University of Wisconsin-Madison

Cooperative Institute for
Meteorological Satellite Studies (CIMSS)

http://cimss.ssec.wisc.edu/

Cooperative Agreement
Annual Report

for the period
1 October 2007 to 30 September 2008
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Cooperative Agreement Annual Report

1 October 2007 to 30 September 2008

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The work conducted as part of the CIMSS Cooperative Agreement for 1 October 2007 to 30 September 2008 is detailed in this report. While primary authors are noted, the research discussed in this report has been a result of numerous collaborations with other CIMSS and NOAA colleagues.

Appendix

Cooperative Agreement Annual Report
1 October 2007 to 30 September 2008

Steven Ackerman **Thomas Achtor**
Director, CIMSS **Executive Director, Editor**

I. Director's Executive Summary

The National Oceanic and Atmospheric Administration (NOAA) and the University of Wisconsin-Madison have collaborated for nearly three decades in satellite meteorology research. This collaborative relationship between NOAA and the UW-Madison, which led to the establishment of CIMSS, has provided outstanding benefits to the atmospheric science community and to the nation through improved use of remote sensing measurements for weather forecasting, climate analysis and environmental issues. Under the auspices of CIMSS, scientists from NOAA/NESDIS and the UW/SSEC have a formal basis for ongoing collaborative research efforts. UW scientists work closely with NOAA/NESDIS' Advanced Satellite Product Branch (ASPB) stationed here at Madison.

CIMSS continues to excel at meeting the three components of its mission statement. We will briefly describe examples relevant to NOAA that demonstrate how CIMSS scientists, in collaboration with ASPB, are meeting our mission goals. Details on individual projects are provided later in the report.

1. Foster collaborative research between NOAA and UW-Madison in those aspects of atmospheric and earth science which exploit the use of satellite technology.

The first part of the CIMSS mission is to foster collaborative research. Our strong research connections with NOAA are seen in our publications in refereed journal articles; more than 40% of CIMSS publications have at least one NOAA co-author. While very important to a research organization, publications are not the only metric of collaboration. For NOAA, another assessment strategy that CIMSS is meeting its goals is our ability to work with NOAA in transferring research to NOAA operations. We have over two dozen research algorithms that have been moved from our research community at CIMSS to NOAA operations. This year brings more transition successes.

We have very long term collaborations with NOAA developing GOES imager and sounder products. For example, fully automated cloud-drift wind production from GOES became operational in 1996, and wind vectors are routinely used in operational numerical models of the National Centers for Environmental Prediction (NCEP) and elsewhere. These analysis algorithms have been transferred to NOAA, but we continue to make improvements and transfer them to NOAA. For example, CIMSS scientists continue to look into the Expected Error index, a new approach to assigning quality to Atmospheric Motion Vector's (AMVs). CIMSS scientists are now exploring the heritage code to modify and to increase the vertical resolution of the background guess, and to include 101 model levels in the radiative transfer software (instead of 42 levels in the current operations). New research is comparing CALIPSO cloud top heights (CTH) to operational AMVs to see if height assignment can be improved. Unfortunately, GOES is of little use at high latitudes due to the poor viewing geometry. So we work closely with NOAA to generate wind vectors over the polar regions from polar-orbiting satellites. We are now working with NOAA to help transition polar winds products to NESDIS operations.

A new version of the Global+RSO WF_ABBA (biomass burning algorithm) began delivery to NESDIS Operations in late August 2008. Support for Meteosat-8/-9, MTSAT-1R, and all GOES from 8 through 14 is present in this delivery. Latency for product generation is under 5 minutes in most cases, with some exceptions in the cases of full disk images containing a very large number of fires. The process to obtain operational certification is underway.

CIMSS has also worked to transition the Automated Dvorak Technique (ADT) to operational use at NESDIS/SAB. The ADT (version 7.2.3) was given "operational status" at NESDIS/SAB after the Critical Design Review (CDR) held in May 2008, just prior to the beginning of the North Atlantic tropical cyclone (TC) season. This version included several upgrades that addressed some of the issues raised by SAB scientists after their 2007 evaluation, including the issues of ADT initialization and shear scene type intensity overestimation.

We work closely with NOAA to assess satellite product quality. For example, NOAA participates in research promoting and advancing the knowledge of intercalibration techniques through the Global Space-Based Inter-Calibration System (GSICS). CIMSS methodology is part of the intercalibration work adopted by the international GSICS. CIMSS receives requests from various users confirming the calibration accuracy for both domestic and international geostationary imagers. In cooperation with the GOFC/GOLD global geostationary fire monitoring network working group, CIMSS is drafting a working paper for submission to the CGMS Global Space-based Inter-Calibration System (GSICS) panel outlining geostationary satellite data access and characterization needs and issues as they relate to fire monitoring.

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 science.

CIMSS has a strong national and international reputation for developing new methods of analyzing satellite observations. For example, NOAA and CIMSS scientists work side-by-side in developing new applications that support aviation hazards. One hazard is volcanic ash, where volcanic ash forecasters and analysts would benefit from automatic and near real-time ash detection and height estimates, which in turn would help improve the accuracy and timeliness of advisories and forecasts. All volcanic ash products in operations today are imagery based and qualitative, and, as such, do not offer information on mass loading or height. The height and mass loading information are important, since they can be used to initialize dispersion models. CIMSS is developing these analysis methods that can be adapted to the GOES-R ABI instrument. CIMSS is using satellite observations to develop convective initiation Nowcast algorithms. CIMSS current operational GOES sounding products are limited to clear skies only, it is very important to expand the GOES sounding coverage into cloudy skies. Research in this area is very promising.

CIMSS continues to conduct research that supports NOAA's goal for future GOES advanced infrared sounding requirements and definition. Our research continues to demonstrate the needs and value of an advanced sounder on GEO orbit. Working closely with NOAA, CIMSS scientists perform trade studies on the spectral coverage/resolution, spatial resolution, temporal resolution and radiometric resolution.

CIMSS is a strong partner with NOAA and other institutes in the NOAA GOES-R Algorithm Working Group. We are developing and adapting algorithms to meet GOES-R ABI needs. These algorithms span a broad area of topics including cloud detection and properties, atmospheric motion vectors, aviation weather products, lake ice, ozone amounts, surface emissivity and fire detection and characterization. Some of these algorithms leverage research previously supported by other agencies such as NASA. The need to develop appropriate testing tools has developed a new capability at CIMSS – the proxy data sets. In this approach model simulations of weather events are first simulated with the WRF model. The atmospheric conditions are then used to simulate ABI type observations, including noise characteristics. The simulated data sets are then used to test and evaluate algorithms.

In addition to supporting the next generation geostationary weather satellite, CIMSS scientists work closely with the NOAA/ASPB scientists stationed in Madison to support the next generation polar satellite instruments, including NPP/NPOESS. We support calibration/validation activities, and cloud and sounding algorithm work.

3. Stimulate the training of scientists and engineers in those disciplines comprising the atmospheric and earth sciences.

CIMSS continues to support NOAA's education goals. NOAA supplies research funds to support graduate and undergraduate student research projects. CIMSS' relationship with the UW-Madison Department of Atmospheric and Oceanic Sciences currently provides graduate student research support to more than a dozen students per year. The education/research center link provides an excellent path for young scientists entering geophysical fields. CIMSS participated in the CoRP 2008 symposium held on the University of Oregon campus on 12 - 13 August 2008, with an estimated 60 people attending from the NESDIS Cooperative Institutes and local CIOSS participants. Steve Ackerman, Director of CIMSS, attended the symposium along with 3 Ph.D. students (E. Hokanson, T. Wagner and Z Li) and one beginning M.S. student (K. Vincent).

Annie Lenz, an undergraduate student won the American Meteorological Society's Macelwane award, which recognizes an original student research paper. She worked with CIMSS scientists studying transverse bands and turbulence using satellite observations and aircraft reports of turbulence. She is currently attending graduate school at Purdue.

We work in collaboration with NOAA and other cooperative institutes in developing training resources for NOAA. For example, we work with the National Weather Service (NWS) to provide the means to get more satellite data products into forecast offices as well as to support the training needed to interpret these images and products. The primary tool used by NWS meteorologists for viewing current weather information is the Advanced Weather Interactive Processing System (AWIPS). The potential exists for the creation and deployment of experimental satellite imagery and products into AWIPS, particularly from the Geostationary Operational Environmental Satellite (GOES) Sounder, that can enhance operations at NWS forecast offices nationwide. The recent capability at CIMSS to fully run the AWIPS environment locally, as well as to provide CIMSS satellite data and products into the AWIPS data stream is being leveraged to advance the exposure and overall usage of such satellite data (geo and polar) in the NWS.

We continue to provide outreach to pre-college (K-12) education. As an example, CIMSS hosted 28 middle and high school science teachers from around the country on 9 - 10 July 2008 at a workshop on Geoscience Time Scales and Global Climate Change at the University of Wisconsin-Madison. This NOAA-supported event covered the topics of weather and climate, geological time and global climate change with an effort to support teaching and learning related to the 2007 Intergovernmental Panel on Climate Change (IPCC) Summary for Policy Makers. In August, a new module detailing the advantages of the ABI instrument planned for GOES-R was added to the CIMSS *Satellite Meteorology for Grades 7-12* on-line course. Updated course CDs are freely distributed at events like the Teacher/Student Day of the 2008 Direct Broadcast Conference in Miami and the Education Symposium at the 2009 AMS Conference in Phoenix.

The above are but a few examples of how CIMSS worked with NOAA this year to achieve our mission goals. Details of these and additional projects follow.

II. Background Information on the Cooperative Institute for Meteorological Satellite Studies (CIMSS)

1. Description of CIMSS, including research themes, vision statement and NOAA research collaborations

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) was formed through a Memorandum of Understanding between the University of Wisconsin–Madison (UW–Madison) and the National Oceanic and Atmospheric Administration (NOAA. The CIMSS formal agreement with NOAA began in 1980. The CIMSS mission includes three goals:

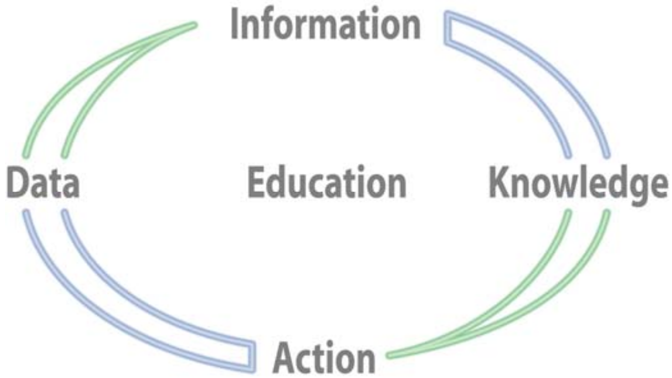
- Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science that exploit the use of satellite technology;
- Serve as a center at which scientists and engineers working on problems of mutual interest can focus on satellite-related research in atmospheric and earth system science;
- Stimulate the training of scientists and engineers in the disciplines involved in atmospheric and earth sciences.

To achieve these mission goals CIMSS conducts a broad array of research and education activities, many of which are projects funded through this Cooperative Agreement with NOAA. This Cooperative Agreement identifies six CIMSS themes, five science research themes and one outreach theme:

1. Weather Nowcasting and Forecasting
2. Clouds, Aerosols and Radiation
3. Global Hydrological Cycle
4. Environmental Trends
5. Climate
6. Education, Training and Outreach

The collaborative relationship between NOAA and the UW-Madison, which led to the establishment of CIMSS, has provided outstanding benefits to the atmospheric science community and to the nation through improved use of remote sensing measurements for weather forecasting, climate analysis and environmental issues. CIMSS research investigations increase understanding of remote sensing and its numerous applications to weather and nowcasting, clouds, aerosols and radiation, the global hydrological cycle, environmental trends, and climate, as well as education and outreach.

CIMSS scientists are engaged in a broad array of research activities ranging from using GOES measurements to estimate the intensity of Atlantic basin hurricanes to designing the next generation satellite instruments. Our research process is represented in the figure below. Algorithms are developed and applied to observations (data) to yield information about Earth. We apply this information to gain knowledge about the Earth system, knowledge that can be utilized in decision-making processes. As we rely on this knowledge to take action we come to realize the need for better observations, and work with our partners, particularly those in SSEC, in designing and testing improved instrumentation. At the center of this research process is education, the training of students and ourselves.



CIMSS conducts a broad array of activities that engages researchers and students in a variety of research and education endeavors

CIMSS plays a unique role to NOAA as a non-profit partner, advisor, consultant and link to UW-Madison students and researchers. As a long-term partner of NOAA, CIMSS helps to serve as part of the NESDIS corporate memory, particularly when government staff change positions and roles. For example, original CIMSS/SSEC staff associated with GOES VAS (the 1st geostationary sounder) and GOES-8/12 design, testing, and checkout are now assisting with similar activities in GOES-R. In addition to bringing "corporate memory" to this new GOES program, the senior staff help to train the next generation of CIMSS scientists who will support future partnerships between CIMSS and NOAA.

CIMSS scientists work side-by-side with the NESDIS/STAR/ASPB (Advanced Satellite Products Branch) scientists who are stationed in Madison. Being collocated in the same building and having similar research interests fosters powerful ties and collaborations. One example of this strong relationship with ASPB is that approximately 40% of the publications in refereed journals by CIMSS scientists include at least one NESDIS colleague stationed at Madison. In addition to working with CIMSS scientists, ASPB scientists often mentor graduate students on research projects. These research projects address NOAA needs while helping to satisfy UW-Madison degree requirements. Based on this positive experience, some of these students go on to work with NOAA.

CIMSS' maintains a close collaboration with the NOAA Office of Systems Development (OSD) as part of the NOAA support team for the future GOES-R ground system development systems. CIMSS also interacts with the Office of Satellite Data Processing and Distribution (OSDPD) in the transfer of research techniques and algorithms developed at CIMSS in collaboration with ASPB, to NOAA operations. Nearly two dozen research algorithms developed at CIMSS have been utilized by NESDIS operations. Through specific research projects, CIMSS has a strong research collaboration with the NPOESS Integrated Program Office (IPO), supporting the instrument design and algorithms of the next generation operational imager and sounder on polar satellites.

Within the NOAA National Weather Service (NWS), CIMSS collaborates on data assimilation projects with the National Centers for Environmental Prediction (NCEP). The CIMSS tropical cyclone research team maintains close collaboration on new products development with the Tropical Prediction Center (NCEP/TPC) in Miami. CIMSS works with the Storm Prediction Center (NCEP/SPC) in Norman, OK on satellite applications to severe weather analysis and forecasting. CIMSS collaborates with the Aviation Weather Center (NCEP/AWC) in Kansas City on aviation safety projects that utilize weather satellite data. CIMSS scientists are involved with local NWS offices on specific projects, and maintain close ties with NWSFOs in Milwaukee/Sullivan, La Crosse and Green Bay. Finally, CIMSS works with CIRA and the COMET office through the NWS Training Center to participate in the VISIT and SHyMet programs.

2. CIMSS management and administration

CIMSS resides as an integral part of the Space Science and Engineering Center (SSEC). CIMSS is led by its Director, Dr. Steven Ackerman, who is also a faculty member within the UW-Madison Department of Atmospheric and Oceanic Sciences. Executive Director Thomas Achtor provides day-to-day oversight of the CIMSS staff, science programs, and facilities. The individual science projects are led by University Principal Investigators (PIs) in conjunction with a strong and diverse support staff who provide additional expertise to the research programs. CIMSS is advised by a Board of Directors and a Science Advisory Council.

The CIMSS administrative home is within the Space Science and Engineering Center (SSEC), a research and development center within the UW–Madison's Graduate School. The SSEC mission focuses on geophysical research and technology to enhance understanding of the Earth, other planets in the Solar System, and the cosmos. To conduct its science mission on the UW-Madison campus, SSEC has developed a strong administrative and programmatic infrastructure. This infrastructure serves all SSEC/CIMSS staff.

SSEC support infrastructure includes:

- **Administrative support**
  The administrative support team includes 13 full-time staff and several students providing services that include human relations, proposal processing and publishing, grant and contract management, accounting, financial programming, purchasing and travel.

- **Technical Computing**
  The technical computing support team includes 5 full-time staff and several students providing consultation and implementation on system design, networking infrastructure, and full support for Unix and pc computing.

- **Data Center**
  The SSEC Data Center provides access, maintenance, and distribution of real-time and archive weather and weather satellite data. The Data Center currently receives data from 8 geostationary and 6 polar orbiting weather satellites in real time and provides a critical resource to SSEC/CIMSS researchers.

- **Library and Media**
  SSEC maintains an atmospheric science library as part of the UW–Madison library system. A full time librarian is on staff and two part time assistants. SSEC also employs a full time media specialist to support the dissemination of information on scientist activities and research results and to develop in-house publications.

- **Visualization Tools**
  SSEC is a leader in developing visualization tools for analyzing geophysical data. The Man-computer Interactive Data Access System (McIDAS), Vis5D and VisAD software are used worldwide in a variety of research and operational environments. The VISITview software is used extensively as a tele-training tool by the NWS and others.

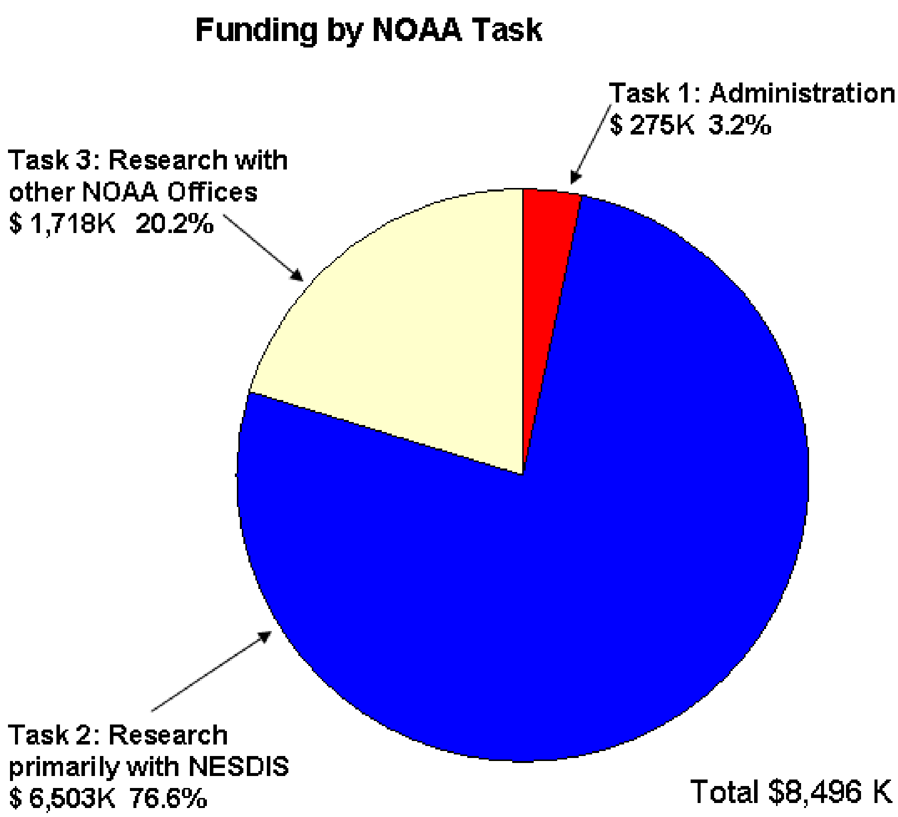
3. NOAA funding summary by task, strategic goal and theme

In 2008, funding to CIMSS through this Cooperative Agreement totaled $8.4M. The following tables and graphics show the distribution of these funds by Task, by NOAA Strategic Goal and by CIMSS Research and Outreach Theme.

Funding by NOAA task:

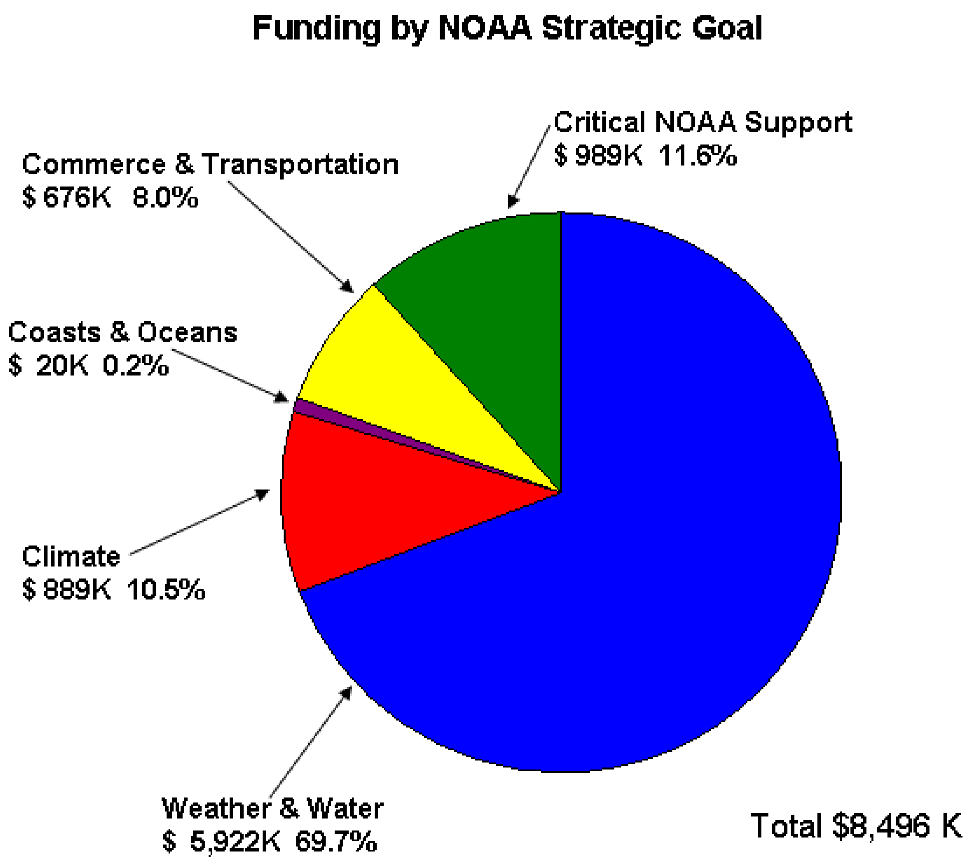
CIMSS Task	Funding in dollars	Percentage
Task 1: Administration	$ 275,000K	3.2%
Task 2: Research primarily with NESDIS	$ 6,503,000K	76.6%
Task 3: Research with other NOAA Offices	$ 1,718,000K	20.2%
	$ 8,496,000K	

Note: Integrated Program Office (IPO) funding through the Cooperative Agreement is referenced as Task 3 work; funding amount is $1,639K



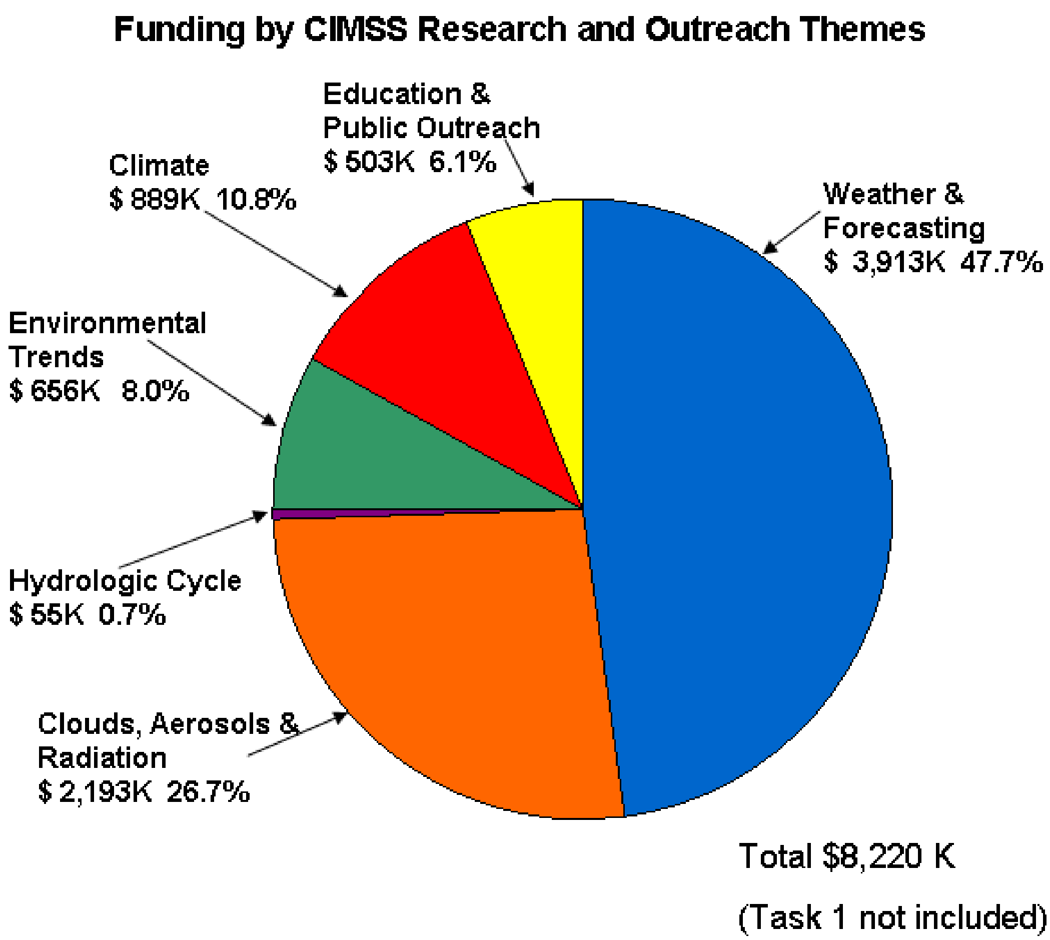
Funding by NOAA Strategic Goal:

NOAA Strategic Goal	Funding in dollars	Percentage
Weather and Water	$ 5,922,000	69.7%
Climate	$ 889,000	10.5%
Coasts and Oceans	$ 20,000	0.2%
Commerce and Transportation	$ 676,000	8.0%
Critical NOAA Support	$ 989,000	11.6%
	$ 8,496,000	



Funding by CIMSS Research and Outreach Themes

CIMSS Theme	Funding in dollars	Percentage
Weather and Forecasting	$ 3,913,000	47.7%
Clouds, Aerosols and Radiation	$ 2,193,000	26.7%
Hydrologic Cycle	$ 55,000	0.7%
Environmental Trends	$ 656,000	8.0%
Climate	$ 889,000	10.8%
Education and Public Outreach	$ 503,000	6.1%
	$ 8,220,000 (Task 1 not included)	



4. Board and Council membership

CIMSS Board of Directors

The Board of Directors meets formally approximately once a year to review the policies, research themes, and priorities of CIMSS, including budget and scientific activities. The Board is also responsible for approving the appointment of members to the Science Advisory Council. The most recent Board of Directors meeting was held in May 2007. Current Board of Directors members include:

Martin Cadwallader, Chair	Dean, UW-Madison Graduate School
Steven A. Ackerman	Director, CIMSS, UW-Madison
Henry E. Revercomb	Director, SSEC, UW-Madison
Jonathan MartinChair,	Dept. of Atm. and Oceanic Sciences, UW-Madison
Mary Kicza	Asst. Admin. for Satellite & Information Svcs., NOAA/NESDIS
Alfred Powell	Director, Ctr. for Satellite Appl. and Research, NOAA/NESDIS
Jeff Key	Chief, Advanced Satellite Products Branch, NOAA/NESDIS
Colleen Hartman	Science Deputy Associate Administrator, NASA
Franco Einaudi	Dir., Earth-Sun Expl. Div., NASA Goddard Space Flight Center
Lelia Vann	Director, Science Directorate, NASA Langley Research Center

CIMSS Science Advisory Council

The Science Advisory Council advising the CIMSS Director in establishing the broad scientific content of CIMSS programs, promoting cooperation among CIMSS, NOAA, and NASA, maintaining high scientific and professional standards, and preparing reports of CIMSS activities. The Science Council normally meets every 1-2 years; however, the last Council meeting was held in August 2004. Science Council members include.

Allen Huang	Distinguished Scientist, CIMSS
Chris Velden	Senior 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, Dept. of Atmospheric Science, Colorado State Univ.
Bob Ellingson	Professor, Department of Meteorology, Florida State University
Arnold Gruber*	Leader, Hydrology Team, NOAA/NESDIS/ORA
Ingrid Guch	Chief, Atmospheric Res. 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

* - affiliation has changed since retirement from government

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III. Project Reports

1. CIMSS Base

CIMSS Project Leads: Steve Ackerman, Tom Achtor
CIMSS Support Staff: Maria Vasys, Leanne Avila, Wenhua Wu, Jenny Stepp
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
2. Understand climate variability and change to enhance society's ability to plan and respond
3. Protect, restore and manage the use of coastal and ocean resources through an ecosystem approach to management
4. Support the nation's commerce with information for safe, efficient and environmentally sound transportation
5. Provide critical support for the NOAA mission

Proposed Work

The CIMSS Task 1 funding supports activities related to CIMSS administration and non-research programs that are important to the workplace environment of CIMSS. Partial administrative support is provided for the CIMSS Director, Executive Director, the Program Assistant, and the CIMSS Webmaster. Task I activities also includes leveraging support for education and outreach projects, per diem support for visiting scientists, post doctoral positions and 1st year graduate students.

Summary of Accomplishments and Findings

The CIMSS Task I funded supported a major redesign of the CIMSS web page (see http://cimss.ssec.wisc.edu/). All top level pages were redesigned to improve accessability. An innovative approach to the research pages allows users to access CIMSS research projects via three paths; alphabetically, by observing platform and by CIMSS research theme.

CIMSS Task I funds also partially supported the expanded development of the PDA Annimated Weather (PAW) project. The creation of satellite and other meteorological products for cellular phones has been a great success in terms of the number of web site hits (see http://www.ssec.wisc.edu/data/paw/). Over the road truckers and many others have sent email thanking the CIMSS developer, Russ Dengel, for making these data and images available. Unfortunately, the project has not been able to secure independent funding; the developer has done much of this work on his own time. The CIMSS Task I funds were used to purchase a new server for the data and for the Mr. Dengel to set up the server.

In 2008, CIMSS Task I funds supported Ms. Agnes Lim, a new graduate student. Ms. Lim has not yet chosen a research topic for her M.S. degree research. CIMSS Task I funds are used in part for new students who are working towards choosing their topic.

2. GIMPAP (GOES Improved Measurements and Product Assurance Program)

2.1. Development of GOES Single Field of View (SFOV) Cloudy Sounding Product

CIMSS Project Leads: Jun LI
CIMSS Support Scientists: Zhenglong Li, Jim Nelson
NOAA Collaborator: Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
4. Support the nation's commerce with information for safe, efficient and environmentally sound transportation

Proposed Work
Current operational GOES sounding products are limited to clear skies only, it is very important to expand the GOES sounding coverage into cloudy skies. In addition, handling surface IR emissivity in the retrieval process is very important for better moisture profiles. The proposed work tasks in 2008 are:

1. Develop cloudy sounding algorithm in thin and low clouds;
2. Deal with emissivity (test three approaches);
3. Validate cloudy sounding algorithm against RAOB and in-situ measurements;
4. Apply cloudy sounding and stability products to storm cases.

Summary of Accomplishments and Findings

1. A GOES cloudy single field-of-view (SFOV) sounding algorithm has been developed based on a statistical approach.
2. Soundings are performed in FOVs where low opaque, low thin, and high thin clouds are suspected with cloud optical thickness (COT) less than 2 (COT<2). Low opaque clouds can be accommodated by setting the surface pressure to cloud-top pressure (CTP), making the surface emissivity equal to one, and performing a physical retrieval.
3. The area of non-retrieval due to clouds is reduced by 57% in one case study. In areas of convective development, the increased sounding coverage helps to depict destabilization hours earlier.
4. Two emissivity approaches are tested in the GOES clear sky sounding retrieval; we found that emissivity has more impact on land surface temperature retrieval than water vapor, further investigations are ongoing.
5. A manuscript on GOES cloudy sounding has been submitted to the Journal of Geophysical Research, and materials have been supplied to STAR (Center for Satellite Applications and Research) scientist Steve Goodman for his nowcasting application talk at the 2008 EUMETSAT satellite conference.

A GOES SFOV cloudy sounding algorithm is being developed. Since the moisture forecast is often worse in cloudy situations than that in the clear skies, GOES SFOV cloudy soundings can improve moisture forecast in some cloudy situations, for example, in thin or low clouds. Unlike the operational GOES retrieval algorithm for clear skies, the GOES SFOV cloudy sounding algorithm (GCSA) starts with a synthetic regression technique. A GOES Sounder cloudy radiative transfer model accounting for molecular absorptions, cloud absorptions and scattering, has been adapted in the synthetic regression algorithm development for GOES cloudy sounding retrieval. Preliminary results are encouraging. Figure 2.1.1 (a) shows GOES relative humidity (RH) root mean square error (RMSE) and bias under thin cloud situations. ARM Cart Site radiosondes (RAOBs) and collocated GOES SFOV cloudy soundings are included in the statistics. Below 500 hPa, the Global Forecast System (GFS) forecast (first guess) has an RH RMSE around 15%. Even in the upper atmosphere, the RMSE is around 35%. The GOES cloudy retrieval error pattern remains the same as the first guess except all the magnitude is reduced. Figure 2.1.1 (b) shows the 3 layer precipitable water (PW) in Sigma coordinates. As expected, PW3 is improved significantly; both the RMSE and the bias are reduced. PW1 has the same improvement although not as much as PW3. PW2 is not improved in both RMSE and bias.

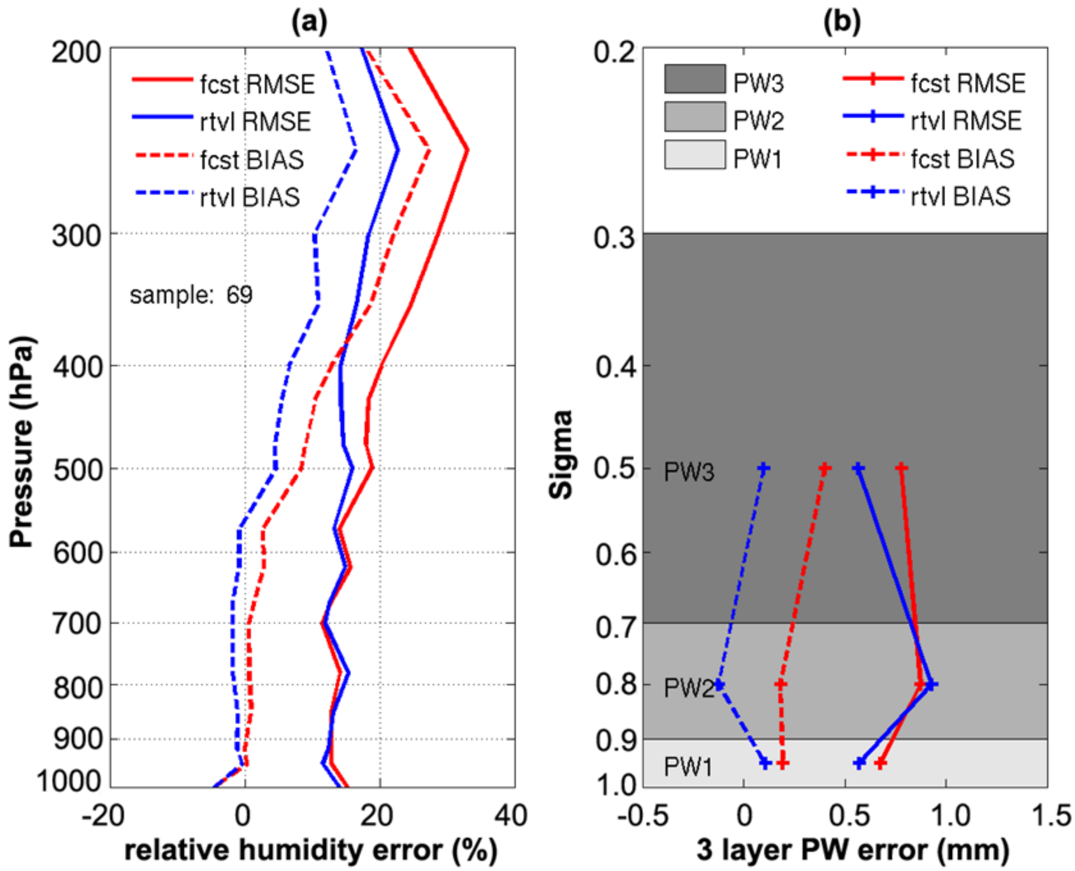


Figure 2.1.1. Error and bias profiles of (a) RH and (b) 3 layer PW for thin clouds with retrieved cloud optical thickness (COT at 0.55 μm) less than 2.0

We also studied GOES SFOV cloudy soundings in low cloud situations; the presence of low clouds typically does not change the radiances too much due to small temperature contrast between the surface and the cloud top. Therefore, with the same cloud optical thickness, low clouds introduce more retrieval errors than ice clouds. Under the low clouds (defined as retrieved cloud-top pressure greater than 850 hPa), the NCEP GFS forecast performs very well (see 1.1.2(a)); the relative humidity (RH) absolute RMSE is less than 10% between 500 and 600 hPa, and less than 20% almost the whole profile below 200 hPa. Closer to the surface, the effect of low clouds becomes more significant. Unlike under the thin clouds, Figure 2.1.2 (a) shows that the retrieval algorithm is able to improve the whole forecast moisture profile above the cloud top. Again, larger improvement is found in the upper atmosphere than in the lower atmosphere. This is even clearer in Figure 2.1.2 (b). Both PW3 (300 – 700 hPa) and PW2 (700 – 900 hPa) have significant improvement. PW1 (900 – Surface), even with surface observations, does not show any improvement at all.

The difference between the low clouds and the thin clouds is that the former could be regarded as thick. Radiation from below the clouds is negligible. It is like the surface is being lifted to the height of the effective cloud top. The lifted surface still has positive impact on PW2 and PW3, and it has neutral impact on PW1. Although the surface observations could help improve retrievals near the surface, the lack of radiation from below the clouds restricts the improvements to close to the surface.

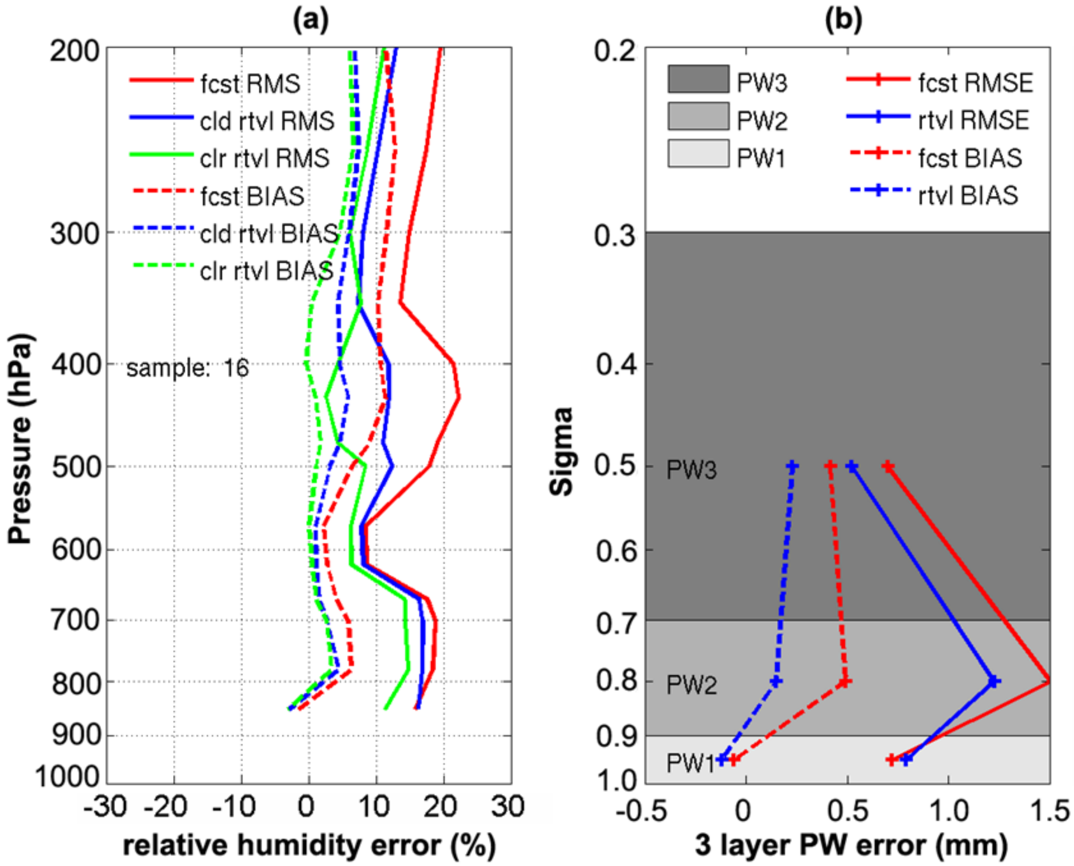


Figure 2.1.2. Error profiles of (a) RH and (b) 3 layer PW for low clouds with retrieved CTP larger than 850 hPa. The green lines show the clear-sky physical retrieval results with surface at the effective cloud top. The dotted red line is for NCEP GFS forecast bias, the solid red line is for NCEP GFS forecast RMSE, the dotted blue line is for cloudy retrieval bias, and the solid blue line is for cloudy retrieval RMSE. The shaded areas denote the vertical coverage for each PW.

In the GOES cloudy sounding algorithm, the CTP and cloud phase are retrieved simultaneously with temperature and moisture profiles. Figure 2.1.3 shows the retrieved CTP (upper right), cloud phase (lower left), along with the composite imager (upper left) for 13 April 2006. The retrieved CTP and cloud phase are consistent with the composite image. Except the “other” clouds, the soundings are retrievable as indicated in the lower right panel of Figure 2.1.3.

Handling surface IR emissivity in sounding retrieval is very important, currently two approaches are tested: (a) using regression derived emissivities; and (2) using the CIMSS baseline fit (BF) emissivity database. Preliminary results show that emissivity has more impact on surface skin temperature retrieval than the moisture. Further investigations on optimal emissivity approach for GOES sounding retrieval are ongoing.

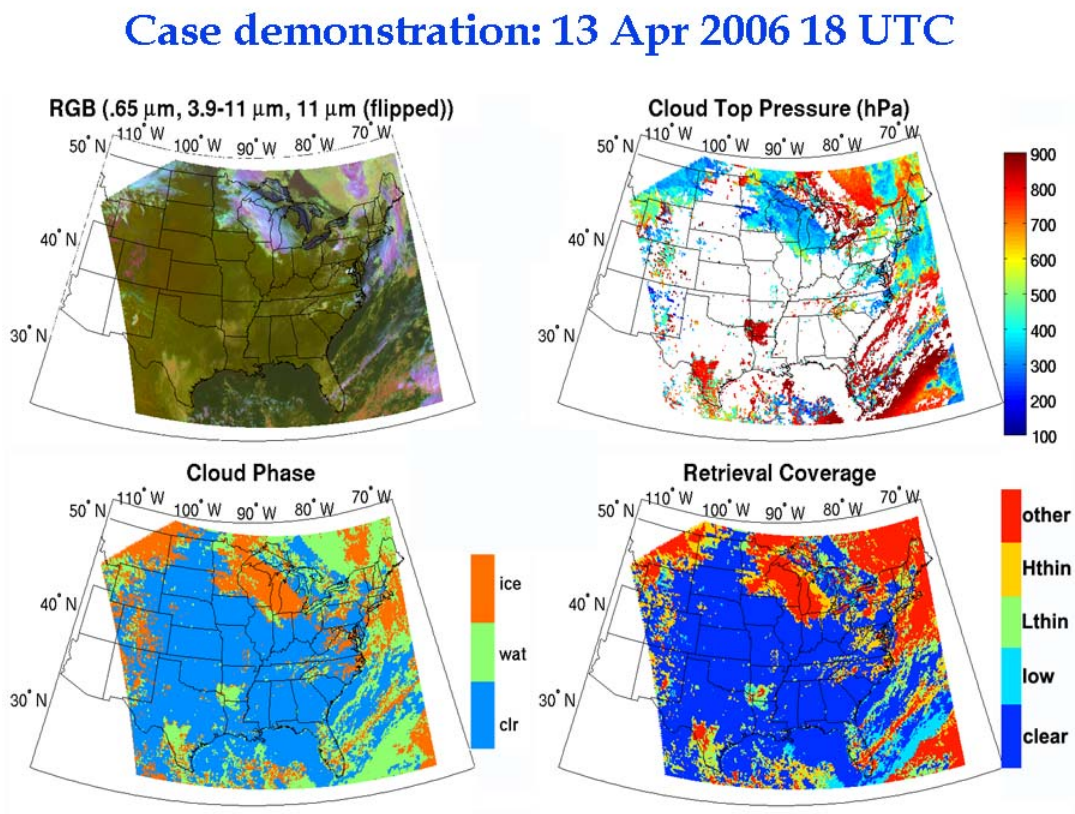


Figure 2.1.3. The retrieved CTP (upper right), cloud phase (lower left), along with the composite imager (upper left) for 13 April 2006.

Publications and Conference Reports

Li, Z., J. Li, W. P. Menzel, T. J. Schmit, J. P. Nelson, III, J. Daniels, and S. A. Ackerman, 2008: GOES sounding improvement and applications to severe storm nowcasting, Geophys. Res. Lett., 35, L03806, doi:10.1029/2007GL032797.

Li, Z., J. Li, W. Paul Menzel, and T. J. Schmit, 2008: High Temporal Resolution Atmospheric Soundings from GOES Sounder and Applications, presentation at PIERS2008 - Progress In Electromagnetics Research Symposium, Hangzhou, China, 24 – 28 March 2008.

Li, Z., J. Li, W. Paul Menzel, et al., 2008: Forecasting and nowcasting improvement in cloudy regions with high temporal GOES Sounder infrared radiance measurements. Journal of Geophysical Research Letter – Atmosphere (submitted).

Li. Z., J. Li, W. Paul Menzel, et al., 2008: Forecasting and nowcasting improvement in cloudy regions with high temporal GOES Sounder infrared radiance measurements. Poster presentation at 3rd AWG annual meeting, 23 – 26 June 2008, Madison, WI.

2.2. GOES Atmospheric Motion Vectors (AMV) Research

CIMSS Project Lead: Chris Velden
CIMSS Support Scientists: Steve Wanzong, Howard Berger, Iliana Genkova
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
4. Support the nation's commerce with information for safe, efficient and environmentally sound transportation

Proposed Work

Our primary goal in this project is to continue to develop new approaches aimed at advancing the NOAA/NESDIS AMV processing algorithm. In this reporting period, we continued to look into the Expected Error index, a new approach to assign quality to AMVs. Also (leveraged with a G-PSDI project), initial heritage code exploration has been started to increase the vertical resolution of the background guess, and to include 101 model levels in the radiative transfer software (instead of 42 levels in the current operations). Finally, a new approach comparing CALIPSO cloud top heights (CTH) to operational AMVs is also being studied.

Summary of Accomplishments and Findings

The CIMSS winds-tracking software continues to be modified to allow for increased vertical resolution of the background model. Background guess specific parts of the software have been identified. A dataset has been compiled. Coding changes and testing will take place in the next reporting period. Finer detail in height assignment will result, with impact especially in areas with inversions.

One of the strong messages from recent International Winds Workshops continues to be that the data assimilation community could use more information on vector characterization and quality. During this reporting period we have continued to test and modify a regression-based quality indicator referred to as the "Expected Error" (EE). This index is designed to attach to every AMV record and indicate the confidence in the form of an expected vector RMSE (in units of m/s). The EE indicator is an extension of the EUMETSAT QI (quality indicator) QI. It linearly regresses the five QI tests along with other vector and model information against actual AMV/RAOB vector differences.

The primary motivation for developing the EE is to see if it can replicate (in a simpler framework) the current quality control performance of the operational AMVs. The operational QC uses a combination of the 'complicated' recursive filter (RF), and QI. A quality baseline from the performance of the existing RF/QI was established. Pre- and post-RF GOES-12 IR AMVs were matched against collocated RAOBS from 03 August - 01 October 2007. AMVs with QI scores less than 0.5, or those with vector differences from the RAOBs greater than 30 ms^{-1} were excluded from the comparisons (as is done in operationally-produced AMV datasets by NESDIS). Our match criteria dictated that the AMVs be within 150 km in the horizontal and 25 hPa in the vertical from their matching RAOBs. Results indicate that the post-RF data have a lower RMSD and bias relative to the pre-RF data. Nearly 10,000 AMVs are removed via the quality control, but the average RAOB speed of both datasets is nearly the same. Thus, by effectively removing bad AMVs and making mostly minor speed/height adjustments to some of the AMVs, the RF significantly improves the quality of the GOES AMV dataset as compared to verifying RAOBS.

Having established this AMV quality baseline, the question that this study attempts to address is whether the EE scheme can provide a similar quality dataset to that of the post-RF dataset? To address this question, EE regression coefficients were generated for the period described previously. Separate coefficients were generated for the pre- and post-RF AMVs. The EE was then used as a threshold maximum in order to select AMVs with the lowest predicted error. Empirical studies indicated that an EE threshold of 6 ms^{-1} gave comparable RMSD statistics to the post-RF dataset. The impact of this threshold indicates that while the RMSD are fairly similar for both datasets, the baseline post-RF dataset retains many more AMVs in the upper-levels, a smaller speed bias at all levels, and higher average mean RAOB speeds (implying faster AMVs are retained). Thus, reducing the EE maximum threshold reduces the average AMV speed in the dataset. Because of this, some AMVs that have low error are removed from the dataset simply because their speed is high. A technique has been developed to alleviate this issue. It involves utilizing the QI's property of preferentially retaining higher speed AMVs. The strategy is as follows:

1. For slow AMVs, use a hard EE threshold.
2. For fast AMVs, retain AMVs that have high QI values regardless of their EE value.

The thinking behind this methodology is that the EE is superior at identifying the quality of relatively slow AMVs. The QI appears better with relatively faster AMVs of good quality. Thus, it is conceivable that the two approaches can be used in tandem. The trick is in choosing the appropriate AMV speed thresholds and corresponding QI tolerances. This is an area of continuing research.

An observation that fell out of these tests is that the linear regression assumes that the predicted variable (AMV-RAOB difference) is normally distributed. This is not the case because the predicted variable, by definition, cannot be less than zero. The EE regression, however, can produce EE values that are negative. The solution to this problem is to transform the predicted variable using the logarithmic function. The following equation can be used:

$$\log(AMV - RAOB + 1) = b_0 + b_1 x_1 + b_2 x_2 + .. + b_9 x_9$$

where b_i represents the new coefficients from the transformed linear regression. Once the regression is completed, the error values can be recovered by using an exponential function. The advantage of this new approach is that when the EE is calculated using the coefficients in the new equation, the minimum possible EE value is 0. The old implementation allows an EE with no minimum value (i.e. negative EEs are possible).

The other major area of AMV research involves the assignment of heights. A newly available tool for comparison studies is CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation). Its data and derived products provide information regarding cloud physical properties. In particular to our project, CALIPSO's Cloud Top Height (CTH) product is viewed as a potential validation source for the ABI AMV altitude assignments. A collocation approach for the CALIPSO cloud height products and the AMV heights was developed at CIMSS, and is graphically shown in Figure 2.2.1 below.

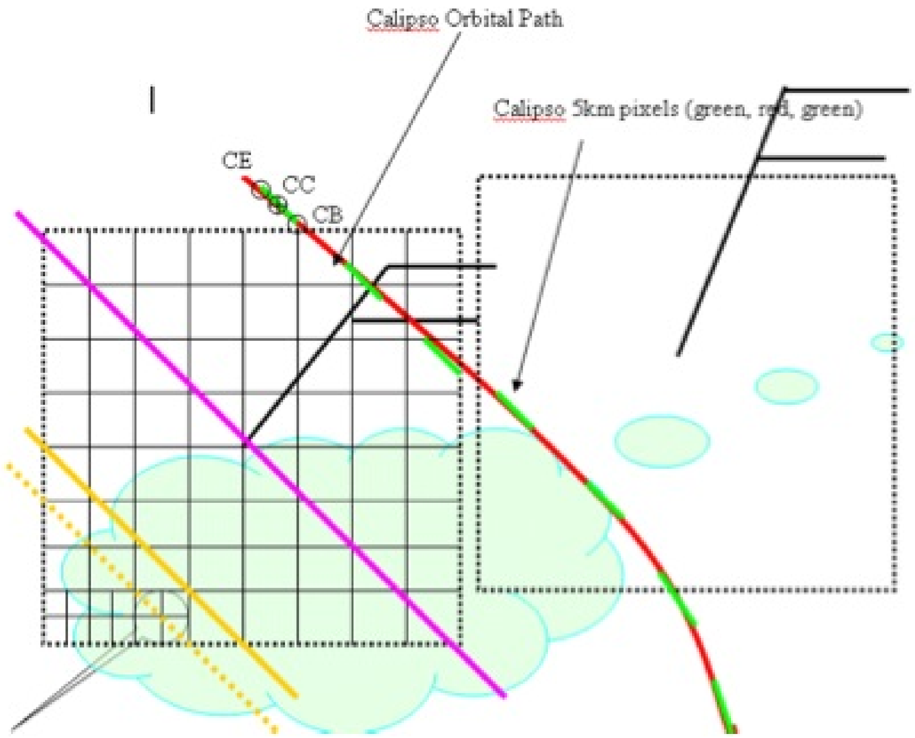


Figure 2.2.1. Schematic showing the collocation approach for CALIPSO and AMV observations. A CALIPSO orbital path is shown with red and green segments being the subsequent 5 km pixels of the CALIPSO CTH product. For each CALIPSO 5km pixel, the CALIPSO Beginning (CB) pixel latitude and longitude, the CALIPSO Center (CC) pixel latitude and longitude, and the CALIPSO Ending (CE) pixel latitude and longitude are shown. These latitude/longitude pixel locations will be used to co-locate the GOES/SEVIRI/ABI AMV locations. Two AMVs (indicated by the wind barbs) are shown as well with their corresponding target boxes. For the left AMV, the target box is gridded in order to illustrate how the 15x15 wind image pixels co-locate spatially with the CALIPSO pixels.

The maximum allowed distance between an AMV target center and a CALIPSO orbit is approximately 30km. To compare the heights from winds and CALIPSO there must be overlap, where overlap is defined to occur only when cloudy pixels are present. A minimum number of overlapping pixels should be required to assure the comparisons will be physically meaningful. This minimum number will be determined empirically through testing.

Another approach for collocating CALIPSO's 5km resolution Cloud Layer Product observations with cloud tracked AMVs derived from the current operational AMV algorithms (via windco software) has been developed and implemented. Given an AMV target center location, CALIPSO measurements within 0.3 degrees (U and V-wise) of this location are determined. This assures that all the CALIPSO measurements fall within the 15x15 pixel AMV target box. On average, about 20-30 cloudy CALIPSO pixels and their associated cloud height products could be used to compare to one AMV. So far we have compared the AMV target altitude to: 1) the one pixel nearest in distance to the AMV target center; 2) the median of all available CALIPSO pixels, 3) the median of the heights from pixels showing cloud tops above the 25th percentile of all heights. This last idea is similar to how we chose what target pixels to be used to assign a height to an AMV. While only a qualitative comparison has been done so far, it demonstrates that the validation approach taken is a viable one. There are some limitations though. First, and foremost, is the existence of a time lag between the GOES (or SEVIRI) images and the CALIPSO data. In the example shown above, the SEVIRI height assignment image is from 12Z, while the CALIPSO orbit starts at 11: 50Z and ends about 20 minutes later. This is one of the best possible matches in time possible between these two datasets. Overpasses this close in time are rare. This limits the sample size of the validation datasets. A second limiting factor is the need to convert the units of cloud heights, determined from the passive IR instruments, from pressure (in hPa) to altitude (in km). This requires some knowledge of the ambient atmospheric temperature profile (i.e., standard atmosphere or from NWP), which can add a measure of uncertainty to the cloud height retrieval.

Further study indicates that the CALIPSO 1km CTH product is optimal for the AMV comparisons. The CALIPSO 5km CTH product, while having the best signal to noise ratio, is extremely sensitive to thin, semi-transparent cirrus clouds. The 333m CTH product reports clouds only at 8km and below. All future comparisons will be with the 1km CTH product.

Publications and Conference Reports

Berger, Howard; Velden, C.; Wanzong, S. and Daniels, J.: Assessing the 'Expected Error' as a potential new quality indicator for atmospheric motion vectors. 9^{th} International Wind Workshop, Annapolis, MD, 14-18 April 2008.

2.3. GOES Tropical Cyclone Applications Research

CIMSS Project Lead: Chris Velden

CIMSS Support Scientists: Dave Stettner, Tim Olander, Derrick Herndon

NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

CIMSS continues to develop algorithms and diagnostic fields derived from GOES data and analyses for applications to Tropical Cyclones (TCs). In 2008, this project concentrated on three main topics: 1) Further research on the ADT, 2) Research on a new satellite consensus intensity estimation method called SATCON, and 3) Development of a new web site and on-line archive for improved user interaction with GOES data and derived products pertaining to TCs.

Summary of Accomplishments and Findings

1. The CIMSS Tropical Cyclones group continues to showcase diagnostic fields derived from GOES data and analyses for applications to TCs. All of these products are featured on a new CIMSS Tropical Cyclones web site (http://cimss.ssec.wisc.edu/tropic2/), which has become an extremely popular site for both the general public and forecasters during TC events. The new site includes an interactive window display that allows users to choose display options for better analysis of data and products. We continue to upgrade these products and develop new ones often based on community/user feedback. Also, GOES data sets and products are continuously requested by and provided to the user community for scientific research on TCs. To address this, we are building a new on-line archive capability that will allow users to access historical GOES datasets produced at CIMSS for their local analyses. The Graphical User Interface to this archive is currently being developed.

2. We continue to upgrade the Advanced Dvorak Technique (ADT) algorithm, which is now used by several of NOAA's tropical cyclone analysis centers. In this reporting period, the algorithm upgrades have focused on the following primary areas: 1) examination and mitigation of logic/rules as applied in situations of rapid intensity changes, and 2) statistical evaluation of the

performance in specific TC cases to better understand the behavior and areas of weakness. Several new schemes were tested and implemented into the experimental ADT code, the major one being the integration of microwave information from polar orbiter overpasses. This approach integrates the eyewall structure information gleaned from 85GHz radiance information into the ADT logic stream for scene types and current intensity estimation. Testing is underway during the 2008 season.

3. 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 consensus algorithm, called SATCON, is designed to better estimate TC intensity. The approach is being tested in near real time during the 2008 hurricane season. A statistical analysis will be performed at the end of the season. For more information, see: http://cimss.ssec.wisc.edu/tropic2/real-time/satcon/

Publications and Conference reports

Velden, C., 2008: The new CIMSS tropical cyclone web site: A portal to advances in satellite analysis. 28th AMS Conf. on Hurricanes and Trop. Meteor., Orlando, FL.

2.4. Analysis and Application of GOES IR Imagery Toward Improving Hurricane Intensity Change Prediction

CIMSS Project Lead: Jim Kossin
CIMSS Support Scientist: Chris Rozoff
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water

Proposed Work

The goal of this research is to apply GOES IR imagery and environmental features toward the construction of a new algorithm for predicting rapid intensification in hurricanes.

Summary of Accomplishments and Results

We developed a statistical forecast scheme for Atlantic and East Pacific hurricane rapid intensity (RI) change using a Bayesian probabilistic model.

A best track, Statistical Hurricane Intensity Prediction Scheme (SHIPS) and GOES brightness temperatures over the period 1989-2006 were utilized to train the scheme.

Based on this extended data set, we improved the RI climatology carried out in Kaplan and DeMaria (2003; Wea. Forecasting).

A rigorous cross validation was completed for 1989-2006 to obtain a measure of the scheme's predictive skill. Allowing for a variety of reasonable RI definitions, the following aspects were learned from validation:

For the Atlantic basin, the scheme has Brier skill scores of 6.7, 9.8, 11.3, and 14.2%, Pierce Skill scores of 2.9, 5.8, 9.5, and 18.6%, and false alarm rates of 1, 4, 1.4 and 3.1% for RI defined as intensity increases of at least 30, 25, 20, and 15 kts over 24-h, respectively. (It should be noted that, in principle, this scheme can be used to assign probabilities to any intensity change interval.)

For the Eastern Pacific basin, the scheme has Brier skill scores of 7.9, 12.6, 19.9, and 20.5%, Pierce Skill scores of 1.6, 8.7, 20.9, and 25.4%, and false alarm rates of 1, 5, 2.2, and 3.4% for RI defined as intensity increases of at least 30, 25, 20, and 15 kts over 24-h, respectively.

The performance of the RI scheme has been assessed on individual storms. For example, Figure 2.4.1 shows several forecasts for various definitions of RI over the lifetime of Hurricane Wilma (2005). As found in the validation, the Bayesian scheme appears to better capture RI when RI is defined with a more moderate threshold for intensity change.

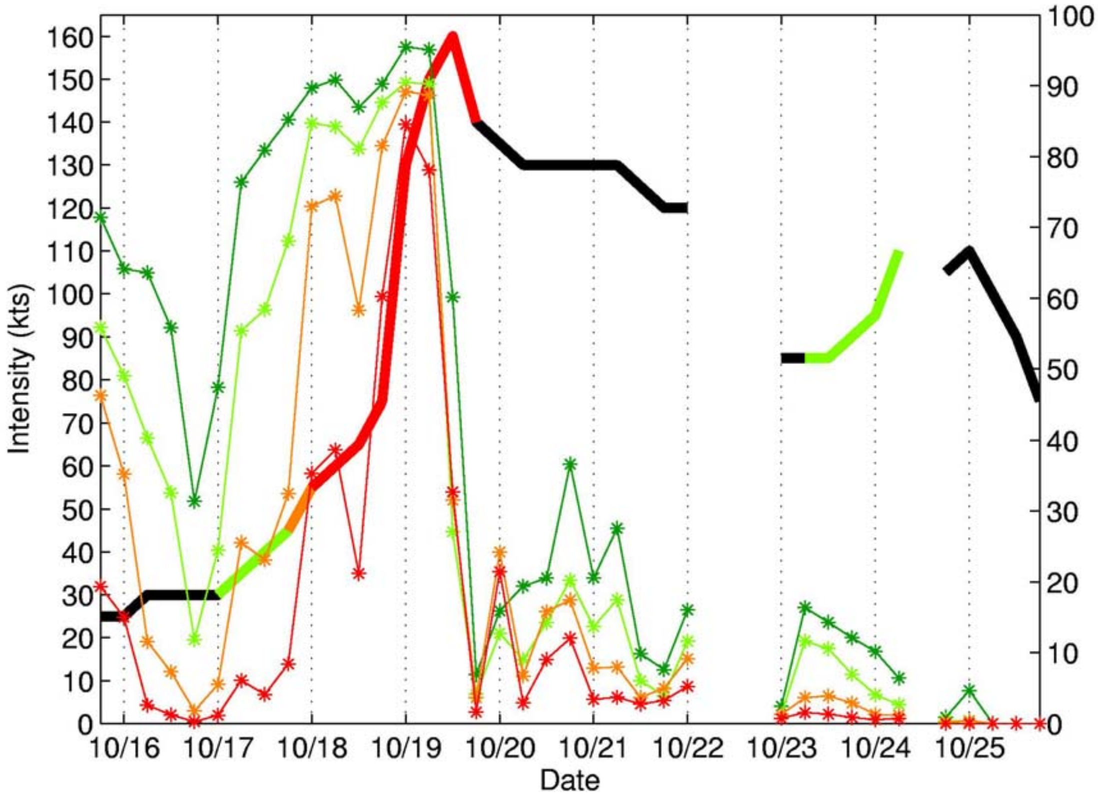


Figure 2.4.1. The thick curve shows the best track intensity of Hurricane Wilma (2005). Missing data indicate periods when the storm was over land. Red, orange, light green, and dark green segments of the intensity curve indicate 24-h periods where Wilma's intensity increased by at least 30, 25, 20, and 15 kts, respectively. The thinner red, orange, light green, and dark green curves provide the Bayesian probability of the storm increasing by at least 30, 25, 20, and 15 kts, respectively, over 24-h intervals. Note that dark green intensity curve segments indicating RI of at least 15 kts intensity change over 24-h do not show up in the above plot because such segments also coincide with 24-h intervals that contain intensity changes of at least 20 kts.

It was found that RI forecast skill is improved using principle components, computed from azimuthal-average GOES IR brightness temperatures, as predictors. For the Atlantic, Brier skill and Pierce scores improved by 2%. Such an analysis is still underway for the Eastern Pacific Ocean.

Efforts to compare this scheme's performance directly with current operational tools are underway.

2.5. Intercalibration

CIMSS Project Lead: Mathew Gunshor
CIMSS Support Scientist: Hal Woolf
NOAA Collaborator: Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

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

Comparison of satellite radiances leading to an improved knowledge of calibration is important for various global applications of satellite data where data from more than one instrument are combined. This has become increasingly important with the emphasis placed on global climate studies, global models and the use of satellite data and products in such models.

NOAA participates in research promoting and advancing the knowledge of intercalibration techniques through the Global Space-Based Inter-Calibration System (GSICS). CIMSS methodology is part of the intercalibration work adopted by the international GSICS. The primary goal of GSICS is to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space component of the WMO World Weather Watch (WWW) Global Observing System (GOS) and Global Earth Observing System of Systems (GEOSS). This project supports GSICS and also the NOAA Mission Goals of Climate and Weather and Water. CIMSS receives requests from various users confirming the calibration accuracy for both domestic and international geostationary imagers; such requests have come in the recent past from the Navy, OSDPD, STAR, and JMA.

Three primary tasks were proposed for FY08. First, a manuscript would be submitted to a peer-reviewed journal outlining the methods used to intercalibrate with AIRS and discussing the results. Second, a database with IASI comparisons to the world's GEOs would be started. Third, the current AIRS gap-filling method would be analyzed using IASI data, which does not have spectral gaps. This would lead to a comparison of methods used for AIRS and IASI; IASI has spatial gaps that may or may not affect the current method of spatial averaging and the current method may need to be altered to do pixel-to-pixel comparisons for IASI.

Summary of Accomplishments and Findings

The first task was accomplished. In April 2008 a manuscript was submitted to the Journal of Atmospheric and Oceanic Technology titled "Intercalibration of broadband geostationary imagers using AIRS" by M. M. Gunshor, T. J. Schmit, W. P. Menzel, D. C. Tobin. Results were presented for approximately 22 months of comparisons with AIRS to GOES-10, GOES-11, GOES-12, Meteosat-8, Meteosat-9, MTSAT-1R, and FY-2C. While the emphasis is on the methodology and results, several other analyses were presented. For the shortwave window band on the imagers, there is a measurable difference in the comparisons between day and night and nighttime comparisons are less noisy with smaller differences between AIRS and the GEOs. Earlier efforts were highlighted working with Japanese scientists at JMA and engineers at Raytheon, resulting in a correction to MTSAT-1R's shortwave window band of approximately 8 K. A stray light problem with China's FY-2C data around satellite midnight was shown to have an effect in all IR bands. The effects of GOES-12 decontamination on the results were shown. An analysis of the errors associated with spectral convolution and the gap filling process was presented. The time-dependency of the GEO/LEO overpass time on the results was also presented. The analysis on the GOES-13 Imager 13.3 micrometer band errors due to a poorly characterized spectral response function (SRF) demonstrated the importance of a post-launch science test to determine potential problems before an instrument becomes operational. In this case, new SRFs from the instrument vendor have been supplied and have since been shown to have improvement over the original. Much of what appears in this manuscript was presented 19-21 February 2008 at the 3rd Conference of the GSICS Research Working Group (GRWG-III) held in Camp Springs, MD.

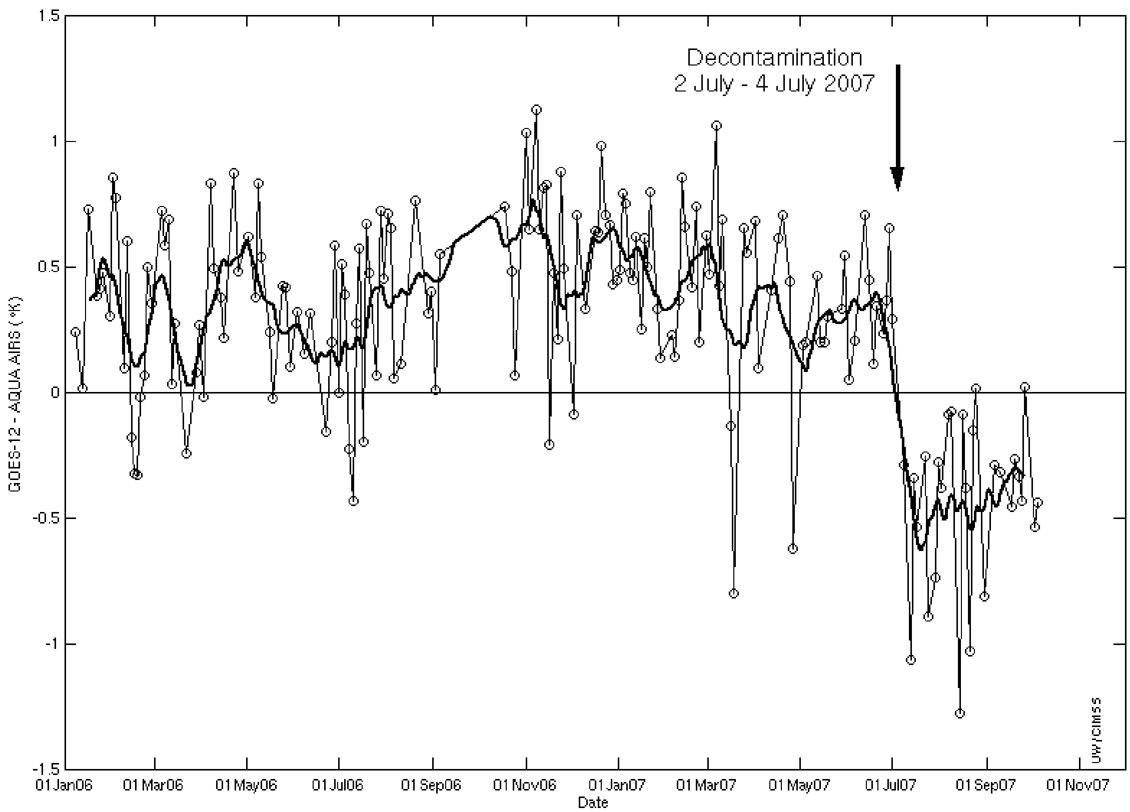


Figure 2.5.1. Time series of intercalibration results between AIRS and the GOES-12 Water Vapor channel illustrating the effect of the GOES-12 decontamination event in early July 2007.

The second and third tasks are in progress. Other projects at CIMSS are being leveraged to accomplish these goals. A database of global IASI data has been started here and the SSEC Data Center provides CIMSS with a global archive of geostationary imager data (this project does contribute funding to Data Center costs). Thus the collection of data has begun. In addition, the methodology for comparison to IASI is being developed and compared to the methodology used with AIRS. Some cases have been run with mixed results. A problem with IASI that does not exist with AIRS is causing changes to the algorithm, though it is expected that the method will not have to change significantly. Due to the nature of the instruments, AIRS can be missing some channels in any given field of view (FOV) whereas with IASI there are occasionally missing FOVs where it is missing data for all channels. It would appear the best way to deal with these missing FOVs in IASI is to ignore them in a spatial average, but this is still under investigation. The GSICS community has adopted a pixel-to-pixel type approach and CIMSS wishes to maintain their own method of spatially averaging data at the GEO sub-point so that the international community has the benefit of seeing comparisons done with another method. Using two methods provides quality control and adds confidence to validate the results.

Publications and Conference Reports
Presented at the 3rd Meeting of GSICS Research Working Group (GRWG-III): "Recent AIRS/GEO Infrared Intercalibration Findings at UW-CIMSS" by Mat Gunshor, Tim Schmit, and Dave Tobin. 19-21 February 2008, NOAA Science Building, Camp Springs, MD.

Submitted for publication to the Journal of Atmospheric and Oceanic Technology: "Intercalibration of broadband geostationary imagers using AIRS" by M. M. Gunshor, T. J. Schmit, W. P. Menzel, D. C. Tobin.

2.6. Global Geostationary Fire Monitoring and Applications

CIMSS Project Lead: Chris Schmidt
CIMSS Support Scientist: Jason Brunner
CIMSS Contractor: Elaine Prins
NOAA Collaborator: Robert Rabin
NOAA Strategic Goals Addressed:

2. Understand climate variability and change to enhance society's ability to plan
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work
The UW-Madison CIMSS fire team proposed five major tasks for 2008. CIMSS proposed to implement an updated version of the WF_ABBA, version 6.5. CIMSS also proposed to continue collaboration with Dr. R. Rabin (NOAA/NSSL) and Dr. P. Bothwell (NOAA/NWS, Storm Prediction Center) on applications of Rapid Scan GOES fire products for early detection of wildfires and agricultural burning and diurnal monitoring of fire variability. CIMSS proposed to continue the GOES WF_ABBA trend analysis throughout the western hemisphere to monitor changes in biomass burning and collaborate with the user community in environmental applications of the WF_ABBA database. The collaboration includes ongoing activities with the atmospheric modeling community to assimilate geostationary WF_ABBA fire products into aerosol/trace gas transport models. The fifth proposed task is to continue to work with GTOS GOFC/GOLD, CGMS, and GEOSS to foster the development and implementation of a global geostationary fire monitoring network with international involvement.

Summary of Accomplishments and Findings
In summer of 2008 CIMSS implemented version 6.5 of the WF_ABBA and began providing fire detection and characterization data from GOES-10/-11/-12/-13, MTSAT-1R, and Met-9 via anonymous FTP. Also provided was a coverage mask file providing users with information on fire locations and classifications, opaque clouds, block-out zones, and areas processed but determined to be fire-free. This coverage data is of particular interest to modelers who use the fire data to help adjust for coverage biases.

During 2008 the UW-Madison CIMSS biomass burning team continued to collaborate with Dr. R. Rabin and Dr. P. Bothwell on applications of Rapid Scan GOES fire products for early detection of wildfires and diurnal monitoring of fire variability. CIMSS provided analysis of three case studies of time series of rapid scan observations of wildfire activity and ancillary information (local meteorological conditions and fire observations if available) to Dr. R. Rabin and Dr. P. Bothwell for evaluation. These case studies included the Hayman, Colorado and Rodeo-Chediski, Arizona Fires in June 2002 and the Bugaboo-Scrub Fire, Georgia/Florida in April/May 2007. In addition, analysis of the southern California fires from October 2007 was included as an additional case study. The focus of this investigation was to determine the utility of providing time series of value-added information to fire weather forecasters for specific wildfires. Figure 2.6.1 shows a plot of time series of GOES-11 power difference and ASOS dewpoint depression observations (Ramona, CA) for the Witch Creek fire. Analyses indicate that there is a relationship between power difference and dewpoint depression. The higher dewpoint depression values often coincide with the larger power difference values and this seems to fluctuate in a diurnal manner, with higher values during the day. The other fire case studies indicated above had similar results. CIMSS will test the power difference method in real-time in AWIPS during the Spring 2009 fire season at NSSL.

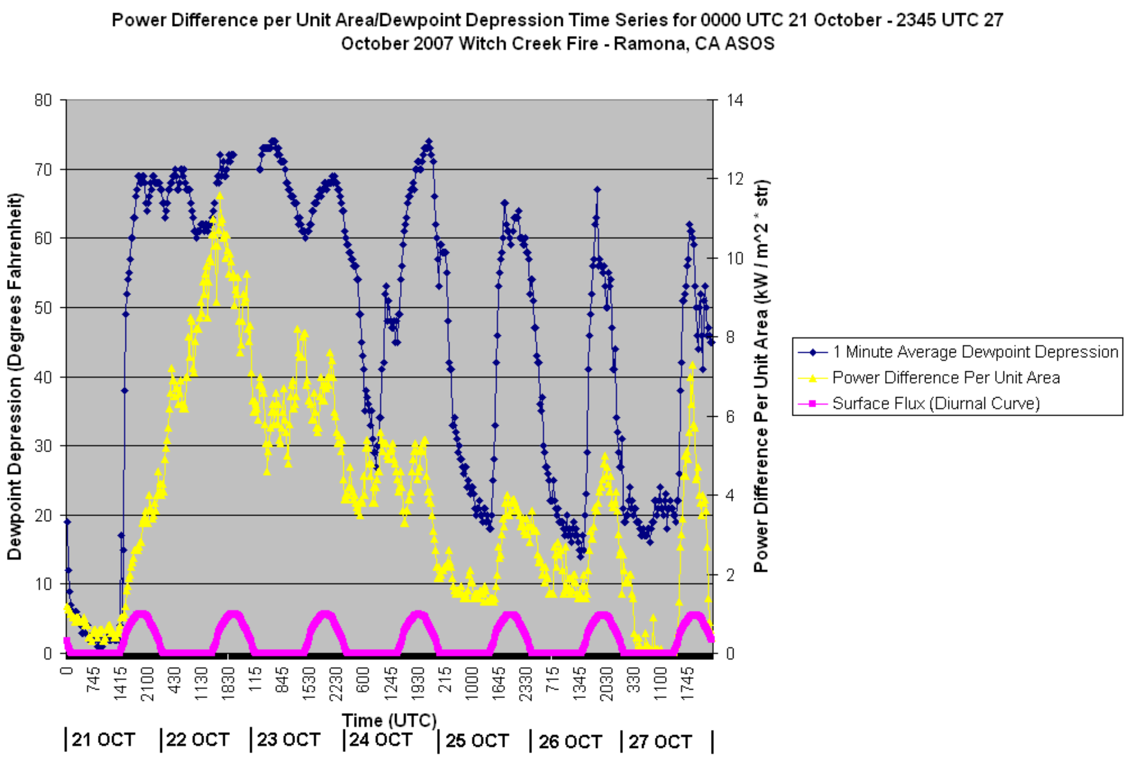


Figure 2.6.1. Time series of GOES-11 power difference (kW per unit area) and ASOS dewpoint depression observations (Ramona, CA) for the Witch Creek fire over southern California in October 2007.

The CIMSS biomass burning team continued to provide the WF_ABBA database (2000-present) to the user community via an ftp site at CIMSS and an on-line database (http://www.nrlmry.navy.mil/flambe/index.html). Efforts are under way with funds leveraged from GIMPAP, G-PSDI, and NASA LBA ECO Phase III, to process 1995-current with the newest version of the WF_ABBA (version 6.5). Version 6.5 of the WF_ABBA provides additional parameters and metadata as requested by the international user community. Improvements include an opaque cloud product to indicate regions where fire detection is not possible; a fire radiative power (FRP) product in addition to

Dozier output of instantaneous estimates of fire size and temperature; metadata on processing region and block-out zones due to solar reflectance, clouds, extreme view angles, saturation, and biome type; and fire/metadata mask imagery. The 14-year diurnal fire climatology will have applications in emissions and air quality modeling, climate change studies, land-use/land-cover change, fire dynamics modeling, fire weather analyses, and socio-economic studies.

Interannual trend analyses of fire activity in the western Hemisphere were expanded to include through September 2008. Figure 2.6.2 shows a difference plot of fires reported over South America for 01 October 2006 - 30 September 2007 (fire pixels in yellow) and 01 October 2007 - 30 September 2008 (fire pixels in red). There was an overall decrease of 41% in fire activity over South America during 1 October 2007 - 30 September 2008 compared to 01 October 2006 - 30 September 2007. As prices for soy and cattle surged in 2007, deforestation and soybean production and associated burning also soared in states along the southern and eastern perimeters of the Amazon (Mato Grosso, Para, Tocantins, Amazonas). In North America the overall decrease in fire activity during 01 October 2007 - 30 September 2008 compared to 01 October 2006 - 30 September 2007 was not nearly as large as South America but was 16%. These fire summary statistics do not include fire activity in the Western Hemisphere from 4 - 16 December 2007 due to lack of data during this time following a GOES-12 hardware fault. This time period typically accounts for only 1% of the annual burning for the Western Hemisphere and the lack of this data should not significantly affect the results for 01 October 2007 - 30 September 2008.

During the past year CIMSS has been involved in several CEOS actions that support corresponding Group on Earth Observation (GEO) tasks. In April E. Prins presented a summary of global geostationary fire monitoring network activities and associated CEOS tasks to the CEOS Disaster SBA Team at their first meeting held in Quebec. In support of GOFC/GOLD Fire Team requests and the NOAA/NESDIS global geostationary fire monitoring effort UW-Madison CIMSS coordinated the following tasks under CEOS Category 1 Disaster Action DI-06-13:

1. Presented case to the SIT for better access to data for fire monitoring and discussed issues listed below.
2. Requested near real-time access to future geostationary satellite data (INSAT-3D, Russian GOMS Elektro L MSU-GS, Korean COMS).
3. For all geostationary satellites with fire monitoring capabilities, requested access to detailed information on data pre-processing chains, ongoing calibration of the 3.9 and 11 µm bands at higher temperatures, characterization of noise levels at higher temperatures.
4. Requested access to 3.9 and 11 µm data that have not been filtered or smoothed.

Both the CEOS SIT chair and CEOS Disaster SBA team felt that future action regarding these tasks should be addressed within the framework of the Coordination Group for Meteorological Satellites (CGMS). In cooperation with the GOFC/GOLD global geostationary fire monitoring network working group, CIMSS is drafting a working paper for submission to the CGMS Global Space-based Inter-Calibration System (GSICS) panel outlining geostationary satellite data access and characterization needs and issues as they relate to fire monitoring.

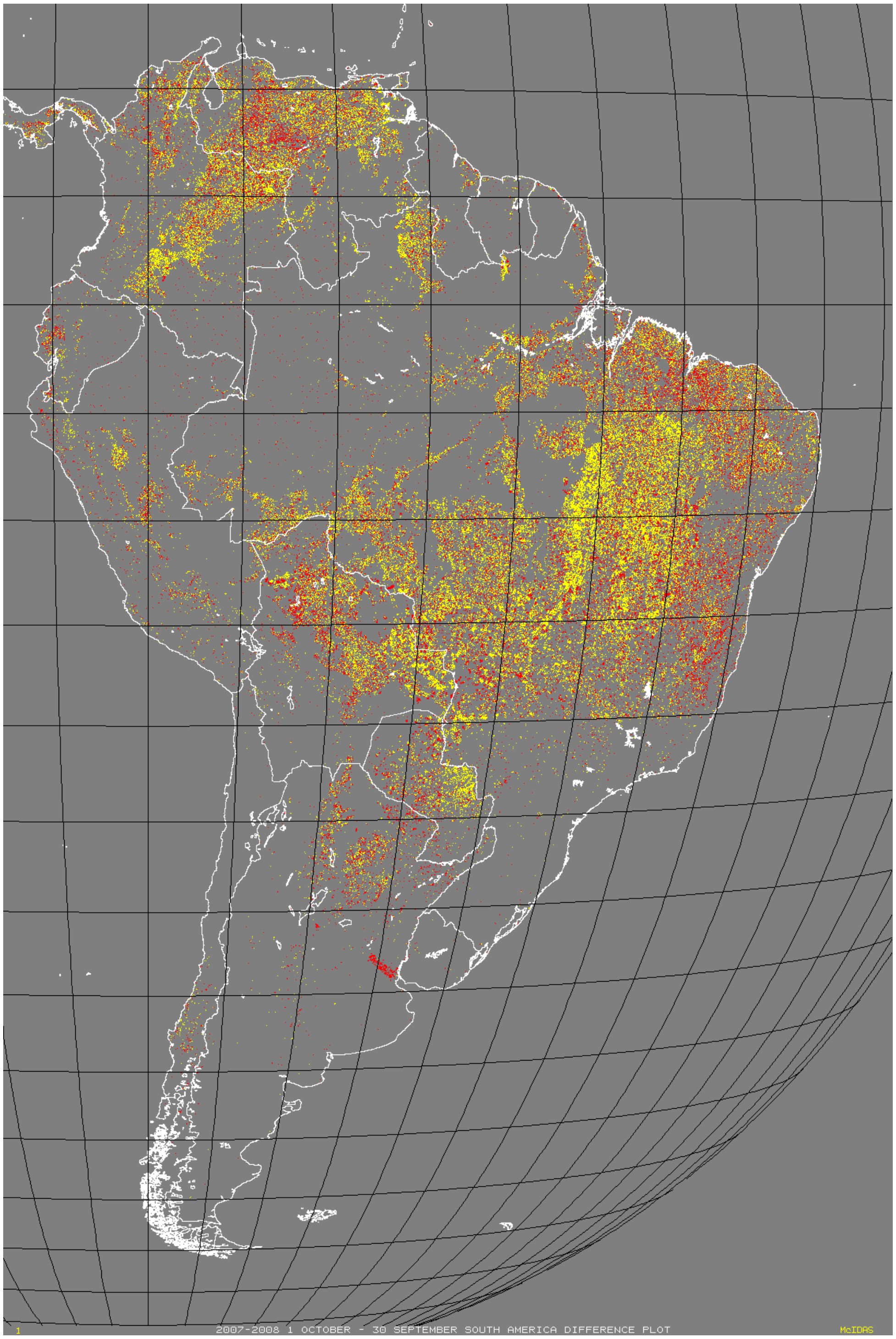


Figure 2.6.2. Difference plot of GOES-East fires detected with WF_ABBA over South America from 1 October 2006 - 30 September 2007 (fire pixels in yellow) and 1 October 2007 - 30 September 2008 (fire pixels in red).

2.7. Automated Volcanic Ash Detection and Volcanic Cloud Height and Mass Loading Retrievals from the GOES Imager

CIMSS Project Lead: Justin Sieglaff
NOAA Collaborator: Michael Pavolonis
NOAA Strategic Goals Addressed:

4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work

With the advent of the GOES-R Algorithm Working Groups, NOAA has begun to develop consensus prototype algorithms for GOES-R. In particular, the Cloud Application Team has developed a prototype system for testing cloud algorithms applied to geostationary imager data. This system is called the Geostationary Cloud Algorithm Testbed (GEOCAT). GEOCAT can process geostationary imager data from GOES, MSG/SEVIRI and MTSAT. The GOES-R volcanic ash products (detection, height, and mass loading) can, in fact, be produced from the current GOES imagers, albeit with reduced accuracy. These quantitative products would greatly benefit current operations. All volcanic ash products in operations today are imagery based and qualitative, and, as such, do not offer information on mass loading or height. The height and mass loading information are important, since they can be used to initialize dispersion models. Therefore, in this project, we plan to capitalize on our GOES-R algorithm development experience in an effort to develop quantitative products for the current GOES imagers. Since the current GOES imagers lack a key channel (8.5 micron) used in the GOES-R algorithm, we need to make modifications to our approach.

Summary of Accomplishments and Findings

Our GOES-R algorithm uses the, 8.5, 11, 12, and 13.3-micron channels to quantitatively detect volcanic ash and retrieve the height and mass loading. Since only the 11 and 12 or 13.3-micron channels are available on the current GOES imager, our work thus far has focused on modifying our approach. Past research has shown that a two-channel "split-window" approach does not provide optimal results for ash detection, so we need to utilize additional GOES channels. Thus, we developed a tri-spectral technique (3.9, 11, 12/13.3-μm) for detecting volcanic ash at night. Analogous to the GOES-R algorithm, we convert the observed radiances to absorption optical depth and then compute optical depth ratios (called β-ratios) using different channel combinations. This approach is more robust than traditional brightness temperature differences since it corrects for the background conditions, which can strongly influence the measured radiances. Figure 2.7.1 below shows the relationship between the 3.9/11-μm β-ratio and the 11/12-μm β-ratio for theoretical volcanic ash, liquid water, and ice clouds. One can see that in this data space it is straightforward to distinguish between volcanic ash and meteorological clouds. Once a volcanic ash cloud pixel is identified, its height and mass loading can be retrieved using a split-window 1-DVAR approach (Heidinger and Pavolonis, 2008). These algorithms were applied to a recent eruption of Chaiten (Chile) captured by GOES-10. Example results are shown in Figure 2.7.2. These early results look promising, but need to be validated. Future work will focus on comparing these results to the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) on the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platform, which made several observations of this ash cloud. We will also implement an enhanced daytime ash detection approach.

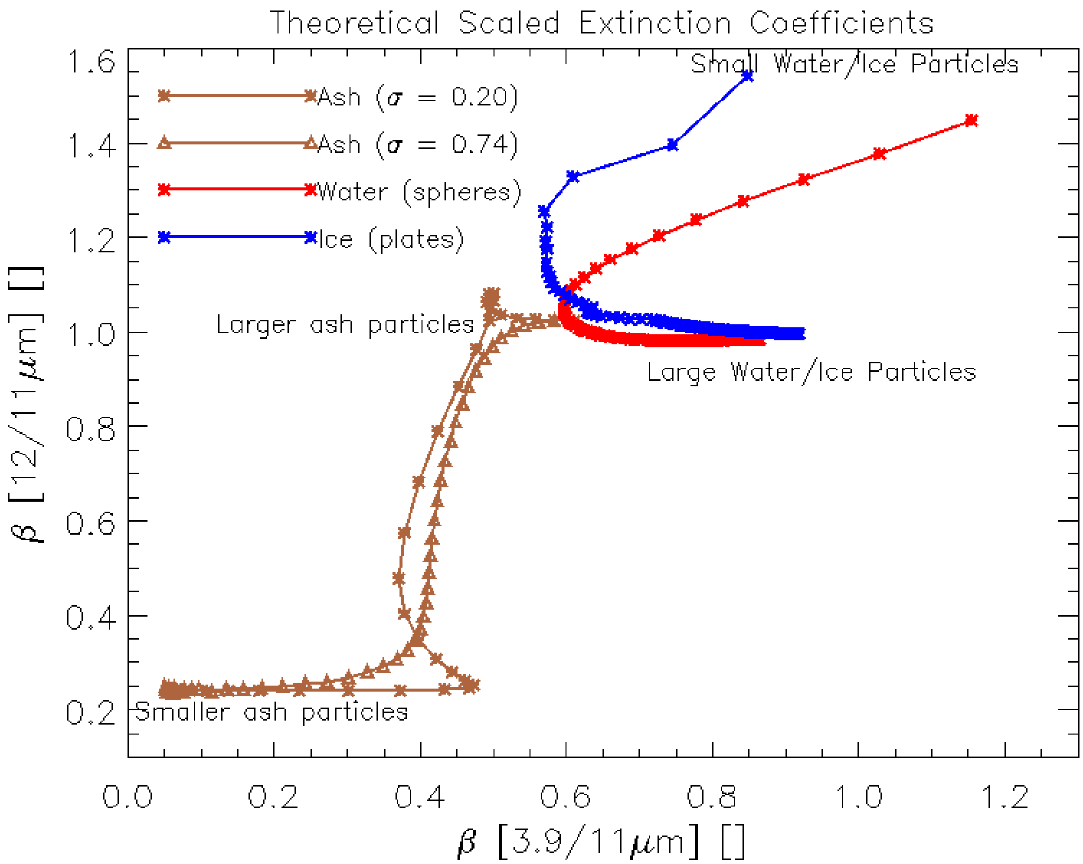


Figure 2.7.1. The figure above shows the difference between volcanic (brown) and meteorological (blue and red) cloud in 3.9, 11, and 12-μm β-ratio space.

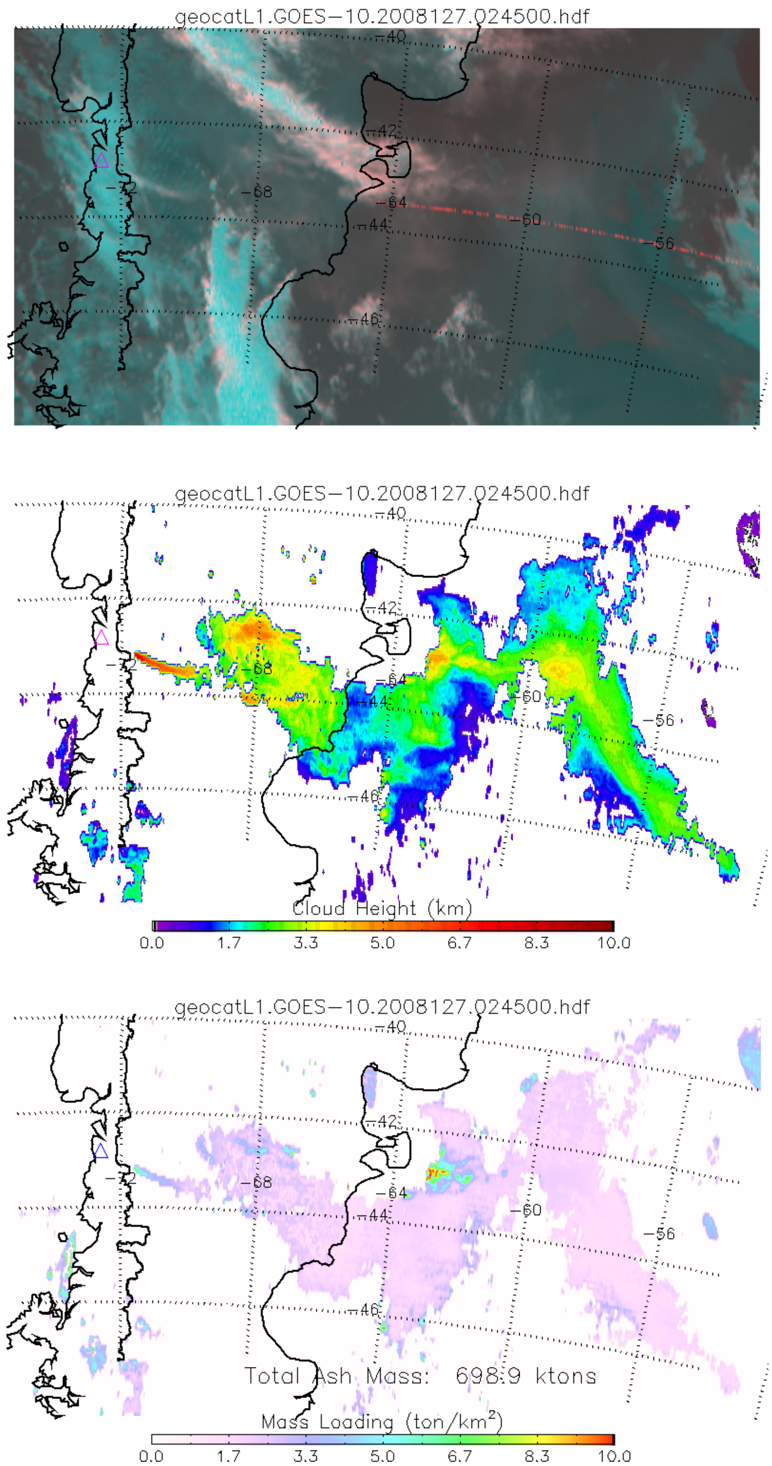


Figure 2.7.2. The results of the height/mass loading retrieval algorithm applied to a volcanic ash cloud produced by Chaiten and observed by GOES-10 on 06 May 2008 at 0245 UTC. A 3-channel false color image (top), the volcanic cloud height (middle), and ash mass loading (bottom) are shown. The height/mass retrieval depends on the volcanic ash detection algorithm to properly detect volcanic ash clouds.

