University of Wisconsin-Madison

Cooperative Institute for
Meteorological Satellite Studies (CIMSS)

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

Cooperative Agreement Annual Report

for the period
1 July 2010 to 31 March 2011
Cooperative Agreement Number: NA10NES4400013

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National Oceanic and Atmospheric Administration (NOAA)

Cooperative Agreement Annual Report from the Cooperative Institute for Meteorological Satellite Studies University of Wisconsin-Madison

1 July 2010 to 31 March 2011

Steven Ackerman
Director, CIMSS

Thomas Achtor
Executive Director, Editor

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

I. Director's Executive Summary

The National Oceanic and Atmospheric Administration (NOAA) and the University of Wisconsin-Madison (UW-Madison) are entering a 4th decade of collaborating on research in satellite meteorology and remote sensing. This collaborative relationship between NOAA and the UW-Madison, which led to the establishment of the Cooperative Institute for Meteorological Satellite Studies (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 monitoring environmental conditions. Under the auspices of CIMSS, scientists from NOAA/NESDIS and the UW-Madison Space Science and Engineering Center (SSEC) have a formal basis for ongoing collaborative research efforts. CIMSS scientists work closely with the NOAA/NESDIS Advanced Satellite Product Branch (ASPB) stationed at Madison. This collaboration is expanding through the inclusion of a scientist from the National Climate Data Center, joining the NOAA employees stationed at CIMSS.

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; here we only refer to a few relevant examples.

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

The first part of the CIMSS mission is to foster collaborative research. One metric of success is to quantify the number of collaborative publications in general, and those with NOAA employees in particular. CIMSS continues to publish more than 40% of its papers with NOAA co-authors (see Appendix 2), indicating the strong collaborations between the two organizations. 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 we continue to work with ASPB to update operational algorithms for NOAA satellites. For example, CIMSS supported GOES-14 processing updates of some products (e.g. WFABBA, atmospheric profile retrievals and cloud properties) to prepare for end of the year GOES-14 activities. The PATMOS-x, data processing, led by ASPB efforts, was transferred to NCDC.

We have very long term collaborations with NOAA developing GOES imager and sounder products. In particular, CIMSS has been involved since the initiation of the NOAA GIMPAP (GOES Improved Measurements and Product Assurance Program) program and continues to make important contributions to this program. For example, the UW-CIMSS group proposed further refinement and validation the experimental University of Wisconsin-Madison Convective Initiation (UWCI) decision support algorithm. This year the UWCI decision support product was distributed to the NOAA Satellite Applications Branch (SAB), the Storm Prediction Center (SPC) during the Hazardous Weather Testbed (HWT) Spring Experiment in 2009, and via AWIPS to various National Weather Service Forecast Offices (NWSFOs). The UWCI algorithm was dramatically improved with participation in the 2009 SPC HWT PG that allowed forecasters to familiarize themselves with the satellite-based convective initiation product.

CIMSS scientists continue to work with NOAA on deriving GOES Atmospheric Motion Vectors (AMV). Although AMVs have had positive impacts on NWP, the representative vector heights have proven to be a relatively large source of observation uncertainty. To improve data assimilation of the AMVs, CIMSS modified the AMV software to include quality control flags and 11 um emissivity along with the tracer height assignment.

CIMSS also has a strong partnership with NOAA in the GOES-R program. CIMSS research activities in the GOES-R Algorithm Working Group (AWG) and the GOES-R Risk Reduction are not covered under this reporting time period, but can be found in our previous CA report. These activities are ongoing and will be included in the next CA report. Importantly, we continue to leverage collaborative activities. For example, GIMPAP supported the real-time implementation of GOES-R ABI cloud property retrieval algorithms on current GOES imager data. The cloud products generated are cloud type (phase included), height, emissivity, optical depth, microphysics (e.g. particle size), and liquid/ice water paths.

NOAA/NWS has declared that tropical cyclone (TC) intensity analysis and forecasting improvement is a high priority research goal. CIMSS is internationally recognized for its tropical cyclone (TC) research, with the development of the program going back to the early 1980s. The Automated Dvorak Technique (ADT) developed at CIMSS is now an established operational TC intensity estimation algorithm used by the NWS. Working with NOAA scientists, CIMSS researchers continue to improve the ADT performance through new innovations that when successful will be transitioned to the operational version. The CIMSS derived TC products, as well as many other products, are distributed through web pages to a broad global audience of forecasts, planners and citizens.

For many years GOES-East/-West were the only operational environmental geostationary platforms with fire monitoring capabilities. The global WF_ABBA has been extended to include Met-9 over Africa and Europe and also MTSAT-1R/-2 over Asia and Australia and when combined with GOES-E/W provides nearly complete global coverage. The WF_ABBA also includes FRP (Fire Radiative Power) and a fire/metadata mask that provides information on processing regions, fire locations, and fire confidence. CIMSS continues to support international satellite fire monitoring efforts.

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 and ASPB scientists continue to work side-by-side in assessing satellite instrument calibrations. CIMSS is active in the international effort to calibrate the world's environmental satellites: Global Space-based Intercalibration System (GSICS). CIMSS is an active partner with NOAA on this endeavor and much of the methodology developed at CIMSS was adopted by the international GSICS team. We continue to improve Infrared band calibration and are also developing an algorithm and process for improving cal/val (calibration/validation) for GOES Sounder IR bands.

To further enhance convective initiation (CI) decision support products, UW-CIMSS has teamed with the NOAA Cooperative Institute of Mesoscale Meteorological Studies (CIMMS) at the University of Oklahoma. OU-CIMMS proposed using the WDSS-II software developed for GOES imager top of troposphere cloud emissivity that has been successfully imported into the WDSS-II (software developed by CIMMS) system, and initial testing/optimization for GOES imager objective tracking has been conducted. The team is validating the UWCI products with radar reflectivity.

CIMSS continues to support NOAA's goal for infrared sounding data assimilation. We are working with personnel from the Atmospheric Infrared Sounder (AIRS) Science Team, the National Center for Environmental Prediction (NCEP), the National Environmental Satellite, Data and Information Service (NESDIS) and others in developing techniques to assimilate AIRS and the Infrared Atmospheric Sounding Interferometer (IASI) water vapor radiances. We also collaborate with the Cooperative Institute for Research in the Atmosphere (CIRA) at the Colorado State University on using GOES-R instruments for hurricane data assimilation to improve hurricane forecasting.

In addition to supporting the next generation geostationary weather satellite, CIMSS scientists work closely with the NOAA/ASPB scientists to support the next generation polar satellite programs, such NPP/JPSS. We support calibration/validation activities, cloud and sounding algorithm work and visualization software.

CIMSS scientists work collaboratively with ASPB scientists to develop global data sets of cloud amount and cloud properties from the Advanced Very High Resolution Radiometer (AVHRR) processing system, this research builds off the successful Pathfinder Atmospheres Extended (PATMOS-x) project data set, which recently delivered 30 years of cloud climate records from NOAA's POES Imager (AVHRR) to NOAA's National Climatic Data Center (NCDC). ASPB/CIMSS scientists have been active participants in international efforts of GEWEX to assess the capabilities of these polar orbiting satellites to define global cloudiness. In 2010, PATMOS-x was selected as one of the first three Climate Data Records (CDR) to become operational CDRs at the NCDC. The version of PATMOS-x chosen for this delivery was the AVHRR-only version. PATMOS-x SDRs use AVHRR measurements with a spatial resolution of 0.1 degree (11 km) spanning 1978 to 2009. The SDR generation component was accomplished using the Atmospheric Product Evaluation And Test Element (PEATE) processing system at CIMSS.

As a final example of cross institute collaborations, we work with colleagues at NOAA/NESDIS, the University of Colorado, and NASA Goddard Space Flight Center, CIMSS as part of a Cryosphere Product Development Team that is providing coordination for the generation, validation, and archival of fundamental and thematic snow and ice climate data records (FCDR and TCDR) that the scientific community can use to help answer the questions about a changing global climate.

CIMSS and SSEC have a strong national and international reputation for producing outstanding visualization tools. An example of this expertise is the Personal Advanced Weather (PAW), a free service provided to the general public. PAW provides access for the mobile Internet community to a suite of enhanced real-time weather products.

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 grants support CIMSS graduate students in the UW-Madison Department of Atmospheric and Oceanic Sciences. The education/research center link provides an excellent path for young scientists entering careers in geophysical fields. A recent M.S. graduate is now working for a private industry in Washington DC to support NOAA activities.

We work in collaboration with NOAA and other cooperative institutes in developing training resources for NOAA. The CIMSS involvement in the Virtual Institute for Satellite Integration Training (VISIT) program has involved research, development, and demonstration of new distance learning techniques and materials to address the utilization and integration of advanced meteorological data sources. This year we continued to create VISITview distance learning modules for a broad satellite meteorology audience, providing valuable satellite imagery interpretation materials that can be used in education and training, and also on maintenance and updates to existing satellite image lesson material.

The presence of fully-functioning Advanced Weather Interactive Processing System (AWIPS) workstations at CIMSS allows for faster development of new educational materials that address these types of satellite interpretation topics (and also facilitates more frequent updates to pre-existing modules) as new case study examples are observed on a daily basis. This real-time AWIPS capability gives CIMSS the unique ability to present these satellite interpretation topics in a context that the National Weather Service (NWS) forecaster can more easily relate to. CIMSS continues to demonstrate learning the value of satellite observations using real time weather analysis distributed through the CIMSS Satellite Blog [http://cimss.ssec.wisc.edu/goes/blog].

As one example, on the day that GOES-13 replaced GOES-12 as the operational GOES-East satellite, a blog post was added to the "Training" category which discussed how the new GOES-13 visible channel was different from that on GOES-12, requiring the use of a different default enhancement for optimal viewing of GOES-13 visible imagery. Presently, the CIMSS Satellite Blog contains nearly 700 posts, covering 38 different categories. CIMSS has also invested in infrastructure to hold weather briefings, science team meetings and visitor meetings that focus on using the analysis and visualization technologies, the CIMSS Analysis and Visualization Environment (CAVE), which includes high-tech graphics and dynamical weather displays on state-of-the-art monitors.

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:

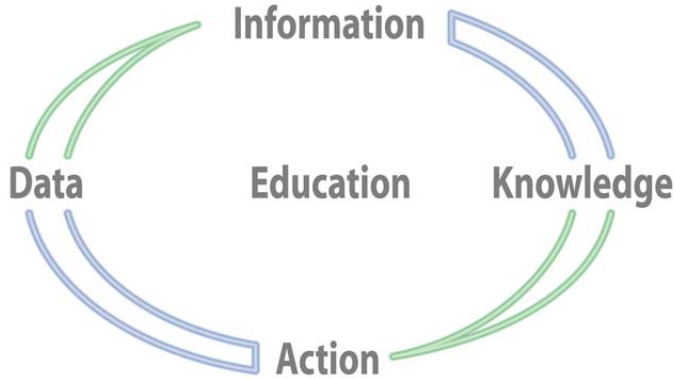
- Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science that exploit the use of satellite technology;
- Serve as a center at which scientists and engineers working on problems of mutual interest can focus on satellite-related research 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. Satellite Meteorology Research and Applications
2. Satellite Sensors and Techniques
3. Environmental Models and Data Assimilation
4. Education 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/forecasting, 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 demonstrate 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 first geostationary sounding instrument) and GOES-8/12 design, testing, and checkout are now assisting with similar activities in GOES-R. On the polar orbiting satellite side, our decades long work with the TOVS and ATOVS sounders and the aircraft HIS (High spectral resolution Interferometer Sounder) and scanning-HIS are aiding in the development of applications for the forthcoming CrIS (Cross-track Infrared Sounder) hyperspectral sounder on Joint Polar Satellite System (JPSS). In addition to bringing “corporate memory” to these new GOES and JPSS programs, 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. 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 and supporting contractors. The National Climate Data Center (NCDC) has stationed a research scientist at CIMSS to further build collaborations. CIMSS plans to leverage this collaboration by providing expertise in using satellite data sets for climate studies. CIMSS and ASPB scientists have developed satellite data sets for climate studies including, a HIRS/2 cloud climatology data set, the PATMOS-X AVHRR data set, an AVHRR polar applications data set, and a GOES cloud properties data set. The polar orbiting satellite data sets extend back more than 20 years.

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 JPSS (formerly 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 (Section II. 4 below).

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 14 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 6 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 7 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.

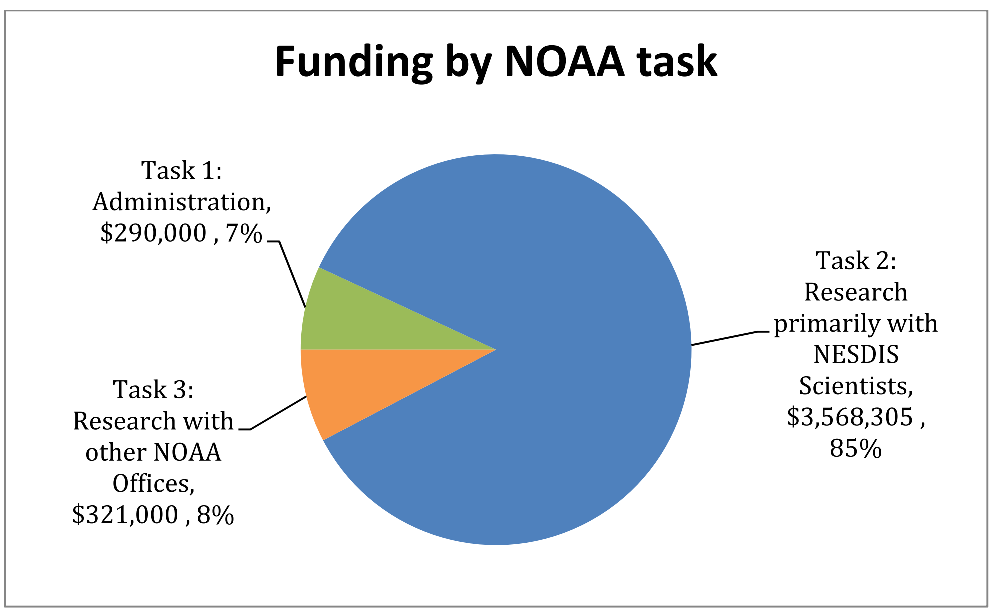
3. NOAA funding to CIMSS Cooperative Agreement NA10NES4400013 in FY2011 - summarized by Research Task, NOAA Strategic Goal and CIMSS Research/Education Theme

In FY2011, funding to CIMSS through Cooperative Agreement NA10NES4400013 totaled $4,179,305. The following tables and graphics show the distribution of these funds by Task, by NOAA Strategic Goal and by CIMSS Research and Outreach Theme. The total represents FY2011 funds provided to CIMSS under the Cooperative Agreement that began on 1 July 2010 and covers the 9 month period through 31 March 2011. Other FY2011 funds were provided to CIMSS under a previous Cooperative Agreement which, after a 1 year no-cost extension, ends on 30 June 2011. The research projects funded through the old CIMSS CA are not reported here; they were last reported on in a CIMSS CA Annual Report from October 1, 2009 through 30 September 2010.

Funding by NOAA task

CIMSS Task	Funding in dollars	Percentage
Task 1: Administration	$ 290,000	7%
Task 2: Research primarily with NESDIS Scientists	$ 3,568,305	85%
Task 3: Research with other NOAA Offices	$ 321,000	8%
	$ 4,179,305	

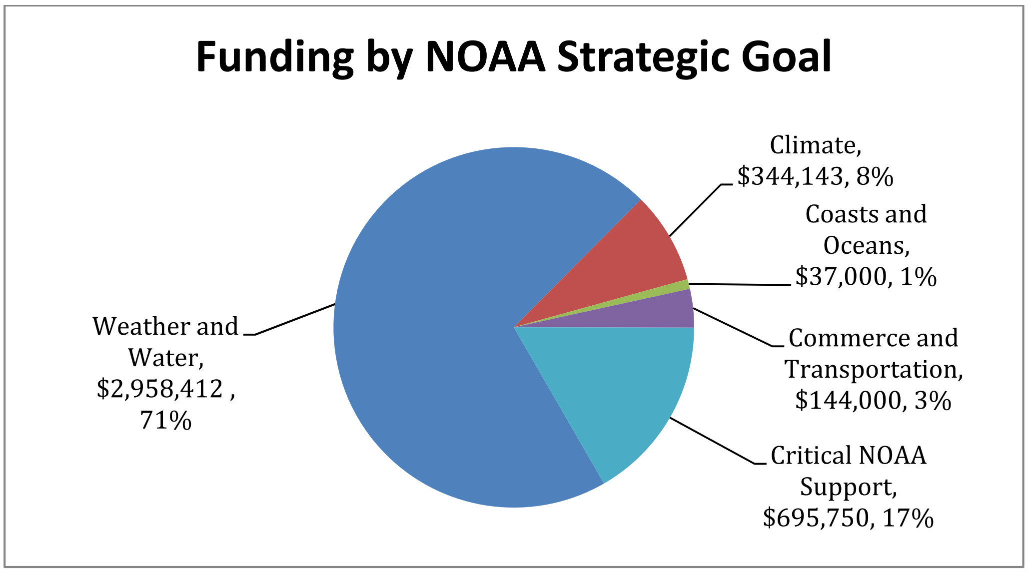
- Note: Task 3 funds are primarily those projects conducted in collaboration with scientists and forecasters in the Joint Center for Satellite Data Assimilation and the NOAA National Weather Service (NWS).



Funding by NOAA Strategic Goal

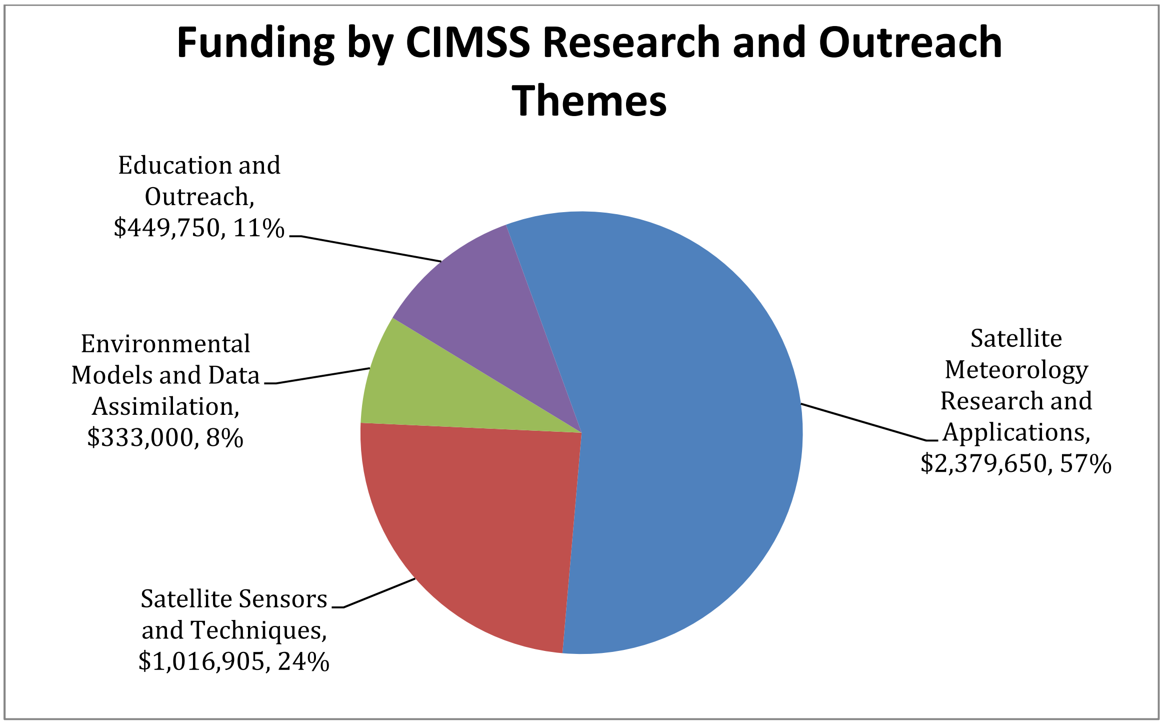
NOAA Strategic Goal	Funding in dollars	Percentage
Weather and Water	$ 2,958,412	71%
Climate	$ 344,143	8%
Coasts and Oceans	$ 37,000	1%
Commerce and Transportation	$ 144,000	3%
Critical NOAA Support	$ 695,750	17%
	$ 4,179,305	

- Note: Funding for Critical NOAA support included CIMSS Task 1 funding, training of NOAA personnel (primarily NWS) and certain development work for the Joint Polar Satellite System (JPSS).



Funding by CIMSS Research and Outreach Themes

CIMSS Theme	Funding in dollars	Percentage
Satellite Meteorology Research and Applications	$ 2,379,650	57%
Satellite Sensors and Techniques	$ 1,016,905	24 %
Environmental Models and Data Assimilation	$ 333,000	8%
Education and Outreach	$ 449,750	11%
	$ 4,179,305	



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 April 2009. 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 Martin	Chair, Dept. of Atm. and Oceanic Sciences, UW-Madison
Mary Kicza	Asst. Admin. for Satellite & Information Services., NOAA/NESDIS
Alfred Powell	Director, Ctr. for Satellite Appl. and Research, NOAA/NESDIS
Jeff Key	Chief, Advanced Satellite Products Branch, NOAA/NESDIS
Jack Kaye	Associate Director for Research, NASA
Franco Einaudi	Dir., Earth-Sun Expl. Div., NASA Goddard Space Flight Center (retired)
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 November 2009. Science Council members include.

Allen Huang	Distinguished Scientist, CIMSS
Chris Velden	Senior Scientist, CIMSS
Trina McMahon	Professor, UW-Madison Engineering
Annemarie Schneider	Professor, UW-Madison, SAGE
Ralf Bennartz	Professor, UW Department of Atmospheric and Oceanic Sciences
Graeme Stephens	Professor, Dept. of Atmospheric Science, Colorado State Univ.
Bob Ellingson	Professor, Dept. of Earth, Ocean, and Atm. Science, Florida State University
Steve Goodman	GOES-R Senior Scientist, GOES-R Program Office
Ingrid Guch	Chief, Atmospheric Res. and Appl. Div., NOAA/NESDIS/ORA
Pat Minnis	Senior Research Scientist, NASA Langley Research Center
Steve Platnick	Acting EOS Senior Project Scientist, NASA Goddard Space Flight Center

III. Project Reports

1. CIMSS Base (Task I)

CIMSS Task Leaders: Steven Ackerman, Thomas Achtor
CIMSS Support Staff: Maria Vasys, Leanne Avila, Wenhua Wu, Jenny Hackel
NOAA Strategic Goals Addressed:

- Serve society's needs for weather and water information
- Understand climate variability and change to enhance society's ability to plan and respond
- Protect, restore and manage the use of coastal and ocean resources through an ecosystem approach to management
- Support the nation's commerce with information for safe, efficient and environmentally sound transportation
- 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 first year graduate students.

Summary of Accomplishments and Findings
The CIMSS Task I funds continue to support development and updates of the CIMSS Web page (see http://cimss.ssec.wisc.edu/). The home page provides 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 partially supported the expanded development of the PDA Animated Weather (PAW) project. The creation of satellite and other meteorological products for smart 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.

CIMSS has created the "NOAA-CIMSS Collaborative Award for developing NOAA's Strategic Satellite Plan to balance requirements, observation capabilities, and resources." These awards may be given to CIMSS scientists who have worked closely with NOAA scientists who have received a NOAA award. The CIMSS award is to recognize the partnership that occurs in research with ASPB and UW-Madison scientists.

CIMSS Task I funding also provide support for two graduate students, Mark Smalley and Ken Vinson, as they fulfilled their academic course obligations and decided on their research thesis topics.

CIMSS Task 1 funds supported a trip for Dr. Chris O'Dell to visit Madison, confer with scientists and present a seminar. CIMSS also supported travel for a prospective graduate student, Ms. Jill Hardy, to visit CIMSS and discuss her research goals.

2. CIMSS Cal/Val Activities with the GOES Sounder

CIMSS Task Leader: Mathew Gunshor
CIMSS Support Scientists: Tony Schreiner, Jim Nelson
NOAA Collaborator: Tim Schmit
NOAA Strategic Goals:

- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes:

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

There are two primary objectives to this research. The first is to improve Infrared band calibration and the second is to develop an algorithm and process for improving cal/val for current and future GOES Sounder IR bands. The method proposed to improve IR calibration is to investigate the diurnal variation of Sounder performance. The diurnal variation will be studied over the operational lifetime of the GOES Sounder and investigated for seasonal trends. This process will lead to the development of an algorithm for improving cal/val for the Sounder.

GOES Sounder calibration performance will be assessed by comparing calculated radiances ("calc") to the actual observed radiances ("obs"). Calculated radiances can be determined from atmospheric profiles of temperature and moisture by using a suitable Radiative Transfer Model (RTM) in a forward model calculation. The RTM being used at CIMSS is PLOD/PFAAST. Atmospheric profiles will be obtained from both forecast model guess data profiles gleaned from Global Forecast System (GFS) forecasts, as well as from collocated RAOB data.

These types of "calc-obs" studies have been done previously in a case-study type of mode. This process could be done in a real-time mode for improved calibration monitoring. This algorithm could then be applied to multiple sensors on multiple satellites and should carry over into the GOES-R era.

Our proposed tasks were as follows:

1. Process near real time calc (GFS forecast) - obs for GOES Sounders over CONUS and adjacent oceanic regions:
    a. Generate time series plots and post to the Web,
2. Process near real time calc (GFS forecast and RAOBs) - obs for GOES Sounders at RAOB sites (00Z and 12Z only):
    a. Generate time series plots and post to the Web,
3. Develop tools and a methodology for processing archived data,
4. Start historical calc (GFS forecast) - obs for GOES Sounders over CONUS and adjacent oceanic regions,
5. Start historical calc (GFS forecast and RAOBs) - obs for GOES Sounders at RAOB sites,
6. Analyze results, and
7. Develop methodology and process for cal/val improvement.

Summary of Accomplishments and Findings

The real time comparisons of calculated brightness temperatures from GFS to observed brightness temperatures from the GOES-East and West Sounders have started. Simple ASCII text files are updated hourly with comparisons in all 18 infrared bands of the GOES Sounder for both GOES-East (GOES-13) and GOES-West (GOES-11). These files are updated at CIMSS after all retrievals have been computed, with the brightness temperatures calculated from the retrieval guess profiles of temperature and moisture being compared to the observed GOES Sounder brightness temperatures. The statistical properties being evaluated currently are bias and standard deviation. These data are then written to the text files, which are then used to produce near real-time time series plots to post to the Web. Currently the options for how best to display the data are being weighed. Figure 2.1 is a time series plot displaying hourly observed brightness temperature minus calculated brightness temperature difference (bias) over a 7-day period. The observed minus calculated brightness temperature difference is computed for each clear-sky retrieval, and the average of all retrievals becomes one data point on the time series plot. In Figure 2.2 another time series plot is shown which highlights just one day and demonstrates another way these data may be visualized as we investigate the possibility of diurnal biases.

As we begin, we expect to have a fairly simple Web page with plots similar to Figure 2.1. We expect to receive feedback from various users on how useful this information is to them and how they could utilize it. As we gain experience, we will continue to make changes and update the Web page to fit the needs.

The next step is to repeat this activity at RAOB sites with brightness temperatures calculated from RAOB data. These plots will be handled somewhat differently since RAOBs are only available twice daily. Once this step is done, a system to process the historical record will be established. Currently this system is envisioned as utilizing the same real-time monitoring tools described above, together with front-end software that can access the historical data from an online archive at CIMSS.

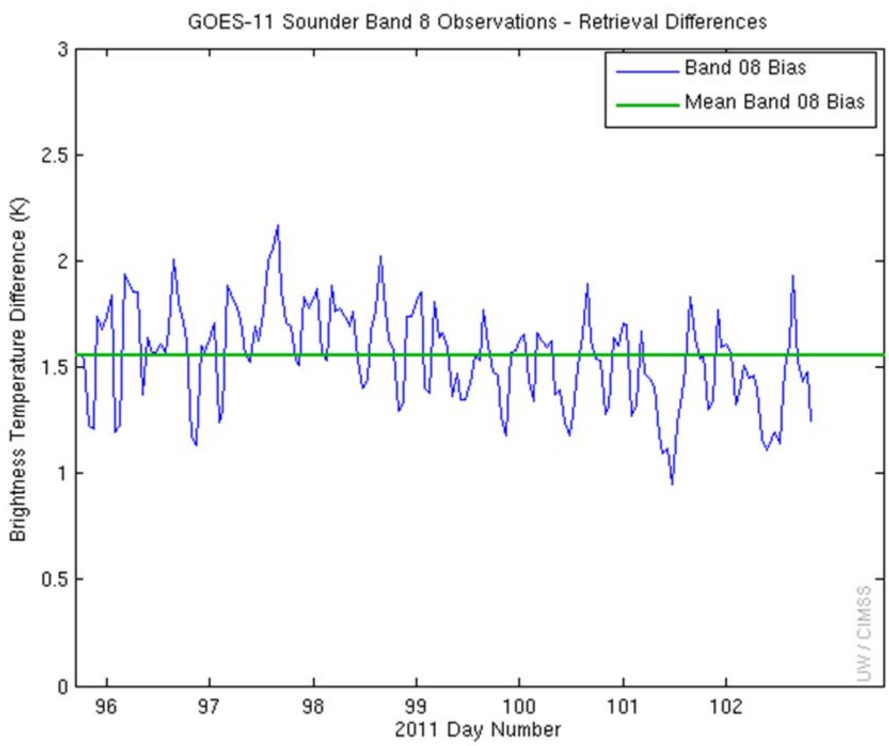


Figure 2.1. GOES-11 Sounder band 08 (11 micrometer) observed minus calculated brightness temperature differences for 05 April 2011 (18 UTC) through 12 April 2011 (20 UTC). The blue line shows hourly average bias, while the green line shows the mean bias for the entire period.

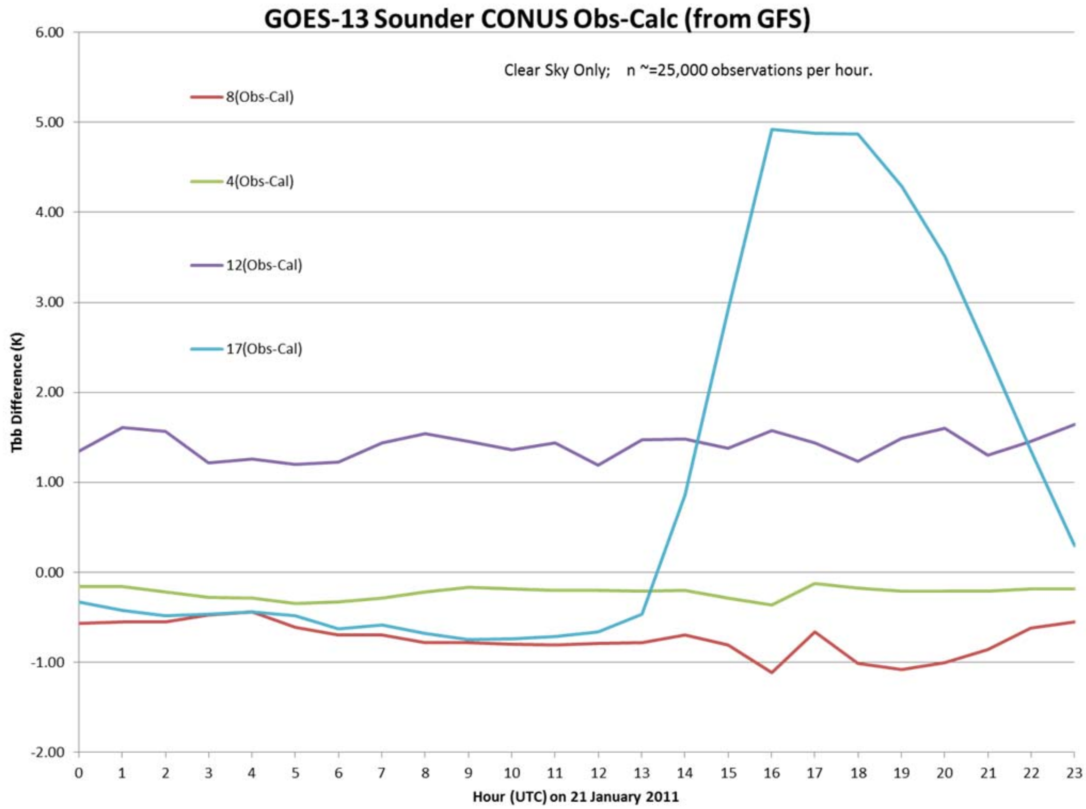


Figure 2.2. GOES-13 Sounder observed minus calculated brightness temperature differences for 21 January 2011. This plot shows four bands: band 4 (13.6 micrometer), 8 (11 micrometer), 12 (6.5 micrometer), and 17 (4 micrometer).Note the large difference in the shortwave band (17) during the daylight hours, indicating that the forward model does not take into account the reflected solar component of shortwave infrared radiation.

3. GIMPAP

3.1 Improvements to the Advanced Dvorak Technique (ADT)

CIMSS Task Leaders: Chris Velden, Tim Olander
NOAA Collaborators: Mike Turk (NESDIS/SAB), Jack Beven (NWS/NHC)
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Project Summary and Proposed Work

NOAA/NWS has declared that tropical cyclone (TC) intensity analysis and forecasting improvement is a high priority research goal. The ADT is now an established operational TC intensity estimation algorithm used by NWS. However, the method's accuracy in certain conditions is still suboptimal. We continue to strive to improve the ADT performance through new innovations that when successful can be transitioned to the operational version.

One such new concept using multispectral geostationary satellite data has been recently developed, and a journal article published (Olander and Velden, 2009). The technique highlights the spectral response differences between geostationary infrared window (IRW) and water vapor (WV) channel data in regions of intense TC convection. As noted in standard tropical atmosphere weighting functions, the WV will typically be colder than the IRW during tropospheric clear sky conditions. However, in opaque cloud conditions associated with intense, active convection penetrating the tropopause, the sign of the measured difference between the two channels (IRWV) can reverse due to the re-emitted radiation from above-cloud water vapor at higher stratospheric temperatures. Quantitative methods discussed in the study involve the predictive quality of the IRWV data in terms of TC intensity changes, primarily during TC intensification. For example, correlations exist between storm intensity change and IRWV values at varying 6-hr forecast interval periods, peaking between the 12-hour and 24-hour time periods. Implications of the IRWV data as a potential input parameter to the ADT are a primary focus of this study.

Summary of Accomplishments

We have run the ADT using the IR and WV imagery and generated history files for 87 storms between 1998 and 2010. The history files contain the number of pixels in a search area (200km from the center) that have a difference value (IR-WV) less than zero (as defined in the W&F study). We are now looking at the correlations between the IRWV signal and the Best Track intensities, and preliminary results indicate similar values to the W&F study, although some of the correlations are not as strong (probably because there are less "rapid intensifiers," so the signals are somewhat less than those in the previous study). Further analysis of the statistics, and incorporating the information into the ADT regressions for impact studies to follow, is work in progress. If the ongoing research is successful and validated, we will see an improved performance in the ADT ability to estimate tropical cyclone intensity.

