun, A. S. Bachmeier, S. S. Lindstrom, A. Mostek, M. DeMaria, and T. J. Schmit, 2011: Training for GOES-R directed towards forecasters. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*, 23-27 January, Seattle, WA.

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Improvements in the Rapid Intensity

DeMaria, M., J.A. Knaff, R. DeMaria, J. Kaplan, and N. Demetriades, 2010: Application of Lightning Measurements to Tropical Cyclone Rapid Intensity Change Forecasting. 1*7th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis, MD

DeMaria, M., J.A Knaff, M J. Brennan, J.L. Beven, R T. DeMaria, A B. Schumacher, J. Kaplan, and N.W.S. Demetriades, 2011: Tropical cyclone rapid intensity change forecasting using lightning data during the 2010 GOES-R Proving Ground at the National Hurricane Center. *AMS Fifth Conference on the Meteorological Applications of Lightning Data*, 23-27 January, Seattle, WA.

Kaplan, J, J. J. Cione, M. DeMaria, J.A. Knaff, J. Dunion, J.F. Dostalek, J. E. Solbrig, J. Hawkins, T. F. Lee, J. Zhang, E. Kalina, and P. Leighton, 2010: Enhancements to the operational SHIPS rapid intensification index. *29th AMS Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

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Velden, C.S., C. Rozoff, A. Wimmers, M. Sitkowski, M. E. Kieper, J. Kossin, J. Hawkins, and J.A. Knaff 2010: An objective method to predict near real time rapid intensification of tropical cyclones using satellite passive microwave observations. *29th AMS Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

In Support of NOAA's Commitment – Virtual Lab

Connell, B. and Veeck, L. 2011 "New Forecaster Training Paradigm for GOES-R?" 91st Annual Meeting of the American Meteorological Society. Seattle, WA, USA. 23-27 January (Poster presented by B. Connell)

Veeck, L., 2010 "The Virtual Laboratory for Education and Training"   The Intergovernmental Oceanographic Commission (IOC) of UNESCO conference (IOC50) "50 Years of Education and Awareness Raising for Shaping the Future of the Oceans and Coasts", St Petersburg, Russia. 27-30 April.

Veeck, L., 2010 "Social networking for education and training" and "Mobile Learning" WMO Regional Training Seminar for National Instructors, Sibiu, Romania. 22-30 May.

Veeck, L., 2010 Topic "Evaluation" Meeting of the "Pedagogical Assistance to Trainers" working group (PATT WG), Vienna, Austria. 13-15 June

Veeck, L., 2010 Facilitator for "Fifth Meeting of the Virtual Laboratory Management Group" and also organized and led specific working groups on "VLab Websites" and "Training calendar, reporting template, assessment sheet", Beijing, China, 12-14 July

Veeck, L. 2010 Facilitator for Hands on Sessions "Using the VLab Moodle site" and "Using COMET's ESRC" Seminar on Training Matters, Beijing, China, 15-16 July

Veeck, L. 2010 "Virtual Laboratory for Education and Training in Satellite Meteorology" 2010 EUMETSAT Meteorological Satellite Conference, Córdoba, Spain, 20-24 September. (Poster was designed by Luciane and was presented by Jose Prieto (EUMETSAT))

Jordaan, W., Caesar, K., and Veeck, L. 2010 "The future of Distance Learning in an Operational Setting" 11th WMP Symposium on Education and Training (SYMET XI) Citeko, Indonesia, 25-29 October (presentation by W. Jordaan)

Deslandes, R., W. Jordaan, E. Podgayskiy, and L. Veeck, 2010 " Ten years of VLab - Challenges ahead of the VLab model of Education and Training" 11th WMP Symposium on Education and Training (SYMET XI) Citeko, Indonesia, 25-29 October (poster presented by E. Podgayski)

Veeck, L., 2010 "Trainer Competencies" Participation in the EUMETCAL Workshop and a meeting of the Pedagogical Assistance to Trainers working group (PATT WG). Geneva, Switzerland, 29 November – 2 December

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Ciesielski, P. E., R. H., Johnson, and S. Williams, 2011: Field campaign atmospheric sounding legacy datasets. Preprints, 27th Conference on Interactive Information Processing Systems. AMS Annual Meeting, Seattle, WA.

NESDIS Research Scientist and Post Doc Program

Dash, P. and A. Ignatov (2010). The SST Quality Monitor (SQUAM): an overview. Group for High Resolution SST(GHRSST) Joint DV-WG, HL-TAG & ST-VAL workshop, 28 Feb – 02 Mar, 2011, Boulder, CO, Presentation: http://www.star.nesdis.noaa.gov/sod/sst/squam/documents/2011_03_03_GHRSST_DVTAG_STVAL_HLTAG_SQUAM.ppt

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Michiko M.,J. S. Woollen, T. Zhu, N. Prive, Y. Xie, T. J. Kleespies, Z. Ma, H. Sun, L. P. Riishojgaard, F. Weng, G. P. Lou, R. L. Vogel, Y. Han, D. Stokes, and K. L. Howard, 2011: Simulation of observation and Calibration for Joint OSSEs at NOAA. 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), 91st AMS, Seattle, WA.

Qin Z., X. Zou, F. Weng and T. Zhu, 2011: A Case Study Assessing the Impact of GOES Imager Data Assimilation on Precipitation Forecast. *The 7th Annual Symposium on Future Operational Environmental Satellite Systems, 91st AMS, Seattle, WA*.

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Connell, B., 2010: A fifteen year perspective on national and international training directed towards forecasters. AMS 17th Conference on Satellite Meteorology and Oceanography in Annapolis, MD, 27-30 September 2010. Note: the above presentation was given during the Session on Training and Education for Current, New, and Future Satellite Observing Systems. http://ams.confex.com/ams/17Air17Sat9Coas/techprogram/paper_174785.htm

Connell, B. and L. Veeck, 2010: New forecaster training paradigm for GOES-R? AMS 91st Annual Meeting, 23-27 January 2011 in Seattle, WA. http://ams.confex.com/ams/91Annual/webprogram/Paper187224.html

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DeMaria, M., J.A Knaff, M J. Brennan, J.L. Beven, R T. DeMaria, A B. Schumacher, J. Kaplan, and N.W.S. Demetriades, 2011: Tropical cyclone rapid intensity change forecasting using lightning data during the 2010 GOES-R Proving Ground at the National Hurricane Center. *AMS Fifth Conference on the Meteorological Applications of Lightning Data*, 23-27 January, Seattle, WA.

DeMaria, M., J.A. Knaff, R. DeMaria, J. Kaplan, and N. Demetriades, 2010: Application of Lightning Measurements to Tropical Cyclone Rapid Intensity Change Forecasting. 1*7th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis, MD

Grasso, L.D., D.T. Lindsey, W. MacKenzie, 2010: Detecting Boundary Layer Moisture Convergence with GOES-R ABI Bands. *25th AMS Conference on Severe Local Storms,* October 11-15, Denver, CO

Grasso, L.D., R. Brummer, R. DeMaria, D. Lindsey, and D. Hillger, 2010: GOES-R Activities at CIRA . Oral presentation by L. Grasso at *14th Great Divide Weather Workshop*, 2-4 November, Billings, MT

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Guch, I., and M**.** DeMaria, 2010: GOES-R Risk Reduction Program. *17th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis MD

Gurka, J.J., S.J. Goodman, T.J. Schmit, C. Siewart, J.L. Bevin and M. DeMaria, 2010: GOES-R proving ground plans for the 2010 hurricane season at the National Hurricane Center (NHC) and the Storm Prediction Center (SPC) spring experiment. *17th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis MD

Gurka J., M. DeMaria, S. Goodman, and T. Schmit 2010: Preparing for Improved Monitoring of Tropical Cyclones in the GOES-R Proving Ground. *Interdepartmental Hurricane Conference*, 1 -4 March 2010, Savannah, Ga.