Publications and Conference Reports

Heidinger, A.K. and M.J. Pavolonis, 2008: Nearly 30 years of gazing at clouds through a split-window: Part I: Methodology, *Journal of Applied Meteorology and Climate*, Accepted.

2.8. Improvement and Validation of Convective Initiation and Mesoscale Wind Applications

CIMSS Project Leads: Wayne Feltz, Kristopher Bedka
CIMSS Support Scientist: Justin Sieglaff
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information;
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed work:
CIMSS, in collaboration with the University of Alabama in Huntsville, currently produces a set of GOES-12 Imager satellite-derived products for diagnosing and nowcasting thunderstorm development, evolution, and motion. These products have been under development for four years under the NASA-supported Advanced Satellite Aviation-weather Products initiative for use in aviation safety applications (Mecikalski et al., 2006). CIMSS is currently providing these products to several groups, including the NOAA/NESDIS Satellite Application Branch (SAB) precipitation desk, in near real-time. The goal of this collaboration is to improve upon existing SAB satellite-derived guidance and precipitation forecasts. CIMSS convective weather products can identify rapidly developing convective storms, which should be monitored for heavy rainfall and flash flooding potential. SAB precipitation estimates are provided directly to National Weather Service Forecast Offices and Regional Forecast Centers and contribute to forecasts disseminated to the general public.

The CIMSS Satellite Nowcasting Aviation Applications (SNAAP) proposed to support further refinement to an experimental convective initiation algorithm implemented at NOAA/NESDIS (SAB precipitation team) and AWIPS relayed products to Sullivan, La Crosse, and Green Bay NWS offices. Preliminary product feedback from NESDIS indicated time latency and false alarm errant cloud tracking using mesoscale atmospheric motion vectors. There is also a need for nighttime convective initiation nowcasting capabilities. New convective initiation research is proposed to increase processing speed over a larger imager domain, decrease false alarms, and provide a more spatially coherent product output using box-averaged cloud properties. Relationships will be developed between box-averaged cloud top cooling rate and radar reflectivity to account for the GOES imager parallax effect.

The following research milestones were proposed to improve convective initiation and mesoscale wind products. First a parallax corrected convective cloud top cooling rate product will be implemented that can be produced over larger geographic domains in near-real time with reduced false alarms and better spatial coherency in the cooling field. The improved product will be distributed to local NWS offices and NOAA/NESDIS SAB. Second is to establish relationships between satellite-observed cloud top cooling rate and radar reflectivity trends that may provide a cooling rate product that can aid in forecasting flash flood potential for developing convection. Third, a prototype nighttime convective storm nowcast product which could identify rapidly developing convection using IR radiances and other satellite-derived cloud properties. The final research milestone would be to continue to collaborate with local NWS offices (Sullivan, Green Bay, and La Crosse) to acquire user feedback and improve upon products where necessary.

Summary of accomplishments and findings

Progress has been made on implementing a parallax corrected cloud-top cooling within an in-house CIMSS AWIPS display. A constant cloud-top height of 9 km was assumed and all cooling convective cloud pixels are shifted accordingly to better match the associated radar reflectivity pattern. Figure 2.8.1 below shows displays of 45-minute accumulated (i.e. three 15-minute periods) GOES cloud top cooling rate with regional radar mosaic and GOES 1 km visible imagery in AWIPS. The parallax correction will help operational forecasters better relate rapid convective cloud growth signals to current and future changes in precipitation intensity.

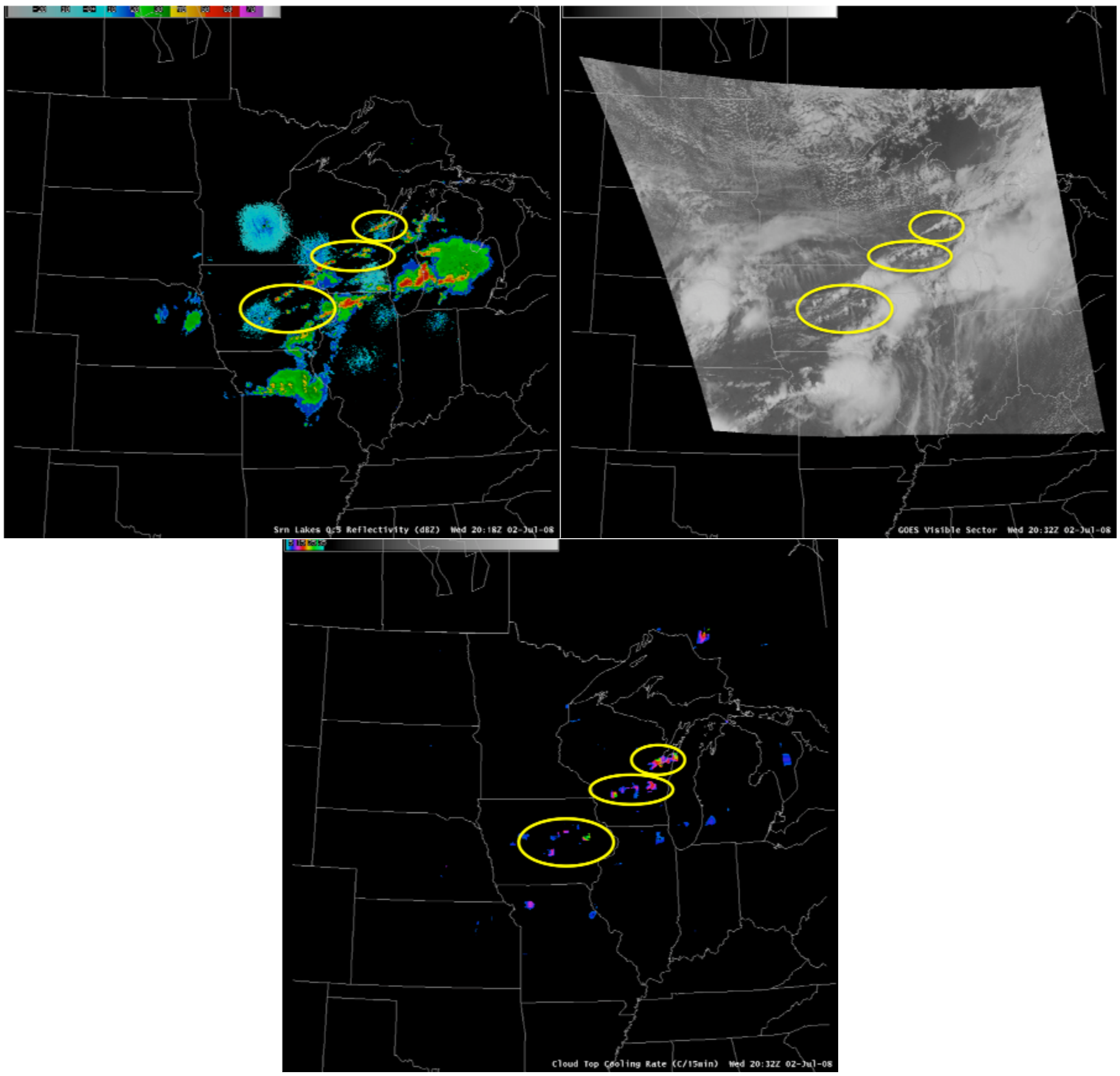


Figure 2.8.1. WSR-88D base reflectivity (upper-left), GOES-12 1 km Visible brightness counts (upper-right), and parallax-corrected 45-minute accumulated cloud top cooling rate displayed in AWIPS at CIMSS.

Research is underway to evaluate the accuracy and lead-time provided by a GOES box-averaged cloud-top cooling rate and convective initiation nowcast products relative to NLDN cloud-to-ground lightning data. Initial validation plans involved the use of WSR-88D radar reflectivity, but further investigation of digital radar datasets distributed by Unidata showed significant issues with ground clutter that would adversely impact objective radar recognition of CI. Radar echo movement and areal expansion are also complicating factors that can cause problems in separating new convective initiation signals from existing echo development. NLDN data, on the other hand, provides a binary yes/no lightning detection, which can be gridded and processed to identify the first occurrence of lightning over a selected grid point (i.e. "lightning initiation"). Several GOES cases have been selected and processed for validation for use in a software framework developed for MSG SEVIRI product validation over South Africa. GOES product validation results will be prepared over the following quarter and described in the subsequent report.

Progress has been made to prototype nocturnal convective cooling rate methodologies. The current research path is to use cloud products (cloud type/phase) that are or will be operational via GEOCAT and CLAVR-X and retire the daytime-only University of Alabama in Huntsville (UAH) statistically based unsupervised clustering convective cloud mask method, which highly relies on visual texturing. The new cloud products have several advantages, 1) physically based on cloud microphysical properties, 2) provides 24 hour cloud properties, 3) uses operational data streams, 4) algorithm logic is applicable to all geostationary sensor although optimal results are obtained when more radiative information is present (SEVIRI vs. GOES) and high temporal resolution is available. We have started work with MSG SEVIRI imagery toward the use of an IR-only cloud microphysical type product to identify newly developing convective storms. This cloud type product will serve as a surrogate to a daytime-only satellite VIS+IR convective cloud mask which has been developed at the UAH, which will extend out nowcasting capability to the nighttime hours. We believe that monitoring the phase (type) change from liquid and supercooled water to ice cloud tops is a key indicator of convective initiation that we can exploit from satellite observations. We are using the GEOCAT framework to produce the cloud-top type product, which allows for flexibility in the spectral channels used as input to the algorithm. We plan to examine the impact of reducing the spectral information supplied to the algorithm on the resulting convective cooling rate product, as GOES has far fewer IR channels than MSG SEVIRI. This should help us to understand the feasibility of using phase (type) information from current GOES in the nowcast process. Figure 2.8.2 shows an example of a day/night SEVIRI CI nowcast product which is being transitioned to current GOES imagery radiance information. Figure 2.8.3 shows the first example of a GOES imager CIMSS convective initiation Nowcast for a nocturnal convective case on June 5, 2006 between 730 and 930 UTC. The goal is to automate and improve POD and FAR numbers using lightning data and eventually use object tracking methodology to implement radar vs. satellite CI POD and FAR values.

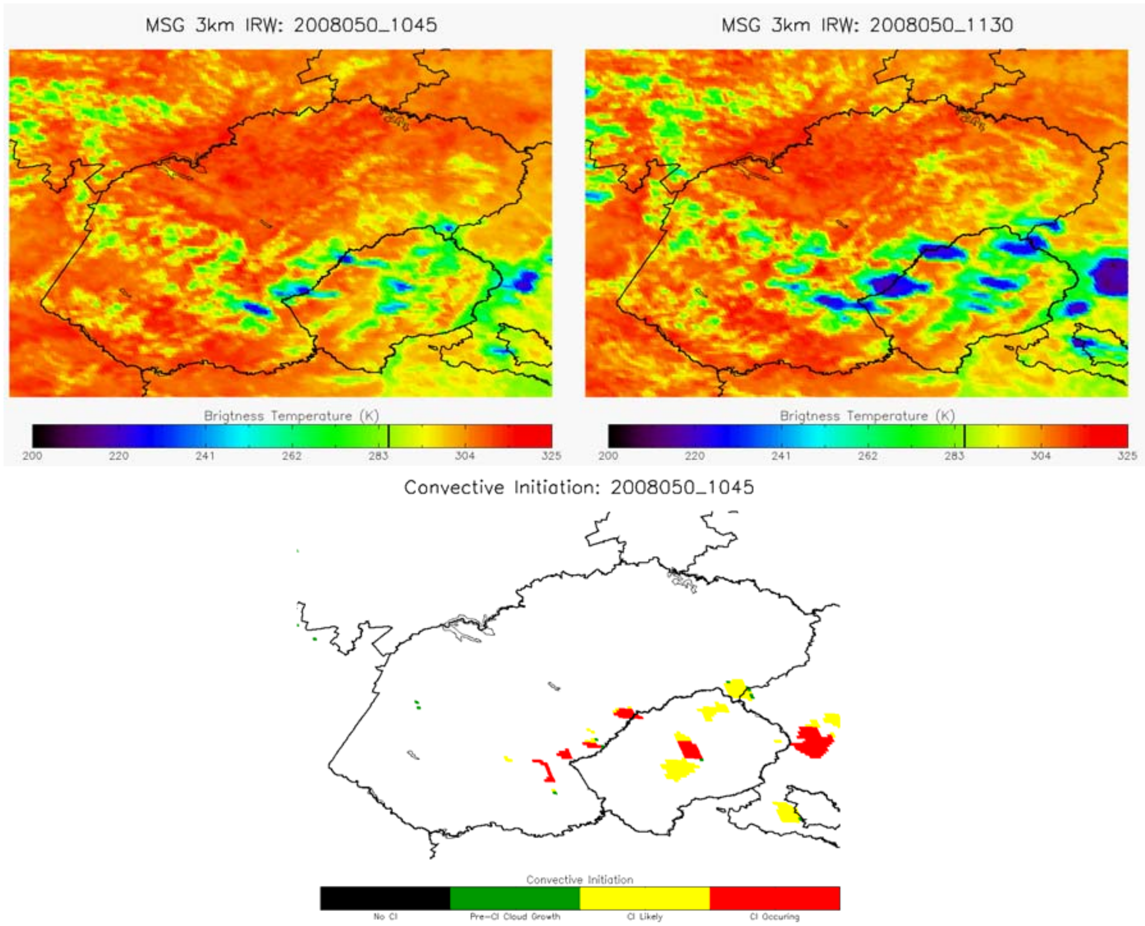


Figure 2.8.2. MSG SEVIRI 10.8 μm brightness temperatures at 1045 (upper-left) and 1130 UTC (upper-right) on 19 February 2008(bottom). A convective initiation nowcast at 1045 UTC based upon box-averaged cloud-top cooling and cloud-top microphysical changes as depicted by the GOES-R Cloud Algorithm Working Group (AWG) cloud typing product. "Pre-CI Cloud Growth" indicates rapid cloud-top cooling of liquid water clouds, "CI Likely" indicates rapid cooling with a recent phase change from liquid to mixed-phase or supercooled water tops, "CI Occurring" indicates rapid cooling with a cloud top that has recently transitioned to thick ice. This logic will be adapted to work with the GOES-12 cloud typing product in the development of a day/night CI nowcast product.

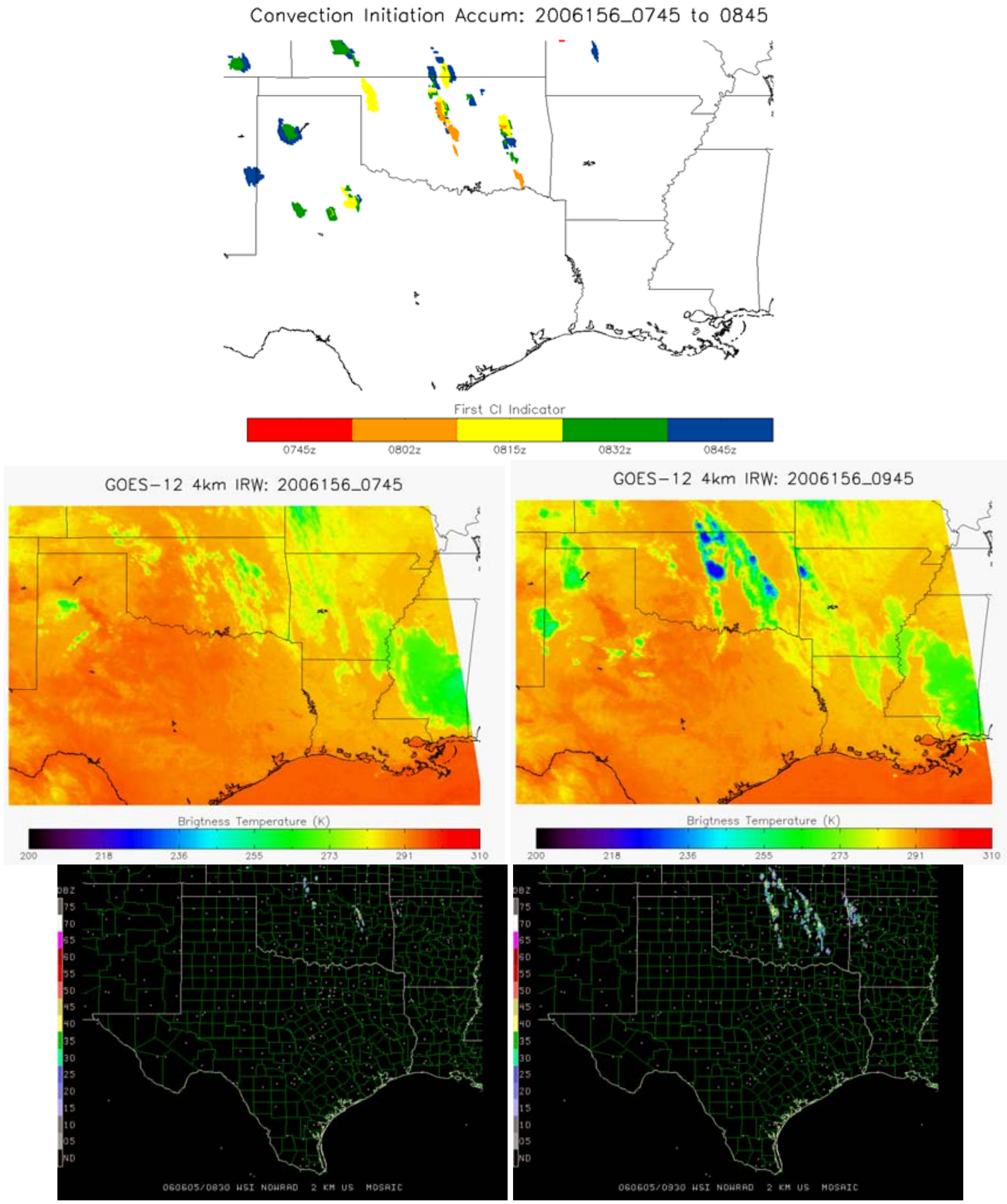


Figure 2.8.3. Example of nocturnal GOES-12 convective initiation using cloud typing and box-averaging methodology (top image) valid on 05 June 2006 at 0845 UTC, infrared imagery at 0745 and 0945 UTC (center imagery), and radar images valid at 0830 UTC and 0930 UTC. Notice that the CIMSS GOES CI Nowcast at 0845 UTC has important 45-minute lead time information.

Collaborations with NOAA SAB and local NWS office to provide iterative avenue for product improvement and future path to operations have continued. Wayne Feltz presented a talk on future satellite-based aviation and nowcasting products titled “Convective Initiation and Future Nowcasting

Related Products" to Aviation Weather Center (AWC) and Central Region NWS in Kansas City on May 29, 2008. Valuable feedback was received with regard to utility of cooling rate on hydrological decisions. Mesoscale wind and turbulence products were also discussed and Central region directory discussed idea of a satellite related Science Operations Officer workshop in coordination with CIMSS.

CIMSS box-averaged cloud-top cooling rate and convective initiation products have been converted into McIDAS MD file format for evaluation by NESDIS SAB analysts (SAB POCs: Jay Hanna and Dustin Scheffler). A mesoscale AMV-based cloud-top cooling rate product was the focus of evaluation last year by SAB. During a visit to SAB by CIMSS scientists in August 2007, box-averaged products were shown to have improved POD and reduced FAR over the AMV-based products, which prompted SAB interest in evaluating the box-averaged product suite during the 2008 convective season.

As described in accomplishment #1 above, CIMSS cloud-top cooling rate and convective initiation nowcast products are implemented into the in-house CIMSS AWIPS display. Internal evaluation of the products is currently being conducted before the products are passed to local National Weather Service offices via a local data manager (LDM) feed.

Publications and Conference Reports

Feltz, W. F., K. Bedka, and J. Sieglaff, 2008: Convective Initiation and Future Nowcasting Related Products, National Weather Service, 10 January, 2008, Green Bay, Wisconsin.

Feltz, W. F., K. Bedka, and J. Sieglaff, 2008: Mesoscale wind, Convective, and Turbulence Nowcasting Related Products, Aviation Weather Center, 29 May 2008, Kansas City, Missouri.

2.9. Using GOES Imager Cloud Products to Study Convective Storm Evolution

CIMSS Project Lead: Justin Sieglaff
CIMSS Support Scientist: William Straka
NOAA Collaborators: Michael Pavolonis, Andrew Heidinger
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

With the advent of the GOES-R Algorithm Working Groups, NOAA has begun to develop consensus prototype algorithms for GOES-R. In particular, the Cloud Application Team has developed a prototype system for testing cloud algorithms applied to geostationary imager data. This system is called the Geostationary Cloud Algorithm Testbed (GEOCAT). GEOCAT can process geostationary imager data from GOES, MSG/SEVIRI and MTSAT. Most of the proposed GOES-R cloud products can, in fact, be produced from the current GOES imagers, albeit with reduced accuracy. The cloud products that can be produced include cloud phase/type, cloud top height, cloud emissivity, particle size, and optical depth. These cloud products have the potential to offer valuable quantitative insight related to the lifecycle of convective systems. For instance, the glaciation of the cloud top may be an indicator that precipitation and lightening are eminent. The cloud optical depth may be closely related to updraft strength. The cloud products should be significantly more robust than traditionally used reflectances, brightness temperatures, and brightness temperature differences, since the viewing geometry, illumination geometry, and the background signal are accounted for when retrieving the cloud properties using various multi-spectral techniques. We proposed to use GEOCAT to produce cloud products for current GOES and then evaluate their utility for diagnosing and predicting the near-term evolution of convective systems through case studies. We utilized the cloud property probability distributions associated with manually derived convective cloud objects to characterize the temporal evolution of thunderstorms.

Summary of Accomplishments and Findings

Over the course of the last nine months we focused on developing an initial set of cloud property derived metrics for assessing convection in its immature and mature stages, with the eventual goal of using the metrics to predict the future behavior of the convective systems. We are using super rapid scan mode GOES-10 data for this analysis since it offers flexibility in our choice of temporal resolution. To accomplish this goal we performed the following work:

- Implemented an improved GVAR navigation scheme in GEOCAT needed to accurately navigate GVAR when "Image Motion Correction" is turned off, as is sometimes the case with Extended High Inclination data from GOES-10.
- Acquired GOES-10 1-minute data at 1-km resolution.
- Acquired corresponding Doppler radar base reflectivity data.
- Processed 4 algorithms to produce 7 products (cloud mask, cloud phase/type, cloud top height, cloud emissivity, infrared cloud microphysical parameter, optical depth, effective particle radius) at a 10-minute time resolution for a chosen convective case. The algorithms run very quickly, so we could readily produce the products at 1-minute resolution when required. Also, all 5 GOES channels were used to produce the combination of all of these products. Thus, we are making full use of the spectral information offered by the GOES.
- Performed a manual analysis to identify targeted convective cloud objects at each image time.
- Constructed evaluation metrics from the cloud property probability distributions.

An example of the cloud property derived metrics is shown in Figure 2.9.2 for a severe storm that produced a tornado in Central Missouri on 26 September 2006. A radar/satellite composite of the storm of interest is shown in Figure 2.9.1. The metrics shown in the top left (cloud phase fraction), top right (cloud emissivity), center right (anvil area), and lower right (small ice crystal area) panels of the Figure 2.9.2 are derived from infrared measurements, so they can be produced during the day and night. The other metrics require visible and near-infrared reflectances, and, hence, are only possible during the day. The results are consistent with a rapidly intensifying storm. The evolution of the cloud microphysics (e.g. transition to smaller ice crystals) may also suggest a strengthening of the updraft. Our future work will focus on processing additional cases as a function of storm strength in an effort to better determine which metrics are most robust for predicting when a storm is going to rapidly intensify.

Figure 2.9.1. A radar/satellite composite of convective storms in Missouri and Arkansas on 22 September 2006 at 1910 UTC. The storm circled in red produced a confirmed tornado and hail.

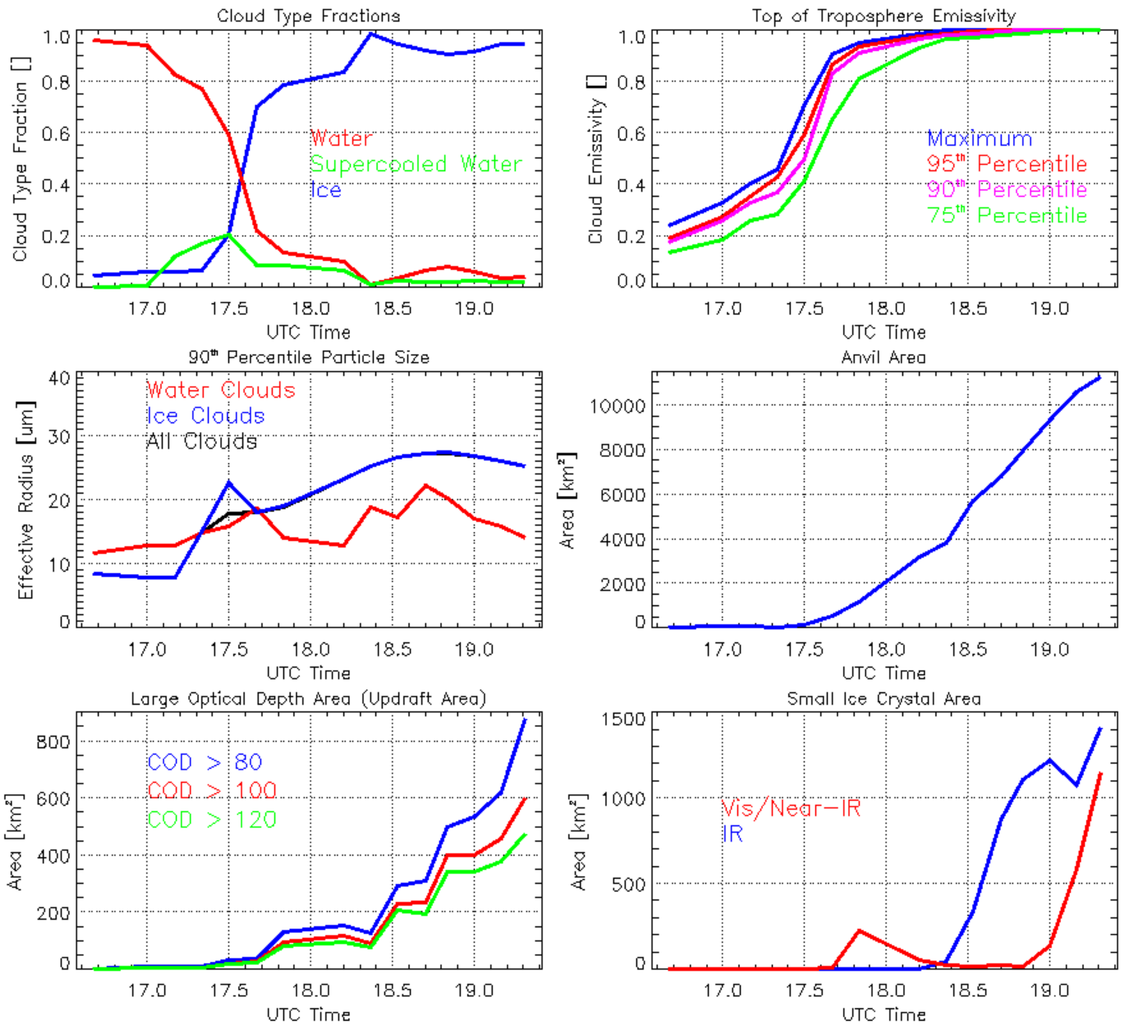


Figure 2.9.2. The above figure shows convective storm metrics, as a function of time, that were derived using various cloud property retrievals. The fraction of liquid water, supercooled water, and ice pixels in the convective cloud object is shown in the top left panel. In the top right panel, a radiative parameter is used to quantify the vertical growth of the convective cloud. The evolution of the cloud particle size is shown in the middle left panel. The anvil area is given in the middle right panel. The cloud area composed of very large optical depths is shown in the bottom left. Finally, the area occupied by small particle dominated ice clouds is depicted on the bottom right.

Publications and Conference Reports

A publication is expected in the second year (2009-2010) of this project.

2.10. Using AWIPS to Expand Use of GOES Imager and Sounder Products in National Weather Service Forecast Offices

CIMSS Project Lead: Scott Bachmeier
CIMSS Support Scientist: Jordan J. Gerth
NOAA Collaborator: Gary S. Wade
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information, and
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed work:
The primary tool used by National Weather Service (NWS) meteorologists for viewing current weather information is the Advanced Weather Interactive Processing System (AWIPS). The potential exists for the creation and deployment of experimental satellite imagery and products into AWIPS, particularly from the GOES Sounder, that can enhance operations at National Weather Service offices nationwide. Demonstration and training are critical to achieving increased acceptance and use of new satellite applications and products. The recent capability at CIMSS to fully run the AWIPS environment locally as well as to provide CIMSS satellite data and products into the AWIPS data stream is being leveraged to advance the exposure and overall usage of such satellite data (geo and polar) in the NWS.

Summary of Accomplishments and Findings:
The following activity goals have been achieved or significantly advanced during 2008.

1. In-person training was successfully conducted on 10 Jan 2008 at the Green Bay, WI (GRB) NWS Forecast Office (FO). Several staff from the GRB FO, as well as a couple from the Marquette, MI (MQT) NWS FO, were in attendance. G. Brusky, the GRB Science and Operations Officer (SOO), was the contact who helped arrange the visit. There was good discussion between the researchers and the forecasters; a number of products were received with interest. [The PowerPoint presentations, by CIMSS and NWS staff, are available at http://cimss.ssec.wisc.edu/~garyw/nws-visits/grb-2008/.]

2. A poster presentation was made, on 20 Jan 2008, at the American Meteorological Society (AMS) 88th Annual Meeting, held in New Orleans, LA, entitled: (P1.25) "A comparison of GOES and MODIS imagery in operational forecasting" by J. J. Gerth (CIMSS/University of Wisconsin-Madison). The poster emphasized both strengths and weaknesses of the geostationary (i. e. GOES) and polar-orbiting (e. g. the MODerate Resolution Imaging Spectroradiometer (MODIS)) satellite systems; the poster discussion was based on previous as well as recent new access to those datasets in AWIPS at NWS FOs. [Via http://ams.confex.com/ams/88Annual/techprogram/paper_136870.htm, the poster is available as: CompMODISGOES-Poster.ppt.]

3. S. Bachmeier participated as an instructor on Day 4 (17 Apr 2008) of the 15-day Cooperative Program for Operational Meteorology, Education, and Training (COMET) Mesoscale Analysis and Prediction Course (COMAP) residence course for NWS Science and Operations Officers (SOOs) held at Boulder, Colorado. A half-day lecture and lab session "Satellite Applications: Dynamic Feature Identification" was given, which discussed the use of GOES and MODIS water vapor channel imagery along with the GOES Sounder Total Column Ozone product to diagnose

important upper tropospheric dynamical structures, such as potential vorticity anomalies and the dynamic tropopause.

4. A total of 16 live tele-training sessions of the VISIT lesson "Water Vapor Imagery and Potential Vorticity Analysis" were given during the period, with 32 NWS forecast offices participating in the training. This lesson demonstrates the utility of the GOES imager water vapor channel and the GOES sounder total column ozone product to diagnose important upper tropospheric dynamical structures. [See - http://cimss.ssec.wisc.edu/goes/visit/wv_pv.html]

[See figure 1, for the title slide from the "Water Vapor Imagery and Potential Vorticity Analysis" VISIT lesson.]

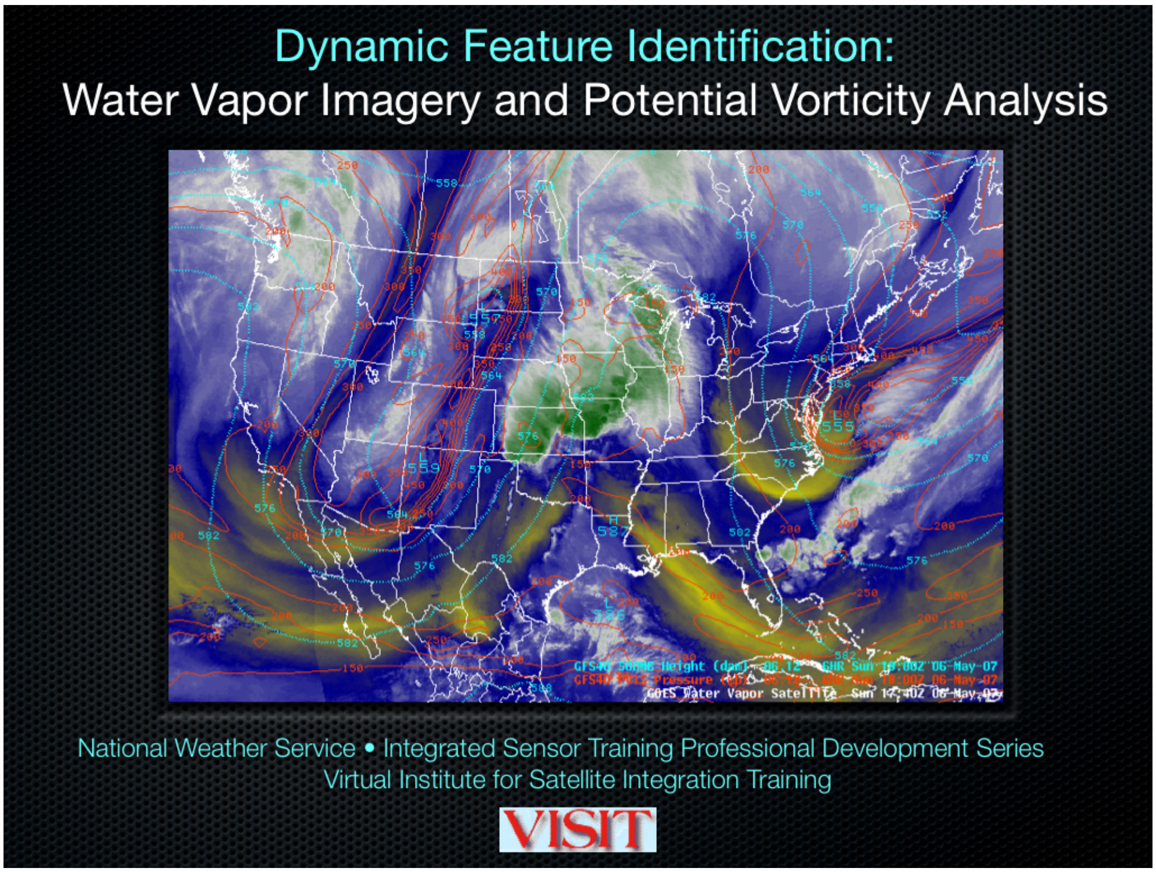


Figure 2.10.1. Title slide from the "Water Vapor Imagery and Potential Vorticity Analysis" VISIT lesson.

5. Since January 2008, 50 new GOES-related entries, actually shown from AWIPS, were posted on the CIMSS Satellite Blog (http://cimss.ssec.wisc.edu/goes/blog/) to demonstrate a wide variety of examples of applications of GOES satellite products to a number of different weather analysis and forecasting tasks. A recurring theme underlying many of the blog examples is the anticipated realization that the GOES-R Advanced Baseline Imager (ABI) will provide (and improve upon) the temporal strengths of the current GOES while adding the horizontal and spectral strengths illustrated by current polar orbiters, such as the MODIS (on Terra and Aqua). The CIMSS Satellite Blog is a popular satellite training resource for NWS forecasters.

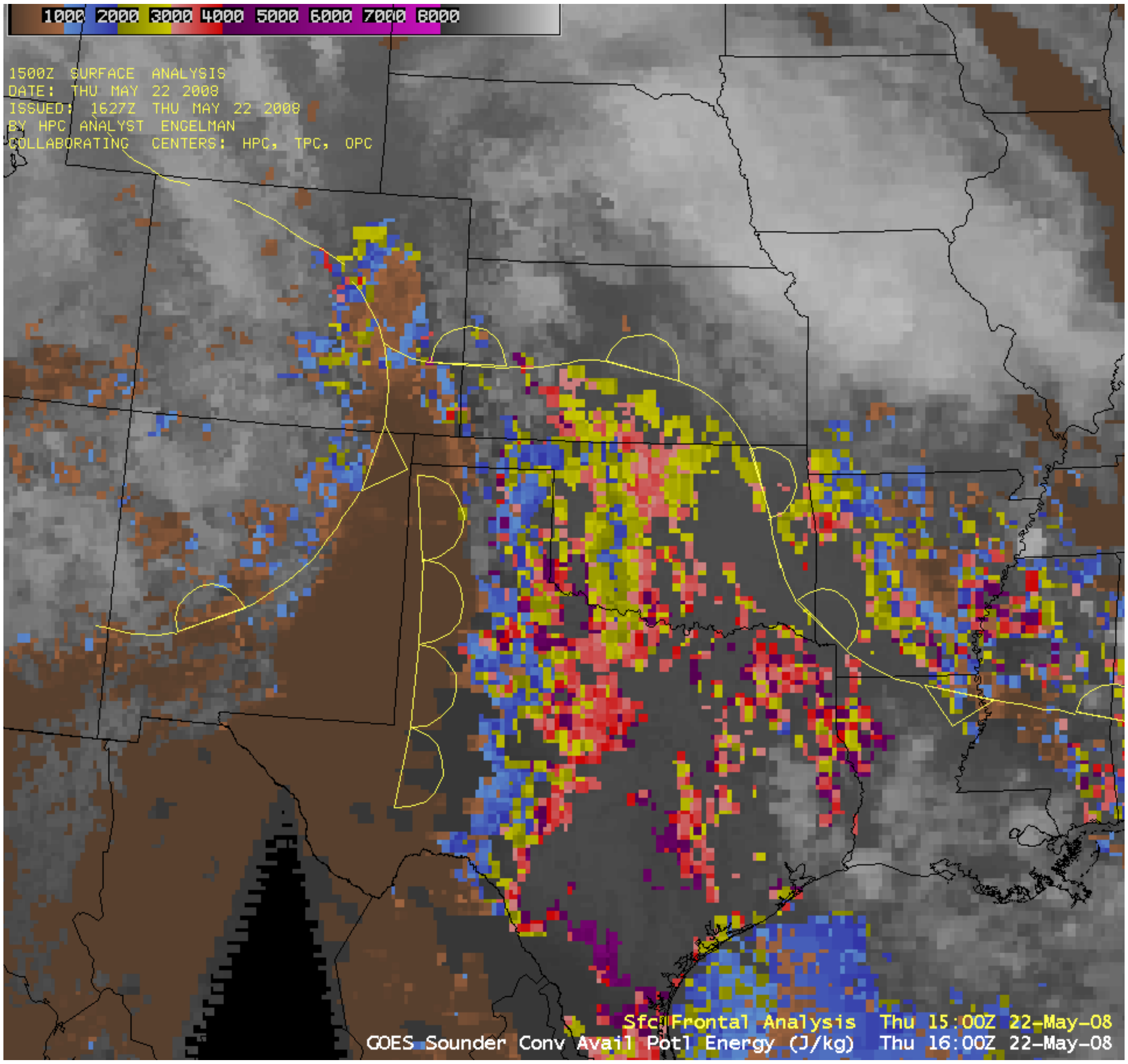


Figure 2.10.2. The GOES Sounder derived Convective Available Potential Energy (CAPE) product on 22 May 2008 indicated that the pre-convective environment across northeastern Colorado during the morning hours was becoming unstable, with CAPE values in the 2000-4000 J kg-1 range *(yellow to red enhancement)* at 16:00 UTC *(10 am local time)*. The air mass south of the warm front and east of the dryline (from southern Kansas into Texas) was also very unstable, with CAPE values in some areas over 4000 J kg-1 *(purple enhancement)*. An example from the CIMSS Satellite Blog entry for 22 May 2008, on "Severe thunderstorms over the Front Range and the Central Plains," at http://cimss.ssec.wisc.edu/goes/blog/archives/660].

6. In-person collaboration/training with NWS staff continued later in the period as planned, with CIMSS and NESDIS ASPB staff visiting Kansas City on 29-30 May 2008. The NWS complex in Kansas City houses both the NWS Central Region (CR) Headquarters (CRH) and the NWS Aviation Weather Center (AWC). G. Noonan served as the CRH point of contact for arranging the workshop/visit, and significant interaction with Noonan occurred prior to the visit to coordinate the effort. Besides CRH and AWC staff, a few forecasters were able to attend from local NWS Forecast Offices (FOs) {EAX-Pleasant Hill, MO; TOP-Topeka, KS}. In addition to those able to attend the presentations in person, NWS personnel in the field (at other CR NWS

FOs) were able to participate via simultaneous Internet broadcast of the presentations via "webinar". The speakers and titles of the talks for the workshop are included in the agenda shown in Table 2.10.1. The satellite overview and associated forecasting applications were presented for both the polar orbiting MODerate Resolution Imaging Spectroradiometer (MODIS) and the geostationary GOES Sounder. Additionally, applications were presented specifically pertaining to aviation forecasting, to numerical forecasting following assimilation of GOES derived products, and to demonstrating a "nearcasting" system, employing dynamical projections of GOES derived products in the short term. These last two applications attempt to exploit information content in the GOES Sounder data that might otherwise not be readily utilized at face value.

Table 2.10.1: Agenda from 28 May 2008 for the CIMSS team workshop visit to the NWS (National Weather Service) KC (Kansas City, MO) complex [(CR (NWS Central Region), AWC (NWS Aviation Weather Center), FOs (NWS Forecast Offices)].

Time	Topic	Staff	
0820 AM	Arrive MCI (from MSN). (***Thu 29 May 2008***)	[dep MSN 0700 AM	
0930 AM	Welcome to NWS KC Complex. Facility orientation. Introductions.	Noonan, G. All	30
1000 AM	CIMSS/SSEC/ASPB overview.	Wade, G.	15
1015 AM	"Introduction to MODIS, and MODIS Applications"	Bachmeier, S.	45
1100 AM	"GOES Sounder Update"	Wade, G.	45
1145 PM	Lunch break.		(60)
1245 PM	"Satellite Applications for Aviation"	Feltz, W.	60
0145 PM	"CRAS - the CIMSS Regional Assimilation System"	Aune, B.	45
0230 PM	"Dynamic Nearcasting"	Petersen, R.	45
0315 PM	Open forum. List of action items (what, who).	All	45
0400 PM	Close of extended presentations. Individual discussions/follow-ups.		(60)
0500 PM	End for the day (*Thu 29 May 2008*)		

0730 AM - 1130 AM	Start for the day (*Fri 20 May 2008*) {brief NWS EAX visit; AWC tour; follow-up to issues from yesterday's discussions**?**}		
1210 PM	Depart MCI (for MSN). (***Fri 30 May 2008***)	[arr MSN 0220 PM]	

Although there were good questions from, and some interesting discussion with, the attendees at the Kansas City complex, notably led by S. Silberberg of AWC and P. Browning of CRH, the level of interaction seemed less effective than that at previous workshop visits which were to individual FOs. Stepping up an administrative level (to "region") seemed to remove the team a bit further from the "grass roots" forecasters using AWIPS - the ultimate target of these efforts to provide better satellite information for improved forecasts. Following the day long presentations and discussion on 29 May 2008, the CIMSS team was able to visit with AWC forecasters on the morning of 30 May 2008. Interest in the satellite products seemed higher again, more reminiscent of the FOs previously visited. The forecast imagery from the CIMSS Regional Assimilation System (CRAS), uniquely using GOES Sounder cloud and moisture information, was of particular interest to forecasters.

[The PowerPoint presentations, by CIMSS and NESDIS ASPB staff, are available at http://cimss.ssec.wisc.edu/~garyw/nws-visits/kc-cr-2008/.]

7. The CIMSS Warning Event Simulator (WES) was upgraded to Version 8.1, and then to Version 8.2, within the period in preparation for work on creating WES training cases. [Although not yet directly related to current GOES data applications, other work has been done recently on a WES case study showing GOES-R ABI (Advanced Baseline Imager) data, simulated from 05 June 2005 high quality model analyses; this ABI demonstration has shown that the WES software here at CIMSS is working successfully.]

8. The on-going effort continues to compile a list of any AFD (Area Forecast Discussion) message that contains specific (named) references to any of the CIMSS-provided products in the AWIPS data stream at any participating FO. As of early August 2008, there had been 82 AFDs mentioning CRAS (i.e., indirect use of GOES Sounding data), as well as 56 AFDs mentioning MODIS (since the beginning of this effort in the late summer of 2006). In the last two months, there have been a few more new CIMSS AWIPS product references noted in AFDs.

9. At the Sullivan (WI) NWS FO (MKX), new transfer M. Cronce was appointed the liaison to the University of Wisconsin-Madison, specifically including CIMSS. On 17 September 2008, Cronce visited Madison for the day, was introduced to many CIMSS staff, and had numerous discussions about and demonstrations of research projects at CIMSS, specifically including GOES applications and the AWIPS capability at CIMSS.

10. A poster presentation was planned for the 33rd National Weather Association (NWA) Annual Meeting to be held in Louisville, KY on 13 October 2008. Unfortunately, the inability to actually use requested and planned FY2009 project funding in the first quarter for federal travel prohibited attendance at the meeting. Despite the loss of the opportunity to engage meeting participants in a discussion of the early results and attempts to provide improved GOES Sounder profile products (which eventually are destined for AWIPS), the poster is still to be shown (but without an author present). The poster, "Assessing development of a refined technique for retrieval of vertical profiles of temperature and moisture from the GOES Sounder, with current real-time products" by Wade, G. S., J. Li, J. P. Nelson, Z. Li, and T. J. Schmit, shows early results of implementing a new version of the GOES Sounder retrieval algorithm developed by J. Li and Z. Li.

Although this experimental version, which uses an improved first guess (derived via regression), handles surface infrared emissivity better in the retrieval procedure, and uses a more reliable background error covariance matrix, has shown improvements versus the current (Ma-based) algorithm with some data, the actual implementation with current, real-time data in McIDAS has not been fully successful yet. Routine comparison displays during the summer, of the resulting GOES Sounder Derived Product Imagery (DPI), showed noticeable lack of deviation from the first-guess for the new Li-based retrievals. [See Figures 2.10.3a and 2.10.3b for examples of the comparison; note specifically the variation in Lifted Index (LI) values across the upper Mississippi Valley (3b), as well as, the overall "smoother" character of the "Li-based" DPI in both TPW and LI.] This inconsistency (and opposition to the goal of providing a more robust retrieval, able to more strongly deviate from the guess, especially when the guess is poor) has forced current re-examination of the implementation in McIDAS.

Although GOES-R will not have an improved hyperspectral interferometer sounder, the Advanced Baseline Imager (ABI) on GOES-R will provide some assortment of multi-spectral channels, capable of generating some sounding-like integrated quantities (such as total moisture or bulk stability). As the current, limited filter-wheel GOES Sounder products have a similar information content to proposed GOES-R products, improvement of the application of current geo sounder products (and eventual incorporation into AWIPS) meshes well with preparations for GOES-R data and products, anticipated to be available in the middle of the next decade.

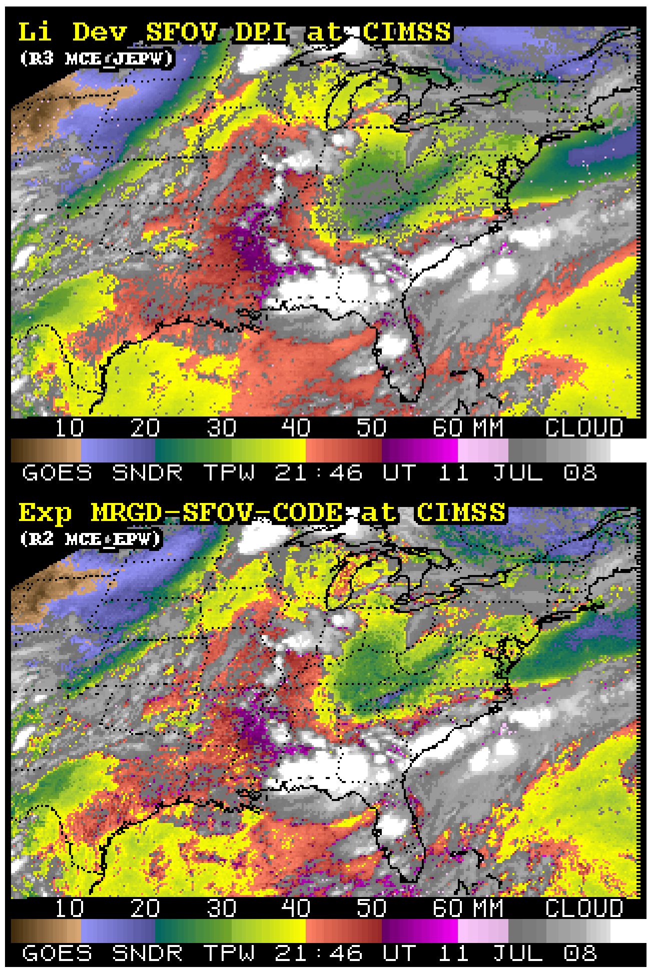


Figure 2.10.3a. GOES Sounder Total Precipitable Water (TPW) Derived Product Image (DPI) at 22 UT on 11 July 2008 from (top) new "Li-based" retrieval algorithm version and (bottom) older, current "Ma-based" retrieval algorithm.

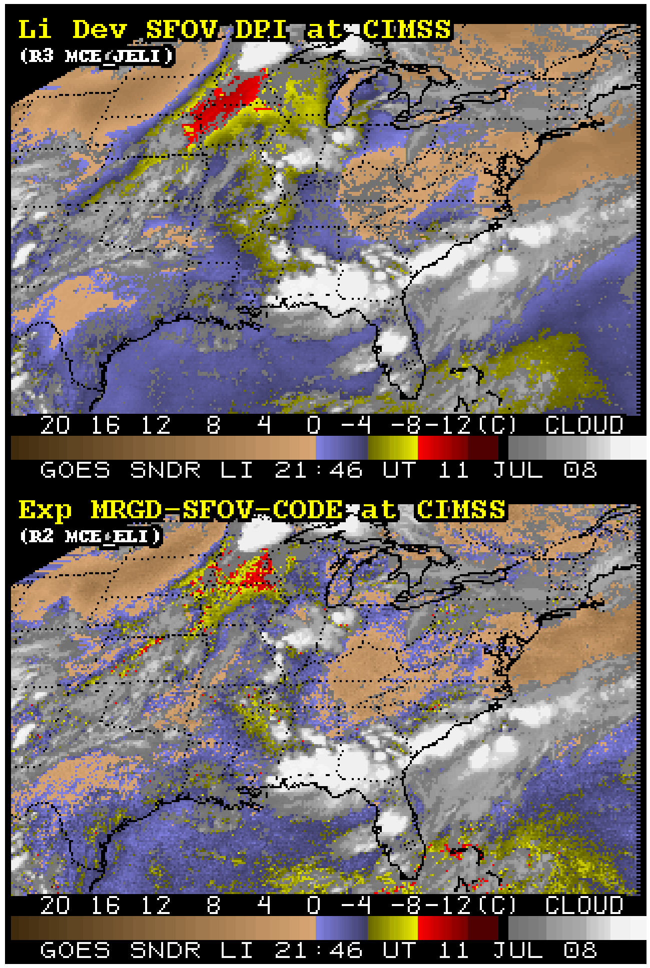


Figure 2.10.3b: Same as Figure 2.10.3a, except for GOES Sounder Lifted Index (LI) Derived Product Image (DPI).

3. CIMSS Support for Polar and Geostationary Satellite Science Topics (P & G PSDI)

3.1. Automatic Volcanic Ash Detection and Height Determination from the AVHRR

CIMSS Project Lead: William Straka
CIMSS Support Scientist: Justin Sieglaff
NOAA Collaborators: Michael Pavolonis and Andrew Heidinger
NOAA Strategic Goals Addressed:

4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work

Volcanic ash poses a large threat to aviation. As such, volcanic ash forecasters and analysts would benefit from automatic and near real-time ash detection and height estimates, which would help improve the accuracy and timeliness of advisories and forecasts. Volcanic ash products that are currently in operations are imagery based and qualitative. Since these products are qualitative, an analyst only looks at them in select regions where volcanic eruptions are thought to be possible. Thus, an unexpected volcanic eruption, even if detectable with current methods, can be missed. In this project, we propose to take existing experimental methods for quantitatively detecting volcanic ash and estimating its height and implement them into the operational Advanced Very High Resolution Radiometer (AVHRR) processing system, CLAVR-x (The Extended Clouds from AVHRR processing system). The first year of this project is focused on implementing and refining the volcanic ash algorithms in CLAVR-x to produce reliable global results on a real-time basis prior to a full operational implementation later in the project.

Summary of Accomplishments and Findings

CLAVR-x was modified in order to accommodate the volcanic ash detection, ash height and ash mass loading algorithms. Modifications to CLAVR-x included the addition of a volcanic ash module, various data manipulation subroutines were added and a volcanic ash output file stream was created. These modifications allowed for the algorithm logic to be implemented and tested on a variety of historical volcanic eruptions.

The automated volcanic ash detection algorithm has been designed to maintain consistency despite varying spectral information associated with the various AVHRR instruments. The automated detection algorithm can be thought of as four algorithms, two separate daytime algorithms, one nighttime algorithm and one terminator algorithm, all of which are needed to account for the varying spectral information that is available. The daytime algorithms utilize the 0.65 µm, 1.6 µm or 3.75 µm (depending upon platform), 11 µm and 12 µm channels. The nighttime algorithm utilizes the 3.75 µm, 11 µm and 12 µm channels. The terminator algorithm utilizes the 11 µm and 12 µm channels. The algorithm logic allows for data from the following current AVHRR platforms to be processed in near-real time: NOAA-15, NOAA-16, NOAA-17, NOAA-18 and METOP-A AVHRR.

Initial results of the algorithm show high detection rates and low false alarm rates. False alarm rates are currently near 0.01 to 0.001%. A very low false alarm rate is critical for an operational system; additional datasets and algorithm revisions will further improve the false alarm statistics. Figure 3.1.1 shows false-color RGB composites and corresponding ash detection algorithm output for two volcanic eruptions.

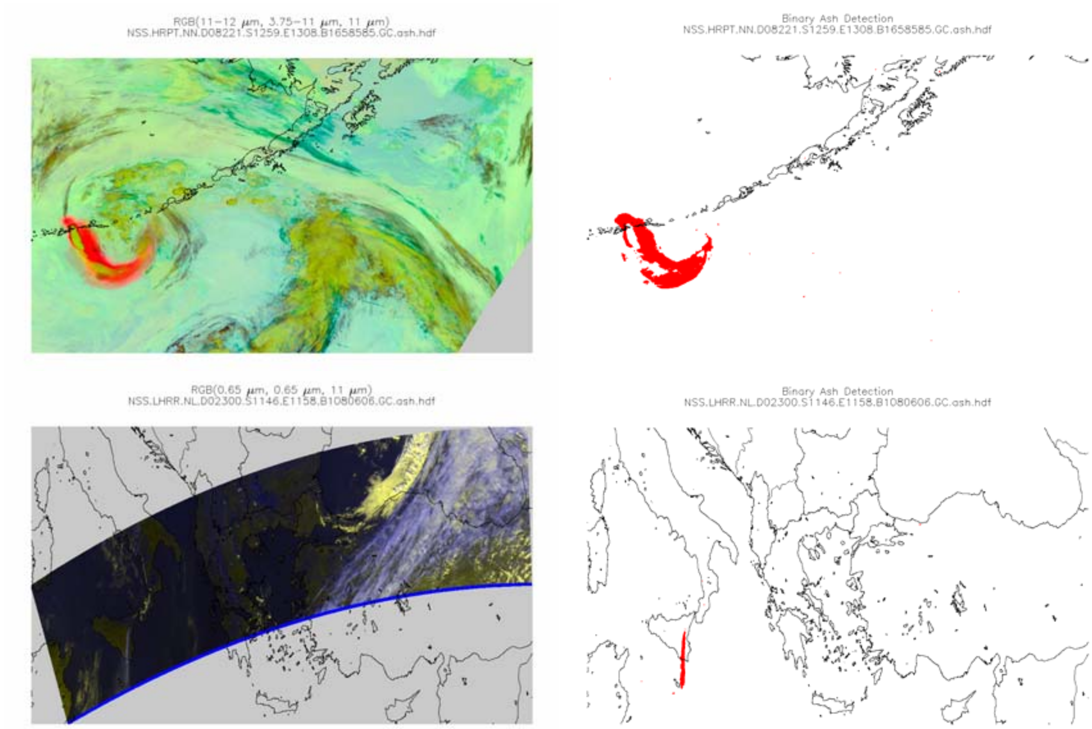


Figure 3.1.1. Top left is a false color composite of a volcanic eruption of Kasatochi, Alaska on 8 August 2008 and the top right is the corresponding automated ash detection algorithm output (currently expressed as a binary ash/no ash, where red is ash and white is no ash). Bottom left is a false color composite of a volcanic eruption of Mount Etna, Italy on 25 October 2002 and the bottom right is the corresponding automated ash detection algorithm output.

Similar to algorithms developed for GOES-R, the AVHRR ash detection output will eventually be expressed as a probability as opposed to the current binary yes/no output. This transition to probabilistic detection will be implemented during the final quarter of 2008. After the detection algorithm processing is complete, the height and ash loading is retrieved for pixels identified as ash. The ash cloud height retrieval and ash mass-loading algorithm is based upon the Heidinger and Pavolonis (JAMC, 2008) cloud height retrieval which has an estimated cloud height accuracy of 3-km and mass loading accuracy of 2 ton/km^2. The quantitative nature of the ash cloud height and ash mass loading is unique for an operational volcanic ash detection system, as current operational products are image-based and qualitative.

Future work in the remainder of 2008 and 2009 will include creating an automated email warning system and generation of output files compatible with McIDAS and AWIPS. The algorithm logic will continue to be refined as needed as pre-operational processing begins.

References

Heidinger, A.K. and M.J. Pavolonis, 2008: Nearly 30 years of gazing at clouds through a split-window: Part I: Methodology, *Journal of Applied Meteorology and Climate*, Accepted.

3.2. Polar Winds from MODIS

CIMSS Project Leads: Dave Santek, Chris Velden
CIMSS Support Scientist: Rich Dworak
NOAA Collaborator: Jeff Key
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

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 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.

The objective of this project is to generate wind vectors over the polar regions from polar-orbiting satellites. Of primary interest is the MODIS instrument on NASA's Terra and Aqua satellites. We have developed an experimental wind product that can be used in numerical weather prediction systems, and have helped transition the product to NESDIS operations. Under this PSDI funding, we continue to evaluate, improve, and extend the product suite.

The project Principal Investigator at CIMSS is Christopher Velden. David Santek performs the analyses, and oversees the implementation and modification of McIDAS and heritage wind generation software for use with MODIS. Rich Dworak assists in data analysis and research activities. Jeff Key, NOAA/NESDIS, works on the project in collaboration with CIMSS scientists, and is the NESDIS point of contact for the project.

Summary of Accomplishments and Findings

Over the past year we have continued the real-time generation of the MODIS polar winds product from both Terra and Aqua. The data are made available to users via anonymous FTP. MODIS data are acquired from the NOAA Real-Time System, which is a NOAA computer at NASA Goddard Space Flight Center. The experimental MODIS wind product is routinely generated by CIMSS for scientific research. The single satellite product (Terra and Aqua separately) transitioned to NESDIS operations in November 2005. We continue to work with our STAR and OSDPD colleagues on code differences and any discrepancies that arise between the CIMSS and OSDPD winds.

We have extended the polar wind generation algorithm for use with the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA polar-orbiting satellites. The winds are derived only in the 11-micrometer infrared channel from the NOAA-15, -16, -17, and -18 satellites. The Global Area Coverage (GAC) data from these satellites are used in order to maximize the product coverage in the polar regions. However, there are fewer AVHRR winds generated compared to MODIS due to the lower spatial resolution GAC and the lack of a water vapor channel. By using the four NOAA satellites, the area coverage at a specific time is potentially more complete than the winds derived only from MODIS. The processing has been extended to include the AVHRR from METOP-A which is at the full 1 km resolution. We expect higher quality winds from METOP not only due to the higher spatial resolution but also from improved geolocation accuracy of the data.

The AVHRR winds are generated for both the NOAA and METOP satellites routinely at CIMSS and evaluations continue at some NWP centers. We are assisting OSDPD with transitioning the code andprocessing scripts from CIMSS to their environment. Additionally, we are aiding in the transition of a mixed-satellite (Terra and Aqua together) MODIS wind product to operations.

To improve the winds product and better understand the technique, statistical estimates of the pressure height error of the historical AVHRR cloud motion vectors were made through comparisons with rawinsonde winds using two best-fit height assignment techniques. Initial results indicate that the AVHRR-derived winds are assigned a height that is, on average, too low.

Santek was invited to the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) in Darmstadt, Germany from 2-10 June 2008 to discuss satellite-derived polar winds from AVHRR data. EUMETSAT is in the process of evaluating the satellite winds code developed at the CIMSS in preparation for their operational derivation of satellite winds from METOP-A AVHRR by the end of 2008. Santek also gave a presentation on the status, application, and technical details associated with the polar winds project at CIMSS.

Eleven numerical weather prediction centers in seven countries continue use the MODIS winds in their operational systems: 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 Fleet Numerical Meteorology and Oceanography Center (FNMOC), Deutscher Wetterdienst (DWD; Germany), MeteoFrance, the Australian Bureau of Meteorology, and the National Center for Atmospheric Research (NCAR).

Velden, Key, Dworak, and Santek attended and presented at the 9th International Winds Workshop held in Annapolis, Maryland from 14-18 April 2008.

Publications and Conference Reports

Dworak, R. and J. Key, 2008: Assessing the quality of historical AVHRR polar wind height assignments, Proceedings of the 9th International Winds Workshop, Annapolis, Maryland, 14-18 April 2008.

Dworak, R. and J. R. Key. 2009: 20 years of polar winds from AVHRR: Validation and comparison to the ERA-40, J. Climate Appl. Meteor., Accepted.

Key J., D. Santek, C. Velden, J. Daniels, R. Dworak, 2008: The polar wind product suite, Proceedings of the 9th International Winds Workshop, Annapolis, Maryland, 14-18 April 2008.

Santek, D. 2008: The impact of MODIS-derived polar winds on global forecasts, Proceedings of the 9th International Winds Workshop, Annapolis, Maryland, 14-18 April 2008.

3.3. GOES-O Wildfire ABBA Upgrades

CIMSS Project Leads: Chris Schmidt, Elaine Prins
CIMSS Support Scientists: Scott Lindstrom, Jay Hoffman
NOAA Collaborators: Gilberto Vicente, Timothy Schmit, R. Bradley Pierce, Ivan Csiszar,
NOAA Strategic Goals Addressed:

2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

FY08 marked a change in the scope of WF_ABBA G-PSDI projects. Previous years were set up as effectively maintenance and upgrade plans that in some cases resulted in focus on the problem of the moment, such as the "rollover" issue that GOES-12 developed in channel 2 in 2006. FY08's project plan focused more explicitly on implementing support for GOES-O and support during the GOES-O post launch test (PLT), updating WF_ABBA documentation to reflect the new version of the WF_ABBA (version 6.5, aka v65) and added satellite support, implementing dynamic saturation point determination, and continuing collaborations on validation with the Hazard Mapping System (HMS) team and scientists at the University of Maryland-College Park (UMD). The project also inherited the delayed completion of delivery of v65 of the WF_ABBA from the previous WF_ABBA PSDI project. Version 6.5 provides support for Meteosat-8/-9, MTSAT-1R, and all GOES satellites from GOES-8 through -14 (aka GOES-O). Version 6.5 also supports GOES Rapid Scan Operations (RSO) to process all data with a low latency, hence the name Global+RSO WF_ABBA.

Summary of Accomplishments and Findings

Version 6.5, the Global+RSO WF_ABBA, began delivery to NESDIS Operations in late August 2008. Alterations were necessary to adapt the processing framework to the configuration used at Operations versus that at CIMSS, and the code is able to function at both locations and produces identical output within the limits of the input data. (The satellite data at the two locations is received by different dishes, and the slight differences in noise do show up sometimes in fire detection and characterization data.) Support for Meteosat-8/-9, MTSAT-1R, and all GOES from 8 through 14 is present in this delivery. Latency for product generation is under 5 minutes in most cases, with some exceptions in the cases of full disk images containing a very large number of fires. The process to obtain operational certification for v65 is underway.

Version 6.5 provides additional information beyond the legacy v61 WF_ABBA running at Operations. Specifically, the text output files contain additional parameters listing the size of the pixel containing the fire and the estimated fire radiated power (FRP) output, in addition to the fire location, instantaneous fire size, instantaneous fire temperature, and other properties present in v61 and earlier. Also provided is an enhanced metadata mask containing fire classifications as well as information on whether a pixel was processed for possible fires and if it was not, why. The information includes whether the pixel was determined to be over water, whether it was part of a block-out zone for solar reflection or biome type, or whether the pixel was determined to be cloudy, among others. The changes were the result of user and SPSRB requests and provide users with information needed to produce much better trend analyses and emissions estimates than was possible with v61 and earlier.

Figure 3.3.1 shows an example metadata mask for Meteosat-9 data from 13:00 UTC on 24 September 2008. Black areas are unprocessed due to ecosystem block-out zones (primarily water and desert) and places with bad emissivity values (typically pixels that partially contain water). Light gray areas were determined to be cloudy. Green areas were processed but no fires were found. The six color codes for fires indicate the types found, and the densest region of detected fires is magnified by 500%. The small "plus signs" visible throughout the mask are an artifact of how the WF_ABBA handles the SEVIRI data and reflects the remapper used to create the perfectly navigated image. For certain block-out zones neighboring 3 km pixels can be impacted due to the diamond-shaped 5 km footprint of the sensor, and to be on the safe side the WF_ABBA screens those out, leading to the small "plus signs". Similar "plus signs" can be seen for many fires in 3.9 µm imagery from SEVIRI. Coverage from SEVIRI includes a substantial region of Brazil, allowing intercomparisons to be performed between WF_ABBA output from SEVIRI and GOES. Such intercomparisons are being performed under other CIMSS projects and have shown agreement at the level expected given the satellite view angles and sensor footprints.

Full documentation following SPSRB guidelines of v65 is currently underway and will be completed in winter 2008/2009.

Preliminary support for GOES-O based on pre-launch characterization of the Imager was implemented in the WF_ABBA v65. The GOES-O launch schedule was delayed and the WF_ABBA support of GOES-O will be evaluated and if necessary updated once the PLT takes place.

Implementation of dynamic saturation temperature determinations has been delayed but should occur during this project's performance period. The delay was due to differences discovered between saturation values determined using the CIMSS technique, which is based on histogram analysis applied to GVAR data, and those determined at the Satellite Operations Control Center (SOCC) using calibration data. The difference was determined to be related to an emissivity correction for the East-West scan mirror which was applied to the data from CIMSS but not applied to the particular data from SOCC that was used in the comparisons. The correction accounted for the differences between the two sets of saturation values. Implementation will proceed and the technique will be included in the v65 documentation.

Collaborations on validation of the WF_ABBA with the HMS team and UMD researchers has continued as personnel has moved on from UMD. Ivan Csiszar, formerly of UMD, is now a member of NOAA/NESDIS/STAR and Wilfrid Schroeder, also of UMD, is now working as a contractor for NOAA. The work continues to focus on intercomparing the WF_ABBA with high-resolution data such as that from ASTER and Landsat ETM+. This year saw estimation of fire area from ASTER and ETM+ data and then compared to the WF_ABBA with mixed results. The manual nature of this work severely limits the number of cases that have been examined thus far, and the work will continue as aspects of other projects given the end of this funding in FY08.

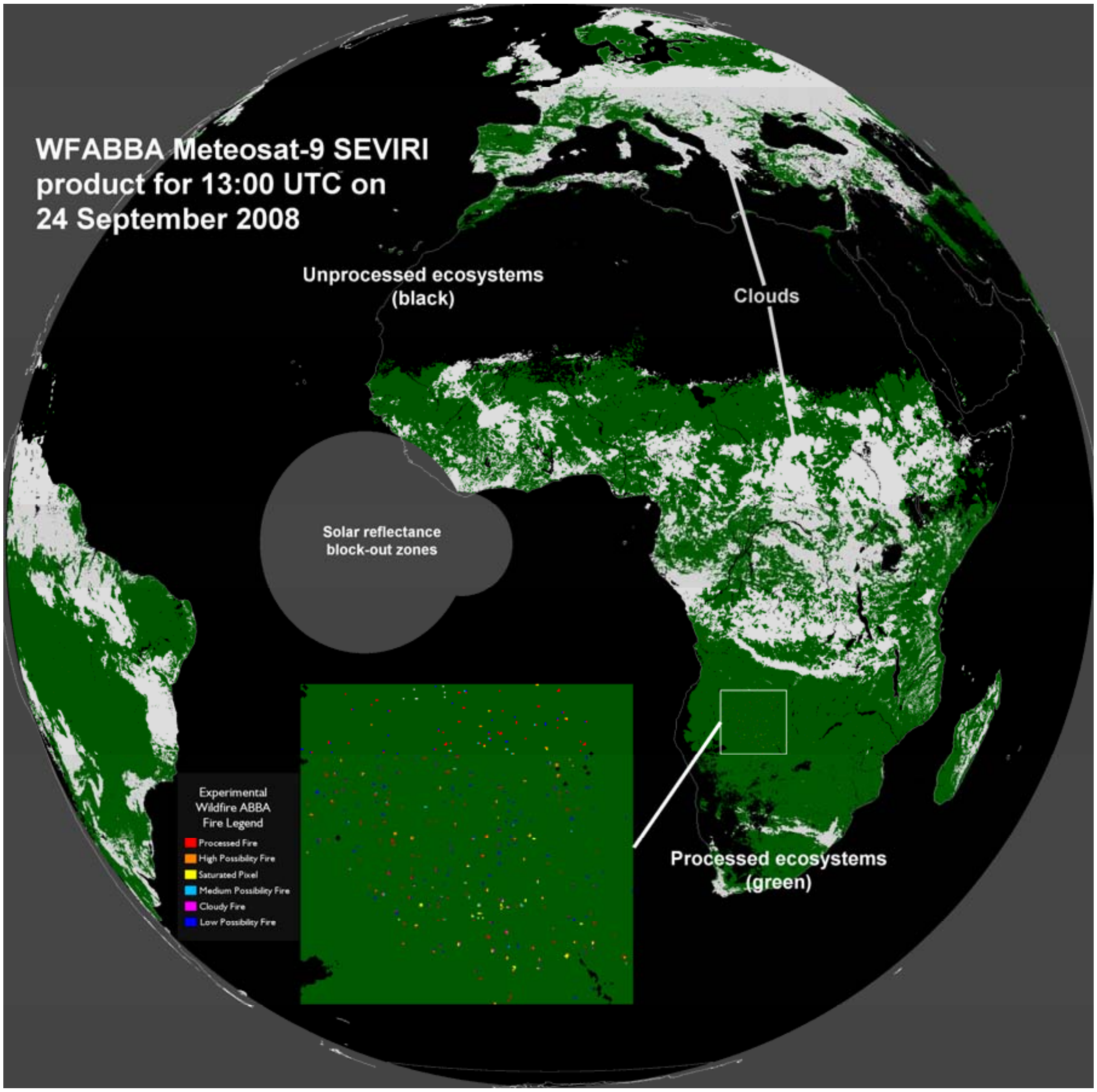


Figure 3.3.1. Example metadata mask for Meteosat-9 data from 13:00 UTC on 24 September 2008. Black areas are unprocessed due to ecosystem block-out zones (primarily water and desert) and places with bad emissivity values (typically pixels that partially contain water). Light gray areas were determined to be cloudy. Green areas were processed but no fires were found. The six color codes for fires indicate the types found, and the densest region of detected fires is magnified by 500%. The biomass burning in that region is largely due to agricultural activity.

3.4. GOES-O(14) Routine Checkout and Data Archive

CIMSS Project Lead: Mathew Gunshor
CIMSS Support Scientists: Jim Nelson, Tim Olander, Tony Schreiner, Dave Stettner, Chris Velden
NOAA Collaborators: Tim Schmit, Jaime Daniels, Gary Wade, Bob Aune
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

CIMSS will conduct research with GOES-O/14 information as part of the post-launch science checkout. The first step will be the data collection phase, followed by analysis of the radiance data and product generation and validations. This checkout of GOES-14 Sounder and Imager is a critical step toward operational use of the data.

At the time of proposal, the launch of GOES-O (to become GOES-14) was scheduled for August 2008. Previously the launch was scheduled for April 2008. Currently it is said to be no sooner than March 2009. The main post launch science checkout will be conducted approximately 5 to 6 months after launch. Before being used operationally, the quality of the data and products must be understood. Therefore, a routine processing system with data from GOES-14 will be built. Work at determining radiance integrity will be conducted. The steps required to complete the checkout are similar to previous post-launch checkouts (Hillger et al, 2003; Hillger and Schmit, 2007).

Specific tasks outlined in the proposal are:

1. Handling of the new field-of-view size of the 13.3 um GOES-O Imager band. This means to incorporate the updated GVAR data stream. Test thermal/vacuum data will be used.

2. Acquisition and saving the GOES-O GVAR data during the NOAA Science test.

3. Operational Software Production issues. In preparation for the operational insertion of GOES-14, software modifications for various operational products, such as, but not exclusive to, Clear Sky Brightness Temperature, Imager and Sounder Cloud Products and Temperature/Moisture Retrieval algorithms will be forwarded to the operational production algorithms.

Similar to previous instrument checkouts, these results will be added to previous results on the web. These will be done in similar fashion as for GOES-11/12/13:

http://rammb.cira.colostate.edu/projects/goes_n/
http://cimss.ssec.wisc.edu/goes/g12_report / and
http://cimss.ssec.wisc.edu/goes/g11_report/ .

Summary of Accomplishments and Findings

The first specific task, to get set handling the new spatial resolution for the 13.3 micrometer band on the Imager has been done. Sample GVAR laboratory data were supplied and were used for verifying the new GVAR format and to test data ingestors and servers. The finer 13.3 micrometer band spatial data are evident in images from both the Sensor Processing Subsystem (SPS) and an updated Man Computer Interactive Data Access System (McIDAS) server. These data were generated using MSPS v6.3.1.

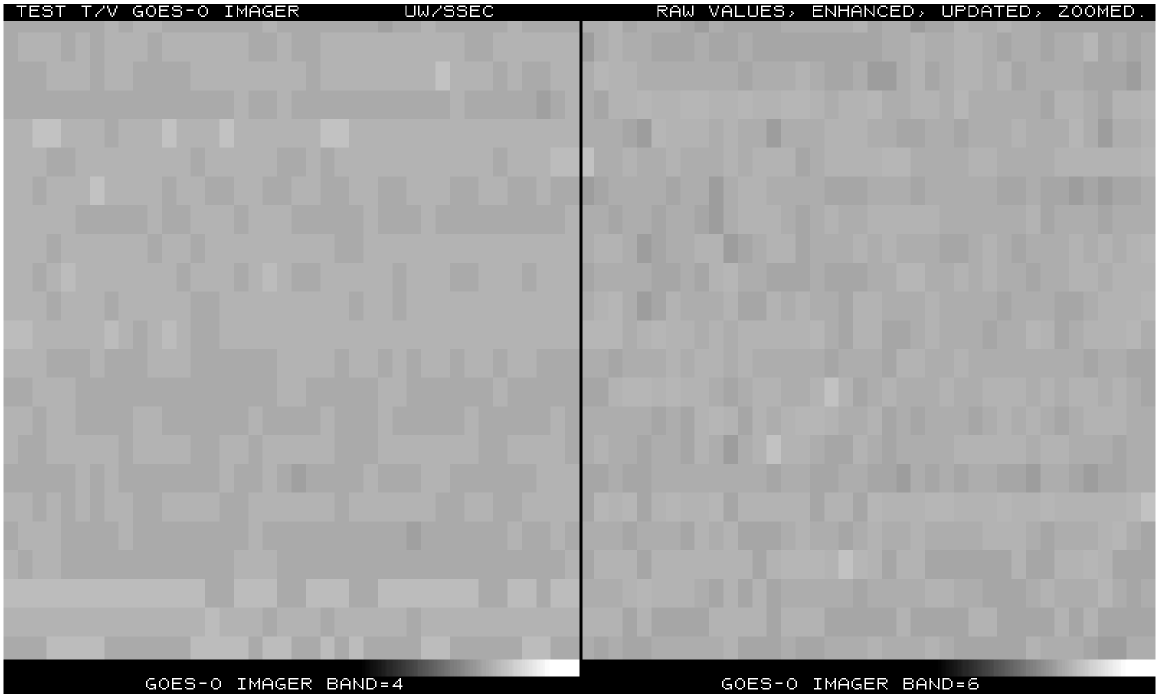


Figure 3.4.1. Image of GOES-O Imager thermal vacuum test data. These images were made using the SSEC McIDAS system. Note the improved spatial resolution of the 13.3 micron band (6) of the GOES-O imager (right panel), which is now the same field-of-view size as the other infrared bands (as shown in the left panel). These images are not calibrated and hence do not reflect instrument noise levels.

Given that GOES-O is expected to launch no sooner than March 2009, the other tasks in this proposal cannot be addressed until after launch when data are being routinely disseminated for NOAA's science test.

3.5. Derived Products from GOES-10 Sounder

CIMSS Project Lead: Anthony J. Schreiner
CIMSS Support Scientist: James P. Nelson III
NOAA Collaborators: Timothy J. Schmit, Gary S. Wade
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information, and
2. Understand climate variability and change to enhance society's ability to plan and respond,
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

The transfer 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, a number of GOES-10 products are available for other use. The products include temperature and moisture profiles, cloud product information, the monitoring of ash and SO_2 by the Washington DC VAAC (Volcanic Ash

Advisory Center), as well as improvement of Antarctica satellite imagery composites for use by aviation interests.

Many countries are now receiving geostationary Sounder data for the first time in 20 years and are developing meteorological products from the GOES-10 Sounder. These countries continue to access (via the web) the derived products from GOES-10 made at CIMSS. Countries that are prepared to locally generate such products can use those produced at CIMSS for validation purposes.

Two main tasks were proposed for 2008:

1. Continue to acquire and save the GOES-10 GVAR signal.
2. Derive and post GOES-10 Sounder products.

Summary of Accomplishments and Findings

The SSEC Data Center continues to acquire and archive the GOES-10 GVAR data. CIMSS science staff and NOAA collaborators continue to produce GOES Sounder derived products on an hourly basis using a tracking antenna, which was purchased and installed in June 2007.

As part of the second phase of this project:

1. GOES-10 Sounder data processed using the McIDAS software are being used to generate temperature/moisture retrieval profiles, cloud top pressure, and effective cloud amount in addition to other products over South America.

2. Derived products from GOES-10 were incorporated into the CIMSS GOES-10 Realtime Derived Products Page (*http://cimss.ssec.wisc.edu/goes/rt/goes10.ph p*). Products include Derived Product Images (DPI) of cloud top pressure, as well as Total Precipitable Water (TPW) and Lifted Index (stability) from the Sounder temperature and moisture profiles.

3. A data archive was created (and continues to grow) for the GOES-10 Sounder data and derived products.

4. Routine monitoring of the GOES-10 data products continues.

In addition, both the GOES-10 Sounder and Imager data were used to detail the track of volcanic dust (Imager) and SO_2 plumes that occurred during the eruption of the Chaiten volcano in Chile during early May 2008 (Figure 3.5.1). This particular eruption demonstrated some dramatic plumes (both dust and SO_2).

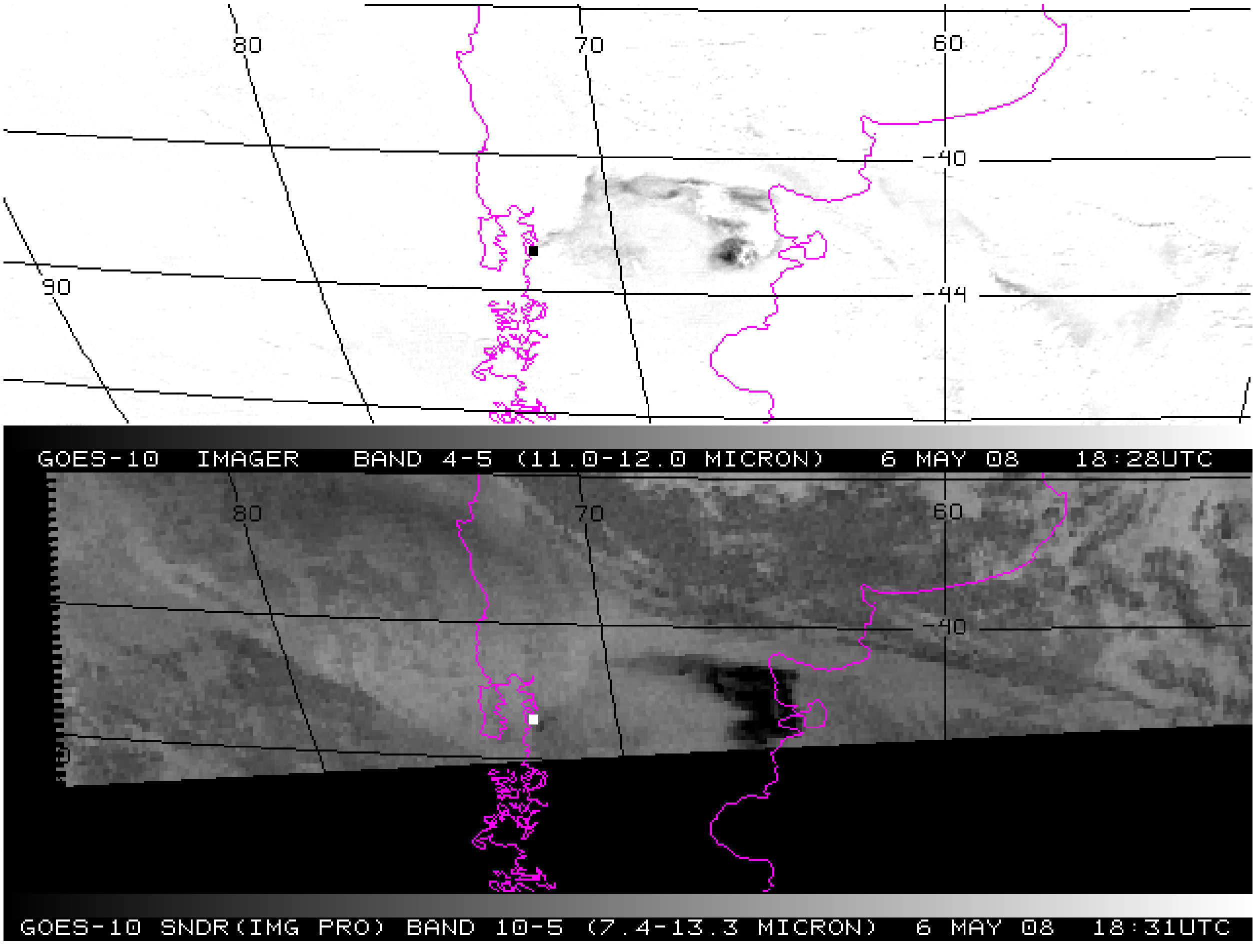


Figure 3.5.1. GOES-10 depiction of the Chaiten volcanic eruption for 6 May 2008 at nominally 1830 UTC. The volcanic dust plume (black) using Imager data is shown at the top. The SO_2 plume (black) based Sounder data is shown at the bottom. The Chaiten Volcano is noted by the black and white square in the top and bottom images, respectively.

Lastly, loops of high resolution GOES-10 Imager data for South America were made available via a link (http://cimss.ssec.wisc.edu/goes/realtime/latamer/aniginwsa.html) to the GOES-10 Realtime Derived Products Page noted above. The purpose of this loop was to assist South American weather forecast offices, that may not have direct access to the GOES-10 data. Starting in March 2008, all 5 spectral bands of the GOES-10 Imager were being posted, which covered northwestern South America at half-hourly intervals and at a nominal horizontal resolution of 4 km. This display answered specific requests from participants at the GEOSS-Americas Workshop, who came from Colombia and Venezuela and did not otherwise have any access to the imagery, and included animations that were significantly improved in resolution compared to the four-hourly interval and 10 km nominal horizontal resolution of the GOES-10 Sounder data.

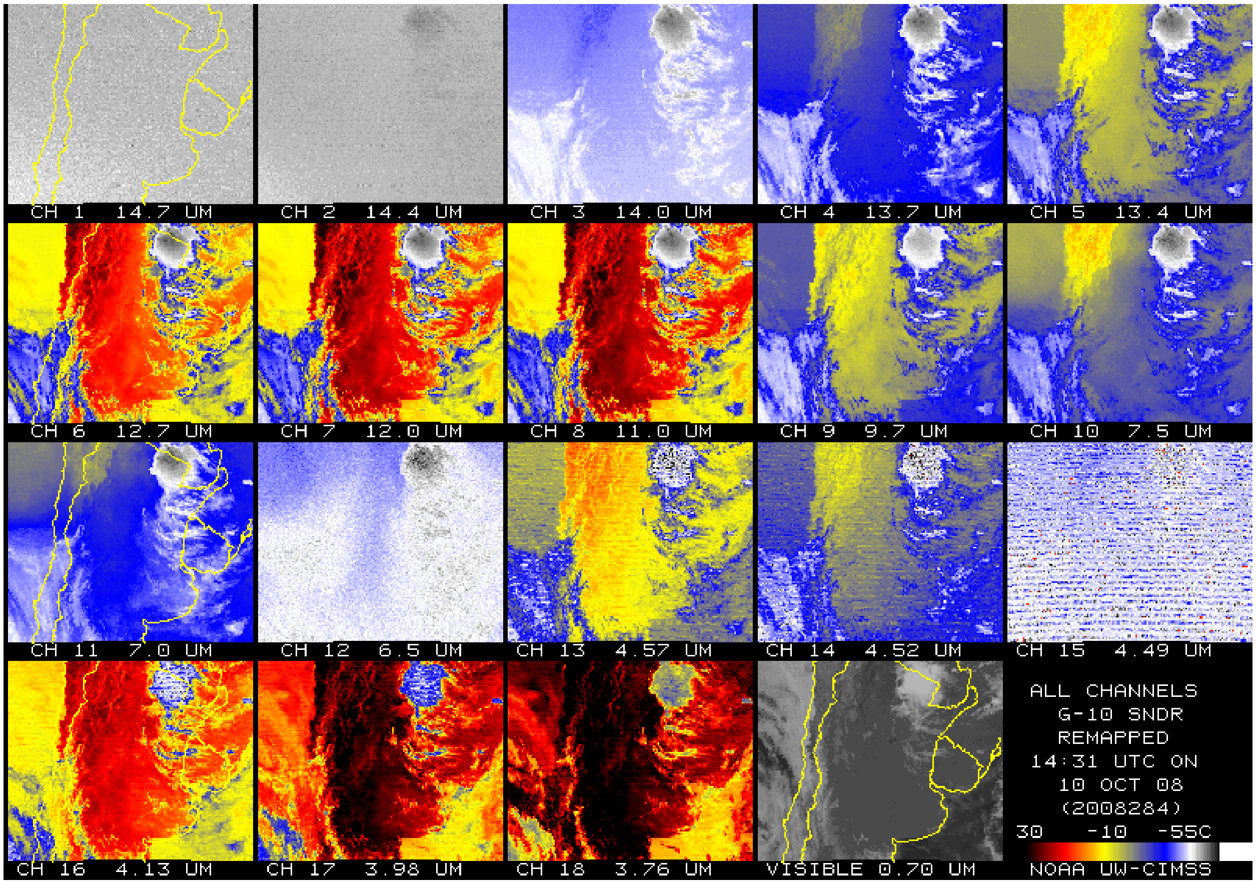


Figure 3.5.2. A nineteen image mosaic showing all the infrared bands plus the one visible band for the GOES-10 Sounder. Real time images can be found at the GOES-10 Realtime Derived Products web site. (http://cimss.ssec.wisc.edu/goes/rt/goes10.php).

Publications and Conference Reports

Schmit, T. J., R. Rabin, A. S. Bachmeier, J. Li, M. M. Gunshor, H. Steigerwaldt, A. J. Schreiner, R. Aune, G. S. Wade, 2008: Many Uses of the GOES-10 Sounder and Imager during a High Inclination State. Accepted by *J. Applied Remote Sensing*.

Schmit, Timothy J, 2008: GOES 10: New uses for an old satellite. *Through the Atmosphere*. SSEC Publication. pp 8-9.

http://www.ssec.wisc.edu/media/newsletter/winter08/goes10.html

3.6. Operational Implementation of the CIMSS Advanced Dvorak Technique (ADT)

CIMSS Project Leads: Tim Olander, Chris Velden
NOAA Collaborators: Mike Turk (NOAA/NESDIS/OSDPD/SSD/SAB). Matthew Seybold (NOAA/NESDIS/OSDPD/SSD/PIB)

NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

The latest McIDAS-based version of the Advanced Dvorak Technique (ADT) (Version 7.2.3) was released to NOAA/NESDIS Satellite Analysis Branch (SAB) forecasters for evaluation before the 2008 Atlantic and West Pacific tropical cyclone (TC) season. The ADT provides intensity estimates for all global TCs using multi-platform geostationary, infrared satellite imagery. The objective ADT algorithm complements the use of the more subjective and time-consuming Dvorak Technique (DT), which has been in use operationally since the 1970s and is the method on which the ADT is based. SAB forecasters will provide an evaluation of the ADT performance and recommended areas of concern to be investigated by CIMSS after the 2008 TC season. The evaluation will also serve to guide the official PSDI recommendation by SAB to implement an upgraded version of the ADT operationally during the 2009 TC season.

Summary of Accomplishments and Findings

Transition of the ADT to operational use at NESDIS/SAB was the primary goal for the 2008 season. The ADT (version 7.2.3) was given "operational status" at NESDIS/SAB after the Critical Design Review (CDR) held in May of 2008, just prior to the beginning of the North Atlantic tropical cyclone (TC) season. This version included several upgrades that addressed some of the issues raised by SAB scientists after their 2007 evaluation. These issues included the following: 1) ADT initialization, 2) Shear scene type intensity overestimation, 3) Pre-eye intensity "plateau", and 4) Land interaction and ADT re-initialization after landfall. Issues 1 and 2 were addressed prior to the release of ADT version 7.2.3 to NESDIS/SAB, while issues 3 and 4 are still being investigated.

Issue 1 was alleviated through the utilization of an additional set of forecast bulletins issued by official tropical cyclone Regional Specialized Meteorological Centers (RSMC), specifically for those outside of the Atlantic Ocean basin. The ADT primarily relied upon position forecasts and intensity estimates issued by the Joint Typhoon Warning Center (JTWC) at Pearl Harbor, Hawaii. The RSMC warning/ forecast products are sometimes released prior to those released by the JTWC and can be released at a greater temporal frequency. The ability of the ADT to be able to ingest and utilize these new RSMC products helped alleviate most of the problems noted with issue 1. Issue 2 was addressed by revising the ADT methodology which defined the distance from the selected storm center to the edge of the convection during a shear scene. This new methodology added distance measurements and new logic to more properly identify the correct cloud shield to be analyzed by the shear scene logic. Investigation of issues 3 and 4 continues and will be the primary focus of the proposed ADT upgrades and implementation for 2009.

Investigation of the remaining two issues mentioned above will be conducted in FY09. Issue 3, the pre-eye intensity "plateau", often occurs during the formation stage of a TC. As the storm organizes into a weak hurricane/typhoon, prior to the appearance of an eye feature in IR imagery, the ADT intensity estimates tend to plateau around a certain intensity value. Utilization of microwave imagery (MI) from polar orbiting satellites provides a possible solution, with its ability to view beneath the cirrus cloud shield to identify the convective structures leading to thee formation of an eye. A technique to objectively identify emerging eye features and quantify the structure organization using the MI imagery is being developed at CIMSS. Preliminary testing of this integrated approach with the ADT has begun, but further research is needed to fine tune the criteria of how and when to use the MI information.

Finally, the issue of how the ADT intensity estimates respond to TC-land interaction needs to be further investigated. This topic had been looked at briefly in the past but a more thorough study is needed (under GIMPAP funding). Addition of a significant number of land-interaction cases over the initial study sample needs to be identified and collected with guidance from SAB scientists.

3.7. Product Quality Assurance and Science (PQAS) Support for Operational GOES Imager and Sounder Products

CIMSS Project Leads: James P. Nelson III, Christopher S. Velden
CIMSS Support Scientist: Anthony J. Schreiner
NOAA Collaborators: Gary S. Wade, Timothy J. Schmit, Jaime Daniels
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

This project supports GOES Imager and Sounder data quality assurance and science algorithm maintenance. It is broad in scope, involving aspects of both computer software and hardware. One example of work conducted for this project is to repair problems that arise concerning the CIMSS GOES Sounder and/or Imager research products, such as modifying software to handle special atmospheric or computing environment conditions. Work supported through this project is vital to maintaining and improving the integrity of all the GOES Imager and Sounder research products that CIMSS makes available to the meteorological community via the following Web sites:

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

From the most recent CIMSS Product Systems Development and Implementation (PSDI) proposal, the following items were targeted for work. Both the retrievals and winds processing software was scheduled to be upgraded from the current state to use a higher-resolution 101-level atmosphere. A new temperature/moisture retrieval algorithm was to be made available to STAR personnel for testing, prior to operational implementation. The GOES Sounder cloud mask algorithm was to be improved. The CIMSS GOES retrievals/clouds online archive was to become a reality. Product validation was slated for improvement, with work being performed on software to generate and display statistics on the Web showing temperature and moisture retrieval quality compared to nearby radiosonde, GPS Total Precipitable Water (TPW), and model data. GOES Sounder Single Field-of-View (SFOV) total ozone retrieval capabilities were to be migrated from CIMSS to STAR/OPDB, and then eventually into NOAA/NESDIS operations within OSDPD/SSD.

