Cooperative Institute for Meteorological Satellite Studies

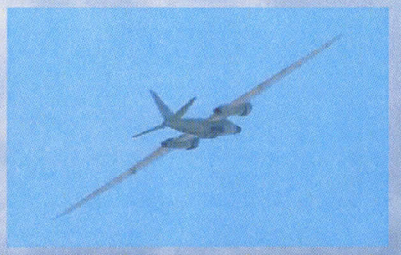
Information

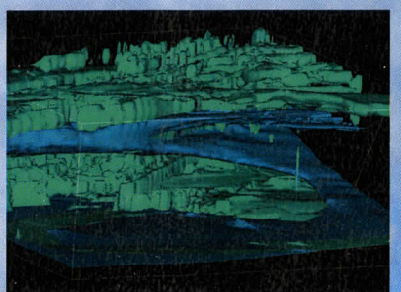
Data

Education

Knowledge

Action





2007 Board of Directors Report

REPORT TO THE BOARD OF DIRECTORS
COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES (CIMSS)
8 May 2007

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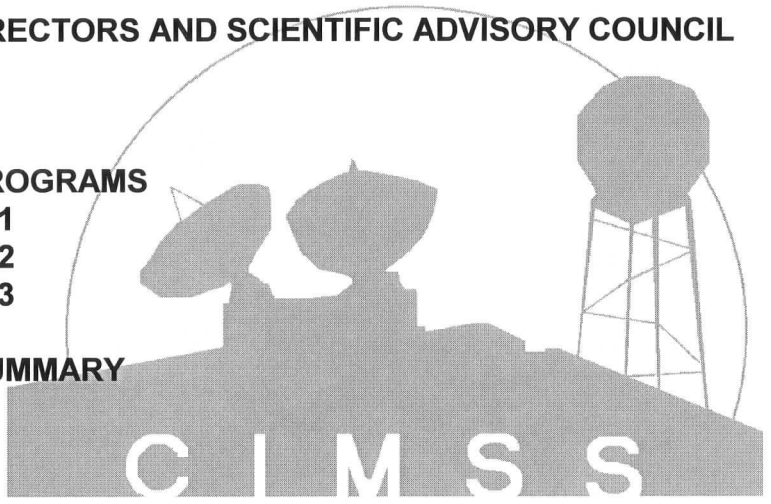

CIMSS BOARD OF DIRECTORS MEETING AGENDA

Tuesday, 8 May 2007
8:30 am - 3:45 pm, Room 351

8:30 am	Welcome and Agenda Review (Ackerman)
8:45 am	UW Research and Graduate School Update (Cadwallader)
9:00 am	SSEC Update (Revercomb)
9:15 am	CIMSS Priorities (Ackerman)
9:30 am	NESDIS Priorities (Kicza)
9:45 am	STAR Priorities (Powell)
10:00 am	Break
10:15 am	NASA Langley Priorities (Vann)
10:30 am	ASPB Priorities (Key)
10:45 am	AOS Priorities (Martin)
11:00 am	Working Lunch with discussion
12:30 pm	Poster Review
1:30 pm	Short Presentations on Specific Science Programs Hurricane Variability on Multidecadal to Hourly Timescales – Jim Kossin Next Generation Data Analysis and Visualization Systems – Tom Rink
2:30 pm	Break
2:45 pm	Discussion, action items and wrap-up (rm 351)
3:45 pm	Adjournment
4:30 pm	Dinner

CIMSS BOARD OF DIRECTORS
May 2007

Martin Cadwallader, Chair
Dean, UW-Madison Graduate School

Steven A. Ackerman
Director, CIMSS

Henry E. Revercomb
Director, Space Science and Engineering Center, UW-Madison

Jonathan Martin
Chair, Department of Atmospheric and Oceanic Sciences, UW-Madison

Mary Kicza
Assistant Administrator for Satellite and Information Services, NOAA/NESDIS

Alfred Powell
Director, Center for Satellite Applications and Research, NOAA/NESDIS

Jeff Key
Chief, Advanced Satellite Products Branch, NOAA/NESDIS

Colleen Hartman
Science Deputy Associate Administrator, NASA

Franco Einaudi
Director, Earth-Sun Exploration Division of the Sciences and Exploration Directorate, NASA Goddard Space Flight Center

Lelia Vann
Director, Science Directorate, NASA Langley Research Center

Invited Representatives:

Terry Millar
Associate Dean for Physical Sciences, Graduate School, University of Wisconsin—Madison

Allen Huang
CIMSS Science Council

Chris Velden
CIMSS Science Council

Thomas Achtor
Executive Director-Science, SSEC/CIMSS

Fred Best
Executive Director-Technology, SSEC

John Roberts
Executive Director-Administration, SSEC

CIMSS SCIENTIFIC ADVISORY COUNCIL
as of May 2007

Steven Ackerman	Director, CIMSS
Allen Huang	Senior Scientist, CIMSS
Chris Velden	Assistant Scientist, CIMSS
John Norman	Professor, UW Department of Atmospheric and Oceanic Sciences
Ralf Bennartz	Professor, UW Department of Atmospheric and Oceanic Sciences
Graeme Stephens	Professor, Department of Atmospheric Science, Colorado State Univ.
Bob Ellingson	Professor, Department of Meteorology, Florida State University
Arnold Gruber*	Leader, Hydrology Team, NOAA/NESDIS/ORA
Fran Holt*	Chief, Atmospheric Research and Appl. Div., NOAA/NESDIS/ORA
Michael King	EOS Senior Project Scientist, NASA Goddard Space Flight Center
Pat Minnis	Senior Research Scientist, NASA Langley Research Center

*** These Council Members need to be replaced. At the Board Meeting Steve Ackerman will nominate replacements to be approved by the Board members.**

An Overview of the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison

CIMSS was established in 1980 to formalize and support cooperative research between the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) and the University of Wisconsin-Madison's Space Science and Engineering Center. Sponsorship and membership of the Institute was expanded to include the National Aeronautics and Space Administration (NASA) in 1989.

During the 1980s, a need emerged for joint federal - university research centers to support the NOAA weather research program. CIMSS was established to focus on the development and testing of the operational utility of new weather satellite observing systems to improve weather analysis and forecasts. Federally sponsored university institutes such as CIMSS have proved to be very cost effective organizations for conducting research and development programs.

CIMSS develops and successfully implements techniques and products for using geostationary and polar orbiting weather satellite visible, thermal and microwave radiation observations to improve forecasts of severe storms, including tornadoes and hurricanes. CIMSS plays a major role in the transfer of new technology into operational practice.

CIMSS also plays a major role in instrument design and testing, and related software development, for improved space-based measurements of the earth's atmosphere. CIMSS is very active in national and international field programs, testing new instrumentation, data processing systems and assessing the geophysical utility of measurements.

Current research also focuses on the development and testing of computer-based analysis and forecast techniques that use observations from existing and planned spacecraft and ground-based weather observing systems as part of a national program to greatly improve weather forecast capabilities for the next decade. The optimal use of satellite data in climate and global change studies has become another essential part of the CIMSS mission.

CIMSS serves as an international center for research on the interpretation and uses of operational and experimental satellite observations and remote sensing data acquired from aircraft and the ground. These data are applied to a wide variety of atmospheric and oceanographic studies and evaluated for their potential operational utility. CIMSS international role is further strengthened through its visiting scientist program that hosts sabbaticals for several foreign scholars each year.

CIMSS' relationship with the UW-Madison Department of Atmospheric and Oceanic Sciences provides graduate student research support to more than ten students per year. The

education/research center link provides an excellent path for young scientists entering geophysical fields.

Visit the CIMSS WWW Home Page at **http://cimss.ssec.wisc.edu**

Organizational Structure within the University of Wisconsin System

Research institutions with the University of Wisconsin system are administered through the Graduate School. The Space Science and Engineering Center (SSEC) is a research institution employing roughly 200 scientists, engineers, programmers and support staff. The SSEC program includes development of the Man-computer Interactive Data Access System (McIDAS), development and construction of spacecraft instrumentation and scientific investigations of earth and other planetary environmental systems. Within the SSEC, the Cooperative Institute for Meteorological Satellite Systems (CIMSS) is a research arm conducting scientific investigation from passive remote sensing systems for meteorological and surface-based applications.

NOAA Team at CIMSS

NESDIS established the Advanced Satellite Products Branch (ASPB) as a research and development facility at CIMSS. ASPB is part of the NESDIS Center for Satellite Applications and Research (STAR). The branch is primarily responsible for the validation and calibration of measured radiances, satellite-derived products useful for short term weather forecasting, algorithms for deriving temperature and moisture soundings, atmospheric motions, cloud properties, and snow/ice characteristics, the optimal use of satellite-derived mass and motion information in data assimilation and numerical weather prediction systems, and satellite-derived fire and smoke products for real time monitoring and climate change studies. The group plays a critical role in transitioning research products to operations, training the user community in new satellite capabilities, and planning the evolution to advanced instrumentation such as improved multi-channel imagers and high spectral resolution interferometer sounders.

ASPB collaborates with the international user community to improve the use of satellite observations. This is accomplished through active participation in the International TOVS and Winds Working Groups as well as a vibrant collaboration with ECMWF and EUMETSAT. ASPB also participates in activities of the World Meteorological Organization (WMO), the Coordinating Group for Meteorological Satellites (CGMS), the Committee on Earth Observation Satellites (CEOS), the Integrated Global Observing Strategy (IGOS), and the Group on Earth Observations (GEO).

CIMSS Research Activity Summaries

(organized by the CIMSS Mission)

Mission 1 ***starting page 9***

Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science which exploit the use of satellite technology.

Mission 2 ***starting page 77***

Serve as a center at which scientists and engineers working on problems of mutual interest may focus on satellite related research in atmospheric studies and earth system science.

Mission 3 ***starting page 171***

Stimulate the training of scientists and engineers in the disciplines involved in the atmospheric and earth sciences.

Scanner's note:

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Mission 1

Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science which exploit the use of satellite technology.

GIMPAP

- Atmospheric Motion Vector Research and Applications
- Biomass Burning Research and Applications
- Intercalibration of GOES and POES Infrared Bands
- Basic Research Applying to Tropical Cyclone Analysis
- Retrieval Science
- Tropical Cyclone Intensity Change from GOES

Product System Development and Implementation (PSDI)

- Wildfire ABBA Operational Support
- GOES-N Science Checkout
- Atmospheric Motion Vector Algorithm Development
- Spectral Response
- Product Quality Assurance and Science Support
- Gridded Cloud Product
- Full Disk Surface Insolation
- GOES-12 Imager Cloud Product
- Polar Winds from Satellite Imagers and Sounders
- Clouds from AVHRR Extended (CLAVR-x)
- Derived Products from GOES-10 Sounder

Global Geostationary Fire Monitoring

Extended GOES Operations at High Inclination Orbit

GOES-R Risk Reduction

- Profile Algorithm Development
- Atmospheric Motion Vector Algorithm Development
- Surface Properties
- Ozone Algorithm Development
- Visualization
- Biomass Burning
- Tropical Cyclone Research
- Nowcasting Studies
- Ground Systems Development

GOES-R Algorithm Working Group

- Proxy Data Set and Model Development
- Sounding Algorithm Evaluation and Selection
- Atmospheric Motion Vector Algorithm Development
- Sounding Algorithm Validation
- ABI Fire Detection and Characterization Algorithm

- Cloud Application Team
- ABI Ozone Detection

GOES-R Instrument and Scan Strategy

GIMPAP: Basic Research to Improve the Derivation and Application of Atmospheric Motion Vectors from GOES

Personnel: Chris Velden (PI), David Stettner, Feng Lu

Funded by: NOAA

Project Description

The CIMSS automated satellite-derived winds tracking algorithm is continuously evolving. In order to advance the algorithm, and identify new applications of the data, innovative science and research ideas need to be developed and tested at CIMSS.

Accomplishments

1. The CIMSS winds-tracking software continues to be modified to allow for easy adaptation to new instruments. Satellite-specific parts of the software have been identified and isolated, thereby minimizing the effort required for adding new satellites and sensors. A specific example is the adaptation of the code to process newly operational GOES-11 data. In addition, the algorithm linkages that were needed to ingest and process GOES-13 data have been successfully integrated, in anticipation of the science checkout period in December 2006.

2. The accuracy of GOES winds is highly dependent on image-to-image navigation/registration. Landmarking techniques are usually employed to deduce precise navigation, however, these landmarks are not always available for certain scans (such as GOES rapid-scanning of hurricanes over the ocean) or when clouds obscure the landmarks. In new research we analyzed the impact of various navigation parameter errors on image navigation accuracy. Methods that employ the Earth edge and image center were tested for GOES imagery. Navigation that is based on earth center determination from earth edge measurements does not rely on landmarks and hence is not vulnerable to excessive cloud cover. Results of these navigation improvements were tested for impact on GOES winds. An image center time series analysis indicates that, for the three-axis stable GOES-9 during the Western Pacific observation mission, the image navigation accuracy is significantly reduced by errors in the forecast of spacecraft attitude. The biases in the roll and pitch can be nearly eliminated by introducing the attitude signal derived directly from earth center information. The resultant GOES winds are an improvement over those without any navigation correction. The strong advantage of the new method is that it can be applied without the need for landmarks, and can be used for attitude forecasts and applied to regional scans such as GOES local area rapid scans operations. Combined with imager star sensing data, it is possible to build up an automatic image navigation system based on these principles.

3. An area of vector height assignment research being investigated is the proposal that the vectors represent a mean *layer* of motion, rather than a single level. To test this hypothesis, GOES-12 Operational winds (IR and WV) are compared to collocated rawinsonde data at both individual levels and layers of varying thickness. RMS differences are calculated for groups of vectors binned by assigned pressure. Figure 1 shows that, in general, upper-level winds agree best with a mean layer motion of ~100 hPa in thickness. Mid- and lower-level winds correspond best to a broader layer ~150 hPa thick. The representativeness of mid-level WV winds can be a very broad layer. Assigning the upper and mid winds to a proper tropospheric *layer* can increase GOES wind-sonde agreement by ~1-2 m/s over the operationally assigned discrete level. Comparatively, the level of best fit only increases agreement by ~0.5 -1 m/s. The next step is to evaluate this idea further by stratifying the GOES wind type/properties (i.e., height assignment methods).

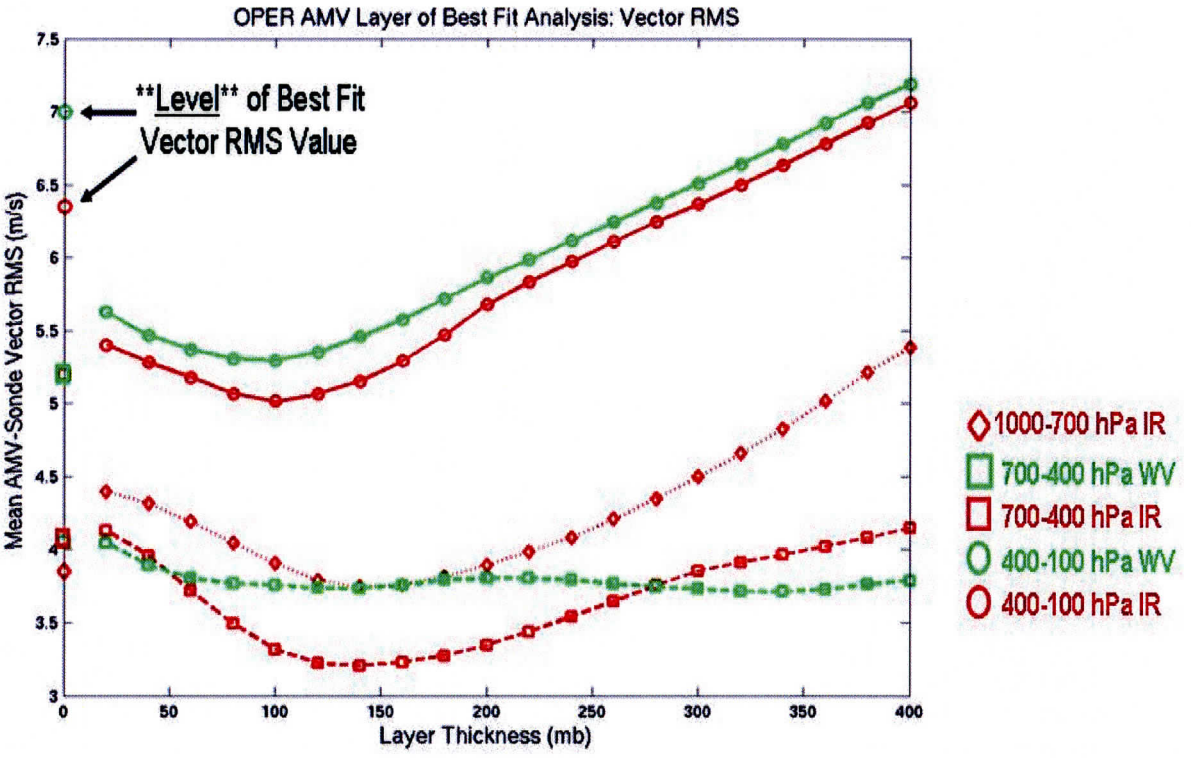


Figure 1. GOES-12 Operational winds (IR and WV, for selected tropospheric layers) are compared to collocated rawindsonde data at both individual levels and layers of varying thickness.

GIMPAP: GOES Biomass Burning Research and Applications

Personnel: Elaine Prins (Consultant), Christopher Schmidt, Jason Brunner, Jay Hoffman, Joleen Feltz

Funded by: NOAA

Project Description

Initially the GIMPAP biomass burning program focused on development, testing, and implementation of GOES active fire monitoring in the Western Hemisphere. Over the past several years GIMPAP funding has been used to support innovative research applications of the GOES WF_ABBA fire product through collaborative efforts with a broad user community including hazards monitoring/assessment, resource management, fire weather, global change research, land-use/land-cover change analyses, fire dynamics research, emissions monitoring/modeling, and air quality. In most instances these collaborations were initially not funded by any other source and often led to more in-depth studies funded by NOAA and other agencies. Furthermore, active collaborations with the user community have provided valuable insight to improve the GOES WF_ABBA and advance geostationary fire monitoring efforts around the globe through international working groups and initiatives (GOFC/GOLD, CGMS, and GEOSS). For the past two years efforts have focused on the following tasks:

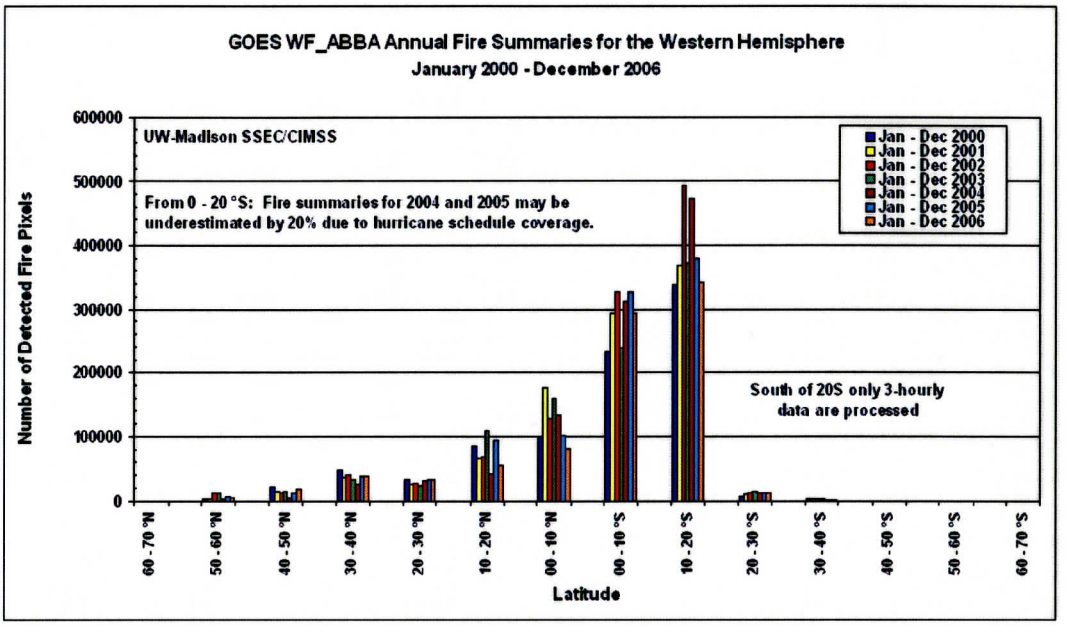
- GOES WF_ABBA trend analysis in the Western Hemisphere;
- Collaborations with the atmospheric modeling and air quality communities;
- Collaborations with NOAA/NSSL and NOAA/NWS/SPC on fire weather applications;
- Activities in support of a global geostationary fire detection and monitoring system in association with GTOS GOFC/GOLD and CGMS.

Accomplishments

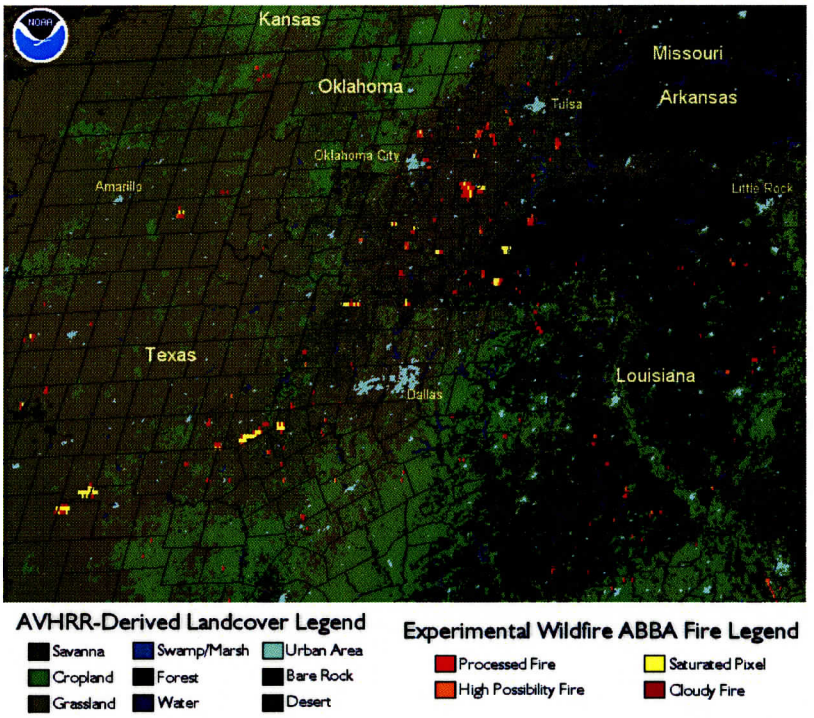
- Continued trend analysis of GOES WF_ABBA fire products for the Western Hemisphere (January 2000 – present). (NASA/Navy cost-share)
- Created summary coverage files for the half-hourly GOES WF_ABBA data base (2000 – 2005) in response to requests from the user community for better information on the impact of special satellite schedules on fire monitoring in the Western Hemisphere. (NASA/Navy cost-share)
- Analyzed differences between version 5.9 and 6.0 of the WF_ABBA. Results indicate version 6.0 is more robust with fewer false alarms and a reduction in fire counts of 4-5% in South America and 7% in North America.
- Collaborated with a variety of agencies and institutions on applications ranging from fire weather to emissions assessment and air quality and land-use/land-cover change (e.g. Georgia Institute of Technology; Universidade Federal do Acre, Brazil; Woods Hole; NASA GSFC; UMD-College Park; NRL/FNMOC; UA-Huntsville; US EPA; NASA Langley; Max Planck Institute; Harvard University; Sonoma Technology - USFS Blue Sky program; NOAA/NSSL; NOAA/NWS/SPC; Oklahoma State University). These collaborations resulted in co-authorships on 5 peer-reviewed papers. (NASA/Navy Cost-Share)
- Master's thesis on a comparison of GOES and MODIS Fire Products. (NASA/Navy cost-share).
- CIMSS continues to serve on the international GTOS GOFC/GOLD fire monitoring and mapping implementation team on the development of a global geostationary fire detection

system. This effort supports GEOSS activities and the Group on Earth Observations (GEO) 2006 work plan.

- CIMSS coordinated and co-chaired the GOFC/GOLD 2nd Workshop on Geostationary Fire Monitoring and Applications held at EUMETSAT on December 4-6, 2006. Over 45 representatives from 18 different countries attended.



GOES WF_ABBA annual fire summaries for the Western Hemisphere for the time period January 2000 through December 2006.



GOES-East WF_ABBA composite of wildfires in the Southern Plains for the time period 23 December 2005 through 4 January 2006.

Intercalibration of GOES & POES Infrared Bands

Personnel: Mat Gunshor, Dave Tobin, Jim Nelson, Hal Woolf, Tim Schmit, Paul Menzel

Funded by: NOAA

Project Description

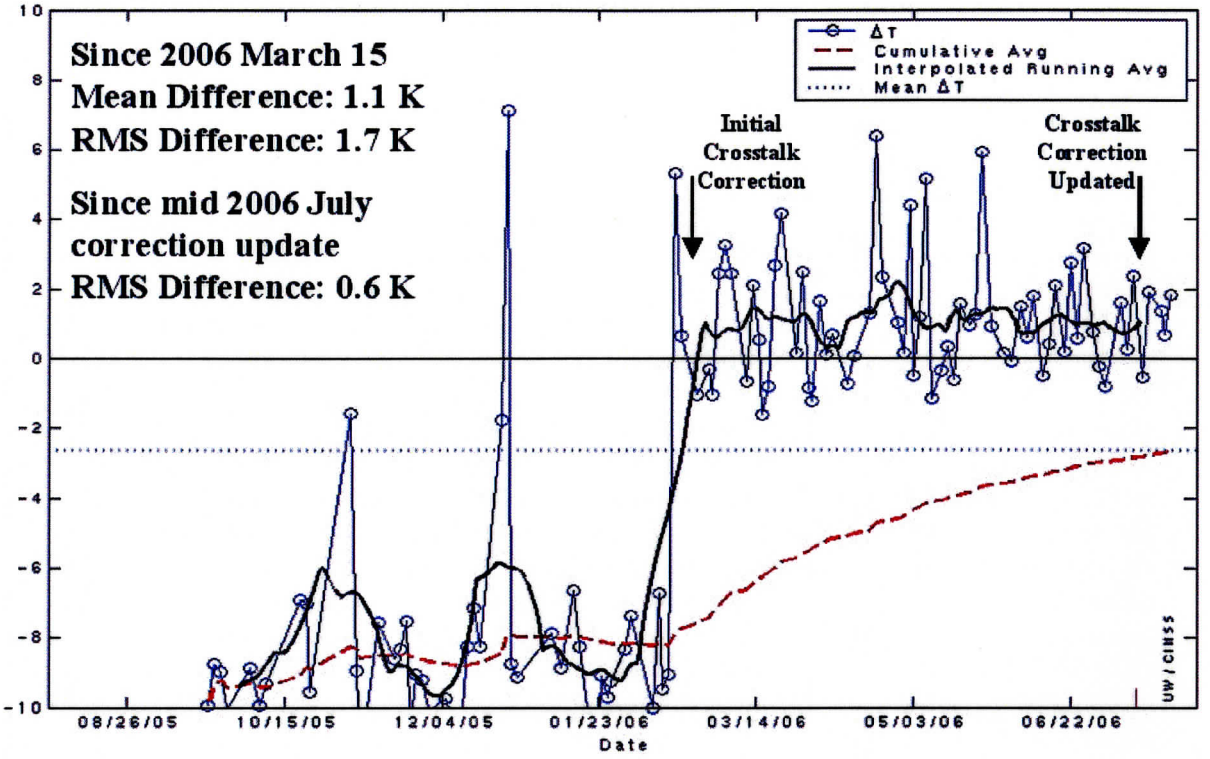
The primary purpose of the intercalibration project is to compare select infrared channel radiances on geostationary Imagers (GOES, METEOSAT, MTSAT) with those obtained from the polar-orbiting instruments (NOAA AVHRR and HIRS, EOS AIRS). Multiple comparisons are made at the geostationary sub-satellite points yielding an average brightness temperature difference between the geostationary imager and the polar orbiter.

Comparison of satellite radiances leading to an improved knowledge of calibration is important for various global applications where data from more than one instrument are combined. This project provides a comparative radiometric assessment of satellite instruments that are used in operational and research products. This has become increasingly important with the emphasis placed on global climate studies, global models and the use of global satellite data and products in numerical weather prediction (NWP). There is an international committee organized through the WMO as part of the space-based component of the Global Observing System (GOS) to address such issues called the Global Space-Based Inter-Calibration System (GSICS) Research Working Group (GRWG). NOAA-NESDIS is one of the members of the working group and CIMSS provides research results and expertise to NESDIS as the GRWG formulates an operational intercalibration approach to be adopted by all of the member-states.

Routine intercalibrations have been conducted for many years at CIMSS. GOES and NOAA HIRS / AVHRR intercomparisons have the longest history. At the same time, research and development of new methods and tools, as well as adding new instruments and new bands, has been an ongoing effort as well. Recently, there has been an effort to compare high-spectral resolution AIRS radiances with the geostationary imager broad-band measurements. AIRS presents a unique opportunity for more accurate comparisons in regions of the infrared spectrum where AIRS has complete, or near-complete, spectral coverage. As the community gravitates to using more high spectral instruments in the future, this work gains in relevance, especially now that EUMETSAT has IASI in orbit. Indeed, the stated goal of the GRWG is to use AIRS and IASI to intercalibrate the global geostationary constellation of imagers.

Accomplishments

- Developed the internationally accepted method of intercalibration with a high-spectral resolution instrument (AIRS).
- Developed multiple methods of dealing with AIRS spectral gaps in intercalibation.
- Compiled 1000's of comparisons between Geostationary Imagers and HIRS, AVHRR, and AIRS.
- Characterized the state of relative calibration accuracy for GOES-10, -11, -12, METEOSAT-5, -7, -8, and MTSAT-1R for all IR bands using AIRS.
- Assisted JMA and Raytheon with MTSAT-1R calibration issues related to cross-talk in the 3.7 micron band.
- Helped NOAA-NESDIS meet the CGMS requirement to validate radiances via intercalibration.



MTSAT-1R 3.7 micrometer band compared to AIRS (MTSAT-AIRS). Temperature differences in degrees K. CIMSS provided colleagues at JMA and Raytheon with feedback such as this to show how the corrections that were applied were improving the accuracy of radiances; this type of plot was also shown to colleagues in NOAA-NESDIS so they could determine how to proceed with products using this instrument.

GIMPAP: Basic Research to Apply GOES Data to Tropical Cyclone Analysis

Personnel: Chris Velden (PI), Dave Stettner, Tim Olander

Funded by: NOAA

Project Description

CIMSS continues to develop new diagnostic fields derived from GOES data and products for applications to Tropical Cyclones (TCs).

Accomplishments

1. The CIMSS Tropical Cyclones group continues to develop diagnostic fields derived from GOES winds analyses for applications to TCs. These products include analyses of vertical wind shear, vorticity, upper-level divergence, vertical wind shear tendency, steering currents, and surface adjusted cloud-drift winds. All of these products are featured on the CIMSS Tropical Cyclones web site (http://cimss.ssec.wisc.edu/tropic/tropic.html), which has become an extremely popular "public outreach" site for both the general public and forecasters during TC events. We continue to upgrade these products and develop new ones often based on community/user feedback. Also, GOES datasets and products are continuously requested and provided to the user community for expanding scientific research on TCs.

2. The research on identifying the Saharan Air Layer (SAL) from GOES and other satellite data, and its influence on TC intensity has been described in previous reports and led to a major paper on the topic (see Dunion and Velden, BAMS, March 2004). The SAL is also detectable using AVHRR split-window approaches. Data from 23 years was processed using a dust mask algorithm developed by Amato Evan (UW-AOS student thesis). Monthly means were calculated during this period over the North Atlantic Ocean basin. TC activity over this basin during these same periods was also calculated. A remarkable correlation is indicated between active SAL and inactive TC activity. The trends support the correlations and the findings/hypotheses in the BAMS paper. A paper on these findings has been published in GRL. We also aim to explore the AVHRR algorithm for applications to our GOES-based SAL algorithm.

3. We continue to upgrade the Advanced Dvorak Technique (ADT) algorithm, which is now used by several of NOAA's tropical cyclone analysis centers. The algorithm upgrades have focused on the following primary areas: 1) refinement of the rules to allow more rapid intensity changes, and 2) statistical evaluation of the performance in specific cases to better understand the behavior and areas of weakness. Several new schemes are being tested.

4. The CIMSS TC group continues to explore an integrated approach to satellite-based TC intensity estimation through a weighted consensus of ADT, and AMSU methods derived at CIMSS and at CIRA. The approach has first identified the strengths and weaknesses of each individual method, which is then used to assign weights for a consensus algorithm designed to better estimate TC intensity. This new approach was tested in near real time during the 2006 hurricane season. A statistical analysis is underway. See: http://cimss.ssec.wisc.edu/tropic/satcon/satcon.html

GIMPAP: Retrieval Science

Personnel: Jun Li, Jim Nelson, Zhenglong Li, Tim Schmit, Sarah Bedka

Funded by: NOAA

Project Description

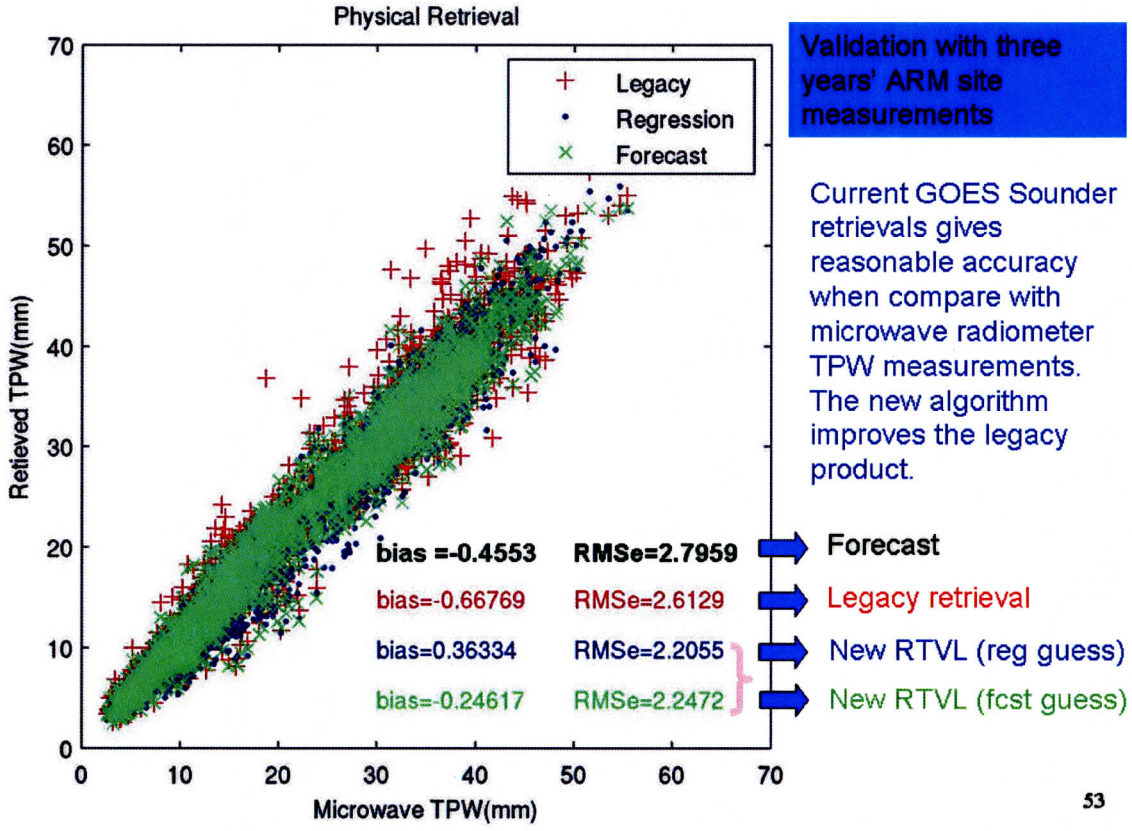
The goal of this project is to improve the retrieval algorithm and processing technique for GOES Sounder single field-of-view (SFOV) sounding and total column ozone (TCO) products. Since the current GOES Sounder data will be used for at least another 10 years, SFOV sounding improvement is very important for applications, especially in regional forecasts. For example, a GOES ozone product may be very useful for many applications (air quality forecast, aviation safety, non-convective wind storm, etc.) because of the product's high temporal resolution and its ability to indicate mesoscale air mass exchange associated with clear air turbulence. Our research focuses on the application of GOES Sounder time continuity in retrieval, handling infrared (IR) surface emissivity and clouds in sounding algorithm, and the evaluation of the impact of improved GOES Sounder products on regional forecast model.

Accomplishments

- Time continuity (TC) and spatial continuity (SC) are the unique aspects of Geostationary Sounder data. We have implemented methods to apply SC and TC in the sounding retrieval algorithm by assuming constant temperature and variable moisture in two adjacent time steps. Initial results are neutral (Li et al. 2006, annual report to STAR/NESDIS), but we are optimistic that this approach will improve the retrieval accuracy. TC and SC will be our emphasis in SFOV sounding improvement.
- The single FOV retrieval algorithm has been implemented into the NOAA/NESDIS operational processing. According to guidance from the Technical Advisory Committee (TAC), we have conducted a study to answer some important questions. These questions include: (1) whether a single FOV retrieval has the same or improved accuracy compared to the 3x3 FOV retrieval, and (2) what is the advantage of a single FOV retrieval over 3x3 FOV retrievals. We found that 3 by 3 FOV retrievals are more accurate than single FOV retrievals while single FOV (10 km spatial resolution) retrievals yield better the moisture spatial gradient. It is very important to reduce the single FOV noise through spatial and temporal filtering. We plan to investigate noise filtering using TC and SC to improve single FOV sounding products.
- Global Positioning System (GPS) water vapor measurements are used to evaluate the GOES sounding retrievals. Usually radiosonde observations (RAOB) are used to evaluate retrievals over CONUS, but the validation is limited to 00 UTC and 12 UTC. Using GPS total precipitable water (TPW) measurements, we can evaluate GOES Sounder moisture retrievals at the time of measurement. Additionally, we investigated combining GPS and GOES Sounder radiances to improve sounding products. We found that combining GPS with GOES Sounder radiances improved the moisture product.
- An improved GOES sounding physical retrieval algorithm has been developed to retrieve temperature and moisture profiles, surface skin temperature, surface emissivities and TPW. We used the forecast error covariance (derived from a historical forecast/RAOB matchup data) in the maximum likelihood (ML) optimal estimation algorithm. Doing so, we found that the forecast error covariance information plays an important role in the GOES sounding retrieval, which is consistent with what was found in a NWP data assimilation study. Unlike the CIMSS legacy and NOAA/NESDIS operational method (Ma et al. 1999, JAM), the new

algorithm is less sensitive to noise. The new algorithm has been verified using three years of microwave radiometer measured TPW over the ARM CART site. We found that the updated algorithm improves the TPW over the legacy algorithm for both 3x3 FOV and SFOV retrievals (Li et al. 2006, annual report to NESDIS/STAR). The figure below shows the scatterplot comparing GOES Sounder TPW retrievals and microwave TPW. The improvement of the new algorithm over both the forecast and legacy products is significant. Currently, we are implementing this new algorithm into the CIMSS merged processing system for routine testing and evaluation. This software will be provided to collaborators at interested Cooperative Institutes and NESDIS/STAR/FPDT for their evaluation at the end of this year.

- A new ozone algorithm has been developed for the GOES Sounder total column ozone (TCO) retrieval. A 1% improvement was found applying the new algorithm over the old version (Li et al. 2001, JTECH). Bias correction is applied in the new version (the old version does not have bias correction). Ozone Monitoring Instrument (OMI) data from the Earth Observing System (EOS) Aura platform were used to validate the new algorithm. Good agreement was found between OMI and GOES-12 Sounder SFOV TCO. A paper on the new GOES Sounder ozone product has been published in *Geophysical Research Letters* (Li et al. 2007). The improved GOES SFOV TCO is being processing at CIMSS in real time (http://cimss.ssec.wisc.edu/goes/realtime/) and is available to interested users.



The scatterplot comparing GOES Sounder TPW and the three years' of microwave TPW at the ARM CART site. Blue dots are physical retrievals using regression as first guess, green Xs are physical retrievals using forecast as the first guess.

GIMPAP: Tropical Cyclone Intensity Change from GOES

Personnel: James Kossin

Funded by: NOAA

Project Description and Accomplishments

The goal of this research is to extract more information from GOES IR imagery that is related to hurricane intensity change, and apply this information to increasing intensity forecast skill through modification of the operational SHIPS model. Previous work has demonstrated that information gleaned from GOES IR imagery about the state of the hurricane inner-core can also be related to intensity change. This was shown by the addition of GOES IR-based predictors to the existing environment-based predictor suite of SHIPS, which increased skill. The GOES data in these previous studies comprised imagery only back to 1995. Our first goal was to extend this dataset back in time and we have significantly extended the record of SHIPS predictors. This required reprocessing GOES imagery, constructing algorithms to analyze the data and extract the required SHIPS predictors, forming a new dataset for inclusion and testing in the SHIPS model, and transferring the data and documentation to collaborators in the NOAA/NESDIS RAMM-B Team at CIRA/CSU (DeMaria and Knaff). Formal testing is presently underway.

PSDI: GOES WF_ABBA Operational Support

Personnel: Christopher Schmidt, Elaine Prins (Consultant), Jason Brunner, Jay Hoffman

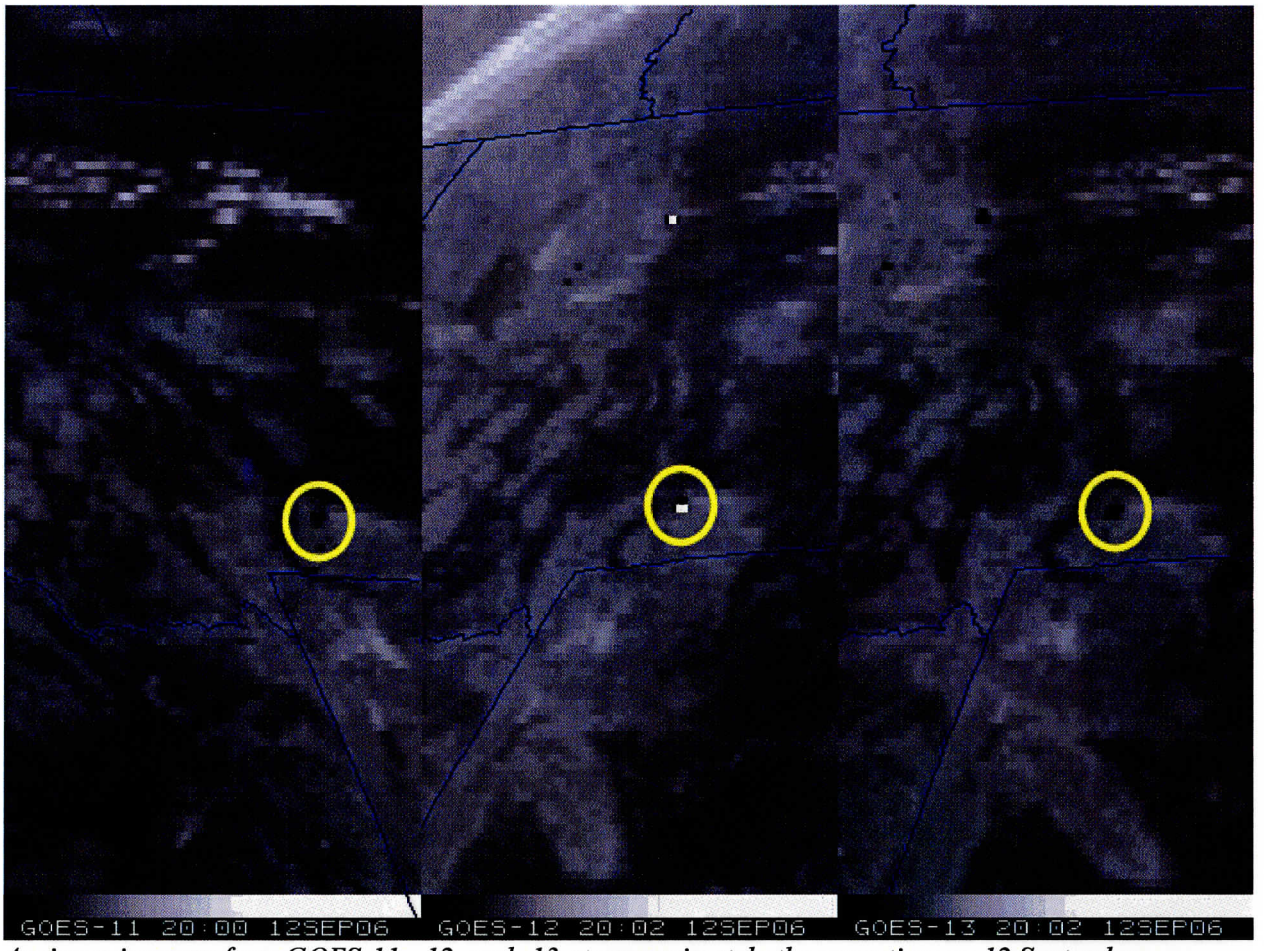
Funded by: NOAA

Project Description

In 2002 CIMSS delivered and NOAA implemented the GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA) as a realtime, operational product. The system has performed reliably but requires periodic maintenance due to changes in satellites, software (such as McIDAS and the underlying operating system), and data availability issues. Upgrades to the processing system are a part of the task as well, with the largest being creation of a system that will process all data from a given (and supported by the WF_ABBA) satellite. This is often referred to as the "RSO Support", though the underlying system must be flexible enough to handle any satellite schedule and remain within the 5 minute latency window. This project also includes tasks to provide WF_ABBA support for Meteosat-8/-9 and MTSAT-1R.

Accomplishments

- Upgrades to McIDAS and the underlying operating system have required a number of adjustments to the system, which CIMSS has performed.
- In March 2006 CIMSS discovered that GOES-12 had developed a "roll-over" or "wrap-around" issue with its 4 micron data, dating back to 1 February 2006. CIMSS worked with NESDIS to identify the problem and create a software solution to patch the incoming satellite data so that information on the hottest fires was not lost. The cause was a loss of sensitivity by the 4 micron sensor, most likely due to contamination of an optical window. Efforts to repair this situation on 22 February 2007 were apparently unsuccessful. CIMSS has since taken its data patch a step further to account for further loss of response by the 4 micron sensor of the GOES-12 Imager.
- CIMSS rapidly, and successfully, deployed the GOES-11 update in June 2006.
- CIMSS developed the GOES-13 update, to be deployed in early May 2007. (This update is concurrent with the fix to handle further loss of response by GOES-12)
- Meteosat -8/-9 and MTSAT-1R support has been developed with full support coming in Summer/Fall 2007.



4 micron imagery from GOES-11, -12, and -13 at approximately the same time on 12 September 2006. The fire hotspot (dark spot) highlighted by the yellow circle is the same fire in all three views. The white hotspot pixels in the GOES-12 imagery are due to the "roll-over" caused by the loss of sensitivity by the 4 micron detector. The loss of sensitivity leads to a higher saturation temperature, and the calibrated scale used by most software has a fixed calibration scale, which causes very hot pixels to appear very cold (in this case, white). (Image courtesy of Scott Bachmeier, http://cimss.ssec.wisc.edu/goes/blog/2006/09/12/fires-in-montana/)

PSDI: GOES-N[13] Routine Check-out and Data Archive

Personnel: Scott Bachmeier, Jim Nelson, Tony Schreiner, Mat Gunshor, Dee Wade, Chris Velden, Steve Wanzong, Gary Wade, Tim Schmit

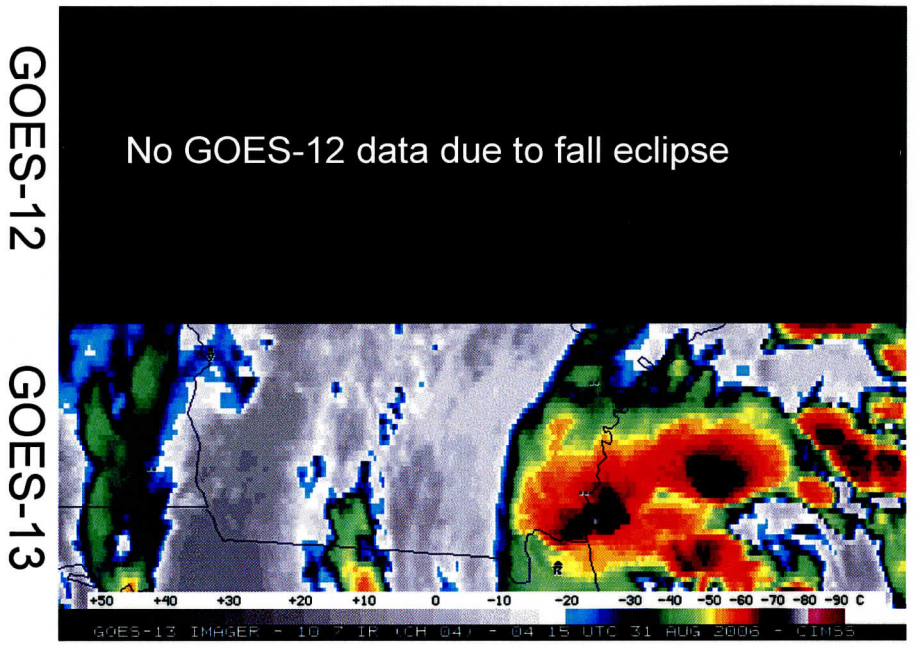
Funded by: NOAA

Project Description

GOES-13 was launched on May 24, 2006. A post launch engineering (July – December 2006) and science (December 2006 – January 2007) checkout was conducted. Even though the data collection phase is now done, additional analysis of the radiance data and product generation and validation remains to be completed. CIMSS has been very active with the GOES-13 science checkout, which is a critical step toward operational use. To assist in the checkout, CIMSS built a routine GOES-13 processing system. The integrity of GOES-13 Imager and Sounder radiances was investigated. Because of the new spacecraft bus for GOES-13, initial work in checking out the improved navigation and "eclipse free" schedules was also performed. The steps required to complete the checkout were similar to previous post-launch checkouts. Preliminary post-launch results are described in Hillger and Schmit (2007). Similar to previous instrument checkouts, these results will be added to previous results on the Web, and information will be provided for a NOAA Technical Report.

Accomplishments

- Archived the Sounder and Imager GVAR signal, during both the 5-week NOAA Science Test while the satellite was stationed at 105°W longitude and the summer of 2006 when GOES-13 was stationed at 90°W longitude.
- First GOES-13 Imager and Sounder images
- First GOES-13 vs GOES-11 comparisons (visible and infrared)
- First GOES-13 vs GOES-10 comparisons (visible and infrared)
- First GOES-13 vs AIRS comparisons (infrared)
- Generated GOES-13 Sounder Temperature/Moisture Retrievals
- Generated Cloud Top Pressure and Effective Cloud Amount (from both the Sounder & Imager)
- Generated GOES-13 Imager winds and compared them to GOES-12 winds
- Generated Clear Sky Brightness Temperatures and made files available to global NWP centers
- Verified the improved GOES-13 navigation
- Generated Derived Product Imagery (DPI)
- Found a GOES-13 Sounder detector-to-detector bias in several surface-viewing bands
- Discovered an apparent cold bias in the GOES-13 Imager 13.3 um band
- Determined the signal-to-noise characteristics of the Imager and Sounder
- Assisted in the initial eclipse and KOZ (Keep Out Zone) analysis
- Placed results on Web pages:
  http://rammb.cira.colostate.edu/projects/goes_n/ or
  http://cimss.ssec.wisc.edu/goes/blog/category/goes-13/
- Developed and posted a GOES-N VISITview training module



One of the important changes made to the GOES-N/O/P series of satellites is the addition of increased onboard battery capacity to enable the satellites to continue to provide Imager and Sounder data during the Spring and Fall season "eclipse periods." During these eclipse periods (which can last from 1-3 hours), the GOES satellites are in the earth's shadow, so their solar panels cannot provide power to all of the satellite instrument payloads. This figure shows GOES-13 10.7 micrometer infrared ("IR window") data from 0415 UTC 31Aug2006, showing convective rain bands. However, no GOES-12 images were available between 04:15 UTC and 06:15 UTC on this date, a period during which this particular convection was exhibiting a trend of cooling cloudtop temperatures.

PSDI: GOES Atmospheric Motion Vectors – Algorithm Development and Operational Transition

Personnel: Chris Velden (PI), Steve Wanzong, Howard Berger

Funded by: NOAA

Project Description

CIMSS has supported the research and development of the automated satellite winds tracking software for the last 25 years. Under this funding, the CIMSS winds research team is committed to help maintain and advance the winds algorithm science modules and capabilities. This includes any new science advances, validation, and developments for the science community. The algorithm upgrades are then made available to colleagues at NOAA/NESDIS for operational consideration/implementation.

Accomplishments

1. Code science advances/upgrades provided to USAF/AFWA (NESDIS operational national backup). CIMSS is providing software assistance and upgrades to AFWA as their GOES winds production is now operational. The goal is to keep the algorithm version reasonably close to the NOAA/NESDIS operational version for output consistency.

2. The implementation and testing of new QC software obtained from John LeMarshall (JCSDA) continues. This code appends a new vector "expected error" (EE), that will be useful for data assimilation purposes. The code has been rewritten from its original format into code compatible with GOES winds algorithm versions currently in place at CIMSS and operationally at NOAA/NESDIS. Testing has yielded reasonable EE values, and it appears this indicator may have more value than the currently employed QI index. The EE is in the process of being evaluated for operational implementation.

In addition to the above accomplishments, CIMSS is a responder to NESDIS Winds POP action items, as well as an active member of the WMO-sponsored International Winds Workshops. Four CIMSS scientists working on GOES winds research attended the recent IWW in Beijing, China. Through these venues, ideas are continuously exchanged between the CIMSS PIs, the NESDIS winds specialists, and the international winds community.

PSDI: Spectral Response

Personnel: Mat Gunshor, Hal Woolf, Tim Schmit

Funded by: NOAA

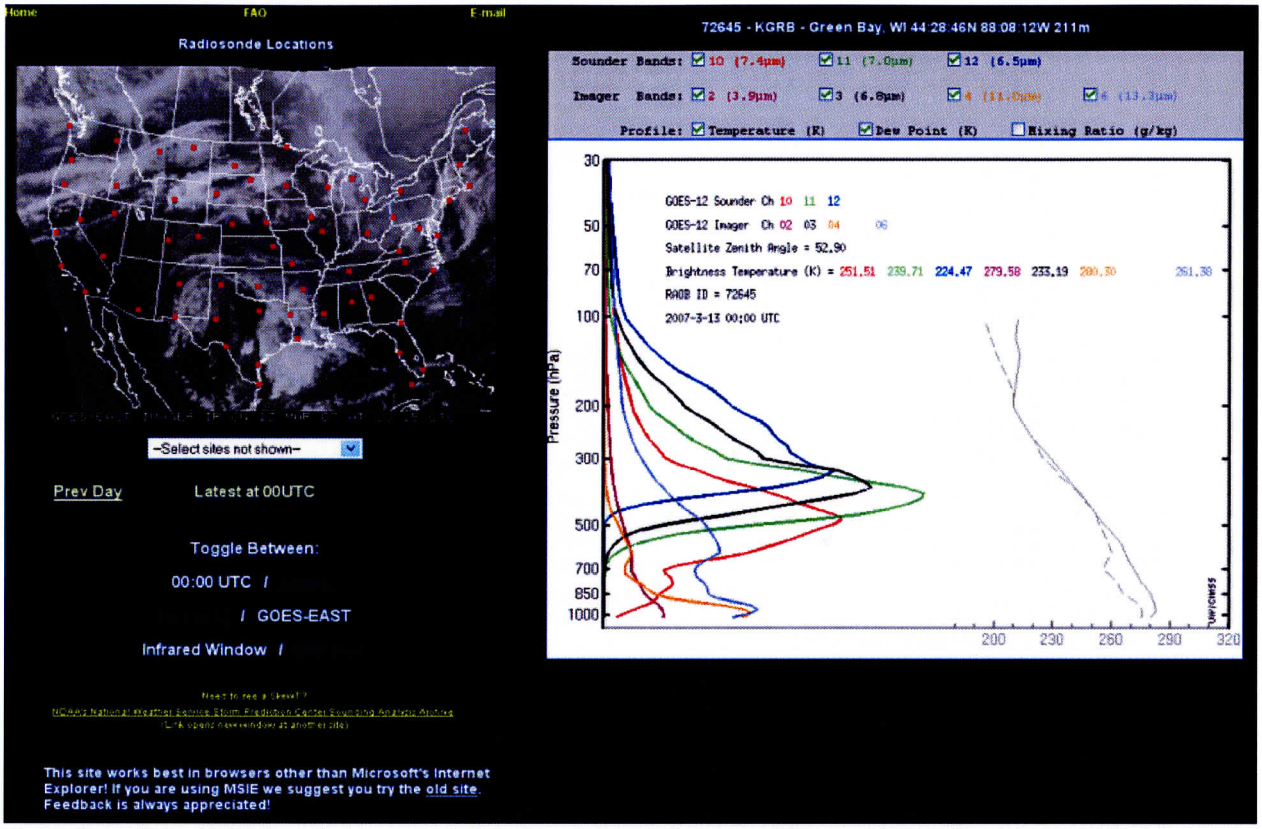
Project Description

CIMSS scientists prepare for quantitative use of satellite radiances by generating transmittance files calculated from Spectral Response Functions (SRF) used in conjunction with a line by line radiative transfer model (LBLRTM). This work is necessary to prepare for the eventual use of those satellite data and eventual generation of research and operational products.

The goal of this research is to maintain a high level of accuracy in the calculations obtained from the GOES series of sounders and imagers. This requires obtaining and maintaining a database of instrument SRFs and transmittance coefficient files for satellite instruments such as GOES (Imager and Sounder), AVHRR, HIRS, MODIS, METEOSAT, MTSAT, and FY2. These are then used in a myriad of research and operational products such as fire detection, atmospheric motion vectors, cloud top pressure, clear sky brightness temperatures, and GOES sounder retrievals. Regular monitoring of updates to the LBLRTM are required as well. AER (Atmospheric Environmental Research, Inc.) continually updates the line by line radiative transfer model and these updates are investigated for their effects on forward model calculations, retrievals, and other related applications such as weighting functions.

Accomplishments

- Maintained a database of global satellite instrument Spectral Response Functions and the associated transmittance coefficient files necessary for the operation of a fast forward radiative transfer model.
- Monitored AER's changes to the LBLRTM for changes that would affect CIMSS.
- Developed a real-time GOES weighting functions web page.



Snapshot of the GOES real-time weighting functions web page. The weighting functions at KGRB (Green Bay, WI) on March 13, 2007 are shown.

PSDI: Product Quality Assurance and Science (PQAS) Support for Operational GOES Imager and Sounder Products

Personnel: Jim Nelson, Tony Schreiner, Chris Velden, Steve Wanzong, Bill Bellon, Gary Wade, Tim Schmit

Funded by: NOAA

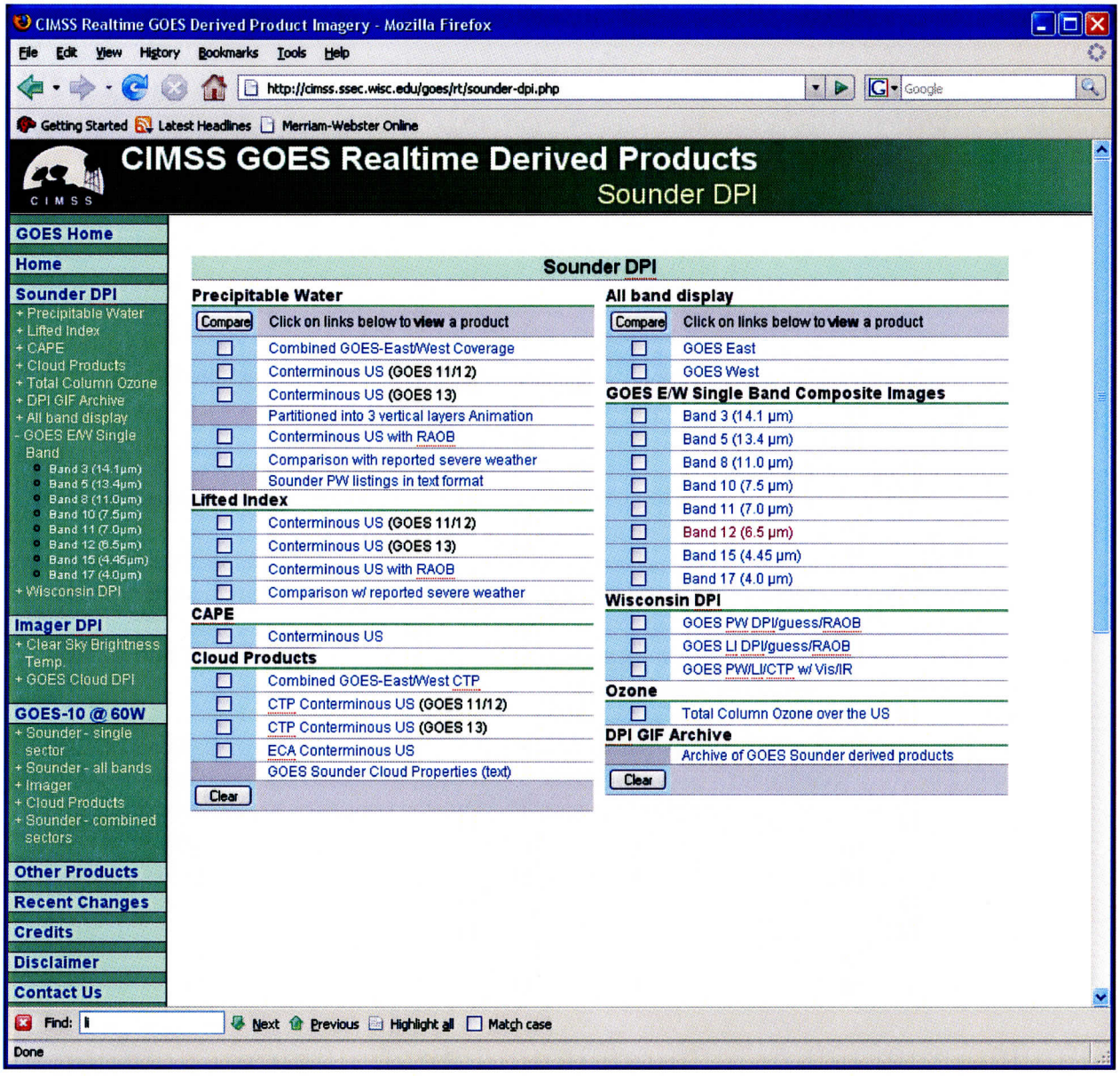
Project Description

This project supports GOES Imager and Sounder data quality assurance and science algorithm maintenance. It is a project broad in scope, involving aspects of both computer software and hardware, and diverse processing such as temperature and moisture retrievals, cloud retrievals, and GOES winds processing. One example of work conducted under this project would be to repair problems with the GOES Sounder and (or) Imager product software to handle special atmospheric or computing environment conditions. Another example would be working with personnel within SSEC to acquire new computing resources. Work supported under this project is vital for maintaining the integrity of all the GOES Imager and Sounder research products produced at CIMSS, many of which can be seen at the following Web sites:

http://cimss.ssec.wisc.edu/goes/rt/
http://cimss.ssec.wisc.edu/tropic/real-time/atlantic/winds/winds.html

Accomplishments

- Software has been written and is now functioning that performs the daily archive at CIMSS of approximately 40GB of temperature/moisture retrieval, cloud retrieval and related data. This archive is vital for any retrospective research, and is of course always available to our colleagues at NOAA/NESDIS.
- More files have been added to the SSEC Concurrent Versions System (CVS) repository that contains various Imager and Sounder software and associated ancillary files. Use of CVS greatly enhances the integrity of CIMSS GOES software and related files. Use of the standard UNIX "make" and "tar" utilities continues to grow, aiding in software development. Together, these utilities are extremely useful for organizing development at the computer program level, and will be valuable when migrating software from CIMSS to NOAA/NESDIS operations.
- On 21 June 2006, GOES-11 replaced GOES-10 as the operational western geostationary satellite, and software updates were performed to make that transition at CIMSS.
- GOES winds software science advances and upgrades were made available to users such as the USAF/AFWA (Air Force Weather Agency). AFWA winds production is now operational; they also serve as a backup to NOAA/NESDIS.
- The latest version of the McIDAS-X software (version 2006) was installed on a number of CIMSS workstations.
- In the latter part of 2006, work began toward acquiring additional computing hardware, that will significantly enhance retrieval processing capabilities.
- The CIMSS near real-time experimental Web page has been updated to use the php and JavaScript languages. The updated page is easier to maintain, and allows more flexibility in terms of image comparisons.



The updated CIMSS GOES Sounder Derived Products Web page. Products from both GOES-11 and -12 Sounders are shown. The URL for this Web page is http://cimss.ssec.wisc.edu/goes/rt/sounder-dpi.php

PSDI: Gridded Cloud Product

Personnel: Anthony Schreiner, Scott Lindstrom, Robert Aune, Timothy Schmit

Funded by: NOAA

Project Description

This was a two year project to determine the quality of the GOES Sounder Effective Cloud Amount (ECA) reformatted to a Lambert Conformal Grid over the CONterminous United States (CONUS) in GRIB-2 format. The goal for CIMSS was to

- Assist in making this an operational product.
- Reconfirm that the Lambert Conformal gridded version produced operationally is qualitatively the same as the native product.

Accomplishments

- Examined the quality of the analyses and performed quality checks on the meteorological "reasonableness" of the gridded product.
- Validated the gridded cloud product against the GOES Sounder cloud product, making sure the derived gridded product was not degraded when transformed from the native product to the Lambert Conformal projection.
- The gridded cloud amount product became available as an hourly NESDIS operational product on 1 November 2006.

Figure 1 is an example of the native product (a Lambert Conformal gridded projection in GRIB-2 format). The color enhancement from tan to blue to yellow infer thin to opaque clouds, respectively. Figure 2 is an example of the operational product (a Mercator projection of the derived image processed by the NOAA/NESDIS/OSDPD group). The colored regions from salmon to light blue to yellow indicate thin to opaque clouds, respectively.