Gurka, J.J., S.J. Goodman, T.J. Schmit, A. Mostek, S.D. Miller, A.S. Bachmeier, M. DeMaria, and B. Reed, 2011: GOES-R proving ground: plans for 2011 and beyond.*AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

Jankov, I., L.D. Grasso**,** M. Sengupta, P.J. Neiman, D. Zupanski, M. Zupanski, D.T. Lindsey, D.W. Hillge**r**, D.L. Birkenheuer, R.L. Brumme**r** and H. Yuan, 2010: An evaluation of five WRF-ARW microphysics schemes using synthetic GOES imagery for an atmospheric river event affecting the California coast, *17th AMS Conference on Satellite Meteorology and Oceanography*, September 27-October 1, Annapolis MD

Knaff, J., M. DeMaria, J. Kaplan, J. Dunion**,** R. DeMaria, 2010: Assessing the impact of total Precipitable water and lightning on SHIPS forecasts. *29th Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

Knaff, J. A., M. DeMaria, J. Kaplan, C. M. Rozoff, J. Kossin, and C. S. Velden: Improvements to statistical intensity forecasts. Interdepartmental Hurricane Conference, Miami, FL, 28 February – 3 March.

Knaff J. A., and M. DeMaria, 2010: Rapid Weakening of Non-Landfalling Atlantic Tropical Cyclones. Interdepartmental Hurricane Conference, Savannah, GA, 1– 4 March

Knaff, J.A., and B.A. Harper, 2010: Tropical cyclone surface wind structure and wind-pressure relationships. Keynote #3, WMO International Workshop on Tropical Cyclones – VII, La Reunion, France, 15-20 November

Knaff J.A., and B. Harper, 2010: TC Surface Wind Structure & the Related Pressure-Wind Relationships, Keynote Topic 1, *WMO International Workshop on Tropical Cyclones*. 15 November 2010, St. Giles, La Reunion, France.

Lindsey, D.T., L.D. Grasso, D. Bikos, J. Sieglaff, J. Otkin, R. Rabin, J. Kain, 2010: Simulating GOES-R Satellite Imagery from WRF Output. *25th AMS Conference on Severe Local Storms*. October 11-15, Denver, CO,

Reed, B., C. W. Siewert, R. S. Schneider, G. L. Hufford, B. Entwhistle**,** M. DeMaria, **D**. Reynolds, and M.J. Brennan, 2011: GOES-R Proving Ground—Demonstrating GOES-R products in 2010. *AMS 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction*, 23-27 January, Seattle, WA.

Schumacher A.S, M. DeMaria, J. Knaff, and D. Brown, 2010: The NESDIS Tropical Cyclone Formation Probability Product: An Overview of Past Performance and Future Plans. *Interdepartmental Hurricane Conference*, 1 -4 March 2010, Savannah, Ga.

Szoke, E.J., R.L. Brummer, H. Gosden, S.D. Miller, M. DeMaria, and D.A. Molenar, 2011: An overview of CIRA's contribution to the GOES-R Proving Ground. *AMS Seventh Annual Symposium on Future Operational Environmental Satellite Systems*. 23-27 January, Seattle, WA.

<u>The Role of the Colorado Climate Center in a Meaningful Drought Early Warning System</u>

Doesken, N. February 24, 2011   Collaborative Drought Monitoring in the Upper Colorado River Basin presented to the NIDIS UCRB Pilot Update meeting -- NOAA- ESRL

Smith, B.   August 4, 2010 - Colorado Climate Center and NIDIS Upper Colorado River Basin Pilot, , oral presentation to the NWS/NIDIS Workshop in Park City, UT

Smith, B., N. Doesken and W. Ryan.   July, 12, 2010 - NIDIS and the Upper Colorado River Basin Pilot: Current Monitoring Efforts and Future Research,   American Association of State Climatologists Annual Meeting, South Lake Tahoe, CA

Smith, B., W. Ryan and N. Doesken.   August 19, 2010 - Overview of the NIDIS Weekly Climate, Water and Drought Assessment.   Drought Portal Meeting at NOAA in Boulder, CO

Tropical Cyclone Model Diagnostics

DeMaria, M., 2010: Tropical cyclone intensity change predictability estimates using a statistical-dynamical model. *29th AMS Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

Jin, Y. and L. Grasso, 2010: Application of synthetic GOES imagery to the Hurricane Forecast Improvement Project. *29th AMS Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

McNoldy, B. D., M. DeMaria, V. Tallapragada, and T. Marchok, 2010: HWRF performance diagnostics from the 2009 Atlantic hurricane season. Preprints, 29th Conf. on Hurricanes and Tropical Meteorology, Tucson, AZ, Amer. Met. Soc.

Schubert, W., , M. DeMaria, B. Sampson, J. Cummings, J. Knaff, B. McNoldy, and K. Musgrave, 2011: Improving Tropical Cyclone Intensity Forecasting with Theoretically-Based Statistical Models, NOPP Review, Feb 25, Miami, FL.

PUBLICATIONS MATRIX

		Institute Lead Author						NOAA Lead Author						Other Lead Author					
		2005	2006	2007-08	2008-09	2009-10	2010-11	2005	2006	2007-08	2008-09	2009-10	2010-11	2005	2006	2007-08	2008-09	2009-10	2010-11
Peer-Reviewed		70	42	46	37	24	24	14	30	26	21	17	16	25	71	80	35	31	20
Non Peer-Reviewed		128	40	6	58	6	45	52	91	2	34	0	33	46	64	5	49	5	20