As new enhancements to the temperature/moisture retrieval algorithm come online at CIMSS, corresponding new retrieval/RAOB collocation files were to be activated to aid in evaluating retrieval quality. Software development to allow retrieval quality evaluation against high-resolution numerical model data in terms of gradient comparisons was to begin. A significant amount of effort was to be expended to update and maintain relevant Web pages. Monitoring of GOES Imager and Sounder product systems hardware was to continue, as was interfacing with technical computing personnel within SSEC. CIMSS was to proceed in its efforts to make its software more robust, in terms of multi-platform use, enhanced code documentation and appearance, etc. Generic solutions were seen as paramount. More software and ancillary data files were to be added to the growing CVS repository. Various new utility software was to be written. The UNIX make and tar utilities were to continue being added into the developmental environment of all CIMSS GOES Sounder and Imager-related software. Lastly, McIDAS software updates were to be installed as needed to upgrade the CIMSS GOES research product computing environment.

Summary of Accomplishments and Findings
During 2008, good progress has been made toward accomplishing a number of the above goals. A 101-level transmittance model has been incorporated into the latest CIMSS clouds-processing software. Incorporation of the same model into retrieval processing remains to be done. One benefit of increasing the vertical resolution of the transmittance model is to allow for more comparisons of observed brightness temperatures to calculated brightness temperatures with respect to height. The end result will be less "blocky" cloud tops. Based on comparisons, the new product tends to produce slightly fewer high clouds (100 to 300 hPa) than the old product (Table 3.7.1). Figure 3.7.1 shows a comparison between the new and old GOES Sounder Cloud Top Pressure (CTP) products for GOES-12 over the central and eastern United States. The new version (top of figure) better identifies the thin cirrus over Virginia, Kentucky, and Tennessee than the old version. Independent comparisons to Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) derived cloud tops must still be performed.

Table 3.7.1. Frequency of cloudiness for the GOES Sounder Cloud Product based on hourly observations during September 2008. The areal coverage is from 20N to 50N and 65W to 130W.

Version	Frequency of Cloudiness	Frequency of Low-level Cld	Frequency of Mid-level Cld	Frequency of High-Level Cld
New Version	47.2%	20.9%	13.9%	12.3%
Old Version	47.2%	20.4%	11.0%	15.8%

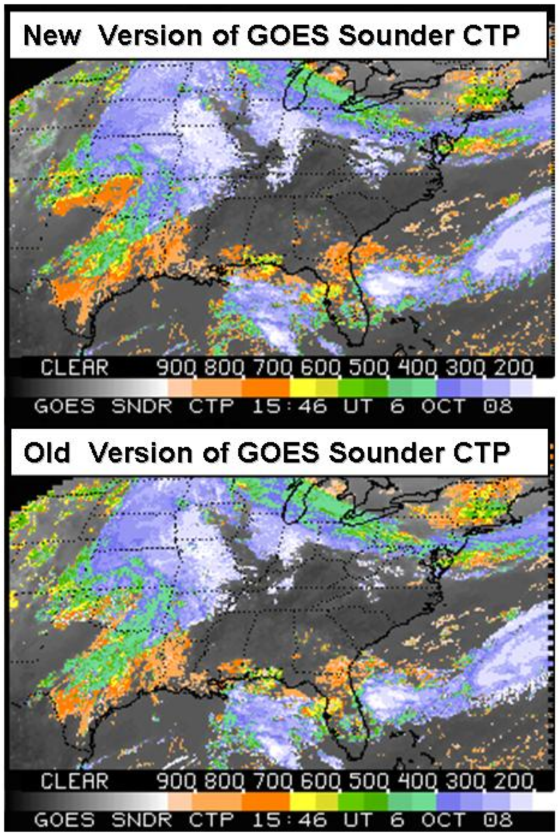


Figure 3.7.1. Comparison of new versus old GOES Sounder Cloud Top Pressure (CTP) products for GOES-12 over the central and eastern U.S from 1546 UTC 06 October 2008. The new version (top of figure) better identifies the thin cirrus over Virginia, Kentucky, and Tennessee than the old version. Independent comparisons to Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) derived cloud tops must still be performed.

Initial work on improving the vertical resolution of the background model used in the winds algorithm was also begun during this reporting period. A test data set has been prepared. Various wind algorithm functions have been indentified as needing code changes. The coding changes will be a two-step process: 1) use a 1 degree version of the GFS global model, with all 26 levels, and 2) attempt to use the 0.5 degree version of the GFS global model, with all 26 levels. The coding upgrades will be completed in this funding cycle. The logic changes will be passed to NESDIS/STAR. The winds algorithm will also be upgraded to use the 101-level transmittance model. Several routines have been identified and will need extensive modifications. We are trying to leverage the knowledge of the GOES sounding team, as they are also incorporating the same 101-level model. The necessary routines have been collected, but the coding changes are still being completed.

The CIMSS online archive has been activated locally, and access to select outside users is being pursued. One good example of time saved by the new archive occurred recently, when a local user was able to quickly access approximately 90 days of specialized imagery that would previously have had to be accessed manually by SSEC Data Center staff from archive tapes. In early March 2008, access to (otherwise unavailable) higher resolution, animated GOES-10 Imager GIF imagery was added to the CIMSS GOES Realtime Derived Products web page (http://cimss.ssec.wisc.edu/goes/rt/) to satisfy a

South American user request. In April 2008, a coefficients file and associated software related to GOES ozone computation was provided to NESDIS personnel. An additional software update may be necessary in the future; however, that is dependent on the outcome of forthcoming investigation into the accuracy of ozone data derived via a somewhat different algorithm. Recently, work progressed that will allow CIMSS personnel to reinstall all relevant software and ancillary files in a timely manner in the event of a catastrophic computer failure.

At different times during the year, programming assistance was provided to both NESDIS and CIMSS personnel, and on one occasion the latest version of McIDAS-X was installed on multiple CIMSS workstations. Other work dealt with purchases of vital computer hardware, and in handling the failure of a RAID disk array at the end of January that involved the loss of several TB of files. Lastly, data requests were fulfilled during the year for scientists at the University of Alabama-Huntsville, the Naval Postgraduate School, and Florida State University. Furthermore, GOES ozone GIF imagery was provided to a pollution control engineer who works at the Connecticut Department of Environmental Protection, and other ozone GIF imagery was provided to a scientist at CIRA (Cooperative Institute for Research in the Atmosphere).

CIMSS strives in work under this project to search for generic, robust solutions to problems. When a problem arises, rather than simply getting a given piece of software to run again as soon as possible, we oftentimes attempt to improve the software in some way at the same time. This process will save time, in the long run. Even cosmetic improvements to software are useful, because the software should then be easier to interpret for the next generation of scientists who will need to interface with the code. Software improvement is a gradual process, and incrementally over time the accumulation of improvements made will result in better GOES Imager and Sounder software making its way into NOAA/NESDIS operations.

4. Ground Systems Research

4.1. Support for CIMSS Satellite Validation Infrastructure

CIMSS Project Leads: Wayne Feltz, Erik Olson
CIMSS Support Scientists: Bruce Flynn and Joe Garcia
NOAA Strategic Goals Addressed:

1. Serve society’s needs for weather and water information

Proposed Work

The University of Wisconsin-Madison SSEC/CIMSS has acquired several advanced, ground-based, remote sensing instruments. These instruments provide valuable near real time validation and quality control of GOES and POES derived meteorological parameters. This support from the NOAA Ground System program will allow us to continue to develop an integrated hardware and software system to acquire an archive database and distribute the measurements in dimensions and formats convenient to the user community. This support will facilitate a very useful reference database for NOAA science projects such as GIMPAP, PSDI and GOES-R by providing validation for atmospheric retrieval products on a routine basis.

SSEC/CIMSS recently acquired a 14-channel microwave profiler and a 90 GHz microwave radiometer, greatly expanding our remote sensing capabilities to measure temperature, water vapor, and cloud properties from our rooftop and mobile weather laboratory. This new acquisition complements the Atmospheric Emitted Radiance Interferometer (AERI) that routinely measures the downwelling infrared radiance at high spectral resolution, providing accurate temperature and moisture retrievals of the lower troposphere every 10 minutes. SSEC is currently building a High Spectral Resolution Lidar (HSRL) with support from NSF funding that will provide continuous retrievals of cloud and aerosol properties. These 4 remote sensing instrument systems will be housed in a SSEC rooftop laboratory and are also available for deployment in the field.

Other existing SSEC/CIMSS rooftop instrumentation includes a Vaisala RS-92 GPS capable rawinsonde launch and receiver system, a Multi-Filter Rotating Shadowband Radiometer (MFRSR) providing solar derived aerosol optical depth, a Total Sky Imager (TSI) providing cloud fraction and daytime sky imagery, a Vaisala ceilometer for cloud base height measurements, a standard surface meteorological tower, and a GPS total precipitable water receiver.

Once fully integrated, this instrument suite will allow for atmospheric monitoring of temperature/moisture profiles, integrated water vapor, liquid water path, aerosol optical depth, total cloud fraction, cloud phase, and cloud extinction profiles useful for ongoing GOES and POES satellite product validation efforts. Both our fixed rooftop site and our mobile laboratory are excellent observation and validation facilities that will greatly benefit NOAA programs.

We seek to develop and implement the control system for these instrument data to acquire, manage and distribute instrument data as needed by the science community. An archival system will also allow acquisition of specific historical data sets that will be assessable to the research community via a web interface. It should be noted that routine instrument and system maintenance is supported by other SSEC projects.

Summary of accomplishments and findings

We have simplified our first display efforts to a) Create 12 hour quicklooks to be displayed on a simple webpage for all instrument quantities. b) Collect data in a central location, convert all data files to NetCDF, and do our best to achieve CF compliance. c) Recode all quicklook generation to a single language. The instrument groups are PTUW (pressure, temperature, relative humidity, and wind), microwave, sky imager, ceilometer, AERI, and lidar.

We are also moving forward with our efforts to enter metadata as well as some of the data streams into the RIG database. A server has been purchased and installed in the datacenter to consolidate database operations and quicklook generation.

A new computer and data server was acquired by this ground system funding to support rooftop instrument data archive and server. The system has eight cores, 16GB of RAM, 650GB of RAID-5 table space, and 100G of RAID1 cache space.

4.2. A Dedicated Processing System for the Infusion of Satellite Products in AWIPS

CIMSS Project Lead: Scott Bachmeier
CIMSS Support Scientist: Jordan Gerth, Kathy Strabala, Ralph Petersen
NOAA Collaborators: Gary Wade, Robert Aune
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
4. Support the nation's commerce with information for safe, efficient and environmentally sound transportation
5. Provide critical support for the NOAA mission

MODIS applications (Kathy Strabala and Scott Bachmeier)
Current GOES Sounder applications (Gary Wade)
Satellite applications for aviation needs (Wayne Feltz)
Synthetic forecast imagery from the CRAS (Robert Aune)
Dynamic "nearcasting" of GOES Sounder data (Ralph Petersen)

Proposed Work

CIMSS continued to expand upon its recent successful integration capability to make new satellite products available in the NWS Advanced Weather Information Processing System (AWIPS) data stream. CIMSS proposed to follow up on that capability and work with selected NWS forecast offices to help them realize their enhanced potential to use new experimental satellite products in their operational duties. Applications focused on use of data from the polar-orbiting MODIS and the geostationary GOES Sounder. This development effort, with accompanying education and support, brought together university and NESDIS researchers with operational NWS forecasters to foster practical use of satellite resources.

Summary of Accomplishments and Results

Jordan Gerth has provided numerous NWS Forecast Offices with coordination, details and packaged sets of scripts for the continuation and enhancement of access to experimental CIMSS satellite products via the NWS AWIPS. Interest has been high for an assortment of these new satellite products, ranging from high resolution MODIS sea surface temperature data to CIMSS Regional Assimilation System (CRAS) forecast cloud and water vapor images, as well as dynamic "nearcasts" of instability (the latter two utilizing data from the GOES Sounder).

A total of 27 NWS offices are currently participating in this ongoing effort:

Aberdeen, SD
Billings, MT
Boulder, CO
Chicago, IL
Davenport (Quad Cities), IA
Des Moines, IA
Duluth, MN
Fort Worth, TX (Southern Region Headquarters)
Glasgow, MT
Green Bay, WI
Indianapolis, IN
Kansas City, MO
Kansas City, MO (Central Region Headquarters)
La Crosse, WI
Las Vegas, NV
Marquette, MI
Milwaukee/Sullivan, WI
Minneapolis, MN
North Webster, Indiana
Pendleton, OR
Reno, NV
Riverton, WY
Salt Lake City, UT (Western Region Headquarters)
Spaceflight Meteorology Group, Houston, TX
Spokane, WA
Springfield, MO
Wichita, KS

One way to track the actual use of these new satellite products in the Forecast Offices has been by noting any Area Forecast Discussions (AFD) issued where these satellite products are mentioned. Over 100 such AFD examples have been recorded so far, with 17 of those occurring in 2008.

Continual updates to the most recent AWIPS software build have been performed to keep CIMSS AWIPS workstations on par with NWS forecast offices. The latest version of the Weather Event Simulator was also installed on a separate workstation, along with a beta version of the AWIPS II software.

A number of visits were made during the reporting period to NWS forecast offices at Milwaukee/Sullivan, WI (3 visits), Green Bay, WI (1 visit), and Nashville, TN (1 visit). At Green Bay, a team of CIMSS scientists presented a day long workshop covering numerous applications of satellite data, specifically emphasizing MODIS and GOES (especially the Sounder). These interactions have continued to promote good collaborations and dialogue between the researcher/provider side and the forecaster/user side. The following talks, which were given during our visit to Green Bay, are available online at http://cimss.ssec.wisc.edu/~garyw/nws-visits/grb-2008/

Examples of the types of satellite products generated at CIMSS that are being made available for display by NWS forecast offices in their own AWIPS environments can be found at: http://cimss.ssec.wisc.edu/goes/blog/cimss-satellite-proving-ground.

To address the education and training component of this effort, the Virtual Institute for Satellite Integration Training (VISIT) distance learning session "MODIS Products in AWIPS" was delivered to 10 NWS forecast offices during the reporting period:
http://cimss.ssec.wisc.edu/goes/visit/modis.html

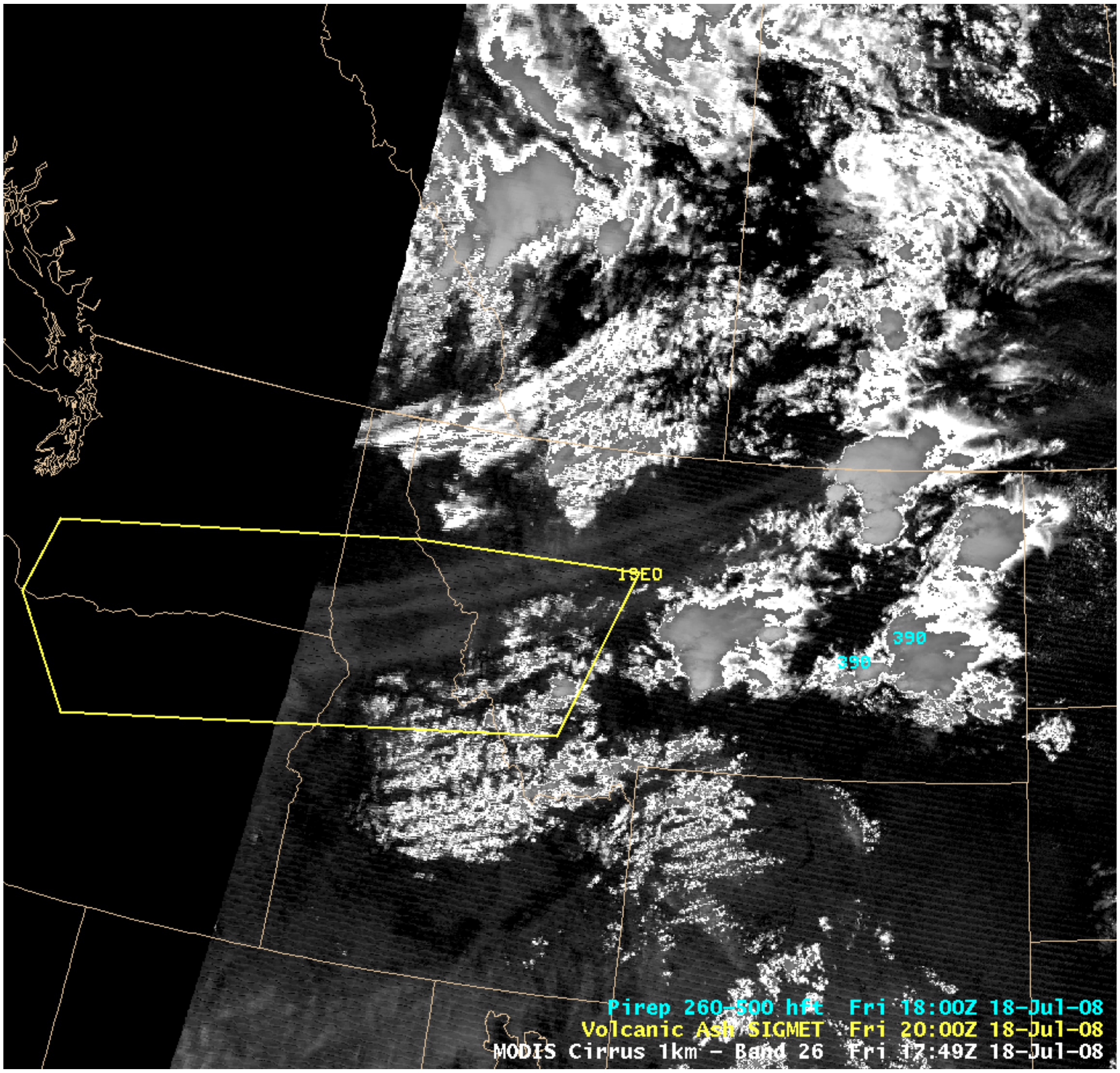


Figure 4.2.1. A MODIS Band 26 (1.3 micrometer) "Cirrus" image of the northwestern U.S. at 17:49 UTC on 18 July 2008, displayed using AWIPS. The boundary of a Volcanic Ash SIGMET advisory (yellow) is shown, which was issued at 20:00 UTC due to a plume from the Okmok volcano that had erupted in the Aleutian Islands. The 17:49 UTC MODIS image indicated that the volcanic plume had actually drifted northeastward across Montana, beyond the boundary of the Volcanic Ash SIGMET.

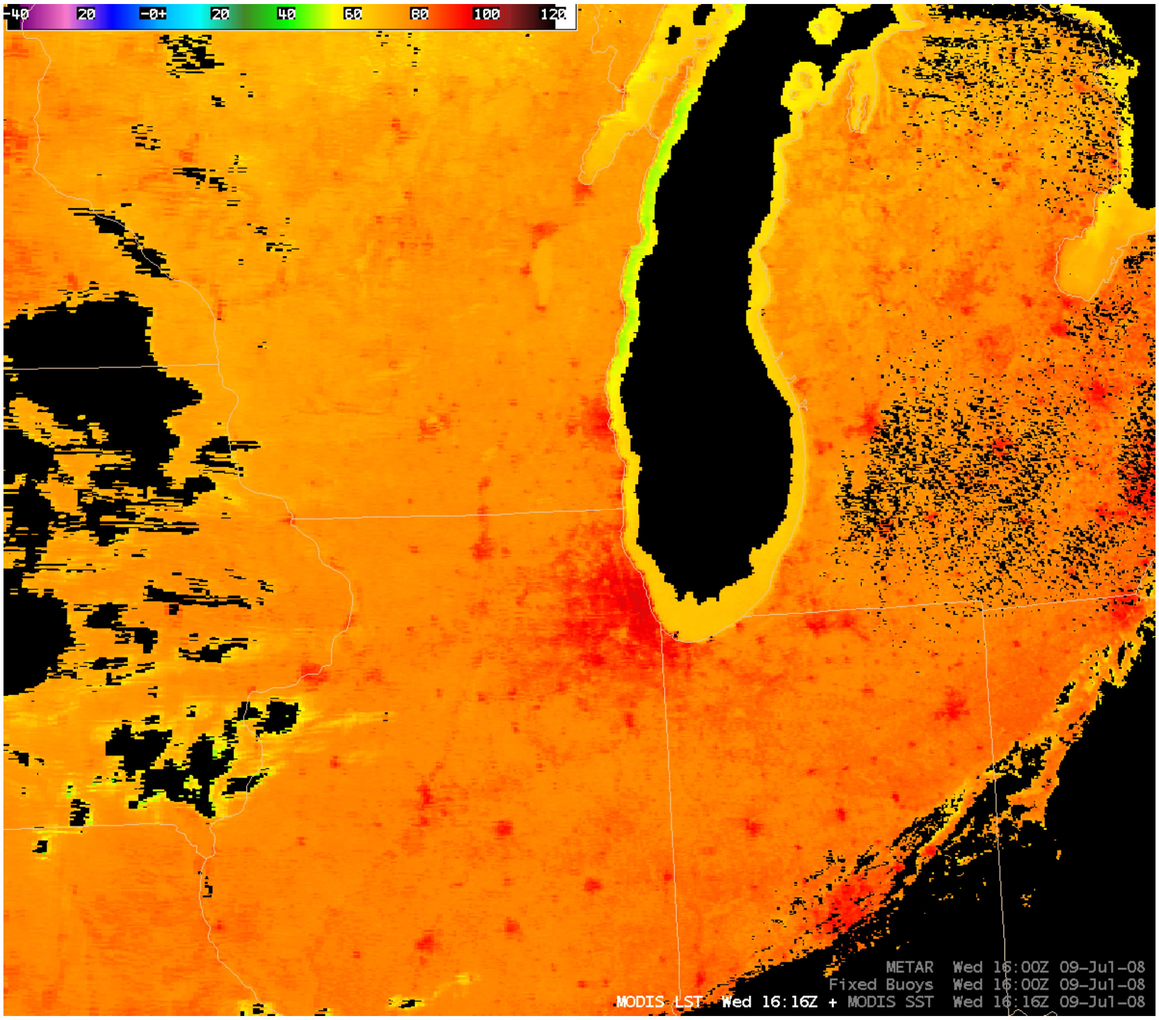


Figure 4.2.2. A MODIS Land Surface Temperature (LST) product centered over the Chicago, IL region at 16:16 UTC on 09 July 2008. The MODIS image revealed significantly warmer LST values (90-95º F, red colors) associated with the many cities across the region. Outside of the cities and urban areas, the MODIS LST values were generally in the 70s F (orange colors).

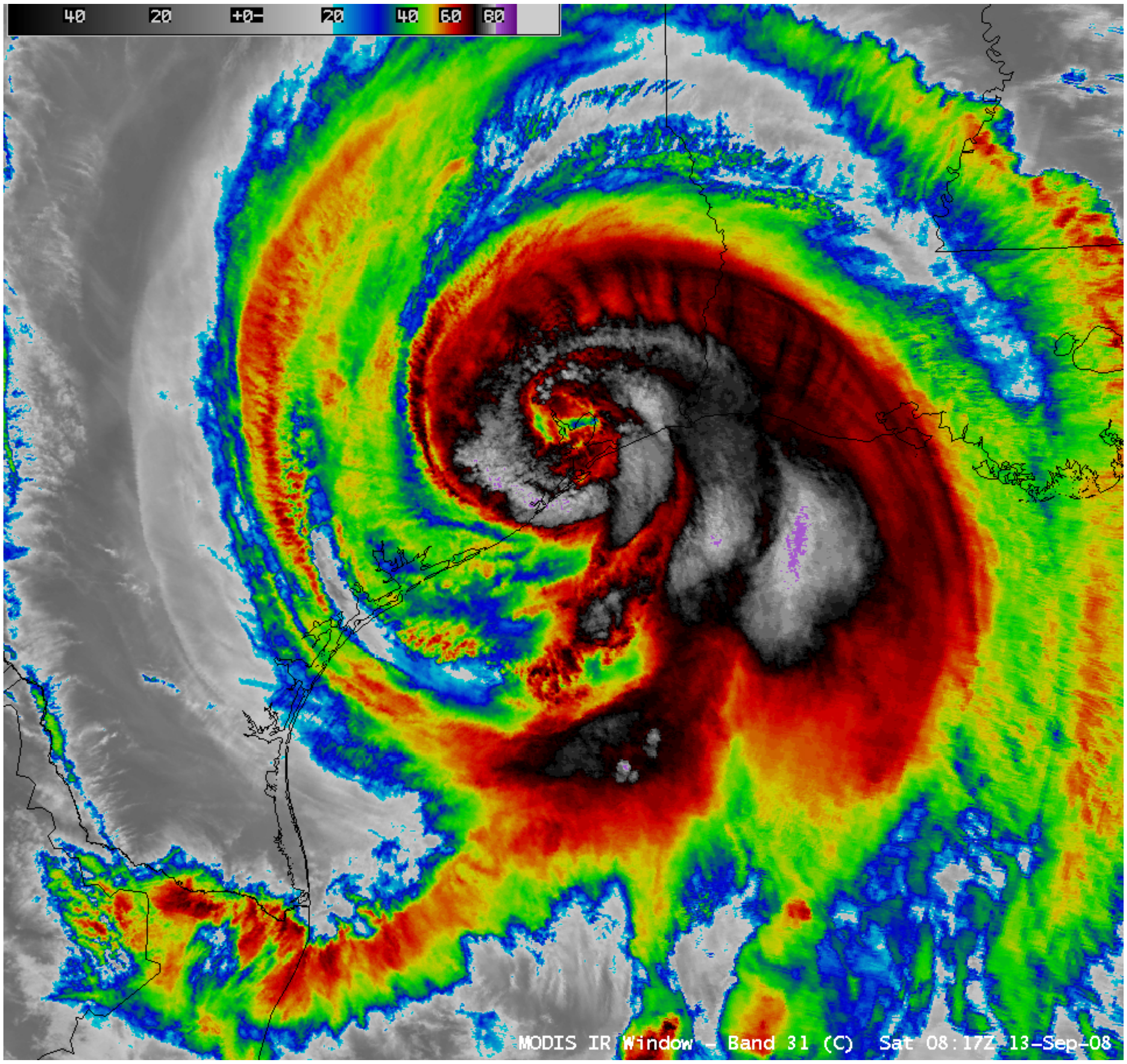


Figure 4.2.3. An AWIPS image of the MODIS IR window channel data at 08:17 UTC on 13 September 2008, shortly after Hurricane Ike made landfall along the Texas coast.

5. GOES-R Risk Reduction

5.1. Improvement of Forward Models for ABI Simulations, Algorithm Development, and Radiance Assimilation

CIMSS Project Leads: Allen Huang, Tom Greenwald, and Bob Knuteson
CIMSS Support Scientists: Eva Borbas and Yong-Keun Lee
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

This project seeks to enhance and verify surface property databases and cloud/aerosol property databases for providing higher quality simulated ABI proxy data sets for algorithm development and testing and for radiance data assimilation experiments. To improve the characterization of the surface reflectance for simulating ABI bands 1-6, new high spatial resolution (1 km) datasets will be obtained of the Bidirectional Reflectance Distribution Function (BRDF) derived from MODIS data. These new data sets will allow for the angular distribution of the surface reflectance and its variation with solar geometry in forward model calculations. UW-Madison CIMSS has developed a global surface emissivity dataset suitable for use with radiative transfer models throughout the thermal infrared (3.6 to 14.3 microns). The first generation UW IR global dataset is based upon monthly global gridded products (5 km resolution) provided by the NASA MODIS land team. Further improvements of the UW global gridded dataset will include 1) investigating a combined Terra and Aqua MODIS product, 2) recomputing the database using the MODIS collection 5 product (currently uses collection 4), and 3) validating the MODIS based emissivities using AIRS and IASI data. Last, we plan to validate the ice cloud and aerosol absorption/scattering properties. Validation data will include in situ measurements from past field campaigns, AIRS and MODIS data, as well as CALIPSO products.

Summary of Accomplishments and Findings

The development of a new BRDF/albedo model database was carried out in collaboration with Crystal Schaaf at the Department of Geography/Center for Remote Sensing at Boston University. Data were processed for the month of August 2006 in order to coincide with the large-scale high-resolution WRF model simulation for 16 August 2006 that was done as part of the AWG Proxy Data activities. The new database is based on the MOD43B BRDF/Albedo Model Parameters Product, which are retrievals of surface albedo from MODIS measurements. The product contains three parameters for each of the MODIS spectral bands. These parameters can be used in a forward version of the reflectance model to reconstruct the surface anisotropic effects. The first step was to find the highest quality MODIS retrieval for the month for each pixel at 30 arc sec spatial resolution. If a valid retrieval was not found over the month for a given spatial pixel, due to cloud cover or snow, then August values based on the temporal curve of five year's worth of MODIS snow-free data was used. For permanent snow pixels, both the August and September 2006 values were used to spatially fill gaps from coarser resolution data over multiple years in August to provide realistic snow values. The final product was then produced on a global equal angle grid at 0.0083^{o} resolution (approximately 1 km resolution at the equator). Figure 5.1.1 shows the geographic distribution of the black sky albedo, i.e., the fraction of incident direction solar radiation that a surface reflects, for selected MODIS bands. The black sky albedo can be computed from the three model parameters mentioned earlier for any solar zenith angle using a simple polynomial expression.

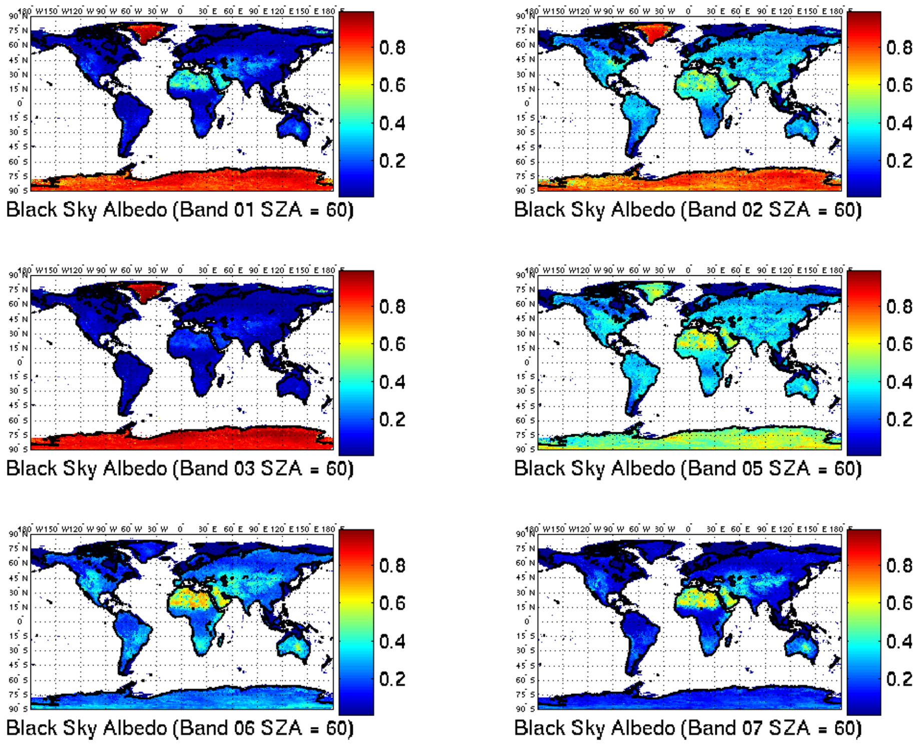


Figure 5.1.1. Filled black sky surface albedo for August 2006 assuming a solar zenith angle (SZA) of 60^{o}. Bands 1, 2, 3, 5, 6, 7 are surrogates for ABI bands 2 (0.64 µm), 3 (0.865 µm), 1 (0.47 µm), 4 (1.378 µm), 5 (1.61 µm), and 6 (2.25 µm), respectively.

Work related to the UW MODIS IR surface emissivity database was undertaken in three main areas:

Maintenance

The UW CIMSS MODIS Baseline Fit (BF) emissivity database uses the MODIS MYD11 product as input; therefore, BF emissivity values will be affected by changes in the MYD11 algorithm. Beginning with January 2007 the NASA LP DAAC began processing the MYD11 data with the new collection 5 (C5) algorithm. The BF emissivity has now been computed using the new C5 MYD11 data as input and is called version 3. Previously, version 2 BF emissivity was derived from the collection 4 (C4) MYD11 data. BF emissivity derived from both C4 and C5 MYD11 data are now available at the UW/CIMSS emissivity website (http://cimss.ssec.wisc.edu/iremis) from September 2002 till August 2008. The database is continuously updated as new MYD11 data becomes available at the NASA LP DAAC server.

Validation

As part of our validation efforts the UW CIMSS Baseline Fit and High Spectral Resolution emissivity database based on both MODIS MYD11 C4 and C5 products was compared to (1) the 8-day (01 - 08 January 2004) composite of the UW AIRS physical emissivity retrievals (see Figure 5.1.2), (2) the best estimate of AIRS-based IR surface emissivity at the SGP ARM site (results not shown) and (3) a test case was performed over the Sahara desert (selected pixel: Lat: 25.07 N, Lon: 26.05 E) on 15 January 2004 at 00:03 UTC where calculated brightness temperatures using different emissivities were compared to the

AIRS observed brightness temperatures, which served as truth (see Figure 5.1.3). On the one hand, the comparisons show that UW/CIMSS BF and HSR emissivity database agree well with the UW AIRS composite emissivity and the best estimate of AIRS-based IR surface emissivities. On the other hand, all indicate that there is a significant difference between the two versions (using MYD11 C4 and C5) of the UW CIMSS BF emissivity data over the desert and non-vegetated areas. The test case (Figure 5.1.3) shows big BT differences (> 6 K) in the long wave region between 8 and 9.5 μm (1050 and 1150 cm^{-1}), which indicates a problem in the MYD C5 product. However, at the ozone band and the short wavelength window there are improvements using the MYD11 C5 data. As a result, due to the magnitude of the changes in our HSR and BF emissivity data using MYD11 C4 vs. C5 data as input, we do not recommend use of version 2 and 3 BF emissivity data as a continuous dataset for users. Also, for desert and non-vegetated areas between 8 and 9.5 μm spectral range only version 2 BF (based on MYD11 C4) emissivity data is recommended for use until the new MYD11 Collection 6 is available.

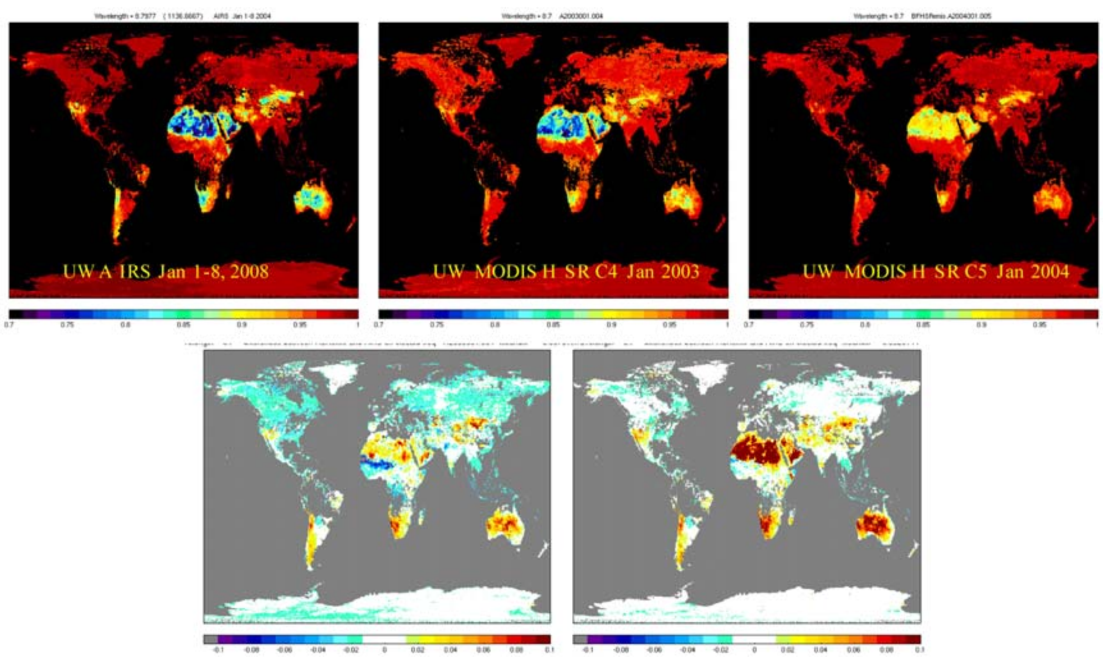


Figure 5.1.2. Top: Comparison of the monthly UW (MODIS based) HSR emissivity maps based on the MODIS MYD11 collection 4 (middle, January 2003) and 5 (right, January 2004) emissivity products with the 8-day composite (01 - 08 January 2004) UW AIRS physical emissivity retrievals (left) at the 8.7 μm wavelength. Bottom: Difference maps between the HSR emissivity based on MYD11 C4 (left) and C5 (right) and the UW AIRS retrievals.

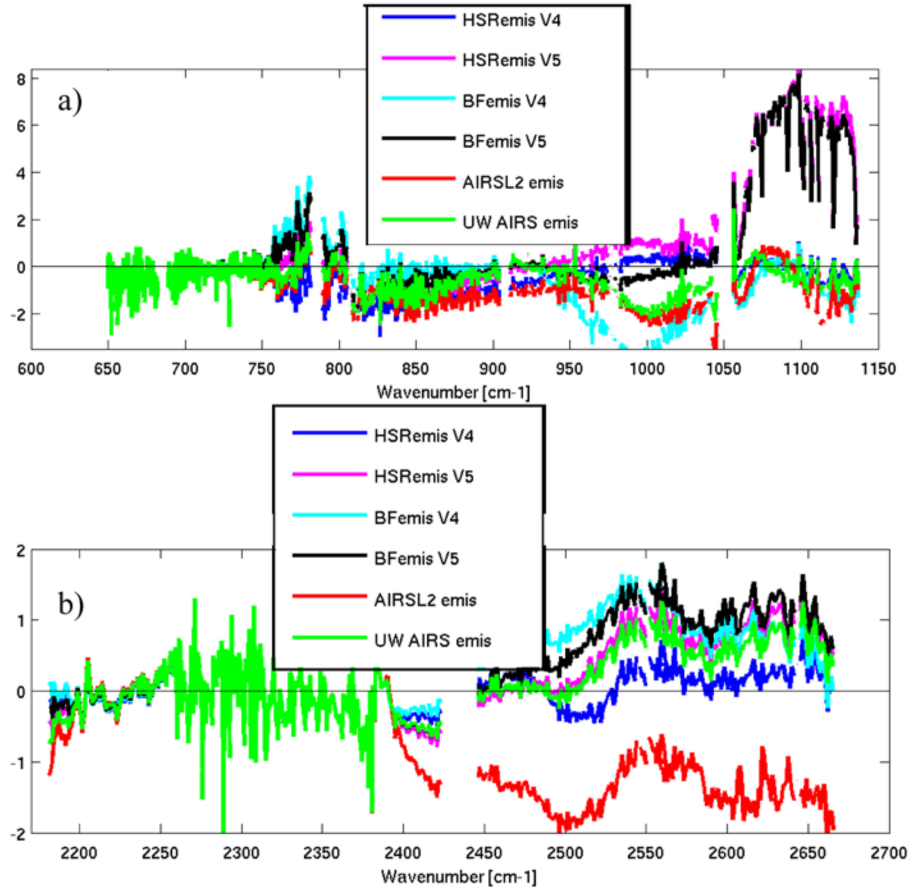


Figure 5.1.3. Brightness temperature residuals between calculated (using Sarta V1.07 forward model) and observed AIRS brightness temperatures separated in the short (a) wavelength and the long (b) wavelength spectral zone.

Software development

The UW CIMSS HSR land surface IR emissivity algorithm that produces HSR emissivity data at 416 wavenumbers (204 cm^{-1} resolution) from the UW CIMSS BF emissivity database and selected laboratory measurements was beta tested by scientists from EUMETSAT, Naval Research Laboratory, Monterey, CA and CIMSS. The algorithm is available now by request through the UW CIMSS iremis website: http://cims.ssec.wisc.edu/iremis/. Interfacing the UW MODIS Baseline fit emissivity data into the ABI forward model has begun. The first, beta version of the "get_lsiremis" module that uses the above-mentioned HSR Emissivity Algorithm and a module that make the multiplication of the instrument (ABI) SRF with the high spectral resolution emissivity product has been created. A module, which takes into account the viewing angle dependence of the surface emissivity, is under development.

Publications and Conference Reports

Borbas, E. E., S. W. Seemann, R. O. Knuteson, E. Weisz, and A. Huang: Recent updates of the UW/CIMSS high spectral resolution global land surface infrared emissivity database (talk), *16th International TOVS Study Conference*, Angra dos Reis, Brazil, 7-13 May 2008

Borbas, E. E., S. W. Seemann, R. O. Knuteson, E. Weisz, and A. Huang: The UW/CIMSS high spectral resolution global IR land surface emissivity database (poster), GOES-R AWG Annual Meeting, Madison, WI, 23-26 June 2008.

Seemann, S.W., E.E. Borbas, R.O. Knuteson, G. R. Stephenson, H.- L. Huang, 2008: A global infrared surface emissivity database for clear sky atmospheric sounding retrievals from satellite-based radiance measurements. *Journal of Applied Meteorology and Climatology,* DOI:10.1175/2007JAM1590.1,Volume 47. No. 1, January 2008, 108-123.

5.2. Study of the Efficient and Effective Assimilation of GOES-R Temporal/Spatial Measurement Information

CIMSS Project Leads: Allen Huang, Jason Otkin

NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

The primary goal of this new project, which started on 1 April 2008, is to evaluate how the assimilation of GOES-R data at different spatial and temporal resolutions impacts the accuracy of atmospheric analyses and affects the skill of short-range numerical model forecasts. The motivation behind this project is the need to reduce the expense associated with assimilating the vast quantity of GOES-R observations and derived datasets while simultaneously preserving as much useful information as possible. Multiple observation system simulation experiments (OSSEs) will be performed in order to provide guidance concerning the optimal assimilation of the information content contained in various quantities, such as simulated infrared radiances, atmospheric motion vectors, and temperature and water vapor sounding retrievals.

Summary of Accomplishments and Findings

Substantial effort has been directed toward developing the necessary infrastructure to perform high-resolution data assimilation studies at CIMSS. Completed tasks include installing two data assimilation systems known as WRF-VAR and the Data Assimilation Research Testbed (DART), which are based on the variational and Ensemble Kalman filter (EnKF) methods, respectively, and writing programs to convert various datasets into the correct format for ingest into DART. All of the data assimilation experiments will be performed using DART whereas WRF-VAR will primarily be used to generate perturbed initial and lateral boundary conditions for each member of the ensemble. It has become popular within the EnKF community to use WRF-VAR for this task since the balanced perturbations it produces are more likely to remain within the model during the forecast cycle rather than simply disperse away if only randomly generated perturbations were added. The maintenance of these perturbations serves to increase the ensemble spread, which helps prevent filter divergence.

Many of the preliminary steps, such as generating the nature run and associated simulated datasets, have already been completed for the first OSSE case study, which tracks the evolution of a severe weather event that occurred across the central U.S. during 4 - 5 June 2005. The high-resolution nature run contains two nested domains covering a large portion of the central U.S. with 6- and 2-km horizontal resolution, respectively. In order to match the expected ABI temporal resolution, model data was output on each domain every 5 minutes during the last 18 hours of the simulation. The Successive Order of Interaction (SOI) forward radiative transfer model was subsequently used to generate simulated ABI infrared radiances for all time steps on both domains. This data was then remapped to a hypothetical 2-km ABI projection in order to produce a simulated dataset with the correct spatial resolution at all zenith angles.

Figure 5.2.1 shows representative examples of the simulated ABI 11.2 µm brightness temperatures from the inner 2-km domain and the corresponding GOES-12 10.8 µm brightness temperature observations. Overall, it is apparent that the nature simulation contains a realistic depiction of the thunderstorm evolution, which also demonstrates that the forward model is capable of producing accurate radiances in both clear and cloudy conditions. Simulated atmospheric motion vectors and temperature and water vapor sounding retrievals have also been generated for this case. Data assimilation studies employing these datasets will be performed next year.

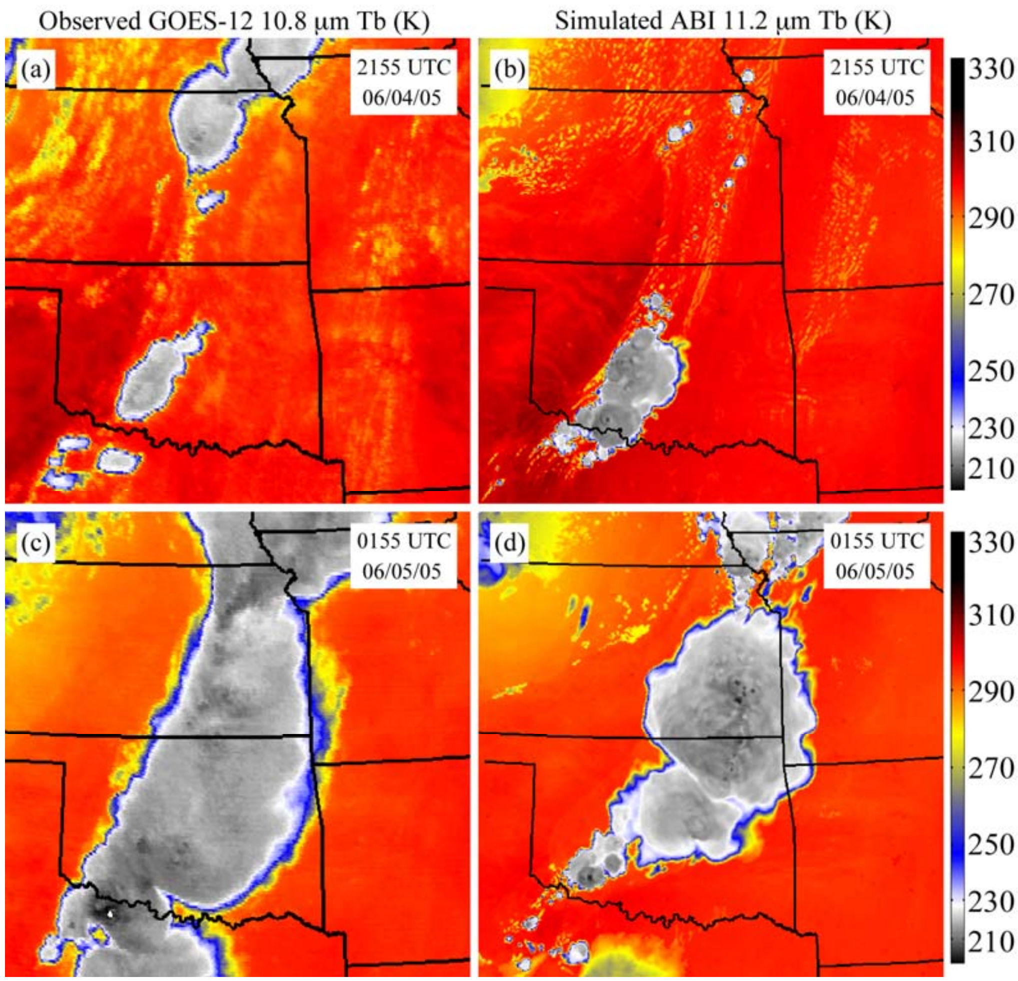


Figure 5.2.1. (a) Observed GOES-12 10.8 µm and (b) simulated ABI 11.2 µm brightness temperatures (K) valid at 2155 UTC on 04 June 2005. (c) Same as (a) except valid at 0155 UTC on 05 June 2005. (d) Same as (b) except valid at 0155 UTC on 05 June 2005.

5.3. GOES-R Atmospheric Motion Vector (AMV) Research

CIMSS Project Leads: Chris Velden, Steve Wanzong and Illiana Genkova
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

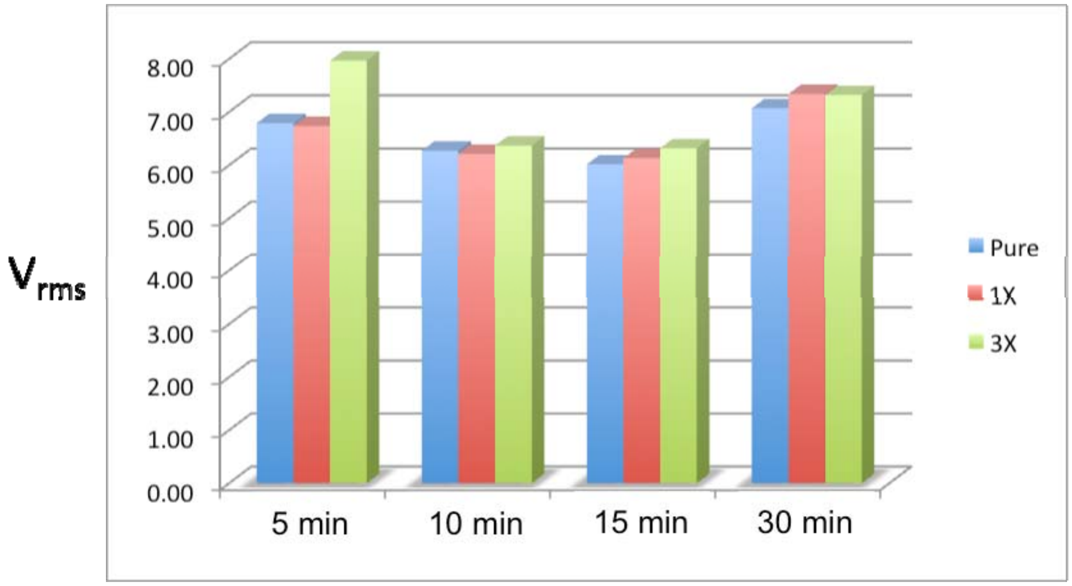
Previous GOES-R Risk Reduction work on AMVs concentrated on demonstrating the ability of the AMV algorithm to target and track features found in WRF modeled moisture fields and simulated moisture retrievals (for potential application to GOES-R sounder data). The ATReC and Ocean Winds data sets were used to successfully demonstrate the feasibility of the concept of altitude-resolved vectors from the derived retrieval constant-pressure moisture analyses. In 2008, it was proposed to focus attention towards ABI AMVs. After working out data formatting issues with ABI simulated imagery (NWP and Meteosat-SEVIRI), we proposed to investigate the extraction of AMVs from ABI heritage channels, and validating using the GOES-R Analysis Facility Instrument for Impacts on Requirements (GRAFIIR).

Summary of Accomplishments and Findings

A significant amount of resources were spent with proxy data formatting issues. This took the form of two distinct problems. The first was gaining the ability to take network Common Data Form (NetCDF) files and directly generate McIDAS AREA files. AREA files are necessary for the GEOCAT framework. In the past, this involved a manually labor intensive process. Now, large volumes of NetCDF files containing simulated ABI radiances can be easily transformed into McIDAS AREA files with a suite of Python scripts.

A second issue appeared with the attempted use of Meteosat-8 5-minute rapid-scan data. The 5-minute data provides a good proxy for the increased temporal ability of the future ABI. EUMETSAT has given CIMSS access to the Unified Meteorological Archive and Retrieval Facility (UMARF). The data source within the archive that contains the Meteosat-8 5-minute Level 1.5 data supplies it in an older version of the McIDAS AREA data structure. Currently, this causes problems with the GEOCAT calibration module. At present, the AREA files supplied by UMARF are single band images. The calibration information contained in the AREA file applies only to the single band image. GEOCAT assumes that the calibration block for all AREA files contains information for all bands. The GEOCAT navigation software also assumes that Meteosat-8 is located at 0 degrees subpoint. However, Meteosat-8's subpoint is now at 9.5 degrees east. Figure 5.3.1 shows this problem. McIDAS software has been modified to 1) replace the calibration block with one that GEOCAT understands, 2) remap the data so that the navigation is correct in GEOCAT.

The GEOCAT framework was used to duplicate the WINDCO CONUS GRAFIIR study that was presented at the 5th GOES Users' Conference. GEOCAT produced AMVs using 5-minute, 10-minute, 15-minute and 30-minute image triplets. As with the WINDCO study, unaltered top of atmosphere (TOA) radiances (Pure) data, and 3-times-all-noise-effects (3X) data were processed. The 3X dataset contained TOA which had combined effects of calibration, sensor noise, navigation and striping, which were 3 times over the projected GOES-R ABI specifications. At this time, only the IRW (11.2 µm) channel has been processed. The graphs below show the findings, which can be used by GOES-R decision-makers pertaining to specification issues.



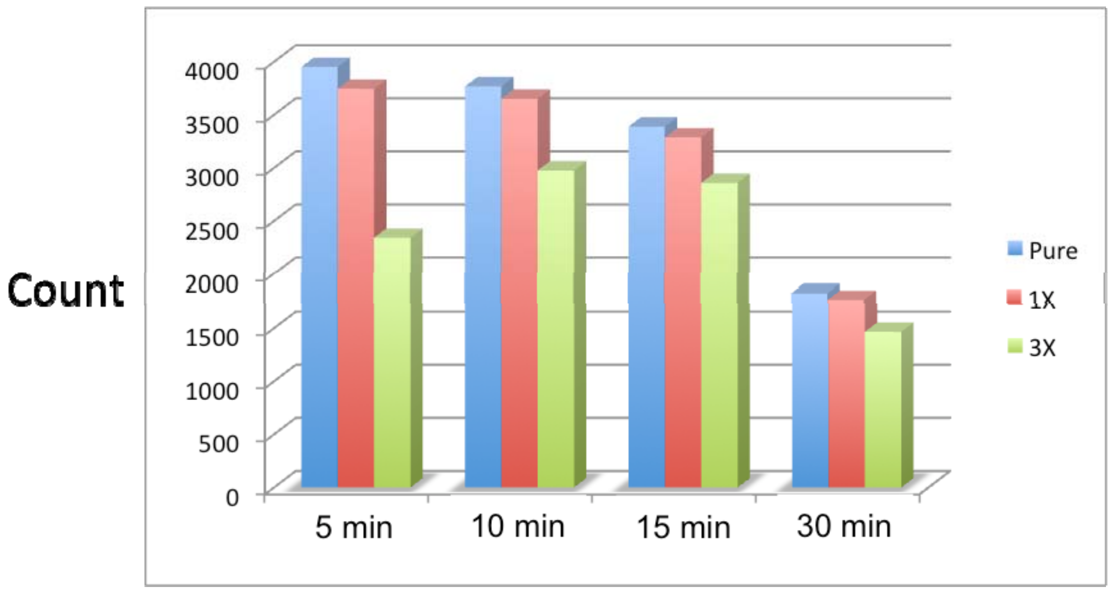


Figure 5.3.1. Shown are the GEOCAT 11.2 um AMV results using 5-, 10-, 15- and 30-minute time steps. Datasets compared includes tracking images from Pure (unaltered TOA), 1-times-all effects (GOES-R specs) and 3-times-all effects. Top graph shows vector RMSE (m/s) vs. coincident WRF model winds (truth). Bottom graph shows the number of vectors produced (counts). Only gross QC checks applied.

Publications and Conference Papers

Genkova, I., Wanzong, S., Velden, C. S., Santek, D. A.., Li, J., Olson, E. R. and Otkin, J. A.: GOES-R wind retrieval algorithm development. 5th GOES Users' Conference, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008.

Huang, Allen and Goldberg, M.: Overview of GOES-R Analysis Facility for Instrument Impacts on Requirements (GRAFIIR) planned activities and recent progress. 5th GOES Users' Conference, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008.

Wanzong, S., Genkova, I., Velden, C., and Santek D.: AMV research using simulated datasets. 9th International Wind Workshop, Annapolis, MD, 14-18 April 2008.

5.4. Hurricane Wind Structure and Secondary Eyewall Formation

CIMSS Project Lead: Jim Kossin
CIMSS Support Scientist: Matt Sitkowski
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

Hurricanes, and particularly major hurricanes, will often organize a secondary eyewall at some distance around the primary eyewall. These events are generally associated with marked changes in the intensity and structure of the inner core, such as large and rapid deviations of the maximum wind and significant broadening of the surface wind field. The latter has particularly dangerous consequences in terms of sea state, storm surge and wind damage extent during landfall events. Despite the importance of secondary eyewall formation in hurricane forecasting, there is presently no objective guidance to diagnose or forecast these events. Forecasters need to rely on aircraft reconnaissance data, coastal radar imagery, or satellite microwave imagery to make a subjective determination of whether secondary eyewall formation (SEF) is occurring or not. These data are not always available in a timely manner. In this project our goal is to construct a new index, based on readily available data, which will provide forecasters with a probability of SEF. The algorithm is based on environmental and GOES infrared satellite features from the SHIPS-model developmental data set applied to a Bayesian probabilistic model.

Summary of Accomplishments and Results

We completed a climatology of secondary eyewall formation events in the North Atlantic and Central and Eastern North Pacific oceans. The climatology documents the distributions of hurricane location, intensity, and time of year associated with secondary eyewall formation events.

We then completed the construction and cross-validation of a new algorithm that provides real-time probabilities of secondary eyewall formation. The method is shown to be skillful when measured against climatology.

We completed and submitted a manuscript to Monthly Weather Review, which documents our results. The manuscript has been accepted and was recently selected as a Paper of Note by the Senior BAMS editor. A description of our results will appear in the November issue of BAMS. The manuscript is available at:
http://www.ssec.wisc.edu/~kossin/sharedfiles/.misc/Kossin_Sitkowski_2008_snglspc.pdf

A real-time prototype of our new algorithm has been constructed and is being run in-house at CIMSS. The results are being made available every 6 hours during the life of each Atlantic and Eastern Pacific hurricane via a local ftp website (ftp://ftp.ssec.wisc.edu/pub/matts/). An announcement has been made to the tropical cyclone research community and feedback has been positive. An example of the real-time probabilities assigned during Hurricane Ike (2008) is shown in Figure 5.4.1.

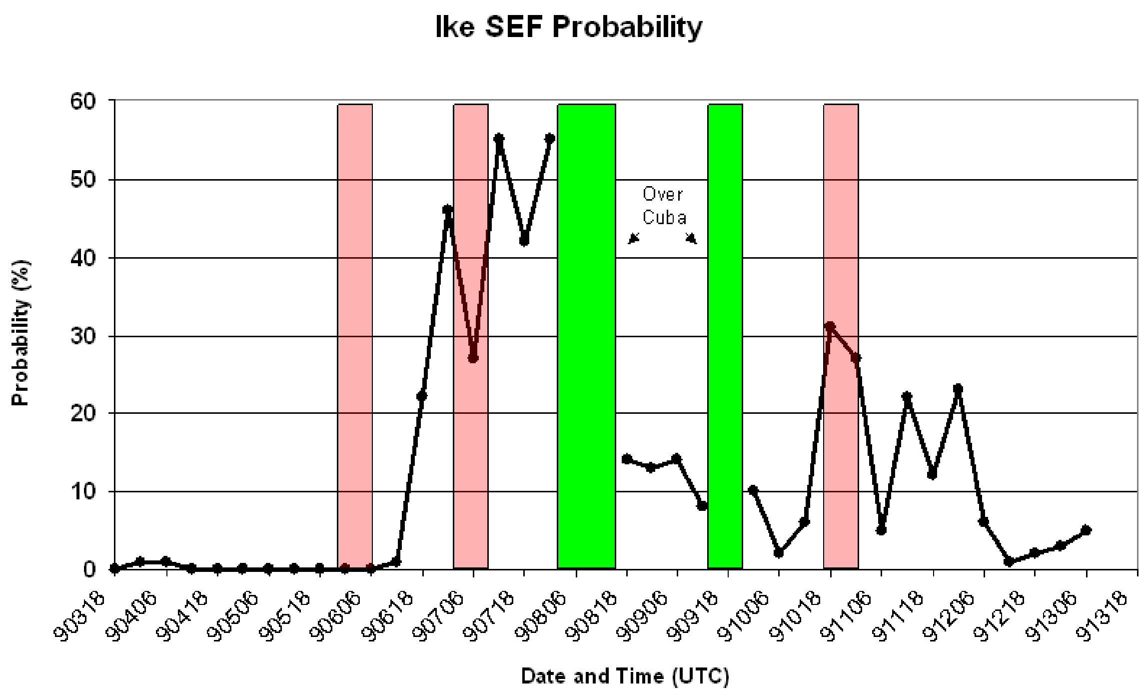


Figure 5.4.1. Probabilities of secondary eyewall formation from the real-time prototype of the algorithm. The black line represents the probabilities. The red columns indicate the time of observed secondary eyewall formation and the green columns mark the time the hurricane was over land and thus a probability was not assigned.

5.5. GOES-R Ozone Product Risk Reduction Study

CIMSS Project Leads: Jinlong Li, Jun Li
CIMSS Support Scientist: Xin Jin
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information.
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

This project will address the following outstanding GOES-R AWG ozone issue, how to develop a total column ozone (TCO) product in cloudy regions. There are a couple of reasons to propose this task. First, the AWG legacy sounding algorithm and current GOES Sounder ozone algorithm are only limited to clear skies. Second, since the peak of the ABI ozone weighting function (9.6µm) is above most clouds, retrieval of total column ozone is possible for cloudy regions, particularly for thin and low cloud regions. Developing a TCO algorithm under cloudy conditions will improve the coverage for the GOES-R ozone product.

In 2008, we proposed three major tasks: (1) testing and using a ABI cloudy radiative transfer model, (2) developing a cloudy TCO statistical approach in thin and low clouds, and (3) testing the algorithm with simulated ABI cloudy radiances

Summary of Accomplishments and Findings

Following the task guidelines, an ABI infrared (IR) cloudy radiative transfer model (RTM) has first been developed and tested. This cloudy RTM was originally developed for hyperspectral sounder radiances through the joint effort from CIMSS and Texas A&M University. It has been used in AIRS and the current GOES Sounder cloudy sounding (temperature and moisture profiles) retrievals, and the results are reasonable. The input cloud parameters for cloudy radiance calculations are the cloud-top pressure (CTP), cloud particle size (CPS) in diameter and cloud optical thickness (COT) at 0.55 μm. Figure 5.5.1 shows the calculated ABI 9.7 μm band ozone weighting functions from various COTs. As expected, the peak of ozone weighting function is above most clouds. The best ozone sensitive layer is between 10 hPa and 300 hPa. With the increase of cloud optical thickness (COT) in ice cloud situations, the weighting function magnitude decreases. However, for ice clouds, the peak value of ozone weighting function only decreases slightly when COT is less than 1.0, while the impact of water clouds on ozone is minimal. Therefore, under the ice cloud situations, the TCO is retrievable for thin clouds, while under the low cloud situations the TCO is retrievable even for thick clouds.

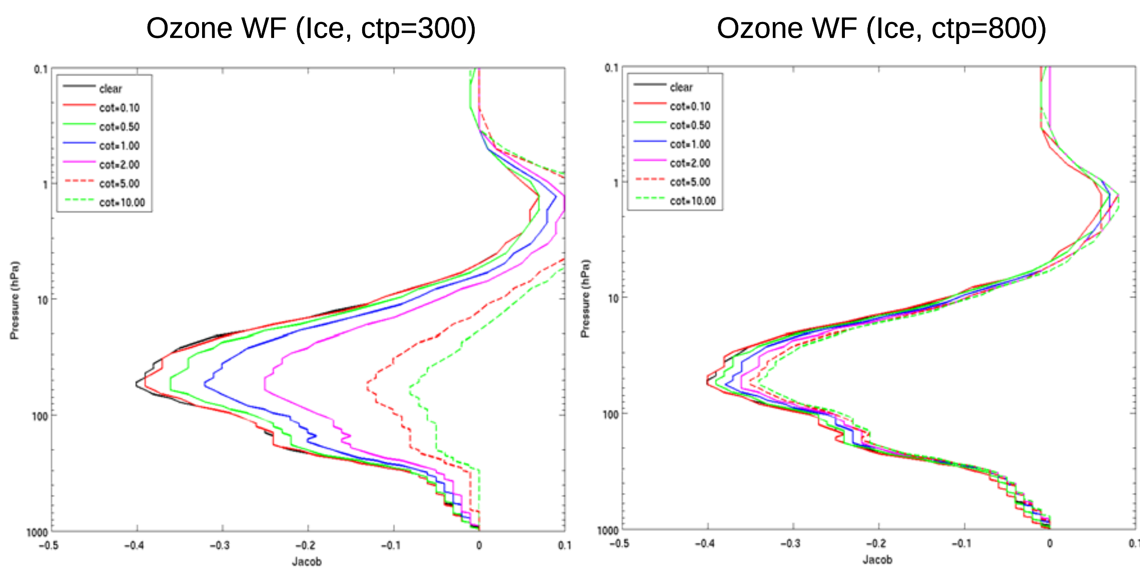


Figure 5.5.1. The calculated ozone weighting functions of ABI 9.7 μm ozone band with different cloud optical thickness (cot). Left panel: Ice cloud with cloud top pressure at 300mb; right panel: water cloud with cloud top pressure at 800 mb.

Similar to the clear sky TCO retrieval algorithm (Jin et al., 2008), a cloudy regression algorithm has been developed for TCO by combining the information from cloudy IR radiances and forecast temperature profiles. Along with the TCO retrievals, we also retrieve cloud top pressure and cloud optical thickness. Simulation studies have shown that for low water clouds TCO retrievals can achieve the comparable accuracy of that in clear skies regardless the cloud optical thickness, while under the ice cloud situations, TCO retrievals can have the similar accuracy of that in clear skies only when clouds are thin (COT<1.0). For a preliminary test, we have applied the cloudy ozone algorithm to the radiance measurements from the SEVIRI onboard Meteosat-8. Figure 5.5.2 shows the TCO results (color, in DU) from clear skies only (left panel) and from clear skies plus thin cloudy skies (right panel), respectively, at 0000 UTC on 15 August 2006. The cloud mask is from the SEVIRI standard product and the cloud phase is adapted from the MODIS algorithm. It is clear that the coverage of TCO retrievals has been greatly improved to include the cloudy pixels. The TCO spatial gradients from cloudy retrievals are very consistent with clear retrievals. We will work with the GOES-R Algorithm Working Group (AWG) cloud team to get the latest cloud mask and cloud phase products in the near future, which will further help the TCO retrievals.

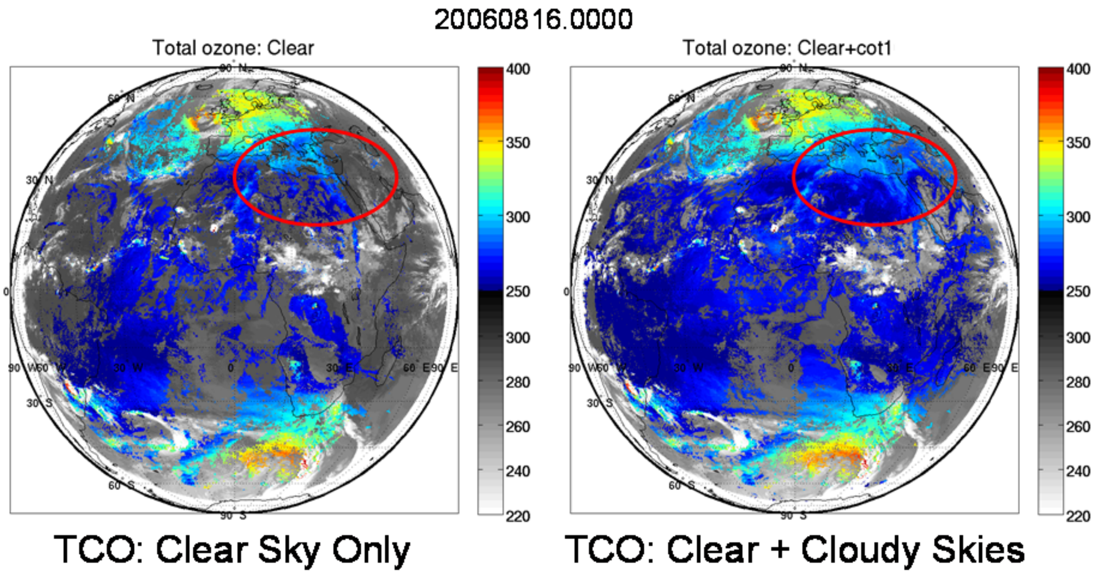


Figure 5.5.2. Total ozone retrievals in Dobson Unit (DU) from SEVIRI measurements (color regions) overlaying on brightness temperature in Kelvin of 8.7 µm channel (black/white regions). Left panel: clear skies only; Right panel: clear skies plus cloudy skies with cloudy optical thickness less than 1.0.

Publications and Conference Reports

Jin, Xin, J. Li, C.C. Schmidt, T.J. Schmit, and J. Li, 2008: Retrieval of Total Column Ozone from Imagers Onboard Geostationary Satellites, *IEEE Transactions on Geosciences and Remote Sensing*, 46, 479 – 488.

5.6. GOES-R Sounding Algorithm Development and Risk Reduction

CIMSS Project Leads: Jun Li, Allen Huang
CIMSS Support Scientists: Jinlong Li, Elisabeth Weisz, Chian-Yi Liu, Hal Woolf
NOAA Collaborators: Tim Schmit, Chris Barnet
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

1. Develop a hyperspectral IR alone sounding with physical approach, which is needed for LEO/GEO synergy, test and evaluate hyperspectral IR alone sounding algorithm with AIRS and IASI data;
2. Test two approaches (predetermined and retrieved emissivities) to handle surface emissivity for ABI legacy sounding product, using SEVIRI and GOES Sounder for algorithm testing and evaluation;
3. Study the time continuity (TC) on ABI product improvement;
4. Provide AWG teams with an improved algorithm and documents; publish research results.

Summary of Accomplishments and Findings in 2008

(a) LEO hyperspectral IR single FOV cloudy sounding physical retrieval algorithm development

Since there is no advanced sounder on GOES-R, ABI will be used to continue the current GOES Sounder products (Schmit et al. 2008). It is important to combine low earth orbit (LEO) hyperspectral IR data and geostationary (GEO) ABI data to create a better GOES-R legacy sounding product. For LEO/GEO synergy, a physical retrieval algorithm has been developed for sounding retrieval from LEO hyperspectral IR radiances alone in both clear and cloudy skies. Sounding retrieval from hyperspectral IR radiances in clear sky is mature but lots of challenges remain in cloudy skies. An advanced physical retrieval algorithm for simultaneous retrieval of atmospheric temperature and moisture profiles, cloud-top pressure, cloud optical depth and cloud particle size has been developed. The coupled clear sky radiative transfer model called SARTA developed by UMBC and the cloudy scattering model developed through the joint effort of the University of Wisconsin and Texas A&M University are used in the cloudy sounding retrieval. The Jacobian matrix or k-matrix under cloudy skies are derived and carefully evaluated. Initial results show that the physical method improves upon the regression technique for sounding retrieval in cloudy skies, especially below the clouds. Progress on the hyperspectral IR cloudy sounding algorithm development has been presented at the International Radiation Symposium in Brazil in August 2008 and the Hyperspectral IR Workshop held in Darmstadt in September 2008 (the two presentations are available upon request).

(b) GEO-ABI/LEO-hyperspectral Sounder synergy algorithm tested with MODIS/AIRS and GOES-Sounder/AIRS data

For GEO/LEO synergy we have used MODIS as a proxy for GEO (geostationary earth orbit) ABI and AIRS for LEO (low earth orbit) hyperspectral IR data. Collocated MODIS clear sky radiances and AIRS radiances are used to derive the soundings at the AIRS single footprint resolution. In AIRS partial cloud cover, MODIS clear radiances within the AIRS footprint help the AIRS cloudy sounding. Our study shows that the combination of MODIS clear radiances and AIRS cloud radiances provides better soundings than that from either MODIS clear alone or AIRS cloudy alone, especially below the clouds. Figure 5.6.1 shows the composited true color using Aqua MODIS reflectance from bands 1, 4, 3 as red, green, and blue, respectively from 1935 to 1945 UTC on 09 May 2003 (panel (a)), the relative humidity (RH) vertical cross section alone the green line in (a) from MODIS clear alone retrievals (panel (b)), AIRS alone retrievals (panel (c)), and the combined AIRS and MODIS retrievals (panel (d)) for AIRS granule 196 on 09 May 2003. MODIS clear radiances improve AIRS soundings in cloudy skies when compared with a radiosonde at ARM Cart Site (not shown). Although the AIRS alone method can retrieve a moist layer approximately at 550 hPa between latitudes 34.5^o and 35.5^o, the synergistic AIRS and MODIS method can retrieve a more prominent feature at the same cross section latitudes, which can be identified as broken clouds from MODIS true color image.

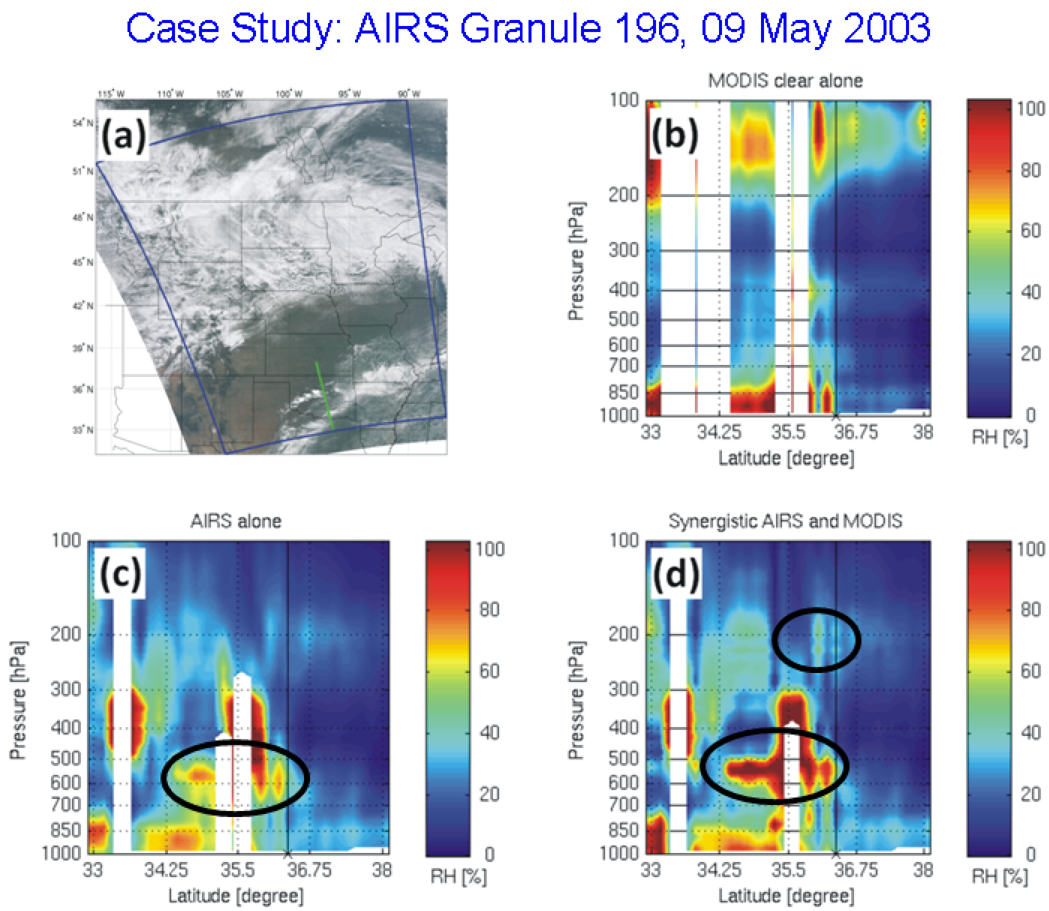


Figure 5.6.1. Composited true color using Aqua MODIS reflectance from bands 1, 4, 3 as red, green, and blue, respectively from 1935 to 1945 UTC on 09 May 2003; the relative humidity vertical cross section alone the green line in (a) from MODIS clear alone retrievals (b), AIRS alone retrievals (c), and the combined AIRS and MODIS retrievals (d) for AIRS granule 196 on 09 May 2003.

We also have used AIRS and the current GOES Sounder for a more realistic LEO/GEO synergy study. The current GOES Sounder is used as a proxy of ABI, and AIRS is used as a proxy of a LEO advanced sounder. AIRS data available twice every day can be used together with hourly GOES Sounder data for better soundings over CONUS. Figure 5.6.2 shows AIRS window brightness temperature (BT) imager (color) overlaying on hourly GOES Sounder BT images (black and white) (left panel, animation is available upon request), and relative humidity profiles from GOES Sounder (red), combination of GOES Sounder and AIRS (blue) along with the two radiosondes at ARM Cart Site (right panel). GOES Sounder alone uses a forecast as first guess while the combination of GOES and AIRS does not use the forecast.

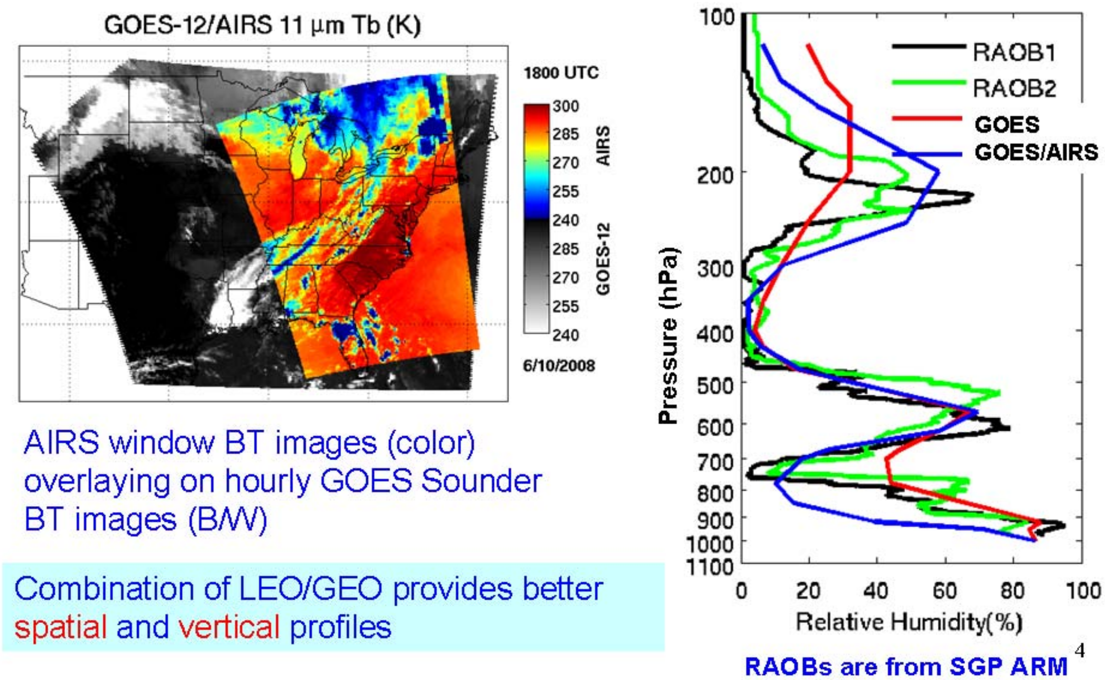


Figure 5.6.2. AIRS window brightness temperature (BT) imager (color) overlaying on hourly GOES Sounder BT images (black and white) (left panel, animation is available upon request), and relative humidity profiles from GOES Sounder (red), combination of GOES Sounder and AIRS (blue) along with the two radiosondes at ARM Cart Site (right panel).

(c) Global hyperspectral IR emissivity product developed from LEO for GEO product testing

Better surface IR emissivity information is very important for many ABI products (land surface temperature, radiation budget, dust/aerosol, cloud-top properties, legacy sounding, etc.). Global emissivity spectra from LEO advanced sounder radiance measurements can serve this purpose. To study the use of emissivity spectra from a LEO advanced sounder, a hyperspectral IR global emissivity map is produced from 8-day AIRS radiance measurements using an algorithm developed by the CIMSS sounding team (Li et al. 2007). In order to further analyze the reliability of the hyperspectral IR emissivity map from AIRS, the operational MODIS (collection 4) broad-band IR emissivity product is used for the comparisons. The MODIS spectral response functions (SRFs) are used to convolve the AIRS hyperspectral IR surface emissivity into the MODIS spectral coverage. Figure 5.6.3 shows the AIRS convoluted 8-day (01 - 08 January 2008) emissivity retrieval at 8.55 µm (upper left panel), the operational MODIS 8-day composite emissivity map (collection 4, lower left). The two types of emissivity agree very well in both pattern and magnitude. Note that MODIS does not provide data in high latitude regions. The emissivity difference map from the two instruments is also shown in the upper right panel of Figure 5.6.3; the histogram of the differences is indicated in the lower right panel. Most pixels have the differences less than 0.05 for the MODIS 8.55 µm band. A few pixels (over the Saharan region) show a few large differences (greater than 0.05), indicating the possibility of large uncertainties in both emissivity products for the 8.55 µm IR spectral region.

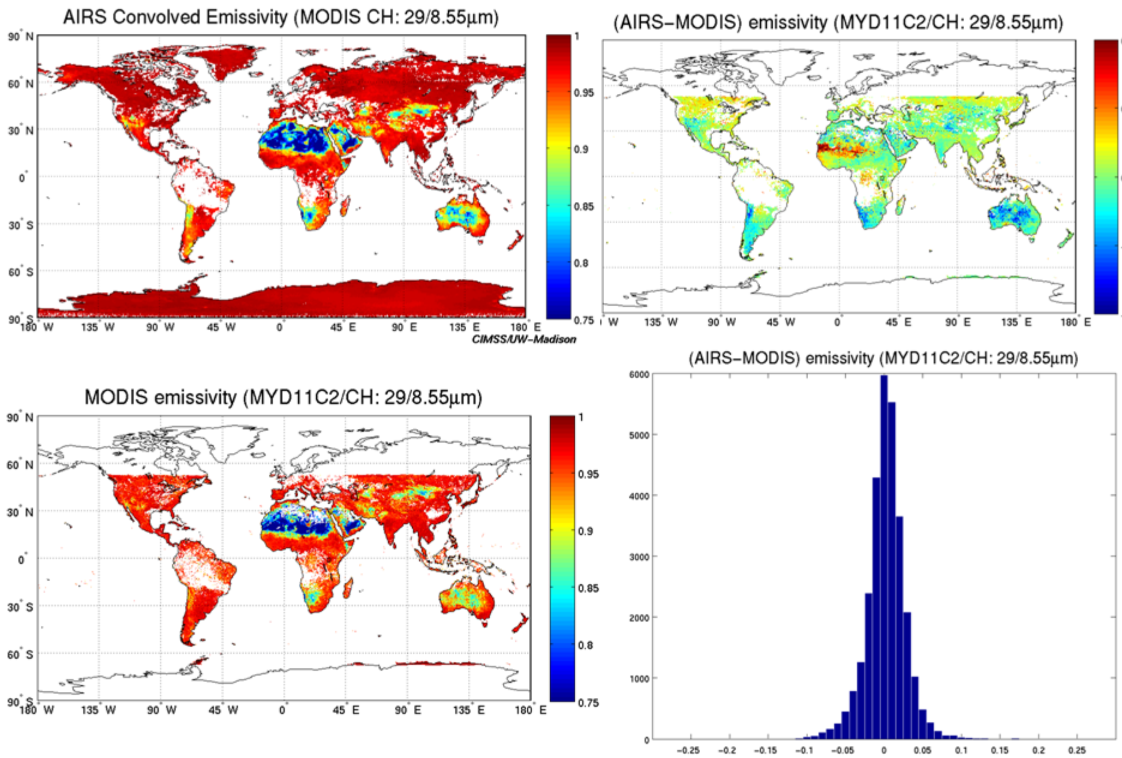


Figure 5.6.3. The AIRS convoluted 8-day (01 - 08 January 2004) emissivity retrieval at 8.55 µm (upper left panel), the operational MODIS 8-day composite emissivity map (lower left), the difference image between AIRS and MODIS (upper right), and the histogram of the emissivity differences.

Figure 5.6.4 shows the cross-section of the AIRS IR surface emissivity spectrum along a line crossing Australia (lower panel), along with the IGBP ecosystem map. The x-axis is the longitude and the y-axis is the wavenumber for AIRS channels. The ecosystem transition from west semi-arid region to east vegetated region is well captured by AIRS emissivity spectrum cross-section in the longwave IR spectral region from 1000 cm^{-1} to 1250 cm^{-1}, as well as the shortwave IR spectral region from 2200 cm^{-1} to 2700 cm^{-1}. This unique IR surface emissivity data from hyperspectral resolution IR radiances will be very useful for the other products with hyperspectral IR radiances, as well as products such as legacy sounding, cloud-top and land surface temperature with ABI onboard GOES-R. A manuscript has been published in Geophysical Research Letters (GRL) on global high spectral resolution IR emissivity product from AIRS (Li and Li 2008).

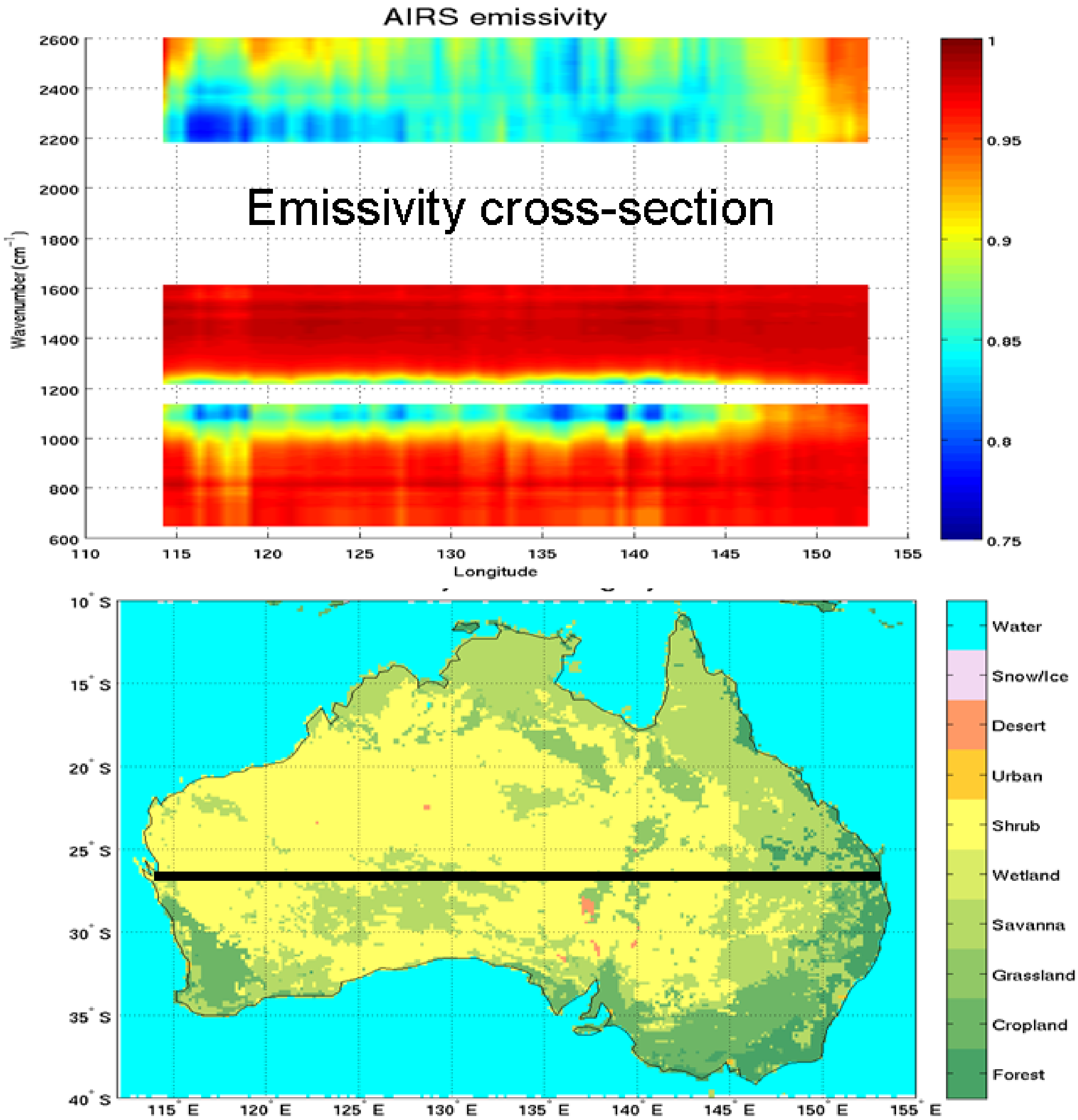


Figure 5.6.4. The cross-section of the AIRS IR surface emissivity spectrum along a line cross the Australia (lower panel), along with the IGBP ecosystem map. The x-axis is the longitude and the y-axis is the wavenumber for AIRS channels.

(d) Time continuity (TC) algorithm studied with SEVIRI data

To take advantage of the high temporal resolution of ABI observations, some products can be improved with time continuity (TC) incorporated. TC application on product improvement has been demonstrated by surface skin temperature retrieval. Since emissivity uncertainty has a large impact on the surface skin temperature retrieval, by assuming that the surface IR emissivity is temporally invariable while the surface skin temperature is temporally variable within 3 hour time period, improved surface skin temperature can be derived. Figure 5.6.5 shows the surface skin temperature images from ECMWF analysis (left panel) and SEVIRI retrieval with TC method (right panel), respectively, at 00 UTC on 1 August 2008. They show the similar patterns, an animation shows the temporal evolution, see the

following link for PPT report containing an animation on emissivity:
ftp://ftp.ssec.wisc.edu/ABS/PPT_2008/Surface_Emissivity_for_ABI_June2008.ppt
The animation indicates that SEVIRI derived surface skin temperatures have more realistic diurnal variation. Time continuity will be further studied for other ABI products (e.g., moisture product) improvement.

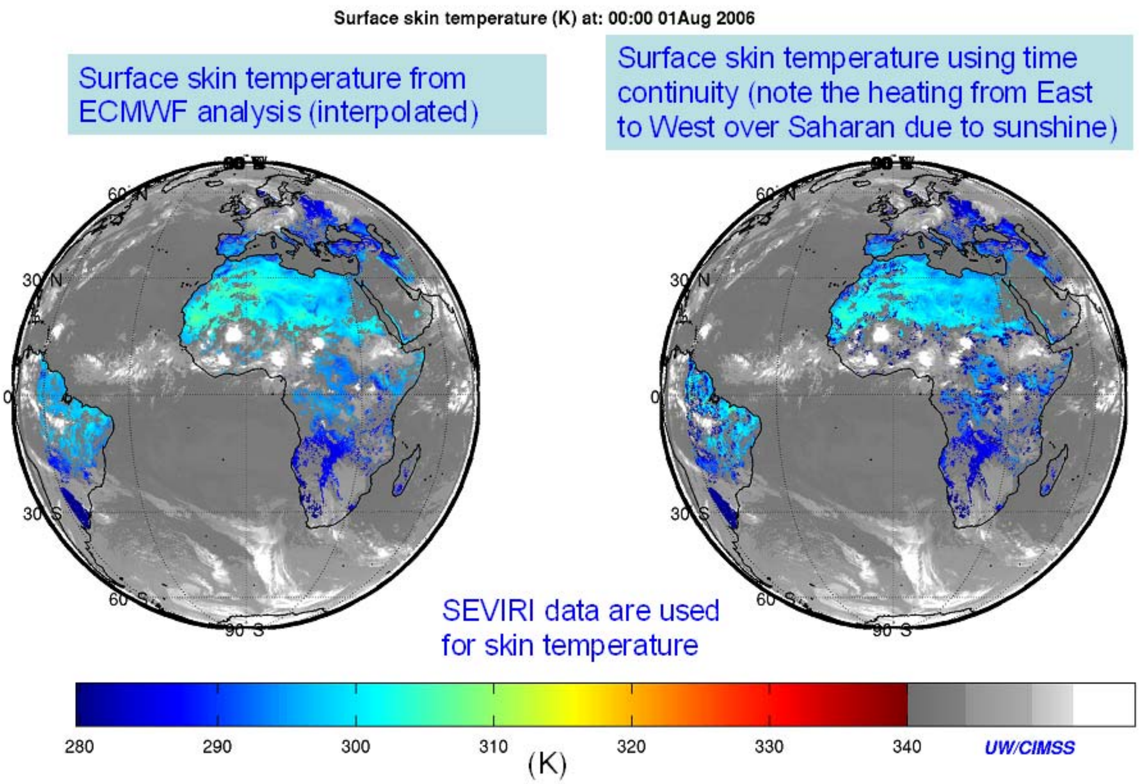


Figure 5.6.5. The surface skin temperature images from ECMWF analysis (left panel) and SEVIRI retrieval with TC method (right panel), respectively, at 00 UTC on 01 August 2008.

Publications and Conference Reports

Jin, X., J. Li, T. J. Schmit, J. Li, M. D. Goldberg, and J. J. Gurka, 2008: Retrieving clear-sky atmospheric parameters from SEVIRI and ABI infrared radiances, J. Geophys. Res., 113, D15310, doi:10.1029/2008JD010040.

Li, J., and J. Li, 2008: Derivation of global hyperspectral resolution surface emissivity spectra from advanced infrared sounder radiance measurements, Geophys. Res. Lett., 35, L15807, doi:10.1029/2008GL034559.

Liu, C., J. Li, E. Weisz, T. J. Schmit, S. A. Ackerman, H. L. Huang:, 2008: Synergistic Use of AIRS and MODIS Radiance Measurements for Atmospheric Profiling, Geophysical Research Letters (in press).

5.7. CIMSS Cal/Val Efforts in Support of GOES-R

CIMSS Project Lead: David Tobin
CIMSS Support Scientists: Mat Gunshor, Bob Holz, Leslie Moy
NOAA Collaborator: Fred Wu
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

Proposed tasks for this effort included participation in GSICS meetings, participation in GOES-R Cal/Val planning, analyses of benchmark aircraft validation data sets in support of GSICS, simulation studies to estimate uncertainties in satellite sensor intercalibrations, and characterization and analysis of ARM site data for atmospheric sounding validation.

Summary of Accomplishments and Findings

Accomplishments this year are similar to those from 2007 and primarily include studies and findings relating to radiance intercalibration work within GSICS.

We performed simulation studies using MODIS data to assess the ability of a proposed infrared climate benchmark sensor (CLARREO) to intercalibrate operational sounders. This provides a robust and accurate way to assess the radiometric uncertainties in the sensor intercomparisons due to differences in the spatial and temporal sampling of CLARREO and the operational sounders. We find that with modest CLARREO radiometric noise performance that the collocation errors for monthly ensembles of intercomparisons are on the order of 0.01K. Future work involves studying the impact of the CLARREO footprint size on the intercomparison uncertainties and also using the same simulation framework to estimate the uncertainties in Simultaneous Nadir Overpass intercomparisons between existing observations such as between METOP-A IASI and Aqua AIRS.