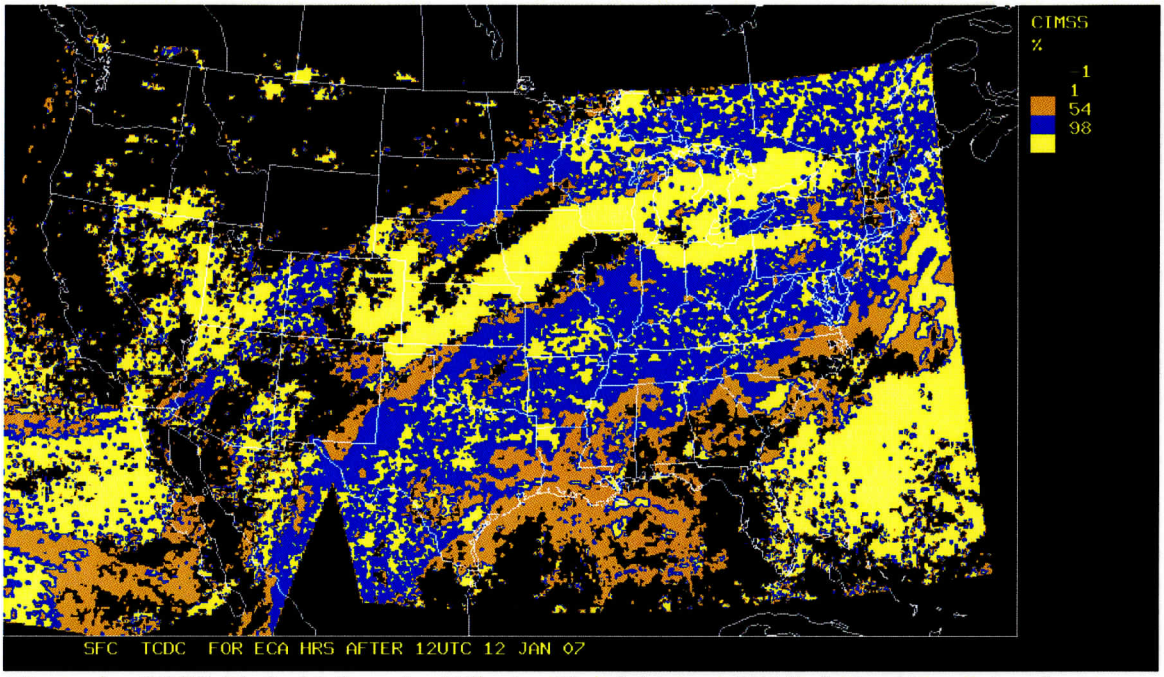


Figure 1: *GOES-11 & -12 Sounder Effective Cloud Amount (ECA) derived image Lambert Conformal gridded projection for 12 January 2007 at 1200 UTC.*

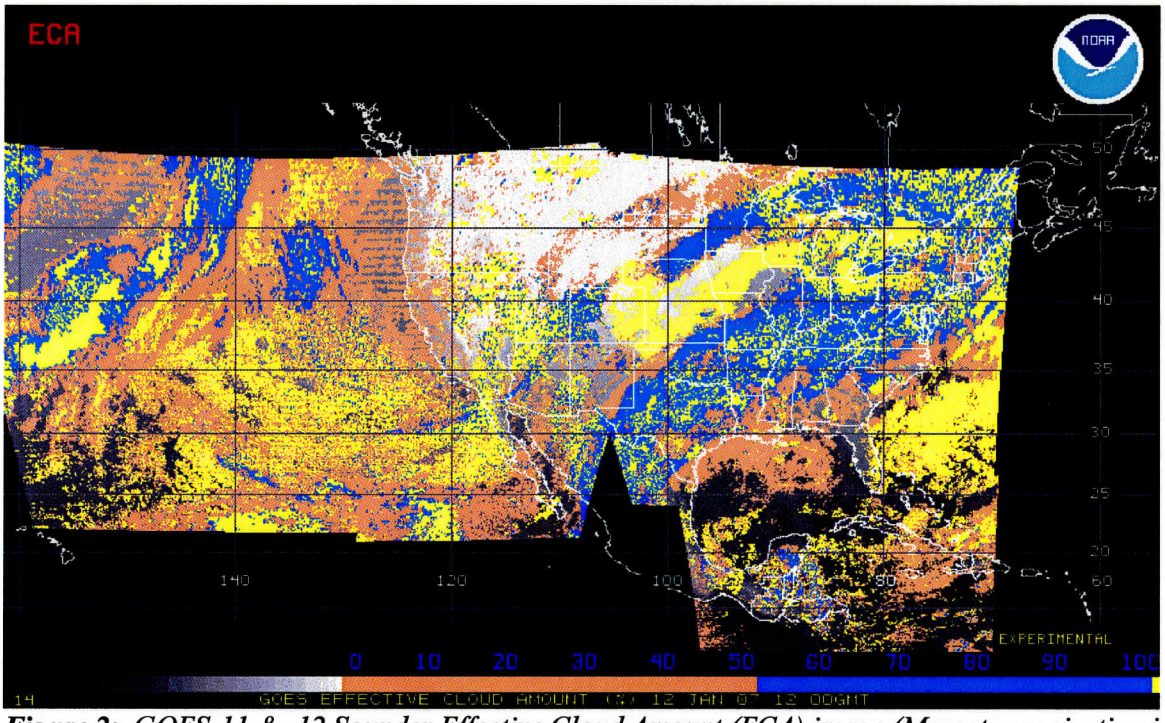


Figure 2: *GOES-11 & -12 Sounder Effective Cloud Amount (ECA) image (Mercator projection in GRIB-2 format) for 12 January 2007 at 1200 UTC.*

PSDI: GOES Full Disk Surface Insolation Project (GSIP-fd)

Personnel: Andrew Heidinger, William Straka

Funded by: NOAA

Project Description

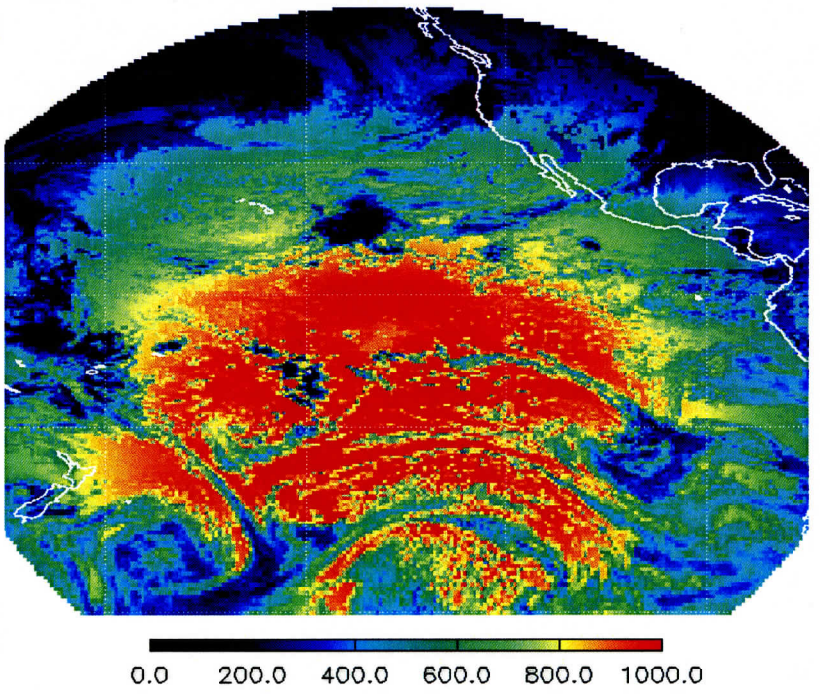
GOES Surface and Insolation Project Processing (GSIP) is a flexible fortran-90 GOES imager processing system. While originally developed by A. Heidinger, NESDIS has continued the development of the GSIP system. The work at CIMSS is focused on solving some remaining technical challenges. These challenges include increasing the speed of the code as well as verifying and optimizing the cloud algorithms. Also, CIMSS is responsible for making some core enhancements to the cloud algorithms. Additionally, CIMSS is tasked with validating the GSIP products over the ocean as requested by the coral bleaching group in NESDIS.

In summary, the objectives of this project are as follows:

- Develop the GSIP full-disk processing system for transition to STAR and eventually NOAA operations
- Develop cloud algorithms appropriate for real-time operations from GOES-NOP imagers
- Validate the GSIP products in collaboration with STAR personnel

Accomplishments

- Modified the GSIP system to produce requested HDF output
- Validated the GSIP insolation over oceans using TAO buoy data
- Implemented CLAVR-x cloud algorithms to ensure consistent POES/GOES cloud product suite



Example image of GSIP Solar Insolation from GOES-10 for 21 UTC on day 341 in 2004. Units are Watts per square meter.

PSDI: Polar Winds from Satellite Imagers and Sounders

Personnel: Jeff Key, Dave Santek, Chris Velden, William Straka III

Funded by: NOAA (PSDI) and NASA

Project Description

Geostationary satellite radiance measurements have been used to generate cloud-drift winds in the low- and mid-latitudes of the western hemisphere for more than two decades. Fully automated cloud-drift wind production from the Geostationary Operational Environmental Satellites (GOES) became operational in 1996, and wind vectors are routinely used in operational numerical models of the National Centers for Environmental Prediction (NCEP). Unfortunately, GOES is of little use at high latitudes due to the poor viewing geometry. To fill the gap, a method was developed to generate wind vectors over the polar regions with MODIS (Figure 1).

Can the polar wind data improve weather forecasts? Overall, the impact of the MODIS polar winds on numerical weather forecasts is positive (Figure 2), meaning that weather forecasts are improved when this new wind data are assimilated in numerical weather prediction models. This is true not only in the polar regions where the data are obtained, but also for the Northern and Southern Hemisphere extratropics (poleward of 20 degrees latitude).

We are also generating and analyzing a 20-year polar wind data set covering both polar regions, poleward of approximately 65 degrees latitude, using historical Advanced Very High Resolution (AVHRR) Global Area Coverage (GAC) data from NOAA satellites. The winds data set will extend the record back 20 years, providing an invaluable product for the verification of, and assimilation in, climate prediction models. An example of the AVHRR winds is shown in Figure 3.

Accomplishments

- MODIS polar winds continue to be produced in real-time with a 3-5 hour delay. They are used operationally by ten (10) numerical weather prediction (NWP) centers in five countries: the Joint Center for Satellite Data Assimilation (JCSDA), the European Centre for Medium-Range Weather Forecasts (ECMWF), the NASA Global Modeling and Assimilation Office (GMAO), the U.K. Met Office, the Canadian Meteorological Centre (CMC), the Japan Meteorological Agency (JMA), the U.S. Navy's, Fleet Numerical Meteorology and Oceanography Center (FNMOC), Deutscher Wetterdienst (DWD; Germany), MeteoFrance, and the National Center for Atmospheric Research (NCAR).
- Model output from several different experiments were investigated to determine possible mechanisms that propagate the polar wind information into mid- and low-latitudes.
- Systems to generate MODIS winds with direct broadcast (DB) data were developed and implemented at Tromsø, Norway, McMurdo, Antarctica, and Sodankylä, Finland. The U.S. Navy has begun operational use of the DB winds.
- All AVHRR GAC data for the project have been acquired, navigated, and calibrated. The period of coverage is 1982-2002 (21 years). Although multiple NOAA satellites are typically in orbit, only one satellite is employed at any given time.
- A comparison of AVHRR and ERA-40 winds with rawinsonde data not assimilated into the reanalysis shows that, overall, AVHRR has much lower speed bias and root-mean-square (RMS) difference values than ERA-40. However, ERA-40 did have slightly better direction

bias and RMS values.

- A three month sample of the AVHRR winds (January through March 1989) was sent to ECMWF to be tested in their new reanalysis. Furthermore, dynamical reasons for differences between ERA-40 and AVHRR winds over the Arctic are currently being investigated.

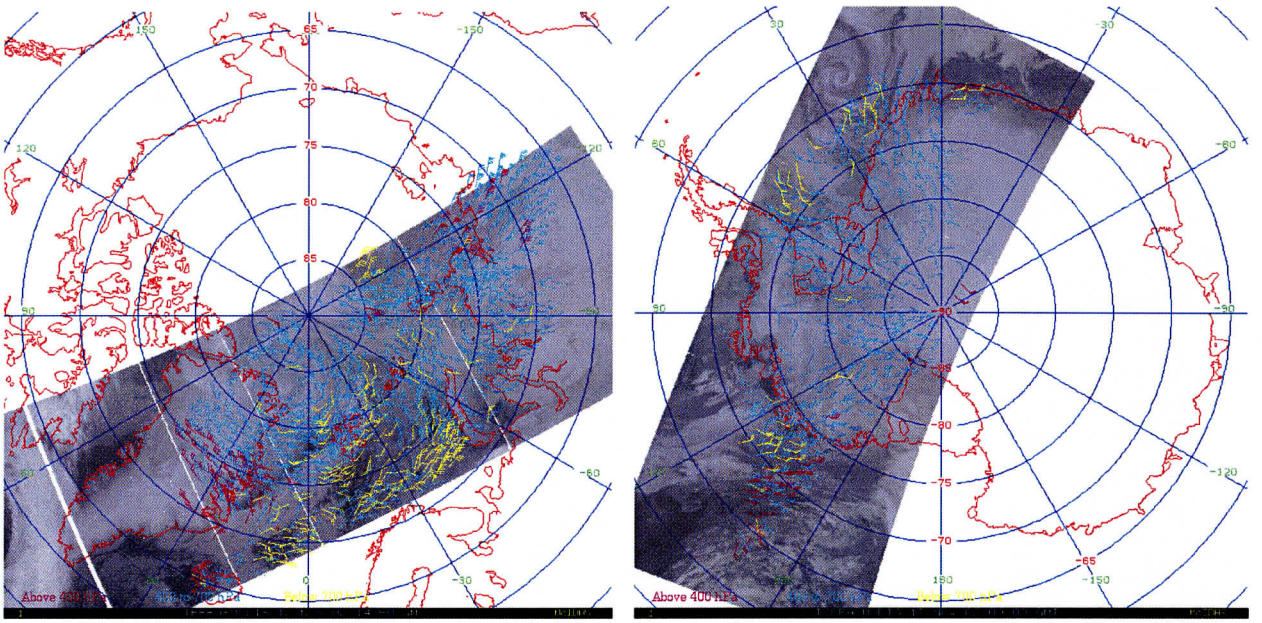


Fig. 1. Winds from Terra MODIS over the Arctic (top) and Antarctic (bottom) for one 100-minute period on November 12, 2002. Wind vector heights are categorized as low (yellow), middle (cyan), and high (magenta).

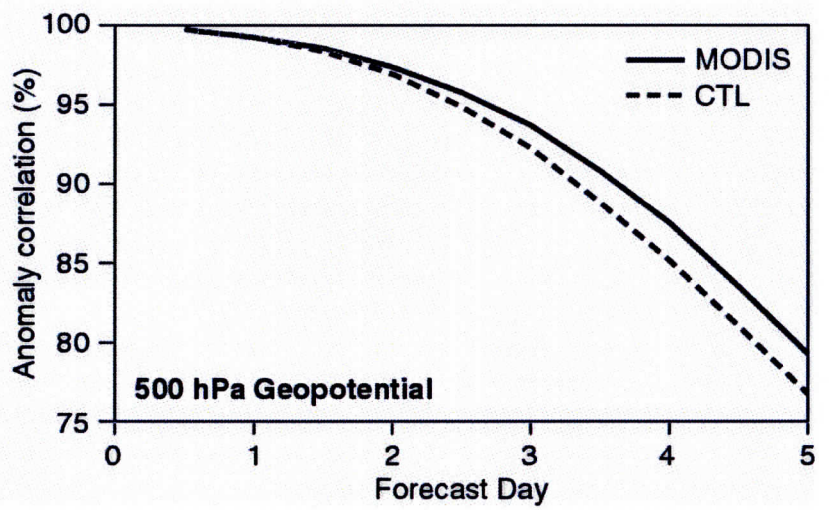


Fig. 2. Forecast scores, or 'anomaly correlation' for a 30-day Arctic case study done by ECMWF. The figure shows the forecast skill for model runs with (MODIS) and without (CTL) the polar winds data. Anomaly correlation expresses the agreement between a forecast and the actual state of the atmosphere, where the higher the percent, the better the agreement. Starting with the second day, the forecasts that used the MODIS winds were in better agreement with the actual weather than the forecasts that did not.

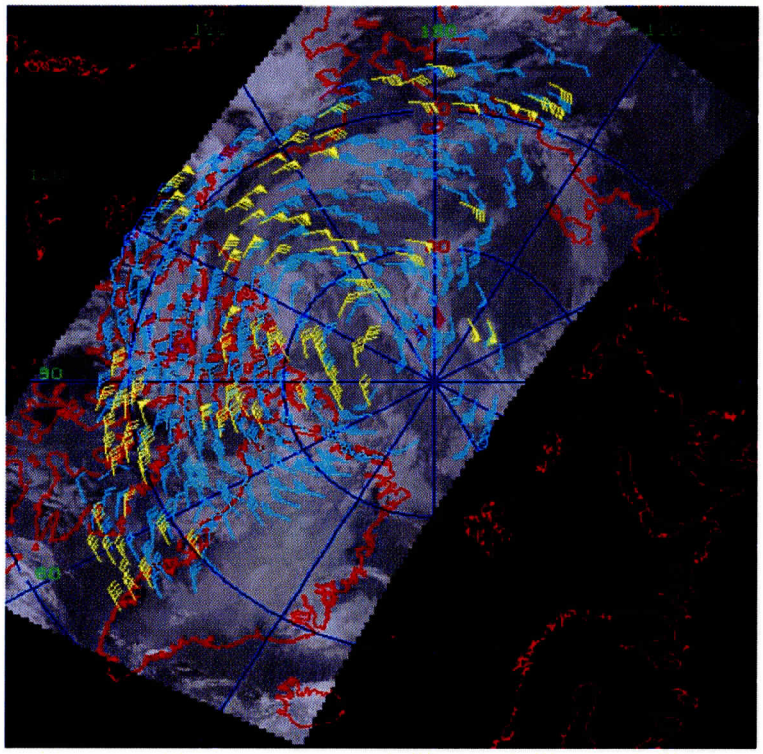


Fig. 3. An example of winds produced from NOAA-11 AVHRR on August 5, 1993 at 1800 UTC. The background is the AVHRR 11 micron brightness temperature image. Wind vectors are grouped into three height categories (for illustration only): below 700 hPa (yellow), from 400 to 700 hPa (cyan), and above 400 hPa (magenta).

PSDI: GOES-12 Imager Cloud Product

Personnel: Anthony Schreiner, James Jung, Timothy Schmit, James Nelson, and Robert Aune

Funded by: NOAA

Project Description

The latest series of Geostationary Operational Environmental Satellites (GOES) Imagers includes a CO_2 band centered at 13.3 μm. With this new band, the Imagers are able to calculate cloud height or cloud top pressure and the effective cloud amount by using the CO_2 absorption technique. The advantages of using the Imager version of the Cloud Product are:

- Covers a larger geographical region,
- Provides more timely information, and
- Offers a cloud product at a more fine resolution than the GOES Sounder cloud product.

Over the course of the development of the GOES-12 Imager Cloud Product processing algorithm several improvements were incorporated. They included a technique to interpolate the cloud top pressure between fixed forward model levels, a brightness temperature bias correction, and an improved method for determining calculated radiances. In addition a comparison of three cloud height techniques (CO_2 Absorption, H_2O Water Vapor Intercept, and IR Window Techniques) using the GOES-12 Imager radiances showed that the CO_2 Absorption Technique outperformed the other two cloud processing algorithms.

This product may benefit a number of uses, including:

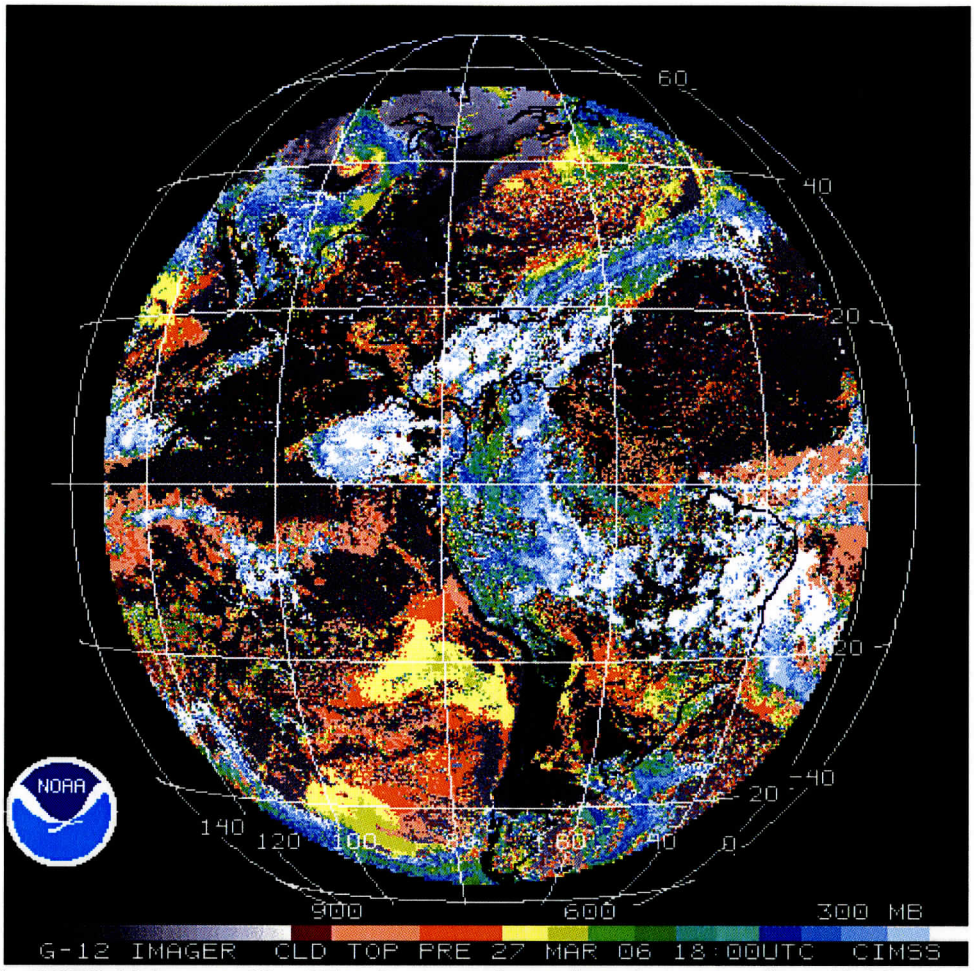
- Aviation weather forecasting,
- Numerical weather prediction (for analysis or validations), and
- Potentially for use in assisting in the identification of volcanic eruptions.

The GOES-12 Imager cloud product is being produced experimentally by CIMSS in near real time. Some validation efforts have been done, which look encouraging.

Accomplishments

Over the past two years the primary accomplishments were:

- After routine processing was demonstrated at CIMSS, the software was made available to the Operational Products Development Branch (OPDB).
- Documentation of the code was completed.
- The GOES-12 Imager Cloud Product became an operational product at OPDB on 31 July 2006.
- At CIMSS the GOES-12 Imager Cloud Product is being used as input in the CIMSS Regional Analysis System (CRAS) forecasts over South America.



An example GOES-12 Imager Cloud Top Pressure derived product image from 27 March 2006.

PSDI: Clouds from AVHRR Extended (CLAVR-x)

Personnel: Andrew Heidinger, Michael Pavolonis, William Straka

Funded by: NOAA

Project Description

CLAVR-x is NOAA's newest AVHRR cloud processing system. CLAVR-x has two responsibilities within NESDIS. First, it provides a common cloud mask to several NESDIS algorithms and is written to the official AVHRR Level-1b data stream. Second, CLAVR-x provides a full suite of cloud properties for NOAA's customers. The cloud properties produced include cloud mask, cloud type, cloud amounts by layer, cloud optical thickness, particle sizes and cloud top heights. The CLAVR-x cloud properties are delivered in an HDF format and are similar to those produced by NASA from the MODIS instrument and those that will be produced from the VIIRS instrument (the successor to the AVHRR).

The CLAVR-x research at CIMSS has been critical to the success of the CLAVR-x program within NOAA. CIMSS scientists have provided the research necessary to finish development and bring to maturity several of the CLAVR-x algorithms. Most notably, CIMSS scientists have played dominant roles in development of CLAVR-x cloud typing and cloud top height algorithms. The CLAVR-x program has benefited from the resident cloud expertise at CIMSS and from the existing cloud validation work done at CIMSS for other programs. In addition to developing CLAVR-x, CIMSS also runs CLAVR-x in near real-time and maintains a web site making data available from all current operational AVHRR data.

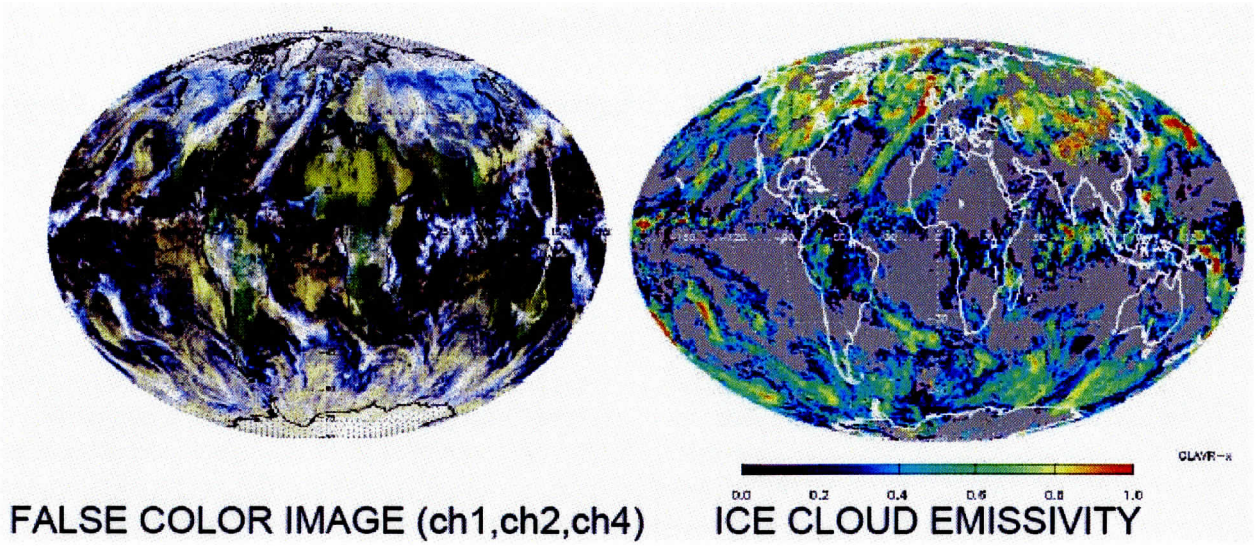
Recently, CLAVR-x has been modified for the METOP mission which will provide the first ever global 1km AVHRR observations. CLAVR-x development continues as lessons learned from GOES-R and NPOESS research is applied to the CLAVR-x algorithms. It is our goal to keep the AVHRR algorithms physically consistent with those applied to other NOAA sensors.

In summary our objectives are as follows:

- Provide a global pixel cloud mask of the AVHRR data,
- Provide high resolution pixel-level cloud properties, and
- Provide global low resolution layered cloud amounts and cloud properties as requested by NCEP.

Accomplishments

- We developed CLAVR-x into a flexible AVHRR processing system that can handle AVHRR data from any satellite and at any resolution.
- We transitioned code developed at CIMSS to NOAA operations in OSDPD.
- Products are used by NCEP, the JCSDA and other NESDIS customers.
- Many algorithms have been adopted or modified for NPOESS and GOES-R.



Example CLAVR-x products. Image on the left is a false color composite derived from three AVHRR channels. Image on the right is the emissivity of ice clouds.

PSDI: Derived Products from GOES-10 Sounder

Personnel: Dee Wade and the SSEC data center, Jim Nelson, Tony Schreiner, Gary Wade, Tim Schmit

Funded by: NOAA

Project Description

The migration of GOES-10 to routinely scan the Southern Hemisphere is a part of the Global Earth Observation System of Systems (GEOSS) project, which is a collaborative effort between NOAA and partners in the Americas and the Caribbean. GOES-10 is the first geostationary Sounder to routinely gather data over South America in more than 20 years. With appropriate data sharing, numerous GOES-10 products and services are available for the user community. These include temperature & moisture profiles, cloud product information, and the monitoring of ash and SO_2 by the Washington DC VAAC (Volcanic Ash Advisory Center). Furthermore, imagery from the GOES-10 Sounder could potentially improve Antarctica satellite composite imagery used by aviation concerns.

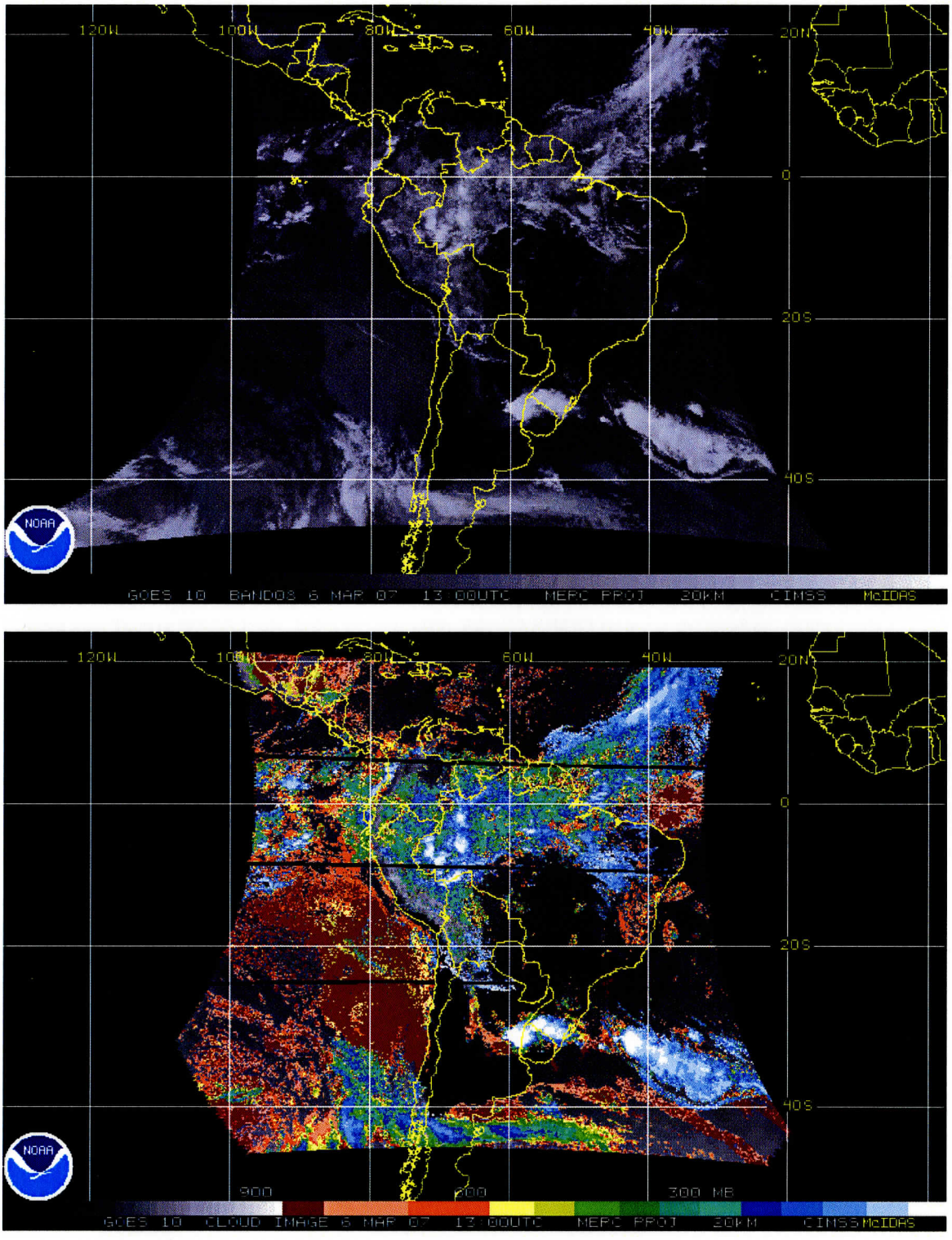
Many countries that are receiving geostationary Sounder data for the first time in 20 years will not be ready to produce meteorological products themselves. Users in those countries that are currently not generating GOES-10 products can access the CIMSS imagery and products via the Web. On the other hand, countries that are producing products can use the CIMSS products for validation purposes.

There are two phases in this project:

- Acquire and save the GOES-10 GVAR signal.
- Derive and post GOES-10 Sounder products.

Accomplishments

- The GOES-10 GVAR signal is being acquired and stored.
- Investigations into the required tracking antenna hardware have begun.
- Near-realtime GOES Sounder radiance images (both individual and multiple bands) are being posted to the Web.
- Near-realtime GOES Imager radiance images are being posted to the Web.
- Near realtime GOES Sounder cloud-top pressure and effective cloud amount images are being generated. Cloud top pressure imagery are being posted to the web.
- *Web site: http://cimss.ssec.wisc.edu/goes/rt/goes10.php*
- Improved 'house-keeping' Sounder scan scenarios were suggested and adopted.



GOES-10 Sounder 11μm infrared window data after merging the four sectors into a Mercator projection (top panel) and the corresponding GOES-10 Sounder cloud-top pressure Derived Product Image (DPI) (lower panel).

Extended GOES Operations at High Inclination Orbit

Personnel: Dee Wade and the SSEC data center, Dave Santek, Dave Parker, Chris Schmidt, Gary Wade, Tim Schmit

Funded by: NOAA

Project Description

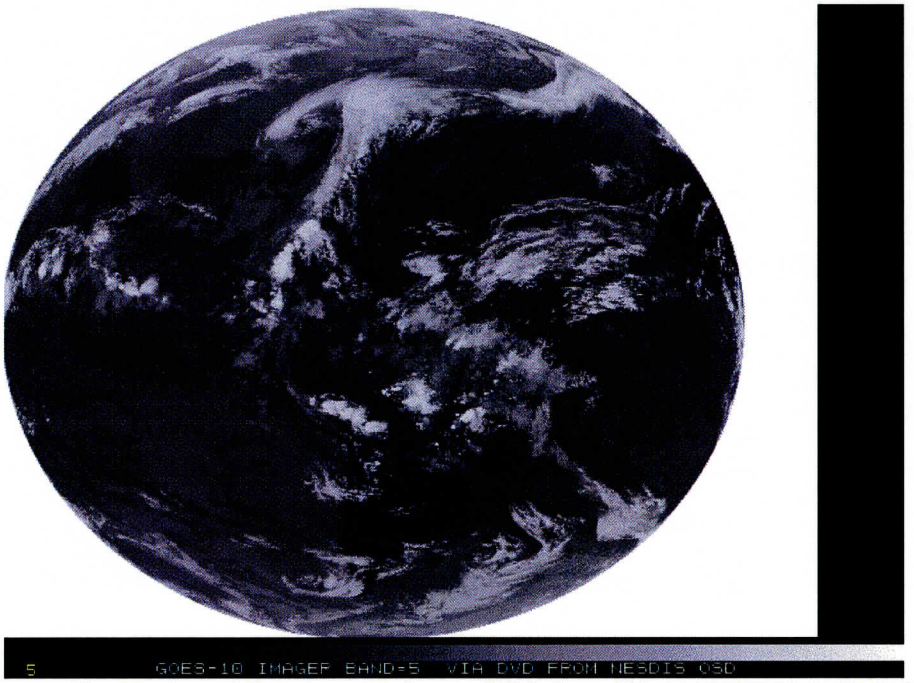
This proposed work is to conduct a study on the impact upon image and data product quality that the predicted high inclination orbit of GOES 10 will create. This proposal consists of two tasks related to the GOES-10 XGOHI (Extended GOES High Inclination) project: GVAR testing and select product testing.

There are two phases:

- Acquire from NOAA/NESDIS Office of Systems Development (OSD) the re-gridded GOES-10 GVAR signal.
- Assess any effect on products, comparing the original to re-gridded GOES-10 Imager data.

Accomplishments

Given that the XGOHI schedule has been pushed back to late April 2007 for sample datasets, and coupled with the fact that GOES-10 only arrived on station at 60 West in early December, limited work was done on this project. That said, sample GOES-10 GVAR signal has been acquired via a DVD. Historically, whenever special GOES GVAR data was needed, the GVAR signal was needed to be broadcast via a spare GOES satellite. Being able to acquire sample data off a DVD allows for much greater flexibility. Several telecoms with the XGOHI team in the Washington DC area were held.



GOES-10 Imager 12μm infrared data acquired via a DVD from NOAA NESDIS OSD (Office of Systems Development) and displayed with McIDAS.

Ground Systems: Global Geostationary Fire Monitoring

Personnel: Elaine Prins (Consultant), Christopher Schmidt, Scott Lindstrom, Jason Brunner, Jay Hoffman

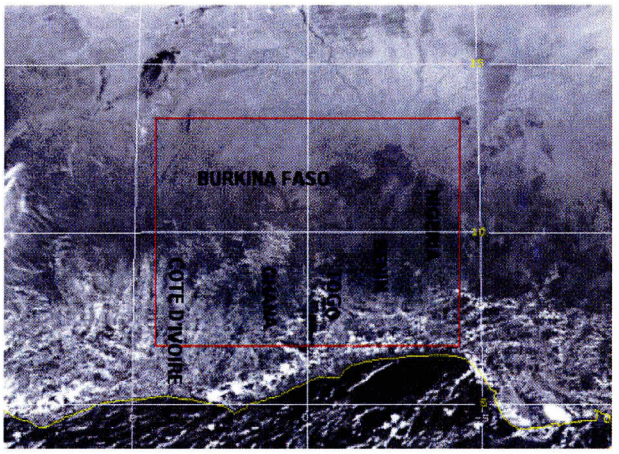
Funded by: NOAA

Project Description

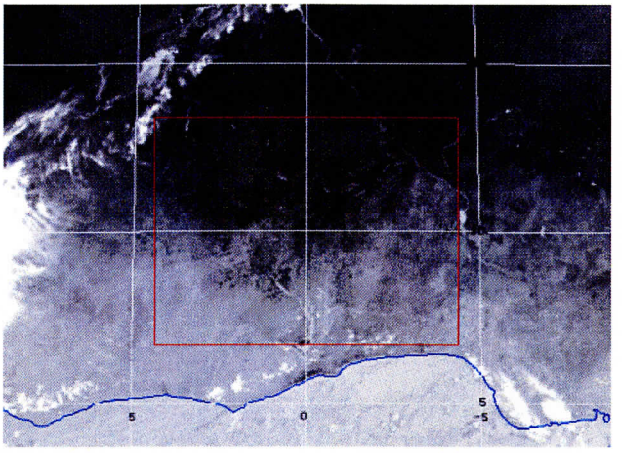
The U.S. and international environmental monitoring and scientific research communities have stressed the importance of utilizing operational meteorological satellites to produce routine fire products and to ensure long-term stable records of fire activity. On an international level, the Global Earth Observation System of Systems (GEOSS) and the Group on Earth Observations (GEO) 2006 work plan called for the initiation of "a globally coordinated warning system for fire and monitoring for forest conversion, including the development of improved information products and risk assessment models (DI-06-13)" and expanding "the use of meteorological geostationary satellites for the management of non-weather related hazards (DI-06-09)." Since the year 2000, the GOES-East/West Wildfire Automated Biomass Burning Algorithm (WF_ABBA) has been providing half-hourly information on active fire locations and sub-pixel fire characteristics for North, Central, and South America in near real-time. In June 2006 CIMSS began a multi-year effort to implement this capability around the globe by adapting the WF_ABBA to Met-8, MTSAT-1R, FY-2C, INSAT-3D and GOMS Elektro L. This work is made possible by cost-sharing with a related NASA IDS/ESE model data assimilation project.

Accomplishments

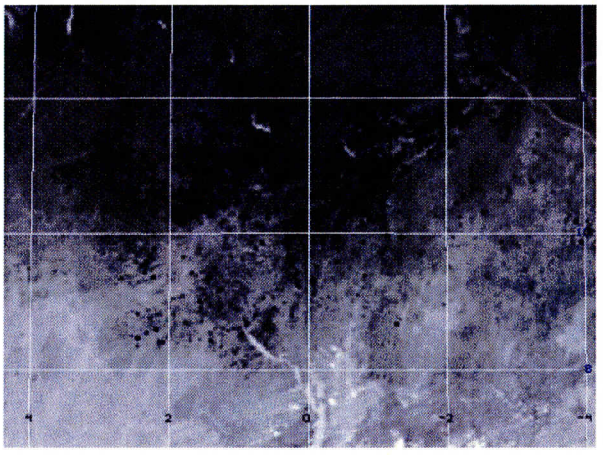
- The GOES WF_ABBA was adapted to Met-8 SEVIRI. This effort involved making substantial modifications to the current code.
- The Met-8 WF_ABBA was applied to a number of test cases in Africa and Europe and the code is being adjusted to better identify isolated single pixel fire events.
- The Met-8/-9 WF_ABBA is being modified to compute fire radiative power (FRP) in addition to Dozier estimates of instantaneous sub-pixel fire size and temperature. The accuracy of these estimates is in question due to the SEVIRI re-gridding/re-sampling protocol.
- A preliminary version of the MTSAT-1R WF_ABBA has been developed and applied to a case study in Southeast Asia. The low saturation temperature (~320 K) in the 4 micron band poses a significant problem for fire detection within 3 to 4 hours of local noon when the majority of burning occurs.
- Comparisons of GOES-9, MTSAT-1R and FY-2C 4 micron imagery showed that even when the region of interest is closer to the FY-2C subsatellite point than it is to GOES-9 and MTSAT-1R, the FY-2C does not seem to identify the fire pixels as readily as the other two platforms. UW-Madison CIMSS has begun a dialogue with Dr. Liu Cheng of the National Satellite Meteorological Center of the China Meteorological Administration to better understand the sensitivity of the FY-2C 4.0 micron channel to sub-pixel hot spots.
- Research activities during the initial phase of this effort have shown that with the substantial differences between the global geostationary instruments, it will be necessary to provide additional meta data to the user regarding processing regions, block-out zones (associated with biome types, regions of saturation, etc.), and opaque clouds.



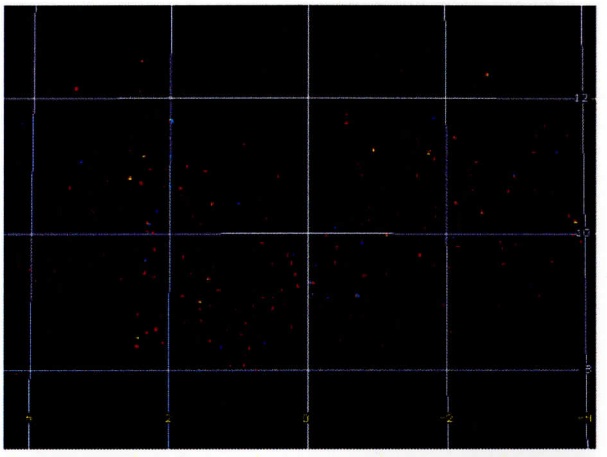
Met-8 Visible Image
Date: 3-Dec-2005 Time: 1300 UTC



Met-8 3.9 micron Image
Date: 3-Dec-2005 Time: 1300 UTC



Met-8 3.9 micron Image (Highlighted Region)
Date: 3-Dec-2005 Time: 1300 UTC



Application of the WF_ABBA to Met-8 SEVIRI data in Western Africa on 3 December 2005 at 1300 UTC. The dark hot spots in the highlighted 3.9 micron data primarily represent agricultural burning.

GOES-R Risk Reduction Profile Algorithm Development

Personnel: Jun Li, Allen Huang, Jinlong Li, Elisabeth Weisz, Xin Jin

Funded by: NOAA

Project Description

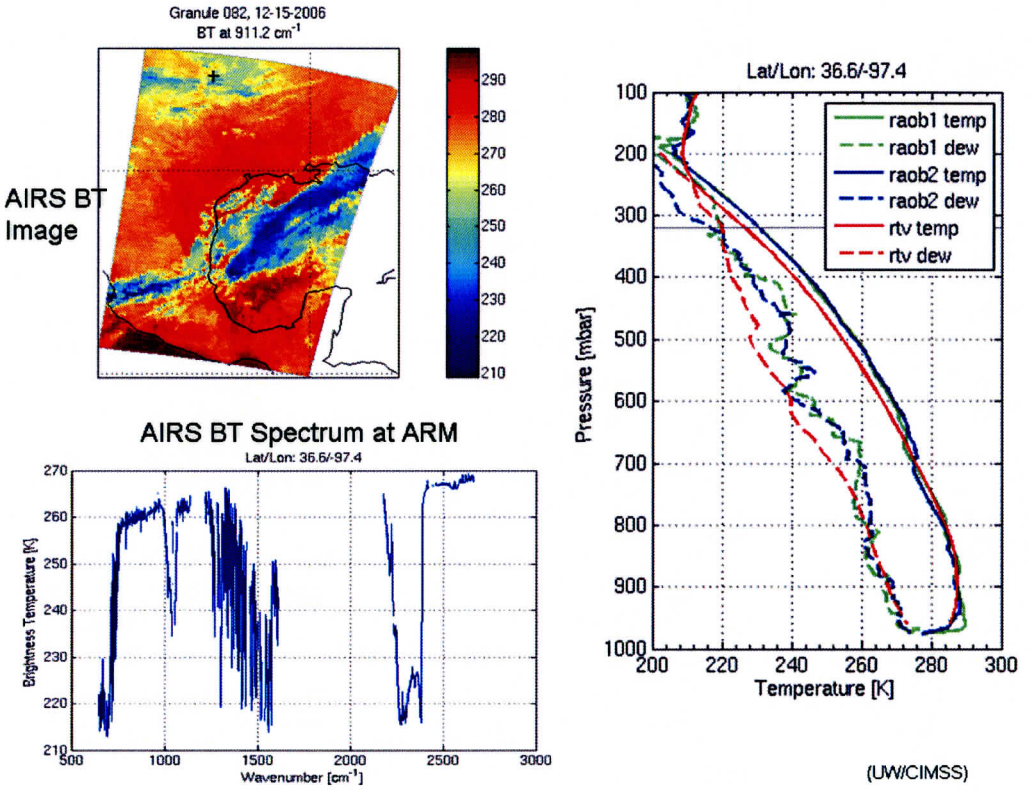
The goals of this project are: to optimize the use of Geostationary Operational Environmental Satellite (GOES)-R infrared (IR) radiances for the retrieval of atmospheric temperature moisture vertical distributions, to reduce the risks due to the cloud and surface emissivity effects in GOES-R IR radiances, to take advantages of time continuity and high spatial resolution of measurements in the retrieval process, and to study the synergy of polar-orbiting, high spectral resolution IR sounder data and GOES-R IR radiance measurements.

Accomplishments

- We have improved handling of surface IR emissivities in profile retrievals. The ability to simultaneously retrieve emissivity spectrum and sounding data with radiance measurements of hyperspectral IR sounders onboard the national and international polar-orbiting satellites is very important because the retrieved hyperspectral IR surface emissivity global map can be used for ABI retrieval processing. In addition, the emissivity retrieval method can be adjusted to process ABI radiances. When we used simultaneously retrieved IR surface emissivity spectra and sounding data from AIRS, we noticed a positive impact on boundary layer temperature and moisture retrieval. We also applied the algorithm to AIRS clear radiance measurements containing various land types (cropland, desert, grassland). According to the analysis by ECMWF and comparison with radiosonde observations, the retrieved profiles have good accuracy. The retrieved emissivity spectrum is very reasonable when compared with the reference emissivity spectra, especially over the desert region. A manuscript on this study has been written and was submitted to *Geophysical Research Letters* in April.
- Single field-of-view (SFOV) cloudy sounding approach was successfully tested with AIRS data. SFOV cloudy sounding is very important because most IR sounder FOVs are contaminated with clouds. While the single FOV profile product is very important for nowcasting severe weather events and forecasting mesoscale features, correctly handling clouds in profile retrieval will help the assimilation of radiances in cloudy regions into numerical forecast models. In addition, the cloudy sounding approach can be adjusted to process ABI radiances under partially cloudy conditions. When cloud properties (cloud-top pressure, optical thickness, particle radius) are simultaneously retrieved with sounding, we found that the AIRS and MODIS have similar cloud-top pressure (CTP) retrievals for most cloudy cases except those with very low clouds. We also compared the cloudy sounding data with radiosonde observations. The following figure shows the AIRS BT image at a window channel, the AIRS BT spectrum at ARM CART Site, AIRS SFOV cloudy temperature and dew point sounding retrievals (red line), two RAOBs at ARM CART Sites during different AIRS overpasses. The AIRS BT image shows cirrus clouds over Southern Great Plains; the slope in the longwave IR window spectral region shows the cirrus cloud signature. However, the clouds are not thick so AIRS sees the low level temperature (the water vapor absorption lines are up in the longwave IR window region). Both cirrus cloud signature and low level temperature inversion are reflected in AIRS BT spectrum. It is interesting to note that the AIRS SFOV cloudy sounding approach retrieves the temperature inversion structure. The RAOBs also reveal the low level temperature inversion. The cloud properties from AIRS are also reasonable. For example, the CTP is 308 hPa for this cirrus case. Note that, according to

MODIS cloud mask, this AIRS footprint at ARM CART Site is overcast. However, the clouds are not optically thick, so AIRS sees down to the surface. The temperature sounding differences between AIRS and RAOBs might be due to the 3-hour time difference.

- LEO/GEO combination for profile evolution is under investigation. With a reliable hyperspectral IR alone sounding approach, the next step is to combine LEO hyperspectral IR sounder (e.g., IASI, CrIS) and GEO imager (e.g., SEVIRI, ABI) for profile evolution. We are also developing the algorithm for profile retrieval using combined ABI simulations and forecast observations. Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) data has been used for testing the algorithm. Mitch Goldberg presented some preliminary results at the Hyperspectral Imaging and Sounding of the Environment (HISE) topical meeting held in Santa Fe, New Mexico from 11-15 February 2007. We have started developing the simulation for CrIS/ABI combination. Some results are expected in near future.



The AIRS BT image at a window channel (upper left), the AIRS BT spectrum at ARM Cart Site (lower left), AIRS SFOV cloudy temperature and dew point sounding retrievals (red line), two RAOBs at ARM CART Sites during different AIRS overpasses.

GOES-R Risk Reduction: Atmospheric Motion Vector Algorithm Development

Personnel: Chris Velden, Steve Wanzong, Iliana Genkova

Funded by: NOAA

Project Description

Based on the recent decisions to delay the HES and descope it from GOES-R, our focus on GOES-R winds research has primarily shifted to the ABI. We are wrapping up the effort to demonstrate the concept of deriving tropospheric winds from retrieved moisture analyses provided by hyperspectral sensors, which was the focus of previous risk reduction wind derivation studies. However, since a sounder of some kind is still being considered for GOES-R, we will continue to demonstrate the potential of this novel approach using the existing GOES sounder.

Accomplishments

- We have begun to refine and optimize the baseline winds algorithm for expected ABI inputs. The focus is on exploring the use of proxy ABI datasets as surrogates for the proposed ABI. We are employing input data provided by the Algorithm Working Group (AWG) proxy data team in the form of model-generated simulated cloud and moisture fields representing selected ABI channels. In addition, we are making use of "ABI-like" instruments that are currently producing data (e.g., SEVERI, MODIS). This surrogate data will be transformed into algorithm-friendly input images of clouds and moisture fields. From a time sequence of these images, we will track gradient features and retrieve motion vectors. Winds derived from this approach will be compared to those derived operationally from current imagers, and evaluated against co-located rawinsondes. We will begin experimenting with traditional tracking channels (i.e. IR, WV), and later expand to new channels expected with ABI that have not yet been investigated for wind derivations.
- Using proxy ABI datasets (simulated and existing ABI-like instruments), we are testing the algorithm's ability to derive winds from the expected new inputs. This task will help create an optimal baseline algorithm for the potential application of GOES-R ABI data for wind retrievals.
- We are continuing to design and refine the ABI baseline algorithms to derive winds, with the prototype suitable for real time data processing and product generation. The design will optimize product performance, and be tested using the methods outlined above. The winds algorithm theoretical basis document (ATBD) is being updated to reflect any identification of potential algorithm risks, as well as proposed solutions to reduce the risks.
- The developmental winds algorithms lay the foundation for future operational processing of GOES-R, and are being tested in an end-to-end system, in conjunction with the GOES-R AWGs.
- The development of a prototype winds algorithm for potential GOES-R sounder applications, using current GOES-derived, altitude-resolved moisture fields from retrievals, has been encouraged to continue. Therefore, the investigation into applying the baseline winds algorithm to current operational GOES sounding moisture fields is ongoing.

GOES-R Risk Reduction: Surface Properties

Personnel: R. Knuteson, E. Borbas, L. Moy, S. Seeman

Funded by: NOAA

Project Description

This project under GOES-R risk reduction has successfully developed a four year time series of monthly global gridded infrared land surface emissivity (LSE) based on satellite observations which covers the entire infrared spectral region needed for the GOES-R Algorithm Working Group (AWG). This UW database is already being extensively used in data assimilation, profile retrievals, and simulation studies over land. This UW LSE database was developed in a very cost effective manner by leveraging the NASA MODIS EOS land surface emissivity data products combined with laboratory spectral measurements collected by NASA JPL for the ASTER project. The algorithm method was developed for use in the MOD07 product for retrievals of temperature and moisture profiles from the NASA MODIS data as part of a project led by Dr. Paul Menzel. The method had been previously successfully applied to a training set of radiosonde observations in order to improve the retrieval performance of regression coefficients. Under this project, the same method was extended to all the global 5 km Aqua-MODIS infrared emissivity data as monthly composites. The Aqua MODIS time series was used beginning at launch in September 2002 and continuing through December 2006 (current).

The objectives of this project are:

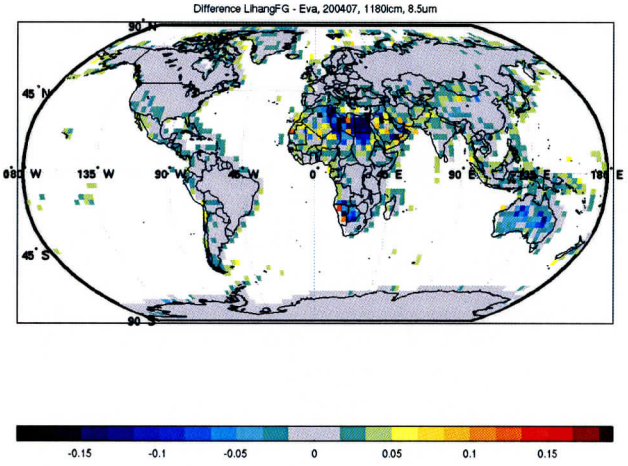
- Create a land surface infrared emissivity database with the following characteristics; continuous time sampling (<= monthly), moderate spatial resolution (<= 5km), continuous spectral coverage throughout the sounding regions of the thermal infrared (3.5 – 15 μm), moderate spectral resolution suitable for use with filter wheel radiometer channels (<= 20 cm^{-1}), good absolute accuracy, and global coverage.
- Publish the methodology used in the creation of the the UW LSE database.
- Validate the UW LSE database against existing state-of-the-art measurements from AIRS and SEVIRI. Future work to include high resolution sensors such as ASTER.

Accomplishments

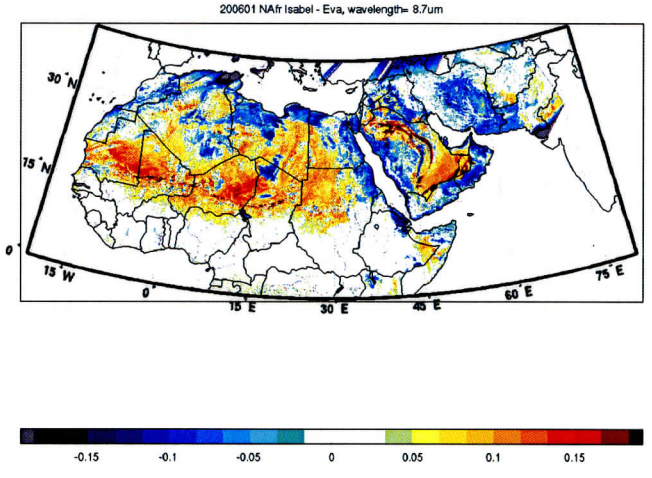
Significant progress was made in each of the task areas: 1) developing the moderate spectral resolution land surface emissivity (LSE) database ("baseline fit or BF" approach, previously called "version A"), 2) finalizing and submitting a peer reviewed paper detailing the derivation of the database and its application to AIRS and MODIS temperature and moisture retrievals, and 3) comparing the UW LSE database with other emissivity databases derived from MSG/SEVIRI and Aqua/AIRS satellite data.

- A second version of the moderate spectral resolution land surface emissivity database (derived by baseline spectral fit to MOD11 points) was released in 2006 and is available from the CIMSS website (http://cimss.ssec.wisc.edu/iremis). This updated version includes improvements to the baseline fitting procedure, emissivity values at 10 (wavelength) inflection points, and a more user-friendly NetCDF data format. A registration procedure has been set up to monitor access to the database on the CIMSS website. This dataset has been made available to the GOES-R proxy data team and is being widely used to simulate the Earth emissivity for ABI.
- The paper describing the UW BF database was submitted to the Journal of Applied Meteorology and Climatology with lead author S. Seeman.

- Preliminary work has been done to compare three infrared land surface emissivity databases: the UW BF database, the operational AIRS products (preliminary version 5), and the database used by the EUMETSAT Land Satellite Applications Facility. The UW BF LSE database and the operational AIRS emissivity retrievals were compared at 42 wavelengths for July 2004. BF LSE database values that fell inside of the AIRS emissivity retrieval FOVs were averaged. Monthly mean differences, the ratio of the differences and the histogram of the values was calculated. The results of this comparison have been presented to the AIRS science team, figure is shown below.
- The comparison of the UW BF database with the EUMETSAT Land SAF database used for SEVIRI data processing was made for 2006 January in four regions of the world at four wavelengths (3.9, 8.7, 10.8, 12.0 μm, SAF spectral resolution). This time, the SAF database grid was interpolated onto the BF database grid. The selected comparisons are shown below for the monthly mean difference between the SEVIRI and BF emissivities at 8.7 microns in North Africa for January 2006. The comparison with the UW BF database shows that the current SAF emissivity is derived from a land surface classification model which does not account for the true variations of the land emissivity. A proposed follow up project will derive true infrared emissivities from the SEVIRI data in order to validate the UW MODIS based database.



Monthly mean differences between the AIRS (v4) and BF emissivities globally at 8.5 microns for July 2004.



Monthly mean differences between the EUMETSAT Land SAF/SEVIRI and UW BF emissivities at 8.7 microns in North Africa for January 2006 showing the errors made in the EUMETSAT model.

GOES-R Risk Reduction: Ozone Algorithm Development

Personnel: Jun Li, Christopher C. Schmidt, Xin Jin

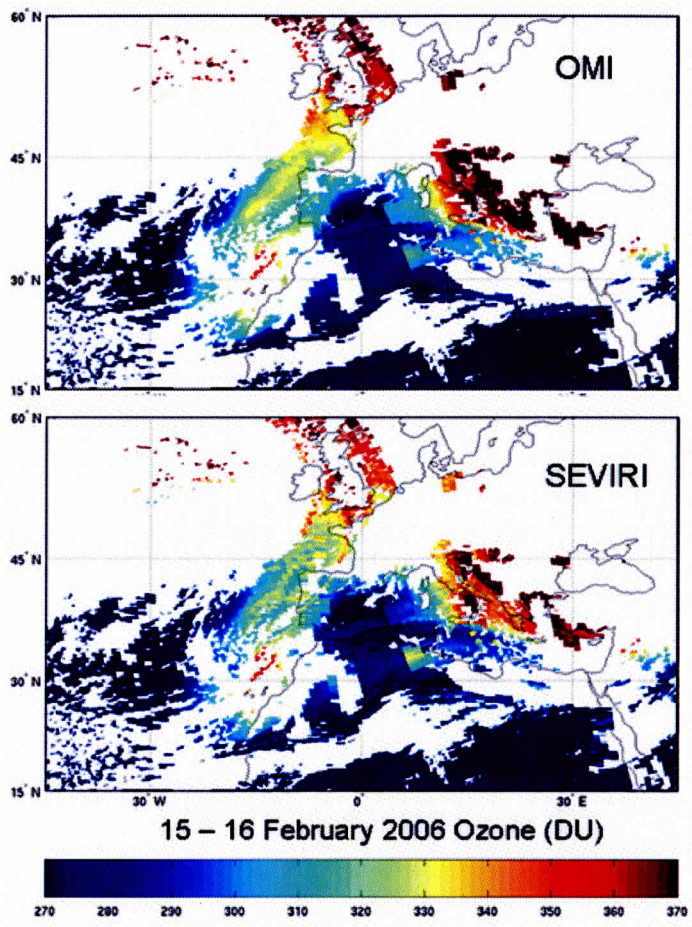
Funded by: NOAA, NASA

Project Description

The goals of this project are: to improve the total column ozone (TCO) accuracy from ABI by using temporal and spatial continuity; to minimize the cloud contamination and increase the retrieval coverage; and to collaborate with EUMETSAT scientists on geostationary imager ozone product estimate and applications.

Accomplishments

- The total column ozone (TCO) algorithm has been developed for ABI. The algorithm has been tested using the SEVIRI onboard Meteosat-8. Simulations show that ozone data from SEVIRI is worse in quality than that from the current GOES Sounder due to lack of stratospheric CO_2 absorption spectral bands from SEVIRI. However, after incorporating temperature profiles from numerical forecasts, the SEVIRI/ABI algorithm provides ozone measurements with accuracy similar to that of the current GOES Sounder (Jin et al. 2006, submitted to IEEE TGARS) but with much larger spatial coverage (disk). Preliminary results show that the TCO retrievals from SEVIRI agree well with ozone measurements from Ozone Monitoring Instrument (OMI) onboard the Earth Observing System's Aura platform. The following figure shows the OMI (upper) and SEVIRI (lower) total column ozone measurements in clear skies from 15-16 February 2006 over Europe. OMI provides global ozone once every day while SEVIRI provides disk coverage of ozone every 15 minutes. Additionally, the 15-minute temporal resolution of SEVIRI depicts the ozone transportation and evolution very well.
- We also collaborated with Dr. Johannes Schmetz, head of Meteorological Division at EUMETSAT, and Marianne Koenig, also at EUMETSAT, on our ABI/SEVIRI ozone retrievals. Currently, EUMETSAT's SEVIRI ozone product has artificial gradients that follow coastlines, especially along desert areas. In the CIMSS SEVIRI ozone research product, the surface artifacts are mitigated due to improved handling of surface emissivity in the retrieval. According to Dr. Johannes Schmetz, Phil Watts at EUMETSAT will revisit the SEVIRI ozone product produced at EUMETSAT and will send us their results.



The OMI (upper) and SEVIRI (lower) total column ozone measurements in clear skies from 15 to 16 February 2006 over Europe.

GOES-R Risk Reduction: Visualization (HYDRA integration)

Personnel: Tom Rink

Funded by: NOAA

Project Description

The integration of HYDRA into the GOES-R visualization and data analysis environment has been broken down into two phases of development effort:

Phase 1: Prototyping HYDRA capabilities within the Integrated Data Viewer (IDV).
The goal of this work is to explore and make an assessment of the process required to integrate the strengths of these two systems, mainly the rich set of libraries for visualizing geo-science data available in the IDV, and the multi- and hyper-spectral data specific capabilities in HYDRA. Both already share a common data model, i.e. VisAD. Many HYDRA users have requested functionality already present in the IDV and conversely IDV users would like HYDRA's functionality available to them. It's important to point out that this development, IDV/HYDRA/VisAD, will be tailored to the precise requirements of the visualization and data analysis needs of the GOES-R program. To this end, it was deemed important to create some demonstrations of how this can be accomplished, and some examples of what the initial system might look like. Some of this work will be directly applicable to Phase 2 below. Figure 1 shows AIRS data being interrogated in the IDV. Figure 2 shows MODIS Aerosol Optical Thickness, and MODIS Cloud Optical Properties combined with the Calipso Lidar in a 3D display. Much of this was accomplished by extending IDV classes, and adapting them to HYDRA classes for multi-spectral data and display.

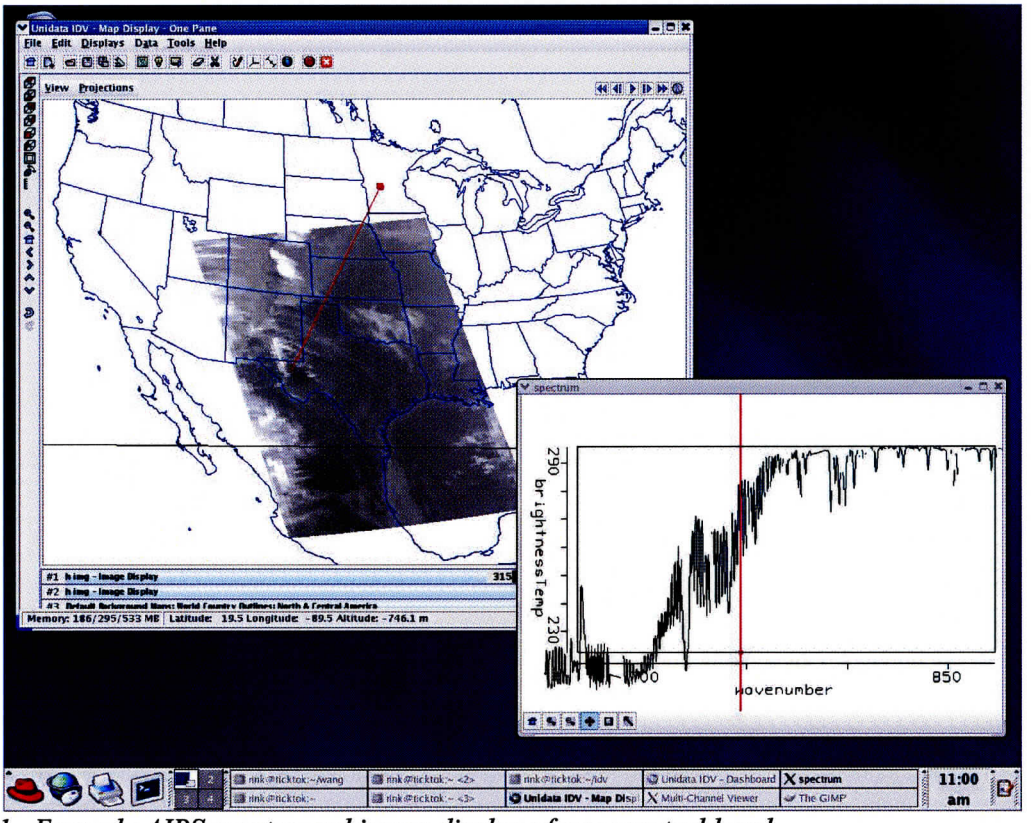


Figure 1. Example AIRS spectra and image display of one spectral band.

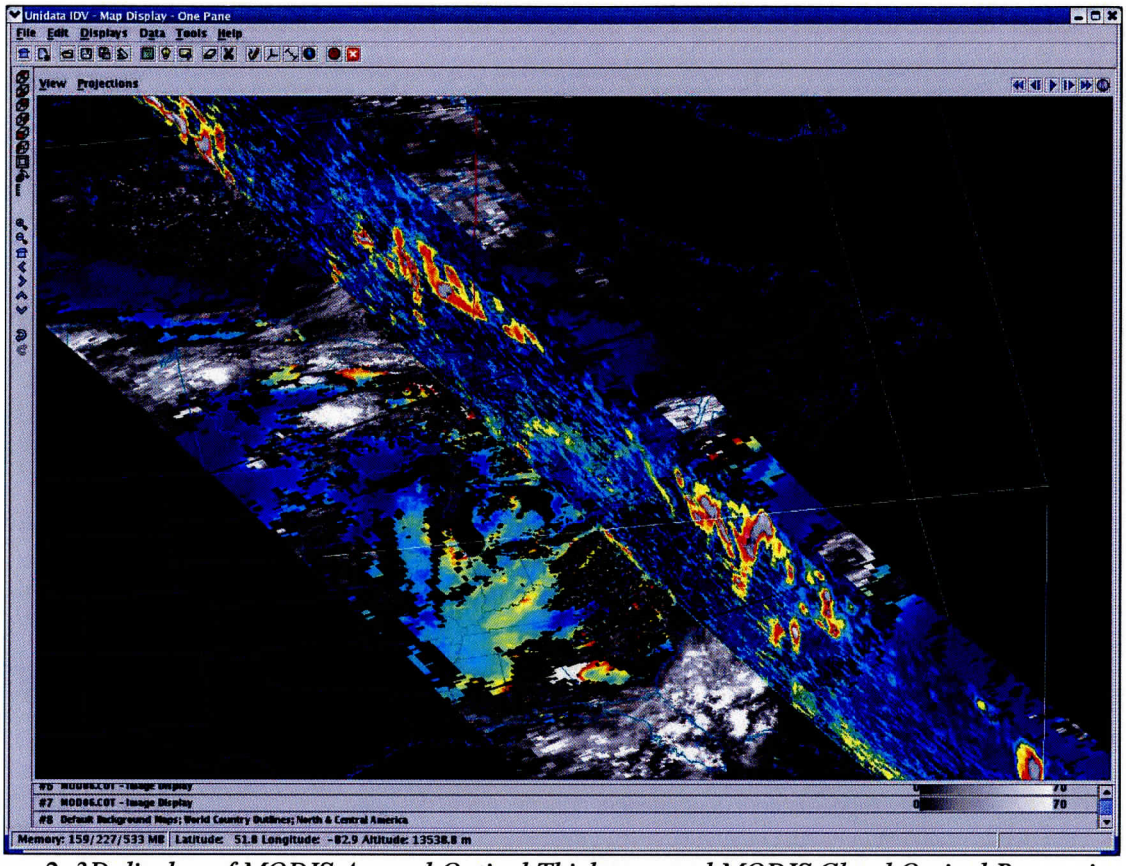


Figure 2. 3D display of MODIS Aerosol Optical Thickness, and MODIS Cloud Optical Properties combined with the CALIPSO Lidar

Phase 2: Implementation. Divided into two categories:

Data:

The goal is to generalize HYDRA's abstract data access layer for multi- and hyper- spectral Level1B and Level2 datasets. Work is in progress to open up HYDRA's local read access to HDF4 via Java, and to create adapters to HYDRA's data access classes which can used within the IDV. There are two concurrent development paths here: the first involves the Level 2 products, e.g. MODIS and AIRS, and the second involves primarily the Level1B hyper-spectral data. The former is a more natural fit to the IDV because of the analogous relationship to the display and internal data representation of meteorology grids. The later is more involved, and will likely take the most effort of the two because of the specialized strategies employed in HYDRA to visualize, analyze and interrogate multi and hyper-spectral Level1B data.