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Angevine, W. M.	Jiang, H.//Mauritsen, T.	2010	Performance of an eddy diffusivity-mass flux scheme for shallow cumulus boundary layers	Monthly Weather Review (In Press)	Journal Article		NA090AR4320074		X		X	
Auligne, T.	Lorenc, A.//Michel, Y.//Montmerie, T.//Hu, M.	2010	Summary of the First International Cloud Analysis Workshop, submitted	Bulletin of the American Meterological Society	Journal Article		NA090AR4320074			X	X	
Barth, M. F.	Benjamin, L. A.//Collander, R. S.//Miller, P. A.//Kent, T. B.//Padmanabhan, G.	2011	A 2011 update to the NOAA MADIS	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074			X		X
Bauer, P.	Auligne, T.//Bell, W.//Geer, A.//Guidard, V.//Heilliette, S.//Kazumori, M.//Kim, M. -J.//Liu, E.//McNally, A. P.//Macpherson, B.//Renshaw, R.//Riishojgaard, L.	2011	Status of satellite cloud and precipitation assimilation at operational NWP centres	(submitted) Quar. Jou. Roy. Meteor. Soc.	Journal Article		NA090AR4320074			X	X	
Benjamin, S. G.	Jamison, B. D.//Moninger, W. R.//Sahm, S. R.//Schwartz, B. E.//Schlatter, T. W.	2010	Relative short-range forecase impact from aircraft, profiler, radiosonde, VAD, GPS-PW, METAR and mesonet observations within hourly assimilation in the RUC	Mon. Wea. Rev.	Journal Article		NA090AR4320074		X		X	
Braun, J. J.		2010	Volcanoes, volcanic ash, training and other stuff	2010 NWS Alaska Aviation and Volcanic Ash Workshop, September 20-23, 2010, Anchorage, AK	Report		NA090AR4320074	X				X
Carrio, G. G.	Cotton, W. R.	2010	Study of the feasibility of the mitigation of the intensity of tropical cyclones by CCN seeding in the outer rainband region: A HAMP Project	29th Conference on Hurricanes and Tropical Meteorology, May 10-14, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074			X		X
Carrio, G. G.	Cotton, W. R.	2010	Virtual flights modifying simulated hurricanes	Annual Meeting of the Weather Modification Association, April 21-23, 2010, Santa Fe, NM	Conference Proceedings		NA090AR4320074			X		X
Carrio, G. G.	Cotton, W. R.	2010	Effects of the Urban growth of Houston on convection and precipitation. Part II: Their dependence on instability	(In Process of Submission) Atmospheric Research	Journal Article		NA090AR4320074			X	X	
Carrio, G. G.	Cotton, W. R.//Cheng, W. Y.	2010	Effects of the Urban growth of Houston on convection and precipitation: Part I: The August 2000 case	Atmospheric Research (In Press)	Journal Article	doi:10.1016/j.atmosres.2010.01.005	NA090AR4320074			X	X	
Chand, D.	Hegg, D. A.//Wood, R.//Shaw, G. E.//Wallace, D.//Covert, D.S.	2010	Source attribution of climatically important aerosol properties measured at Paposo (Chile) during VOCALS	Journal of Atmospheric Chemistry and Physics	Journal Article		NA090AR4320074	X			X	
Chand, D.	McClure, S. E.//Schichtel, B. A.//Huddleson, J.M.//Malm, W. C.//Wood, R.//Moore, C.T.	2010	Transpacific transport of Eastern Asian aerosols based on the climatology of MODIS observations		Journal Article		NA090AR4320074	X			X	
Chen, Y.	Han, Y.//Liu, Q.//van Delst, P.//Weng, F.	2010	A Fast Radiative Transfer Model for Stratospheric Sounding Unit Channels	(submitted) Journal of Geophysical Research - Atmosphere	Journal Article		NA090AR4320074	X			X	
Chen, Y.	Han, Y.//Liu, Q.//van Delst, P.//Weng, F.	2010	Community radiative transfer model for stratospheric sounding unit channels	(accepted) J. Atmos. Oceanic. Technol.	Journal Article		NA090AR4320074	X			X	
Chen, Y.	Han, Y.//van Delst, P.//Weng, F.	2010	On water vapor Jacobian in fast radiative transfer model	J. Geophys. Res.	Journal Article	doi:10.1029/2009JD013379	NA090AR4320074	X			X	
Ciesielski, P. E.	Johnson, R. H.//Williams, S. M.	2011	Field campaign atmospheric sounding legacy datasets	AMS 27th Conference on Interactive Information Processing Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074			X		X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Cifelli, R. C.	Chandrasekar, V.//Lim, S.//Kennedy, P. C.//Wang, Y. P.//Rutledge, S. A.	2010	A new dual-polarization radar rainfall algorithm: Application in Colorado precipitation events	(in press) J. Atmos. Oceanic. Technol.	Journal Article		NA090AR4320074	X			X	
Cimini, D.	Ware, R. H.//Giuliani, G.//Oreamuno, J.//Campos, E.//Albers, S. C.//Joe, P.//Koch, S. E.//Cober, S.G.	2010	Boundary layer thermodynamic profiling using ground-based microwave radiometry and 1DVAR for Nowcasting	International Symposium on Advancements in Boundary Layer Remote Sensing (ISARS), June 28-30, 2011, Paris, France	Conference Proceedings		NA090AR4320074			X		X
Connell, B. H.	Bikos, D. E.//Braun, J. J.//Bachmeier, A. S.//Lindstrom, S.//Mostek, A. J.//DeMaria, M.//Schmit, T. J.	2011	Training for GOES-R directed towards forecasters	AMS 7th Annual Symposium on Future Operational Environmental Satellite Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Connell, B. H.	Veeck, L.	2011	New forecaster training paradigm for GOES-R	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Connell, B. H.		2010	A fifteen year perspective on national and international training directed towards forecasters	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-30, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074	X				X
Connell, B. H.		2010	CIRA/RAMMB GOES-R Proving Ground Activities and NEW VISIT and SHYMET training	NWS Eastern Region Satellite Virtual Workshop, November 9, 2010, Charleston, SC	Report		NA090AR4320074	X				X
Connell, B. H.		2010	GOES satellite: Scans, calibration and scaling (deriving temperatures), image features, products, channel combinations	Presentation to Remote Sensing Class at Metropolitan State College, November 30, 2010, Denver, CO	Report		NA090AR4320074	X				X
Conte, D.	Moscatello, A.//Albers, S. C.//Levizzani, V.//Miglietta, M. M.	2010	A GIS approach to ingest Meteosat Second Generation data into the Local Analysis and Prediction System	Environmental Modelling & Software	Journal Article		NA090AR4320074			X	X	
Dash, P.	Et, al.	2010	The SST Quality Monitor (SQUAM)	MyOcean SST Validation & STVAL European Intermediate Meeting, January 20-21, 2010, Lannion, France	Conference Proceedings		NA090AR4320074	X				X
Dash, P.	Ignatov, A.//Kihai, Y.//Sapper, J.	2010	Recent improvements to the NESDIS SST Quality Monitor (SQUAM)	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-October 1, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074	X				X
Dash, P.	Ignatov, A.//Kihai, Y.//Sapper, J.	2010	The SST Quality Monitor (SQUAM)	J. Atmos. & Ocean. Tech.	Journal Article		NA090AR4320074	X			X	
Dash, P.	Ignatov, A.	2011	The SST Quality Monitor (SQUAM): An overview	Group for High Resolution SST (GHRSST) Joint DV-WG, HL-TAG & ST-VAL Workshop, February 28-March 2, 2011, Boulder, CO	Report		NA090AR4320074	X				X
DeMaria, M.	Knaff, J. A.//Brennan, M. J.//Beven, J.//DeMaria, R. T.//Schumacher, A. B.//Kaplan, J.//Demetriades, N.	2011	Tropical cyclone rapid intensity change forecasting using lightning data during the 2010 GOES-R proving ground at the National Hurricane Center	AMS 5th Conference on the Meteorological Applications of Lightning Data, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
DeMaria, M.		2010	Tropical cyclone intensity change predictability estimates using a statistical-dynamical model	AMS 29th Conference on Hurricanes and Tropical Meteorology, May 8-12, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074		X			X
DeMaria, M.	Knaff, J. A.//DeMaria, R. T.//Kaplan, J.//Demetriades, N.	2010	Application of lightning measurements to tropical cyclone rapid intensity change forecasting	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-October 1, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074		X			X
DeMaria, M.	Hogsett, W.	2010	Applications Development and Diagnostics Team	HFIP Annual Review Meeting, November 9-10, 2010, Miami, FL	Report		NA090AR4320074	X				X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Denig, W.F.	Purcell, P. B.//Reimer, C.D.	2011	Space weather from the SEM-N sensor suite for operational use	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Deslandes, R.	Jordaan, W.//Podgayskiy, E.//Veeck, L.	2010	Ten years of VLab: Challenges ahead of the VLab model of education and training	The Eleventh WMO Symposium on Education and Training - SYMET-XI, October 25-29, 2010, Citeko, Indonesia	Conference Proceedings		NA090AR4320074			X		X
Djlalova, I.	Wilczak, J. M.//McKeen, S. A.//Grell, G. A.//Peckham, S. E.//Pagowski, M.//Delle Monache, L.//McQueen, J.//Lee, P.//Tang, Y.//McHenry, J. N.//Gong, W. M.//Bouchet, V.//Mathur, R.	2010	Ensemble and bias-correction techniques for air-quality model forecasts of surface O3 and PM2.5 during the TEXAQS-II Experiment of 2006	Atmospheric Environment	Journal Article	doi:10.1016/j.atmosen .2009.11.007	NA090AR4320074			X	X	
Doesken, N.	Reges, H.	2010	The value of the citizen weather observer	Weatherwise	Journal Article		NA090AR4320074			X	X	
Doesken, N.		2011	Collaborative drought monitoring in the upper Colorado River basin	NIDIS UCRB Pilot Update Meeting, February 24, 2011, Boulder, CO	Report		NA090AR4320074			X		X
Edwards, G. J.	Fluke, J.//Lawrence, B.	2011	AWIPS II extended task: Data delivery paradigm	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Edwards, G. J.	Barth, M. F.//Miller, P. A.//Helms, D.	2010	MADIS web services in support of NextGen	AMS 14th Conference on Aviation, Range and Aerospace Meteorology, January 17-21, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074	X				X
Ferraro, R. R.	Kusselson, S. J.//Kidder, S. Q.//Zhao, L.//Meng, H.	2010	Application of AMSU-based products to support NOAA's mission goals	National Weather Digest	Journal Article		NA090AR4320074		X		X	
Finch, J.	Bikos, D. E.	2010	A long-lived tornadic supercell over Colorado and Wyoming, 22 May 2008	Electronic J. Severe Storms Meteor.	Journal Article		NA090AR4320074		X		X	
Finch, Z. O.	Johnson, R. H.	2010	Observational analysis of an upper-level inverted trough during the 2004 North American Monsoon Experiment	Monthly Weather Review (Early Online Release)	Journal Article		NA090AR4320074		X		X	
Fromm, M.	Lindsey, D. T.//Servranckx, R.//Yue, G.//Trickl, T.//Sica, R.//Doucet, P.//Godin-Beekmann, S.	2010	The untold story of pyrocumulonimbus	Bull. Amer. Meteor. Soc.	Journal Article	doi: 10.1175/2010BAMS3004.1	NA090AR4320074			X	X	
Goni, G. J.	Knaff, J. A.//Lin, I-I	2010	TC heat potential (TCHP)	Bull. Amer. Meteor. Soc.	Journal Article		NA090AR4320074		X		X	
Grasso, L. D.	Lindsey, D. T.//MacKenzie, W.	2010	Detecting boundary layer moisture convergence with GOES-R ABI bands	AMS 25th Conference on Severe Local Storms, October 11-15, 2010, Denver, CO	Conference Proceedings		NA090AR4320074	X				X
Grasso, L. D.	Lindsey, D. T.	2010	An example of the use of synthetic 3.9 Âµm GOES-12 imagery for two-moment microphysical evaluation	(in press) International Journal of Remote Sensing	Journal Article		NA090AR4320074	X			X	
Grasso, L. D.	Sengupta, M.//DeMaria, M.	2010	Comparison between observed and synthetic 6.5 and 10.7 Âµm GOES-12 imagery of thunderstorms	International Journal of Remote Sensing	Journal Article	DOI: 10.1080/01431160902894483	NA090AR4320074	X			X	
Grasso, L. D.	Brummer, R. L.//DeMaria, R. T.//Lindsey, D. T.//Hillger, D. W.	2010	GOES-R activities at CIRA	14th Great Divide Weather Workshop, November 2-4, 2010, Billings, MT	Report		NA090AR4320074	X				X
Grasso, L. D.	Feltz, J. M.	2010	GOES-R Activities at CIMSS	14th Great Divide Weather Workshop, November 2-4, 2010, Billings, MT	Report		NA090AR4320074	X				X
Guch, I. C.	DeMaria, M.	2010	GOES-R Risk Reduction Program	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-October 1, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074		X			X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Gurka, J.	Goodman, S.//Schmit, T. J.//Mostek, A. J.//Miller, S. D.//Bachmeier, A. S.//DeMaria, M.//Reed, B.	2011	GOES-R proving ground: plans for 2011 and beyond	AMS 7th Annual Symposium on Future Operational Environmental Satellite Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Gurka, J.	DeMaria, M.//Goodman, S.//Schmit, T. J.	2010	Preparing for improved monitoring of tropical cyclones in the GOES-R proving ground	64th Interdepartmental Hurricane Conference, March 1-4, 2010, Savannah, GA	Conference Proceedings		NA090AR4320074		X			X
Gurka, J.	Goodman, S.//Schmit, T. J.//Siewart, C.//Beven, J.//DeMaria, M.	2010	GOES-R proving ground plans for the 2010 hurricane season at the National Hurricane Center (NHC) and the Storm Prediction Center (SPC) spring experiment	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-October 1, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074		X			X
Gutman, S. I.	Albers, S. C.//Forsythe, J. M.//Jones, A. S.//Kidder, S. Q.//Ward, B.//White, A. B.//Wick, G.A.	2010	Improved characterization and monitoring of moisture associated with atmospheric rivers	2010 AGU Fall Meeting, December 13-17, 2010, San Francisco, CA	Conference Proceedings		NA090AR4320074		X			X
Hand, J. L.	Schichtel, B. A.//Malm, W. C.//White, W. H.//Ashbaugh, L. L.//Pitchford, M. L.	2010	Spatial and seasonal variability in urban and rural PM2.5 speciated aerosol composition data from the IMPROVE and CSN networks	The American Association for Aerosol Research International specialty conference: Air Pollution and Health: Bridging the Gap from Sources to Health Outcomes, March 22-26, 2010, San Diego, CA	Conference Proceedings		NA090AR4320074	X				X
Hillger, D. W.	Schmit, T. J.//Bachmeier, A. S.//Gunshor, M. M.//Knaff, J. A.//Lindsey, D. T.	2011	science test results from the GOES-14 and -15 imager and sounder (poster)	AMS 7th Annual Symposium on Future Operational Environmental Satellite Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Hillger, D. W.	Brummer, R. L.	2010	The GOES-14 and GOES-15 science tests: Last of the current GOES series	CIRA Newsletter	Journal Article		NA090AR4320074		X		X	
Hillger, D. W.		2010	GOES-15 science test: Starting 11 August 2010	GOES-15 Science Test Plan Review, July 28, 2010, Camp Springs, MD	Report		NA090AR4320074		X			X
Hillger, D. W.	Schmit, T. J.	2010	GOES-14 science test: December 2009	Management Review Meeting of the National Satellite Operations Facility, November 8, 2010, Suitland, MD	Report		NA090AR4320074		X			X
Hillger, D. W.	Schmit, T. J.	2010	The GOES-14 science test: Imager and sounder radiance and product validations		Report		NA090AR4320074		X			X
Ito, T.	Woloszyn, M.//Mazloff, M.	2010	Anthropogenic carbon dioxide transport in the Southern Ocean driven by Ekman flow	Nature	Journal Article	doi:10.1038/nature08687	NA090AR4320074		X		X	
Jankov, I	Albers, S. C.//Yuan, H.//Wharton, L. S.//Toth, Z.//Schneider, T. L.//White, A. B.//Ralph, M.	2011	Ensemble prediction system development for Hydrometeorological Testbed (HMT) application	AMS 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Jankov, I	Albers, S. C.//Yuan, H.//Wharton, L. S.//Toth, Z.//Schneider, T. L.//White, A. B.//Ralph, M.	2010	Ensemble prediction system development for Hydrometeorological Testbed (HMT) application	10th EMS Annual Meeting and European Conference on Applications of Meteorology (ECAM), September 13-17, 2010, Zurich, Switzerland	Conference Proceedings		NA090AR4320074	X				X