Global intercomparisons of Aqua AIRS and MODIS infrared radiance observations over five years were performed to assess the calibration accuracy and trends of the observations. Preliminary analyses of the intercomparisons suggest that there are no significant changes in the observed biases as a function of time.

We performed intercomparisons of METOP-A IASI and Aqua AIRS infrared spectral observations using Simultaneous Nadir Observations over the METOP-A mission time period. The results to date confirm the hypotheses that the high spectral resolution sounder observations can be used as benchmark observations, to within a determined uncertainty, for assessment of other Geo and Leo observations with the GSICS framework. No significant trends are detected and mean differences are generally on the order of 0.1K or less. The remaining differences are under investigation.

Quality control on ARM dedicated radiosonde launch data collected in the fall of 2007 was performed for METOP-A and Aqua overpasses of the ARM sites.

Publications and Conference Reports

Holz, R.E., F. Nagle, D.C. Tobin, R.O. Knuteson, S. Dutcher, H.E. Revercomb. An investigation of the capability of CLARREO to calibrate operation sounders with a focus on both spatial and temporal sampling uncertainties, (2007), *Eos Trans. AGU, 88* (52), Fall Meet. Suppl., Abstract A31B-0313.

Tobin, D., High-Altitude Aircraft Observations Providing NIST-Traceable Benchmark Infrared Observations for GSICS, GSICS Quarterly Newsletter, Vol. 1, No. 3, 2007.

Tobin, D., An SNO Analysis of IASI and AIRS Spectral Radiance, GSICS Quarterly Newsletter, Vol. 2, No. 3, 2008.

Holz, R. E., D. C. Tobin, R. O. Knuteson, S. T. Dutcher, H. E. Revercomb, F. W. Nagle, Investigating the capability of CLARREO to calibrate operational sounders with a focus on both spatial and temporal sampling uncertainties, paper 7081-28, SPIE Optics and Photonics, San Diego, CA, 10-14 August 2008.

5.8. GOES-RRR Fire Detection, Monitoring, and Characterization

CIMSS Project Leads: Chris Schmidt, Elaine Prins
CIMSS Support Scientists: Jay Hoffman, Jason Brunner, Scott Lindstrom
NOAA Strategic Goals Addressed:

2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

CIMSS proposed to work with the CIMSS and CIRA proxy teams to create improved fire hot spot simulations and perform case studies on the data to evaluate the impact of sub-pixel aggregation, sub-pixel detector saturation, and sampling/regridding. CIMSS also proposed to examine the application of the 2.2 µm band for fires work, especially at night, and also to refine the use of the 10.35 and 11.2 µm bands, which replace the legacy 10.7 µm band. Proposed research also included investigating similarities and differences between GOES/MODIS/SEVIRI (etc.) fire detection and characterization (FRP) and possible data fusion techniques and exploring ways to exploit both high temporal data and temporal/diurnal climatologies for improved initial fire detection. CIMSS also proposed to research the impact of sensor properties like the point spread function (PSF) and processes like remapping on fire detection.

Summary of Accomplishments and Findings

CIMSS has continued to work with CIRA and CIMSS proxy data teams to aid in the development of the hot spot simulations used in GOES-R Wildfire Automated Biomass Burning Algorithm (WF_ABBA) development. Work in 2008 has particularly focused on developing and refining a dataset of simulated fires over Central America created by CIRA as well as development of a new simulated dataset based on October 2007 fires in California. In both of those cases WF_ABBA data from the current GOES is used to initialize fire locations, temperatures, and sizes. Temperature is then varied by applying a diurnal cycle over the course of the model run and clouds are included in order to simulate real-world conditions. The Central America case and the Kansas case generated in 2007 both showed the WF_ABBA for ABI could detect fires emitting 75 MW of power or larger, which represents a relatively small difference in temperature between fire pixel and background, or roughly a couple of degrees Kelvin difference in the 3.9 µm brightness temperature. Surface types, viewing angles, and other factors can change the minimum detection threshold. The October 2007 California case (currently in development at CIRA) will also include 2.25 µm simulated ABI data so that its application may be examined.

CIMSS has been generating ABI proxy data from MODIS data by applying point-spread functions (PSFs) that accurately reflect the specifications for the ABI instrument to the MODIS data, and then running the WF_ABBA on the resulting data. In 2008 CIMSS refined the PSF being applied to better match the specifications of ABI, specifically the energy contained within the nominal footprint of the pixel (which is a subset of the PSF). Doing so produced a noticeable difference in the output temperatures as illustrated in

Figure 5.8.1. The primary differences are on the edges of fires. The new PSF captures more signal in the nominal footprint, sharpening the image and reducing how much a fire is smeared out. The difference image illustrates with the ring around the hottest pixel, which is shown on the same color scale as the images, indicating that the new PSF captures more of the signal than the old PSF.

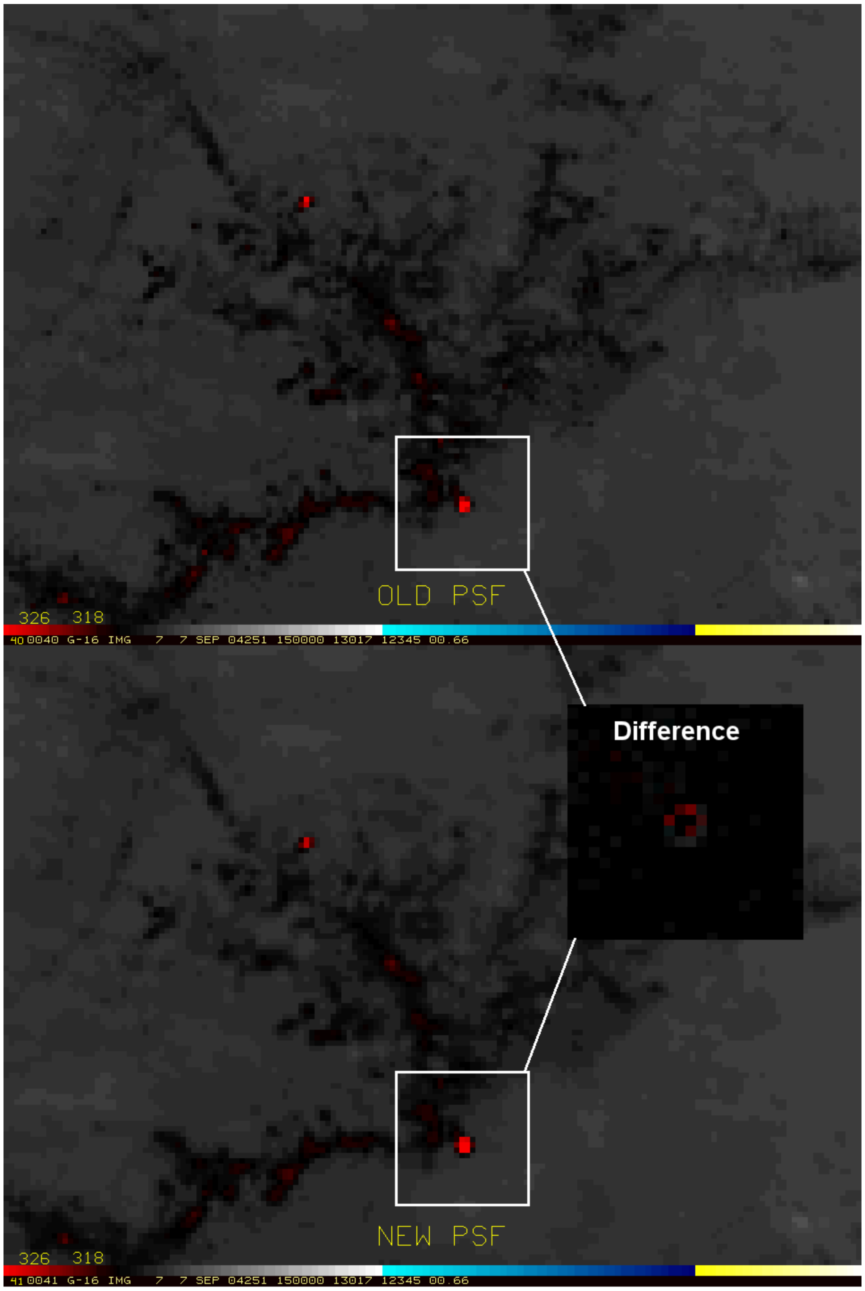


Figure 5.8.1. Simulated ABI images created from MODIS data on 7 September 2004 utilizing two different point spread functions (PSFs). The new PSF matches the ABI specifications better than the old one and thus is effectively "sharper", capturing more of the signal within the nominal GOES-R ABI footprint. The difference image utilizes the same color bar as the images do, indicating how the old PSF lost energy relative to the new PSF due to its wider spread.

Investigation of the impact of sensor properties on fire detection capabilities has continued though full modeling of the impact of the ABI sensor and the proposed ABI remapping scheme has not been achieved. Experience with a similar remapping scheme applied to GOES-10 and the remapping applied to SEVIRI data by EUMETSAT has shown that remapping does cause a decrease in detected fires as well as changes to how fires are characterized. Comparisons between GOES-12, GOES-10, and SEVIRI WF_ABBA data to each other and to MODIS are more outlined in the next paragraph.

With the implementation at CIMSS in summer 2008 of v6.5 of the WF_ABBA to current GOES-10/-11/-12/-13, MTSAT-1R, and SEVIRI on Met-8/-9 studies of their comparisons and approaches to data fusion techniques began. Eastern Brazil provides an area covered frequently by GOES-10, GOES-12, SEVIRI, and MODIS as well as a large number of fires due to agricultural and land clearing activities. Various facets of the comparison data have been examined. Figure 5.8.2 contains the mean fire radiated power (FRP) for co-located fires using WF_ABBA data from GOES-10, GOES-12, and Met-9 as well as data from MODIS. The geographic co-locations were made by finding the fires that matched within twice the square root of the pixel area (to represent pixel width and account for pixel size changes at high viewing angles) for the satellite with the largest footprint. For example when GOES-12 is compared to Met-9, the size from the Met-9 footprint is used. Temporally the three WF_ABBA supported satellites, GOES-10, GOES-12, and Met-9, were matched at exact times corresponding to full disk scans, whereas MODIS co-locations were made within 15 minutes. 10 days from 2 September 2008 to 12 September 2008 were used in this initial study, providing several thousand matches for each satellite with the others. 12 combinations are shown in the figure. The first satellite listed was used as the basis for the comparison, and all fires from the three other satellites were matched to it. This means that, for example, the results when comparing GOES-12 to MODIS are different than when comparing MODIS to GOES-12. The 12 combinations suggest that:

1) The mean WF_ABBA FRP of Met-9 fires when Met-9 fires are matched to the other satellites is very consistent across platforms. The consistency is likely due to the relatively high heat output of the fires Met-9 can see. “Cool” fires are harder to see within the large footprint and after modification by the SEVIRI data remapper.
2) The mean WF_ABBA FRP of GOES-10 and GOES-12 fires as well as MODIS FRP when compared to Met-9 is higher than when the other three are compared to each other. This is likely due to needing hotter/larger fires to match the fires found in the Met-9 data.
3) The mean WF_ABBA FRP of GOES-12 when matched with Met-9 is the highest mean. This may be due to the two satellites having the largest separation in conjunction with remapping applied to Met-9 data, which removes some of cooler fires that GOES-12 does see and Met-9 may have seen had the data not been remapped.
4) The mean WF_ABBA FRP of GOES-12 fires compared to GOES-10 is higher than that of GOES-10 fires compared to GOES-12. This may again be a remapping effect, as while the two satellites should have the best match overall the FRPs derived from GOES-10 data will be lower on the whole than GOES-12 due to the remapping.

Additional co-location studies with longer time periods will be performed to refine the results of this initial comparison. Fusing fire data from these different platforms requires parameterizing the types of platform differences highlighted by the initial study. This lays the groundwork for fusing ABI WF_ABBA and VIIRS fire data.

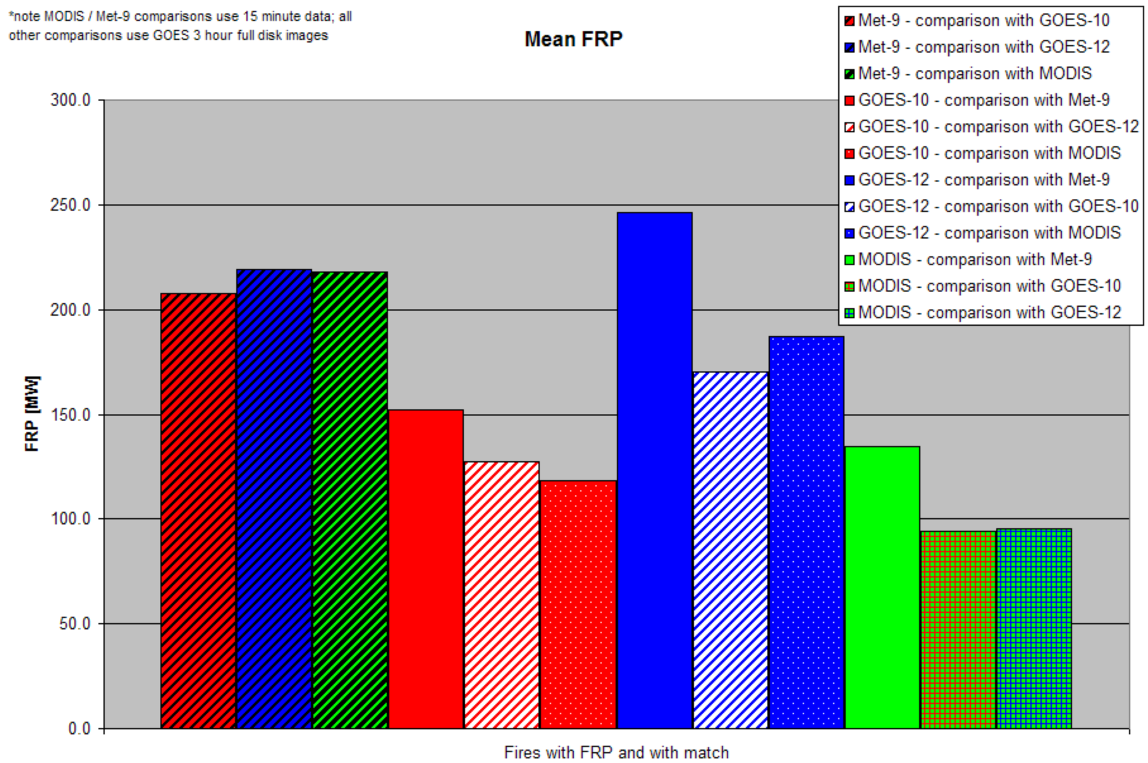


Figure 5.8.2. Twelve combinations of satellite co-locations and the mean fire radiated power (FRP) associated with them. Fires using WF_ABBA data from GOES-10, GOES-12, and Met-9 were matched at full disk image times and MODIS was matched within 15 minutes. Geographic matches were made using twice the square root of the pixel area for the larger pixel in the comparison.

CIMSS was asked to assess the value of a solar correction method based on that used in the AVHRR Fire Identification, Mapping and Monitoring Algorithm (FIMMA) with an eye toward application to GOES-R. The FIMMA method employs a type of forward modeling using information about surface reflectance to estimate the reflected amount of solar 3.9 µm radiance. The WF_ABBA, in contrast, utilizes the difference between the 3.9 µm background radiance calculated from the 11 µm channel and the observed 3.9 µm background radiance to estimate the solar contribution. The FIMMA method's primary sources of potential error are uncertainty in surface emissivity, the assumption that surfaces are Lambertian reflectors, and that atmospheric attenuation is known. The WF_ABBA's error sources also include the surface emissivity at 3.9 µm and atmospheric attenuation as well as 11 µm emissivity, all of which impact the estimation of background temperature. Figure 5.8.3 shows the impact of varying background radiance and estimated solar contribution. Errors in the estimated solar contribution have a larger impact than errors in background radiance estimation. The FIMMA method does not appear to perform any better than the WF_ABBA method based on the sensitivity study and would require additional ancillary data and processing time.

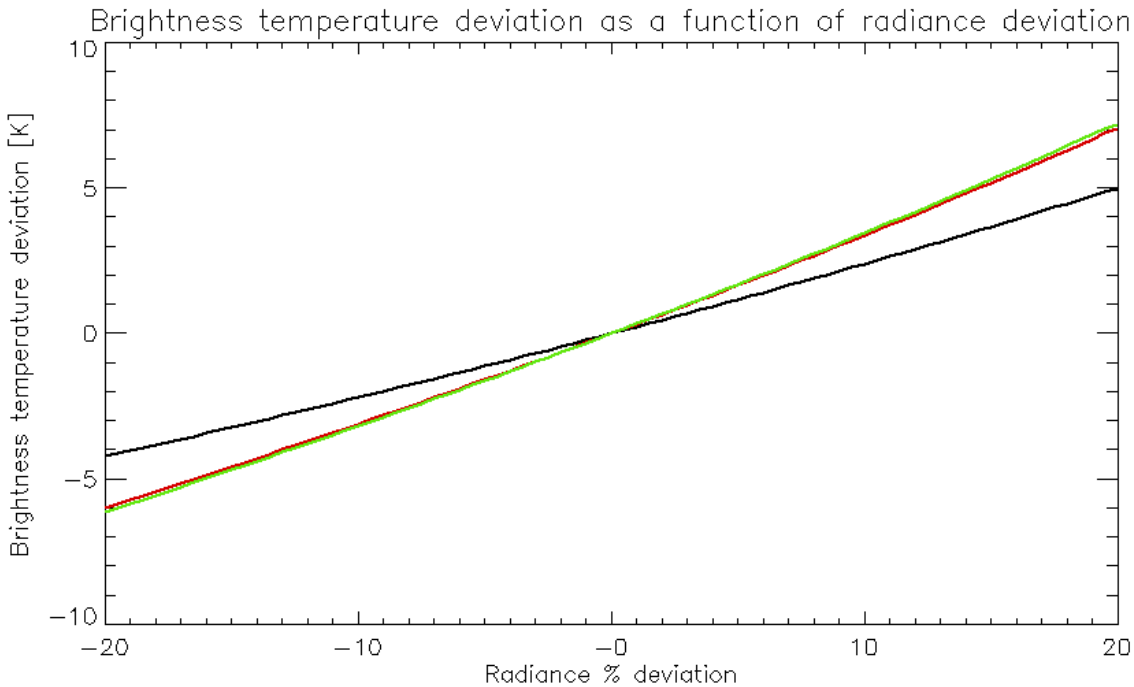


Figure 5.8.3. Results of a sensitivity test on a pixel with a derived 290K surface temperature and 345K 3.9 µm effective solar temperature. The radiance deviation term is added to the surface term (black), solar term (red), and total pixel radiance (green) and then the pixel brightness temperature was recalculated and compared against the brightness temperature of the control. Deviations to the solar term had a much larger impact than deviations to the surface/background term.

Publications and Conference Reports

Lindstrom, Scott S., Christopher C. Schmidt, Elaine M. Prins, Jay P. Hoffman, Jason C. Brunner, Timothy J. Schmit, 2008: Proxy ABI datasets relevant for fire detection that are derived from MODIS data, 5th GOES User's Conference and 88th America Meteorological Society (AMS) Annual Meeting, New Orleans, LA, 20-24 January 2008.

5.9. Nearcasts - Filling the Gap Between Observations and NWP Using Dynamic Projections of GOES Moisture Products

CIMSS Project Lead: Ralph Petersen
NOAA Collaborator: Bob Aune
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Project Summary

The overall goal of this continuing project has been to provide forecasters with new tools to help identify areas of convective destabilization 3-6 hours in advance of storm development using products from current and future GOES satellites. The NearCasting system development has reached sufficient maturity so that the broad objective for 2008 is directed at performing product testing in selected NWS/WFOs. Through this work, WFOs and some NCEP Service Centers (e.g., AWC, SPC) will improve their very-short-range forecasts and the GOES-R program will have examples showing the benefit of temporal and spatial improvements available when GOES data are used effectively.

Summary of Accomplishments and Findings

The majority of the effort during this year has focused on expanding NWS community participation and providing training and getting user feedback. Recognizing that convective destabilization is only one of many possible thermodynamic indicators of the timing and location of near-future development of convection, new scientific efforts have also been made to ensure that the NearCasting system can be expanded to include other indicators of potential for other hazardous weather events (e.g., LI, CAPE, etc.). It should also be noted that results of a leveraged study of temporal moisture variability using AERI data from the ARM CART site is also quantifying the short-range nature and important time scales of moistening and the process of convective destabilization in the lower troposphere only observable from observing systems like GOES that provide continuous series of observations both in time and space.

Milestone for FY08 were expanded from those presented at the 2007 review and include:

- NearCast Model running 24/7 at CIMSS
- Testing in selected Mid-Western WFOs
- *Focus on pre-convective environment*
- *Consider both organized and hard-to-forecast isolated summertime convection*
- Initial development of VISITview-based forecaster training tools *(Underway)*

Additional Tasks added at no additional cost:

+ *Expanding system to include additional Stability Indices*
+ *Expanded evaluation base to include AWC and EUMETSAT*
+ *Enhanced output types to emphasize GRIB-II*

Efforts for the year have focused on preparations necessary to assure reliable and useful delivery of real-time products, rather than major scientific advances. All milestones were met or are near completion. Most notable were: 1) steps needed to provide NearCast products in real-time; 2) ability to expand number of output parameters in future NearCast versions; and 3) briefings on the NearCasting system and products made to NWS/WFOs in WI and MI, NWS CR/HQ and NCEP's AWC, all NWS/SSD Chiefs (electronically) and EUMETSAT. Details follow.

The NWS forecast office in Green Bay, WI (GRB) hosted a regional satellite workshop in January which, among other things, was intended to expand the scope of the NearCast product evaluation. This workshop included all of their forecast staff plus Science and Operations Officers (SOOs) and forecasters from NWS Marquette. The WFOs confirmed that one of their largest forecasting challenges remains predicting the timing and location of isolated, rapidly growing summer-time convection. They also confirmed that they need additional tools to perform these forecasting tasks adequately and welcomed the potential use of predictive satellite products for this purpose.

Based on discussion there, it was decided that the final mix of display mediums (web-based or AWIPS) used for evaluation in other locations will be based upon initial experience in GRB. The strong preference to have the NearCast products displayed in AWIPS has required that all output fields needed to be made available using the WMO GRIB-II output format standard. All necessary modifications to the real-time processing codes have been completed. Efforts are underway to ingest these experimental data into AWIPS for display. (It should be noted that substantial effort was required to accommodate a number of 'undocumented' features of the AWIPS GRIB-II implementation.)

In May, NWS Central Region (NWS/CR) Headquarters and NCEP's Aviation Weather Center (AWC) hosted a small regional workshop, which among other things, was intended to expand the scope of the NearCast product evaluation. This workshop included all NWS/CR HQ and AWC Science staff and plus videoconference connections with Science and Operations Officers (SOOs) in the NWS/CR. Discussions revalidated that one of their largest forecasting challenges remains predicting the timing and location of isolated, rapidly growing summer-time convection. They also reconfirmed that they have insufficient existing tools to perform these forecasting tasks adequately and welcomed the potential use of predictive satellite products for this purpose. This was particularly important to AWC in development of their various Convective Outlook products, including the Collaborative Convective Forecast Product (CCFP) – done jointly with FAA and airline input. Based on these discussions and real-time demonstration of the utility of the system to convection occurring that day, AWC has volunteered to participate in future NearCasting evaluations for the entire US and surrounding oceanic areas.

The workshop also again expressed a strong preference to have the NearCast products displayed in AWIPS using the WMO GRIB-II output format standard. After substantial efforts to determine the 'non-standard' characteristics needed to allow GRIB-II products from the real-time NearCasting system to be ingested into AWIPS, necessary modifications to the real-time processing codes have been completed. Efforts are underway to ingest these experimental data into AWIPS for display. The additional complications encountered with the AWIPS GRIB-II encoding process has forced the implementation of the web-based products for other WFOs to be delayed slightly. In an effort to further speed up the delivery of the NearCast products, changes are also being made to the CIMSS DPI generation process to allow the NearCasts to be run within 10-15 minutes after the GOES scan of the CONUS is completed, rather than waiting the current 40-45 minutes.

A video-teleconference in late August to all of the NWS Scientific Services Division (SSD) Chiefs endorsed further exploration of the Lagrangian NearCasting approach and suggested that the potential utility of the system be expanded to additional weather events, including heavy precipitation events and details of precipitation distribution in the SW US monsoon. After a presentation to EUMETSAT staff, they have also identified several cases for testing where the NearCasting approach might expand the utility of MSG data. Specific cases in Poland and South Africa were identified that were similar to situations which occur in the US. These cases can serve as a test of future GOES-R imager products.

Training materials are being collected into PowerPoint presentations that can be used either by the SOOs at the WFOs to train bench forecasters or by CIMSS personnel in VISITview sessions. This material will be made available to evaluation sites in conjunction with the availability of the web-based NearCasts.

Although the initial forecaster feedback will be subjective, it was also decided that CIMSS will work with the WFOs to develop simplified objective feedback procedures, based in part on experience gained from the more complex evaluation schemes developed at the NASA/SPoRT program. Such objective information will be needed to support potential future operational implementation.

It should also be noted that following the presentation of the NearCasting system at the AMS Aviation Conference in New Orleans, representatives from MIT Lincoln Labs expressed strong interest in using satellite-based convective destabilization products as a means of extending the utility of their shorter-range, radar-based Nowcasting systems which are being used to support FAA operations. Further discussions with personnel from NASA's aviation program and NCAR's Aviation Research staff further endorsed this expanded interaction.

Several scientific efforts are also worth noting. One activity will expand the current NearCasting system to include other indicators of potential for other hazardous weather events (e.g., LI, CAPE, etc.). In all cases, the indices are being chosen to assure that the parameters which GOES observes best (i.e., 2-3 layers of moisture and 5-6 layers of temperature data) will have the major influence. Working through EUMETSAT, these activities are being coordinated with similar efforts there and new efforts in South Africa to develop a 'most-likely ensemble' from the individual indices.

Another activity had sought to identify the value added by the NearCasting products relative to corresponding GOES DPI images. One means of validation is to compare the projected GOES data (obtained from the Nearcasts) with validating GOES DPI products in clear sky areas and with other independent data sets in areas that become cloudy. One such example comparing a NearCast with GPS Total Precipitable Water measurements was presented in last years' report. The primary focus during this year has been to identify the amount of information added by the NearCasts in areas where clouds obscure subsequent GOES DPIs. The example in Figure 5.9.1 clearly show that *none* of the information about rapid convective destabilization occurring prior to a hail-storm not forecast by operational NWP systems would have been available without the NearCast products.

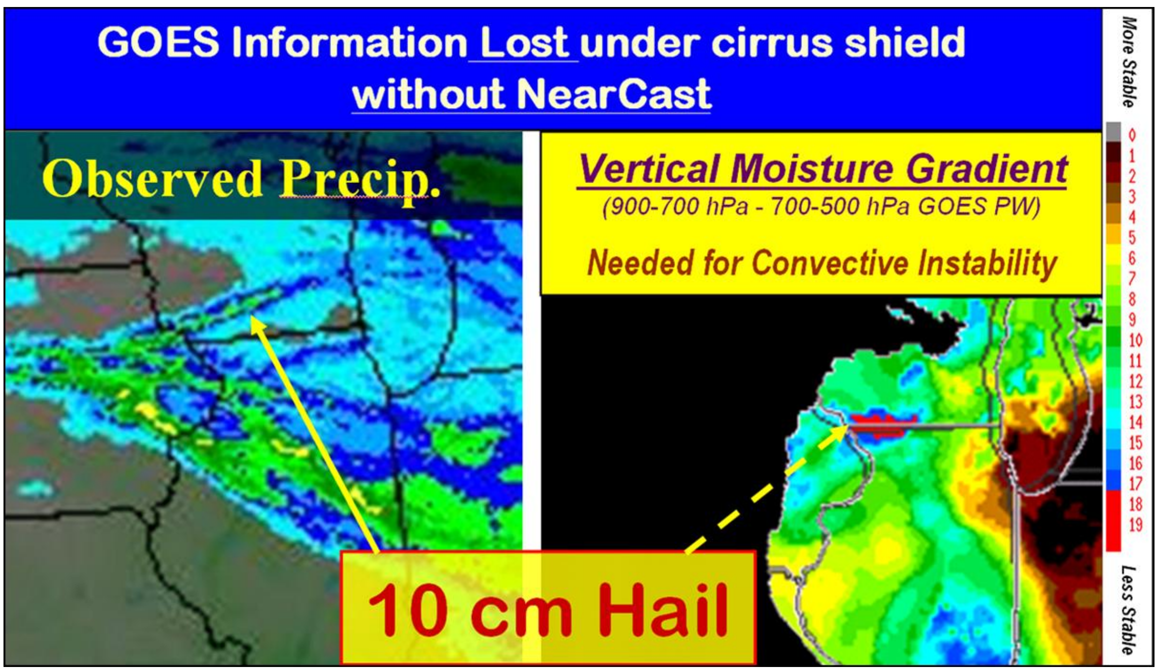


Figure 5.9.1. Comparison of observed 24-hour accumulated precipitation (left - derived from NWS radar reports) and areas of NearCast convective instability (right - as indicated by development bright red areas of large vertical moisture gradients) immediately prior to onset of Hail Storms in southern WI. NearCast data shown only in areas that were obscured by clouds at the time of the storm development and void of DPI data at the time – indicating the amount of information (derived from previous GOES observation) that was *added* by the NearCasting approach.

Publications and Conference Reports

Formal Presentations:

Petersen, R., R. Aune, Jan. 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection. At 1) AMS Satellite Conference, New Orleans, LA and 2) AMS Aviation and Range Meteorology Conference, New Orleans, LA.

Petersen, R., R. Aune, Aug. 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Products. SPIE Remote Sensing Conference, San Diego, CA

Petersen, R., R. Aune, Sept. 2008: A Lagrangian NearCasting tool that optimizes the impact of Multi-spectral GOES Products in forecasting isolated convection. EUMETSAT Satellite Conference, Darmstadt, Germany.

Informal Presentations:
Petersen, R., R. Aune, Jan. 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection - at NWS/WFO/GRB.

Petersen, R., R. Aune, May 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection - at NWS/CR HQ and NCEP AWC.

Petersen, R., R. Aune, Aug. 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection – electronically to all NWS SSD Chiefs.

5.10. ABI Proxy Data Studies: Regional Assimilation of SEVIRI Total Column Ozone

CIMSS Project Lead: Todd Schaack
NOAA Collaborator: Brad Pierce
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work
This project will use the WRF-CHEM regional chemical model coupled to the Real-time Air Quality Model (RAQMS) global chemical analyses to evaluate the impacts of GOES-R ABI-like Total Column Ozone (TCO) retrievals on Air Quality (AQ) forecasts. SEVIRI measurements will be used as ABI proxy data. WRF-CHEM regional air quality predictions, initialized with ozone analyses with and without SEVIRI TCO, will be used for AQ forecast impact studies.

Summary of Accomplishments and Findings
The proposed work requires the adaptation and use of WRF/CHEM, the NOAA Gridpoint Statistical Interpolation (GSI) system, the Community Radiative Transfer Model (CRTM) and RAQMS. The research is focused on the period of August 2006.

The first nine months of this effort has focused on preparing and validating RAQMS global analyses, assembling and adapting the necessary components required to carry out the research (e.g., emissions inventories, the WRF/Chem, the GSI and the CRTM), and initial analyses over the SEVIRI region.

August 2006 RAQMS chemical and aerosol assimilation data denial experiments have been conducted to determine the optimal combination of satellite ozone measurements for the RAQMS global ozone analysis. RAQMS ozone analyses constrained with Ozone Monitoring Instrument (OMI) TCO, and Tropospheric Emission Spectrometer (TES) and Microwave Limb Sounder (MLS) ozone profile retrievals have been completed for August 2006 and evaluated with respect to ozonesondes over the SEVIRI domain (Africa/EU). Comparisons with August 2006 WMO sondes show excellent (<10% bias) agreement in stratosphere and reasonable (<20% low bias) agreement in the troposphere at Ascension Island (Figure 5.10.1). These analyses will be used to provide initial conditions and lateral boundary conditions for WRF/CHEM simulations.

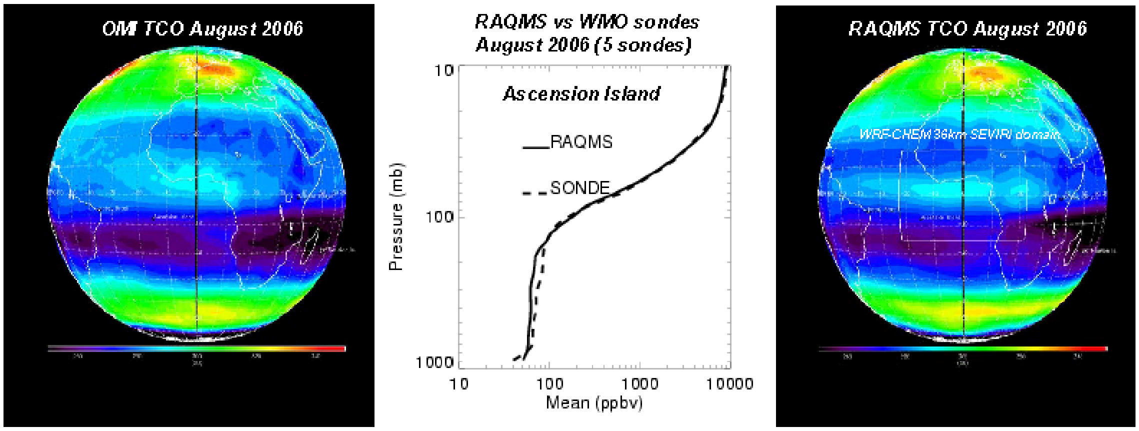


Figure 5.10.1. August 2006 OMI V8 TCO retrieval (left), RAQMS TCO Analysis (right), and RAQMS/WMO ozonesonde comparison (middle). RAQMS ozone assimilation includes MLS ozone profiles from NASA Aura Satellite. TCO enhancement over central Africa is associated with tropospheric ozone column enhancements due to biomass burning.

During this reporting period, the WRF/CHEM has been ported to our local computer and software developed to employ RAQMS global chemical analyses for initial conditions and lateral boundary conditions for WRF/Chem simulations. Figure 5.10.2 shows the 36-hour WRF/Chem forecast (36 km grid) of lower-layer ozone distribution over a portion of the SEVIRI region. This simulation was initialized at 12Z 15 August 2006 from RAQMS global chemical analyses and integrated for 36 hours using RAQMS chemical lateral boundary conditions.

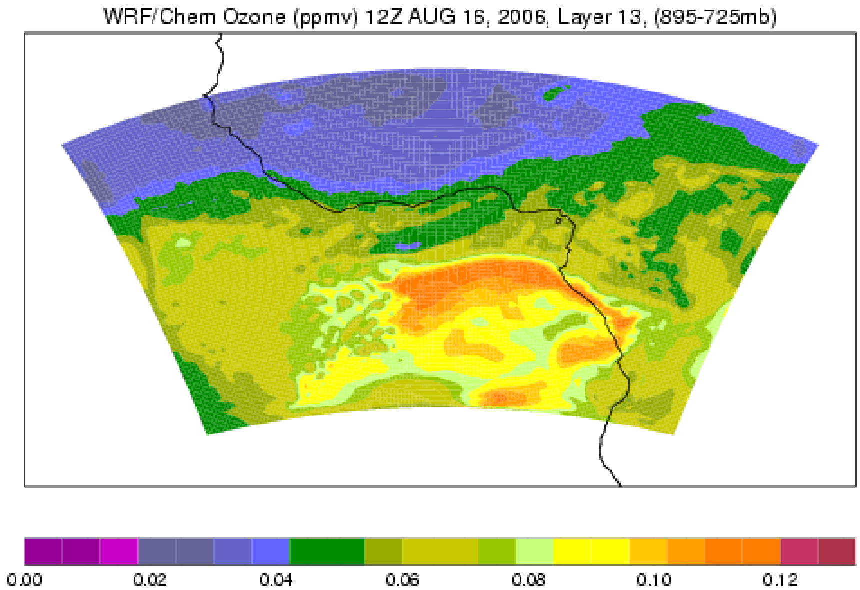


Figure 5.10.2. WRF/Chem 36 hour forecast of low layer (pressure varies between 895 and 725 mb) ozone (ppmv) valid 12z 16 August 2006. The forecast was initialized from RAQMS global chemical analyses and used RAQMS lateral boundary conditions.

The CRTM version used operationally with the GSI has been acquired. An interface with RAQMS and WRF-CHEM has been developed to use the CRTM for our studies. The CRTM radiative transfer code will be used to generate synthetic radiances and brightness temperatures from WRF-CHEM tropospheric plus RAQMS stratospheric chemical and meteorological analyses. The radiative transfer calculations account for the observation geometry, solar zenith angle, surface emissivity, etc. and allow for direct comparisons between the synthetic and observed radiances and for use in radiance assimilation studies.

Figure 5.10.3 shows the comparison between clear sky synthetic (RAQMS/CRTM) and observed (AIRS, SEVIRI) brightness temperatures on 16 August 2006. This figure for a region just off the northwest coast of Africa shows a 2K warm bias at 1050cm-1, consistent with the underestimate in analyzed upper tropospheric O3 mixing ratios relative to WMO ozonesondes (Figure 5.10.1).

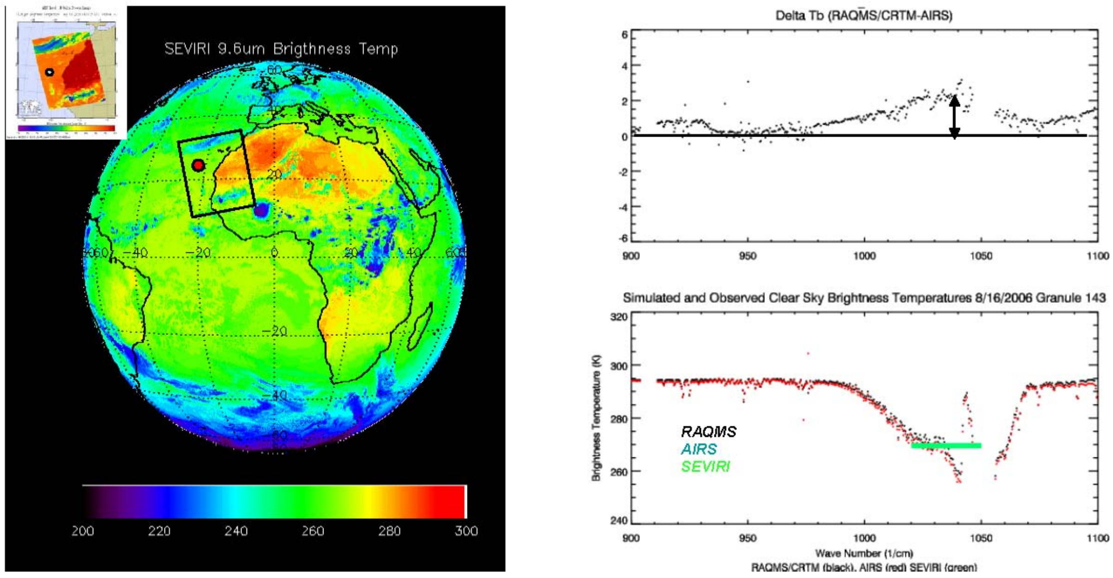


Figure 5.10.3. 16 August 2006 SEVIRI 9.6um BT (left) and RAQMS/AIRS/SEVIRI brightness temperature comparison (right).

The NOAA GSI has also been ported to our local computer during this period. The WRF-ARW/regional GSI system has been tested (without ozone assimilation). The global GSI has been adapted for use with RAQMS and global RAQMS/GSI SBUV ozone assimilation has been tested.

Publications and Conference Reports

Pierce et al., "RAQMS TES/OMI/MLS/OSIRIS data denial studies: Impacts of Satellite measurements on Tropospheric ozone" at the JCSDA workshop (June 9-10, 2008 Baltimore, MD)

5.11. Optimization of Convective and Mountain Wave Turbulence Detection in Support of GOES-R Aviation Requirements

CIMSS Project Leads: Wayne Feltz, Tony Wimmers, Kris Bedka
CIMSS Support Scientist: Justin Sieglaff
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information;
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

This effort focuses on demonstrating the benefits of future GOES-R ABI imagery for convective storm nowcasting and mountain wave detection. ABI will have improved spatial and temporal resolution combined with greater spectral coverage, which will have significant impacts on the formulation and performance of objective satellite algorithms. Improved spatial resolution will help improve detection of overshooting convective cloud tops and mountain waves. Better spectral coverage will improve our ability to diagnose cloud type and cloud-top microphysical phase for cumulus clouds in addition to our understanding of the vertical structure of mountain waves. Shorter time intervals between images will allow for more accurate identification of rapidly developing convective storms at greater lead times. For this GOES-R Risk Reduction effort, specific 2008 milestones include:

Convection Studies

- Provide improved convective initiation, overshooting top, thermal couplet detection techniques for the GOES-R Aviation AWG
- Take advantage of higher temporal image resolution to monitor microphysical (from GOES-R Cloud AWG) and cooling rate changes to detect convective initiation and storm maintenance
- Work toward GOES-R pre-convective, initiation, and mature convective product suite which would be used by aviation, hydrology, and weather nowcasting interests
- Work with Cloud AWG to improve CI nowcasting using ABI derived cloud typing product (using SEVIRI based proxy imagery)

Mountain Wave Studies

- Gather in situ and satellite observations for validation studies
- Use current MODIS imagery to optimize Mountain Wave Turbulence (MWT) feature pattern recognition technique in water vapor imagery

Summary of Accomplishments and Findings

Convection Studies

Objective convective storm initiation (CI) nowcasting during both day and night is a significant challenge. Current state-of-the-art methods utilize visible and near-IR channel reflectance coupled with IR brightness temperatures (BT) and mesoscale atmospheric motion vectors (AMVs, Bedka and Mecikalski (JAM, 2005)) from GOES-12 to objectively identify cumulus clouds and monitor the vertical growth of cumulus cloud tops (i.e. cooling rate). Use of solar reflectance data within this algorithm limits applicability to daytime only scenes. Mesoscale atmospheric motion vectors are also very time consuming to process, negating our ability to nowcast CI over the entirety of CONUS. Lastly, quantitative validation of CI nowcast products has remained a challenge due to the time lag and movement of cumulus clouds between the time of initial cloud growth and the first signals of significant precipitation (> 35 dBZ) or lightning.

In order to address these concerns, a new day/night CI nowcasting approach has been developed at the UW CIMSS using the concept of box-averaging to compute IR Window (IRW) channel cloud-top cooling rate and cloud-top microphysical type trends derived from multispectral IR data. The cloud-top microphysical type information used within the UW CIMSS CI (UWCI) nowcast algorithm has been developed by the GOES-R ABI Cloud AWG for future operational use with ABI data at NOAA NESDIS. The UWCI algorithm has an advantage over other CI nowcast methods in that it can operate very efficiently over an entire full disk during both day and night utilizing high temporal resolution and state-of-the-art cloud microphysical type observations. The UWCI algorithm is developed and tested upon SEVIRI data over South Africa and Lesotho for four CI cases that occurred during February 2008. As SEVIRI shares many spectral channels with the future ABI, SEVIRI represents a useful proxy dataset for ABI convective initiation nowcast algorithm development. The UWCI product is validated against cloud-to-ground lightning strike data collected by the South African Weather Service to: 1) understand the cloud-top temperature characteristics of new lightning producing storms in IRW satellite imagery and to 2) evaluate the accuracy of the UWCI product for thunderstorm nowcasting.

The foundation of the UWCI nowcast algorithm is based upon the concept of “box-averaging”. The term “box-averaging” refers to the computation of the mean IR window brightness temperature (BT) for a group of pixels in a small box that meet a given set of cloud-type criteria. The premise for using this box-average framework is that, as current and future satellite imagers provide data at 5-minute temporal resolution, newly developing convective clouds do not move very far between consecutive images. For example, the average movement of developing convective clouds over CONUS in "rapid-scan" GOES-12 imagery was 5 km/5 min, with a standard deviation (SD) of 2 km/5 min, based upon manual tracking of 50 clouds across multiple cases using McIDAS. When box-averaging is applied to MSG SEVIRI imagery, the UWCI algorithm computes the mean IRW BTs for all water, supercooled, mixed, thin cirrus (ice), and thick ice pixels within a given box. The box-averaged BT is determined for two consecutive SEVIRI scans and then a cooling rate is established by taking the difference of the mean BTs. Methods for reducing false alarms induced by rapid storm movement and other complicated scene types/evolution have been developed.

Figure 5.11.1 provides examples of IR window BT, GOES-R ABI cloud type algorithm output, and UWCI nowcast algorithm output during a period where convective storms developed over the Free State of South Africa and the nation of Lesotho. The cloud typing output shows a transition from liquid/supercooled water and mixed phase to thick ice cloud tops. This occurred in association with a ~30 K decrease in IR window BT over a 45 minute period. Figure 5.11.1e shows the box-averaged cloud-top cooling rate accumulated over this 45 minute period, which clearly depicts the rapid vertical growth that had occurred. Rapidly growing cloud pixels are assigned one of three UWCI nowcast categories, based upon the pixel 15-min cooling rate and the cloud type. Category 1 represents growing (< -4 K/15 mins) liquid water cloud pixels, category 2 represents growing mixed phase or supercooled water pixels, and category 3 represents pixels that have recently transitioned to a thick ice cloud top. Figure 5.11.1f shows the earliest time that any one of these three UWCI nowcast categories were produced at a given point. Locations in red were produced at 1000 UTC, and analysis of the IR window imagery indicates that these pixels provided a 45 minute lead time for nowcasting the future presence of deep convection.

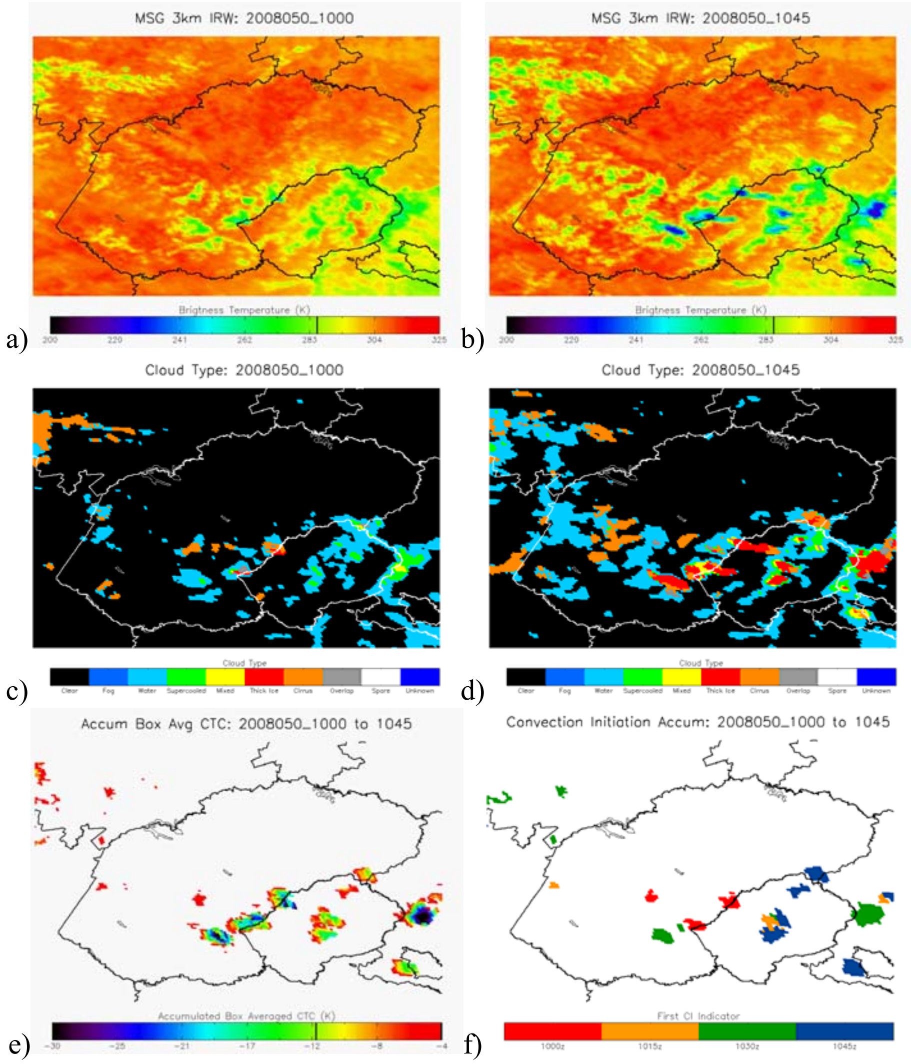


Figure 5.11.1. MSG SEVIRI 10.8 µm brightness temperatures at (a) 1000 UTC and (b) 1045 UTC on 19 February 2008. GOES-R ABI cloud typing algorithm output at (c) 1000 UTC and (d) 1045 UTC. (e) Time accumulated box-averaged cooling from 1000 UTC to 1045 UTC. (f) Four sets of UWCI nowcasts accumulated between 1000 and 1045 UTC. Nowcast categories 1-3 are colored by the time the nowcast was made, with red produced at 1000 UTC and blue produced at 1045 UTC.

Figure 5.11.2 shows a histogram of lightning initiation nowcast lead time for each of the three UWCI nowcast categories. Identification of the initial growth of liquid water clouds most often provides a 60 minute lead time ahead of the first cloud-to-ground lightning strike. As not every cooling water cloud evolves into a lightning producing storm, these pixels have the highest nowcast false alarm rate (46%, not shown). UWCI nowcast category 2 most often provides a 45 min lead time with the lowest false alarm rate of the three categories (21%). Category 3 provides the shortest lead time of all UWCI nowcast categories as clouds that have recently transitioned to thick ice cloud tops often produce lightning at a very short time in the future. The false alarm rate for category 3 pixels was 25%.

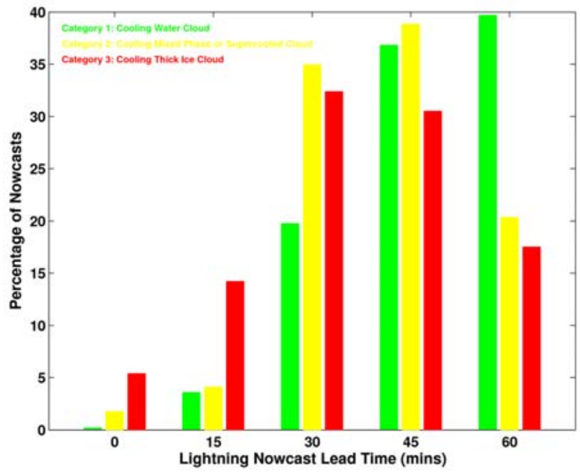


Figure 5.11.2. Lightning initiation nowcast lead time for the three categories produced by the UWCI nowcast algorithm.

Additional work has been done toward comparing UWCI algorithm results when both 5 minute rapid scan and 15 minute operational SEVIRI data are used as input. Use of 5 minute data resulted in improved recognition of developing convection (not shown) for one case with widespread convection over central Europe. We believe that the improvement in product performance should be even more pronounced for fast moving convective clouds and we will seek to demonstrate this in the near future.

Much of the underlying applied research that was instrumental in the development of the objective ABI overshooting top and enhanced-V detection algorithms was supported by GOES-R Risk Reduction. The reader is encouraged to examine Section 6.9 of this document for examples of ABI overshooting top and enhanced-V detection output. Output from these algorithms are currently being combined with atmospheric stability retrievals, destabilization rate, and convective initiation nowcasts to produce an end-to-end convection diagnostic and nowcast system that will 1) identify favorable environments for convective storm growth, 2) identify newly developing thunderstorms at up to a 60 min lead time, and 3) identify storm severity and aviation turbulence signatures.

Mountain Wave Studies

Mountain waves are responsible for producing significant aviation turbulence over the U.S. An analysis of daily MODIS imagery over the central Rockies from October-April 2005-2006 and 2006-2007 reveals that mountain waves were present in 6.7 μm water imagery for 68% of all days during these months. CIMSS has collected 3.5 years of state-of-the-art Eddy Dissipation Rate (EDR) turbulence observations (Cornman et al., J. Aircraft, 1995) from researchers at NCAR (POC: Robert Sharman) in an effort to better understand the relationship between satellite-observed mountain wave signatures and aviation turbulence. Figure 5.11.3 shows an example of imagery from two turbulent mountain wave cases with coincident EDR turbulence observations. For perspective, moderate or greater intensity turbulence occurred on average for only .35% of all EDR observations over the Rocky Mountain Region throughout the duration of this 3.5 year EDR database. Research is being done at CIMSS to objectively identify mountain waves through Morlet wavelet transformation. Figure 5.11.4 shows an example of the preliminary results from this work. Our hope is to develop an accurate objective mountain wave turbulence product for ABI that can be combined with other objective satellite turbulence indicators such as tropopause folding and overshooting tops to provide a real-time diagnostic of hazardous regions for aviation operations.

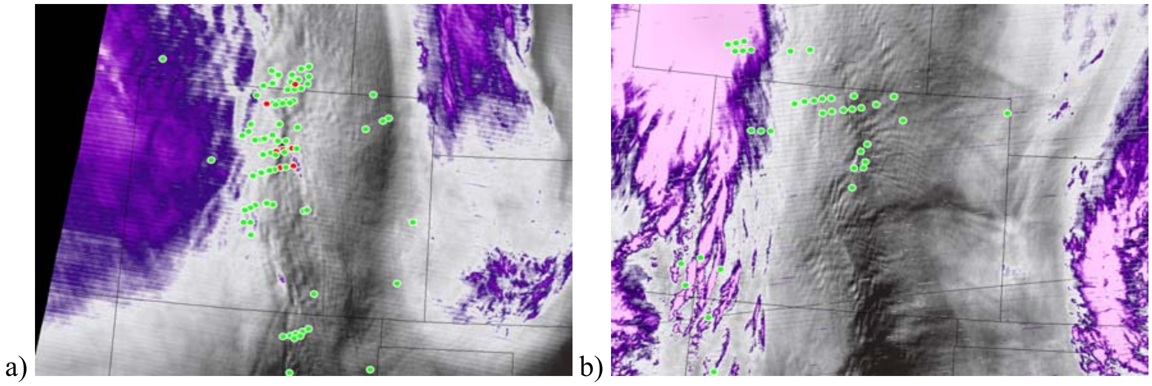


Figure 5.11.3. Color enhanced MODIS 1 km 6.7 μm water vapor imagery on (a) 12 November 2005 at 1720 UTC and (b) 27 December 2005 at 2005 UTC. Lighter grayscale and purple shading indicates greater amounts of upper level water vapor and clouds, respectively. Green (Red) circles represent moderate (severe) intensity EDR turbulence observations within a +/- 2 hour period from the time of the images.

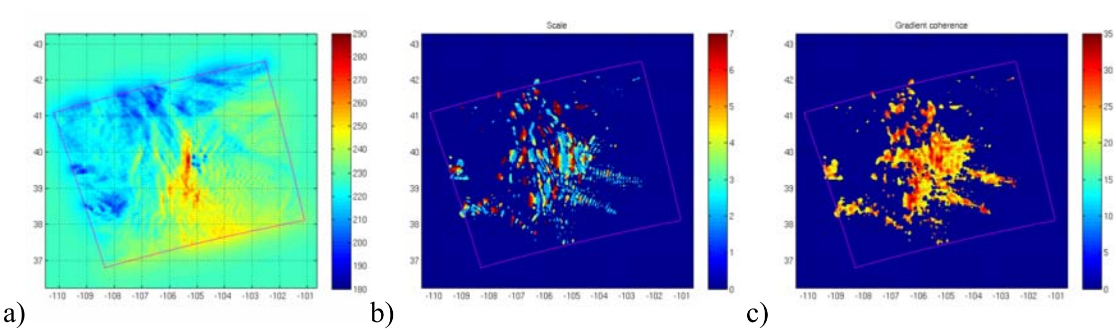


Figure 5.11.4. (a) Color enhanced MODIS 1 km 6.7 μm water vapor imagery on 6 March 2004 at 1950 UTC. (b) Wavelength scale (1 scale=2 km) of objectively detected mountain waves. (c) Spatial coherence of mountain wave detections. High spatial coherence indicates a spatially consistent wave feature. Low spatial coherence is a signal of mountain wave interference.

Publications and Conference Reports

Bedka, K. M., W. F. Feltz, J. R. Mecikalski, and M. Koenig, 2008:Use of geostationary rapid scan imagery in the observation, detection, and nowcasting of convective storms. 2008 EUMETSAT Meteorological Satellite Conference. Darmstadt, Germany. 8-12 September 2008.

Bedka, K. M., W. F. Feltz, J. Sieglaff, and J. R. Mecikalski, 2008: Improving diagnosis and nowcasting of convective storms using MSG SEVIRI, MODIS, and GOES-12 for ABI Risk Reduction. 5th GOES Users' Conference. New Orleans, Louisiana. 20-24 January 2008.

Bedka, K. M., J. Sieglaff, W. F. Feltz, and M. Pavolonis, 2008: Nowcasting convective storm initiation using box-averaged cloud-top cooling and microphysical phase trends. Submitted to J. Appl. Meteor.

Feltz, W. F., K. M. Bedka, J. A. Otkin, T. Greenwald, and S. A. Ackerman, 2008: Understanding satellite-observed mountain wave signatures using high-resolution NWP output. Wea. Forecasting, In press.

5.12. Investigation of Daytime-Nighttime Inconsistencies in Cloud Optical Parameters

CIMSS Project Lead: Bryan Baum
NOAA Collaborator: Andy Heidinger
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water

Proposed Work

Ice cloud optical thickness and effective particle size are necessary for the inference of ice water path (IWP), which is a quantity of interest in numerical weather models and general circulation models. For assimilation of satellite-based ice cloud products, one needs to know both the cloud top height and IWP. Heritage ice cloud retrieval algorithms generally adopt a shortwave (SW) approach for daytime data and a longwave (LW)-based approach for nighttime data. While a LW-based approach can be employed regardless of solar illumination (i.e., not just nighttime), this has not been used historically because most imagers had so few IR channels available and the resulting products have more limitations than with SW-based retrievals, especially for lower-level water clouds. For ice clouds, however, it is of interest to better understand the differences between SW- and LW-based methods.

Our experience with the inference from satellite imager data of ice cloud optical thickness and effective particle size has revealed a discrepancy in the results from approaches that use solely shortwave (SW) channels versus those that use solely longwave (LW) infrared channels. The discrepancy is this: SW-based retrievals result in smaller values of particle size and larger values of optical thickness than those inferred from LW channels. This means that daytime and nighttime results for IWP may be inconsistent. This could have an effect on how modelers interpret the satellite products as well as in the resulting satellite-based cloud climatology. This same issue will affect the anticipated ice cloud products from GOES ABI, which will provide these properties using both SW and LW approaches. Because of the SW-LW discrepancy in ice cloud optical thickness and particle size, daytime and nighttime cloud optical thickness/particle size statistics need to be analyzed separately. The goal of this one-year project is to investigate and potentially determine a way to mitigate the differences found between daytime and nighttime retrievals of ice cloud optical thickness and particle size.

Summary of Accomplishments and Findings

This investigation focuses on the ice cloud bulk scattering models that are used in the generation of static libraries (or look-up tables, henceforth LUTs) of ice cloud parameters that are used in the actual satellite retrievals. These bulk scattering models provide information such as single-scattering albedo, asymmetry factor, scattering/absorption cross-sections and efficiencies, and scattering phase function. Each parameter is a function of effective particle size, ice habit(s), and wavelength. The inference of the bulk scattering properties for ice clouds is more complex than for water clouds as ice particles are exceedingly complex, while water clouds are assumed to be composed solely of spherical droplets. In our development of ice cloud bulk scattering/absorption parameters for the GOES-R Cloud Working Group, described in the current ATBDs and used in the current GOES-R Cloud algorithms, we used a mixture of hollow columns, solid columns, droxtals, hexagonal plates, aggregates, and 3D solid bullet rosettes. The smallest particles in a given particle size distribution (PSD) are represented by droxtals, which are roughly spherical particles with 20 facets. The largest particles in a given PSD are represented by 3D solid bullet rosettes and aggregrates. The aggregate particle is composed of a number of hexagonal solid columns that are randomly attached. The primary assumption thought to contribute most to the daytime-nighttime discrepancy is whether the ice particles have smooth or roughened facets.

However, the current SW database of ice particle scattering properties used in the development of the GOES-R and SEVIRI models was developed almost ten years ago and is being recomputed at the time of this writing. In addition to incorporating a number of recent advances in light scattering computations, results are being generated for a new particle: a hollow bullet rosette. Additionally, a member of the GOES-R Cloud Working Group is developing a model for calculating scattering properties for a new aggregate habit consisting of plates rather than solid columns – observations of aircraft in situ data show that this is a much more realistic aggregate particle than one composed of columns. Most importantly, the new scattering property database will include a new treatment of ice particle surface roughening. The importance of particle roughening needs to be fully investigated, and may hold the key to mitigating daytime-nighttime differences.

Once the new ice particle scattering property database is available, new bulk scattering and absorption models for ice clouds will be developed using particles with both smooth and roughened surfaces. The software to compute these new models has been updated over the past several months to minimize the time required to generate the new models. Once developed, a new LUT will be computed by employing a radiative transfer (RT) model to simulate a cloud layer over a range of cloud optical thicknesses, cloud heights, and cloud effective particle sizes. The RT model to generate a new look-up table has already been developed and tested by the GOES Cloud Working Group members. With the new LUT, we will subsequently perform a sensitivity analysis to determine the expected changes due to particle roughening, and also test on SEVIRI data. These tasks will be accomplished upon delivery of the new SW ice particle scattering database, and the results from this work will be prepared for publication soon thereafter.

Publications and Conference Reports
The contribution of this effort is being documented in the GOES Cloud AWG ATBD that will be finished by the end of February 2009.

Zhang, Z., P. Yang, G. W. Kattawar, J. Riedi, L. C. Labonnote, B. A. Baum, S. Platnick, and H. L. Huang: Influence of ice particle model on retrieving cirrus cloud optical thickness from satellite measurements: model comparison and implication for climate study. In preparation, almost ready for submittal to a peer-review journal (as yet undecided).

5.13. Improving Ice Thickness and Age Estimation With the ABI

CIMSS Project Lead: Xuanji Wang
CIMSS Support Scientist: Yinghui Liu
NOAA Collaborator: Jeffrey R. Key
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information.

Proposed Work
To meet the GOES-R Mission Requirements Document (MRD) requirements and accomplish the goals outlined in the GOES-R Risk Reduction Activity Plan, this project was initiated for the evaluation, improvement, and development of sea and lake ice thickness and age retrieval algorithms for application with GOES-R ABI. Ice thickness and age information is needed for weather forecasting, climate prediction, agricultural planning, transportation, and hazard assessment. During this period, the work has focused on the development of a One-dimensional Thermodynamic Ice Model (OTIM) for the purpose of

better and efficient ice thickness and age estimation, model test runs with proxy data from a variety of data sources, and model validation against submarine and station measurements as described briefly below.

Summary of Accomplishments and Findings

The major accomplishment this year was the development, implementation, preliminary test runs, and validation of the algorithm, as described below. Preliminary results are very promising and exciting.

1. One-dimensional Thermodynamic Ice Model (OTIM) and Ice Age Classification

A One-dimensional Thermodynamic Ice Model (OTIM) has been developed based on the surface energy balance at thermo-equilibrium, containing all components of the surface energy balance as formulated in equation (1):

$$(1-\alpha_s)\, F_r - I_0 - F_l^{up} + F_l^{dn} + F_s + F_e + F_c = F_a \qquad (1)$$

where $\boldsymbol{\alpha_s}$ is ice surface broadband albedo, $\boldsymbol{F_r}$ is the downward solar radiation flux at the surface, $\boldsymbol{I_0}$ is the solar radiation flux passing through the ice interior, $\boldsymbol{F_l^{up}}$ is the outgoing thermal radiation flux from the surface, $\boldsymbol{F_l^{dn}}$ is the incoming thermal radiation flux from the atmosphere towards the surface, $\boldsymbol{F_s}$ is the turbulent sensible heat flux at the surface, $\boldsymbol{F_e}$ is the turbulent latent heat flux at the surface, $\boldsymbol{F_c}$ is the conductive heat flux within the ice slab, $\boldsymbol{F_a}$ is the residual absorbed energy that contributes to melting at or near the surface. By the definitions of the terms in the equation (1), $\boldsymbol{\alpha_s}$, $\boldsymbol{F_r}$, $\boldsymbol{I_0}$, $\boldsymbol{F_l^{up}}$, $\boldsymbol{F_l^{dn}}$ should be always positive, $\boldsymbol{F_s}$, $\boldsymbol{F_e}$, and $\boldsymbol{F_c}$ would be positive or negative, and $\boldsymbol{F_a}$ is zero in the absence of a phase change. Parameterization work has been done for most of the radiation terms and ice microphysical properties such as ice transmittance and conductivity. Coding this model was a formidable task.

Sea ice is often classified into following types: new, nilas, grey, grey white, first-year thin, first-year medium, first-year thick, and multi-year deformed. These ice types represent both age and thickness, so the two terms can be used somewhat interchangeably in this context. Generally speaking, older ice is thicker than younger ice. In essence, this assumption is valid as tested and verified by many other researchers (e.g., Tucker et al., 2001; Yu et al., 2004; Maslanik et al., 2007). So we use ice thickness as a proxy for ice age. There is an internationally accepted terminology for ice form and conditions, coordinated by the WMO. This terminology is used by the Canadian Ice Service as the basis for reporting ice conditions (refer to http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=1&Lang=eng), and adopted here with minor modifications for classifying ice into those 8 age categories in terms of ice thickness, as listed in Table 5.13.1.

Table 5.13.1. Ice Age Name and Definition for Sea Ice.

Name	Definition
New	A general term for recently formed ice which includes frazil ice, grease ice, slush and shuga. These types of ice are composed of ice crystals which are only weakly frozen together (if at all) and have a definite form only while they are afloat, ***less than 5 cm thick***.
Nilas	A thin elastic crust of ice, easily bending on waves and swell and under pressure growing in a pattern of interlocking “fingers” (finger rafting). Nilas has a matte surface and is ***5-10 cm*** thick and may be subdivided into dark nilas and light nilas.
Grey	Young ice ***10-15 cm*** thick. Less elastic than nilas and breaks on swell. Usually rafts under pressure.
Grey-white	Young ice ***15-30 cm*** thick. Under pressure it is more likely to ridge than to raft.
First-year Thin	First-year ice of not more than one winter's growth, ***30-70 cm*** thick.
First-year Medium	First-year, ice ***70-120 cm*** thick.
First-year Thick	First-year ice ***120-180 cm*** thick.
Old	Sea ice that has survived at least one summer's melt. Topographic features generally are smoother than first-year ice, and ***more than 180 cm*** thick. May be subdivided into second-year ice and multi-year ice.

2. Preliminary Test Run Results

The OTIM and ice age algorithm have been coded in IDL and Fortran 95 languages, and implemented and tested with proxy data from the Advanced Very High Resolution Radiometer (AVHRR), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) onboard different meteorological satellites. Figure 5.13.1 is a case of retrieved ice thickness and ice age with MODIS Aqua data on 31 March 2006 under clear sky condition for the Arctic. Figure 5.13.2 is another case of retrieved ice thickness and ice age with MODIS Aqua data on 24 February 2008 under clear sky condition for the Great Lakes. Figure 5.13.3 shows an example of retrieved ice thickness and ice age with SEVIRI data on 27 January 2006 under clear sky condition for the Caspian Sea.

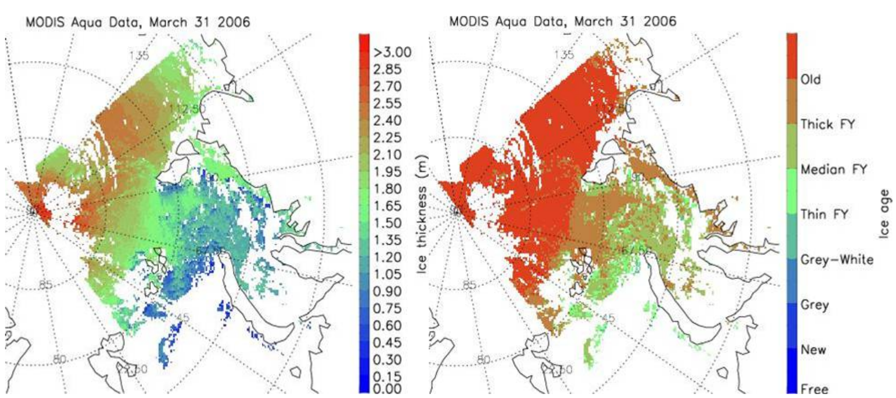


Figure 5.13.1. Retrieved ice thickness (left) and ice age (right) with MODIS Aqua data on 31 March 2006 under clear sky condition for the Arctic Ocean.

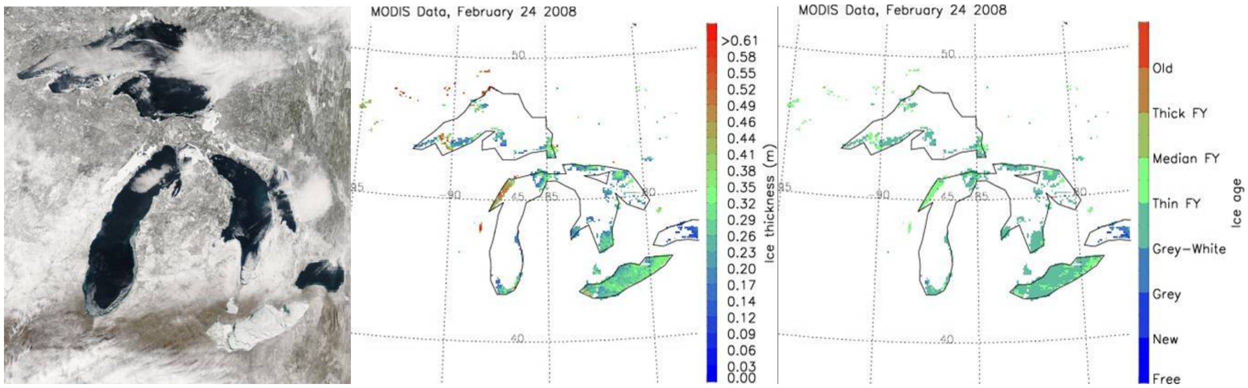


Figure 5.13.2. MODIS Aqua true color image (left), retrieved ice thickness (middle), and ice age (right) with MODIS data on 24 February 2008 under clear sky condition for the Great Lakes.

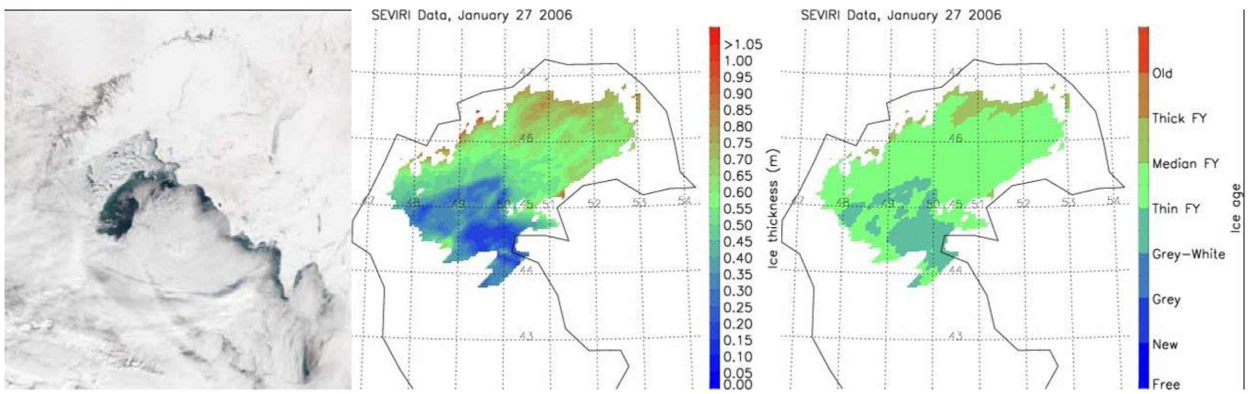


Figure 5.13.3. MODIS Aqua true color image (left), and retrieved ice thickness (middle) and ice age (right) with SEVIRI Data on the same date of 27 January 2006 under clear sky condition for the Caspian Sea.

3. Validation

To estimate the performance and accuracy of our algorithm, we have used comprehensive numerical model simulations, submarine upward-looking sonar measurements, and meteorological station measurements. A Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS) was used for this study for because it is not a direct measurement of ice thickness, but rather a numerical simulation. Two actual in-situ measurement records of ice thickness are from U.S. Navy submarine during the Scientific Ice Expeditions (SCICEX) in 1999 and from Canadian meteorological stations sponsored by Canadian Ice Service during the New Arctic Program starting from 2002. Overall the OTIM (this study) ice thickness is much more accurate than the PIOMAS simulation when compared to in-situ measurements made by both submarine and at surface stations. Figure 5.13.4 shows the comparisons of ice thickness retrieved by OTIM with APP-x data, measured by U.S. Navy submarine, and simulated by numerical model PIOMAS in terms of cumulative frequency and absolute magnitude during 02 April - 13 May 1999, and Figure 5.13.5 provides the comparisons of ice thickness from OTIM, PIOMAS, and one station at Resolute, Northwest Territories, Canada over 2002~2004 in cumulative frequency and in absolute magnitude.

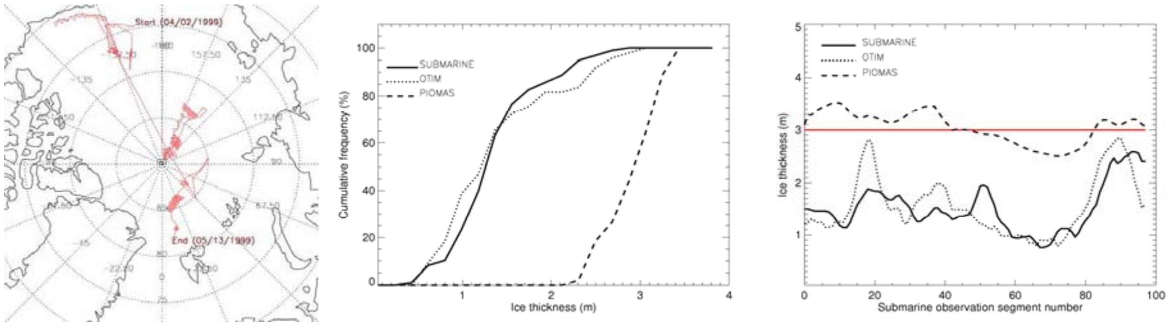


Figure 5.13.4. U.S. Navy submarine track (left) during 02 April - 13 May 1999, and comparisons of ice thickness retrieved by OTIM with APP-x data, measured by U.S. Navy submarine, and simulated by numerical model PIOMAS in cumulative frequency (middle) and in absolute magnitude (right).

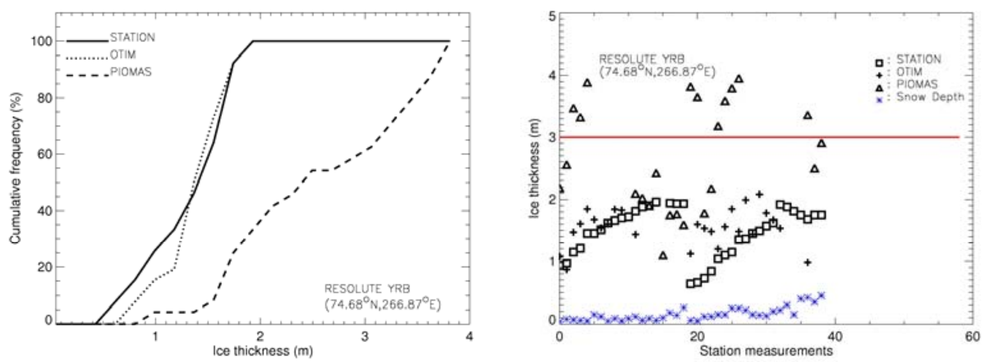


Figure 5.13.5. Comparisons of ice thickness from OTIM, PIOMAS, and one station at Resolute, Northwest Territories, Canada over 2002~2004 in cumulative frequency (left) and in absolute magnitude (right).

Publications and Conference Reports

Xuanji Wang, Jeffrey R. Key, Yinghui Liu, William Straka III, Estimation of Sea and Lake Ice Characteristics with GOES-R ABI, *AMS 88th Annual Meeting/5th GOES Users' Conference,* 20-24 January 2008, New Orleans, LA.

5.14. Algorithm Development, Data Analysis and Visualization Capabilities for the GOES-R Program

CIMSS Project Lead: Tom Rink, Ray Garcia, Tom Achtor,

NOAA Strategic Goals Addressed:

5. Provide critical support for the NOAA mission

Proposed Work

To aid scientists and algorithm developers in the testing and evaluation of their GOES-R development, the CIMSS visualization team is developing McIDAS-V analysis and visualization capabilities for the ABI (Advanced Baseline Imager) according to requirements specified by the GOES-R AWG Imagery and Visualization Team which were outlined in the draft ATBD (September 2008). This includes investigations concerning best methods for image enhancements, use of interpolated or analytic earth navigation, and adoption of NetCDF-4 format for single and multi-banded images.

Integration of McIDAS-V and GEOCAT will provide GOES-R scientists with an intuitive interface to the GEOCAT environment. Additionally, the amount of time required to process large datasets through GEOCAT will be reduced by using cluster computing, the details of which are hidden from the user. It will also be simpler for the user to compare GEOCAT output with reference data from numerical models, satellite, and other observations for algorithm development, evaluation and refinement.

Finally, a continuing project is to complete remaining HYDRA /McIDAS-V integration tasks, and add new functionality for enhancing satellite remote sensing analysis and visualization for McIDAS-V by interfacing with, and meeting the needs of scientists. For example, scientists are providing us with HYDRA wish list items that include new functionality. One item that is still needed for McIDAS-V/ HYDRA is the ability to compare multiple parameters on the same geographic transect display. With the upcoming beta release of McIDAS-V, we anticipate expanded scientist use and increased user requests for added functionality and capability.

Summary of Accomplishments
Many of HYDRA's interactive visualization capabilities have been incorporated into McIDAS-V with some refinement still needed as users start to work in the new environment. Figure 5.14.1 shows the scatter analysis tool being used with simulated ABI imagery. The user can use the mouse to draw curves or boxes on either the image, or on the scatter display to help understand the relationship between bands or combination of bands. This tool can also be used with other types of data, for example grids, as well. A jython based McIDAS-V tool adds the capability to create arbitrary combinations of channels, and complements the original GUI based linear combination tool as it was in HYDRA, an example is shown in Figures 5.14.2 and 5.14.3. These features were presented at SPIE, Atmospheric and Environmental Remote Sensing, August 2008, San Diego CA.

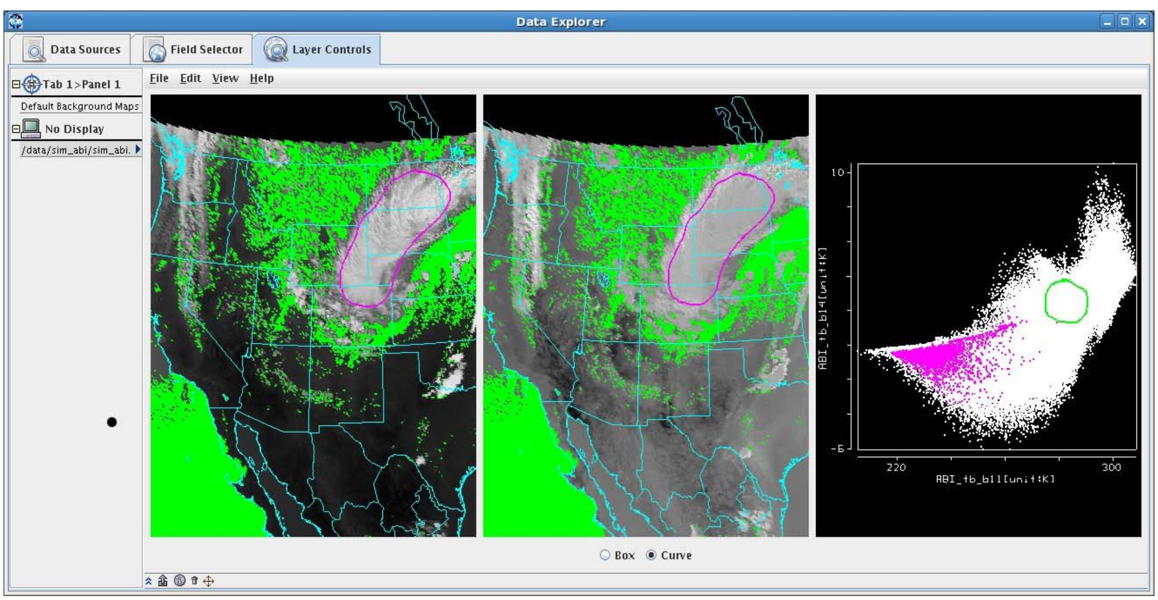


Figure 5.14.1. Scatter Analysis tool in McIDAS-V demonstrating cloud phase discrimination using simulated ABI data, using Band 11, and Band (11 - 14)

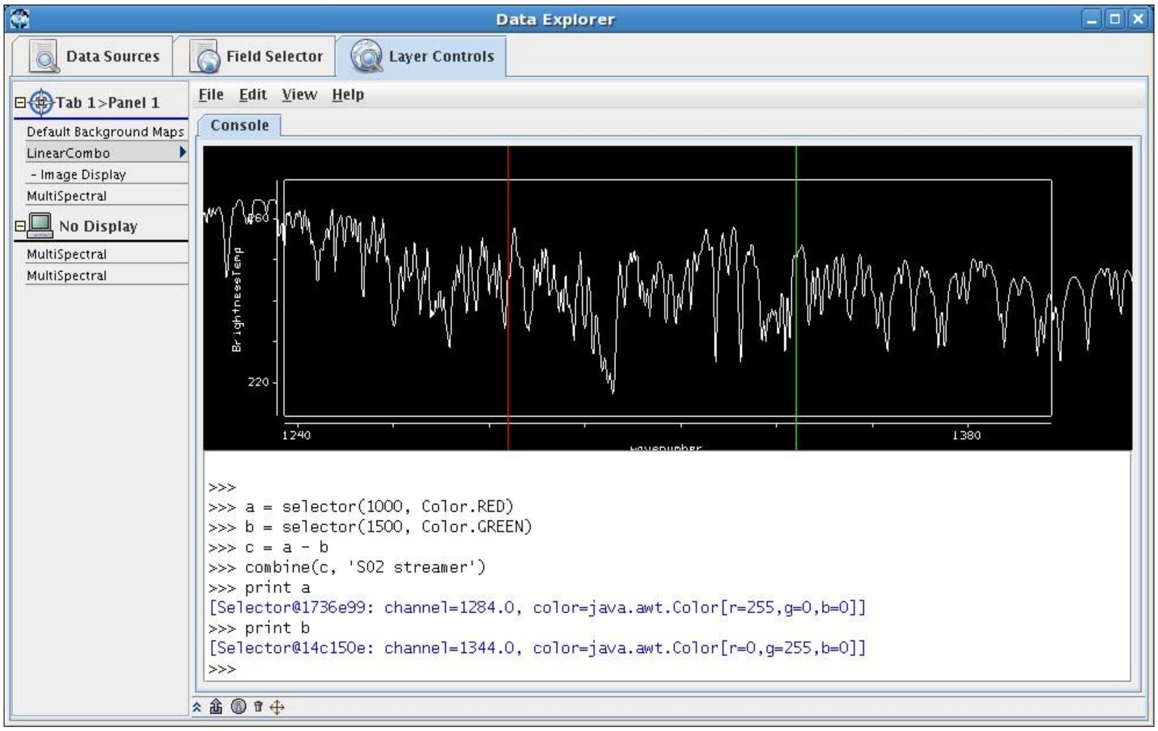


Figure 5.14.2. Jython channel combination console: with a couple simple commands, users can associate bands with variables and assemble new pseudo-channels. Here a simple IR channel difference using IASI L1C is used for $S0_2$ detection. The difference image is shown in Figure 5.14.3.

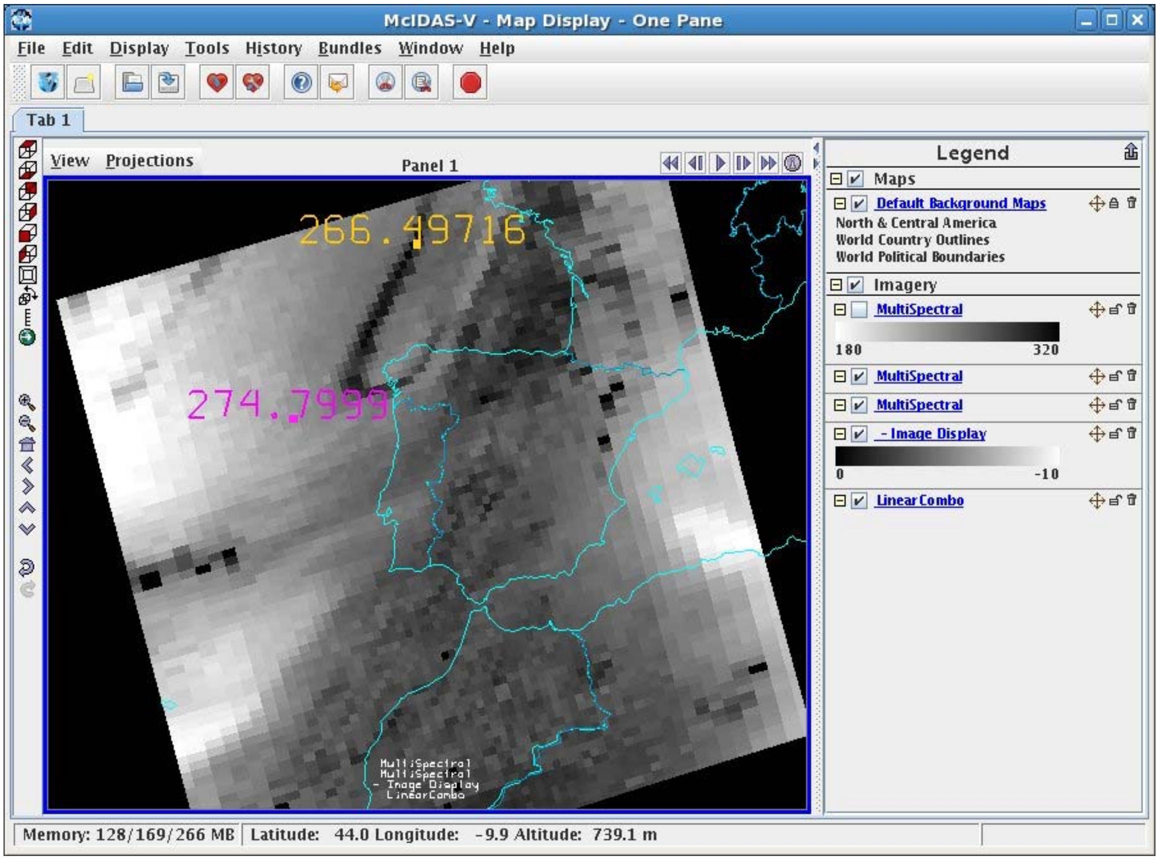


Figure 5.14.3. The IR channel difference image using IASI L1C for $S0_2$ detection.

5.15. GOES-R Education and Public Outreach

CIMSS Project Leads: Steve Ackerman, Margaret Mooney
NOAA Collaborators: Tim Schmit, Nina Jackson
NOAA Strategic Goals Addressed:

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

Western Hemisphere animations simulating all 16 bands of ABI data were displayed on a 3D weather globe at the GOES-R planning meeting at CIMSS in April 2008. In August, a new module detailing the advantages of the ABI instrument planned for GOES-R was added to the CIMSS *Satellite Meteorology for Grades 7-12* on-line course. Updated course CDs will be freely distributed at the Teacher/Student Day of the 2008 Direct Broadcast Conference in Miami and the Education Symposium at the 2009 AMS Conference in Phoenix.

6. GOES-R Algorithm Working Group

6.1. GOES-R Proxy Data Sets and Models to Support a Broad Range of Algorithm Working Group (AWG) Activities

CIMSS Project Leads: Allen Huang and Tom Greenwald
CIMSS Support Scientists: Jason Otkin, Yong-Keun Lee, Justin Sieglaff, Erik Olson
NOAA Collaborator: Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

This year's effort focused on conducting validation studies and preparing for the incorporation of predicted aerosols and ozone into the simulated ABI proxy data sets. Validation is an important part of evaluating the quality of the model simulations and the forward modeling, particularly for clouds. SEVIRI Infrared and CloudSat measurements were used to evaluate the WRF model simulation performed over the domain covered by Meteosat Second Generation (MSG). Additional work involved refining the forward model system, producing simulated ABI proxy data sets for last year's hurricane Katrina model simulation, and providing simulated ABI proxy data sets to other AWG research teams, including GRAFIIR.

Summary of Accomplishments and Findings

Forward model development

Limited work was done with respect to forward model development. Coefficients for the gas absorption model for the SEVIRI solar bands (0.6 µm, 0.8 µm, 1.6 µm, and 3.9 µm) were obtained from our collaborators at Texas A&M. Lookup tables for cloud scattering properties (ice and liquid) at these bands were generated as well. In addition, the IR part of the forward model system was upgraded to the official Release 1.1 of CRTM.

Work began on incorporating predictions of aerosols by the UW Regional Air Quality Modeling System (RAQMS) into selected simulated ABI proxy data sets. Some modification of the IR forward model code was done to accept aerosol physical properties. Once this work is completed, new simulated ABI proxy data sets will be produced at selected times for the MSG WRF model simulation. Eventually these new datasets will be supplied to the AIT group and used as the reference simulated ABI proxy data set for testing all AWG algorithms.

A required deliverable was provided on 30 May to Dr. Fuzhong Weng consisting of forward model source code, input databases, and documentation for the latest solar/IR forward model system, entitled: "Users Manual to the Fast Solar/Infrared Radiative Transfer Model."

Production of simulated proxy datasets

Last year a WRF model simulation of hurricane Katrina was performed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. The simulation was initialized at 18 UTC on 28 August 2005 with 1° GFS data and then run for 48 hours on a double-nested domain containing 4.5-km and 1.5-km horizontal grid spacing, respectively. Figure 6.1.1 shows sample ABI imagery (2 km resolution) generated from this simulation.

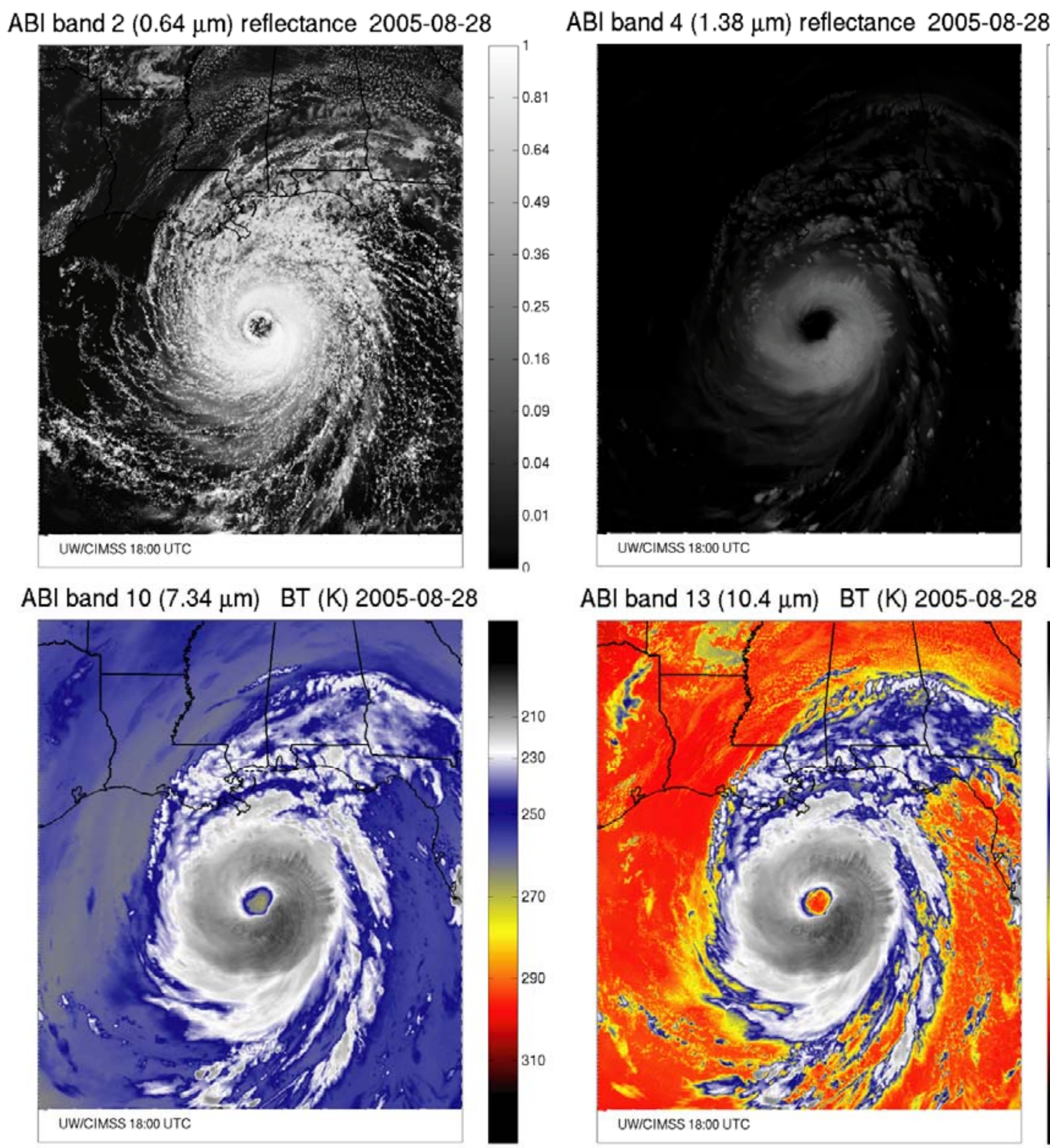


Figure 6.1.1. Selected ABI bands generated from the hurricane Katrina simulation. Bands 2 and 4 are expressed in reflectance, whereas bands 10 and 13 are given as brightness temperature (K).

A summary of the simulated ABI proxy data sets produced for this simulation is given in Table 6.1.1.