Capabilities:

We plan to reuse, where possible, HYDRA classes for analyzing and interrogating high spatial and/or spectral resolution datasets. We will tailor the User Interface (UI) directly to the needs of the scientists.

GOES-R Risk Reduction: Biomass Burning

Personnel: Christopher Schmidt, Elaine Prins (Consultant), Jay Hoffman, Scott Lindstrom, Jason Brunner

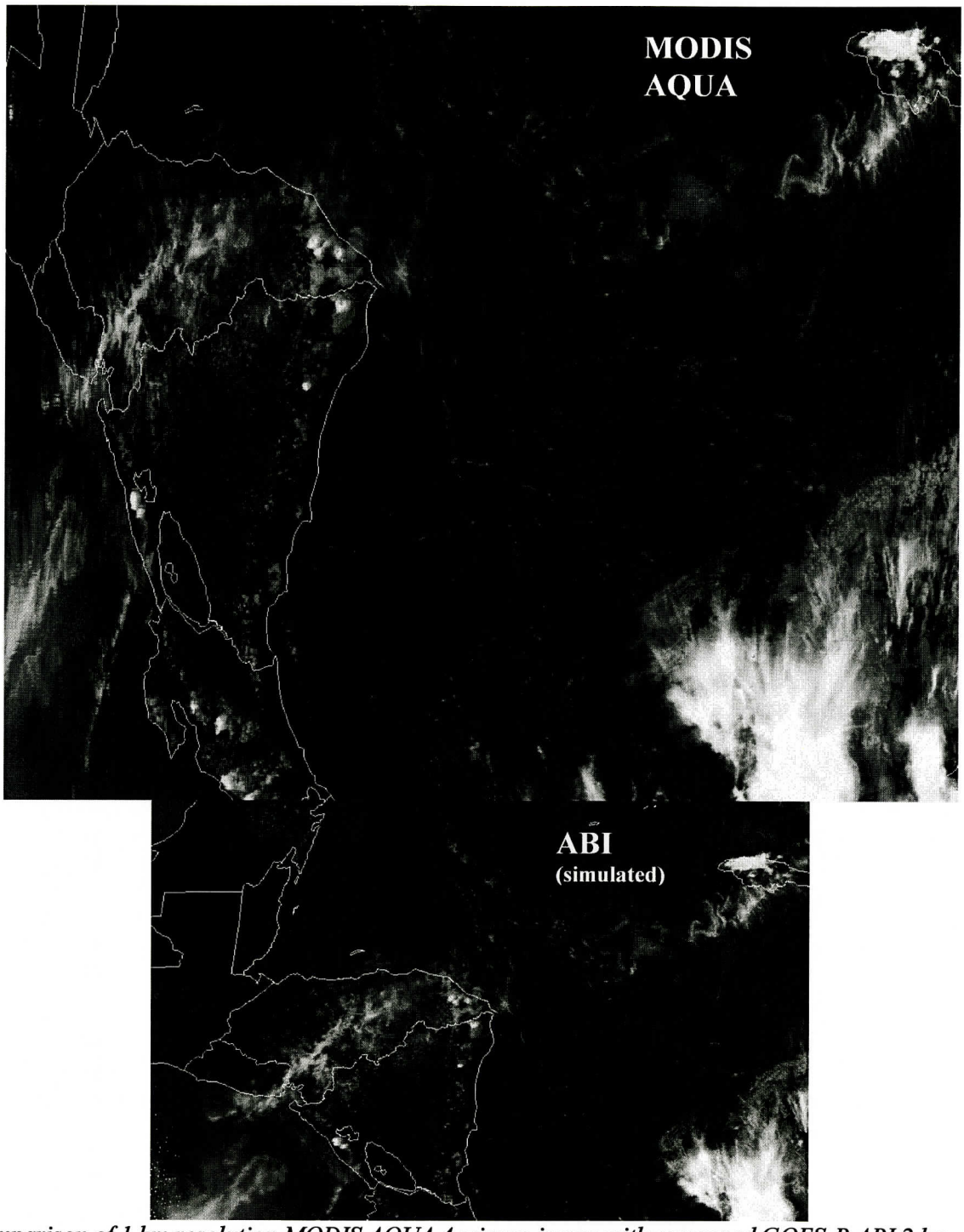
Funded by: NOAA

Project Description

GOES-R ABI biomass burning research and development focuses on improving the Wildfire Automated Biomass Burning Algorithm (WF_ABBA) to take advantage of the improved resolution and radiometric characteristics of ABI, which will in turn provide better fire detection and sub-pixel characterization. Simulated data, as well as current geostationary multispectral data, are being used to test the algorithm. CIMSS is also investigating application of the UW Baseline Fit Emissivity dataset which contains monthly estimates of spectral band emissivities derived from MODIS data to improve sub-pixel fire characterization. 15-minute Met-8/-9 SEVIRI data and the WF_ABBA product over Africa will be used to investigate how to exploit high temporal resolution data, which has specific application to identifying and monitoring small fast-burning agricultural and grass fires. Fire Radiated Power (FRP) is being included in the algorithm. FRP is another way of expressing the same instantaneous fire size and temperature information that the WF_ABBA has historically provided. Collaborations continue with NRL-Monterey and NESDIS on emission studies and data assimilation into the NAAPS model. These risk reduction activities will ensure enhanced future fire detection, monitoring and characterization.

Accomplishments

- ABI data was simulated from MODIS data utilizing the sample point spread functions available to CIMSS. Navigation transforms were handled rigorously to achieve the best remapping possible.
- CIMSS compared FRP calculated from Dozier instantaneous sub-pixel fire characteristics with FRP calculated from the 3.9 micron radiances. For relatively large fires with Dozier fire temperatures between 650 K and 1200 K there is a nearly 1:1 correlation between the two techniques, which had been expected because the Dozier technique is known to work best for those fires. Unfortunately these results do not address the accuracy of FRP estimates for small and cool, large and cool, or small and hot fires (size and temperature as determined by the Dozier technique).
- The UW Baseline Fit (formerly known as SeeBor) Emissivity dataset has successfully been applied to the WF_ABBA. Further study of its impacts is underway.



Comparison of 1 km resolution MODIS AQUA 4 micron image with remapped GOES-R ABI 2 km image. Missing pixels in the lower left of the ABI image are due to a minor issue with handling the "bow-tie" effect in the MODIS data. The images are presented at their relative sizes.

GOES-R Risk Reduction: Tropical Cyclone Research

Personnel: James Kossin, Christopher Velden

Funded by: NOAA

Project Description and Accomplishments

The first goal of this project is to explore the relationships between GOES IR imagery and structure and size of the low-level wind fields of hurricanes. Information about storm structure/size is presently very limited but is a high-priority item for the NOAA National Hurricane Center forecast office.

Using a new dataset constructed in a collaborative effort between CIMSS and the NOAA National Climatic Data Center (NCDC), we have significantly extended the record of critical wind radii in hurricanes. These radii are now available for all storms during the period 1983–2005. This new record is unique and will serve to help us better understand the damage potential of hurricanes. For example, Hurricane Charley (2004) was stronger at landfall than Hurricane Katrina (2005), but its compact size constrained the associated damage swath and storm surge. The new data comprise a systematic compilation of GOES imagery during this period, and will be updated annually through the present period and into all future GOES projects. An example of a general wind radii climatology is shown in Fig. 1. We are in the process of more thoroughly documenting the error characteristics of our algorithm under various stratifications of interest to forecasters, and our climatologies will have associated error bars in the near future.

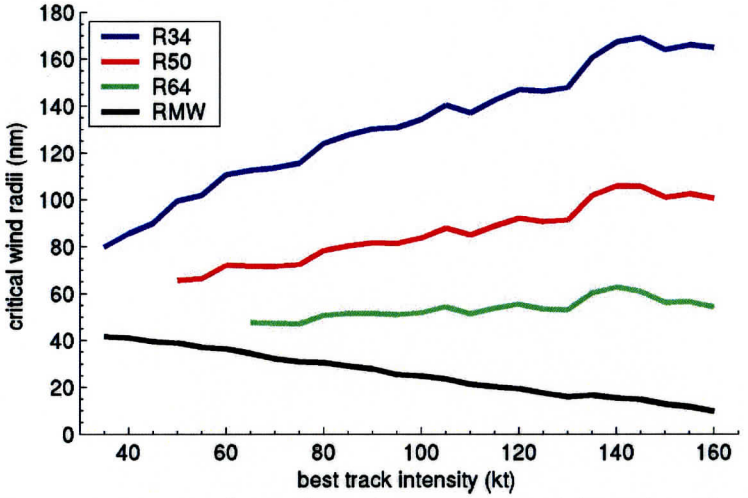


Figure 1: Mean radii [radius of maximum wind (RMW), and radius of 34, 50, and 64 knot wind (R34, R50, R64)] as a function of hurricane intensity.

Another objective of our GOES-R risk reduction work is to demonstrate what will be achievable with the availability of the ABI 5-min scans. As a proxy for this, we used special GOES-11 rapid-scan data (5-min imaging) to produce high-resolution AMV datasets over selected tropical cyclones in 2005. From these datasets we have constructed diagnostic fields from the resultant upper-level analyses, and related certain signatures to concurrent TC intensity change.

As a demonstration of this capability, GOES-11 AMVs were derived from 5-min. r/s imagery during a special observing period as NASA's Tropical Cloud Systems and Processes (TCSP) experiment was

taking place in July of 2005. Hurricane Emily traversed the sampling domain and provides a good case study, as the intensity fluctuated during the period of observation. High-resolution data such as this will be routinely possible from the GOES-R ABI, and our intent is to see what we can observe and learn from current GOES capabilities (special observing modes) in advance of this deployment. We are in the process of creating time series of upper-level quantities derived from the GOES r/s AMVs over Emily and other TCs. From these we hope to identify trends and potentially associations with the hurricane's structure and intensity fluctuations. In order to investigate kinematic quantities such as vorticity and divergence, the AMVs had to be analyzed on a uniform grid. This was done using an iterative Barnes scheme. The Barnes scheme allows an analysis to fit the observations coarsely where observations are sparse and tightly where the observations are dense.

Figure 2 shows an example of a storm-centered vorticity field calculated from the analysis of Emily valid 18Z on the 18th of July 2005. The observation wind barbs (ms^{-1}) that made up the analysis are plotted on top of the vorticity field as well. Although Emily was a weak category-one hurricane at this time, she intensified 10 kts in the subsequent 6-hours. The analysis captures the cyclonic circulation over the storm's center, and the asymmetric, anti-cyclonic outflow region to the north and northeast of the storm.

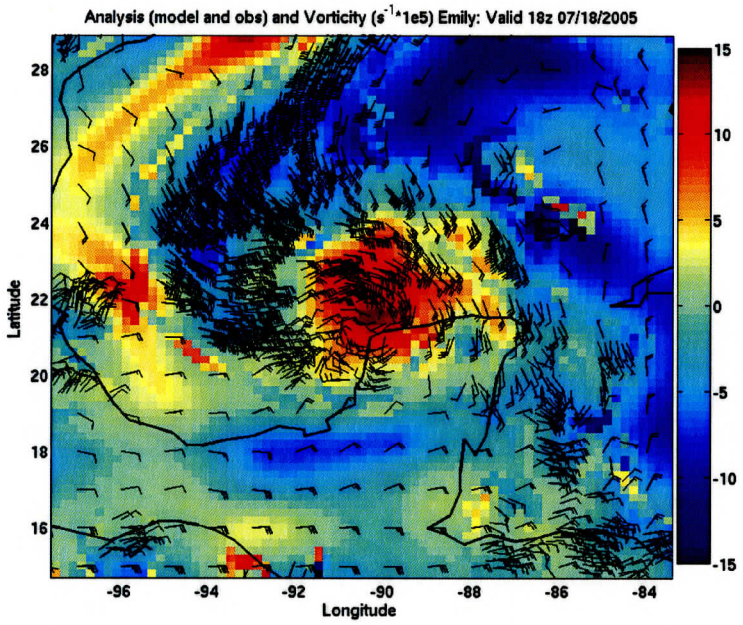


Figure 2: Storm-Centered vorticity analysis and observed AMVs at 18Z on July 18th, 2005 for Hurricane Emily. The color-contours show vorticity (10^{5}s^{-1}) and the wind barbs show the observations in ms^{-1}. The analysis captures the cyclonic structure in the storm's center and the anti-cyclonic outflow to Emily's north. These asymmetric outflow channels are often associated with storm strengthening. Emily is a weak hurricane at this time, but subsequently intensifies 10-kts in 6 hours, and 55-kts in 30-hours.

GOES-R Risk Reduction: Nowcasting

Personnel: Ralph Petersen, Bob Aune

Funded by: NOAA

Project Description

This work focuses on identifying areas of convective destabilization 3-6 hours in advance of storm development based on moisture data from current/future GOES satellites. To meet this goal, a new trajectory-based objective nowcasting tool has been formulated which preserves and takes full advantage of both the detailed horizontal and vertical detail (discontinuities) inherent in future hyperspectral satellite products and the frequently refreshed information updates available from current and future geostationary instruments. The technique:

- Is fast (a must due to the perishability of information regarding severe weather development),
- Is designed to preserve the observed data to the fullest extent (e.g., retains data extremes),
- Provides the opportunity to integrate GOES-R data with data from all other sources in a timely and faithful manner, and
- Uses minimal computing resources, a necessity for forecast office application.

Recent study areas include:

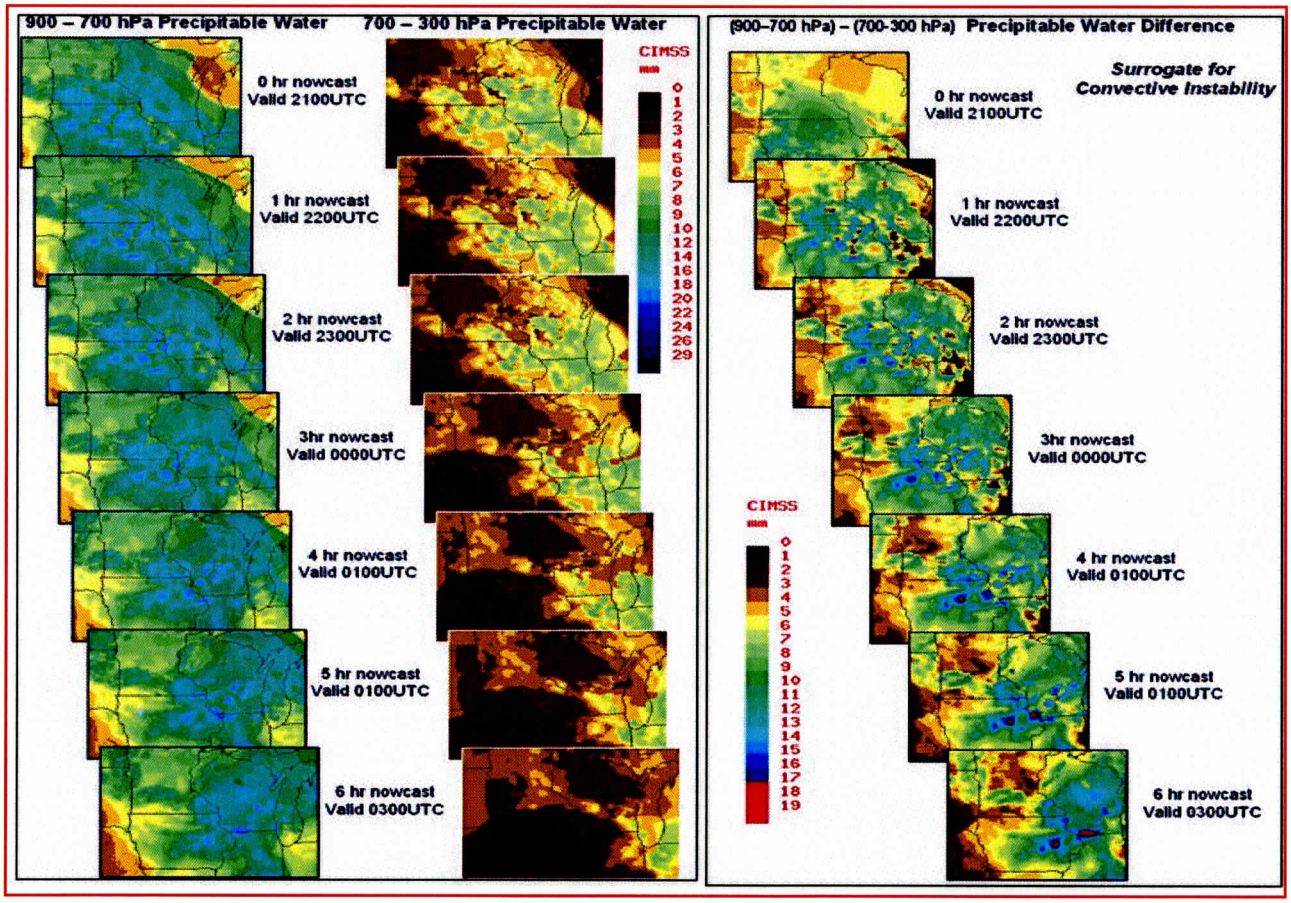
1) Continued development and testing of the Lagrangian model,
2) Improved use of existing/future satellite moisture products by projecting GOES DPIs ahead in time and space – focusing on hard-to-forecast isolated severe thunderstorm events,
3) Development of tools to visualize predicted DPIs in same formats as DPI observations, and
4) Interaction with NWS/WFOs to evaluate the new objective nowcasting products.

Accomplishments

- **Development and testing of Lagrangian model; and improved utilization of satellite sounders to provide new nowcasting products.** Efforts included completing initial case study tests and improving the wind data used to initialize the Lagrangian forecast parcels. Emphasis was placed on a 20 July 2005 Derecho event over the upper Midwest and the 13 April 2006 southern WI hail event that was not captured in conventional operational NWP guidance, but was evident in detailed nowcasts of GOES DPIs and derived convective instability made 6-hours ahead. The nowcasting system is also being expanded to include multi-layer predictions of Equivalent Potential Temperature (2e) and vertical differences (the rigorous definition of convective instability).

  The 13 April 2006 Wisconsin hail storms tracked from south of Madison to west of Milwaukee and caused millions of dollars of property damage. Although the standard NWP guidance from the NAM model showed no evidence for this storm development, the nowcast system (see Figure below) indicated that the low-level moisture observed over central Indiana in the initial DPI data would be transported to an isolated band across south-central Wisconsin within six hours. Simultaneously, an overlaying narrow area of mid-level dryness was shown to move into the same area from south-western Minnesota. Derived vertical moisture differences show an initial development of isolated instability (dark blue to bright red area) over central Iowa at the time of a tornado sighting there, followed by rapid development of instability over extreme southern Wisconsin six hours into the nowcast, when and where the hail storms developed. The results clearly show both the value of the multi-layer moisture data from GOES and the ability of the nowcast system to retain and project isolated moisture extremes in anticipation of hard-to-forecast convective events

- **Develop visualization tools to view predicted DPIs.** Visualization tools and web presentation capabilities have been developed that will allow operational forecaster to easily integrate images of the DPI nowcasts that both are consistent with existing observational products and are useful in rapidly identifying the most important features. A prototype nowcast web page showing the WI hail event nowcasts is available at http://cimss.ssec.wisc.edu/model/ncstR_13Apr06/nowcast.html. It includes hourly animations of DPI-like images of mid- and high-level precipitable water and derived vertical moisture gradients (key indicators for convective instability), along with verification satellite imagery. In addition, the production of nowcast product images has been modified to use a contemporaneous image from the previous hourly nowcast run as a 'first-guess' and to show 'clouds' in areas where no nowcast data have been available for more than 6 hours. This process increases resolution and retains past nowcast data in new products.
- **Interact with NWS/WFOs to evaluate new objective nowcasting products.** Initial discussions have begun with NWS/Green Bay (GRB) and NWS/Sullivan. GRB has offered to host an overview seminar based on the fully functional web page and real-time model output. The seminar will include discussions of how to best quantify the usefulness of the products, and how to improve presentation methods for future severe storm seasons. Based on review of the case study results, NWS/GRB has offered to participate in a real-time evaluation of the nowcasting products and to host a seminar to support broader evaluation at NWS offices at Sullivan, LaCrosse, Minneapolis and Marquette.



Sequence of GOES multi-layer DPI moisture observations and nowcasts (left) and derived Convective Instability (right) for severe hail case study over southern Wisconsin.

GOES-R Risk Reduction: Ground Systems Development

Personnel: R. Knuteson, R. Garcia, G. Martin, M. Smuga-Otto, D. Tobin

Funded by: NOAA

Project Description

The CIMSS GOES-R Risk Reduction activities related to ground data processing design and system studies in 2006 had three major objectives; 1) the evaluation of on-orbit algorithms for the L0 to L1 calibration of the Geostationary Imaging Fourier Transform Spectrometer (GIFTS) as a risk reduction activity for the GOES-R Hyperspectral Environmental Suite (HES) sounder, 2) the preliminary design of ground processing architectures suitable for the large data volumes and high throughput requirements of the GOES-R sensors (ABI and HES), and 3) the demonstration of advanced computing technology in the areas of data storage and retrieval, cluster computing, high speed networks and distributed computing specifically applied to the data anticipated in the GOES-R time frame. Significant progress was made in each of these areas which we believe can now be transitioned from risk reduction conceptual demonstrations into the implementation needed for NOAA Algorithm Working Group integration and into a future ground data processing system for GIFTS or any other geostationary hyperspectral infrared sounder.

Accomplishments

Significant progress was made in each of the task areas. Highlights are provided below:

- A 24 hour simulation of "full-disk" Earth emitted radiances was developed under this risk reduction activity in order to support the large scale simulation studies required for the ABI and HES sounder. This dataset has since become one of the proxy datasets that will be used by the Algorithm Working Groups. A paper on the 24 hour full disk simulation was presented at the AMS annual meeting in January 2006. The full simulation was completed mid-year and is available upon request. In addition to the WRF model fields, the dataset includes top of atmosphere radiances for a broad continuous spectral region of the infrared but at high enough spectral resolution to allow the simulation of numerous infrared sensors including the ABI and GIFTS. In addition, interferograms were created from this dataset simulating the GIFTS on-orbit observations. This "raw" sensor data has been used in a successful demonstration of the scalability of the GIFTS Information Processing System (GIPS) software under another NOAA grant for the Office of Systems Development (McKenzie). It is anticipated that future simulated datasets of this type will be supported by the AWG proxy data team using the approach developed under this risk reduction task.
- A draft GIFTS L0-L1 Algorithm Theoretical Basis Document (ATBD) was prepared in conformance to the NOAA STAR documentation guidelines and is available from the UW-SSEC web site. A paper was presented at the 2006 AMS annual meeting on this topic. The draft GIFTS L0-L1 ATBD is intended to be an evolutionary document that describes both the theoretical equations for the target algorithms but also the detailed performance tradeoffs that need to be considered in software implementation of the algorithms. In 2006, real data from the GIFTS thermal vacuum testing was used to evaluate existing algorithms and modify or extend them for application to the actual thermal vacuum test data. Data sets with both laboratory blackbody and sky-viewing scenes were identified from tests run by NASA at Space Dynamics Laboratory in Logan, Utah between May and September 2006. Simply acquiring these datasets for evaluation is a significant task due to the relatively large data volumes involved and the need to develop new tools for working with the data files as provided by NASA. The GIFTS ATBD has been used in the GIPS software development

project mentioned previously. While there is a need for continuing refinement of these algorithms it is suggested that further ATBD changes be funded by a GIFTS specific ground system development activity rather than under GOES-R risk reduction. This is consistent with the mature level of this algorithm development.

- Designs of the system level concept for processing of GOES-R data in an efficient and reliable manner have been captured in the form of data flow diagrams. The primary technologies that are being leveraged for the future system designs are cluster computing and intelligent storage systems combined with high speed networks for efficient parallel processing of sensor fields of view. This approach of parallel mass computing reflects the needs of the GOES-R program where the future sensors are anticipated to collect multiple fields of view simultaneously with nearly two orders of magnitude increase in sensor data rates. The UW-SSEC has also performed some computing and cost estimation studies which are summarized below for the GIFTS sensor as it is currently configured for flight. Further work to refine these system designs will be deferred until the status of the geostationary hyperspectral sounder is clarified.
- A preliminary design study for GOES-R Level 2 processing was conducted assuming the use of simulated Earth observations in a high performance computing environment. Diagrams showing an example data flow are available upon request. Numerous technical details have been identified in an assessment of the existing UW-SSEC software code base which will be used in the development of a prototype implementation of the water vapor winds processing. The activities under this risk reduction task are being coordinated with the AWG Algorithm Integration Team (AIT) leader (W. Wolf). It is anticipated that further CIMSS work in this task area will be supported directly by the AWG AIT under separate funding.
- A forward looking demonstration, called Origami, was developed during the task period in order to link distributed computing methods, client-server data distribution, and database management to visualization tools with a user friendly web interface. The Origami demonstration was extremely successful in illustrating how existing modern infrastructure technologies, e.g. storage area network, database engines, cluster computing, and open data access protocols, can be coupled with the next generation UW-SSEC visualization tools (the IDV which is built upon VISAD) to create a development environment suitable for the GOES-R era. While the Origami demonstration was intended to highlight the integration of modern technologies, it also shows how large scale computing resources can be coupled in a seamless manner to three dimensional visualization of model and observed state parameters in a manner that can be scaled up to any size problem. The scalability of a computing system suitable for GOES-R that has the features contained by the existing McIDAS system for the current GOES sensor plus the additional functionality required for the GOES-R series is the ultimate goal of this work. A diagram of the Origami concept was presented at the Fall AGU meeting in December 2006. Future progress in this area will be limited by available funding but continuing the exploration of this work under GOES-R risk reduction is highly recommended.

GOES-R Algorithm Working Group: Proxy Data Sets and Models to Support a Broad Range of AWG Activities

Personnel: Allen Huang, Tom Greenwald, Jason Otkin, and Mat Gunshor

Funded by: NOAA

Project Description

The main focus of this project is to provide state-of-the-art proxy datasets, models, software tools, and the associated documents and/or user guides in support of a broad range of GOES-R AWG application and development team activities. These efforts will enable most of the AWG team members to use the common GOES-R sounder and Advanced Baseline Imager (ABI) datasets and software tools. Our work will allow the various AWG teams to concentrate on their own area of expertise and will facilitate sharing results among the teams. The refined and up-to-date databases will include: 1) global infrared surface emissivity, 2) ice and water cloud microphysical properties, 3) aerosol/dust microphysical properties, and 4) models. The models include: 1) community NWP models, 2) community infrared radiative transfer models, and 3) community infrared emissivity models.

Additionally, we plan to generate ABI-like datasets (for most ABI bands) from MODIS imagery. Some of the steps to simulate the spatial, geometric and radiometric features include: acquiring the MODIS hdf format images, selecting bands with similar central wavenumbers, de-striping the IR bands with an algorithm developed at CIMSS, and averaging to appropriate ABI resolution.

Accomplishments

Major accomplishments are the on time delivery of the models, tools and datasets on 31 January and 8 February 2007.

- Full-disk WRF model data for 0000, 0040 and 0120 UTC, 25 June 2003
- Simulated full-disk high-resolution spectral radiance data for 0000, 0040 and 0120 UTC, 25 June 2003
- Simulated full-disk ABI radiance data for 0000, 0040 and 0120 UTC, 25 June 2003
- Documentation for WRF model data sets and simulated radiance data sets
- Images of full-disk ABI radiance data
- Source code, documentation and input databases for the fast IR forward model and ABI radiance generation

All data files are in netCDF except for several input databases as described in the *User's Manual to the Fast Infrared Radiative Transfer Model.*

Some of the information on these files is also available at:
http://cimss.ssec.wisc.edu/goes_r/awg/proxy_awg_project/deliverables/

In addition, the satellite-derived ABI proxy datasets have been generated using five environmentally unique scenes from MODIS, which have been destriped, averaged to ABI spatial resolution, and resampled at ABI bit-depth. The scenes each cover a 1000km by 1000km area, which corresponds to the planned size of ABI in its mesoscale operations mode. The environmentally unique scenes are: fire and smoke, mountain wave, convective clouds, daytime clouds and dust. Documentation on these datasets is provided.

All data files are in netCDF and are also available via FTP. This information is available at: http://cimss.ssec.wisc.edu/goes_r/awg/proxy_awg_project/deliverables/

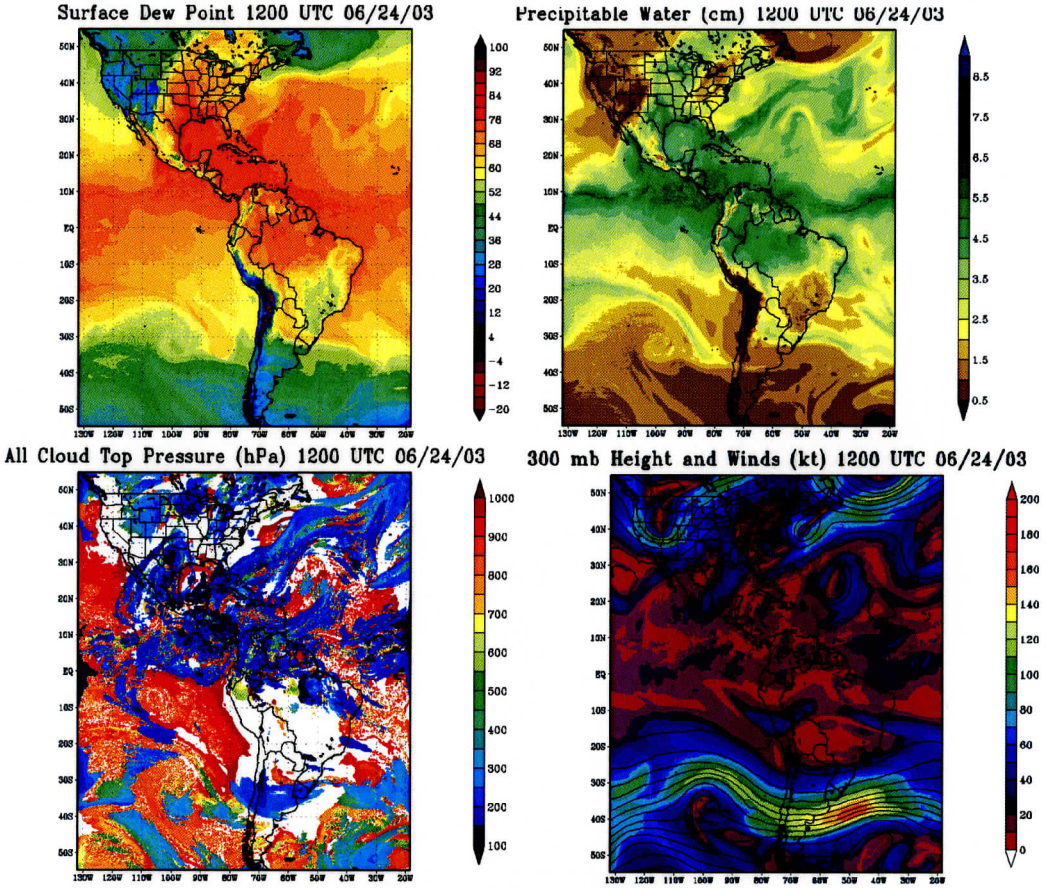


Figure 1. Example proxy data sets created to emulate GOES-R semi-full disk coverage. The atmospheric variables shown are surface dew point temperature (upper left), precipitable water (upper right), all cloud top pressure (lower left) and 300 mb height and winds (lower right) for 1200 UTC 24 June 2003.

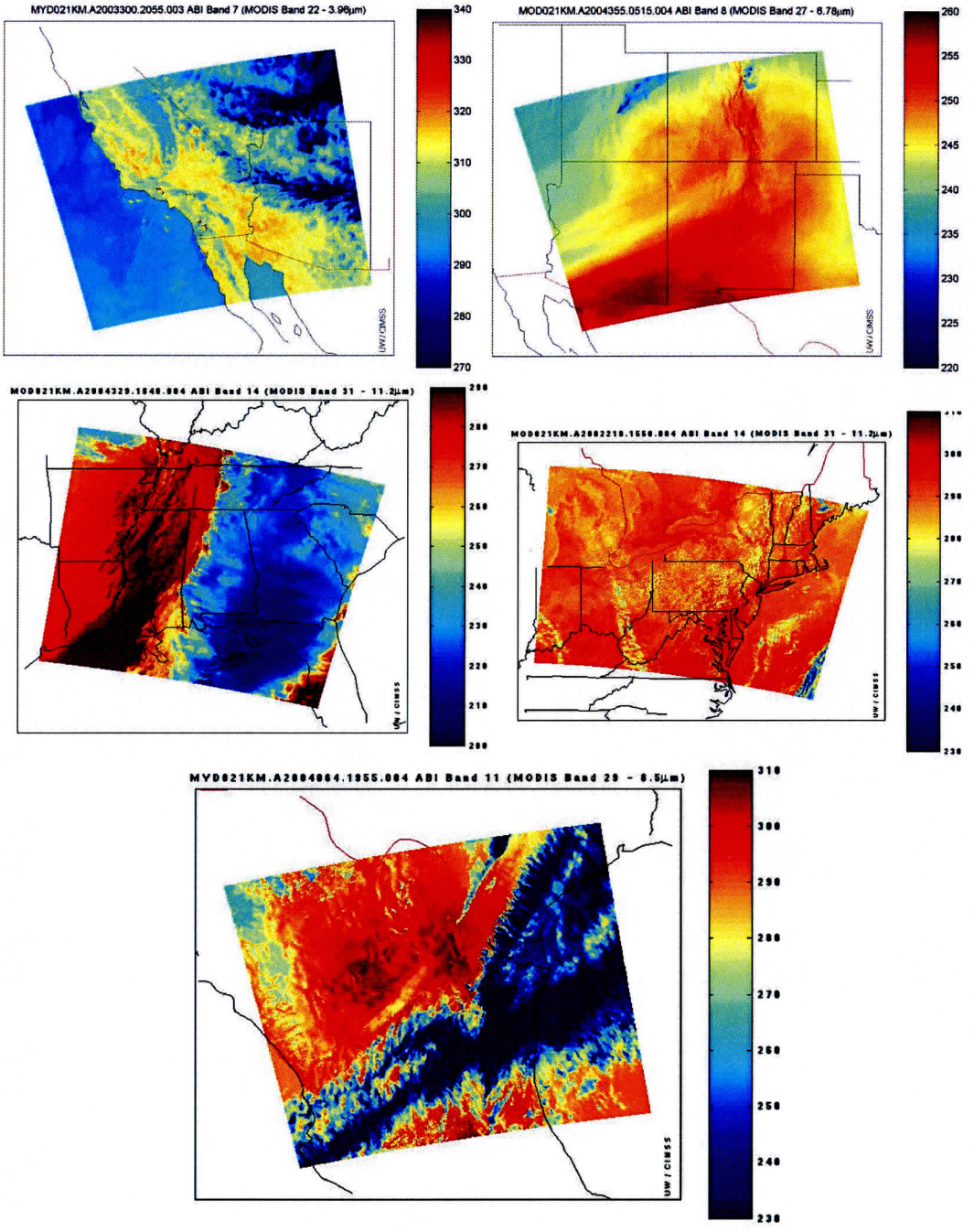


Figure 2. Example of satellite derived proxy datasets for the Fire and Smoke Case (upper left), Mountain Wave Case (upper right), Convective Cloud Case (mid left), Daytime Cloud Case (mid right) and Dust Case (lower center).

GOES-R Algorithm Working Group: Sounding Algorithm Evaluation and Selection

Personnel: Jun Li, Jinlong Li, Xin Jin, Hal Woolf and Timothy J. Schmit

Funded by: NOAA

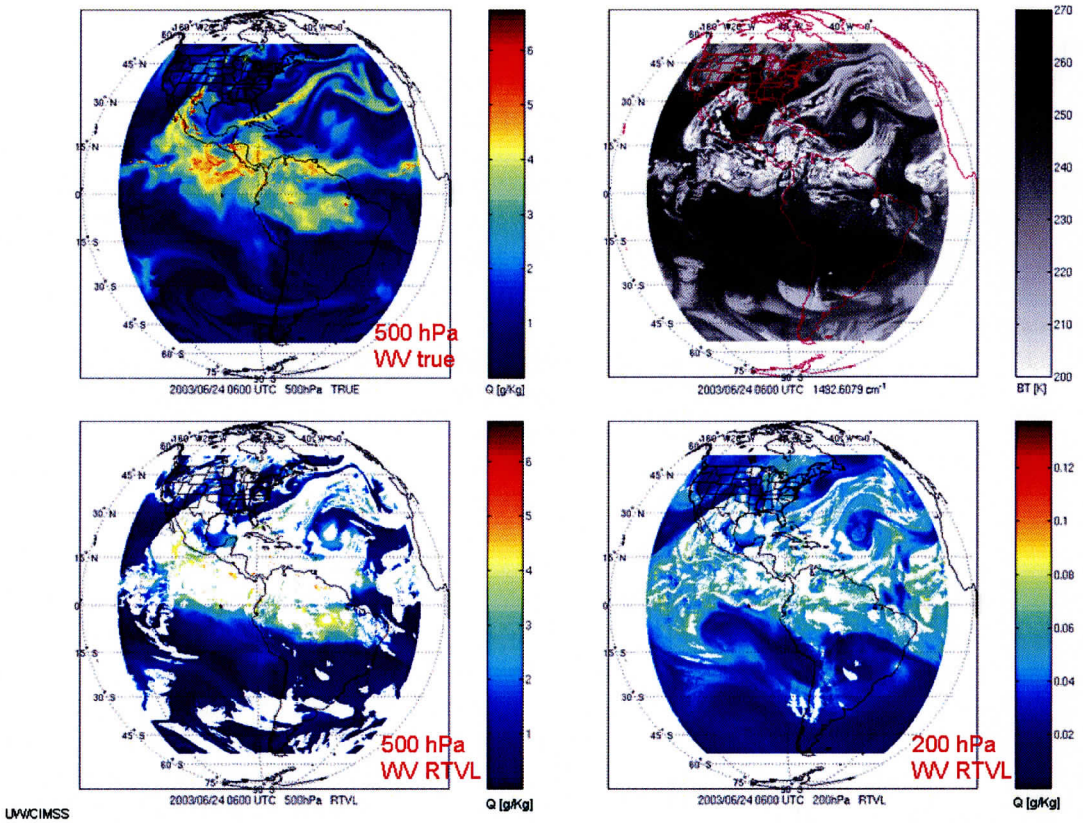
Project Description

The main focus of this project is to evaluate and select the legacy profile algorithm capable of processing data from the GOES-R Advanced Baseline Imager (ABI) (Schmit et al. 2005 - BAMS). This project requires CIMSS researchers to compare, evaluate and select existing legacy profile algorithms; add to the chosen algorithms the time continuity and spatial continuity uniquely suitable for GOES-R ABI profile products generation; and improve algorithm's ability to handle infrared surface emissivity and cloudiness in profile retrievals.

Accomplishments

- The version 1.0 package of hyperspectral infrared (IR) alone sounding algorithm and code has been provided to STAR (Center for SaTellite Applications and Research). The version 1.0 package uses an efficient statistical approach. A generic hyperspectral IR sounder (650 – 2400 cm^{-1} with a spectral resolution of 0.625 cm^{-1}) instrument is assumed in the version 1.0 algorithm. CIMSS AWG proxy team generates the proxy data. The algorithm includes clear sky sounding and above-cloud direct sounding approaches. The algorithm and software have been applied to one day's worth of full disk hyperspectral IR proxy data at 10-km spatial resolution and 1-hour temporal resolution. The following figure shows the 500 hPa water vapor mixing ratio from WRF run (truth, 06 UTC on 24 June 2003), simulated brightness temperature (BT) image of an water vapor absorption channel, 500 hPa water vapor mixing ratio retrieval from clear and above-cloud conditions, and 200 hPa water vapor mixing ration retrieval from clear and above-cloud conditions. Simulation results indicate that the 500 hPa water vapor retrievals are close to the truth. Since fewer clouds exist higher than 200 hPa, the hyperspectral IR radiances provide more retrieval coverage at 200 hPa than at 500 hPa.
- An efficient and accurate Jacobian algorithm (Li 1994 - AAS) and software have been provided to AWG sounding team. Fast Jacobian calculation is needed in sounding physical retrieval process.
- The Advanced Baseline Imager and Hyperspectral Environmental Suite (ABI/HES) cloud-clearing approach (Li et al. 2005 - TGARS) has been extensively tested using data from the Moderate Resolution Imaging Spectroradiometer and Atmospheric InfraRed Sounder (MODIS/AIRS). The approach can be applied to data from the Infrared Atmospheric Sounding Interferometer and Advanced Very High Resolution Radiometer (IASI/AHVRR) for further algorithm testing and demonstration. In the future, the approach can be applied to ABI and geostationary hyperspectral IR data processing. The MatLab version of imager/sounder cloud clearing is available now; it can be rewritten in FORTRAN if needed.
- We have also started to select and test the ABI alone profiling algorithm. We chose the operational MODIS profiling algorithm for ABI moisture profile retrieval demonstration. The ABI acquisition process starts earlier than geostationary hyperspectral sounder. It is very important that the legacy products from the current GOES Sounder that are used by the NWS can be generated from ABI data. The necessary 'continuity' products (radiances, TPW, LI, skin temperature, clouds, and winds) from today's low-spectral resolution sounder can be compatibly provided by ABI. ABI alone sounding related products are also very important. Unlike MODIS, there is only one CO2 absorption infrared spectral band on ABI, so

temperature profile information is limited in ABI radiances. Combination of forecast and ABI radiances should be considered to continue the current GOES-N class sounder products. Preliminary simulation results using near-global radiosonde observations with ABI sounding version 1.0 algorithm (statistical approach) were presented at AWG GOES-R meeting held in NOAA Science Center on 13 September 2006.



The 500 hPa water vapor mixing ratio from WRF run (truth) (upper left), simulated BT image of an water vapor absorption channel (upper right), 500 hPa water vapor mixing ratio retrieval image (lower left), and 200 hPa water vapor mixing ration retrieval image (lower right).

GOES-R Algorithm Working Group: Readying the GOES-R Atmospheric Motion Vector Algorithm for Transition to Operational Use

Personnel: Chris Velden (PI), Iliana Genkova, Steve Wanzong, Dave Santek

Funded by: NOAA

Project Description

The development and automated processing of wind vectors from satellites has its heritage at CIMSS. Our research objectives in this project seek to continue this heritage by adapting current methods and algorithms to NOAA's next generation of geostationary satellites, starting with GOES-R. The ABI will provide both traditional and new spectral channels that the CIMSS winds team will employ to test, process and validate AMVs using simulated and proxy datasets provided by other members of the GOES-R AWG project. We plan to use locally-available hardware resources initially for software testing, with a phased transition to a collaborative testbed environment as it comes online. The proxy data will leverage off of existing imagery from GOES and MSG/SEVERI. We will also employ ABI simulated imagery for select case studies. The algorithm development, testing and validation will focus on heritage algorithms currently being used in NESDIS operations today to generate winds from satellite imagery. We will leverage and adapt current algorithms/software to expected ABI characteristics, focusing first on ABI heritage channels (VIS, IR-W, WV) for winds testing. We will then turn our attention to the new spectral capabilities afforded by the ABI for wind derivation. All software development will follow accepted AWG standards, and will be accompanied by documentation. This work will insure the readiness of the CIMSS/NESDIS automated winds algorithm for eventual operational implementation upon the deployment of GOES-R ABI.

Accomplishments

This study has only been activated for the past few months. We have begun to adapt and optimize the CIMSS/NESDIS automated feature tracking algorithm for deriving atmospheric motion vectors from sequential satellite imagery for applications to the GOES-R ABI. In addition, we are assembling proxy datasets to use as simulated ABI imagery. This project includes major software code modifications and streamlining, and will soon include testing on proxy datasets, validation, and documentation.

GOES-R Algorithm Working Group: Sounding Algorithm Validation

Personnel: David Tobin, Leslie Moy, Robert Holz, Kenneth Vinson

Funded by: NOAA

Project Description

These activities provide essential validation datasets and analysis for assessing candidate GOES-R temperature and water vapor sounding algorithms. The primary focus is on the production and use of highly accurate temperature and water vapor profiles from the Atmospheric Radiation Measurement (ARM) sites and from aircraft campaigns.

Achieving temperature and water vapor soundings with high accuracy and optimal vertical resolution is a major goal of GOES-R. The high accuracy and vertical resolution is required for various applications, such as nowcasting the onset of severe weather over CONUS. Highly accurate validation and representative validation data is therefore required to assess the candidate sounding algorithms that are to be investigated by the AWG. The ARM sites are perhaps the best sites in the world for providing atmospheric state, cloud, and radiation observations for this type of validation activity. Also, high spectral resolution infrared radiance observations collected by the Scanning-High resolution Interferometer Sounder (S-HIS) and the NPOESS Aircraft Sounder Testbed-Interferometer (NAST-I) from high altitude aircraft are useful for sounding algorithm assessment.

Accomplishments

Accomplishments to date include the production of ARM site atmospheric profiles for the assessment of satellite retrievals and the use of such products to characterize the performance of various retrieval algorithms. This includes the AIRS version 4 and version 5 retrieval algorithms and several retrieval algorithms developed with CIMSS. Other accomplishments include the collection and production of validation data from aircraft field campaigns for retrieval algorithm validation.

GOES-R Algorithm Working Group: ABI Fire Detection and Characterization Algorithm

Personnel: Elaine Prins (Consultant), Christopher Schmidt, Scott Lindstrom, Jason Brunner, Jay Hoffman

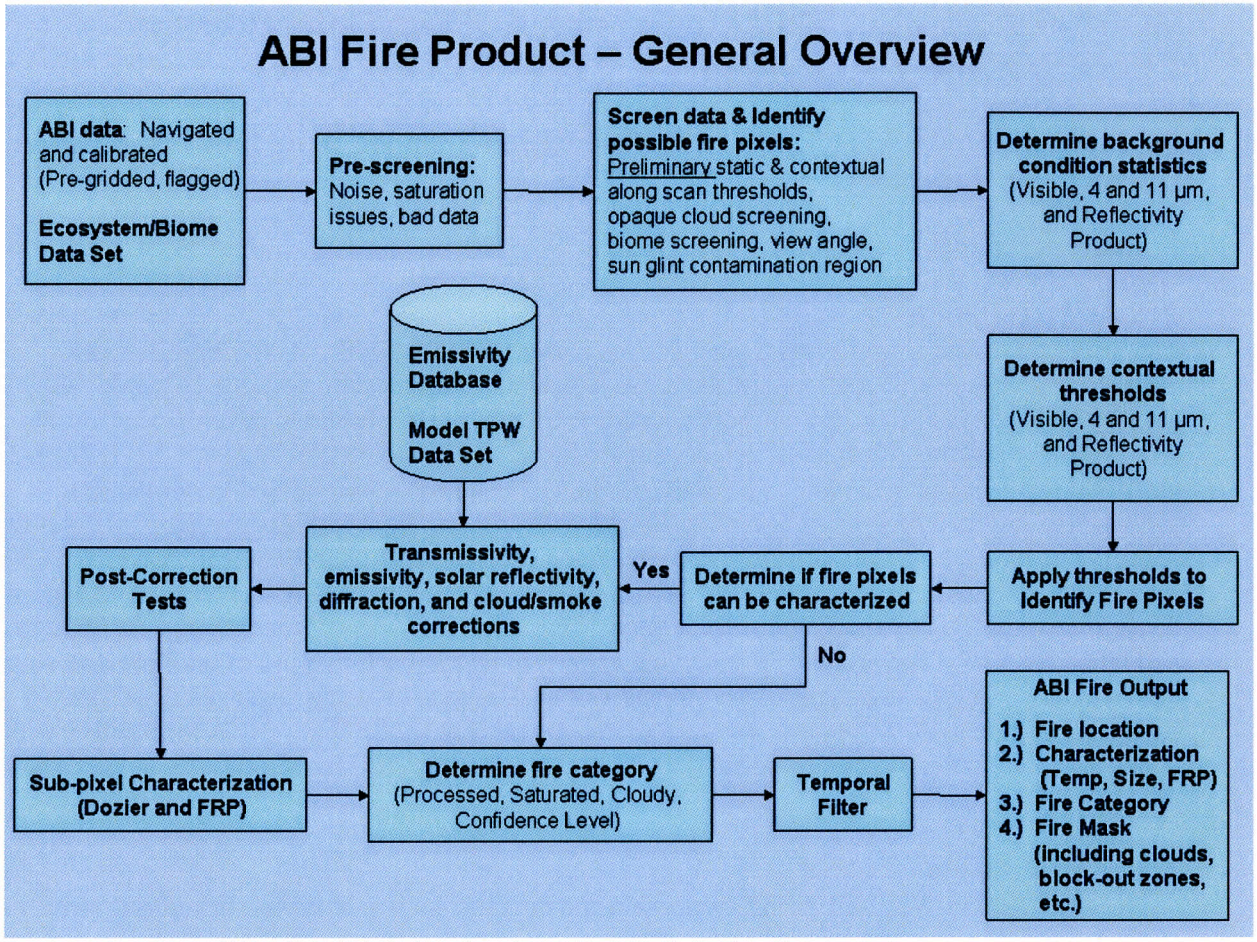
Funded by: NOAA

Project Description

The primary focus of this effort is to evaluate the current GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA) and adapt the algorithm for application with the GOES-R ABI. This activity builds on historical and current expertise at CIMSS in fire algorithm development for the GOES Imager and the global geostationary fire observation network (MSG, MTSAT-1R, INSAT-3D, etc.). CIMSS is revising the WF_ABBA to address GOES-R ABI observational requirements utilizing the improved fire monitoring capabilities on GOES-R. This includes updating modules that identify and characterize sub-pixel fire activity, demonstrating and validating the prototype GOES-R ABI WF_ABBA using various GOES-R ABI proxy data sets, and providing a version of the algorithm for further evaluation by the AWG science team. This effort involves collaborations with MODIS and NPOESS VIIRS fire product development experts to maximize future use of multiple data sources (geo and leo) and take advantage of the strengths of each system to create improved fused fire products. This activity will ensure continuity from the current GOES WF_ABBA to GOES-R with enhanced future geostationary fire detection, diurnal monitoring, and characterization in the GOES-R era.

Accomplishments

- The current WF_ABBA code was evaluated on a line by line basis and flowcharts were created to show where updates/modifications may be necessary for GOES-R ABI applications.
- CIMSS worked in cooperation with the AWG Land Surface Team on the design of the fire test plan and validation protocol.
- CIMSS participated in the Algorithm Design Review in December 2006. At this review CIMSS also outlined high risk areas.
- CIMSS has been working in conjunction with CIRA and the CIMSS AWG proxy data team to identify and create appropriate fire proxy data simulated from models and higher resolution satellite sensors. (cost-share with NOAA GOES-R Risk Reduction)
- To date CIMSS has worked on the following components to update the WF_ABBA code for GOES-R ABI: evaluation of the UW Madison BF emissivity data set, evaluation of fire radiative power based on the Dozier and MIR techniques; development of a fire/opaque cloud/processing mask file. (cost-share with NOAA GOES-R Risk Reduction)



General overview of the GOES-R ABI fire detection and characterization algorithm.

GOES-R Algorithm Working Group: Cloud Application Team

Personnel: Andrew Heidinger, Michael Pavolonis, Tony Schreiner, JimJung

Funded by: NOAA

Project Description

This project involves developing algorithms and assembling the required documentation for meeting the specifications of the GOES-R ABI cloud products. The approach of the cloud application team is to develop and optimize the cloud algorithms using real data as opposed to simulated GOES-R data. While the physical basis of cloud algorithms is well established, we propose the best way to achieve optimal consensus is through the analysis of results from real data. Therefore, a critical component of the cloud application team's efforts will be testing cloud algorithms using real data. We propose that the data from SEVIRI imager from the MSG series of European Geostationary Satellites and data from the MODIS imager serve as the basis for this prototype.

In addition to developing the required prototype systems using SEVIRI and MODIS, the project requires the selection and development of appropriate cloud algorithms. Many of these algorithms will come from other members of the cloud application team. However, some algorithms, including an infrared-only cloud height, will require development under this proposal. Lastly, this project will include validation of all algorithms and documentation of their performance.

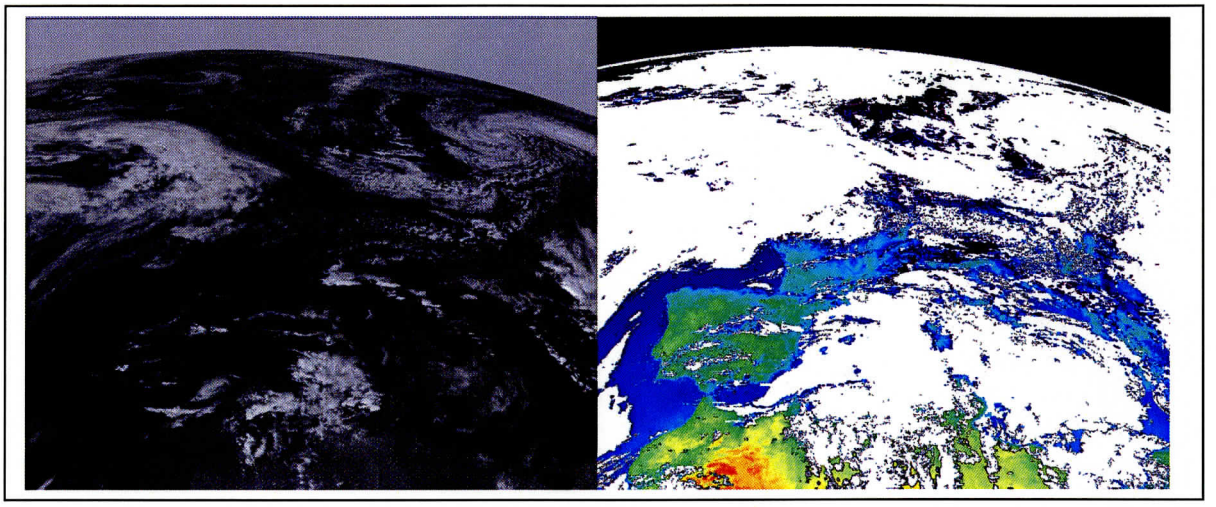
A major part of this project was the development of the Geostationary Cloud Algorithm Test-bed (GEOCAT). GEOCAT allows multiple versions of an algorithm to be run simultaneously on the same dataset. This capability isolates algorithmic effects on product performance.

In summary, the project objectives are as follows:

- Develop a Geostationary Cloud Algorithm Test-Bed (GEOCAT) to facilitate algorithm implementation, comparison and verification
- Develop ABI algorithms for cloud detection, cloud type and cloud height
- Work with cloud team to implement algorithms for cloud optical and microphysical properties
- Deliver required code and documentation to the STAR integration team

Accomplishments

- First version of GEOCAT developed and released to local CIMSS algorithm developers.
- Prototype ABI cloud detection and cloud typing routines implemented in GEOCAT.
- One month (August 2006) processed through GEOCAT for demonstration. Level-1 HDF files made available within CIMSS to assist other AWG efforts.



Example application of the GOES-R prototype ABI cloud mask to MSB/SEVIRI data. Image on the left shows a 0.65 mm reflectance. Image on the right shows the cloud mask placed on top of a derived surface temperature field.

GOES-R Algorithm Working Group: ABI Ozone Detection

Personnel: Christopher Schmidt, Xin Jin, Jun Li

Funded by: NOAA

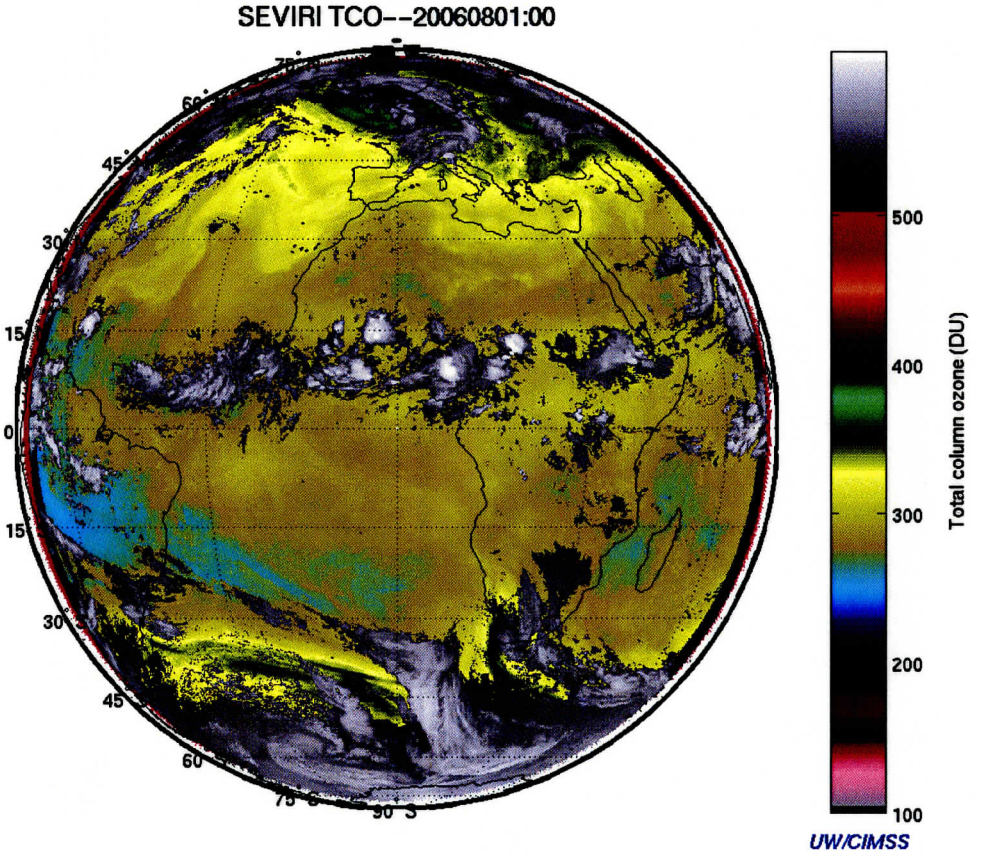
Project Description

The Advanced Baseline Imager (ABI) on GOES-R has sufficient spectral coverage, most importantly the 9.6 μm ozone absorption band, to retrieve total column ozone over its coverage area. The legacy GOES I-M Sounder experimental total column ozone (TCO) algorithm from CIMSS can be applied to ABI. ABI ozone will provide high spatial and temporal resolution sampling of ozone features that primarily reflect ozone distribution in the stratosphere and upper troposphere. ABI ozone alone cannot meet requirements for measuring the tropospheric column ozone. ABI ozone provides continuity with the current ozone capabilities and function as a part of an ABI Sounding package. ABI ozone may also find an application in turbulence monitoring, specifically with regard to mesoscale airmass exchange.

The primary sources of proxy data for this project are the Meteosat-8/-9 SEVIRI instruments. Models usually use climatological ozone, rendering them poor proxy data sources for this work. Polar orbiting instruments such as MODIS can provide proxy data for ABI Ozone studies, but the primary focus is on SEVIRI given the similarities in spectral coverage and temporal and spatial resolution.

Accomplishments

- The GOES Sounder ozone regression was successfully tested on ABI data in simulations. It was found that utilizing a-priori information about the temperature profile of the atmosphere improved the ABI TCO estimates, thus achieving better results in simulation than current GOES Sounder TCO.
- The algorithm was successfully applied to SEVIRI data and when compared to AURA Ozone Monitoring Instrument (OMI) data was found to have a %RMSE of under 5% when an ECMWF model-based forecast of the temperature profile is used.
- CIMSS will soon be running the SEVIRI ozone algorithm in real-time to build up a database of SEVIRI ozone and OMI collocations to use for further studies.



SEVIRI total column ozone for 0 UTC on 1 August 2006. Ozone estimates are carried out to 80 degrees satellite zenith angle. The cloud mask used in this case is basic, so some cloud artifacts are present. Overall the image is an accurate representation of the ozone field, and fine-scale features can be seen evolving during a day-long loop of this product. Data quality issues over the Saharan Desert are also evident in that loop.

GOES-R Instrument and Scan Strategy Studies

Personnel: Jun Li, Tim Schmit, Mat Gunshor, Jinlong Li, Chian-Yi Liu, Hal Woolf

Funded by: NOAA

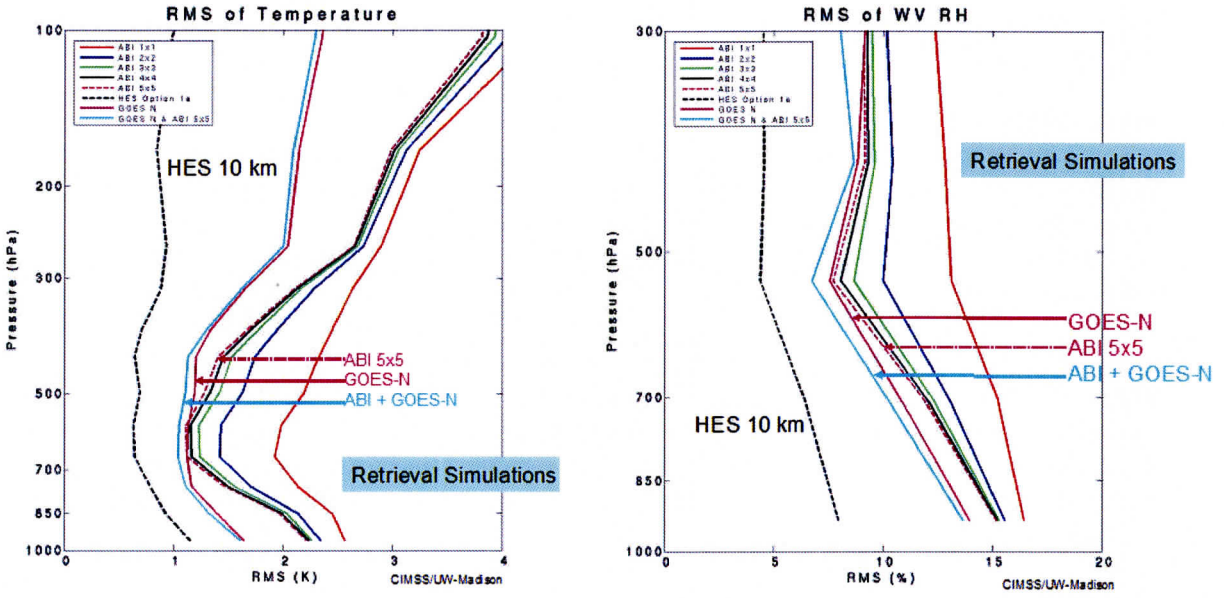
Project Description

CIMSS will conduct instrument and scan strategy studies on sounding and imaging systems for the GOES-R and beyond. Studies conducted include spectral coverage and resolution, spatial resolution, temporal resolution, signal-to-noise ratio, Detector Optical Ensquared Energy, scan rate and coverage, GOES-R position, etc. Studies are also conducted to demonstrate the improved or new capabilities from the GOES-R (and beyond) system over the current GOES system. The results from these studies will support the requirement and formulation of GOES-R instruments and offer better understanding of GOES-R observing systems. GOES-R scan strategy will be studied to demonstrate a wide variety of applications of imaging and sounding data with improved temporal resolutions in nowcasting and forecasting. The sounding option for GOES-R (e.g., using combined ABI and model forecast information for the continuation of the current class sounder products) is also studied; the quantitative information degradation of ABI/forecast combination compared with geostationary hyperspectral sounder (GHS) is being investigated.

Accomplishments

- 10 peer reviewed journal papers have been published during past 2 years (24 in past 5 years) under or partially under support of this project.
- ABI spectral bands are studied and selected. Simulation on ABI spectral coverage, spatial resolution, temporal resolution and their advantages on various applications over the current GOES Sounder are studied.
- We have studied the HES (Hyperspectral Environmental Suite) spectral coverage, spectral resolution, spatial resolution, temporal resolution, signal-to-noise ratio, point spread function, etc. by performing trade-off studies per AOL TAP (Atmosphere-Ocean-Land Technical Advisory Panel) request. Results of a general trade-off study for a geostationary advanced sounder was published in Applied Optics (Wang et al. 2007, Applied Optics). CIMSS scientists also participated in the HES (end of HES formulation) review.
- Point Spread Function (PSF) causes a blurring error. The impact of blurring on retrievals has been studied using MODIS 1 km IR data. We found that the blurring error is not random, it varies spectrally. 90%, 80% and 70% EE (Ensquared Energy) will cause approximately 0.07, 0.10 and 0.15 K additional temperature retrieval errors, respectively, in the boundary layer with MODIS. For the water vapor relative humidity (RH), 90%, 80% and 70% EE will cause approximately 0.4%, 0.6% and 0.8% additional retrieval errors, respectively. These results have been published in the IEEE Transactions on Geosciences and Remote Sensing (Zhang et al. 2006).
- Using ABI for the continuation of the current GOES Sounder operational products is being studied. Since ABI will fly before the geostationary hyperspectral infrared sounder, it is very important to study the continuation of the current GOES Sounder operational products (temperature and moisture soundings, total precipitable water, lifted index, cloud-top properties, etc.) with ABI. Initial simulation shows that ABI can provide similar moisture information to the current GOES Sounder with a fast coverage rate. However, a geostationary hyperspectral IR sounder is needed if advanced temperature and moisture sounding products are required. The following figure shows the temperature (left panel) and relative humidity

(right panel) retrieval RMSE from various ABI fields of regard, along with the GOES-N class Sounder and HES.



The temperature (left panel) and relative humidity (right panel) retrieval RMSE from various ABI fields of regard, along with the GOES-N class Sounder and HES.

Mission 2

Serve as a center at which scientists and engineers working on problems of mutual interest may focus on satellite related research in atmospheric studies and earth system science.