References

Olander, T. and C. Velden, 2009: Tropical cyclone intensity and convection analysis using differenced Infrared and Water Vapor imagery. *Wea. & Fore*, **24**, 1558-1572.

3.2 Improvement and Validation of Convective Initiation/Cloud Top Cooling Rate Using WDSS-II Object Tracking

CIMSS Task Leaders: Wayne Feltz, Justin Sieglaff, Lee Cronce, and Dan Hartung
NOAA Collaborators: Mike Pavolonis, Bob Rabin
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

In 2007, K. Bedka, J. Sieglaff, L. Cronce and W. Feltz proposed for GIMPAP resource to use the Mike Pavolonis (NOAA NESDIS, STAR) IR-only cloud typing and Andrew Heidinger (NOAA NESDIS, STAR) cloud mask (has pathway to operations and is day/night GOES-R AWG cloud typing proxy methodology) coupled with a method called "box-averaging." The UWCI algorithm is a GOES imager based product used to diagnose and nowcast convective initiation. The UWCI algorithm uses GOES-11 (West) and GOES-13 (East) imager infrared radiance data to determine immature convective clouds that are growing vertically and hence cooling in infrared satellite imagery. The technique identifies pixels with a rapid 10.7 μm Cloud-Top Cooling (CTC) rate coupled with cloud microphysical transition (Sieglaff et al., 2011). The cloud phase information is utilized to deduce whether the cooling clouds are immature water clouds, mixed phase clouds or ice-topped (glaciating) clouds. Scenes having a large amount of cirrus (ice) cloud are omitted. The UWCI decision support product provides a coherent signal (much like radar) that can be used as a direct nowcast product in AWIPS or N-AWIPS for forecaster decision as demonstrated in the Storm Prediction Center (SPC) Proving Ground Hazardous Weather Testbed (HWT) and local Milwaukee-Sullivan (MKX) NWS in 2009-present. The methodology provides up to a 45-minute lead-time before significant radar reflectivity thresholds are observed.

The UWCI algorithm was dramatically improved with participation in the 2009 SPC HWT PG that allowed forecasters to familiarize themselves with the satellite-based convective initiation product. This algorithm development and improvement is currently funded by NOAA/NESDIS Geostationary Product Assurance Plan (GIMPAP) and is on path to geostationary Product Systems Development and Implementation (PSDI). The UWCI product has continued to flow to forecaster N-AWIPS terminals at SPC since spring of 2009. The local Milwaukee Sullivan (MKX) NWS office has also been receiving an AWIPS feed since the summer of 2009. The UWCI decision support product was requested and is being provided to the Space Meteorological Group (SMG) and NWS Central /Southern/Western Region Headquarters for dissemination to NWS WFO's for use as a convective initiation decision support aid.

UWCI was developed to target the following requirements:

1. Develop a consistent methodology to provide day/night CI nowcast signal,
2. Minimize false alarm at the expense of some probability of detection,
3. Use alternative method for time trend computation (non-AMV) to minimize pixilation, and
4. Provide coherent radar-like satellite-based CI signal as direct AWIPS/N-AWIPS satellite convective initiation decision support aid in the field.

The UW-CIMSS Satellite Nowcasting Aviation Applications (SNAAP) team proposed via 2010-2011 GIMPAP resources to:

1. Support further refinement of an experimental cloud-top cooling/convective initiation nowcast algorithm (UWCI) developed with GIMPAP funding resources;
2. Integrate object tracking using the Warning Decision Support System Integrated Information (WDSS-II, http://www.wdssii.org/) software developed by the NOAA Cooperative Institute of Mesoscale Meteorological Studies (CIMMS) at the University of Oklahoma to allow robust radar to satellite validation and improvement in convective initiation detection; and
3. Incorporate satellite CTC/CI decision support product by OU-CIMMS into WDSS-II warning/nowcasting decision support system (currently consisting primarily of radar data) which has already been made available to SPC.

Summary of Accomplishments and Findings

This funding has allowed optimization of the algorithm from feedback learned from field program end-user interaction. The UWCI decision support product was demonstrated again through CIMSS participation at SPC HWT GOES-R Proving Ground in Spring 2010 (interaction logistics supported with GOES-R Proving Ground funding).

To further enhance UWCI CTC and convective initiation (CI) decision support, UW-Madison/CIMSS and OU-CIMMS proposed using the WDSS-II software developed by the NOAA Cooperative Institute of Mesoscale Meteorological Studies (CIMMS) at the University of Oklahoma. GOES imager top of troposphere cloud emissivity (Pavolonis, 2010) has been successfully imported into the system and initial testing/optimization for GOES imager objective tracking has been conducted. We propose to validate UWCI CTC/CI with radar reflectivity by taking advantage of a common object tracking framework for validation of UWCI signal using radar and linking satellite based decision support to anticipated radar reflectivity (and other) signal(s).

Milestone progress

1. Implement UWCI cloud-typing/box-averaging improvements and validate based upon GOES-R PG and SPC HWT activities. The following improvements were implemented to address issues with UWCI methodology false alarm rate found during NOAA Hazardous Weather Testbed interaction in Spring 2009. All of these improvements were tested and validation, published in Sieglaff et al. (2011), indicated a FAR of 26% and POD of 55% (POD includes all possible CI in scene even if satellite-based methodology would not work due to masked CI signal by cirrus/glaciated clouds). This improved methodology was tested again at NOAA Hazardous Weather Testbed with positive forecaster feedback.
    - Improved diagnosis of small cumulus in cloud typing algorithm to increase Nowcast POD and lead time;
    - Mitigated false alarms associated with thin cirrus moving over small cumulus. This improvement was accomplished through updated logic within the box-average framework but including nested box averaging to screen for cirrus moving into area of small cumulus providing CI signal which was not valid;
    - Addressed the false alarm rate from rapid anvil expansion; and
    - Implemented GOES-11 UWCI product (12.0 vs. 13.3 μm channel changes in cloud typing algorithm).
2. Get object tracking working on pre-CI interest fields in collaboration with UW-OU: Done
    - WDSS-II object tracking function is now being used to connect UWCI cloud top cooling rate trends with various radar-derived quantities. This research path was driven by feedback from NWS WFO forecasters who wanted to know the link between satellite-based convective cloud top cooling and anticipated future radar reflectivity, Vertically Integrated Liquid (VIL), etc.
    - Through various test configurations, the optimal WDSS-II configuration for object tracking has been developed, validation framework has been developed, and initial test cases analyzed. Figure 3.2.1 shows WDSS-II cloud objects tracked across space and time during the afternoon of 29 April 2009. Any number of radar and satellite fields can be tracked over time for each object. This validation framework allows for automatic validation of UWCI CTC versus various radar fields. Figure 3.2.2 shows an example of how the magnitude of UWCI CTC relates to observed radar values of VIL for convective objects on the afternoon of 29 April 2009. While the sample size is quite small, the full validation will have hundreds of storms. The information in this study is valuable to forecasters because it answers the question:

"If a developing storm has UWCI CTC of a certain value, how often will a certain value of VIL be attained in the future and with what lead-time?"

For the afternoon of 29 April 2009, storms with UWCI CTC of at least -20 K/15 mins always corresponded (100% of the time) to a 30 kg/m^2 VIL, while storms with a UWCI CTC of at least -10 K/15min correspond to a 30 kg/m^2 VIL roughly 33% of the time. These results are encouraging as they suggest a relationship between UWCI CTC magnitude and future radar observations. The exact numbers in this example are not important because the sample size is too small to draw concrete conclusions, but the full validation as described in bullet 5 below will contain a robust sample size.

- Additionally (not shown in the below figures), lead-times of all UWCI CTC and radar field relationships will be examined. In the above example of UWCI CTC and VIL, the first UWCI CTC signal preceded 30 kg/m^2 VIL by 40-60 minutes. Many other fields are also being examined including: composite reflectivity, base reflectivity, reflectivity at various isotherms, echo tops, probability of severe hail (POSH), maximum expected hail size (MESH), etc. Also for the presented April 2009 case, the first UWCI CTC signal preceded the first 15 dBZ composite reflectivity echo for all tracked storms by -15 minutes to 2 minutes and the first UWCI CTC signal preceded the first 45 dBZ composite reflectivity between -5 minutes and 60 minutes. The increased lead-time for more significant composite reflectivity echoes compared to minor echoes agrees with observations during various field experiments during 2009 and 2010.

3. Provide UWCI products to SPC via WDSS-II: Done
    - WDSS-II object tracking function (w2segmotionll) has been optimized for satellite-based parameter object tracking by setting various tunable parameters in collaboration with Dr. Lakshmanan (OU-CIMMS). OU-CIMMS has access to optimized scripts for GOES imager object tracking.
4. Assess bake-off between box-average vs. object tracking convective initiation methodology: April 2011
    - Once validation phase has been completed, there will be some initial research to access if WDSS-II could provide another method for connecting image-to-image relationships. UWCI would be a candidate for PSDI research-to-operations path since the object-tracking methodology to track CI is preliminary.
5. Preliminary assessment of CI vs. Radar WDSS-II validation: September 2011
    - Robust UWCI vs. Radar validation will occur and peer reviewed paper will be constructed for publication.
6. Incorporate CI information into probabilistic hazard nowcasts of severe weather: October 2011.
7. Reassess CI/CTC methodology progress after spring SPC HWT experiment including quantitative validation study: August 2011.
8. Evaluate progress in anticipation of PSDI transition to operations: November 2011.

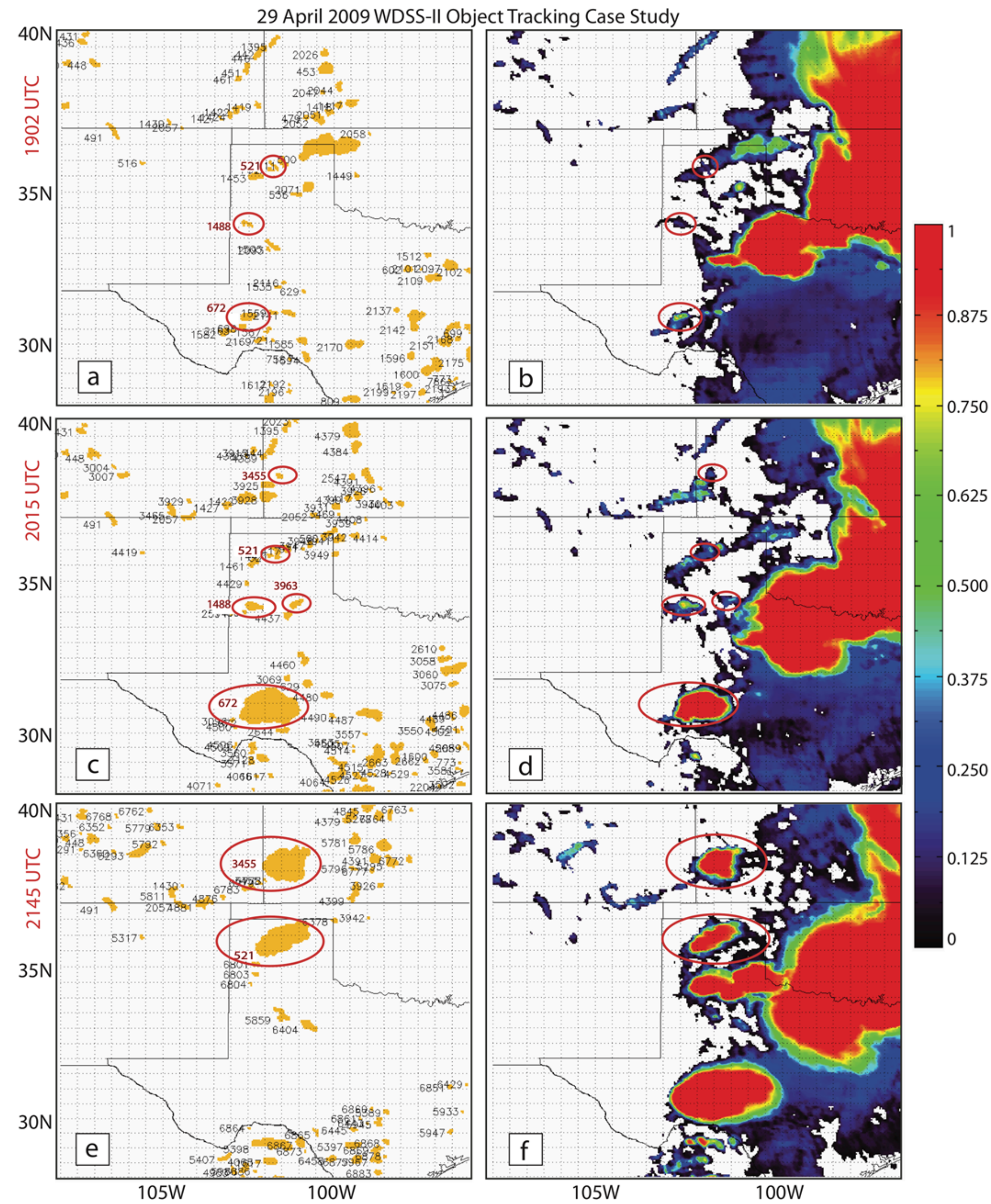


Figure 3.2.1. WDSS-II cloud objects tracked through space and time (panels a, c, and e) with corresponding intermediate cloud property, top of troposphere emissivity (panels b, d, f) for reference on 29 April 2009 (times indicated to the left of panels a, c, and e). The numbers to the southwest of each object reflect the WDSS-II object ID (panels a, c, and e). Red circles and red object ID numbers highlight some of the developing convective clouds for this day. Object IDs are consistent over time, allowing developing storms to be automatically tracked while minimizing broken tracks. Any desired satellite or radar fields are tracked along with each object ID (UWCI Cloud Top Cooling Rate, Brightness Temperatures, Composite Reflectivity, Vertically Integrated Liquid, etc.).

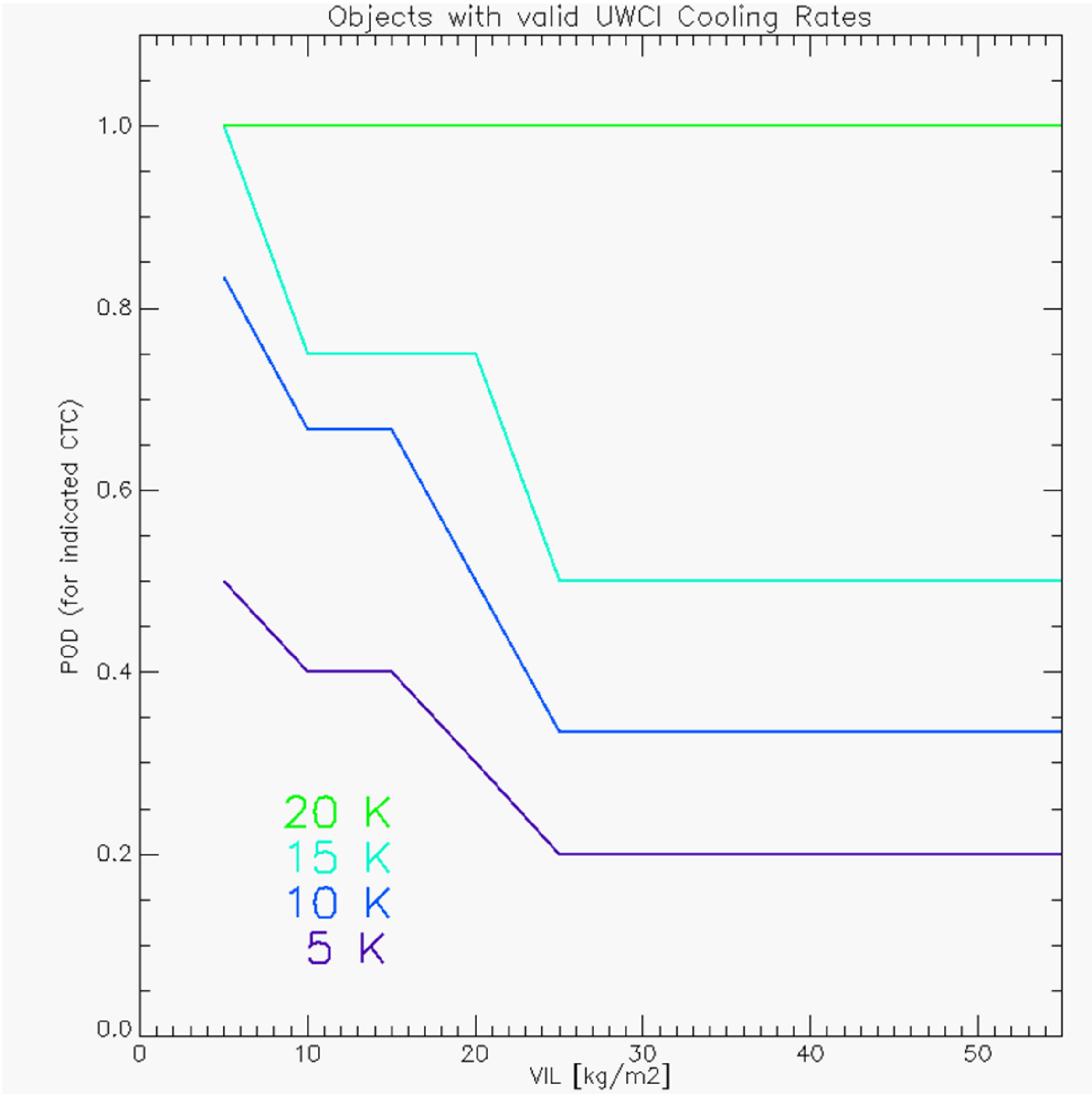


Figure 3.2.2. Probability of a storm achieving a given value of Vertically Integrated Liquid (VIL) for various magnitudes of UWCI Cloud-Top Cooling Rate for the afternoon of 29 April 2009. Preliminary results are encouraging; larger cooling rates more often correspond to significant values of VIL, though the sample size for this afternoon is too small to draw concrete conclusions. These plots answer the question of the forecaster, if I see a developing storm with a UWCI cooling rate of X K/15min, what value of VIL will the storm likely achieve at a later time?

Publications and Conference Reports

Sieglaff, Justin M., Lee M. Cronce, Wayne F. Feltz, Kristopher M. Bedka, Michael J. Pavolonis, and Andrew K. Heidinger, 2011: Nowcasting Convective Storm Initiation Using Satellite-Based Box-Averaged Cloud-Top Cooling and Cloud-Type Trends. *J. Appl. Meteor. Climatol.*, **50**, 110–126. doi: 10.1175/2010JAMC2496.1

3.3 GOES I-M Cloud Climate Products

CIMSS Task Leader: Michael Foster
CIMSS Support Scientists: Christine Molling, William Straka III
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

This project aims to fill a hole in the climate data provided by NOAA. Currently, there is no publicly available record of GOES imager cloud products. Just recently CLASS has begun to archive the real-time products from GOES Surface and Insolation Project (GSIP) but there is no plan to go back in time. While the International Satellite Cloud Climatology Project (ISCCP) is using GOES Imager data, only two channels are used and they are sampled at a very coarse spatial resolution.

This project aims to build off the successful Pathfinder Atmospheres Extended (PATMOS-x) project, which recently delivered 30 years of cloud climate records from NOAA's POES Imager (AVHRR) to NOAA's National Climatic Data Center (NCDC) in September 2010. We leverage off PATMOS-x by using the same software, data formats and analysis tools. For this one-year project, we propose to only do this work for the GOES-11 (2006-2009) Northern Hemisphere domains (every 30 minutes) and the GOES-10 (2007-2008) Southern Hemisphere domains (every 15 minutes). Once the methodology of data production and the Web interface are mature, we will move on to the entire GOES-I-M record and then GOES-NOP.

Constructing an easy to use GOES cloud climatology was many advantages. First, the user base developed under PATMOS-x will certainly benefit from similar information available at higher temporal frequencies. Because these products are made with algorithms that are analogs to those developed for GOES-R (Heidinger and Pavolonis, 2009; Heidinger, 2010), this climatology will serve to educate and prepare the community for using GOES as a quantitative platform to observe clouds. Also, this dataset will serve as a geostationary complement to the 30-year AVHRR cloud climatology and allow for diurnal cycle adjustments and therefore more confident trends from the combined AVHRR/GOES time-series

Summary of Accomplishments and Findings

During the past six months, we have accomplished several of our key milestones. They are listed below.

- Modification of the PATMOS-x processing system to process GOES imager data using the existing GSIP routines.
- Implementation of the latest GOES-R algorithm analogs into PATMOS-x.
- Generation of an archive of GOES-11 imager data from the Northern Hemisphere domain for the entire GOES-11 period (2006 – 2010).
- Modification of the PATMOS-x level2b (our climate dataset) generation system to include a suitable GOES-West domain.
- Modification of all PATMOS-x IDL tools to support GOES-11.

Publications and Conference Reports

The cloud mask method we are using in PATMOS-x for AVHRR, GOES and any other sensor was submitted for publication in January 2011.

Heidinger, A.K., A. T. Evan, M. J. Foster and A. Walther, 2011: A Naïve Bayesian Cloud Detection Scheme Derived from CALIPSO and Applied within PATMOS-x. *submitted to JAMC December 2010.*

References

Heidinger, Andrew K. and Michael J. Pavolonis, 2009: Gazing at cirrus clouds for 25 years through a split window, part 1: Methodology. *Journal of Applied Meteorology and Climatology*, **48**, Issue 6, 1100-1116.

Heidinger, Andrew K., 2010: ABI Cloud Height Algorithm (ACHA) Theoretical Basis Document v1.0. GOES-R ATBD, GOES-R Program Office.

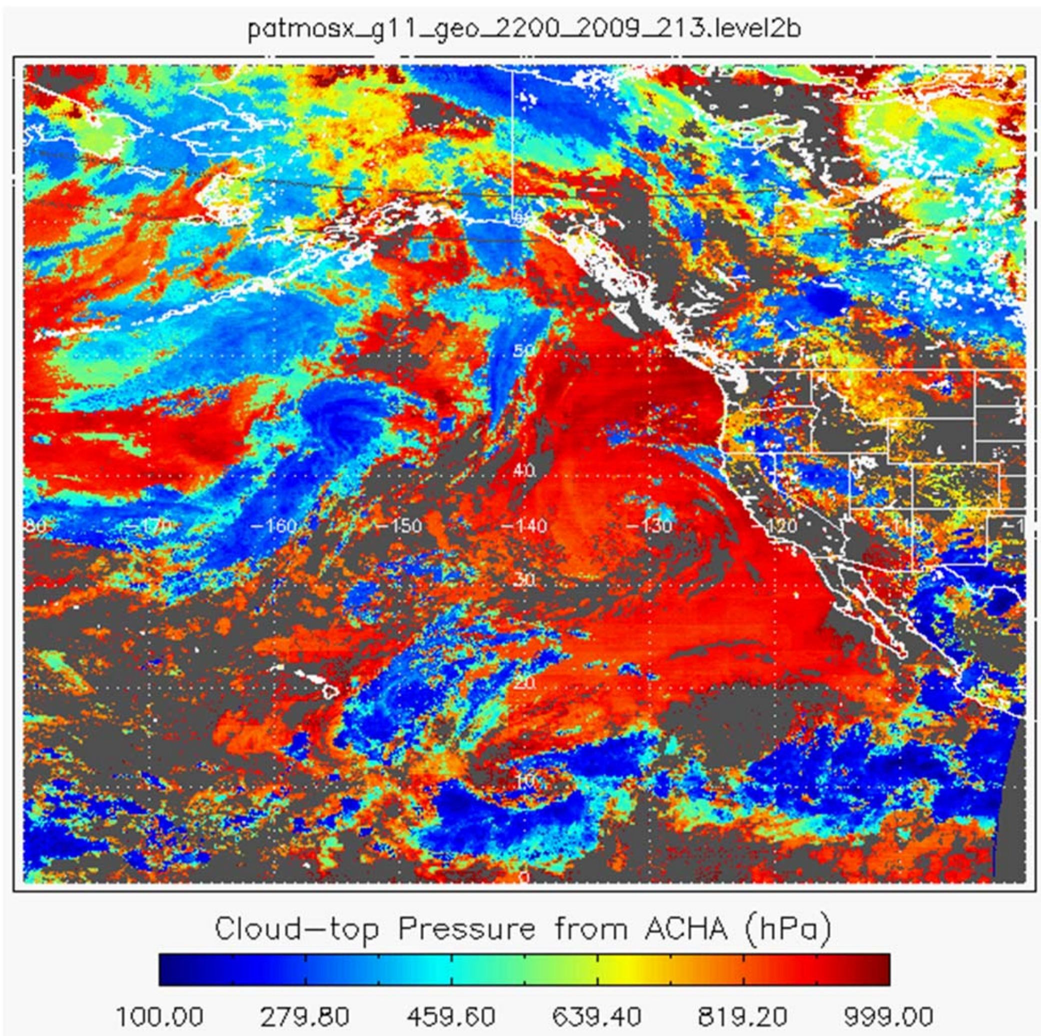


Figure 3.3.1. The above image shows the cloud-top pressure derived from PATMOS-x using GOES-11 on day 213 of year 2009 at 22:00 UTC. The image shows the proposed GOES-WEST NHEM domain in PATMOS-x (180W-100W,0N-70N). The cloud-top pressure is derived from the AWG Cloud Height Algorithm (ACHA) using the 6.7, 11 and 12 micron channels on GOES-11.

3.4 Automated Volcanic Ash Detection and Volcanic Cloud Properties from the GOES Imager

CIMSS Task Leader: Justin Sieglaff
NOAA Collaborator: Michael Pavolonis
NOAA Strategic Goals

- Support the nation's commerce with information for safe, efficient and environmentally sound transportation
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

Under a previously funded GIMPAP project (FY08-FY09), an automated volcanic ash detection and retrieval algorithm was developed for GOES. While these algorithms generally work well, there are a few important scientific issues that need to be addressed prior to an operational implementation. The 13.3 μm version of the algorithm must be improved. Difficulties with this channel include larger FOV (GOES-12 and GOES-13) and SRF uncertainties, which adds significant uncertainty to the atmospheric correction procedure. The current ash detection false alarm rate (0.01%) must be improved to allow for highly reliable automated warning to be sent to ash forecasters. In addition, a methodology for detecting ice topped volcanic clouds (volcanic convection) needs to be developed.

Summary of Accomplishments and Findings

In this section, a brief progress report is given for each project milestone.

- *Implement robust cloud object capabilities into the Geostationary Cloud Algorithm Testbed (GEOCAT).* The Geostationary Cloud Algorithm Testbed (GEOCAT) has been updated to allow for the flexible cloud object based processing that is required to accurately detect volcanic ash from GOES.
- *Implement dynamic clear sky atmospheric transmittance bias correction into processing.* This milestone is still being worked on (FY10 funding did not arrive at CIMSS until the Summer of 2010).
- *Test ash algorithms in real-time at CIMSS.* The GOES volcanic ash algorithms have been tested in real-time and monitored using an internal CIMSS Web site.
- *Determine ash detection skill.* Upon analysis it was determined that ice topped volcanic ash clouds were not being reliably detected using the GOES methodology. Thus, a methodology that utilizes the temporal trend in cloud top properties to distinguish between meteorological thunderstorms and ice topped volcanic clouds was developed. This overall as detection effort will continue until the end of the project.
- *Validate retrieval results using CALIOP.* The ash cloud property retrievals that can be performed using the current series of GOES imaging instruments were validated using the spaceborne lidar CALIOP (see Figure 3.4.1 for an example).

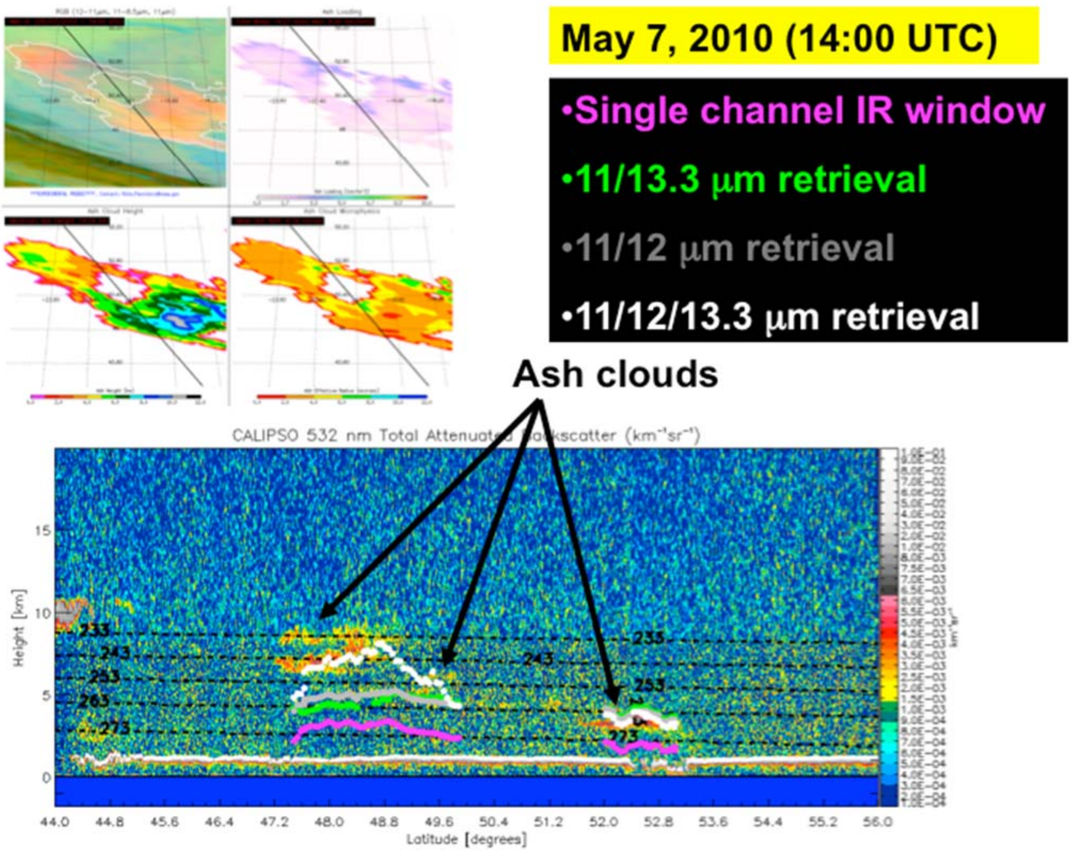


Figure 3.4.1. The ash cloud height retrieved using four different methodologies is compared to the ash cloud boundaries inferred from the total attenuated backscatter cross section measured by a spaceborne lidar (CALIOP). Eyjafjallajökull (in Iceland) produced the ash cloud depicted in the lidar data on May 7, 2010. The ash cloud height retrieved using the GOES-11 methodology is shown in gray, the ash cloud height retrieved using the GOES-12 – GOES-15 methodology is shown in green, the GOES-R methodology is shown in white, and the height inferred from a traditional single channel approach is shown in magenta.

Publications and Conference Reports

Pavolonis, M. J., 2010: Advances in extracting cloud composition information from spaceborne infrared radiances: A robust alternative to brightness temperatures. Part I: Theory. *J. Applied Meteorology and Climatology*, **49**, 1992-2012.

Pavolonis, M. J., 2011: Advances in extracting cloud composition information from spaceborne infrared radiances: A robust alternative to brightness temperatures. Part II: Proof of concept. To be submitted to: *J. Applied Meteorology and Climatology*.

Pavolonis, M.J., A.K. Heidinger, and J. Sieglaff, 2011: Automated retrievals of volcanic ash and dust cloud properties from upwelling infrared measurements. In Prep.

Pavolonis, M.J. and J. Sieglaff, 2010: Automated monitoring of volcanic ash micro and macro-physical properties: A comparison of future and current satellite instrument capabilities, presentation at the IGARSS Meeting, Honolulu, HI.

Pavolonis, M.J. and J. Sieglaff, 2010: The evolution of convective cloud properties: Meteorological vs. volcanically driven convection, presentation at the CoRP Symposium, Fort Collins, CO.

Pavolonis, M.J. and J. Sieglaff, 2010: Addressing traditional limitations of satellite based volcanic cloud monitoring, presentation at the Australian Bureau of Meteorology, Darwin Australia.

3.5 GOES Biomass Burning Research and Applications

CIMSS Task Leader: Chris Schmidt
CIMSS Support Scientists: Jason Brunner, Elaine Prins, Jay Hoffman
NOAA Collaborators: Robert Rabin (NOAA/NSSL), Phillip Bothwell (NOAA/NWS/SPC), Ivan Csiszar (NOAA/NESDIS/STAR), Shobha Kondragunta (NOAA/NESDIS/STAR)
NOAA Strategic Goals

- Understand climate variability and change to enhance society's ability to plan and respond
- Support the nation's commerce with information for safe, efficient and environmentally sound transportation
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques
- Environmental Models and Data Assimilation

Proposed Work

For many years GOES-E/-W were the only operational environmental geostationary platforms with fire monitoring capabilities. With the launch of Met-8/-9, MTSAT-1R/-2, and future instruments (INSAT-3D, COMS, etc.), this capability is now global. The Wildfire Automated Biomass Burning Algorithm (WF_ABBA) has been recently upgraded to Version 6.5.006 (v65) to provide new metadata and to support the international constellation of geostationary satellites that can provide fire detection and characterization, including but not limited to current GOES, Met-8/-9, and MTSAT-1R/-2. The new version of the WF_ABBA is capable of producing output for all data scanned by those satellites, including the Rapid Scan Operation (RSO) and Super Rapid Scan Operation (SRSO) modes of GOES. In order to successfully use these global satellite data products for real-time fire monitoring, trend analyses and applications in data assimilation and long-range transport, new techniques must be developed to characterize and integrate the data.

This project utilizes the WF_ABBA's 16-year and growing fire database and brings support online for new geostationary satellites in the global constellation. A key component of this work is collaboration with NSSL via Dr. Bob Rabin and Dr. Phillip Bothwell to create a climatology of wildfires from the WF_ABBA v65 data and to examine whether the WF_ABBA data could be used in conjunction with other ancillary information to create a "fire potential" product. The fire potential product aims to improve predictions of fire potential for a 24-48 hour time frame. The climatology and, if proven successful, the fire potential product, will be of use to NSSL's Storm Prediction Center (SPC) forecasters and others. The creation of the climatology leverages techniques developed for fire studies over South America under the NASA LBA program.

Summary of Accomplishments and Findings

The global WF_ABBA v65 includes the addition of FRP and a fire/metadata mask that provides information on processing regions, fire locations, fire confidence, cloud cover, block-out zones, and other useful information. The GOES WF_ABBA v65 trend analysis is being expanded to extend around the globe and now includes Met-9 over Africa and Europe and also MTSAT-1R/-2 over Asia and Australia. The combination of Met-9, MTSAT-1R/-2 and GOES-E/-W provides nearly complete global coverage by the WF_ABBA.