Table 6.1.1. Simulated ABI proxy data sets produced for the hurricane Katrina WRF model run. IR refers to ABI bands 8-16 and Solar refers to ABI bands 1-7.

Domain	Bands	Time Range (UTC)	Time Sampling	Data Volume*
Inner	IR	0600 (28 August) – 1800 (29 August)	15 min	1.6 TB of raw model data, 75 MB of remapped IR ABI data per time step, 36 MB of remapped solar ABI data per time step, additional GOES-12 imager data was also produced but excluded here
Inner	Solar	0600 (28 August) – 1800 (29 August)	15 min	

* These totals do not include the unmapped radiance/reflectance data sets.

Data distribution

Selected simulated ABI proxy data sets have been provided to the GRAFIIR team to show the impact of instrument errors on atmospheric soundings, derived winds, and cloud retrievals.

Animations of our latest simulated ABI proxy data sets were given to Mitch Goldberg on a CD. Also, simulated ABI and GOES-12 imagery, as well as animations, were provided to Jim Gurka’s presentation at the Hurricane Center.

A required deliverable was provided on 30 May to Dr. Fuzhong Weng consisting of the following simulated proxy data sets:

- Full-disk single-band ABI proxy data files for bands 8-16 from 22 UTC 4 June 2005 to 00 UTC 5 June 2005 at 30-min increments
- CONUS single-band ABI proxy data files for all bands from 22 UTC 4 June 2005 to 00 UTC 5 June 2005 at 5-min increments

Validation

Substantial effort was directed this year toward validating a large-scale, high-resolution Weather Research Forecasting (WRF) model simulation that was performed at the National Center for Supercomputing Applications (NCSA) in 2007. The simulation contained a single 5950 x 5420 grid point domain covering the entire Meteosat viewing area between 58º S and 58º N with 3-km horizontal resolution. The large geographic scope of the simulation provides a valuable opportunity to evaluate the accuracy of the entire modeling system used to generate proxy satellite data sets. Our goals were (1) to evaluate the overall quality of the proxy data sets using infrared measurements from SEVIRI and (2) to evaluate the vertical structure of the simulated clouds using CloudSat radar reflectivity measurements.

Overall, a comparison of the simulated and observed SEVIRI brightness temperatures revealed that the simulated data realistically depicted many of the observed cloud and atmospheric features. For brevity, only the brightness temperature difference (BTD) portion of the validation results will be presented here. Figure 6.1.2 shows a representative example of the simulated and observed 10.8 μm brightness temperatures and the 10.8 – 12.0 μm and 8.7 – 10.8 μm BTD for all pixels with a zenith angle less than 70º. Enhanced water vapor absorption at 12.0 μm causes the 10.8 – 12.0 μm BTD to be positive in most regions, with the largest values occurring over the tropics where significant low-level moisture is present. Additional elongated and circular bands of large positive BTD associated with thin cirrus clouds are located over central Africa, the north Atlantic, and the southern mid-latitude regions. The deeper convective clouds across these regions contain smaller BTD since the larger ice particles near the cloud top cause the weighting functions for both channels to peak near the same level, thereby resulting in similar brightness temperatures and a small BTD. Large areas of negative BTD values are primarily limited to arid and semi-arid locations, such as the Sahara and much of southern Africa. The large positive bias in the simulated BTD data over the western two-thirds of the Sahara is likely due to the lack of dust in the numerical model, which was important for this case since a significant dust storm was ongoing across this region.

The 8.7 – 10.8 μm BTD data can be used to effectively discriminate liquid and ice clouds due to differences in their radiative properties. Typically, ice clouds are characterized by a positive BTD while liquid clouds have a negative BTD. This distinction is clearly illustrated in Figure 6.1.2 by the close relationship between the positive BTD and the coldest 10.8 μm brightness temperatures across the entire domain. The realistic distribution of positive BTD in the simulated data indicates that the cloud properties produced by the WRF microphysics scheme and the scattering and absorption properties used by the forward model are both realistic. Clear areas are generally characterized by negative BTDs in both datasets due to greater water vapor absorption at 8.7 μm. The largest negative BTDs occur over desert areas due to a lower surface emissivity at 8.7 μm than at 10.8 μm.

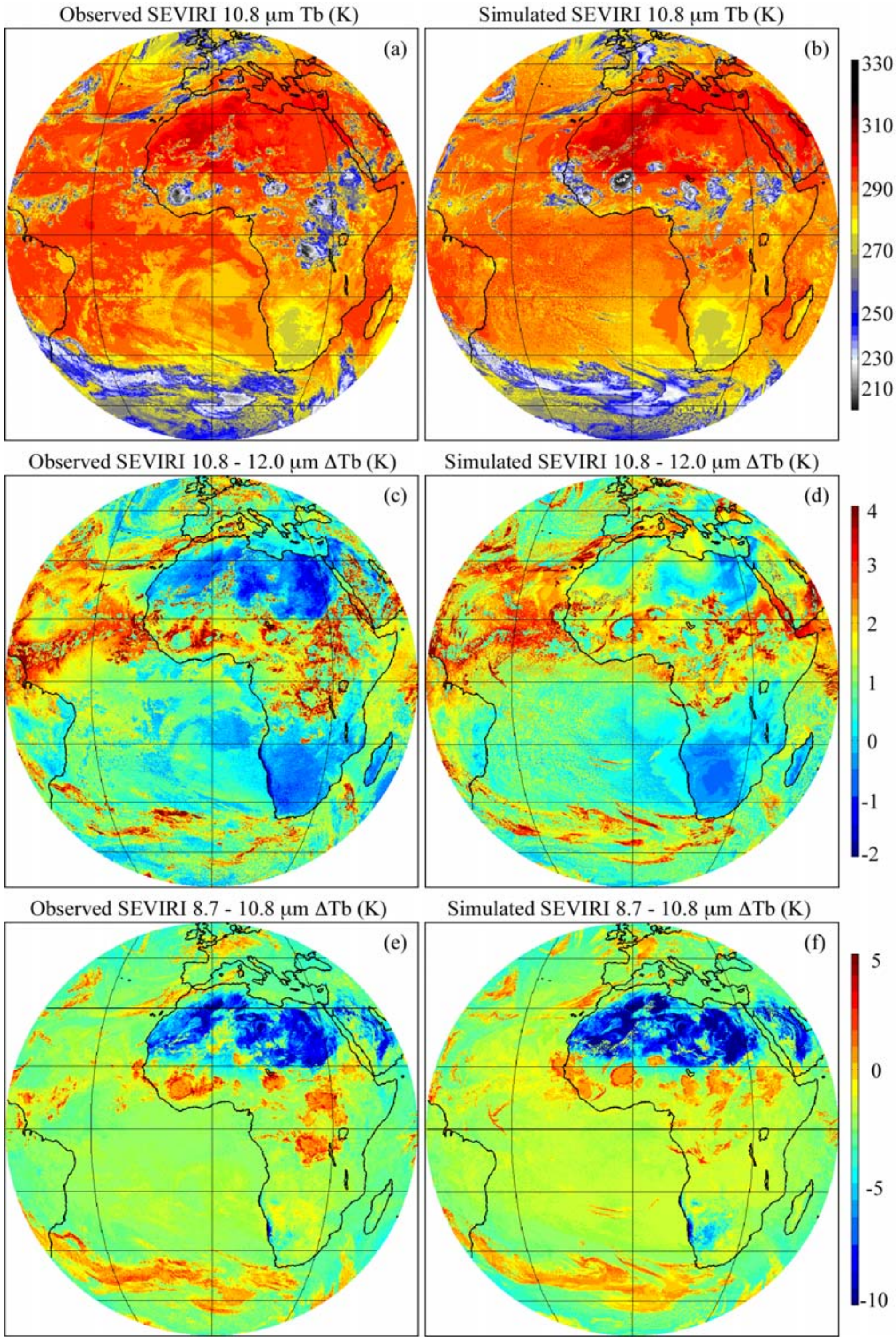


Figure 6.1.2. (a) Observed and (b) simulated SEVIRI 10.8 μm brightness temperatures (K). (c) Observed and (d) simulated SEVIRI 10.8 - 12.0 μm brightness temperature differences (K). (e) Observed and (f) simulated SEVIRI 8.7 - 10.8 μm brightness temperature differences (K). All images valid at 22 UTC 16 August 2006.

For the comparison of the model clouds to CloudSat measurements a cluster analysis was applied to joint relative frequency of occurrence histograms of height and radar reflectivity. Model data were matched to within 5 km of the ground track of CloudSat over the entire day on 16 August 2006. Quickbeam was used to simulate radar reflectivity. However, significant modifications were made to Quickbeam to accommodate both mixing ratio and particle diameter for each of the model's hydrometeor types and to include more realistic particle scattering properties as determined from Discrete Dipole Approximation (DDA) calculations. The inclusion of DDA-derived properties was shown to significantly improve the reflectivity calculations for snow hydrometeors.

The five categories resulting from the cluster analysis shown in Figure 6.1.3 each represent a unique cloud regime. The first category (Figure 6.1.3a) may be best interpreted as thin cirrus over boundary layer cloud and is by far the most common cloud regime encountered. The simulations are found to compare well to the observations, although it is somewhat difficult to say for boundary layer clouds where the observations have been removed in the lowest 1 km due to surface backscatter effects. The second category (Figure 6.1.3b) is principally boundary layer cloud but indications of thin cirrus also exist. Here, the simulated reflectivities are much greater than observed, implying the simulated clouds are precipitating more vigorously. The third category (Figure 6.1.3c) is interpreted as thicker cirrus because of the larger reflectivities, which are associated with frontal systems or are in isolation. The simulations compare well to the observations although the clouds are somewhat geometrically thicker. The fourth category (Figure 6.1.3d) is mainly associated with less organized weather systems, as indicated by shallower convection and a less distinct region of cirrus anvil. The simulated reflectivities are comparable to the observations, although the clouds appear to be somewhat deeper. The last category (Figure 6.1.3e), which occurred least frequently, is tied to frontal features of cyclonic systems. Both simulations and observations show the characteristic deep convection (high reflectivities) associated with these systems along with the trailing cirrus shield of less reflective high clouds. These systems produced the largest simulated and observed reflectivities seen, but the simulations tended to have relatively fewer reflectivities over 10 dBZ. This discrepancy may be a result of not including multiple scattering effects in Quickbeam. While these results are promising, further work is needed to quantify the level of agreement between the simulation and CloudSat observations.

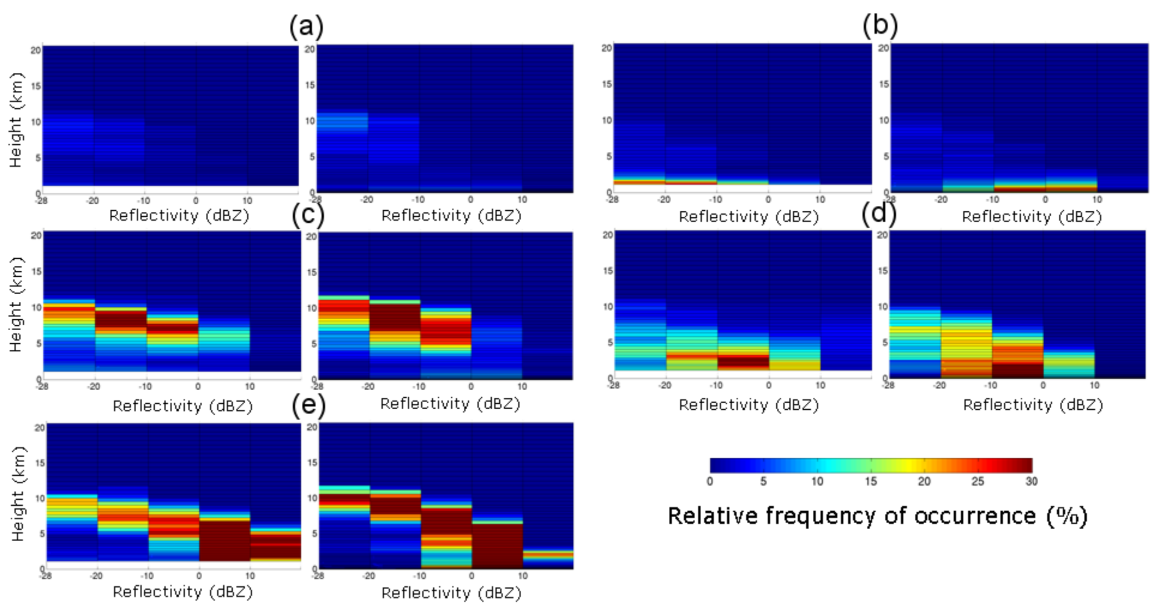


Figure 6.1.3. Observed (left portion of panel pairs) and simulated (right portion of panel pairs) height-dBZ histograms for each of the five cluster centroids (a-e) in order of most common to least common.

Publications and Conference Reports

Otkin, J. A., and T. J. Greenwald, 2008: Comparison of WRF model-simulated and MODIS-derived cloud data. *Mon. Wea. Rev*, **136**, 1957-1970.

Otkin, J. A., T. J. Greenwald, J. Sieglaff, and H.-L. Huang, 2008: Validation of a large-scale simulated brightness temperature dataset using SEVIRI satellite observations, submitted for publication in *J. Atmospheric and Oceanic Tech*.

Otkin, J. A., J. Sieglaff, T. Greenwald, and Y.-K. Lee, 2008: Using satellite observations to validate a large-scale high-resolution proxy dataset. *GOES-R AWG Annual Meeting*, Madison, WI.

Greenwald, T., Y.-K. Lee, J. Sieglaff, J. Otkin, and H.-L. Huang, 2008: Preliminary assessment of simulated proxy data cloud fields using GOES-12 imager data. *GOES-R AWG Annual Meeting*, Madison, WI.

Otkin, J. A., Y.-K. Lee, T. Greenwald, J. Sieglaff, and R. Bennartz, 2008: Using satellite observations to validate a large-scale high-resolution WRF model simulation. *9th Annual WRF User's Workshop*, Boulder, CO.

Otkin, J. A., H.-L. Huang, T. Greenwald, E. R. Olson, and J. Sieglaff, 2008: Large-scale WRF model simulations used for GOES-R research activities. *5th GOES User's Conf*., New Orleans, LA.

Greenwald, T., Y.-K. Lee, J. Otkin, and Justin Sieglaff, 2008: Verification of a cloud resolving NWP model simulation using satellite measurements. *International Radiation Symposium* 2008, Foz do Iguazu, Brazil.

Greenwald, T. J., J. Sieglaff, Y.-K. Lee, H.-L. Huang, J. Otkin, E. Olson, and M. Gunshor, 2008: Verifying large-scale, high-resolution simulations of clouds for GOES-R activities. *5th GOES User's Conf*., New Orleans, LA.

Gunshor, M. M., E. Olson, J. Sieglaff, T. Greenwald, A. Huang, and J. A. Otkin, 2008: GOES-R ABI proxy data set generation at CIMSS. *5th GOES User's Conf*., New Orleans, LA.

6.2. GOES-R Analysis Facility Instrument for Impacts on Requirements (GRAFIIR)

CIMSS Project Lead: Allen Huang
CIMSS Support Scientists: Mat Gunshor, Justin Sieglaff, Jason Otkin, Wayne Feltz, Steve Wanzong, Iliana Genkova, Chris Velden, Tom Greenwald, Erik Olson, Jerry Robaidek, Scott Lindstrom, Jun Li, Xin Jin, Jinlong Li
NOAA Collaborators: Tim Schmit, Mike Pavolonis
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

The GOES-R Analysis Facility for Instrument Impacts on Requirements (GRAFIIR) is a project established to leverage existing capabilities and those under development for both current GOES and its successor in data processing and product evaluation to support the analysis of impacts on meeting user and product requirements on GOES-R ABI. As such, GRAFIIR is often a cross-cutting project, designed to respond to the needs of the GOES-R AWG community and to work with NOAA, the instrument vendor (ITT Industries), and scientists at other institutes such as those at other cooperative institutes and MIT Lincoln Labs. In 2008, GRAFIIR proposed several specific goals: refine GRAFFIR sensor modeling capability, improve GRAFIIR algorithm testing framework, enhance GRAFIIR with even more ABI products, demonstrate enhanced GRAFIIR in 2008 AWG annual meeting, expand GRAFIIR capability to include other sensor effects, continue to provide comprehensive simulated ABI datasets with various sensor effects to AWG application team members for processing algorithm evaluation and testing.

Summary of Accomplishments and Findings

The GRAFIIR facilities continue to improve. Efforts have been made to streamline the processes from the sensor modeling capability (generation of datasets containing sensor instrument effects) to the framework (testing of these datasets on various algorithms). The project continues to leverage the efforts of other GOES-R efforts to provide the processing framework, unaltered ABI proxy data, algorithms, data formats, and other necessary tools. In addition, GRAFIIR is utilizing the Atmosphere Ocean Land Technical Advisory Panel's (AOL TAP) efforts to maintain a working dialogue with the instrument vendor and stay apprised of future developments in possible alterations of instrument specifications.

Band to band co-registration errors were added to the GRAFFIR sensor modeling capability. The ABI vendor had indicated that the co-registration specification (spec) error between 2 km bands might need to be relaxed from 6.3 micro-radians to 8.4 micro-radians. These errors were introduced to CONUS domain ABI proxy data, remapped to a 2-km approximate ABI projection, which are simulated from NWP and sophisticated forward models. Co-registration error data were created for the 04 June 2005 5-minute CONUS proxy data set from 22:00 to 23:00 UTC (13 time steps). Co-registration errors of 6.3, 8.4, 14, 28, and 56 micro-radians were generated for this time period.

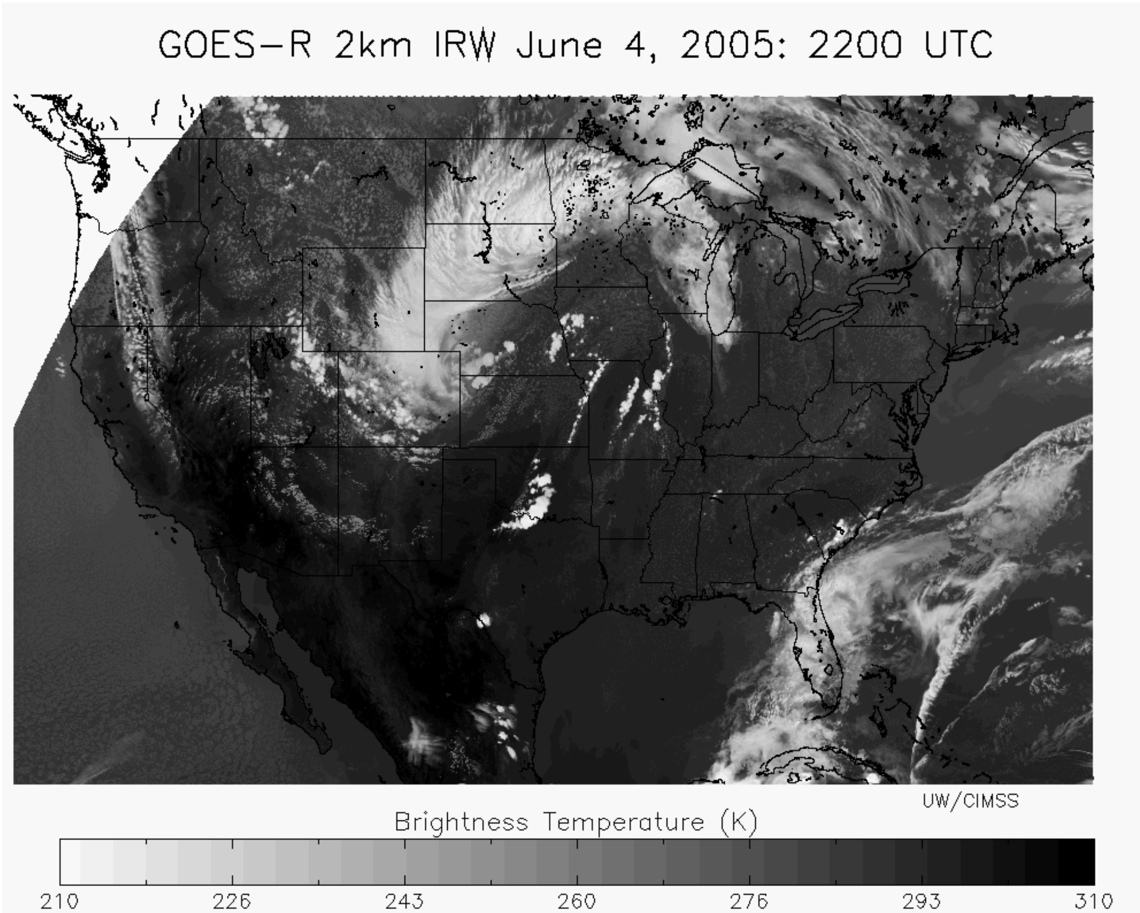


Figure 6.2.1. ABI simulated data for 04 June 2005 22:00 UTC, band 14 IR Window (11.2 micrometer). Data are simulated from high-quality, high resolution 2-km NWP model output which are put through the ABI forward model to simulate radiances and then remapped to an approximate ABI 2 km resolution (based on satellite sub-point of 0 N, 75 W).

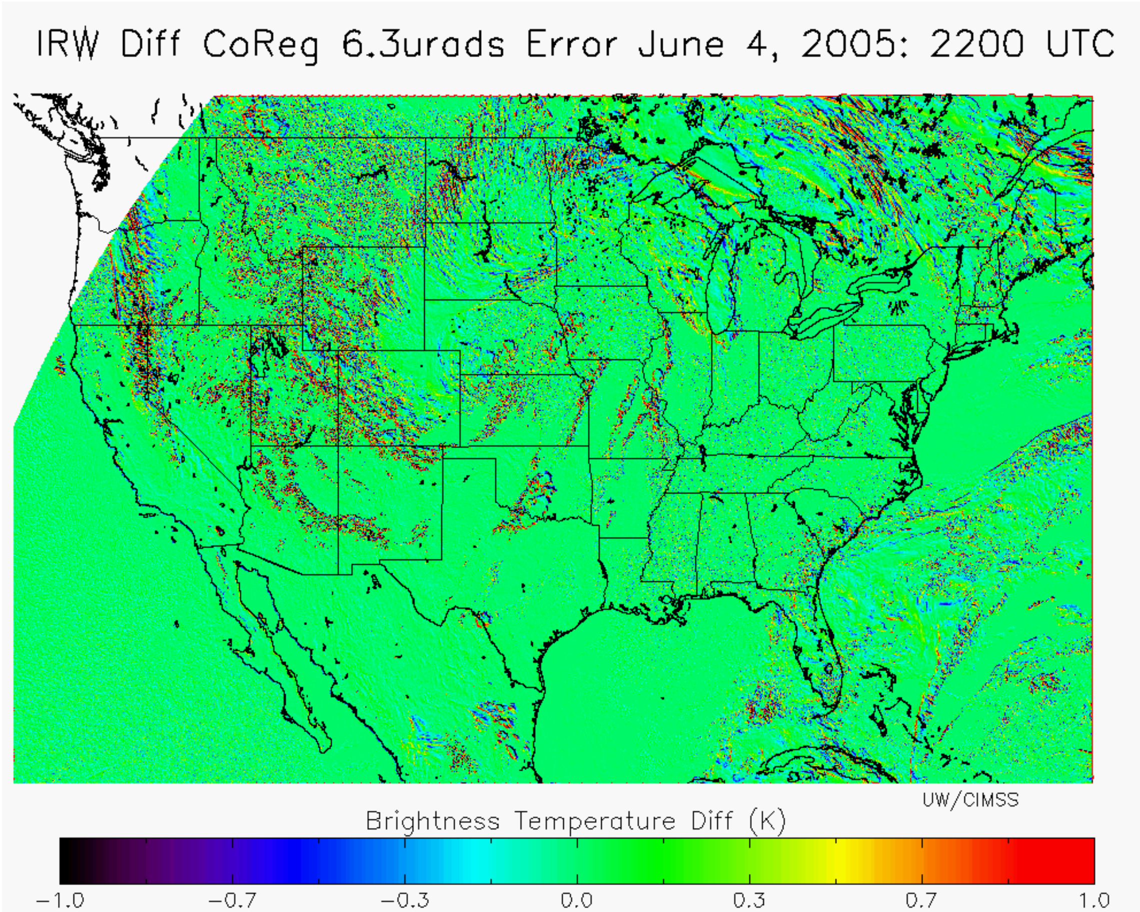


Figure 6.2.2. The difference between unaltered ABI simulated data and the same data with a 6.3 micro-radian shift applied. Data are simulated for 04 June 2005 at 22:00 UTC, band 14 IR Window (11.2 micrometer).

GRAFIIR expanded the product list to include cloud top pressure. The co-registration errors were believed to be most significant between a visible or near-IR band and an IR band. The cloud products are some of the only products that simultaneously use visible/near-IR and IR bands. The co-registration error data were used to test the clear sky mask, cloud phase, and cloud top pressure algorithms. The results of this simulation did not show a large difference between the simulated 6.3 and 8.4 micro-radian channel-to-channel co-registration errors. It was noted that the impact on any algorithm would depend on the algorithm's innate ability to meet its own requirements.

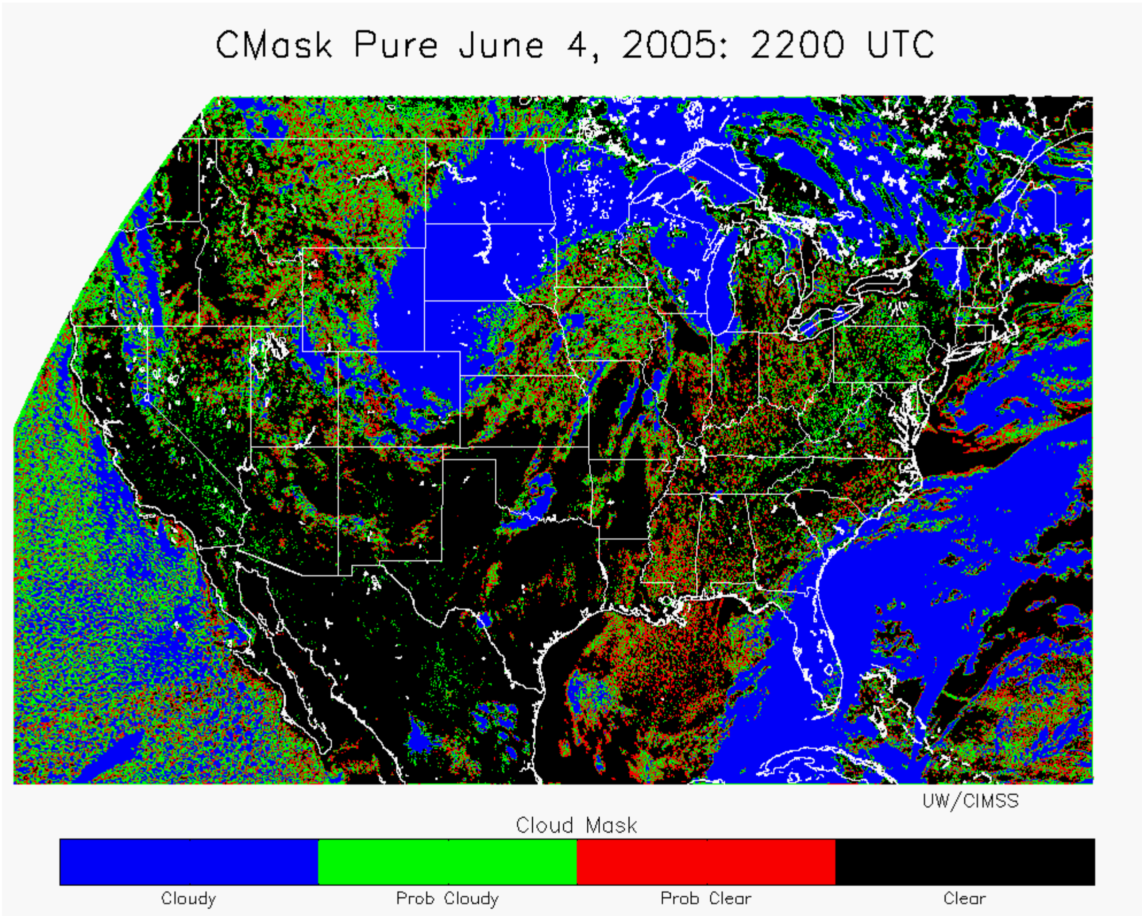


Figure 6.2.3. Clear sky mask (cloud mask) for the unaltered ABI simulated data 04 June 2005 at 22:00 UTC.

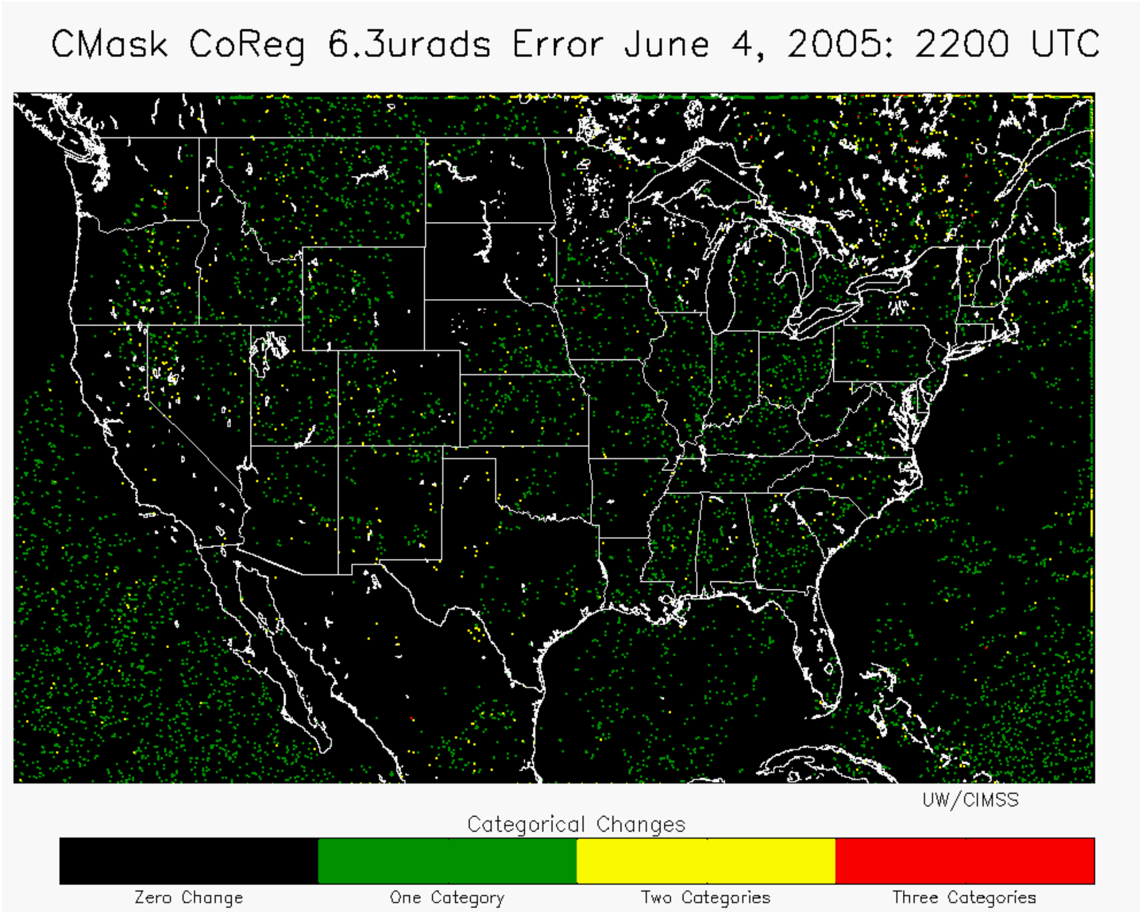


Figure 6.2.4. Cloud mask errors introduced by a 6.3 micro-radian co-registration error introduced to the band 14 (11.2 micrometer) radiances. The algorithm uses ABI bands 2 (0.64), 7 (3.9), 14 (11.2), and 15 (12.3).

Table 6.2.1. Three GOES-R AWG cloud product algorithms were tested on data with various co-registration error amounts. The difference between the algorithm results on unaltered data and those of the co-registration error data are treated as "error" caused by band-to-band co-registration. Cloud Mask (clear sky mask) spec is binary (clear/cloudy) with accuracy of "11% probability of incorrect detection" and it appears relaxing the co-registration spec from 6.3 to 8.4 micro-radians would not severely impact this product. Cloud phase and cloud top pressure errors are for pixels that change at least 1 cloud phase category, but are cloudy (cloudy/prob cloudy) in both pure and error added datasets. Cloud phase specs are 20% classification error in accuracy and cloud top pressure accuracy spec is 100 hPa.

Co-Reg Error		6.3urad	8.4urad	14urad	28urad	56urad
Cloud Mask	"Binary" Error	0.77%	1.03%	1.75%	3.69%	7.39%
Cloud Phase	Error	1.03%	1.27%	1.97%	3.65%	5.62%
Cloud Top Pressure	RMSE (hPa)	57.1 hPa	61.0 hPa	73.5 hPa	94.9 hPa	116.6 hPa

GRAFIIR has adopted GEOCAT as the algorithm processing framework. This framework should be fairly similar in function to the framework that will eventually be adopted by NOAA's AIT. In addition, many of the GOES-R AWG team algorithms are already functioning in GEOCAT. GRAFIIR continues to assist in implementing and testing algorithms in GEOCAT, such as the cloud products.

The GRAFIIR capabilities were presented at the 2008 annual GOES-R AWG meeting (June 2008). This presentation demonstrated GRAFIIR's unique position in being able to utilize the efforts of both AWG and GOES-R Risk Reduction projects. Examples of proxy data with navigation, noise, calibration, and striping effects, and combinations of those effects, were shown. In addition, it was shown how the instrument effects affected products such as cloud mask, cloud phase, winds (atmospheric motion vectors and height assignments), retrievals, and total precipitable water.

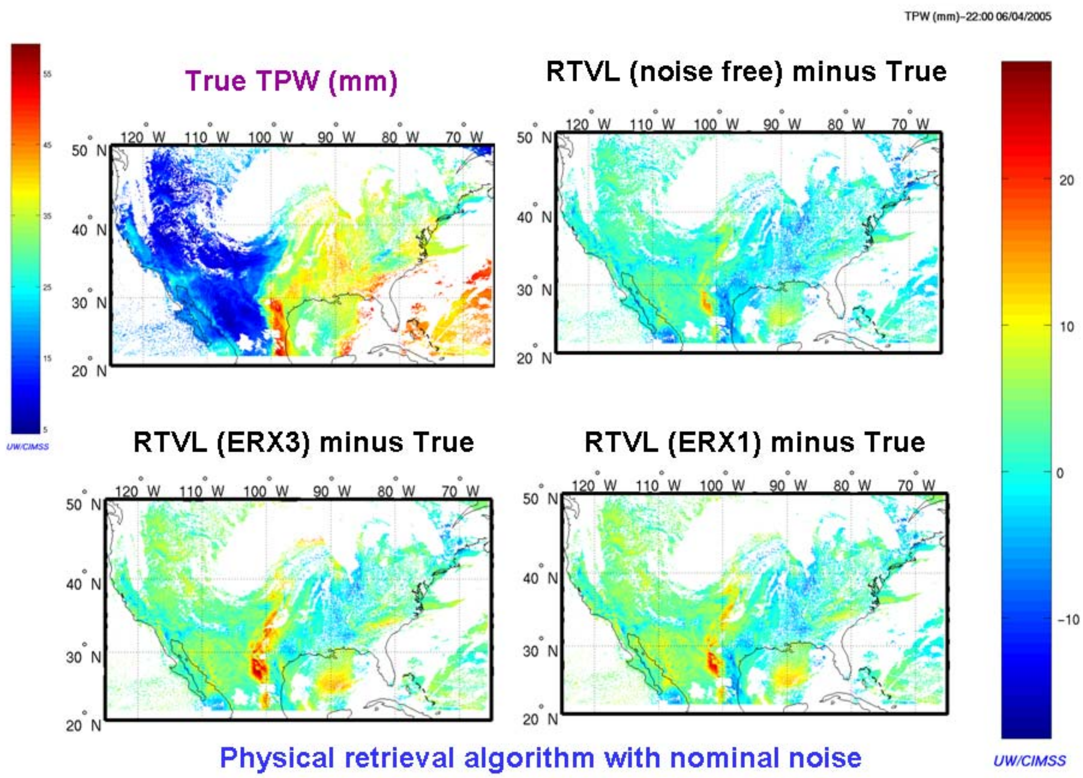


Figure 6.2.5. Example of retrieval (Total Precipitable Water) using ABI proxy data from 04 June 2005 simulation at 22:00 UTC. The results of applying noise to the data are shown.

In summary, GRAFIIR continued expanding capabilities and refining methods through the remainder of fiscal year 2008. This coincided with adding more products to GEOCAT and testing them on AWG proxy data. The winds algorithm is currently being tested on the co-registration error data-sets. The work in connecting GRAFIIR to legacy sounding and other cloud algorithms, and to assist AWG algorithm developers in GEOCAT implementation continue to fulfill the goals proposed.

Publications and Conference reports/presentations
12 August 2008: System Processing Approach in Analyzing the GOES-R Measurements Impacts on the Product Requirements, SPIE 2008 annual meeting: Remote Sensing System Engineering, San Diego, CA.

6.3. AIT Technical Support

CIMSS Project Leads: Ray Garcia, Graeme Martin
CIMSS Support Scientists: Maciek Smuga-Otto, Tom Demke
NOAA Collaborator: Michael Pavolonis
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

1. Develop and support a uniform algorithm testbed, GEOCAT (Geostationary Cloud Algorithm Testbed)
2. Assist in the integration of AWG algorithms into this testbed in support of GOES-R AWG needs
3. Support GEOCAT users with documentation, bug fixes, feature enhancements and design improvements
4. Track and manage inter-algorithm dependencies in support of software integration and documentation
5. Advise the Algorithm Integration Team on framework design and implementation, based on experience of working directly with AWG scientists
6. Support the integration of GEOCAT into larger ensemble testing environments such as GRAFIIR
7. Author any necessary tools to support algorithm testing and verification

Summary of Accomplishments and Findings
AIT Technical Support

1. Assisted AIT with development of coding standards based on NOAA guidelines and industry best practices; worked to clarify delivery requirements
2. Attended AWG technical interchange meetings and worked to resolve dependencies, test datasets and software design constraints, and review framework software design
3. Maintained schedules and tracked delivery milestones for CIMSS algorithm software and documentation
4. Advised algorithm teams located at CIMSS on algorithm development and code deliveries, including standards compliance and theoretical basis document correspondence with software implementation
5. Wrote and distributed to AIT team members a tool to rename variables and routines in Fortran 90 source code to bring it into compliance with AIT coding standards
6. Assisted algorithm groups with use of code checking and re-factoring tools
7. Worked with AIT to standardize the algorithm data interface and utility functions to ensure interoperability of algorithm modules with both GEOCAT and AIT frameworks
8. Developed and demonstrated a zero-overhead structural equivalencing technique to allow GEOCAT to offer an AIT convention compliant algorithm interface alongside the legacy interface to support regression testing and transitional code
9. Wrote and distributed a NetCDF to McIDAS AREA file converter to generate GEOCAT-compatible simulated ABI data files

GEOCAT

1. Released Version 0.6 of GEOCAT software and manual
2. Added ability to process Met-9 SEVIRI data (see Figure 6.3.1)
3. Replaced GVAR navigation routines with operational OGE Earth Locator software
4. Added algorithm-accessible utility routines and output variables
5. Fixed various bugs
6. Internal refactoring: auto-generation of output structure from XML algorithm description
7. User support

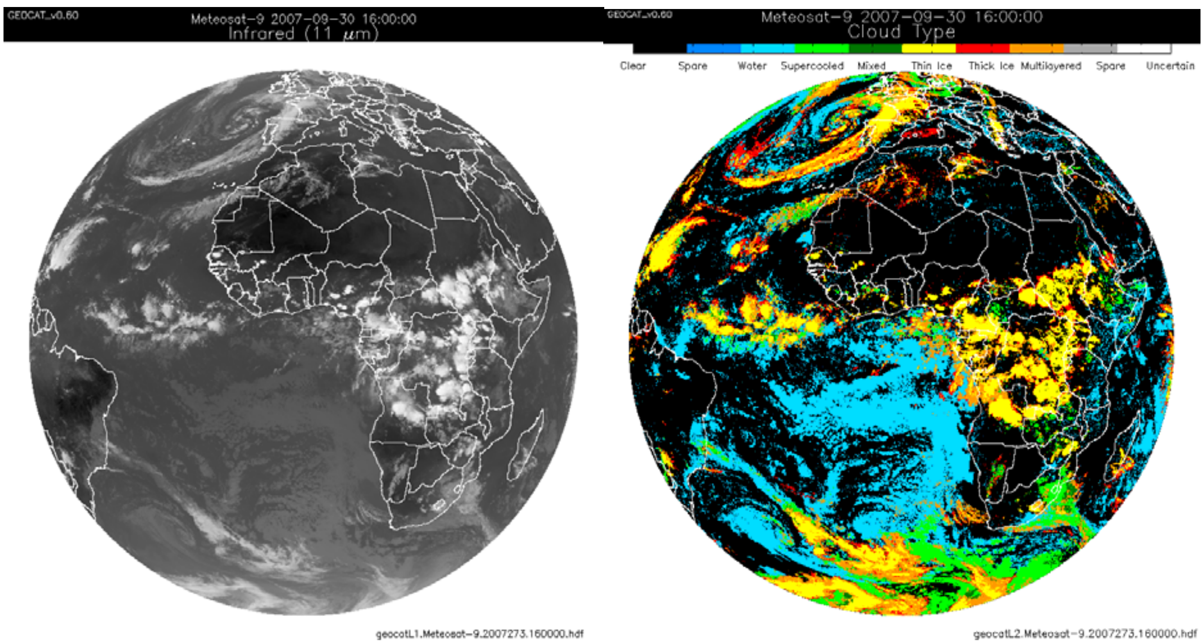


Figure 6.3.1. Example GEOCAT Met-9 SEVIRI output for 30 September 2007. An infrared window image is shown on the left and the AWG Cloud Team cloud-typing product on the right.

6.4. Total Ozone Retrieval from ABI

CIMSS Project Leads: Chris Schmidt, Jun Li
CIMSS Support Scientists: Xin Jin
NOAA Collaborator: Shobha Kondragunta
NOAA Strategic Goals Addressed:

2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

This effort is focused on adapting the legacy regression algorithm used to determine total column ozone (TCO) using GOES Sounder data to GOES-R ABI. CIMSS proposed to build on historical and current expertise with the GOES Sounder TCO algorithm and develop such an algorithm for ABI. In FY08 the task included preparing and delivering the Critical Design Review (CDR), Algorithm Theoretical Basis Document (ATBD), Algorithm Implementation and Test Plan Document, the 80% code delivery, and continued testing with proxy data from Meteosat SEVIRI and, if it became available, model-derived data that did not resort to climatological ozone for its ozone fields.

Summary of Accomplishments and Findings

The CDR for the TCO algorithm was held as part of the Air Quality Team's CDR on 05 June 2008. The first draft of the ATBD was delivered to the Algorithm Integration Team (AIT) and was reviewed and sent forward with minimal changes. Both deliverables contained the results of TCO algorithm development and testing for ABI and have been accepted by the GOES-R AIT. The testing contained in both deliverables focused on using SEVIRI data as a proxy for ABI.

The single best source for ozone ABI proxy data is data from the current SEVIRI instrument due to the similarities in their broadband IR coverage above 4 μm. Both instruments lack coverage of the CO_2 absorption region, coverage that is present on the current GOES Sounder. To make up for this shortfall and to ensure the best performance of the algorithm, temperature profiles from numerical weather prediction (NWP) models are added to the regression alongside the selected channel brightness temperatures. Doing so has resulted in performance with percent root mean square error (%RMSE) on the order of 4% and a bias of less than 1 Dobson Unit. Comparisons are made to the UV-based ozone detection instrument on Aura, the Ozone Monitoring Instrument (OMI). These results were included in the CDR and ATBD delivered this year.

In the remaining three months of the contract period the 80% code delivery of the TCO algorithm will occur to the AIT, along with additional testing on SEVIRI data and comparison with OMI TCO data. Ground-based ozone observations will be utilized as well.

6.5. ABI Cloud Products

CIMSS Project Leads: Tony Schreiner, Andi Walther
CIMSS Support Scientists: Corey Calvert, William Straka
NOAA Collaborators: Andrew Heidinger, Michael Pavolonis
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

The GOES-R Advanced Baseline Imager represents a significant advance in NOAA's geostationary cloud observation capability. In recognition of this, NOAA has funded the Algorithm Working Group (AWG) to develop new algorithms to make use of these improvements for all products. This projects deals with the development, validation and documentation of the cloud algorithms for the GOES-R ABI sensor. Specifically, the CIMSS group is responsible for the following products:

Cloud Detection Mask	Cloud Layer
Cloud Phase	Cloud Optical Depth
Cloud Type	Cloud Particle Size
Cloud Height	Cloud Liquid Water Path
Cloud Pressure	Cloud Ice Water Path
Cloud Temperature	

The CIMSS group works in concert with groups from NASA and academia who are also members of the GOES-R ABI cloud application team. This report specifically covers the work done by the CIMSS support scientists. During this year, the CIMSS component of this project worked on the Daytime Cloud Optical and Microphysical Approach and the Cloud Mask Algorithm.

Summary of Accomplishments and Findings

Cloud detection with GOES-R ABI is critical because other algorithms are mandated to use the results in generating their products. One problem has included detecting low clouds immediately after (before) sunrise (sunset). A potential resolution to this dilemma is proposed by using a temporal difference approach which exploits the advances in temporal resolution offered by the ABI.

Some success in identifying low level (and in some cases high level) clouds has been shown by looking at the hourly rate of change of the difference between the Longwave and Shortwave Infrared Windows for the METEOrological SATellite (METEOSAT) -8 Spinning Environmental Visible and InfraRed Instrument (SEVIRI) data. Derived images based on the difference between the Longwave and Shortwave Windows are generated using IDL (Interactive Data Language). A second derived image is generated based on hourly differences. An example of the Temporal Hourly Differences and how it may be used to identify low clouds is shown in Figures 6.5.1 through 6.5.3 below.

This technique exploits the relative temporal difference in "heating" of the Shortwave Infrared Window and the Long Wave Infrared Window with respect to water clouds, land, and ocean. Based on these relative temporal differences for low clouds just after sunrise or just prior to sunset (i.e. Solar Zenith Angle less than 900, and greater than 700) can be identified.

Further work is, first, needed to determine the proper threshold differences. This includes the min and max difference thresholds between the Longwave and Shortwave bands and the optimal temporal difference (i.e. Δt= 15 min, 30 min, 1 hour, etc) to utilize for this technique. The second goal is to insert this logic into the cloud mask algorithm.

Another major effort undertaken by CIMSS has been the development of the daytime cloud optical and microphysical products from ABI. While these approaches have been in existence for many years, there was no heritage algorithm available to meet the needs of the GOES-R ABI. At CIMSS, we have undertaken a rigorous effort to optimization the use of the ABI observation for estimating cloud optical thickness and particle size. In previous years, we have developed the lookup tables that drive our retrievals based on collaborations with our NASA and academic partners. This year, we have recoded the algorithm to meet the requirements of the GOES-R Algorithm Implementation Team (AIT). In addition, we have tried to optimize the retrieval approach which is based on the optimal estimation methodology. This work dealt with specifying the optimal estimation parameters and covariance matrices to give the best results with a minimum computational effort. Figure 6.5.4 illustrates the retrieval products for SEVIRI observations.

In addition to algorithm development work, much progress was made this year in developing the validation tools required to assess performance. We have developed an ability to collocate SEVIRI and MODIS observations to allow us to compare our results against those from NASA and EUMETSAT. In addition, we have continued to develop CALIPSO validation tools.

Lastly, much effort this year was devoted to supporting the Critical Design Review (CDR) for the GOES-R AWG Cloud Application Team. The CDR presentation included over 700 slides and was conducted at the NASA Goddard Space Flight Center. This year also saw the delivery of the second version of the cloud algorithm and the modification of the codes to meet the naming conventions developed by NOAA.

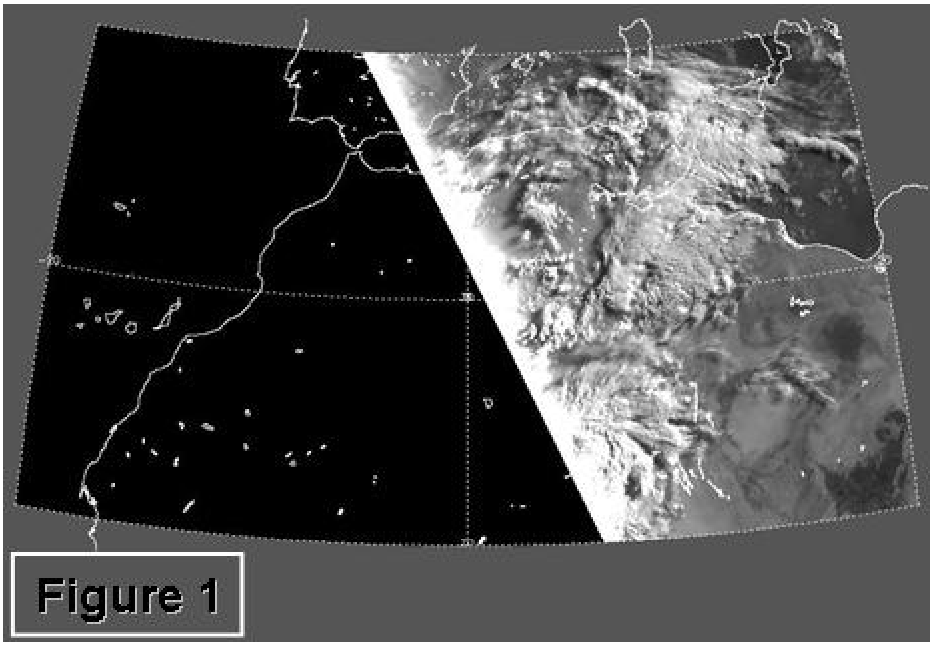


Figure 6.5.1. Visible METEOSAT-8 SEVIRI band for 1 June 2005 at 05UTC. Area displayed is from 20N to 40N and 20W to 20E. Note the terminator cutting through the center of the image.

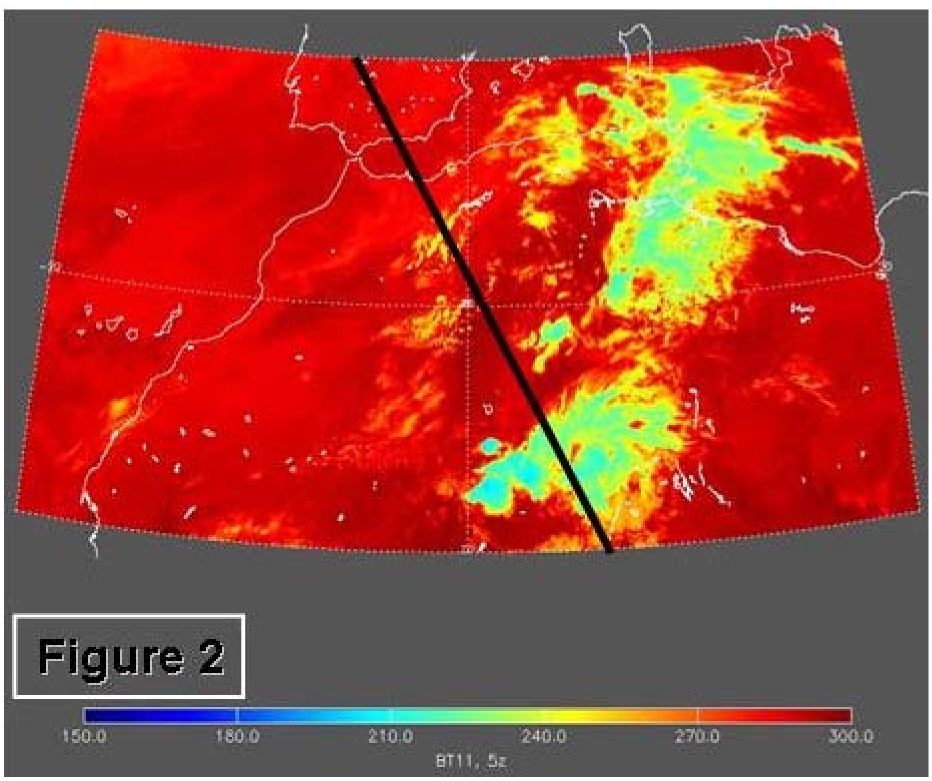


Figure 6.5.2. Same as Figure 6.5.1 except the Long Wave Window (11.0 µm) band is displayed. The black line indicates the location of the terminator.

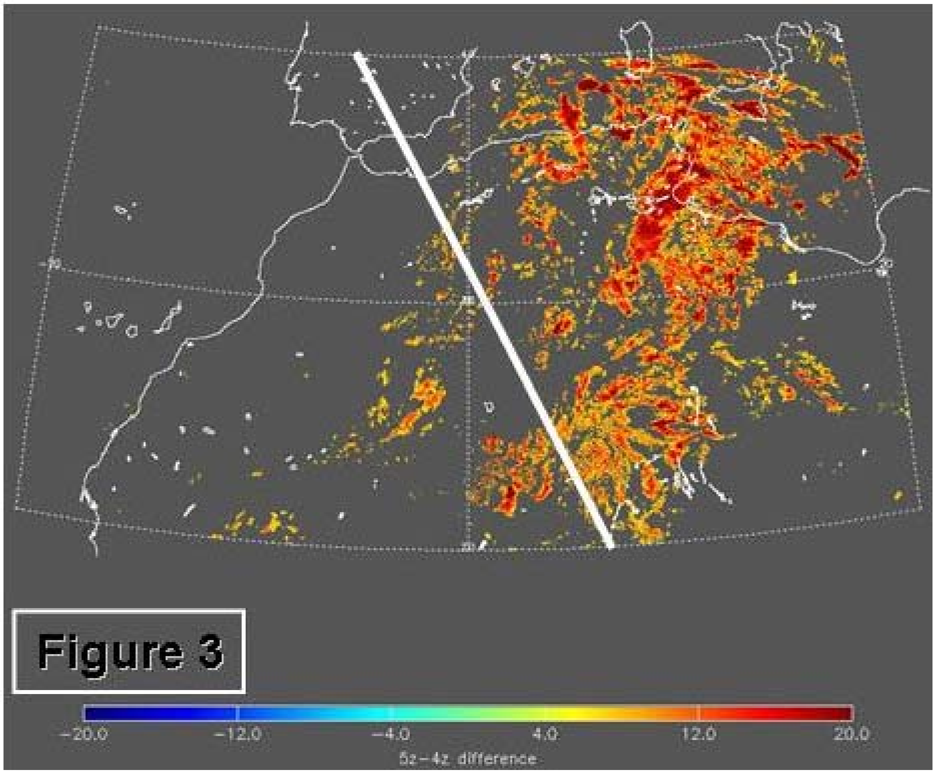


Figure 6.5.3. Same as Figure 6.5.1 except the Short Wave Window (3.9 µm) minus the Long Wave Window temporal difference (05UTC – 04UTC) is displayed. The orange to red regions represent areas where the delta temperature (C) is greater than 60 C. The white line indicates the location of the terminator.

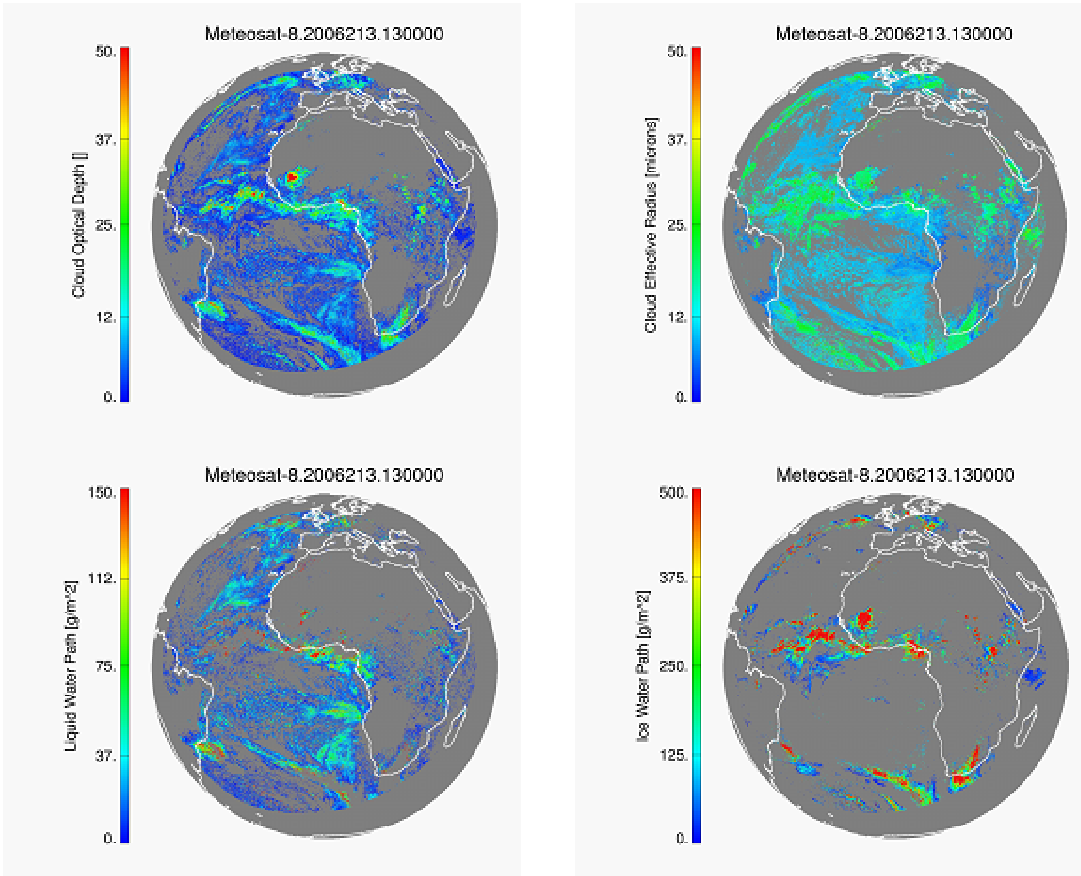


Figure 6.5.4. Example for the daytime cloud optical retrieval for SEVIRI observations of 01 August 2006 12:00 UTC. Upper panel shows optical depth (left) and effective radius (right). Lower panel shows liquid water path (left) and ice water path (right).

Publications and Conference Reports

Walther, Andi and Andrew Heidinger, GEWEX Cloud Climatology Assessment Report, June 2008. New York, New York.

Walther, Andi and Andrew Heidinger Conference proceedings, EUMETSAT Conference 8th-12th September 2008, Darmstadt, Germany.

6.6. GOES-R ABI Fire Detection and Characterization Algorithm Development and Evaluation

CIMSS Project Lead: Chris Schmidt
CIMSS Support Scientists: Jay Hoffman, Jason Brunner, Scott Lindstrom, Elaine Prins
NOAA Collaborator: Yunyue Yu
NOAA Strategic Goals Addressed:

2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work

The primary focus of this effort is to evaluate and adapt the current GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA) to GOES-R ABI. CIMSS proposed to build on historical and current expertise at CIMSS in fire algorithm development for the GOES Imager and the global geostationary fire observation network by revising the WF_ABBA to address GOES-R ABI observational requirements. The updated WF_ABBA also utilizes the improved fire monitoring capabilities on GOES-R and contains updates to the modules that identify and characterize sub-pixel fire activity. In FY08 the task included preparing and delivering the Critical Design Review (CDR), Algorithm Theoretical Basis Document (ATBD), Algorithm Implementation and Test Plan Document, the 80% code delivery, modification of the ABI fire code to address the impacts of sensor characteristics on fire detection/characterization, implementing applicable results from the WF_ABBA GOES-R Risk Reduction effort, and coordinating with the NPOESS VIIRS fire team and the University of Maryland College Park regarding fire code updates/modifications to maintain consistency between current and future geo and polar fire code.

Summary of Accomplishments and Findings

The primary tasks for FY08 were the CDR and ATBD for the GOES-R ABI WF_ABBA. The CDR was held on 8 May 2008 as part of the Land Team's CDR presentation. The first draft of the ATBD was delivered in July. Both deliverables contained the results of WF_ABBA algorithm development and testing for ABI and have been accepted by the GOES-R Algorithm Integration Team (AIT). The testing utilized sets of proxy data created by teams at CIRA and CIMSS and derived in part from work done for GOES-R Risk Reduction. The testing showed that the WF_ABBA is capable of meeting the performance thresholds required for ABI.

CIMSS created proxy data from MODIS imagery by applying a point spread function (PSF) to the MODIS data while simultaneously remapping the data to the ABI projection. This method provided a way to compare performance of the WF_ABBA against the MODIS fire detection algorithm. Figure 6.6.1 illustrates one such case from 24 April 2004 at 18:45 UTC over Central America. The top image is the simulated ABI image. The middle image shows the detected fires as well as applicable block-out zones, which are based on surface types (green) and solar reflectance (dark gray). The bottom image shows the WF_ABBA fires again, plotted slightly larger, and the MODIS detected fires for the same image. The correlation between the two is very high.

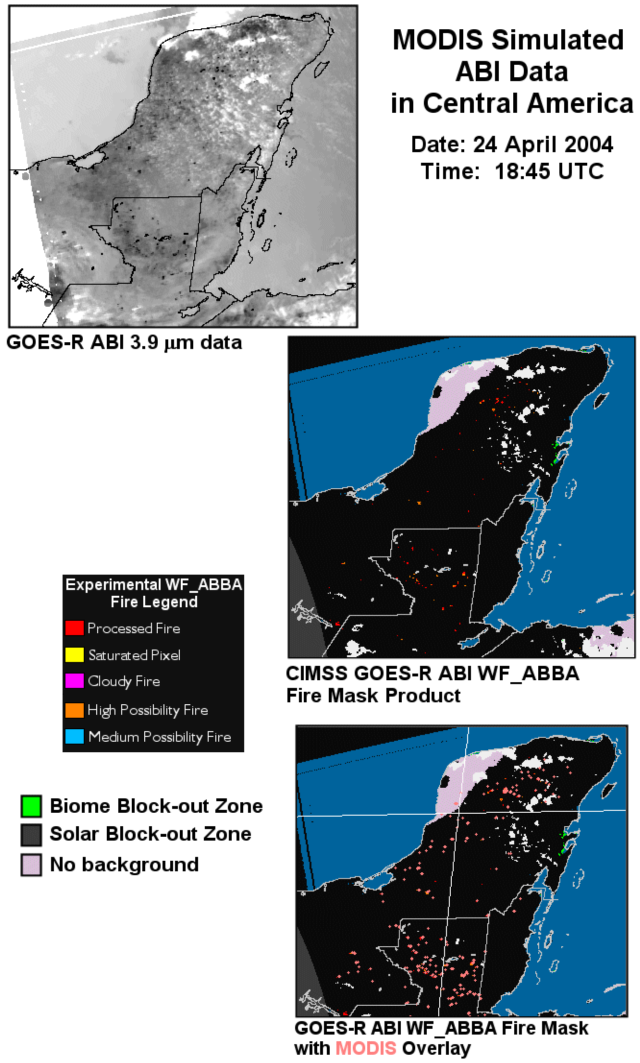


Figure 6.6.1. ABI proxy data created from MODIS data over Central America for 24 April 2004 at 18:45 UTC. The top image is the simulated ABI image. The image below that shows the detected fires as well as applicable block-out zones, which are based on surface types (green) and solar reflectance (dark gray).

Figure 6.6.2 contains an analysis of WF_ABBA fire characterization using a model-created dataset provided by CIRA. The model covered a region of Central America on 23 April 2004 from 15:00 UTC to 20:55 UTC at 5 minute steps. The CIRA mesoscale model produced the surface and atmospheric properties while actual GOES-12 WF_ABBA output was used to provide the fire sizes and temperatures. The fires varied in time as defined by the WF_ABBA data. The simulation included clouds. In this case 94% of the fire clusters present were detected. Of the fire pixels that were emitting 75 MW or more of fire radiated power (FRP) 82% were detected. The false alarm rate was less than 1%. Due to the nature of the simulation containing an application of the PSF the "truth" value of fire area is difficult to determine. The original grid cells in the simulation are combined with the PSF when the ABI image is created, creating situations where the fire area is split between multiple pixels. The plot in Figure 6.6.2 used WF_ABBA derived FRP divided by the Stephan-Boltzmann constant and the known temperature of the given fire cluster or pixel to the fourth power, per the definition of FRP. The size axis was then plotted as a log scale. Lines of constant FRP are shown in gray and labeled. This approach led to the generally orderly separation of fires into ranks that are roughly defined by FRP. Below approximately 75 MW the WF_ABBA found no fires at all, and only a small number of its misses, corresponding to cooler, smaller fires, are above the 75 MW line. The notable exceptions are fires not detected due to block-out zones, which consist primarily of the region impacted by solar reflectance. Saturated fires are all above an FRP of 1,100 MW. The smallest fires below 500 K were most often undetected, which is consistent with previous studies of WF_ABBA performance.

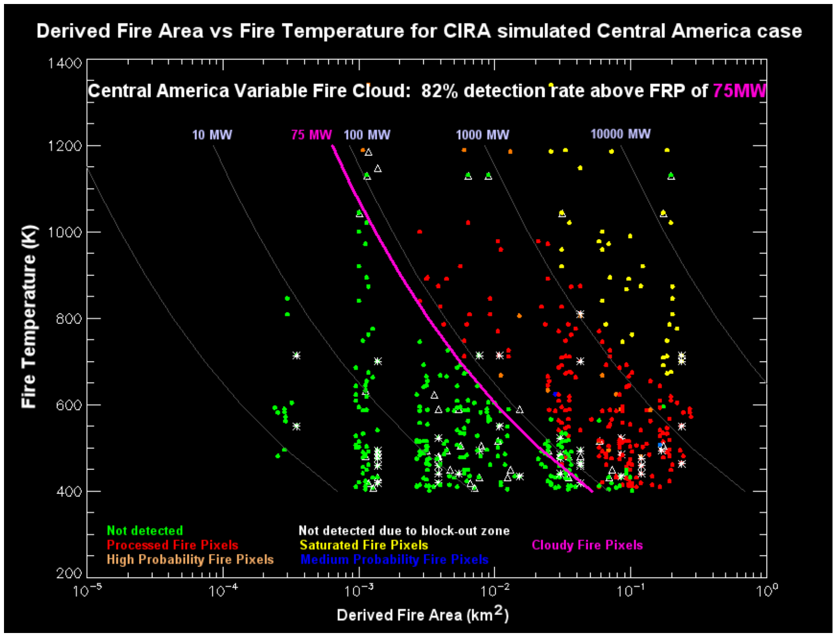


Figure 6.6.2. Analysis of WF_ABBA fire characterization using a model-created dataset provided by CIRA covering Central America on 23 April 2004 from 15:00 UTC to 20:55 UTC at 5 minute steps. Fires were simulated using GOES-12 WF_ABBA fire characterization data as the source. Fire temperature is plotted on the Y-axis and is known. Fire size is estimated from the definition of FRP and the fire temperature. Lines of constant FRP are in light gray. The fires generally fall into three ranks, undetected fires below 75 MW, detected and characterized fires between 75 MW and ~1100 MW, and saturated fires above 1100 MW. Some cooler and smaller fires emitting more than 75 MW are missed by the ABI WF_ABBA, which is consistent with previous studies. The final image shows the WF_ABBA fires again, plotted slightly larger, and the MODIS detected fires for the same image.

The ABI version of the WF_ABBA is currently in McIDAS-X and is being ported to the GEOCAT framework. Delivery of this code to the AIT along with test datasets and related documentation is scheduled for December 2008. This represents a schedule change, due largely to the time needed to complete the transition of the ABI WF_ABBA to the GEOCAT framework, which is compatible with the AIT framework. The McIDAS-X version of the WF_ABBA achieved the performance threshold for this delivery, and the GEOCAT version will perform similarly.

At the request of the AOL TAP and GOES-R Ground System Program Office CIMSS reviewed the ABI fires requirements and after extended discussions it was decided to list the fire requirements in terms of the 3.9 µm brightness temperature created by making a forward calculation using WF_ABBA derived fire characteristics. It was determined that this formulation allows all three fire characteristics (size, temperature, and FRP) to be provided. During development CIMSS has used thresholds based on recommended values from NPOESS/VIIRS as adapted for the ABI sensor, thresholds that result in a higher quality output without degrading algorithm performance or increasing latency.

Publications and Conference Reports

Schmidt, Christopher C., Elaine M. Prins, Jay P. Hoffman, Scott S. Lindstrom, Jason C. Brunner, 2008: GOES-R ABI Fire Detection and Monitoring Development Activities, 5th GOES User's Conference and 88th America Meteorological Society (AMS) Annual Meeting, New Orleans, LA, 20 - 24 January 2008.

6.7. GOES-R Legacy Profile and Surface Infrared Emissivity Algorithm Development

CIMSS Project Lead: Jun Li
CIMSS Support Scientists: Xin Jin, Elisabeth Weisz, Chian-Yi Liu, Jinlong Li
NOAA Collaborators: Tim Schmit, Chris Barnet
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

The main focus of this project is to develop and evaluate the operational legacy profile algorithm for GOES-R Advanced Baseline Imager (ABI) (Schmit et al. 2005) data processing. The proposed work in 2008 includes:

1. Jun Li to work with Timothy J. Schmit and Christopher Barnet for GOES-R sounding algorithm critical design review;
2. Develop Algorithm Theoretical Basis Documents (ATBD) version 1.0;
3. Develop and improve Version 2.0 of ABI legacy profile retrieval algorithm;
4. Continue to collaborate with GOES-R AWG cloud team (Dr. Heidinger) on applying updated cloud mask algorithm;
5. Demonstrate Version 2.0 algorithm legacy product and characterize errors using simulated full disk ABI proxy data provided by proxy team;
6. Evaluate Version 2.0 of ABI retrieval algorithms with SEVIRI (collaborate with EUMETSAT nowcasting Satellite Application Facility)
7. Make available the version 2.0 prototype science codes and documents to STAR (Center for Satellite Applications and Research) for implementation in the STAR collaborative environment;
8. Assist in the demonstration and interpretation of version 2.0 performance with ABI proxy datasets;
9. Develop algorithm for IR surface emissivity product, using SEVIRI to test the algorithm;
10. Incorporate progress from other GOES-R sounding team members into legacy profile algorithm.

Summary of Accomplishments and Findings

1. AWG sounding algorithm critical design review (CDR) was held in June 2008. Co-chair Tim Schmit, sounding algorithm team (SAT) member Jun Li and Algorithm Integration Team (AIT) leader Walter Wolf presented the CDR. CIMSS sounding team members helped prepare the CDR material.
2. Draft version of Algorithm Theoretical Basis Documents (ATBD) for GOES-R ABI legacy sounding products was developed and delivered to GOES-R Program Office (GPO).
3. Version 2.0 (physical retrieval) algorithm has been developed.
4. Collaborated with AWG cloud team on the application of cloud mask.

5. Version 2.0 algorithm was evaluated with simulated ABI radiances from high resolution WRF output, ABI simulated radiances are from AWG proxy team.
6. Version 2.0 algorithm was evaluated with collocated SEVIRI radiance measurements, ECMWF forecast, and radiosonde observations for August 2006.
7. Version 2.0 prototype science codes and documents were provided to AIT; AIT determined it met 80% of standards. It is being implemented in the STAR collaborative environment.
8. CIMSS sounding team assisted in the demonstration and interpretation of version 2.0 performance with ABI proxy datasets
9. Surface IR emissivity algorithm is being developed for IR surface emissivity product, SEVIRI data were used for testing the algorithm;

The GOES-R legacy sounding algorithm version 2.0 has been provided to the Algorithm Integration Team (AIT) for testing and implementation. Version 2.0 for both ABI (V2.0A) proxy data and SEVIRI (V2.0S) radiance measurements were provided. The impact of radiative transfer model (RTM) on the GOES-R legacy sounding product has been studied. Two RTMs (PFAAST and RTTOV9.1) were used in SEVIRI retrieval experiment. Figure 6.7.1 shows the relative humidity (RH) RMSE from 465 comparisons between SEVIRI retrievals and radiosondes for August 2006. It can be seen that regression retrievals are similar using RTTTOV9.1 (solid blue line) and PFAAST (solid red line), indicating that the brightness temperature (BT) calculations are similar between RTTOV9.1 and PFAAST. Both regression retrievals are better than the ECMWF forecast (solid black line). However, the physical retrieval with RTTOV9.1 (dash blue line) is significantly better than that with PFAAST (dash red line) due to a better Jacobian in RTTOV. Both retrievals are better than regression and forecast. The RMSE is based on the absolute differences between retrievals and radiosondes. The best RTM with accompanying Jacobian should be used in the ABI legacy sounding product generation.

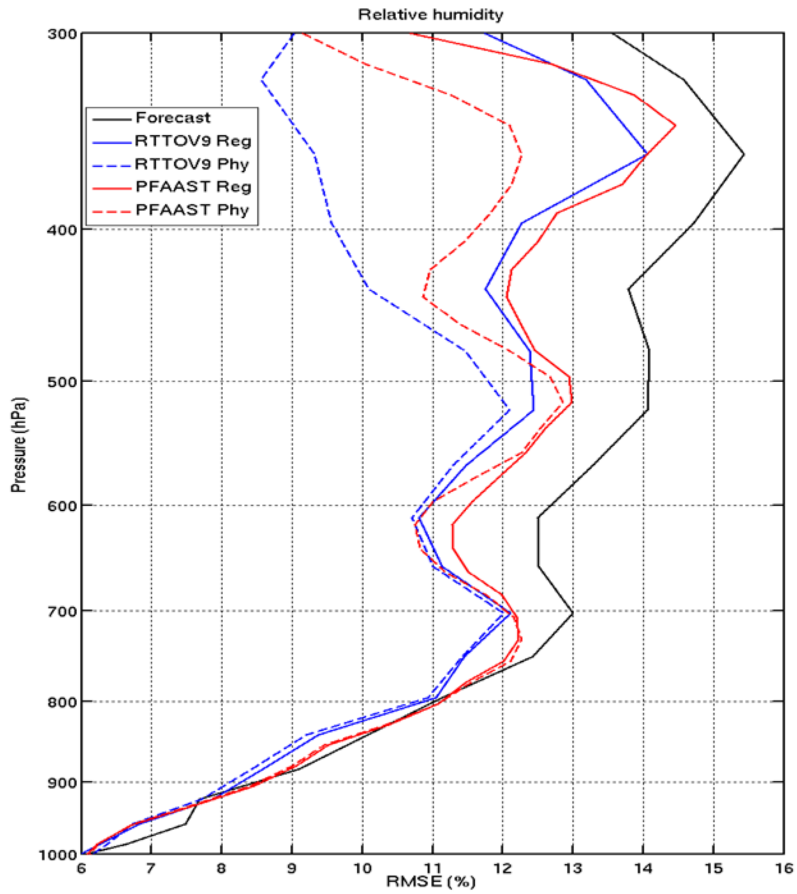


Figure 6.7.1. RH RMSE from 465 comparisons between SEVIRI retrievals and radiosondes for August 2006.

In addition, the impact of forecast models on the ABI legacy sounding product has also been studied. ABI radiance proxy (provided by AWG proxy team) calculated from high resolution Weather Research and Forecasting (WRF) model output, the regional forecast from the North American Mesoscale (NAM) and the global forecast from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used as backgrounds, respectively, in the ABI legacy sounding retrieval experiment. Results indicate that the regional model provides a better background for the legacy sounding product (Jin et al. 2008b).

Progress has been made on ABI surface infrared (IR) emissivity algorithm development. The surface IR emissivity algorithm is based on the assumption that the surface IR emissivity is temporally invariable while the surface skin temperature is temporally variable within 3 hour time period. By using ABI IR radiances from multiple time steps, surface skin temperatures and surface IR emissivity can be derived. Our study shows that IR radiances from two time steps that have large surface skin temperature contrast are good for the surface properties retrieval. The temperature and moisture profiles from the short range forecast model are used for atmospheric correction in the ABI surface property retrieval. The algorithm has been successfully tested with Spinning Enhanced Visible and Infrared Imager (SEVIRI) radiance measurements. Figure 6.7.2 shows the surface IR emissivity images at 8.7 µm band from single time step (left panel) and TC method (right panel), respectively, at 00 UTC on 01 August 2006. The TC method improves the single time step approach, the animation (see the link below) shows that single time step derived surface IR emissivities have false diurnal variation while the TC derived surface emissivities have more constant evolution.

ftp://ftp.ssec.wisc.edu/ABS/PPT_2008/Surface_Emissivity_for_ABI_June2008.ppt

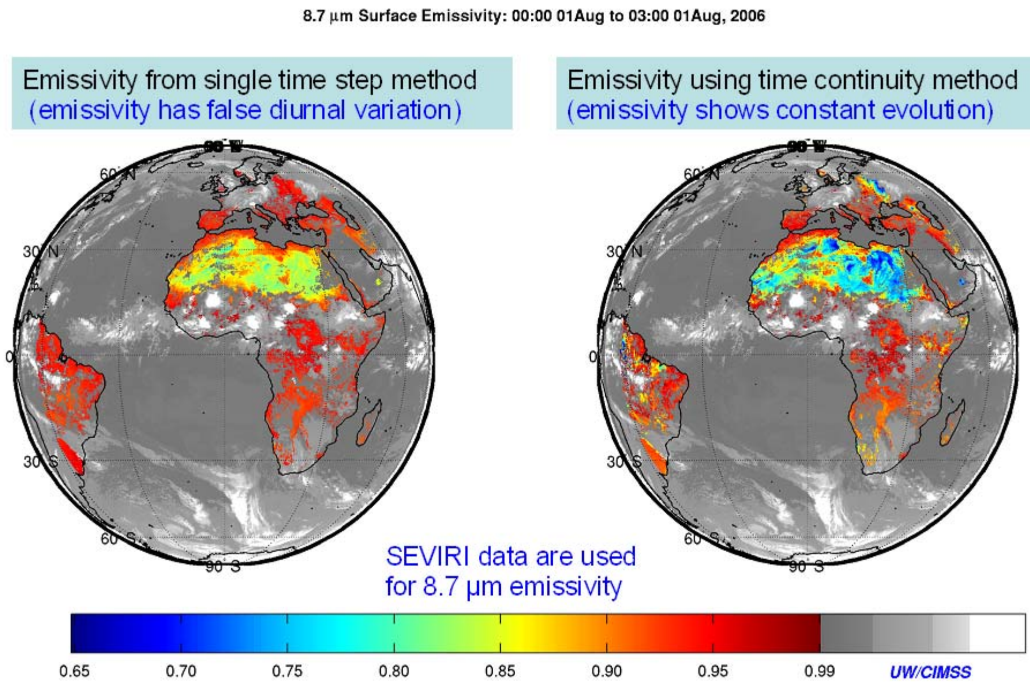


Figure 6.7.2. The surface IR emissivity images at SEVIRI 8.7 μm band from single time step (left panel) and TC method (right panel), respectively, at 00 UTC on 01 August 2006.

Publications and presentations

Jin, X., J. Li, T. J. Schmit, J. Li, M. D. Goldberg, and J. J. Gurka, 2008a: Retrieving clear-sky atmospheric parameters from SEVIRI and ABI infrared radiances, J. Geophys. Res., 113, D15310, doi:10.1029/2008JD010040.

Li, J. et al. 2008: Surface emissivity retrieval from high temporal resolution geostationary imager infrared radiances, presented at International Society for Optical Engineering (SPIE)'s annual meeting held August 10-14, 2008 in San Diego.

Jin, X., et al. 2008b: GOES-R/ABI legacy profile algorithm evaluation using MSG SEVIRI and AMSR-E, presented at International Society for Optical Engineering (SPIE)'s annual meeting held 10 - 14 August 2008 in San Diego.

Schmit, T. J.**,** J. Li, J. J. Gurka, M. D. Goldberg, K. Schrab, Jinlong Li, and W. Feltz, 2008: The GOES-R ABI (Advanced Baseline Imager) and the continuation of GOES-N class sounder products, *J. of Appl. Meteorol. and Climatology*. (in press)

6.8. AWG Winds

CIMSS Project Leads: Chris Velden, Steve Wanzong, Tim Olander
CIMSS Support Scientists: Howard Berger, Iliana Genkova
NOAA Collaborator: Jaime Daniels (STAR)
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Atmospheric Motion Vectors (AMVs)

Proposed Work

The development and automated processing of wind vectors from satellites has its heritage at CIMSS. The work plan research objectives 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 test, process and validate using simulated and proxy data sets provided by other members of the GOES-R AWG project. This work ensures the readiness of the CIMSS/NESDIS automated winds algorithm for eventual operational implementation upon the deployment of GOES-R ABI.

In 2008, we planned to put most of our efforts into the GEOCAT framework for producing AMV datasets. At CIMSS, most of the development and testing employed simulated GOES-R ABI imagery for the CONUS domain. This is a 2km ABI simulation, with some time steps as small as 5 minutes. We also ported the "Expected Error" (EE) algorithm into the GEOCAT framework.

Summary of Accomplishments and Findings

During this reporting year, the development of the winds retrieval algorithm for GOES-R ABI targeted the following goals:

1) Install and run the GEOCAT AMV software locally at CIMSS.
2) Modify the GEOCAT AMV software to include the EE algorithm.
3) Assist the GOES-R AWG Winds team lead in preparing the Algorithm Theoretical Basis Document (ATBD).

GOES-R AMV software development and testing is being done within a common processing framework that supports a tiered algorithm processing approach that allows the output of lower-level algorithms to be available to subsequent higher-order algorithms while supplying needed data inputs to all algorithms through established data structures. NOAA employees based at CIMSS have developed the current framework, GEOCAT, that allows user algorithms to be plugged into its framework. The framework performs input data handling of calibrated/navigated radiances and ancillary data. These data are then loaded into established data structures that can be accessed by all algorithms. Other established data structures enable the output of the lower-level algorithms to be accessible by higher-level algorithms. While we are leveraging and building upon existing target selection/quality control/feature tracking that is used operationally on GOES data at NESDIS today, there are some important differences. For example, the target selection and height assignment will rely on utilization of pixel level cloud mask and cloud height products generated upstream via algorithms delivered by AWG cloud application team. Therefore, simulated ABI data experiments are necessary to test the software adaptability.

The proxy ABI imagery begins as a high resolution Weather Research and Forecasting (WRF) model simulation. The CONUS simulation was performed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign by the GOES-R AWG proxy data team. Simulated atmospheric fields were generated using version 2.2 of the WRF model (ARW core). The simulation was initialized at 00 UTC on 04 June 2005 with 1° GFS data and then run for 30 hours using a triple-nested domain configuration. The outermost domain covers the entire GOES-R viewing area with a 6-km horizontal resolution while the inner domains cover the CONUS and mesoscale regions with 2-km and 0.667-km horizontal resolution, respectively.

WRF model output, including the surface skin temperature, atmospheric temperature, water vapor mixing ratio, and the mixing ratio and effective particle diameters for each hydrometeor species, were ingested into the Successive Order of Interaction (SOI) forward radiative transfer model in order to generate simulated top of atmosphere (TOA) radiances. From these TOA data, imagery is derived and used to track features. The targeting and tracking software was developed outside of CIMSS, but within the GOES-R AWG Winds team. It has been successfully installed and tested on local CIMSS hardware. The EE software was translated into the targeting/tracking software module. At this time, the generation of the regression coefficients is not part of the framework, so static coefficients have been used within GEOCAT. As most of the AMV datasets have used simulated ABI proxy data, the EE is a proof of concept variable at this time. An example IRW AMV dataset from the above simulation is shown in Figure 6.8.1.

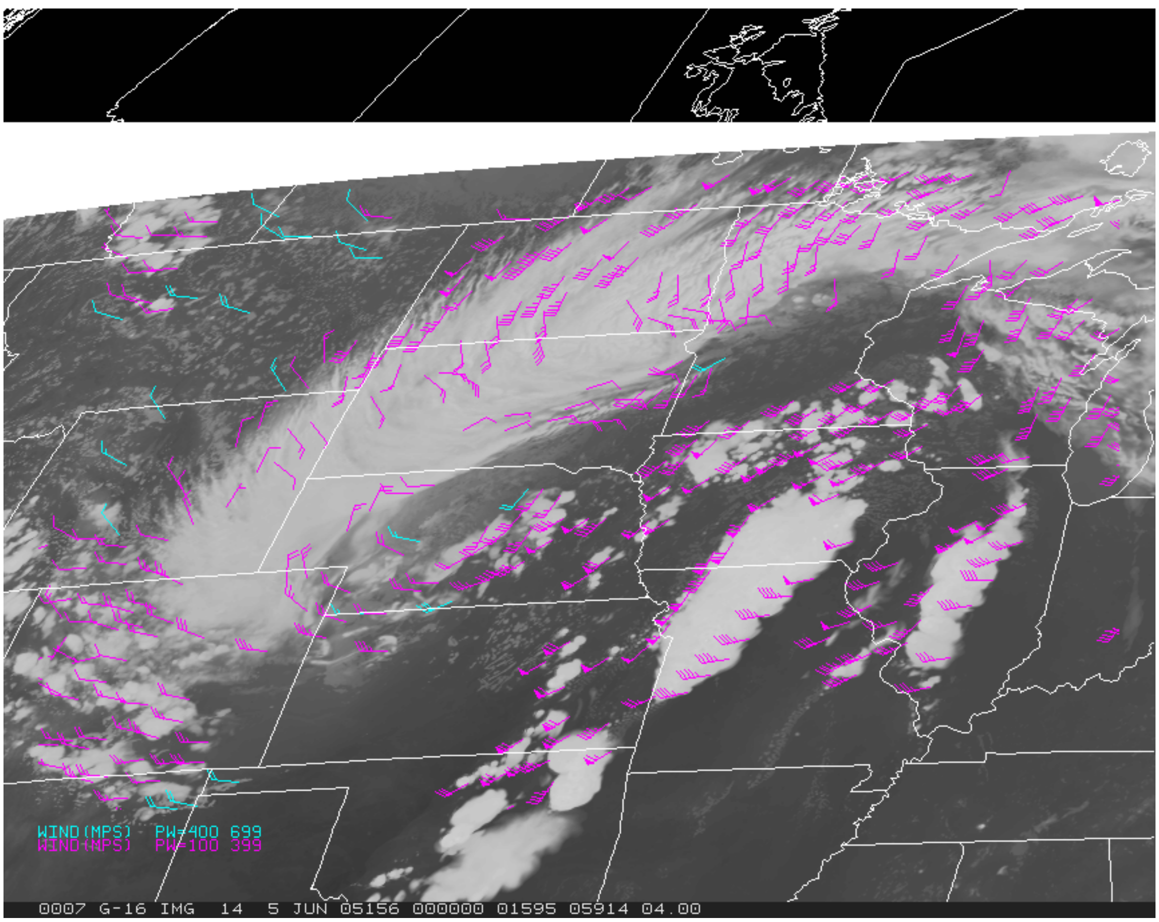


Figure 6.8.1. AMVs derived within GEOCAT framework, from a WRF-simulated set of proxy ABI 11-micron images.

Finally, the CIMSS GOES-R AWG Winds team members actively participated in development of the first draft version of the Algorithm Theoretical Basis Document (ATBD) that was delivered to the GOES-R AIT team for review.

Hurricane Intensity from ABI

Proposed Work

The development and automated processing of objective, operational tropical cyclone intensity estimates from the Advanced Dvorak Technique (ADT) has its heritage at CIMSS. The proposed work plan goals are to adapt and implement the ADT to perform with GOES-R ABI data. The ABI will provide the traditional IR spectral channels that the CIMSS team will test, process and validate the ADT using simulated and proxy data sets provided by other members of the GOES-R AWG project.

Summary of Accomplishments and Findings

Activities during 2008 focused on completing the initial validation study begun in 2007, and on preparation of the ADT code for the GOES-R AWG framework as defined by AIT programmers. The validation study included the use of simulated GOES-Advanced Baseline Imager (ABI) data provided by CIRA. The simulated data set consisted of all available high-resolution MODIS infrared imagery for selected North Atlantic tropical cyclones (TC). From these images, TC intensity estimates were derived using the CIMSS Advanced Dvorak Technique (ADT). The ADT intensity estimates from the simulated GOES-ABI data were compared to ADT intensity estimates using coincident GOES infrared imagery as well as intensity estimates obtained from several operational TC forecast centers (OpCen). Statistical analysis of the ADT (for each GOES data set) and OpCen performance were compared to in situ aircraft reconnaissance measurements of mean sea level pressure (MSLP) to assess the impact of simulated GOES-ABI imagery over current GOES imagery. The preliminary analysis reported on in 2007 showed some inferiority of the ABI results when compared with real GOES data. Some tuning of the ADT scene type and intensity determination schemes was necessary to account for the improved ABI spatial resolution and resulting scene type samples (i.e. more eye scenes), which we suspected was causing much of the differences in the results. Final examination of the suspect cases after the tuning yielded satisfactory results.

The primary task accomplished in 2008 was the removal of the ADT from the Man computer Interactive Data Analysis System (McIDAS-X). McIDAS-X is a visualization tool developed at the University of Wisconsin-Madison/Space Science and Engineering Center (SSEC) to allow for display and interrogation of a variety of satellite imagery. AWG coding standards require that all McIDAS-specific interaction and code be removed from the ADT library so the code could be considered a “stand-alone” application within the AWG framework. This task was completed and provided to AIT programmers.

The current area of focus is concentrating on bringing the ADT code up to AWG standards, as defined by AIT programmers. This is a significant undertaking for the ADT algorithm since it consists of about 22,000 lines of C code.

Publications and Conference reports

Daniels, Jaime M.; Bresky, W.; Velden, C.; Genkova, I.; Wanzong, S. and Santek, D.: Algorithm and software development of atmospheric motion vector products for the GOES-R ABI. 5th GOES Users' Conference, New Orleans, LA, 20 - 24 January 2008. American Meteorological Society, Boston, MA, 2008.

Daniels, Jaime; Velden, C.; Bresky, W.; Genkova, I and Wanzong, S.: Algorithm and software development of atmospheric motion vector (AMV) products for the future GOES-R advance baseline imager (ABI). 9th International Wind Workshop, Annapolis, MD, 14 - 18 April 2008.

Daniels, Jaime; Bresky, W.; Velden, C.; Genkova, I; Berger, H. and Wanzong, S.: Algorithm and software development of atmospheric motion vector products for the GOES-R ABI. 2008 GOES-R Algorithm Working Group Annual Meeting, Madison, WI, 23 - 26 June 2008.

Genkova, Iliana; Wanzong, S.; Velden, C. S.; Santek, D. A.; Li, J.; Olson, E. R. and Otkin, J. A.: GOES-R wind retrieval algorithm development. 5th GOES Users' Conference, New Orleans, LA, 20 - 24 January 2008. American Meteorological Society, Boston, MA, 2008.

Wanzong, Steve; Genkova, I.; Velden, C. and Santek D.: AMV research using simulated datasets. 9th International Wind Workshop, Annapolis, MD, 14 - 18 April 2008.

6.9. Aviation Weather

6.9.1. AWG Aviation Weather – Volcanic Ash/SO_2

CIMSS Project Lead: Justin Sieglaff
CIMSS Support Scientist: Andrew Parker
NOAA Collaborator: Michael Pavolonis
NOAA Strategic Goals Addressed:

4. Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

Proposed Work

This year we proposed to refine all of our Advanced Baseline Imager (ABI) volcanic ash and SO_2 algorithms. More specifically, one goal was to refine our baseline infrared-based approach for detecting volcanic ash and to express the results as a probability. This information is important since it is supplied to an ash cloud height and mass loading retrieval scheme. Another goal was to upgrade our SO_2 detection algorithm such that it is sensitive to SO_2 contaminated ice clouds, which tend to be more common than pure SO_2 clouds with loadings large enough to be detected by the ABI. In addition, through validation, all approaches were to be refined over time and the algorithm code written to the appropriate standards. A first draft of the algorithm theoretical basis documents was also to be written. This project will insure the readiness of the volcanic ash and SO_2 algorithms for operational implementation upon the deployment of GOES-R.

Summary of Accomplishments and Findings

Potential volcanic ash pixels are identified using a tri-spectral (8.5, 11, and 12 μm) cloud optical depth based approach. The cloud optical depth based approach improves upon traditional brightness temperature difference methods by 10% or more (in terms of skill score). This general approach was modified such that the result of the ash detection algorithm is expressed as a probability as opposed to a binary yes/no. In order to accomplish this, look-up tables, based on measured radiances from the Spinning Enhanced Visible and Infrared Imager (SEVIRI), were created. An example of these probabilistic results is shown in Figure 6.9.1.1.

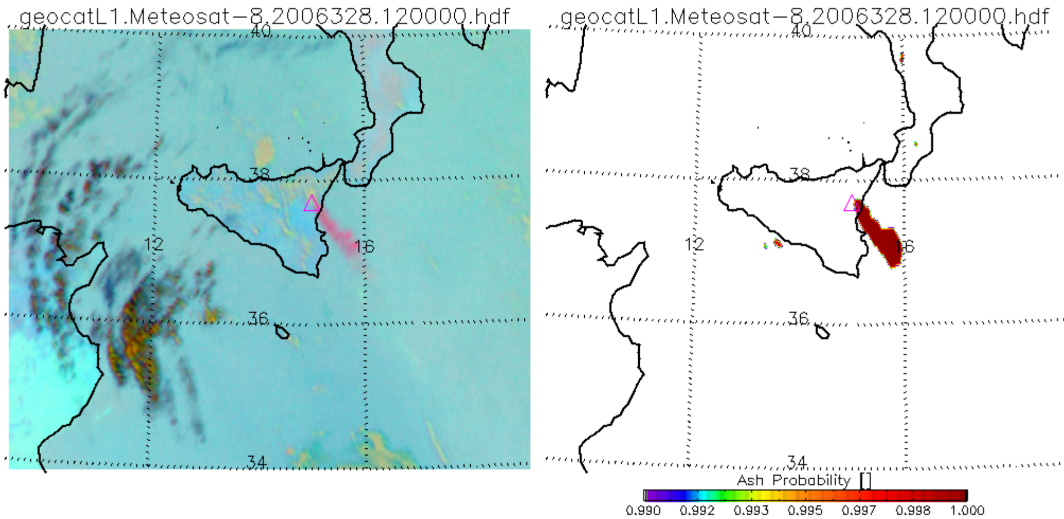


Figure 6.9.1.1. Example results from the ABI probabilistic ash detection algorithm for 24 November 2006 at 12 UTC. An eruption of Mount Etna is shown.