Field Programs and Calibration/Validation

- Land Surface Characterization using Aqua AIRS
- High Spectral Resolution Observations for ARM Program
- Microphysical Properties of Arctic Mixed Phase Clouds
- ARM Site Atmospheric State Best Estimates for Aqua
- WVSS Field Program
- Improve Impact of Satellite Data in NWP through THORPEX
- NASA TCSP Field Experiment (Tropical Cyclone Intensity)
- ARM Raman Lidar Support
- ARM AERI Support
- Deriving Liquid Water Content Profiles from ARM Raman Lidar
- Radiative Heating in Underexplored Bands Campaign
- Instrument Acquisition: Microwave Radiometer

Data Assimilation and Numerical Weather Prediction

- Data Compression Research for Future NOAA GOES
- Community Radiative Transfer Model (CRTM)
- Winds Assimilation
- Data Impact Studies
- Forecast Impact of WindSat/Coriolis Data in NCEP GDAS
- Advanced Weather Information Processing System (AWIPS)
- AIRS/MODIS Co-Registration and Cloud Characterization for Data Assimilation

EOS Research and Products

- EOS Real-time Products
- Refining MODIS Calibration and Deriving Cloud Top Properties
- CO2 Column over Clouds
- MODIS MOD07 Atmospheric Profile Retrievals
- MOD35 – MODIS Cloud Mask Algorithm
- Global Analysis of MODIS Level 3 Cloud Properties
- IMAPP for EOS Direct Broadcast Data

IPO Research and Products

- NPP Atmosphere Product Evaluation and Test Element (PEATE)
- NPP VIIRS Level 1 Product Early Assessment
- NPOESS Cal/Val and Product Development
- Validating Snow and Ice Products in Polar Regions for NPOESS
- International Polar Orbiting Processing Package (IPOPP)

Polar Science

- Cloud and Radiation Properties in the Polar Regions

Environmental and Ecosystems

- Analysis of Long-term Fire Dynamics and Impacts on the Amazon
- Using Real-time Biomass Burning Products in Model Data Assimilation
- Three-Dimensional Air Quality System (IDEA)
- Texas Air Quality Study

Tropical Cyclones

- Tropical Cyclone Applications Using Satellite Data
- Hurricane Inner-Core Dynamics and Intensity Change
- Tropical Cyclone Structure, Intensity Change, and Eyewall Replacement Cycles
- Hurricane Variability and Trends
- Global Reanalyses of Tropical Cyclone Intensity Records

Clouds and Precipitation

- Thunderstorm Avoidance
- Applications of GOES Rapid Scan Winds
- AVHRR Pathfinder Atmospheres Extended (PATMOS-x)
- Support of NASA/MSFC Nowcasting
- CALIPSO – Cloud and Aerosol Studies
- Advanced Satellite Aviation-weather Products
- Multi-Instrument Data Analysis and Synthesis
- Enhanced V Detection
- Scientific Support for Deriving Cloud Properties
- China MERSI Cloud Mask

Land Surface Characterization Using Aqua AIRS

Personnel: R. Knuteson, S. Moeller, K. Vinson

Funded by: NASA

Project Description

This project was funded as a separate effort under the NASA Aqua Validation announcement of opportunities. The PI of this project was previously a member of the AIRS science team as a co-I of Dr. H. Revercomb since 1990 and has been active in the topic of land surface emissivity with an emphasis on the new information provided by high spectral resolution infrared observations. In particular, a new temperature/emissivity separation method was implemented in this project for the separation of land surface temperature and infrared emissivity using the reflected signal from the downwelling atmosphere at the surface. This UW product has been used in the validation of emissivity produced by the AIRS team product with frequent reports to the science team on the performance of team algorithm versions especially with regard to absolute accuracy of the infrared emissivity. The proposed effort also includes comparison of AIRS and MODIS land surface products for both infrared emissivity and skin temperature.

The objectives of this project are:

- Create a validation dataset from single field of view AIRS observations using the PI's land surface temperature and emissivity separation algorithm (known as the spectral variance algorithm).
- Compare AIRS and MODIS land surface temperature and emissivity products on a common space and time scale.
- Support the validation and improvement of the AIRS land surface products with the goal of improving the accuracy of sounding air temperature and water vapor concentration in the atmospheric boundary layer.
- Collaborate with data assimilation experts in the proper use of AIRS data over land.

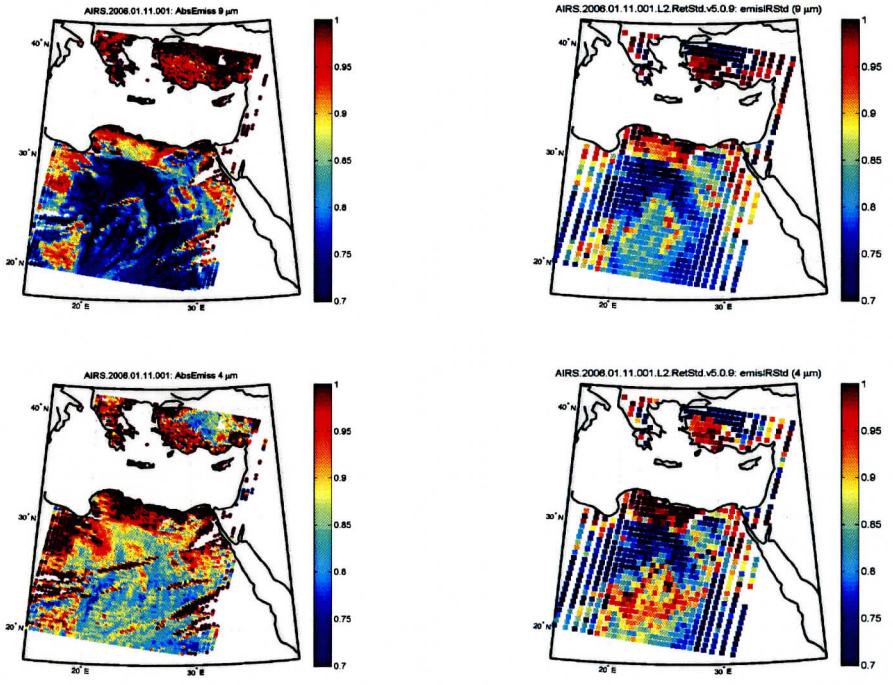
Accomplishments

Significant progress was made in each of the task areas:

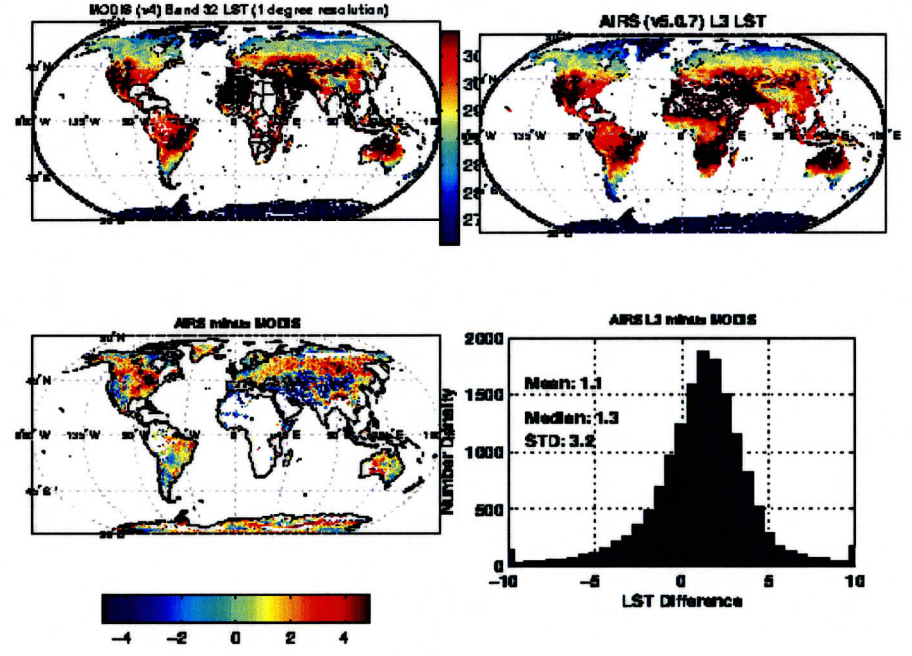
- The UW spectral variance algorithm was implemented using the UMBC SARTA radiative transfer model and the method applied to test datasets. See figure below.
- A method for comparison of AIRS and MODIS products was developed and used to perform detailed analysis of the AIRS products. AIRS version 4 over land was found to be unsatisfactory while the most recent version 5 has improved performance. See figure below.
- Numerous presentations have been made to the AIRS science team regarding the team algorithm performance for surface skin temperature and infrared emissivity.
- Attended the First Workshop on Land Surface Remote Sensing and Modeling under the ITWG and later submitted a peer reviewed paper for a special issue of IGARS on the topic of the use of AIRS data over snow and ice covered surfaces (Greenland): "A Proposed Methodology for the Determination of Surface Temperature and Effective Infrared Emissivity for Advanced Infrared Sounder Fields of View at High Latitudes."

Additional work in this topic remains to be accomplished to achieve the full benefit of the high spectral resolution observations of Aqua AIRS, MetOp IASI, and the future NPP CrIS. A follow-up

proposal is pending from the NASA ROSES announcement in 2006 and the MEASURES announcement in 2007.



Validation of AIRS version 5 product over Egypt; upper panels are 9 μm, lower panels are 4 μm, left is UW validation product using spectral variance method of the PI, right is the AIRS team product (v5.0.9).



Example comparison of the AIRS and MODIS skin temperature from the Aqua satellite for August 2005 showing regions of disagreement and the global histogram of differences.

High Spectral Resolution Observations for the ARM Program: Clear and Cloudy Sky Applications

Personnel: Henry Revercomb, David Tobin, Robert Knuteson, Leslie Moy, Lori Borg, Jun Li, Daniel DeSlover, Robert Holz, David Turner

Funded by: DOE

Project Description

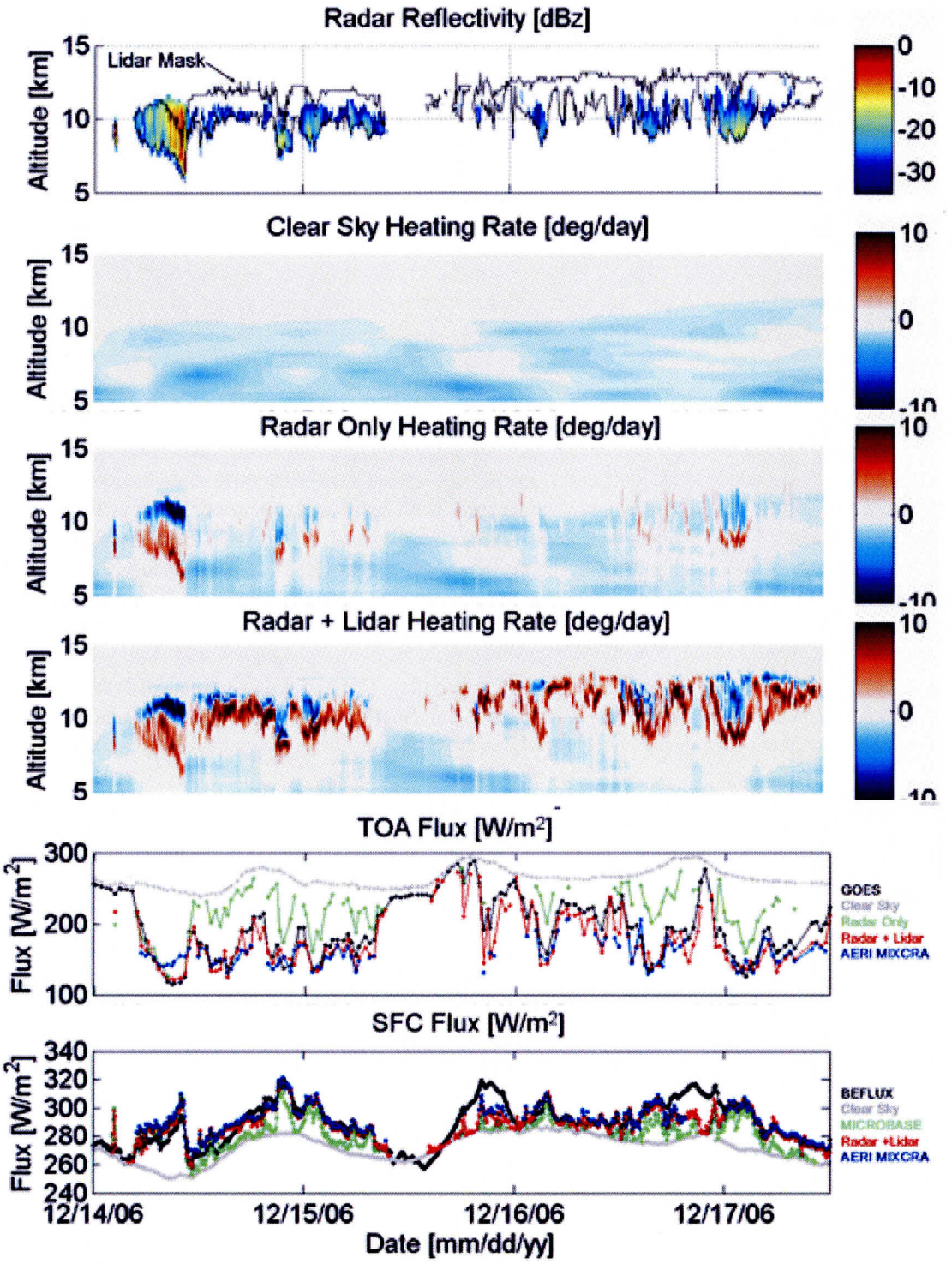
The overall objective of this project is to contribute to observational assessments for model representations of radiation and the atmospheric state under the wide range of conditions sampled at the ARM permanent and mobile sites. The project significantly extends the ARM applications of the ground-based Atmospheric Emitted Radiance Interferometer (AERI) by adding the high spectral resolution "view from above" via aircraft and satellite observations under all sky conditions. The specific approach and expertise offered here is application of highly accurate infrared spectra from our Scanning High-resolution Interferometer Sounder (S-HIS) and from the NASA Atmospheric IR Sounder (AIRS) to provide refined cloud properties, upper level moisture distributions, and surface properties, in addition to radiance constraints over both local and extended GCM grid-cell domains. AIRS data product generation will be focused on contributing to the ARM Broadband Heating Rate profile (BBHRP) activity. The BBHRP couples inputs from ARM working groups on cloud properties, clear sky radiation, aerosols, and cloud parameterization and modeling to provide a product for testing the dynamical effects of heating rates in models. AIRS products augment those from other satellite observations for testing both instantaneous properties and the variational analyses employed in BBHRP to obtain grid cell average results. The special strengths offered by high-resolution observations are better sensitivity and heights for low optical depth clouds, nighttime cloud and surface properties, upper level water vapor and more direct constraints on spectral radiance.

Accomplishments

Recent accomplishments of this research contribute to the ARM BBHRP project in terms of assessing our ability to compute clear sky and cloudy sky heating rates and fluxes. Specific accomplishments include:

1. Assessed the ability to compute TOA and surface fluxes for clear sky conditions. Extended the BBHRP methodology from the focus period of three months to 6 years, allowing for a more accurate assessment of the TOA flux closure, and the study of diurnal, seasonal, and inter-annual differences.
2. Assessed differences between GOES OLR TOA fluxes and Aqua CERES OLR TOA fluxes.
3. Improved and quantified the uncertainties in the RRTM flux calculations using AIRS high spectral TOA radiance spectra.
4. Computed AIRS "partial fluxes" so that AIRS radiances could be used to assess BBHRP fluxes, a useful new method of evaluating the sources of uncertainty (which include radiometric observations, radiative transfer models, and observations of the atmospheric state which drive the models).
5. Assessed the ability, using ARM observations, to compute heating rates and TOA and surface fluxes for uniform cirrus cloud events.

The figure below shows the results of a study of a uniform cirrus cloud event and the comparison of heating rates and fluxes computed using radar-only cloud properties to cloud properties derived using radar, lidar, and AERI observations. The study highlights the need to properly characterize the cloud optical depth in order to accurately compute the heating rates and fluxes.



Cirrus cloud flux closure study. top panel: Radar and Raman lidar cloud observations; panels 2 through 4: Heating rates computed for clear sky and cloudy sky using Radar-only and Radar+Lidar cloud properties; panels 5 and 6: Computed and observed TOA and surface fluxes.

Microphysical Properties of Arctic Mixed-phase Clouds

Personnel: Dave Turner

Funded by: DOE Office of Science

Project Description

The principal objective of this project is to assess and improve our understanding of the interaction of radiation and mixed-phase (and liquid water) Arctic clouds by analyzing the multi-year dataset collected at the DOE Atmospheric Radiation Measurement (ARM) program's Climate Research Facility in Barrow, Alaska. This proposal addresses a central goal of the ARM program, namely the improved treatment of radiation and clouds in climate models.

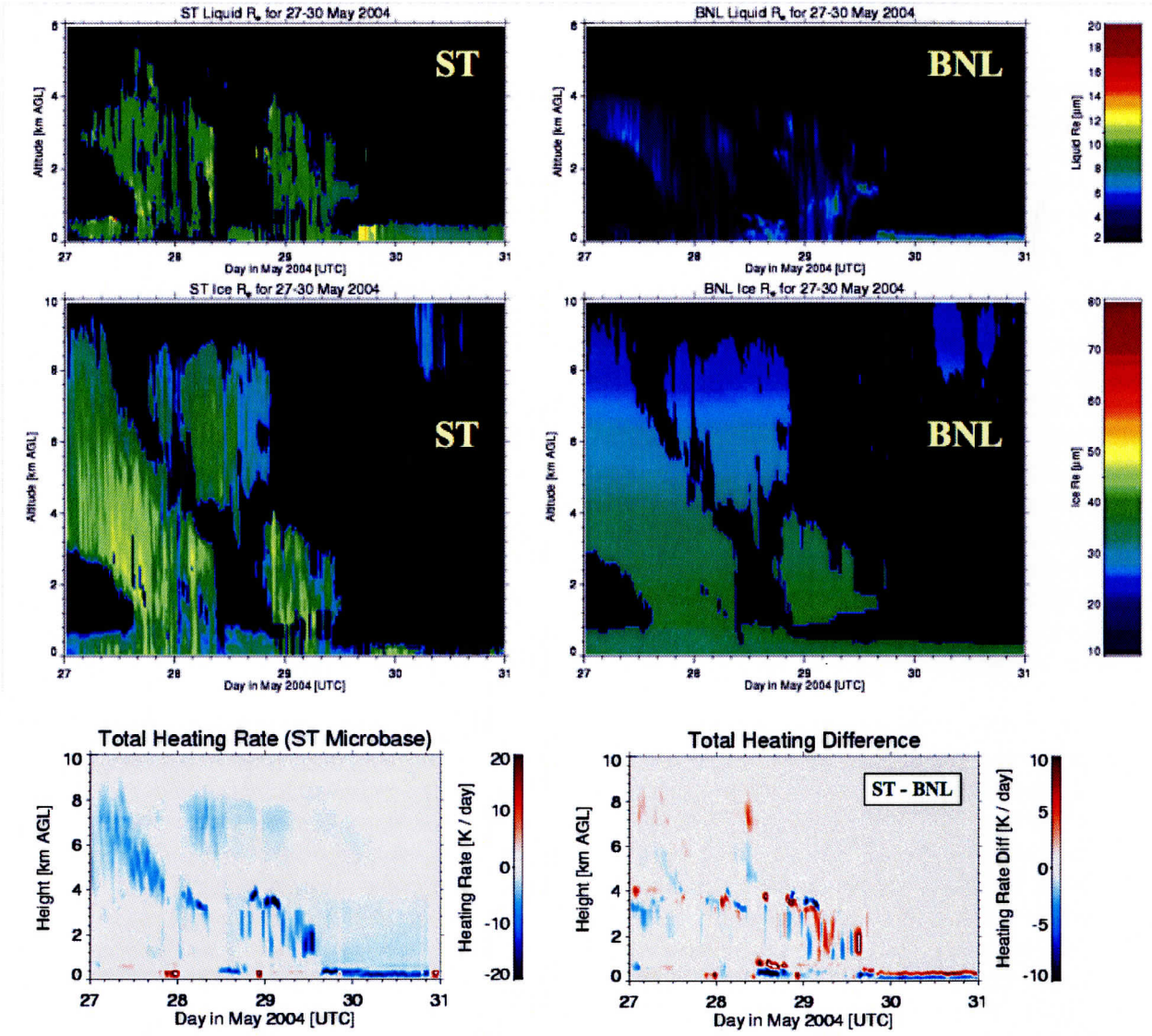
Mixed-phase and liquid water clouds are prevalent during all seasons in the Arctic boundary layer, with the liquid water path (LWP) frequently (over 70% of the time annually) being less than 100 g/m^2. The most common way to determine the LWP is to use a ground-based microwave radiometer (MWR); however, the uncertainty in the MWR-retrieved LWP is at least 25 g/m^2, resulting in very large relative errors in the LWP. We have developed a technique to retrieve LWP from a ground-based infrared interferometer called the Atmospheric Emitted Radiance Interferometer (AERI) that is much more sensitive to LWP, with uncertainties in LWP of less than 5 g/m^2 for LWP less than 50 g/m^2. Furthermore, this algorithm is able to retrieve not only the LWP, but also the optical depth of the ice component and the effective radii of both the ice and liquid components of mixed-phase clouds, providing that the precipitable water vapor (PWV) is less than 1 cm (which often occurs in the Arctic). Therefore, this AERI-based mixed-phase cloud retrieval algorithm (MIXCRA) provides a unique way to characterize the microphysical properties of Arctic clouds.

To investigate the radiative effects of Arctic clouds, we have distributed the column-averaged properties retrieved by MIXCRA vertically using observations from micropulse lidar and cloud radar. These vertical profiles of cloud properties are then input into a radiative transfer model to compute surface and top-of-atmosphere (TOA) radiative flux (both longwave and shortwave components), as well as profiles of radiative heating rate (RHR). First, we assessed the differences in the surface and TOA longwave and shortwave broadband flux residuals (observed minus computed) with our new MIXCRA-based product relative to the original ARM cloud product; our product has significantly lower bias and less scatter. Furthermore, the impacts on the RHR profile are considerable, with the differences being as large as 10 degrees / day at some atmospheric locations. Differences in the RHR profile of this magnitude are very significant, as heating in the atmosphere drives vertical motion of the atmosphere and thus helps drive the atmospheric circulation, and thus errors in the RHR profile result in errors in the simulated atmospheric circulation.

Accomplishments

- Developed the AERI-based Mixed-phase Cloud Retrieval Algorithm (MIXCRA).
- Validated the MIXCRA-retrieved LWP and liquid water effective radius using radiative closure studies in mid-latitude marine stratocumulus cloud fields.
- Validated the simultaneous MIXCRA liquid and ice optical depth retrievals using a specialized high-spectral-resolution lidar, which was developed at SSEC / University of Wisconsin – Madison and used in a field experiment at the ARM site in Barrow in Oct-Nov 2004.

- Developed a new algorithm that distributes the MIXCRA-retrieved cloud properties vertically, and utilized the output of this algorithm in a radiative transfer model to show improvements over the standard ARM product.



Profiles of liquid water effective radius (top), ice particle effective radius (middle) for the MIXCRA-based (ST, left) cloud properties and the standard ARM product (BNL, right). The total RHR profile for the MIXCRA-based results are shown in the lower left, and the differences in the RHR profile between the MIXCRA-based and standard ARM product are shown in the lower right. The large differences in the RHR profiles (lower right) are due to the significantly different cloud properties used in the two algorithms. Any errors in the cloud properties may result in errors in the atmospheric circulation when the cloud properties are used in an atmospheric model, especially if the errors in the RHR profile are as large as those shown for the standard ARM product.

ARM Site Atmospheric State Best Estimates for Aqua: Retrieval, Radiance, and Forward Model Validation

Personnel: David Tobin, Leslie Moy, Wayne Feltz, Robert Knuteson, Henry Revercomb

Funded by: NASA

Project Description

The overall goal of this research is a proper validation (uncertainty assessment) of the primary Atmospheric Infrared Sounder (AIRS) products of TOA spectral radiance and temperature and water vapor retrievals and analogous products from MODIS. The investigations fall into two main areas: 1) development and production of atmospheric state and surface property best estimate products for Aqua overpasses of the Atmospheric Radiation Measurement (ARM) sites, and 2) Aqua validation studies using the ARM site overpass data sets.

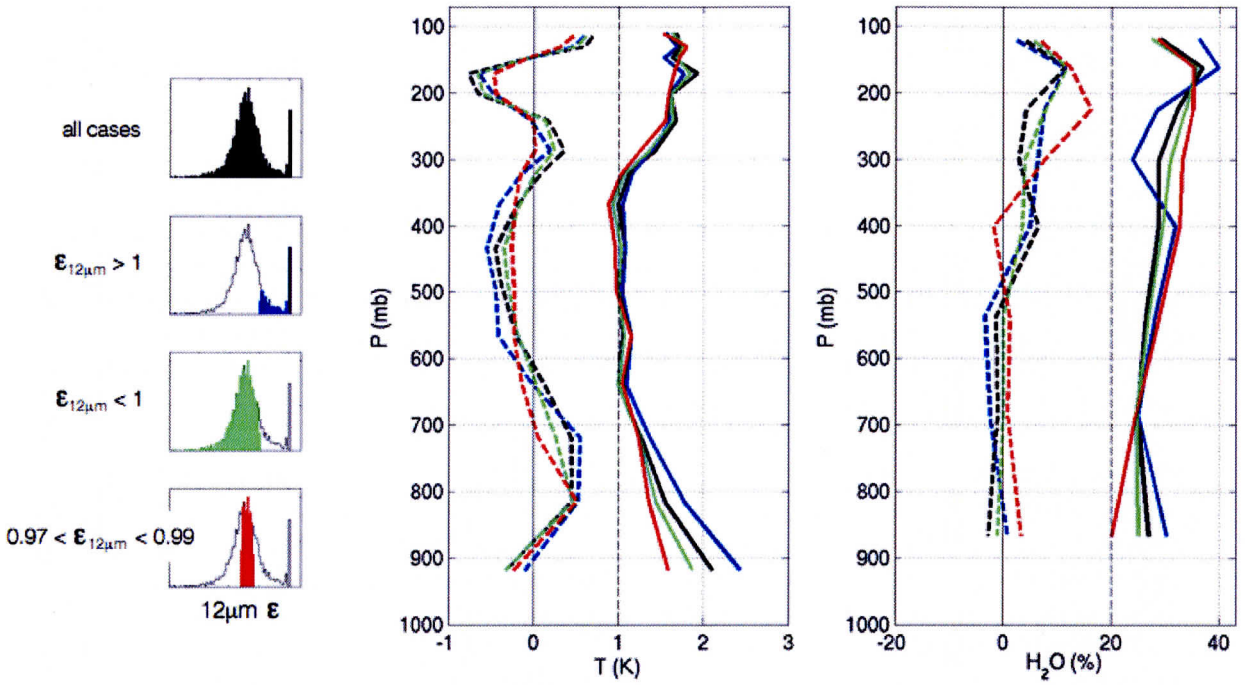
Accomplishments

Accomplishments of this work include the production and accurate characterization of ARM site best estimate atmospheric state and surface properties for Aqua overpasses of the three primary ARM sites and the use of the validation products to validate the AIRS products. Regarding production of the ARM validation products, in particular, this includes coordination and collection of ensembles of radiosonde observations collocated with the satellite overpasses, various studies regarding the accuracy and precision of various ARM observations, and the use of ARM and other data to reduce and characterize the effects of temporal and spatial collocation. Possessing high accuracy and precision and statistical representativeness, the ARM products have proven to be extremely valuable for assessing the advanced sounder products for their use in weather and climate applications.

Regarding validation of the AIRS products, the major accomplishments include the use of the ARM validation products to characterize and improve the accuracy of the AIRS Radiative Transfer algorithms (Strow et al., 2006), the validation of the AIRS version 4 temperature and water vapor retrievals (Tobin et al., 2006; Chahine et al., 2006), and assessment of the recently released AIRS version 5 products. This includes detailed assessment of the bias, RMS performance, and yield at the ARM Southern Great Plains (SGP), Tropical Western Pacific (TWP), and North Slope of Alaska (NSA) sites.

A particularly interesting and recent finding of this work is shown in the figure below. Atmospheric sounding of the boundary layer temperature and water vapor has proven to be difficult over land surfaces due to the interaction of the surface temperature and spectral emissivity retrieval with the profile retrievals; retrieval bias and RMS performance over the land sites (SGP and NSA) is degraded with respect to results over ocean (TWP). Improved retrieval performance in the boundary layer is the major emphasis of the AIRS retrieval development, and a new method for surface emissivity retrieval was implemented in the AIRS version 5 retrievals. Relative to previous versions, the version 5 retrieved emissivities have spectral dependence and range which more closely matches nature. For the SGP site, the surface emissivity can be accurately represented as the linear combination of bare soil emissivity and vegetated emissivity, and is found to have a very small range (~0.97 to ~0.99) at the so-called Christensen point at 12 μm. While the version 5 AIRS retrievals do not follow this behavior for all retrievals, they do cover the range. The encouraging finding of the validation analyses, as shown in the figure, is that when the retrieved emissivity falls within the physical range, the bias and RMS of the resulting profile retrievals in the boundary layer is improved significantly.

This type of information is currently being used to guide the development of version 6 AIRS surface temperature and emissivity retrievals.



AIRS version 5 temperature and water vapor retrieval performance at the Southern Great Plains site. The bias (dashed) and RMS performance (solid) of the retrievals with respect to the ARM validation products is shown for four ensembles of profiles sorted by the retrieved surface emissivity at 12 μm. When the retrieved emissivity falls within the physical range (red curves), the temperature and water vapor retrievals are found to improve significantly in the boundary layer.

WVSS Field Program

Personnel: Ralph Petersen, Wayne Feltz, Sarah Bedka, Kris Bedka, Erik Olson

Funded by: NOAA/NWS

Project Description

The CIMSS suite of in situ and remote sensing weather instruments was used to assess and valid the quality of moisture and temperature profiles from newly installed Water Vapor Sensing Systems - II (WVSS-II) sensors on United Parcel Services (UPS) airline aircraft. Long term efforts include a series of the field program deployments and data analysis, as well as a study of high temporal resolution water vapor profiles to objectively determine optimal spacing and sampling frequency needed from the data.

Efforts have been conducted in four areas:

1) Collection and evaluation of the co-located WVSS-II/radiosonde data taken in 2005,
2) Development of an alternative reporting algorithm to increase WVSS-II data precision for values greater than 10 g/kg,
3) Collection of data from a second WVSS-II field assessment in Louisville using sensors modified to improve data taken on descent, and
4) Continuation of efforts to determine the time/space variability of low-level atmospheric moisture.

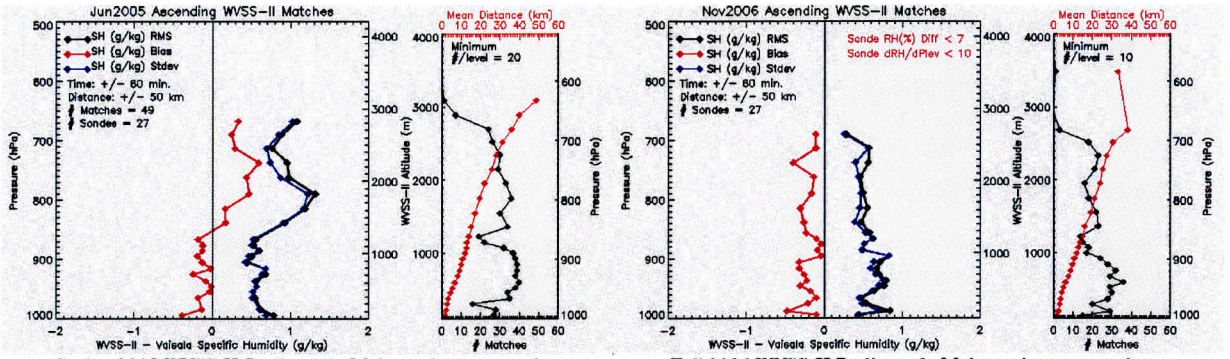
Accomplishments

Collection and evaluation of the co-located WVSS-II/radiosonde data. Co-located Radiosonde and WVSS-II data were collected for 2 week periods in June 2005 and November 2006. Statistical evaluations were made of the performance of a variety of factors important for the optimal objective use of the aircraft data in combination with other data sources by assessing:

1. similarity of reports from the different observing systems and different aircraft,
2. biases between ascent and descent reports from individual aircraft,
3. variability between different aircraft (to assess instrument calibration and effects of aging), and
4. capability of the WVSS-II of to capture sharp moisture gradients accurately, including as aircraft emerge from clouds.

Overall statistical comparisons show very small biases between WVSS-II and Radiosonde data sets. Root Mean Square (RMS) and Standard Deviation (SD) fits are around 1 g/kg for specific humidity, especially in the more stable areas of the lower troposphere in these night-time comparisons. When only data with high reporting precision are used, the results for observations below 10 g/kg improve significantly, while comparisons of data subjected to larger truncations show much more variability. For values below 10 g/kg (see Figure 1-left), the SD fit for these data approaches 0.5 g/kg in the boundary layer. Comparisons of Relative Humidity for these data (derived from a combination of aircraft moisture data and rawinsonde temperature observations to remove biases in the aircraft temperature reports) show accuracies near 5% - meeting WMO requirements. Early assessment results from the November 2006 assessment (Figure 1-right) show that the differences between the radiosonde and aircraft data during ascent are very similar to those obtained during 2005, with small biases and SDs reduced to <0.5 g/kg or less throughout most of the lower half of the troposphere.

Development of an alternative reporting algorithm to increase WVSS-II data precision. An alternative reporting scheme was developed by CIMSS and implemented by UPS which preserves the intended precision of better than 0.1 g/kg for all reports without increasing the number of digits required for report transmission. This change was needed to preserved data above 10 g/kg.



Spring 2005 WVSS-II/Radiosonde Moisture intercomparisons *Fall 2006 WVSS-II/Radiosonde Moisture intercomparisons*

Figure 1. Sample results of WVSS-II/Radiosonde Specific Humidity (SH) intercomparisons for June 2005 and November 2006. Co-locations made within 60 minutes and 50 km, with restrictions to remove extreme moisture variations in time and space.

Determining the time/space variability of low-level atmospheric moisture. The time/space variability of low-level atmospheric moisture will be determined using a combination of AERI moisture profiles and Wind Profiler data. Characteristics of the 6-minute Wind Profiler data needed to be determined before the data sets could be used in combination. New results from this effort include:

a. Development of an improved Quality Control procedure for the 6-minute data,
b. Calculation of the Wind Profiler Instrument Error (~0.5 to 1.5 m/s at various levels),
c. Determination of Atmospheric Variability for co-located reports (~1.2 to 1.6 m/s), and
d. Estimations of how that variability increases in both space and time.

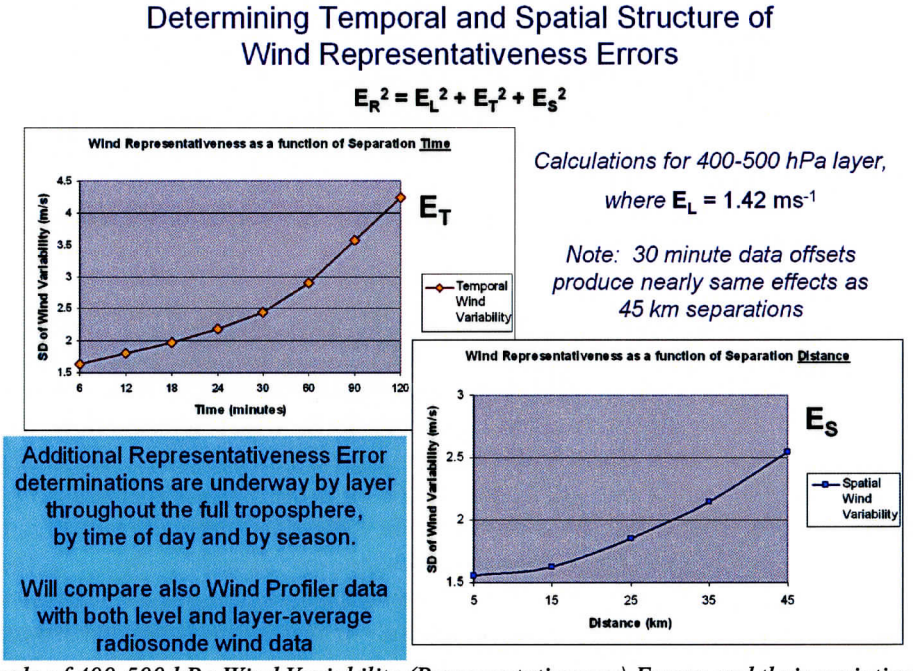


Figure 2. Sample of 400-500 hPa Wind Variability (Representativeness) Errors and their variations with time and space as determined from Wind Profiler at Rawinsonde data taken at OK ARM-CART site.

Improving the Impact of Satellite Data in NWP Using THORPEX Opportunities

Personnel: Chris Velden (PI), Howard Berger

Funded by: NOAA

Project Description

The overarching goal of this study is geared toward optimizing satellite data extraction and thinning methods, taking advantage of adaptive (dynamic) sampling opportunities (e.g., rapid scanning (RS) from geo satellites), and working closely with data assimilation centers of expertise (such as the JCSDA) to integrate the satellite data into model initializations that will lead to improved forecasts. These objectives are in line with the themes of Thorpex. Specifically, our research is designed to analyze whether there is increased potential of GOES atmospheric motion vectors (AMVs) to impact the NCEP numerical weather prediction system if improved data characterization is provided to the assimilation process.

To investigate this impact, we are using a promising data set that became available in 2005. GOES RS-AMVs were obtained during the TROpical cyclone Predictability EXperiment (TROPEX). TROPEX is a collaboration between CIMSS and the Naval Research Laboratory to investigate the effect of satellite-derived winds during the 2005 and 2006 North Atlantic tropical cyclone seasons. RS-AMV data sets were derived by CIMSS for tropical cyclones during these two hurricane seasons. These datasets are more frequent and at a higher horizontal resolution than previously assimilated AMVs and are being tested in data assimilation studies using NCEP's GFS model.

Accomplishments

A promising new quality characterization method for AMVs is that of the "expected error" (EE) as originally proposed by Dr. John LeMarshall and developed at the BoM. This method extends and modifies the current AMV quality indicator (QI) scheme that is used operationally by numerical forecast centers to thin the AMV input. Our research shows that AMVs with lower EE have better quality (Figure 1) and also relatively lower correlated error (Figure 2). Therefore the EE indicators will be used for our proposed data impact experiments.

As a preliminary investigation into the impact of AMVs on the GFS, all operational AMVs were removed from the data assimilation system for most of the TROPEX time period (July 28th-October 2005). The AMV-denied runs of the GFS model for Atlantic tropical cyclones during the period are then compared to a control with all of the operational AMV observations. Table shows the forecast track error for the CNTRL and no-AMV experiments. The experiment that includes the AMVs (CNTRL) has a lower forecast track error than the experiment without AMVs (NO AMV) at all forecast time periods. These results suggest that the AMVs improve the tropical and mid-latitude steering currents, thereby improving the track. They also suggest that the higher resolution TROPEX RS AMVs could subsequently improve the track even more, especially with superior quality-tagged information (EE). This evaluation will help us better understand the data quality and behavior of both the operational and RS GOES AMV as we optimize assimilation experiments within NCEP's model.

Experiment	12-hour	24	36	48	60	72	84	96	108	120
CNTRL	87.6	125.9	162.2	187.3	229.4	264.6	311.4	373.2	467.0	549
NO AMV	91.0	131.7	167.0	205.4	257.9	312.0	367.7	429.0	520.7	607.9
Number of Cases	89	81	69	65	56	55	50	48	41	39

Table 1: Forecast error (km) as a function of forecast time. The CNTRL experiment has a lower tropical cyclone track forecast error for all forecast times than the NO AMV experiment.

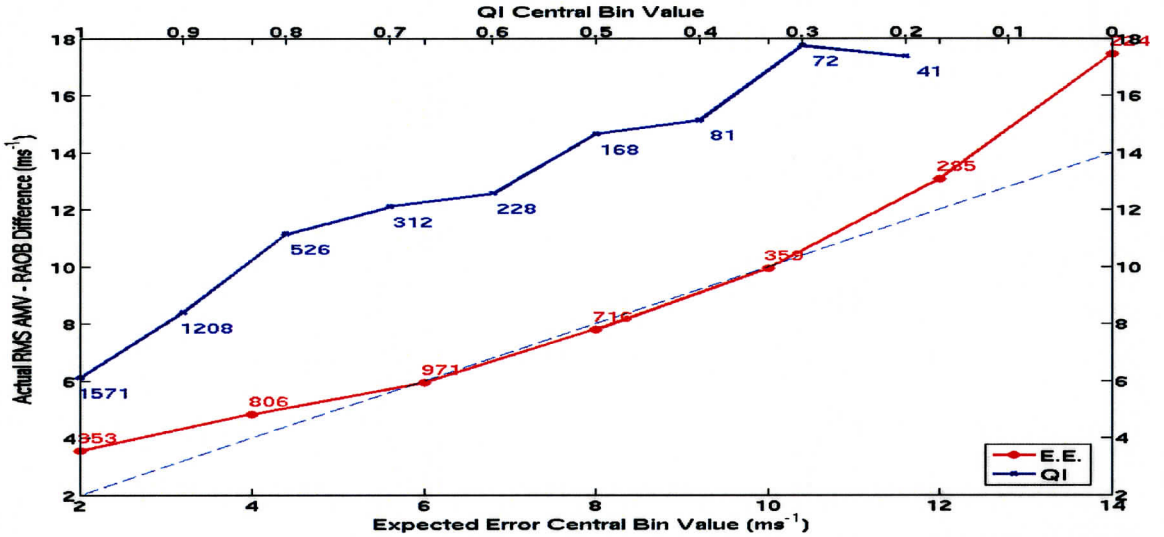


Figure 1: Comparison of the new Expected Error (EE, solid red curve) AMV quality indicator with the current operationally employed AMV Quality Indicator (QI, solid blue curve) for operational GOES IR AMVs during January 2007. Actual RMS differences between collocated AMV – RAOB are used to assess each parameter as a quality indicator. As the curves show, the EE relationship is a better predictor of measured AMV – RAOB differences than the QI. The 1-1 line (dashed blue) is plotted for reference. The numbers in red and blue represent, respectively, the number of AMVs in the EE and QI bins.

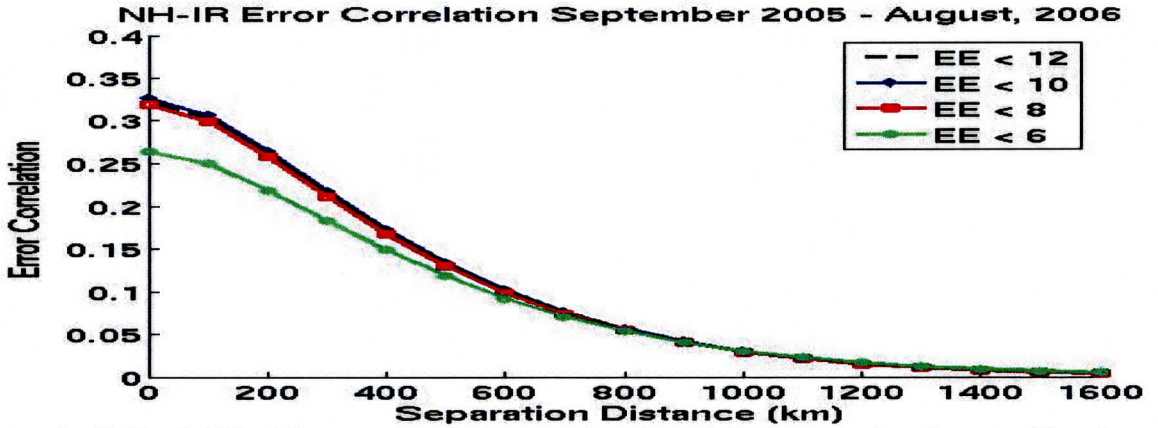


Figure 2: AMV – RAOB difference correlation as a function of AMV separation distance. The plot above is for GOES-E water vapor winds between September 2005 and August. In general, a lower expected error threshold has lower spatially correlated error.

Satellite Data Investigations of Tropical Cyclone Intensity Change During the NASA TCSP Field Experiment

Personnel: Chris Velden (PI), Howard Berger

Funded by: NASA

Project Description

The principal research work led by CIMSS during the TCSP project involves the investigation of the upper-levels of the troposphere during tropical cyclone (TC) genesis. These upper-levels are being examined by analyzing GOES rapid-scan atmospheric motion vectors (AMVs) that were produced by CIMSS during the one-month TCSP field phase. We are diagnosing the upper-level flow fields over cases of TCs during the TCSP experiment in order to investigate kinematic quantities and trends such as vorticity and divergence, and ultimately relating them to TC intensity changes.

Accomplishments

As a first test, AMVs are analyzed during Hurricane Emily (July 11th – 21st, 2005) onto a 0.2-degree grid. Included in the analyses are AMVs assigned a height between 150 hPa and 200 hPa and located approximately 700 kilometers from the NHC best-track storm center. In regions without AMVs, a 1-degree numerical weather prediction background was used. Figure 1 shows an example of a storm-centered vorticity field calculated from the analysis of Emily valid 18Z on the 18th of July 2005. The observation wind barbs (ms^{-1}) that made up the analysis are plotted on top of the vorticity field as well. Although Emily was a weak category-one hurricane at this time, she intensified 10 kts in the subsequent 6-hours. The analysis captures the cyclonic circulation over the storm's center, and the asymmetric, anti-cyclonic outflow region to the north and northeast of the storm.

To examine the kinematic trends over the lifecycle of the storm, average vorticity values were calculated and compared with Emily's intensity trends. For each analysis, a circular region in the inner 200 kilometers and the outer 200 kilometers are averaged in order to examine the inner cyclonic flow in the storm's eye-wall and its anti-cyclonic outflow. A time series of the average values of these two quantities is compared to Emily's maximum wind-speed as shown in Figure 2.

The time series show how the two vorticity averages change as Emily's intensity changes. In general, as Emily intensifies, its inner vorticity increases. The one period where this relationship is not as strong is during Emily's peak intensity. This may be related to the difficulty in generating AMVs over a TC's center when it is very intense due to the uniformity (or lack of cloud in eye) in the core region. The vorticity-intensity relationship is much clearer during the final intensification period around July 20th (day 201). The inner-vorticity increases significantly while the outer-region is getting more negative, corresponding to increased anticyclonic outflow. The inner-vorticity average correlates to Emily's intensity at about 60%.

The geographic constraints of our data prevented us from capturing the very early stages of Emily. One can see, however, how the two-vorticity quantities do not differ appreciably prior to intensification or after it dissipates. It is possible that these quantities can be used to investigate genesis, and will be examined more thoroughly for additional storms and disturbances. Although this is one case study, it shows the importance of high-density satellite data in analyzing the upper-level flow and the potential for diagnosing TC intensity and intensity change. Further investigation into these and other parameters will lead to more understanding as to how the upper-levels impact, and are modified by, TC intensity change.

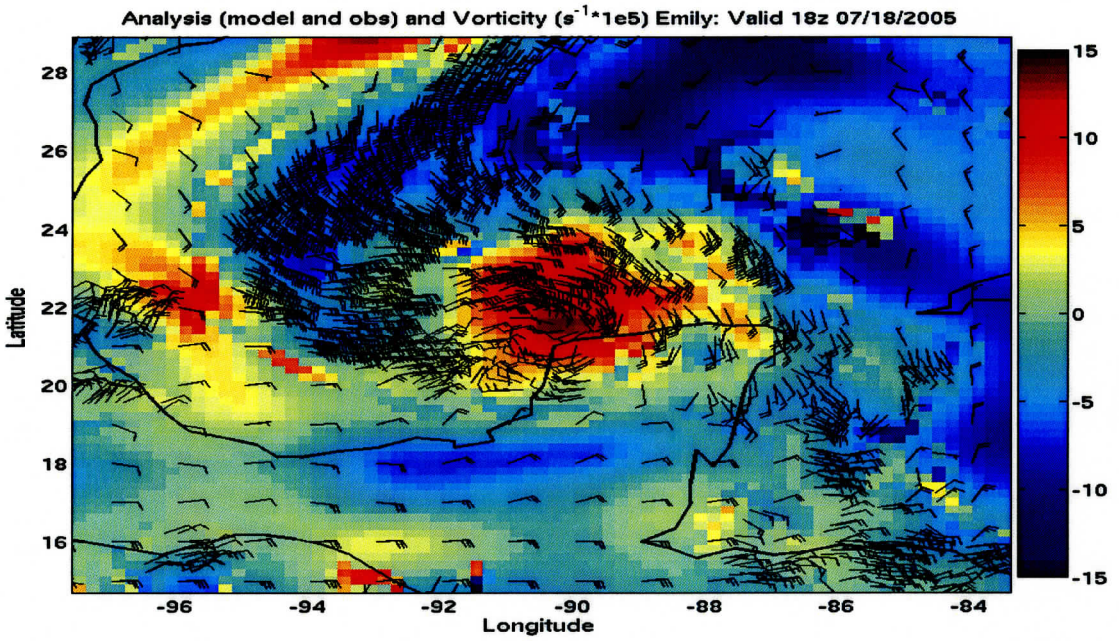


Figure 1: Storm-centered vorticity analysis and GOES AMVs. Color-contours show vorticity ($10^5 s^{-1}$) and wind barbs show the observations in ms^{-1}. The analysis captures the cyclonic structure in the storm's center and anti-cyclonic outflow to Emily's north. These asymmetric outflow channels are often associated with storm strengthening. Emily is a weak hurricane at this time, but subsequently intensifies 55-kts in 30-hours.

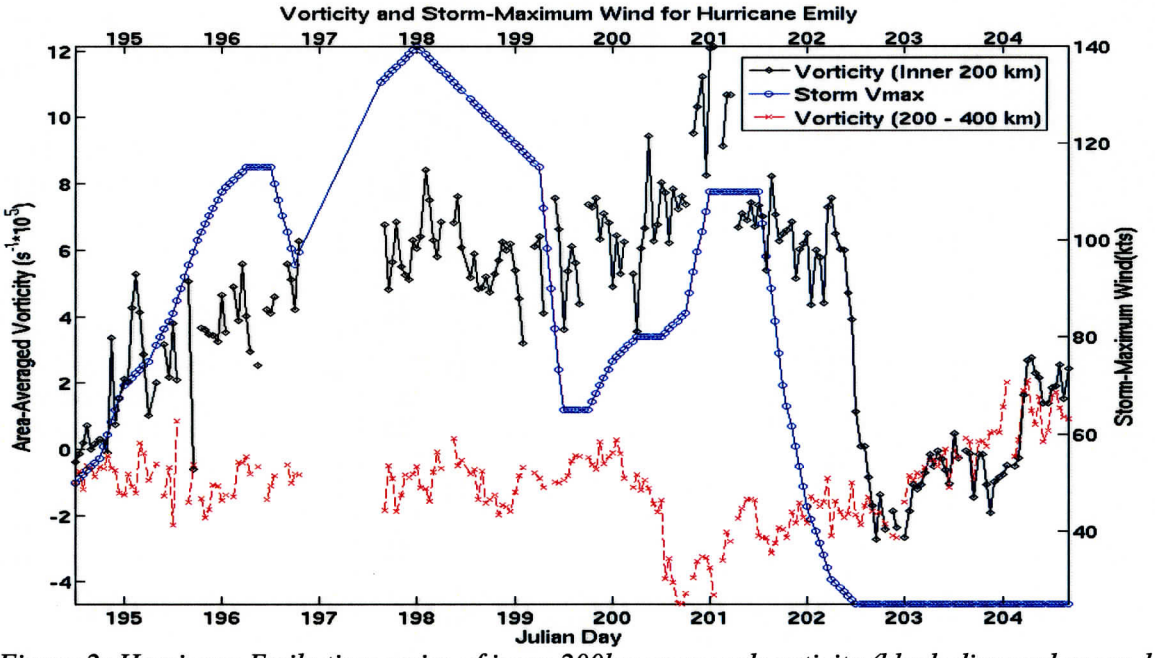


Figure 2: Hurricane Emily time series of inner 200km averaged vorticity (black-diamond curve, left-axis), outer 200-400 km averaged vorticity (red-x curve, left axis) and best-track storm maximum wind-speed (blue-circles, right axis). During the re-intensification around day 201 (July 20th), the inner-region increases even more and the outer vorticity average becomes more negative. The inner-vorticity and storm maximum wind speed are correlated at about 60%.

ARM Raman Lidar Instrument Mentor

Personnel: Dave Turner

Funded by: DOE Office of Science

Project Description

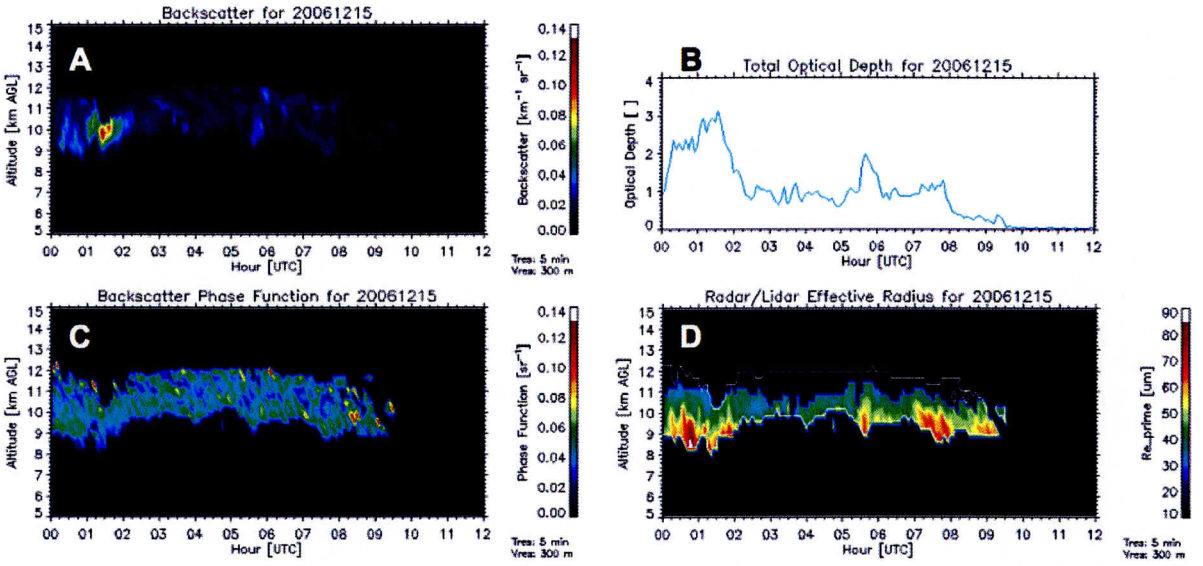
The principal objective of this project is to serve as the 'instrument mentor' for the operational Raman lidar at the DOE Atmospheric Radiation Measurement (ARM) program's Climate Research Facility in north-central Oklahoma. The Raman lidar is an advanced ground-based active remote sensor, sending out pulsed laser energy to profile water vapor, aerosols, and clouds above the ARM site at high temporal (10 s to 1 min) and spatial (35 m to 300 m) resolution. It is the only operational Raman lidar in the world collecting data 24 hour per day, 7 days per week. The instrument mentor tasks include:

- Monitoring the day-to-day operations to ensure instrument health.
- Working with ARM site operations staff to rectify and document any problems that may arise.
- Controlling the quality of the data.
- Developing new and improved data processing algorithms.
- Performing any upgrades to the system, as needed.

Accomplishments in 2006-2007

- Installed a new quad-detector boresight alignment device in the Raman lidar. This device will be used to actively maintain the alignment of the outgoing laser beam in the detectors' field-of-view, and thus will greatly improve the quality of the Raman lidar dataset.
- Developed a new algorithm to derive cirrus cloud optical depth and profiles of extinction, backscatter, particulate depolarization ratio, and backscatter phase function from the Raman lidar. This algorithm also includes input data from the collocated 35 GHz cloud radar; using the lidar and radar data together allow an estimate of the particle size to be retrieved.
- Identified the source of the recent 40% degradation in the system's signal-to-noise ratio and rectified it.

The ARM Raman lidar in north-central Oklahoma.



Cirrus optical and microphysical properties derived from Raman lidar data using the newly developed algorithm on 15 December 2006. A: Backscatter coefficient; B: cirrus optical depth; C: backscatter phase function (at 180 degrees); D: effective radius of the ice crystals derived from the ratio of the cloud radar reflectivity and Raman lidar extinction profile. The data shown have 5 min temporal and 300 m vertical resolution.

ARM Atmospheric Emitted Radiance Interferometer (AERI) Instrument Mentor

Personnel: Dave Turner, Ralph Dedecker, Denny Hackel, Nick Ciganovich, Tim Dirkx

Funded by: DOE Office of Science

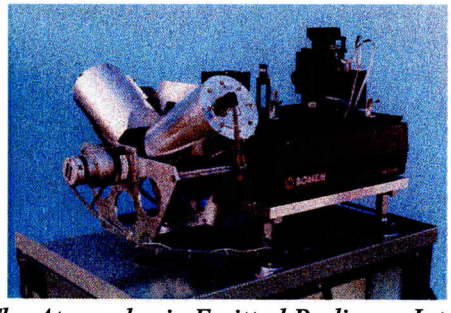
Project Description

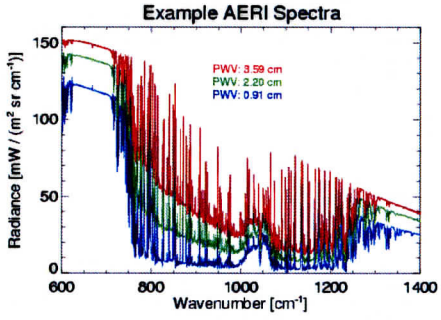
The principal objective of this project is to serve as the 'instrument mentor' for the seven (7) Atmospheric Emitted Radiance Interferometers (AERIs) deployed at the DOE Atmospheric Radiation Measurement (ARM) program's Climate Research Facilities. The AERI is an advanced ground-based passive remote sensor, observing downwelling infrared radiance from 3.3 to 19 μm at 0.5 cm^{-1} resolution. Two AERIs have been modified to have extended spectral range for operation in dry climates (such as at the ARM site in Barrow, Alaska) and observe downwelling radiance in the far-infrared (out to 25 μm). The AERI provides a critical dataset for the ARM program, and is being used to (a) validate line-by-line and other radiative transfer models, (b) retrieve profiles of water vapor and temperature, (c) retrieve microphysical and optical properties for liquid, ice, and mixed-phase clouds, (d) retrieve microphysical and optical properties of atmospheric aerosol (primarily dust), and (e) trace gas retrievals. The instrument mentor tasks include:

- Monitoring the day-to-day operations to ensure instrument health
- Working with ARM site operations staff to rectify and document any problems that may arise
- Controlling the quality of the data
- Developing new and improved data processing algorithms
- Performing any upgrades to the system, as needed

Accomplishments in 2006-2007

- Upgraded 5 (of the 7) instruments to use new hardware and software, and thus make them more reliable.
- Modified the AERI systems to collect data at 10x the original temporal resolution, to improve the utility of the data for cloud retrievals.
- Developed a principal-component based algorithm to reduce the uncorrelated noise in the AERI radiance spectra.
- Supported the AERI in multiple field experiments, such as the Radiative Heating in Underexplored Bands Campaign, which focused on improving radiative transfer models in the far-infrared.





Left: The Atmospheric Emitted Radiance Interferometer (AERI). Right: Example clear sky spectrum observed by the AERI in north-central Oklahoma for three different water vapor amounts.

Deriving Liquid Water Content Profiles from the ARM Raman Lidar

Personnel: Dave Turner

Funded by: DOE Office of Science

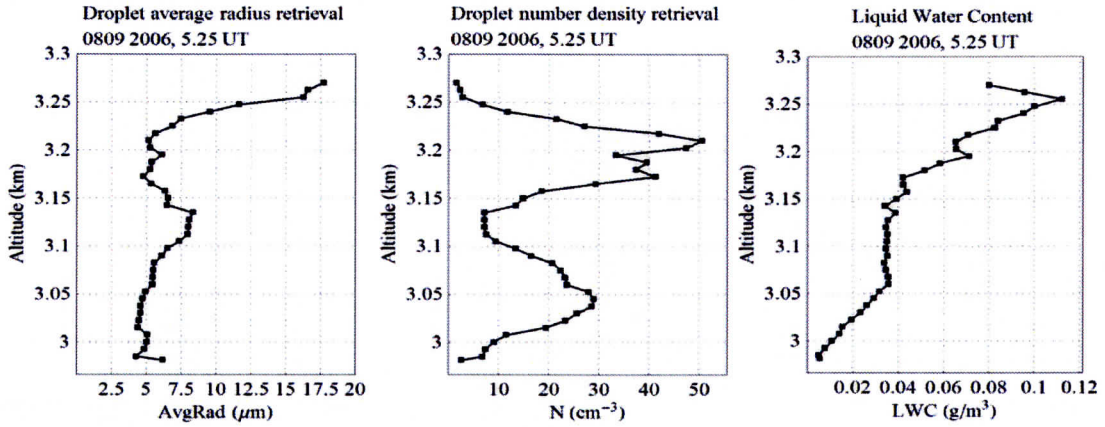
Project Description

The Atmospheric Radiation Measurement (ARM) program has a state-of-the-art Raman lidar at its Southern Great Plains Climate Research Facility in north-central Oklahoma. This Raman lidar is the only operational Raman lidar in the world collecting data 24 hours per day, 7 days per week. It sends pulses of laser energy vertically into the atmosphere to profile water vapor, aerosols, and clouds above the ARM site at high temporal (10 s to 1 min) and spatial (35 m to 300 m) resolution.

In 2005, several new detection channels were added to the Raman lidar to extend its scientific utility. In particular, a new channel was added that detects the backscatter from the Raman scattering of liquid water. This provides the opportunity for a single remote sensing instrument to observe aerosol extinction, liquid water content, and liquid water backscatter simultaneously. The latter two allow the cloud droplet effective radius to be retrieved as well as the cloud droplet number density. Together with the aerosol extinction below cloud base (using extinction as a proxy for aerosol number concentration), the indirect effect of aerosols on clouds can be investigated at high temporal and spatial resolution.

Calibration of the Raman lidar products is essential, and thus we are attempting to calibrate the liquid water content profile from first principles using the calibration derived for the water vapor mixing ratio. The water vapor mixing ratio is calibrated such that the integrated water vapor profile matches the precipitable water vapor (PWV) amount retrieved from the collocated two-channel microwave radiometer, which has been shown in previous experiments at the ARM sites to be a robust and accurate measurement at the ARM site in Oklahoma. The water vapor calibration essentially accounts for the differential transmission through the optics of the lidar, and this knowledge, together with the knowledge of the transmission/reflection of a single beamsplitter, allows us to calibrate the liquid water content profile. We are currently evaluating the accuracy of this first principles calibration by comparing the liquid water path (which is the vertical integral of the liquid water content) with that retrieved from the Atmospheric Emitted Radiance Interferometer.

After confirming that this calibration approach works, we will investigate the aerosol indirect effect on clouds; namely how the size of the cloud's effective radius changes as the aerosol extinction at cloud base increases. The lidar is only able to profile through clouds with very low liquid water paths (less than about 15 g/m^2); however, we will also perform this analysis on the lowest levels of thicker liquid water clouds.



Liquid water cloud microphysical properties derived from Raman lidar observations on 9 August 2006 at 10 minute resolution. Left: cloud droplet average radius; middle: cloud droplet number density; right: cloud liquid water content.

Radiative Heating in Underexplored Bands Campaign (RHUBC): AERI-ER deployment

Personnel: Dave Turner, Ralph Dedecker, Denny Hackel, Nick Ciganovich, Tim Dirkx

Funded by: DOE Office of Science

Project Description

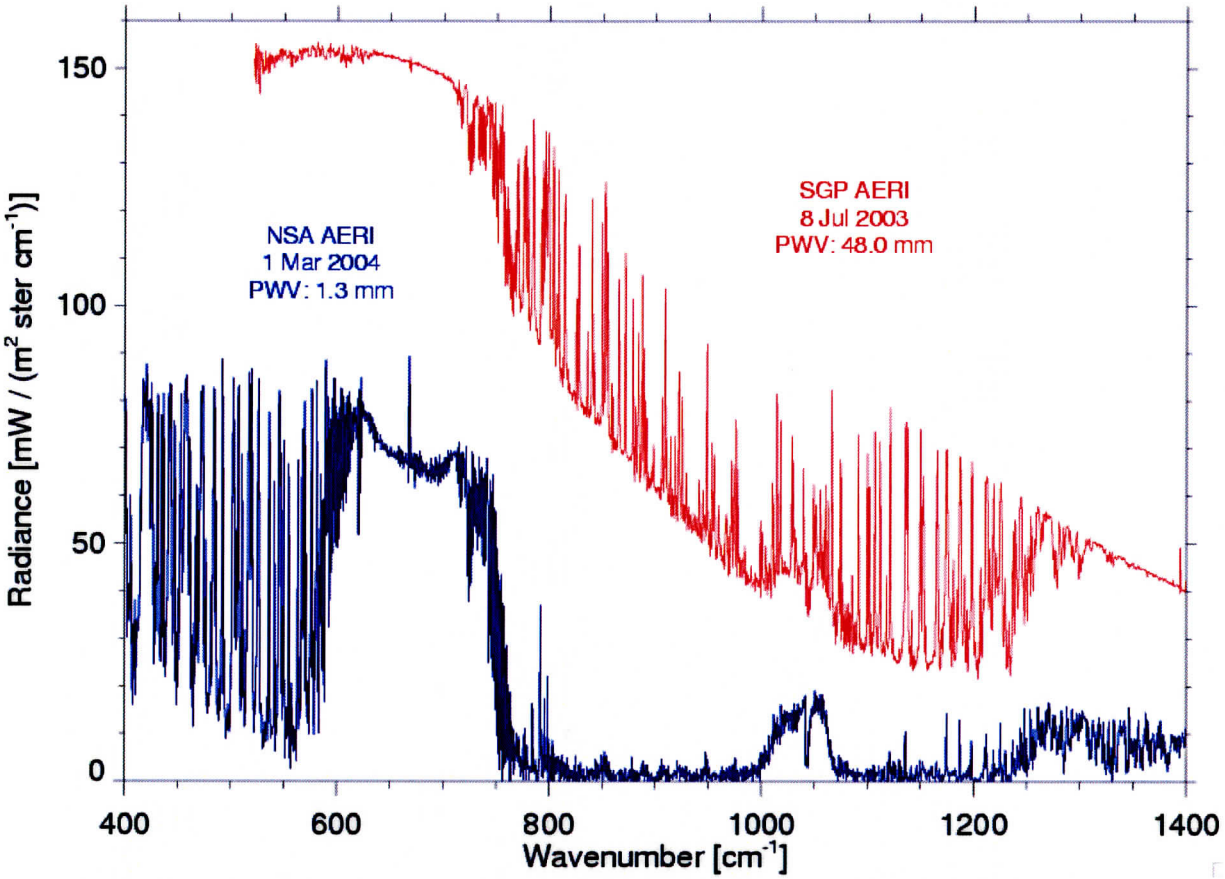
The primary objective of the Atmospheric Radiation Measurement (ARM) program is to improve the treatment of clouds and radiation in global climate models (GCMs), thereby improving the predictive capability of these models. High spectral resolution radiance observations are critical to ensure that radiative transfer models used in the GCMs correctly treat the absorption and scattering in both transparent and absorbing regions of the spectrum. While most regions of the electromagnetic spectrum have been well observed and thus characterized, the far-infrared spectral region ($\lambda > 15$ μm) is woefully under-sampled and thus there are still considerable uncertainties in the radiative transfer, especially regarding the spectroscopy of the water vapor absorption. The far-infrared has not been well observed in the past due to primarily three things: (a) the far-infrared is opaque at most surface locations due to the strong absorption by water vapor, (b) the lack of accurate high-spectral-resolution radiometers operating in the far-infrared, and (c) accurate precipitable water vapor (PWV) measurements.

The uncertainty in radiative transfer in the far-infrared has important implications for climate. First, about 40% of the total outgoing longwave radiation (OLR) of the planet comes from the far-infrared region of the spectrum. Since GCMs typically 'tune' their models to match the OLR observations in space, any errors in the radiative transfer model in the far-infrared utilized in the GCMs translate into inappropriate tuning, which has a complex impact on the results. Secondly, most of the radiative cooling in the middle and upper troposphere in the clear sky atmosphere occurs in the far-infrared portion of the spectrum, and this radiative cooling leads to changes in the vertical velocity that is a significant part of the atmospheric circulation. Finally, cirrus clouds cover a substantial portion of the earth and modulate the radiative transfer; however, their impact on radiative transfer in the far-infrared needs to be confirmed with observations.