The code used for the development of the GOES WF_ABBA v65 climatology of fires is completed and the processing of the WF_ABBA v65 fire/metadata mask for the climatology has begun. The fire/metadata mask allows for analysis of the fires to take into account coverage by opaque clouds and other regions where fire detection was not possible. Figure 3.5.1 shows GOES East WF_ABBA v65 total number of fires (all fire categories included but low possibility) satellite coverage corrected and 0.25 degree binned for 9 April 2009 over the western Hemisphere. Fires were most prevalent over the central and southern Great Plains of the United States and the Yucatan Peninsula of Mexico. In addition, there was some fire signal over Cuba and the Amazon region.

The initial time period of focus for the fire potential product is June – October 2010 over the United States. The ancillary datasets that will be used along with the WF_ABBA fire climatology are a Surface Dryness product, the NDVI product, a Surface Type/Land Use dataset, the Fosberg Fire Weather Index, and a Cloud to Ground Lightning database. The collection of the ancillary datasets and the development of the fire potential product will occur over the next few months. CIMSS has participated and will continue to communicate with Dr. Bob Rabin and Dr. Phillip Bothwell with regard to the development of the fire potential product.

The WF_ABBA v65 was modified to process GOES-15 and MTSAT-2 data. In addition, updates were made to reflect changes in the 3.9 micron saturation temperature for GOES-11, -12, and -13. The GOES-15 WF_ABBA was executed on diurnal imagery collected in August and the code performed as expected. Evaluation of the MTSAT-2 WF_ABBA fire product during July and August 2010 indicate that performance is similar to MTSAT-1R. The MTSAT-2 3.9 micron saturation threshold of ~320.0 K is similar to MTSAT-1R and hinders fire detection and characterization, which is especially evident over Australia where large areas are saturated within several hours of local noon. The updated global WF_ABBA v65 was transferred to NESDIS operations in the fall 2010.

The GOES East/West fire products continue to be used in aerosol transport models (e.g., Navy NAAPS, INPE CPTEC, WRAP, FLEXPART, IDEA, and others), emissions assessment and modeling, air quality applications, and climate change analyses. CIMSS actively collaborates with the user community to help to ensure proper applications of geostationary satellite derived fire products in a variety of ongoing and new applications. As the CIMSS geostationary fire program expands to monitor burning around the globe, applications are expanding as well. NRL is currently testing integration of global geostationary fire products (GOES, MTSAT, Met-9) into the NAAPS model. At U.C. Irvine, M. Mu and J. T. Randerson are incorporating emissions derived from multi-year GOES WF_ABBA fire products into the Global Fire Emissions Database version 3 (GFED3). As part of this effort, CIMSS is collaborating with U.C. Irvine on a publication titled "Daily and hourly variability in global fire emissions and consequences for atmospheric model predictions of atmospheric carbon monoxide." CIMSS has also just begun an informal collaboration with scientists at UC Davis who are developing and testing new temporal/spatial techniques for early wildfire detection in the western U.S. using GOES-West.

CIMSS continues to support international satellite fire monitoring efforts by being actively involved in GEOSS, GTOS GOFC/GOLD, CEOS, and CGMS activities. This effort includes involvement in international planning committees, workshops and technology transfer to global partners in Europe, Africa, Asia, Australia, etc. One of the primary goals is to foster closer connections to international working groups and inter-agency efforts to gain better insight into the needs of the global user community, to enable better coordination of data sources and products, and to provide input for future missions. Currently, global geostationary fire monitoring is being considered as a CEOS Constellation Concept.

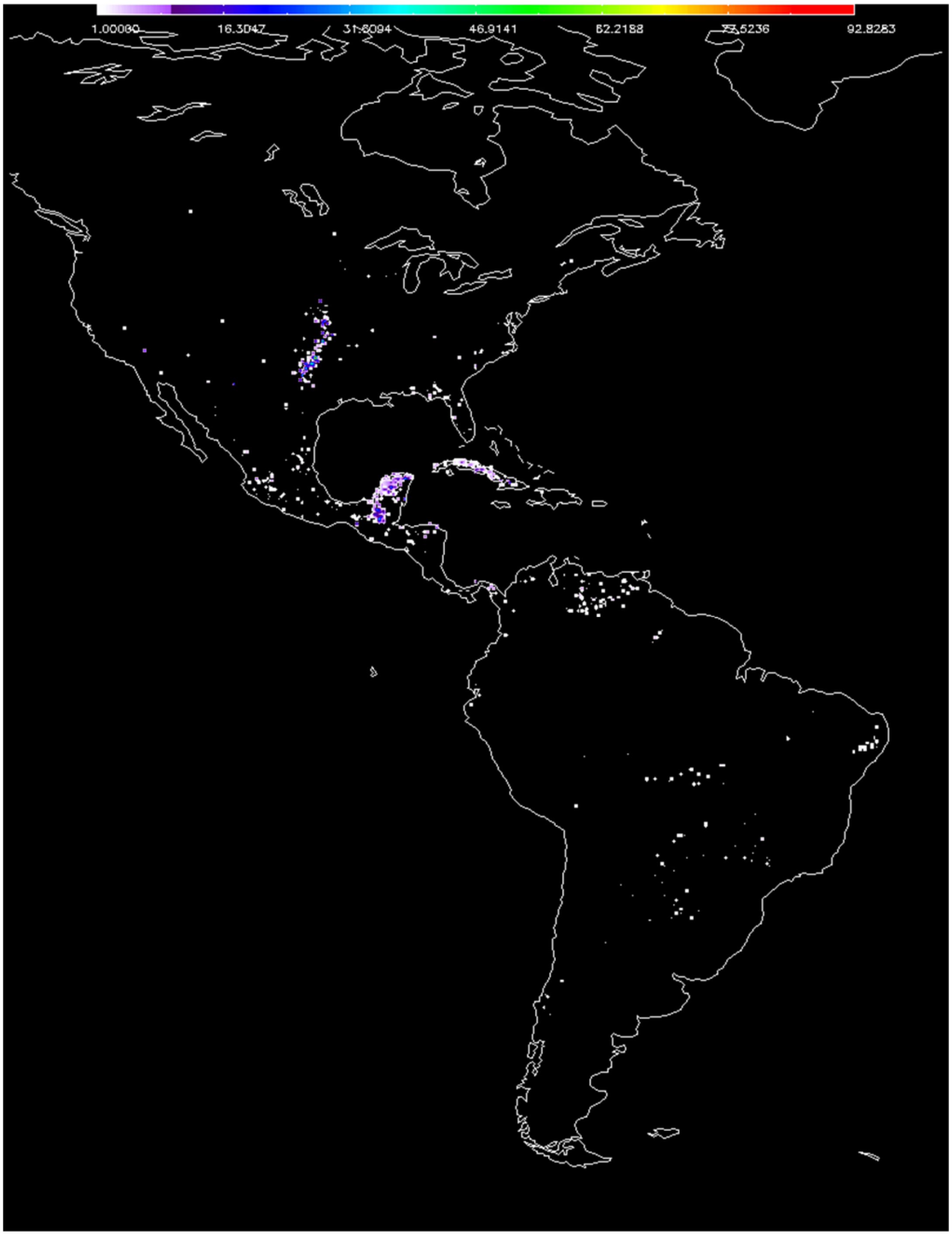


Figure 3.5.1. GOES East WF_ABBA v65 total number of fires (all fire categories included but low possibility), satellite coverage corrected and 0.25 degree binned for 9 April 2009. Fires were most prevalent over the central and southern Great Plains of the United States and the Yucatan Peninsula of Mexico. In addition, there was some fire signal over Cuba and the Amazon region.

Publications and Conference Reports

Brunner, J. C., C. C. Schmidt, R. M. Rabin, E. M. Prins, J. M. Feltz, J. P. Hoffman, and P. D. Bothwell, 2010: The development of a Western Hemisphere trend analysis of fires and United States fire potential product from version 6.5 WF_ABBA data. 17th Conference on Satellite Meteorology and Oceanography. Annapolis, MD. September 2010, Amer. Meteor. Soc., P4.16.

Hoffman, J. P., C. C. Schmidt, J. C. Brunner, E. M. Prins, 2010: Geostationary fire detection with the Wildfire Automated Biomass Burning Algorithm. AGU Fall Meeting, San Francisco, CA, December 13-17, 2010.

Prins, E. M., C. C. Schmidt, J. C. Brunner, J. P. Hoffman, S. S. Lindstrom, and J. M. Feltz, 2010: The global geostationary Wildfire ABBA fire monitoring network. 17th Conference on Satellite Meteorology and Oceanography, Annapolis, MD, September 2010, Amer. Meteor. Soc., P9.13.

Schroeder, W., I. Csiszar, L. Giglio, and C. C. Schmidt, 2010: On the use of fire radiative power, area, and temperature estimates to characterize biomass burning via moderate to coarse spatial resolution remote sensing data in the Brazilian Amazon. JGR, 115, D21121, doi:10.1029/2009JD013769.

3.6 GIMPAP: Testing of New Height Assignment Methodology for GOES Atmospheric Motion Vectors (AMVs)

CIMSS Task Leaders: Chris Velden, Steve Wanzong
NOAA Collaborators: Jaime Daniels (STAR), Andrew Heidinger (ASPP)
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Project Summary and Proposed Work

Although AMVs have had positive impacts on NWP, the representative vector heights have proven to be a relatively large source of observation uncertainty, because in most cases the satellite imagers actually sense radiation emitted from a finite layer of the troposphere rather than just one specific level. Problems in data assimilation of AMVs can arise from the difficulty in accurately placing the height of the tracer. Thus, we have proposed to take a fresh look at developing a specific quality indicator for AMV height assignment. To this end, we are working with cloud height experts. Once developed, we will work with data assimilation colleagues to address the issue of exploiting this new AMV height assignment information in numerical model simulations to determine the potential forecast impact.

The AMV processing algorithm uses upstream cloud team algorithms for AMV height assignment. Included in the pixel-level cloud height output structure are estimated pressure and temperature errors. It is still hoped that this will eventually be a way to estimate AMV tracer cloud height uncertainty for use in NWP. Also included in the cloud team output structure are quality flags with respect to the cloud height retrieval for each pixel. We will look at cloud retrieval quality estimates and 11-micron emissivity values compared against AMV-CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) cloud height comparisons. Software modifications will need to be introduced to read this information from the upstream cloud height algorithm and include the quality flags and emissivity values that make up the height assignment set of pixels.

Summary of Accomplishments

We have modified the AMV software to include QC flags and 11 um emissivity along with the tracer height assignment, and added them as new output. We also modified the ASCII to NetCDF software to allow 2 new output variables: representative quality and emissivity of the target pixels. Work in progress involves taking the AMV NetCDF file and collocating with CALIPSO data. We will then correlate AMV-CALIPSO comparisons with representative QC flag (or emissivity) values for the target scene, and evaluate. If the proposed research is successful and validated, we will see an improved ability for NWP to effectively assimilate AMVs and to positively impact analyses and forecasts.

3.7 Using Quantitative GOES Imager Cloud Products to Improve Short-Term Severe Weather Forecasts

CIMSS Task Leaders: Justin Sieglaff, Dan Hartung
NOAA Collaborators: Andy Heidinger, Michael Pavolonis
NOAA Strategic Goals

- Serve society’s needs for weather and water
- Support the nation’s commerce with information for safe, efficient and environmentally sound transportation
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

In FY07, GIMPAP supported the real-time implementation of GOES-R ABI cloud property retrieval algorithms on current GOES imager data. The cloud products generated are cloud type (phase included), height, emissivity, optical depth, microphysics (e.g., particle size), and liquid/ice water paths. The algorithms are the GOES-NOP version of the GOES-R ABI algorithms developed by the Algorithm Working Group (AWG) Cloud Application Team. Quantitative cloud properties from GOES have been under-utilized. The goal of this project is to extract information from the cloud properties that can be used to make short-term predictions on convective storm evolution, throughout the storm’s lifecycle. This information can then be used within existing convective weather decision support tools (e.g., see Feltz et al. and Lindsey GIMPAP projects). The proposed work will build upon the pilot studies conducted with FY08-09 GIMPAP funds.

Summary of Accomplishments and Findings

In this section, a brief progress report is given for each project milestone.

1. Derive metrics, based on the temporal and spatial distribution of cloud properties, which are useful for studying and predicting convective storm evolution (from beginning to end). It is possible to extract far more quantitative information on clouds from GOES than is currently being extracted for use by forecasters.

   Figure 3.7.1 provides a reference of WDSS-II cloud objects output and associated top of troposphere cloud emissivity field (input tracked within WDSS-II) for strong storms (circled in red) on 13 May

2009 and weak storms (circled in blue) 25 May 2008. The strong storms achieved at least 55 dBZ composite reflectivity and had severe weather reports, while the weak storms began to develop, produced moderate to strong radar reflectivity, but ultimately decayed and did not produce severe weather (not shown).

The temporal and spatial trends of these storms and the differences between strong and weak cells are the focus of this research project. Specifically how can the trend information be used to distinguish 1) storms that will develop into strong thunderstorms and which will not and 2) when are storms either in the process of, or likely to, decay.

The trends in strong and weak cells from the automated WDSS-II tracking method exhibit strong agreement between manual analyses shown in previous reports. This agreement is important because the automated nature of WDSS-II object tracking will allow for quick processing of a statistically significant count of thunderstorms, with numbers not practical by manual analysis. Once the large number of storms has been processed, we will develop a framework using the physical cloud properties and their spatial and temporal trends for predicting convective storm development and decay.

In Figures 3.7.2 and 3.7.3, there are similarities and differences between strong and weak storms. Both groups of storms may achieve significant amounts of ice cloud (panel c), however the rate at which storms glaciate (panel c) and rate and extent of vertical growth (panel a) is different. Additionally, the rate of storm anvil expansion (panel b) and the combination of growth rate and extent of the 90th percentile of cloud effective radius (panel d) exhibit differences. The project goals will be met by analyzing temporal trends of spatial information for the presented cloud properties, as well as additional derived cloud properties, for strong versus weak cells. Results will be disseminated in future reports.

2. Incorporate knowledge gained by this research into the CIMSS and CIRA convective weather decision support tools.

   The results of milestone #1 will be made available to and likely incorporated into convective weather decisions support tools once the analysis is complete later in the FY.

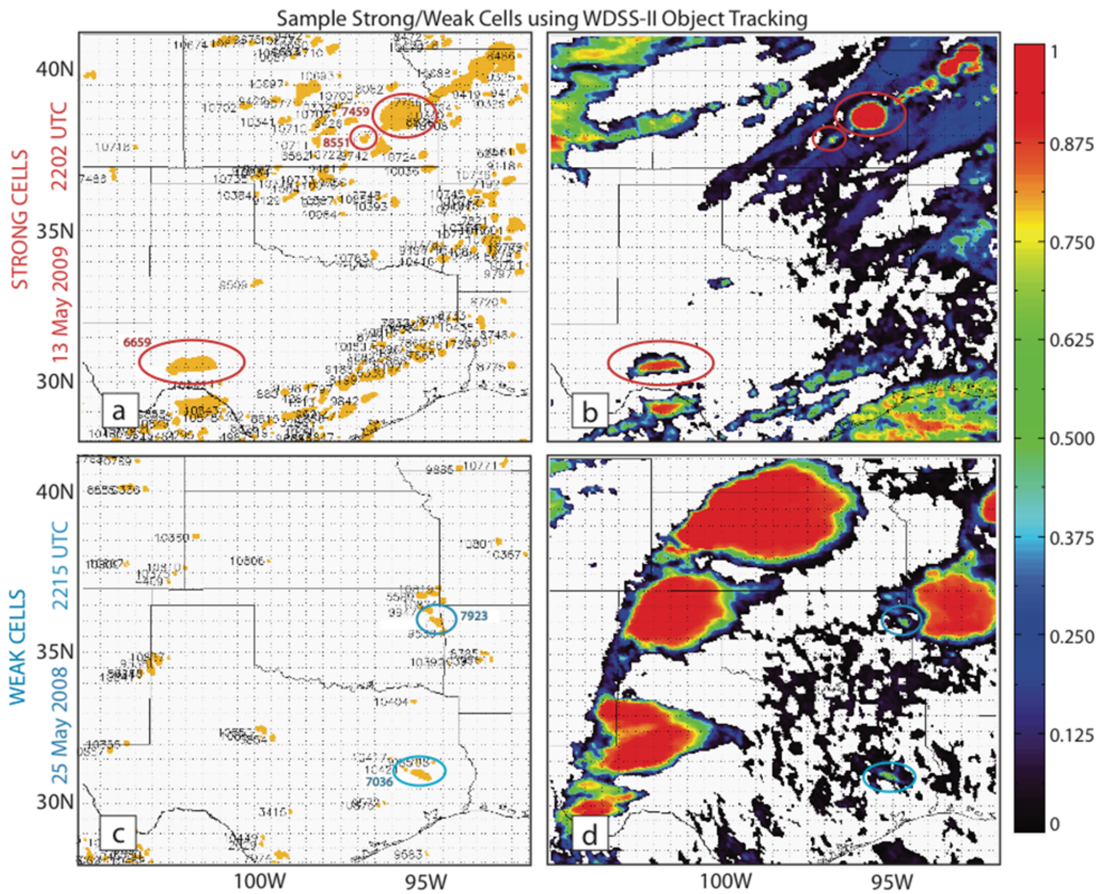


Figure 3.7.1. WDSS-II objects and associated IDs [panels (a) and (c)] with strong cells (red circles) and weak cells (blue circles) identified for a case on 13 May 2009 (a) and 25 May 2008 (b), respectively. Panels (b) and (d) display top of troposphere emissivity used to identify and track the cells identified to their left. It is worth noting that identified weak cells did not achieve a maximum emissivity value greater than 0.8.

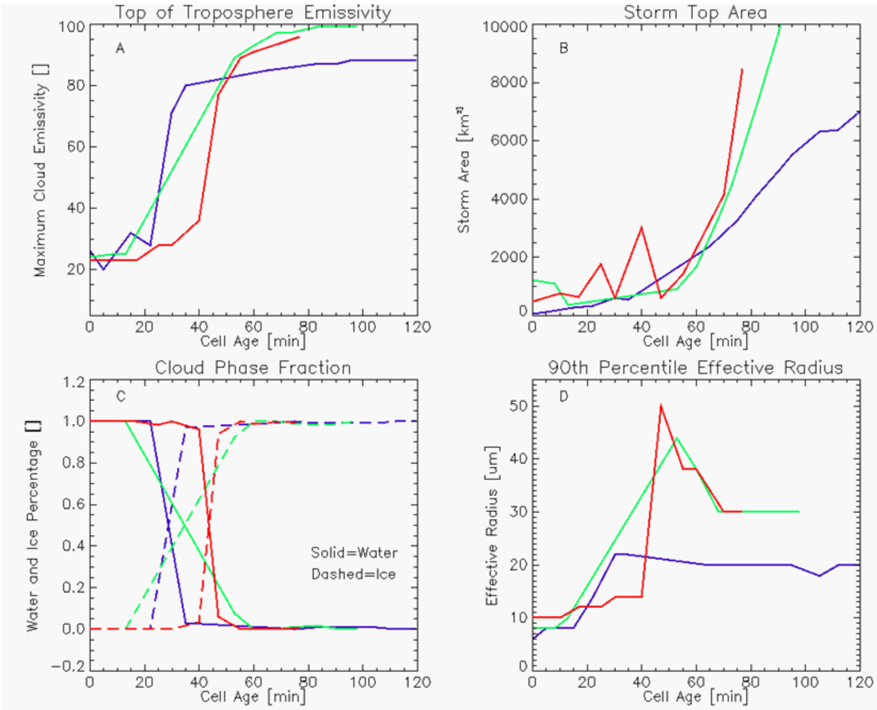


Figure 3.7.2. Temporal trends of spatial information of various cloud property fields for three severe storms on 13 May 2009. The different colors correspond to different storms. The storm times are normalized to begin at storm age of zero minutes.

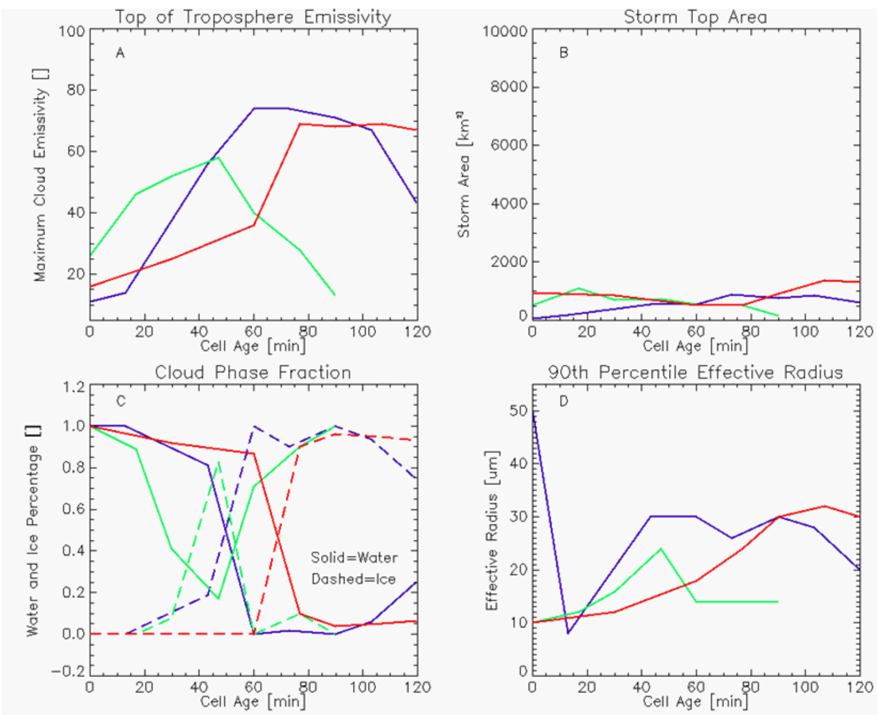


Figure 3.7.3. Temporal trends of spatial information of various cloud property fields for three weak storms on 25 May 2008. The different colors correspond to different storms. The storm times are normalized to begin at storm age of zero minutes.

Publications and Conference Reports

Pavolonis, M.J. and J. Sieglaff, 2010: The evolution of convective cloud properties: Meteorological vs. volcanically driven convection, presentation at the CoRP Symposium, Fort Collins, CO.

Pavolonis, M. J., 2010: Advances in extracting cloud composition information from spaceborne infrared radiances: A robust alternative to brightness temperatures. Part I: Theory. *J. Applied Meteorology and Climatology*, **49**, 1992-2012.

Pavolonis, M. J., 2011: Advances in extracting cloud composition information from spaceborne infrared radiances: A robust alternative to brightness temperatures. Part II: Proof of concept. To be submitted to: *J. Applied Meteorology and Climatology*.

4. CIMSS Research Activities in the Virtual Institute for Satellite Integration Training (VISIT) Program in 2010

CIMSS Task Leaders: Scott Bachmeier, Steve Ackerman
CIMSS Support Scientists: Scott Lindstrom, Tom Whittaker, Jordan Gerth
NOAA Collaborators: Tim Schmit, Robert Aune, Cooperative Institute for Research in the Atmosphere (CIRA), Forecast Decision Training Branch (FDTB)
NOAA Strategic Goals Addressed

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Education and Outreach

Proposed Work

The focus for the proposed work this year was on continuing to create VISITview distance learning modules for a broad satellite meteorology audience, providing valuable satellite imagery interpretation materials that can be used in education and training, and also on maintenance and updates to existing satellite image lesson material.

There remains a lack of adequate satellite-based education and training on a number of important topics that have direct relevance to typical forecast problems. Some of these topics include: identification of deformation zones, cloud patterns related to upper level wind fields, jet streaks, moist conveyor belts, fog detection, turbulence signatures, and air quality.

The presence of fully-functioning Advanced Weather Interactive Processing System (AWIPS) workstations at CIMSS allows for faster development of new educational materials that address these types of satellite interpretation topics (and also facilitates more frequent updates to pre-existing modules) as new case study examples are observed on a daily basis. This real-time AWIPS capability gives CIMSS the unique ability to present these satellite interpretation topics in a context that the National Weather Service (NWS) forecaster can more easily relate to.

We also proposed to begin exploring the creation of lessons in the self-contained Weather Event Simulator (WES) format, which is an AWIPS training format that is widely used by NWS forecast offices. A WES case using simulated Advanced Baseline Imager (ABI) data has been developed at CIMSS as part of the GOES-R Proving Ground effort headed by Tim Schmit.

We planned to continue to leverage the real-time AWIPS capability at CIMSS to collect a variety of satellite and other remote sensing data during interesting or high societal impact weather events that occurred in a variety of regions and seasons. It was also proposed that CIMSS continue to act as a "beta test site" for the next-generation AWIPS II. In addition, we proposed to continue to utilize our AWIPS capability to serve as a testbed for new satellite products in an operational environment (as was successfully accomplished with the "MODIS Products in AWIPS" project that has been ongoing since 2006, and also the "POES and AVHRR Satellite Data in AWIPS" project that was recently initiated).

Summary of Accomplishments and Findings

Twenty-five "live" instructor-led VISITview teletraining sessions were given to a total of 91 NWS forecasters during this period, on the following seven topics: (1) Interpreting Satellite Signatures, (2) TROWAL Identification, (3) CRAS Forecast Imagery in AWIPS, (4) POES and AVHRR Satellite Data in AWIPS, (5) Morphed Total Precipitable Water Detection (MIMIC), (6) The UW-Madison NearCasting Product, and (7) The UW-Madison Convective Initiation Product. These lessons – and others – are also available in the US Department of Commerce Learning Center.

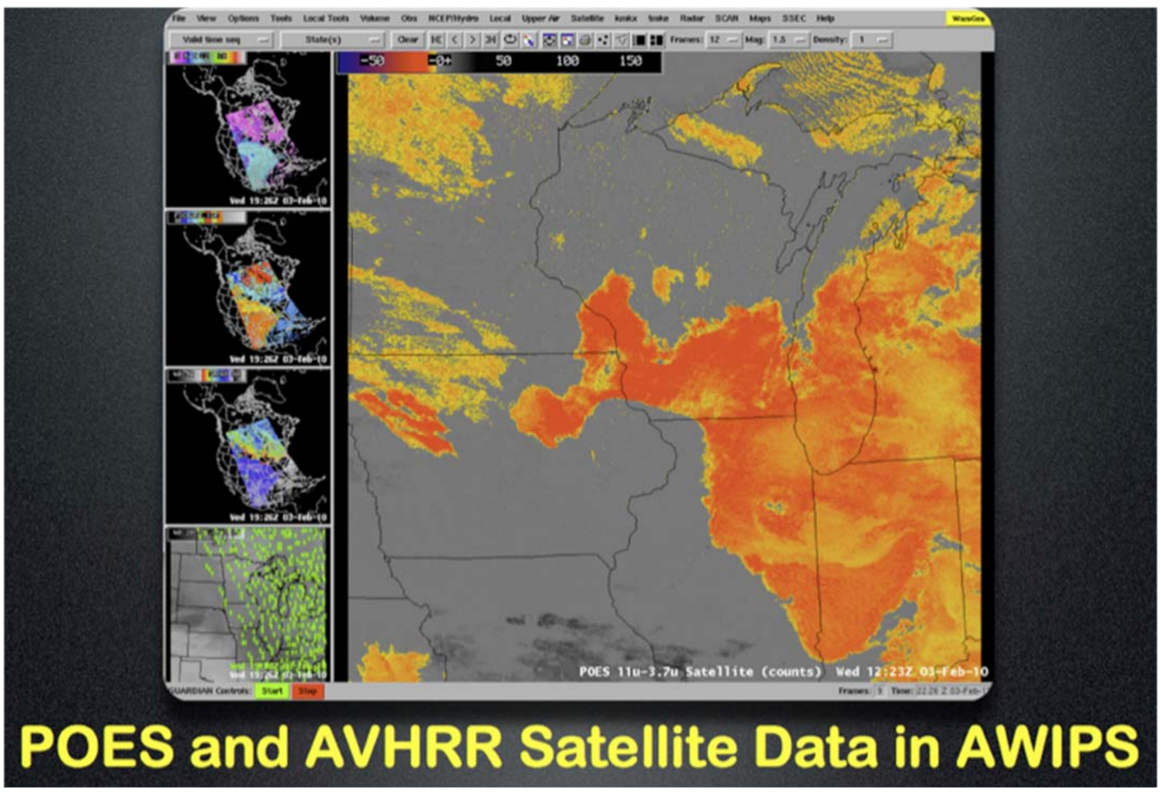


Figure 4.1. Title slide for the new "POES and AVHRR Satellite Data in AWIPS" VISITview lesson that was added to the VISIT training calendar in 2010.

Two new lessons that were developed and added to the VISIT training calendar were: (1) Morphed TPW Detection (MIMIC), and (2) Objective Overshooting Top / Thermal Couplet Detection. These lessons introduce new satellite products that a NWS forecast office can choose to add to their local AWIPS workstations. Four lessons that received significant revisions and updates were: (1) POES and AVHRR Data in AWIPS, (2) The UW-Madison Convective Initiation Product, (3) The UW-Madison NearCasting Product, and (4) TROWAL Identification. Recorded versions of four lessons were created (or revised) and placed within the Department of Commerce Learning Center: (1) Morphed TPW Detection (MIMIC), (2) Objective Overshooting Top / Thermal Couplet Detection, (3) the UW-Madison Convective Initiation Product, and (4) The UW-Madison NearCasting Product. In addition, work continued on the development of another upcoming VISIT lesson: A One-Stop Inventory of Satellite Products in AWIPS.

VISIT support allowed for a variety of new posts to be added to the CIMSS Satellite blog: http://cimss.ssec.wisc.edu/goes/blog (the top hit in a Google search for the term 'Satellite blog'). The CIMSS Satellite Blog continues to serve as an expanding searchable repository of satellite products that can be used in future VISIT teletraining modules, and also acts as a source of Just-In-Time satellite training material. For example, the blog entry on blowing dust in West Texas (http://cimss.ssec.wisc.edu/goes/blog/archives/7636) was used by the National Weather Service in Wilmington OH in an on-line discussion of a 'dirty rain' event in their County Warning Area (http://www.erh.noaa.gov/iln/muddyrain.php). Table 1 shows a list of dates when CIMSS Satellite Blog entries were created and posted.

Table 4.1. Dates when blog entries were made on the CIMSS Satellite Blog (URL: http://cimss.ssec.wisc.edu/goes/blog)

Month	Days with CIMSS Satellite Blog Entries
July 2010	6, 8, 9, 12, 13, 15, 16, 20 , 23, 25, 26, 27
August 2010	3, 4, 8, 9, 12, 14, 17, 18, 21, 23-31
September 2010	1-22, 24-27, 29, 30
October 2010	2, 3, 5, 8, 11, 12, 18, 26, 27, 31
November 2010	2, 5, 8, 10, 11, 13, 17, 18, 19, 23, 26, 28, 30
December 2010	4, 5, 12, 19, 27, 31
January 2011	1, 5, 8, 13, 14, 19, 20, 21, 25, 26, 29
February 2011	2, 10, 13, 14, 19, 27, 28
March 2011	7, 9, 11, 12, 15, 17, 23, 28, 30, 31

Members of the CIMSS VISIT team also participated in GOES-R Proving Ground teleconference calls and VISIT/SHyMet teleconference calls. These activities are important because they help in the identification of potential new satellite training topics, especially related to GOES-R Proxy data that are helping prepare NWS forecasters for the GOES-R era.

We also participated in local GOES-R Proving Ground Training activities with the National Weather Service forecast office (WFO) in Milwaukee/Sullivan, WI (MKX) – CIMSS staff traveled to MKX to brief forecasters one-on-one about a variety of new satellite-based products (UWCI, Overshooting Top/Thermal Couplet Objective Detection, and NearCasting). Scott Bachmeier traveled to NWS in Green Bay, WI (GRB) and presented a talk on new satellite data available in AWIPS – a skeleton of the future VISIT teletraining lesson that will highlight the "One-Stop Inventory" of satellite products in AWIPS.

For his work in support of the NOAA Post-Launch Test of the GOES-15 satellite, Scott Bachmeier received the NOAA Team Member of the Month Award for October 2010.

5. PSDI

5.1 VIIRS Polar Winds

CIMSS Task Leaders: Dave Santek, Chris Velden
CIMSS Support Scientist: Nick Bearson
NOAA Collaborator: Jeff Key
NOAA Strategic Goal Addressed

- Serve society's needs for weather and water

CIMSS Research Theme

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

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 other numerical weather prediction (NWP) centers. Winds over the polar regions have been generated with Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's Terra and Aqua satellites and the Advanced Very High Resolution Radiometer (AVHRR) on NOAA satellites at CIMSS since 2001, and by NESDIS operations since 2005 (MODIS) and later (AVHRR). MODIS and AVHRR polar wind products are used operationally by 12 NWP centers in eight countries.

In preparation for the NPOESS Preparatory Project (NPP) satellite and the future Joint Polar Satellite System (JPSS), this project will adapt the MODIS and AVHRR polar winds algorithm to use with the Visible/Infrared Imager/Radiometer Suite (VIIRS) instrument.

The project Principal Investigator at CIMSS is David Santek. Christopher Velden will consult on the project. Jeff Key, NOAA/NESDIS, works 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 polar winds products from Terra and Aqua MODIS and AVHRR on NOAA-15 through -19 and METOP-A. The MODIS and AVHRR infrared window (IR) channels serve as proxy data for VIIRS (Figure 5.1.1), given that VIIRS will not have a water vapor channel. The spatial resolution of VIIRS is higher than that of MODIS and AVHRR, at 750 m pixels compared to 1 km for the IR window channels. We do not anticipate that the improved spatial resolution of VIIRS will add to product quality, as earlier studies have indicated that remapping to a 2 km equal-area grid provides the best compromise between computational efficiency and accuracy of the derived product. Nevertheless, we are investigating this issue.

A significant effort is being devoted to changing the wind retrieval code base. We have decided to employ the code developed for the GOES-R Advanced Baseline Imager (ABI), which has some fundamental differences from our traditional procedure. Most importantly, cloud-drift wind heights are determined by using an externally generated cloud height product rather than internal routines. We must therefore incorporate cloud properties code (courtesy of Andrew Heidinger).

We have been working closely with the NPOESS Data Exploitation (NDE) integration team. This team is a NESDIS/STAR group developing the product generation system for NOAA-unique products such as the VIIRS polar winds. We have contributed to the development of coding standards, delivery package contents, documentation, ancillary data requirements, and other issues of concern for the operational implementation of our research code. This work will continue beyond the NPP launch in October of this year (2011).

We are currently preparing for a critical design review (CDR), which will be delivered in late April (2011).