The SO_2 detection algorithm is now able to detect SO_2 contaminated ice clouds by exploiting a 4-channel spectral (7.3, 8.5, 11, and 12 μm) signature. Similar to the volcanic ash detection, the measurements are converted to cloud optical depth and ratios of various optical depth pairs (termed β-ratios) are used to distinguish between SO_2 contaminated clouds and meteorological clouds. The 7.3 and 8.5 μm channels are sensitive to SO_2 absorption; the 11 and 12 μm channels are not. The 8.5, 11, and 12 μm channels are sensitive to the presence of small particles, which tend to be present in SO_2 contaminated ice clouds. Thus, the ratio of the 7.3 μm and the 11 μm optical depth is sensitive to SO_2 absorption, the ratio of the 8.5 μm and the 11 μm optical depth is sensitive is both SO_2 absorption and particle size, and the ratio of the 12 μm and the 11 μm optical depth is sensitive to the presence of small particles. Examples results from this approach are shown in Figure 6.9.1.2.

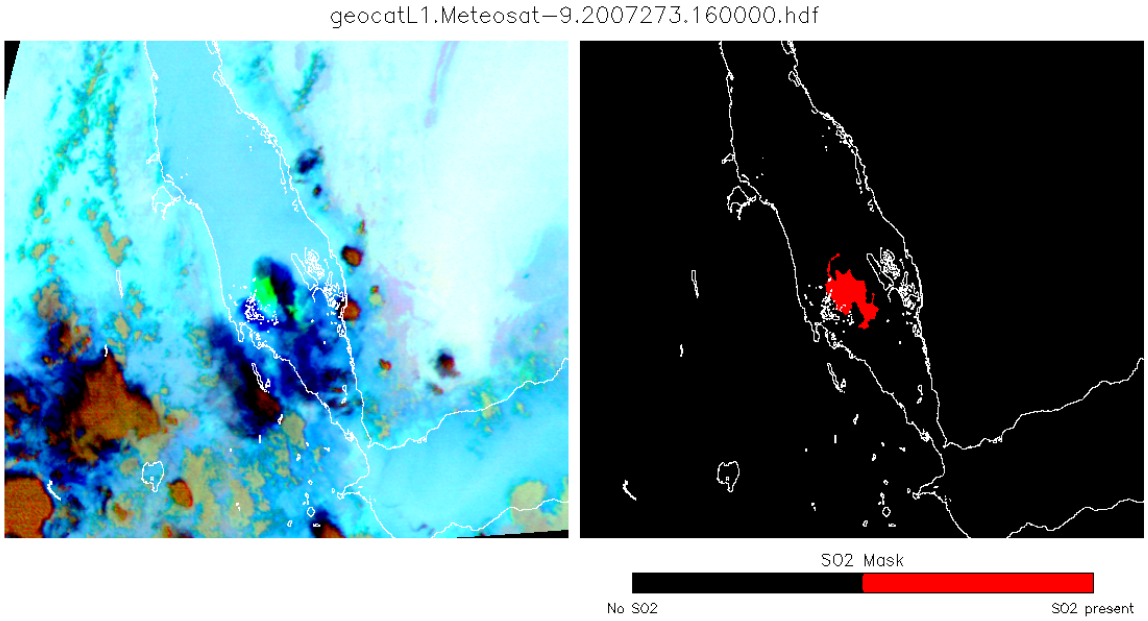


Figure 6.9.1.2. Example results from the ABI SO_2 detection algorithm for 30 September 2007 at 16 UTC. An eruption of Jabel Al-Tair in Yemen is shown. The green shade in the false color image on the left is indicative of SO_2.

The following significant code and documentation milestones were also achieved:

- A first draft of the volcanic ash Algorithm Theoretical Basis Document (ATBD) was submitted.
- A first draft of the SO_2 Algorithm Theoretical Basis Document (ATBD) was submitted.
- The volcanic ash and SO_2 algorithm code was hosted on the Algorithm Implementation Team's (AIT's) test computer.

Publications and Conference Reports

GOES-R Volcanic ash Algorithm Theoretical Basis Document (ATBD), First Draft submitted July 08.
GOES-R SO_2 Algorithm Theoretical Basis Document (ATBD), First Draft submitted July 08.

6.9.2. AWG Aviation Weather – Fog/Low Cloud

CIMSS Project Lead: Corey Calvert
CIMSS Support Scientist: William Straka
NOAA collaborators: Michael Pavolonis

1. Serve society's needs for weather and water information.
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

When possible, we have adopted the heritage low cloud/fog detection and geometrical depth retrieval methodologies currently used for GEO imager data. Unfortunately, these heritage approaches are only designed to work at night and they do not utilize the full capabilities of the Advanced Baseline Imager (ABI). Thus, we have proposed to implement additional approaches (e.g. a daytime approach and a terminator approach) so that fog/low cloud products are generated regardless of sun angle. We also proposed to supplement the heritage approaches using some of the additional spectral information provided by the ABI. In addition, through validation, all approaches will be refined over time and the algorithm code will be written to the appropriate standards. A first draft of the algorithm theoretical basis document will also be written. This project will insure the readiness of the fog/low cloud algorithm for operational implementation upon the deployment of GOES-R.

Summary of Accomplishments and Findings
The main physical properties of fog are: low cloud base, small liquid water droplets, and low liquid water content. This year, we implemented an approach that utilizes cloud properties (produced by upstream algorithms), such as cloud phase, cloud particle size, cloud top height, cloud optical depth, and cloud liquid water content to identify fog, when possible. When cloud properties are not available (e.g. in the day/night terminator, failed retrievals, etc…), alternative means of detecting fog are applied. These alternative means consist of the heritage 3.9 – 11 μm brightness temperature difference (at night only) and the ratio of absorption optical depth between 8.5 and 11 μm. The absorption optical depth approach was developed this year to supplement the heritage 3.9 – 11 μm algorithm. An example of the cloud property based algorithm is shown in Figure 6.9.2.1.

A new approach for estimating fog depth was also implemented. The fog depth is estimated using the retrieved liquid water path and a constant liquid water content, which is based on values in the literature. When the retrieved liquid water path is unavailable, the algorithm reverts to the heritage empirical 3.9 – 11 μm approach (at night only). An example of the fog depth algorithm is also shown in Figure 6.9.2.1.

As a means of validating the fog algorithm output, we developed a methodology to compare the results to the spaceborne lidar, the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP). Figure 6.9.2.2 shows the results of the fog detection algorithm relative to the cloud boundaries derived from the CALIOP. The early results are promising in that the ABI fog detection algorithm successfully identifies well-defined fog/low cloud layers shown in the CALIOP data.

Finally, the following significant code and documentation milestones were also achieved:

- A first draft of the Algorithm Theoretical Basis Document (ATBD) was submitted.
- The algorithm code was hosted on the Algorithm Implementation Team's (AIT's) test computer.

Publications and Conference Reports
GOES-R Fog/Low Cloud Algorithm Theoretical Basis Document (ATBD), First Draft submitted July 08.

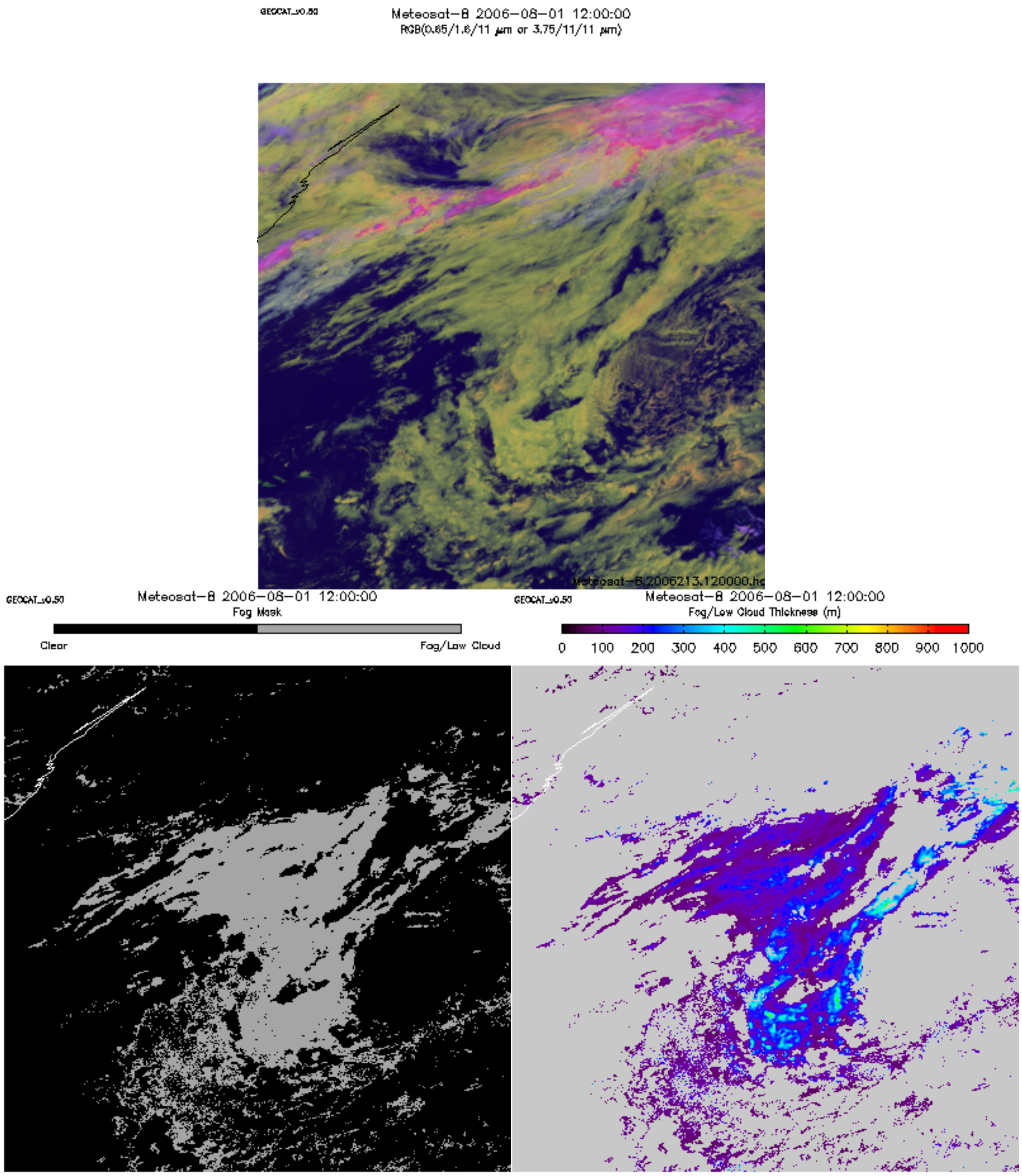


Figure 6.9.2.1. Example output from the ABI fog detection and fog depth retrieval algorithm from August 1, 2006 at 12 UTC over the North Atlantic. The top panel is a 3-channel false color image. The bottom left panel gives the results of the binary yes/no fog detection algorithm and the bottom right panel shows the fog depth in meters.

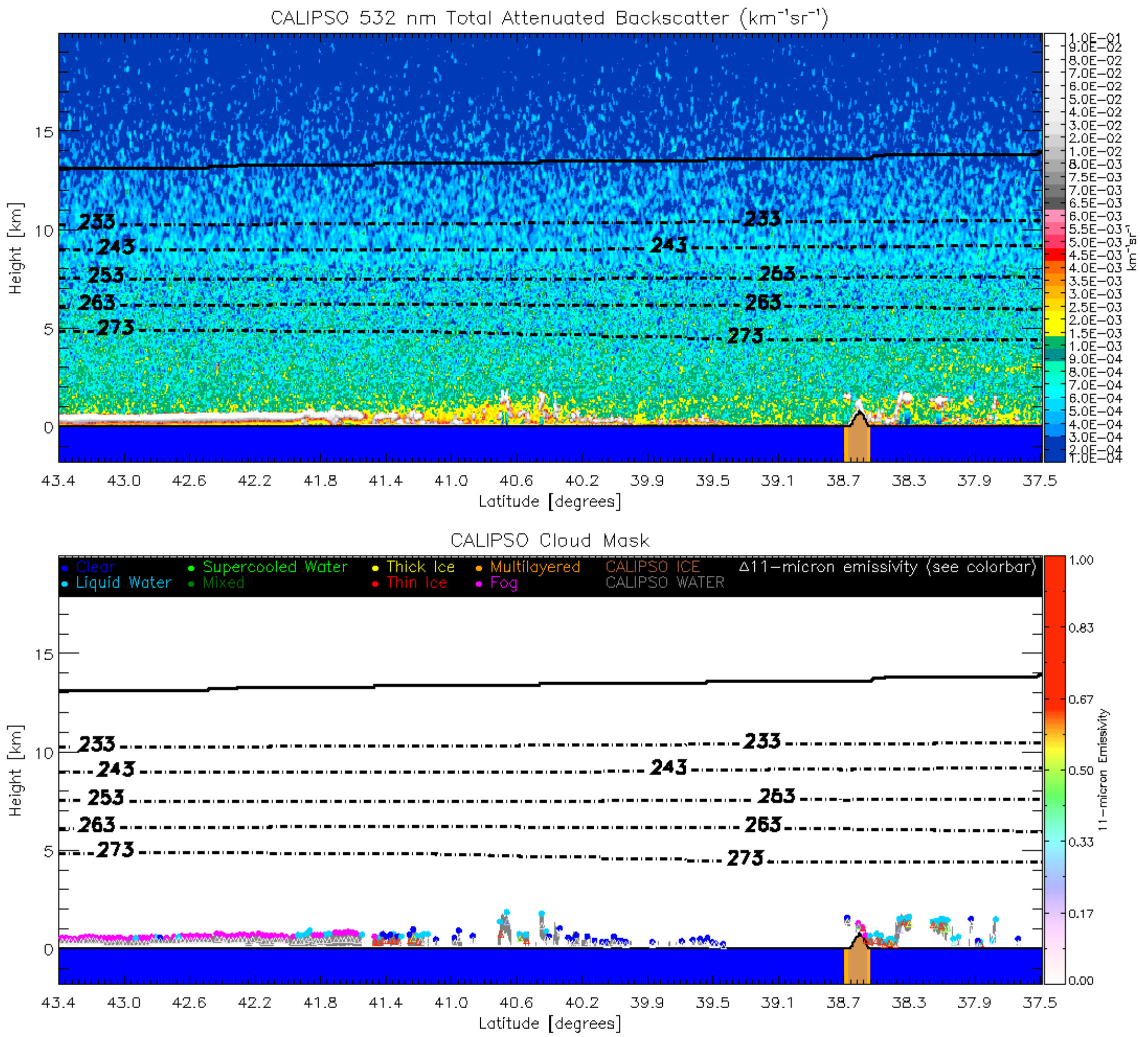


Figure 6.9.2.2. The top panel shows the 532 nm lidar backscatter for a CALIOP data segment featuring low cloud/fog and the bottom panel shows the results of the fog detection algorithm overlaid on the CALIOP-derived cloud boundaries. A magenta dot is shown when the ABI algorithm detects fog.

6.9.3. GOES-R Algorithm Working Group: Aviation Weather, Tropopause Fold Turbulence Detection

CIMSS Project Leads: Wayne Feltz, Anthony Wimmers

NOAA Strategic Goals addressed:

1. Serve society's needs for weather and water information;
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

We proposed to adapt the technique used by Wimmers and Moody for the detection of upper tropospheric zones of turbulence to an application optimized for GOES-R (2004a, b). This project involves software development, testing on proxy data sets, validation and documentation. This work will ensure the readiness of the turbulence detection algorithm for operational implementation upon the deployment of GOES-R.

The accuracy of the tropopause-folding algorithm was improved by refining the criteria for satellite signatures corresponding to upper-tropospheric turbulence. We now consider gradient feature size, aircraft angle of approach, and distance from the tropopause fold. Also, the algorithm was tested on a 12-month data set of over two million automated, in-situ observations. Further turbulence prediction requirements were refined using model wind data. The algorithm was adjusted to fit more closely with the theory of clear air turbulence due to tropopause folding.

Validation of the tropospheric fold algorithm with NCAR United Airlines Eddy Diffusion Rate (EDR) objective turbulence reports over eastern United States from 01 May 2004 - 30 April 2006 was accomplished. The validation from proxy GOES-12 data yielded successful results. Results were compiled in the following cross-sectional contour plots. As seen below, the algorithm achieved a probability of detection of approximately 20% for Light-or-Greater turbulence observations. The algorithm showed a smaller area of 10% detection for the much less frequent Moderate-or-Greater turbulence cases. Also, the algorithm had little skill for the very infrequent Severe-or-Greater cases. The significance of these numbers is discussed in more detail in the following section. The most robust prediction of turbulence occurred in the months of December – February. The high volume of data in the EDR reports enabled a determination of aircrafts' directional sensitivity to turbulence around the jet stream. Figure 6.9.3.1 shows the correlation between theoretical fold location and EDR data turbulence location.

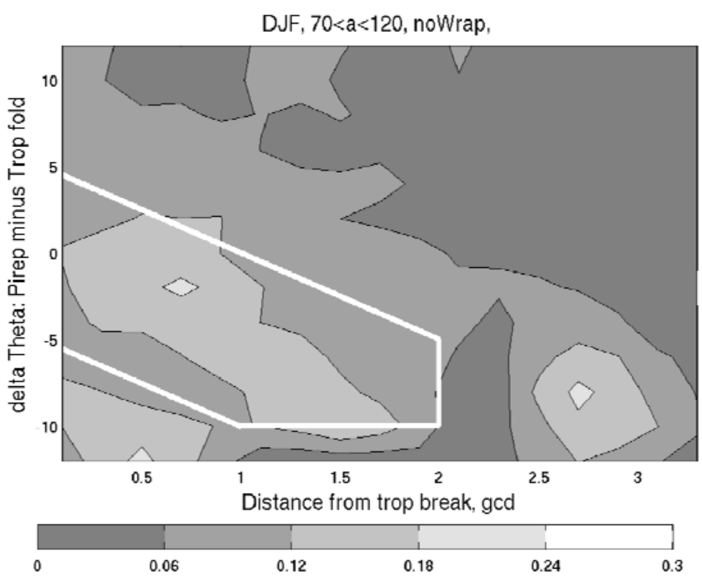


Figure 6.9.3.1. Vertical cross-section of turbulence probability at a tropopause fold. Horizontal axis is great circle degrees (gcd = 111 km); vertical axis is the potential temperature normalized for the tropopause height; solid white line is the expected area of turbulence.

A presentation about the turbulence algorithm was given at the EUMETSAT/AMS satellite conference in Amsterdam in September 2007. The presentation was titled "A prediction scheme for aircraft turbulence at tropopause folds using satellite imagery and EDR data."

Finally, a detailed algorithm flowchart package was delivered to GOES-R AIT. Charts are available at: http://www.orbit.nesdis.noaa.gov/star/goesr/FlowChartPackage/status.php.

The Turbulence ADR was finished on 16 November 2007 and a presentation can be obtained at: http://www.orbit.nesdis.noaa.gov/star/goesr/ADR/adr_avn.zip.

Summary of Accomplishments and Findings
Algorithm development was completed and tropopause fold algorithm was implemented into GEOCAT, adhering to AIT coding standards. Tests are currently being conducted to make sure standards are met. Several Matlab modules were converted to F90 and they have been made available to other AWG algorithm teams. These include smoothing, gradient/laplacian and contouring routines.

AIT account resources were requested for hosting algorithm at AIT. An Operational Matlab version of the algorithm has been delivered to the AIT team for hosting until full conversion to AIT standards occurs. Incremental updates to the code will be delivered as appropriate.

Algorithm testing and validation continues with New Eddy Dissipation Rate (EDR) data which has been received and will be processed to help with testing and validation. Algorithm transition within #1 above has been modified to allow direct comparison to current Matlab version script output. The algorithm has been transitioned from Matlab to Fortran 90. The tropopause fold turbulence algorithm has been implemented into GEOCAT.

Preliminary software documentation has almost been completed. Much was encapsuled within ATBD which has been delivered to AIT and GPO.

Considerable resources were spent on understanding how to use the EDR validation data set to validate the Tropopause fold turbulence interest field. What is the significance of the probability of detection for turbulence? A detection rate of 20% may appear low, and in other circumstances it would be. However, this low number is due to a highly sensitive observational system (automated EDR) rather than a lack of skill in the methods. Figure 6.9.3.2 illustrates this point.

Turbulence within a tropopause fold, especially at the scale in which an aircraft experiences abrupt interruptions, is small and ephemeral compared to the size and longevity of the tropopause fold itself. Therefore an aircraft passing through a tropopause fold should not experience turbulence constantly. Rather, it will experience turbulence only when it encounters a short-lived eddy (shown in yellow in the diagram below) within the larger tropopause fold (gray). (Positive observations of turbulence are shown in red, and null reports are shown in blue).

The EDR reports used for validation segment the observations into 3-minute intervals, reporting the value of the maximum inertial disturbance over that period. Thus for a typical pass through the width of a tropopause fold, at typical commercial aircraft speeds, it will make four separate observations. If, however, the system only collected observations every 12 minutes, it would make only one observation per pass through the tropopause fold. Suppose each flight encountered the same turbulent eddy. Is the first flight only 25% accurate, because it measured three non-turbulent segments and one turbulent segment; and is the second flight 100% accurate, because it measured no non-turbulent segments and one turbulent segment?

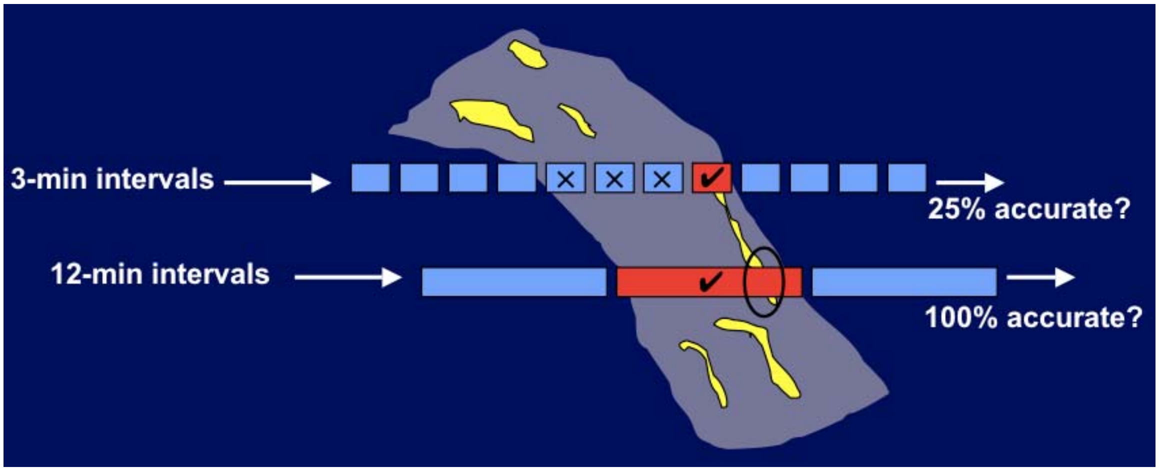


Figure 6.9.3.2. Conceptual diagram of two aircraft passes through a tropopause fold, scaled to the average width of a tropopause fold (shown in gray) and the typical speed of a commercial jet passing through. Turbulent zones are shown in yellow. The top pass supposes a 3-minute interval between observations, and the bottom pass supposes a 12-minute interval between observations.

This question is settled by considering scale. The accuracy of our EDR reports is inherently tied to its frequency of observation and the spatial scale of the hazard that is being detected by the product. The ultimate question that we attempt to answer with the TFTP product is "What is the likelihood of experiencing turbulence during the entire passage of a tropopause fold?" This question is independent of the frequency of observation.

However, we can make a rough calculation to estimate the frequency of turbulence detection over the length of a tropopause fold rather than over 3-minute intervals. Assuming each observation is independent, and assuming four 3-minute observations per crossing, then the likelihood of at least one LOG turbulent event per crossing is:

$$f = 1 - (1 - p)^4$$

where p is the probability of detecting turbulence over a 3-minute interval. When p = 20% as we have found here, then f = 59%. However, this number decreases if the intervals are not completely independent. Because we can expect some correlation between neighboring observations, this result is probably closer to 50%.

Also, it is worth noting that the hypothetical case of the 12-minute interval observation would have a similar result when averaged over many cases because of the many events when the interval overlaps on only part of the tropopause fold crossing.

Publications and Conference Reports

GOES-R Tropopause Fold Turbulence Detection Algorithm Theoretical Basis Document (ATBD), First Draft submitted August 08.

6.9.4. GOES-R Algorithm Working Group: Aviation Weather, Overshooting Top and Enhanced-V Detection

CIMSS Project Leads: Wayne Feltz, Kristopher Bedka
CIMSS Support Scientists: Jason Brunner, Justin Sieglaff

1. Serve society's needs for weather and water information;
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation.

Proposed Work

This work represents the first year of a multi-year effort to develop algorithms to objectively identify overshooting convective cloud tops and the enhanced-V signature within GOES-R ABI imagery as required by the GOES-R Aviation Algorithm Working Group. These algorithms must be able to operate during both day and night and meet coding standards and accuracy requirements specified by the GOES-R Algorithm Integration Team.

Overshooting top (OT) detection is the process of identifying thunderstorm cloud tops with heights above the tropopause. OTs are important indicators of storm intensity, where the most intense radar reflectivity echoes are well correlated with overshooting top signatures observed in satellite imagery. OTs are also a significant aviation turbulence hazard, as a deep layer of strong vertical motions are required to penetrate the statically stable tropopause. Horizontally and vertically propagating gravity waves are generated as the overshooting cloud tops interact with the stable tropopause region, which can produce turbulence for aviation far from the convectively-generated gravity wave source region as shown in Figure 6.9.4.1.

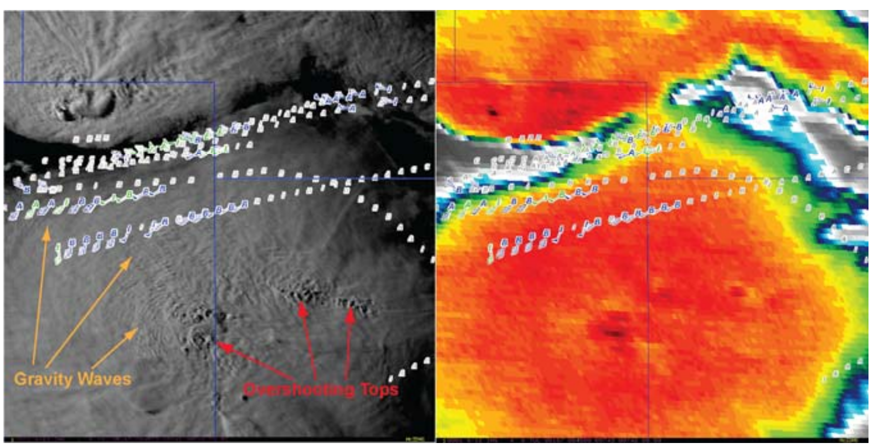


Figure 6.9.4.1. *(left)* GOES-12 1 km Visible channel imagery at 0045 UTC on 6 July 2005. Overshooting tops for one cluster of thunderstorm cells are highlighted by the red arrows, with the gravity waves induced by these overshooting tops identified by orange arrows. Objective EDR turbulence observations of light (moderate) intensity are shown in blue (green). Null turbulence observations are shown in grey. *(right)* The corresponding GOES-12 4 km 10.7 µm IR window channel imagery with EDR observations.

Anvil thermal couplets (ATC) are present in association with the "enhanced-V" signature in IR window channel imagery (see Figure 6.9.4.2). Brunner et al. (WAF, 2007) describe the relationship of storms exhibiting the enhanced-V signature to severe weather such as strong winds, large hail, and tornadoes. Brunner et al. show that V-producing storms with a minimum IR window OT BT ≤ 205 K and a downstream warm region BT ≥ 212 K (i.e. an ATC ≥ 7 K) corresponded to severe weather 92% of the time during the 2003 and 2004 convective seasons. They also describe the broad range of morphologies of the enhanced-V signature in IR imagery, where the length of V pattern "arms" and the arm angular separation can vary significantly based upon the magnitude of the environmental wind field and other unknown factors. This suggests that objective detection of the V signature itself through pattern recognition would be very difficult and prone to false alarm. As every V-pattern contains a downstream warm region, accurate detection of the ATC is much more attainable and equally relevant, as the presence and magnitude of an ATC shows a direct relationship to severe weather occurrence at the surface.

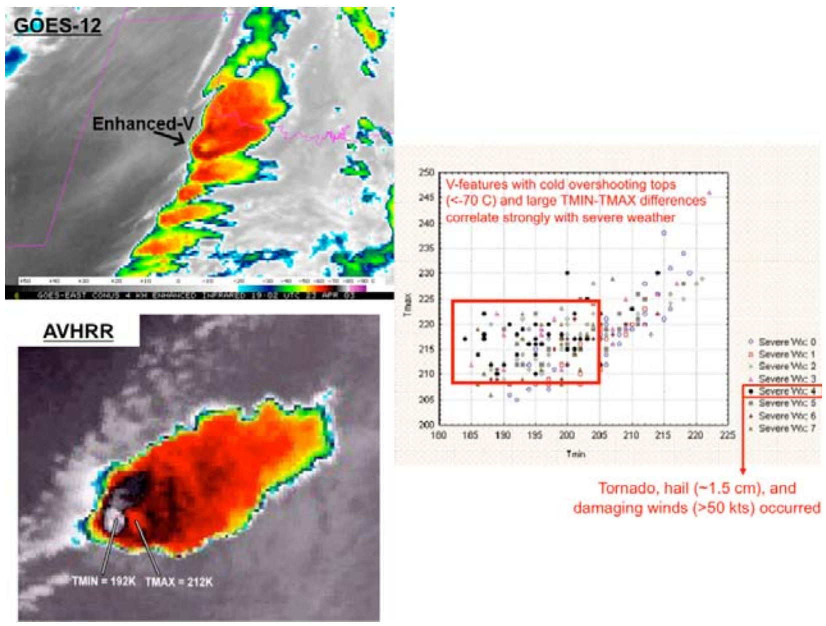


Figure 6.9.4.2. (upper-left) GOES-12 4 km IR window channel imagery showing the enhanced-V and ATC signatures. (lower-left) AVHRR 1 km IR window channel imagery showing another enhanced-V case with labels for the location of the OT (TMIN) and downstream warm area (TMAX) at higher horizontal resolution. The ATC magnitude in this case is 20 K. (right) A scatterplot of various severe weather type combinations relative to the OT IR window BT minimum (Tmin) and downstream warm area BT maximum (Tmax) during the summer 2003 convective season. All severe weather types occurred simultaneously (i.e. 'Severe Wx: 4') when cold OT and large ATC were present (see red box). See Brunner et al. (WAF, 2007) for a full description of these results.

Summary of Accomplishments and Findings

Draft versions of the Advanced Theoretical Basis Document and Validation Test Plan were submitted for both the OT and enhanced-V product requirements by the 31 August 2008 deadline.

We are performing an objective validation study of the ABI OT detection algorithm. This involves comparison of: 1) OT detections using 5-min CONUS WRF-simulated GOES-R ABI proxy IR window BT as input, with 2) co-located lower stratospheric total hydrometeor mixing ratio (THMR) from the parent WRF model simulation. Extremely high values of 150 hPa THMR indicate that strong upward vertical motions are present within and below the lower stratosphere and that cloud tops are located far above the tropopause. Using this validation method, 92% of OT pixels as defined by WRF THMR are detected by the ABI OT detection algorithm. See Figure 6.9.3 for an example of ABI OT detects using AVHRR imagery at 2 km resolution as input.

Comparison of enhanced-V (i.e. ATC) detection algorithm results to couplets identified by a human analyst show good agreement. For the example shown in Figure 6.9.4.3, 4 of the 5 total ATCs are identified with no false alarms (the missed detect is located in far western Tennessee). Testing and evaluation of this algorithm on a diverse set of enhanced-V cases (> 25 events) is ongoing.

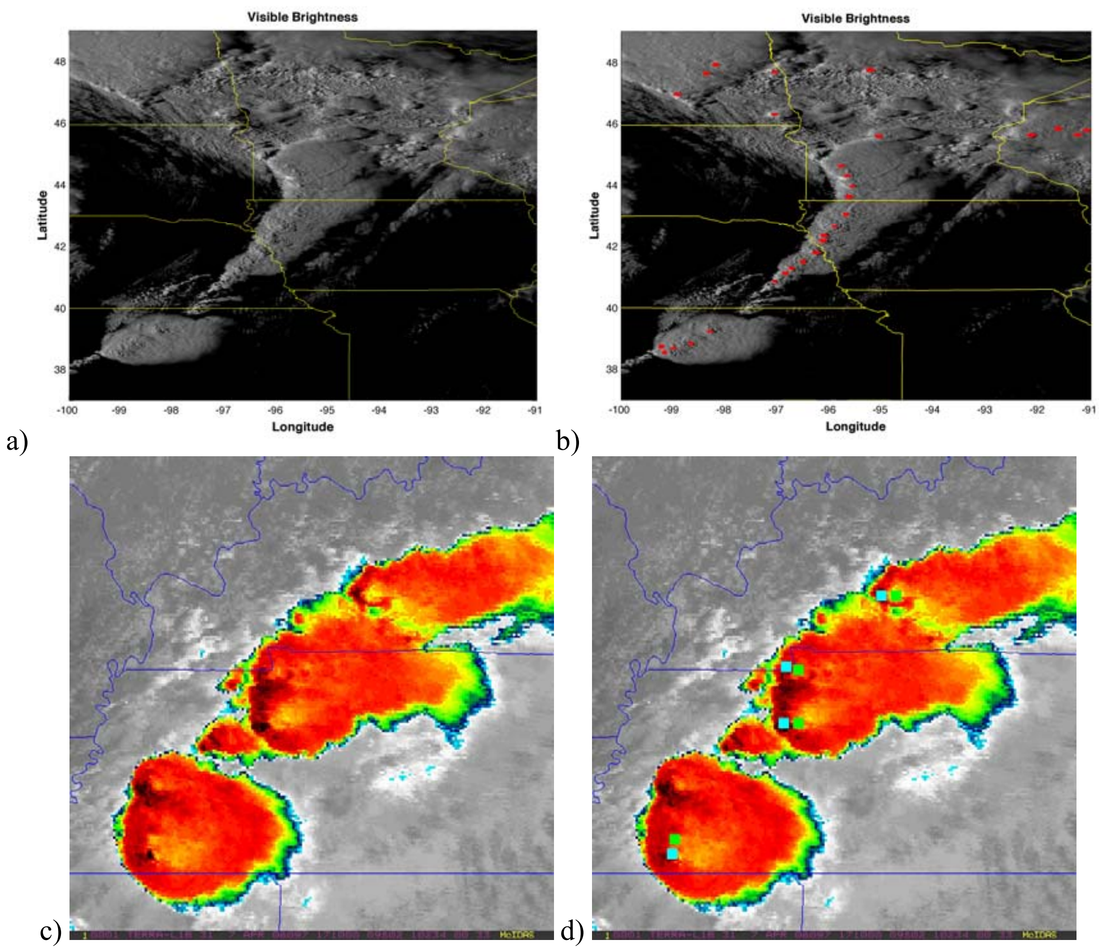


Figure 6.9.4.3. a) AVHRR 1 km Visible channel imagery at 2330 UTC on 11 June 2008. b) Overshooting tops detected by the ABI algorithm (in red) using AVHRR IR window channel imagery degraded to the 2 km ABI resolution. c) MODIS 1 km IR window channel imagery at 1710 UTC on 07 April 2006. d) Anvil thermal couplet detected by the ABI algorithm. Cyan boxes represent detected overshooting top locations and green boxes represent the downstream warm areas coupled with the overshooting tops.

Publications and Conference Reports

GOES-R Overshooting Top Detection Algorithm Theoretical Basis Document (ATBD), First Draft submitted August 08.

6.10. Estimation of Sea and Lake Ice Characteristics with GOES-R ABI

CIMSS Project Leads: Xuanji Wang, Yinghui Liu
NOAA Collaborator: Jeffrey R. Key
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

To accomplish the goals outlined in the GOES-R AWG Project Plan, we need to evaluate, improve, and further develop sea and lake ice property retrieval algorithms for application with GOES-R ABI. This project is dedicated to the estimation and analysis of sea and lake ice extent, concentration, thickness, age, and motion. The work will serve as a test-bed of the algorithms for ice products, and will allow for algorithm testing and optimization to be done in a consistent manner. This activity will ensure enhanced future geostationary cryosphere applications in the GOES-R era.

Summary of Accomplishments and Findings

The project started in May 2007. The major accomplishment this year was the development, implementation, and validation of the first versions of algorithms that generate the ice products. The first versions of the Cryosphere AWG Algorithm Theoretical Basis Documents (ATBDs) were delivered to the GOES-R AWG Algorithm Implementation Team (AIT) on 30 June 2008, and revisions after peer review were submitted on 26 September 2008. We also helped review the Radiation Team ATBDs. In addition, we also delivered our Fortran 95 algorithm code to the AIT for testing on 30 July 2008. AVHRR, MODIS, and SEVIRI data are being used as proxy data for the purpose of the algorithm testing, and submarine and meteorological station measurements were used to do the validation for ice thickness and age retrievals. Preliminary results are very promising for all ice products created from our algorithms.

1. Ice concentration and extent

A sea ice concentration and extent algorithm was developed and implemented. The current algorithm takes advantage of three existing ice concentration/extent retrieval algorithms: (1) a group threshold technique from the Earth Observation System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) snow and sea ice mapping algorithms based on the normalized difference snow index and visible reflectance observations; (2) tie point analysis from the National Polar-Orbiting Operational Environment Satellite System (NPOESS) Visible/Infrared Imager/Radiometer Suite (VIIRS) fresh water ice algorithm; and (3) tie point analysis from the Algorithm developed by Lindsay and Rothrock (1995). This algorithm has been applied to and tested with proxy data, including AVHRR, MODIS and SEVIRI data, and the retrieved products compare in good agreement with Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) Level-3 gridded daily mean product. An additional product, ice surface temperature retrieval, was accomplished with the split-window technique developed by Key and Haefliger (1992). This is the first step to retrieve ice concentration particularly at night, validation is ongoing. Figure 6.10.1b is an example of retrieved ice concentration for the Great Lakes with MODIS data.

2. Ice thickness and age

A One-dimensional Thermodynamic Ice Model (OTIM) has been developed on the theoretical basis of surface energy balance at thermo-equilibrium. OTIM uses all components of the surface energy balance to estimate sea/lake ice thickness. Based on the OTIM estimate of ice thickness, ice is classified into eight categories: open water, new/fresh ice, grey ice, grey-white ice, thin first year ice, medium first year ice, thick first year ice, multi-year ice, commonly called ice age. OTIM has been coded in IDL and Fortran 95, and implemented and tested by this team and the AIT with proxy data of AVHRR, MODIS, and SEVIRI. Figures 6.10.1c and 6.10.1d show the retrieved ice thickness and derived age for the Great Lakes area from MODIS. In addition, the ice thickness/age algorithm has also been extensively compared and validated with numerical model simulations from A Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS), submarine upward looking sonar ice draft data from Scientific Ice Expeditions (SCICEX) in 1999 (Figure 6.10.2), and Canadian station measurements from the Canadian Ice Service (CIS) with 11 new Arctic Program Stations starting in 2002. The performance of the OTIM is the best in terms of ground "truth."

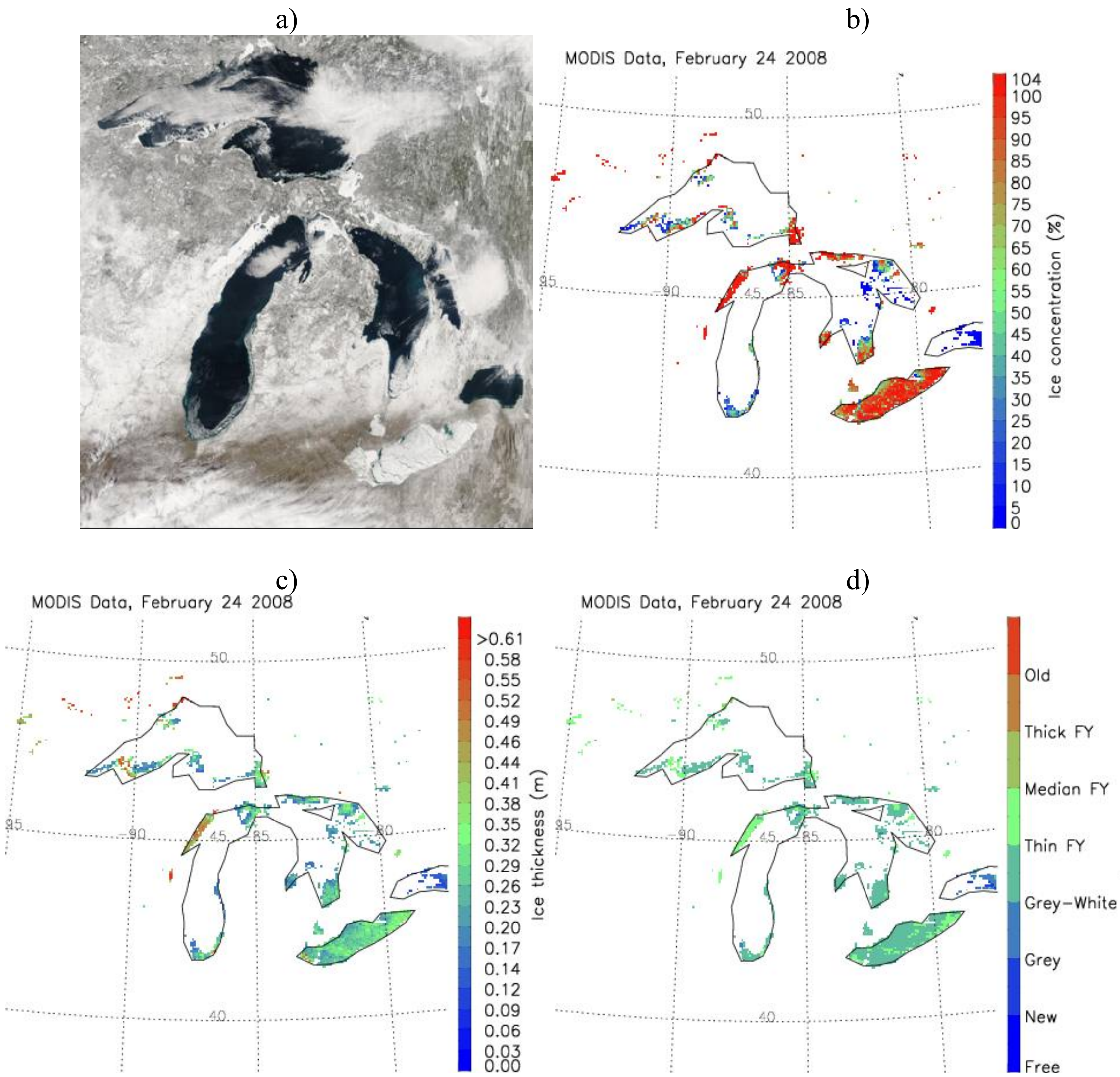


Figure 6.10.1. MODIS Aqua true colour image (a) on 24 February 2008 over Great Lakes, and correspondingly retrieved ice concentration in percentage (b), ice thickness in meter (c), and ice age (d) under clear sky condition.

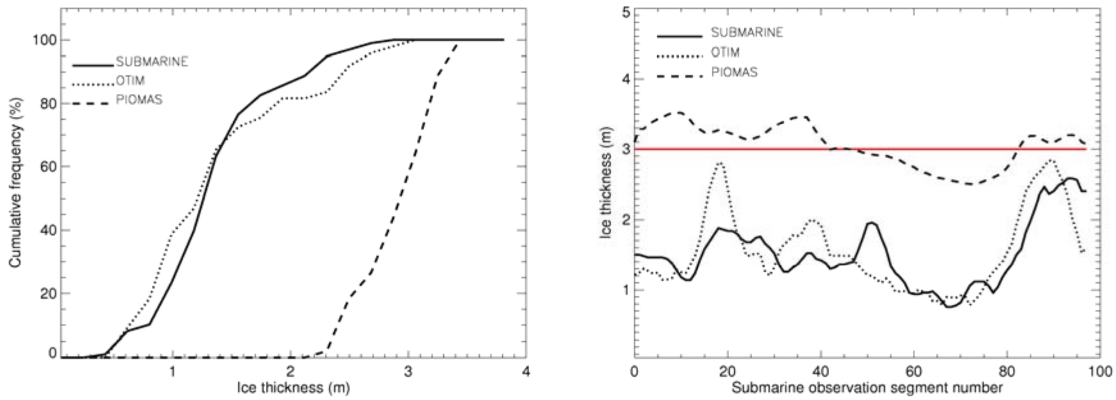


Figure 6.10.2. U.S. Navy submarine track for SCICEX ice draft data collection during 02 April – 13 May 1999 (left), and the comparison of ice thickness retrieved by OTIM with APP-x data, measured by submarine, and simulated by numerical model PIOMAS in cumulative frequency (middle) and in absolute magnitude (right).

3. Ice motion

The heritage ice motion algorithm developed by Fowler et al. (2004) has been adopted, improved, and implemented at the direct broadcast site in Tromsø, Norway using MODIS data as well as using archived SEVIRI data. This approach has been used by the National Snow and Ice Data Center with AVHRR passes routinely. A variety of time steps can be used to track the ice, though the best results are given when using images that are 24 hours apart. One disadvantage to using this technique is that motion is detected in only a small fraction of the area due to cloud cover. Comparisons of this algorithm with the Medium Range Forecast Model (MRF) surface winds have yielded positive results, showing that the detected motion is similar to that of the surface wind (Figure 6.10.3). Ongoing work on validation, including the use of ocean buoys, is being explored.

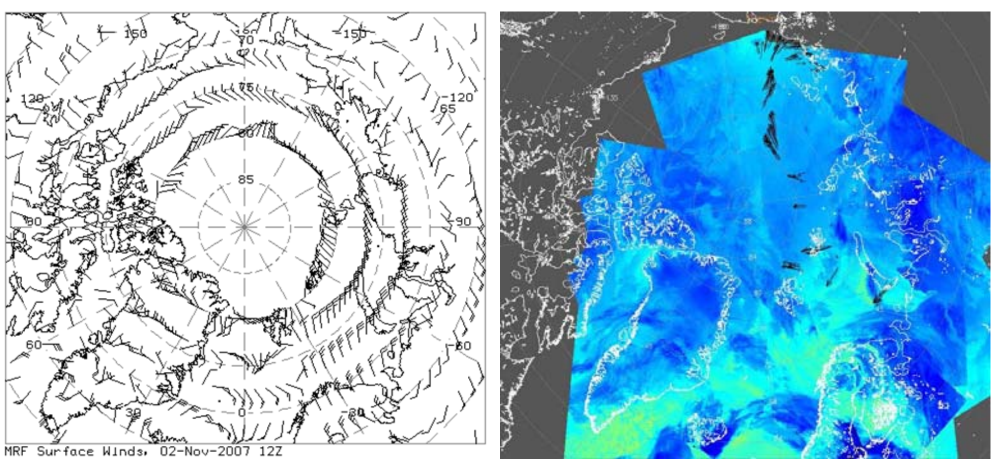


Figure 6.10.3. Comparison of ice motion from MODIS, utilizing the Tromsø direct broadcast site for 1252 UTC on 03 November 2007, and the MRF model surface winds (left) at 12 UTC. Orientation is the same on the right image that is a composite for 19 December 2007.

Publications and Conference Reports

Xuanji Wang, Jeffrey R. Key, Yinghui Liu, William Straka III, Estimation of Sea and Lake Ice Characteristics with GOES-R ABI, *AMS 88th Annual Meeting/5th GOES Users' Conference,* 20 - 24 January 2008, New Orleans, LA.

6.11. GOES-R Aerosol and Ozone Proxy Data Simulation

CIMSS Project Lead: Todd Schaack
NOAA Collaborator: Brad Pierce
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

This task supports NOAA Mission Goal(s) to "Serve society's needs for weather and water information" through the generation of GOES-R proxy data sets for ozone and aerosols. The addition of aerosol and ozone distributions into the WRF proxy data set will allow generation of synthetic radiances for all GOES ABI bands. This will facilitate the development of algorithms supporting retrievals of aerosol properties, total column ozone, and detection of dust, smoke and SO_2 in preparation for deployment of GOES-R.

Proposed Work

The main focus of this project is to augment the current GOES-R AWG WRF Advanced Baseline Imager (ABI) proxy data capabilities with proxy data sets for aerosols and ozone over the continental US. The aerosol and ozone proxy data sets will be generated with WRF-CHEM air quality simulations [Grell et al, 2005] coupled to global chemical and aerosol analyses from the Real-time Air Quality Modeling System (RAQMS) [Pierce et al., 2007]. Chemical data assimilation will be used to provide observational constraints on the global chemical and aerosol analyses.

Output from the coupled RAQMS/WRF-CHEM ozone and aerosol simulations will be used to construct simulated radiances using the NOAA Community Radiative Transfer Model (CRTM) [Han et al., 2006]. The addition of aerosol and ozone distributions into the WRF proxy data set will allow generation of synthetic radiances for all ABI bands. This will facilitate the development of algorithms supporting retrievals of aerosol properties (optical depth, aerosol type, effective radius, fine vs. coarse mode fraction), total column ozone, and detection of dust, smoke and SO_2. This work will be conducted in close collaboration with the existing GOES-R WRF proxy data simulation team at CIMSS (Lead, Allen Huang, CIMSS) and with the ABI aerosol retrieval and GOES-R aerosol assimilation activities under the GOES-R Air Quality and Aerosols AWG (Lead, Shobha Kondragunta, NOAA/NESDIS).

Summary of Accomplishments and Findings

The 2008 milestones for this project were:

May 2008: Complete RAQMS GOCART implementation

The RAQMS-GOCART implementation has been completed and thoroughly tested. Global MODIS aerosol optical depth (Terra and Aqua) assimilation has been carried out for extended time periods including the period of this study.

June 2008: Complete CIMSS WRF-CHEM implementation

WRF-CHEM has been implemented on CIMSS computers. The capability to initialize WRF-CHEM with RAQMS chemical analyses has been developed, along with the capability to use RAQMS chemical analyses for WRF/CHEM lateral boundary conditions.

August 2008: Complete test (36km) August 2006 CONUS WRF-CHEM+RAQMS simulations

WRF/CHEM 36 km ozone and aerosol simulations have been completed. Figures 6.11.1 and 6.11.2 show upper tropospheric (pressure varies between 250 and 350 mb) ozone and black carbon plus organic carbon aerosol (BC+OC) distributions from a 36 hour WRF/CHEM forecast over CONUS valid 12Z 16 August 2006. This 36 km simulation was initialized from 00Z 15 August RAQMS global chemical and aerosol analyses. It used RAQMS lateral boundary conditions that were constrained with stratospheric ozone measurements from the Microwave Limb Sounder (MLS) onboard the NASA Aura satellite, and with aerosol optical depth (AOD) measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Aqua and Terra satellites. The nested RAQMS/WRF-CHEM simulation shows enhanced upper tropospheric ozone mixing ratios behind the cold front located off the northeast coast of the US and arriving onshore over Northern California (Figure 6.11.1). The simulation shows enhanced BC+OC extending from Saskatchewan to Nova Scotia associated with continental scale transport of smoke from wild fires that were burning in the Pacific Northwest during this time period. Ozone enhancements over the Great Lakes and Wyoming are associated with elevated carbonaceous aerosols, indicating photochemical ozone production due to wildfire emissions. The elevated ozone over Northern California and Quebec are associated with low carbonaceous aerosol loadings, suggesting stratosphere troposphere exchanging processes contribute to the predicted ozone enhancements in these regions.

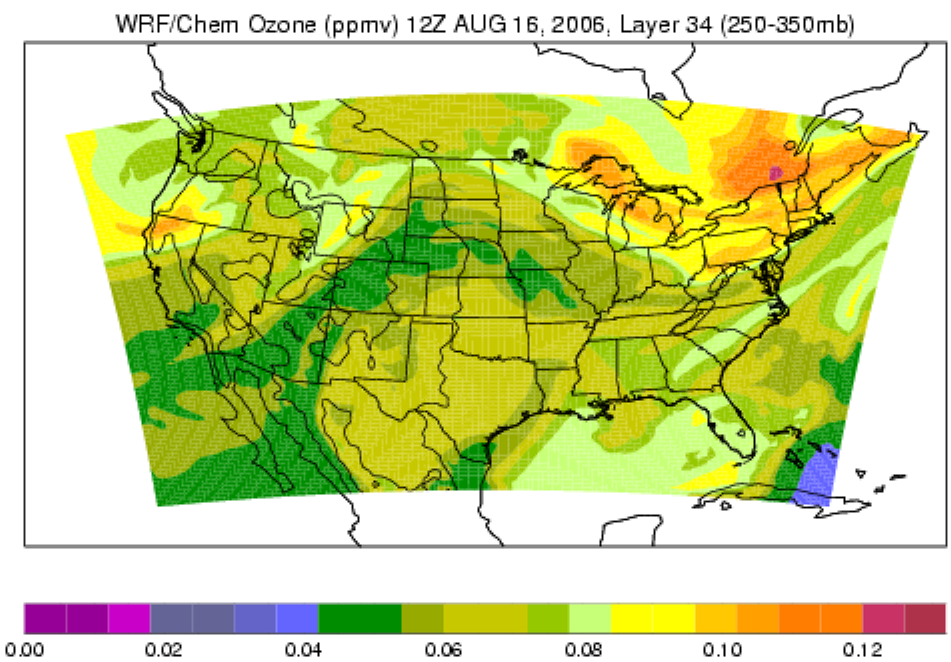


Figure 6.11.1. WRF/CHEM 36 hour forecast of upper layer (ranging between 250 and 350 mb) ozone (ppmv) for 12z 16 August 2006.

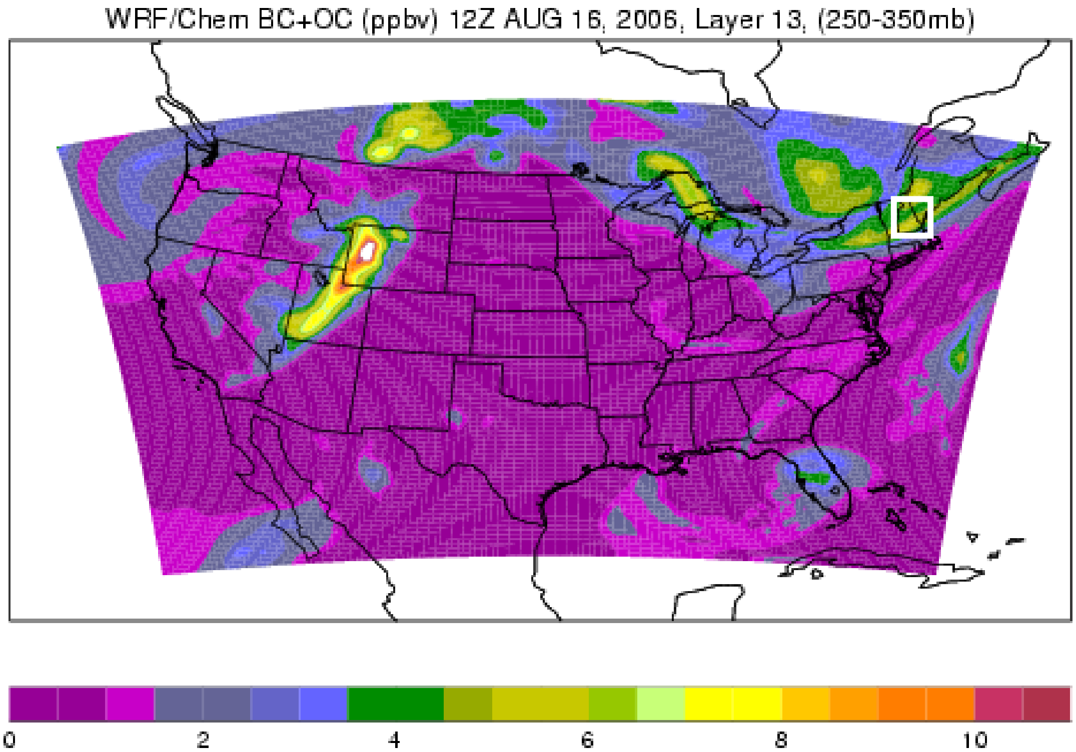


Figure 6.11.2. WRF/CHEM 36 hour forecast of upper layer (ranging between 250 and 350 mb) BC_OC (ppbv) for 12z 16 August 2006. The white box off the coast of Maine indicates where clear-sky comparisons with AIRS radiances were performed.

The NOAA Community Radiative Transfer Model (CRTM) has been implemented on CIMSS computers and adapted for use in our research efforts. Figure 6.11.3 shows the comparison of clear sky RAQMS synthetic versus AIRS observed brightness temperatures for clear sky pixels within the plume of high carbonaceous aerosol off the coast of Maine (44N-42N, 69E-67E) for at 18Z 16 August 2006. Agreement between the synthetic and observed brightness temperatures is generally within 1K within the Mid IR window region and 9.6 micron ozone band with systematic underestimates of 3K within the water vapor continuum due to underestimates in water vapor mixing ratios.

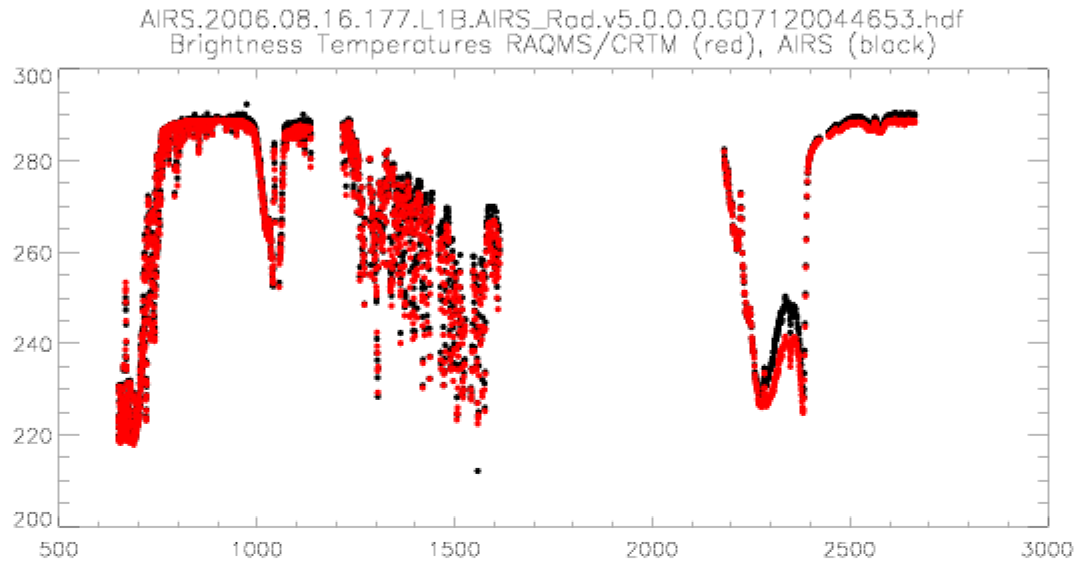


Figure 6.11.3. Comparison between simulated (RAQMS/CRTM, red) and observed (AIRS, black) clear sky brightness temperatures as a function of wavenumber averaged over one AIRS granule for 16 August 2006.

Publications and Conference Reports
Pierce et al., "Impact of MODIS Terra/Aqua AOD assimilation on global aerosol analyses"NWS Technical workshop on Air Quality predictions, 16 September 2008. Silver Spring, Maryland

References
Grell, G. A., et al., Fully coupled online chemistry within the WRF model, Atmos. Environ., 39, 6957-6975, 2005.
Han, Y., et al., Community Radiative Transfer Model (CRTM) - Version 1. *NOAA Technical Report* 122, 2006.
Pierce, R. B., et al. (2007), Chemical data assimilation estimates of continental U.S. ozone and nitrogen budgets during the Intercontinental Chemical Transport Experiment–North America, J. Geophys. Res., 112, D12S21, doi:10.1029/2006JD007722.

7. CIMSS Instrument Studies for GOES-R and Beyond

CIMSS Project Lead: Jun Li
CIMSS Support Scientists: Jinlong Li, Hal Woolf, Chian-Yi Liu, Kevin Baggett, and Justin Sieglaff
NOAA Collaborator: Tim Schmit, Jim Gurka
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work

1. To conduct research on future GOES advanced infrared sounding requirements and definition, to demonstrate the needs and value of advanced sounder on GEO orbit on severe storm nowcasting,

and to perform trade studies on the spectral coverage/resolution, spatial resolution, temporal resolution, radiometric resolution, ensquared energy, etc. for a cost effective option of advanced sounder for future GOES.

2. To help the GOES-R Program Office (GPO) and GOES user community to define the users' needs, operational requirements, and science data product requirements for the GOES-R (and beyond) mission. To publicize the GOES-R system and help GOES user communities understand the new and improved data/products from GOES-R series.

3. To study the advantages and benefits from the GOES-R (and beyond) system over the current GOES system in forecasting and nowcasting the significant weather and environmental events. The current advanced imager and sounder data such as MODIS and IASI from Low Earth Orbit (LEO) will be used to simulate the spatial and spectral information of the current GOES and GOES-R, while the high resolution WRF model data will be used to simulate the temporal information of the current GOES and GOES-R.

Summary of Accomplishments and Findings

Study the needs of future GOES advanced sounder

Although Hyperspectral Environmental Suite (HES) has been removed from GOES-R, NOAA continues to have strong requirements for measurements from an advanced hyperspectral sounder in Geo orbit. Studies have been conducted to demonstrate the advantages of a geostationary hyperspectral InfraRed (IR) sounding system. Materials from our studies have been supplied to the center for SaTellite Applications and Research (STAR) for HES (Hyperspectral Environmental Suite) briefing and to the GOES-R Program Office (GPO). Mesoscale model atmospheric fields from the International H2O Project (IHOP) are used to simulate the performance of ABI (Advanced Baseline Imager) and geostationary hyperspectral IR sounder on capturing the atmospheric instability before the convective initiation. In addition, the vertical structure of AIRS (Atmospheric InfraRed Sounder) single field-of-view (SFOV) soundings developed by CIMSS are compared with dropsondes and current GOES soundings. Clearly the hyperspectral IR depicts the fine structure while the current GOES Sounder has limited capability.

The IHOP (12 June 2002) numerical model output (MM5, 2 km, 5 minutes) are used to simulate the ABI and geostationary hyperspectral IR (e.g., HES end of formulation) radiances with assumed observation noise contained. The model output serves as the truth field in the simulation. Atmospheric temperature and moisture profile retrievals (Li et al. 2000 - JAM), instability index such as lifted index (LI), theta-E and total precipitable water (TPW) are generated from both the truth field and retrieved fields from ABI and HES radiances for performance comparisons. In Figure 7.1.1, the lower left panel shows the TPW from simulated hyperspectral IR (blue) and ABI (green), along with the "truth" at the indicated location. The lower right panel is the same as the lower left panel but for LI. Grey colors in the upper panels denote cloud-top temperature. The significant LI and TPW improvements can be seen from HES over ABI in the potential of estimating the convective instability that results in the formation of severe weather/storms. HES depicts the region of instability hours earlier than the ABI.

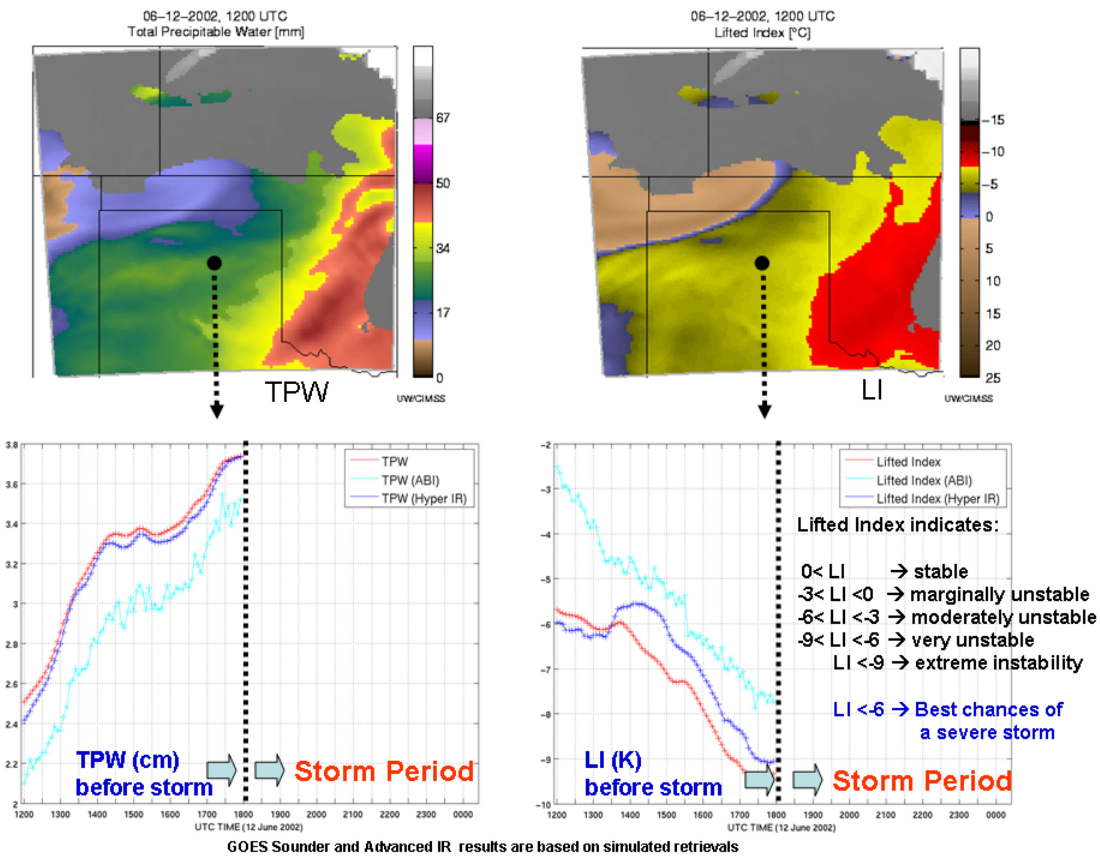


Figure 7.1.1. TPW (upper left panel) and LI (upper right panel) from IHOP (12 June 2002) model output (MM5, 2 km, 5 minutes). Lower left panel shows the TPW from simulated HES (blue) and ABI (green), along with the "truth" (red) at the indicated location. The Lower right panel is the same as lower left panel but for LI. Grey colors in the upper panels denote cloud-top temperature.

In addition, the Theta-E differences between 800 and 600 hPa are also used in the analysis as one component of thunderstorm potential. In Figure 7.1.2, the upper left panel shows the true field of Theta-E (difference between 800 and 600 hPa); the upper right panel shows the simulated Theta-E from HES while the lower right panel shows the Theta-E from ABI at 17 UTC for 12 June 2002, the difference image between HES and ABI is also shown in the lower left panel. The HES indicates the unstable region which is similar to the true field while ABI has weak indication of pre-storm development. Three hours later the convective storm started to develop in this region. The GOES Imager data (not shown) also indicates the similar pattern of the storm development.

This case demonstrates that (1) rapid storm growth in the 'truth' fields begins when the storm enters the area of convective instability, and requires knowledge of strong vertical gradients of temperature and especially moisture; (2) HES showed the development of instability earlier than the ABI alone – by several hours, and (3) ABI under-estimated the convective instability by 20-30% compared to the HES in this case.

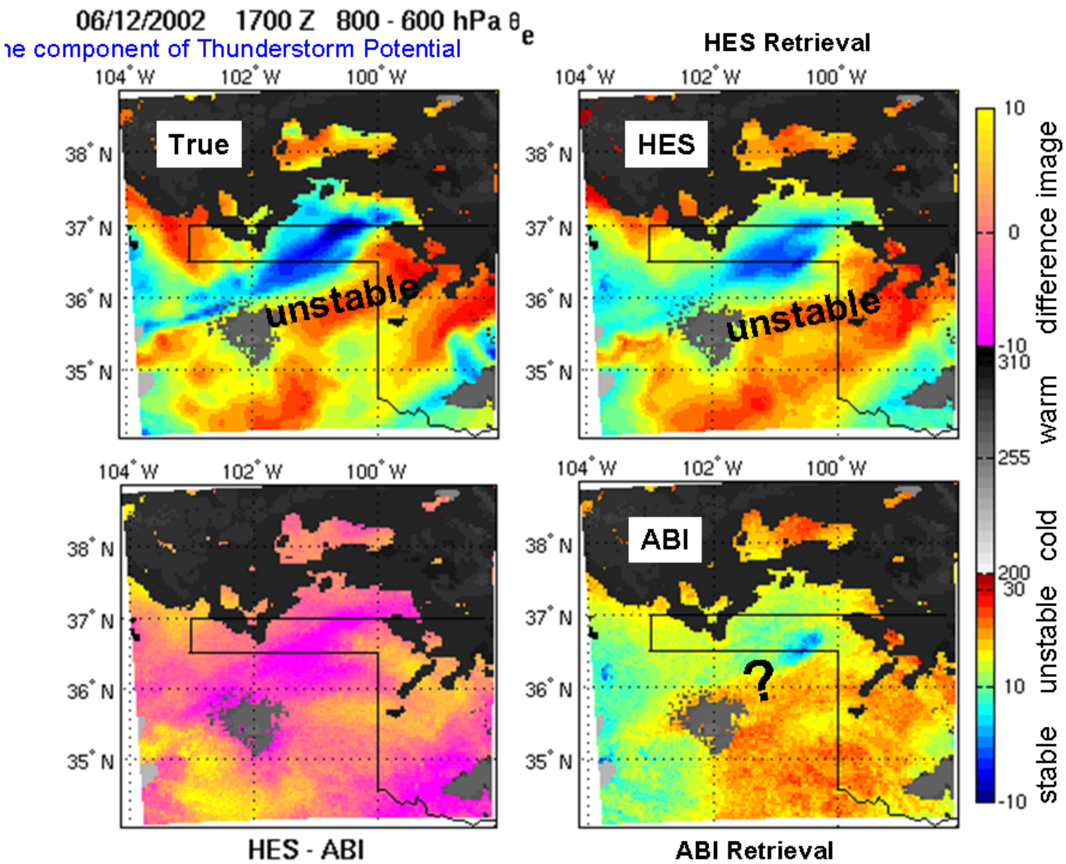


Figure 7.1.2. Truth field of Theta-E (upper left), Theta-E from HES (upper right), Theta-E from ABI (lower right) at 17 UTC for 12 June 2002, along with the difference image between HES and ABI (lower left).

This IHOP case will be studied with the Weather and Research Forecasting (WRF) model. HES, ABI and radar data will be simulated to demonstrate the unique value of the high temporal advanced sounder on storm forecasts by depicting the instable region before the storm development although radar provides good precipitation information during the storm development. Figure 7.1.3 shows the simulated radar reflectivity at 12:00 UTC on 12 June 2002 from WRF.

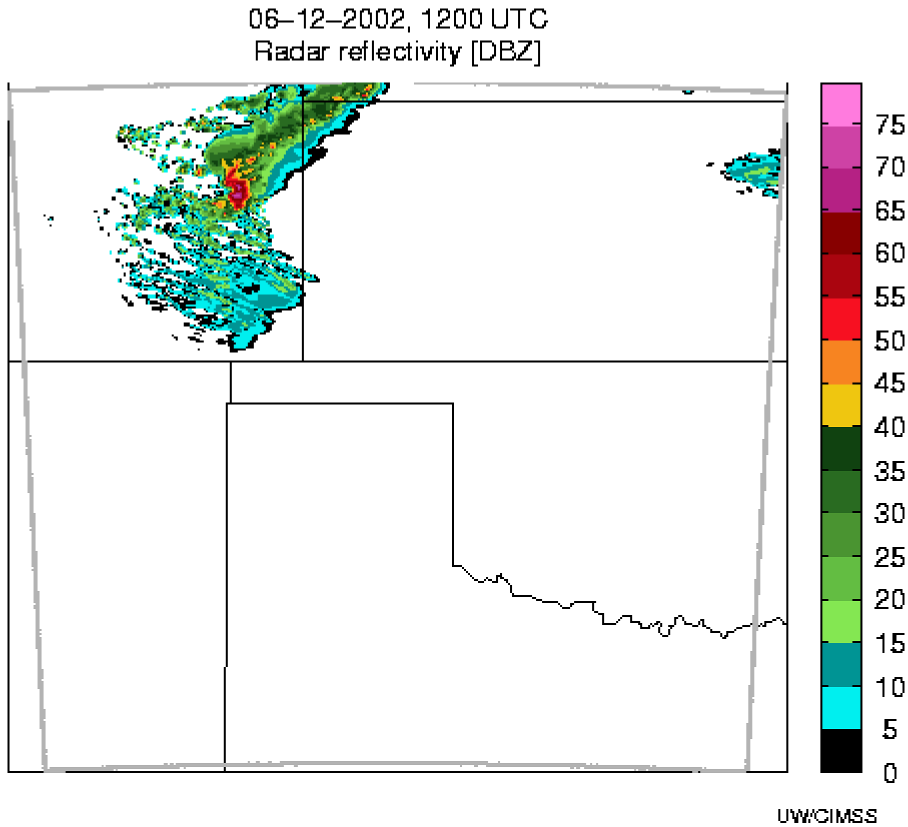


Figure 7.1.3. The simulated radar reflectivity at 12:00 UTC on 12 June 2002 from WRF.

The advanced sounder provides fine structure of moisture profile, which is critical for improving the mesoscale forecast. The CIMSS sounding team has developed the hyperspectral IR single field-of-view (SFOV) sounding algorithm for both clear and cloudy skies. Collocated Atmospheric InfraRed Sounder (AIRS) and GOES Sounder soundings along with dropsondes are used for demonstrating the capability of the advanced sounder for detecting the fine vertical structure. Figure 7.1.4 shows the GOES Sounder 11 µm BT image at 18:46 UTC on 29 April 2007 (left panel), the dropsonde site is indicated by a small star over the Gulf of Mexico. The time of AIRS overpass is about 19 UTC (AIRS granule 193). Three RH soundings are plotted in the right panel. Although GOES (red) has reasonable accuracy in general it lacks vertical structures when compared with dropsonde (blue). In order to show the independent GOES sounding information, the forecast is not used in the GOES retrieval in this case. AIRS SFOV sounding (green) depicts the fine structures in this case, which are similar to those from the dropsonde.

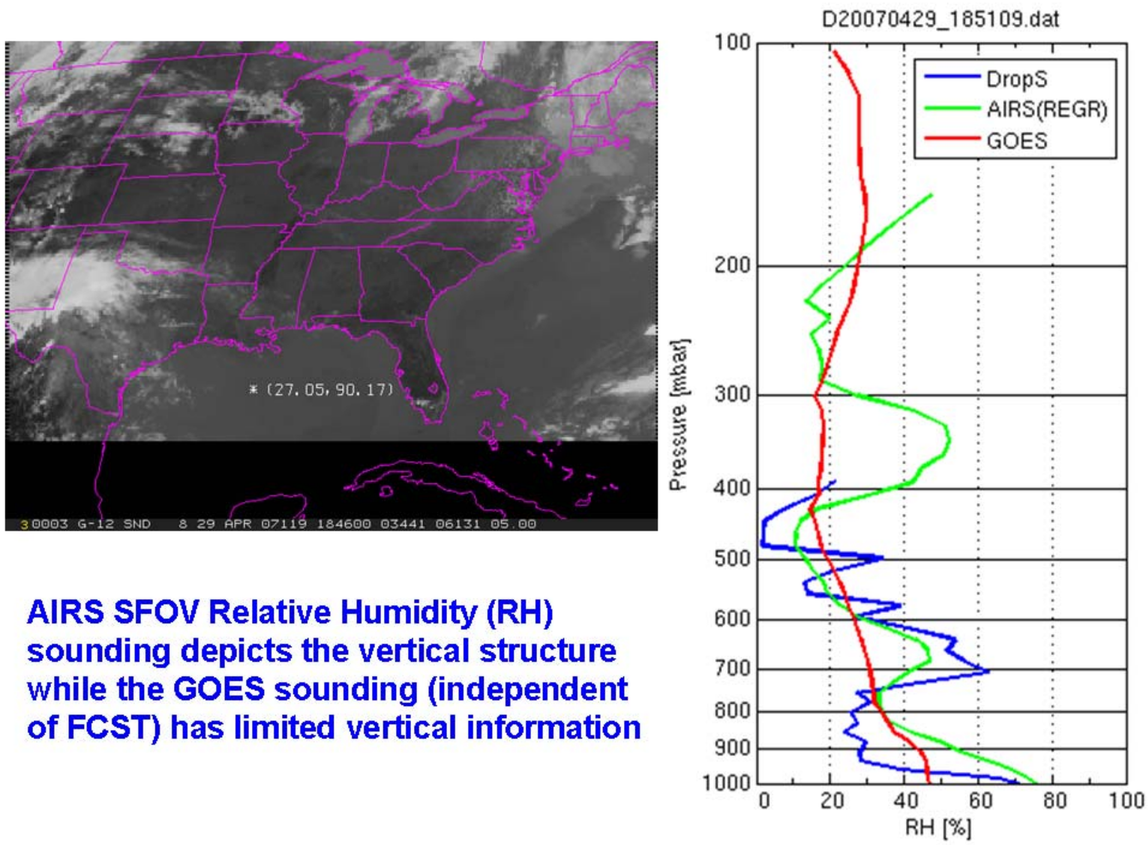


Figure 7.1.4. The GOES Sounder 11 µm BT image at 18:46 UTC on 29 April 2007 (left panel), the soundings from AIRS, GOES Sounder and dropsonde (right panel).

Help GPO and User Community to define the users' needs and operational requirements, and to understand the new and improved products.

High spatial resolution and high temporal resolution are the unique features for applications when compared with the Low Earth Orbit data. Through collaboration between CIMSS and National Center for Atmospheric Research (NCAR, Dr. Hui Liu), a study has been conducted to demonstrate the importance of high spatial resolution data on hurricane track and intensity forecast. NCAR WRF/DART (Data Assimilation Research Testbed) ensemble assimilation system at 36 km resolution is used for Hurricane Dean forecast. AIRS SFOV clear sky soundings from 10 granules on 15 August 2007 (80^{o}W – 5^{o}W; 5^{o}S – 45^{o}N) are generated using physical retrieval algorithm (Li et al. 2000 JAM). Figure 7.1.5 shows the clear sky AIRS SFOV water vapor mixing ratio retrievals at 700 hPa on 15 August 2006 overlaying on the 11 µm brightness temperature (back/white) image; each pixel in color provides vertical temperature and moisture soundings in clear skies.

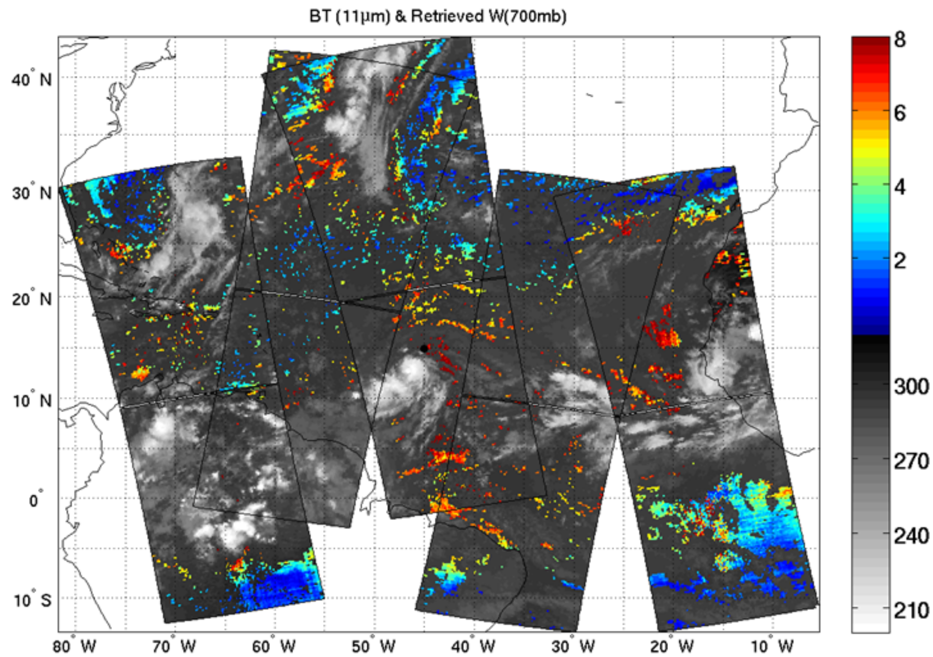


Figure 7.1.5. The clear sky AIRS SFOV water vapor mixing ratio (g/kg) retrievals at 700 hPa on 15 August 2006 overlaying 11 μm brightness temperature (K) (back/white) image.

A NCAR WRF/DART ensemble assimilation system at 36 km resolution for 00 UTC 13 - 16 August 2007 (analysis is generated every 3 hours) is used. A total of 36 ensemble members are included in the assimilation. The CTRL run already assimilates radiosonde, satellite visible and imager water vapor cloud winds, aircraft data, QuikScat surface winds, and hurricane position data. Two assimilation runs are carried out:

(1) AIRSstd run: Same as CTRL run plus AIRS standard T and Q soundings (50 km at Nadir, 3 by 3 AIRS fields-of-view).
(2) CIMSS run: Same as CTRL run plus CIMSS single field-of-view T and Q soundings (13.5 km at Nadir).

Figure 7.1.6 shows the Hurricane Dean track forecast from the control run (blue line), assimilation of AIRS standard profiles (black line), assimilation of AIRS SFOV clear sky soundings developed at CIMSS (green line), along with the hurricane track observation (red line). For a 72 hour forecast, the track error was cut in half. The forecast differences between using AIRS SFOV soundings and using AIRS standard soundings might be due to the different spatial resolutions. AIRS standard sounding product (~50 km spatial resolution at Nadir) has been shown to have positive impact on the global forecast model; the regional forecast model needs the high spatial resolution sounding product as indicated in Figure 7.1.3. The AIRS SFOV sounding product (~13.5 km spatial resolution at Nadir) shows positive impact on the hurricane track forecast with the WRF/DART system at 36 km spatial resolution.

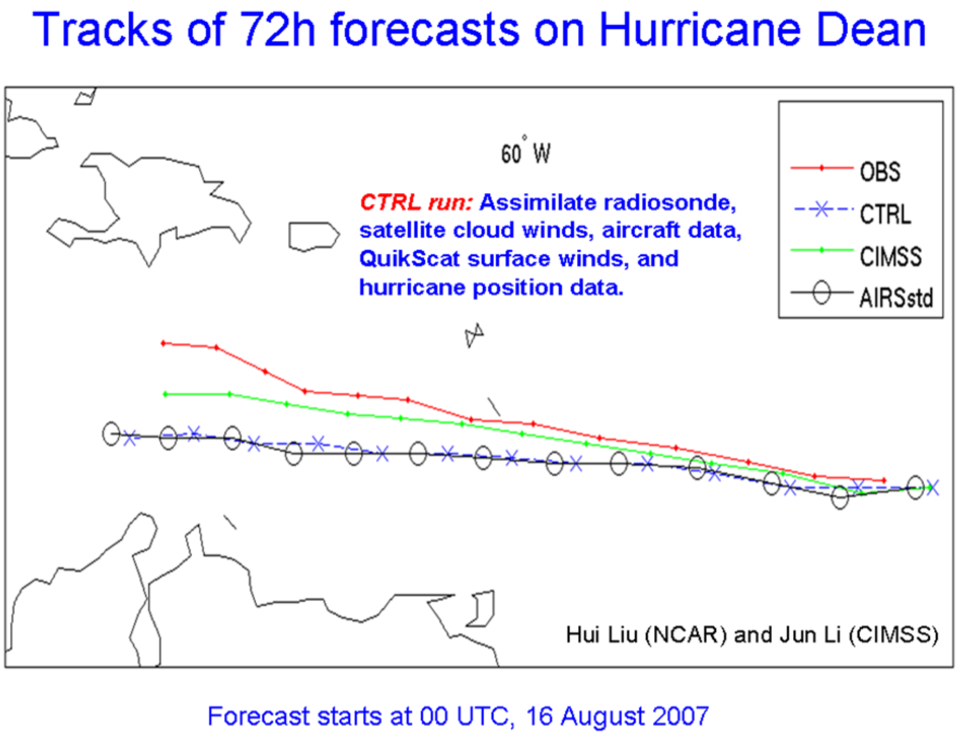


Figure 7.1.6. The Hurricane Dean track 72-hour forecast from control run (blue line), assimilation of AIRS standard profiles (black line), assimilation of AIRS SFOV clear sky soundings developed at CIMSS (green line), along with the observation (red line).

This study demonstrates the unique application of high spatial resolution data. More studies will be carried out on the application of high temporal information.

To study the advantages of GOES-R (and beyond) system over the current GOES system
A recent storm case (Hurricane Ike) was used to demonstrate the advantages of GOES-R ABI on storm nowcasting over the current GOES system due to ABI's higher spatial and temporal resolutions. AWIPS images of the current GOES 10.7 µm IR spectral band were used to generate the animation (see the following link for the animation):
http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2008/09/080913_g12_g13_ir_anim.gif

Hurricane Ike made landfall as a Category 2 storm during the early hours of 13 September 2008. A sequence of AWIPS images of the 1-km resolution MODIS 11.0 µm IR channel data (see the following link - http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2008/09/080913_modis_ir_anim.gif) show better details of the cloud features than could be seen using the 4-km resolution GOES IR imagery.

Figure 7.1.7 shows the simulated 11µm brightness temperature (BT) image for ABI (left) and the current GOES Imager (right). MODIS 1 km spatial resolution data are used. ABI shows more detailed structures of Hurricane Ike after it landed due to its high spatial resolution.

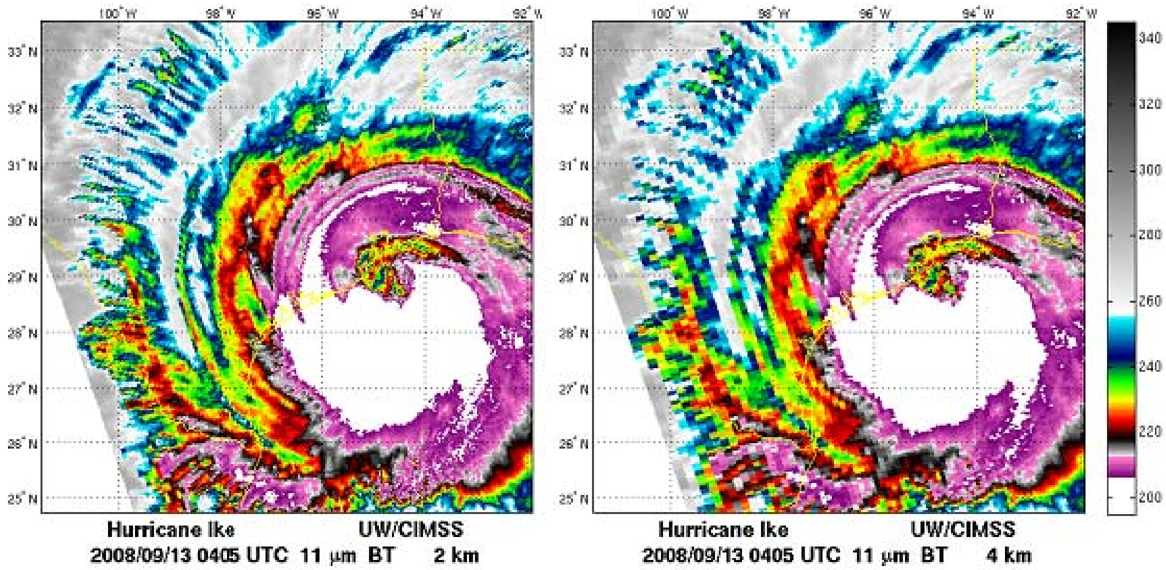
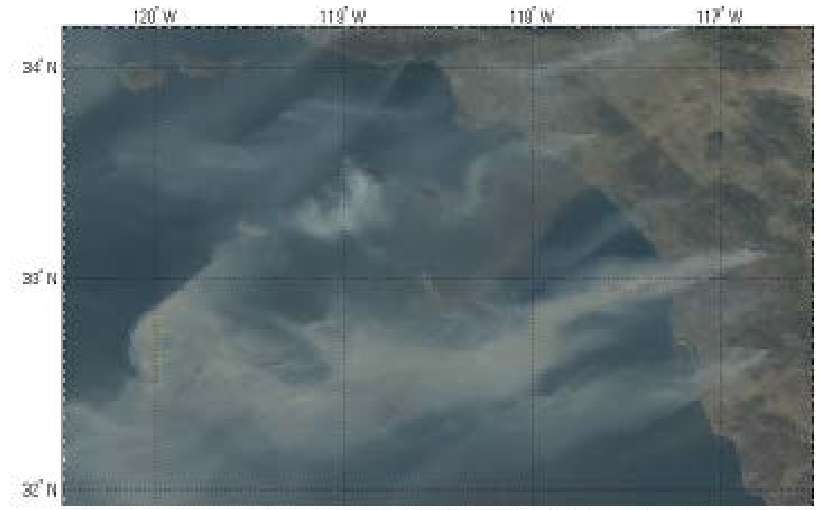
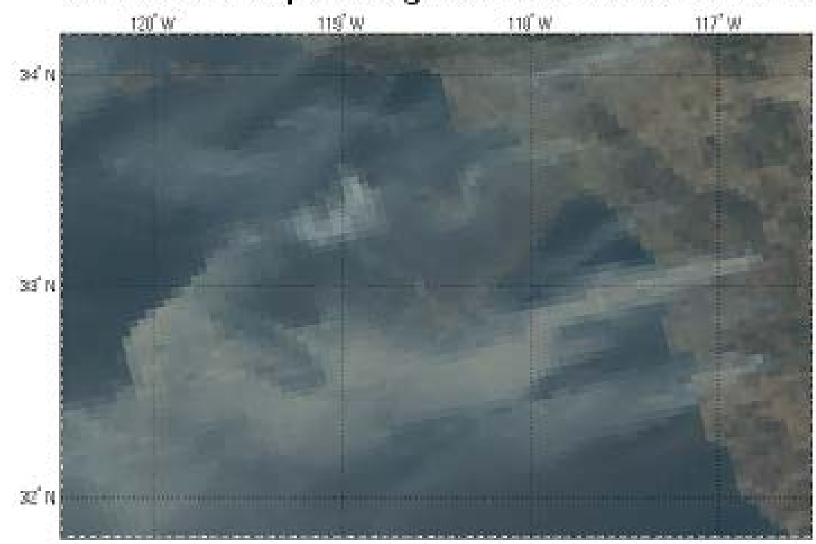


Figure 7.1.7. The simulated 11μm brightness temperature (BT) image for ABI (left) and the current GOES Imager (right) at the time of Hurricane Ike's landing. MODIS 1 km spatial resolution data are used.

Another case is the California wildfire. Fueled by the powerful Santa Ana winds that whip from the high-altitude deserts of the Great Basin toward the Pacific Ocean, 12 large wildfires raged in California on 23 October 2007. The fires clouded the air over the Pacific with dense plumes of smoke that stretched across hundreds of miles. MODIS image illustrates the immensity of this historic fire event. The fire had destroyed hundreds of homes and commercial buildings according to the National Interagency Fire Center. With ABI the smoke evolution can be captured with more details. Figure 7.1.8 shows the simulated ABI composite image (upper) and GOES composite imager (lower), MODIS data from Aqua at 21:00 UTC on 22 October 2007 are used for the simulation. ABI has higher capability on composited environmental image due to more spectral bands; also ABI provides better details for smoke evolution due to its high spatial resolution.



Simulated ABI composite image from MODIS for 22 October 2007



Simulated current GOES composite image from MODIS for 22 October 2007

Figure 7.1.8. The simulated ABI composite image (upper) and GOES composite imager (lower) from Aqua MODIS data at 21:00 UTC on 22 October 2007.

Related Publications and Presentations

Schmit, T. J., J. Li, J. J. Gurka, M. D. Goldberg, K. Schrab, Jinlong Li, and W. Feltz, 2008: The GOES-R ABI (Advanced Baseline Imager) and the continuation of GOES-N class sounder products, *J. of Appl. Meteorol. and Climatology*. (in press)

Jin, X., Jun Li, T. J. Schmit, et al. 2008: Retrieving Clear Sky Atmospheric Parameters from SEVIRI radiance measurements and simulated ABI radiances, *J. Geophys. Res.*, 113, D15310, doi:10.1029/2008JD010040.

Tim Schmit, Jun Li and Jinlong Li attended the 5th GOES Users' Conference (GUC) held from 23 to 24 February 2008 in New Orleans, LA. Tim Schmit gave an oral presentation on ABI, Jinlong gave a poster presentation on trade study for future GOES hyperspectral IR Sounder, Jun Li gave a poster presentation on the applications of current GOES Sounder and future needs. In addition, materials supported under this project are presented by Tim Walsh, Jim Gurka, Jack Beven from NOAA at the 5th GUC.

Li J., T. J. Schmit, J. J. Gurka, H. Bloom et al. 2008: Advanced Infrared Sounding System for Future Geostationary Satellites, ITSC16, Angra dos Reis, Brazil, 7 - 12 May 2008.

Schmit et al. 2008: Baseline Instruments on GOES-R, 3rd GOES-R AWG annual meeting, 23 - 26 June 2008, Madison, WI.

Li, J., T. J. Schmit, J. J. Gurka, et al. 2008: GOES-R trade studies, 3rd GOES-R AWG annual meeting, 23 - 26 June 2008, Madison, WI.

Schmit, T., 2008: GOES derived product images: Past, present and future. The 2008 EUMETSAT Meteorological Satellite Conference, Darmstadt, Germany , 8 - 12 September 2008.

8. CIMSS Participation in the Development of GOES-R Proving Ground

CIMSS Project Leads: Kaba Bah, Scott Bachmeier
CIMSS Support Scientist: Kathy Strabala, Justin Sieglaff
NOAA Collaborator: Jim Gurka, Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
5. Provide critical support for the NOAA mission

Proposed Work

In 2008, the goal of our research is to prepare National Weather Service (NWS) forecasters in the use of GOES-R Advance Baseline Imager (ABI) data prior to launch. This undertaking involves testing and validating new products and display techniques in an operational system. The CIMSS Proving Ground team is working directly with NWS forecast offices, involving NWS personnel in the early evaluation of these new satellite products. This way the CIMSS Proving Ground team can address any concerns NWS personnel might have, strengthen our relationships and expand participation. Together with forecasters, we are testing and evaluating GOES-R proxy data and algorithms. This will ensure that GOES-R products will be available and useful to the NWS forecasters soon after launch.