Fortunately, the limitations preventing the observation of the far-infrared have been overcome by instrument development efforts of several research groups. The ARM Climate Research Facility in Barrow, Alaska frequently experiences dry (less than 3 mm of PWV) clear sky conditions in February and March, and during these events the far-infrared portion of the spectrum is semi-transparent. There now exist at least four groups that have built instruments that observe far-infrared radiance with high-spectral-resolution interferometers. Similarly, there are now commercially built microwave radiometers that sense downwelling radiance around the 183.3 GHz water vapor line, and these observations can be used to provide accurate observations of PWV in dry conditions. However, the far-infrared interferometers and the 183 GHz microwave radiometers all use different measurement and calibration approaches, and thus it is important to perform an intercomparison of these different technologies to ensure that they are indeed operating as they should.

Thus, the Radiative Heating in Underexplored Bands Campaign (RHUBC) was proposed to ARM by ARM science team members DD Turner (University of Wisconsin – Madison) and EJ Mlawer (Atmospheric and Environmental Research, Inc.). RHUBC was conducted from Feb 22 to Mar 14, 2007, at the ARM site in Barrow. This experiment resulted in a small project (this one) to reconfigure and deploy a second extended-range Atmospheric Emitted Radiance Interferometer (AERI) to the

Barrow site to provide redundancy to the AERI already there, and to provide travel funds for the RHUBC PI. These things were accomplished in time, and the RHUBC experiment was a success. Data analysis (using funds from a different project) is now underway.



Downwelling infrared radiance in clear sky scenes observed by the AERI at the Southern Great Plains (red) and North Slope of Alaska (blue) sites. During the low PWV conditions at the Barrow, Alaska site, the far-infrared portion of the spectrum (a portion of it is shown here between 400 and 600 cm^{-1}) becomes semi-transparent, allowing the water vapor spectroscopy (absorption line strengths and widths, as well as the water vapor continuum) to be evaluated.

Instrument Acquisition - Microwave Radiometer (MWR)

Personnel: Steve Ackerman, Wayne Feltz, Dave Turner, and Ed Eloranta

Funded by: NSF

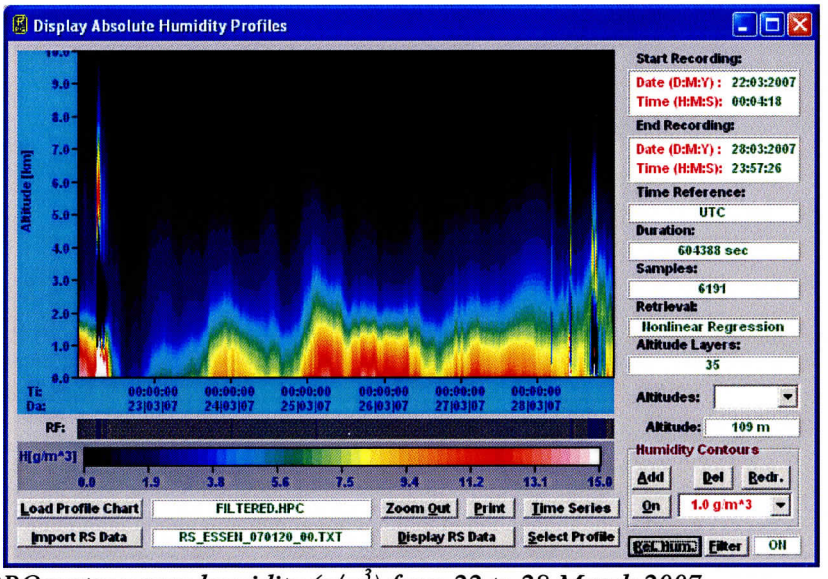
Project Description

This NSF equipment grant is for the purchase of two microwave radiometers and the building of a high spectral resolution radar to improve UW capabilities to study mixed phase clouds. In November 2006, the first instrument, a 22-30/52-58 GHz MWR, or HATPRO, was received in February. The instrument has been temporarily installed on the SSEC roof. The vendor, with UW participation, performed a training, calibration, and operations checkout.

Since then, the instrument has been running and has already supported an inter-comparison between the UW's AERI instrument and the NASA/LaRC FIRST instrument. The March inter-comparison was conducted in Madison, WI. Figure 1 displays a sample data set collected during the inter-comparison.

Accomplishments

- One instrument received, tested and installed on SSEC rooftop.
- Large student involvement to date.
- Part of lidar with long lead time are on order.



Retrieved HATPRO water vapor humidity (g/m^3) from 22 to 28 March 2007

CIMSS Data Compression Research for Future NOAA Geostationary Operational Environmental Satellites

Personnel: Bormin Huang, Allen Huang

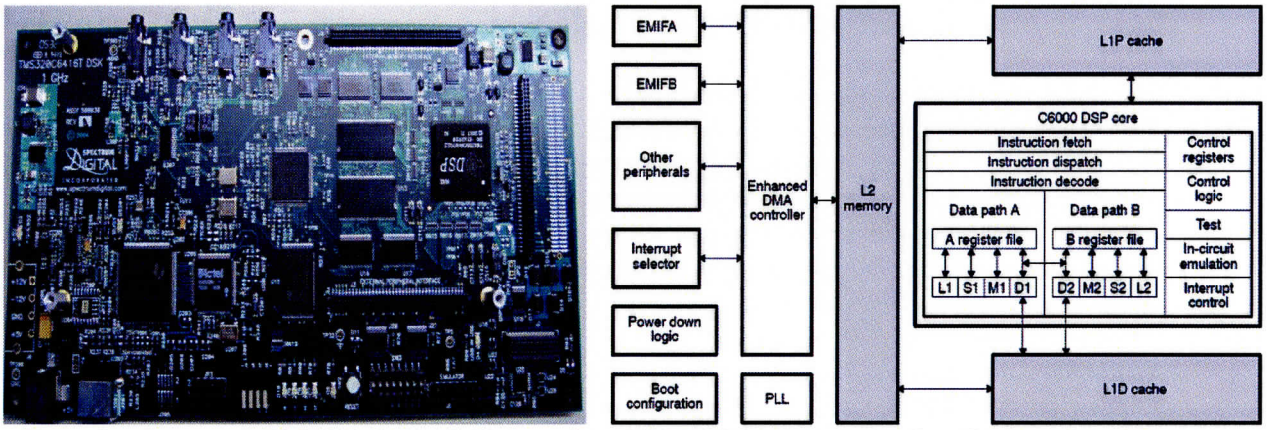
Funded by: NOAA

Project Description

In this project, the CIMSS satellite data compression team has systematically conducted lossless compression studies for NOAA next-generation advanced imagers and sounders.

Major efforts have been to develop:

- different data compression methods with various algorithmic complexity for 3 different compression needs: onboard compression, data rebroadcast, and data archiving;
- different compression methods with various error resilience or correction capabilities for satellite noisy transmission; and
- DSP implementation for compression codes.



Texas Instruments' TMS320C6416 DSP board. TMS320C6416 two-level cache-based architecture.

Figure 1. A memory-limited DSP version of 3DWT-RVLC code is implemented on Texas Instrument's TMS320C6416 DSP board to explore its feasibility for real-time satellite rebroadcast processing.

Accomplishments

- Two pieces of data compression software have been publicly released to NOAA and the IEEE/SPIE data compression society (available at http://math.ssec.wisc.edu/compression/software.html);
- One invited book chapter and 56 journal or conference papers have been generated since 2004 (listed at http://math.ssec.wisc.edu/compression/publications.html);
- Six data compression patent applications are ongoing;
- The PI has been chairing SPIE International Conference on Satellite Data Compression, Communication, and Archiving since 2005. He was also invited to serve as chairs of several compression-related sessions in IEEE international conferences (e.g. IEEE ICCT 2006, IEEE IGARSS 2006, IEEE FIEOS 2006, IEEE ICACT 2006).

Development of the Community Radiative Transfer Model (CRTM)

Personnel: Paul van Delst, Tom Achtor

Funded by: NOAA

Project Description

The main goal of this project is to improve the use of satellite measurements in NCEP/EMC Global Data Assimilation System (GDAS) and forecasting skill by being better able to simulate those measurements. The process for simulating satellite measurements can be divided into three categories:

1. Generation of line-by-line (LBL) model based instrument resolution clear sky transmittances,
2. Computation of regression coefficients for the fast gaseous absorption model used in the CRTM,
3. Adding additional functionality to the CRTM to simulate physical processes other than just clear sky radiances.

The generation of LBL-based instrument resolution transmittances for spectral response function (SRF) based infrared and microwave instruments is now done routinely at the JCSDA – as LBL model and spectroscopic data updates become available, the calculations are redone. Focus in this area is now being placed upon the upcoming Fourier Transform Spectrometers (FTS), such as IASI on MetOp-A and CrIS on NPOESS. Software is being developed to handle generic FTS instruments.

The improvement of the regression-based clear sky gaseous absorption model at the core of the CRTM is ongoing. Currently, the CompactOPTRAN algorithm is used operationally in the CRTM. Research in this category involves improving the algorithm itself (via the addition of a separate water vapour continuum component, trace gas absorption, etc. to the algorithm) and also including the capability to use other algorithms in the CRTM. The initial focus has been on the latter, with software design changes being made so that the CRTM can more easily integrate algorithms such as RTTOV, SARTA, and OPTRANv7 simultaneously with CompactOPTRAN.

While the computation of clear sky radiances over simple surfaces (e.g. water assuming specular or Lambertian behaviour) is not quite a solved problem, attention has been focused on addressing the more complicated processes in radiative transfer – cloud and aerosol scattering and absorption, and surface emissivity. In cooperation with other JCSDA researchers, the ability to handle cloud and aerosol scattering and absorption has been added to the CRTM, as have more sophisticated surface emissivity models. These improvements are in the process of being tested and validated. It should be noted that these new capabilities must be made useful in the context of satellite data assimilation where there are strong time constraints on the computation of satellites radiances. A balance needs to be found between the speed (too slow and data will not be able to be used in time) and accuracy (too different from observations and the data will not pass quality control) of computation.

Accomplishments

- Along with Yong Han and Yong Chen (JCSDA/NESDIS), redesigned the CRTM to handle multiple gaseous absorption algorithms.
- Visited Roger Saunders at the MetOffice to test elements of the new design by developing a prototype that integrates RTTOV into CRTM.
- Updated LBL computations for new sensors. GOES-13 and MetOp-A sensors are now part of the CRTM (MetOp-A IASI coefficients are still being developed).

- Developed detector specific models for the GOES sounder sensors to allow the 1x1 FOV radiances to be assimilated (previously a 5x5 FOV average was assimilated).
- Delivered an updated CRTM that can generate cloudy radiances to the mesoscale modeling group at EMC. They are now generating cloudy radiance fields in their post processing that we will be using for validation.
- Developed test suites to evaluate the forward, tangent-linear, and adjoint models for the cloud and aerosol scattering modules in the CRTM. Several bugs were uncovered.
- Refactored a new low frequency microwave surface emissivity model developed at the JCSDA by Masahiro Kazumori, a visiting scientist from JMA, and Quanhua Liu, (QSS/NESDIS). Some bugs were fixed and the execution time decreased by about a factor of two (i.e. refactored code is faster). This code will be integrated into the CRTM microwave water surface optics module along with FASTEM-3 (for the high frequency microwave emissivity).
- Updated the bias correction scheme in the NCEP Gridpoint Statistical Interpolation (GSI) analysis code. The across-scan variability in the bias correction was reduced, particularly for microwave sensors such as AMSU-A.
- Developed a coding standards and guidelines document for CRTM developers.

Winds Assimilation

Personnel: Tom Zapotocny, James Jung

Funded by: NOAA

Project Description

A new parameter has been developed to estimate the error of the GOES and MODIS Atmospheric Motion Vectors (AMVs). It is derived from comparison of the AMVs to nearby rawinsondes. This new parameter then generates an expected vector error (EE) for AMVs based on past statistics. Datasets containing all the GOES and MODIS EE information are now being generated in real time by the National Environmental Satellite Data and Information Service (NESDIS) for the Joint Center for Satellite Data Assimilation (JCSDA) and the National Centers for Environmental Prediction's (NCEP) personnel. These data are currently being produced in BUFR format and are being processed by NCEP consistent with their data cutoff times so any experiments will be consistent with the operational database.

We have started preliminary assimilation tests to use the EE for quality control within NCEP's Global Forecast System (GFS). We used the version of the GFS scheduled to be operational in May 2007 and conducted the experiments at the operational resolution of T382 with 64 layers. Our assimilation test used EE thresholds based on approximate model errors for three vertical layers. The thresholds for these three layers are:

- Surface to 700 hPa < 3.0 m/s
- 699-300 hPa < 2.5 m/s
- 299 hPa and above < 4.5 m/s

Theses thresholds were used for the GOES and MODIS AMVs in our assimilation test. AMVs with an EE value less than these thresholds were used by the assimilation system, the others were rejected. Figure 1 and 2 present the forecast anomaly correlation die-off curves results at 500 hPa from this EE experiment. These figures illustrate that this EE wind experiment has a neutral impact on the forecast through day 7 in the Northern Hemisphere (Fig 1) but markedly improves the wind vector anomaly correlation at 200hPa in the tropics (Fig 2). Using the EE for quality control also has a generally positive forecast impact in the Southern Hemisphere through day 7 (not shown).

Accomplishments

- Expected Error (EE) predictor coefficients generated for GOES and MODIS winds;
- AMVs generated in real time containing the EE;
- NCEP's GFS modified to use EE for AMV quality control; and
- Winds assimilation tests conducted with NCEP's GFS.

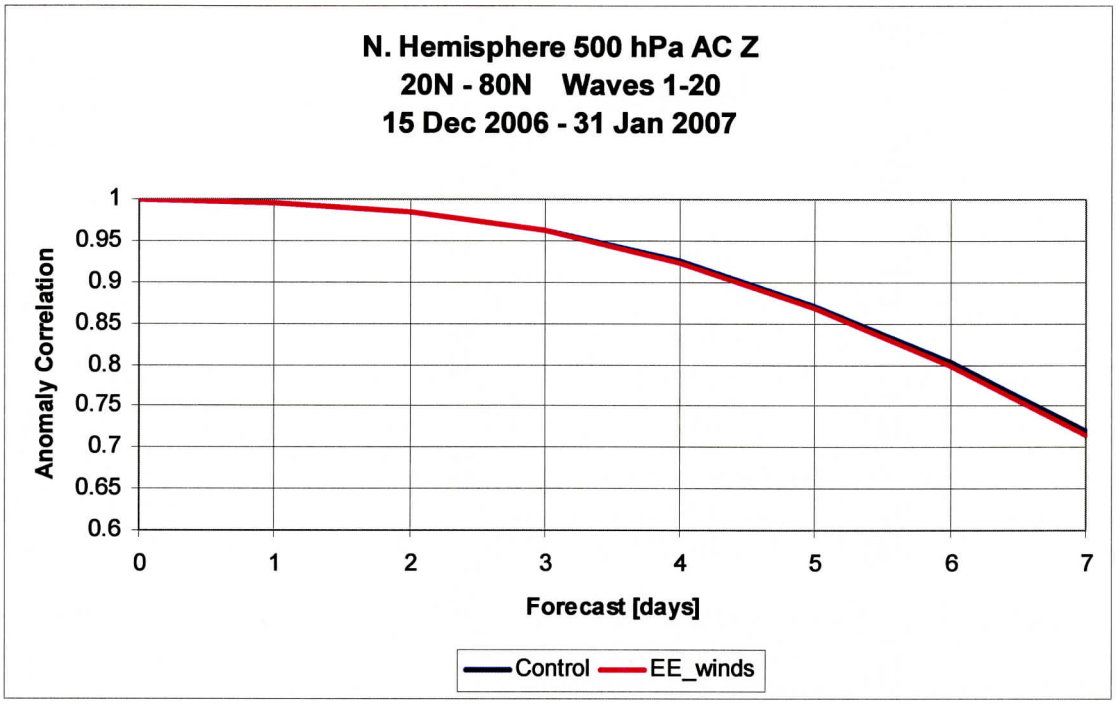


Fig. 1. Anomaly correlation die-off curves from a control simulation (dark blue) and using the EE as a QC threshold (magenta) for the Northern Hemisphere 500 hPa geopotential heights.

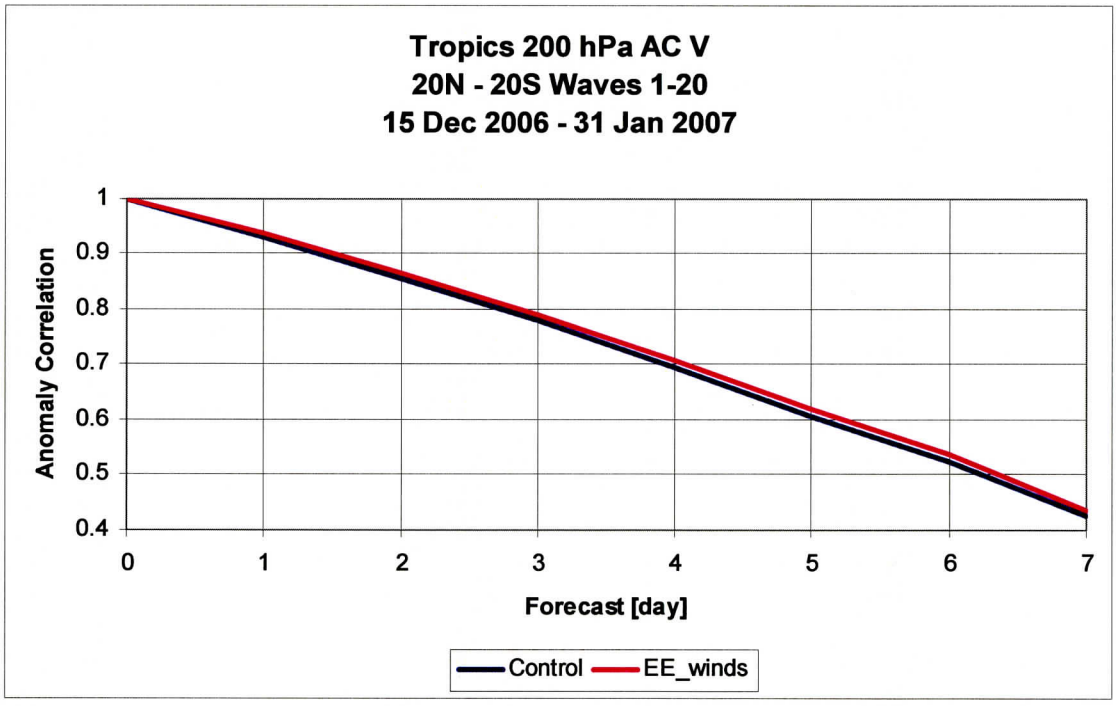


Fig. 2. Anomaly correlation die-off curves from a control simulation (dark blue) and using the EE as a QC threshold (magenta) for the 200 hPa tropical wind vector.

Data Impact Studies

Personnel: James Jung, Tom Zapotocny

Funded by: NOAA

Project Description

A technique to determine the surface emissivity which uses several infrared surface channels, called the emissivity minimum variance technique, was used with the Atmospheric Infrared Sounder (AIRS) to calculate surface emissivity. The Community Radiative Transfer Model (CRTM), used by the National Centers for Environmental Prediction's (NCEP) Global Forecast System (GFS), identifies several surface types and has corresponding surface emissivity spectra. The emissivity minimum variance technique was incorporated into NCEP's the Grid Scale Interpolation (GSI) portion of the GFS for calculating the surface emissivity during the assimilation of the AIRS data. We compared the surface emissivity used by the CRTM with those derived from the AIRS radiances.

The emissivity minimum variance technique has been used over ocean to verify the ocean emissivity model used by the CRTM. The results are very similar as shown in Figure 1. The technique was then used to calculate emissivity spectra over the various land, ice, and snow categories used by the CRTM. We have found significant discrepancies in the surface emissivity spectra used in the CRTM and what were calculated from the AIRS radiances. Figure 2 is an example of the CRTM and AIRS derived surface emissivity for July 2006.

Accomplishments

- We incorporated a technique to derive surface emissivity into NCEP's GFS.
- We verified the technique calculates surface emissivities, over ocean, which are consistent with the CRTM's ocean emissivity model.
- This technique is capable of calculating surface emissivity over land, snow, and ice within the data assimilation portion of the GFS.

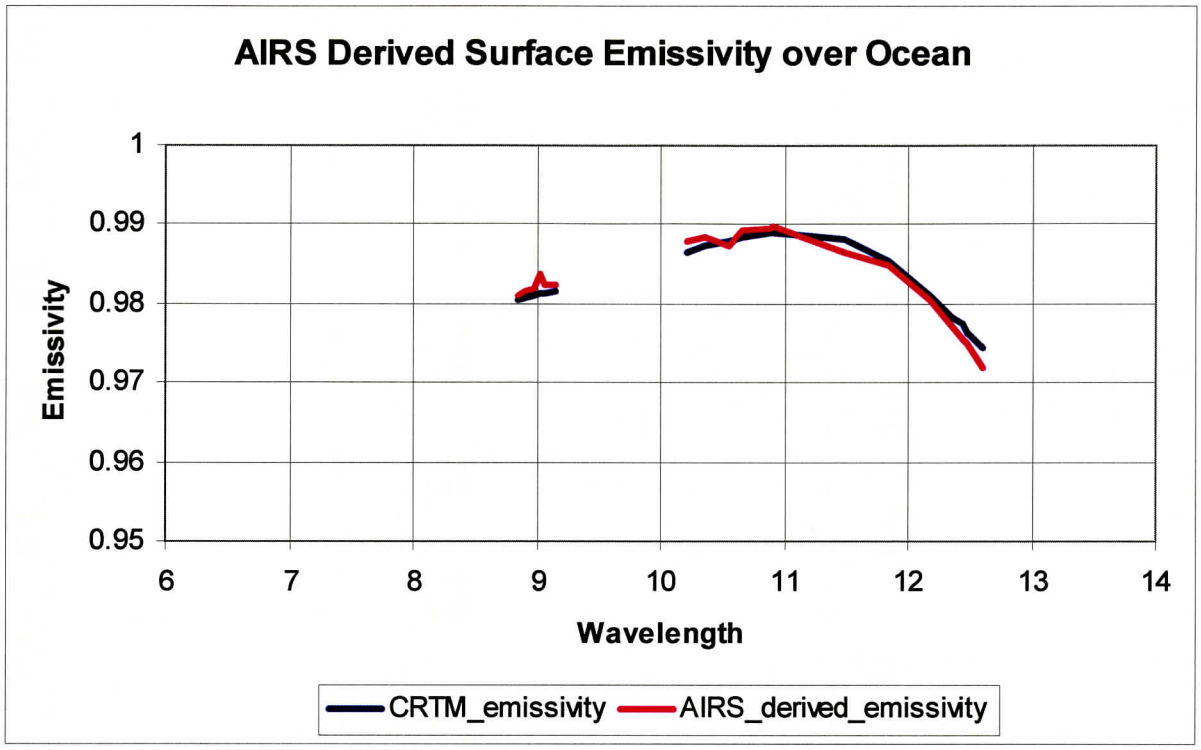


Fig. 1. CRTM vs. AIRS derived emissivity over ocean. Blue lines are the emissivity spectra in the CRTM, magenta lines are emissivity spectra derived from AIRS.

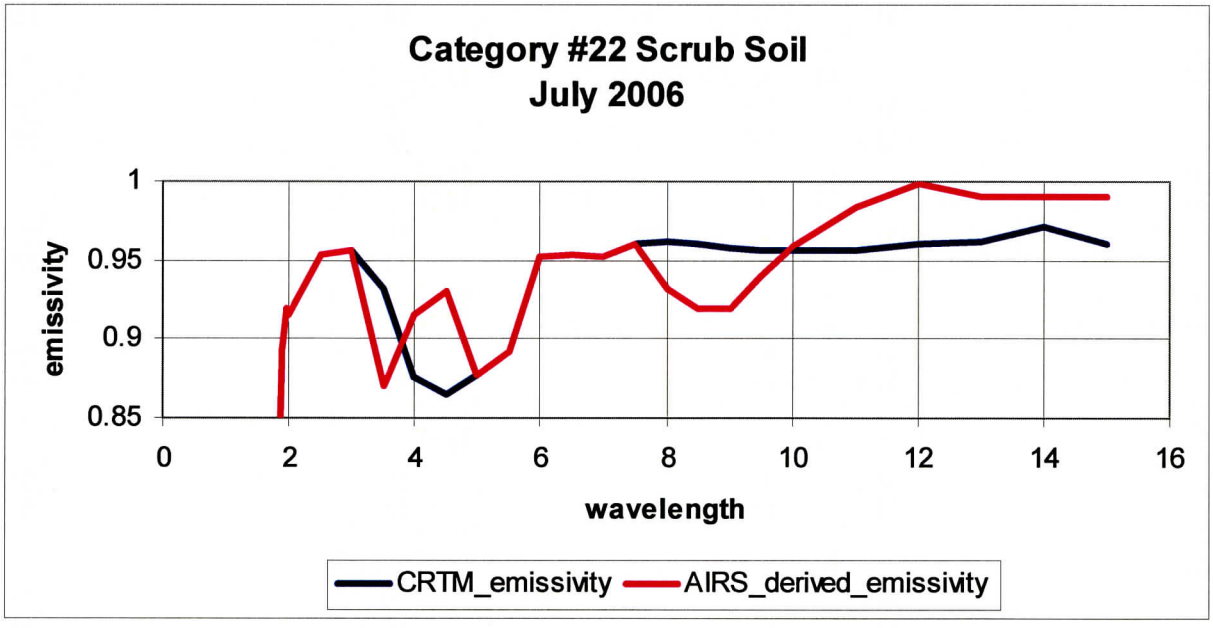


Fig. 2. CRTM versus AIRS derived emissivity during July 2006 for the scrub soil category within the CRTM. The blue line is the emissivity spectra in the CRTM, magenta line is emissivity spectra derived from AIRS.

Assessing the Forecast Impact of WindSat/Coriolis Data in the NCEP GDAS

Personnel: Tom Zapotocny, Li Bi, John Le Marshall and James Jung

Funded by: NOAA

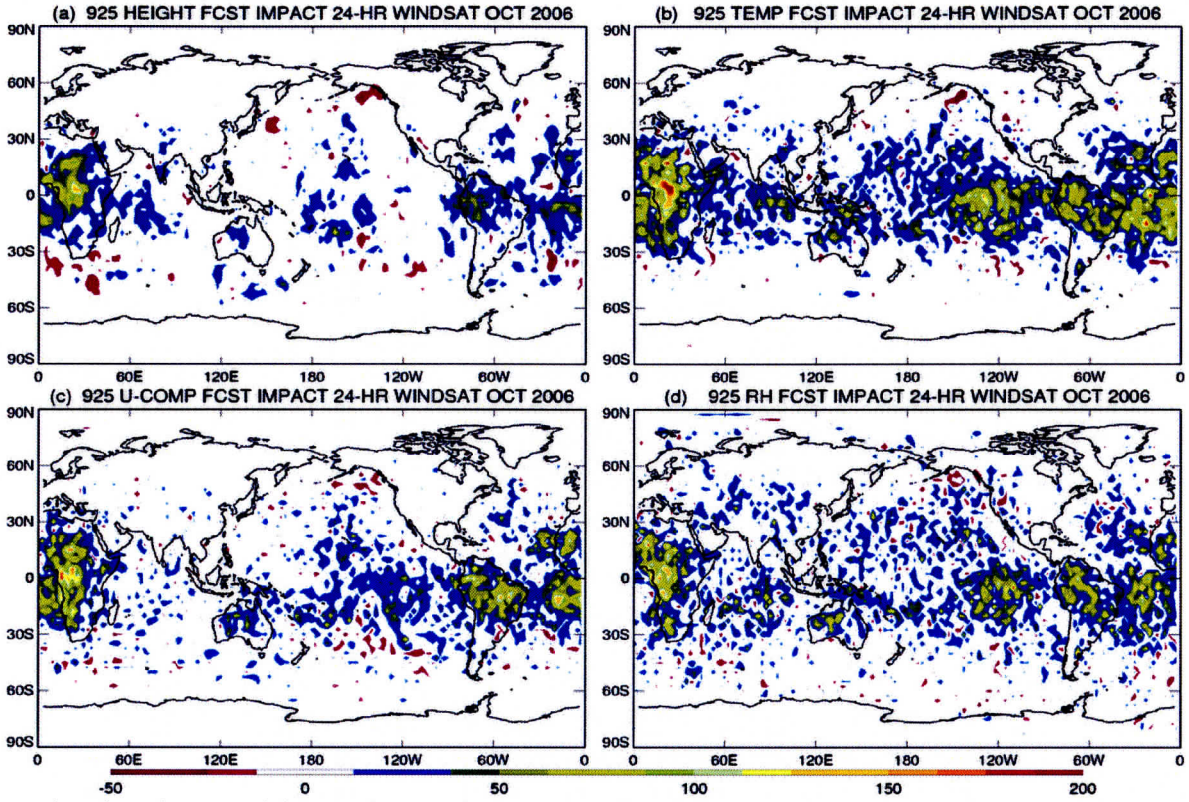
Project Description

Passive polarimetric microwave radiometry is being introduced as an alternative vector wind measurement approach to the active remote sensing approach of QuikSCAT and other instruments. The United States WindSat/Coriolis mission was placed in polar orbit in 2003 by NASA as a proof of concept mission. The follow-on CMIS (Conical scanning Microwave Imager/Sounder) polarimetric microwave radiometer instrument on NPOESS is tasked with providing accurate vector wind measurements over a 1,700 km swath. Early evaluation of the accuracy and utility of the CMIS surface vector wind measurements by operational meteorological centers has been requested by NOAA to assure rapid and efficient post-launch operational use of the data.

It is the intent of this project to evaluate assimilation techniques and the forecast impacts obtained with WindSat/Coriolis data in real time experiments and compare that impact with QuikSCAT data from the same time periods. Ultimately these efforts should lead to operational implementation of WindSAT data in the NCEP models.

Accomplishments

- Forecast impact with QuikSCAT data in the NCEP GDAS/GFS has been demonstrated.
- Forecast impact with both Navy WindSat data and NESDIS WindSat data in the NCEP GFS has been demonstrated and compared with QuikSCAT data.
- Some quality control for WindSat data has been done in the retrieval process.
- Several diagnostics have been performed on the archived data once the WindSat experiments were completed.
- Results from NAVY WindSat data and NESDIS WindSat data were compared to determine quality control procedures for operational use of the data.



Geographic distribution of the 925 hPa 24-hr Navy WindSat forecast impact averaged over October 2006. The four impacts shown are (a) geopotential heights, (b) temperature, (c) u-component of the wind and (d) relative humidity.

Advanced Weather Information Processing System (AWIPS)

Personnel: Scott Bachmeier, Jordan Gerth, Scott Lindstrom, Kathy Strabala, Russ Dengel, Steve Wanzong, Jerrold Robaidek, Robert Aune

Funded by: NOAA/NESDIS

Project Description

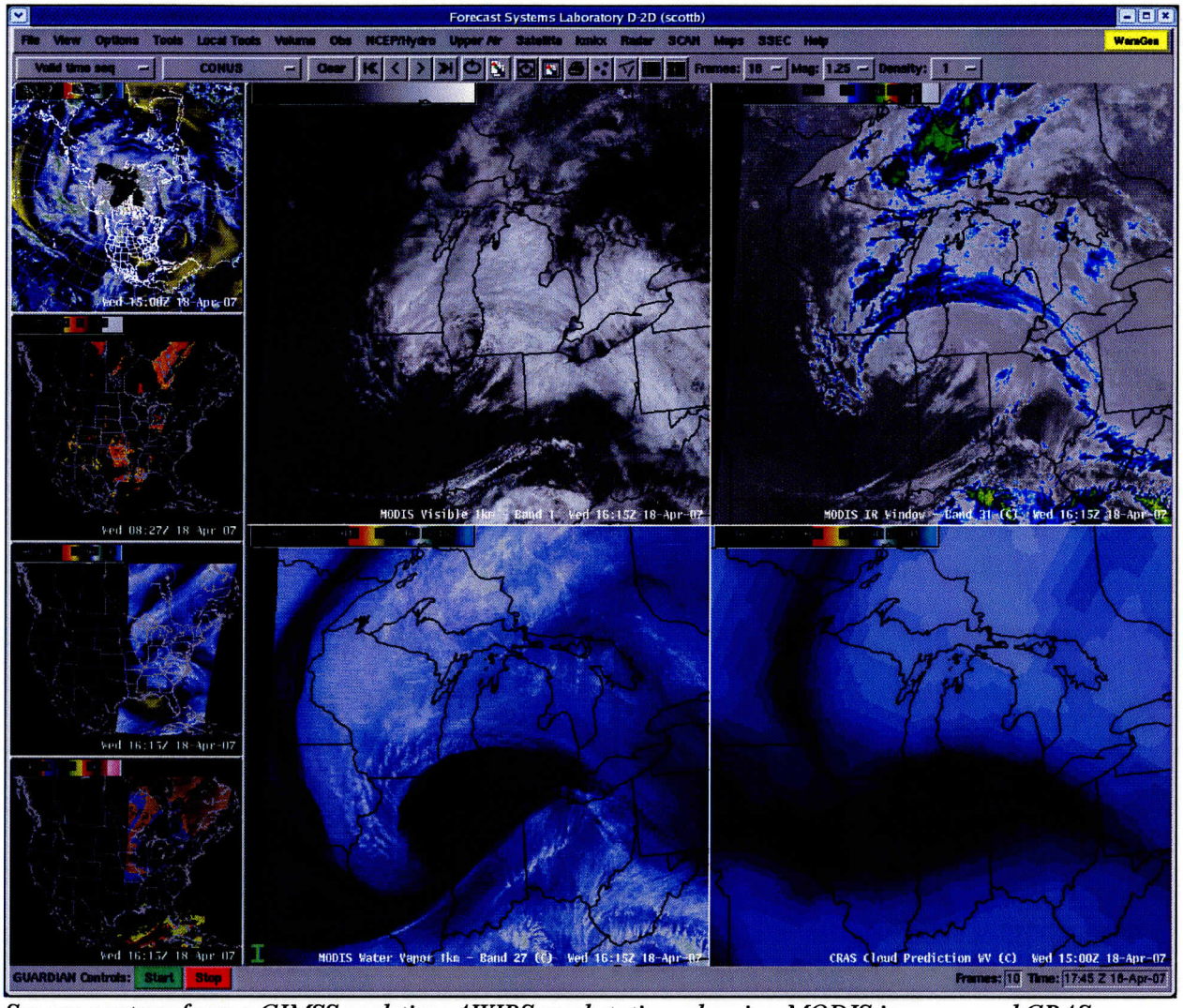
A real-time Advanced Weather Information Processing System (AWIPS) workstation capability is now fully functional at CIMSS. AWIPS is the primary warning and forecast tool utilized at all National Weather Service forecast offices, and this permits CIMSS researchers to test and evaluate new satellite products in an environment similar to that used by operational NWS forecasters. The real-time AWIPS capability also allows CIMSS staff to monitor current weather events and select cases for use in VISIT and SHyMet training modules.

The goals of the AWIPS program are to:

- Function as a satellite test-bed for new CIMSS products; and
- Provide real-time data and imagery for use in VISIT and SHyMet training modules.

Accomplishments (April 2006-April 2007)

- Added 12 MODIS products to AWIPS, and set up their distribution to the NWS Central, Southern Western, and Eastern Region headquarter AWIPS servers;
- Added CRAS model forecast cloud image products to AWIPS;
- Added CIMSS mesoscale winds products to AWIPS;
- Added GOES sounder Total Column Ozone and Convective Available Potential Energy (CAPE) products to AWIPS; and
- Conducted site visits to the NWS forecast offices at Milwaukee/Sullivan, WI and La Crosse, WI to discuss the new satellite products in AWIPS with NWS staff.



Screen capture from a CIMSS real-time AWIPS workstation, showing MODIS imagery and CRAS model forecast imagery over the Great Lakes region.

AIRS/MODIS Co-Registration and Cloud Characterization for Data Assimilation

Personnel: Allen Huang, Hong Zhang

Funded by: NASA

Project Description

The objective of this FPGA proposal is the comprehensive demonstration of AIRS and MODIS co-registration and synergistic cloud characterization for data assimilation of cloud affected AIRS data. Current AIRS/AMSU cloud clearing (Smith et al, 2003 and Huang & Smith, 2004) of radiances for data assimilation yields little valid data over land. Synergistic use of AIRS and MODIS data can greatly improve the yield but requires significant processing which is prohibitive without using high performance computing tools. Use of MODIS will improve real time cloud characterization and improve the use of AIRS cloudy radiances in NWP (a priority area for JCSDA). The expected outcomes can be summarized as:

- Enhanced and complementary EOS AIRS/AMSU data utility.
- Optimal use of EOS AIRS/MODIS data in NWP.
- Demonstration of high performance computing power to achieve efficient real-time data processing.
- Preparatory demonstration of optimal use of high spatial resolution global NPP/NPOESS CrIS/VIIRS data.
- Risk Reduction for sustained GOES-R HES/ABI high temporal resolution synergistic data processing.
- and most of all, to provide NWP models with processed ultraspectral data that meet time latency in data assimilation to further improve analysis and 3 to 6 -day forecast skill.

Accomplishments

MODIS and AIRS synergistic cloud clearing approach was developed to process 45 days of global AIRS and MODIS data. Figure 1 demonstrates the use of MODIS data provide additional information to improve the quality of AIRS/AMSU cloud-cleared radiances. Figure 2 shows the statistics of the clear, cloud-cleared, overcast and cloud cleared failed to demonstrate the processing result. Figure 3 further demonstrates more than 20% of successful cloud-cleared radiances can be potentially used in the data assimilation to improve the use of cloud contaminated hyperspectral measurements provided by AIRS.

- 45 days of global AIRS/MODIS cloud cleared radiances were delivered to Global Modeling and Assimilation Office (GMAO) at GSFC NASA on December 2006 for data assimilation into the GMAO's global model.
- Published AIRS/MODIS cloud clearing paper in ITSC15. Paper entitled "Global Analysis and Characterization of AIRS/MODIS Cloud-Clearing."
- MODIS and AIRS collocation and cloud clearing algorithms were delivered to NASA LaRC for FPGA implementation and testing.

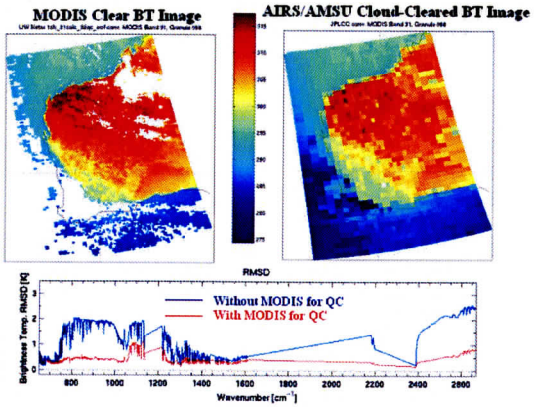


Fig. 1. AIRS/AMSU cloud-cleared root mean square error (blue curve) is much improved when MODIS clear radiances are used directly as quality control (red curve).

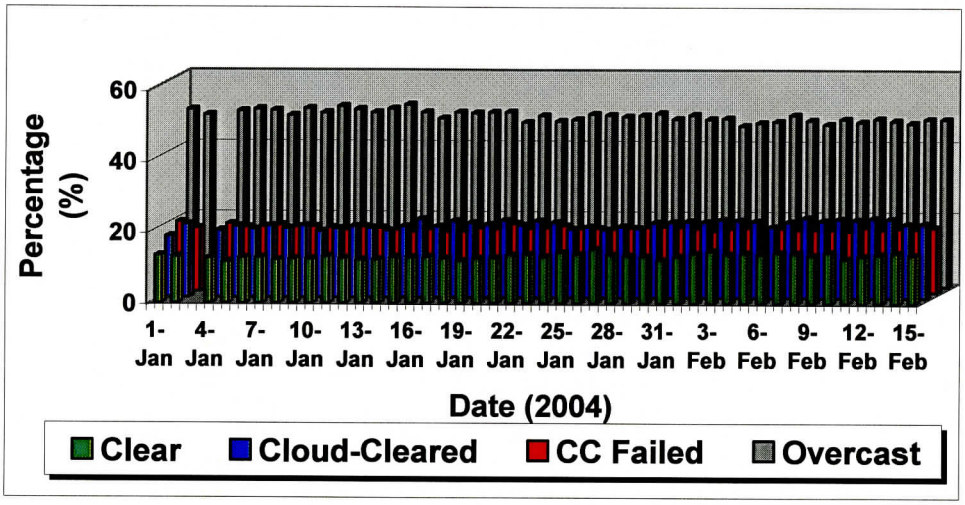


Figure 2: 45 days global cloud clearing statistics from January 1st to February 15th, 2004 (no January 3rd due to short of data)

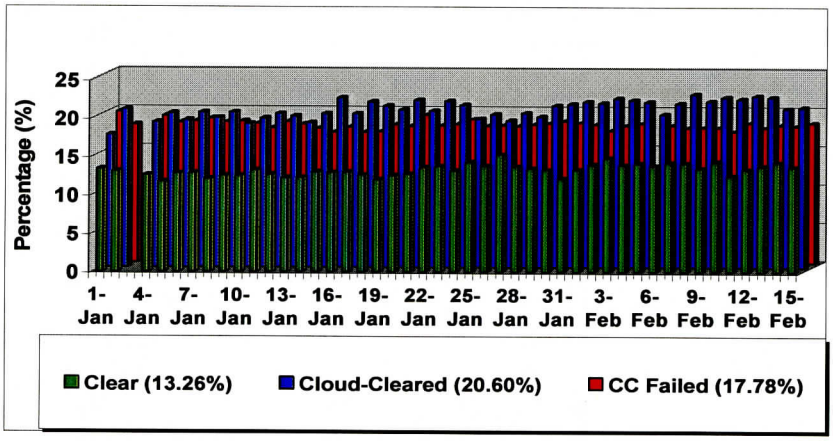


Figure 3: 45 days global cloud clearing statistics from January 1st to February 15th, 2004 (no January 3rd due to short of data), on average, 13.26% clear, 20.60% cloud-cleared successful, and 17.78% cloud-cleared failed.

Earth Observing System (EOS) Real Time Products

Personnel: Liam Gumley, Kathleen Strabala

Funded by: NASA

Project Description

Our goals are to use our expertise in automated direct broadcast product generation to create a suite of near real time geophysical products covering North America using instruments on the EOS Aqua and Terra spacecraft to support short term decision making, forecasts and warnings.

Our current suite of EOS products includes MODIS L1B and calibration data sets, true color images in .jpg and .GeoTIFF formats, MODIS cloud mask, cloud top properties, cloud phase, vertical profiles of temperature and moisture, total precipitable water vapor, aerosol optical depth, sea surface temperature and near infrared water vapor. The AIRS/AMSU and AMSRE L1B products are also generated in near real time as well as two different AIRS vertical temperature and moisture profiles at 3x3 and single pixel resolution.

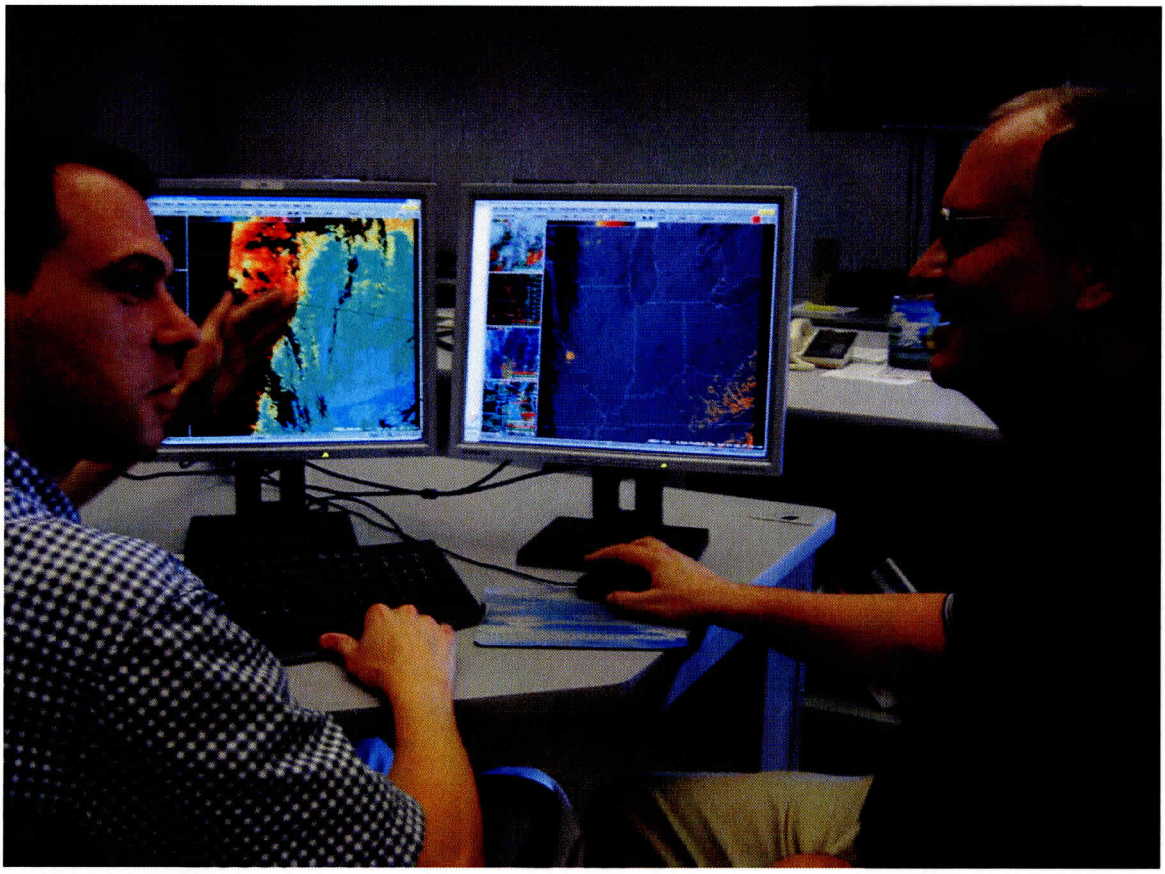
These images and products support a wide range of environmental monitoring and forecast activities where the timeliness and quality of the data are vital. A short list includes:

- Public service – True color images of local and national public interest (Hurricanes, dust storms, tornado damage paths, for example).
- Ice monitoring for shipping concerns (Great Lakes Coast Watch and the Canadian Ice Service).
- Marine animal migrations (Sea Surface Temperatures in the Delaware Bay region).
- Numerical Weather Prediction initialization (1 km resolution MODIS Sea Surface Temperatures used by Melbourne NWS for local NWP analysis).
- Air quality forecasting support (MODIS aerosol optical thickness is the baseline for Infusing Satellite Data for Environmental Applications (IDEA) in support of the EPA).
- Weather forecasters (MODIS products are now inserted into AWIPS and used by NWS forecasters).

Accomplishments

- NOAA NWS Forecasters find the UW DB MODIS products useful in AWIPS.
    - NWS forecasters describe the utility of MODIS products in several forecast discussions.
    - Training sessions held in MKE and KARX NWS offices.
    - 13 VISITview MODIS Teletraining sessions given with 38 different NWS Forecast Offices participating.
- Turtle migrations monitored using MODIS sea surface temperatures.
- Support an average of two requests per month from the general public for MODIS true color images.
- IDEA project moved to CIMSS because of direct broadcast facility.
- High resolution MODIS sea surface temperatures provide 50 times the resolution of NCEP SST previously used by Melbourne NWS NWP analysis.
- CIMSS MODIS true color images featured several times by the NASA EOS Earth Observatory.

- Major provider of MODIS, AIRS and AMSR-E data sets for NASA's Short-term Prediction Research and Transition (SPoRT) center.



Sullivan, Wisconsin, National Weather Service Forecasters discuss the utility of MODIS data to operational forecasting while viewing the MODIS total precipitable water vapor product and the fog product in AWIPS. This image was taken in July 2006.

Refining the MODIS Calibration and Deriving Cloud Top Properties

Personnel: Paul Menzel, Chris Moeller, Richard Frey, Hong Zhang, Kathy Strabala, Bryan Baum, and Paolo Antonelli

Funded by: NASA

Project Description

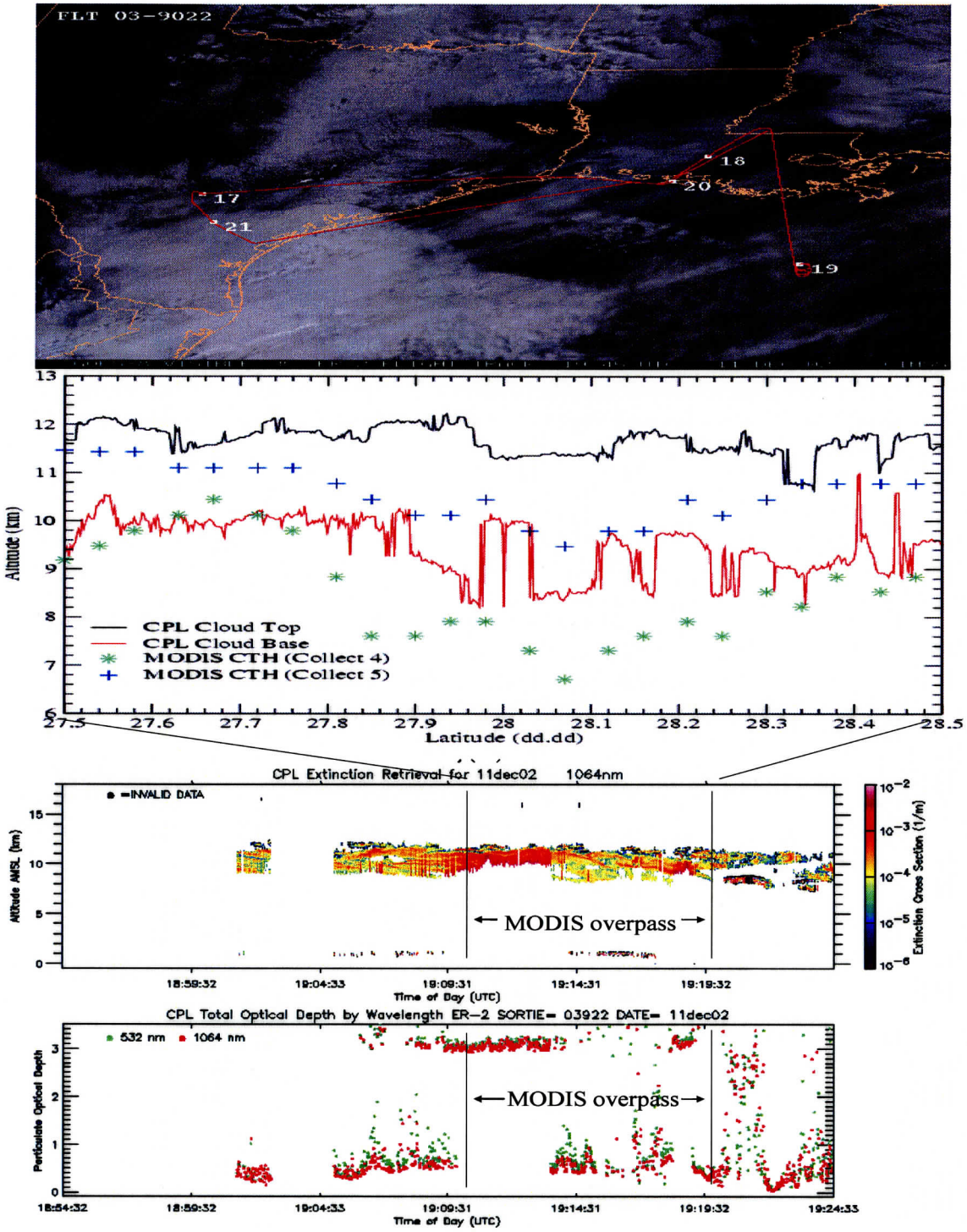
This project involves maintenance of existing cloud top properties (CTP) algorithms established for the Terra MODIS and adapted to the Aqua MODIS. These algorithms include preprocessing of multi-detector data into a coherent image (destriping), calibration of the data into quantitative radiances (level 1a radiances), identification of cloud presence within a MODIS field of view (cloud mask), mapping of cloudy sky temperature height and ice/water properties (cloud properties), and production of global clear sky moisture and ozone products (atmospheric characteristics).

Accomplishments

- MODIS Infrared Calibration Adjustments - The MODIS LWIR CO_2-sensitive bands have shown persistent out-of-specification behavior on both Terra and Aqua, particularly bands 35 and 36. Uncertainty estimates are incomplete, particularly for scan mirror reflectance and for out-of-band (OOB) influence. Recent ER-2 nighttime flights ("Tahoe 2006") are being used to update and further the L1B assessment for Aqua MODIS.
- MODIS CTP ATBD Updated - The MOD06 Cloud Top Properties Algorithm Theoretical Basis Document (ATBD) was updated to reflect current collect 5 practices.
- Journal Article on MODIS CTP - A paper was submitted to JAOT for publication that includes a description of: the Collect 5 version of the Cloud Top Properties (temperature, height, effective cloud amount) algorithm; sensitivity to radiance bias, scan angle, and field of regard; comparisons with Cloud Physics Lidar (see figure below), CALIPSO, and HIRS; and example level 3 global fields for summer and winter seasons. Paper was conditionally accepted in March 2007.
- MODIS CTP Validation - MOD06 cloud top properties from collect 5 are being compared to CALIPSO determinations and algorithm adjustments are being considered based on the comparisons.

Projected Efforts for 2007

- Investigate CO_2 algorithm accommodation of seasonal / geographical changes in CO_2 and O_3 concentrations using MODIS and CALIPSO/Cloudsat comparisons as a guide.
- Study algorithm adjustments in the presence of low level inversions.



CPL cloud top and bottom compared with the Collection 5 MODIS cloud top heights (inferred from pressure using the GFS pressure profiles) over cirrus clouds on 11 December 2002. (top) ER-2 flight track overlaid on GOES-8 image with ER-2 locations indicated in UTC. Segment from 1910 to 1920 UTC coincided with MODIS / Aqua overpass. (bottom) CPL altitude and total optical depth determinations from 1854 to 1924 UTC; CPL sees cloud at roughly 10 km starting with optical depths of about 3 and dropping to 0.5 at 1913 UTC.

Carbon dioxide above clouds from NASA's Orbiting Carbon Observatory

Personnel: Ralf Bennartz, Jerome Vidot, Andrew K. Heidinger

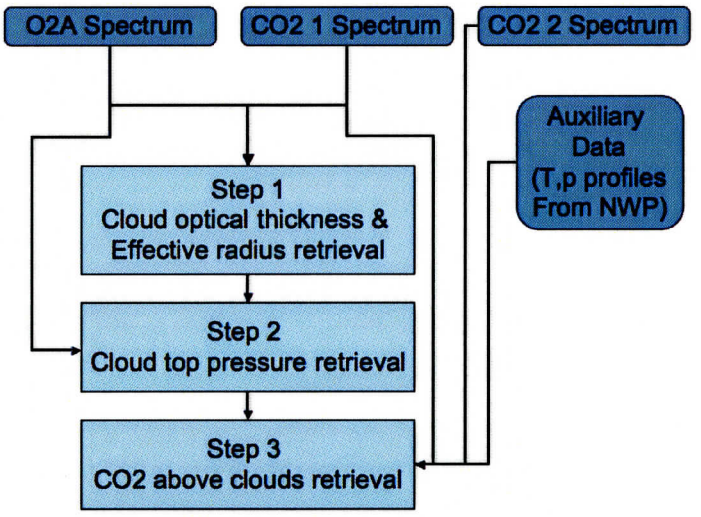
Funded by: NASA

Project Description

In 2008/2009 NASA will launch the Orbiting Carbon Observatory (OCO) whose main focus will be the global mapping of sources and sink of carbon dioxide. This will be achieved by measuring the column amount of carbon dioxide (XCO2) in cloud-free atmospheres using differential absorption techniques in two carbon dioxide bands in the solar spectral range. The particular objective of our project is to estimate carbon dioxide column over clouds and thus to make use of the about 60% of measurements of OCO that cannot be used in the operational XCO2 retrieval due to cloud contamination.

Accomplishments

1. Optimal estimation (OE) methods to derive CO_2 above clouds have been implemented and tested on simulations as well as observations. The OE has been split into three steps. In an initial step, cloud optical and microphysical properties are derived. Then, using these properties, cloud top pressure and CO_2 above clouds is derived. See attached Figure.
2. The cloud optical properties retrieval as well as the CO_2 retrieval has been applied to observations. Cloud optical properties have been validated against aircraft observations. CO_2 retrievals have been applied to SCIAMACHY. Research using SCIAMACHY as a proxy for OCO is ongoing.
3. Initial studies on the influence of polarization on the measured signal have been performed.
4. Open issues concerning spectroscopic databases, algorithm accuracy, and polarization are currently being studied and it is anticipated that a first operational version of the algorithm will be ready and validated in time for the launch of OCO.



This figure shows the general algorithm flow of the carbon dioxide above clouds retrieval. The algorithm uses optimal estimation techniques to derive cloud properties as well as carbon dioxide above clouds. The algorithm will be applied to NASA's Orbiting Carbon Observatory to be launched in 2008/2009.

MODIS MOD07 Atmospheric Profile Retrievals

Personnel: Suzanne Seemann, Eva Borbas, Gordon Stephenson

Funded by: NASA

Project Description

The operational algorithm for retrieving temperature and moisture profiles and total column ozone from infrared (IR) radiances observed by the National Aeronautics and Space Administration/Earth Observing System (NASA/EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) instrument is a clear sky synthetic regression retrieval algorithm called MOD07 (Seemann et al. 2003, 2006, 2007). The MOD07 retrieval algorithm uses clear-sky radiances over land and ocean for both day and night from eleven MODIS infrared channels (25, 27-36). The algorithm employs a statistical retrieval with an option for a subsequent nonlinear physical retrieval. Atmospheric retrieval algorithms such as MOD07 require a global set of profiles and corresponding surface data (surface emissivity, surface skin temperature, and surface pressure) to train the synthetic regression. Radiance calculations for each training profile and surface values are made using a transmittance model, and the calculated radiance/atmospheric profile pairs are then used to derive the regression relationship.

Objectives

To develop, maintain, evaluate, and document the MODIS MOD07 algorithm.

Recent Accomplishments

- A paper was written and submitted to JAMC detailing the derivation of a global surface emissivity for application to atmospheric synthetic regression retrieval algorithms such as MOD07. The new emissivity was applied to the MOD07 algorithm and significant improvements over a constant emissivity of 1.0 or 0.95 were noted (See Figure 1).

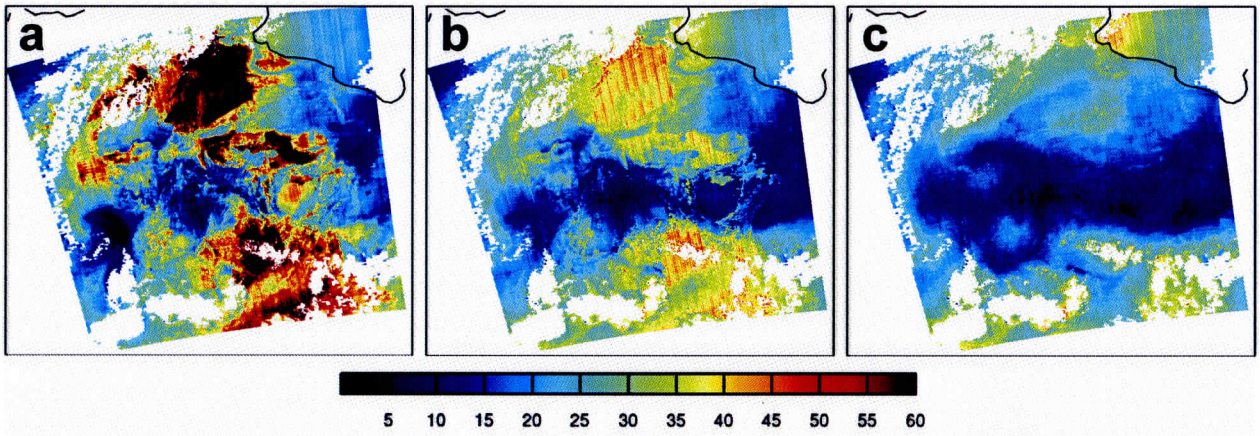


***Figure 1**: MODIS MOD07 TPW (mm) for the 5 minute Terra granule beginning at 21:40 UTC on August 1, 2005. This granule is in the north-central Sahara desert. Emissivities of 0.95 (a), 1.0 (b), and the baseline fit emissivity (c) were applied to the training data used in the regression retrieval algorithm.*

- The MOD07 ATBD was updated to include the most recent algorithm description and validation.

- The Collect 5.2 MOD07 algorithm for Terra was delivered to the DAAC for operational processing. With this new algorithm, the RMSE between MODIS and the microwave radiometer (MWR) was reduced from 2.87 mm to 2.49 mm for 313 clear sky cases at the SGP ARM site between April 2001 and August 2005. Overall bias was reduced from 0.98mm to –0.04mm (positive bias indicates MOD07 is drier than MWR). Updates with this collection include new synthetic regression coefficients computed from an updated set of 15,704 training data profiles, substitution of the pCRTM model to compute synthetic radiances instead of PFAAST, and the use of new surface emissivities in the computation of the regression coefficients.
- Ongoing work toward possible Collection 6 updates: Continued experimentation with improvements to the algorithm, training data, and regression coefficients are underway to prepare for a possible Collection 6. Testing already underway includes including updated estimates of instrument noise, altering the number of land/ocean band 31 BT zones, improved handling of radiance bias adjustments, and improvements to the skin temperature estimates.
- Selected updates to the evaluation of the MOD07 algorithm are described below
    - The MOD07 IR TPW retrieved product and the near IR TPW and IMAPP near IR TPW product derived from the UW-Madison IMAPP (Huang et al., 2004) algorithm which employs the method of P. Albert et al. (2005) were compared with ECMWF, RAOB, and MWR TPW at the SGP ARM site over land with an RMSE compared with the SGP MWR of 2.0 mm for the near-IR TPW, compared with 2.5 mm for the MOD07 IR TPW (Terra satellite). For the Aqua satellite, the MOD07 IR TPW performs worse with an RMSE of 3mm, compared with 1.6mm for the near IR TPW. Comparisons were also made over the Carpathian Basin, where the NIR and IR TPW algorithms performed similarly with an RMS of 2.3mm when compared with radiosondes and 2.6mm compared to ECMWF, although the NIR algorithm showed a larger bias.
    - A new set of validation sites have been added for near-real time evaluation of the MODIS MOD07 TPW products from Terra and Aqua. TPW from six GPS sites throughout the U.S. is compared with that retrieved by MODIS. UW-Madison direct broadcast processing of MODIS data is used and the process is automated to update the comparison twice per day.
    - Profiles of temperature and moisture retrieved with the MOD07 algorithm were compared with the NASA v4 operational AIRS product, derived from Aqua AIRS radiances. Collocated AIRS and MODIS profile retrievals were compared with the best-estimate (BE) profiles (Tobin et al., 2006) at the SGP ARM site for 80 clear sky Aqua cases between October 2002 and August 2005. As an instrument with moderate spectral resolution, MODIS is not as well equipped for sounding as GOES or AIRS are. However, MODIS can retrieve profiles with a certain degree of accuracy despite its spectral limitations, see Figure 2.

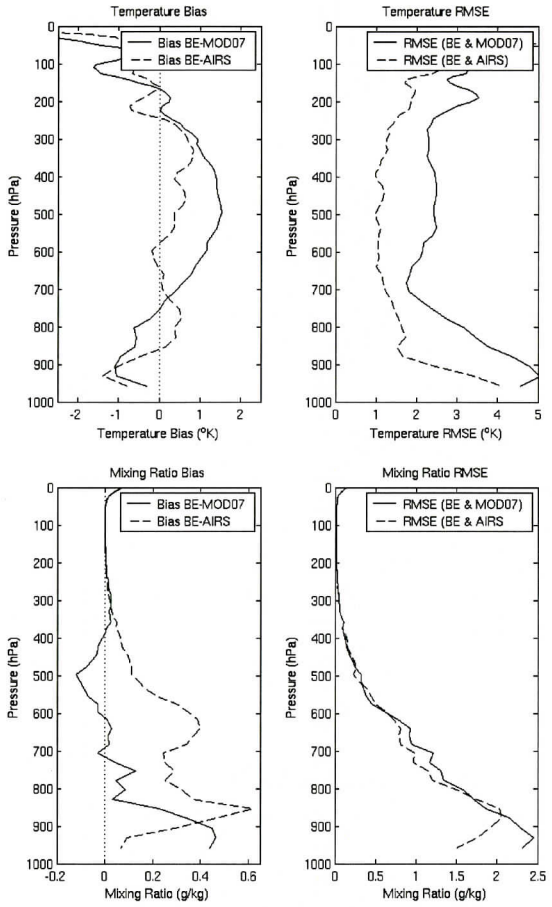


Figure 2: Mean RMS differences between Aqua MODIS MOD07 and AIRS v4 operational temperature and moisture profiles and the "best estimate of the atmosphere" (Tobin et al., 2006) dataset for 80 clear sky cases over the SGP ARM site are shown at the left. The best estimate profiles of the atmospheric state are an ensemble of temperature and moisture profiles created from two radiosondes launched within two hours of the Aqua satellite overpass times.

MOD35 – MODIS Cloud Mask Algorithm

Personnel: Steven A. Ackerman and Richard Frey

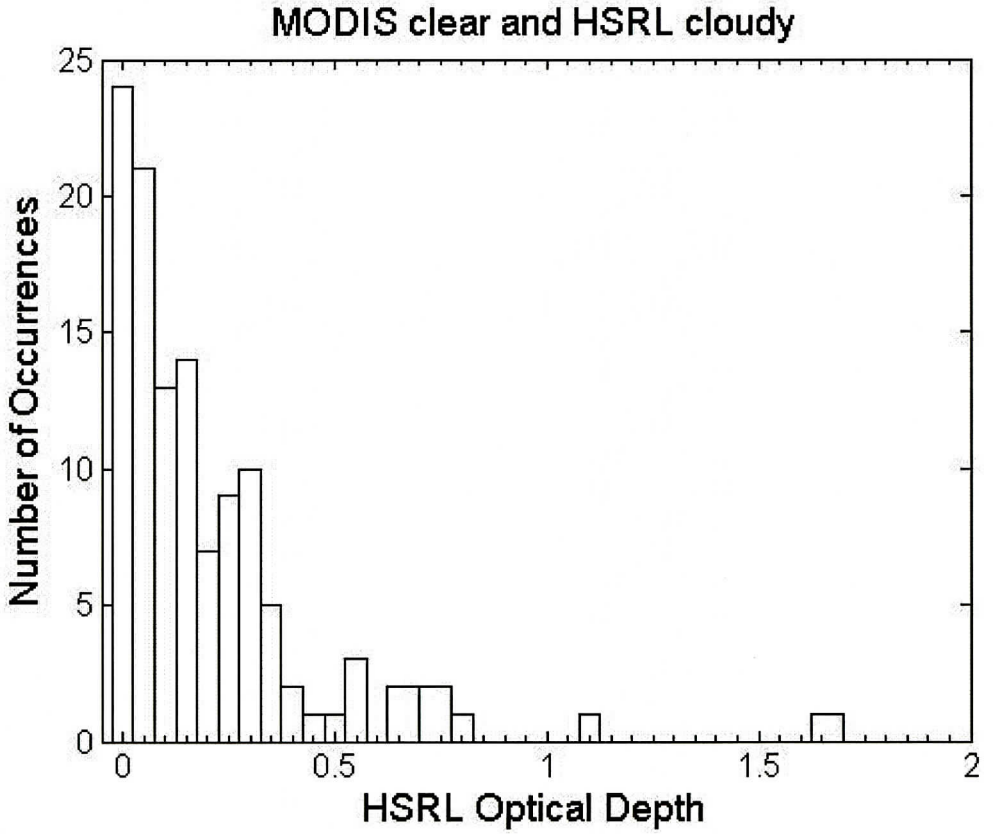
Funded by: NASA

Project Description

This project is to maintain and test the MODIS cloud mask algorithm for NASA. Developed in collaboration with members of the MODIS science team, the MODIS cloud screening approach was the first to include new spectral techniques, setting the stage for new methods of measuring cloud cover from satellites. The focus on the last year has been a validation of the algorithm.