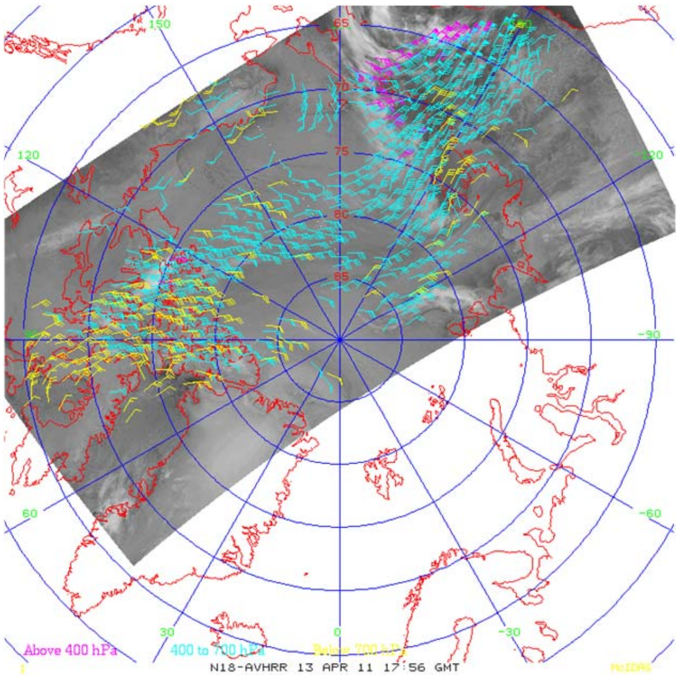


Figure 5.1.1. Polar winds from AVHRR HRPT (direct readout) data collected at Barrow, Alaska, on 13 April 2011. The AVHRR data are 1 km at nadir, remapped to 2 km.

Publications and Conference Reports

Dworak, R., and J. R. Key, 2009: 20 years of polar winds from AVHRR: Validation and comparison to the ERA-40. *J. Appl. Meteor. Climatol.*, **48**, 24-40.

Santek, D., 2010: The impact of satellite-derived polar winds on lower-latitude forecasts. *Mon. Wea. Rev.*, **138**, 123–139.

Dworak, R. and J. Key, 2009: 25 Years (1982-2007) of polar winds from AVHRR: Validation and comparison to the ERA-40 reanalysis. Proceedings of the 10th Conference on Polar Meteorology and Oceanography, Madison, Wisconsin, 18-21 May 2009.

Santek, D., 2009: The impact of satellite-derived polar winds in global forecast models. Proceedings of the 10th Conference on Polar Meteorology and Oceanography, Madison, Wisconsin, 18-21 May 2009.

5.2 Transition of AWG Cloud Algorithms to Current GOES Sensors

CIMSS Task Leader: William Straka III
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

National Environmental Satellite, Data, and Information Service, Center for Applications and Research (NESDIS/STAR) and the Cooperative Institute for Meteorological Studies (CIMSS) have been developing a suite of products that will offer advanced cloud detection and retrievals of cloud properties utilizing the GOES-R ABI instrument. This work is to transition the algorithms from the GOES-R Cloud AWG to work on the current set of GOES sensors (GOES-11/12/13/14/15) for usage. These include the ABI Cloud Mask (ACM) and ABI Cloud Height Algorithm (ACHA)

Most of thee techniques can be modified to operate on current sensors. This project deals with the modification of the GOES-R ABI Cloud Mask (ACM) and GOES-R ABI Cloud Height Algorithm (ACHA) to operate on the current GOES Imagers. The code will be transitioned to NOAA/NESDIS/STAR for transition to operational status.

Summary of Accomplishments and Findings

The ABI Cloud Mask was originally developed with multiple sensors in mind. It consists of multiple tests that automatically turn off if the required channel information is absent. For application to current GOES, GOES-specific thresholds were developed.

The ABI Cloud Height algorithm (ACHA) has made significant strides in the past year, including the ability to run the same method of deriving the cloud height across multiple platforms, including the current GOES sensors, utilizing various. Figure 5.2.1 shows just one of the 6 channel combinations available in the latest version of ACHA, as applied to GOES-12. ACHA Mode 2 utilizes the 11 and 13 micron channels, which is a more traditional approach to deriving the cloud height. Other modes include a three channel approach that can work on GOES-12 type satellites (6.7/11/13.3 micron), a two channel approach that will work on GOES-11 type satellites (11/12 micron) and a three channel approach that works on GOES-11 type satellites (6.7/11/12 micron). A large part of the ACHA effort involved working in collaboration with the GOES-R Winds Team to help optimize the performance of ACHA.

In addition to developing code, the CIMSS team has also implemented these algorithms into its own local processing system and generates products in near real-time from the current GOES-EAST, GOES-WEST and GOES-SOUTH domains. These data are made available via ftp and displayed in Google Earth. These same data will be made available in the GOES-R Proving Ground this summer.

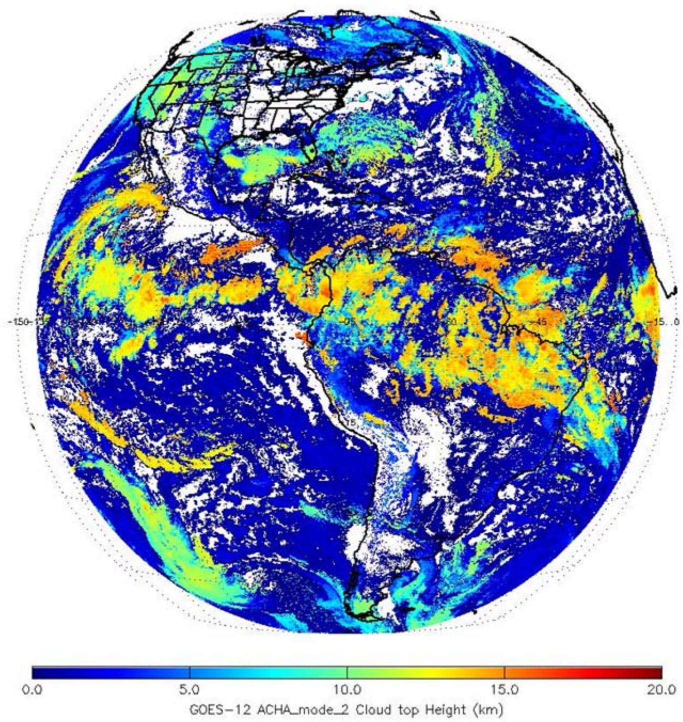


Figure 5.2.1. An example image of ACHA Cloud-top Pressure from the GOES-12 Imager. This image was generated using the 11 and 13.3 µm observations.

Publications and Conference Reports

Heidinger, A. K.; Pavolonis, M. J.; Holz, R. E.; Baum, Bryan A. and Berthier, S., 2010: Using CALIPSO to explore the sensitivity to cirrus height in the infrared observations from NPOESS/VIIRS and GOES-R/ABI. *Journal of Geophysical Research*, **115**, Doi:10.1029/2009JD012152.

References

GOES-R ABI Cloud Mask Algorithm Theoretical Basis Document (100% delivery)
GOES-R ABI Cloud Height Algorithm Theoretical Basis Document (100% delivery)

6. The Development of Hyperspectral Infrared Water Vapor Radiance Assimilation Techniques in the NCEP Global Forecast System

CIMSS Task Leader: James Jung
NOAA Collaborators: John Derber, Russ Treadon, Chris Barnet, and Walter Wolf
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Support the nation's commerce with information for safe, efficient and environmentally sound transportation
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques
- Environmental Models and Data Assimilation

Proposed Work

We are working with the Atmospheric Infrared Sounder (AIRS) Science Team, the National Center for Environmental Prediction (NCEP), the National Environmental Satellite, Data and Information Service (NESDIS) personnel and others in developing techniques to assimilate AIRS and the Infrared Atmospheric Sounding Interferometer (IASI) water vapor radiances. There are several problems which must be resolved in using these data. In general, the non-linearity of the water vapor channels makes them difficult to assimilate and channels which have significant dependencies to water vapor in the stratosphere are not modeled well by the Gridpoint Statistical Interpolation (GSI) software. The specific issues of supersaturation and small negative moisture values in the GSI must also be addressed before the water vapor radiances can be effectively used in NCEP operations.

We propose to continue investigating various assimilation techniques for infrared (IR) water vapor channels with the NCEP's Global Data Assimilation System / Global Forecast System (GDAS/GFS). We will continue to work with NCEP personnel to identify and resolve outstanding water vapor assimilation issues. The focus of our work this year will be to reduce the number of negative moisture values generated within the GSI. We will start by identifying the causes of these negative values, then work with the appropriate people within NCEP and NESDIS toward resolving them.

Once the negative moisture values are reduced we will start investigating the impacts of using the AIRS and IASI water vapor channels which have impact in the troposphere. We will look at various criteria both internal and external to the GSI. We will also be investigating two upgrades to the Community Radiative Transfer Model (CRTM). The internal criteria will consist of overall system convergence, contribution to the penalty the water vapor channels make, channel bias and standard deviation. Criteria evaluated which are external to the GSI will consist of negative and supersaturated points, total precipitable water, relative humidity and impact on precipitation. Finally, we will work closely with NCEP personnel to help facilitate moving these new techniques into operations.

Summary of Accomplishments and Findings

Various instability problems have appeared during the spinup and tests of the water vapor assimilation. These problems were resolved when they appeared. Adjustments for negative moisture values and supersaturation were necessary. It has been decided that extending the length of the experiments is necessary to ensure all of the instability and various other problems have been resolved before transitioning to NCEP operations. Consequently, we will be conducting a four season experiment (continuous cycle for one year) rather than the normal two extreme seasons.

The first and second season of our water vapor assimilation experiment is complete. Several water vapor analysis and forecast improvements have been identified both in the stratosphere and troposphere. In assimilating the water vapor radiances from AIRS and IASI which have sensitivities in the stratosphere, a reasonable estimation of the specific humidity in the stratosphere can be generated as shown in Figure 6.1. An unexpected benefit of the stratospheric humidity is a reduction in the stratospheric temperature drift. Figure 6.2 is the GFS model comparison to rawinsonde temperatures in the stratosphere. In the control, Figure 6.2a, the temperature drift with time is observed in the bias. When the water vapor is assimilated in the stratosphere the temperature drift in the bias is greatly reduced (Figure 6.2b). The reduction in the temperature drift comes from the model radiation scheme having more reasonable moisture values to compute its heating and cooling rates.

Figure 6.3 is the GFS model comparison to rawinsonde water vapor in the troposphere. Figure 6.3 suggests significant improvement of the RMS both in the analysis and first guess of the experiment. This figure (6.3) shows both the bias (left) and RMS (right) comparison to rawinsondes. The solid lines are the control, the dotted lines are the experiment. The prediction skill for water vapor is typically very short for the GFS and is usually less than 6 hours. This is confirmed in Figure 6.4a, where the 6 hour forecast already has roughly the same RMS error (comparison with rawinsondes) as the 12, 24, 36 and 48 hour forecast. The new water vapor assimilation technique has improved the skill to almost 12 hours as shown in Figure 6.4b where the RMS errors are much less at 6 hours than at 12, 24, 36, and 48. These trends continue through the second season and are expected to continue through the entire experiment.

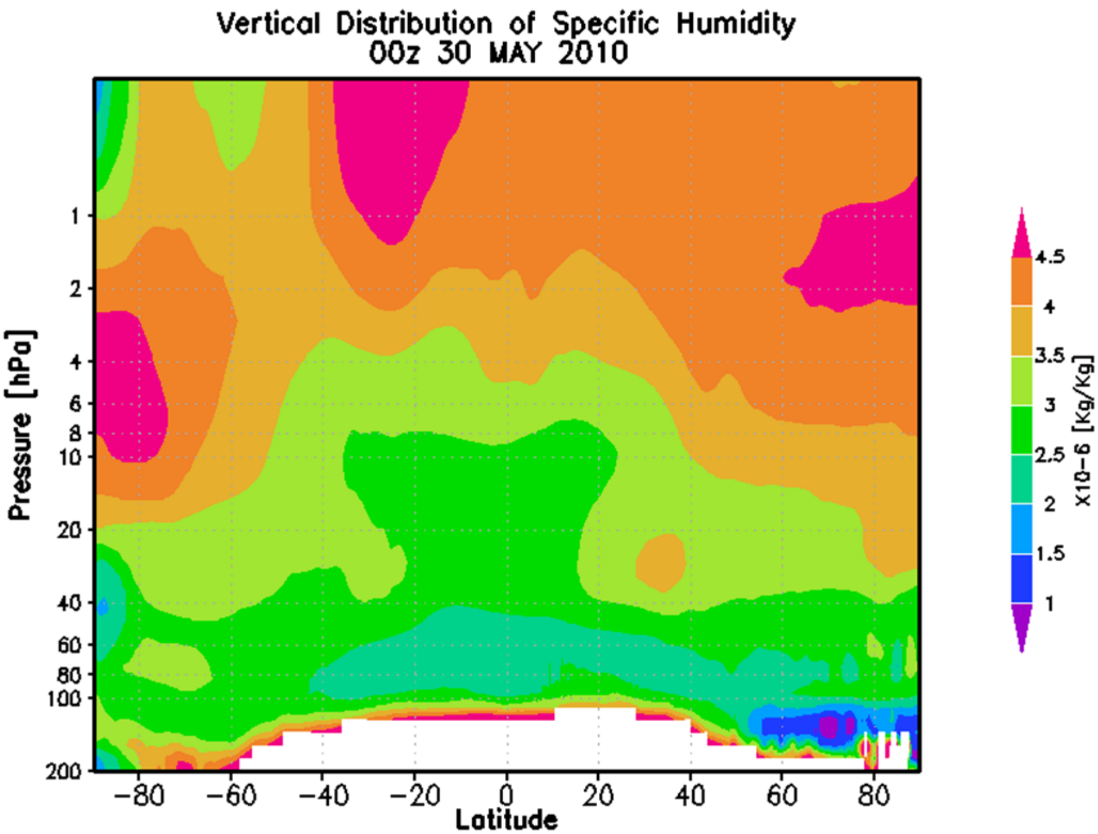


Figure 6.1. Vertical distribution of specific humidity generated from assimilating AIRS and IASI water vapor radiances which have stratospheric information.

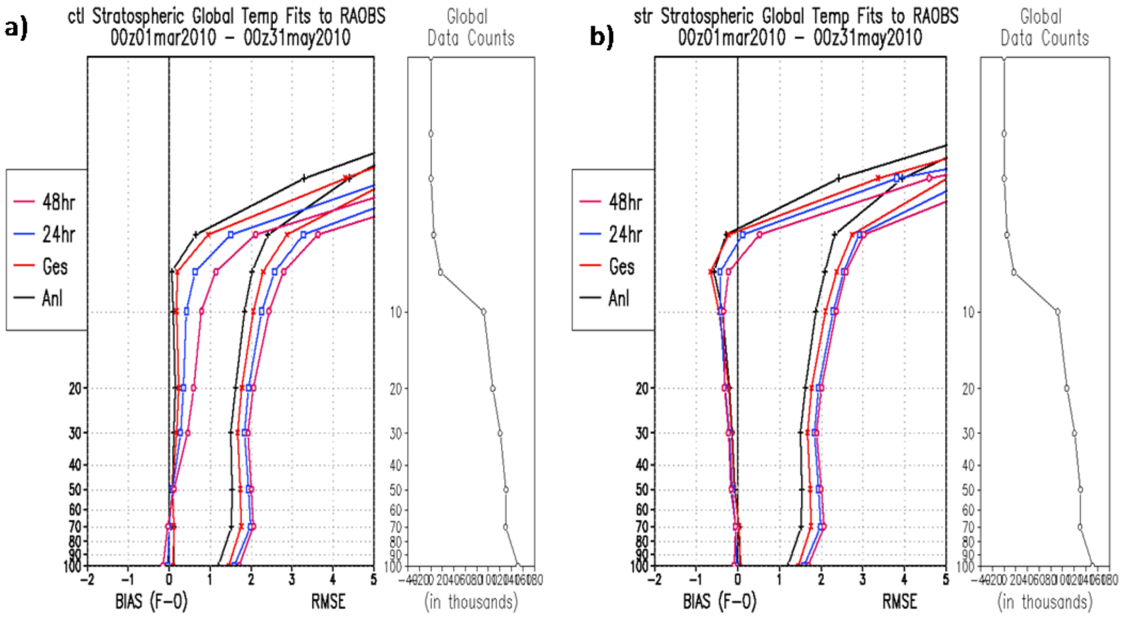


Figure 6.2. GFS model stratospheric temperature comparison to rawinsondes out to 48 hours for a) control and b) experiment for March-April-May 2010. Note the temperature drift in the bias with time from 50 to 10 hPa in the control (a) which is absent in the experiment (b)

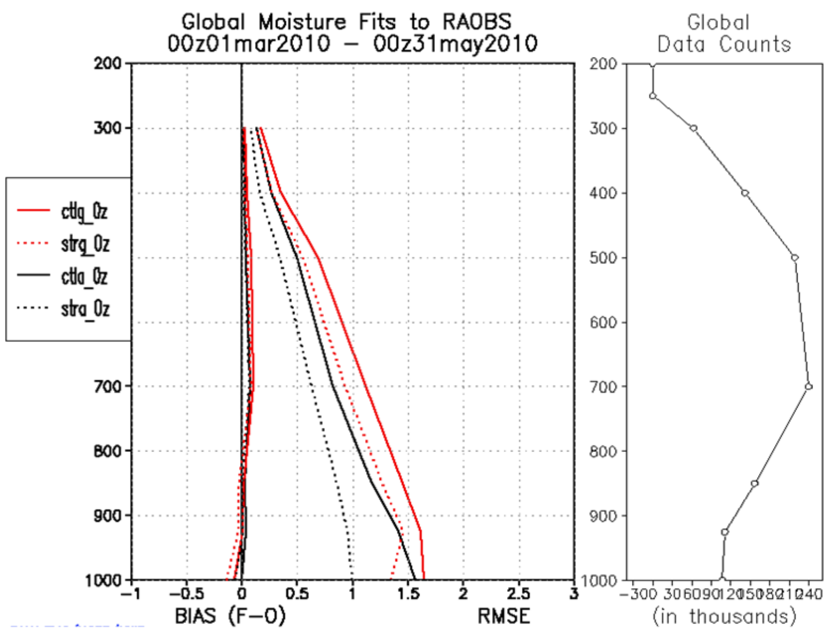


Figure 6.3. GFS model water vapor comparison to rawinsondes for March-April-May 2010. The solid lines are the control, the dotted lines are the experiment. Red is the first guess or 6 hour forecast, the black is the analysis. Note the experiment improvement in the analysis and first guess over the control.

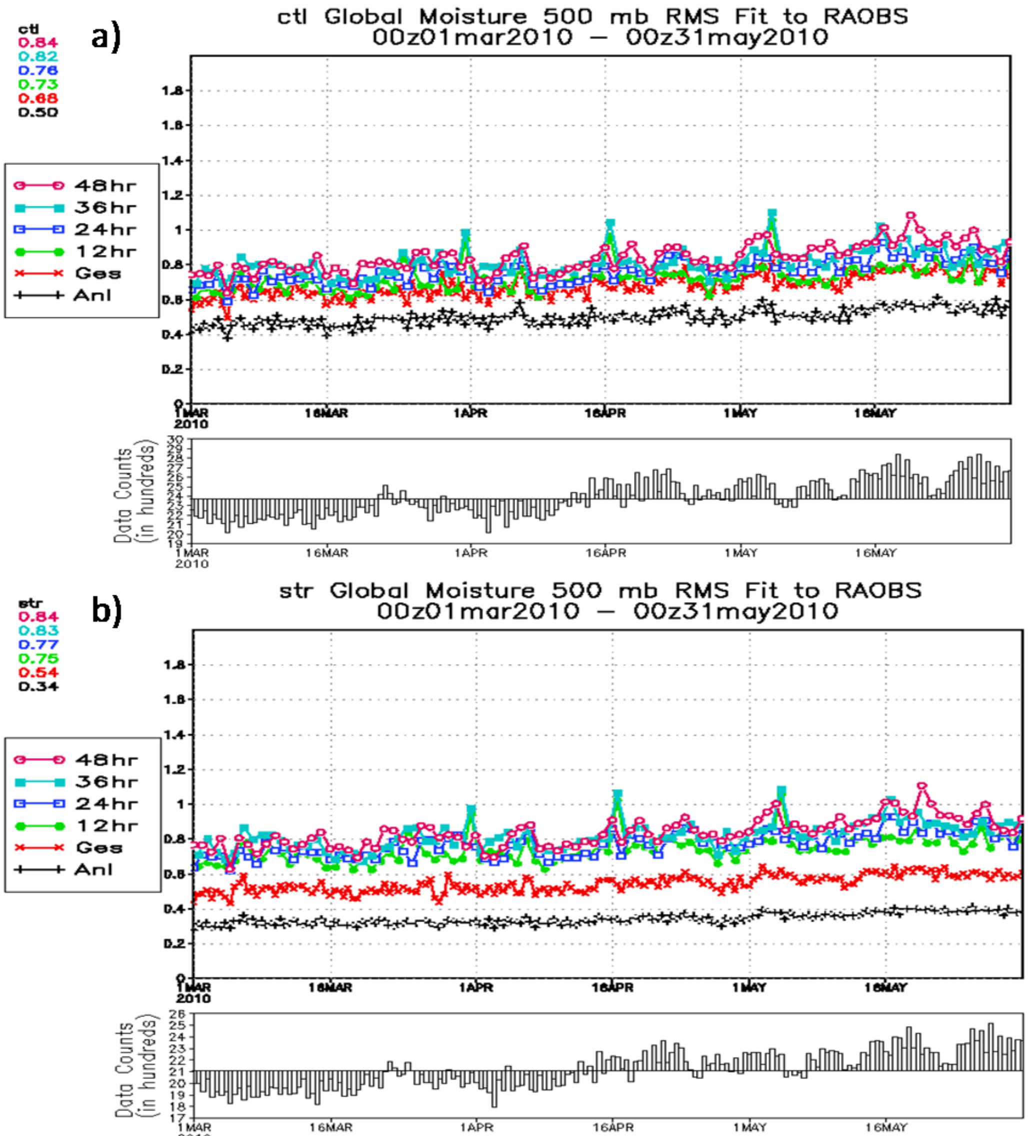


Figure 6.4. Time series of GFS model water vapor RMS compared to rawinsondes at 500 hPa for March-April-May 1010. a) is the control, b) is the water vapor assimilation experiment. Note the improvements in RMS of the analysis (black) and first guess (red) in the experiment.

Publications and Conference Reports

Bi, L., J. A. Jung, M. C. Morgan, and J. F. Le Marshall, 2010: ASCAT Surface Wind Retrievals Impacts Study in the NCEP Global Data Assimilation System. *Accepted in Mon. Wea. Rev.*

Jung, J. A., L. P. Riishojgaard, and J. F. Le Marshall, 2010: Impacts of Assimilating Hyperspectral Infrared Water Vapor Channels in Numerical Weather Prediction. *17th Conference on Satellite Meteorology and Oceanography*, Annapolis Maryland, 27 Sept – 1 Oct 2010.

Le Marshall, J. F., W. Smith, D. K. Zhou and J. A. Jung, 2010: Improved Use of Ultraspectral Observations in Numerical Weather Prediction. *Submitted to Bull. Am. Meteorol. Soc.*

7. Implementation of GOES and OMI Total Column Ozone Assimilation within NAM-CMAQ to Improve Operational Air Quality Forecasting Capabilities

CIMSS Task Leader: Steven A. Ackerman
CIMSS Support Scientist: Allen Lenzen
NOAA Collaborator: R. Bradley Pierce
NOAA Strategic Plan-Mission Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Environmental Models and Data Assimilation

Proposed Work

This project utilizes the NCEP Gridpoint Statistical Interpolation (GSI) system (Wu et al., 2002) implemented into a developmental version of the North American Meso-scale (NAM) Community Multi-scale Air Quality (CMAQ) Modeling System (NAM-CMAQ) to test capabilities to assimilate GOES sounder and OMI Total Column Ozone (TCO) data. NAM-CMAQ is used for operational National Air Quality Forecast Guidance at the National Center for Environmental Prediction (NCEP) Environmental Modeling Center (EMC). Data denial studies will be conducted to determine the impact of GOES, OMI and GOES+OMI TCO on regional ozone analyses via comparison with IONS ozonesonde measurements (Thompson et al., 2008). Upon completion of the first year tasks, the NAM-CMAQ/GSI GOES and OMI regional TCO assimilation capability will be delivered to developers at the Air Resources Laboratory (ARL) for forecast impact assessments. Results of the ARL assessments will provide guidance for operational implementation at EMC. We will work closely with the National Air Quality Forecasting Capability (NAQFC) team to improve the GOES TCO assimilation capability and determine if GOES TCO assimilation results in improved air quality forecasts.

Summary of Accomplishments and Findings

FY10 tasks under this activity included: 1) development of GOES TCO bias correction, 2) conducting NAM-CMAQ/GSI TCO data denial studies, 3) generation of tropospheric background error covariance statistics, and 4) delivery to ARL for pre-operational testing.

Accomplishments

- Tools for collocation of GOES and OMI TCO measurements and bias corrections for GOES East and West TCO retrievals during May-June, 2010 were developed.
- Baseline (no TCO assimilation) NAM-CMAQ simulations for May 17-June 30 with operational fixed and experimental time dependent lateral boundary conditions were conducted and evaluated using ozonesonde measurements.
- Updates to include combined GFS stratospheric and NAM-CMAQ tropospheric background ozone predictions in GSI TCO assimilation capabilities were developed.
- Scripts for 6hr cycling of NAM-CMAQ forecasts and GSI analysis for GOES TCO assimilation have been developed and tested on NCEP vapor computer.

- A series of NAM-CMAQ/GSI GOES TCO cycling experiments have been completed for the period from May 20th to June 30th, 2010.
- Code to compute background error covariance statistics from NAM-CMAQ output using NCEP NMC method has been developed and cycling experiments using merged NAM-CMAQ/GFS background error covariances are underway.

Findings

Comparisons with OMI TCO during the May-June 2010 study period show that the current operational GOES-11 (West) and GOES-13 (East) Single Field of View TCO retrievals have systematic biases of 9.66 and -4.53 Dobson Units (DU) respectively. These biases could be up to 50% of the partial ozone column in the NAM-CMAQ domain and require correction prior to assimilation. The large GOES TCO biases arise due to the use of outdated bias correction tables, which are based on comparisons between GOES-8 and Total Ozone Mapping Spectrometer (TOMS), in the current operational algorithms. Updated bias correction tables have been generated using collocated OMI and GOES-11 and GOES-13 TCO retrievals during the study period and have been applied to the operational GOES TCO retrievals prior to assimilation. The updated bias correction reduces the GOES-11 and GOES-13 biases relative to OMI to 0.31 and -0.25 DU, respectively.

NAM-CMAQ/GSI data assimilation experiments where conducted during May-June 2010 using an experimental version of NAM-CMAQ with updated Carbon Bond 5 (CB05) chemistry. May-June 2010 was chosen due to the availability of enhanced ozonesonde launches during the NOAA CalNex field mission The NAM-CMAQ/GSI GOES TCO cycling experiments used operational fixed and experimental time dependent Lateral Boundary Conditions (LBC). Time dependent LBC were based on forecasts from the Real-time Air Quality Modeling System (Pierce et al., 2007). Bias corrected GOES-11 and GOES-13 TCO data were assimilated at 6 hour intervals from May 17th through June 30th, 2010. GFS 6 hour ozone forecasts were used to specify ozone profiles above the NAM-CMAQ model domain which only extends up to100hPa.

Figure (7.1) shows results of the GOES TCO assimilation experiments for both fixed and RAQMS LBC at 06Z on June 18, 2010. Both experiments show similar TCO analyses which are in very good agreement with the GOES observations (r^2=0.94). However, scatter plots of the first guess and GOES TCO observations shows that the experiment with RAQMS LBC is able to retain more information from previous GOES TCO assimilation cycles than the experiment with fixed LBC. The RAQMS LBC first guess accounts for 75% of the observed variance (r^2=0.75) and has relatively small mean biases (5.65 DU) while the fixed LBC first guess accounts for only 22% of the observed variance (r^2=0.22) and has larger mean biases (17.21 DU).

Validation with respect to CalNex ozonesondes has been used to understand the differences between the RAQMS and fixed LBC experiments. The fixed LBC experiment has a large low bias (up to a factor of 4) in ozone mixing ratio between 300 and 100hPa relative to CalNex ozonesonde measurements resulting in significant underestimates in the first guess TCO (up to 100DU). The RAQMS LBC improves the representation of upper tropospheric/lower stratospheric ozone and reduces the biases relative to CalNex ozonesonde measurements resulting in improved first guess TCO. The magnitude of GSI analysis increments are determined by observation minus first guess (O-F) and the relative magnitude of the observation and background errors. The background errors are larger for higher ozone mixing ratios. Upper tropospheric and lower stratospheric mixing ratios are low in the fixed LBC, consequently, the largest adjustments occur above 100mb (outside the NAM-CMAQ domain) and do not influence the NAM-CMAQ ozone profile. The higher upper tropospheric/lower stratospheric ozone mixing ratios in the RAQMS LBC experiment lead to more adjustments occurring within the NAM-CMAQ domain during the analysis cycle and more information from the GOES TCO assimilation is retained. O-F statistics also show that the RAQMS LBC experiment has a more Gaussian error distribution, which also improves the analysis.

We have also assessed the impacts of using GFS instead of NAM-CMAQ ozone forecasts for the first guess ozone profile in the upper troposphere/lower stratosphere. This modification has been shown to improve the retention of the GOES TCO information within the NAM-CMAQ domain in the fixed LBC experiments and results in the best agreement with respect to IONS ozonesonde. Assimilation experiments are currently underway that use more realistic horizontal and vertical length scales based on blending background error statistics computed from the NAM-CMAQ RAQMS LBC baseline experiments and GFS background error statistics used in the GDAS ozone assimilation.

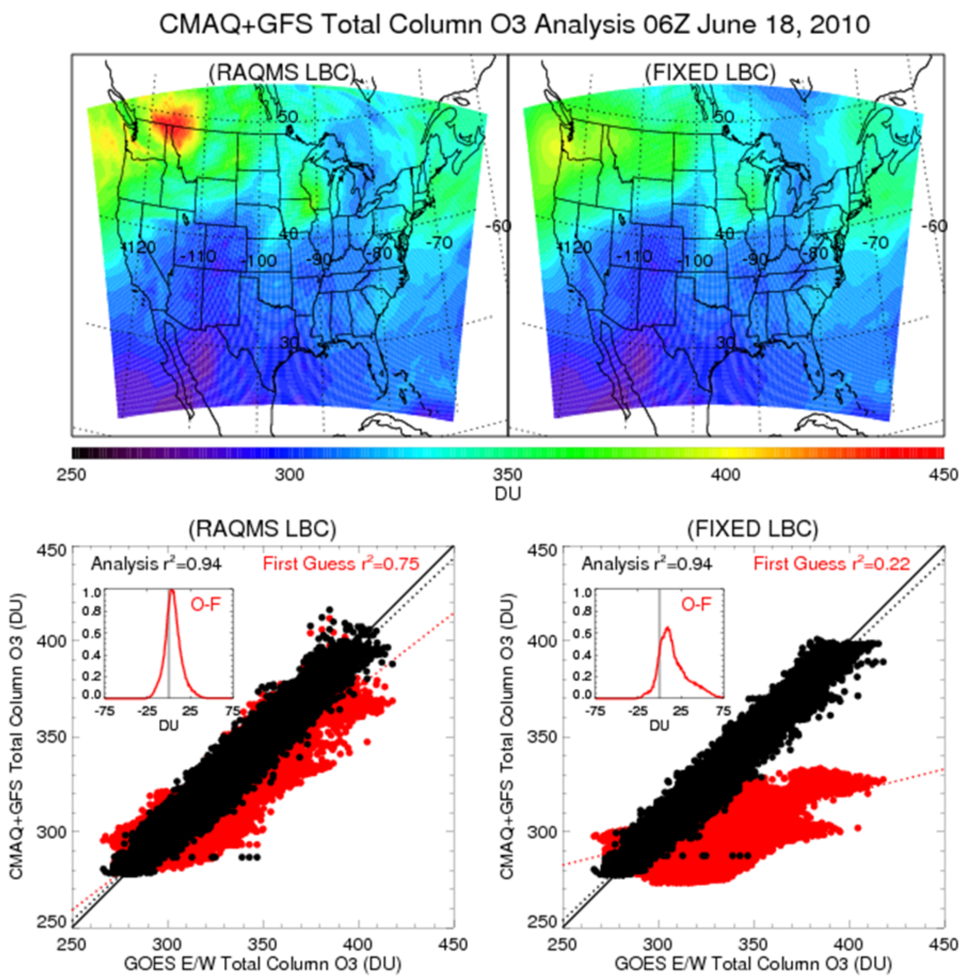


Figure 7.1. CMAQ+GFS Total Column Ozone (TCO) analyses (DU) at 06Z on June 18th, 2010 during data assimilation experiments assessing the impact of GOES East and West Single Field of View TCO retrievals on CMAQ ozone analysis (upper panel). Results are shown for two experiments, one using Lateral Boundary Conditions (LBC) from the Real-time Air Quality Modeling System (RAQMS) and one using fixed LBC. The lower panels show scatter plots of CMAQ+GFS TCO analysis (black) and first guess (red) verses GOES TCO for experiments using RAQMS (left) and fixed (right) LBCs. The distribution of observation-first guess (O-F) is shown in the upper left corner of the scatter plots.

Publications and Conference Reports

Pierce, R. B., A. Lenzen, and T. Schaack (2011), GOES Total Column Ozone Assimilation within the Community Multi-scale Air Quality Forecast Model, Science Update, Joint Center for Satellite Data Assimilation Quarterly Newsletter, No. 34, March 2011, available online at http://www.jcsda.noaa.gov/documents/newsletters/201103JCSDAQuarterly.pdf

References

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.

Thompson, A. M., J. E. Yorks, S. K. Miller, J. C. Witte, K. M. Dougherty, G. A. Morris, D. Baumgardner, L. Ladino, and B. Rappenglueck (2008), Tropospheric ozone sources and wave activity over Mexico City and Houston during Milagro/Intercontinental Transport Experiment (INTEX-B) Ozonesonde Network Study, 2006 (IONS-06), Atmos. Chem. Phys., 8, 5113–5126.

Wu, W.-S., R. J. Purser, and D. F. Parrish, 2002: Three-dimensional variational analysis with spatially inhomogeneous covariances, *Mon. Wea. Rev*., **130**, 2905-2916.