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Jankov, I	Grasso, L. D.//Sengupta, M.//Neiman, P.J.//Zupanski, D.//Zupanski, M.//Lindsey, D. T.//Hillger, D. W.//Birkenheuer, D. L.//Brummer, R. L.//Yuan, H.	2010	An evaluation of five WRF-ARW microphysics schemes using synthetic GOES imagery for an atmospheric river event affecting the California coast	AMS 17th Conference on Satellite Meteorology and Oceanography, September 27-October 1, 2010, Annapolis, MD	Conference Proceedings		NA090AR4320074	X				X
Jankov, I	Grasso, L. D.//Sengupta, M.//Neiman, P.J.//Zupanski, D.//Zupanski, M.//Lindsey, D. T.//Hillger, D. W.//Birkenheuer, D. L.//Brummer, R. L.//Yuan, H.	2010	An evaluation of five WRF-ARW microphysics schemes using synthetic GOES imagery for an atmospheric river event affecting the California coast	(in press) J. Hydromet.	Journal Article		NA090AR4320074	X			X	
Jiang, H.	Feingold, G.//Sorooshain, A.	2010	Effect of aerosol on the susceptibility and efficiency of precipitation in warm trade cumulus clouds	J. Atmos. Sci.	Journal Article		NA090AR4320074	X			X	
Jin, Y.	Grasso, L. D.	2011	Application of synthetic GOES imagery to the Hurricane Forecast Improvement Project	AMS 29th Conference on Hurricanes and Tropical Meteorology, May 8-12, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074		X			X
Jordaan, W.	Caesar, K.//Veeck, L.	2010	The future of distance learning in an operational setting	The Eleventh WMO Symposium on Education and Training - SYMET-XI, October 25-29, 2010, Citeko, Indonesia	Conference Proceedings		NA090AR4320074			X		X
Kaplan, J.	Cione, J. J.//DeMaria, M.//Knaff, J. A.//Dunion, J. P.//Dostalek, J. F.//Solbrig, J. E.//Hawkins, J. D.//Lee, T. E.//Zhang, J.//Kalina, E.//Leighton, P.	2010	Enhancements to the operational SHIPS rapid intensification index	29th AMS Conference on Hurriucanes and Tropical Meteorology, May 8-12, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074		X			X
Kaplan, J.	DeMaria, M.//Knaff, J. A.	2010	A revised tropical cyclone rapid intensification index for the Atlantic and Eastern North Pacific basins	Weather and Forecasting	Journal Article		NA090AR4320074		X		X	
Kidder, S. Q.		2010	Orographic Rain Index (ORI)	Off-Conus Pacific Proving Ground Meeting, July 27-30, 2010, Honolulu, HI	Report		NA090AR4320074	X				X
Knaff, J. A.	DeMaria, M.//Kaplan, J.//Rozoff, C. M.//Kossin, J. P.//Velden, C. S.	2011	Improvements to statistical intensity forecasts	65th Interdepartmental Hurricane Conference, February 28-March 3, 2011, Miami, FL	Conference Proceedings		NA090AR4320074		X			X
Knaff, J. A.	DeMaria, M.	2010	Rapid Weakening of Non-Landfalling Atlantic Tropical Cyclones	64th Interdepartmental Hurricane Conference, March 1-4, 2010, Savannah, GA	Conference Proceedings		NA090AR4320074		X			X
Knaff, J. A.	Harper, B.A.	2010	Tropical cyclone surface wind structure and wind-pressure relationships	WMO International Workshop on Tropical Cyclones VII, November 15-20, 2010, La Reunion, France	Conference Proceedings		NA090AR4320074		X			X
Knaff, J. A.	Kaplan, J.//Dunion, J. P.//DeMaria, R. T.//DeMaria, M.	2010	Assessing the impact of total precipitable water and lightning on SHIPS forecasts	29th AMS Conference on Hurriucanes and Tropical Meteorology, May 8-12, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074		X			X
Knaff, J. A.	DeMaria, M.//Molenar, D. A.//Sampson, C. R.//Seybold, M.G.	2011	An automated, objective, multi-satellite platform tropical cyclone surface wind analysis	(submitted) J. Appl. Meteor.	Journal Article		NA090AR4320074	X			X	