Accomplishments

- Comparisons with radar/lidar observations at the SGP ARM site indicates agreement approximately 85% of the time.
- The sensitivity of the MODIS algorithm to fov and thresholds has been assessed.
- Comparison with CALIPSO indicates agreement approximately 85% of the time.
- Participation in the GEWEX cloud detection workshop show MODIS doing well in comparison to other methods.
- Comparison with HSRL lidar over SSEC indicates optical depth threshold for cloud detection is approximately 0.4.



The number of occurrences that a MODIS pixel was identified as clear by the MODIS cloud-mask algorithm while the HSRL detected a cloud with a given cloud optical depth.

Global Analysis of MODIS Level-3 Cloud Properties and their Sensitivity to Aggregation Strategy

Personnel: Steven A Ackerman and Brent Maddux

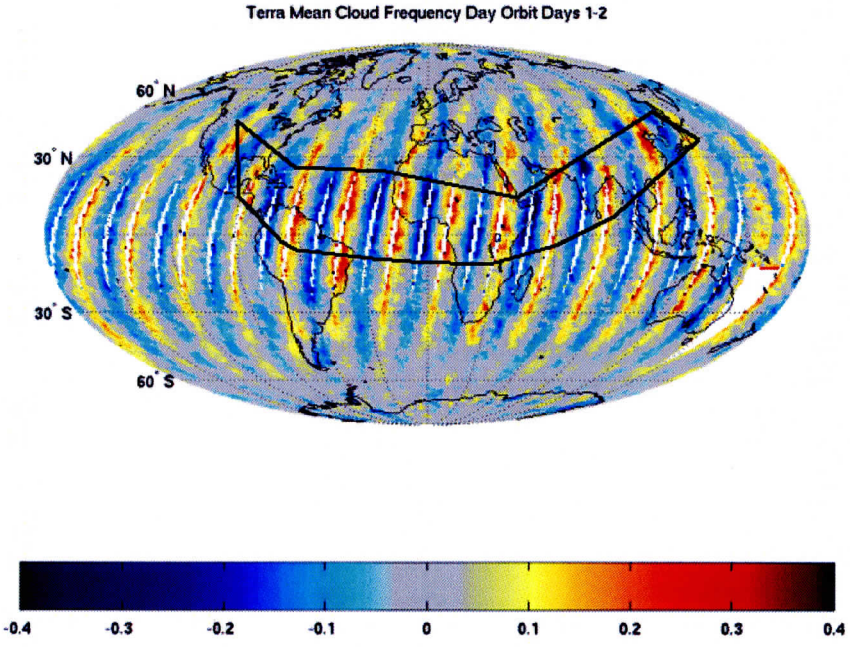
Funded by: NASA

Project Description

The MODIS Terra and Aqua operational cloud products include cloud detection along with optical, microphysical, and cloud-top properties of water and ice clouds. We are studying the global distribution of MODIS cloud products using the MODIS Atmosphere Level-3 data and examine the sensitivity of spatial/temporal aggregation strategies on the results. Studies include global hemispheric and land/ocean differences as a function of cloud type, as well as correlations among the products. Specific regional studies are also being undertaken, including comparison of tropical and midlatitude cirrus and deep convective systems, and the major marine stratocumulus regimes.

Accomplishments

- Participated in the GEWEX cloud detection comparison workshop.
- Quantified the dependence of global averages on viewing geometries.
- Compared cloud amounts between Terra and Aqua and various temporal and special scales.
- Demonstrated new Level-3 cloud properties that result from MODIS higher spatial resolution averaging.



Differences in the Orbit Day 1 minus Orbit Day 2 mean daytime cloud fraction. Differences are greatest over areas of climatologically high aerosol optical depths--the u-shaped arc is of maximum differences from the Caribbean to Africa to China.

International MODIS/AIRS Processing Package (IMAPP) for EOS Direct Broadcast Data – Maintenance and Continuation of Development and Support

Personnel: Allen Huang, Liam Gumley, and Kathy Strabala

Funded by: NASA

Project Description

The Direct Broadcast capability of the NASA EOS Terra and Aqua platforms allows the international science community to receive and process EOS data in a timely manner, and helps to foster the development of regional products for a variety of inter-disciplinary fields, including weather forecasting and warning, process studies, and natural resource management. IMAPP, so far, has provided more than 150 direct broadcast stations the crucial capability to transform the real time instrument measurements to calibrated and geolocated radiances. Over twenty countries are currently using IMAPP to process EOS data and training workshops have been conducted in Perth, Australia; Nanjing, China; Beijing, China; Taipei, Taiwan; Adoya, Norway; and Pretoria, South Africa. IMAPP Level 2 atmospheric, ocean, and land products' open source software are also the keys that enable direct broadcast users to optimize the acquired regional data for their unique applications.

CIMSS/SSEC continues to maintain, refine and expand this software package for processing Direct Broadcast MODIS, AIRS, AMSU, HSB, and AMSR-E data in near real-time to provide calibrated and geolocated radiances, and a suite of geophysical products. The goals in this period are:

1. To continue to maintain, refine, and expand a freely available software package (IMAPP) for international distribution which allows any ground station capable of receiving Direct Broadcast data from the EOS Terra and Aqua platforms to produce calibrated and geo-located visible reflectance, near infrared and infrared radiances and microwave brightness temperatures, and selected geophysical products, in near real-time (within 1 hour of satellite overpass).
2. To continue to develop and implement a synergistic visible, near infrared, infrared and microwave algorithm for Direct Broadcast data that utilizes the high spatial resolution of MODIS data, the high spectral resolution of AIRS data, and the cloud penetrating AMSU/HSB and AMSR-E microwave data.
3. Using the SSEC X-band ground station and IMAPP, to routinely receive EOS Direct Broadcast data over North America and generate a suite of MODIS, AIRS/AMSU/HSB, and AMSR-E products within one hour of overpass.

Accomplishments

Summary of the IMAPP S/W releases, training workshops conducted and data and products provided in the past two years:

1. **R24. November 14, 2006** (AIRS Level 2 v1.3) Update to AIRS Level 2 University of Wisconsin-Madison Single Pixel Retrieval Release.
2. **R23. September 06, 2006** (AMSR-E Level 2 v1.1) First AMSR-E Level 2 Soil Moisture Retrieval Software Release.
3. **R22. March 21, 2006** (AIRS Level 2 v1.1) Update to AIRS Level 2 University of Wisconsin-Madison Single Pixel Retrieval Release.
4. **R21. November 14, 2005** (AIRS Level 2 v1.0) First AIRS Level 2 University of Wisconsin-Madison Single Pixel Retrieval Release.

5. **R20. September 22, 2005** (AIRS/AMSU/HSB Processing Package for Direct Broadcast v4.0) First release of AIRS/AMSU/HSB package to retrieve temperature and water vapor profiles.
6. **R19. August 30, 2005** (MODIS Level 2 Product Collect 5 Updates) Updates to MODIS Level 2 Cloud Mask, Cloud Top Properties, Atmospheric Profiles and Ancillary software packages (v1.8).
7. **R18. July 06, 2005** (AMSR-E Level 2 Rain Rate/Rain Type) First AMSR-E Level 2 Release.
8. **R17. April 25, 2005** (AMSR-E Level 1B (also known as Level 2A)) First AMSR-E Level 1Release.

IMAPP Training Workshops conducted:

1. **April 3-7, 2006**: MODIS/AIRS Training and Applications Workshop, South Africa National Biodiversity Institute, Pretoria, South Africa
2. **February 28 – March 2, 2006**: MODIS Remote Sensing Workshop, Andenes Norway
3. **May 18-24, 2005**: International Symposium of remote Sensing and Space Technology for Multi-disciplinary Research and Application and the 2nd International MODIS and AIRS Processing Package training Workshop. Peking University, Beijing, China
4. **January 12-14, 2005:** Earth Observing Systems: MODIS Direct Broadcast and remote Sensing Application Workshop. National Central University, Chung-Li, Taiwan

IMAPP data and products provided so far:

MODIS

1. Level-1B radiances
2. Cloud mask
3. Cloud phase
4. Cloud top height
5. Cloud top temperature
6. Cloud emissivity
7. Temperature profile
8. Water vapor profile
9. Total precipitable water
10. Total ozone
11. Stability
12. Cloud aerosol optical depth
13. Sea surface temperature
14. near-IR water vapor
15. De-stripping band 26 (correction for band 5 spectral leak)
16. True color image generation

AIRS

17. AIRS/AMSU/HSB level 1B radiances
18. Multiple FOV AIRS/AMSU temperature profile
19. Multiple FOV AIRS/AMSU water vapor profile
20. Multiple FOV AIRS/AMSU ozone concentration
21. Multiple FOV AIRS/AMSU SST
22. Single FOV AIRS clear temperature profile
23. Single FOV AIRS clear water vapor profile
24. Single FOV AIRS clear ozone concentration
25. Single FOV AIRS clear SST

AMSR-E

26. AMSR-E Level 1B radiances
27. Rain Rate/type (B05 algorithm)
28. Soil Moisture

The NPP Atmosphere Product Evaluation and Test Element (PEATE)

Personnel: Hank Revercomb (PI), Liam Gumley (Co-I, PM), Bryan Baum, Paul Menzel, Scott Mindock, Steve Dutcher, Paolo Antonelli, Robert Holz, Andy Heidinger, Mike Pavolonis, Steve Cooper

Funded by: NASA

Project Description

The NPOESS Preparatory Project (NPP) mission scheduled to launch in 2009 will provide a first look at a new generation of products from U.S. operational polar orbiting Earth observing satellites. Production of Sensor Data Record (SDR) and Environmental Data Record (EDR) products will be accomplished by the Interface Data Processing Segment (IDPS) of the NPOESS Ground System. The NASA NPP Science Team has been tasked with evaluation of the operational products from the IDPS within a facility known as the Science Data Segment (SDS). Within the SDS, NASA has established five Product and Evaluation and Test Elements (PEATEs) to enable the NPP Science Team to efficiently and effectively evaluate the operational SDRs and EDRs from NPP. The PEATEs are organized into categories including Atmosphere, Land, Ocean, Ozone and Sounder. The Atmosphere PEATE has been established within the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison.

The Atmosphere PEATE will enable the NPP Science Team to:

- assess the impact of on-orbit instrument performance on SDRs and subsequently on Atmosphere EDRs;
- evaluate the quality of Atmosphere EDRs at sensor resolution over a wide range of spatial and temporal conditions;
- validate Atmosphere EDRs against ground-based and satellite-based measurements;
- develop improved Atmosphere EDR algorithms
- evaluate the climate quality of the Atmosphere EDRs.

Computing resources will be provided by a cluster of Linux servers, and the system will be designed to allow global SDR and EDR product generation at more than 100 times real-time processing speed, enabling one month of data to be processed in one day. This will allow the NPP Science Team to rapidly assess the impact of calibration and science algorithm changes on climatologically significant subsets of the NPP data record.

The project has begun with the design and development of a first-generation computing system that will enable a demonstration of the product evaluation. The demonstration will use NASA EOS MODIS and AIRS data and science team algorithms as a testbed to evaluate the processing capability to fulfill requirements for NPP. The Atmosphere PEATE has also started evaluating the NPOESS contractor algorithm for atmosphere and cloud products from NPP, and has also established a calibration/validation facility for automated comparison of NPP and precursor products against satellite and ground based data.

Accomplishments

An initial Atmosphere Product Evaluation Demonstration was completed in 2006 to demonstrate the workflow necessary to evaluate a VIIRS atmosphere EDR for climate product quality. Aqua MODIS proxy data were chosen because it is the best available spectral simulation of VIIRS. Products to be compared included:

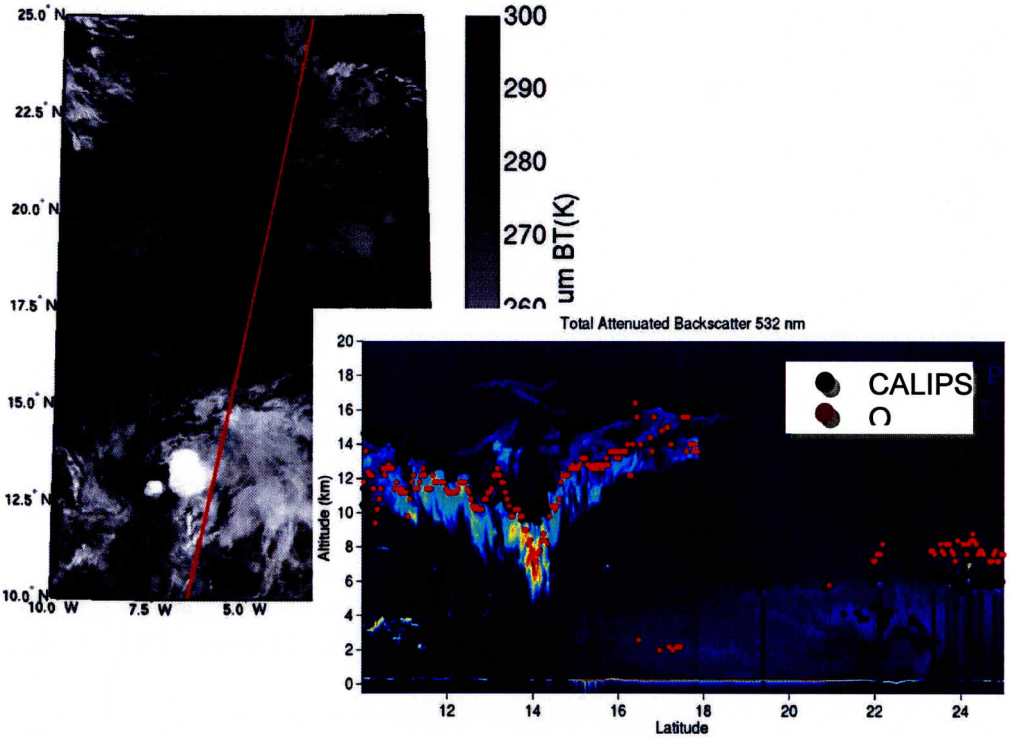
- VIIRS OPS Cloud Mask (versions 1.3 and 1.4)
- MODIS operational cloud mask (collection 5)
- MODIS operational cloud mask with VIIRS bands only

Activities in the demonstration included obtaining products (from archive, or generate from scratch), running a quality control process on each product, intercomparison of products, and validation of products. The work plan for the Atmosphere Product Evaluation Demonstration was as follows:

1. Process one global month of Aqua MODIS proxy data (day/night), starting with Level 1A data (RDR).
2. Run MODISL1DB algorithms for geolocation and calibration.
3. Run DAAC operational algorithm for Level 1B destriping.
4. Run Cloud Mask algorithms.
5. Examine quality of each individual product (e.g., algorithm success/failure and retrieval yield statistics; 6. processing summaries (per granule, per day); granule-based images; clear radiance composites (daily, 8-day, monthly).
6. Intercompare the products (compute and map differences in clear sky radiance statistics for final retrieval and intermediate spectral tests).
7. Validate each product by collocating with CALIPSO lidar and comparing to CALIPSO cloud mask.

The System Requirements Review for the Atmosphere PEATE was successfully completed on 9/13/2006.

The Preliminary Design Review for the Atmosphere PEATE was successfully completed on 4/10/2007.



CALIPSO lidar data is being used to evaluate the VIIRS cloud products using MODIS proxy data. In this example, CALIPSO cloud boundaries are compared to cloud heights derived from MODIS.

NPP VIIRS Level 1 Product Early Assessment

Personnel: Chris Moeller, Dan LaPorte, Paul Menzel

Funded by: NASA

Project Description

The follow-on global climate research instrument to MODIS is the Visible Infrared Imaging Radiometer Suite (VIIRS), constructed by Raytheon-Santa Barbara under the direction of Northrup-Grumman (SSPR contractor) in contract with the Integrated Project Office (IPO). A NASA NPP Science Team has been funded to provide guidance, experience, and oversight to the development of the VIIRS sensor and associated level 1 (SDR) and level-2 (EDR) product algorithms, with a special focus on the SDR and EDR quality for climate research.

University of Wisconsin personnel are funded primarily to contribute to the understanding of the L1 SDR performance for VIIRS. This includes hardware design considerations, hardware component and system performance, performance specification compliance, performance anomaly detection and mitigation, and product algorithm evaluation. Some EDR impact assessment is also provided when useful for cloud products (e.g. VIIRS Cloud Mask). The participants bring a body of experience built up through participation in the MODIS instrument development to this project. Some specific activities in this project include:

- Review of pre-launch ambient phase, pre-thermal-vacuum (TVAC) phase, TVAC phase, post TVAC phase, and Spacecraft phase test plans;
- On-site presence at Raytheon Santa Barbara to observe pre-launch VIIRS test data collection;
- Obtain and analyze pre-launch test data for performance assessment;
- Participate in pre-launch performance anomaly mitigation strategies;
- Participate in developing strategies for post-launch SDR evaluation.

The personnel of this project have participated in the special X-DAWG (cross-talk) and Y-DAWG (multi-focus) teams to address specific known and anticipated instrument performance issues and anomalies, as well as the NASA NPP L1 Team activities. Personnel also participate in Raytheon-hosted test data evaluation reviews, test readiness reviews, Cal/Val working group meetings, technical information meetings (TIMs), and a variety of other meetings too numerous to mention.

Accomplishments

- Contributions towards understanding the impact of electronic (static and dynamic) and optical (light leak) crosstalks on the VISNIR focal plane of EDU and FU-1, including testing VIIRS proxy data in a prototype VCM.
- Test data analysis and modeling to reveal the level of ambient lab atmospheric absorption influence on VIIRS bands during spectral characterization.
- Forward model application demonstrating spectral offset as a function of position on the VIIRS focal plane during spectral characterization. A correction will be made for this effect.
- On-site participation as an observer during EDU TVAC test data collection. Planned also for Flight Unit – 1 testing.
- Participated in working group to develop and refine VIIRS on-orbit performance evaluation tasks for purpose of demonstrating and validating sensor performance.

NPOESS Cal/Val and Product Development

Personnel: Paul Menzel, Eva Borbas, Youri Plokhenko

Funded by: IPO

Project Description

Data and products from MODIS, AIRS, AMSU, and CHAMP are being used as proxy for VIIRS, CrIS, ATMS, and Radio Occultation sensor capabilities to test algorithms that will produce the required EDRs. This work reduces risk and assures successful transition from the current polar orbiting operational environmental satellites to the future NPOESS. This work is contributing sensor inter-calibration studies, cloud property algorithm mitigation for absence of IR opaque channels, multi-sensor profile retrieval studies, and visualization tool development.

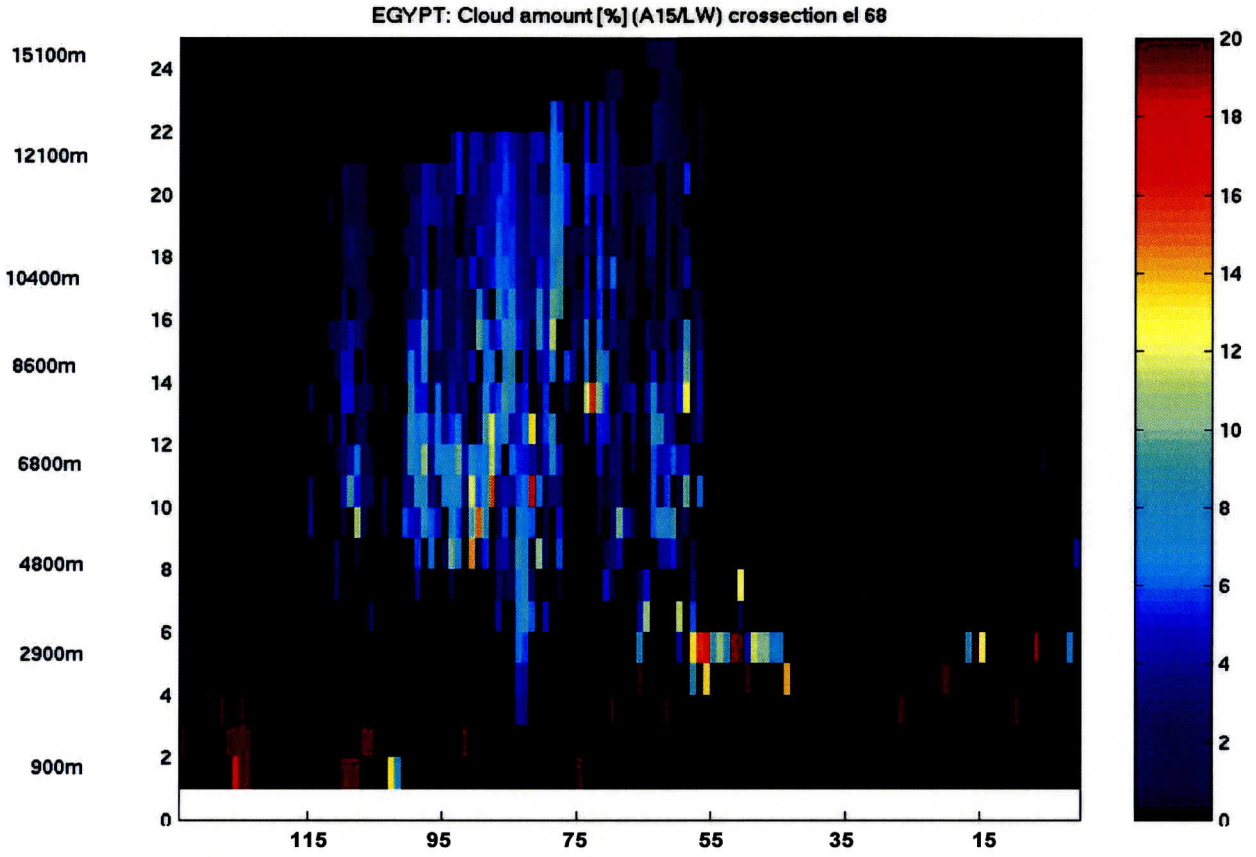
Accomplishments

Recent accomplishments include:

- Participated in analysis of VIIRS vacuum test data;
- Explored AIRS/MODIS intercalibrations and CART site determination of calculated and observed differences in MODIS radiances in preparation for VIIRS post-launch radiance validation;
- Demonstrated CrIS cloud profiles alleviating VIIRS night-time cloud problems (using AIRS and MODIS data; see below for an example);
- Submitted paper to JAMC on combining radio occultation CHAMP data with infrared and microwave AIRS / AMSU data; conditional acceptance received April 2007;
- Studied sounding retrieval optimization by quantifying sensitivity of AIRS temperature and moisture profile retrievals to CO2 and O3 amounts; and
- Continued development of HYDRA visualization tools for interrogation of multispectral data by adding colocation of MODIS data with AIRS and CALIPSO.

Projected Efforts for 2007

- VIIRS test data will continue to be studied.
- Capability to view IASI along with AIRS and MODIS will be added to HYDRA.
- Inter-calibration of IASI and MODIS will be attempted.
- GPS plus AIRS/AMSU paper will be revised in accordance with reviewers suggestions.
- Paper on cloud profile estimation with AIRS will be submitted to Applied Optics.
- Sensitivity of retrievals to CO2 profiles (not total column) will be studied.
- CrIS plus VIIRS (using AIRS plus MODIS) high cloud amount retrieval algorithm will be simplified for routine application.



Cloud amount profiles up to 15100 meters (on the y-axis) shown as a transect (on the x-axis) along a cloud in an AIRS granule over Egypt. The good continuity in the single FOV retrievals from one AIRS field of view to the next is noteworthy.

Validating Snow and Ice Products in Polar Regions for NPOESS

Personnel: Jeff Key, William Straka III

Funded by: Integrated Program Office

Project Description

The goal of this project is to generate snow and ice products in an operational environment at direct broadcast (DB) sites in the Arctic and Antarctic, and to provide automatic validation of these products. Snow/ice and cloud products are being generated with contractor code (Northrop Grumman Space Technology, NGST) and our own algorithms, then validated with surface measurements and other data sets, when and where available, in real-time. MODIS data is being used as a proxy for VIIRS data. Products of interest include ice/snow surface temperature, ice/snow albedo, sea ice age, sea ice motion, and snow and ice cover/extent. Additionally, other high-latitude products that may eventually become VIIRS Environmental Data Records (EDRs) will be generated and validated, most notably polar winds. The proposed system builds on DB product generation systems and a product suite already in place and running at McMurdo, Antarctica and at Tromsø, Norway. The work includes the generation of VIIRS EDRs, using the contractor code, and compares it to an established algorithm. The benefits of using real-time direct broadcast data are that (1) it provides for an unlimited number of validation cases, as opposed to the more common situation where only a few ideal test cases are used, (2) it provides a truly operational environment, and (3) it prepares us for future DB implementations of NPP and NPOESS products.

Accomplishments

The core parts of each EDR operational code set are used in our direct broadcast processing system, which operates on MODIS Level 1b data. The ice surface temperature (IST) and snow cover operational code is currently running at Tromsø, Norway (since May 2006) and McMurdo, Antarctica (since June 2006). The two VIIRS IST algorithms are being compared to each other as well as comparing them to the IST algorithm that was being generated at the sites previously. Less than 0.5% of the pixels in the 1-channel VIIRS IST algorithm have a larger than 2 degree difference when compared the two 2-channel algorithms. The areas and magnitudes of the differences between the 2-channel and 1-channel algorithms are similar. Studies to determine the nature of the differences are underway.

In addition to inter-comparing the various algorithms, we are also comparing the satellite-derived ice surface temperatures to surface observations. We are looking at established WMO surface sites as well as other observational systems, particularly the Automatic Weather Stations (AWS) across Antarctica. The AWSs are maintained by the SSEC Antarctic Meteorological Research Center and their international partners. There are six sites in the Arctic (all WMO sites) and nine sites in Antarctica that are currently being used in the validation study. More sites may be added in the future as data becomes available. Daily analysis, statistics and histograms are being produced in real-time for evaluation of the various algorithms. Options for validation of the snow mask are being explored.

CIMSS/SSEC Activities in Support of the International Polar Orbiting Processing Package (IPOPP) for Direct Broadcast Users

Personnel: Allen Huang, Liam Gumley, and Kathy Strabala

Funded by: NOAA

Project Description

The X-band Direct Broadcast (DB) capability of the NPP and NPOESS platforms will allow the international operational weather forecasting, environmental monitoring and science communities to receive and process the next generation of polar orbiting satellite data and products in a timely manner. Moreover, the DB facility helps to foster the development of value-added regional high spatial resolution products for a variety of inter-disciplinary fields, including natural hazard monitoring, process studies, and resource management.

CIMSS is a team member, along with the NPOESS Integrated Program Office (IPO) and the NASA GSFC Direct Readout Laboratory (DRL), in the development of the International Polar Orbiter Processing Package (IPOPP). The package is to enable the worldwide X-band DB community to process, visualize, and evaluate NPP Sensor Data Records and Environmental Data Records (SDRs and EDRs). The package will be a key enabling technology for the X-band DB user community in its transition from the NASA Earth Observing System (EOS) to NPP and NPOESS and other future generation of polar orbiting systems. The guiding principles the IPOPP project are to:

1. Meet the high expectations of the DB international community for mission continuity from NOAA, EOS, METOP, to NPP and NPOESS with user friendly processing packages for global as well as regional optimized value added applications;
2. Enable global feedback loop for METOP and NPP/NPOESS Cal/Val campaigns, allowing DB users to contribute their regional validated processing approaches/products to assist and improve global calibration/validation efforts;
3. Establish a continuity to support other international polar orbiting systems as part of the contribution to Global Earth Observing System of Systems (GEOSS).

CIMSS/SSEC is to adopt the algorithms provided by NPOESS and to extend it into a user-friendly and value added DB software package (IPOPP). CIMSS/SSEC will partner with DRL to provide standard RD, SDR, and EDR products from VIIRS, CrIS, and ATMS in a DB environment. CIMSS/SSEC will also develop value added services to 1) support North American real-time regional users, 2) add value to the standard products including regionally optimized/unique and specialty/synergistic products, 3) provide continuous calibration/validation & evaluation support, 4) engage the global direct broadcast community in the NPP/NPOESS mission, and 5) leverage other ongoing efforts to implement METOP IASI/AVHRR/AMSU SDR and EDR processing algorithms.

Accomplishments

CIMSS is becoming a critical partner of the IPOPP team. CIMSS is to contribute in many areas of the end-to-end processing of NPP and NPOESS as shown in Figure 1 below.

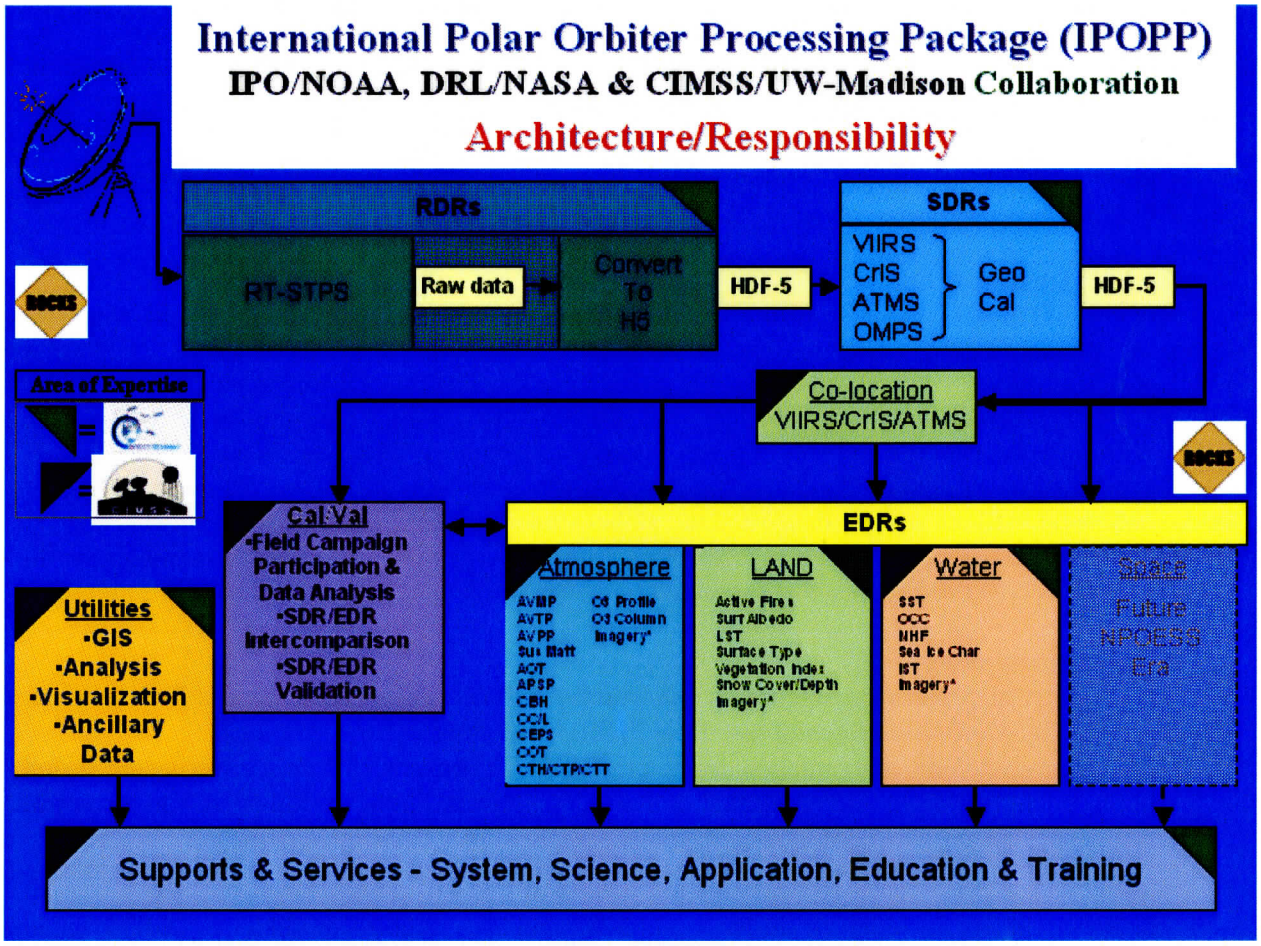


Figure 1. Top level architecture and responsibility of IPOPP team members of IPO, NASA and CIMSS.

Cloud and Radiation Properties in the Polar Regions

Personnel: Jeff Key, Xuanji Wang, Yinghui Liu

Funded by: NOAA (SEARCH project), NSF (Land Surface Fluxes; Lateral Heat Advection)

Project Description

The goal of this project is to estimate surface temperature, albedo, cloud amount, height, thickness, and phase, and surface radiation fluxes in the polar regions with the Advanced Very High Resolution Radiometer (AVHRR), to assess their role in the surface energy budget, and to examine trends over the last two decades. A 20-year satellite cloud climatology over the Arctic and Antarctic continent has been developed. The research not only examines overall changes in the Arctic during the past 20 years, but also explores feedback mechanisms, regional variability in climate change, and the relationship between Arctic change and the global climate system. Our focus is on clouds and radiation but attention is also given to surface properties, especially pertaining to recent trends in Arctic snow cover and sea ice that can induce a temperature-cloud-albedo feedback.

Accomplishments

- Satellite retrieval techniques for use with the AVHRR Polar Pathfinder (APP) dataset were refined and validated with data from SHEBA and from Barrow, Alaska.
- Surface, cloud, and radiation characteristics for 23 years of APP data, covering the period 1982-2004, have been estimated, and a data product has been made available to the public. The new product is called the extended AVHRR Polar Pathfinder, or APP-x.
    - An analysis of trends shows that the Arctic has been cooling at the surface during the winter, particularly over the ocean, but warming at other times of the year, particularly over land (Figures 1 and 2). The surface albedo has decreased, especially during the autumn months. Cloud amount has been decreasing during the winter but increasing in spring and summer. During summer, fall, and winter, cloud forcing has tended toward increased cooling (or decreased warming). This implies that if Arctic cloud cover had not been changing the way it has over the past two decades, surface temperatures would probably have risen at an even greater rate than what has been observed.
    - Decreases in sea ice extent and albedo that result from surface warming modulate the increasing cloud cooling effect, resulting in little or no change in the radiation budget.
    - Changes in summer albedo over Alaska correlate with a lengthening of the snow-free season that has increased atmospheric heating locally by 3 W/m-2/decade. Current trends in shrub and tree expansion could further amplify this by 2-7 times. (Done in collaboration with T. Chapin, University of Alaska)
- The APP-x product was used in combination with horizontal heat and moisture advection derived from the TIROS Operational Vertical Sounder (TOVS) Path-P product, and with clear sky temperature inversion data derived from the High Resolution Infrared Radiation Sounder (HIRS, part of TOVS). The goal was to examine the relationship between trends in cloud properties, temperature inversion characteristics, advection, and surface radiation.
    - The decreasing trend in winter surface temperature over the central Arctic cannot be explained solely by large-scale atmospheric circulation changes. There is a strong coupling between changes in surface temperature and changes in inversion strength, but that trends in some areas may be a result of advection aloft rather than warming/cooling at the surface.

- Other researchers have reported that the loss of Arctic perennial ice cover is almost 10% per decade. We found that the relative roles of advection and radiation in this process vary by region. (Done with J. Francis, Rutgers University).

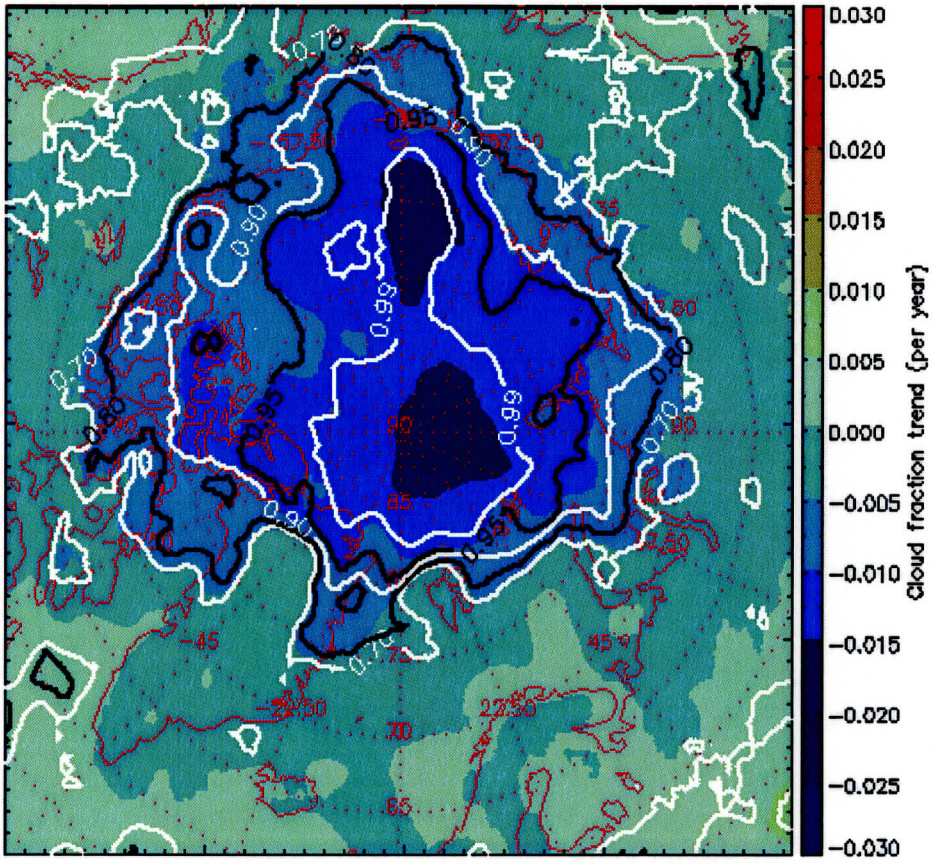


Fig. 1. Winter trend in cloud fraction over the Arctic (Greenland at bottom left) based on the 1982-2000 AVHRR Polar Pathfinder extended (APP-x) product.

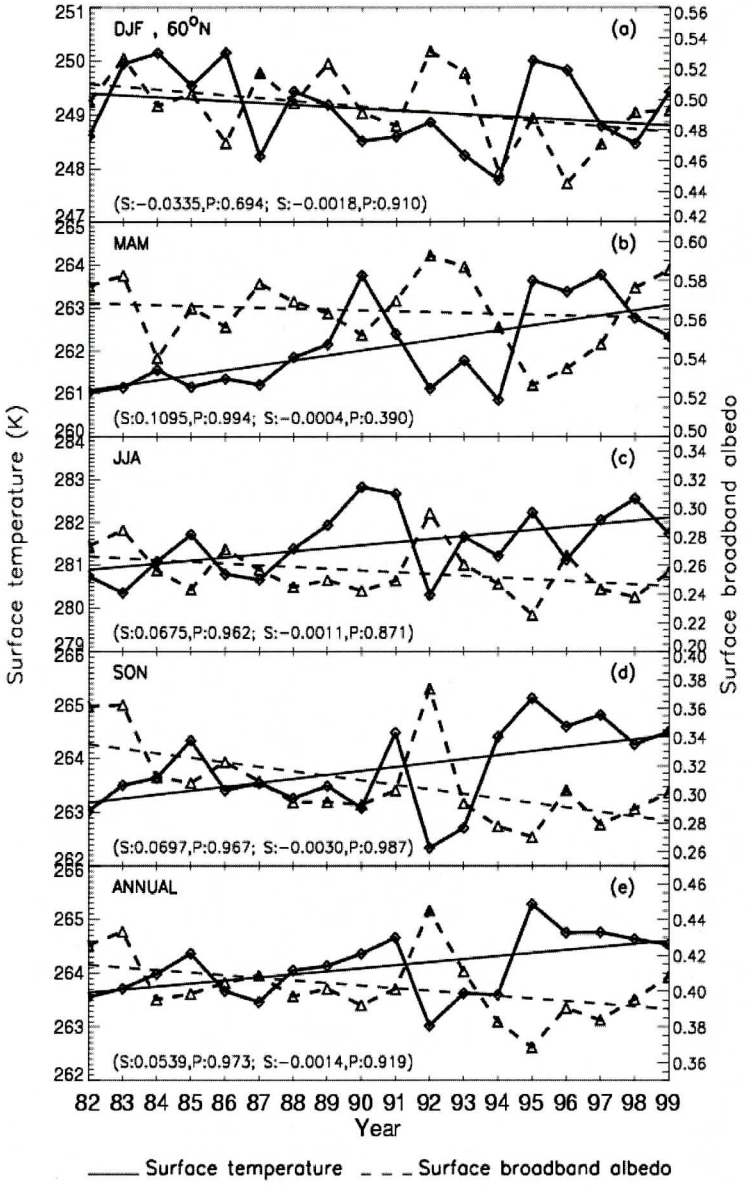


Fig. 2. Seasonal and annual trends in surface temperature and surface albedo over the Arctic.

LBA-ECO III: Analysis of Long-Term Fire Dynamics and Impacts on the Amazon Using Integrated Multi-Source Fire Observations

Personnel: Christopher Schmidt, Elaine Prins (Consultant), Jason Brunner, Jay Hoffman, Scott Lindstrom

Funded by: NASA

Project Description

In 2005 the University of Maryland (UMd), NASA Goddard Space Flight Center (GSFC), UW-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) and the Brazil Instituto Nacional de Pesquisas Espaciais (INPE) and Center for Weather Prediction and Climate Studies (CPTEC) proposed a study titled "Analysis of long-term fire dynamics and impacts in the Amazon using integrated multi-source fire observations" in response to NASA Research Announcement NNH05ZDA001N, "Large Scale Biosphere-Atmosphere Experiment in Amazonia." The primary goal of this collaborative effort is to create a standardized fire data record for the Amazon as derived from multiple satellite sensors and to use the resulting data set to quantify fire impacts in the region. It builds on previous projects conducted under LBA-ECO Phase II. As part of this joint research project, UW-Madison CIMSS provides geostationary satellite Wildfire Automated Biomass Burning Algorithm (WF_ABBA) fire products for the period from 1995 to the present day. The proposed 3-year effort focuses on the following tasks:

- Acquire from the UW-Madison SSEC Data Center and process with the WF_ABBA and the CPTEC/INPE fire detection algorithm all half-hourly GOES-East data for the period from 1 January 1995 through 31 December 1999.
- Create a cloud product for the period of 1 January 1995 through 31 December 1999 to supplement the fire record.
- Participate in multi-satellite fire product intercomparisons and validation efforts and fusion of GOES and MODIS fire products in collaboration with UMd and NASA-GSFC.
- Participate in fire dynamics analyses and emission modeling efforts with UMd and CPTEC/INPE
- Make the extended GOES fire data records available to the scientific community (LBA and others) via a data bank architecture that will be accessible online and deliver the 5-year WF_ABBA fire product to the LBA Data and Information System (LBA-DIS).

The reprocessing task is expected to begin in June 2007.

Accomplishments

- A small processing cluster was purchased which is expected to allow for reprocessing of GOES data with the WF_ABBA at the rate of 2 weeks per year of data, if not faster.
- SSEC Data Center is providing the GOES-East data.
- The cloud product has been created and is currently being implemented.
- Data and metadata formats for LBA-DIS have been determined.

Using Real-time Biomass Burning Products in Model Data Assimilation

Personnel: Elaine Prins (Consultant), Christopher Schmidt, Jason Brunner, Jay Hoffman, Scott Lindstrom, Joleen Feltz

Funded by: NASA/Navy

Project Description

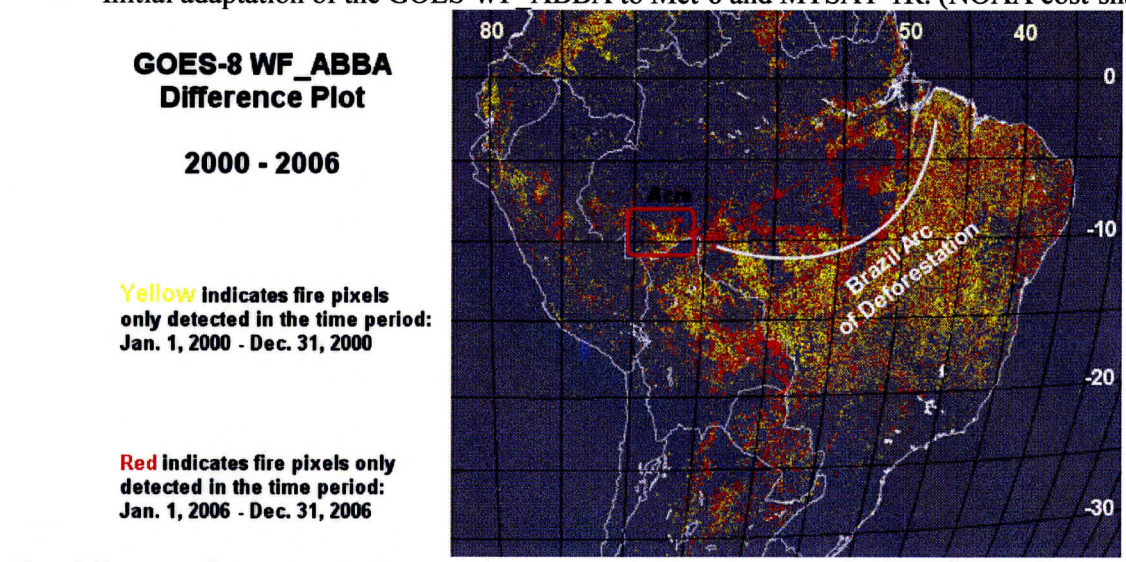
This effort is part of the NASA ESE/IDS funded multi-disciplinary Fire Locating and Modeling of Burning Emissions (FLAMBÉ) project. The primary contribution of CIMSS is to provide diurnal geostationary fire products for model data assimilation and participate in data analysis and evaluation efforts. This includes the initial adaptation of the GOES WF_ABBA to Met-8 and MTSAT-1R in a cost-share effort with NOAA/NESDIS. Over the past two years CIMSS efforts have focused on the following tasks:

- WF_ABBA trend analysis of fire activity in the Western Hemisphere;
- Collaborative research activities with the air quality and data assimilation modeling community;
- GOES/MODIS fire product comparisons and validation;
- Updates to the WF_ABBA processing system;
- Initial development of a global geostationary fire monitoring system;
- Comparison of WF_ABBA detected fire activity with other emission and aerosol products.

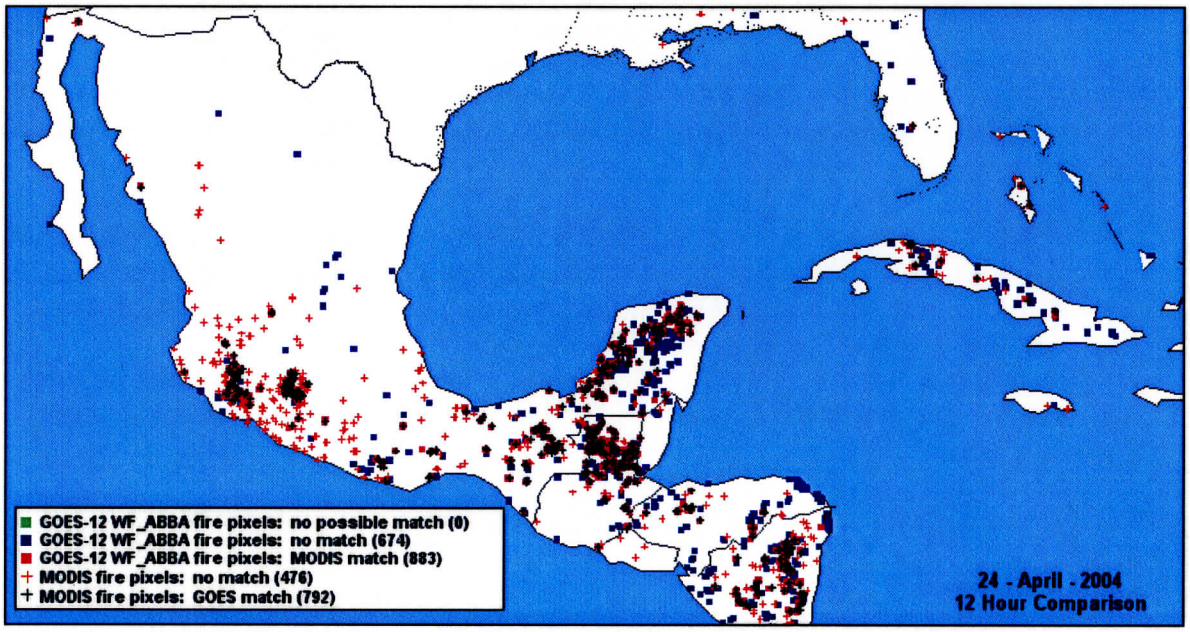
Accomplishments

- Provided half-hourly GOES WF_ABBA fire products to NRL-Monterey in near real-time for model assimilation and for distribution via the FLAMBE web site (http://www.nrlmry.navy.mil/flambe/index.html).
- In the year 2006, CIMSS provided value-added data sets and analyses to more than 15 different groups.
- Participated in the effort to transition FLAMBE research activities into operations at NRL-Monterey FNMOC.
- Continued analysis of GOES WF_ABBA fire products for the Western Hemisphere (January 2000 – present) to assess spatial and interannual trends in biomass burning. (NOAA cost-share)
- Created summary coverage files for the half-hourly GOES WF_ABBA data base (2000 – 2005) in response to requests from the user community for better information on the impact of special satellite schedules on fire monitoring in the Western Hemisphere. (NOAA cost-share)
- Modifications were made to speed up the WF_ABBA processing and reduce the lag between the satellite observation time and product availability. (NOAA cost-share)
- Collaborated with a variety of air quality, emissions, and model data assimilation groups (e.g. Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Spain ; UC-Irvine; Brazil INPE/CPTEC; NCAR-Atmospheric Chemistry Division (4 efforts); UA-Huntsville; US EPA; NASA Langley; Max Planck Institute; Harvard University; Sonoma Technology - USFS Blue Sky program, Molina Center for Energy and the Environment; NOAA NESDIS STAR). These collaborations resulted in co-authorships on 6 peer-reviewed papers. (NOAA cost-share)
- Jay Hoffman completed a Master's thesis on a comparison of GOES and MODIS fire products and implications for data fusion and model data assimilation. (NOAA cost-share)

- Initial adaptation of the GOES WF_ABBA to Met-8 and MTSAT-1R. (NOAA cost-share)



This difference plot, spanning 7 years, shows expanded burning (in red) along the northern edge of the arc of deforestation and along the perimeter of previous fire activity in Acre.



	GOES Fire Pixels			MODIS Fire Pixels	
Comparison Time	Outside MODIS FOV	No MODIS Match	MODIS Match	No GOES Match	GOES Match
1-hour Window	68%	13%	19%	57%	43%
12-hour Window	0%	43%	57%	38%	62%

Comparison of GOES WF_ABBA and MODIS Fire Products for 24 April 2004. Validation studies have shown that GOES and MODIS see different fires with both products demonstrating a false alarm rate of approximately 15% in regions of active deforestation and less than 5% in North America.

Three-Dimensional Air Quality System (3D-AQS)

Personnel: Steve Ackerman, Anthony Wimmers, Jerrold Robaidek, Scott Bachmeier, Bill Bellon, Scott Lindstrom, Thomas Rink

Funded by: NASA

Project Description

For several years the NASA Earth Observation Satellite program has made possible a daily, high-resolution detection of aerosols over the U.S., which has enhanced air quality forecasting through improved visualization of wildfire smoke plumes, accumulations of urban haze, and other sources of fine particulate matter. Understanding and forecasting the distribution of fine particulate matter is a public health concern because it is known to cause respiratory damage to sensitive individuals and reduce visibility. However, the satellite imagers measure only aerosol optical depth (AOD), which is affected by aerosol concentration at all levels in the atmosphere. AOD correlates with surface concentrations of fine particulate matter but does not vary with it exactly. Hence the most-needed additional capability of a remote-sensing observing system is the ability to distinguish boundary layer aerosol from aerosol further aloft.

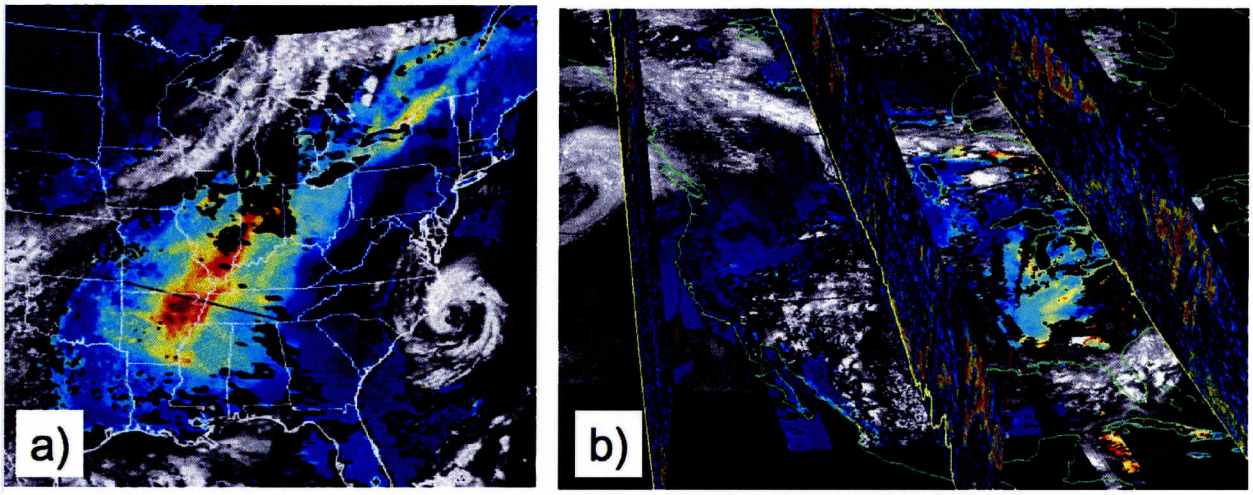
The 3D-AQS project is an inter-agency collaboration led by the University of Maryland Baltimore County to create a real-time synthesis of three-dimensional air quality data from satellite and ground station centers to be used by air quality forecasters across the U.S. The role of the CIMSS group in the 3D-AQS project is to develop a set of 3-D visualizations of aerosols to be adopted in by NOAA in 2009 as an operational web-based forecasting tool. Specifically, the CIMSS group has the following objectives:

- Transfer the software for existing 2-D MODIS aerosol forecasting tools to NOAA/NESDIS.
- Develop a 3-D derived product based on the Integrated Data Viewer software that combines MODIS aerosol retrievals, CALIPSO aerosol backscatter and ground-based lidar aerosol backscatter (See image "B" in the attached figure).
- Maintain a website to troubleshoot the operational performance of the new derived products.
- Report on new methods of interpreting these products in real-time to improve air quality forecasting.

This project began in the summer of 2006 and will be completed at the end of 2008.

Accomplishments

- Transferred the software for existing 2-D MODIS aerosol forecasting tools to NOAA/NESDIS.
- Wrote a technical user's guide for the software transferred to NOAA/NESDIS, available in printed form or as a searchable and expandable wiki.
- Successfully added a module to the Integrated Data Viewer that adds multiple vertical swaths of CALIPSO aerosol backscatter to the visualization environment.
- Reported on the relative merits of the NASA 'Collection 4' and 'Collection 5' aerosol retrievals (Collection 5 is more accurate but Collection 4 has more data coverage in high-aerosol areas of interest).
- Developed an advanced, gradient-preserving interpolation scheme to estimate aerosol values in small data gaps due to cloud cover (<150 km in width). This interpolation scheme can significantly increase data coverage and improve the visualization for the end-users.



a) Current real-time display of aerosol optical depth from MODIS retrievals; b) Composite 3-D view of MODIS aerosol optical depth (horizontal to the surface) and CALIPSO aerosol backscatter (vertically oriented w.r.t. the surface) currently under development. In both images, the colorscale represents increasing aerosol from blue to red. The cloud mask is shown in grayscale.

TexAQS: Texas Air Quality Study 2006

Personnel: Christopher Schmidt

Funded by: NOAA

Project Description

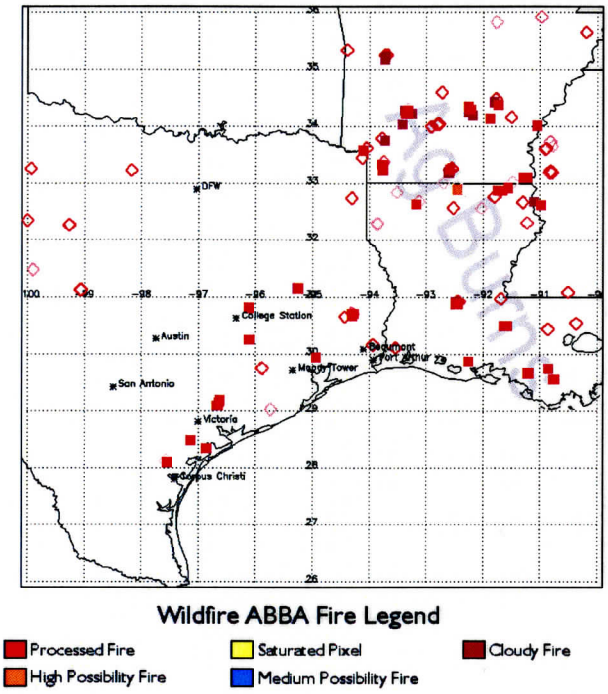
TexAQS was a field campaign that ran during August and September of 2006 with the goal of studying the air pollution in the Houston area as well as examining sources from outside the Houston metropolitan area. A wide range of instrument platforms were involved, from sensors such as LIDAR mounted on planes like the NOAA King-Air and the ER-2 to the NASA Earth Observing satellites such as AQUA, TERRA, and AURA. CIMSS provided about 10 days of in-person assistance to the TexAQS team with satellite data related tasks during their 2006 field campaign, including:

- Providing access to and interpretation of GOES Sounder Ozone in near realtime. This ozone data can be used to establish the contribution of stratospheric ozone to the troposphere. One of the goals of TexAQS was to monitor ozone levels in the troposphere.
- Assisting with interpretation of GOES WF_ABBA/HMS fires and derived GOES PM2.5 emissions. An understanding of what GOES can and cannot do with regards to fire detection is very important for applying the data to real-life situations. TexAQS measured aerosols, thus identification of sources was important.
- Providing interpretation of GOES Aerosol Optical Depth (AOD) data.
- Providing general assistance with satellite imagery
- Providing, if necessary, rapid, on-the-fly data processing (ex: WF_ABBA, GOES Ozone, and others) as necessary.

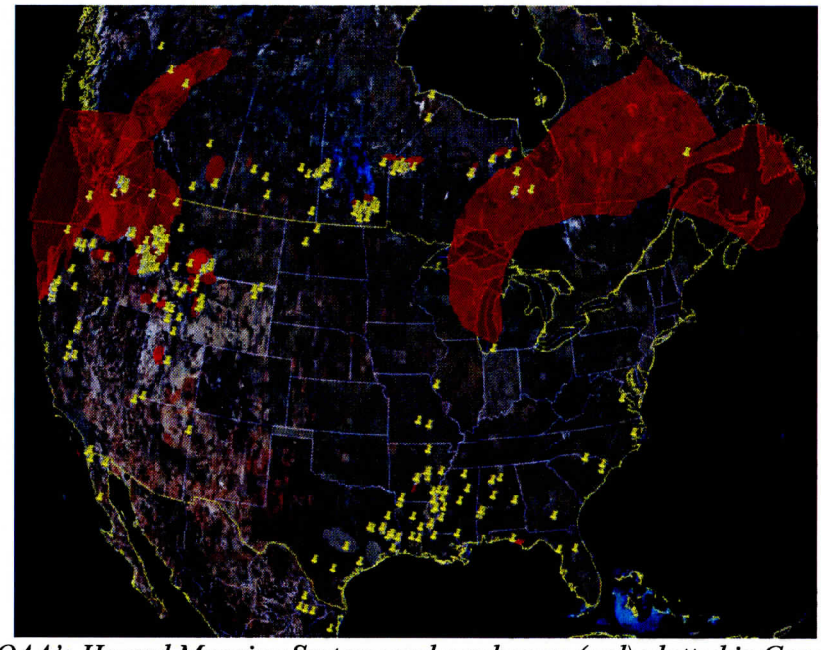
CIMSS participation ran from the last week of August through 9 September 2006.

Accomplishments

- Provided plots of the GOES WF_ABBA and MODIS fire detects for the TexAQS daily briefings from 31August to 29 September 2006 (during and after the time spent in Houston).
- Collaborated with various teams on interpretation of satellite and other data.
- Tracked a large smoke plume from Montana to Texas and assisted in identifying it in LIDAR and other data.
- Created a Perl script to convert GIS shape files to Google Earth compatible KML files for visualization purposes, specifically to convert data provided by NOAA's Hazard Mapping System (HMS) into a format to be combined with the flight tracks and satellite data that other teams were importing. The script has been taken by NOAA programmers to use as a basis for their own conversion of HMS data to KML format.



TexAQS daily briefing fires composite for 9 September 2006. Hollow diamonds are MODIS fires, colored squares are GOES fires. Fire size is not reflected on the image. On this particular day a large number of agricultural burns were taking place in Arkansas and Louisiana.



Example of NOAA's Hazard Mapping System smoke polygons (red) plotted in Google Earth. Yellow "thumb tack" icons represent MODIS detected fires for the same day.

Tropical Cyclone Applications Using Satellite Data

Personnel: Chris Velden (PI), Tim Olander, Derrick Herndon, Tony Wimmers, James Kossin, Howard Berger

Funded by: NRL

Project Description

The overarching objective is to investigate methods to improve quantitative atmospheric observations from meteorological satellites, and further the application of these observations to specific meteorological phenomena pertinent to Naval fleet operations. This program focuses on continued research into improved satellite data extraction algorithms, assisting NRL in the transition of these algorithms into fleet operational environments, and the application of satellite-derived quantities towards improved analyses and forecasts of the atmospheric state. Specifically, we: 1) provide the DoD meteorological data user community with the latest algorithm advances through innovative techniques aimed at the derivation of winds from satellite imagery, and 2) investigate new methods to improve objective estimates of intensity and structure of tropical cyclones (TCs) from both IR and microwave observations. The research involved in this program will improve our understanding of the capabilities and limitations of satellite-derived techniques and products.

Accomplishments

- Developed the Advanced Dvorak Technique (ADT), now used operationally by several TC analysis centers to estimate TC intensity (example of improved ADT performance for our latest upgraded version is shown in Figure 1).
- Continued the improvements to a microwave-based (AMSU) method to estimate TC intensity, which is also being evaluated by operational TC analysis centers
- Formulated the concept of a consensus approach to TC intensity analysis, called SATCON, using the above methods and one developed at CIRA. Preliminary results are very encouraging (See Table 1).
- Continued the development of MIMIC (Morphed Integrated Microwave Imagery at CIMSS), a tool to visualize polar-orbiting microwave imager depictions of TCs as a continuous animation.
- Completed the initial investigation into TC secondary eyewall formation as an indicator/predictor of subsequent TC intensity fluctuations.
- Completed an initial study of TC wind radii distributions based on IR imagery.

All of the above projects are ongoing, and being leveraged by other agency funding sources so that the results are not just applicable to the Navy operations. NOAA operations also benefit, as will our understanding of TC behavior.

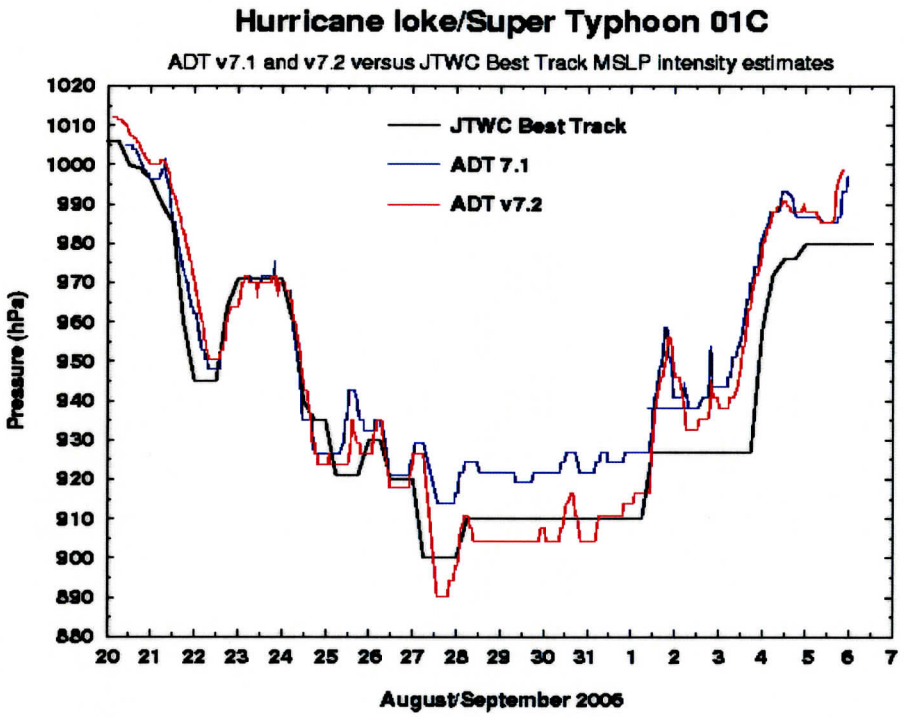


Figure 1. Example of the CIMSS Advanced Dvorak Technique satellite-based method to estimate TC intensity, for TC Ioki in 2006. ADT 7.1 (blue) is a previous version; ADT v7.2 (red) is the latest upgrade.

1999-2006 Stats (Pressure)

	CIMSS AMSU	CIMSS ADT	CIRA AMSU	SATCON
BIAS	-0.3	3.8	-2.9	-0.5
AVG ERROR	5.7	9.7	6.7	4.9
RMSE	7.5	13.5	10.3	6.9
N	258	258	258	258

Values in millibars. Validation is aircraft recon pressure +/- 3 hours from estimate time - bias = method was too weak. Simple average of 3 members RMSE = 7.8 hPa

Table 1. Results for the new satellite-based weighted-consensus (SATCON) TC intensity estimation scheme vs. existing independent methods that are members of SATCON. The statistics are for estimates of MSLP, and the validation is concurrent reconnaissance aircraft measurements.

Hurricane Inner-Core Dynamics and Intensity Change

Personnel: James Kossin
Remote Collaborator: Wayne Schubert (Colorado State University)

Funded by: NSF

Project Description and Accomplishments

Many of the most significant gaps in our present understanding of tropical cyclones involve questions regarding the evolution of storm intensity. We know that environmental conditions play a key role – for example, if a storm moves over colder water or land, or if the ambient environmental vertical wind shear increases, weakening typically follows. Alternatively, an environment that is not conducive for intensification can become more favorable over time, and strengthening would typically occur. Ideally then, we would be able to explain the variance of tropical cyclone intensity change in terms of the variance of the synoptic-scale storm environment, which is fairly easy to measure. This is not the case however, and it is commonplace for storms to rapidly strengthen or weaken without any commensurate changes in the external storm environment. Although the specific processes involved remain an open question, this behavior is widely believed to result from internal vortex-scale processes that can have a profound effect on how storm intensity evolves, and this means that our ability to model and ultimately predict tropical cyclone intensity change is dependent on our ability to contemporaneously model a very broad range of interacting spatial scales, from around one kilometer to thousands of kilometers. This poses a significant challenge.

From a more pragmatic viewpoint, it's revealing to note that our operational ability to accurately forecast tropical cyclone motion (track) has improved dramatically in the past 20 years, and that the reason for this lies in our improving ability to predict evolving synoptic-scale fields with our present numerical guidance – tropical cyclone tracks are controlled almost entirely by the environmental steering flow that the storm vortex is embedded in. Contrary to track forecasting however, our ability to forecast tropical cyclone intensity change has shown almost no progress in the past 20 years and again it is widely believed that this is due to our present inability to model small-scale internal processes in tropical cyclones.