8. CIMSS Participation in the Utility of GOES-R Instruments for Hurricane Data Assimilation and Forecasting

CIMSS Task Leader: Jun Li
CIMSS Support Scientist: Jinlong Li
NOAA Collaborator: Sid Boukabara
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Environmental Models and Data Assimilation

Proposed Work

This task is a collaborative proposal with the Cooperative Institute for Research in the Atmosphere (CIRA) at the Colorado State University entitled "Utility of GOES-R instruments for hurricane data assimilation and forecasting" with PI Milija Zupanski. CIMSS at the UW-Madison will develop a full spatial resolution advanced sounding dataset from the Atmospheric InfraRed Sounder (AIRS) and Infrared Atmospheric Sounding Interferometer (IASI) to emulate the future geostationary sounding system in terms of its spectral and spatial characteristics, and demonstrate the advantage of a combined GOES-R imaging and sounding system on hurricane data assimilation and forecasting. CIMSS scientists will collaborate with CIRA scientists to examine the utility of the GOES-R ABI and GLM, and of the advanced IR sounder, for hurricane data assimilation and prediction, using ensemble data assimilation with the NCEP operational Hurricane WRF (HWRF) modeling system.

Summary of Accomplishments and Findings

Develop the Full Spatial Resolution Advanced Infrared Soundings for Hurricane Assimilation Experiments

The wealth of information available with launching the next-generation series of Geostationary Operational Environmental Satellites, starting with the GOES-R mission, offers the opportunity to use multi-channel multi-instrument data in new ways. One of the new instruments on the GOES-R satellite is the Advanced Baseline Imager (ABI). The ABI is a 16-channel imaging radiometer that will sample nine infrared (IR) wavelengths, and have a footprint about 75 % smaller than current GOES. The ABI will observe water vapor and clouds with the potential for improvement in the analysis of these fields and their forecast. However, without an advanced IR sounder on the GOES-R series, the vertical resolution of water vapor measurements from ABI is very limited. The advanced IR sounders onboard the polar-orbiting satellites will bring additional information related to high vertical resolution of temperature and moisture profiles along with cloud microphysical properties. Assimilation of measurements from the GOES-R ABI and JPSS (Joint Polar-orbiting Satellite System) advanced IR sounder will help in improving the assessment of water vapor, clouds, and storms. The combined impact of these observations via data assimilation can be especially beneficial for the prediction of tropical storms. This CIMSS/CIRA collaborative proposal seeks to answer the following important question: what is the impact on hurricane forecasts if we combine GOES-R ABI and advanced IR sounding products? With full spatial resolution advanced IR soundings from the Atmospheric InfraRed Sounder (AIRS) onboard the NASA Earth Observing System (EOS) Aqua platform, the Infrared Atmospheric Sounding Interferometer (IASI) onboard the EUMETSAT Metop-A satellite, and in the future the Cross-track Interferometer Sounder (CrIS) onboard the NOAA JPSS series included in the assimilation system, the unique value of high spatial and high vertical resolution aspects of advanced IR soundings can be demonstrated.

From 01 June to 31 March 2011, CIMSS scientists have collaborated with CIRA scientists on identifying typical tropical cyclone cases for this study; Hurricane Fred from 2009 was selected for assimilation experiments. The Meteosat Second Generation (MSG) SEVIRI which covers Europe and the Eastern and Central Atlantic is used as a proxy for GOES-R ABI data. The time period for this experiment is from 00 Z on 05 September 2009 to 00 Z on 14 September 2009, which covers a good spin-up of the system. We have processed the AIRS data for this time period; AIRS sub-pixel cloud detection was performed using the collocated MODIS 1 km spatial resolution cloud mask products (Li et al., 2004, Journal of Applied Meteorology). The AIRS full spatial resolution or single field-of-view atmospheric temperature and moisture profiles are derived using a variational methodology (Li et al., 2000), and the atmospheric temperature and moisture profiles are retrieved with an iterative approach.

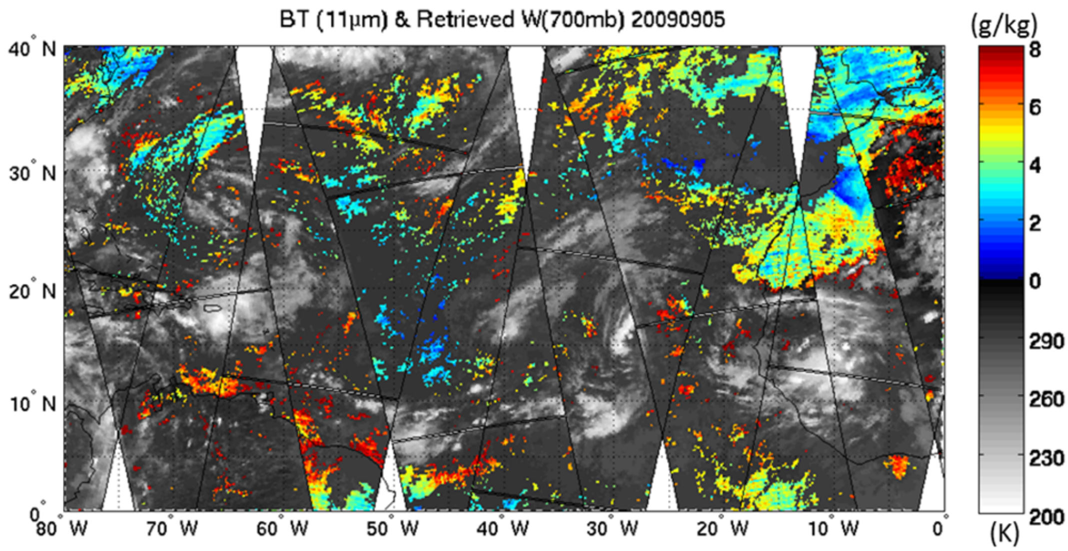


Figure 8.1. The 700 hPa water vapor mixing ratio retrievals (color) in clear skies from AIRS overlaying on an AIRS 11 µm channel brightness temperature (black/white) for 05 September 2009.

Figure 8.1 shows the 700 hPa water vapor mixing ratio retrievals in clear skies (color) from AIRS overlaying AIRS 11 µm channel brightness temperatures (black/white) for 05 September 2009. Each pixel in the color region presents an atmospheric sounding. There are fluent soundings retrieved in the pre-convection environment, all the soundings in other days are also processed, and the full spatial resolution temperature and moisture profiles derived from AIRS have been provided to CIRA collaborator Milija Zupanski for assimilation experiments. The retrievals are processed clear skies in the first stage and will be expanded to cloudy skies later.

Assimilating AIRS Single Field-of-view (SFOV) Soundings in WRF/3VAR Assimilation and Forecast System

The CIMSS sounding team has also implemented the WRF/3DVAR for assimilation studies. Hurricane Ike (2008) is used for assimilation experiments, and AIRS SFOV soundings are used in the WRF/3DVAR assimilation and forecast system. Three AIRS granules (g066/067/068) at 06 UTC on 06 September 2008 are used in the WRF/3DVAR experiment. The control (CTRL) run uses the NCEP 6-hour final operational global analysis (1.0 x 1.0 degree grids; http://dss.ucar.edu/datasets/ds083.2/), including radiosondes, satellite winds, pilot report, GPS, ship, profiler, surface observations etc., starting at 06 UTC on 06 September 2008; the AIRS (Control + AIRS) run uses the SFOV soundings in clear skies from three AIRS granules, but only assimilates 13 levels of AIRS temperature profiles between 500 and 800 hPa in the first experiment, results show that the AIRS SFOV temperature soundings improve the 48-hour track forecasts, which is consistent with that from the WRF/DART assimilation and forecast system (Li and Liu 2009; Liu and Li 2010). Figure 8.2 show the 48-hour track forecasts from the control (CTRL) and AIRS runs, along with track observations. The forecasts start 06 UTC on 06 September 2008.

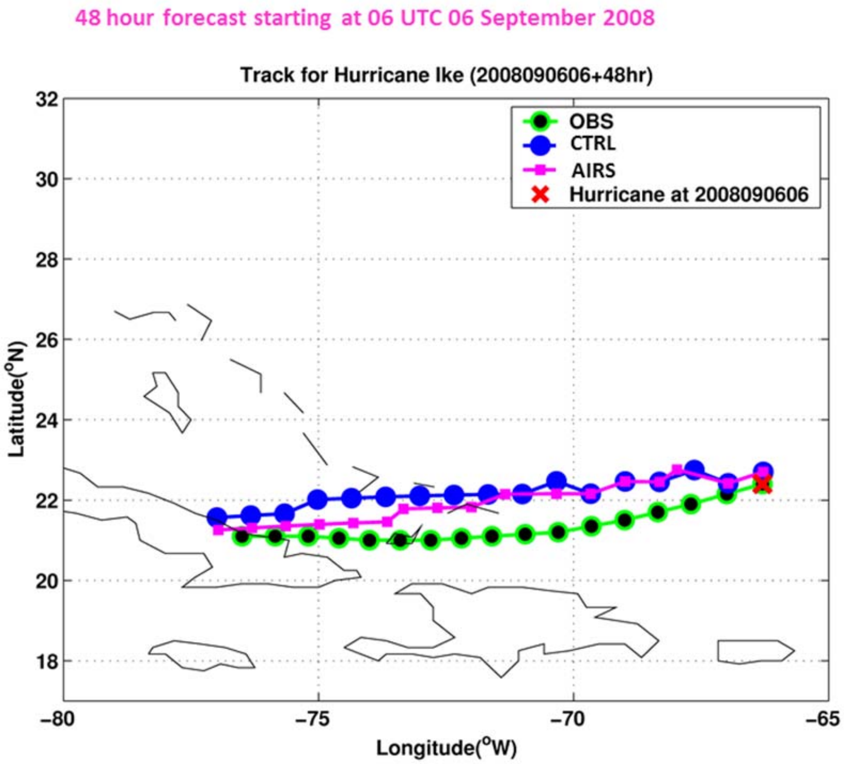


Figure 8.2. The 48-hour track forecasts from control (CTRL) and AIRS runs, along with track observations.

Publications and Conference Reports

Li, Jun, 2011: High impact weather nowcasting and short-range forecasting with advanced IR soundings, Presentation at the High Impact Weather Working Group Kick-off Workshop, 24 February 2011, Norman, OK.

References

Li, J., H. Liu, 2009: Improved Hurricane Track and Intensity Forecast Using Single Field-of-View Advanced IR Sounding Measurements. *Geophysical Research Letters*, **36**, L11813, doi:10.1029/2009GL038285.

Liu, H., and J. Li, 2010: An improved in forecasting rapid intensification of Typhoon Sinlaku (2008) using clear-sky full spatial resolution advanced IR soundings. *J. Appl. Meteorol. and Cli.*, **49**, 821 - 827.

9. Support for NOAA Cloud Climate Data Records

CIMSS Task Leader: Michael Foster
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

The Pathfinder Atmospheres Extended (PATMOS-x) is a NOAA/NESDIS climate dataset generated in partnership with CIMSS. Until recently, PATMOS-x dealt exclusively with data from the Advanced Very High Resolution Radiometer (AVHRR) with instruments on the POES and METOP series of polar orbiting spacecraft. PATMOS-x has been modified to generate products from MODIS, GOES and the VIIRS sensor.

In 2010, PATMOS-x was selected as one of the first three Climate Data Records (CDR) to become operational CDRs at the National Climatic Data Center (NCDC). The version of PATMOS-x chosen for this delivery was the AVHRR-only version. NCDC's main goal was to host the PATMOS-x solar reflectance sensor data records (SDRs), which included the 0.63, 0.86 and 1.63 µm reflectances. The deadline for the initial operational CDRs was the end of the 3rd quarter, or 1 October 2010, so this report is covering objectives met between 1 July and 1 October 2010 .The work this proposal is centered on is conducting the required dataset generation, documentation and delivery.

Summary of Accomplishments and Findings

During this reporting year, the milestones necessary to transition the PATMOS-x reflectance SDRs to operational CDRs at NCDC are as follows:

- Generate PATMOS-x SDRs using AVHRR measurements with a spatial resolution of 0.1° (11 km) spanning 1978 to 2009.
- Verify the integrity of the dataset, identifying corrupt/missing files, and format naming conventions and metadata to NCDC specifications.
- Document all code thoroughly and generate a processing flow chart with run instructions.
- Deliver compressed SDRs with checksums along with source code to NCDC for archival and distribution as operational CDRs.

This project was a collaborative effort with NCDC. Each of these milestones was met, and these data are available as an operational CDR from NCDC's site (http://www.ncdc.noaa.gov/sds/operationalcdrs.html). The SDR generation component was accomplished using the Atmospheric Product Evaluation And Test Element (PEATE) processing system at CIMSS. The AVHRR instrument records processed included those flown on TIROS-N, NOAA-7, -9, -11, -12, -14, -15, -16, -18, -19 and MetOp-A. Figure 9.1 shows an example false-color image of the three channels used to generate the SDRs.

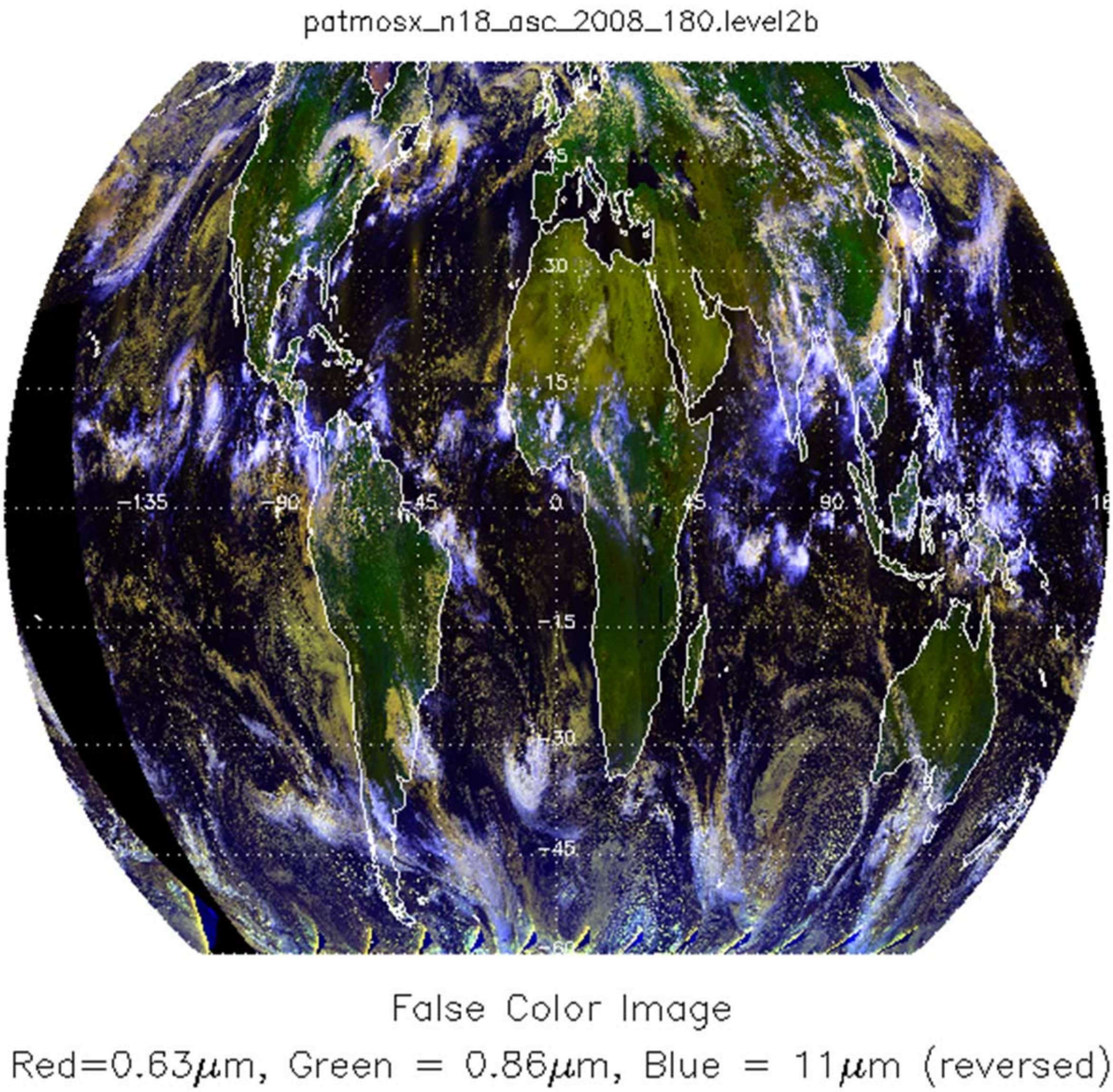


Figure 9.1. An example image of PATMOS-x SDR values displayed as a false color image. The resolution of the PATMOS-x level-2b data is 0.1 degree in latitude and longitude. The NCDC delivery provided twice-daily data separated by orbital node for all AVHRR data from 1978 to 2009.

The files were formatted to NCDC specifications, and a processing flow chart and run instructions were created. Of the approximately ninety subroutines used in the processing of PATMOS-X data about half required additional commenting. Missing files due to data corruption were identified and the compressed SDRs and source code were delivered to NCDC with checksums. The data were received, archived and processed into operational CDRs by the NCDC 3rd quarter deadline, 1 October 2010.

Publications and Conference Reports

Heidinger, A. K., M. J. Foster and A. T. Evan 2011: A CALIPSO derived Naïve Bayesian Cloud Detection Scheme for the Pathfinder Atmospheres Extended (PATMOS-x) data set. *submitted to JAMC.*

References

Heidinger, Andrew K.; Straka, William C. III; Molling, Christine C.; Sullivan, Jerry T. and Wu, Xiangqian, 2010: Deriving an inter-sensor consistent calibration for the AVHRR solar reflectance data record. *International Journal of Remote Sensing*, **31**, Issue 24, pp.6493-6517.

10. A Product Development Team for Snow and Ice Climate Data Records

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

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications

Proposed Work

The availability, consistency and accuracy of cryosphere (snow and ice) products are critical for applications such as climate change detection, weather and climate modeling, shipping, and hazard mitigation. The development of cryosphere products can benefit greatly from contemporary advanced satellite remote sensing techniques along with the support provided by a coordinated group of data and applications experts. In collaboration with colleagues at NOAA/NESDIS, the University of Colorado, and NASA Goddard Space Flight Center, CIMSS is part of a Cryosphere Product Development Team that is providing such coordination for the generation, validation, and archival of fundamental and thematic snow and ice climate data records (FCDR and TCDR) that the scientific community can use to help answer the questions about a changing global climate. We are coordinating existing and new products, establishing "best practices," and updating heritage products to allow NOAA to continue with their production and dissemination. The CIMSS focus is on the cryosphere products that can be derived from optical (visible, near-IR, and thermal IR) imagers. FCDRs are being created where necessary and used in the production of TCDRs.

Summary of Accomplishments and Findings

This project started in July 2009. This report covers the period from 1 July 2010 to 31 March 2011. During this period, the primary accomplishments were to inventory existing algorithms and models, collect data from 2004 to 2010 (beyond the previous coverage of 1982-2004) and begin pre-processing, revise and add new algorithms to our retrieval software suite (CASPR), especially for consistent cloud detection, inter-satellite calibration, and ice characteristics. The eXtended AVHRR Polar Pathfinder (APP-x) products have been updated over the period 1982~2004, validation efforts have provided quantitative error assessments, and the extension and update of APP-x products beyond 2004 is underway. In APP-x processing, the NCEP Reanalysis product has been replaced with atmospheric profile data from the Modern Era Retrospective-analysis for Research and Applications (MERRA), and surface type data from Special Sensor Microwave/Imager (SSM/I) are now employed.

The APP-x products currently include climate information about clouds, surface temperature and albedo, solar and thermal radiation, and sea ice. Figure 10.1 illustrates some of these products. The APP-x suite has been used to generate climatologies of cloud, surface temperature, ice thickness, and is being used to study the feedbacks between processes in the Arctic climate system. A number of papers have been published on the use of the APP-x snow and ice CDR products for climate studies. The major findings are:

- APP-x data have been used to drive a thermodynamic model for estimating sea and lake ice thickness, creating a new climatology of Arctic sea ice thickness.
- Changes in sea ice concentration and cloud cover played major roles in the magnitude of recent Arctic surface temperature trends. Significant surface warming associated with sea ice loss accounts for most of the observed warming trend. In winter, cloud cover trends explain most of the surface temperature cooling in the central Arctic Ocean.
- The APP-x product was used in a study of controls on snow albedo feedback (SAF), which is important for assessing the validity of feedbacks in global climate models.

There have been numerous updates to our core APP-x algorithm code, including the addition of ice concentration and thickness/age algorithms, sun glint to improve cloud detection, and surface type change tracking. Based on our experience in producing long-term geophysical fields from satellite data, we plan to extend current APP-x products to the JPSS VIIRS era.

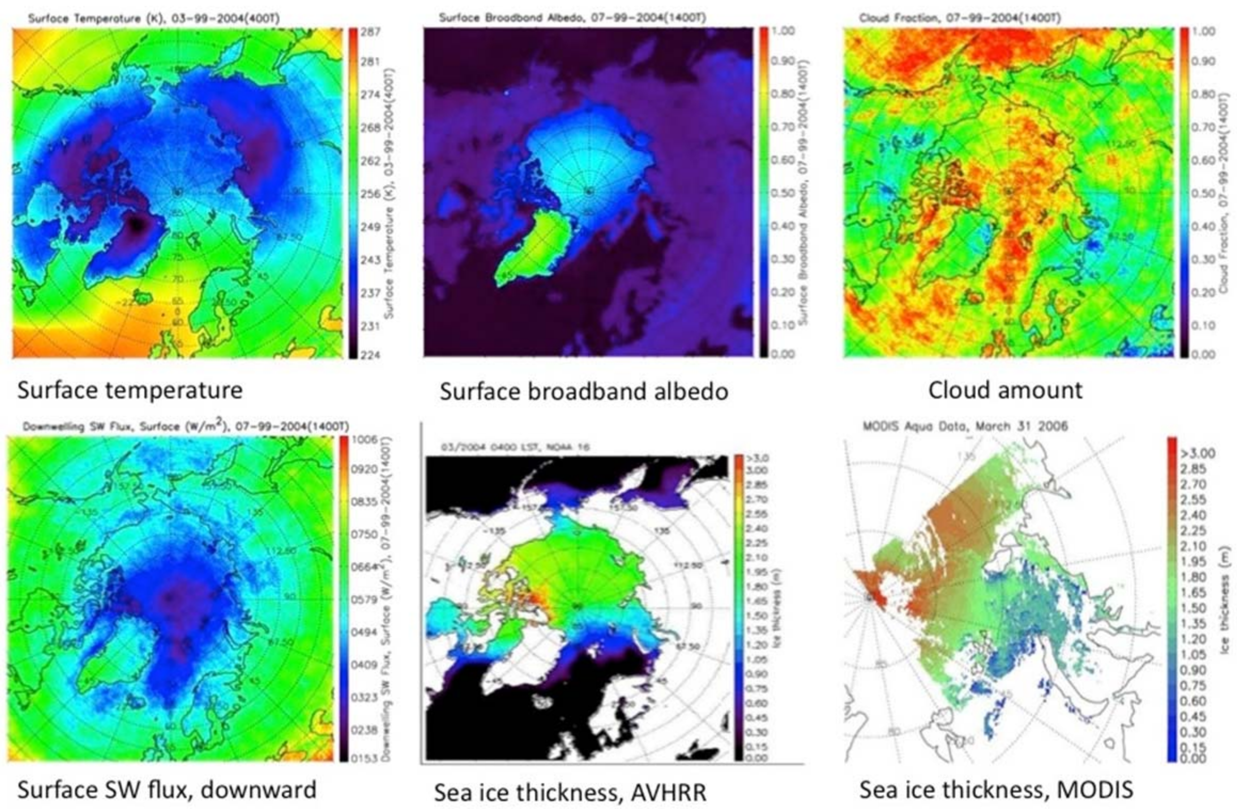


Figure 10.1. Examples of APP-x products. Clockwise from upper left: surface temperature, surface albedo, cloud fraction, sea ice thickness from MODIS, sea ice thickness from AVHRR, and surface downwelling shortwave flux.

Publications and Conference Reports

Wang, X., J. R. Key, and Y. Liu, 2010: A thermodynamic model for estimating sea and lake ice thickness with optical satellite data. *J. Geophys. Res.*, 115, C12035, 14 PP., 2010, doi:10.1029/2009JC005857.

Wang, X., J. R. Key, Y. Liu, 2010: Extended AVHRR Polar Pathfinder (APP-x) Products for Studying the Cryosphere During the Satellite Era, 2010 AGU Fall Meeting, 13-17 December 2010, San Francisco California, USA

Liu, Y., J. R. Key, and X. Wang, 2009: The influence of changes in sea ice concentration and cloud cover on recent Arctic surface temperature trends. *Geophys. Res. Lett.*, 36, L20710, doi:10.1029/2009GL040708.

Fernandes, R., H. Zhao, X. Wang, J. R. Key, X. Qu, and A. Hall, 2009: Controls on Northern Hemisphere snow albedo feedback quantified using satellite Earth observations. *Geophys. Res. Lett.*, 36, L21702, doi:10.1029/2009GL040057.

Wang, X., J. R. Key, Y. Liu, 2010: Changing Arctic Sea Ice, Its Trends and Impacts on Arctic Climate Change over 1982-2004, 17th Conference on Satellite Meteorology and Oceanography, American Meteorological Society Fall Meeting, 27 September -1 October 2010, Annapolis, MD, USA.

Wang, X., J. R. Key, Y. Liu, 2010: Changing Arctic Sea Ice and Its Trends over 1982-2004, STATE OF THE ARCTIC, 16-19 March 2010, at Hyatt Regency, Miami, Florida, USA.

Liu, Y., J. R. Key, X. Wang, 2009: On the Interactions of Arctic Sea Ice, Cloud Cover, and Surface Temperature from Satellite Observations, 2009 AGU Fall Meeting, 14-18 December 2009, San Francisco, California, USA.

11. Weather Information and Research Satellite Products on Mobile Devices

CIMSS Task Leader: David Santek
CIMSS Support Scientists: Russell Dengel, David Parker
NOAA Collaborator: Jeffrey Key
NOAA Strategic Goals

- Serve society's needs for weather and water

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Education and Outreach

Proposed Work

The Personal Advanced Weather (PAW) (Dengel2010a; Dengel2010b) is a free service provided to the general public by SSEC. It is intended to provide access for the mobile internet community to a suite of enhanced real-time weather products. While the product suite provides a traditional selection of atmospheric products, the underlying goal is to introduce recent and ongoing research in the field of remotely sensed atmospheric parameters. By presenting these advanced elements as blended products, we provide displays that present the community with a standard frame of reference while extending the content with collocated overlays of these newer fields.

The evolution and acceptance of mobile- and Web-based applications has resulted in a number of advanced processing services dedicated to creation, delivery, and interface for the image, field, and point datasets projected over geo-located displays. These tools provide a standard streamlined alternative to the manual approach developed for, and currently use by the PAW product production environment. Within these new server environments, large geo-located fields can be reprojected, co-located, and disseminated from a generic environment.

A new generation of the PAW product production facility based on geo-referenced map servers will provide a standard mechanism to research scientists to render and disseminate enhanced displays featuring leading-edge algorithms. This facility will eliminate rendering restrictions imposed by the current production engine, provide a standard environment for a wide variety of research formats and projections, and enhance the presentation for all levels of browser-based functionality.

To advance this goal, SSEC has created a prototype Web Map Service (WMS) environment. The facility is a technical development tool providing real-time product access and dissemination tuning. The distinguishing characteristic of the WMS is its modular construction. By using standards-based product generation (OGC-WMS 1.1.1 and KML)[1] and separating the products from their visualization, any number of clients can view the resulting products.

We propose to:

- Enhance the demonstration WMS to handle tiling, subsecting, and other image functions more efficiently and improve user control when displaying portions of large images. The current method (PAW) sectorizes large images into smaller regions at fixed boundaries. This approach negatively affects the user experience (e.g., panning and zooming is not seamless) and makes it difficult to include additional products; and
- Survey NOAA/NESDIS satellite products, especially those produced at CIMSS, and determine methods to effectively display these products through the WMS for use by the general public and specific groups, such as emergency managers.

Summary of Accomplishments and Findings

A WMS was installed on existing and upgraded hardware at SSEC. We are transitioning from the current PAW production environment to the WMS-based PAW. This transition has required adapting the process to take advantage of the WMS enhanced capability to build products and deliver to the user in real-time. Specifically, we have created new interfaces for desktop and mobile browsers, provided the user the ability to create custom displays, and added a mechanism to quickly upload new products.

Two Web-based product viewers have been created. The Simple interface (Figure 11.1) provides access to users with reduced/limited performance devices. This interface allows for product layering, zoom, roam and animation capabilities while being constrained by a minimal hardware and software configuration.

[1]Open Geospatial Consortium (OGC); Keyhole Markup Language (KML).

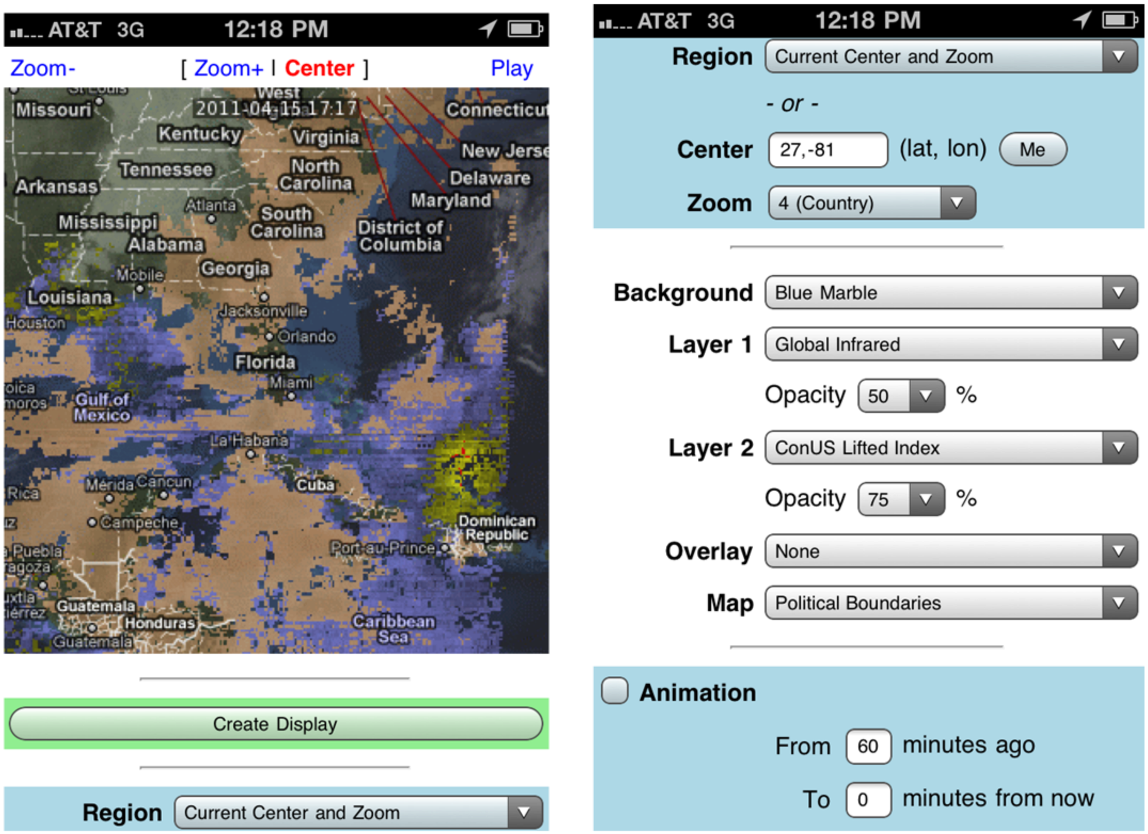


Figure 11.1. The Simple interface as it appears on an iPhone. The left panel is the view of the products; in this case the GOES infrared channel (gray) is blended with the GOES sounder-derived lifted index product (color shaded). The right panel contains the controls for the user to specify the products to overlay. On the mobile device, the user scrolls vertically between these two panels.

The Gmap interface is intended for users of moderate to high performance devices capable of supporting OGC compliant display engines such as Google Maps. Gmap provides users with increased functionality in terms of dynamic zoom/roam with greater product layering potential. While these Web interfaces deviate in terms of display capabilities, they both retain a common protocol and the ability to scale displays independent of the client device.

Support for scientists/authors wishing to introduce new data fields into the product suite is being addressed. A script that permits a data provider to directly transfer products to the WMS is currently being tested by local and remote providers. This utility uses anonymous ftp to transfer GeoTIFF and McIDAS AREA files to the WMS ingest system. Files are examined and, if necessary, processed before being added to the WMS product suite. A utility to translate standard image enhancement tables between McIDAS and WMS environments was created for researchers to associate a color table with their product.

The product suite includes a comprehensive cross-section of traditional and advanced imagery, field (polygon) and point datasets. Imagery includes examples of both measured and derived parameters from satellite, radar, model and observed sources. These data are contributed by a number of organizations including both in-house (CIMSS, SSEC) and collaborating institutions (NSSL, NASA Langley, Wisconsin Department of Transportation (DOT)). Field and point data are rendered as tiled graphics overlays, or as interactive “clickable” objects (shapefiles).

Extensions to the standard WMS functionality include a comprehensive animation handler. Animation is a key function due to temporal variability of most atmospheric conditions. This variability is compounded by the generic layering capability provided by a standard WMS server. Users can create multi-layered displays, blending data types with varying sampling rates. The animation controller provides a standard mechanism to create a time ordered sequence of multi-layered parameters based on the sampling rate of one of the included fields. This master layer imposes the time interval around which all other layers are co-located. A set of tuning controls are included to allow the user to construct custom animation sequences.

The SSEC hardware configuration has been expanded to include three server class machines. The distribution of services provides a redundant operational configuration with a third machine devoted to product development, configuration testing and performance tuning. Server tuning and code optimization has resulted in improved rendering times resulting in an order of magnitude increase in performance. Pre-generated tiles eliminate request latency for updated products.

SSEC is supporting an internal project which extends the WMS effort. Native apps for iPhone/iPad and Android platforms are being developed. These apps draw upon resources available on current generation of smartphone and tablet devices. Spatial awareness (GPS), expanded access to the internet and access to the native controls/interface provide increased functionality over the above mentioned Web-based counterparts. While these device specific interfaces provide access to the same WMS product suite they permit users to access and present these data as self-centric displays.

Publications and Conference Reports

Santek, D., R. Dengel, D. Parker, S. Batzli, N. Bearson, and W. Feltz, 2010: Access to real-time weather satellite products from desktops and mobile devices through a Web Map Service. 17th Conference on Satellite Meteorology and Oceanography. Annapolis, MD, September 2010. American Meteorological Society.

Dengel, R., D. Santek, D. Parker, S. Batzli, and N. Bearson, 2011: Mobile Device Access to Real-time Weather Products using a Web Map Service. 27th Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology. Seattle, WA, January 2011. American Meteorological Society.

Santek, D., R. Dengel, D. Parker, S. Batzli, N. Bearson, W. Feltz, L. Cronce, J. Sieglaff, J. Brunner, and K. Bedka., 2011: Satellite Based Nowcasting and Aviation Applications for Mobile Devices. 27th Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology. Seattle, WA, January 2011. American Meteorological Society.