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Knaff, J. A.	Courtney, J.//Gallina, G. M.//Beven, J.//Brown, Daniel P.	2010	An evaluation of Dvorak technique-based tropical cyclone intensity estimates	Weather Forecasting	Journal Article		NA090AR4320074	X				X
Knaff, J. A.		2010	Overview of tropical cyclone research and development at CIRA/RAMMB	CORP Science Symposium, August 10-11, 2010	Report		NA090AR4320074	X				X
Kulie, M. S.	Bennartz, R.//Greenwald, T.//Chen, Y.//Weng, F.	2010	Uncertainties in active and passive microwave remote sensing of frozen precipitation	J. Atmos. Sci.	Journal Article	doi: 10.1175/2010JAS3520.1	NA090AR4320074			X	X	
Lakhankar, T.	Jones, A. S.//Combs, C. L.//Sengupta, M.//Vonder Haar, T. H.//Khanbilvardi, D. R.	2010	Analysis of large scale spatial variability of soil moisture using a geostatistical method	Sensors	Journal Article		NA090AR4320074			X	X	
Lavanant, L.	Fourrie, N.//Gambacorta, A.//Grieco, G.//Heilliette, S.//Hilton, F.//Kim, M. -J.//McNally, A. P.//Nishihata, H.//Pavelin, E. G.//Rabier, F.	2010	Comparison of cloud products within IASI footprints for the assimilation of cloudy radiance	(submitted) Quart. Journal Roya. Meteor.	Journal Article		NA090AR4320074			X	X	
Liang, X.	Ignatov, A.	2010	Validation and improvements of daytime CRTM performance using AVHRR IR 3.7um band	13th AMS Conference on Atmospheric Radiation, June 28-July 2, 2010, Portland, OR	Conference Proceedings		NA090AR4320074	X				X
Liang, X.	Ignatov, A.// Lokupitiya, E. Y.	2010	Monitoring of IR clear-sky radiances over oceans for SST (MICROS): Near-real time, web-based tool for monitoring CRTM-AVHRR biases	(Submitted) Journal of Geophysical Research	Journal Article		NA090AR4320074	X			X	
Liang, X.	Ignatov, A.	2010	Monitoring of IR clear-sky radiances over oceans for SST (MICROS)	(accepted) J. Atmos. Oceanic Technol.	Journal Article		NA090AR4320074	X			X	
Lindsey, D. T.		2010	A statistical hail prediction product	AMS 25th Conference on Severe Local Storms, October 11-15, 2010, Denver, CO	Conference Proceedings		NA090AR4320074		X			X
Lindsey, D. T.	Grasso, L. D.//Bikos, D. E.//Sieglaff, J.//Otkin, J.//Rabin, R. M. //Kain, J. S.	2010	Simulating GOES-R Satellite Imagery from WRF Output	AMS 25th Conference on Severe Local Storms, October 11-15, 2010, Denver, CO	Conference Proceedings		NA090AR4320074		X			X
Lindsey, D. T.	Miller, S. D.//Grasso, L. D.	2010	The impacts of the 9 April 2009 dust and smoke on convection	Bulletin of the American Meteorological Society	Journal Article		NA090AR4320074		X		X	
Lindsey, D. T.		2010	Simulating satellite imagery from high-resolution WRF output: A method for cloud verification	Model Verification Workshop, November 3, 2010, Boulder, CO	Report		NA090AR4320074		X			X
Lipschutz, R. C.	Hagerty, D.//Hamer, P.//Lannigan, P.//MacDermaid, C. H.	2010	A high performance LDM data cluster	AMS 26th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, January 17-21, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074	X				X
Machol, J.L.	Green, J.C.//Rodriguez, J.V.//Onsager, T.G.//Denig, W.F.//Purcell, P. B.	2010	New operational algorithms for particle data from low-altitude polar-orbiting satellites	AGU Fall Meeting, December 13-17, 2010, San Francisco, CA	Conference Proceedings		NA090AR4320074	X				X
Maloney, E. D.	Sobel, A. H.//Hannah, W. M.	2010	Intraseasonal variability in an aquaplanet general circulation model	Journal of Advances in Modeling Earth Systems	Journal Article	doi:10.3894/JAMES.2010.2.5	NA090AR4320074			X	X	
McNoldy, B. D.	DeMaria, M.//Tallapragada, V.//Marchok, T.P.	2010	HWRF performance diagnostics from the 2009 Atlantic hurricane season	AMS 29th Conference on Hurricanes and Tropical Meteorology, May 8-12, 2010, Tucson, AZ	Conference Proceedings		NA090AR4320074			X		X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Michiko, M.	Woollen, J. S. //Zhu, T.//Prive, N.//Xie, Y. F.//Kleespies, T. J. //Ma, Z.//Sun, H.//Riishojgaard, L.//Weng, F.//Lou, G. P.//Vogel, R. L.//Han, Y.//Stokes, G.//Howard, K. L.	2011	Simulation of observation and calibration for joint OSSEs at NOAA	AMS 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074			X		X
Miller, P. A.	Helms, D.//Barth, M. F.//Benjamin, L. A.//Kent, T. B.//Collander, R. S.	2010	Planned product improvements for the NOAA Meteorological Assimilation Data Ingest System (MADIS)	AMS 26th Conference on International Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, January 17-21, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074		X			X
Miller, S. D.		2010	Proving Ground Activities and Plans at CIRA	Proving Ground Annual Meeting , May 18-19, 2010, Boulder, CO	Report		NA090AR4320074	X				X
Moninger, W. R.	Benjamin, S. G.//Jamison, B. D.//Schlatter, T. W.//Smith, T.S.//Szoke, E. J.	2010	Evaluation of regional aircraft observations using TAMDAR	Wea. Forecasting	Journal Article		NA090AR4320074		X		X	
Nance, L.B.	Bernardet, L.//Bao, S.//Brown, B.//Carson, L.//Fowler, T.//Gotway, J.H.//Harrop, C.//Szoke, E. J.//Tollerud, E. I.//Wolff, J.//Yuan, H.	2010	The HFIP high resolution hurricane forecast test	AGU Fall Meeting, December 13-17, 2010, San Francisco, CA	Conference Proceedings		NA090AR4320074			X		X
Pagowski, M.	Grell, G. A.//McKeen, S. A.//Peckham, S. E.//Devenyi, D.	2010	Three-dimensional variational data assimilation of ozone and fine particulate matter observations. Some results using the Weather Research and Forecastingï¿½Chemistry model and Gridpoint Statistical Interpolation	Quarterly Journal of the Royal Meteorological Society	Journal Article		NA090AR4320074	X			X	
Prive, N.	Xie, Y. F.//Koch, S. E.//Atlas, R.//Majumdar, S.//Masutani, M.//Woollen, J. S. //Riishojgaard, L.	2010	An observing system simulation experiment for the use of unmanned aircraft systems in improving tropical cyclone forecasts	AGU Fall Meeting, December 13-17, 2010, San Francisco, CA	Conference Proceedings	A41B-0071	NA090AR4320074	X				X
Qin, Z.	Weng, F.//Zhu, T.//Zou, X.	2011	A case study assessing the impact of GOES imager data assimilation on the precipitation forecast	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074			X		X
Reed, B.	Siewart, C.//Schneider, R.//Hufford, B.//Entwistle, B.//DeMaria, M.//Reynolds, D.//Brennan, M. J.	2011	GOES-R proving ground: Demonstrating GOES-R products in 2010	AMS 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Roberts, W. F.	Cheatwood, L. K.//LeFebvre, T.	2010	Evaluating components of the forecast process for populating and maintaining the NextGen Weather Information Database	AMS 14th Conference on Aviation, Range, and Aerospace Meteorology (ARAM), January 18-21, 2010, Alanta, GA	Conference Proceedings		NA090AR4320074		X			X
Rodriguez, M. A.	Barna, M. G.//Moore, T.	2010	Regional impacts of oil and gas development in the western United States	the American Association for Aerosol Research international specialty conference:Air Pollution and Health: Bridging the Gap from Sources to Health Outcomes, March 22-26, 2010, San Diego, CA	Conference Proceedings		NA090AR4320074	X				X