This project seeks to uncover and flesh-out these small-scale processes in the tropical cyclone inner core. In particular, much of this research has concentrated on the non-divergent barotropic aspects of the dynamics of hurricane-like vortices. This was a choice that needed substantial defending, particularly early on, since the transverse (divergent) circulation is strong in the inner-core region encompassing the tropical cyclone eye and eyewall. But many of our results from within this framework have now been confirmed in full-physics model simulations, and our publications continue to be very actively cited by the community. There has also recently been a substantial amount of observational evidence that supports our results and is now being formally documented in the literature by a number of authors. One striking example occurred in Hurricane Isabel (2003) and demonstrated that the flow in the hurricane inner-core can convolve into exotic patterns that we had previously predicted to emerge from quasi-steady solutions in our two-dimensional barotropic framework. A more detailed discussion on these patterns is available in our 2004 BAMS note (Kossin and Schubert) and the Hurricane Isabel link:
http://cimss.ssec.wisc.edu/tropic/isabel_2003.html. A link to the BAMS note can also be found there.

Presently, we're conducting research that adds non-conservative forcing terms to our simplified framework, and we're uncovering the dual nature of asymmetric potential vorticity mixing between

the tropical cyclone eye and eyewall. We find that when diabatic forcing in the eyewall is included in the physics, PV mixing can occur episodically in the form of well-defined events and these events act as a transient suppressant to intensification. An interesting aspect of this behavior is that while PV mixing acts as a transient suppressant to intensification of the vortex, the cumulative effects of the mixing episodes, under certain conditions, allows the vortex to become stronger than it could if the PV mixing was filtered from the dynamics (Fig.1). In other words, the mixing inhibits intensity change on short time scales, but allows a greater maximum intensity on longer timescales. In addition to its relevance to the understanding and forecasting of hurricane intensity change, this has important ramifications for predicting how hurricanes might react to natural and anthropogenic climate forcing.

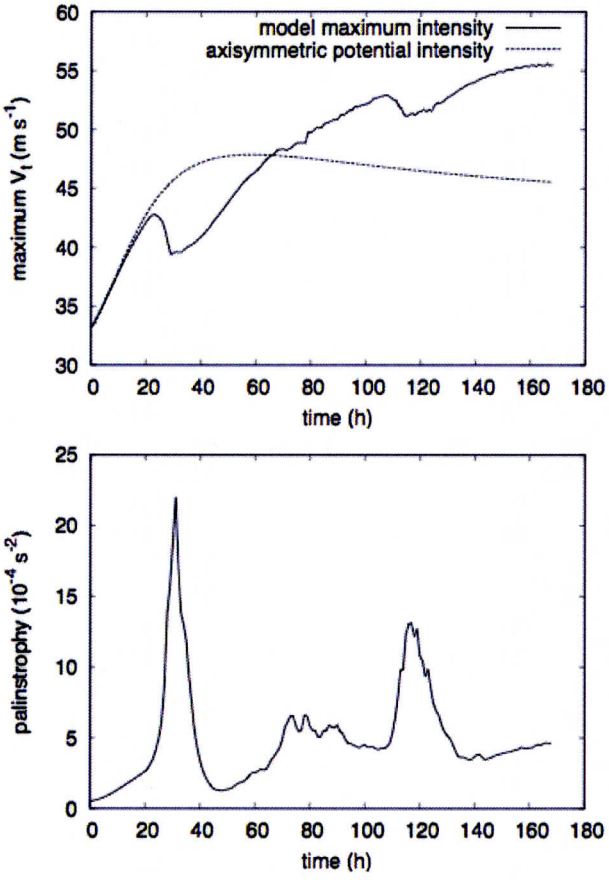


Figure 3: Top panel: Evolution of the maximum tangential wind in the model (solid curve) and the axisymmetric potential intensity (dashed curve) that would result from the forcing alone (i.e., with no mixing). Bottom panel: Evolution of palinstrophy in the model fields. The PV mixing events and their amplitudes are identified by the palinstrophy spikes.

Tropical Cyclone Structure and Intensity Change: Relationships with Eyewall Replacement Cycles

Personnel: James Kossin
Remote Collaborator: David Nolan (University of Miami)

Funded by: ONR

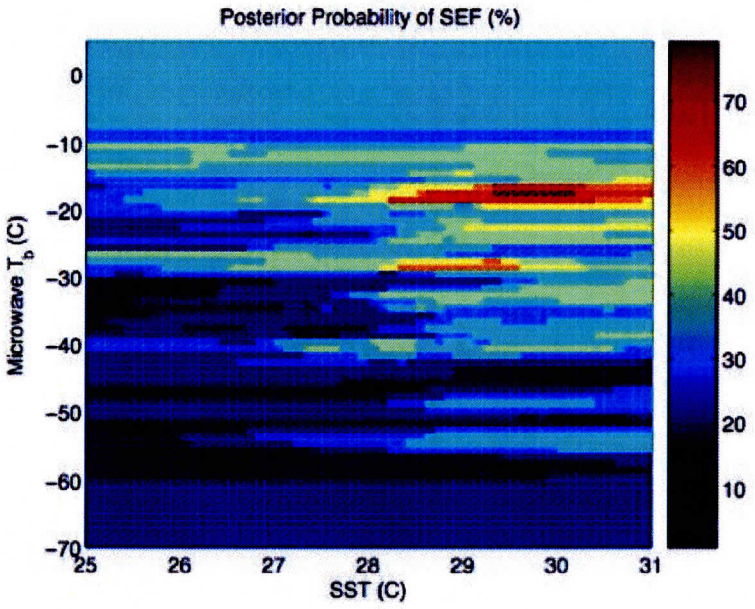
Project Description and Accomplishments

This project will serve to further our understanding of the internal and external processes that control tropical cyclone structure and intensity changes that are associated with the formation of secondary eyewalls. Two important classes of storm evolutions emerge from secondary eyewall formation: eyewall replacement cycles and annular storm formation. Although both classes begin in the same way, the latter parts of their evolutions are very different. Eyewall replacement cycles are associated with anomalously rapid changes in structure and intensity, while annular storms are associated with anomalously steady flows. A significant part of the present structure and intensity forecasting problem is due to the regular occurrence of these types of storm evolutions. This problem can be especially dangerous to life and property when a storm is approaching land. For example, Hurricane Andrew (1992) underwent an eyewall replacement just prior to landfall and strengthened rapidly, resulting in much more severe damage than expected. This new CIMSS project will serve two important purposes. First, by identifying the external and internal factors that are associated with eyewall replacement cycles and annular hurricane formation, we will increase our understanding of the basic physics involved and the relationship with structure and intensity change. Second, since most of the identified factors are expected to be empirically measurable in a real-time setting, our results will have the potential to be applied directly to reduce intensity forecasting errors.

This work is following a two-pronged attack: First we're developing our understanding of the environmental factors associated with secondary eyewall formation and subsequent eyewall replacement or annular storm formation. This is largely an empirical study utilizing microwave and infrared satellite imagery and reanalysis fields with an emphasis on the Northwestern Pacific basin (a preliminary result is shown in Fig.1). Second, we are developing our understanding of the internal dynamical factors associated with flows in storms with primary and secondary eyewalls. This part of the project consists of three-dimensional linear analyses that will elucidate the thermodynamic response to eyewall evolutions associated with eyewall replacement and annular storm formation, and an idealized modeling study with full-physics numerical simulations.

Bayes Classifier

Provides probability of SEF



Combines *a priori* (climatological) probability of group membership and probability of membership based on feature values. Probability density in feature phase-space is determined by the method of K-nearest neighbors.

Figure 1: An objective classifier to identify secondary eyewall formation (SEF) in terms of the environmental sea surface temperature (SST) and a microwave satellite-based parameter.

Hurricane Variability and Trends: Understanding Differences Between Ocean Basins on Interannual to Decadal Timescales

Personnel: James Kossin

Funded by: Risk Prediction Initiative

Project Description and Accomplishments

The relationship between tropical cyclone variability and climate variability is unique in the North Atlantic when compared to the other storm-prone ocean basins. Consequently, Atlantic hurricanes respond differently to changes in sea surface temperature (SST). This has important consequences in seasonal prediction as well as our understanding of multi-decadal trends, particularly when SST increases due to global warming are considered. In this project, we are uncovering the basic physics that reconcile these differences between the ocean basins.

Recently documented upward trends in the existing global "best track" records of hurricane intensity and their relationship to increasing sea surface temperatures suggest that hurricane intensity may be increasing due to global warming. However, it has been recently shown that these upward trends are partly due to inconsistencies in the best track data in every ocean basin except the North Atlantic. Specifically, when the global records of hurricane intensity are consistently reanalyzed over the past two decades, there are no trends found in the Western and Southern Pacific and Northern and Southern Indian Oceans, the trend in the Eastern Pacific is significant but downwards, and the trend in the Atlantic is significant and upwards.

Thus, a consistent reanalysis of hurricane records suggests that the only basin in which we find an upward trend in hurricane intensity is the North Atlantic, which comprises less than 15% of the total hurricane activity occurring globally. Yet, it has been well documented that sea surface temperature (SST) has been trending upwards in every ocean basin. This underscores a potential problem with our present understanding of the controls of hurricane intensity on decadal or longer timescales. In particular, it challenges the paradigm that increasing SST alone will lead to concomitant increases in hurricane intensity.

In this new project, we are exploring two different pathways to better understanding of why the linkages between hurricane and climate variability appear to be fundamentally different between the ocean basins. The first path will utilize our new globally consistent hurricane record to explore the covariance between climate indices and hurricane-based metrics. For example, we will address questions relating to the relationship between SST and shear and their respective relationships with hurricane activity. Additionally, we are considering how large-scale/global variability relates to local conditions and hurricane intensity as measured in the new data record. We have recently uncovered new relationships between the Atlantic Meridional Mode (AMM), the Atlantic Multi-decadal Mode (AMO), and contemporaneous measures of hurricane activity. For example, we find that the AMM and AMO both correlate strongly with storm duration on a multi-decadal timescale, but unlike the AMO, the AMM also correlates strongly on an *interannual* timescale. We are exploring these relationships to extract systematic environmental features that can be separated according to an AMM index. Finally, we have also found that a significant part of the variance of the boreal summertime AMM can be predicted 6 months in advance. This predictability, when combined with the contemporaneous correlation of the AMM with hurricane activity, can be exploited in seasonal forecasting of Atlantic hurricanes. We propose to test the present forecast method of Gray with the inclusion of the predicted AMM index. Preliminary results have been encouraging.

Global Reanalyses of Tropical Cyclone Intensity Records

Personnel: James Kossin
Remote Collaborator: Kenneth Knapp (NOAA/NCDC)

Funded by: NSF

Project Description and Accomplishments

This project marked the beginning of a significant body of new research at CIMSS to uncover relationships between tropical cyclone variability and climate change. This was a 6-month project with funding from the NSF SGER program in which we constructed a new homogeneous record of hurricane intensity in order to test the fidelity of previously documented trends in global tropical cyclone activity. This work has garnered a lot of attention from the scientific community, as well as the insurance industry, policymakers, and the media, and our results been presented at a broad variety of distinguished venues. These have included an AMS seminar on Capitol Hill in Washington D.C., an Expert Elicitation meeting organized by the insurance and risk management industries, and the U.S. Climate Change Science Program (CCSP) Lead Author's Meeting in Hawaii.

In collaboration with the NOAA National Climatic Data Center (NCDC), we created a large and unprecedented archive of tropical cyclone-centric satellite observations. The archive comprises 169,000 observations in more than 2,000 storms worldwide during the period 1983 to present, and represents a new and wholly unique record that can be applied to future hurricane reanalysis projects. The data set will be updated annually and work is also underway to expand the data set backward to the late 1970s. The new data record is now publicly available at the National Climatic Data Center as a new official data product known as HURSAT (http://www.ncdc.noaa.gov/oa/rsad/b1utc/b1utc.html).

Using the new HURSAT data, we created a new objective algorithm that estimates storm intensity from the satellite data. The algorithm was developed and fully cross-validated using aircraft reconnaissance information, and then used to create a new record of global intensity estimates. This new record has been named the UW/NCDC dataset. We then applied trend analyses to the UW/NCDC data to test the veracity of the trends that have been documented in the existing records of tropical cyclone intensity (Fig. 1).

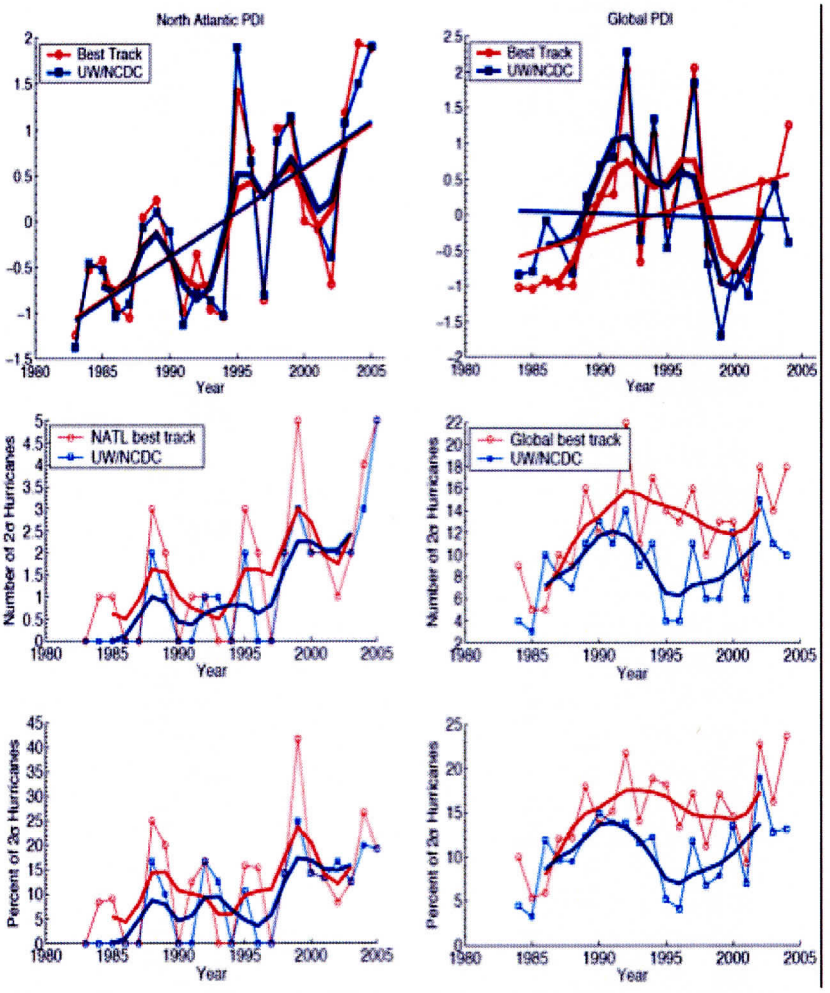
We have published four peer-reviewed articles and have disseminated the results in eight invited talks. This work was reported on by a variety of journals and media outlets and was discussed and highlighted in a "News of the Week" feature in Science Magazine. One of our journal articles was also listed as an Editor's Choice Feature in Science Magazine.

Comparisons between the present global best track records (red) and the new homogeneous UW/NCDC record (blue).

Top panels show time series of Power Dissipation Index (PDI) which is a measure of hurricane destructive potential.

The middle and bottom panels show the global number and percentage, respectively, of the most extreme storms.

All trends in the North Atlantic (left panels) are well-corroborated by our new data and are upward and statistically significant. However, the new data does not corroborate the presence of upward trends in the global hurricane record (right panels). All trends in the global best track are significant, but none are significant in the homogeneous UW/NCDC record. The North Atlantic accounts for less than 15% of annual global hurricane activity.



Adapted from Kossin, J. P., K. R. Knapp, D. J. Vimont, R. JMurnane, and B. A. Harper (2007), A globally consistent reanalysis of hurricane variability and trends,Geophys. Res. Lett., 34, L04815,doi:10.1029/2006GL028836.

Figure 1: Results from the NSF SGER project.

Decision Support for Thunderstorm Avoidance of Convectively Induced Turbulence

Personnel: Wayne Feltz, Kristopher Bedka, Annelise Lenz, Jordan Gerth

Funded by: NASA

Project Description

This project represents a collaborative effort between UW-CIMSS, NCAR, and UAH to enhance aviation safety by providing better nowcasts and forecasts of convectively-induced turbulence (CIT). Unlike clear-air turbulence forecasts which can be developed to a large extent from NWP model output, CIT forecasts require higher spatial temporal and spatial resolution cloud observations that are only provided by satellite. Specifically we are seeking to identify signatures in GEO and LEO satellite imagery closely associated with convectively-induced turbulence, such as:

1. Overshooting convective tops
2. Convective gravity waves
3. Rapid cirrus anvil expansion, indicative of strong divergence
4. Transverse cirrus bands
5. Newly developing convective storms

A climatology has been developed using experimental Eddy Dissipation Rate (EDR) observations to identify highly turbulent convective events. This EDR data, collected by United Airlines Boeing 757 aircraft, represents an objective measure of the vertical accelerations induced by turbulent atmospheric phenomena. EDR observations have a distinct advantage over traditional pilot reports (PIREPS) of turbulence, which are subjective and are often reported at a location and time differing from the actual turbulent episode. For highly turbulent events, EDR observations are plotted upon GOES, MODIS, and AVHRR VIS, IR window, and WV imagery to identify cloud-top signatures consistently associated with moderate to severe turbulence.

Of special interest to this effort are turbulent encounters occurring along the edge or outside of a thunderstorm anvil cloud. Because of turbulence hazards in the clear air above and surrounding intense thunderstorm updrafts, FAA flight guidelines suggest that pilots should "avoid by at least 20 miles any thunderstorm identified as severe or giving an intense radar echo." These guidelines imply that the anvil edge region is relatively "safe" for air traffic. Research from this project suggests that the regions outside the anvil can actually be quite turbulent. Figure 1 shows two cases with a large number of moderate and severe EDR turbulence observations, highlighting the turbulent nature of rapidly expanding anvil clouds and convective gravity waves.

The eventual goal of this effort is to develop satellite-derived interest fields using objective pattern recognition techniques that can be included for testing within the FAA-supported second generation Graphical Turbulence Guidance (GTG2) at NCAR. Improved GTG2 guidance will aid aviation meteorologists, dispatchers, and pilots in making strategic and tactical decisions for avoiding turbulent convection.

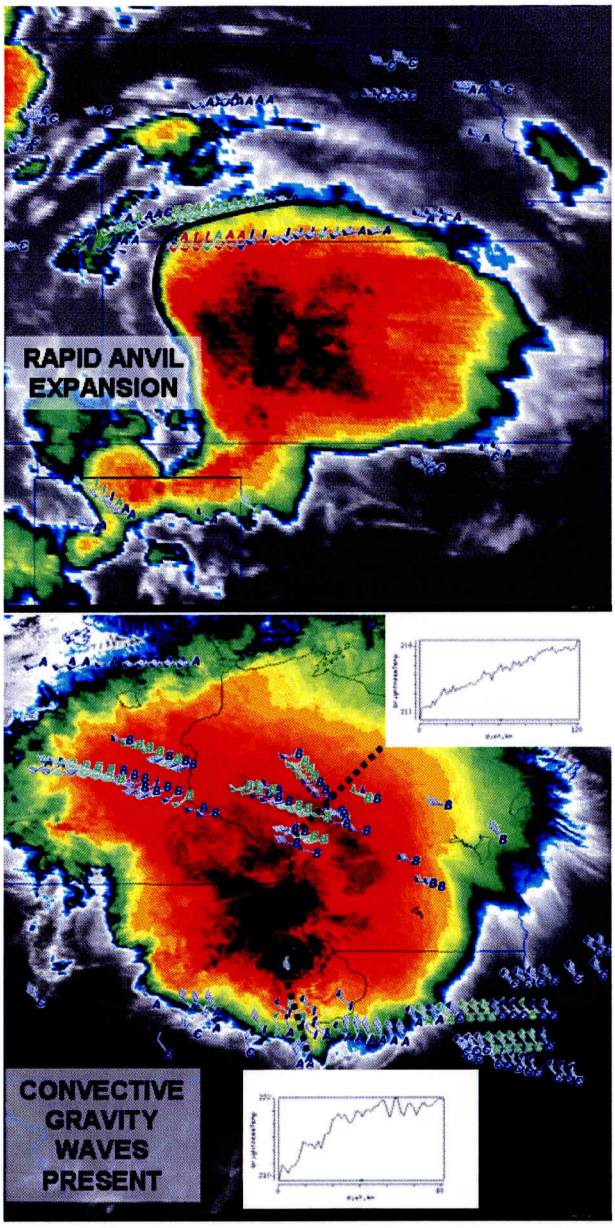


Figure 1: (top) GOES-12 4 km IR window imagery on 6/16/2005 showing numerous observations of moderate to severe turbulence associated with a rapidly expanding anvil cloud. Plotted in blue are light, green are moderate, and red are severe EDR turbulence observations. The letter A indicates observations above cloud top, B are below cloud top, C are clear air, and I are at the cloud top. Aircraft observed wind barbs are also shown. (bottom) MODIS 1 km IR window imagery on 7/19/2006 showing turbulence in association with convective gravity waves. Convective gravity waves found during this study have horizontal wavelengths in the 4-6 km range and can only be observed in high-spatial resolution LEO imagery.

Applications of GOES Rapid-Scan Winds

Personnel: Chris Velden (PI), Howard Berger, David Stettner

Funded by: ONR

Project Description

Long Term Goals

The overarching goal is to obtain special data sets of GOES rapid-scan (RS) atmospheric motion vectors (AMV) to assimilate and test for improvements in NAVY global numerical model (NOGAPS) forecasts of tropical cyclones (TC) using targeting information provided by NRL-MRY. There is the potential for forecast benefits with the GOES R/S-AMV since the higher image frequency yields more accurate observations in comparison to routinely-produced GOES AMV data.

Objectives

This is focusing on the GOES RS-AMV datasets processed by CIMSS during two, 3-month focused periods of Atlantic TC activity in 2005 and 2006. These experimental and advanced datasets are being used 1) to demonstrate targeting concepts, 2) for satellite data assimilation trials, and 3) to test for predictability impacts on NOGAPS forecasts of TC tracks and intensity.

Approach

RS-AMV from GOES-12 VIS and IR imagery (7.5 minute image intervals) were provided for this study using the CIMSS automated processing algorithm. During the 2005 and 2006 ATL hurricane seasons, the CIMSS PI contacted the NOAA/NESDIS Satellite Operations Center to alert them for requests of special RS schedules to be invoked during targeted TCs (based on NRL-MRY guidance on potential targets of opportunity from NOGAPS adjoint singular vector approaches). Upon request approval from NESDIS and NWS, the GOES-12 RS-AMV datasets were derived by CIMSS every hour the R/S data were available, and made available to NRL for further model impact studies

Work Completed/Accomplishments

GOES-12 R/S-AMV datasets were successfully collected during several major Atlantic hurricanes in 2005 (including hurricanes Dennis, Emily, Katrina, Ophelia and Rita), and 2006. A web site with real time and collected/archived datasets produced for this study can be found at: http://cimss.ssec.wisc.edu/tropic/tropex/index.html

In a first NOGAPS impact test, the GOES-12 RS-AMV data were used to test an observation targeting strategy during Hurricane Katrina. The winds were assimilated into the Navy NAVDAS, which provides the initial conditions for the NOGAPS forecast model (see Fig. 1). The resulting NOGAPS Katrina 72-hr track forecast position is improved by 25% (Fig. 2). Further data assimilation and modeling experiments are in progress. Not only is this innovative approach to deriving high quality wind information from GOES a benefit to the hurricane research community, but the exercise also demonstrates the GOES wind products can be better assimilated and employed for improving NWP.

Impact/Applications

The basic hypothesis in this study is that regions of TC analyses that are sensitive to initial conditions can be successfully targeted, and when enhanced data are applied to those regions, the numerical forecasts will improve. If this theory is further proven in this study, it could have a significant impact on future operational procedures to observe TCs, provide a better understanding of the processes affecting track and motion, and improve their predictability.

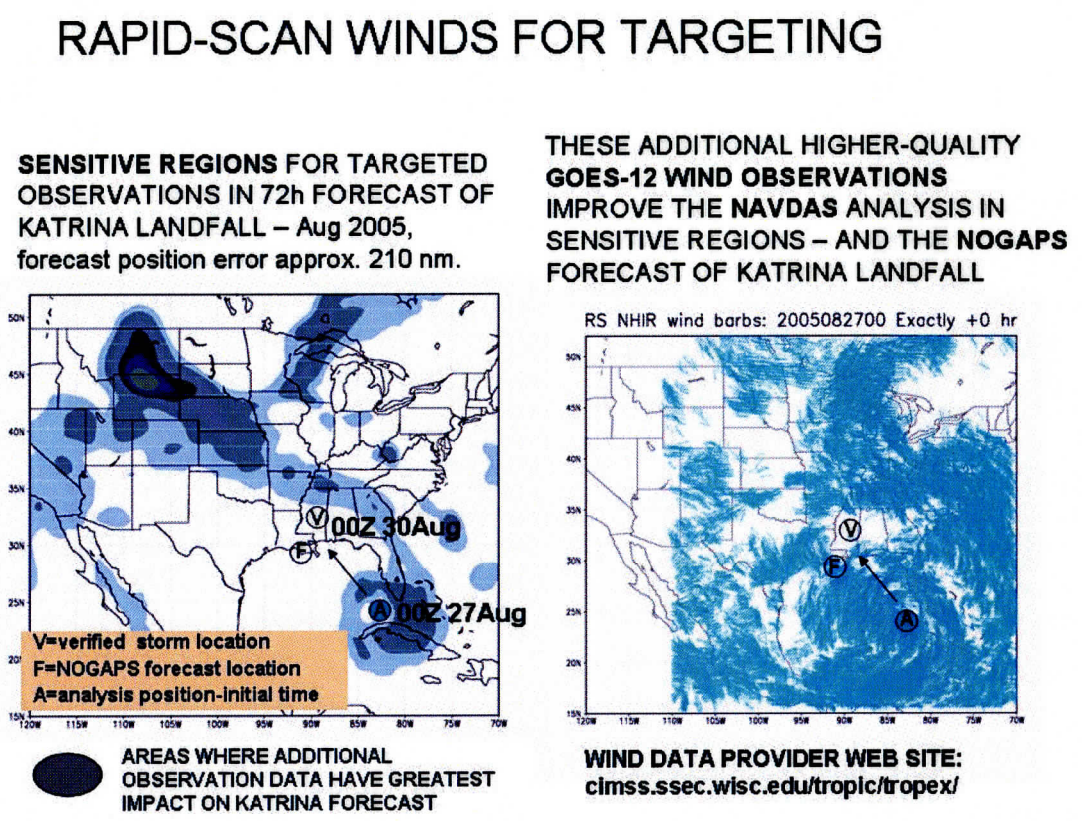


Fig. 1. GOES-12 rapid scan winds data assimilation experiment for Hurricane Katrina.

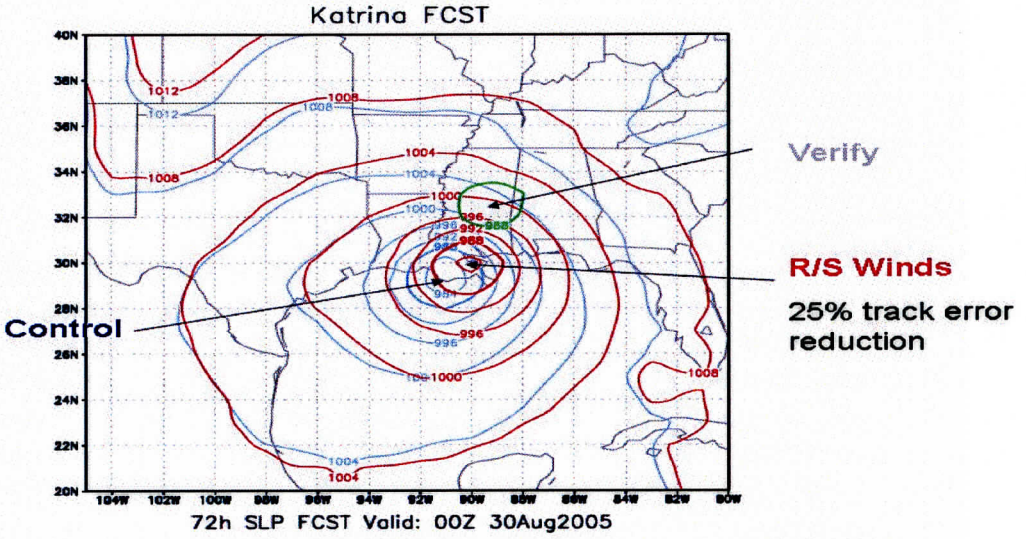


Fig. 2. Results of a NAVDAS data assimilation experiment for Hurricane Katrina showing improved 72-h hurricane track using GOES 12 rapid-scan winds.

AVHRR Pathfinder Atmospheres Extended (PATMOS-x)

Personnel: Andrew Heidinger, Michael Pavolonis, Amato Evan

Funded by: NOAA

Project Description

The AVHRR Pathfinder Atmospheres Extended (PATMOS-x) is a cloud climatology developed within the NOAA/NESDIS Office of Research and Applications. The development of PATMOS-x was part of a larger ORA effort to develop an infrastructure for AVHRR reprocessing and data improvement. PATMOS-x is a successor to the original PATMOS which was developed in the 1990s with support from NOAA/OGP. PATMOS-x differs from PATMOS in that it uses new algorithms to compute a full suite of cloud properties where PATMOS only produced total cloud amount. In addition, PATMOS-x also processes data from the AVHRR's morning orbits, which double the diurnal sampling over that of PATMOS. Lastly, PATMOS-x benefits from calibration and geolocation improvements made since PATMOS. Due to improvements in the physical behavior of the algorithms for varying viewing conditions, the PATMOS-x time series is much smoother over time. Furthermore, the discontinuities seen in the PATMOS data occur at transitions from one afternoon AVHRR to another. These roughly 3–5 oscillations reflect orbital drift effects which, over the lifetime of a satellite, can significantly alter the viewing geometries and data products.

PATMOS-x is based on algorithms developed within NESDIS for operational processing of the AVHRR. While validation is ongoing, the approaches have been validated using surface observations and comparisons to products from advanced sensors such as MODIS. The products provided by PATMOS-x include various cloud amounts, such as estimates of the total, ice-phase, water-phase, high, middle and low cloud amounts. PATMOS-x also provides information estimates of cloud height, cloud emissivity, cloud optical thickness and cloud particle size. In general, we have attempted to develop AVHRR algorithms that are physically consistent with those from MODIS where possible. The baseline resolution of the PATMOS-x products is a 55 km equal-area. To illustrate the resolution of the data, Figure 1 shows an example monthly averaged high cloud amount for July from PATMOS-x.

The strength of PATMOS-x is that it delivers consistent cloud properties from all AVHRR orbits in order to provide a sampling of roughly 4 times per day. In this way, PATMOS-x complements the International Satellite Cloud Climatology Project (ISCCP) which has superior diurnal sampling but inferior spectral information, leading to day/night differences in the cloud products. ISCCP has certainly developed corrections for many of the day/night discontinuities, but we argue that PATMOS-x offers an improved diurnal cycle in some cloud parameters such as those associated with optically thin cirrus. In no way are we suggesting the PATMOS-x should replace ISCCP. Our goal is to improve in areas where ISCCP is known to have difficulties due to the restrictions imposed by the limited spectral information that is common to all geostationary imagers.

In summary its objectives are as follows:

- Provide a global climatology of cloud products from the AVHRR.
- Provide a global climatology of non-cloud products from the AVHRR that facilitate cloud feedback studies.
- Provide climate resolution AVHRR observations for the climate community.

Accomplishments

- Developed a STAR AVHRR reprocessing system;
- Acquired the entire GAC Archive from CLASS;
- Developed AVHRR geolocation improvements;
- Developed AVHRR reflectance calibration improvements;
- Generated a first version of PATMOS-x products from 1981 to 2006;
- Participated in the GEWEX cloud climatology assessment workshop (2004,2006); and
- Dust/Hurricane analysis done with PATMOS-x covered by media in 2006.

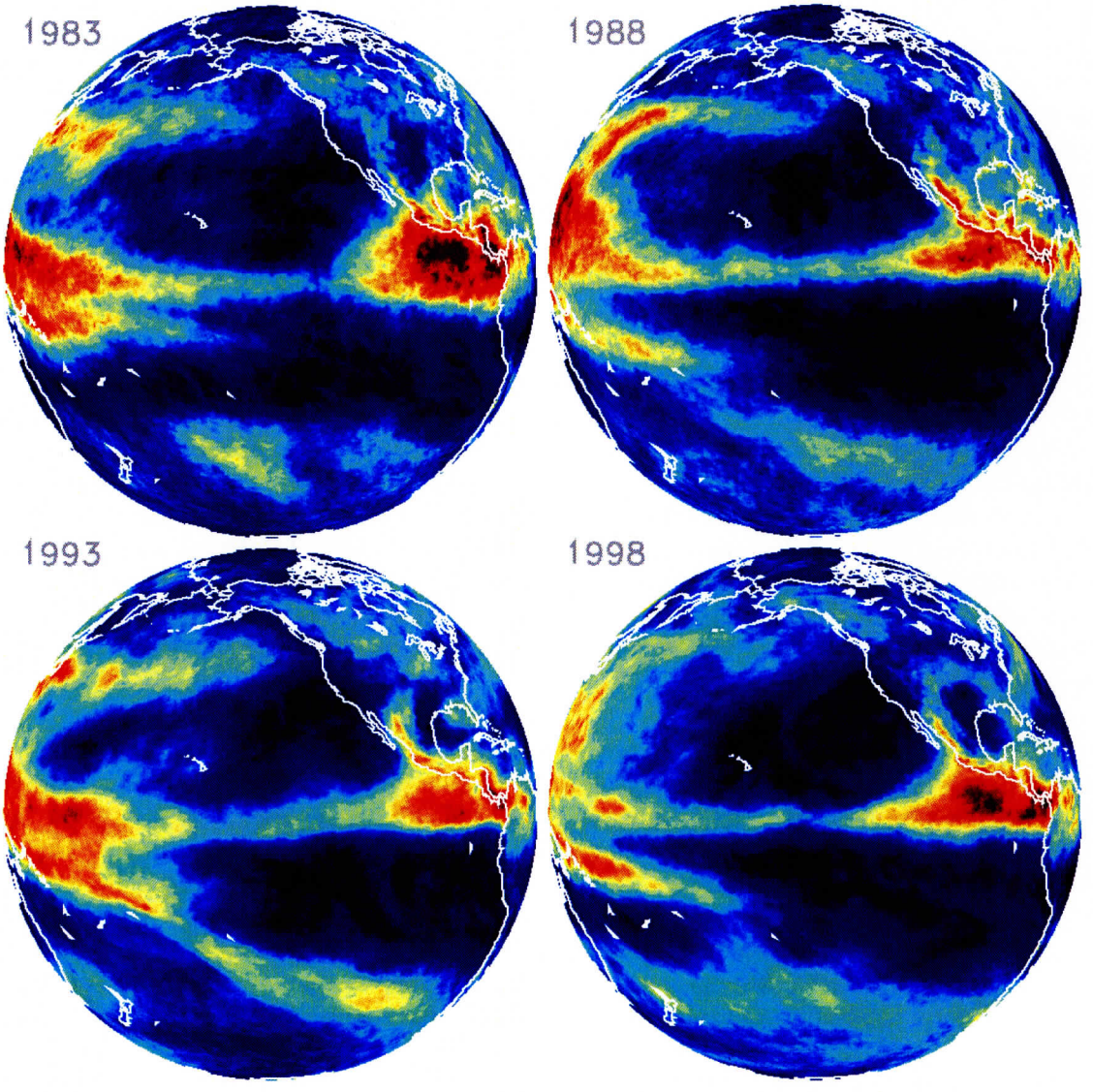


Figure 1. Example PATMOS-x products. Images show the annual variability in the derived high cloud amounts over the Pacific for several years.

UW Cooperative Agreement Proposal in Support of NASA/MSFC Broad Area of Nowcasting and Other Related Activities

Personnel: Allen Huang and Kathy Strabala

Funded by: NASA

Project Description

The NASA Short-term Prediction Research and Transition (SPoRT) Center at MSFC (http://weather.msfc.nasa.gov/sport/) accelerates the transition of unique observing, modeling, and data assimilation capabilities developed under the auspices of the NASA Science Mission Directorate (SMD) to National Weather Service Forecast Offices (NWSFO's) and decision makers. The SPoRT Center conducts both discovery and product-driven research associated with advanced algorithm development, land/atmosphere interactions, satellite data assimilation, convective initiation and evolution, lightning/severe storm kinematics, and quantitative precipitation estimation and forecasting. Observations from a number of NASA satellite missions and state-of-the-art community-based mesoscale prediction/assimilation systems are used.

The SPoRT Center currently provides a number of products from MODIS, AIRS, and AMSR-E, supplemental numerical guidance from the WRF models, and total lightning from the Lightning Mapper Array (LMA) to six NWSFO's in the NWS Southern Region. NASA is extending the SPoRT activity to selected Florida NWS Forecast Offices and has proposed to support the SERVIR (Spanish acronym for Regional Visualization and Monitoring System, http://servir.nsstc.nasa.gov/) activity in Central America with similar capabilities. These products and tools have provided forecasters with a better description of the regional environmental conditions.

The resources and satellite expertise at UW/SSEC/CIMSS in the area of MODIS multispectral, AIRS hyperspectral and passive microwave data and products compliment many of the ongoing and planned SPoRT activities. It is the desire of the UW/SSEC/CIMSS to enhance the SPoRT project through collaborative research efforts with NSSTC/MSFC/GHCC. In response to the cooperative agreement between MSFC/NASA and CIMSS/UW-Madison the following initial task efforts are proposed to support the broad area of these activities.

Accomplishments

- To provide operational McIDAS software package capable of performing imagery remapping and display capabilities which account for pixel overlap (bowtie effect) in McIDAS processing, demonstrate capabilities with Level 1 and Level 2 MODIS data, and make new capabilities an operational component of the McIDAS software package
- To provide IMAPP software package capable of performing AMSR-E atmospheric and surface products.
- Continuing to provide and maintain real time EOS MODIS and/or AIRS data and products in support of SpoRT activities.

CALIPSO- cloud and aerosol studies at UW Madison

Personnel: Steve Ackerman, Robert Holz, and Thomas Rink

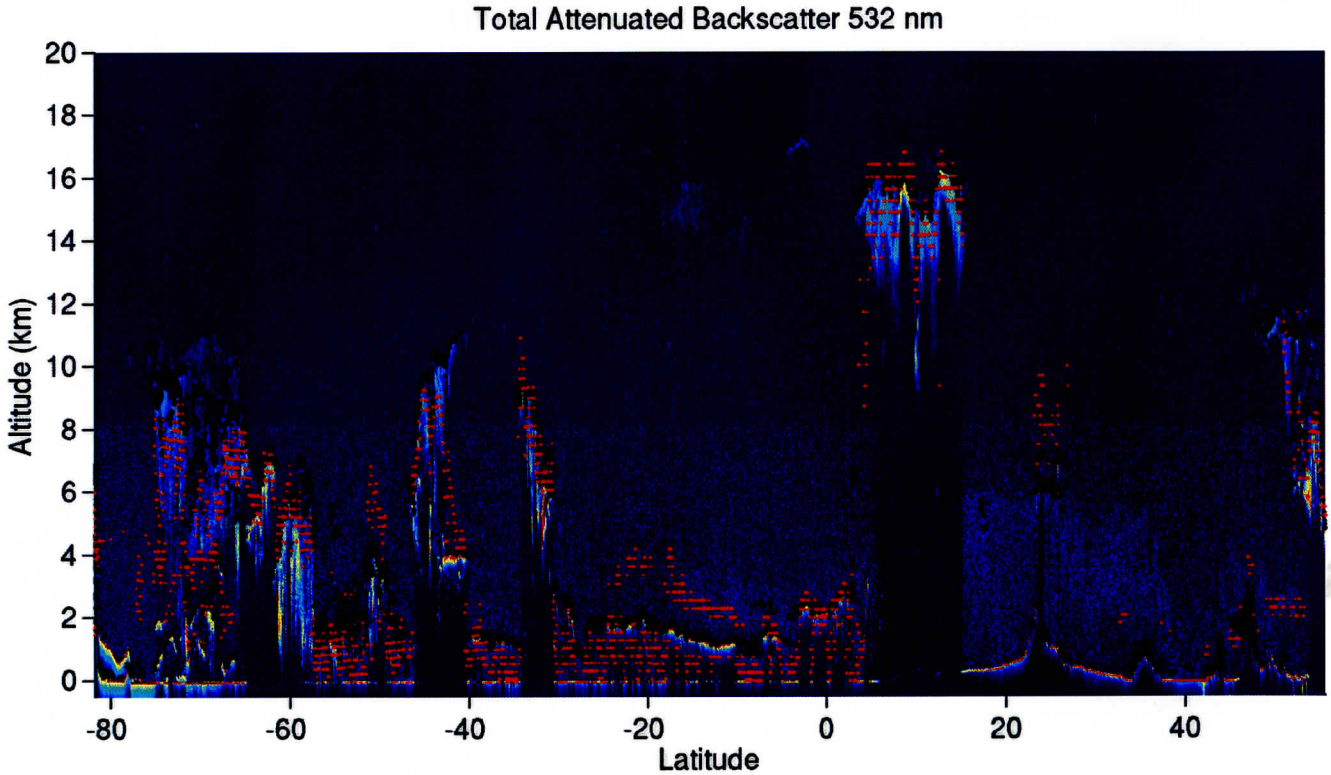
Funded by: NASA

Project Description

Dr. Ackerman has long served on the CALIPSO science team. His role was to analyze clouds and aerosols using the MODIS IR and AIRS observations in combination with CALIPSO lidar and imagers.

Accomplishments

- A method of accurately collocating MODIS with CALIPSO has been developed.
- We have compared results from the MODIS cloud mask algorithm with the CALIPSO cloud boundary algorithm.
- We have compared results from the MODIS cloud height algorithm with the CALIPSO cloud boundary algorithm.
- CALIPSO and CloudSat data have been incorporated into HYDRA for easy exploration and analysis of the combined data sets.



An example of the CALIPSO backscatter (image) MODIS cloud height (red) and cloud tops from the CALIPSO lidar (black).

Advanced Satellite Aviation-weather Products (ASAP)

Personnel: Wayne Feltz, Kristopher Bedka, Mike Pavolonis, Tony Wimmers, Sarah Bedka, and Ralph Petersen

Funded by: NASA

Project Description

The UW-CIMSS ASAP team develops satellite-based nowcasting tools for improving aviation weather forecasting. Current areas of research focus on aviation hazards such as convection, turbulence, and volcanic ash. The applications are developed with direct contact to the end user community and decision support agencies such as FAA Product Development Teams (PDTs), Volcanic Ash Advisory Centers (VAACs), NOAA/NESDIS, and EUMETSAT. The goals of the initiative are to test and evaluate existing satellite algorithms that have been developed or are proposed by FAA AWRP team members, introduce new techniques and data sets to the FAA and NCAR products from the satellite community, and facilitate PDT access to satellite data sets for research and development available through UW-CIMSS and UAH. The project mission is to increase and optimize the use of satellite data sets within the existing FAA PDT structure and to transfer satellite expertise to the PDTs. New satellite products or data sets will be integrated into the PDTs' suite of weather products and undergo the normal FAA procedures for testing and transition to operational use. Current research utilizes satellite technology from instruments such as GOES, MODIS, AIRS, and AVHRR. Future work will focus on exploiting the dramatic improvements in remote sensing capability that will be possible with hyperspectral sounding and imaging instruments.

Current areas of scientific emphasis:

Convective Weather :

- Develop satellite-based information that will aid in the realtime nowcasting of convective initiation (CI) and the diagnosis of convection on meso- and synoptic scales.
- Develop a series of CI "interest fields" from existing satellite sensors (e.g. GOES, MODIS) that can help predict future convection on local scales (i.e., 1-4 km).
- Develop satellite imagery recognition tools to objective determine enhanced-V and overshoot top features.
- Improved Diagnostic Cloud Property and Mescoscale Wind Fields.
- Develop new methods for using hyperspectral data for accomplishing these goals.

Turbulence Detection:

- Develop satellite-based techniques to identify and characterize regions of moderate and severe clear-air (e.g., mountain waves), and cloud-induced turbulence (e.g., thunderstorms), as detectable in GOES, and especially MODIS infrared data.
- Develop value-added products of turbulence from satellite data sets that can be used in conjunction with numerical simulation and existing PDT turbulence prediction systems.

Volcanic Ash

- Develop satellite-based information that will aid in the realtime diagnosis of volcanic ash, ash clouds and ash characteristics.
- Emphasize use of MODIS imagery and other high-spectral resolution data.

Accomplishments

- NOAA/NASA/DOD Joint Planning and development Office (JPDO) Observation Team Member 2005 - Present
- NASA Honors Group Achievement Award (ASAP) 2006
- NASA Earth Sciences Application Team Group Award (ASAP) 2005
- NASA Aviation Safety and Security Program Award (ASAP) 2005
- 9 Peer Reviewed Publications including BAMS ASAP overview article to be published 2007
- A mature satellite convective initiation detection algorithm providing 45-60 lead time prior to radar indicated CI. Distributed to EUMETSAT, NESDIS, and other Aviation forecasting entities.
- An improved volcanic ash detection methodology, drastically reducing false alarm rates for new objective volcanic ash warning implementation within international Volcanic Ash Advisory Centers.
- Several satellite turbulence interest fields have been developed and integration into operational Graphical Turbulence Guidance product (NCAR-based development) is ongoing.

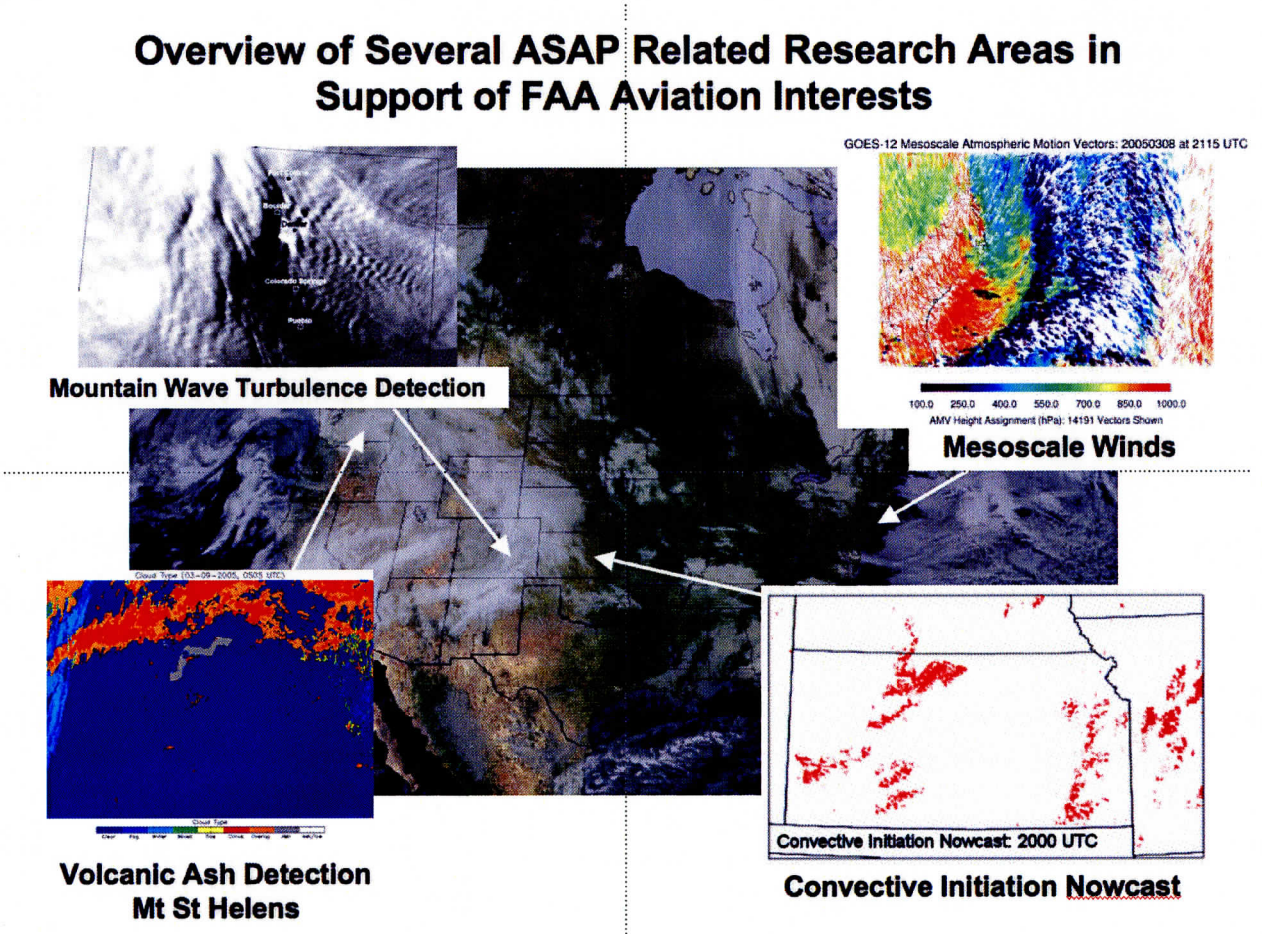


Figure 1: An overview figure of several satellite-based aviation research areas including mesoscale winds, mountain wave turbulence, convective initiation, and volcanic ash detection.

Multi-Instrument Data Analysis and Synthesis (MIDAS) project to develop neural network-based data fusion techniques

Personnel: Robert E. Holz

Funded by: NASA

Project Description

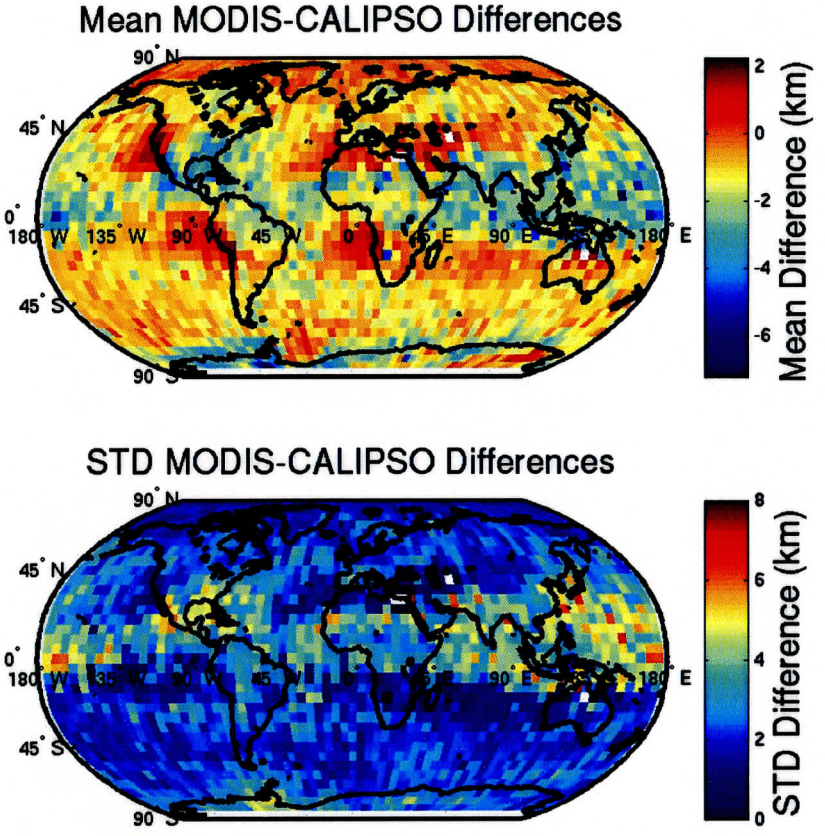
Current uncertainties in the role of aerosols and clouds limit our ability to accurately model the Earth's climate system and to predict climate change. These limitations are due primarily to difficulties in adequately measuring aerosols and clouds on a global scale. NASA's A-Train satellites provide an unprecedented opportunity to address these uncertainties. The various active and passive sensors aboard the A-Train use a variety of measurement techniques to provide in-depth observations of the multi-dimensional properties of clouds and aerosols. However, to fully achieve the potential of this ensemble requires a robust data fusion framework that can optimally and efficiently map this disparate collection of measurements into a comprehensive set of cloud and aerosol physical properties.

Over the past three years, researchers at Goddard Space Flight Center (GSFC), Langley Research Center (LaRC), and the University of Wisconsin CIMSS have worked together under the auspices of the Multi-Instrument Data Analysis and Synthesis (MIDAS) project to develop a data fusion framework using collocated airborne data sets as proxies for A-Train measurements. With the successful launch of the Cloud-Aerosol Lidar Infrared Pathfinder Spaceborne Observations (CALIPSO) satellite, the algorithms developed and tested on the airborne data can now, in principle, be applied to the satellite measurements and used to investigate relevant scientific questions. Specific science questions being addressed include:

- Investigating dust-cloud interactions: A specific research goal is to use the MIDAS architecture to quantify the impact of the Saharan and Taklimakan dust on suppression or enhancement of cloud development. We will also use the MIDAS framework to verify and/or improve the cloud-aerosol discrimination algorithm used to process data from the Moderate Resolution Imaging Spectroradiometer (MODIS).
- Using active remote sensing data to improve passive remote sensing retrievals: We will investigate using the vertical profile information available from CALIPSO measurements to generate new column-averaged microphysical retrievals from passive remote sensing instruments. An important aspect of this research element is to develop a new parameterization that uses the lidar-derived extinction profile to permit accurate passive infrared retrievals in cirrus clouds.
- Developing a realistic assessment of measurement errors to constrain climate prediction models: The advantage of the MIDAS data fusion technique is its ability to accurately identify the 3D structure of clouds and aerosols along the nadir track, and then to extend that knowledge to off-nadir pixels using similarity analyses. This phase of the proposal will (a) validate the off-nadir scene classification results; (b) apply the improved scene classifications to reduce the uncertainties in estimating radiative forcing of complex cloud and aerosol objects (e.g., multi-layer cloud and/or aerosols, and dust-contaminated clouds); and (c) provide a quantitative assessment of the impact that these reductions in observational uncertainties will have in reducing climate prediction uncertainties through an innovative perturbed physics ensemble approach.

Accomplishments

- Developed both aircraft and satellite collocation algorithms to collocated both imager and sounder (MODIS/AIRS) and nadir active remote sensed measurements with the imager and sounder (CALIPSO/AIRS and CALIPSO/MODIS)
- Using the collocation we compared one month of global cloud retrievals between the active and passive sensors.
- Developed cluster algorithms using aircraft data as a proxy of satellite retrievals
- Applied the aircraft algorithms to MODIS and CALIPSO.



The mean cloud top height differences are presented in the top image. For each 5-degree grid box the mean cloud height difference (MODIS – CALIPSO) is calculated. A negative difference (blue) results when mean MODIS cloud height is below the CALIPSO. The bottom image presents the standard deviation of the MODIS – CALIPSO cloud height differences for each 5-degree region.

Enhanced-V Detection

Personnel: Jason Brunner, Wayne Feltz, Kristopher Bedka, Robert Rabin, and Tom Whittaker

Funded by: NASA

Project Description

Our technical approach involves developing a capability to evaluate prototype components for image event detection that can support the needs of complex multi-discipline physical models. The question we want to answer is whether this event detection and tracking technology is general enough to be applicable for a variety of physical models such as the complex Enhanced-V, convective initiation and warm-cold couplets. The prototype detection and tracking algorithms and techniques will serve as a basis for comparative analysis of detailed implementation approaches for the virtual sensor platform and event data models. This proposal would support development of objective satellite imagery based detection of Enhanced-V, convective initiation, and warm-cold couplet features.

The enhanced-V detection project focuses on two areas of scientific emphasis:

Enhanced-V Feature/Warm-Cold Thermal Couplet:

- Develop satellite-based objective detection technique for the enhanced-V feature and warm-cold thermal couplet from existing satellite sensors (e.g. MODIS, AVHRR, GOES).
- Enhanced-V detection technique uses pattern recognition and correlation statistics between fabricated enhanced-V matrices and enhanced-V feature observed on satellite sensors.
- Test enhanced-V and warm-cold thermal couplet detection technique on a set of MODIS, AVHRR, and GOES cases.

Overshooting Top Feature:

- Develop techniques to isolate overshooting top locations on existing satellite sensors (e.g. MODIS, AVHRR, GOES).
- Test overshooting top techniques on a set of MODIS, AVHRR, and GOES cases.
- Search regions around overshooting top locations for warm-cold thermal couplets and enhanced-V features.

The effectiveness of the detection methods will be examined using GOES, MODIS and AVHRR image data for case studies in the 2003-2006 seasons. The Wisconsin team will determine what methods are usable, re-usable, and recommend what can be adapted toward the general case. Successful results using GOES data will determine whether we can consider how instrument resolutions, sensitivity and look-angle impact skill.

Accomplishments

Paper accepted for publication in *Weather and Forecasting* (2007).

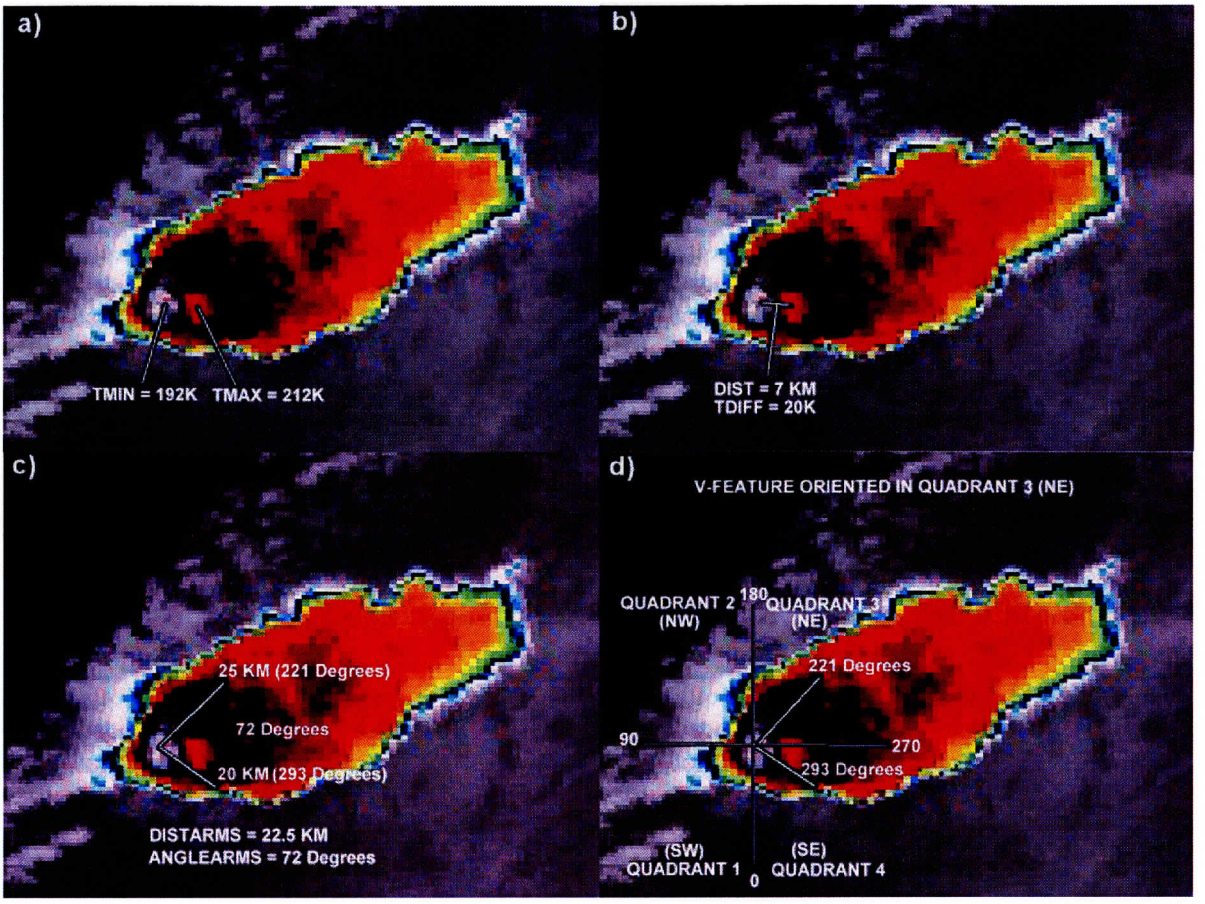


Figure 1: A zoomed-in POES NOAA-AVHRR one-kilometer spatial resolution enhanced 10.8 μm IR channel image over southwestern Texas on 9 May 2003 at 2102 UTC. The enhanced-V quantitative parameters are labeled in the four panels (a) TMIN (K) and TMAX (K) (b) TDIFF (K) and DIST (km) (c) DISTARMS (km) and ANGLEARMS (degrees), and (d) ORIENTATION.

Scientific Support for Derivation of Cloud Properties from Satellite Data

Personnel: Pat Heck

Funded by: NASA

Project Description

This project provides scientific and developmental analyses in support of several satellite programs and research tasks. The enhancement of existing cloud property retrieval algorithms and development of new techniques, as well as improvements to ancillary datasets and algorithms, are developed for the following projects:

- CERES
- GOES-R
- ARM
- NASA ASAP
- SEVIRI
- CALIPSO

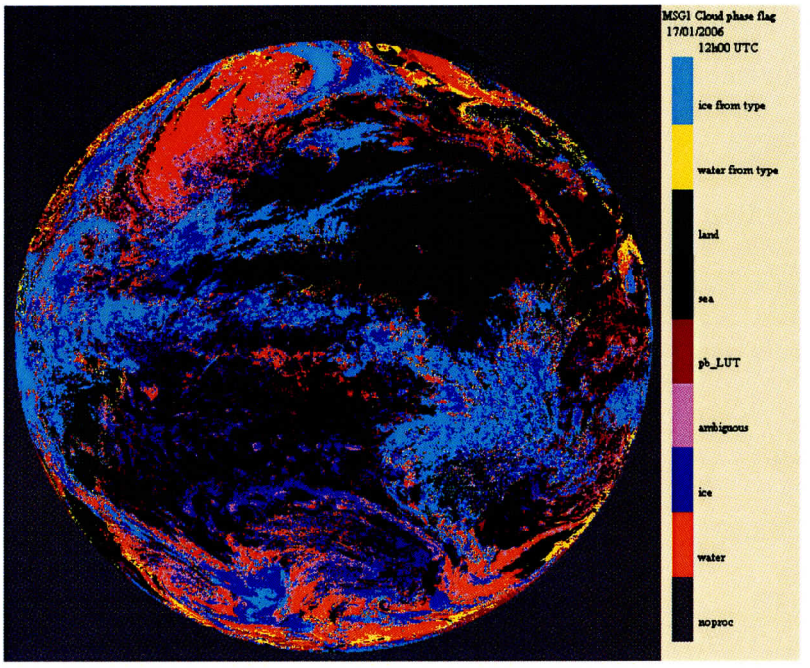
Cloud phase, cloud height, cloud particle sizes and other macro and microphysical properties are retrieved using techniques developed at NASA Langley in support of these projects. Validation of existing and newly developed techniques are also conducted using co-located surface-based retrievals and comparisons of retrievals from other satellite instruments using both analogous algorithms and results from other teams. Troubleshooting and diagnostic analyses of operational retrievals are conducted on an ongoing basis for previously implemented algorithms and for newly developed techniques that are applied to a variety of GEO and LEO satellites.

The nighttime portion of the NASA Langley cloud retrieval algorithm is being enhanced and prepared for porting as part of a collaboration with the CIMSS GOES-R Cloud Property Algorithm Working Group. The enhanced algorithm will operate in the CIMSS GEOCAT testbed to facilitate comparisons of algorithms and their respective performances.

The figure below shows preliminary results from the prototype phase retrieval algorithm that was developed for the EUMETSAT SAFNWC for application to full disk SEVIRI data. The project was funded externally by EUMETSAT, but portions of the algorithm and results from the study are being evaluated and considered as potential enhancements to the NASA Langley phase retrieval algorithm.

Accomplishments

- Initiated transition of NASA Langley nighttime cloud algorithm to GOES-R developmental framework at CIMSS.
- Completed 1-year collaboration with Météo-France for the EUMETSAT SAFNWC in developing prototype daytime cloud phase retrieval algorithm using SEVIRI data.
- Continued development and integration of cloud retrieval algorithm improvements to NASA Langley retrievals of cloud properties and fluxes, including CO2-slicing techniques, improved multi-layer detection and validation of clear and cloudy sky properties.



First results from the SAFNWC/MSG prototype phase retrieval algorithm from 17 January 2006, 1200UTC. Cloud phase flag shows the retrieved phase where "from type" indicates that ancillary information beyond 0.64 and 1.6 μm simulations were used, e.g., thermal channels and other SAFNWC products.

CHINA MERSI Cloud Mask

Personnel: Richard Frey, Kathy Strabala, Jun Li, Steve Ackerman

Funded by: China Meteorological Administration

Project Description

CIMSS has conducted the MERSI (Medium Resolution Spectral Imager) cloud mask processing package for global users. MERSI will be onboard the Chinese FY-3 (Feng Yun) weather satellite to be launched in October 2007, and is an imager instrument similar to MODIS (Moderate Resolution Imaging Spectroradiometer). The project is to develop the MERSI high spatial resolution cloud mask during daytime, the cloud mask will be used for other product generation, and to make available to the global user community the software and test data set for running the MERSI cloud mask.

Accomplishments

- Algorithm has been developed for MERSI cloud masking using visible and near infrared spectral bands;
- Algorithm and software has been successfully tested by MERSI proxy from MODIS Terra L1b data, and it can be run in real time to process the MERSI proxy from EOS (Earth Observing System) Direct Broadcast (BD) MODIS data.
- Study with various cases shows that approximately 93% of MODIS cloud mask pixels can be achieved with MERSI cloud mask.

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Mission 3

Stimulate the training of scientists and engineers in the disciplines involved in the atmospheric and earth sciences.

- Science on a Sphere
- SAGE Distance Learning Course
- Global and Regional Climate Change Distance Learning Course
- Satellite Observations in Science Education
- VISIT
- SHYMET
- EOPA Workshop
- NCEP Collaboration – International Interaction/Outreach

Science on a Sphere

Personnel: Steve Ackerman, Tom Whittaker, Rick Kohrs

Funded by: NOAA

Project Description

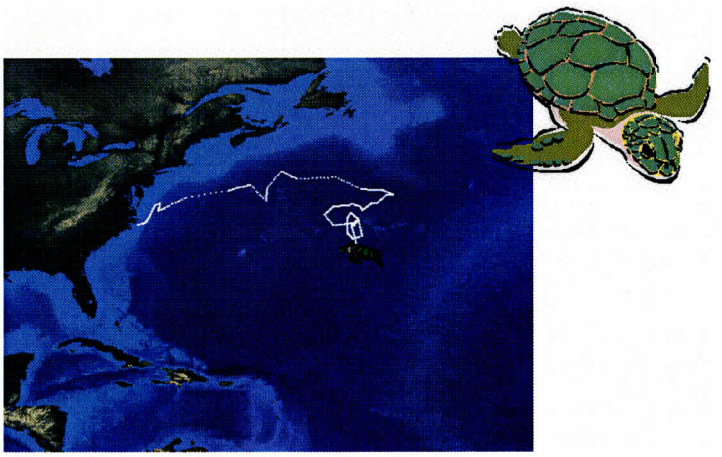
This is a collaboration between UW-Madison, Nauticus-the National Maritime Museum and Hampton University.

The role of UW in this collaboration is:

- Provide global polar orbiting and geostationary satellite feed to TNMC SOS exhibit.
- Prepare satellite and environmental data animations for educational exhibit display on the TNMC museum SOS system.
- Develop associated student/teacher educational modules that seek to optimally apply the SOS technology.
- Provide occasional guest professor/expert research scientist/student docent support for TNMC's Nauticus museum exhibit.
- Develop kiosk and associated activities in support of SOS data.

Accomplishments in 2006-2007

- Several data sets have been developed and delivered to Nauticus.
- We worked with NOAA to find efficient means of getting data to the Nauticus sphere.
- We developed a kiosk and an associated activity. The activity was tested at the AMS WeatherFest activity in January 2007.
- We participated in a NOAA sponsored SOS meetings to explore collaborations and data needs.