Santek, D., R. Dengel, D. Parker, S. Batzli, N. Bearson, 2011: A Web Map Service for Display of Real-time Satellite Products. 2011 National Severe Weather Workshop. Norman, OK, March 2011.

References

Dengel, R., 2010a: Adapting satellite data for display on mobile devices. 26th Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology. Atlanta, GA, 18-21 January 2010. American Meteorological Society.

Dengel, R., 2010b: Creation and manipulation of meteorological products for mobile devices. 26th Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology. Atlanta, GA, 18-21 January 2010. American Meteorological Society.

12. Satellite Applications for Geoscience Education and Aviation

CIMSS Task Leader: Margaret Mooney
CIMSS Support Scientists: Tom Whittaker, Wayne Feltz, Justin Sieglaff
NOAA Collaborator: Nina Jackson
NOAA Strategic Goals

- Support the nation’s commerce with information for safe, efficient and environmentally sound transportation

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Education and Outreach

Proposed Work

This effort involves revision and updates to a Web-based resource developed to promote the use of satellite data in science classrooms called ***Satellite Applications for Geoscience Education (SAGE)*** http://cimss.ssec.wisc.edu/sage/. Originally funded by NSF in 2007, SAGE features lessons in remote sensing, climate, meteorology, oceanography and geology. Along with the revisions, CIMSS is developing a new aviation lesson and educational applet in collaboration with the SNAAP team (Satellite-based Nowcasting and Aviation Application). By combining SNAPP expertise on aviation hazards with CIMSS software expertise we are creating an aviation lesson that will be engaging, educational and fun.

Summary of Accomplishments and Findings

Course revisions and content for the new lesson are complete along with a new CD cover (see figure). The aviation applet is under development and nearing completion. 100 CDs will be shipped to NESDIS Education headquarters before Memorial Day weekend with a second batch scheduled to be sent to the Satellites Educators Conference in August 2011.

Figure 12.1. New SAGE CD cover design.

Conference Reports

Mooney, M., Ackerman, S., Jackson, N., and Whittaker, T., 2011: Infusing satellite data into earth science education with SAGE, ESIP and SNAAP. 91st Annual Meeting of the American Meteorological Society, 20th Symposium on Education, Seattle, WA, Jan 24th.

13. Distributing NOAA Climate Stewards Mini-Grants

CIMSS Task Leaders: Margaret Mooney, Steve Ackerman
CIMSS Support Scientists: Russ Dengel, Dave Parker and Dave Santek
NOAA Collaborators: Rusty Kapela, Bruce Moravchik, Peg Steffen and Nina Jackson
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Protect, restore and manage the use of coastal and ocean resources through an ecosystem approach to management
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Education and Outreach

Proposed Work

In support of NOAA's flagship class of Climate Stewards, CIMSS agreed to distribute mini-grants to certified stewards under the direction of the Climate Stewards Education Program (CSEP) leadership team. CSEP is a national network of formal and informal educators created to align with NOAA's education goals in their 2009-2029 Strategic Plan Once certified, Climate Stewards are eligible for a mini-grant to develop and execute action plans ranging from community projects, opportunities for service learning, classroom projects and curriculum infusion.

Summary of Accomplishments and Findings

Five mini-grants have been awarded to date. In addition, CIMSS EPO Manager, Margaret Mooney, is implementing a local climate steward's project in collaboration with NOAA's National Weather Service (NWS) to raise awareness of regional climate change through the Milwaukee-Sullivan (MKX) storm spotter program. Mooney, a former National Weather Service employee and current climate steward, is inviting storm spotters in southern Wisconsin to a Web seminar scheduled for May 10th presented by CIMSS director Steve Ackerman. The 1-hour Webinar will feature information from two recent reports: the 2009 U.S. Global Change Research Program and the Wisconsin Initiative on Climate Change Impacts (WICCI) 2011 assessment. Along with educating storm spotters on climate change topics, Mooney and Ackerman will encourage mitigation and stewardship activities while leveraging CIMSS/SSEC efforts to engage mobile phone users by demonstrating how to access real-time weather and climate data.

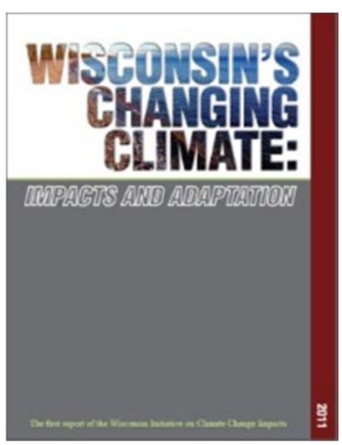


Figure 13.1. Cover of *Wisconsin's Changing Climate: Impacts and Adaptation,* February 2011.

14. Research Tasks in Support of the Integrated Program Office (IPO) JPSS Program

14.1 Cloud Property Determination, Sounding Studies, and Multi-spectral and Hyperspectral Visualizations

CIMSS Task Leaders: Eva Borbas, Tom Achtor
CIMSS Support Scientists: Tommy Jasmin, Jun Li, Youri Plokhenko, and Tom Rink
NOAA Collaborator: Heather Kilcoyne
NOAA Strategic Goals Addressed

- Serve society's need for weather and water

CIMSS Research Themes

- Weather
- Clouds
- Hydrological cycle
- Trends
- Climate
- Outreach

Proposed Work

Data and products from the Moderate resolution Imaging Spectroradiometer (MODIS) and the Atmospheric Infrared Sounder (AIRS) will continue to be used to explore Visible Infrared Imager Radiometer Suite (VIIRS) and Cross Track Infrared Sounder (CrIS) capabilities for producing the required Environmental Data Records (EDR). Visualization tools to interrogate the NPOESS multi-spectral data will continue using the HYDRA (HYperspectral viewer for Development of Research Applications). This work reduces risk and assures successful transition from the current polar orbiting operational environmental satellites to the future NPOESS. The proposed efforts are in three categories:

1. Estimating Cloud Top Pressure with VIIRS
   Test VIIRS plus CrIS high cloud property definition:
   - Explore alleviation of VIIRS cloud problems using CrIS (use MODIS and AIRS for test data); and
   - Study cloud profile estimation with AIRS / CrIS in semi-transparent cloud situations (for cloud thickness and cloud bottom EDRs).
2. Estimating Cloud and CO2 profiles from AIRS measurements
   Study cloud profile retrieval with CrIS:
   - In preparation for validation of the VIIRS cloud thickness and cloud bottom EDRs, perform global tests of cloud profile estimation with AIRS / CrIS in semi-transparent cloud situations (using CALIOP as reference);
   - Investigate three dimensional strategy for combined surface and atmospheric profile estimation with AIRS data; and
   - Explore alternative algorithms for estimating CrIS equivalent clear radiances from combined CrIS cloudy radiances and VIIRS data at CrIS single field-of-view (SFOV) basis.
3. Visualization Tools
   Develop McIDAS-V/HYDRA visualization tools for interrogation of multispectral data:
   - Demonstrate with MODIS, AIRS, IASI data; and
   - Establish McIDAS-V as a NPP Cal/Val tool.

Summary of Accomplishments and Findings

Estimating Cloud Top Pressure with VIIRS

The VIIRS+CrIS (represented by MODIS+AIRS) combined cloud top pressures (CTP) were derived by two methods: (1) the 4-layer lapse rate (4LR) method using band 31, and (2) the 3-band Merging Gradient (3MG) approach using bands 29, 31 and 32. The 1-km resolution MODIS MOD06 pre-Collection 6 CTP (CO2 slicing) was also processed for comparison.

By comparing the CTPs for 189 granules on 28 August 2006, using the MODIS 1–km products as truth, we find that for all clouds the 4LR method produces somewhat smaller bias and standard deviation than the 3MG method and the CrIS-only products. For high clouds the 4LR shows a smaller standard deviation but a larger bias than the 3MG. All the biases have a strong latitudinal effect, where the best performance is achieved in the tropics.

VIIRS will need help from CrIS for high, thin clouds at nighttime, thus comparisons with CALIOP are our primary interest, since it is very sensitive to optically thin clouds. CPR measures the extent of thick clouds, but is not able to detect thin clouds at higher levels. We estimate VIIRS-only Cloud Top Height (CTH) performance using a simplified IRW BT approach. In Figure 14.1.1 we show the CTH comparison with CALIOP. VIIRS+CrIS corrects the VIIRS only CTH mistakes, especially between 3 and 5 N.

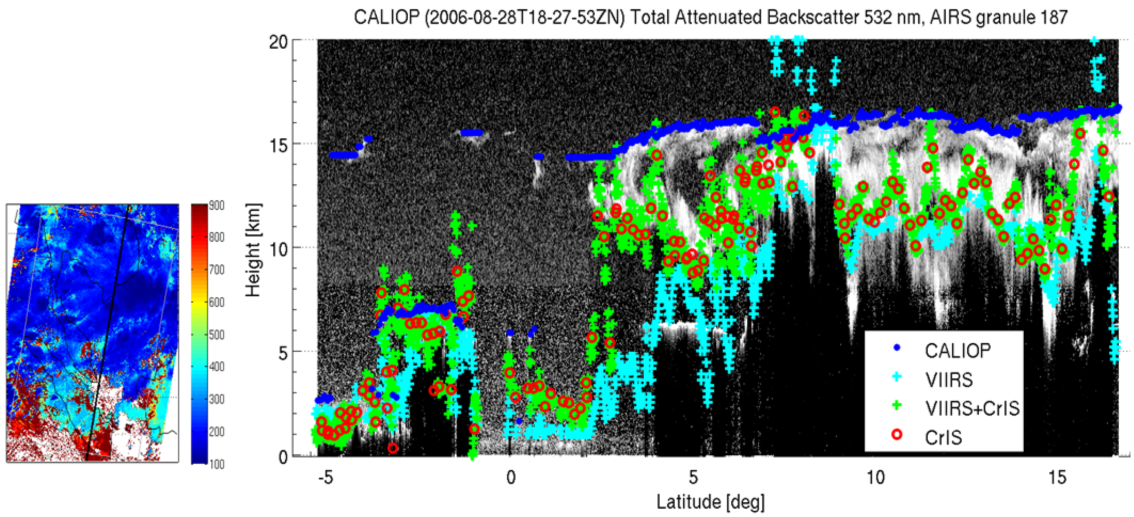


Figure 14.1.1. (right) Cross-section along the CloudSat/CALIPSO track for AIRS granule 187 (28 Aug 2006). CALIOP 532 nm total attenuated backscatter/km/steradian (grey background). Cloud Top Heights from CALIOP (blue), VIIRS-only CTH (cyan), VIIRS+CrIS CTH (MG) (green, from MODIS+AIRS using Merging Gradient Approach). (Left) The MOD06 CTP (hPa) on August 28, 2006. Black shows the CloudSat/CALIPSO overpass.

Statistics with respect to CALIOP for VIIRS+CrIS 4LR,VIIRS-only, CrIS-only, and MOD06 CTHs for 4 granules are presented in Table 14.1.1. MOD06 with the many H2O and CO2 sensitive spectral channels outperforms VIIRS at 1 km, but VIIRS+CrIS recovers much of the performance. CrIS-only at 15 km is more sensitive to very thin cirrus (e.g., granule 124). These 4LR results are similar to the MG results (not shown).

Table 14.1.1. Cloud height statistics for CALIPSO CALIOP minus VIIRS, CrIS, VIIRS+CrIS (4LR) and MOD06 for 4 selected granules on August 28, 2006.

Granule	Nb of Pixels		Bias [km] (CALIPSO – VIIRS/CrIS)			
	VIIRS	**CrIS**	**VIIRS**	**CrIS**	**VIIRS+CrIS (4LR)**	**MOD06**
47	517	93	6.38	4.36	4.08	3.67
87	684	106	4.74	4.60	3.97	3.36
124	765	109	6.31	2.35	2.66	5.37
187	687	140	4.42	4.46	4.21	3.69

Granule	Nb of Pixels		STDEV [km] (CALIPSO – VIIRS/CrIS)			
	VIIRS	**CrIS**	**VIIRS**	**CrIS**	**VIIRS+CrIS (4LR)**	**MOD06**
47	517	93	4.68	4.63	4.06	3.82
87	684	106	4.86	3.25	3.15	2.82
124	765	109	1.96	3.01	2.06	2.05
187	687	140	6.24	3.66	3.02	2.94

Estimating Cloud and CO2 Profiles from AIRS Measurements

Combining CrIS and VIIRS for Single Footprint Cloud-cleared Radiance and Cloud Property Products

UW-Madison continued to study the use of one dimensional variational (1DVAR) methodology for cloud-top pressure retrieval. AIRS radiance measurements were used in the retrieval and the regression derived cloud parameters (Weisz et al., 2007) were used as the first guess in this iterative retrieval process. The retrieved results were evaluated by comparison with the operational MODIS (Moderate Resolution Imaging Spectroradiometer) cloud product and the active measurements from radar and lidar instruments onboard the EOS (Earth Observing System) CloudSat and CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) satellites. It was demonstrated that the 1DVAR algorithm can significantly improve the results over those from a statistical approach.

For AIRS granule 8 on 22 July 2006, retrieval results from the two algorithms are shown in Figures 14.1.2b and 14.1.2c. The distributions of high clouds on the right hand side of the granule are similar. But, significant differences exist on the left hand side of the granule, in which some of the middle clouds with CTPs ranging from 400 to 500 hPa in Figure 14.1.2b correspond to the CTPs greater than 600 hPa in Figure 14.1.2c. However, the CTPs from the physical retrieval agree better with the MODIS CTPs. AIRS retrieved cloud-top heights (CTHs) are demonstrated and compared with those of CPR and CALIOP in Figure 14.1.2d. AIRS CTPs are converted to height by using ECMWF analysis profiles of temperature and moisture interpolated to AIRS grids.

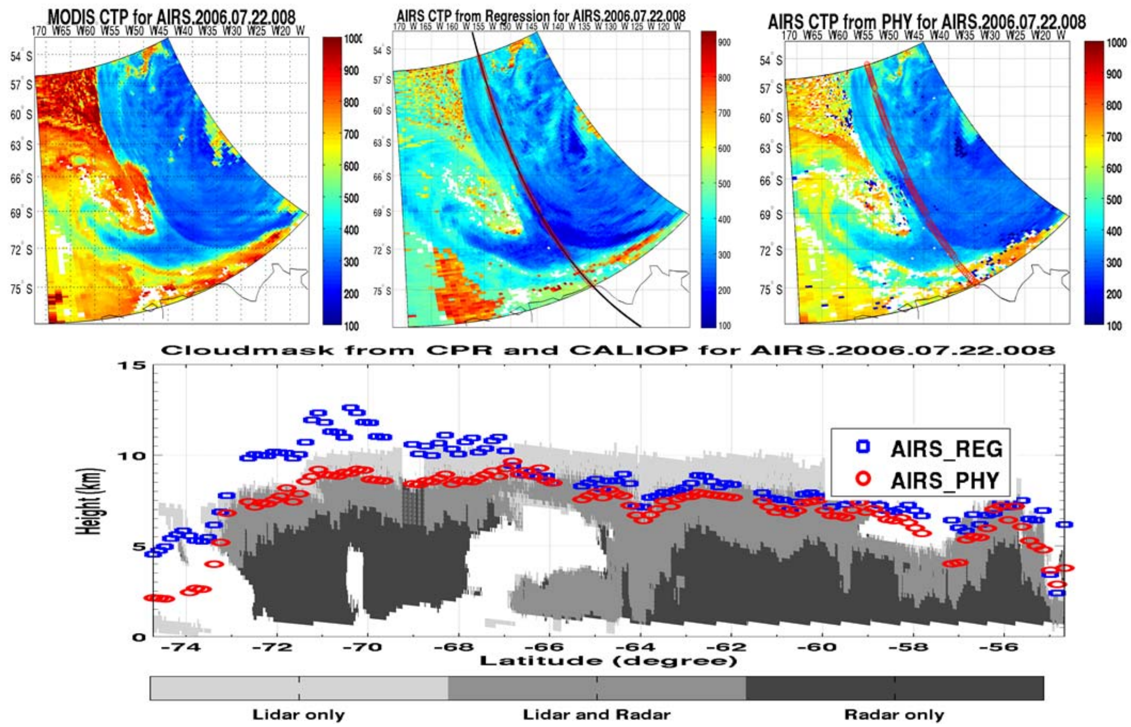
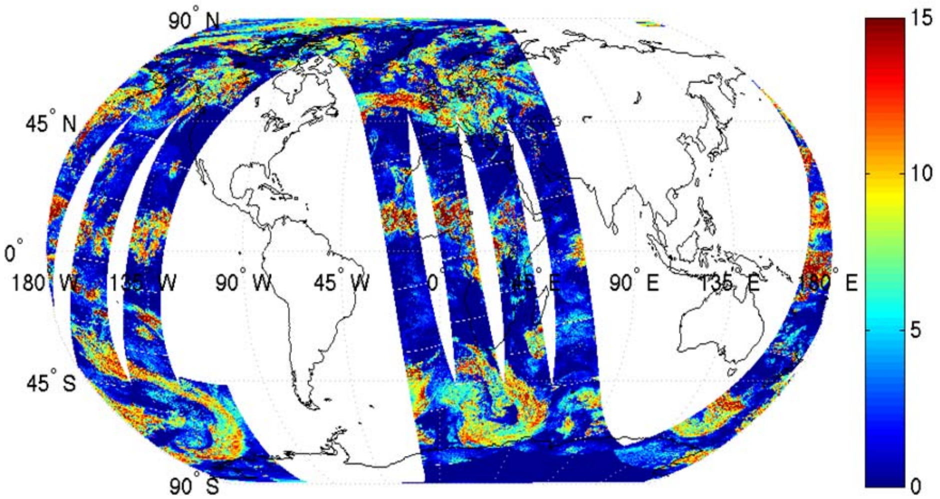


Figure 14.1.2. Comparison of AIRS cloud top height retrievals with MODIS, CPR and CALIOP for AIRS granule 008 on July 22, 2006: (left) operational MODIS CTP (hPa); (middle) AIRS regression CTP (hPa) and (right) AIRS physical retrieval CTP. (bottom) Cloud detection from CPR (dark grey), CALIOP (light grey), and CTHs from AIRS regression (red) and physical (blue) retrievals.

Estimating Cloud Profiles from AIRS Measurements

Global dataset processing continues and adjustments to the reprocessing software are being studied. A first guess of the CO2 concentration is now calculated from a model that is a function of time year and location. Time interpolation of the first guess atmospheric state parameters estimated from numerical weather prediction models is pending. The number of cloud layers detected has been added as a new output parameter. Examples of the number of cloud layers detected and the total cloud absorption are shown in Figure 14.1.3. Good spatial continuity from fov to fov and orbit to orbit are found in the AIRS cloud profile product. The number of cloud layers shows structure not evident in the total cloud absorption (see for example the tropical cyclone located at 180 E and 20 N).



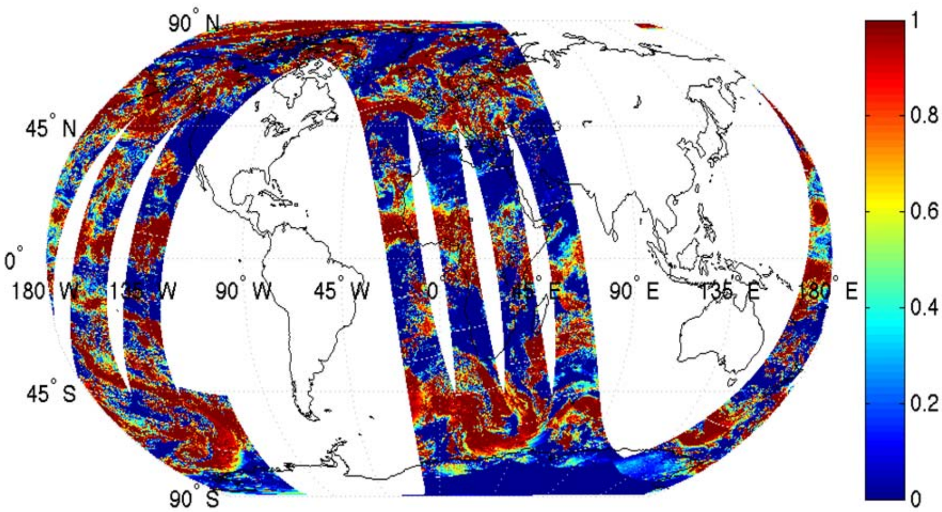


Figure 14.1.3. Cloud processing for 28 August 2006 showing (top) number of cloud layers detected and (bottom) total cloud absorption.

Visualization Tools

Development of visualization and analysis tools for NPP instrument data products within McIDAS-V has continued with the creation of custom Java components which extend the McIDAS-V framework. A specialized Data Source class analyzes a directory containing NPP proxy data, collects the appropriate metadata including scaling coefficients and pixel navigation, and generates an instance of the abstract Data model. These internalized Data can be rendered to the main display by the core system's data-to-display transformation algorithms, and/or used in computation with other Data. Granule aggregation allows the user to interactively select spatial subsets across several consecutive granules with the swaths time-ordered and automatically stitched together on-the-fly for display or computation (Figure 14.1.4). Previous IPO funded development to introduce the multi/hyper-spectral capabilities of HYDRA into McIDAS-V has been instrumental in this process, leveraging experience and software development with MODIS/AIRS.

The initial focus has been on VIIRS SDR/EDR, but work has begun with proxy ATMS and CrIS. Previous code to handle the conversion from time ordered to spatially contiguous FOV displays for IASI L1C will be adapted for use with CrIS which has a similar storage format. An initial version of a re-projection process for VIIRS to handle image artifacts is being developed. (Figure 14.1.5).

Further software development has led to the incorporation of ATMS and CrIS SDR proxy data into the multi/hyper-spectral analysis and visualization component of McIDAS-V. Individual CrIS granules, from separate files, can not be aggregated along the spacecraft polar track with the IFOVs reorganized to spatial coherence for display. Associated CrIS long-wave spectra at the IFOV selected by the moveable probes in the main display can now be displayed. The spectra and pixel value readout update automatically while the user changes the probe's position in the display.

Much progress has been made to parse and analyze external XML metadata files and tie this metadata to the corresponding data file objects. In fact, the current set of metadata XML files for all of the JPSS proxy data are now carried along with McIDAS-V as a system resource. This approach means users will not have to retrieve the metadata files themselves, and possibly obtain the wrong file for a particular JPSS product.

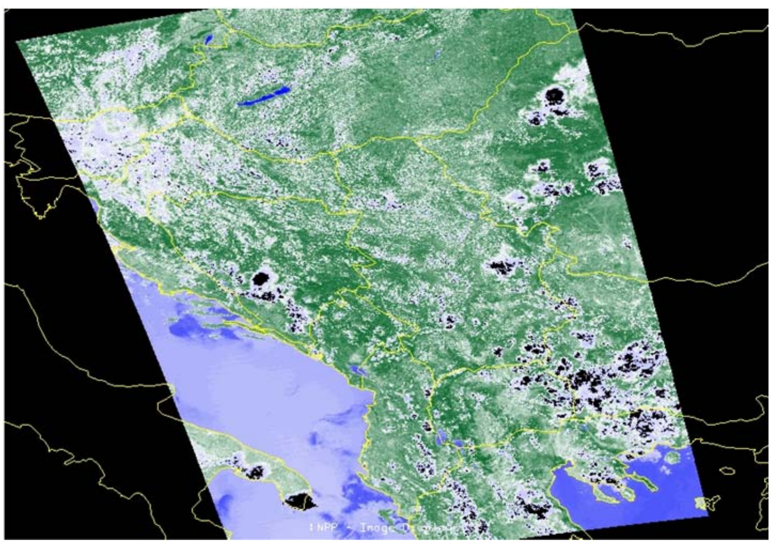


Figure 14.1.4. VIIRS I-band 1,2 combined to create NDVI displayed in McIDAS-V. This image is actually from 3 consecutive aggregated granules contained in separate files. An interactive image enhancement tool was used for the color mapping.

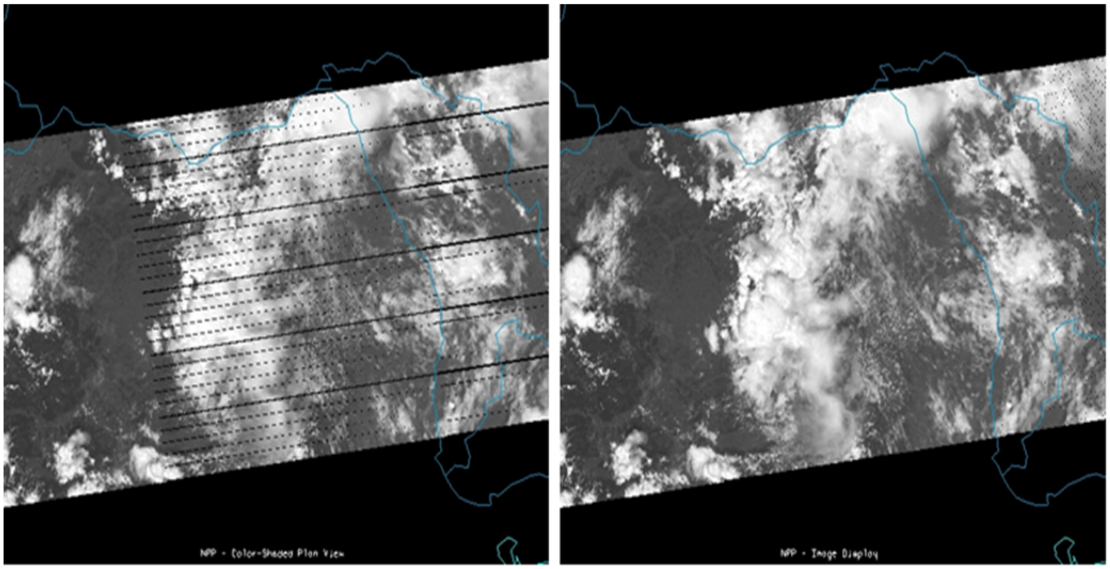


Figure 14.1.5. Original (left) and re-projected (right) VIIRS I-Band 1.

Publications and Conference Reports

Borbas, E.E., E. Weisz and W.P. Menzel: Estimation of the altitude of high thin clouds at night from VIIRS and CrIS, posters were presented at the 2010 A-Train Symposium held Oct 26-28 in New Orleans, LA.

Plokhenko, Y., W. P. Menzel, R.O. Knuteson and C. M. Moeller: Estimating cloud profiles with AIRS," was submitted to JGR.

Tom Rink and Tommy Jasmin gave a software demonstration of NPP Data Visualization with McIDAS-V on IGARSS 30th, held in Honolulu, Hawaii 25-30 July 2010.

Weisz, E. W.P. Menzel, R. Frey and E.E. Borbas: An Approach for Merging High Spectral Resolution Images Data to infer Cloud Cover Properties, was submitted to JAMC.

References

Weisz, E., H-L. Huang, J. Li, E. Borbas, K. Baggett, P. Thapliyal, and G. Li, 2007: International MODIS and AIRS processing Package: AIRS products and applications. *Journal of Applied Remote Sensing*, Volume 1.

14.2 VIIRS Radiance Calibration/Validation

CIMSS Task Leader: Chris Moeller
CIMSS Support Scientist: Dan LaPorte
NOAA Strategic Goals

- Understand climate variability and change to enhance society's ability to plan and respond

CIMSS Research Themes

- Satellite Sensors and Techniques

Proposed Work

This task supports expert participation in VIIRS pre-launch performance evaluation. The support is for participation in government team meetings and studies. SSEC/CIMSS proposed to:

1. Participate in Government Team (non-VOAT) F1 performance evaluation moving towards the 4th quarter 2011 NPP launch:
    - Reach consensus on F1 sensor level RSR characterization; and
    - Evaluate S/C level RSR in context of on-orbit performance.
2. Participate in Government Team efforts towards F2 performance testing:
    - F2 test program planning and recommendations.

Summary of Accomplishments and Findings

Over the reporting period, Dan LaPorte and Chris Moeller have continued participation in the VIIRS pre-launch test and assessment program. Activities have largely centered around evaluating VIIRS F1 pre-launch performance (particularly spectral characterization), and contributing towards planning and decisions for the F2 test program. Participation on the VIIRS SDR team is also supported under this funding.

F1 Sensor Level Spectral Characterization

The relative spectral response (RSR) subgroup of the government team (non-VOAT) participated in the data collection and analysis of the sensor level spectral characterization. This subgroup, consisting of elements from NASA, Aerospace Corp. and Lincoln Lab/MIT and led by Univ. Wisconsin (Chris Moeller), undertook an intensive review of the sensor level RSR characterization to determine a government team “best” sensor level RSR characterization (see Figure 14.2.1). The objectives of this effort were to:

1. Provide explanation on RSR discrepancies and choose best path forward for reaching consensus on government team sensor level RSR for F1, and
2. Identify value-added measures to improve the overall characterization of F1 RSR as provided by government team analysis.

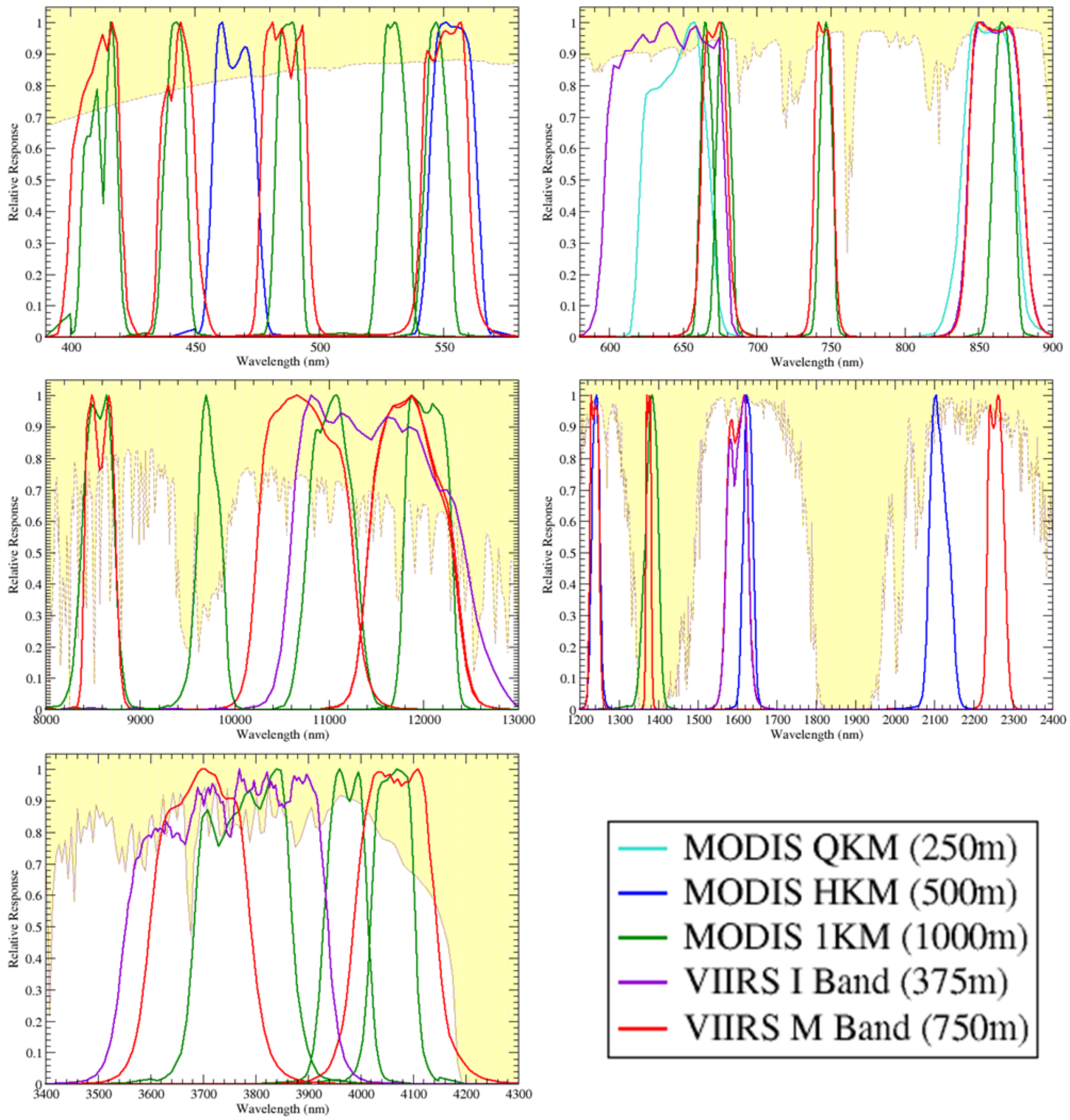


Figure 14.2.1. Government team "best" sensor level in-band Relative Spectral Response (RSR) for VIIRS Flight 1 instrument, shown with Aqua MODIS RSR. The government team independently derived VIIRS RSR to support and verify industry RSR and specification compliance, as well as to identify value added measures to improve the RSR information content. Color coded legend applies to all panels. Model based atmospheric extinction is represented by the yellow background of each panel.

The team conducted the effort through a series of special topic telecons over a 3 month period, resulting in the following progress and findings:

- All discrepancies between the Aerospace and NICST (NASA) analyses were identified and resolved and a consensus sensor level RSR was identified.
- Differences in the SNR filtering methodology of each analysis proved to be the root cause of a majority of RSR discrepancies.
- SNR filtering is necessary in the RSR analysis to avoid distorting the response level of the noise floor for cold focal plane bands. It is helpful, but not critical, for VisNIR bands.

- Band averaged SNR is an effective metric for discriminating "real" from noise-driven response features. SNR filter thresholds were fine tuned for each band.
- Spacecraft VisNIR RSR measurements using flood illumination were useful in guiding the interpretation of sensor level VisNIR RSR features.
- Bands M9 and M13 RSR benefit from mitigating atmospheric absorption influence

This effort resulted in the release of the government team "best" sensor level RSR for F1 cold focal plane bands (Sept 17, 2010) and for VisNIR bands (Sept 24, 2010) to the VIIRS user community. These RSR have been cleared of ITAR restrictions and placed in the public domain (http://www.star.nesdis.noaa.gov/star/jpss) to be accessed by the community to develop forward models and to evaluate impact on EDR products from SDR spectral performance. A poster introducing the government team "best" RSR and comparing it to that of Aqua MODIS was presented at the 2010 A-Train Symposium held Oct 26-28 in New Orleans, LA.

F1 Spacecraft Level Spectral Characterization

The VIIRS F1 sensor was shipped by the instrument vendor, Raytheon Corp., to the spacecraft vendor, Ball Aerospace and Technology Corp (BATC) in Jan 2010 and underwent special spectral testing in March 2010 to re-characterize the VIIRS F1 RSR for VisNIR bands under flood illumination conditions. These tests were motivated largely by the observance of cross talk in the sensor level test program and by the difficulty of confidently assigning uncertainties to the out-of-band (OOB) portion of the VisNIR band spectral characterization. The tests were designed to use flood illumination of the VIIRS focal plane so that all optical and electronic effects would be captured simultaneously in a "test as you fly" condition. Additionally, the NIST provided a laser based source (T-SIRCUS) with a NIST traceable calibration for the testing.