Summary of Accomplishments and Findings

The GOES-R Algorithm Working Group (AWG) at CIMSS has produced a 2-km spatial resolution CONUS simulation for the convective outbreak on 4-5 June 2005. These 2-km CONUS Weather Research and Forecasting (WRF) output data were used as input into radiative transfer models to simulate the 16 ABI bands.

1. We have developed two independent algorithms to read in these simulated ABI datasets and output new NetCDF files for easy display in the Advanced Weather Interactive Processing System (AWIPS) environment. The first technique involves using McIDAS-X to create "AREA" files that can also be displayed in McIDAS; these "AREA" files are then converted into AWIPS-ready NetCDF files. The second technique uses IDL to convert simulated ABI NetCDF files directly into AWIPS-ready NetCDF files. Both methods allow simulated GOES-R ABI data to be displayed in AWIPS. We continue to test both methods rigorously for possible improvements.

2. The AWIPS-ready NetCDF files created at CIMSS have been used to display successfully all 16

simulated ABI bands on our local NWS Weather Event Simulator (WES). Figure 8.1.1 shows bands 9 [6.96 µm] through 16 [13.3 µm] of our simulated ABI west CONUS displayed in AWIPS. WES training software, using archived data, is a post-time emulator of AWIPS Display Two Dimensions (D-2D), which forecasters use on shift as if in real time. The WES framework allows forecasters to learn about ABI spectral bands and products within a familiar operational-style environment and to become involved at an early stage in product applications. This way, forecasters can evaluate the products' utility and provide comments and feedbacks so that algorithms and displays can be modified to suit their needs. This collaboration is helping to strengthen and expand our existing partnerships with the NWS forecast offices. Working directly with the NWS forecasters and providing training before launch is necessary so all ABI spectral bands and derived products can be used successfully by forecasters immediately after ABI enters operational scan mode after launch.

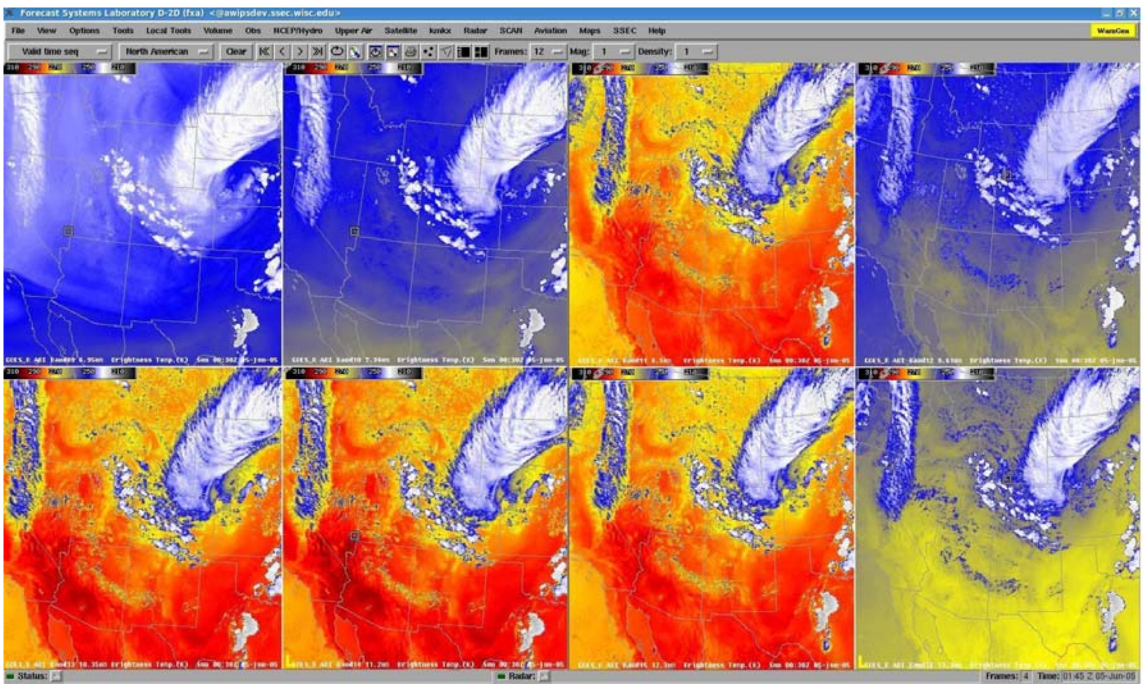


Figure 8.1.1. ABI Bands 9-16 converted to an AWIPS-ready NetCDF and displayed in AWIPS.

3. We used spectral band differences to derive products such as Normalized Difference Vegetation Index (NDVI) [0.865-0.64] µm, low versus high clouds [6.19-11.2] µm, mid level temperatures [13.3-11.2] µm, cloud phases via visible/near-infrared [1.61-0.64] µm, and cloud phase via infrared [11.2-3.9] µm.

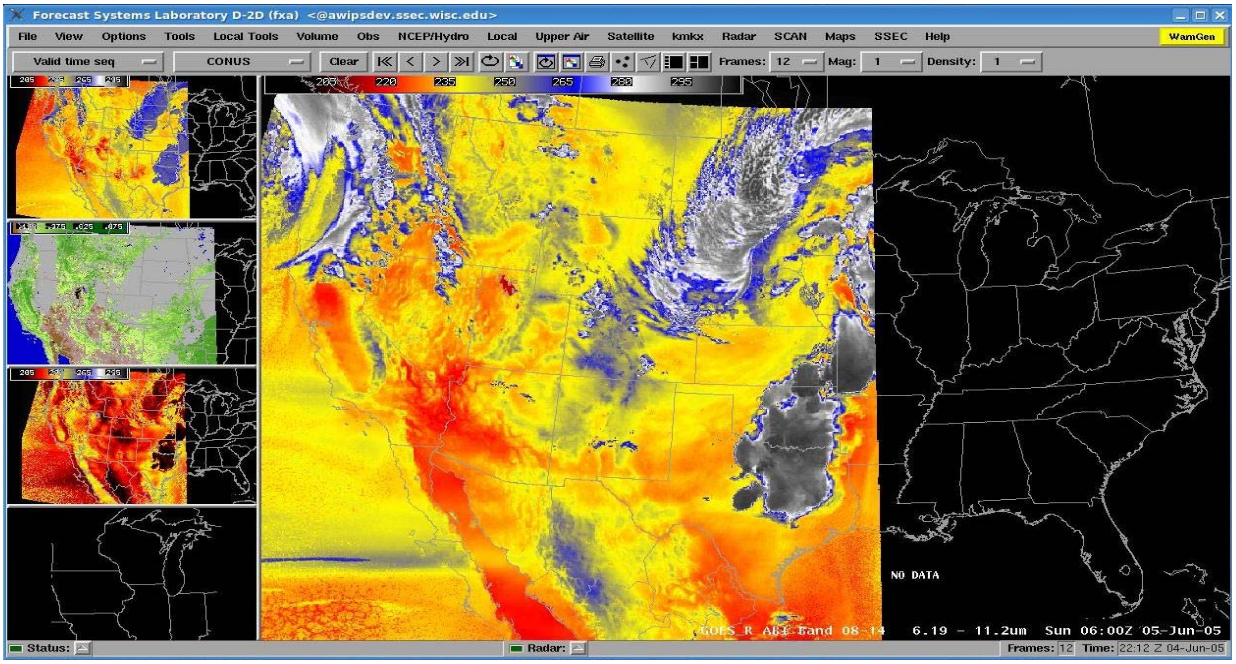


Figure 8.1.2. ABI band differences for bands 08 and 14 [6.19-11.2] μm converted to an AWIPS-ready NetCDF file. This particular band difference allows us to identify low clouds versus high clouds.

4. On 31 July 2008, NWS staff members Kim Licitar, Curt Backlund, Steve Hentz, and Chris Franks from the Milwaukee/Sullivan office came to visit the CIMSS GOES-R proving ground team members and to take a look at the next generation AWIPS and get a first hand demonstration of our simulated ABI data and derived products displayed in AWIPS. On 17 September 2008, Marcia Cronce, the newly-appointed liaison between the NWS at Sullivan and CIMSS/SSEC came to visit. We gave her a tour and demonstrated AWIPS-2 and our simulated ABI datasets and derived products in WES/AWIPS. Feedbacks from both groups regarding our proving ground efforts were very positive. We have already added extra color bars in our localized simulated ABI study case as a result of these feedbacks.

5. On 29 - 31 July 2008, two of our team members, Scott Bachmeier and Kathy Strabala, attended the Alaska Environmental Satellite Workshop at Fairbanks, Alaska, where they gave presentations and talks on CIMSS satellite proving ground activities and the International MODIS/AIRS Processing Package (IMAPP) respectively. Links to the respective presentations can be found at: http://cimss.ssec.wisc.edu/goes_r/proving-ground.html

6. In addition to successfully integrating these simulated ABI datasets into our local WES study case, we were able read these ABI NetCDF files into McIDAS-V and used some of the built in product display tools to generate scatter plots and analyze correlations between bands at particular areas of interest as shown in Figure 8.1.3.

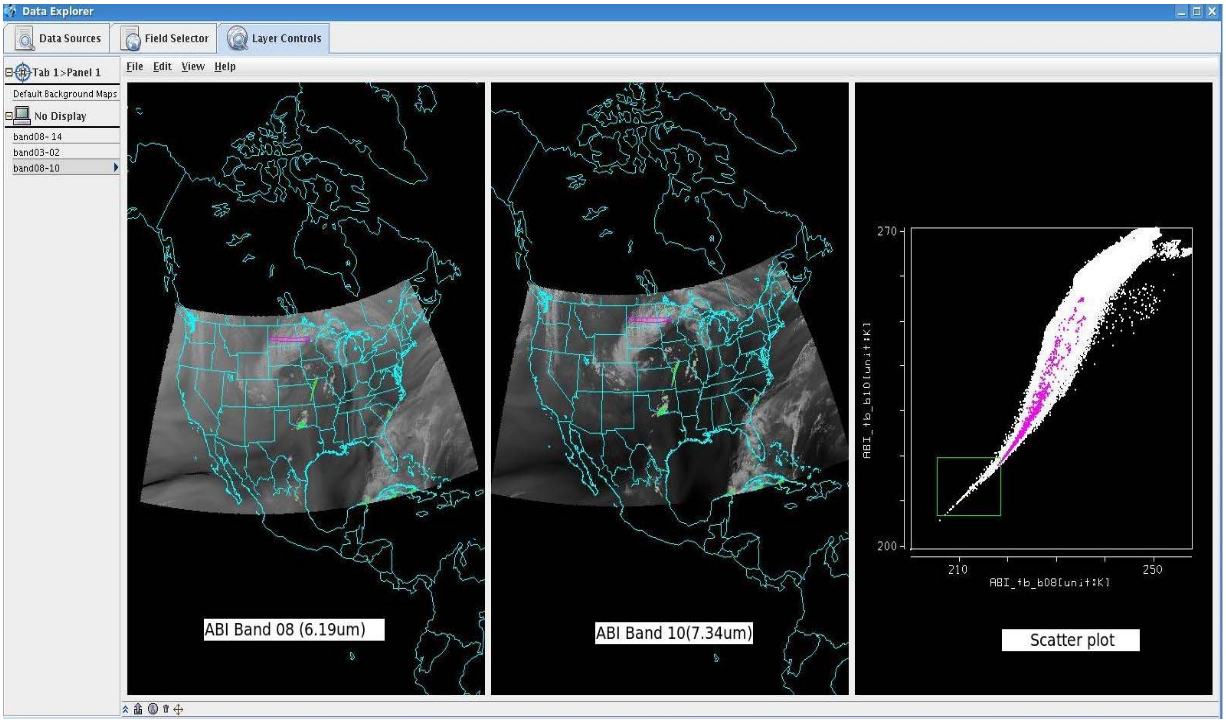


Figure 8.1.3. Simulated ABI bands 08 (6.19 µm) and band 10 (7.34 µm) with the corresponding scatter plot displayed in McIDAS-V. Note the linkage between the images and scatter plot (magenta), or the scatter plot and the image (green).

Presentations and Conference reports

J. Sieglaff, K. Bah, T.J. Schmit, J. Gerth, S. Bachmeier, S. Ackerman, W. Feltz, K.Strabala, G. S. Wade, J. Otkin, 2008. CIMSS GOES-R Proving Ground Plans, Presented at the GOES-R AWG Annual Review Meeting, 23 - 26 June 2008, UW-Madison, Madison, Wisconsin.

S. Bachmeier, K. Strabala, J. Gerth, 2008. CIMSS Satellite Proving Ground Activities presented at the Alaska Environmental Satellite Workshop, 29 - 31 July 2008, Fairbanks, Alaska.

K. Strabala, L. Gumley, A. Huang, J. Key, E. Weisz, J. Li,, 2008. IMAPP: Software to Transform EOS Direct Broadcast Data into Science Products, Presented at the GOES-R AWG Annual Review Meeting, 23 - 26 June 2008, UW-Madison, Madison, Wisconsin.

9. Investigations in Support of the GOES-R Program Office

CIMSS Project Lead: Paul Menzel

NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
5. Provide critical support for the NOAA mission

EUMETSAT and AMS Satellite Conference in Amsterdam

From 24 - 28 September 2007 I attended the EUMETSAT / AMS Met Sat Conference. 630 people from 40 countries participated in over 70 oral and 350 poster presentations. I was especially impressed with the applications of SEVIRI and IASI. It was gratifying to see several students from my mini-remote sensing schools in Europe –Alessio Bozzo, Elisa Carboni, Igor Gunta, Andrzek Kotarba, Eszter Labo, Tiziano Maestri, Monika Pajek, Sylvia Puca, and Piotr Struzik. The quality of the papers and posters was very high and the conference provided an excellent opportunity for young scientists from both sides of the Atlantic to meet and plan collaborations.

Several items stand out: (1) Nick Nalli presented a model that accounts for increasing sea surface emissivity with increasing wind speed, (2) Thomas Nauss described an improved algorithm for infrared delineation of raining and non-raining clouds, (3) Darren Jackson showed an impressive poster of twenty year trends in HIRS radiances accounting for orbit drift, sensor to sensor differences, and CO2 increase – we discussed collaboration on the HIRS cloud work, (4) Thomas Wagner presented evidence where increased SST results in decreased cloud cover with clouds occurring higher in the atmosphere, (5) Hermann Mannstein noted that Germany was providing guidance to aircraft so that cirrus contrail formation could be avoided, and (6) Alexander Uspensky requested help in installing our AIRS cloud detection and spatial filtering software in exchange for some of the CO2 profile verification data sets – Youri Plokhenko and Alexander Kukharsky will be connecting to work out some of the details.

GOES-R Independent Review Team

The GOES-R IRT met 7 - 8 November 2007 to review the Flight Program, SE&I, and Ground Segments (I was not able to attend but reviewed the conclusions and provided input). The IRT concluded that DOC, NOAA, and NASA have taken the right steps to put together a sound GOES-R Program. Progress in the Ground area was substantial and reflective of significant work; the Algorithm Working Group presentation provided confidence regarding a key performance risk areas. My concern with the report was that it implied that fewer dollars for the ground segment mean fewer products - I believe it means some products arriving a little later. Some remaining concerns of the IRT include (1) the two satellite GOES-R Program baseline is insufficient to address GOES operational requirements - a minimum of three satellites is required; (2) addressing any deltas in cost as part of outyear budget processes fails to adequately provide contingency and may result in a decrease in the likelihood of successful Program execution; and (3) NOAA should consider separating Operations and Sustainment (O&S) cost and budget from development and procurement cost and budget. Internally, the IRT felt that the GOES-R Program is ready for KDP-C/D.

Review of Satellite Recapitalization Plan

In December 2007, I reviewed a draft of the NOAA Satellite Recapitalization Plan. I noted that this document should make planning much more coherent and made a few comments/corrections. These included: (1) Re-establishing a water vapor imaging capability on subsequent NPOESS imagers is not assured – this should be mentioned as an area for NOAA vigilance. (2) A major deficiency in the current observing system is its inability to measure boundary layer temperature and moisture structure changes – short term weather forecast improvements will hinge uniquely on meeting requirements for these measurements. (3) A geo coastal waters imager is needed to observe coastal processes – multiple LEOs cannot offer the time resolution required (e. g. red tides). (4) A clearer research to operations path must be sought – perhaps this is not the document to spell this out but it should be noted – R2O need not only be sought with NASA as ESA/EUMETSAT may also be viable partners. (5) It would be useful to add plots of space and time domains for land, ocean, and atmospheric events for which NOAA must observe the event, analyze the measurements, and initiate appropriate actions – those plots would tie the satellite plans to the required measurements.

GOES-R Presentations

On 20 February 2008, I gave a presentation on “Evolving to a Geostationary High Capability Sounder” at the 6th Annual NOAA-CREST Symposium held at the University of Puerto Rico in Mayagüez, PR. I stressed the need for high spectral resolution infrared measurements to measure boundary layer temperature and moisture structure changes; short term weather forecast improvements will hinge uniquely on meeting requirements for these measurements.

EUMETSAT MTG User Consultation

In November 2007, EUMETSAT asked for guidance regarding geo imager and sounder proximity in orbit and scan scenarios for improved winds for regional weather forecasting. (1) Regarding geo imager and sounder separation, I replied that the thought for ABI and HES was that they had to be separated by 75 km. With this separation, the products that needed both ABI and HES would be fine. It was felt that this was not too difficult in that it is done all the time with ComSats. I also noted that a one degree distance in longitude between the two satellites will cause up to 0.1 K BT difference for ABI 11 um band in clear skies due to the two-satellite system for ABI and HES. That said, I concluded that I was not sure that one can argue very strongly for retaining a spec if it is causing concern. (2) Regarding atmospheric motion vector derivation, I indicated that 30-min was preferred for GOES-8 (4 km). For the HES/GIFTS retrieval winds, we have used 30-min and 40-min cubes. Our intuitive feel is for traditional wind tracking with 5km imagery, 30-min improves on 60-min. I concluded by recommending that the International Winds Working Group could address this in their meeting in Annapolis, MD during the week of 14 April.

Discussions with ISRO on Possible Collaborations

Mr. Virender Kumar (Attache for Indian Space Research Organization, Embassy of India, Washington, DC) and Dr. Ramakrishnan Rajgopalan (ISRO software specialist) visited SSEC on 4 - 6 December 2007 to discuss possible collaborations between ISRO and SSEC regarding the Geo-Sounder to be launched in 2008 as part of the Indian Earth Observation Space Program. It was noted that SSEC has had a leadership role in geostationary soundings since the launch of the VISSR Atmospheric Sounder on GOES-4 in 1981; this has continued with the current GOES Sounders started in 1994. With the pending launch of INSAT-3D, it is the hope that collaborations on geostationary soundings could be started. As the US and India will be the only countries with space agencies providing geostationary sounding data in the near future, it is the belief that working together will improve the products available and enhance the utilization of these data. Some resources would be necessary to prepare the sounding software for transfer to ISRO as well as to gather materials for training seminars. A list of possible SSEC projects that might be of interest to ISRO was drafted and sent to ISRO for consideration; these include McIDAS licenses and training, GEO Sounder algorithms and software and training, and broader data sharing plans.

Discussion of GOES-R Sounding Strategy

On 24 April, Greg Mandt, Hal Bloom, and Jim Gurka from the GOES-R Program Office visited CIMSS to discuss strategies for resurrecting the geostationary sounding program and to hear about GOES-R activities at CIMSS. Dave Crain from ITT also attended. Greg noted that the GOES-R Sounder was low on the list of priorities within NESDIS and that the user community needed to make a convincing case for the expected benefit. Dave noted that ITT was preparing to launch an advanced ABI with additional sounding channels for Japan; he suggested that global coverage with rapid refresh of a broadband sounder might have impact on global NWP. It was noted that the regional impact of geo-soundings, especially with hyperspectral resolution, would come from the improved depiction of boundary layer moisture; the OSSE published in 2000 (Aune, R. A., W. P. Menzel, J. Thom, G. Bayler, H.-L. Huang, and P. Antonelli, 2000: Preliminary Findings from the Geostationary Interferometer Observing System Simulation Experiments (OSSE). NOAA Technical Report NESDIS 95, U.S. Department of Commerce, Washington, DC, 18 pp.) gave strong evidence of the expected positive impact. The meeting concluded with the suggestion that Jack Hayes, Director of NWS, be scheduled for a briefing on the geo-sounding capabilities and expected benefits.

Science Steering Committee of the JCSDA

On 11 - 12 June 2008, I participated in the meeting of the Science Steering Committee (SSC) of the Joint Center for Satellite Data Assimilation at the University of Maryland Baltimore Campus outside of Baltimore, MD. Director Lars Peter Riishojgaard noted the revised JCSDA mission statement focusing on NWP performance improvement and reported on recent progress in many areas including assimilation of IASI radiances with positive impact, utilization of COSMIC refractivities, wind vectors impact experiments, preparations for new sensors, and continued support for the Community Radiative Transfer Model (CRTM). The SSC offered several suggestions. They included:

- a short Directors report would help focus SSC evaluation of the past year and steering the next
- results from studying NWP impact of satellite data should be presented with indicators of statistical significance
- a useful metric that should be considered is forecast imagery which can be validated against GOES, METEOSAT, etc. The prevalent metric of 500 hPa anomaly correlation is not a reliable indicator of a perfect forecast. It is computed using virtual temperature and thus can contain offsetting errors in temperature and specific humidity.
- a stronger effort on water vapor assimilation and prediction is needed – a plan to evaluate use of AIRS water vapor sensitive measurements must be made and executed.
  * more regional model impact studies should be pursued to study more effective assimilation of hourly GEO radiances
- better usage of existing and planned new satellite data will require implementing some management lessons from our European partners – agreement on goals, well defined metrics, a reward system for supporting community software, adequate staffing for assimilation as well as validation,…
- the new emphasis on NWP performance suggests that higher priority should be given to activities focused on the first two activity areas (CRTM and preparing for NPP data) – the other four activity areas should be supported in the context of accomplishing tasks in the first two
- JCSDA demonstration of assimilation of new satellite data must be followed by EMC operational implementation as quickly as possible – R2O efficiency must be charted – it will be a must for NPP – the lessons from the slow IASI implementation must be learned

EUMETSAT MTG User Consultation

On 19 - 20 June I attended the Meteosat Third Generation (MTG) Mission Team Meeting. About thirty scientists from Europe gathered to hear about recent Phase A studies for the Infrared Sounder (IRS) and Lightning Imager (LI) planned for MTG. MTG will have two separate platforms: one for the Fast Combined Imager (FCI) with Lightning Imager that must be available 2015 and another for the IRS that must be available 2017. There are still possibilities that MTG will also have an UltraViolet Sounder (UVS) on one of the platforms. The ESA Sentinel 4 mission that includes a geo-IR sounder and geo-UV sounder are also being included in the MTG mission configuration planning – some instruments will be swapped over to the MTG and omitted from Sentinel 4. Differences in the instrument plans are being investigated and compromises will be discussed. EUMETSAT Council approval for the MTG Program is expected on 09 October 2008; ESA ministerial approval for Sentinel inclusion in MTG plans is anticipated in November 2008.

Industry bids for the instruments from Thales Alenia Space (TAS) and Astrium are currently being reviewed by ESA/EUMETSAT. Challenges for the FCI inter channel co-registration are being addressed. False alarm detection in the LI is being specified very tight – alleviation is possible if the NESDIS algorithm is understood and used. Navigation in the IRS can be accomplished with a Built in Imager or higher resolution super pixels – one approach will be selected soon. IRS full disk coverage will be accomplished in 60 minutes comprising of four 15 minute local area coverages. IRS detector arrays are being bid by SOFRADIR (France), SELEX (UK), and AIM (Germany).

Stephen Tjemkes spoke about the IRS simulations that are underway – good collaboration with NESDIS/CIMSS was noted. Currently Optimal Spectral Sampling (OSS) is the radiative transfer code of choice – it is an order of magnitude faster than RTTOVS for profiles and adjoints. Applications for LI and FCI combined with TRMM/TMI data for detection of convective initiation and estimation of rainfall amounts were explained by Dan Rosenfeld. Vicarious calibration approaches for vis/NIR data were presented by Yves Govaerts – an on board Solar Diffuser will be supplemented by ground based data. IRS detection of pollution events was deemed promising by Cathy Clerbaux and Thierry Phulpin in complementary presentations – tropospheric O3 (within 10%) and total column CO (within 10%) were viewed as possible in spite of winter challenges for thermal contrast. Peter Builtjes described simulations of PM2.5 air quality forecast potential with inclusion of IRS data. Hans Huang showed modest positive impact from IRS data in local forecasts in several IHOP case studies. It was concluded by MTG Planning team chairman Wolfgang Benesch that the pre-launch studies are indicating that MTG will be able to fulfill the lofty expectations that have been placed upon it.

I gave an update on GOES-R status, noting that movement toward a geo-sounder was strongly supported by the NRC and the environmental remote sensing community.

CEOS Support

In the past year, I participated in several telecoms regarding the CEOS response to the GCOS Implementation Plan, the Way Forward to CEOS Virtual Constellations, and preparations for the upcoming CEOS meetings.

I also reviewed the responses to the questionnaires regarding actions underway in the GEOSS Societal Benefit Areas. I noted that the responses represent a good start to a dialogue, but I felt that another iteration was needed to fine tune the action / issue list. The next version of the Questionnaire should focus on the critical questions – what, why, when, who, and how (and maybe how much effort is needed). References for products and/or web sites should be encouraged. Some organizations should coordinate responses better (e.g. STAR with respect to SST, retrieval system & assimilation,…). Agency commitment to these CEOS actions seems to be missing (not surprisingly many responses indicated funding as an issue – some indication of how much is needed would have helped). Common issues (aside from funding) were open data access, need for validation exercises with in situ observations, and better definition of actions was waiting upon pending Working Group meetings.

I prepared some thoughts regarding plans for a Workshop on AVHRR plus HIRS Climate Data Records (CDRs) to be held in late 2008. Andy Heidinger and Fred Wu will be the conference chairs. Current thinking is that CDRs relevant to land, ocean, and atmosphere will be discussed. Product leads will arrange for presentations on products in a cross-cutting way. The first day of the workshop will focus on radiance calibration.

10. A CIMSS Research Study of the Next Generation GOES Data Compression

CIMSS Project Leads: Bormin Huang, Allen Huang
NOAA Collaborators: Roger Heymann, Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

CIMSS is developing data compression techniques for the Geostationary Imaging Fourier Transform Spectrometer (GIFTS) that was develop by the NASA Langley Research Center under the NASA New Millennium Program. The National Academy of Sciences' Committee on Earth Science and Applications from Space recommended that NASA and NOAA complete the fabrication, testing, and space qualification of the GIFTS instrument. The EUMETSAT has formalized their decision to proceed with flying a payload including the Infrared Sounder (IRS) on the geosynchronous Meteosat Third Generation (MTG). The IRS is an advanced, high spectral resolution sounder which is very much like the GIFTS. The use of robust data compression techniques with error resilience capabilities for efficient and effective data rebroadcast will be essential for future NOAA geostationary environmental satellites.

Summary of Accomplishments and Findings

- Demonstrated the GIFTS data compression at NASA Langley. Finished the GIFTS lossless data compression software for delivery to NOAA and NASA.
- Presented the GIFTS data compression work at the CCSDS Multispectral and Hyperspectral Data Compression (MHDC) meeting.
- Developed lossless error-resilient compression code for the GIFTS data rebroadcast.
- Organized the 2008 SPIE International Conference on Satellite Data Compression, Communications, and Archiving, which was held in San Diego, CA, 10 - 14 August 2008.
- Provided GIFTS & AIRS data compression benchmark for the CIMSS PPVQ compression code vs. the GZIP used in the NCDC archiving.

Publications and Conference Reports

Bormin Huang, Shih-Chieh Wei, Hung-Lung Huang, William L. Smith, and Hal J. Bloom: "Vector Quantization with Self-Resynchronizing Coding for Lossless Compression and Rebroadcast of the NASA Geostationary Imaging Fourier Transform Spectrometer (GIFTS) Data," *Proc. SPIE*, *7084-7*, 2008.

Shih-Chieh Wei and Bormin Huang: "Ultraspectral Sounder Data Compression Using the Non-Exhaustive Tunstall Coding," *Proc. SPIE*, *7084-5*, 2008.

11. Joint Center for Satellite Data Assimilation (JCSDA)

11.1. Assimilating Sea Surface Winds Measured by ASCAT and Evaluating the Impact of ASCAT and WINDSAT/CORIOLIS in the NCEP GDAS/GFS

CIMSS Project Leads: Li Bi, James Jung, Steve Ackerman
NOAA Collaborators: John Derber, Russ Treadon , Zorana Jelenak
NOAA Strategic Goals Addressed:

1. Serve Society's Needs for Weather and Water Information

Proposed Work

We propose to work with JCSDA (Joint Center for Satellite Data Assimilation) personnel to evaluate assimilation techniques and the forecast impact of assimilating the new scatterometer Advanced SCATterometer (ASCAT) in the National Center for Environmental Prediction (NCEP) Global Data Assimilation/Global Forecast System (GDAS/GFS). We plan to develop the quality control (QC) procedures for the assimilation process for ASCAT data. We also plan to modify NCEP's Gridpoint Statistical Interpolation (GSI) software to test a thinning routine for the ASCAT winds. We will conduct a two season ASCAT assimilation experiment, testing and comparing the attributes of using the ASCAT data. We will work with JCSDA on thinning resolution selection and assimilation weights of the ASCAT data. After the two season ASCAT experiment is completed, we propose to compare the attributes of using the ASCAT data to a control experiment by computing the geographic distribution of Forecast Impact (FI) along with using NCEP's verification software to quantify forecast impacts. Ultimately these efforts should lead to operational implementation of ASCAT data in the NCEP weather forecast models.

Summary of Accomplishments and Findings

We completed the two season GFS simulations from 01 July - 31 August 2007 and from 01 December - 31 January 2008. A simulation containing all of the NCEP operational data (control) and a simulation containing all of the NCEP operational data and including ASCAT sea surface wind observations. The latest version of NCEP's GSI and its associated scripts were modified to read, spatially thin, and assimilate the ASCAT data. Quality control and thinning procedures were derived. These QC procedures are similar to the WindSat and QuikSCAT. The operational version of NCEP's global forecast model at the current operational resolution was also used. Procedures outlined by NCEP to transition new data types into operations were used for these experiments.

Data thinning experiments were conducted at 150, 100, and 50 km resolution. ASCAT thinned to 100 km had the best overall results. Large observational errors were found in the ASCAT data near coasts and in regions of sea ice. These observations were rejected by our QC criteria. Various assimilation weights were also tested. Observation errors of 3.5 m/s also produced the best overall results. All software modifications made to assimilate ASCAT are available to NCEP and others.

Figure 11.1.1 displays the geographic distribution of standard deviation of the 10 meter wind speed for observation minus background (O-B) and observation minus analysis (O-A) during January 2008. The largest standard deviations are found over the Northern Pacific, in the topical Western Pacific and north Atlantic (Figure 11.1.1.a). As expected, after ASCAT data were assimilated by the GSI, the standard deviations are significantly reduced in almost all regions (Figure 11.1.1).

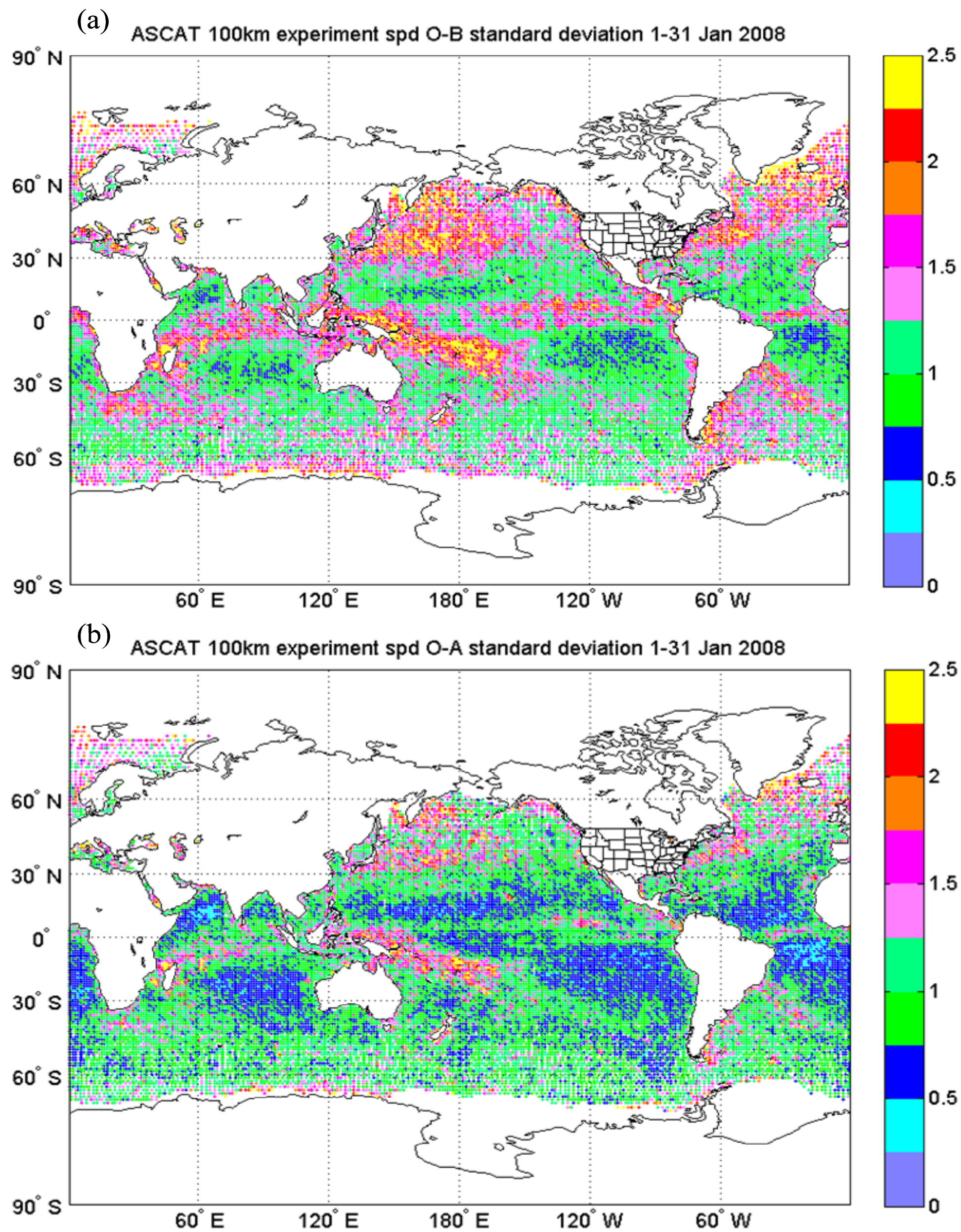


Figure 11.1.1. The geographic distribution of standard deviation for ASCAT during January 2008. Panel (a) shows the results of observation minus background (O-B) and panel (b) shows the results of observation minus analysis (O-A) for January 2008.

The geographic distribution of FI, explained in Zapotocny et al. (2007), was used to show the improvement/degradation the ASCAT data had on the daily forecasts. Figure 11.1.2 displays the 10 meter wind speed geographic distributions of FI for August 2007 (a) and January 2008 (b) in the 6 hour forecast. The range of FI is from -60 to 200. The largest FI are in Africa, South America and China for August and in Africa, South America and Australia for January. Figure 11.1.3 shows the 500 hPa temperature geographic distribution of FI. The largest FI of temperature in the 6 hour forecast are found in tropics during both the August 2007 (a) and January 2008 (b) experiments.

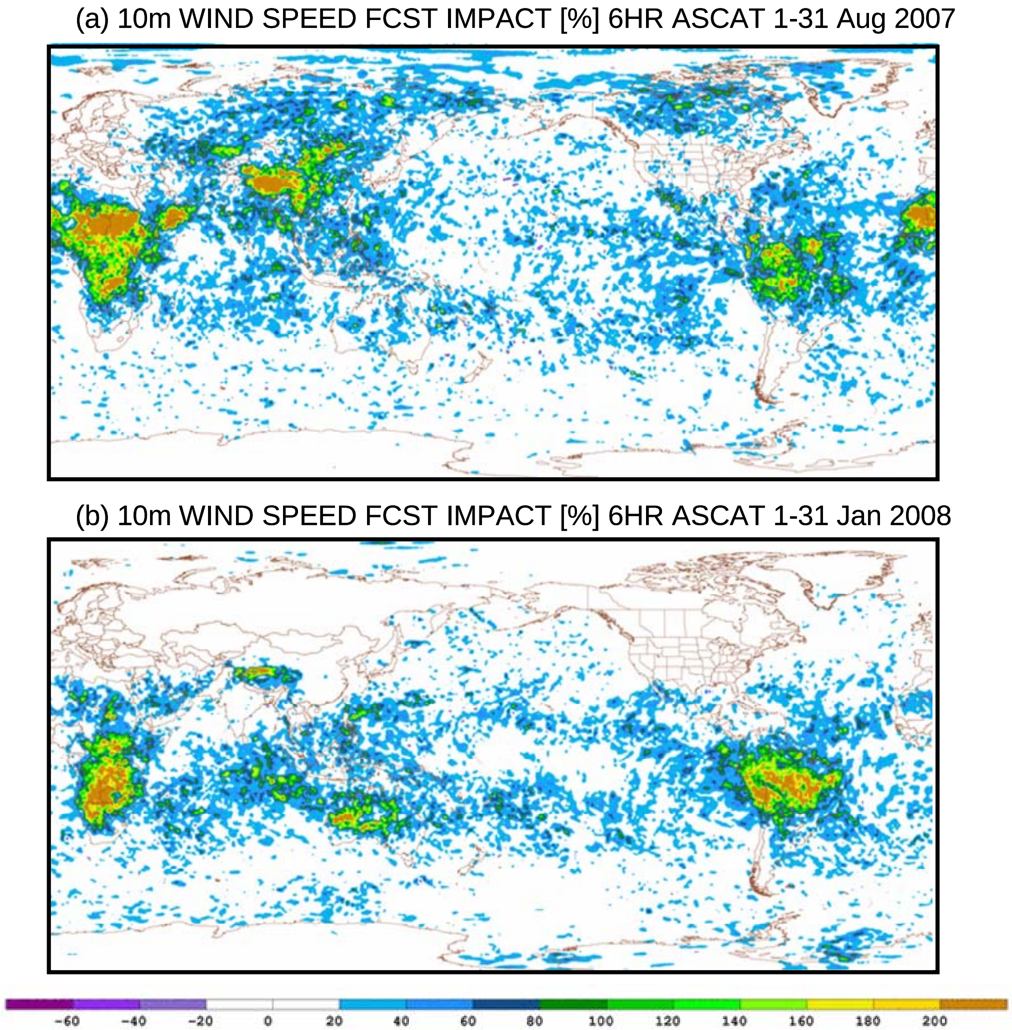


Figure 11.1.2. Forecast impact on the 10m wind speed in the 6 hour forecast from assimilating ASCAT winds. Panel (a) is during August 2007 and (b) is during January 2008. Blues, greens and yellows are varying degrees of improvement, reds are degradations.

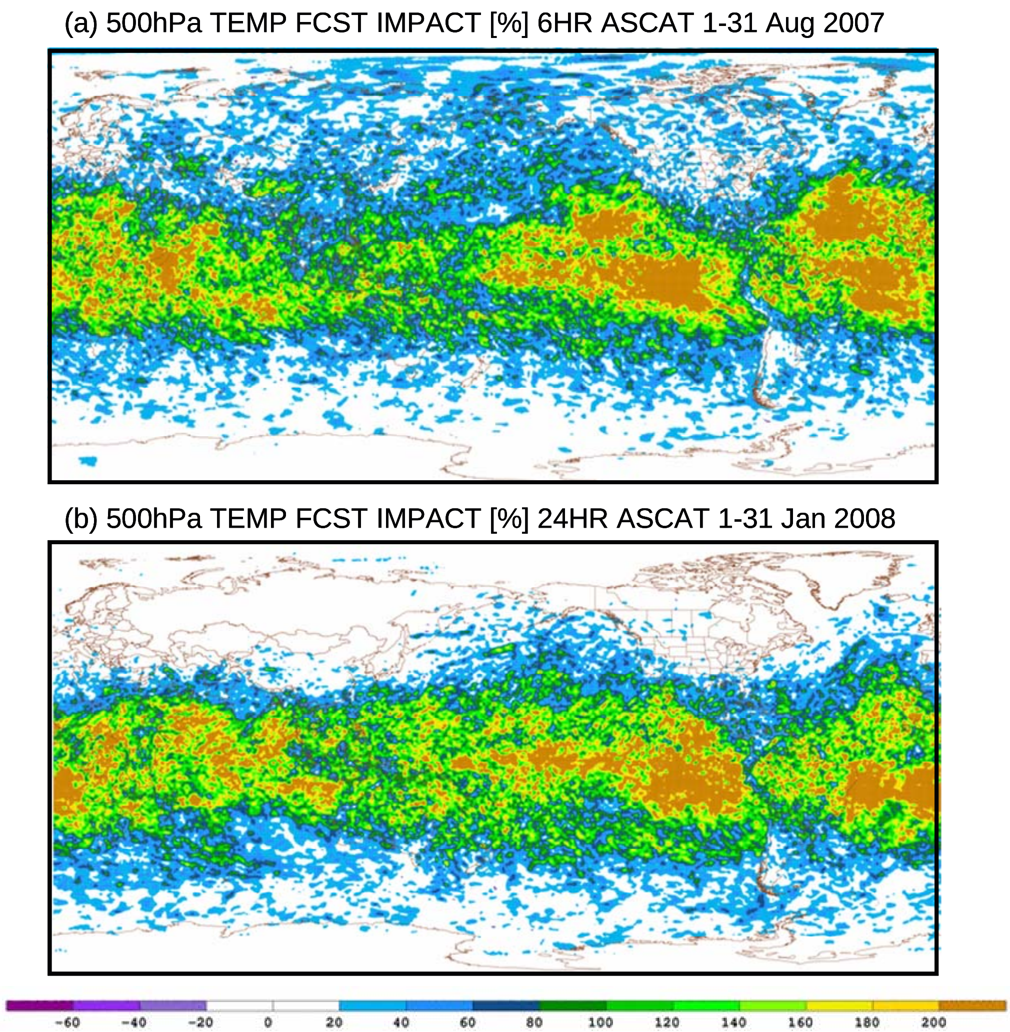


Figure 11.1.3. Forecast impact on the 500hPa temperature field in the 6 hour forecast from assimilating ASCAT winds. Panel (a) is during August 2007 and (b) is during January 2008. Blues, greens and yellows are varying degrees of improvement, reds are degradations.

Publications and Conference Reports

Presented ASCAT data assimilation results at the 6th annual Joint Center for Satellite Data Assimilation (JCSDA) workshop, Linthicum, MD, 10 - 11 June 2008.

Bi, L., J. A. Jung, M. C. Morgan and J. F. Le Marshall 2008: A Two-Season Impact Study of the WindSat Surface Wind Retrievals in the NCEP Global Data Assimilation System. Submitted to *Wea. Forecasting.*

Bi, L., J. A. Jung, M. C. Morgan and J. F. Le Marshall 2008: A One-Season Assimilation and Impact Study of the NESDIS and Navy WindSat Retrieved Data in the NCEP Global Data Assimilation System. *2008 AMS Annual Meeting,* New Orleans, LA., 21 - 24 January 2008.

Bi, L., J. A. Jung, and J. F. Le Marshall 2008: Assimilating the WindSat Winds in the NCEP Global Data Assimilation System and Determining the Forecast Impact from a Two-Season Study, 9th *International Winds Workshop,* Annapolis MD., 14 - 18 April 2008.

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Zapotocny, T. H., J. A. Jung, J. F. Le Marshall, and R. E. Treadon, 2007: A Two Season Impact Study of Satellite and In Situ Data in the NCEP Global Data Assimilation System. *Wea. Forecasting*, **22**, 887-909.

11.2. The Development of IASI Radiance & AIRS Cloudy Radiance Assimilation Techniques Within the NCEP Global Forecast System

CIMSS Project Leads: James Jung, Li Bi, Steve Ackerman
CIMSS Support Scientists: Todd Schaack
NOAA Collaborators: John Derber, Russ Treadon, Chris Barnet
NOAA Strategic Goals Addressed:

1. Serve Society's Needs for Weather and Water Information

Proposed Work

We propose to continue to work with the National Center for Environmental Prediction (NCEP) and the National Environmental Satellite, Data and Information Service (NESDIS) personnel to modify NCEP's Gridpoint Statistical Interpolation (GSI) software to assimilate the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) Infrared Atmospheric Sounding Interferometer (IASI) radiances. We have been working with NESDIS to resolve various Binary Universal Format for the Representation of meteorological data (BUFR) issues and other problems prohibiting operational use of the data. We have collected several months of IASI data and are archiving it on tape enabling us to conduct a two season impact experiment. We plan to work with NCEP on quality control, channel selection and assimilation weights of the IASI data. We will also conduct impact tests over two seasons to ensure the IASI data has a positive effect on NCEP's weather forecasts.

Summary of Accomplishments and Findings

We have been working with NESDIS and NCEP to resolve the logistics problems associated with assimilating IASI data. Upon our recommendations, software modifications were made to resolve timing issues with the IASI data for NCEP. Various software modifications to collect and process IASI data in real time were completed and made available to NCEP. The IASI data are now being processed in real time by NCEP.

The latest version of NCEP's GSI and its associated scripts were modified to read, spatially thin, and assimilate the IASI data. Quality control and thinning procedures were then derived which are similar to the Atmospheric Infrared Sounder (AIRS). All software was made available to NCEP and others. The software for this IASI assimilation technique has been integrated into NCEP's operational version of the GSI. Implementation of this software by NCEP Operations is now scheduled for 17 December 2008.

Procedures defined by NCEP to transition new data types into operations were used. These procedures include:

- Using the NCEP operational data assimilation system and forecast model
- Using all current operational data from all sources (satellite and in-situ)
- Running the data assimilation and forecast model at the operational resolution
- Conduct assimilation experiments during 2 seasons for at least 30 days each.
- Verify forecast results using the procedures outlined by NCEP.

The impact of assimilating IASI data (EUMETSAT version) was explored in detail. Two season test periods were identified to be 01 - 31 August 2007, 16 December 2007 - 15 January 2008. These tests used only the range of the IASI channels from 648.75 – 1320.0 cm^{-1} to maximize forecast impact while using the least amount of data. Figure 11.2.1 is a summary of the anomaly correlations at day 5 at mid-latitudes for August 2007 (a) and December - January 2008 (b). Assimilating the IASI data has a consistently positive effect in the NCEP forecast system when compared to the assimilation system not using IASI data.

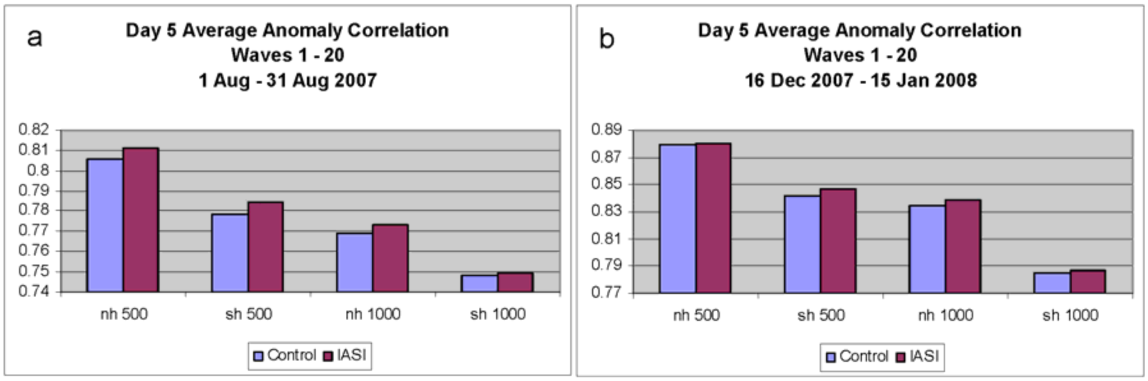

Figure 11.2.1. Day 5 anomaly correlations for geopotential height at 500 and 1000 hPa in the Northern and Southern Hemisphere for (a) August 2007 and (b) December 2007 - January 2008. Greater average anomaly correlation scores for IASI indicate forecast improvement by using IASI radiances.

The forecast impacts (Zapotocny et al., 2007) of temperature are almost entirely positive for both time periods with the greatest improvements in the tropics. Figure 11.2.2 is the temperature forecast impacts at 12 hours for August 2007(a) and December - January 2008 (b).

The IASI dataset delivered to NCEP contains both assimilation channel selections proposed by EUMETSAT and NESDIS. Assimilation tests identifying the differences in forecast skill between the different versions (EUMETSAT and NESDIS) of IASI data were conducted. The EUMETSAT channels were selected for use by NWP using the method described in Collard and Matricardi (2005). The NESDIS channels were selected to generate temperature and moisture retrieval products at NESDIS (Chris Barnet, personal communication).

The same procedures used in the initial IASI radiance assimilation tests, were used with this experiment. The results are not directly comparable to the initial IASI experiment due to computer architecture and compiler differences along with an upgrade to NCEP's GSI.

The impact of assimilating different IASI channel selection data was explored in detail. Two season test periods were identified to be 01 -31 August 2007 and 15 December 2007 - 15 January 2008. These tests also used only the range of the IASI channels from 648.75 – 1320.0 cm^{-1}. The total number of IASI channels used is almost identical with the EUMETSAT version using 165 and the NESDIS version using 162. Figure 11.2.3 is a summary of the anomaly correlations at day 5 at mid-latitudes for August 2007 (a) and December - January 2008 (b). The NESDIS version is consistently better in the Northern Hemisphere while the EUMETSAT version is generally better in the Southern Hemisphere for both time periods.

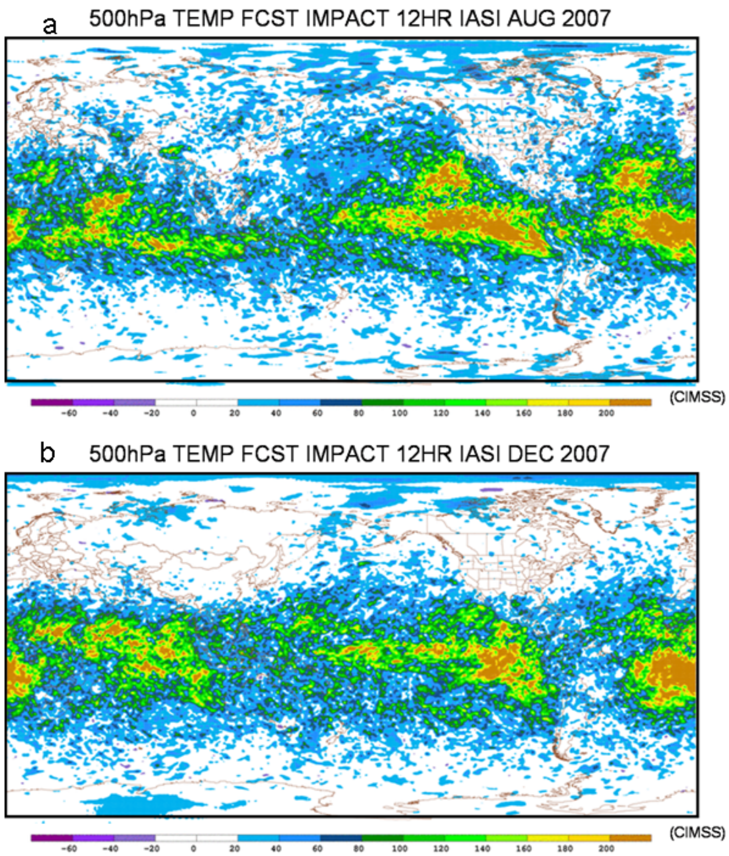

Figure 11.2.2. Forecast impact on the 500 hPa temperature field in the 12 hour forecast from assimilating IASI radiances. Panel (a) is during August 2007 and (b) is during December 2007 - January 2008. Blues, greens and yellows are varying degrees of improvement, reds are degradations.

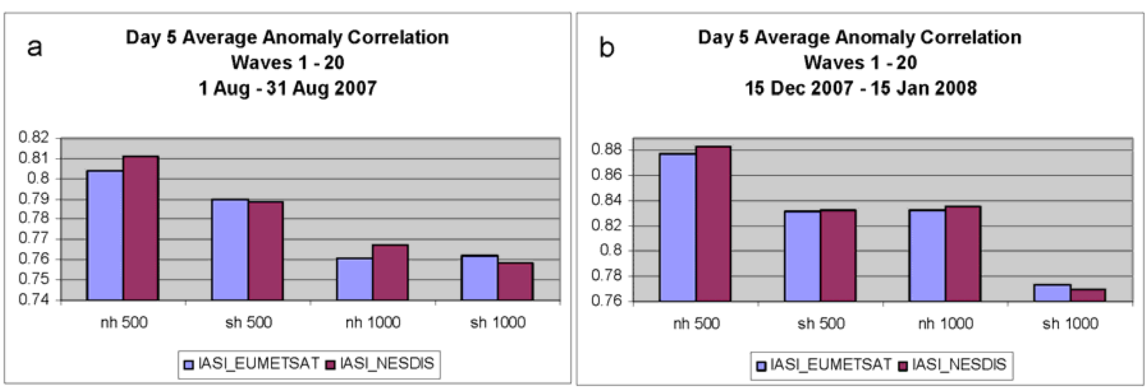

Figure 11.2.3. Day 5 anomaly correlations for geopotential height at 500 and 1000 hPa in the Northern and Southern Hemisphere for (a) August 2007 and (b) December 2007 - January 2008. Greater average anomaly correlation scores indicate forecast improvement by using the specific (EUMETSAT or NESDIS) channel selection.

Publications and Conference Reports.
Presented IASI data assimilation results at the 6th annual Joint Center for Satellite Data Assimilation (JCSDA) workshop, Linthicum, MD., 10 - 11 June 2008.

Bi, L., J. A. Jung, M. C. Morgan and J. F. Le Marshall 2008: A Two-Season Impact Study of the WindSat Surface Wind Retrievals in the NCEP Global Data Assimilation System. Submitted to *Wea. Forecasting.*

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11.3. Observation Error Characterization for Radiance Assimilation of Clouds & Precipitation

CIMSS Project Leads: Ralf Bennartz, Tom Greenwald
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

1. Further develop, integrate, and test the Successive Order of Interaction (SOI) forward, tangent linear and adjoint infrared and microwave radiative transfer models within the Community Radiative Transfer Model (CRTM) framework.

2. Determine observation error covariances under cloudy and rainy conditions both in the infrared and microwave separating effects of (1) radiative transfer solvers, (2) approximations in optical properties of clouds and precipitation, (3) cloud overlap assumptions, (4) neglecting three-dimensional radiative transfer and beam filling.

3. Quantify regional and global biases between numerical weather prediction models and observations for different model setups as well as for different cloud microphysical parameterizations.

Summary of Accomplishments and Findings
The project started in September 2007. Within the first year of this project we have worked on the refinement of SOI and have started initial collaborations with NOAA and NCEP staff to evaluate the SOI model in the bigger CRTM framework. A direct exchange of source code between NCEP and UW is currently being set up via NCEP's version control system. We have further supported the implementation and use of SOI in the framework of GOES-R risk reduction. As a result, SOI has played a major role in the generation of high quality proxy data used by many researchers within the GOES-R Algorithm Working Group (AWG).

With respect to objectives 2 and 3, we have successfully installed WRF-ARW (Advanced Research WRF) locally at UW and are currently running it in Ensemble Kalman filter (EnKF) mode. Figure 11.3.1 below exemplarily shows comparisons between simulated and observed radar reflectivities for two simulated cases. These data will be used to quantify observation errors and study forward model sensitivities.

Radiance assimilation of passive microwave data under cloudy and precipitating conditions requires detailed knowledge about ice particle scattering properties and their uncertainties. Various authors have made attempts to characterize scattering properties of ice particles in the microwave. Results differ wildly and currently no consensus on what scattering properties to use has been found. We have created a comprehensive database of databases including all available scattering properties from various authors. The panels in Figure 11.3.2 shows a comparison of ice particle scattering properties.

Optical properties vary over one to two orders of magnitude depending on what particles are assumed. In future work we will use the particle scattering properties we have collected to study uncertainties in forward radiative transfer.

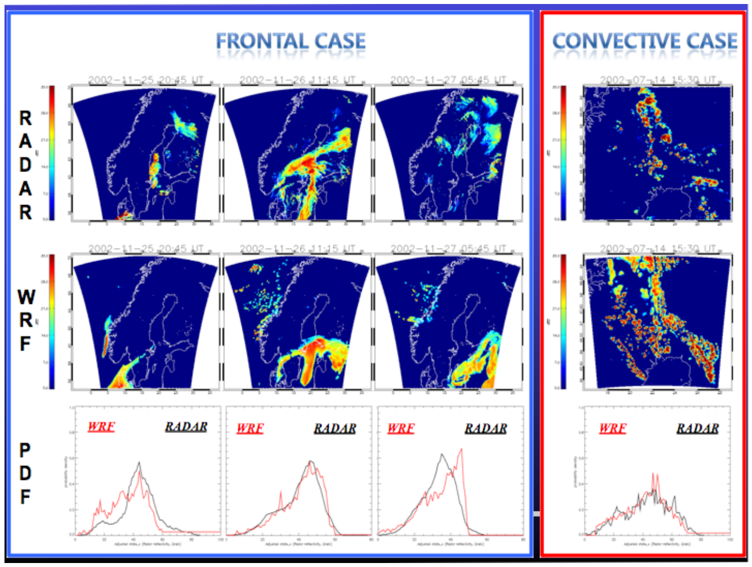

Figure 11.3.1. WRF-ARW simulations of convective and frontal precipitation events. The upper panels show radar composite images. The middle panels show the corresponding WRF simulations. The lower panels show histograms of simulated and observed radar reflectivities after bias-correction.

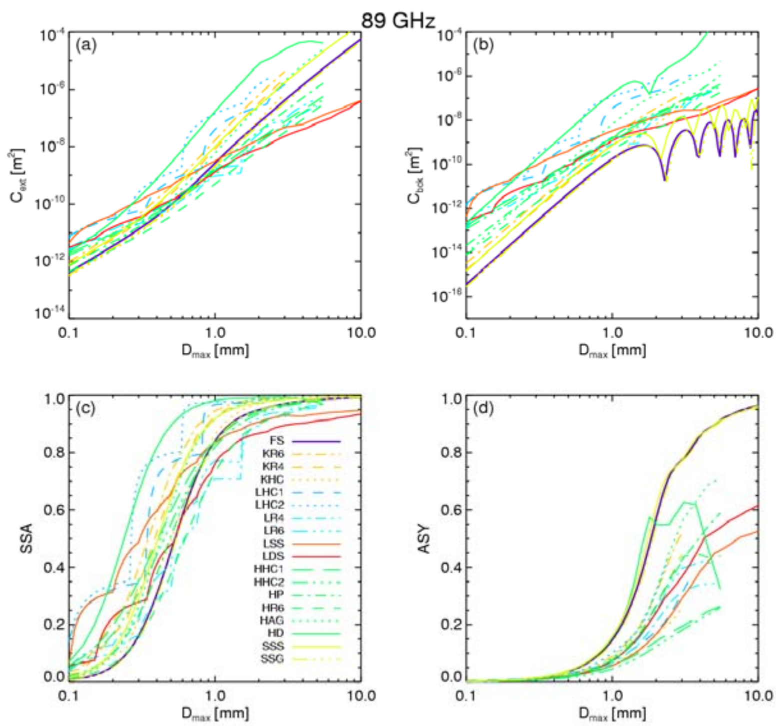

Figure 11.3.2. Scattering properties of various ice particles at 89 GHz. The panels show (a) extinction cross-section, (b) radar reflectivity, (c) single scattering albedo, and (d) asymmetry parameter of various ice particles. Scattering optical properties were collected from (Liu, 2004, JAS; Kim, 2007, JAS; Hong et al., 2005,JGR; Bennartz & Petty, 2001, JAM; and Surussavadee & Staelin, TGARS, 2008).

Publications and Conference Reports

Bennartz, R., M. Kulie, C.W. O'Dell, and M.-J. Kim, 2008:Error Modeling related to microwave radiance assimilation of clouds and precipitation. International Geoscience and Remote Sensing Symposium, Boston, MA, 6 - 11 2008.

Kulie, M.S. and R. Bennartz, 2008: A multi-sensor strategy to investigate precipitation at higher latitudes. 12th Conference on IOAS-AOLS, American Meteorological Society, New Orleans, USA, 20-24 January 2008.

12. VISIT Participation

CIMSS Project Leads: Steve Ackerman, Scott Bachmeier, Tom Whittaker
CIMSS Support Scientist: Scott Lindstrom
NOAA Collaborators: Gary Wade, Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
5. Provide critical support for the NOAA mission

Proposed Work

We proposed to continue exploring methods of improving and enhancing the content and techniques utilized for effective distance learning activities that are part of the Virtual Institute for Satellite Integration Training (VISIT) program.

Summary of Accomplishments and Findings

During the January-September 2008 period, changes were implemented to the VISITview software suite at the request of CIRA to provide easier access to lessons via the VVRemote program. Also during this period, a small grant was received from EUMETSAT to implement changes to enable "internationalization" of VISITview. This consisted of changing the client code to display "widget" (buttons, menus, etc) labels in languages other than English, and to allow the Chat window to work with characters beyond the standard 128 ASCII (Western) set. The language translations are provided by members of the community, and the code was changed in such a way as to easily allow the inclusion of any language. All these code changes are underway, and will be released by the end of this year.

The capability of utilizing operational real-time Advanced Weather Information Processing System (AWIPS) workstations at CIMSS was further refined and leveraged in 2008. This in-house AWIPS capability greatly enhances the process of VISIT lesson content creation by allowing immediate access to a diverse array of meteorological data sets from current weather events in a format that is familiar to National Weather Service (NWS) forecasters. We facilitated the insertion of MODerate-resolution Imaging Spectroradiometer (MODIS) imagery, GOES sounder derived product imagery, and CIMSS Regional Assimilation System (CRAS) model forecast products into the AWIPS Operational Build 8, which is currently running at CIMSS. Work is also beginning on the transition to AWIPS II, which is scheduled to replace AWIPS I in 2010.

Eight CIMSS-developed VISITview lessons ("MODIS Products in AWIPS", "CRAS Forecast Imagery in AWIPS", Mesoscale Convective Vorticies", "The Enhanced-V: A Satellite Indicator of Severe Weather", "TROWAL Identification", "Basic Satellite Interpretation", "Water Vapor Imagery and Potential Vorticity Analysis", and "Interpreting Satellite Signatures") were offered on the VISIT training calendar during the reporting period. A total of 44 training sessions were conducted by CIMSS staff with 75

National Weather Service forecast offices participating.. A new VISITview instructional module was developed and delivered during 2008: "Interpreting Satellite Signatures" serves as an entry-level or a refresher course in satellite imagery interpretation, offering examples of satellite-observed features that occur frequently. It includes information on the atmospheric conditions that support the observed satellite features, and how that increased knowledge of the atmosphere might be used to add value to a forecast.

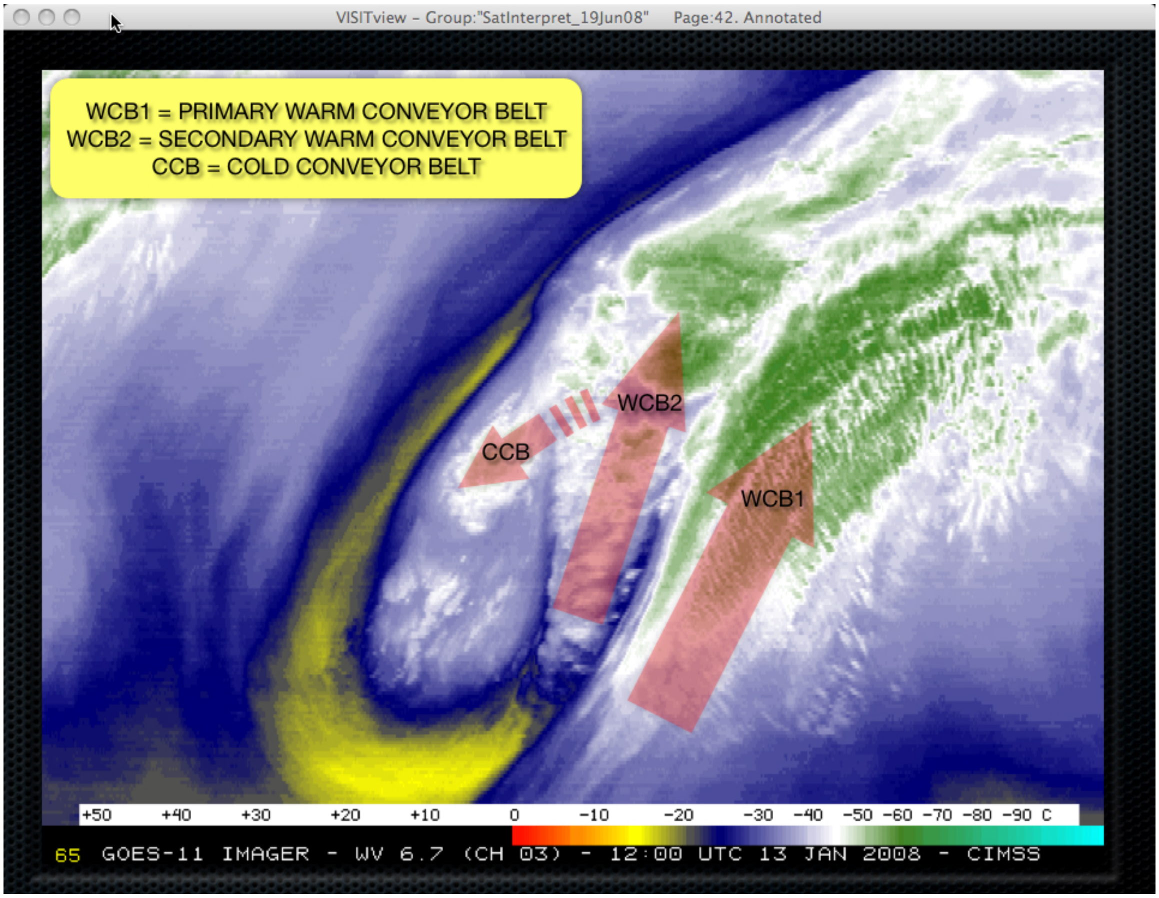

Figure 12.1.1: Sample slide from the new "Interpreting Satellite Signatures" VISITview lesson, which was introduced in July 2008.

Work also continued to update existing versions of the "TROWAL Identification," "Mesoscale Convective Vorticies," "Water Vapor Channel Satellite Imagery," "GOES High Density Winds," "The Enhanced-V Signature: A Satellite Indicator of Severe Weather," and "GOES Sounder Data and Products" VISITview lessons, adding new examples collected using the real-time AWIPS workstations at CIMSS. The ongoing process of periodically revising these existing instructional modules with new content helps to keep the material relevant and follow the pace of today's rapidly evolving satellite learning objectives.

Publications and Conference Reports

A lecture and laboratory exercise "Satellite Applications: Dynamic Feature Identification" was given as part of the COMET Mesoscale Analysis and Prediction (COMAP) course in April 2008.

13. SHyMet Activities

CIMSS Project Lead: Steve Ackerman, Scott Bachmeier
CIMSS Support Scientist: Bill Bellon
NOAA Collaborator: Gary Wade, Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
5. Provide critical support for the NOAA mission

Proposed Work

CIMSS continued to further develop the Satellite Hydro-Meteorology (SHyMet) training course through close collaboration with experts at the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University, Colorado. The role of CIMSS in SHyMet is to 1) provide advice on the educational design of the program, 2) assist in the development of the curriculum, 3) support distance education activities, 4) develop and test appropriate satellite education materials, and 5) assist in the teaching of the courses as appropriate.

Summary of Accomplishments and Findings

SHyMet Statistics for the reporting period:

- 48 (of 54 registered) completed the "GOES Sounder Data and Products" lesson
- 45 (of 54 registered) completed the "GOES High Density Winds" lesson

The teletraining portion of the course is being met by utilizing the already established Virtual Institute for Satellite Integration Training (VISIT) program. Previously, CIMSS developed and delivered lessons for the training topics "GOES Sounder Data and Products" and "GOES High Density Winds". The "GOES Sounder Data and Products" lesson provides an introduction to the data and products available from the latest generation of GOES Sounder instruments, along with examples of sounder Derived Product Imagery (DPI) and their applications to weather analysis and forecasting. The "GOES High Density Winds" lesson reviews techniques for measuring satellite winds (atmospheric motion vectors), and provides details on the display of GOES high density winds on AWIPS. These distance learning courses were again delivered in 2008 using the VISITview software. A new lesson "Water Vapor Channel Satellite Imagery" was completed in September 2008, which will be added to the SHyMet curriculum. CIMSS staff are tasked with maintaining the lessons, evaluating feedback from the course, and making appropriate modifications based upon input from the students.

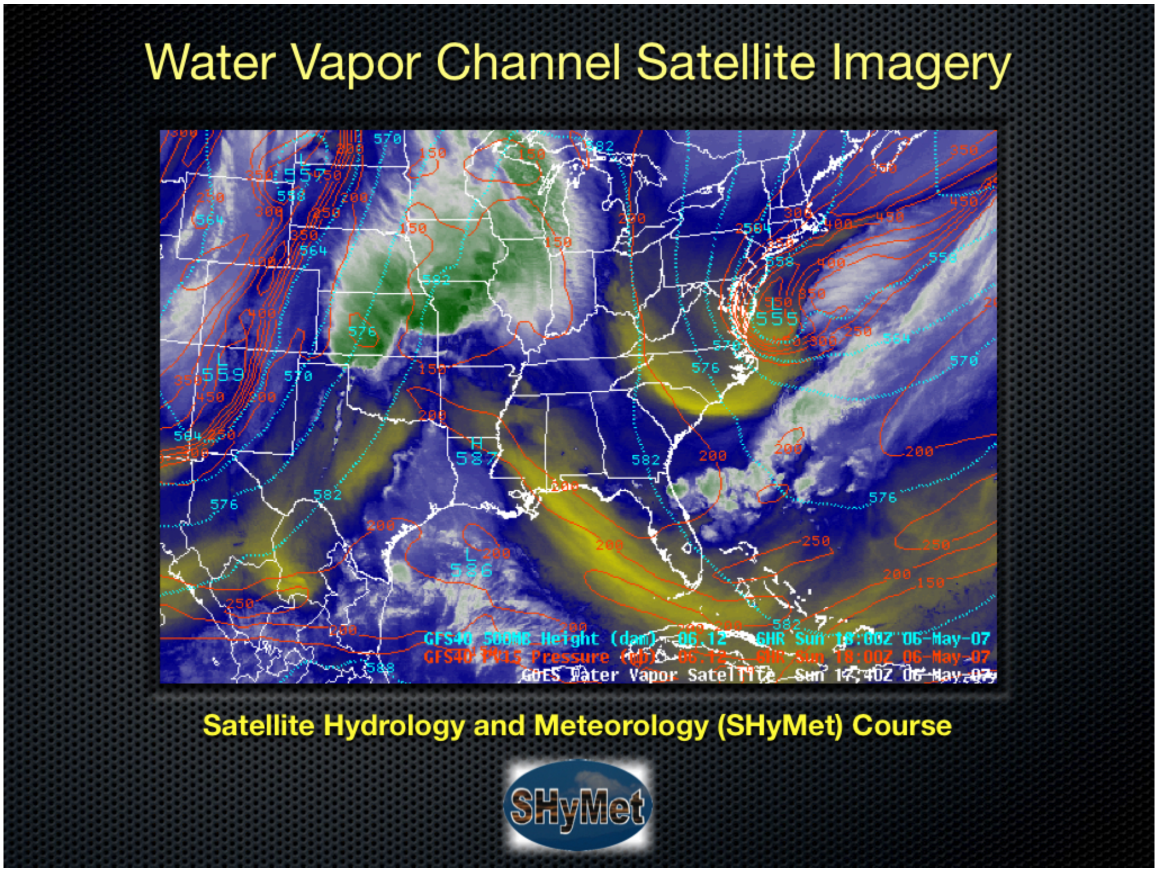

Figure 13.1.1: Title slide from the new SHyMet lesson “Water Vapor Channel Satellite Imagery”, which was completed in September 2008.

14. Maintenance and Annual Update of the Global Homogeneous UW/NCDC Tropical Cyclone Intensity

CIMSS Project Lead: Jim Kossin

NOAA Strategic Goals Addressed:

1. Serve society’s needs for weather and water
2. Understand climate variability and change to enhance society’s ability to plan and respond

Proposed Work

In response to the critical need for a homogeneous global record of tropical cyclone intensity, we are maintaining a new intensity record based on the consistently analyzed global satellite data archive described by Knapp and Kossin (2007) and Kossin et al. (2007). The first version of the dataset spanned 1983 - 2005. Here we proposed to annually update this dataset, and make appropriate fixes along the way. The satellite data archive is now an official NCDC product known as HURSAT. The new homogeneous record of hurricane intensity is denoted as the UW/NCDC (University of Wisconsin-Madison/National Climatic Data Center) record.

Summary of Accomplishments and Results

In this first year, we analyzed the latest version (Version 3) of the HURSAT dataset maintained by NCDC, and made a number of improvements to the intensity estimation model.

A new correction for satellite view-angle bias between the pre- and post-MeteoSat-7 eras in the North and South Indian Oceans was created and applied to the satellite data. Some analyses with the new dataset are shown in Figure 14.1.1.

A new dataset comprising one value per storm (at the storm's lifetime maximum intensity) was constructed and applied to a new global intensity trend analysis. The results were disseminated in the September 4th issue of the journal *Nature*.

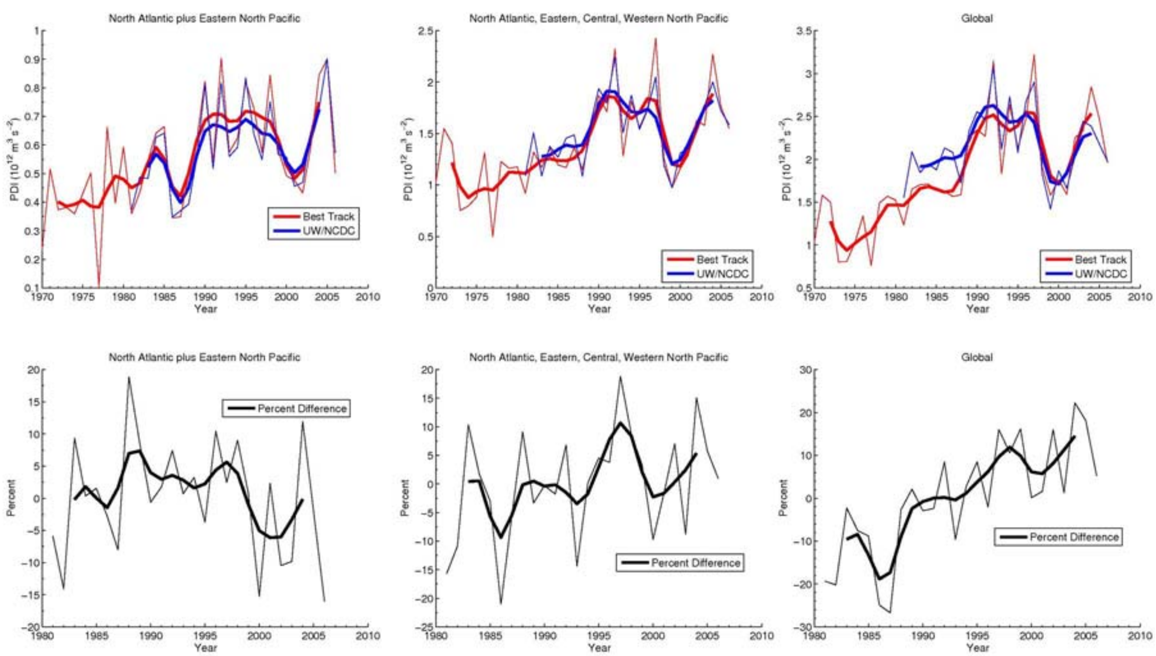

Figure 14.1.1: Power Dissipation Index calculated using the global best track and the homogeneous UW/NCDC record. The differences in global PDI highlight the potentially inflated trends in the best track data.

15. Support for the WVSS-II Field Program

CIMSS Project Leads: Ralph Petersen, Wayne Feltz

NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond
4. Support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Proposed Work

CIMSS will conduct a third ground-truth assessment of the WVSS-II systems being flown on UPS aircraft at either Louisville, KY and/or Rockford, IL. Proposed objectives included: 1) assessing the accuracy of WVSS-II observations from the re-engineered WVSS-II units by comparing them to rawinsonde observations and 2) continue to provide guidance about optimal water vapor observing strategies through the ongoing evaluation of temporal moisture variability intended to help define the temporal and spatial requirements for aircraft observations.

Summary of Accomplishments and Findings

The report is divided into two parts. The first provides a status report on the rawinsonde-WVSS-II intercomparison test, and the second provides additional information regarding the optimal spacing and timing of operational aircraft moisture observations.

Observing Systems Available for WVSS-II Validation

It is planned that re-engineered WVSS-II sensors will be compared with observations made at a site immediately adjacent to the Louisville and/or Rockford airports after the sensors have been deployed on the UPS aircraft for several months. Non-aircraft observations will again be taken from the portable "AERIbago" vehicle 24 hours/day during weekdays throughout the full experiment period. Primary observational systems include: a portable surface station reporting temperature, dewpoint temperature and wind information; a NWS standard Ceilometer; a GPS receiver for use in calculating total precipitable water (GPS-TPW); an upward-looking AERI to measure boundary layer temperature and moisture at 10 minute temporal resolution; and a Vaisala GPS rawinsonde system. Model RS-92 sensors will be used for all rawinsonde launches. To avoid the possible introduction of previously observed instrument "aging" errors, the moisture sensors will all be less than three months old. Data taken by the UW-CIMSS systems will be archived at UW-CIMSS for future use. The full set of aircraft data will also be collected from the FSL MADIS data retrieval system for use in the UW-CIMSS assessment.

Status of Intercomparison Data Collection and Analysis

Based in part on the results of WVSS-II/rawinsonde intercomparisons that CIMSS has conducted during the past several years, the vendor providing the WVSS-II instruments to the NWS has made substantial engineering changes to the sensor and data processing systems. These systems, originally scheduled to be installed on UPS aircraft during the summer of 2008, were delayed. At the request of NWS, CIMSS has postponed the testing period until Spring 2009.

Some additional analysis of the data collected in the previous tests was performed. In particular, data from the 2006 tests were examined to determine if errors varied as a function of increasing relative humidity levels in the observations. Analyses were made using only data from the sensors which showed the greatest overall quality during and after the 2007 observation period. To assure that aircraft temperature observation errors did not affect the results, the Relative Humidity (RH) data were calculated using aircraft moisture and rawinsonde temperature observations. The results in Figure 15.1.1 show 1) that the observations showed slightly wet biases for RH<50% and slightly dry biases for larger amounts, and 2) that the observations with 60%<RH<90% showed slightly higher Standard Deviations than those from lower and very high RH environments. All of these values are near/within WMO guidelines.

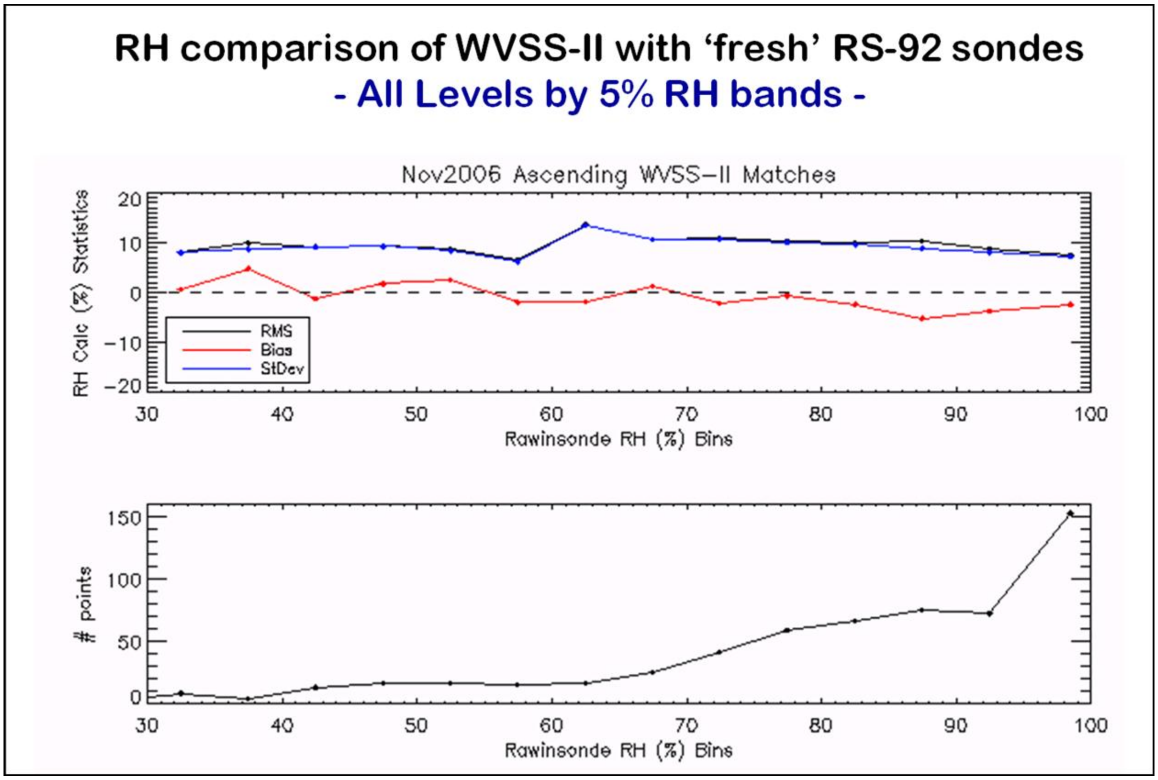

Figure 15.1.1: Evaluation of WVSS-II accuracy as a function of environmental Relative Humidity (RH). Observations divided into 5% RH bands. Bias, RMS and Standard Deviation shown in top panel, with number of observations in each RH band shown in lower panel.

Temporal Moisture Variability Evaluation

Analyses of existing high time resolution boundary layer moisture profiles were also begun to help determine the optimal moisture observing frequency. Using-term time series of 7.2 minutes frequency AERI moisture profiles from surface-700 hPa made at the DOE ARM/CART site at Lamont OK are being used to assess the observed temporal (and spatial in future) moisture variability. A two-sided quality control procedure similar to that used in the Wind Profiler evaluation discussed in the report form last year was applied to the AERI moisture profiles as an additional check for possible cloud contamination or other intermittent errors. It should be noted that these data were only available in clear sky conditions. Efforts during this FY have substantially expanded the software base used for these evaluations and identified a number of errors in the ARM/CART data sets that are being corrected by CIMSS before the analysis can be completed.

Results presented in last years' report showed that the time rate of change of moisture (measured in g/kg/hr) increases greatly as the time interval between observation decreases. Examinations conducted for shorter time intervals throughout the day showed substantial diurnal variability in moisture tendency. More detailed analysis, however, indicated that anomalously large tendencies were present in the AERI data throughout the entire boundary layer near 0000 and 1200 UTC during the summer months. These tendencies were large enough to substantially skew the overall results. Comparison with other surface- and tower-based observations, as well as Total Precipitable Water observations from a microwave radiometer and GPS instruments indicates that large corrections to the moisture structure of the RUC-based first guess fields occur at approximately the same times. Several approaches to correct this error in the AERI data are being investigated without cost to this project. Once the data have been reprocessed, the previously developed analysis software will be used to complete the study.

Results from other seasons for the period from 2002-2004 continue to indicate that observations of moisture changes taken no more frequently than 1 per hour may not be sufficient to detect many significant moisture changes which occur in the atmosphere. This includes both increases in moisture in the lowest levels and the simultaneous decrease of moisture in the upper part of the boundary layer, a necessary condition for the development of convective instability. Additional evaluations will be conducted to better understand implications of these results as a function of year, time-of-day and/or time-of-year, relative to significant weather events and in terms of changes in the vertical moisture structure.

Publications and Conference Reports

Formal Presentations:
Petersen, R, S Bedka, W. Feltz, E. Olson and D. Helms, January 2008: Evaluation of the WVSS-II Moisture Sensor using co-located, is-situ and remotely sensed observations. AMS Aviation and Range Meteorology Conference, New Orleans, LA.

Petersen, R, S Bedka, W. Feltz, E. Olson and D. Helms, August 2008: Evaluation of the WVSS-II Moisture Sensor using co-located, is-situ and remotely sensed observations. SPIE Remote Sensing Conference, San Diego, CA.

Informal Presentations:
Included as part of: Petersen, R., R. Aune, May 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection - at NWS/CR HQ and NCEP AWC.

Included as part of: Petersen, R., R. Aune, August 2008: An objective NearCasting tool that optimizes the impact of GOES Derived Product Imagery in forecasting isolated convection – electronically to all NWS SSD Chiefs.

16. Real-Time and Historical Satellite Data Products in Support of IPY

CIMSS Project Lead: Xuanji Wang
CIMSS Support Scientists: Yinghui Liu, Richard Dworak
NOAA Collaborator: Jeff Key
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work
The International Polar Year (IPY) is a large scientific program focused on the Arctic and the Antarctic from March 2007 to March 2009. The IPY was organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO). IPY 2007 - 20088 is actually the fourth polar year, following those in 1882, 1932, and 1957. The current IPY covers two full annual cycles

(March 2007 - March 2009), involving over 200 projects with scientists from over 60 countries working on a wide range of physical, biological and social research topics.

While the IPY takes place over a two-year period, we are developing products not only for field missions and scientific studies during the IPY, but also as an IPY legacy. We are therefore developing or enhancing a suite of both real-time and historical satellite-derived products, with the intention of continuing the real-time products beyond IPY, merging them with, and thereby extending, the historical products.

The primary activity is to provide real-time products at direct broadcast (DB) sites at Tromsø, Norway, Sodankylä, Finland, McMurdo, Antarctica, and Fairbanks, Alaska. We have been generating some Moderate Resolution Imaging Spectroradiometer (MODIS) products at Tromsø, Sodankylä, and McMurdo for more than a year. The Fairbanks Command & Data Acquisition Station (FCDAS; aka "Gilmore Creek") is a NESDIS facility where we are currently developing a MODIS polar wind system. Our plan is to expand the product suite at all these DB sites to include tropospheric winds, cloud properties (amount, height, phase), and snow and ice properties (snow and ice extent, ice thickness, ice concentration, and ice motion). The data for all products will be available to the public and archived. Currently only wind data are available and archived.

We are also refining two important historical polar products: The extended AVHRR Polar Pathfinder (APP-x) and our historical AVHRR winds. APP-x provides cloud, surface, and radiation properties over both poles. It currently covers the period 1982-2004. It has been used extensively in climate studies and has been instrumental in a number of climate discoveries. We are bringing the product up to date and implementing a procedure to extend the product automatically in near real-time. The historical AVHRR wind product covers the period 1982-2001, but with only one satellite at any given time. It will be enhanced to include a second satellite (and hence better temporal coverage for assimilation), and extended to the present.

Summary of Accomplishments and Findings

The project began in May 2008. Progress to date has been on real-time product additions and reprocessing of historical data. In the real-time, direct broadcast systems, an ice motion was added, and ice concentration and thickness are being added now. Additionally, a polar wind system was developed for Advanced Very High Resolution (AVHRR) data acquired at NESDIS' High Resolution Picture Transmission (HRPT) receiving station in Barrow, Alaska. That system generates winds from NOAA-16, -17, and -18 satellites using 2 km pixels.

Regarding the historical products, AVHRR wind product reprocessing has begun with additional satellites. APP-x has been reprocessed with improved algorithms.

17. NPOESS Studies

17.1. VIIRS Cloud Studies for NPOESS

CIMSS Project Leads: Richard Frey, Sebastien Berthier
CIMSS Support Scientists: Corey Calvert, William Straka
NOAA Collaborators: Andrew Heidinger, Michael Pavolonis
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

The main effort and outcome of this proposal is to work with the IPO, NGST, and NPP to improve the VIIRS Cloud Environmental Data Records (EDRs) using our experience with the heritage products from the current NOAA operational imagers. To date, we have been successful in collaborating with NGST on the VIIRS cloud mask and cloud type algorithms. In terms of the VIIRS cloud mask, we have helped NGST correct errors and implement new tests aimed at improving the SST performance. For the VIIRS cloud type, we have suggested algorithm improvements that mitigate errors noted by NGST in the baseline algorithm. In addition, we plan to expand this direct collaboration into other cloud EDR algorithms.

The secondary goal of this study is to start processing global MODIS data through VIIRS algorithms in partnership with NPP Atmospheric PEATE. By processing MODIS data through VIIRS algorithms globally, we can use our traditional validation approaches to expose weakness in VIIRS algorithms that might go unnoticed until after launch. In addition, we plan to run modified algorithms in parallel with the VIIRS baseline algorithms and demonstrate improvements for future algorithm updates.

Lastly, this study allows for the support of VOAT/IPO analyses that arise, as NGST or the IPO require assistance in defining new specifications or modifying EDR algorithms. The investigator of this project currently serves the VIIRS operational algorithm team (VOAT) Atmospheres Group lead.

In terms of specific goals for this year, our first goal is to validate the VIIRS Cloud Mask (VCM) thresholds using CALIPSO observations. The second goal of this work is to explore the performance of the VIIRS 4-channel Nighttime Cloud Properties approach using our experience from similar approaches applied to MODIS and to AVHRR.

Summary of Accomplishments and Findings

Our two main efforts this year have dealt with the VIIRS Cloud Mask (VCM) and the VIIRS Nighttime Cloud Properties Algorithm. This section will describe the progress of work on the VCM first and then on the nighttime cloud properties.

Much work has been done in developing an analysis to allow us to examine various spectral cloud tests within the VCM. VCM cloud test thresholds were applied to Aqua MODIS (Moderate Resolution Imaging Spectroradiometer) radiance data and compared to observed spectral measures in clear-sky situations, where "clear" was determined by collocated CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) data. The CALIOP instrument is onboard the CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) space platform and is part of the "A-Train" constellation of polar orbiting satellites that includes the Aqua platform. CALIPSO trails Aqua by approximately 75 seconds.

Thus far, cloud tests for ocean surfaces during both day and night have been considered. These include the 0.87 µm and 1.38 µm reflectance tests, the 0.87/0.67 µm reflectance ratio test, and the 3.7-4.1 µm brightness temperature difference (BTD) test (day only), the 10.8-3.7 µm, 10.8-12.0 µm, and 8.6-10.8 brightness temperature difference (BTD) tests (day and night), as well as the sea-surface temperature (SST) test (night only). Investigations have shown that some test thresholds may need to be adjusted for maximum cloud detection efficiency (8.6-10.8 µm and daytime 10.8-3.7 µm BTD tests).

In addition, calculations of nighttime 10.8-3.7 µm BTD test thresholds (functions of precipitable water and viewing zenith angle) appear to be shifted in the positive direction by a constant value. This may be remedied by changing the sign of a constant in the computation from positive to negative. It may also be necessary to change the threshold function to be nonlinear with respect to precipitable water rather than linear. Figure 17.1.1 shows MODIS BTDs and VIIRS test thresholds for 28 August 2006.

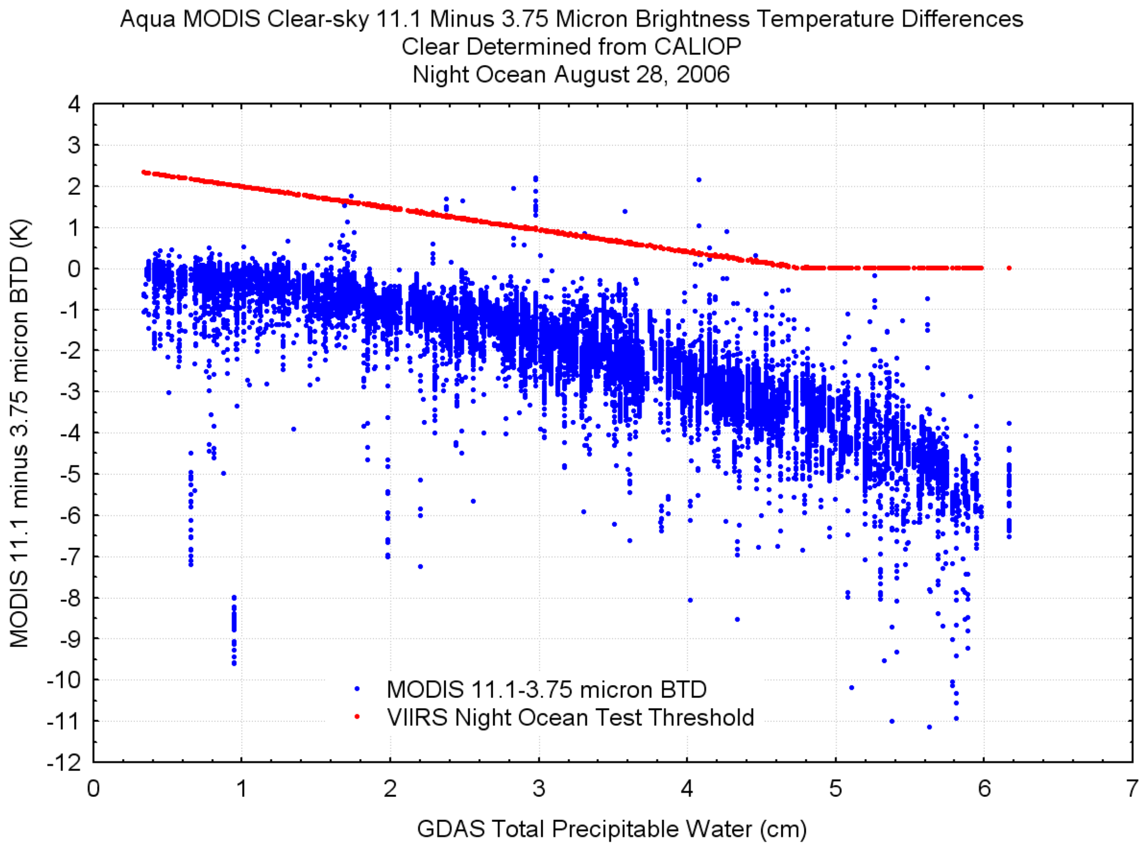

Figure 17.1.1. Clear-sky observed MODIS 11.1-3.75 BTDs (blue dots) and VIIRS test thresholds (red line).