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Saha , S.	Moorthi, S.//Pan, H. -L.//Wu, X.//Wang, J.//Nadiga, S.//Tripp, P.//Kistler, R.//Woollen, J. S.//Behringer, D.//Liu, H.//Stokes, D.//Grumbine, R.//Gayno, G.//Hou, Y.-T.//Juang, H. M.//Sela, J.//Iredell, M.//Treadon, R.//Kleist, D.//van Delst, P.//Keyser, D.//Derber, J.//Ek, M. B.//Meng, J.//Wei, H.//Yang, R.//Lord, S.//van den Dool, H.//Kumar, A.//Wang, W.//Long, C.//Chelliah, M.//Xue, Y.//Huang, B.//Schemm, J.//Ebisuzaki, W.//Lin, R.//Xie, P.//Chen, M.//Zhou, S.//Higgins, W.//Zou, C.-Z.//Liu, Q.//Chen, Y.//Han, Y.//Cucurull, L.//Reynolds, R. W.//Rutledge, G. K.//Goldberg, M. D.//Chuang, H.-Y.	2010	The NCEP climate forecast system reanalysis	Bull. Amer. Meteor. Soc.	Journal Article	doi: 10.1175/2010BAMS3001.1	NA090AR4320074		X		X	
Saide, P. E.	Carmichael, G. R.//Spak, S. N.//Gallardo, L.//Osses, A. E.//Mena-Carrasco, M. A.//Pagowski, M.	2011	Forecasting urban PM10 and PM2.5 pollution episodes in very stable nocturnal conditions and complex terrain using WRF-Chem CO tracer model	(in press) Atmos. Environ.	Journal Article		NA090AR4320074			X	X	
Sampson, C. R.	Kaplan, J.//Knaff, J. A.//DeMaria, M.//Sisko, C.	2010	A deterministic rapid intensification aid	(in press) Weather Forecasting	Journal Article		NA090AR4320074		X		X	
Santos, P.	DeMaria, M.//Sharp, D.	2010	The determination of optimal thresholds of tropical cyclone incremental wind speed probabilities to support expressions of uncertainty within text forecasts: An update	AMS 20th Conference on Probability and Statistics in the Atmospheric Sciences, January 17-21, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074		X			X
Schranz, S. W.		2010	Joint Research Objectives and Joint MOU	NOAA/USFS Fire Weather Research Collaboration meeting	Report		NA090AR4320074	X				X
Schranz, S. W.	Koch, S. E.	2010	FY09/10 joint NWS/OAR fire weather progress on SAB model research recommendations	Meeting with Director Hayes, Silver Spring, MD	Report		NA090AR4320074	X				X
Schubert, W.	DeMaria, M.//Sampson, B.//Cummings, J.//Knaff, J. A.//McNoldy, B. D.//Musgrave, K.	2011	Improving tropical cyclone intensity forecasting with theoretically-based statistical models,	NOPP Review, February 25, 2011, Miami, FL	Report		NA090AR4320074			X		X
Schultz, P. J.		2010	ESRL/GSD improved wind forecast research and model downscaling	NOAA/USFS Fire Weather Research Collaboration Meeting	Report		NA090AR4320074	X				X
Schumacher, A. B.	DeMaria, M.//Brown, Daniel P.//Knaff, J. A.	2010	The NESDIS tropical cyclone formation probability product: An overview of past performance and future plans	64th Interdepartmental Hurricane Conference, March 1-4, 2010, Savannah, GA	Conference Proceedings		NA090AR4320074	X				X