The RSR subgroup of the government team actively participated in the special spectral test program and analyzed the data to produce spacecraft (SC) level RSR in the field. The RSR subgroup, led by Wisconsin (Moeller), subsequently met over a 5 month period in special topic telecons with objectives similar to those for the sensor level RSR review, including the release of the government team "best" spacecraft level RSR product. Key elements of progress are noted below:

- Root causes have been identified and corrected for all discrepancies in the RSR analyses between various elements of the government team. The government team RSR analyses have been "unified" to present one "best" government team RSR product.
- Analysis methodology has been modified to reduce contributions to biases and uncertainties in the resulting RSR. Examples include applying linear interpolation in wavelength space to estimate source monitor calibrated radiance, using IB sweep response data to replace saturated OOB sweep data, reducing or eliminating response level biases in multiple sweeps of the same spectral region, shutter status refinements to avoid partial scan data biases, and filtering individual out-of-family response measurements caused by test equipment instability during operation.
- A signal-noise ratio (SNR) based Data Quality Flag has been developed as an assessment on the data quality of the response at each wavelength of each band. "Low" quality response data is generally regarded as noise driven response, i.e., noise floor. The government team recommends that all low quality response data be discarded in any effort to fuse SC level with Sensor level RSR or to otherwise apply the SC RSR. This strategy retains the option for users to apply further processing techniques such as wavelength or detector averaging to the SC RSR data if the user deems it appropriate for their goals.
- An electronic crosstalk influence investigation was conducted in an effort to identify and flag those response wavelengths that are believed to be significantly influenced by electronic

crosstalk. An Electronic Crosstalk Flag was generated to identify contaminated observations. This flag is independent of the Data Quality Flag, but follows a similar strategy of informing the user of the crosstalk influence and yet allowing the user to apply innovative techniques if desirable.

- The complexity of the SC level RSR dataset and the subsequent effort to understand this dataset has resulted in deep familiarity with the strengths and weaknesses of the data collection, analysis, and information content of the data. Lessons learned and suggestions for improvements in the RSR characterization effort using the NIST T-SIRCUS source have been collected. Further, because the S/C level RSR will play an integral role in the NG "fused" RSR product, the government team effort to produce a "best" RSR greatly enhances government team insight and understanding of the NG "fused" RSR.

The release of the government team "best" SC level RSR is imminent. The data will be placed on CasaNosa for distribution within the VIIRS user community and later on a public Web site (after appropriate ITAR review and clearance).

F2 Test Program Recommendations

Wisconsin has provided input to the government team consensus list of recommended potential VIIRS upgrades (including testing upgrades) for F2 and beyond. Follow-up analyses and review will be needed to evaluate cost/risk aspects of these upgrades. Wisconsin supports the government team position to add FTIR and laser based (T-SIRCUS) spectral calibrations to the F2 (and beyond) test program. Wisconsin (LaPorte) has taken a leadership role in a team that is interfacing with industry elements to develop and implement test design, strategy, and hardware for the demonstration of the FTIR based spectral measurement in the first half of CY 2011. Wisconsin has also provided recommendations on characterization and operation of ground support equipment used in the test program including spectral characterization of the windows on the thermal vacuum chamber, timely calibration of the sources used on the Spectral Measurement Assembly, real-time source monitoring, improvement in spectral sampling of some measurements, and additional testing of the sources to characterize spatial degrees of freedom.

Publications and Conference Reports

Dan LaPorte and Chris Moeller attended the CalCon 2010 conference held in Logan, UT August 23-26. Moeller presented "VIIRS F1 Spacecraft Level Test Program: Strategy and Implementation of Laser Based Spectral Testing," and LaPorte contributed to "Interferometer- based Relative Spectral Responsivity for a VIIRS Type Sensor."

A poster titled "Welcome to the NPP VIIRS: VIIRS Relative Spectral Response from the Gov't Team" was presented at the 2010 A-Train Symposium held Oct 26-28 in New Orleans, LA by Chris Moeller.

A poster titled "Continuity of the A-Train MODIS Observations: Welcome to the NPP VIIRS" was presented at the 2010 A-Train Symposium held Oct 26-28 in New Orleans, LA. Chris Moeller was a co-author on this poster.

14.3 NPP-VIIRS Ice Cloud Property EDR Validation Activities

CIMSS Task Leader: Bryan Baum
CIMSS Support Scientist: Nick Bearson
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques
- Education and Outreach

Proposed Activities

- As more experience is gained with assessment using active measurements, repeat evaluation of NPP cloud properties globally, but over lengthier periods of data (at least one year of CALIPSO/CloudSat/MODIS), focusing on problem areas such as clouds over snow/mountains, data from low-sun conditions (terminator).
- Begin imager/sounder evaluation of ice cloud heights, working with Andy Heidinger.
- Prepare summary of problem areas that need additional focus for validation activities.
- Evaluate whether the NGAS algorithms will be of sufficient quality to meet required specifications pre-launch.
- Provide final assessment of each cloud product, in terms of demonstrated of the global matchup files generated over at least one year of MODIS/CALIPSO/CloudSat data.

Summary of Accomplishments

We have been able to evaluate very limited amounts of NGAS daytime cloud properties, apart from the cloud mask, for the simple reason that we were never able to obtain more than two orbits of anticipated VIIRS cloud products from the mini-IDPS, or any other source for that matter. The Atmosphere PEATE spent considerable resources to understand the VIIRS cloud code in the most recent operational delivery package, and worked towards running this software in the PEATE framework. However, progress was limited due to the complexity of the NGAS operational build and the lack of documentation. Ours was not the only group to recognize the complexity of working with the contractor software. Partly in response to the science teams, an effort is now underway by NOAA and the JPSS contractor to build the science algorithms in a framework called the Algorithm Developer Library (ADL). Currently only the VIIRS cloud mask is available in the ADL. Once the cloud algorithms are in ADL, the PEATE will be able to process imager data using the cloud algorithms, at which point we can assess the global cloud properties. The scientists on the newly constituted NASA NPP Science Team, of which I am a part, decided to suspend the effort to work with the NGAS cloud algorithms outside of the ADL effort.

My experience to date with the Northrop Grumman algorithm theoretical basis documents (ATBDs), the associated software, and two orbits of preliminary cloud products provided by the mini-IDPS at NASA GSFC indicates that VIIRS cloud mask seems to be in fairly good shape and can be worked with after launch to make necessary modifications. However, my assessment is that the inference of other cloud properties will stand out as a major deficiency in the current operational build of the software. If the current complexity of the software is any guide, I also think that it will take a very long period of time to improve the cloud EDR performance after launch. The combination of software complexity and operational processing requirements is not an optimal situation.

Given the issues, we are developing a new framework that will greatly ease implementation, testing, and cal/val activities for the cloud products in the future. There are two goals at work here. First, we want to be able to transition as much knowledge from global MODIS (and other imager) processing as possible to VIIRS. Second, we would like to be able to modify and test algorithms using a common development framework with both VIIRS and MODIS data. Because of this and other improvements in the process strategy, we have been re-thinking the process for how we are going to work with VIIRS data and cloud products when they become available. We are developing a new framework in a scripting language called Python and can provide further details upon request.

In preparing for MODIS Collection 6 activities, we have greatly improved the cloud retrieval algorithms. The accuracy of these improvements is being assessed through intercomparison with CALIPSO Version 3 products following Holz et al. (2009) and is underway. A journal article (Baum et al., 2011) is under development that describes the new algorithms for MODIS and initial results from the intercomparison with CALIPSO. The MODIS infrared (IR) cloud thermodynamic phase product is an example of a research advancement than should be transitioned to VIIRS. This MODIS cloud phase method has been modified significantly to incorporate recent work involving cloud emissivity ratios (Heidinger and Pavolonis 2009; Heidinger et al., 2010). An example of the improvement in cloud thermodynamic phase for a single MODIS granule is provided in Figure 14.3.1. The discrimination of ice cloud is much improved from the previous collection, resulting in fewer “uncertain phase” retrievals. Figure 14.3.2 shows results from this updated algorithm for global daytime results. Since only IR bands are used, results will be consistent regardless of solar illumination. Note that the earlier MODIS approach is similar to what has been adopted for use with VIIRS. The new approach requires a forward model to calculate clear-sky radiances from an input set of temperature, humidity, and ozone profiles provides by a gridded meteorological product. This method increases the complexity of the algorithm, but this will not pose a problem with our Python system.

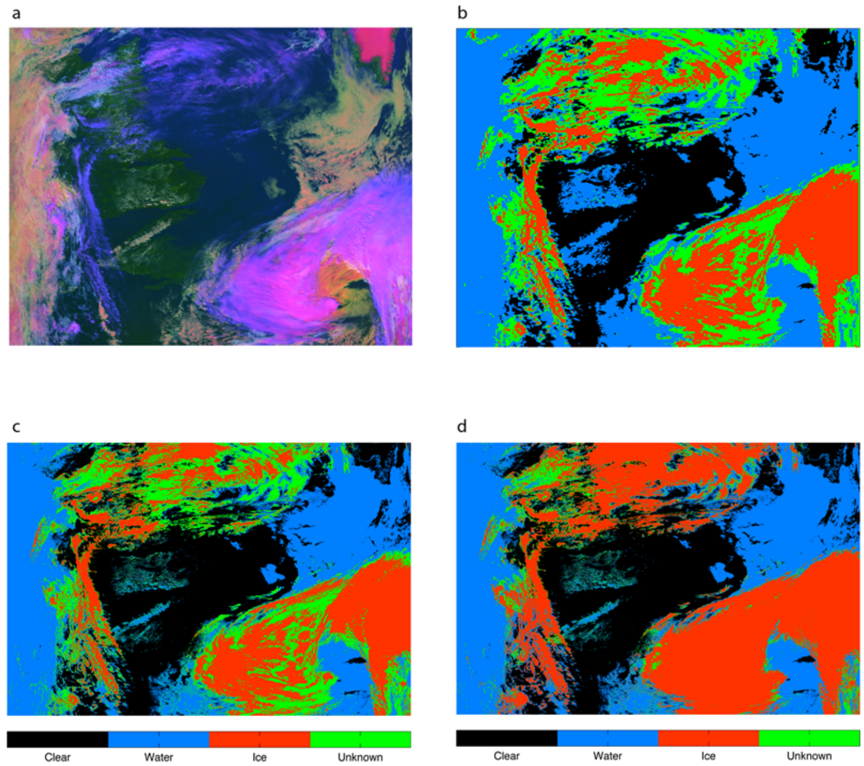


Figure 14.3.1. Results of IR cloud phase for a MODIS granule at 1630UTC on 28 August, 2006, over the northern Atlantic Ocean. (a) a false color image (Red: 0.65 μm; Green: 2.15-μm, Blue: 11-μm reversed) where ocean is dark, land is green, cirrus is blue, optically thick ice cloud is magenta, and low clouds are yellow/white, (b) Collection 5 IR phase results at 5-km resolution, (c) Collection 5 IR phase algorithm applied at 1-km spatial resolution, and (d) improved IR cloud phase. For the Collection 5 results, the "mixed-phase" pixels are merged into the "uncertain" category, as will be done with Collection 6.

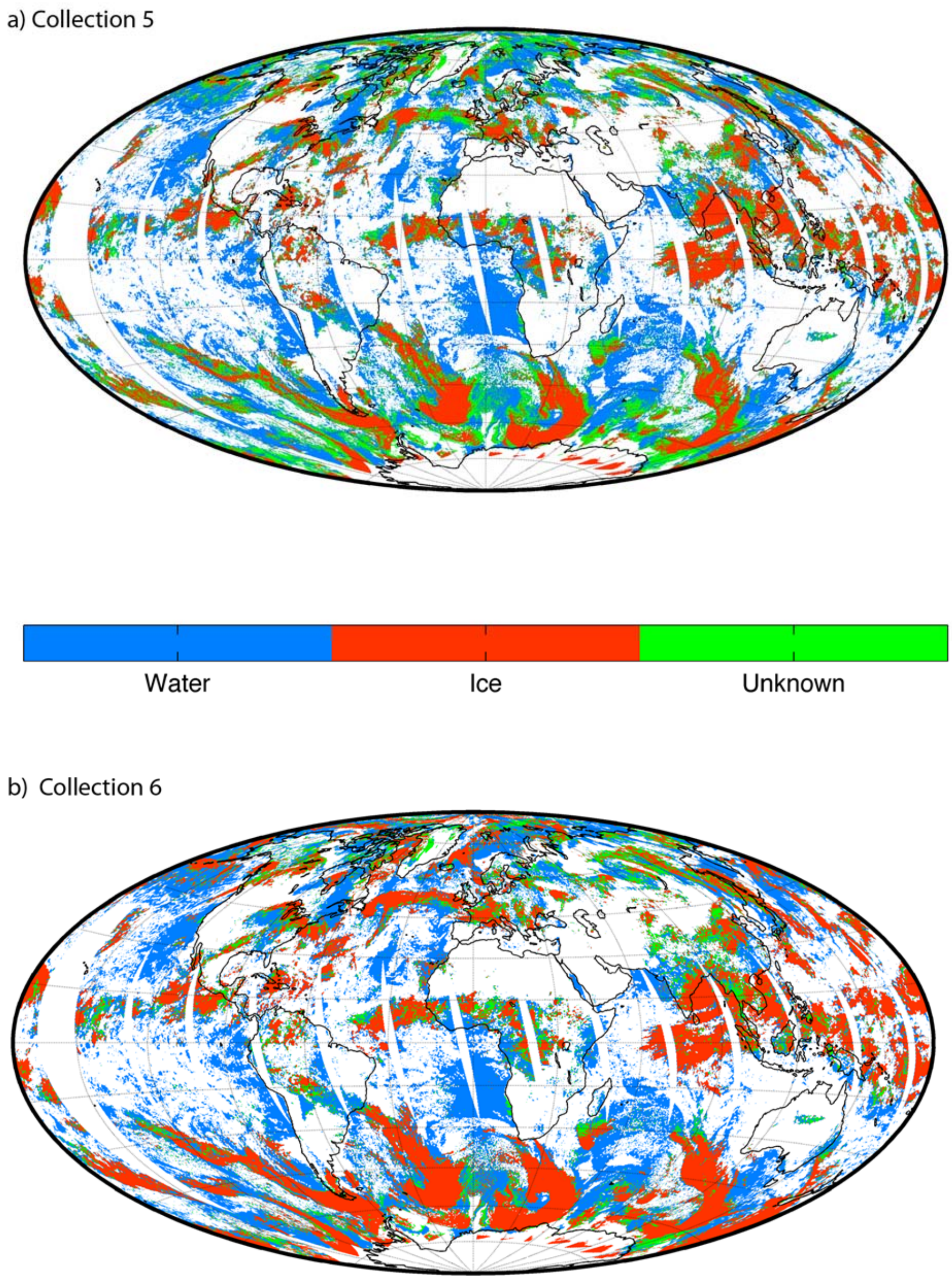


Figure 14.3.2. Snap-to-grid daytime results for IR cloud phase on 28 August, 2006, for (a) Collection 5 IR phase algorithm, and (b) improved IR cloud phase. For the Collection 5 results, the "mixed-phase" pixels are merged into the "uncertain" category, as will be done with Collection 6.

References

Baum, B. A., W. P. Menzel, R. A. Frey, D. Tobin, R. E. Holz, and A. K. Heidinger: MODIS cloud top property refinements for Collection 6. In preparation for submittal to *J. Appl. Meteor. Clim.*

Heidinger, A. K.; M. J. Pavolonis, R. E. Holz, B. A. Baum, and S. Berthier, 2010: Using CALIPSO to explore the sensitivity to cirrus height in the infrared observations from NPOESS/VIIRS and GOES-R/ABI. *J. Geophys. Res*., **115**, doi:10.1029/2009JD012152.

Heidinger, A. K. and M. J. Pavolonis, 2009: Gazing at cirrus clouds for 25 years through a split window, part 1: Methodology. *J. Appl. Meteorol. Clim* , **48**, 2009, pp.1100-1116.

Holz, R. E., S. A. Ackerman, F. W. Nagle, R. Frey, S. Dutcher, R. E. Kuehn, M. Vaughan, and B. A. Baum, 2008: Global MODIS cloud detection and height evaluation using CALIOP. *J. Geophys. Res*., **113**, D00A19, doi:10.1029/2008JD009837.

14.4 VIIRS-CrIS Radiance Intercomparison and Validation

CIMSS Task Leader: David Tobin
CIMSS Support Scientists: Greg Quinn, Steve Dutcher
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

It is the intent of this work to perform studies with CrIS and IASI high spectral resolution measurements to create highly accurate comparisons with VIIRS broadband sensor observations. AIRS and MODIS measurements will be used as surrogates. IASI intercomparisons with Aqua and Terra MODIS will also be used as surrogates for IASI/VIIRS intercomparisons that will be performed initially after NPP launch. IASI and HIRS intercomparison will also be performed. Previous work done with AIRS and MODIS has established the appropriate approach.

Comparisons of the AIRS and MODIS radiance observations have been published (Tobin et al., JGR 2006); these have illustrated the utility of using high spectral resolution measurements to create highly accurate comparisons with broadband sensor observations. In the analysis, the high spectral resolution AIRS spectra were reduced to MODIS spectral resolution and the high spatial resolution MODIS data were reduced to AIRS spatial resolution for global data collected on selected days. Gaps present in the AIRS spectral coverage were accounted for (referred to as convolution corrections) by simulating the effects of the AIRS spectral gaps in computed spectra for each MODIS band. Spatially uniform scenes were selected and the observed differences were characterized as a function of several parameters including scene temperature, sensor scan (view) angle, and solar zenith angle. The comparisons were within the expected radiometric accuracies of the sensors, with mean brightness temperature differences of 0.1 K or less for many of the MODIS bands. However, for some MODIS bands the differences were greater and suggested that the spectral response functions should be adjusted (shifted and possibly half-width altered). The impact of these spectral shifts on several MODIS products (cloud top pressures, cloud phase, cloud micro-physics) continues to be studied.

Specific proposed activities include:

- Intercompare IASI and Aqua MODIS and IASI and Terra MODIS to simulate IASI/VIIRS post-launch processing; and
- Intercompare IASI and HIRS measurements from METOP and study the effects of suggested spectral shifts on HIRS cloud products.
- Intercompare VIIRS and CrIS and study the effects of suggested spectral shifts on HIRS cloud products and TPW; and
- Pay special attention to VIIRS IRW cold scene behavior and any impact on cloud products.

Summary of Accomplishments and Findings

In previous years the impact of spectral shifts in MODIS bands 34, 35, and 36 on the cloud top pressure product were determined. More high thin clouds and fewer low opaque clouds were found. CALIOP was used to confirm this MODIS cloud product improvement. The impact of AIRS derived spectral shifts on the Aqua MODIS water vapor bands and associated products was also investigated.

A major accomplishment regarding this work is the incorporation of the AIRS-derived MODIS SRF spectral shifts into the MODIS Collection 6 processing software and datasets. This effort is described in a paper in preparation (Baum et al., 2011).

Our most recent efforts have focused on the intercomparison of IASI and MODIS radiances. For VIIRS, one of the most useful evaluation analyses that will be performed soon after launch is the intercomparison of VIIRS infrared radiance observations with METOP-A IASI observations for Simultaneous Nadir Overpass (SNO) conditions. To prepare for this analysis, and for its own merit for MODIS, we have conducted MODIS/IASI SNO analyses, which exercises the same methodology and code. Using techniques developed previously for SNOs and Aqua AIRS/MODIS evaluations, here we present some initial results of evaluating both Terra and Aqua MODIS using SNO based comparisons with METOP-A IASI. Based on evaluations of IASI using numerous techniques, IASI is an excellent reference for evaluating MODIS. Particularly regarding previous evaluations using AIRS, a so-called “convolution correction” to account for spectral gaps, is not required for IASI due to its continuous spectral coverage.

The approach used for these initial evaluations is to determine the exact nadir crossings of the Aqua and METOP-A and Terra and METOP-A platforms. Criteria for spatial and temporal “simultaneity” are then defined and mean MODIS and IASI spectra are computed for each SNO. Data within calendar year 2009 are included for approximately 3500 cases. Nominal (i.e., not spectrally shifted) detector averaged MODIS SRFs are used for this analysis. Results for all IR bands are shown below. Figure 14.4.1 shows mean differences between Terra MODIS and IASI and Aqua MODIS and IASI using SNOs from 2009. Also shown is the difference between Terra MODIS and Aqua MODIS. For the longwave CO2 bands, the result here using IASI to assess Aqua MODIS is very similar to the result obtained using AIRS to assess Aqua MODIS. This analysis using IASI also shows very good agreement between Terra and Aqua MODIS for the longwave CO2 bands.

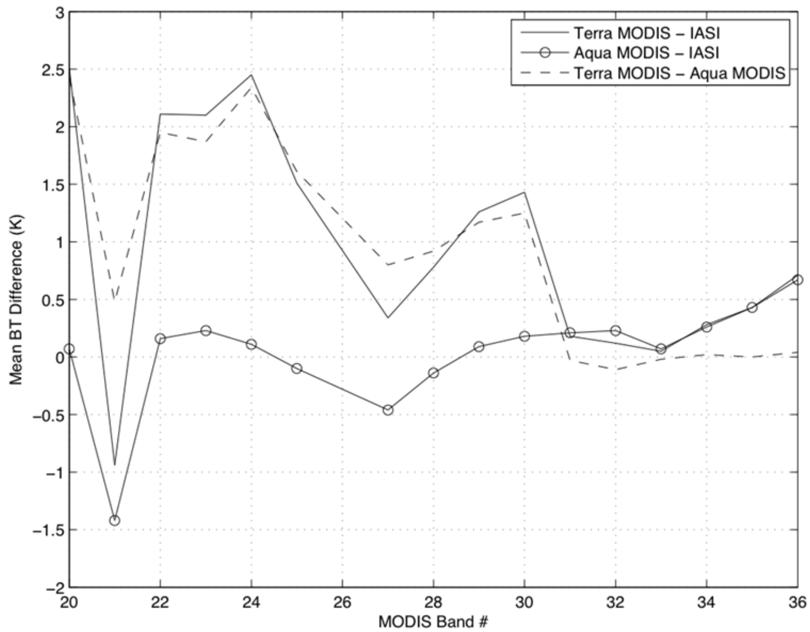


Figure 14.4.1. Analysis of Aqua and Terra MODIS version 5 using SNOs with IASI.

Publications and Conference Reports

Baum, B. A., W. P. Menzel, R. A. Frey, D. C. Tobin, R. E. Holz, and A. K. Heidinger, 2011: MODIS Cloud Top Property Refinements for Collection 6. *Journal of Applied Meteorology and Climatology*, to be submitted.

References

Tobin, David C.; Revercomb, Henry E.; Moeller, Christopher C. and Pagano, Thomas S., 2006: Use of Atmospheric Infrared Sounder high-spectral resolution spectra to assess the calibration to Moderate resolution Imaging Spectroradiometer on EOS Aqua. *Journal of Geophysical Research*, **111**, doi:10.1029/2005JD006095.

14.5 Cloud and Aerosol Data Product Comparisons

CIMSS Task Leader: Robert Holz
CIMSS Support Scientists: Min Oo, Geoff Cureton
NOAA Collaborator: Andrew Heidinger
NOAA Strategic Goals:

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

The proposed work focuses on evaluating the latest versions of the cloud and aerosol algorithms and leverages our expertise developing and validating global cloud retrievals at UW-Madison SSEC. To date, the validation of the NGAS cloud and aerosol algorithms has been hindered by a lack of pre-launch product availability from NGAS with only limited data being provided to our team for validation. To expand our validation we have spent considerable effort porting the contractor cloud and aerosol algorithms to run locally at SSEC. Once complete this work will provide global proxy VIIRS data leveraging our extensive MODIS datasets. The proposed research continues our porting and verification of the contractor algorithms into a Linux environment, developing our collocation and matchup file infrastructure, and providing an initial assessment of the VIIRS cloud products.

Summary of Accomplishments and Findings

The UW-Madison SSEC IPO effort has focused on finalizing the Linux implementation of the contractor aerosol algorithms and continuing our intercalibration characterization of Terra, Aqua, and HIS with IASI and AIRS. For the aerosol component our goal is to refine the Linux implementation so that our implementation agrees closely with the contractor results. Our accomplishments for this quarter are noted below.

Comparison between LEOCAT (Linux) with mini-IDPS and NGAS

To provide a context to this work, Northrop Grumman (NP) has provided limited VIIRS proxy datasets that provide our only means to confirm the UW-Madison LEOCAT AOT retrievals accurately reproduce the contractor algorithms. These are:

- mini-IDPS aerosol product: mini-IDPS (operational code) intended for IDPS functional tests base on operational code. There are two orbits of data available for 2003 Jan 25; and
- NGAS aerosol data: NPP proxy 24 granules test data results from NGAS science code. 14 granules of 2002 Sep 6 and 10 granules of 2003 Jan 25 are available.

The UW-Madison implementation of the VIIRS contractor algorithms LEOCAT (Low Earth Orbit Cloud Algorithm Testbed) VIIRS algorithm works in a Linux environment and can produce both VIIRS and MODIS resolution products. For the VIIRS resolution processing flow, SDR granules from mini-IDPS processing chain are directly used as input to LEOCAT VIIRS software. For the MODIS resolution processing, MODIS L1 B is used as input to VIIRS algorithm in LEOCAT. The same algorithm (and code) is used for both processing streams. For both VIIRS and MODIS processing, LEOCAT uses GDAS and NCEP model data. The VIIRS resolution processing applies the VIIRS LUT while the MODIS resolution processing applies MODIS LUT. The MODIS resolution LEOCAT implementation runs on MODIS Level 1b granules providing the capability to produce years of retrievals leveraging the UW-Madison SSEC processing capability.

Based on AOT comparison we found significant differences between the LEOCAT, mini-IDPS, and NGAS results with a granule level comparison. For NGAS the largest differences are over land. Further investigation has revealed LEOCAT uses a different granulation (gridding) method to the 1-degree ancillary data (NCEP) used by mini-IDPS and NGAS proxy data. We also found significant differences in the cloud filtering between the LEOCAT and contractor implementations. Much of our efforts have focused on addressing these issues to improve the closure between LEOCAT, min-IDPS and NGAS.

MODIS resolution LEOCAT VIIRS algorithm

Using the LEOCAT MODIS resolution processing we created a six-month AOT dataset leveraging the UW-Madison processing capabilities. The six months of LEOCAT processing took approximately four days. Results from one day of LEOCAT AOT are presented in Figure 14.5.1. In addition to comparisons with contractor retrievals we compared the LEOCAT VIIRS results to the collection 5 MODIS MYD04. The global image and quantitative comparisons are presented in Figure 14.5.1. Because the MODIS MYD04 is at 10km resolution and LEOCAT (VIIRS) IP is 1km resolution, we select every 10th LEOCAT pixel to aggregate up to the 10km MODIS resolution. We compare only pixels when both the MODIS and

LEOCAT (VIIRS) successfully retrieve an AOT. We find that the majority of the large AOT differences occur over land or in heavy aerosol regions when compared to MODIS AOT. Further investigation has revealed that much of the differences can be attributed to the cloud/aerosol masking in LEOCAT.

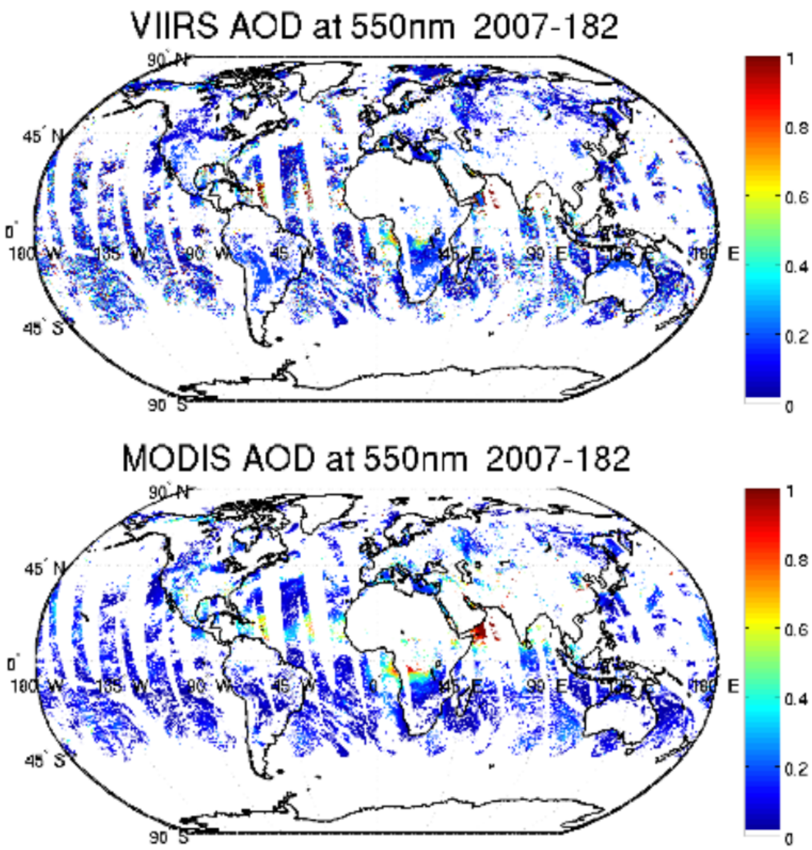


Figure 14.5.1. Global comparisons between the MODIS derived AOD pixels of MODIS and VIIRS (LEOCAT).

14.6 A Broad Scope of Calibration/Validation and Independent Verification and Validation Activities in Support of JPSS, with Emphasis on CrIS

CIMSS Task Leader: Hank Revercomb
CIMSS Support Scientists: Fred Best, Bob Knuteson, Joe Taylor, Lori Borg, Dave Tobin
NOAA Collaborators: Yong Han and others
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques
- Environmental Models and Data Assimilation

Proposed Work

The University of Wisconsin-Madison (UW-Madison) Space Science and Engineering Center (SSEC) has proposed to support a broad scope of activities aimed at providing the government with expertise in specific technical areas related to the NPOESS mission. The general purpose of these efforts is to provide expertise to the IPO that (1) reduces schedule, cost, and performance risk, (2) helps assess performance of industry, (3) points to feasible observing system improvements, and (4) leads to increased positive impact of NPOESS goals, by making use of the broad experience in instrument design, testing, algorithms, and science gained from previous and ongoing UW-Madison SSEC research activities. Special focus is in the areas of (1) pre-launch CrIS instrument performance assessments, (2) pre- and post-launch CrIS and IASI calibration and validation, and (3) independent verification and validation of SDR and EDR products through development of test cases and detailed evaluation of industry provided code performance.

Summary of Accomplishments and Findings

Efforts in this period have focused on evaluation of the CrIS SDR algorithm, and various efforts related to being prepared for post-launch cal/val activities of the CrIS SDRs.

Most recently, we have helped to develop a comprehensive and efficient plan for optimization and validation of the CrIS performance in the Sensor Checkout and Intensive Cal/Val periods following launch. To assess the CrIS radiances in the post-launch sensor checkout period, we are preparing for the following tasks:

1. Internal consistency checks on Radiometric Calibration,
2. Radiometric Non-linearity Evaluation,
3. Radiometric Noise assessment,
4. Variable artifact assessment using Principle Component Analysis,
5. Early broadband comparisons with GOES and other GEOs,
6. Clear sky Observed minus Calculated Analysis,
7. Internal Consistency checks on spectral self-apodization correction and resampling,
8. Analysis of non-uniform scene effects on the ILS,
9. SDR evaluations using SNO comparisons with IASI and AIRS,
10. CrIS/VIIRS Radiance Comparisons,
11. ICT Environmental Model Evaluation and Refinement, and
12. In-orbit RU Estimation.

Our analysis will involve several types of processing. In the early Sensor Checkout period, efforts will be focused on adjusting the various calibration coefficients in the CrIS engineering packets to obtain optimal performance. This work will be done in the context of the operational SDR algorithm, implemented with the ADL environment and used as given in Figure 14.6.1. An Engineering Packet Editor will be used to produce alternate sets of SDRs which will then be used to compare to SDRs produced with the nominal at-launch calibration parameters, and evaluated in various ways using selected validation datasets. An ADL implementation of the SDR algorithm will allow us to ensure that the candidate changes to the calibration parameters will be optimal for the operational IDPS SDR algorithm. For example, the nonlinearity coefficients, a2, will be adjusted using the Engineering Packet Editor to produce alternate SDRs, and this process will be iterated until there is agreement between all nine FOVs in all spectral bands and optimal agreement is found with external validation datasets such as AIRS and IASI.

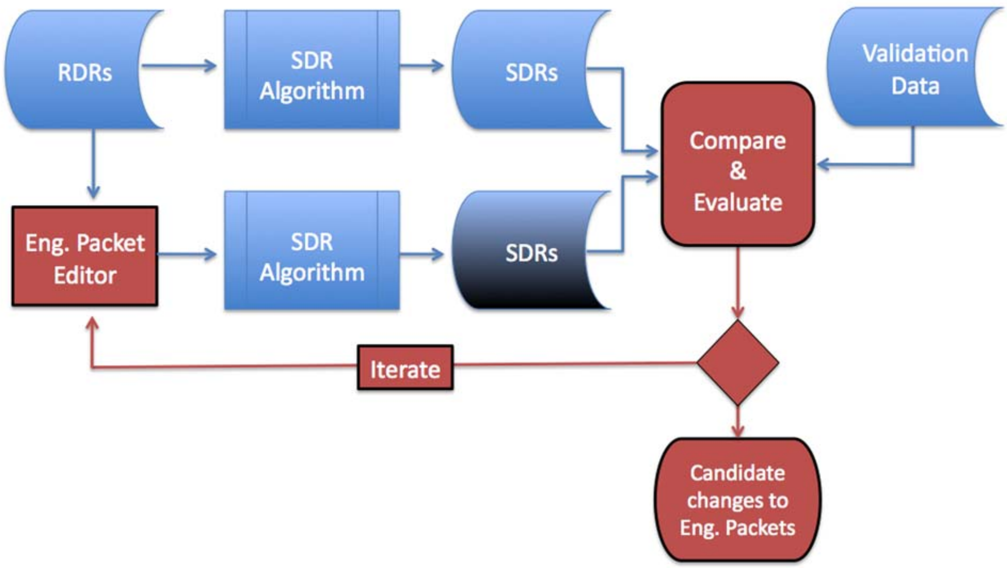


Figure 14.6.1. CrIS Sensor Checkout Data Analysis Flow.

We are also developing an independent set of SDR analysis software for use in the post-launch cal/val phase. This software is based on developments during the CrIS TVAC analysis phase and also follows the basic FTS processing flow that we have used for all of our in-house calibration efforts including those for HIS, AERI, Scanning-HIS, NAST-I, GIFTS, etc. The basic flow is shown in Figure 14.6.2. This software package will aid us in performing many of the SDR cal/val tasks listed above, and will also serve as an independent check on the official implementation of the SDR algorithm.