It has been noted that improvements could be made to the form of the SST test. Currently, an estimate of the difference between bulk SST obtained from ancillary data and observed 10.8 µm (M15) BT for a given pixel is calculated and then compared to the actual difference. Large differences correspond to cloudy conditions. An alternate method uses a SST calculation directly, comparing it to ancillary data (not VIIRS-derived, in this example non-MODIS). It is seen that the latter method produces greater discrimination between clear and cloudy conditions. Figure 17.1.2 shows cumulative histograms of test thresholds minus actual values for both methods in clear scenes. Large negative values on the x-axis correspond to false clear designations while large positive values indicate false cloud. One can deduce from the plots that 1) the latter formulation is more sensitive to the presence of clouds (steeper slope) and 2) the former test produces thresholds that are sometimes too high as seen from the larger differences needed to include all clear pixels. Here, a constant threshold of 2.5K (bulk SST minus calculated SST from MODIS BTs) was used for the revised method.

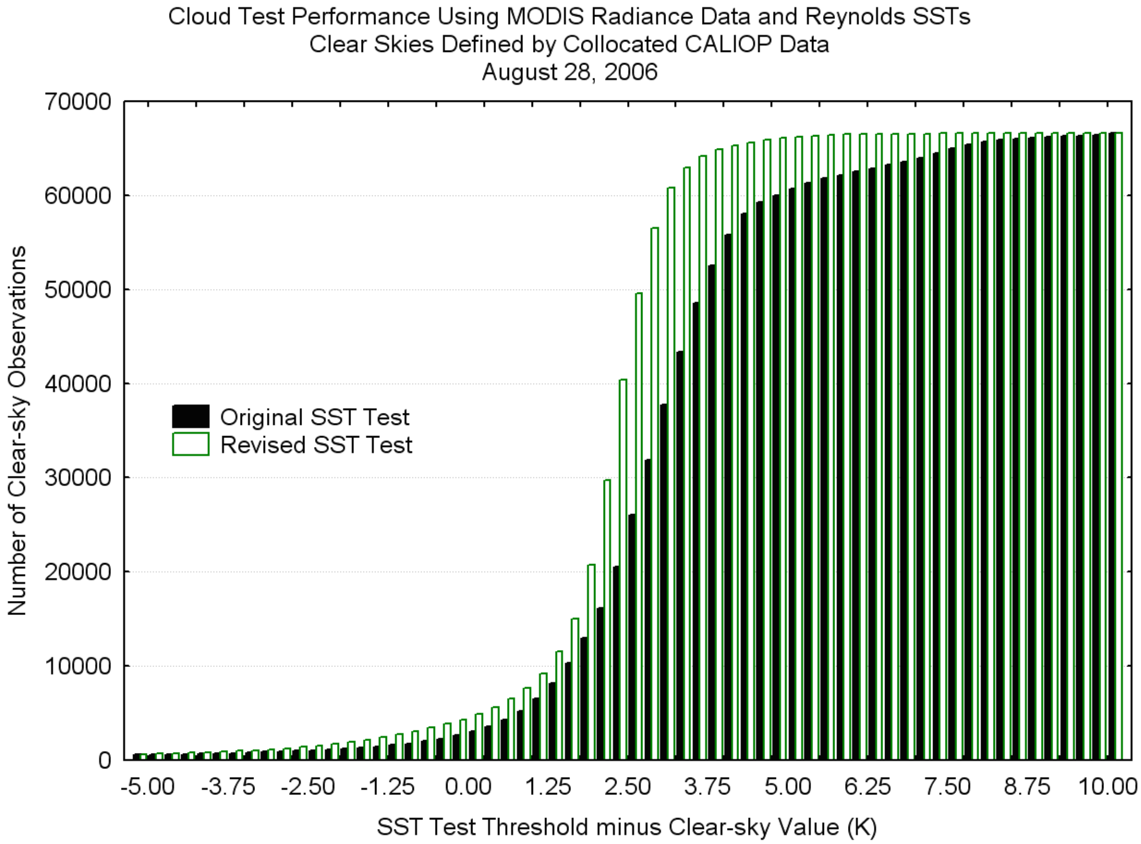

Figure 17.1.2. Cumulative histograms of SST test thresholds minus actual values. Original test in solid bars, revised in open bars.

In addition to the VCM work, we have also made great progress on the VIIRS Nighttime Cloud Properties Algorithm. The VIIRS approach is based on a relatively new 4-channel approach developed by Northrup Grumman, the VIIRS contractor. Our goal has been to explore the validity of the assumptions made by the approach and to assess the overall accuracy.

In a poster presented at the AMS, we demonstrated that the assumed microphysical models employed by the baseline VIIRS approach did not match those inferred from observations. We have demonstrated the benefits of modifying the operational VIIRS algorithm using new IR scattering models provided by Professor Ping Yang of Texas A&M University.

We successfully characterize the cloud parameter: we retrieve a mean value of 12.98±2.53 km for the cloud top altitude, a mean value of 58 ±14 µm for the Particle Effective Diameter, and a mean value of 217 ±17 K for the cloud top temperature.

The following comparisons demonstrate the performance of the modified VIIRS results applied to MODIS data to those from standard MODIS products (MYD06). Figure 17.1.3 shows an image of the Cloud Top Temperature Comparison (CTT). A strong correlation of about ~0.96 was observed between cloud top temperature from the modified VIIRS and the MYD06 cloud product on the cirrus areas. The results of the standard VIIRS approach are not shown because for this scene, the baseline approach did not converge for many of the cloudy pixels. The cause of this behavior is the incorrect microphysical assumption employed in the baseline approach. We refer to the baseline VIIRS approach modified with microphysical parameters from Ping Yang's data as the modified VIIRS approach. We have communicated these issues to NGST and the IPO.

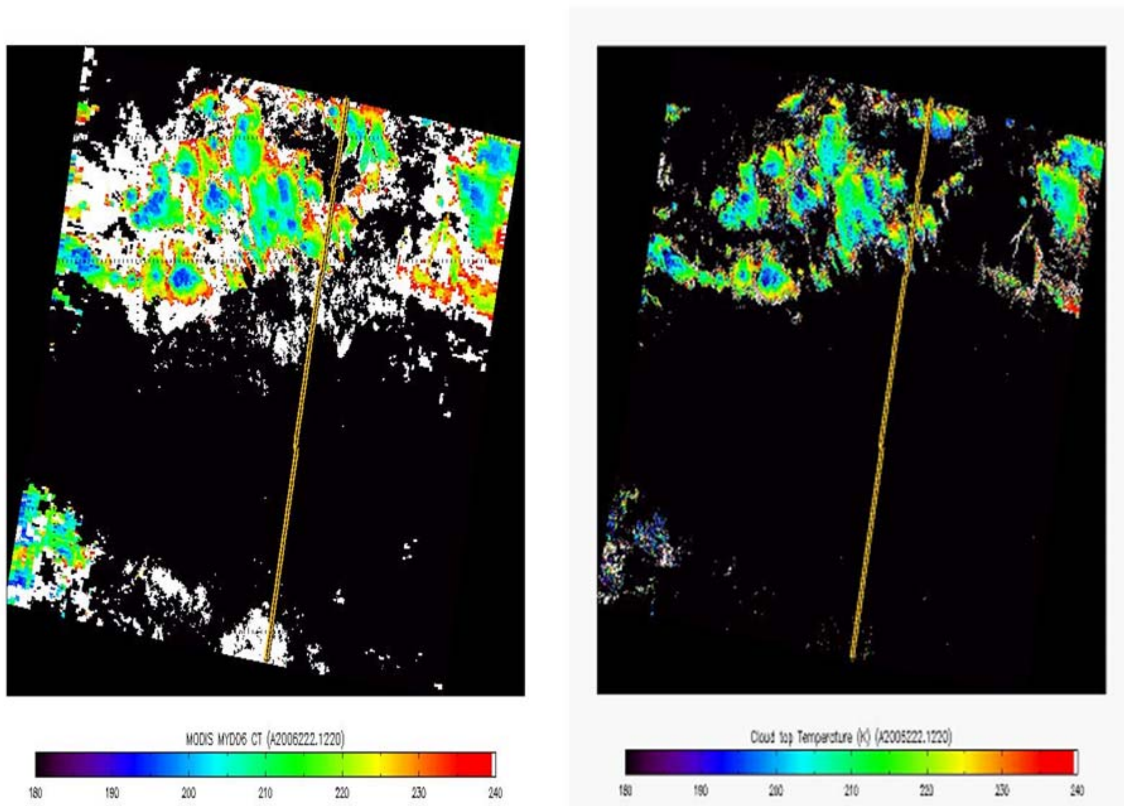

Figure 17.1.3. MODIS MYD06 (left panel) and Modified VIIRS Cloud Top Temperature (right panel). The yellow line gives the path of CALIOP.

With the launch of CALIPSO and CloudSat in EOS A-Train, NASA has provided us a new opportunity to evaluate the characteristics of cloud remote sensing from passive instruments. This data has been a critical component of our project. During this year, we have used the CALIPSO data to characterize the performance of the VIIRS approach. Figure 17.1.4 illustrates a comparison between the cloud layers detected by CALIPSO and the heights from our modified VIIRS product. The results show a strong correlation of ~0.92 for cloud top altitude in the case of single layer clouds. As expected (see Berthier et al, 2008), we retrieve an underestimation of the cloud top height in the case of multilayered structure.

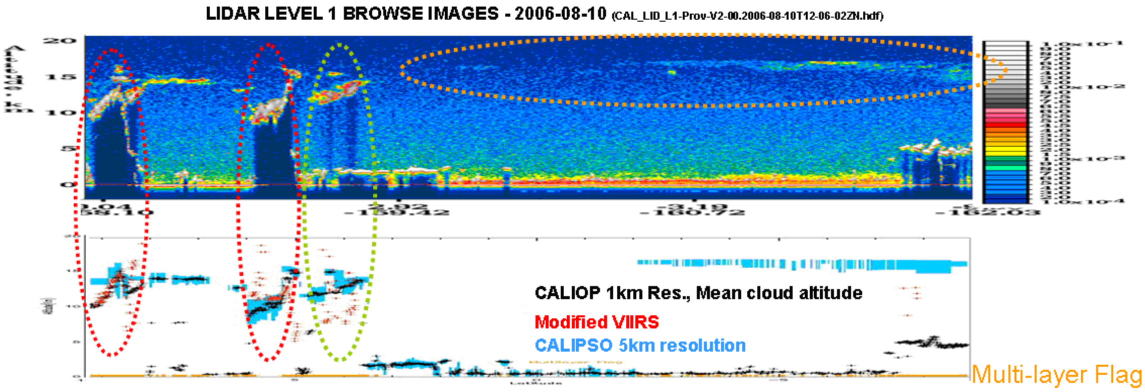

Figure 17.1.4. (Upper panel) CALIOP Level 1 raw lidar profile; (Lower panel) CALIOP cloud mask at 5km of resolution, CALIOP CTH at 1km of resolution (black crosses), and the output of the modified VIIRS algorithm CTH (red crosses). The scene is the same as one given in the Figure 17.1.3.

Publications and Conference reports

Sébastien Berthier, Andrew Heidinger, and Michael Pavolonis. "Developing day/night consistent cirrus microphysical properties from MODIS and VIIRS infrared window observations", MODIS Science Team Meeting, Baltimore, MD, May 2008 (Poster Presentation).

Heidinger, Andrew: Cloud-top Pressure Solution Space Offered by NPOESS/VIIRS and GOES-R/ABI. MODIS Science Team Meeting, Baltimore, MD, May 2008 (Oral Presentation)

17.2. Radiance Cal/Val, Cloud Property Determination and Combined Geometric plus Radiometric Soundings with Emphasis on VIIRS

CIMSS Project Leads: W. Paul Menzel
CIMSS Support Scientists: Eva Borbas, Youri Plokhenko, Chris Moeller, Tom Rink, Dan LaPorte
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water

Summary of Accomplishments and Findings

Senior Science Review of VIIRS Sensor

On 28 – 29 February, a Senior Science Review (SSR) of the VIIRS sensor was held at Aerospace Corp in El Segundo, CA; the review team included Vincent Salomonson, Paul Menzel, and Tom Kopp. Northrop Grumman and Raytheon scientists presented EDU and FU1 vacuum test results, waivers requested for FU1, and plans for upgrades to FU2. Additional background information was provided by scientists from MIT/LL, GSFC, and Aerospace. FU1 issues include cross talk in the vis/NIR bands, aggregation of saturated SMWIR/LWIR pixels, noise in the dual gain bands at the gain transition point, reflective band non-uniformity (in part due to polarization changes), out of band responses, sensor calibration stability, and structured scene responsivity. Mitigating these issues include replacing the IFA (not likely unless a schedule opportunity arises), inserting a flag when saturated pixels occur (this software fix needs to be investigated), adjusting the gain transition point (but keeping the ocean color measurements within the high gain), characterizing the polarization effects along the detectors in one band (this is planned), performing end-to-end vis/NIR calibration (feasibility of this will be explored), and relaxing the structured scene specification (VIIRS is outperforming MODIS in this regard). It was noted in conclusion that VIIRS is performing very well (except in some cases at the edge of scan beyond 45 degrees), the KPPs of imagery and SST will likely be within specification, delivery of FU1 on schedule as much as possible is a high priority, and most problems identified in FU1 are planned to be fixed in FU2. The review team was pleasantly impressed with the expected performance of the FU1 and the expectations for FU2; it appears that VIIRS will be an effective sensor and offer much to be excited about even as measured against the performance of MODIS or other heritage sensors.

NPP Mission Operation Review for Cal/Val

The NPP Mission Operations Review of the Calibration/Validation on 22 May 2008 was chaired by P. Menzel. NGST and IPO teams presented SDR and EDR cal/val plans for CrIS, ATMS, VIIRS, and OMPS – CERES has no NGST counterpart. It was felt that considerable effort has been expended and results are evident. There seem to be good preparations for (1) ensuring product operational viability, (2) providing independent verification of NGST results, (3) supporting data integration for mission systems, and (4) supporting the NOAA and DoD user community. However, several key actions were noted that must be addressed through the Cal/Val planning process in order to assure that sensor characterization pre-launch can be combined with system performance post-launch to provide adequate measurements for spec-compliant data products. It was the feeling of the review team that these can be addressed within the process that was outlined at the review. The MOR resulted in 27 Requests for Action. A report was submitted by the review committee (Gene Poe, Jeff Reid, Tom Pagano, Paul Menzel) that evaluated each of the RFAs and made several general comments concerning resources for field campaigns, defining the roles and responsibilities for the major phases of the Cal/Val, and utilizing the lessons learned from EOS.

Assessing VIIRS Prelaunch Performance

Chris Moeller and Dan LaPorte at UW continued to participate in VIIRS TDRs and DRBs, VT-DAWG and GVT-DAWG over the last quarter. Planning and readiness for the FU-1 TVAC testing has intensified in the last quarter. Government Team recommendations on FU-1 TVAC test plan modifications were finalized and reviewed by all parties (IPO, Raytheon, NGST) for inclusion in the FU-1 TVAC test program. This work is partially supported by Integrated Project Office funding. Paragraphs regarding work on EFR-2386, SpMA characterization, and testing FU-1 FP-15 and FP-16.

EFR-2386 addresses a difference between BCS known emission and the calibrated signal when VIIRS is viewing the BCS. A number of possible influences were considered; these include RVS error, OBC temperature and emissivity knowledge error, possible stray light contributions when viewing the BCS and the space view source during testing. The Government Team approved of the use of an additional well characterized external (to VIIRS) radiometric source inside TVAC during testing to isolate effects of the BCS from those of the OBC (as well as other benefits). However, this became unlikely based on the Raytheon response. In lieu of a 2nd source inside TVAC, the Government Team recommended that the OBC stability be evaluated by resampling certain BCS temperature levels during RC-05. These efforts targeted agreement on FU-1 TVAC testing and procedures prior to PER (currently scheduled for late April 2008). Dan LaPorte participated as a co-chair on this team. The team reviewed anomalous behavior in both LWIR and MWIR bands. Possible spectral characterization influences were reviewed by assessing the influence of response in the wings of each band. For M13, the influence of CO2 absorption in the longwave wing was also reviewed as a possible contributing factor to spectral characterization influences.

The spectral “smile” in the output of the SpMA was characterized in preliminary (i.e. not “run for the record”) test data sets for all 4 gratings. It showed that the spectral smile is much more symmetrical after SpMA refurbishment than it was during EDU testing. For the “run for the record” test data set, it was recommended that the number of samples be increased (reduced sampling interval) near the peak response at each position along the focal plane axis; this will reduce uncertainty in the spectral offset retrieved at each position along the focal plane. Further it was recommended that the number of positions along the focal plane be increased from five to seven so that the spectral offset can be retrieved from end to end of the focal plane, and yet maintain good coverage in the interior 70% or so along the focal plane axis.

Sampling intervals, spectral resolution, and number of data points were agreed upon between the Government Team and Raytheon for these tests. The goal of 100% sampling of the in-band spectral coverage was achieved or nearly (>90%) achieved for each “M” band. The Government Team request that Raytheon characterize the transmission of the ZnSe window of the FU-1 TVAC chamber was adopted, and the Government Team requested information on the characterization that will be used to remove the ZnSe window transmission influence on RSR measurements. This information is needed in the analysis of both in-band and out-of-band RSR.

Both Chris Moeller and Dan LaPorte participated in shaping the Government Team recommendations on FU-1 TVAC test plan modifications including FP-15, -16 and RC-05 testing, and M9 test data collection setup that includes accommodation for water vapor sensitivity (support atmospheric correction for test analysis). Raytheon responded to these recommendations with estimates for Non-TVAC critical path and TVAC test time impact on the VIIRS schedule.

Raytheon adopted the recommendation for matching spectral sampling and bandpass for FU-1 in-band RSR characterization as part of the FU-1 TVAC schedule. Further, the Government Team recommended that the Relative Spectral Output (RSO) of the SpMA be monitored during FP-15 (in-band) and -16 (out-of-band) testing. A goal was to measure a small (< 5) selection of spectral positions both before and after completing the FP-15 measurement for each VIIRS band with a well characterized reference detector. This will provide information on trends in RSO during test data collection. A similar strategy for FP-16 was also developed. Additionally, the Government Team requested that Raytheon characterize the transmission of the ZnSe window of the FU-1 TVAC chamber in order to capture any spectral shape that would influence FP-15 or -16 data analysis.

Visualization Tools

HYDRA continues to add capabilities for interrogating and visualizing imager and sounder data. Currently it can accommodate data from MODIS, AIRS, IASI, SEVIRI, CALIPSO, GOES Imager and Sounder. HYDRA has recently been used to search for transport of ammonia in the atmosphere using on-line minus off-line differences at 966 and 983 cm-1 respectively in AIRS measurements (see Figure 17.2.1). Verification with EPA data is underway.

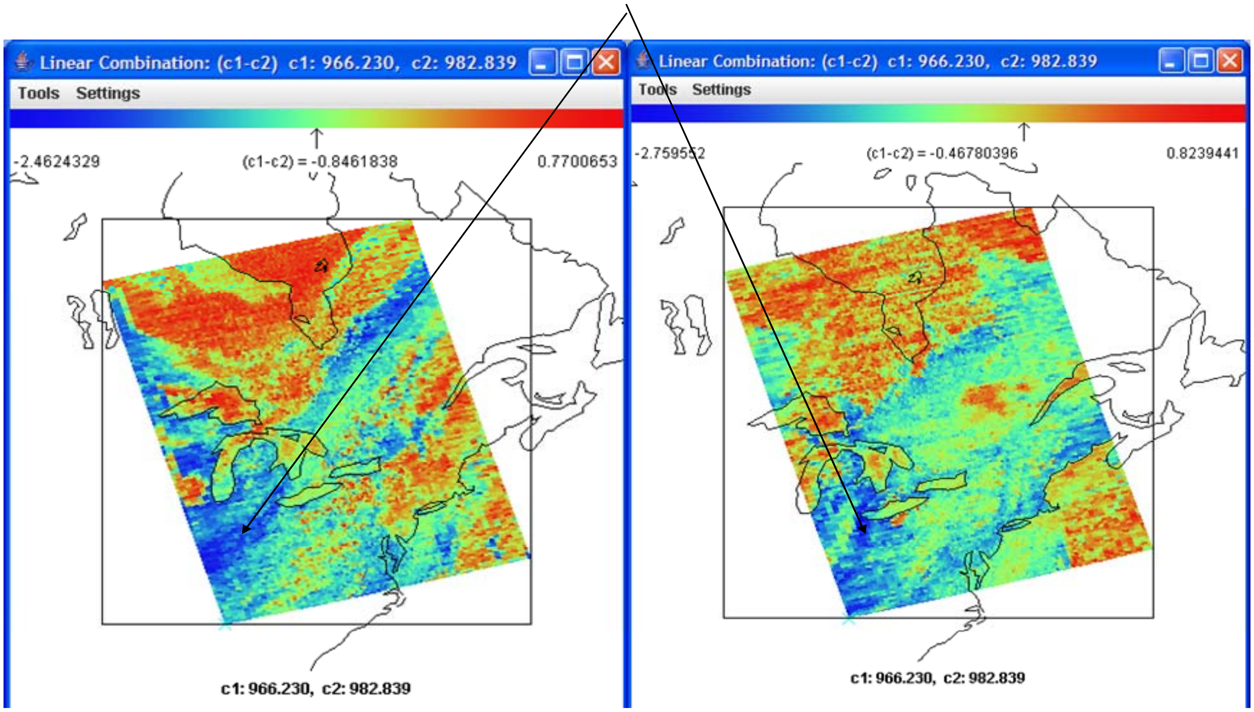

Figure 17.2.1. Images of AIRS 966 minus 983 cm-1 measurements on 19 July 2004 (left) and 21 July 2004 (right) indicating possible detection of ammonia transport eastward from the Great Lakes. Presence of ammonia is suspected when the online minus offline differences are more negative than minus one degree.

3-D displays comparing cloud profiles derived from AIRS and those observed by CALIPSO have also been developed. Figure 17.2.2 shows an example.

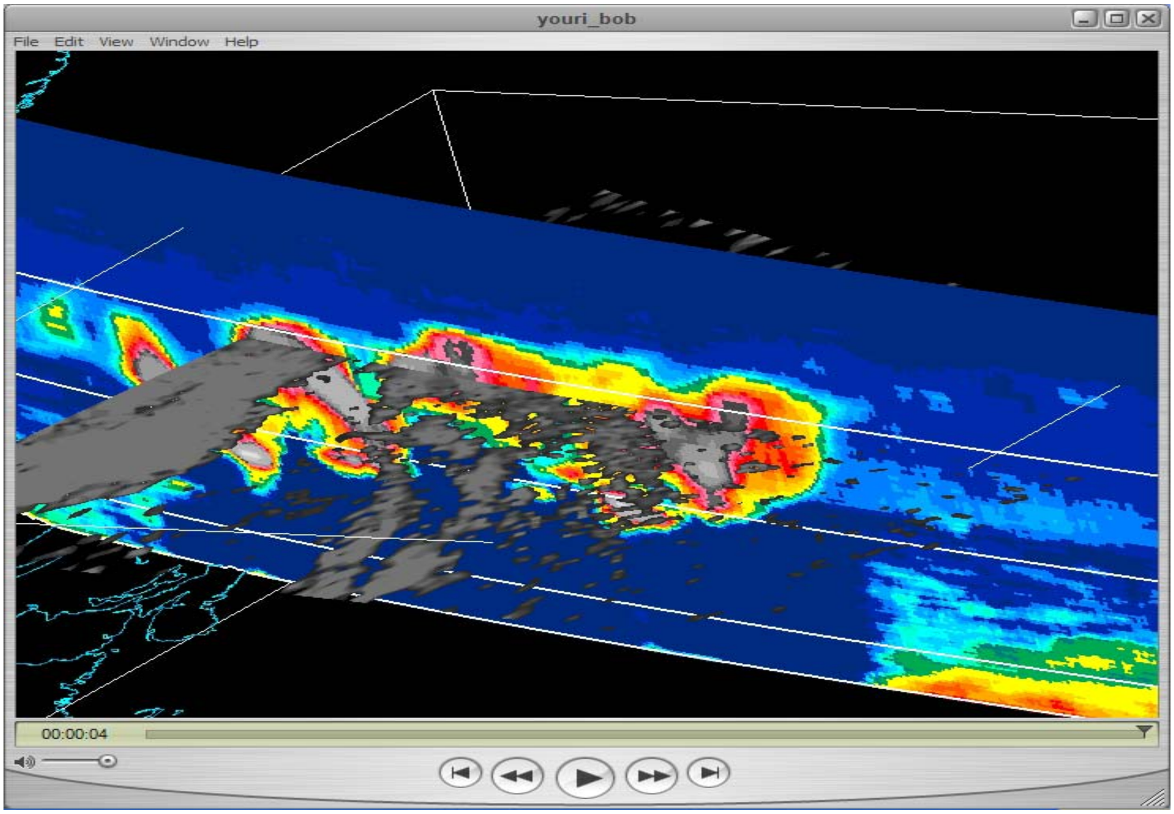

Figure 17.2.2. 3-D display of CALIPSO attenuated backscatter (at 532 nm) for a flight segment on 15 June 2006 along with vertical distribution of effective cloud amount derived from AIRS measurement along collocated scan element.

Estimating cloud profiles from AIRS measurements

Work continued on the estimation of cloud amount profiles from AIRS high spectral resolution infrared measurements. Cloud amount profiles derived from longwave only measurements have been compared to those derived from shortwave only measurements. Figure 17.2.3 shows the comparison with the CALIPSO determinations. LW & SW estimates of cloud absorption complement each other in describing cloud 3D distribution. Both show very good agreement in the cloud vertical structure with respect to the CALIPSO backscatter; both find the cloud extended between 5 and 15 km in height with denser segments near cloud bottom in similar locations. During daylight, when reflected solar contributions in the shortwave can confuse cloud property determinations, those derived from longwave only have been demonstrated to be of comparable quality. The MODIS CO_2 slicing cloud top pressures are also shown; these cloud top pressure determinations are indicative of the radiative mean of these thinner high clouds.

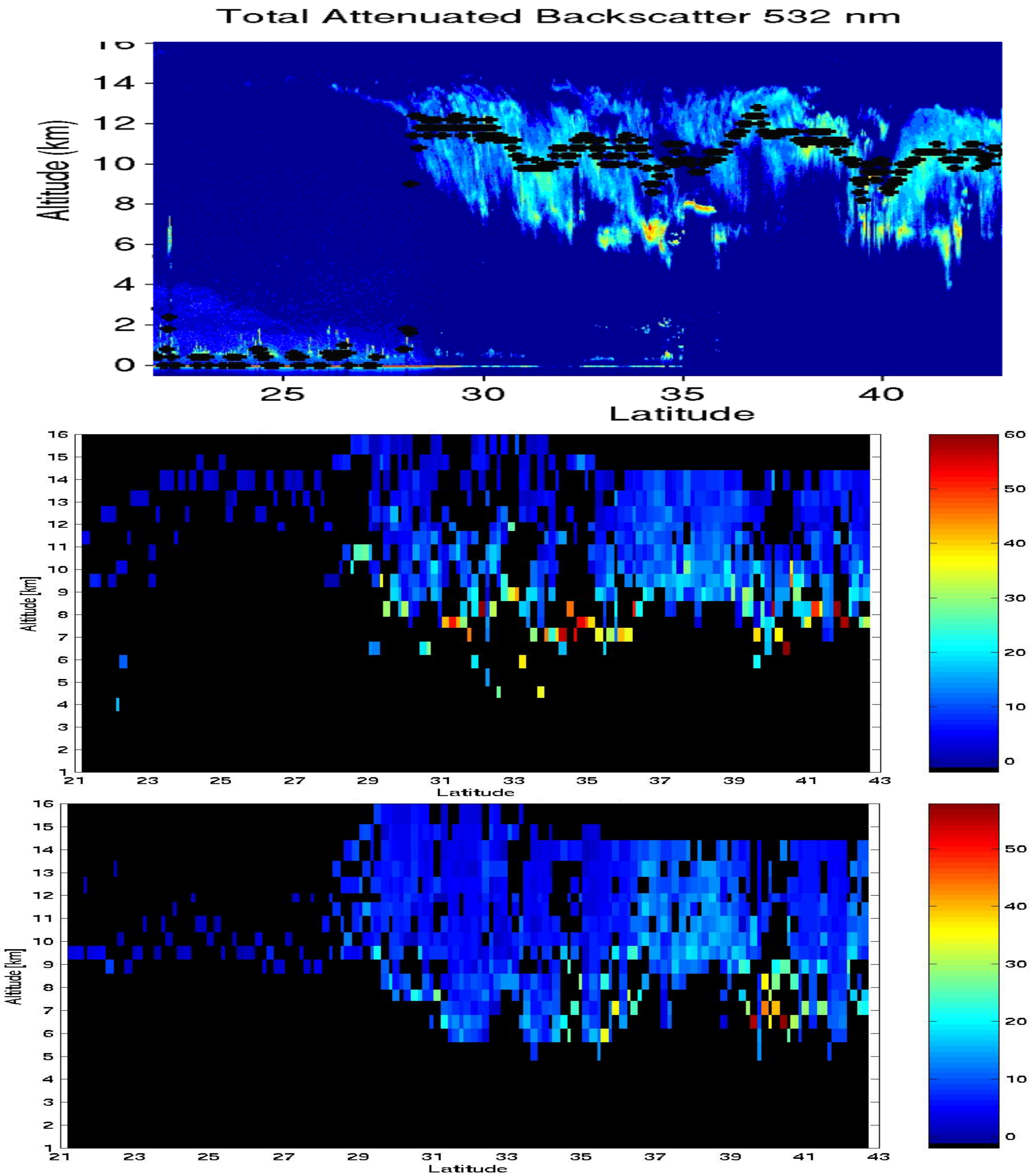

Figure 17.2.3. (top) CALIPSO attenuated backscatter (at 532 nm) and Aqua MODIS cloud top heights (black pluses) for a flight segment on 15 June 2006, zoom on high cirrus at 30^o to 40^o N latitude; (middle) Vertical distribution of effective cloud amount derived from AIRS measurement along collocated scan element derived from LW (13.3-14.4 μm) and (bottom) SW (4.1-4.6 μm) spectral measurements.

Estimating CO_2 profiles from AIRS measurements

Studies continued on estimating CO_2 concentrations by minimizing residuals between AIRS measured radiances versus radiative calculations (via SARTA). Initial first guess CO_2 concentrations are alternated from 5 ppmv too high for one fov to 5 ppmv too low for the next (referred to as a checkerboard initialization). CO_2 profile solutions from high and low first guesses converge to a common value where the AIRS spectral measurements provide adequate information; this is found to be from 150 to 350 hPa. Figure 17.2.4 shows average estimates of vertical CO_2 concentration for two initial first guess values (RED – 375 ppmv, GREEN - 365 ppmv); the average solution is shown for 3 iterations in which the solutions merge for atmospheric layer 150-350 hPa to a solution of 369 ppm at 150 hPa increasing to 372 ppm at 350 hPa. Figure 17.2.2 shows the spectral distribution of average of absolute (measurement – estimate) residual and its variation for the first guess of 365 ppmv (black) and the 3rd iteration (red). Response to CO2 change of +5ppmv is shown in blue (shifted by dT of +0.9 K). A normalized spectrum is shown in green.

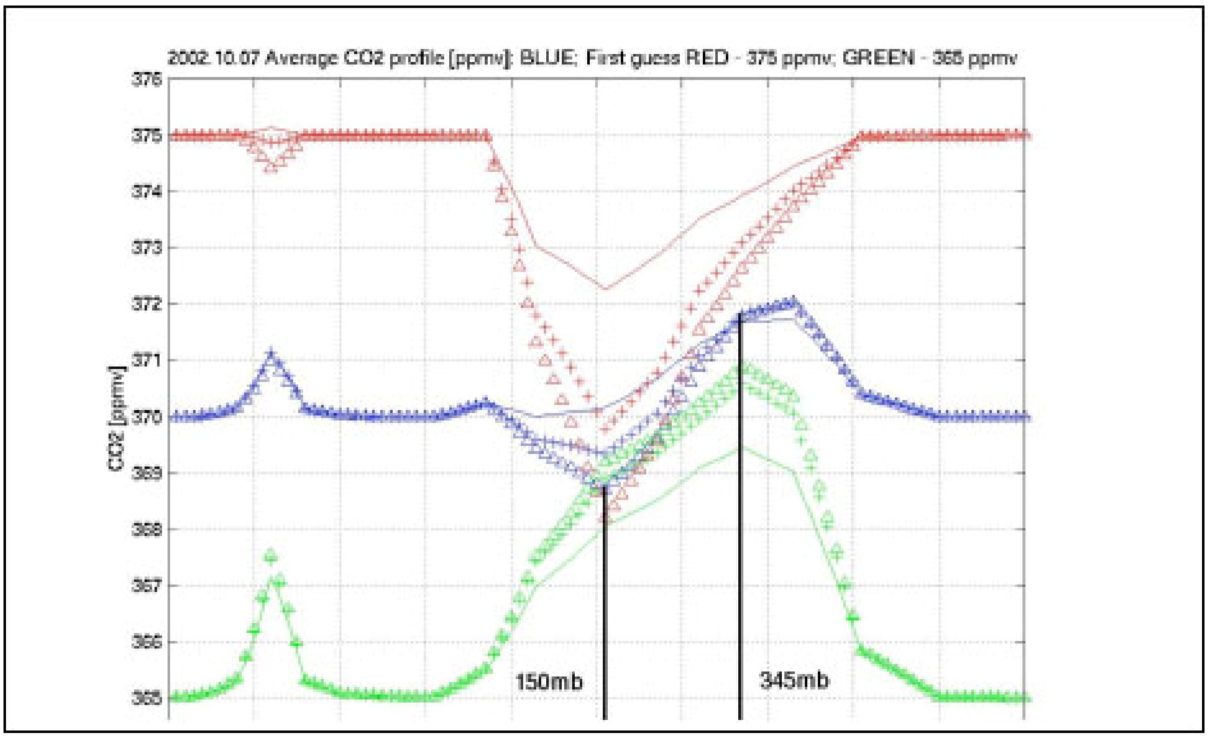

Figure 17.2.4. Average estimates of vertical CO_2 concentration for two initial CO_2 values (RED – 375 ppmv, GREEN - 365 ppmv) are shown. Each average solution is shown for 3 iterations (1-solid line,2 - +, 3 - Δ). The solutions merge for atmospheric layer 150-350 hPa to 369 ppm at 150 hPa increasing to 372 ppm at 350 hPa.

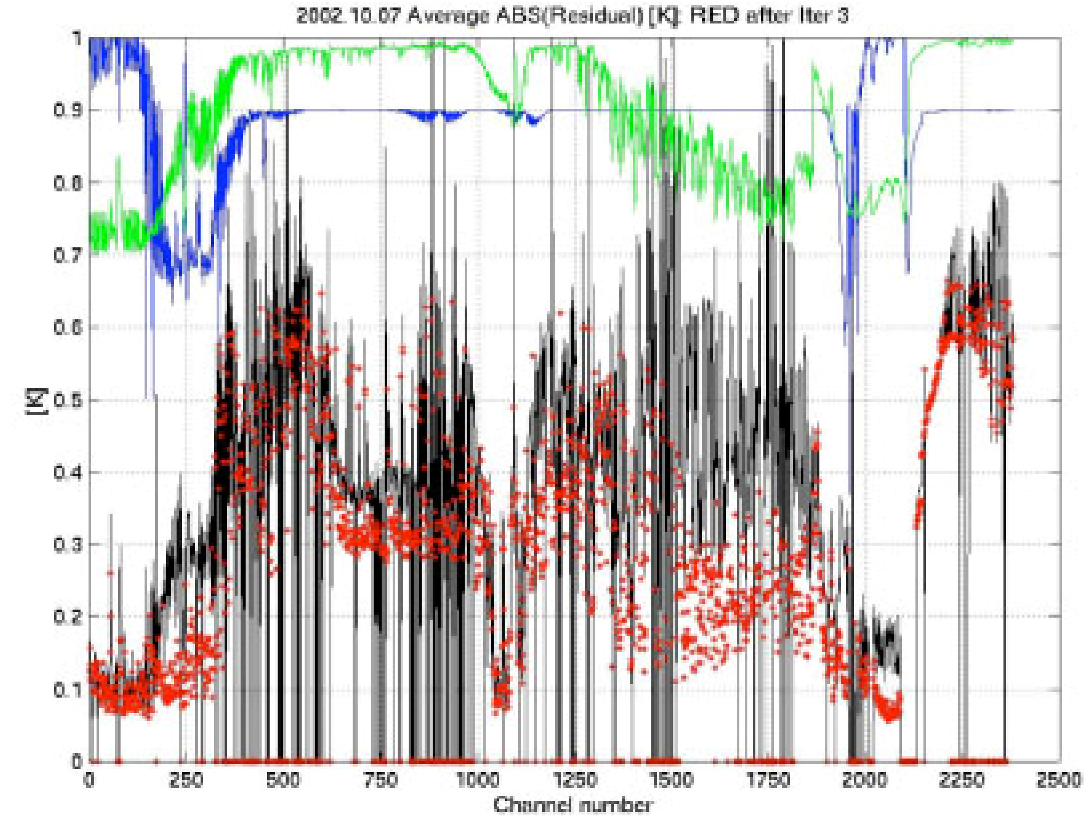

Figure 17.2.5. Spectral distribution of average of the absolute (measurement – estimate) residual (in degrees K) and for the first guess (shown in BLACK) and the 3rd iteration (RED). For the first guess the CO2 concentration was fixed (365 ppmv) and all other modeling parameters were estimated. At iteration 1 and thereafter the CO_2 concentration vertical profile was estimated. Measurement response to CO2 variation +5ppmv (shifted by dT +0.9K) is shown in BLUE; changes of 0.2 K are found between 13 and 14 microns. A normalized spectrum is shown in GREEN.

Investigating the Effect of Ozone on CO2 channel Radiances

Atmospheric ozone affects the calculation of CO_2 sensitive radiances, and hence cloud property determinations with CO_2 slicing. Calculations were performed using SARTA to determine what part of the O_3 profile was most influential on the CO_2 radiances. Figure 17.2.6 shows that the ozone between 100 and 10 hPa has the biggest impact. The CO_2 slicing algorithm was changed so that O_3 profiles were estimated with the Global Forecast System (GFS) rather than climatology. Cloud top properties in the tropics are being studied to determine to overall effect.

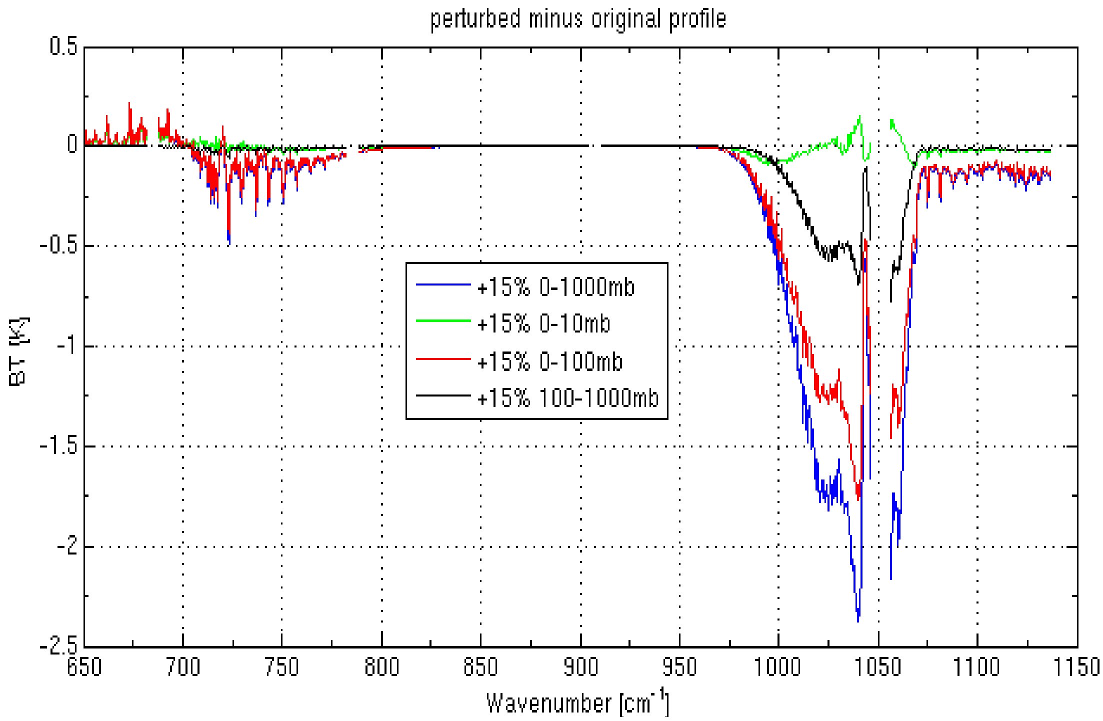

Figure 17.2.6. Ozone effect on SARTA calculated brightness temperatures. A 15% increase in O_3 between 100 and 10 hPa has the same effect in the CO_2 sensitive region from 675 to 775 cm-1 as a 15% increase in O_3 between 1000 and 0 hPa.

GPS and Sounders

The paper on combined CHAMP/AIRS/AMSU profile retrievals was published. The reference is Borbas, E. E., W. P. Menzel, E. Weisz, and D. Devenyi, 2008: Deriving atmospheric temperature of the tropopause region/upper troposphere by combining information from GPS radio occultation refractivity and high spectral resolution infrared radiance measurements. Jour of App Meteor and Clim., Vol. 47, No. 9, 2300-2310. The paper reports that AIRS/AMSU temperature retrievals show an improvement of about 0.5 C in the tropopause region from the inclusion of GPS data.

Publications and Conference Reports

Plokhenko, Y., W. P. Menzel, H. E. Revercomb, E. E. Borbas, P. Antonelli, E. Weisz, 2008: Analysis of multi spectral fields of satellite IR measurements: Using statistics of second spatial differential of spectral fields for measurement characterization. *International Journal of Remote Sensing*, **29**, 2105-2125, doi:10.1080/01431160701268988.

P. Menzel and C. Moeller attended the MODIS-VIIRS Science Team meeting held in Baltimore, MD 14 - 16 June 2008.

17.3. A Broad Scope of Cal/Val and Independent Verification and Validation Activities in Support of IPO, with Emphasis on CrIS

CIMSS Project Lead: Hank Revercomb
CIMSS Support Scientists: Fred Best, Dave Tobin
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
5. Provide critical support for the NOAA mission

Proposed Work

The work proposed concentrates on applying our experience to NPOESS instrument testing, characterization, calibration, radiance and product validation, and suggested improvements. Specific areas of focus are listed below:

- Support CrIS Planning and Review Meetings
- CrIS Pre-launch Test Support and Performance Analyses
- CrIS Sensor Data Record (SDR) Algorithm Support and Development
- Validation Analyses and Technique Demonstration
- Aircraft Instrument Support and Calibration
- Plan and Conduct Field Campaigns
- Mock Cal/Val Using Proxy CrIMSS Observations for Risk Reduction

Summary of Accomplishments and Findings

The major focus of our efforts has been in support of the CrIS instrument testing, evaluation, and problem resolution. Due to the problems we help uncover related to the far lower than expected flight instrument internal blackbody emissivity and significant radiometric non-linearity, it became necessary to realign our efforts to help narrow down the source of the problems and then help identify the most effective solutions. Due to this realignment of focus we were unable to address Validation Analyses and Technique Demonstration and Mock Cal/Val Using Proxy CrIMSS Observations for Risk Reduction. A summary of the work performed is provided below, by task:

Support CrIS Planning and Review Meetings

We supported major CrIS review meetings held at ITT, including several Technical Interchange Meetings, two Test Readiness Reviews, and several Sensor Data Record Reviews. We also support the weekly "Thursday Technical Telecons."

CrIS Pre-launch Test Support and Performance Analyses

This task has expanded beyond the originally defined scope due to the problems uncovered during CrIS thermal vacuum testing that showed significant radiometric non-linearity and that the emissivity of the flight blackbody was far less than expected.

As part of this effort Hank Revercomb participated in daily Radiometic Tiger Team Meetings that spanned a period two months.

The UW team has been actively involved in many aspects of the CrIS Flight Model 1 testing. The thermal vacuum radiometric testing revealed three significant issues which we identified and have been active in resolving. These issues are very significant in terms of improving the CrIS performance to meet its original radiometric requirements and for proper understanding of the sensor and data for end-user weather and climate applications. The three primary issues can be seen in Figure 17.3.1 and include:

1. very low emissivity of the Internal Calibration Target (ICT),
2. significant radiometric nonlinearity in the longwave and midwave spectral bands, and

2. significant temperature gradients and absolute value uncertainties in the External Calibration Target (ECT).

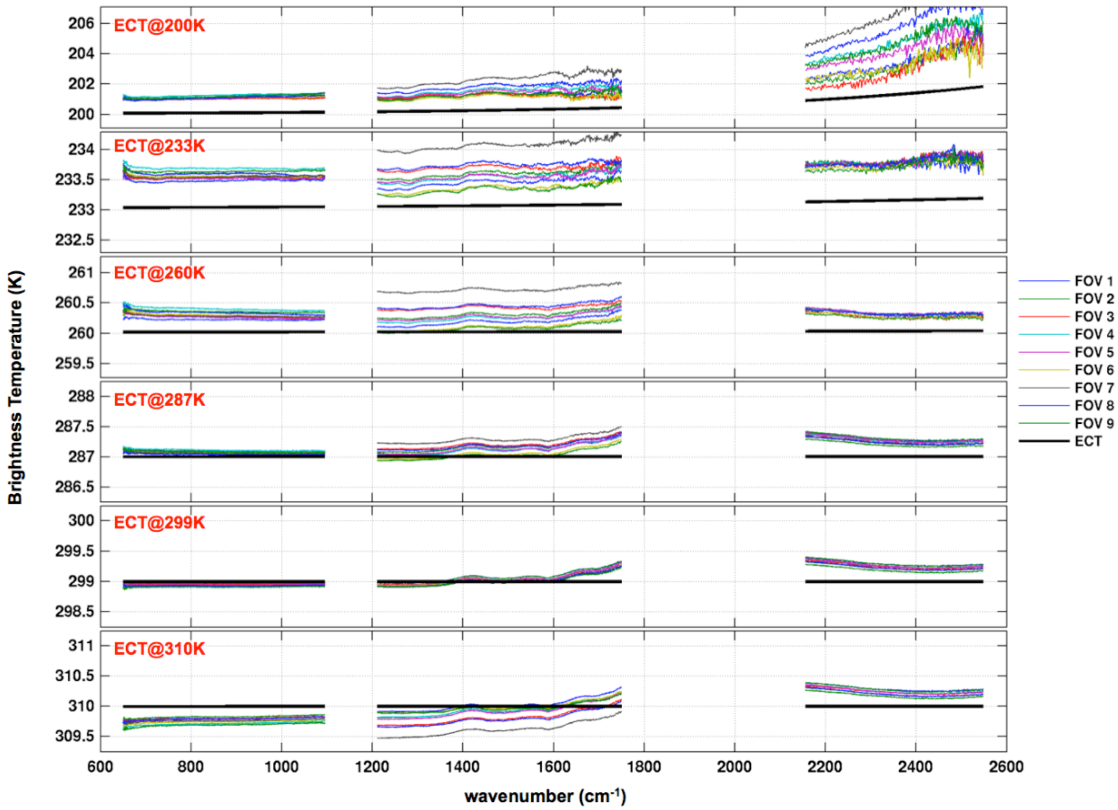

Fig 17.3.1. Thermal vacuum radiometric calibration test results for the CrIS Flight Model 1. The figure shows comparisons of CrIS observed brightness temperatures for its nine Fields of Fov (FOV) when viewing the External Calibration Target (ECT) compared to the predicted brightness temperature of the ECT, for six different temperature plateaus of the ECT. Differences related to the three primary issues discussed in the text are evident. The spectral non-flatness of the observed, calibrated spectra for the 299K ECT plateau in the midwave and shortwave spectral regions are due to the low emissivity of the Internal Calibration Target (ICT); in the longwave and midwave spectral bands the radiometric non-linearity causes the dispersion of results among the nine fields of view for the other ECT plateaus; temperature gradients in the ECT are evident in the shortwave band calibrated spectra.

These issues and probable root causes were identified early in the thermal vacuum testing and we first presented the findings to the CrIS team on May 23 (CrIS_Calibration-UW-23May08.ppt) and on 30 May 2008 (CrIS_Calibration-UW-30May08-ff.ppt). Since then, we have participated in the process to resolve these issues, including:

1. the decision to replace the FM1 ICT with the previous Engineering Development Unit (EDU) ICT and its characterization,
2. further characterization and root cause determination of the radiometric non-linearity signatures and development of the non-linearity correction algorithm, and
3. the use of UW reference temperature sensors, and other analyses, to understand and improve the ECT temperature uncertainties.

PowerPoint's:
CrIS_Calibration-UW-23May08.ppt
CrIS_Calibration-UW-30May08-ff.ppt
Round_robin_tobin.ppt

CrIS Sensor Data Record (SDR) Algorithm Support and Development
UW defined the test protocol and provided the data analysis that was used to characterize the CrIS detector non-linearity. A correction algorithm, based on previous UW research, was provided to the CrIS team and has been adapted to the CrIS and shown to effectively minimize the non-linearity. A considerable effort has been made to determine the optimal correction coefficients and their uncertainties. The revised version of the SDR algorithm, including the non-linearity correction algorithm, will be released soon.

PowerPoint's:
CrIS_Calibration-UW-30May08-ff.ppt
Nasti_nonlin_slides.ppt
CrIS_Nonlinearity_UW_Analysis_23July08.ppt
a2values_18Jul2008.ppt

Aircraft Instrument Support and Calibration
As a further tie of UW developed blackbodies to NIST traceable standards, UW is working on a study with NIST to demonstrate relevant existing and forthcoming NIST capabilities suitable for blackbody system-level characterization that could form the foundation for the much-anticipated NASA climate mission (CLARREO). In support of this study UW provided an AERI blackbody for testing using NIST's Fourier Infrared Spectrophotometric (FTIS) and Advanced Infrared Radiometry and Imaging (AIRI) facilities that provide primary measurements of absolute spectral emissivity and spectral radiance of materials and blackbody sources at near-ambient temperatures and ambient environment. The AERI blackbody provided for this effort was that same unit that was used in earlier testing with the NIST TXR that showed: a) better than predicted blackbody cavity emissivity with a blackbody of the same fundamental design as the Scanning HIS Aircraft instrument; and b) absolute radiometric performance of the Scanning HIS was well within predicted uncertainty.

Plan and Conduct Field Campaigns
We are working with IPO to refine the Cal/Val plan and to determine how aircraft campaigns fit into the overall scheme.

Publications and Conference Reports
Bedka, Sarah; Antonelli, P.; DeSlover, D.; Dutcher, S.; Knuteson, R.; Revercomb, H.; Smith, W.; Taylor, J.; Tobin, D.; Woolf, H. and Zhou, D.. Retrievals of atmospheric thermodynamic structure from University of Wisconsin Scanning-High-resolution Interferometer Sounder (S-HIS) upwelling radiance observations using Bayesian Maximum A Posteriori (MAP) inverse method. Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), 12th, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008, Paper P2.7. Call Number: Reprint # 5644.

Dykema, John A.; Holz, R.; Tobin, D.; Kirk-Davidoff, D. B.; Leroy, S. S.; Knuteson, R. O.; Best, F. A.; Revercomb, H. E. and Anderson, J. G.. Benchmark measurements for achieving societal objectives. Symposium on Future National Operational Environmental Satellites, 4th, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008, Manuscript not available for publication.

Larar, Allen M.; Smith, W. L.; Revercomb, H. E.; Zhou, D. K.; Liu, X.; Tobin, D.; Taylor, J. P.; Schlussel, P. and Mango, S. A.. The Joint Airborne IASI Validation Experiment (JAIVEx) and select contributions from NAST-I. Symposium on Future National Operational Environmental Satellites, 4th, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008, Manuscript not available for publication.

Liu, Xu; Zhou, D. K.; Larar, A. M.; Smith, W. L.; Schlussel, P.; Taylor, J. P.; Revercomb, H. and Mango, S. A.. Atmospheric temperature and moisture profile retrievals using more than eight thousand channels. Symposium on Future National Operational Environmental Satellites, 4th, New Orleans, LA, 20-24 January 2008. American Meteorological Society, Boston, MA, 2008, Manuscript not available for publication.

Antonelli, Paolo; Tobin, Dave; Revercomb, Hank; Turner, Dave; Dutcher, Steve; Howell, Ben; Knuteson, Bob; Vinson, Kin and Smith, William L.. Application of PCA to hyperspectral data for noise characterization, noise filtering and instrument monitoring. Recent Developments in the Use of Satellite Observations in Numerical Weather Prediction, Reading, UK, 3-7 September 2007. ECMWF seminar proceedings. European Centre for Medium-range Weather Forecasts (ECMWF), Shinfield Park, Reading, UK, 2008, pp.111-126. Call Number: Reprint # 5668.

Shephard, Mark W.; Worden, Helen M.; Cady-Pereira, Karen E.; Lampel, Michael; Luo, Mingzhao; Bowman, Kevin W.; Sarkissian, Edwin; Beer, Reinhard; Rider, David M.; Tobin, David C.; Revercomb, Henry E.; Fisher, Brendan M.; Tremblay, Denis; Clough, Shepard A.; Osterman, Gregory B. and Gunson, Michael. Tropospheric Emission Spectrometer nadir spectral radiance comparisons. Journal of Geophysical Research, Volume 113, 2008, Doi:10.1029/2007JD008856, 2008. Call Number: Reprint # 5718

Pre–Launch Spectral Calibration of the CrIS Sensor on NPOESS/NPP
Larrabee Strow, Howard Motteler, Scott Hannon – University of Maryland Baltimore County; David Tobin, Joe Taylor, Lori Borg, Graeme Martin, Hank Revercomb – University of Wisconsin, SSEC

Analysis of CrIS Flight Model 1 Radiometric Linearity and Radiometric Noise
David Tobin, Hank Revercomb, Fred Best, Lori Borg, Robert Knuteson, Joe Taylor – University of Wisconsin, SSEC

Inter–Calibration of the AIRS and IASI Operational Infrared Sensors
Larrabee Strow, Scott Hannon – University of Maryland Baltimore County; David Tobin, Hank Revercomb – University of Wisconsin, SSEC

17.4. The International Polar Orbiting Processing Package (IPOPP) for Direct Broadcast Users

CIMSS Project Lead: Allen Huang
CIMSS Support Scientists: Liam Gumley, Kathy Strabala
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water

Proposed Work:
CIMSS/SSEC proposed to coordinate with IPO and the NASA Direct Readout Lab (DRL) in executing the common work plan established in the March 2007 TIM. CIMSS/SSEC planned to:

1. Participate and engage in IDPS Algorithm Transformation Evaluation to evaluate the existing approaches for transforming IDPS algorithms into a form where they can be run on Linux. A study report on the advantages and disadvantages of each approach will be generated to recommend a strategy for adoption by IPOPP.
2. Evaluate selected IDPS algorithms for
   a. Ancillary data requirements;
   b. Algorithm interdependencies;
   c. Suitability for real-time direct broadcast processing.
3. Provide assistance for NISGS installation on Draca for testing and evaluation.
4. Install NISGS on SSEC cluster for testing and evaluation.
5. Assemble initial test data sets.
6. Collect and provide important documents to the IPOPP team.
7. Establish IPOPP team website and/or mailing list.
8. Establish software development environment on Draca.
9. Create draft of IPOPP user web site (e.g., FAQ, relevant documents, schedules)
10. Support DRL, in time for Polar Max 2007, in the creation of a real-time processing system that runs a subset of VIIRS and equivalent MODIS algorithms in parallel driven by Aqua MODIS direct broadcast proxy data. Candidate algorithms include Cloud Mask, Fire Mask, cloud top property, and SST.

Summary of Accomplishments and Findings
SSEC released the new "MODIS Today" real-time true color image website to the public:
http://www.ssec.wisc.edu/modis-today/
In conjunction with MODIS Today, SSEC also released a new capability to display real-time MODIS images in Google Earth.

The project added two SSEC software engineers to the IPOPP project (50% time each) to work on the CrIS and ATMS RDR and SDR code.

The MODIS MOD09 Land Surface Reflectance for DB package was delivered to NASA DRL in January for Science Processing Algorithm (SPA) wrapper integration. DRL subsequently released the code to the DB community in June.

Installed and tested the IPOPP Alpha DVD received from NASA DRL on 17 April 2008. A test report was delivered to IPO.

To facilitate use of big-endian coefficient files from the IDPS on little-endian Linux systems, investigated tools and techniques for generating byte order flipping code (to-file and in-memory). Using the GCC-

XML tool set with pygccxml, wrote a short utility "backflip.py" which generates a C++ header file with in-memory byte order flipping of arbitrary C data structures.

The VIIRS OPS 1.5.0.18 Cloud Mask code was successfully integrated into LEOCAT.
- Code now compiles and runs successfully on one Aqua MODIS daytime granule.
- Cloud mask image products have been generated and compared to the output from VIIRS OPS 1.4. No major differences in the output are obvious for this particular granule. Work started on integrating the VIIRS COP, CTP, and CBH algorithms in LEOCAT.

A framework was established to run the CrIS SDR OPS 1.5 code outside of IDPS. A detailed review of CrIS SDR driver code already in the IDPS was done, and science separation points identified similarly to what was done with CrIMSS EDR (though the CrIMSS EDR code has the simplifying factor of being a Fortran-to-C interface). The APIs for replicating IDPS functionality were built and are now being integrated into the CrIMSS SDR calibration algorithm.

The CrIMSS EDR OPS 1.5 code was compiled and run to completion on Linux and generated what appears to be reasonable atmospheric temperature and moisture profiles. A report on this work was sent to the IPOPP team. CrIS SDR test data obtained from the GSFS Mini-IDPS FTP site were used as input, and an NWP model field was substituted for the ATMS derived first guess field. Byte order of binary files required for input was handled with the Portland F90 compiler byte-swap compiler flag. The science routines for the CrIMSS EDR were executed via a F90 driver which replaced the IDPS infrastructure code. Developed a plan for testing the CrIMSS EDR package. Will run in CrIS-only and CrIS+ATMS modes locally using input data from mini IDPS. Obtained EDR output from mini IDPS for comparison.

Meetings Attended

Allen Huang, Liam Gumley, and Kathy Strabala attended the EOS/NPP DB Meeting in Thailand (Mar. 31 - Apr. 4).

Liam Gumley attended the NPOESS Direct Readout Customer Forum (4 - 5 March 2008) at GSFC/DRL.

Allen Huang, Kathy Strabala, and Liam Gumley attended the ITSC-XVI conference in Angra dos Reis, Brazil from 7-13 May 2008. John Overton, Kathy Strabala, and Liam Gumley convened a technical working group meeting on Direct Broadcast issues of concern to the polar orbiting meteorological satellite community, and came up with a list of actions to be worked on to support the DB community who use atmospheric products from Terra, Aqua, POES, MetOp currently and FY-3, NPP, and NPOESS in the future. The conference was very successful for the IPOPP team in that it allowed plans for IPOPP to be shared with the DB atmosphere community and established a continuing presence of the IPOPP team in the work of the International TOVS Working Group.

18. CIMSS Support of Calibration/Validation

CIMSS Project Lead: David Tobin
CIMSS Support Scientist: Mat Gunshor
NOAA Collaborator: Tim Schmit
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

The primary task of this project is to compare five years of polar-orbiting, high spectral resolution AIRS data to the infrared channels on operational GOES Imagers. Multiple comparisons will be made at the geostationary sub-satellite points yielding an average brightness temperature difference between the geostationary imagers and AIRS. This project aims to look back at approximately five years of AIRS and GOES observations, comparing the entire AIRS data record to date to the GOES Imagers that were operational during that time.

Such a comparison of AIRS and GOES will be beneficial for several reasons. Using a single version of AIRS data, the same set of channels, for the entire data record and applying the same methods will provide a consistent comparison and analysis that does not currently exist. This should provide insights into the calibration accuracy of the GOES Imagers during this five year time-period. The effects of Imager operations such as decontamination and patch temperature on calibration accuracy may be revealed as well. Of particular interest will be the 13.3 micrometer band on GOES-12 since this band seems to be not well calibrated on either GOES-12 or GOES-13, and EUMETSAT seems to have a similar problem with that band on their own Imagers. Whether this band's calibration is consistent in time may affect how the problem is handled with other imagers.

NOAA participates in research promoting and advancing the knowledge of intercalibration techniques through the Global Space-Based Inter-Calibration System (GSICS). The primary goal of GSICS is to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space component of the WMO World Weather Watch (WWW) Global Observing System (GOS) and Global Earth Observing System of Systems (GEOSS). While the bulk of the effort currently with GSICS is in getting a system working for currently operational sensors, there is also a task to look back in time and make assessments of past instrument performance. This project supports GSICS and also the NOAA Mission Goals of Climate and Weather and Water.

Summary of Accomplishments and Findings

This project was a late start under the cooperative agreement. As such, at the end of this reporting period, it is just getting underway. A new rack-mounted system was purchased and much of the software necessary to do the processing has been installed. The AIRS data will be provided by a separate CIMSS project which has stored the entire AIRS data record in an easily accessible data storage network (internal to CIMSS). GOES data will be acquired from the SSEC Data Center. The system has been tested on a small number of cases and will soon be ready to begin the approximately 5 year analysis.

19. Support for the International TOVS Study Conference (ITSC 16)

CIMSS Project Lead(s): Allen Huang
CIMSS Support Scientists: Maria Vasys, Bill Bellon, Leanne Avila
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water
2. Understand climate variability and change to enhance society's ability to plan and respond
5. Provide critical support for the NOAA mission

Proposed Work:
CIMSS/SSEC proposed to provide meeting administration and management for The Sixteenth International TOVS Study Conference, held near the town of Angra dos Reis in Brazil from 6 - 13 May 2008. In addition to coordinating meeting activities, CIMSS/SSEC also arranged travel support for 15 international scientists.

Conference and Meeting Participation:
Around 130 participants from 18 countries and 3 international organizations attended the Conference and provided scientific contributions; this number of attendees was the highest ever and included a large number of new younger scientists. There were 95 oral presentations, including 14 poster introductions, 16 working group and technical sub group presentations and 86 posters presented during the conference. All of the talks and many of the posters can be viewed at the ITWG Web site, located at http://cimss.ssec.wisc.edu/itwg.

Summary of Accomplishments and Findings:
During the Conference, a session on Working Group Status Reports considered activities that had taken place since ITSC-XV in Maratea. This session also reviewed progress on the Action Items and Recommendations identified by the ITSC XV Working Groups. Many of these items formed the basis for further discussion by the Working Groups at ITSC XVI. Several technical sub groups also met during ITSC-XVI to discuss developments and plans concerning specific software packages, shared and in common use, and microwave frequency protection.

The Working Groups had very useful discussions. This was the first opportunity for the conference to discuss the use of new data from MetOp-A, which was launched just after ITSC-XV, and it was exciting to see the substantial progress already achieved by several centers.

Working Groups were formed to consider six key areas of interest to the ITWG, including Radiative Transfer and Surface Property Modeling; Use of ATOVS in Numerical Weather Prediction; Use of TOVS and ATOVS for Climate Studies; Advanced Sounders; International Issues; and Satellite Sounder Science and Products. The Working Groups reviewed recent progress in these areas, made recommendations on key areas of concern and identified items for action. Working Group reviews and recommendations comprise an important part of the ITSC-XV Working Group Report. A summary of the key points arising from the conference are listed below.

1. The results of new observing system experiments presented at ITSC-XVI demonstrate that satellite data have a large impact on weather forecast accuracy and promising new results suggest the potential for future enhancements in the use of satellite sounder and imager data. It is crucial that future instruments as a baseline maintain, and if cost effective, improve upon, the quality of AMSU and IASI.
2. Many NWP centers are now assimilating radiances operationally or experimentally from the Infrared Atmospheric Sounding Interferometer, IASI, and getting significant positive forecast

impacts. The experience with AIRS was crucial to the rapid implementation of IASI.

3. The success of the JAIVEx campaign in support of cal/val for IASI was a major theme at ITSC-XVI both in support of assimilation of IASI observations in NWP and to improve characterization of climate data records. The group urged similar campaigns for future instruments.
4. Many centers are experiencing difficulty using moisture sensitive channels and the group urged more focused effort in this area and encouraged more exchanges of experience between centers.
5. Since ITSC-XV several centers have made significant progress in understanding and using cloud-affected radiances, with progress in radiative transfer, data assimilation and more sophisticated cloud screening. As a result more satellite sounding data can be used.
6. The IASI and AIRS radiances assimilated are still a small fraction of those available but some efforts are underway to allow a more complete use of the data (e.g. through use of reconstructed radiances or principal components).
7. The number of NWP centers using level 1b ATOVS radiances in their variational assimilation systems continues to grow but there are still centers which rely on the level 2 retrievals provided by NESDIS.
8. The Regional ATOVS Retransmission Service, RARS, has continued to develop since ITSC-XV. The Asia-Pacific RARS service has continued to expand and more NWP centers are using the RARS data. RARS networks in S. America and Africa are now available. The group encouraged WMO and the space agencies to continue to develop this ATOVS retransmission service as a low cost means of providing more timely ATOVS data for 90% of the globe. The Southern ocean and North Pacific were identified by one study as particularly needing RARS.
9. The group continues to strongly support the SafetyNet concept, identifying it as one of the most attractive features of NPOESS. WMO and the RARS Implementation Group were invited to consider an expansion of RARS for NPP and NPOESS-C1 as SafetyNet will become fully operational only from NPOESS-C2 onwards.
10. An important issue for consideration is that when MODIS is retired, according to current plans, there will not be an imager in polar orbit with a channel in the water vapor band. This will degrade the accuracy of any polar satellite derived winds. Space agencies are urged to consider the best means for providing a polar orbiting imager with water vapor channels along with the conventional VIS and IR channels.
11. Further progress in the pre-processing of SSMIS data has been made with the development of the unified preprocessor, jointly developed by several centers with a strong interest in SSMIS data quality. More NWP centers are now able to use the DMSP-F16 SSMIS sounding channels operationally and progress is being made with DMSP-F17 SSMIS. The group encouraged the SSMIS cal/val team to make the data available from DMSP-F18 as early as possible after the launch to expedite their use in operational systems.
12. The group encouraged the careful characterization of new satellite instruments, notably promoting the use of pre and post-launch traceable calibration standards for future sounders.
13. The group recommended further studies on the optimization of the size of the advanced sounder fields of view using experience with the MetOp HIRS/4 and NOAA-17 HIRS/3 instruments.
14. The group noted that lossy datasets for advanced sounders may not be suitable for all applications and consequently recommended techniques for spatial as well as spectral thinning to be studied for distribution of advanced sounder data, notably IASI.
15. The community software packages (i.e. AAPP, IAPP, IMAPP) have been essential in the use of ATOVS, IASI, AIRS and MODIS data by the meteorological community. The group encouraged satellite agencies to continue to support these packages for existing missions and to develop and release pre-processing software packages as soon as practical before launch e.g. IPOPP.
16. The group urged space agencies to provide documentation on data formats well before launch to allow similar community software packages to be developed for planned new satellites (e.g. FY-3

and NPP).

17. The group urged space agencies to use expertise from NWP centers throughout the cal/val phase for new instruments, as proved particularly successful for SSMIS and IASI.
18. The group noted the increasing threat of RF interference in microwave imager channels. All members were urged to lobby their respective radio communication authorities to support protection of the imager and sounder bands and specifically to identify useful bands between 275 and 3000 GHz and to undertake more detailed studies in support of 52.6-59.3 GHz and 86-92 GHz.
19. Satellite provider agencies were again encouraged to continue and expand their support for education and training of the next generation of remote sensing scientists.
20. It was also noted that research into truly lossless compression techniques continues in the wider scientific community. It is recommended that space agencies investigate both lossless and lossy data compression techniques which may be used to aid dissemination of advanced sounder observations.
21. Optimal use of community state-of-art software packages within the central operational processing for satellite programs has been raised again and the group is continuing to recommend to that space agencies promote partnerships in building environmental satellite systems where government, industry and university science communities share their expertise.
22. The time series of (A)TOVS now exceeds 29 years and the quality and number of climate products continues to grow. It was recognized that the fundamental instrument parameters of all the (A)TOVS sensors should be retained for future reprocessing efforts.
23. The group supported the continuing efforts to develop the GCOS Reference Upper Atmospheric Network (GRUAN) for climate with the primary objective of creating long term records of critical upper air measurements and associated error characteristics to support their continuing integration in climate applications and research.
24. The ITWG noted that the TOVS/ATOVS lower tropospheric climate data record is view geometry dependent and this product would be lost if there was a migration to a conical viewing geometry.
25. It was recognised that high spectral resolution imaging radiometers on geostationary platforms are likely to be an important part of the future global observing system. The group supported plans for operational missions but would also welcome a preparatory mission earlier than 2015 if possible.
26. The group noted that LEO IR and MW sounding capability on 3 orbital planes is essential to proper sampling of atmospheric temperature and humidity vertical profiles. At present there is no IR sounding capability planned for the early morning orbit and the performance of the MIS sounding channels is yet to be assessed. The group recommended WMO, CGMS and CEOS investigate scenarios for sounding instruments in the early morning orbit.
27. The group noted that GPSRO data has allowed better characterization of biases in passive sounding data from 20-40 km and consequently operational continuity for COSMIC is now important to maintaining good quality passive upper level sounding data.

Future Plans:

The ITWG will continue to meet and inform the ATOVS community of the latest news and developments through its Web site and the email list, currently maintained by CIMSS/SSEC. The 4th Hyperspectral Workshop was held at EUMETSAT, Darmstadt, Germany 15 - 17th September 2008, and ITWG undertook to assist coordination between this group, the AIRS science team, the IASI conference and the ITWG advanced sounder working group to ensure effective exchange of information. The ITWG will also be holding the second workshop on remote sensing and modeling of surface properties prior to ITSC-17, tentatively scheduled for June 2009.

The website will continue to evolve to become an even more important tool for ITSC, with many new ideas proposed and endorsed at ITSC-16. This could include some interactive elements to the website (e.g., wiki).

The ITSC-XVI Working Group Report, a Proceedings for ITSC-XVI from the papers submitted will be provided to attendees and other interested persons on CD-ROM. The oral and poster presentations from ITSC-XVI are already available as pdf files which can be downloaded from the ITWG Web site. The next meeting of the ITWG is scheduled to take place in February 2010, depending on final choice of venue. Topics of interest will include more extensive evaluation of MetOp data, initial assessment of FY-3 data and status of preparations for the NPP launch.

20. CIMSS Cooperative Research Exchange

CIMSS Project Leads: Steve Ackerman, Margaret Mooney
NOAA Collaborator: Ingrid Guch
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information

Proposed Work

The CoRP website states that, **"**CoRP's branches, Institutes and its Center work together on remote sensing of the environment in these focus areas:

- Conduct investigations of the Earth with satellite observations
- Design observing systems for satellites
- Develop algorithms, products and applications for satellite data
- Simulate new observations from satellites

To help achieve this goal the NESDIS CIs have a summer student symposium.

Summary of Accomplishments and Findings

This summer Cooperative Institute for Oceanographic Satellite Studies (CIOSS) at Oregon State University hosted the annual NESDIS Cooperative Institute CoRP Science Symposium for 2008. The theme for the Symposium is "Data-Model Fusion – Use of Satellite Data with in situ Data and Models," covering everything from simple data-model comparisons to complex data assimilation. This is an opportunity for the NESDIS CIs and Center to share their activities in the theme area, and in particular to showcase student, post-doc work.

The 2008 symposium was held on the Oregon campus on August 12-13, with an estimate of about 60 people attending from the NESDIS Cooperative Institutes and local CIOSS participants. Steve Ackerman, Director of CIMSS, attended the symposium along with 3 PhD students (E. Hokanson, T. Wagner and Z Li) and one beginning M.S. student (K. Vincent)

Publications and Conference Reports

There were four presentation given at this symposium:

- Erin Hokanson presented a poster titled: An Investigation of Boundary Layer Turbulence Profiles and the Relationship to Model Predicted Parameters

- Timothy Wagner Hokanson presented a poster titled: Remotely Retrieved Entrainment Rates for Cumulus Clouds

- Zhenglong Li gave an oral presentation titled: Utilization of Forecast Models in High Temporal GOES Sounding Retrievals.

- Steve Ackerman gave a oral presentation title: Fusing Satellite and In Situ Data with Model Output

Timothy Wagner's poster was one of the winners for best student poster.

21. Support for a CIMSS Teacher Workshop

CIMSS Project Leads: Margaret Mooney, Steve Ackerman
NOAA Collaborator: Nina Jackson
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Summary of Accomplishments and Findings

CIMSS hosted 28 middle and high school science teachers from around the country on July 9th and 10th at a workshop on Geoscience Time Scales and Global Climate Change at the University of Wisconsin-Madison. This NOAA-supported event covered the topics of weather and climate, geological time and global climate change with an effort to support teaching and learning related to the 2007 Intergovernmental Panel on Climate Change (IPCC) Summary for Policy Makers. Lectures and presentations were interspersed with hands-on activities and lively discussions. One session took place with the visual aid of a 3D weather globe displaying GOES and POES satellite imagery generated at CIMSS. The workshop agenda, a list of participants, presentations, resource links, and evaluations are on-line at *http://cimss.ssec.wisc.edu/teacherworkshop/2008/*. Twenty-one teachers rated the experience as "excellent"; the rest marked the next best category of "very good" in the evaluations. One teacher commented that the workshop was "the single best professional development class this year (out of four)".

22. AVHRR Calibration

CIMSS Project Leads: William Straka III, Christine Molling
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals Addressed:

1. Serve society's needs for weather and water information
2. Understand climate variability and change to enhance society's ability to plan and respond

Proposed Work

Both polar and geostationary satellites are often calibrated independently with different methodologies and calibration/validation sites. This can lead to large discrepancies in the products generated across various polar orbiting satellites, including the various satellites of the POES program. Since the AVHRR instrument does not have an onboard calibration source, there is no one set of slope/intercept functions that relate the raw count values to radiances. Therefore, determining a consistent calibration of counts to radiances for the polar orbiting satellites, particularly using the AVHRR instrument, is vital in making cloud climatology from the polar orbiting satellites as well as producing consistent operational products. Thus, this research is aimed at quantifying the differences among the various calibration methods currently used. It is also aimed at understanding and producing a more accurate calibration for the AVHRR instruments.

Summary of Accomplishments and Findings.

The first thing that must be done is to understand what calibrations are currently being used. These were compiled from an extensive literature search as well as from conference presentations and calibrations available on the internet (particularly the official NOAA calibrations). In addition, collaboration and correspondence with the scientists and groups responsible are used when available. This has provided roughly 14 different sets of calibrations for the AVHRR instrument on NOAA polar orbiters 7 through 18. These represent the pre-launch calibrations and the post-launch calibrations from eight different research organizations. These calibrations were encoded and monthly time series of calibrated July reflectances using these various calibration methods were computed for channels 1 and 2. A number of reflectance targets were chosen. These were the Libyan Desert (which is a well known calibration location for polar orbiting satellites), two locations in Greenland, the Amazon rainforest, the Midwest US, and a low-reflectance region over the southeastern Pacific Ocean. We have extracted clear-sky-only AVHRR data over Midwest and Amazon targets, which will be used to compute the calibrated NDVI in the upcoming months. Figure 22.1.1 shows a subset of the channel 1 calibrated reflectances over the Libyan Desert for the ascending afternoon node. As can be seen, there are differences between the various calibration sources. We are in the process of evaluating the results from these time series.

In addition to calibrations, we also compared related data that differ depending on source: solar irradiance spectra and spectral response functions. Difference in these inputs can result in calibrated radiance differences of a few percent. The Committee on Earth Observation Satellites (CEOS) and its Working Group on Calibration and Validation (WGCV) have designated the solar irradiance profile provided by Thuillier as their standard. However, in order to understand the difference between various solar irradiance profiles on the AVHRR instrument, we have used the various solar irradiance profiles with the spectral response functions for each channel, as provided by NOAA/NESDIS/STAR, to determine the total solar irradiance and the normalized filter function for each channel for the various NOAA POES satellites. The results are posted at (http://cimss.ssec.wisc.edu/clavr/calibration/irradiance.html) and will be compared with other analyses that have been performed.

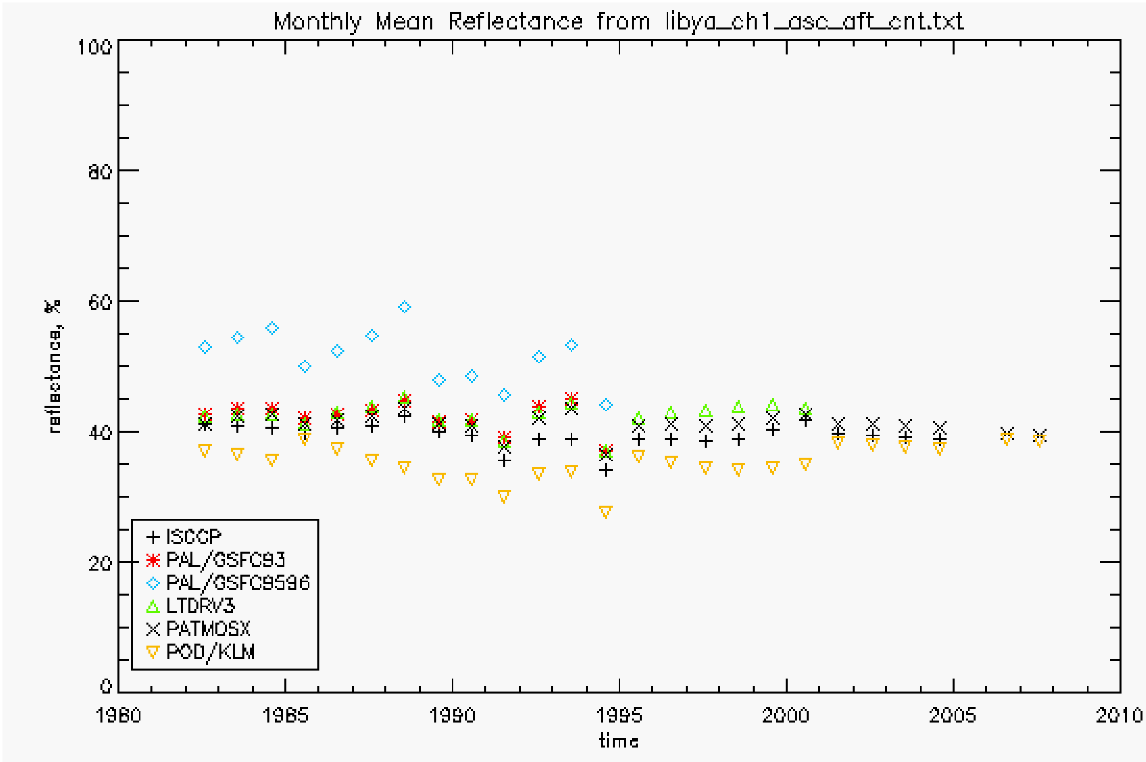

Figure 22.1.1. Monthly mean reflectances for AVHRR Channel 1, NOAA-7 through NOAA-18. Source data are 0.5 degree average instrument counts averaged over a target in the Libyan Desert, during Julys. Calibrations are from ISCCP – International Satellite Cloud Climatology Project, PAL/GSFC93 – Goddard Space Flight Center scattering/glint,, PAL/GSFC 95/96 - Goddard Space Flight Center tropical cumulus, LTDRV3 – Goddard Space Flight Center Land Long Term Data Record Version 3, PATMOS-X – CIMSS Clouds from AVHRR Extended, and POD/KLM – NESDIS prelaunch.

The final part of this project is to work toward a new, updated calibration for all AVHRR satellites. To do this, we employ several methods of intercalibration between satellites as well as calibration with ground sites. The first intercalibration method used was using simultaneous nadir overpass (SNO) data from two different NOAA POES satellites, as well as between the NOAA POES and NASA EOS satellites. The reason SNOs from two different satellites are used, is to determine the relationship between the raw counts between the two satellites over the same target within a short amount of time. SNOs between NOAA POES and the NASA EOS satellites are used because the NASA EOS satellites, AQUA and TERRA, have onboard calibration sources. Thus, we assume that their sensors, particularly for the visible channels, can be used as a “truth” value. The results of the SNO analysis between NOAA POES satellites have been posted on the internet at http://cimss.ssec.wisc.edu/clavr/calibration/snocompare.html). In addition, the analysis of the SNO results between the NOAA POES and NASA EOS satellites has also been completed and is currently being reviewed.

In addition to the intercalibration between satellites, we also are using two ground targets as calibration sites. We determine what MODIS sees at nadir for a wide range of solar zenith angles and, using that as a truth value, construct what the AVHRR instrument should see. We can then compare that to what is actually seen and determine the slope between the two. Two targets were used, the Libyan Desert and Dome-C (Antarctica). The Libyan Desert target is well defined and is used in many calibration efforts of polar orbiting satellites. The Dome-C target in Antarctica has been proposed as a core CEOS intercalibration site for several reasons: it is relatively cloud free, there are lower uncertainties due to dry atmosphere with low aerosol loading and wind speed, and there are frequent satellite overpasses of this site creating more calibration opportunities as well as SNO opportunities (such as between MetOP and Aqua. Using the data from these two targets, we can construct a best fit, and thus construct a set of slopes and intercepts for each satellite over the course of its lifetime. Also, because the afternoon satellites are only able to see the Libyan Desert during the daytime, we can use the SNO's between the morning and afternoon satellites to determine what the slopes of the morning satellites should be. Dome-C allows for both morning and afternoon satellites. This means the analysis can be performed all the way back to the beginning of the AVHRR series in 1978 with the launch of TIROS-N. We have recently finished the analysis over the Libyan target and are currently working on the analysis at the Dome-C site. Figure 22.1.2 is the analysis of the monthly averaged slope of the measured counts compared to what MODIS would see for the afternoon satellites over the Libyan Desert for channel 1.

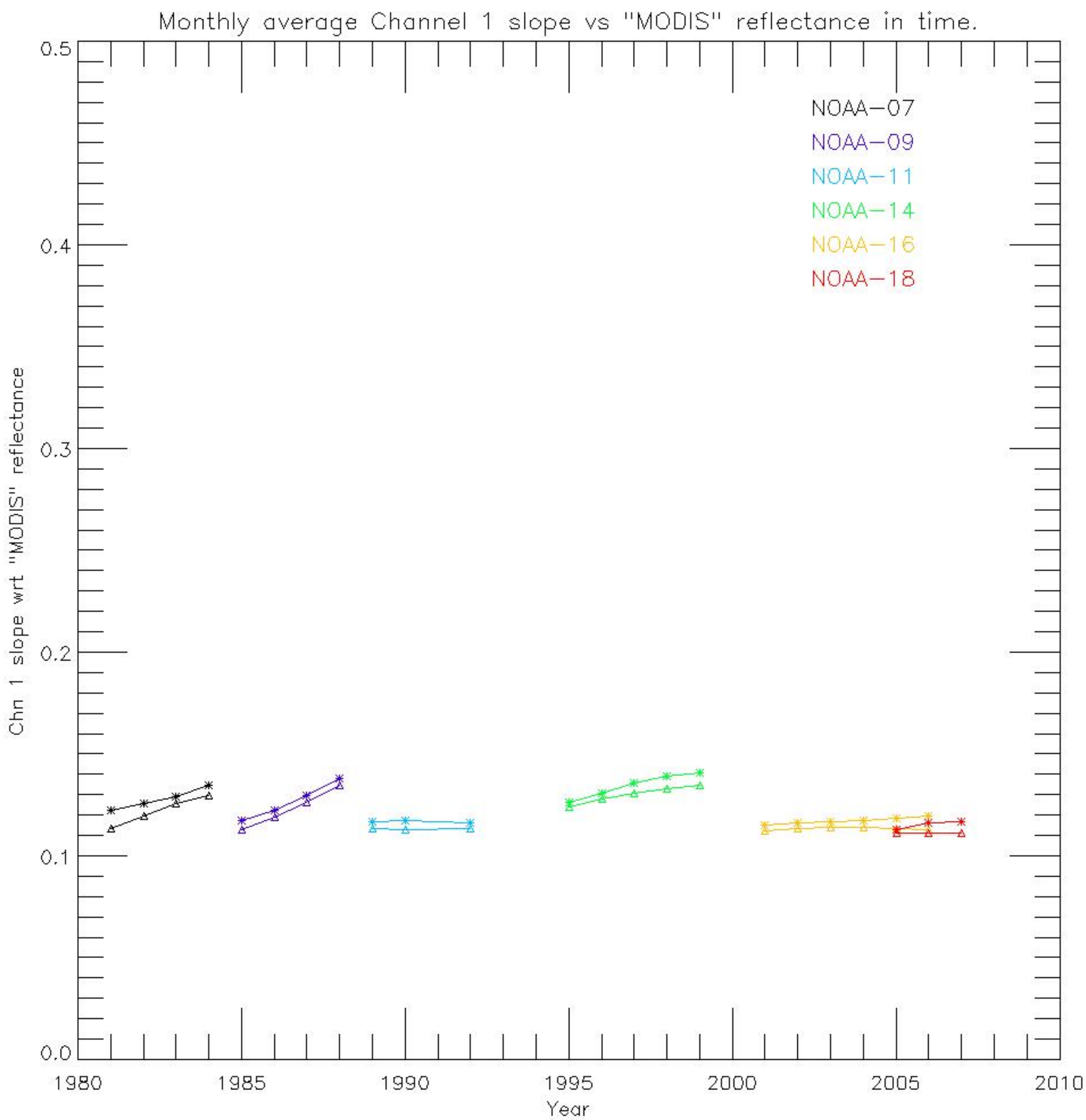

Figure 22.1.2. Yearly averaged count to radiance slopes for the Afternoon satellites from 1980-present (excluding TIROS-N) are the * symbols. Triangles indicate the current PATMOS-x calibration slopes.

Further analysis is ongoing in several aspects of this project, including analysis of the various calibration methods and their relationship to NDVI as well as the calibration analysis over the Dome-C site. Because of the nature of this project, we will continue to collaborate with other groups as well as the WGCV in order to foster a consistent calibration for the AVHRR instrument on-board the NOAA polar orbiters.

Publications and Conference reports

Heidinger, Andrew: PATMOS-x AVHRR Reflectance Calibration. CEOS Calibration Meeting and Canada Center for Remote Sensing, Ottawa, Canada. June 2008.

Heidinger, Andrew, Wu, Fred and Ackerman, Steve.: Towards a Consensus AVHRR Reflectance Calibration for Climate Studies. Darmstadt, Germany. September 2008.

Appendix

1. List of Awards to Staff Members

The GOES-N Series Team, including **Tim Schmit** (NOAA/ASPB) and **Paul Menzel**, received a Group Achievement Award from NASA for their work on GOES-N/13. Schmit served as a co-coordinator of the post-launch tests of the satellite. He and a cadre of colleagues analyzed observations from the GOES-13 sounder and imager to determine if the instruments functioned properly.

Dave Tobin received the "Young Scientist Award" from the International Radiation Symposium.

Allen Huang was named as SPIE Fellow for his career contributions.

Wayne F. Feltz, Patrick W. Heck, Anthony J. Wimmers, and Michael J. Pavolonis received the 2007 Paul F. Holloway Non-Aerospace Technology Transfer Award as part of the NASA Advanced Satellite Aviation-weather Products (ASAP) Project Team.

Steven Ackerman received the American Meteorological Society Teaching Excellence Award.

Anneliese Lenz received the AMS Macelwane award, recognizing an original student research paper. She worked with Kris Bedka and Wayne Feltz on transverse bands and turbulence using satellite observations and aircraft reports of turbulence.

Chris Velden was elected as a new AMS Fellow.

Andy Heidinger (NOAA/ASPB) received the NASA Group Achievement Award for NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (CALIPSO). The team won the award for "exceptional achievements in the successful development, launch, and operation of the CALIPSO satellite."

Paul Menzel was honored upon his recent retirement from NOAA after forty years of service with a special plaque recognizing his contributions to the global understanding of atmospheric science and his enduring commitment to advancing the field across the globe.

2. Publications

The tables below show the number of papers where CIMSS and ASPB scientists were first author (Table 2.1) or contributors (Table 2.2) to referred journal articles.

Table 2.1: Peer Reviewed and Non Peer Reviewed Journal Articles Having CIMSS and/or NOAA Lead Authors, 2006-2008*. Publications Categorized by Institute, NOAA and Other Lead Author.

	Institute Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
Peer Reviewed	13	32	17	3	1	1	26	38	22
Non Peer Reviewed	0	2	3	0	1	0	0	1	0

*2008 data is incomplete

Table 2.2: Peer Reviewed and Non Peer Reviewed Journal Articles Having CIMSS and/or NOAA Co-Authors, 2006-2008*

	Institute Co-Author**			**NOAA Co-Author**		
	2006	2007	2008	2006	2007	2008
Peer Reviewed	38	56	34	8	15	10
Non Peer Reviewed	0	2	0	0	0	0

*2008 is incomplete
**Multiple co-authors on the same article are counted once (in each category where appropriate)

3. Employee Information

Number of employees/students receiving 100% of their support from NOAA: An SSEC/CIMSS full time equivalent (FTE) employee delivers at least 1,750 direct support hours per year. During the 12 months from October 1, 2007 to September 30, 2008, 13 SSEC personnel were fully funded by NOAA. These people are shown in bold italics in Table 3.1 below.

Number of employees by title with 50% support from NOAA: The SSEC/CIMSS delivered over 99,000 (56.6 FTE) direct support hours to NOAA during this reporting period. 48 personnel (including six students) received over half of their funding from NOAA. These people are shown in Table 3.1, sorted by SSEC labor category.

Number of GS and UG receiving any level of support from NOAA: Eight graduate students and five undergraduate students receive support from NOAA. These students are shown by name in Table 3.2.

Table 3.1: SSEC/CIMSS employees supported at least 50% by NOAA (100% in bold)

Name	SSEC Labor Cat	Hours	FTE %
Huang, Hung-Lung	Scientist III	880	50.29%
Greenwald, Thomas	Scientist II	1474	84.23%
Li, Jun	Scientist II	1532	87.54%
Feltz, Wayne	Scientist I	1126	64.34%
Huang, Bormin	Scientist I	912	52.11%
Plokhenko, Youri	**Scientist I**	**1932**	**100.00%**
Berthier, Sebastien	Scientist, PostDoc	1376	78.63%
Jung, James	**Researcher III**	**1820**	**100.00%**
Lenzen, Allen	Researcher III	884	50.51%
Nelson, James III	**Researcher III**	**1874.7**	**100.00%**
Schmidt, Christopher	Researcher III	1339.2	76.53%
Schreiner, Anthony	**Researcher III**	**1768**	**100.00%**
Bachmeier, Anthony	**Researcher II**	**1864**	**100.00%**
Bedka, Kristopher	Researcher II	1004	57.37%
Borbas, Eva	Researcher II	1408	80.46%
DeSlover, Daniel	Researcher II	1066	60.91%
Evan, Amato	Researcher II	1516	86.63%
Genkova, Iliana	Researcher II	1712	97.83%
Gunshor, Mathew	Researcher II	1641	93.77%
Li, Jinlong	Researcher II	1588	90.74%
Olander, Timothy	**Researcher II**	**1756**	**100.00%**
Otkin, Jason	Researcher II	1577.5	90.14%
Wanzong, Steven	Researcher II	1606	91.77%
Woolf, Harold	Data Manager II	976	55.77%
Calvert, Corey	Researcher I	1738	99.31%
Dworak, Richard	Researcher I	1274.2	72.81%
Hoffman, Jay	Researcher I	1296	74.06%
Huang, Jun	Researcher I	1096.4	62.65%
Jin, Xin	**Researcher I**	**1988**	**100.00%**
Lee, Yong-Keun	**Researcher I**	**2024**	**100.00%**
Liu, Yinghui	**Researcher I**	**1856**	**100.00%**
Qiu, Hong	Researcher I	920	52.57%
Sieglaff, Justin	**Researcher I**	**1816**	**100.00%**
Stettner, David	**Researcher I**	**1788**	**100.00%**
Straka, William	Researcher I	1325	75.71%
Wang, Xuanji	Researcher I	1668.2	95.33%
Walther, Andi	**Researcher I**	**1848**	**100.00%**
Garcia, Raymond	Computer Scientist III	1308	74.74%
Martin, Graeme	**Computer Scientist I**	**1823**	**100.00%**
Olson, Erik	Computer Scientist I	977	55.83%
Taylor, Joseph	Engineer II	1244	71.09%
Vasys, Egle	Executive Assistant	1009.8	57.70%
Bi, Li	Student, Graduate	900	51.43%
Hokanson, Erin	Student, Graduate	900	51.43%
Li, Zhenglong	Student, Graduate	1350	77.14%
Lim, Agnes	Student, Graduate	900	51.43%
Liu, Chian-Yi	Student, Graduate	1350	77.14%
Gerth, Jordan	Student, Undergrad	1146	65.49%

Table 3.2: Students receiving support from NOAA

Name	SSEC Labor Cat	Hours	FTE %
Bi, Li	Student, Graduate	900	51.43%
Hartung, Daniel	Student, Graduate	272.8	15.59%
Hokanson, Erin	Student, Graduate	900	51.43%
Li, Zhenglong	Student, Graduate	1350	77.14%
Lim, Agnes	Student, Graduate	900	51.43%
Liu, Chian-Yi	Student, Graduate	1350	77.14%
Sitkowski, Matthew	Student, Graduate	375	21.43%
Vinson, Kenneth	Student, Graduate	675	38.57%
Gerth, Jordan	Student, Undergrad	1146	65.49%
Harris, Jelani	Student, Undergrad	144.5	8.26%
He, Feng	Student, Undergrad	225	12.86%
Schiferl, Luke	Student, Undergrad	688.6	39.35%
Vidot, Jerome	Student, Undergrad	352	20.11%

4. Subcontracts summary

Dr. Ping Yang, Texas A&M University
"Research in Support of GOES-R Risk Reduction Project"
January 2007 to date; total funding $100,000 in 2007 and $50,000 in 2008.

Dr. Xiolie Zhou, Florida State University
"FSU Participation in the CIMSS GOES-R Risk Reduction Project"
January 2007 to date; total funding $50,000 in 2007 and $50,000 in 2008.