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Schumacher, R. S.	Lindsey, D. T.//Schumacher, A. B.//Braun, J. J.//Miller, S. D.//Demuth, J. L.	2010	Multidisciplinary analysis of an unusual tornado: Meteorology, climatology, and the communication and interpretation of warnings	Weather and Forecastig	Journal Article		NA090AR4320074			X	X	
Setvak, M.	Lindsey, D. T.//Rabin, R. M. //Wang, P. K.//Demeterova, A.	2010	Possible moisture plume above a deep convective storm on 28 June 2005 in MSG-1 imagery	(Accepted) Monthly Weather Review	Journal Article		NA090AR4320074			X	X	
Setvak, M.	Lindsey, D. T.//Novak, P.//Wang, P. K.//Radova, M.//Grasso, L. D.//Kerkmann, J.//Su, S.-H.//Rabin, R. M. //Stastka, J.//Charvat, Z.	2010	Satellite-observed cold-ring-shaped features atop deep convective clouds	Atmos. Research	Journal Article	doi: 10.1016/j.atmosres.2010.03.009	NA090AR4320074			X	X	
Setvak, M.	Radova, M.//Novak, P.//Lindsey, D. T.//Grasso, L. D.//Wang, P. K.//Su, S.-H.//Rabin, R. M.//Kerkmann, J.//Stastka, J.//Charvat, Z.//Kyznarova, H.	2010	Convective storms with a cold-ring shaped cloud top feature	Journal of Atmospheric Research	Journal Article		NA090AR4320074			X	X	
Shaman, J.	Esbensen, S. K.//Maloney, E. D.	2010	The Dynamics of the ENSO Atlantic Hurricane Teleconnection: ENSO-Related Changes to the North African Asian Jet Affect Atlantic Basin Tropical Cyclogenesis	Journal of Climate	Journal Article		NA090AR4320074			X	X	
Shaman, J.	Maloney, E. D.	2010	Shortcomings in climate model simulations of the ENSO-Atlantic hurricane teleconnection	(Submitted) Geophysical Research Letters	Journal Article		NA090AR4320074			X	X	
Shi, W.	Wang, M.	2010	Sea ice optical properties measured by MODIS-Aqua, remote sensing of the coastal ocean, land, and atmosphere environment	SPIE Asia-Pacific Remote Sensing Symposium, October 11-14, 2010, Icheon, South Korea	Conference Proceedings	doi:10.1117/12.869282	NA090AR4320074	X				X
Shi, W.	Wang, M.	2011	Satellite observations of asymmetrical physical and biological responses to Hurricane Earl	Geophys. Res. Lett.	Journal Article	doi:10.1029/2010GL046574	NA090AR4320074	X			X	
Shi, W.	Wang, M.	2010	Characterization of global ocean turbidity from MODIS ocean color observations	J. Geophys. Res.	Journal Article	doi:10.1029/2010JC006160	NA090AR4320074	X			X	
Shi, W.	Wang, M.//Li, X.//Pichel, W.	2010	Ocean sand ridge signatures in the Bohai Sea observed by satellite ocean color and synthetic aperture radar measurements	(in press) Remote Sens. Environ.	Journal Article		NA090AR4320074	X			X	
Shi, W.	Wang, M.	2010	Satellite observations of environmental changes from Tonga Volcano eruption in the southern tropical pacific	(In press) Int. J. Remote Sens.	Journal Article		NA090AR4320074	X			X	
Shi, W.	Wang, M.	2010	Satellite observations of the seasonal sediment plume in the central east China Sea	J. Mar. System	Journal Article	doi:10.1016/j.jmarsys.2010.06.002	NA090AR4320074	X			X	
Smith, R.		2010	Colorado Climate Center and NIDIS upper Colorado River basin pilot	NWS/NIDIS Workshop, August 4, 2010, Park City, UT	Report		NA090AR4320074		X			X
Smith, R.	Doesken, N.//Ryan, W. A.	2010	NIDIS and the upper Colorado River basin pilot: Current monitoring efforts and future research	Annual Meeting of the American Association of State Cllimatologists, July 12, 2010, South Lake Tahoe, CA	Report		NA090AR4320074		X			X
Smith, R.	Doesken, N.//Ryan, W. A.	2010	Overview of the NIDIS weekly climate, water and drought assessment	Drought Portal Meeting, August 19, 2010, Boulder, CO	Report		NA090AR4320074		X			X
Sobel, A. H.	Maloney, E. D.//Bellon, G.//Frierson, D. M.	2010	Surface fluxes and tropical intraseasonal variability: A reassessment	Journal of Advances in Modeling Earth Systems	Journal Article	doi:10.3894/JAMES.2010.2.2	NA090AR4320074			X	X	
Stewart, J. Q.	Leon, M.//MacDermaid, C. H.//Schultz, M. S.//Sherretz, L.	2011	NextGen 4-D data cube development and tools for content developers	AMS 27th Conference on Interactive Information Processing Systems (IIPS), January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Szoke, E. J.	Albers, S. C.	2011	A comparison of several analysis schemes in their ability to diagnose boundaries	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Szoke, E. J.	Albers, S. C.//Xie, Y. F.//Wharton, L. S.//Glancy, R.//Thaler, E.//Barjenbruch, D. B.//Meier, B.//Toth, Z.	2011	A comparison of several analysis schemes in their ability to diagnose boundaries	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Szoke, E. J.	Benjamin, S. G.//Brown, J. M.//Fiorino, M.//Jamison, B. D.//Moninger, W. R.//Sahm, S. R.	2011	FIM performance for some of the major events of the 2009-2010 winter season	AMS 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Szoke, E. J.	Brummer, R. L.//Gosden, H.//Miller, S. D.//DeMaria, M.//Molenar, D. A.	2011	An overview of CIRA's contribution to the GOES-R Proving Ground	AMS 7th Annual Symposium on Future Operational Environmental Satellite Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Szoke, E. J.	Albers, S. C.//Xie, Y. F.//Wharton, L. S.//Thaler, D.//Barjenbruch, D. B.//Meier, B.//Toth, Z.//Glancy, R.	2010	Assessing the utility of several analysis schemes for diagnosing precursor signals for convective initiation and non-supercell tornadogenesis along boundaries	AMS 25th Conference on Severe Local Storms, October 11-15, 2010, Denver, CO	Conference Proceedings		NA090AR4320074	X				X
Tollerud, E. I.	Jensen, T. L.//Jankov, I/Yuan, H.//Gotway, J.H.//Oldenburg, P.	2011	The performance of high-resolution WRF ensemble QPF during heavy winter precipitation events in California	AMS 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Tollerud, E. I.	Jensen, T. L.//Yuan, H.//Gotway, J.H.//Oldenburg, P.//Jankov, I/Clark, W.L.//Wick, G.A.//Bullock, R.	2010	WRF ensemble model performance during atmospheric river events in California	AGU Fall Meeting, December 13-17, 2010, San Francisco, CA	Conference Proceedings		NA090AR4320074		X			X
Toth, Z.	Brown, B. G.//Jankov, I/Jensen, M. L.//Yuan, H.//Tollerud, E. I.//Wharton, L. S.//McCaslin, P. T.//Kuo, B.//Nance, L.B.//Koch, S. E.	2011	The DTC ensemble testbed: A new testing and evaluation facility for mesoscale ensembles	AMS 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Veeck, L.		2010	The Virtual Laboratory for Education and Training	Intergovernmental Oceanographic Commission (IOC) International Conference"50 Years of Education and Awareness Raising for Shaping the Future of the Oceans and Coasts," April 27-30, 2010, St. Petersburg, Russia	Conference Proceedings		NA090AR4320074			X		X
Veeck, L.		2010	Virtual laboratory for education and training in satellite meteorology	2010 EUMETSAT Meteorological Satellite Conference, September 20-24, 2010, Cordoba, Spain	Conference Proceedings		NA090AR4320074			X		X
Veeck, L.		2010	Social networking for education and training and mobile learning	WMO Seminar for National Trainers of RA VI, May 22-30, 2010, Sibiu, Romania	Report		NA090AR4320074			X		X
Veeck, L.		2010	Trainer competencies	Sixth Eumetcal Workshop, November 29-December 2, 2010, Geneva, Switzerland	Report		NA090AR4320074			X		X

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Velden, C. S.	Rozoff, C. M.//Wimmers, A. J.//Sitkowski, M.//Kieper, M. E.//Kossin, J. P.//Hawkins, J. D.//Knaff, J. A.	2010	An objective method to predict near real time rapid intensification of tropical cyclones using satellite passive microwave observations	29th AMS Conference on Hurricanes and Tropical Meteorology, May 8-12, 2010	Conference Proceedings		NA090AR4320074			X		X
Vescio, M. D.	Johnson, R. H.	2011	The wind response to transient mesoscale pressure fields associated with squall lines	Mon. Wea. Rev.	Journal Article		NA090AR4320074		X		X	
Wang, M.	Shi, W.//Tang, J.	2011	Water property monitoring and assessment for China's inland Lake Taihu from MODIS-Aqua measurements	J. Remote Sens. Environ.	Journal Article		NA090AR4320074		X		X	
Ware, R. H.	Cimini, D.//Guiliani, G.//Campos, E.//Oreamuno, J.//Joe, P.//Cober, S.G.//Albers, S. C.//Koch, S. E.//Westwater, E. R.	2010	Thermodynamic profiling at the alpine venue of the 2010 Winter Olympics	WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2010) , August 30-September 1, 2010, Helsinki, Finland	Conference Proceedings		NA090AR4320074			X		X
Xie, Y. F.	Prive, N.//Koch, S. E.//Masutani, M.//Woollen, J. S.//Atlas, R.//Riishojgaard, L.	2011	A preliminary assessment of UAS data impact on tropical cyclone track forecasts based on a global OSSE system	AMS 91st Annual Meeting, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074		X			X
Xu, F.	Ignatov, A.	2010	Evaluation and quality control of in situ SSTs for use in the calibration and validation of satellite retrievals	NESDIS, 90th annual meeting, January 16-22, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074	X				X
Xu, F.	Ignatov, A.	2010	Implementation and evaluation of quality control for in situ SST for use in satellite Cal/Val	AGU Ocean Sciences Meeting, Feburuary 22-26, 2010, Portland, OR	Conference Proceedings		NA090AR4320074	X				X
Yu, W.	Han, W.//Gochis, D.//Maloney, E. D.//Xie, Shang-Ping	2010	Observations of eastward propagation of atmospheric intraseasonal oscillations from the Pacific to the Atlantic	(Submitted) Journal of Geophysical Research	Journal Article		NA090AR4320074		X		X	
Yuan, H.	Xie, Y. F.//Albers, S. C.//Jankov, I	2011	Impacts of the STMAS cycling data assimilation system on improving severe weather forecasting	AMS 15th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074			X		X
Zhu, T.	Weng, F.	2011	Plan of use of IR emissivity data to improve assimilation of GOES-R ABI in GFS	AMS 7th Annual Symposium on Future Operational Environmental Satellite Systems, January 23-27, 2011, Seattle, WA	Conference Proceedings		NA090AR4320074	X				X
Zhu, T.	Weng, F.//Vogel, R. L.//Krasowski, G.//Goldberg, M. D.//Derber, J.	2010	Application of GOES and MSG data in NWP models	AMS 6th Annual Symposium on Future National Operational Environmental Satellite Systems - NPOESS and GOES-R, January 17-21, 2010, Atlanta, GA	Conference Proceedings		NA090AR4320074	X				X
Zhu, T.	Weng, F.//Liu, H.//Derber, J.	2010	Improvement of the use of MSG and GOES data in the NCEP GDAS	SPIE Asia-Pacific Remote Sensing Symposium, October 11-14, 2010, Icheon, South Korea	Conference Proceedings		NA090AR4320074	X				X
Zhu, T.	Weng, F.//Krasowski, G.//Liu, H.//Derber, J.//Goldberg, M. D.	2010	Impacts of SEVIRI and GOES imager data in NCEP GFS with GSICS calibration correction	2010 NOAA STAR AWG/GOES-RRR Review, June 7-11, 2010, Madison, WI	Report		NA090AR4320074	X				X
Zupanski, D.		2010	Information measures in ensemble data assimilation	Data Assimilation for Atmospheric, Oceanic and Hydrologic Applications	Book Chapter	DOI: 10.1007/978-3-540-71056-1_4	NA090AR4320074	X			X	
Zupanski, D.	Zhang, S. Q.//Zupanski, M.//Hou, A. Y.//Cheung, S. H.	2010	Ensemble-based assimilation and downscaling of the GPM-like satellite precipitation information	PMM Science Team Meeting, October 26-29, Salt Lake City, UT	Conference Proceedings		NA090AR4320074	X				X
Zupanski, D.	Zhang, S. Q.//Zupanski, M.//Hou, A. Y.//Cheung, S. H.	2011	Development of a WRF-based ensemble data assimilation system for dynamically downscaling satellite precipitation observations	Journal of Hydrometerology (Submitted)	Journal Article		NA090AR4320074	X			X	