Migration data provided by NOAA staff at the Nauticus Museum Great White Shark and Turtle and UW made the animation for the sphere.

Satellite Applications for Geoscience Education: developing and delivering a new distance learning course for high school science teachers

Personnel: Steve Ackerman and Margaret Mooney

Funded by: NSF

Project Description

CIMSS and the Applied Physics Laboratory (APL) at the University of Washington in Seattle are collaborating to develop, implement and evaluate an inquiry-based distance learning professional development course for high school science teachers that will teach Earth System Science with a focus on satellite-based observations.

A pivotal planning for this project session occurred at a Curriculum Design Summit held in Seattle during November 2006. One teacher from Madison and four from the state of Washington convened with project Co-PI Ellen Lettvin and Co-Investigator Margaret Mooney while Co-PI Steve Ackerman participated remotely from Madison during a scheduled VISITview session. VISITview, which will be utilized in the new course, is distance learning software developed at CIMSS to train National Weather Service forecasters. Two experts from the System-wide Change for All Learners program (SCALE), an NSF comprehensive math and science partnership, also participated in the planning session.

Since the summit, work on the Internet course is underway with the overall web design and several lessons completed. Teachers test lessons as they are developed and provide feedback for improvement. Progress can be monitored at http://cimss.ssec.wisc.edu/sage/

Once the course is underway, CIMSS will facilitate the instruction of pertinent lessons via VISITview on-line sessions. Along with affording many instructional aspects similar to a traditional classroom for teachers taking the course, VISITview will enable content experts to make on-line follow-up visits to the classroom. These virtual classroom visits by geoscientists will expose teachers and students to practicing geoscientists, increasing the awareness of geoscience careers and enabling scientists to share their excitement and enthusiasm with course participants and their students. This exposure and interaction will be particularly valuable to those groups currently underrepresented in science, technology, engineering, and mathematic (STEM) disciplines.

Accomplishments

- Curriculum Design Summit held in Seattle November 2006.
- Web page added to the Internet in February 2007.
- Lesson development and teacher recruitment currently underway.

Course Banner

Satellite Observations in Science Education

Personnel: Steve Ackerman, Tom Whittaker, and Tommy Jasmin

Funded by: NASA

Project Description

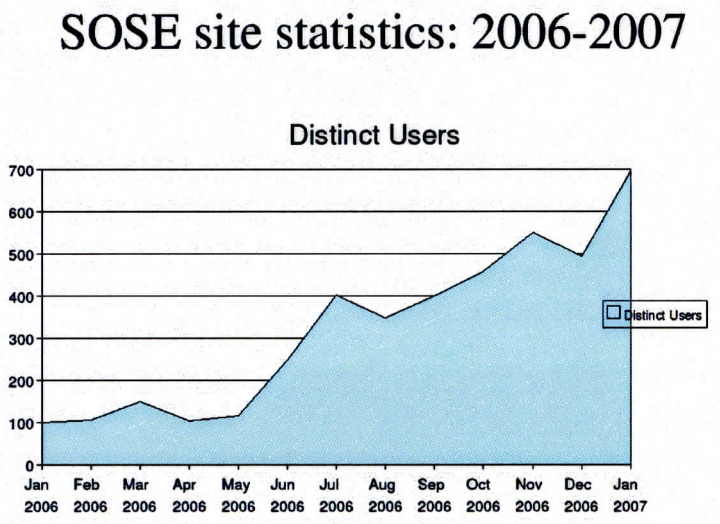
The project is collaboration between University of Wisconsin-Madison, the American Meteorological Society, New Media Studio and the University of California - Santa Barbara. CIMSS is the lead on this project and our primary responsibility is the development of remote sensing modules using NASA data and development of Reusable Content Objectives. The Reusable Content Object (RCO) strategy is to create, store, reuse, and repurpose content to create high quality learning support materials.

The long-term goal of this project is to improve the teaching and learning of the Earth system through quality educational resources that make use of satellite observations. Strategies include:

- Create effective tools and strategies for preparing students for careers in remote sensing;
- Promote and support Web-based, remote-sensing learning activities; and
- Train students on the appropriate use of observations to address complex real-world problems.

Accomplishments

- The AMS has successfully run and evaluated several teacher workshops and online activities.
- CIMSS has developed over a dozen RCOs and we are currently working with UCSB on incorporating Reusable Evaluation Objects (REOs), allowing the user to easily devise on-line assessment strategies.
- All SOSE learning activities will be completed this year.
- We developed a strategy and procedure for collaborations between scientists and instructional designers.
- Upcoming UW focus is the integration of REO into existing RCOs and GUI for using the RCO.



The SOSE URL is primarily publicized through presentations and the number of users continues to grow. The website is http://www.ssec.wisc.edu/sose/

Global and Regional Climate Change: Second in a series of distance learning courses for high school science teachers

Personnel: Steve Ackerman, Leanne Avila, Margaret Mooney, and Tom Whittaker

Funded by: University of Wisconsin Credit Outreach Program

Project Description

Starting summer 2007, CIMSS will lead the development of an on-line professional development course in **Global and Regional Climate Change** for middle and high school science teachers. Course content will be developed collaboratively by University of Wisconsin staff at the Atmospheric and Oceanic Sciences (AOS) department, the Space Science and Engineering Center (SSEC), the Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Center for Climate Research (CCR) and the Geology and Geophysics department. Core content will be based on findings of the 2007 Intergovernmental Panel on Climate Change (IPCC). By enlisting on-site NOAA STAR reviewers during development, CIMSS further plans to infuse course content with NOAA data and educational materials.

This 12-week course will be leveraged with efforts currently underway to develop a NSF supported distance learning course for science teachers called "Satellite Applications for Geoscience Education" (http://cimss.ssec.wisc.edu/sage/). Along with using the same design template and portions of the Geoscience web page we intend to follow similar NSF supported course development techniques, such as holding a Curriculum Design Summit (CDS) to gather teacher input on course content, having teachers provide feedback during development, and collecting educators feedback after the debut semester. By including teachers at every juncture, we will ensure that educators find the course useful.

Along with these leveraging capabilities, this project has considerable potential for expansion and sustainability through collaborations with SCALE (System-wide Change for All Learners) colleagues and the fact that educators in Wisconsin, and most states, need professional development opportunities in order to maintain their teaching license and advance in district salary. It is envisioned that this Climate Change course could be combined with the Geoscience course towards a certificate in Earth Science, or possibly a Masters program. Educators will be able to register for either 2 or 3 credits for this course, enabling them to adjust costs and accreditation with their career needs. Those who register for the 3-credit option will be expected to conduct a VISITview session in their schools, enabling UW experts to conduct "virtual visits" to K-12 classrooms around the Midwest.

The course will include multiple interactive activities created by Tom Whittaker and Steve Ackerman, including two new Climate Change applets. The design and topic conveyed by these new applets will be determined from feedback acquired at the July CDS.

Accomplishments

- An initial 1 hour planning meeting was held on April 17th, 2007.
- Teacher recruitment for the July Curriculum Design Summit is currently underway.

Virtual Institute for Satellite Integration Training (VISIT)

Personnel: Scott Bachmeier, Scott Lindstrom, Tom Whittaker

Funded by: NOAA/NESDIS

Project Description

The VISIT (Virtual Institute for Satellite Integration Training) program performs pioneering research in the use of tools, data, and techniques for supporting distance learning activities in the atmospheric sciences. The U.S. National Weather Service, the World Meteorological Organization, and weather services in other countries have made use of the VISITview software and VISIT lesson material to support their needs for decentralizing training activities to their respective constituents.

The goals of the VISIT program are to:

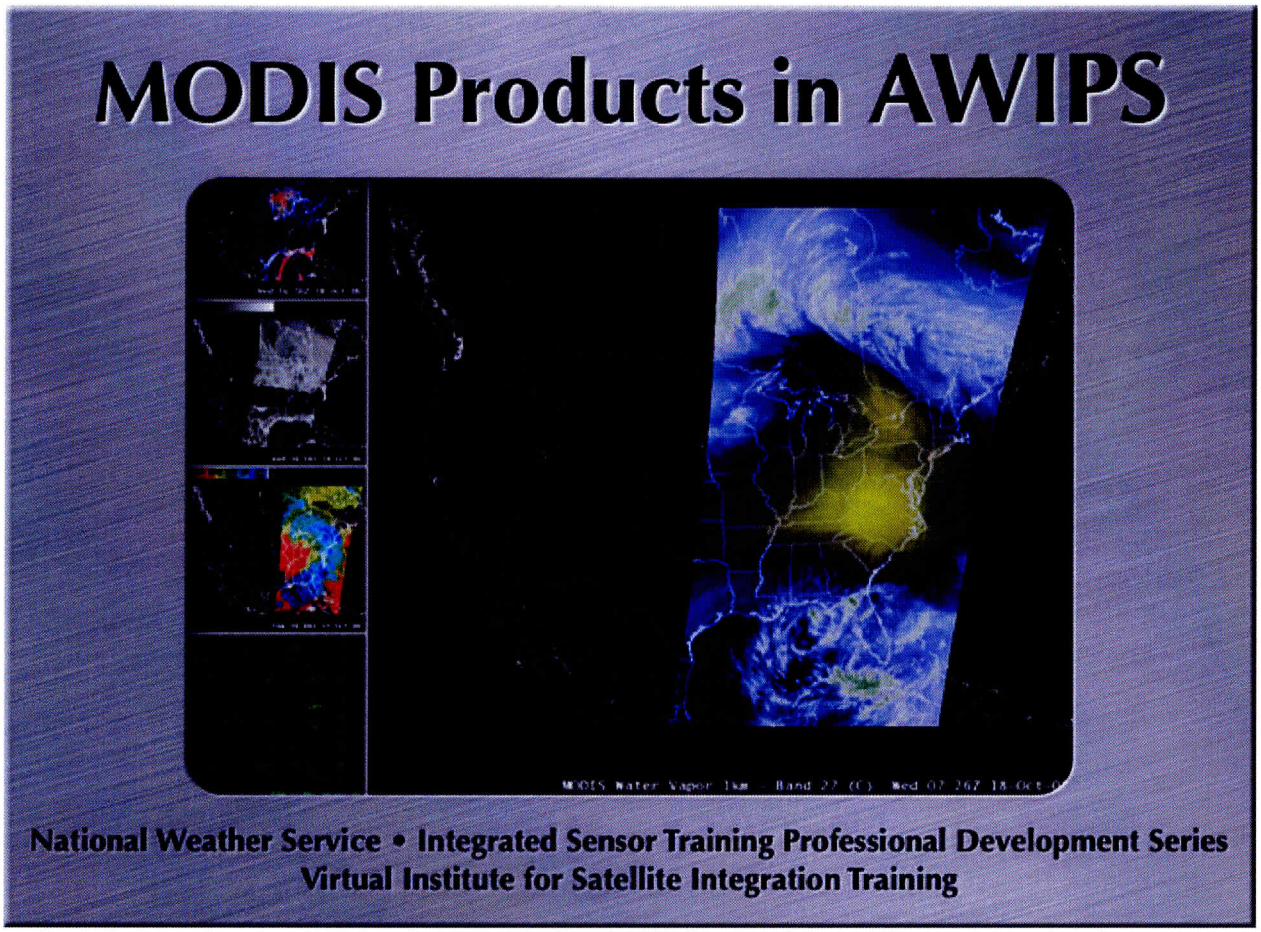
- Develop distance learning material that integrates satellite data into forecast operations;
- Continue to improve the functionality of VISITview software;
- Update existing VISIT lesson content with new material; and
- Explore new distance learning techniques.

The following instructor-led VISIT lessons were offered in 2006-2007:

1. MODIS Products in AWIPS
2. CRAS Forecast Imagery in AWIPS
3. TROWAL Identification
4. Mesoscale Convective Vortices
5. GOES Sounder Data and Products
6. GOES High Density Winds
7. Water Vapor Channel Satellite Imagery
8. The Enhanced-V: A Satellite Severe Storm Signature

Accomplishments (April 2006-April 2007)

- 46 VISIT sessions conducted, with 121 NWS offices participating;
- New "MODIS Products in AWIPS" lesson developed;
- New "CRAS Forecast Imagery in AWIPS" lesson developed; and
- New "Basic Satellite Principles" lesson developed.



Title slide from the "MODIS Products in AWIPS" VISIT lesson; this was the most popular distance learning session, with 38 NWS offices participating during the April 2006-April 2007 period.

Satellite Hydro-Meteorology (SHyMet) Course

Personnel: Steve Ackerman, Scott Bachmeier

Funded by: NOAA/NESDIS

Project Description

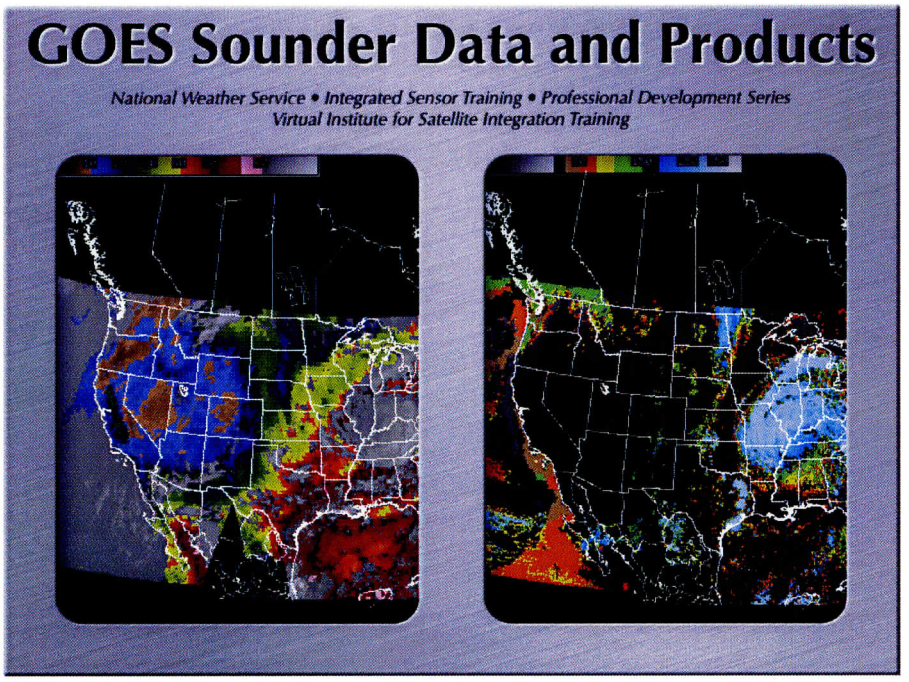
The Satellite and Hydro-Meteorology (SHyMet) training course is a collaborative effort between CIMSS and CIRA to develop and deliver distance learning material to prepare NWS interns to better understand and utilize the increased observing capabilities of current (GOES, MODIS, AIRS) and future (GOES-R+, NPOESS) geostationary and polar orbit satellites.

The goals of the SHyMet course are to:

- Expand the current library of distance learning modules with new satellite and hydrology topics; and
- Evaluate student feedback from course surveys and comments, and modify the instructional material as appropriate.

Accomplishments (April 2006-June 2006)

- Conducted 17 instructor-led distance learning lessons ("live" VISITview sessions);
- "GOES Sounder Data and Products" lesson: 42 NWS interns participated;
- "GOES High Density Winds" lesson: 37 NWS interns participated; and
- Audio playback versions of these two VISITview lessons were prepared and posted on the NOAA e-Learning Management System (LMS).



Title slide from the "GOES Sounder Data and Products" SHyMet lesson.

NOAA EOPA Remote Sensing and CIMSS IMAPP Training and Education Workshop

Personnel: Allen Huang

Funded by: NOAA

Project Description

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison (UW-Madison) proposes to collaborate with the NOAA National Weather Service (NWS), International Activities (IA) office, and other NOAA and NASA participants, to present a workshop in Buenos Aires, Argentina on acquiring and using NASA EOS MODIS and AIRS measurements.

The program includes participation by CIMSS and NOAA scientists, as well as guest lecturers from NASA and from participating countries in South America. The overall objective of this workshop is to facilitate understanding of general remote sensing principles and applications of the NASA EOS MODIS and AIRS instruments and the data processing and science applications available through the International MODIS/AIRS Processing Package software developed at CIMSS.

This workshop will be presented in support of the NOAA Earth Observation Partnership of the Americas (EOPA) now with the new program of GEOSS for Americas/Caribbean. The proposed educational project addresses the following NOAA mission goals :

- Serve society's needs for weather and water information; and
- Provide critical support for the NOAA mission.

Furthermore, it supports NOAA's Cross-Cutting Priorities in the areas of:

- Integrating global environmental observations and data management;
- Promoting environmental literacy; and
- Exercising international leadership.

Accomplishments

- Attended NOAA capability building meeting in 2007 AMS annual and GOES-10 press event held in D.C on April 2007;
- Organizing sounding workshop as part of NOAA's GEOSS for America integrated training activities; and
- Visiting potential workshop site and to draft workshop agenda.

NCEP Collaboration – International Interaction/Outreach

Personnel: Ralph Petersen

Funded by: NOAA (NWS)

Project Description

This small effort supports initial distribution of models and supporting data to specific candidate developing countries. Specific activities included representing NCEP/EMC at meetings of the national and international NWP community and continued planning and development of a forecaster training program on the use of NWP output to be conducted in parallel with model implementation. These efforts are being fully coordinated with NWS/IA.

Accomplishments

In November 2005, Dr. Ralph Petersen represented NWS/NCEP/EMC at the meeting of the WMO Working Group on Numerical Experimentation in St. Petersburg, Russia. He presented a number of papers describing current and planned numerical modeling and data assimilation activities in the US. A detailed set of annotated minutes of the meeting has been provided directly to NCEP, including action items and areas of concern. Final discussion of this activity occurred in early 2006. Also in November 2005, Dr. Petersen represented ECM and CIMSS as well as chaired the annual review of the NASA Short-Term Prediction Research and Transition (SPoRT) Center in Huntsville, AL.

In September 2006, Dr. Petersen gave an invited talk to the WMO AMDAR Panel. In November, Dr. Petersen was an invited lecturer at a WMO Workshop on Severe Weather Forecasting conducted at Pretoria, South Africa for forecasters from developing countries in southern Africa. In December 2007, Dr. Petersen gave an invited lecture at the bi-annual meeting of the WMO Commission on Aeronautical Meteorology, reviewing international aviation forecasting improvements over the past 20 years and providing guidance concerning the direction of future forecast improvement priorities. Preparation for these events was supported in part by these funds. In 2007 and beyond, funding for these type of activities is expected to come directly from NWS/IA instead of NWS/NCEP/EMC.

CIMSS PROPOSAL SUMMARY
Currently Pending as of May 2007

Submitted	Title	Agency	Amount	PI
7/17/06	Algorithm Maintenance and Validation of MODIS Cloud Mask, Cloud Top-Pressure, Cloud Phase and Atmospheric Sounding Algorithms	NASA	1,343,871	Ackerman
7/17/06	Refinement of Ice Cloud Bulk Optical Models: From Microphysical Measurements to Global Retrievals Using Multiple Satellite Instruments	NASA	717,624	Baum
7/17/06	Assessment of Cloud Parameters in the NPOESS Environmental Data Records and Climate Records Data	NASA	272,242	Baum
7/17/06	Global Assessment of Stratiform Boundary Layer Clouds from Aqua: Reducing uncertainties in the magnitude of the first indirect aerosol effect	NASA	507,399	Bennartz
7/17/06	Land Surface Characterizationi Using High Spectral Resolution and Moderate Spatial Resolution Observations from EOS,METOP, and NPP for Assessment of Climate Products	NASA	877,259	Knuteson
7/17/06	Dynamic Assimilation of High Spatial and Temporal Resolution MODIS Moisture Profile and Wind Products in MM5 Over High Latitude Regions	NASA	900,000	Li
7/17/06	Development of a Decadal Cloud Climatology from NOAA (AVHRR and HIRS) through EOS (MODIS and AIRS) to NPOESS (VIRRS and and CrIS)	NASA	1,357,649	Menzel
7/17/06	Validation and Analysis of Middle and High Latitude Ocean Precipitation for AMSR-E	NASA	938,951	Petty
7/17/06	Assessment and Optimization of IR Radiance Measurements for Climate, Assimilation, and Remote Sensing Applications	NASA	1,330,573	Revercomb
7/17/06	ARM Site and Ship-based Measurements for Validation of EOS, METOD, and NPP Atmospheric Soundings and Infrared Radiances	NASA	1,309,313	Tobin
7/25/06	Towards a Consensus AVHRR Reflectance Calibration	NOAA	232,031	Ackerman, Heidinger
9/20/06	Development of a Fast Radiative Transfer Computational Package for Satellite Data Assimilation Under Cloudy Skies	Texas A&M Research Foundation	137,471	Baum

9/25/06	CIMSS Participation in the GOES Improved Measurements and Product Assurance Plan (GIMPAP)	NOAA	467,000	Ackerman
10/3/06	Far-Infrared Properties of Earth Radiation	NASA	299,927	Tobin
10/23/06	Linking Aerosol Observations to their Sources and Climate Effects	Columbia University	105,000	Bennartz
10/26/06	Implemmentation of SATCON (Satellite CONsensus) TC Intensity Estimation Algorithm Into TPC Operationis	NOAA	110,000	Velden Herndon
1/12/07	CIMSS Instrument and Scan Strategy Studies for GOES-R	NOAA	350,000	Li
2/22/07	An Intercalibration Activity in the GOES Improved Measurements and Product Assurance Plan (GIMPAP)	NOAA	46,000	Ackerman
2/27/07	Community Development of Global Cloud Data Records from Infrared Polar Orbiter Data	NASA	3,860,264	Baum
2/27/07	Generation of Representative Water Vapor ESDR/CDR from EOS Aqua MODIS, AIRS/AMSU, and AMSR-E Measurements	NASA	3,168,250	Li
2/28/07	CIMSS Participation in the GOES R Risk Reduction Program for 2007	NOAA	800,000	Ackerman
3/9/07	Investigations in Support of the GOES R Program Office	NOAA	75,000	Menzel
3/9/07	NCEP International Model Support Activities	NOAA	8,428	Petersen
3/19/07	Collaborative Research: Role of Intensified Storm Activity in Amplified Changes of Sea Ice Mass Balance: A Synthetic Study of Model Simulations and IPY Field Observations	NSF	164,092	Wang
3/20/07	CIMSS Research Activities in Support of Geostationary and Polar Orbiting Weather Satellite Science Topics (Geo-PSDI)	NOAA	562,000	Ackerman
3/28/07	CIMSS Research Activities in the NOAA Ground System Program for 2007	NOAA	110,000	Ackerman
3/29/07	CIMSS Research Activities in the VISIT Program for 2007	NOAA	180,000	Ackerman
4/3/07	CIMSS Research Activities for the SHyMet Program for 2007	NOAA	75,000	Ackerman
4/6/07	Continued Development of the Community Radiative Transfer Model (CRTM)	NOAA	160,000	Van Delst
4/16/07	CIMSS Research Activities in Support of the GOES-R Algorithm Working Group (AWG)	NOAA	2,289,000	A. Huang
4/24/07	GOES-R NDA and ITAR documents	NOAA	-	Ackerman

4/30/07	Extratropical Transition of Tropical Cyclones Over the Western North Pacific: Physical Characteristics, Downstream Impacts, and Predictability	NSF	210,000	Velden
5/2/07	Suomi-Simpson Graduate Fellowship	NASA	75,000	Ackerman
5/2/07	Evaluating global aerosol models and aerosol and water vapor properties near clouds	DOE	210,010	Turner
5/3/07	Parameterization of Radiative Properties for single-layered ice and mixed-phase clouds and stratiform overlapping clouds based on ARM data for application to the NCAR community atmosphere model (CAM)	DOE	182,349	Baum
5/4/07	MAS Fast Transmittance Models for Generating TC-4 Field Products	GSFC	9,357	Ackerman, Moeller
5/4/07	Characterizing the Microphysical and Radiative Properties of Optically Thing Clouds and Evaluating Radiative Closure in the Far-Infrared	DOE	387,606	Turner
5/4/07	Analysis of Dust from AMF Observations in Miamey	DOE	120,112	Turner
7/28/06, Revised 4/5/07	Scanning HIS Participation in TC4 207 for Validation of A-Train Products	NASA	100,488	Revercomb
	Observation Error Characterization for Radiance Assimilation of Clouds and Precipitation	NOAA	450,000	Bennartz
	Utilization of GOES Rapid-Scan Wind Data for Tropical Cyclone Predictability Experiments	ONR	65,509	Velden
	JCSDA	NOAA	658,817	Zapotocny
	Assimilating and Determining the Impact of Sea Surface Winds Measured By Winidsat/Coriolis in the Global Forecast System	JCSDA	106,674	Zapotocny

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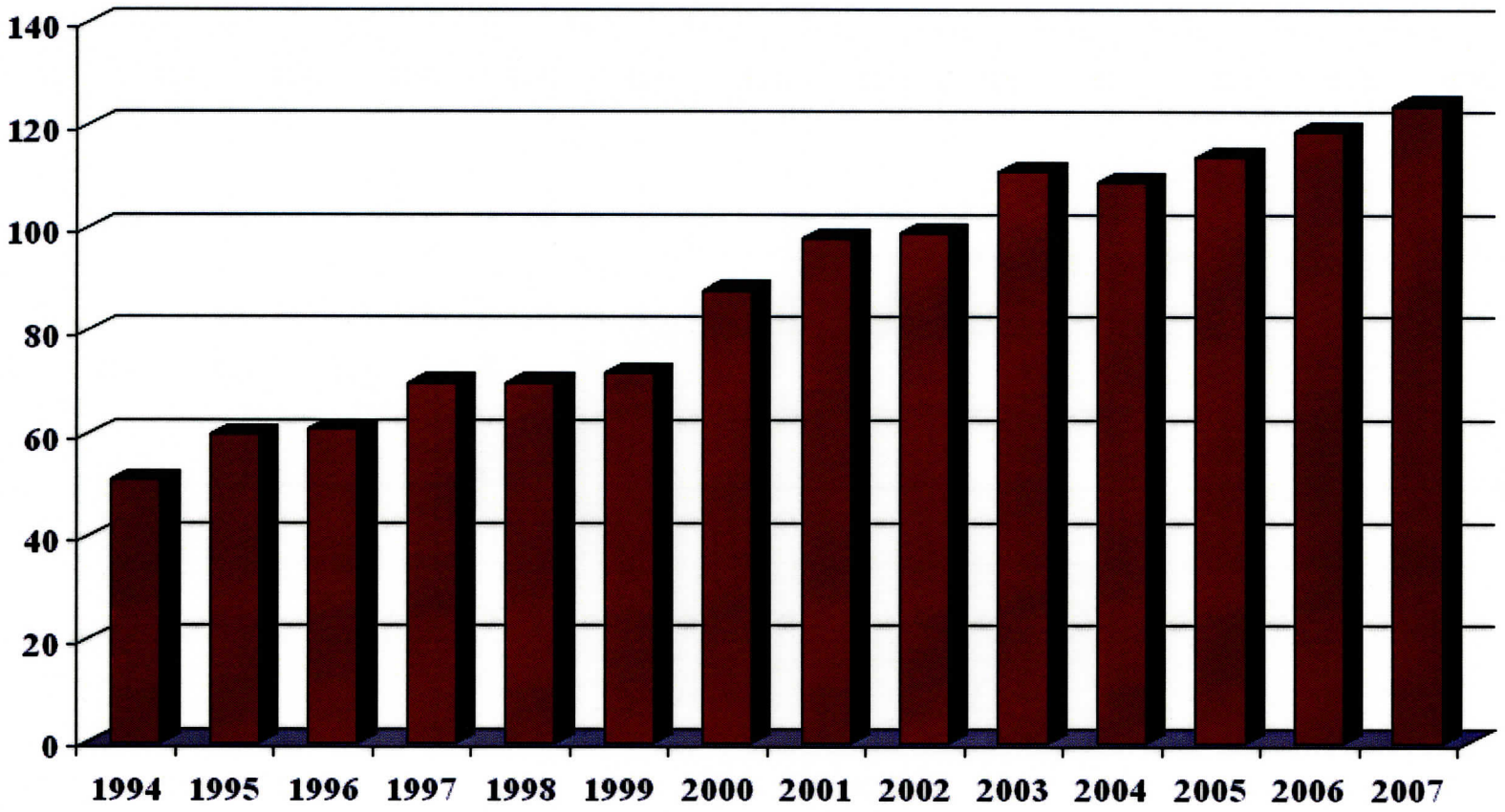
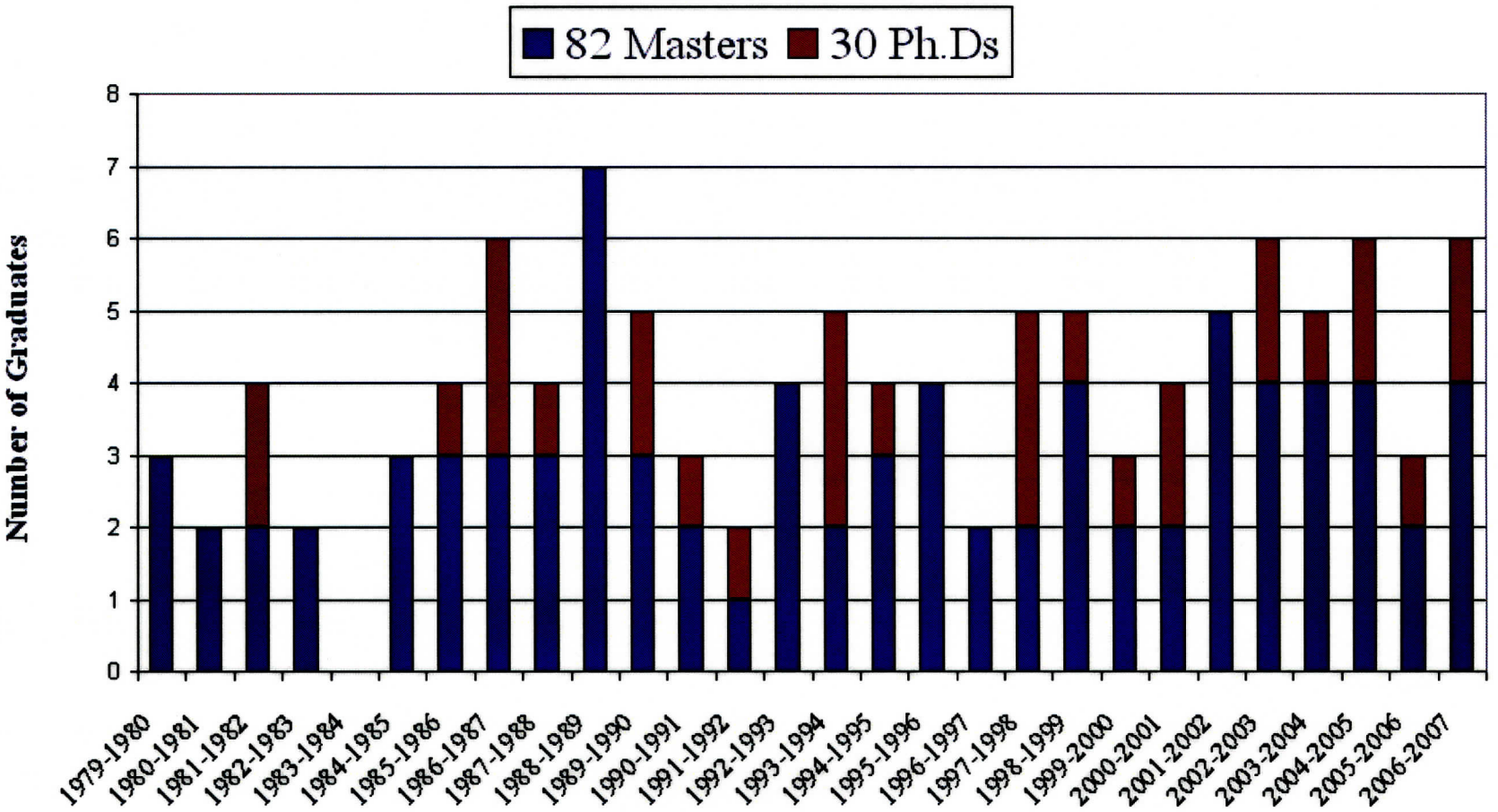
CIMSS Personnel History
1994-2007

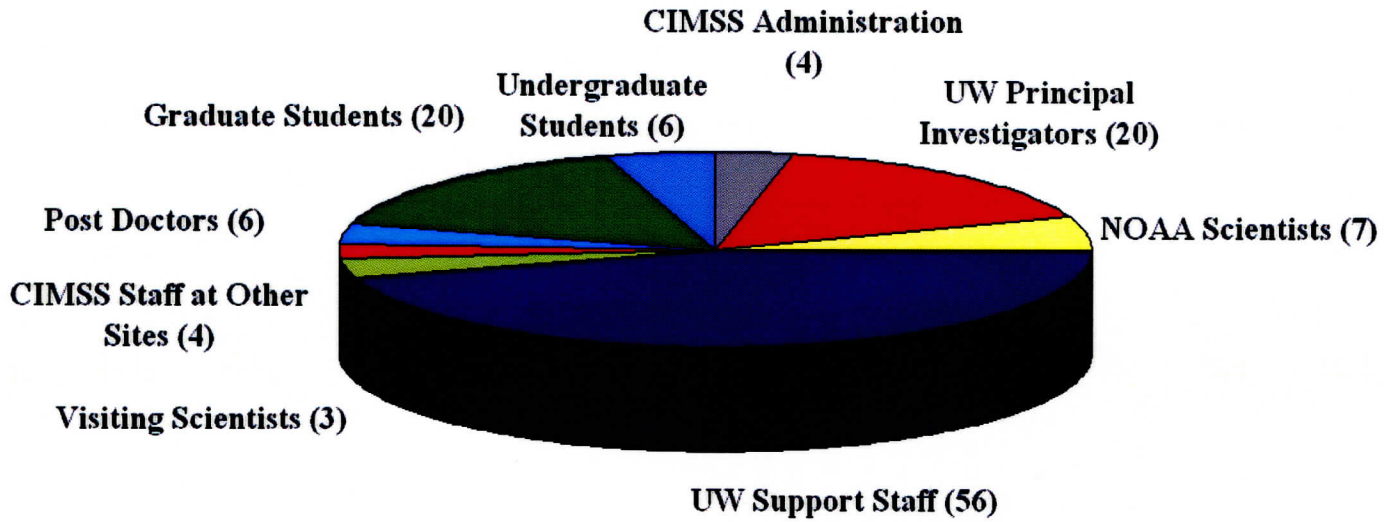


CIMSS Graduates



CIMSS Personnel (124 Associates)

May 2007



CIMSS PERSONNEL SUMMARY: (123 Associates) **May 2007**

CIMSS ADMINISTRATION AND TECHNICAL SUPPORT (4):	Steve Ackerman	Director
	Tom Achtor	Executive Director
	Maria Vasys	University Services Associate
	Leanne Avila	Editor/Webmaster

UNIVERSITY PRINCIPAL INVESTIGATORS: (20)

(Steve Ackerman	Professor, AOS	Clouds / Aerosols)
Bryan Baum	Associate Scientist	Cloud Microphysics
Ralf Bennartz	Professor, AOS	Microwave / Radiative Transfer
Wayne Feltz	Researcher	Aviation Weather
Tom Greenwald	Associate Scientist	Microwave / Data Assimilation
Liam Gumley	Instrument Innovator	Direct Broadcast and Data Analysis
Allen Huang	Distinguished Scientist	Retrieval Science / Hyperspectral
Bormin Huang	Assistant Scientist	Data Compression / Retrieval Science
Bob Knuteson	Assistant Scientist	Hyperspectral Instruments / Data Analysis
Jim Kossin	Assistant Scientist	Tropical Cyclones
Jun Li	Associate Scientist	Retrieval Science / Hyperspectral
Paul Menzel	Senior Scientist	Clouds and Climate / Instrumentation
Ralph Petersen	Senior Scientist	NWP / Nowcasting
Grant Petty	Professor, AOS	Microwave / Rainfall
Elaine Prins	Contracting Scientist	Biomass Burning / Aerosols
Hank Revercomb	Senior Scientist	Hyperspectral Instruments/Data Analysis
Bill Smith Sr.	Senior Scientist	Hyperspectral Instruments/Data Analysis
Dave Tobin	Assistant Scientist	Radiative Transfer
Dave Turner	Associate Researcher	AERI instrument and science
Chris Velden	Senior Scientist	Satellite Winds / Tropical Cyclones
Tony Wimmers	Associate Researcher	Turbulence / Aerosols

NOAA PERSONNEL: (7)	Jeff Key	ASPB Team Leader
	Robert Aune	
	Andrew Heidinger	
	Mike Pavolonis	
	Tim Schmit	
	Gary Wade	
	Robert Rabin	National Severe Storms Lab

UNIVERSITY SCIENTIFIC AND PROGRAMMING STAFF (56)	Paolo Antonelli	Researcher
	Scott Bachmeier	Researcher
	Kris Bedka	Associate Researcher
	Sarah Bedka	Associate Researcher
	Howard Berger	Associate Researcher
	Eva Borbas	Researcher
	Lori Borg	Research Intern
	Jason Brunner	Assistant Researcher
	Corey Calvert	Asst. Instrument Technician
	Ralph Dedecker	Asst. Instrument Innovator
	George Diak	Emeritus Scientist

UNIVERSITY SCIENTIFIC AND PROGRAMMING STAFF (continued)

Dan DeSlover	Researcher
Steve Dutcher	Instrument Technician
Amato Evan	Assistant Researcher
Joleen Feltz	Assistant Researcher
Bruce Flynn	Assoc. Instrument Technician
Richard Frey	Researcher
Ray Garcia	Instrument Technician
Iliana Genkova	Assistant Researcher
Mat Gunshor	Associate Researcher
Denny Hackel	Instrumentation Technician
Pat Heck	Researcher
Jay Hoffman	Research Intern
Bob Holz	Assistant Researcher
Ben Howell	Researcher
Jun Huang	Assistant Researcher
Tommy Jasmin	Instrumentation Tech
Xin Jin	Associate Researcher
Jinlong Li	Associate Researcher
Graeme Martin	Assoc. Instrument Technician
Szu-Chia Moeller	Assistant Researcher
Chris Moeller	Researcher
Christine Molling	Associate Researcher
Margaret Mooney	Outreach Specialist
Leslie Moy	Associate Researcher
Fred Nagle	Emeritus Researcher
Jim Nelson	Researcher
Tim Olander	Researcher
Erik Olson	Associate Researcher
Jason Otkin	Associate Researcher
Youri Plokhenko	Researcher
Tom Rink	Senior Instrumentation Tech
Dave Santek	Assoc. Instrument Innovator
Chris Schmidt	Assistant Researcher
Tony Schreiner	Researcher
Maciej Smuga-Otto	Senior Instrument Technician
Dave Stettner	Associate Researcher
Kathy Strabala	Researcher
William Straka	Assistant Researcher
Ken Vinson	Research Specialist
Xuanji Wang	Assistant Researcher
Steve Wanzong	Assistant Researcher
Elisabeth Weisz	Associate Researcher
Tom Whittaker	Researcher
Hal Woolf	Researcher
Hong Zhang	Researcher

POST DOCTORS: (4)	Steve Cooper	Research Associate
	Yong-Keun Lee	Research Associate
	Yinghui Liu	Research Associate
	Chris Rozoff	Research Associate
STAFF AT OTHER SITES: (4)	Derrick Herndon	AFWA/Research Specialist
	Jim Jung	NCEP/Associate Researcher
	Suzanne Seemann	Eureka CA/Assoc Researcher
	Paul vanDelst	NCEP/Researcher
VISITING SCIENTISTS (3)	Lu Feng	NSMC China
	O-Ung Kwon	KMI South Korea
	Nadia Smith	U.Stellenbach South Africa

GRADUATE STUDENTS: (19)

Student	Degree	Science Advisor	Academic Advisor
Li Bi	Ph.D.	LeMarshall	Morgan
Richard Dworak	M.S.	Key	Ackerman
Alex Harrington	M.S.	Heidinger	Ackerman
Wei Huang	Ph.D.	Petty	Petty
Ralph Kuehn	Ph.D.	Ackerman	Ackerman
Mark Kulie	Ph.D.	Bennartz	Bennartz
Matthew Lazzara	Ph.D.	Ackerman	Ackerman
Zhenglong Li	Ph.D.	J. Li	Ackerman
Agnes Lim	Ph.D.	A. Huang	Ackerman
Chian-Yi Liu	Ph.D.	J. Li	Ackerman
Brent Maddux	M.S.	Ackerman	Ackerman
Chan-Hwang Park	Ph.D.	Bennartz	Bennartz
Michael Pavolonis	Ph.D.	Heidinger	Ackerman
Dave Santek	Ph.D.	Ackerman	Ackerman
Justin Sieglaff	M.S.	Schmit	Ackerman
Jessica Staude	M.S.	Lazzara	Ackerman
Tim Wagner	M.S.	Feltz	Ackerman
Longtao Wu	Ph.D.	Petty	Petty
Wei Zhou	Ph.D.	Bennartz	Bennartz

UNDERGRADUATE STUDENT EMPLOYEES (6)	Anna Bradford
	Jordan Gerth
	Jelani Harris
	Annie Lenz
	Carolynn Rauber
	Luke Schiferl

CIMSS Graduate Students Research Topics

Li Bi
Evaluates data assimilation techniques and forecast impacts obtained with WindSat data in real time experiments, and compares the impact with QuikSCAT data in the NCEP GDAS/GFS, as well as, investigates quality control which will lead to operational implementation of WindSat data in the NCEP models.

Richard Dvorak
Completed 20 years of AVHRR winds from 1982 to 2002. Master Thesis on Validation and Comparison to ERA-40.

Alex Harrington
Uses 55km AVHRR satellite data to assess trends in tropical and mid-latitude upper-tropospheric humidity, and its impact on high cloud fraction and outgoing longwave radiation. Current findings suggest a lack of correlation between AVHRR high cloud fraction and outgoing longwave radiation, likely attributed to the time of data capture.

Mark Kulie
Develops a forward model in an optimal estimation framework that includes the following components: 1-D parametric rainfall model, non-spherical representations of frozen hydrometeors to calculate optical properties, ocean surface emissivity model, radiative transfer model, and radar beam model. By using this modeling pathway and comparing our results to actual passive and active microwave measurements, attempts to quantify the information content of using ground-based radar data merged with satellite-based passive microwave data to study precipitation at higher latitudes.

Matthew Lazzara
Thesis title: "A diagnostic study of fog in the Ross Island Region of Antarctica." This is the first formal study of fog in the Antarctic, with a focus on an area that impacts aviation operations for the US Antarctic Program.

Zhenglong Li
A new physical retrieval algorithm on temperature and moisture profiles using GOES-12 Sounder data has already been created. Currently, tries to use time continuity (high temporal resolution of 1 hour) to improve the retrieval.

Agnes Lim
Cloud clearing for AIRS using MODIS-operational code.

Chian-Yi Liu
Deals with cloud through synergistic use of imager and sounder systems for atmospheric profile evolution, including cloud-clearing algorithm and keeps single footprint sounding retrieval to discover cloud properties and lower atmospheric phenomena.

Brent Maddux
Research centers around analyzing the state and variability within the global cloud field as seen by MODIS on regional and local scales. These efforts will better quantify the long-term trends and characteristics globally of cloud properties within the larger hydrological cycle and radiation budget.

Dave Santek
Doctoral thesis title: "The Global Impact of Satellite-Derived Polar Winds on Model Forecasts," investigates mechanisms that propagate wind information from the polar regions to lower latitudes, resulting in improved global forecasts.

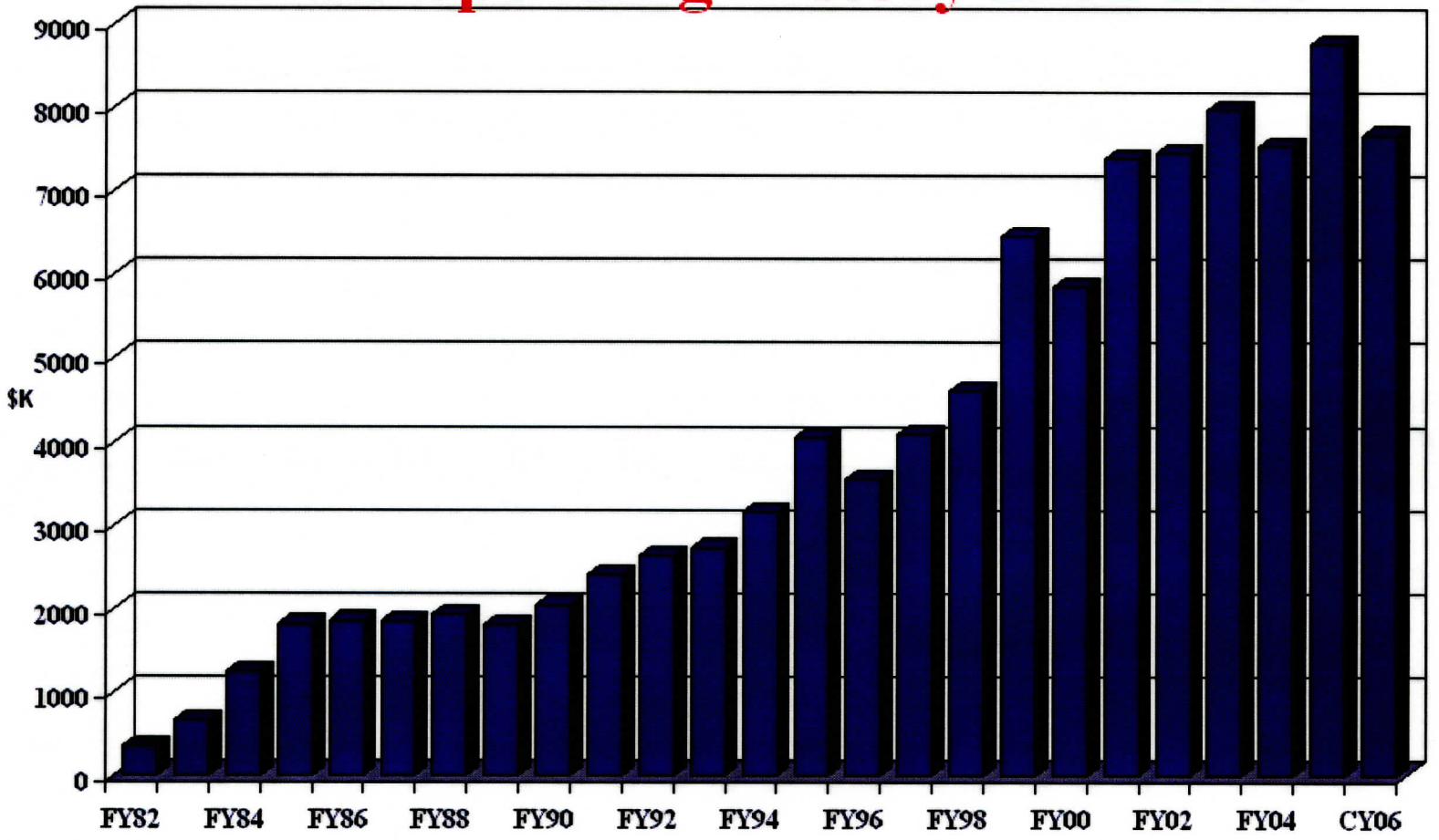
Justin Sieglaff
Investigates the sensitivity of high spectral resolution infrared sounders to thermodynamic variability of the lower troposphere. Specifically, shows micro-absorption lines within the infrared window have sensitivity lower tropospheric temperature and moisture changes and the information obtained from these absorption lines could potentially be used to improve short term convective forecasts.

Jessica Staude
Thesis title: "An Antarctic Climatology - Cloud Mass Transport," searches for a relationship between cloud mass transport and several different climate indicies.

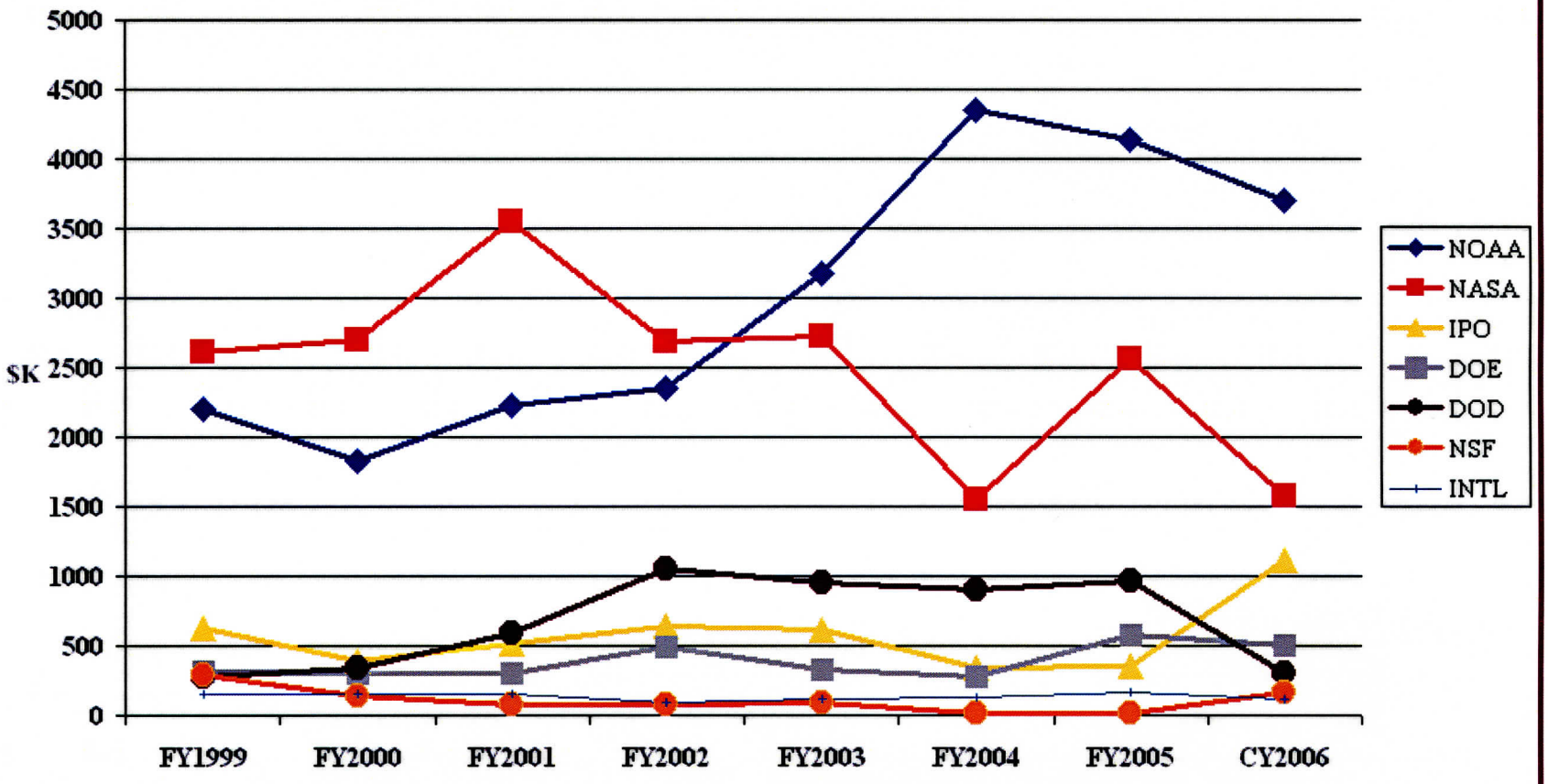
Tim Wagner
Cumulus clouds are not well-paramaterized in climate models. By combining a cloud parcel entrainment model with high temporal resolution remotely sensed moisture profiles, calculates more accurate evolution of cumulus characteristics for a given environment.

Wei Zhou
Focuses on the use of the successive order of interaction (SOI) model to simulate the radiation transfer process for the atmosphere as well as the cloud in the wide spectrum range from the microwave to the thermal infrared.

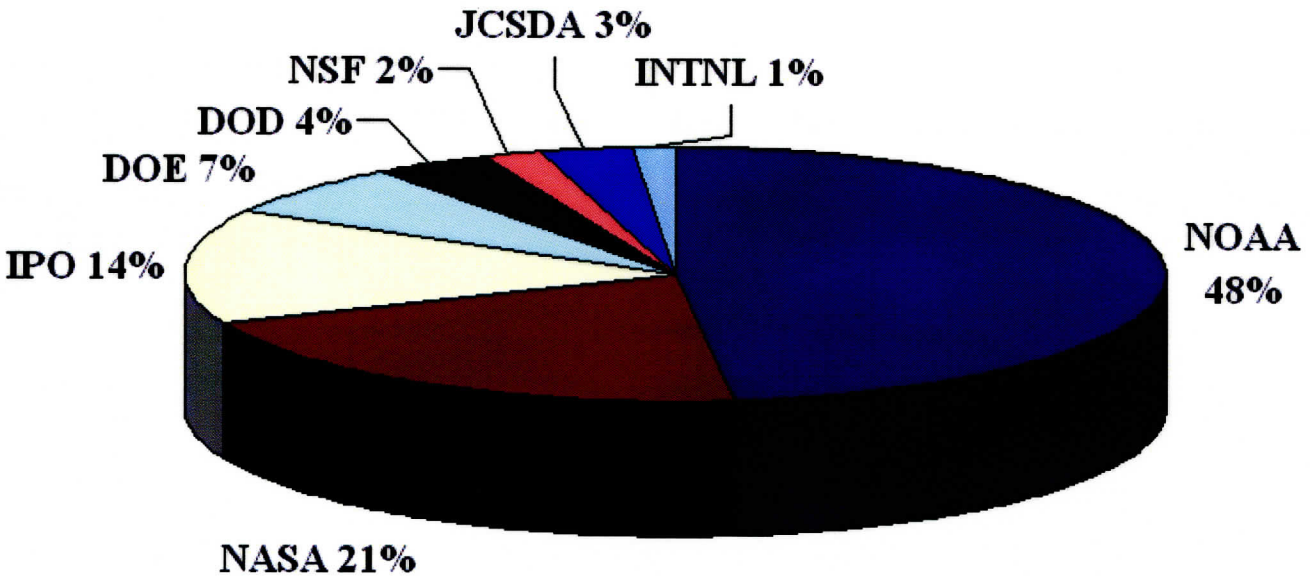
CIMSS Spending History 1982-2006



Agency Spending at CIMSS
1999 - 2006



CIMSS Spending by Agency
CY2006



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CIMSS Publishing Statistics
1995-2006

Contents:

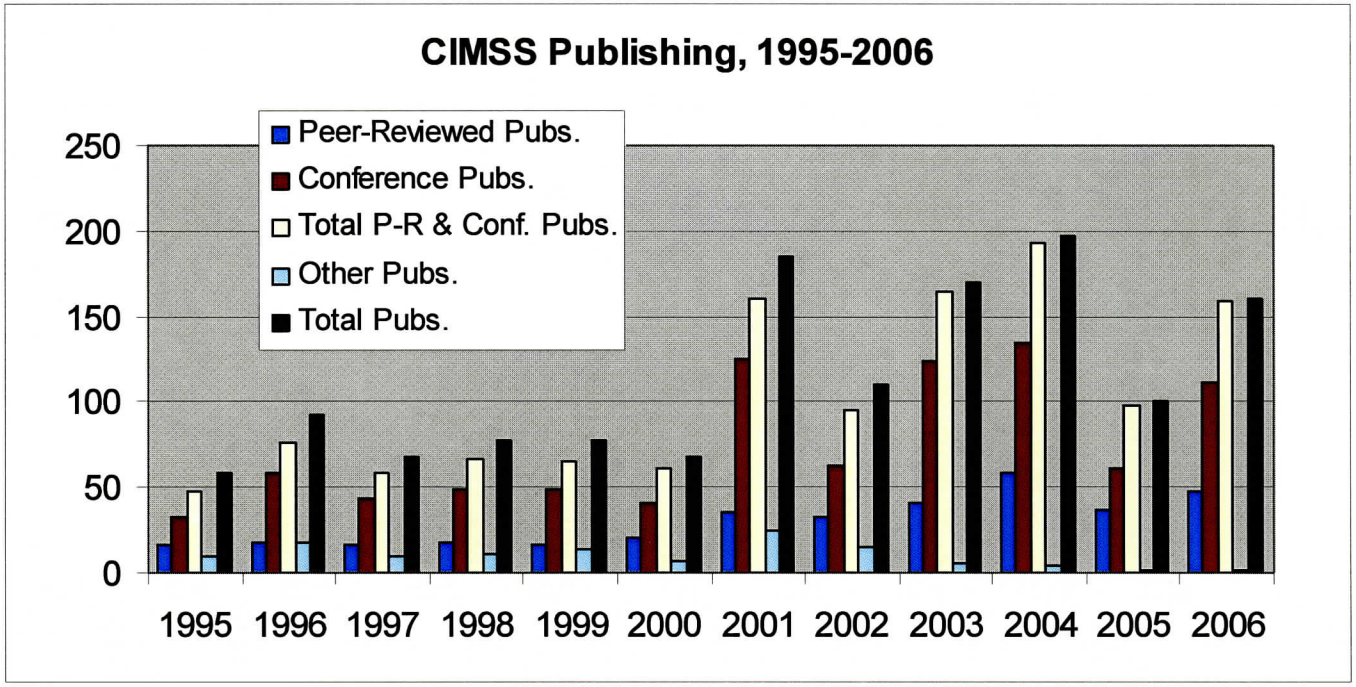
CIMSS Publishing, 1995-2006
(Graph, reviewed and conference publications)

Top 25 Most Frequently Cited Papers of the CIMSS

Top 20 Meteorology and Atmospheric Science Journals

Reviewed Publications of the CIMSS, 2005-2007

Compiled by
Jean M. Phillips, Librarian
Schwerdtfeger Library
May 2007



1) Total publishing is increasing. The number of peer-reviewed papers has tripled since 1995 and conference papers have nearly tripled.
2) The ratio of peer-reviewed publications can be represented as a percentage of total (peer-reviewed + conference). In 1995, peer-review accounted for 33.3%; 1996, 22.3%; 1997, 27%; 1998, 26.8%; 1999, 24.6%; 2000, 32.7%; 2001, 32.7%; 2001, 22.3%; 2002, 33.6%; 2003, 24.8%; 2004, 30.5%; 2005, 37.7%, 2006, 29.5%. Nearly 30% of published papers appear in peer-reviewed literature.
3) CIMSS scientists published a total of 1365 documents during the period 1995-2006. Of those, 458 or about 34% were co-authored by a NOAA scientist. The overall rate of collaboration has been stable .
4) Publishing totals reflect the output of most CIMSS scientists, however, there may be some publications not represented. Because some conference literature is not indexed, some conference paper totals may be low.
5) Data was extracted from Web of Science, Meteorological and Geoastrophysical Abstracts, NTIS, Conference Papers Index, INSPEC and through in-house tracking.
6) As of 3 May 2007, CIMSS scientists have published 19 articles in peer-reviewed journals – about 40% of the total published in 2006 (47). This does not include papers that have been submitted or accepted for publication in 2007.

Top 25 Most Frequently Cited Papers of the Cooperative Institute for Meteorological Satellite Studies For the Period 1995-2006

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1)	**132***	Kaufman, Y. J.; Hobbs, P. V.; Kirchhoff, V. W. J. H.; Artoxo, P.; Remer, L. A.; Holben, B. N.; King, M. D.; Ward, D. E.; Prins, E. M.; Longo, K. M.; Mattos, L. F.; Nobre, C. A.; Spinhirne, J. D.; Ji, Q.; Thompson, A. M.; Gleason, J. F.; Christopher, S. A. and Tsay, S. -C. Smoke, Clouds, And Radiation-Brazil (SCAR-B) experiment. Journal of Geophysical Research, Volume 103, 1998, pp.31,783-31,808
2)	**129**	Platnick, Steven; King, Michael D.; Ackerman, Steven A.; Menzel, W. Paul; Baum, Bryan A.; Riedi, Jerome C., and Frey, Richard A. The MODIS cloud products: Algorithms and examples from Terra. IEEE Transactions on Geoscience and Remote Sensing, Volume 41, Issue 2, 2003, pp459-473.
3)	**110**	Ackerman, Steven A.; Strabala, Kathleen I.; Menzel, W. Paul; Frey, Richard A.; Moeller, Christopher C. and Gumley, Liam E. Discriminating clear sky from clouds with MODIS. Journal of Geophysical Research, Volume 103, 1998, pp.32,141-32,157.
4)	**109**	King, Michael D.; Menzel W. Paul; Kaufmann, Yoram J.; Tanre, Didier; Gao, Bo-Cai; Platnick, Steven; Ackerman, Steven A.; Remer, Lorraine A.; Pincus, Robert, and Hubanks, Paul A. Cloud and aerosol properties, precipitable water, and profiles of temperature and water vapor from MODIS. IEEE Transactions on Geoscience and Remote Sensing, Volume 41, Issue 2, 2003, pp442-458.
5)	**90**	Velden, Christopher S.; Hayden, Christopher M.; Nieman, Steven J.; Menzel W. Paul; Wanzong, Steven and Goerss, James S. Upper-tropospheric winds derived from geostationary satellite water vapor observations. Bulletin of the American Meteorological Society, Volume 78, Issue 2, 1997, pp.173-195. Call Number: Reprint # 2411
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7)	**72**	Wylie, Donald P. and Menzel, W. Paul Eight years of high cloud statistics using HIRS. Journal of Climate, Volume 12, Issue 1, 1999, pp.170-184. Call Number: Reprint # 2545
8)	**60**	Anderson, M. C.; Norman, J. M.; Diak, G. R.; Kustas, W. P. and Mecikalski, J. R. A two-source time-integrated model for estimating surface fluxes using thermal infrared remote sensing. Remote Sensing of Environment, Volume 60, 1997, pp.195-216. Call Number: Reprint # 2445.
9)	**57**	Prins, Elaine M.; Feltz, Joleen M.; Menzel, W. Paul and Ward, Darold E. An overview of GOES-8 diurnal fire and smoke results for SCAR-B and 1995 fire season in South America. Journal of Geophysical Research, Volume 103, 1998, pp.31,821-31,835. Call Number: Reprint # 2511
10)	**55**	Langland, R. H.; Toth, Z.; Gelaro, R.; Szunyogh, I.; Shapiro, M. A.; Majumdar, S. J.; Morss, R. E.; Rohaly, G. D.; Velden, C.; Bond, N. and Bishops, C. H. The North Pacific Experiment (NORPEX-98): Targeted observations for improved North American weather forecasts. Bulletin of the American Meteorological Society, Volume 80, Issue 7, 1999, pp.1363-1384. Call Number: Reprint # 2734.
11)	**53**	Smith, William L.; Knuteson, R. O.; Revercomb, H. E.; Feltz, W.; Howell, H. B.; Menzel, W. P.; Nalli, N. R.; Brown, Otis; Brown, James; Minnett, Peter and McKeown, Walter Observations of the infrared radiative properties of the ocean - Implications for the measurement of sea surface temperature via satellite remote sensing. Bulletin of the American Meteorological Society, Volume 77, Issue 1, 1996, pp.41-51. Call Number: Reprint # 2112.

12)	**46**	Baum, Bryan A.; Kratz, David P.; Yang, Ping; Ou, S. C.; Hu, Yongxiang; Soulen, Peter F. and Tsay, Si-Chee Remote sensing of cloud properties using MODIS airborne simulator imagery during SUCCESS. 1. Data and models. Journal of Geophysical Research, Volume 105, 2000, pp.11,767-11,780. Call Number: Reprint # 2786.
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14)	**42**	Vicente, Gilberto A.; Scofield, Roderick A. and Menzel, W. Paul The operational GOES infrared rainfall estimation technique. Bulletin of the American Meteorological Society, Volume 79, Issue 9, 1998, pp.1883-1898. Call Number: Reprint # 2472.
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19)	**35**	Ackerman, S.A. Remote sensing aerosols using satellite infrared observations. Journal of Geophysical Research-Atmospheres, Volume 102, 1997, pp17069-17079.
20)	**35**	Feltz, Wayne F.; Smith, William L.; Knuteson, Robert O.; Revercomb, Henry E.; Woolf, Harold M. and Howell, H. Ben Meteorological applications of temperature and water vapor retrievals from the ground-based Atmospheric Emitted Radiance Interferometer (AERI). Journal of Applied Meteorology, Volume 37, Issue 9, 1998, pp.857-875. Call Number: Reprint # 2490.
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22)	**31**	Bosart, Lance F.; Velden, Christopher S.; Bracken, W. Edward; Molinari, John and Black, Peter G. Environmental influences on the rapid intensification of Hurricane Opal (1995) over the Gulf of Mexico. Monthly Weather Review, Volume 128, Issue 2, 2000, pp.322-352. Call Number: Reprint # 2677.
23)	**31**	Smith, W. L.; Ackerman, S.; Revercomb, H.; Huang, H.; DeSlover, D. H.; Feltz, W. and Gumley, L. Infrared spectral absorption of nearly invisible cirrus clouds. Geophysical Research Letters, Volume 25, Issue 8, 1998, pp.1137-1140. Call Number: Reprint # 2672.
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25)	**31**	Minnett, P.J. et al. The Marine-Atmospheric Emitted Radiance Interferometer: a High-Accuracy, Seagoing Infrared Spectroradiometer. Journal of Atmospheric and Oceanic Technology, Volume 18, 2001, pp994-1013.

Top 20 Meteorology & Atmospheric Science Journals in 2005 Sorted by Total Cites*

Rank	Abbreviated Journal Title	ISSN	Total Cites	Impact Factor	Immediacy Index	Articles	Cited Half-life
1	ATMOS ENVIRON	1352-2310	16408	2.724	0.352	685	5.6
2	J ATMOS SCI	0022-4928	14369	2.078	1.469	277	>10.0
3	J CLIMATE	0894-8755	11702	3.402	0.373	338	5.8
4	MON WEATHER REV	0027-0644	10122	2.003	0.532	216	>10.0
5	B AM METEOROL SOC	0003-0007	6101	3.055	0.542	83	8.1
6	Q J ROY METEOR SOC	0035-9009	5850	2.033	0.357	143	9.8
7	WATER AIR SOIL POLL	0049-6979	5061	1.258	0.054	205	8.9
8	GLOBAL BIOGEOCHEM CY	0886-6236	4977	3.373	0.838	117	6.0
9	J APPL METEOROL	0894-8763	4756	1.702	0.326	135	>10.0
10	AGR FOREST METEOROL	0168-1923	4038	2.461	0.211	109	6.7
11	ADV SPACE RES	0273-1177	3830	0.706	0.198	283	5.3
12	J AEROSOL SCI	0021-8502	3406	2.477	0.433	90	8.0
13	CLIM DYNAM	0930-7575	3279	3.468	0.630	108	5.3
14	ANN GEOPHYS-GERMANY	0992-7689	3173	1.450	0.557	325	5.0
15	J ATMOS SOL-TERR PHY	1364-6826	3081	1.309	0.226	186	8.0
16	CLIMATIC CHANGE	0165-0009	3023	2.479	0.610	105	6.4

17	BOUND-LAY METEOROL	0006-8314	2986	1.414	0.310	100	>10.0
18	J AIR WASTE MANAGE	1047-3289	2856	1.317	0.380	166	6.4
19	INT J CLIMATOL	0899-8418	2749	1.622	0.421	121	5.8
20	J ATMOS OCEAN TECH	0739-0572	2713	1.527	0.290	145	6.3

*Total Cites is the number of total citations to articles in the journal for the current Journal Citation Reports (JCR) year. 2005 is the most recent year with complete data. All information extracted from Journal Citation Reports 2005. JCR clusters journals based on primary subject, with meteorology, the geosciences and remote sensing selected for examination.

During the period 1995-2006, CIMSS authors published 355 articles in peer-reviewed journals. Of those, 166 or 47% were published in one of the top twenty meteorology and atmospheric science journals with the highest total cites. Another 67 or 19% were published in the Journal of Geophysical Research or Geophysical Research Letters, the two most cited journals in the geosciences.

CIMSS authors also published 23 papers in the primary journals of remote sensing: Remote Sensing of Environment, IEEE Transactions on Geoscience and Remote Sensing, and the International Journal of Remote Sensing.

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