Primary Author	Other Authors	Year	Publication Title	Published In	Type of Publication	Citation Number (DOI)	Research Support Award No.	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
Zupanski, D.	Zupanski, M.//Grasso, L. D.//Brummer, R. L.//Jankov, I//Lindsey, D. T.//Sengupta, M.//DeMaria, M.	2010	Assimilating synthetic GOES-R radiances in cloudy conditions using an ensemble-based method	(in press) International Journal of Remote Sensing	Journal Article		NA090AR4320074	X			X	

NOAA PROJECTS BY TITLE

NOAA PROJECT THEME MATRIX

Title	Project #	PI	Satellite Algorithm Development, Training & Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
NOAA Non-competitive Projects									
A Cooperative Institute to Investigate Satellite Applications for Regional/Global-Scale Forecasts (Task I)	5-311070	Kummerow							
A GOES-R Proving Ground for National Weather Service Forecaster Readiness	5-312570	Miller	x						
CIRA Activities and Participation in the GOES Improved Measurements and Product Assurance Plan (GIMPAP)	5-311190	Miller	x						
CIRA Research collaboration with the NOAA/NESDIS NGDC for the NPOESS SEM Sensor	5-312510	Matsumoto	x						
CoCoRaHS: The community collaborative rain, hail and snow network--enhancing environmental literacy through participation in climate monitoring and research	5-312270	Doesken, Cifelli							x
Continuation of the CIRA research collaboration with the NWS meteorological development lab	5-312160	Matsumoto					x		
Development of a polar satellite processing system for research and training	5-312670	Connell	x						x
Ensemble Data assimilation for hurricane forecasting	5-311110	Zupanski			x				
Environmental Applications Research (EAR)	5-312500	Matsumoto			x	x	x	x	x
Further expansion of CIRA research collaboration with the NWS Meteorological Development Lab	5-311150	Matsumoto					x		

Title	Project #	PI	Satellite Algorithm Development, Training & Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Getting Ready for NOAA's Advanced Remote Sensing Programs A Satellite Hydro-Meteorology (SHyMet) Training and Education Proposal	5-312540	Connell	x						
Global Tropical Cyclone Formation Probability Product	5-312490	Dostalek	x						
HMT Field Coordinator Position in NOAA ESRL Physical Science…	5-312720	Cifelli				x			
Improvements in the rapid intensity index by incorporation of inner-core information	5-312530	Dostalek	x						
In support of NOAA's commitment to the coordination group for meteorological satellites: enhancing the international virtual laboratory	5-312680	Connell	x						x
Investigation of smoke aerosol-cloud interactions using large eddy simulations	5-312520	Matsumoto			x	x			
Legacy Atmospheric Sounding Data Set Project	5-312750	Johnson						x	x
NESDIS Research Scientist & Postdoctoral Program	5-311080	Miller							
Young Chen					x				
Prasanjit Dash			x					x	
Lide Jiang			x						
Min-Jeong Kim					x				
Peter Kiss, Post Doc			x						
XingMing Laing			x					x	
Korak Saha, Post Doc			x						
Wei Shi			x						

Title	Project #	PI	Satellite Algorithm Development, Training & Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Tong Zhu			x						
POES-GOES blended hydrometeorological products	5-311180	Kidder			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	5-312740	Miller	x						
Satellite Analysis of the Influence of the Gulf Stream on the Troposphere: Convective Response	5-312550	Schumacher	x						
Scientific Support to the GOES-R Algorithm Review Board	5-312640	Vonder Haar	x						
Severe Weather/Aviation impact from hyperspectral assimilation	5-312710	Matsumoto		x	x				
Support of the Virtual Institute for Satellite Integration Training (VISIT)	5-312560	Bikos	x						x
Teaching Modeling at Universities	5-312650	Randall		x					x
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
Tropical Cyclone Model Diagnostics and Product Development	5-312070	Schubert	x						
Upgrade to eTRaP—Probability Calibrations	5-311200	Kidder	x			x			

NOAA PROJECT THEME MATRIX

Title	Project #	PI	Satellite Algorithm Development, Training & Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Validation of Satelite-based thermodynamic retrievals in the tropics	5-311160	Dostalek	x						
Validation of Satellite-Based Thermodynamic Retrievals in the Tropics	5-312480	Dostalek	x						
Weather Satellite Data and Analysis Equipment and Support for Research Activities	5-312580	Hiatt/Kummerow					x		
NOAA Competitive Projects & Shadow Awards									
Advanced applications of the Monte Carlo wind probability model	5-312610	Kidder				x			
A fundamental climate data record of SSMI, SSMIS and future microwave imagers	5-312660	Kummerow				x			
Data fusion to determine North American sources and sinks of carbon dioxide at high spatial and temporal resolution from 2004 to 2008	5-312470	Denning		x		x			
Future changes of the Southern Ocean CO2 fluxes	5-312630	Ito		x		x			
Monsoon flow and its variability during NAME: Observations and models	5-312350	Johnson		x		x			
Quantifying the source of atmospheric ice nuclei from biomass burning aerosols	5-312700	DeMott, P.				x			
Remote versus local forcing of intraseasonal variability in the IAS region: consequences for prediction	5-312620	Maloney, Xie		x		x			

Title	Project #	PI	Satellite Algorithm Development, Training & Education	Regional to Global Scale Modeling Systems	Data Assimilation	Climate-Weather Processes	Data Distribution	Societal/Economic Impact Studies	Education and Outreach
Simulation and analysis of the interaction between aerosols and clouds, precipitation and the radiation budget over the Gulf of Mexico and Houston	5-312310	Cotton		x					
The Madden-Julian Oscilltion: Model Development and Diagnosis of Mechanisms	5-312600	Maloney		x		x			
Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting	5-311210	Zupanski, Grasso			x				