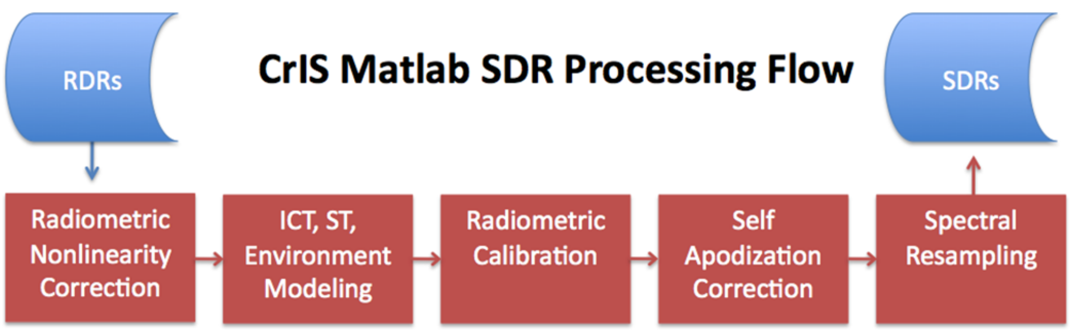


Figure 14.6.2. CrIS Sensor Checkout Data Analysis Flow.

Publications and Conference Reports

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14.7 CrIMSS Post Launch EDR Assessment

CIMSS Task Leader: Robert Knuteson
CIMSS Support Scientists: Ashley Sorce, Jacola Roman
NOAA Collaborator: Chris Barnet
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Environmental Models and Data Assimilation

Proposed Work

Continuously operating Raman Lidars can provide a very valuable resource for the validation of satellite derived water vapor profiles, particularly in regard to exact time coincidence (compared to radiosondes) and in the validation of upper tropospheric water vapor. The DOE ARM Raman lidar mixing ratio profile has been calibrated using the total column water vapor from a coincident microwave radiometer (MWR) to achieve good absolute accuracy in the vertical profile. We propose here to use the existing Raman lidar products from the ARM Southern Great Plains site to assess the accuracy of the CrIMSS water vapor profiles. Preliminary assessment of AIRS and NOAA IASI retrievals of upper level water vapor will be used to develop the validation methodology. A new Raman lidar is being installed in Darwin, Australia that will be incorporated into the validation of CrIMSS in subsequent years. Dr. Robert Knuteson is the lead of this effort.

Summary of Accomplishments and Findings

In the peer reviewed paper Bedka et al. (2010), the UW-Madison CIMSS determined the bias in retrieved water vapor from AIRS v5 L2 products using total column water vapor measurements from coincident DOE SGP ARM site Microwave Radiometer (MWR) and SuomiNet GPS. A 10% dry bias was determined to occur mainly at nighttime and mainly in the summer months. The right-hand column of the figure below shows the statistical summary of six years of coincident satellite overpasses of the SGP central facility and a geographic map showing the summertime difference between day and night. In this project we are further investigating the cause of that previous result by including the validation of the water vapor vertical profile using the coincident Raman Lidar observations and radiosonde data interpolated to the overpass times. The left-hand column of Figure 14.7.1 compares the winter-nighttime (upper left) to the summer-nighttime (lower left). While the AIRS v5 water vapor profiles in winter are relatively unbiased (in absolute g/kg units), the summer profiles show a clear bias relative to both Raman and Radiosonde. A comparison of Raman and radiosonde profiles for the year 2008 is provided for reference showing the validation data are self-consistent and convincingly demonstrating that the profile bias is in the AIRS v5 retrieved profiles. The cause of this profile bias is not yet determined but may be related to the presence of nocturnal inversions in the Southern Great Plains since the daytime observations appear to be unbiased (not shown). A publication on the methods used for the water vapor profile validation used in the evaluation of AIRS v5 profiles is in preparation that will document the approach to be used for validation of the CrIMSS Water Vapor profile EDR.

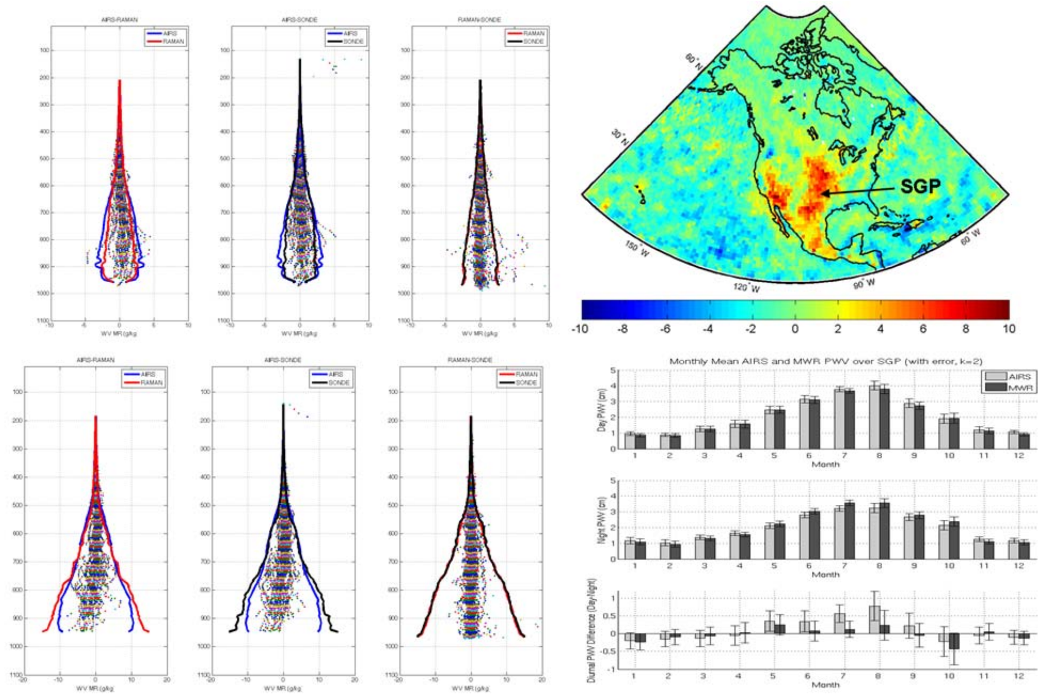

Figure 14.7.1. Winter (ul) and Summer (ll) water vapor mixing ratio profile retrieval error distributions for 2008 at the ARM SGP site (ur) comparing AIRS-Raman, AIRS-Sonde, and Raman-Sonde (left to right) explains the nighttime summer dry bias seen in the AIRS total precipitable water vapor (lr). The solid colored lines in the left-hand column are the mean profiles for the coincident dataset; the dots represent the mixing ratio differences at the vertical resolution of the Raman Lidar sensor for each matchup profile.

In a related effort, the SuomiNet and NOAA Wind Profiler Demonstration Network (WPDN) of ground-based GPS receivers have been used to evaluate the monthly variability of total column water vapor in the U.S. Great Plains and Midwest regions. The GPS measurements of total column water vapor will be used to provide a regional evaluation of the CrIMSS water vapor profile EDR. In preparation for using these data for EDR validation, a student (J. Roman) in the UW-Madison Atmospheric and Oceanic Sciences department has used the GPS PWV data to investigate the realism of Global Climate Models (GCMs) (Roman et al., 2011).

Publications and Conference Reports

Roman, Jacola A.; Knuteson, R.; Revercomb, H. and Tobin, D., 2011: Validation of Global Climate Model moisture trends for the Coupled Model Intercomparison Project (CMIP) using GPS Precipitable Water Vapor (PWV) observations in the US Great Plains from 2000 to 2010. 23rd Conference on Climate Variability and Change, Seattle, WA, 23-27 January 2011. Boston, MA, American Meteorological Society (AMS).

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14.8 CrIMSS Post Launch EDR Assessment – Sounding Evaluation Through Assimilation

CIMSS Task Leader: Jun Li
CIMSS Support Scientist: Jing Zheng
NOAA Collaborator: Chris Barnet
NOAA Strategic Goals

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Environmental Models and Data Assimilation

Proposed Work

The SSEC/CIMSS sounding team will conduct studies on NPP sounding product evaluation through the use of a regional data assimilation and forecast system - WRF/DART (Weather Research and Forecasting Model/Data Assimilation Research Testbed). Assimilation of soundings in numerical weather prediction (NWP) models provides a supplementary and powerful evaluation technique, especially through assimilating soundings in a mesoscale forecast model. Key advantages of using regional assimilation techniques for sounding evaluation are: (1) spatial/temporal information can be evaluated through impact study; (2) sounding performance over ocean can be evaluated; and (3) it will help understand the applications of NPP soundings on short range mesoscale forecasts. Dr. Jun Li is the lead of this effort.

Summary of Accomplishments and Findings

The AIRS single field-of-view soundings are used in the evaluation in the first experiment. Typhoon Sinlaku (2008) track and intensity (central sea level pressure) analysis with and without AIRS soundings through WRF/DART are compared with the observations. The control (CTL) run contains the radiosondes, satellite cloud winds, aircraft measurements, surface pressure, and JTWC (Joint Typhoon Warning Center) advisory tropical cyclone (TC) position. A six-hourly cycle is used in the analysis. The assimilation cycle started 08 September 2008. A 9 km moving nest grid with feedback to 27 km grid in the WRF forecasts is used when a TC is present. The following experiments are conducted through WRF/DART:

- Control (CTL): RAOBs, satellite winds, aircraft measurements, surface pressure, TC position etc.
- CIMSS-T: Add AIRS T soundings from CIMSS algorithm.
- CIMSS-Q: Add AIRS Q soundings from CIMSS algorithm.
- CIMSS-TQ: Add both AIRS T and Q soundings from CIMSS algorithm.

Figure 14.8.1 shows the track (upper panel) and sea level pressure (lower right panel) analysis from CTL, CIMSS-T, CIMSS-Q, and CIMSS-TQ along with the observation. The track errors are shown in the lower left panel. From the upper and lower left panels it can be seen that the combined temperature and moisture soundings provide the best analysis over either the temperature soundings alone or the moisture soundings alone. Either temperature soundings alone or moisture soundings alone performs better than the control run. The temperature soundings play a more important role than the moisture soundings in the track analysis for this particular case. For the sea level pressure analysis (lower right panel), it can be seen that the temperature soundings alone, the moisture soundings alone and the combination of temperature and moisture soundings all improve the control run in general, however, the moisture soundings alone provide the best sea level pressure analysis in this particular case. The reason why the moisture soundings alone perform better than the combined temperature and moisture soundings is still under investigation. This work is a collaboration between UW-Madison CIMSS and NCAR (Dr. Hui Liu). This study demonstrates the positive impact of AIRS SFOV soundings on the hurricane track and intensity analysis. The next step is to evaluate the operational AIRS soundings.

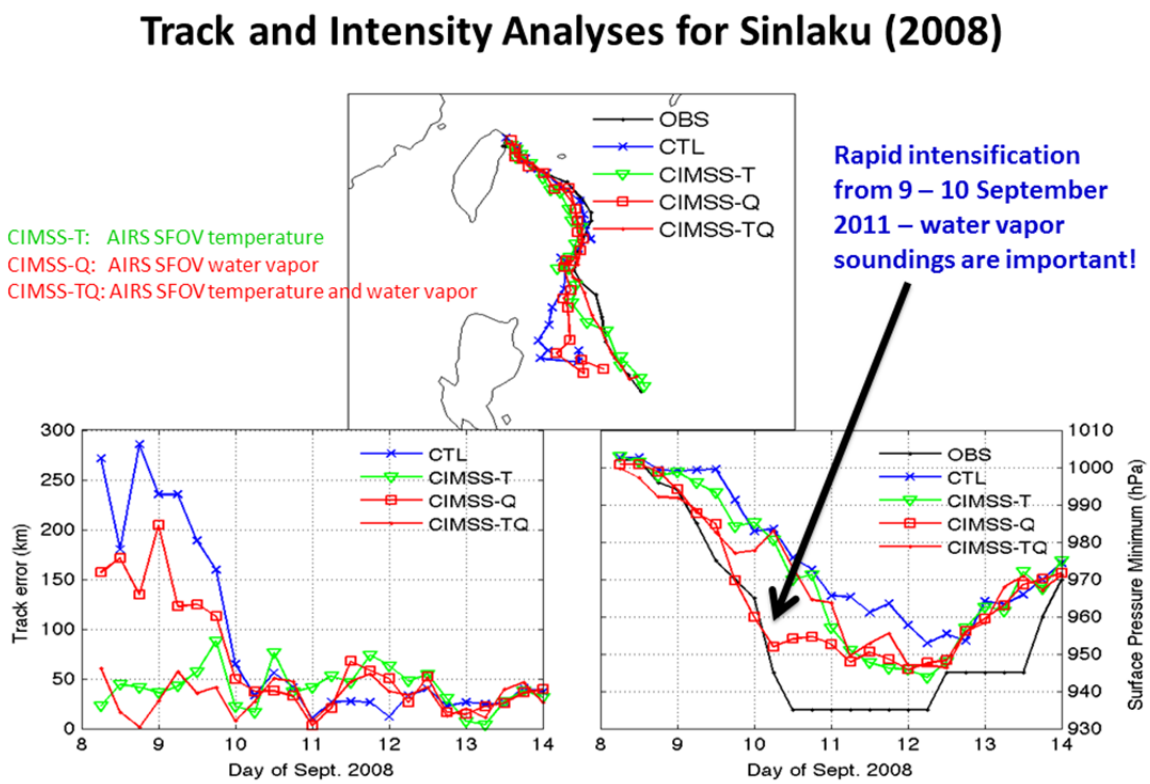

Figure 14.8.1. The track (upper panel) and sea level pressure (lower right panel) analysis from CTL, CIMSS-T, CIMSS-Q, CIMSS-TQ along with the observation, and the track errors from analysis (lower right panel).

Publications and Conference Reports

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14.9 ARM Site Support

CIMSS Task Leader: David Tobin
CIMSS Support Scientists: Lori Borg, Robert Knuteson
NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

The basic philosophy of the proposed validation work is straightforward. It is to collect relatively small ensembles of high quality research-grade validation data which are collocated in time and space with the satellite measurements, to fully understand the characteristics of the validation data, and to then to use direct comparisons of the satellite and validation data to assess the accuracy of the satellite products. Because the validation measurements are well characterized and the data are collected on a routine basis from various sites, the resulting ensembles are representative, statistically significant, and of high accuracy. This method has been found to be complimentary to other validation approaches, such as the use of larger ensembles of poorer quality validation data (e.g., the national radiosonde network) or much smaller ensembles of higher quality data (e.g., dedicated aircraft campaigns).

A significant portion of the proposed effort is the production and improvement of the ARM site atmospheric state best estimates for NPP profile validation. Best estimates of vertical profiles of atmospheric pressure, air temperature, water vapor concentration, and surface parameters are produced for satellite overpasses of the ARM sites using ARM and other data. This section includes a brief introduction to the ARM sites included in this effort, a description of what data are used and how the best estimate products are created, a discussion of the accuracy and statistical significance of the products for AIRS temperature and water vapor profile retrieval validation, and a summary of the proposed continuation effort. A detailed description of the ARM best estimate efforts, and their use in assessing the AIRS temperature and water vapor retrievals, is provided in Tobin et al., 2006.

Proposed work for this year before NPP launch includes two major components: 1) the assessment of ARM site sensors and measurements for use in the ARM site best estimate products, and 2) refinement of ARM site sonde launch strategies. Since it has been some time since performing these efforts, item number 1 will be aimed at ensuring the data flow and characterization of key sensors used in this effort, including radiosondes, microwave radiometers, AERI retrievals, and GOES observations. Item 2 is necessary to account for any differences in the ARM site costs of launching the satellite overpass radiosondes and the available budget in the next funding cycle. We anticipate the first radiosonde launch campaign to begin approximately three months after NPP launch, pending instrument performances.

Summary of Accomplishments and Findings

Efforts this year have focused on coordinating and developing plans for the upcoming ARM site efforts. We now have a plan in place, which is described further below. Other efforts include getting sample proxy CrIMSS EDR data files and interfacing our validation analysis software with those files.

Coordinated ARM Site Efforts for Validation of NPP CrIMSS EDRs (March 2011)

This section summarizes the planned efforts to use Atmospheric Radiation Measurement (ARM) field sites for the validation of NPP/JPSS CrIMSS EDR products. This project is a coordinated effort involving ARM, UW-Madison, and the JPPS project. In this arrangement, radiosondes are launched from the ARM sites coincident with the satellite overpasses of the sites, and analysis is performed by UW-Madison personnel to compare the radiosonde and CrIMSS EDR products to assess the accuracy of the satellite products. This effort follows very closely similar efforts that were performed for AIRS on the NASA Aqua satellite. Further science justification and details of the approach for this effort are described in detail in Tobin et al. (2006).

Scope of Planned ARM Site Radiosonde Launch Efforts

The ARM effort involves launching Vaisala RS-92 radiosondes from three of the ARM field sites, including the Southern Great Plains (SGP), North Slope of Alaska (NSA) and Tropical Western Pacific (TWP) Manus island sites. At the SGP and NSA sites, we aim to collect coincident validation data for 90 NPP satellite overpasses of each site per year, with two radiosonde launches per overpass, resulting in 360 radiosonde launches per year. At the TWP site, we will launch one radiosonde per overpass for 90 overpasses. The total number of launches is 450. The first set of radiosonde launches are expected to begin approximately 3 months after NPP launch (currently scheduled for 25 October 2011). This effort is anticipated to be conducted throughout the NPP mission life into FY15. The seasonality of the radiosonde launches will vary from year to year to sample a range of atmospheres at each site.

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14.10 Algorithm Development Library

CIMSS Task Leader: Liam Gumley
CIMSS Support Scientists: Scott Mindock, Geoff Cureton, Ray Garcia, Graeme Martin
NOAA Collaborator: Richard Ullman
NOAA Strategic Goals Addressed

- Serve society's needs for weather and water

CIMSS Research Themes

- Weather Nowcasting and Forecasting

Proposed Work

SSEC proposes to become a member of the ADL Team in cooperation with IPO and Raytheon, and to contribute to the following specific areas of the ADL effort:

1. Porting of additional algorithms to ADL, including (but not limited to) VIIRS Cloud EDRs, CrIS SDR, and CrIMSS EDR;
2. Adapting ADL ported algorithms to work in NPP Direct Broadcast mode;
3. Testing algorithms ported to ADL by other parties including Raytheon;
4. Providing ADL distribution, installation, and operation support to end users (including the NPP Direct Broadcast community); and
5. Providing ADL training to end users.

Summary of Accomplishments and Findings

During the reporting period, SSEC received the ADL version 2.0 distribution DVDs from Raytheon. Within the space of two weeks, SSEC created and published a Web site for authorized users to download the ADL package and associated data files and documentation:

https://jpss.ssec.wisc.edu/adl/

In addition, SSEC created a user forum for the ADL user group, which is now available at

https://forums.ssec.wisc.edu/viewforum.php?f=23

Several members of the CIMSS/SSEC ADL team built the ADL v2.0 package from source code using the instructions supplied by Raytheon. A variety of Linux host platforms, operating systems, and compilers were used. It was found that the ADL install and build process could be somewhat complicated for those who are not Linux experts, due to the multiple prerequisite software packages needed by ADL. In order to simplify and automate the build process, bash scripts were created to:

- Download all required prerequisite software,
- Build all required prerequisite software,
- Build the ADL software,
- Configure the ADL environment,
- Download and install the ADL v2.0 test data, and
- Execute the ADL v2.0 test suite.

These scripts make it much easier for an end user to install ADL, and they are now provided in the download area of the CIMSS/SSEC ADL Web site.

To support users of ADL who either (a) do not have a Linux system, or (b) do not have the necessary permissions to install the required prerequisite software on their Linux computer, or (c) find it more convenient to use a Windows or Apple computer as their environment for running ADL, CIMSS/SSEC has developed and released an ADL Virtual Appliance (VA). The ADL VA is implemented in the form of a VMware virtual machine running Fedora Linux v14 64-bit. Inside the VA, ADL and all the prerequisite software have been installed and are ready to run. The user simply needs to:

- Run a script to download and install the ADL v2.0 test data, and
- Run a script to execute the ADL v2.0 test suite.

The ADL VA is supported on Microsoft Windows 7, Vista, and XP; Apple OS X, and Intel Linux host platforms. The freely available VMware Player application is required to run the ADL VA on Windows and Linux, while VMware Fusion is required on Apple platforms. If the ADL VA user wishes to run the VIIRS RDR/SDR algorithms, then at least 6GB of RAM must be available to the ADL VA. The ADL VA has been successfully tested by several Windows users at NOAA, and at the JPSS project. It has proven to be a very successful way for users to quickly install and run the ADL v2.0 system in a complete development environment, where they can learn about and experiment with the IDPS PRO algorithms.

Since all input and output files in ADL v2.0 are stored in binary BLOB format (Raytheon is adding HDF5 file I/O for ADL v3.0), CIMSS/SSEC developed a set of Python scripts for ingesting and decoding the BLOB files. The main Python script (adl-blob.py) creates a structure in memory containing the decoded contents of the BLOB file, using the XML files provided in ADL to describe the BLOB format. This approach provides an easy way to provide developers with access to the numerical values of the different fields in the BLOB files. For example, CIMSS/SSEC developers have been able to use the GLANCE tool developed at SSEC for comparing similar datasets to inspect the contents of the RDR, SDR, and EDR level BLOB files delivered with ADL v2.0 by Raytheon, and compare them to the equivalent BLOB files created in ADL when it is run locally.

CIMSS/SSEC is provided all locally-developed ADL resources via the ADL Web site and ADL forum, and via an in-house ADL groups on the CIMSS/SSEC groups server. CIMSS/SSEC has also provided support to a number of ADL users at NOAA on issues related to ADL installation.

CIMSS/SSEC has begun to develop a set of requirements and specifications for real-time ingest and preprocessing of the ancillary data required by the algorithms in ADL. Applying experience developed over the last 10 years in supporting real-time users of MODIS algorithms in IMAPP, CIMSS/SSEC is designing a system that will:

- Determine automatically the date and time of the granule being processed in ADL,
- Check the local disk for the required native format ancillary data,
- Download the required native format ancillary data if required from a SSEC HTTP or FTP site,
- Preprocess the native format ancillary data into the format required by ADL,
- Invoke ADL gridding and/or granulation processing, and
- Supply the processed ancillary data to the science algorithm.

SSEC hosted a meeting of the ADL team at UW-Madison in January 2011.

14.11 International Polar Orbiting Processing Package (IPOPP) for Direct Broadcast Users

CIMSS Task Leaders: Allen Huang, Liam Gumley
CIMSS Support Scientists: Geoff Cureton, Ray Garcia, Graeme Martin, Nadia Smith
NOAA Collaborator: Richard Ullman
NOAA Strategic Goals Addressed

- Serve society's needs for weather and water

CIMSS Research Themes

- Weather Nowcasting and Forecasting

Proposed Work

CIMSS/SSEC proposes to adopt the algorithms provided by NPP/JPSS of U.S. and EUMETSAT of European Union and to extend it in IPOPP. CIMSS/SSEC will partner to provide standard SDR, and EDR products from VIIRS, CrIS, and ATMS in a DB environment. CIMSS/SSEC will also develop value added services to:

1. Support North American real-time regional users;
2. Add value to the standard products including regionally optimized/unique and specialty/synergistic products;
3. Expand and leverage NOAA GOES-R proving ground effort in demonstrating operational use of MODIS/AIRS/AMSU (proxy of VIIRS/CrIMSS) and IASI/AMSU (proxy of CrIS and ATMS) polar orbiting products for convective storm initiation, severe weather, environmental hazard, aviation safety and other time critical real-time demanding monitoring and forecasting applications;
4. Provide continuous calibration/validation & evaluation support;
5. Engage the global direct broadcast community in the NPP/JPSS mission;

6. Leverage other ongoing efforts to implement METOP IASI/AVHRR/AMSU visible, infrared and microwave imager and sounder SDR L1 and EDR L2 processing algorithms;
7. Modernize in house Direct Broadcast Processing System (DBPS) using evolving virtual appliance and high performance computing (HPC) technology (such as GPU) to achieve efficient, easy to understand, configure, maintain, and expand for the end user, especially for the demanding real-time applications; and
8. Develop and support real-time applications in air quality, short term regional weather forecast, and others such as aviation safety, and fire management .

Summary of Accomplishments and Findings

Virtual Appliance technology for direct broadcast applications continued to be improved and enhanced with the addition of several new features to the IMAPP Virtual Appliance (VA). The IMAPP VA is a prototype of the processing system that will be released by CIMSS/SSEC to support NPP/JPSS direct broadcast users. New features were added to the IMAPP VA:

- MODISL1DB updated to version 1.7. This new version of the MODIS geolocation and calibration software fixes a persistent problem with direct broadcast processing, where invalid geolocation data are created for large vertical stripes in a DB pass. This new version also brings DB users into line with the latest MODIS calibration lookup table updates being used operationally by NASA.
- SeaDAS updated to version 6.2. This version brings the MODIS Level 2 ocean product generation algorithms up to date with the latest versions being used by NASA.
- User defined processing was added to the IMAPP VA. This feature allows a user to easily add their own locally developed algorithm to the VA processing system. This feature was demonstrated by the CIMSS/SSEC Volcanic Ash team, when they deployed the IMAPP VA on their own Linux system to process MODIS direct broadcast data from Alaska. The MODIS Volcanic Ash retrieval software was incorporated into the VA processing system in less than a day, and is now supporting GOES-R Proving Ground activities.

Planning commenced at SSEC for the procurement and installation of a new polar orbiter direct broadcast reception system. While the existing X-band antenna at SSEC remains fully operational, it is not capable of receiving data from other current and future polar orbiting satellites that are of interest to CIMSS/SSEC. With this in mind, CIMSS/SSEC has prepared a set of requirements for a dual X/L-band antenna with a diameter of approximately 2.4 meters, and the appropriate feeds, demodulators, and associated hardware to allow direct reception of Level 0 data from Terra, Aqua, NPP, JPSS-1, POES, Metop, FY-1D, FY-3A, and FY-3B. Release of a request for bids is imminent, and initial site location surveys have been conducted. The primary candidate for installing the new system will be the Engineering Research Building on the UW-Madison campus. Selection of a vendor for the new system is expected by the end of May 2011.

The JPSS Common Ground System Algorithm Development Library (ADL) version 2.0 was received at CIMSS/SSEC in Dec. 2010. Developed by Raytheon, ADL is an environment that allows NPP/JPSS IDPS PRO operational algorithms to run on little-endian Linux platforms outside the IDPS environment. The algorithms in ADL (limited to VIIRS and ATMS in ADL v2.0) are exactly the same as the algorithms running in IDPS, since ADL and IDPS share a common source code management system. CIMSS/SSEC has started examining ADL to determine what features will need to be added to make it compatible with real-time NPP direct broadcast processing. Some of the specifications of ADL v2.0 relevant to real-time direct broadcast are as follows:

- Runs on Red Hat Intel Linux (64-bit is required for VIIRS RDR/SDR),
- Compatible with GNU gcc/g++/gfortran compilers,

- Granule sizes are consistent with IDPS (e.g., 80 seconds for VIIRS),
- File input and output is via binary large objects (BLOBs),
- Processing is via individual algorithms (algorithms are not chained together), and
- Ancillary data ingest is not included.

CIMSS/SSEC has been working on several areas related to making ADL compatible with real-time direct broadcast processing (particularly for VIIRS), including:

- Testing the package on freely available Linux distributions (e.g., CentOS, Fedora);
- Automating the ADL installation and build process;
- Creating specifications and a design for a VIIRS SDR granule aggregator (by time and band);
- Creating Python scripts for ingesting and decoding binary BLOB files;
- Creating Python scripts for visualizing VIIRS and CrIS RDR, SDR, EDR, IP, and ancillary data;
- Designing prototypes for simple algorithm chaining that do not require additional complicated software systems, such as SQL databases, XML files, or Java code; and
- Creating specifications and a design for an ancillary data ingestor and preprocessor for ADL that does not require the IDPS Ingest subsystem.

In order to support real-time true color image creation from VIIRS, MODIS, and MERSI, CIMSS/SSEC has developed a Multi-sensor Image Processing System (MIPS). This system allows a user to create high resolution (up to 250 meters/pixel) imagery over user-specified regions in real-time from MODIS, MERSI, and in the coming months VIIRS. It is designed to be simple to install, configure, and operate in automated mode, and image products are created in JPEG, GeoTIFF, and KML. The system runs on Intel Linux host computers, and all source code is included and freely available. Public release of the first version of MIPS is expected in Q3 2011.

15. NPP/NPOESS Cryospheric Products Calibration & Validation Activities

CIMSS Task Leader: Xuanji Wang
CIMSS Support Scientist: Yinghui Liu
NOAA Collaborator: Jeff Key
NOAA Strategic Goals Addressed

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

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) (to be launched in October 2011) and afternoon overpass Joint Polar Satellite System (JPSS, formerly NPOESS) platforms will each carry the 22-band Visible/Infrared Imager/Radiometer Suite (VIIRS). Data from VIIRS will be used operationally to generate a suite of land and cryosphere products, including Environmental Data Records (EDRs), Application Required Products (ARPs) and Intermediate Products (IPs). This project is the cryosphere portion of the Land and Cryosphere Validation Plan. Our objective is to evaluate the accuracy of VIIRS algorithms for snow and ice products, increase our understanding of their limitations, and suggest improvements where appropriate. This project is reducing risk and assuring a successful transition from current polar orbiting operational environmental satellites to the future system. Each of the multiple data products, including ice surface temperature, surface albedo over snow/ice, ice age/thickness, and an ice concentration intermediate product, requires a validation strategy, effort and investment. The proposed work is being done in collaboration with Dr. James Maslanik, University of Colorado-Boulder, who is funded separately.

Summary of Accomplishments and Findings

The project started in June 2009. This report covers the period from July 1, 2010 to March 31, 2011. During this period, validation datasets were acquired. These datasets include AVHRR-derived APP-x data (surface temperature); NCEP reanalysis (surface temperature); buoy observations from the International Arctic Buoy Programme (surface temperature); AMSR-E passive microwave imagery for ice concentration and extent; National Ice Center charts; high spatial resolution data from Landsat; upward-looking submarine sonar from Scientific Ice Expeditions (SCICEX); in situ ice thickness and on-ice snow depth measurements from the Canadian Ice Service; and ice draft data from the Beaufort Gyre Exploration Project.

Validation datasets also include products generated with our own algorithms for ice age and thickness (One-dimensional Thermodynamic Ice Model (OTIM), Wang et al., 2010), surface temperature data (Key and Haefliger 1992), and ice concentration. These products have been validated with collocated in situ observations and other satellite observations. Results show high accuracy and high precision of these products (Table 15.1 and 15.2). These products are ready to be compared to NPP/NPOESS products using the VIIRS proxy data from NPP-Land PEATE.

MODIS swath data have been acquired corresponding to dates used by Northrop Grumman Aerospace Systems (NGAS), which developed the algorithm for NPP. In-house algorithms have been applied on these swath data to produce ice surface temperature, ice cover and concentration, ice thickness and ice age. Products from NGAS and from our own algorithm have been compared (Figure 15.1). We continue to work with NGAS (R. Mahoney) on algorithm issues.

Products based on VIIRS proxy data (from MODIS) were generated by the NPP Land PEATE, and have been downloaded. A problem that we recently detected in the PEATE code has been corrected. Validation of these products with in situ observations and other satellite products is ongoing.

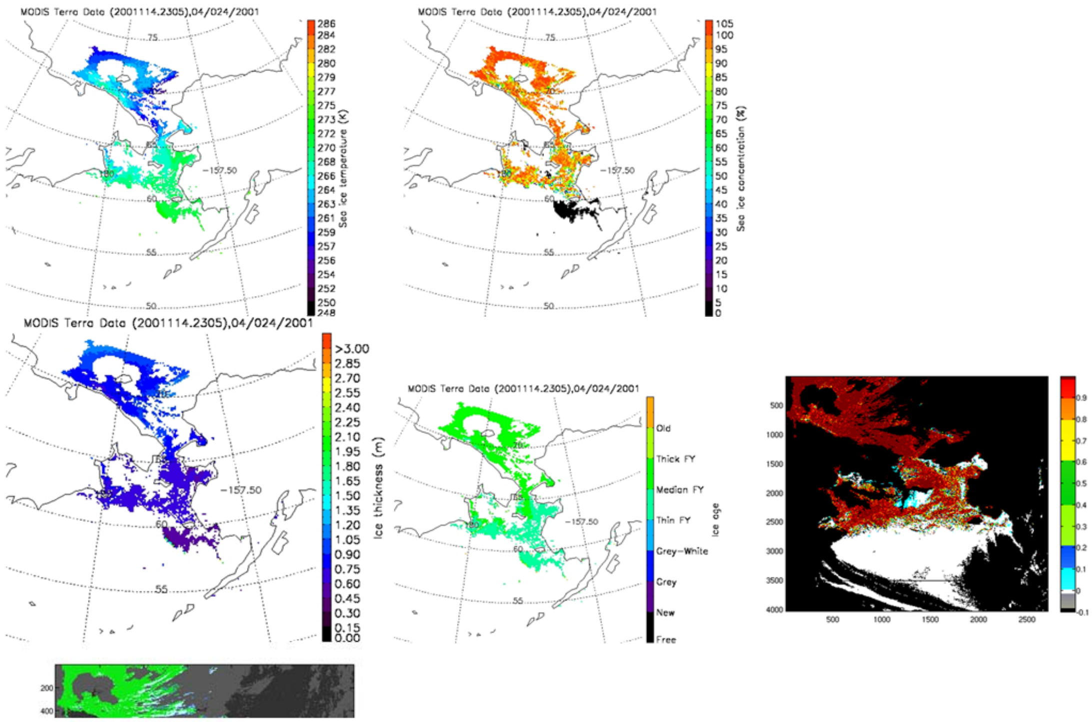


Figure 15.1. Sea ice surface temperature, concentration, thickness (top panel, left to right), and age (left bottom panel) from our OTIM algorithm, and sea ice concentration and age (middle and right bottom panel) from NGAS.

Table 15.1. Performance of retrieved ice concentration using our own algorithm with those from AMSR-E.

Ice concentration difference of AMSR-E product and MODIS product as proxy	Mean bias (%)	Standard Deviation (%)
Over Arctic Ocean	4.0	15.7
Over Great Lakes	-4.0	25.6

Table 15.2. Comparison of OTIM derived Ice Thickness with Submarine and Moored ULS measurements, and station measurements.

In situ Measurements and OTIM	Thickness mean (m)	Bias (m)	Accuracy (%)
Submarine	1.80	-0.07	96
OTIM	1.73		
Mooring Sites	1.29	-0.09	93
OTIM	1.20		
Stations	1.31	-0.11	91
OTIM	1.20		
All	1.47	-0.09	94
OTIM	1.38		

Publications and Conference Reports

Wang, X., J. R. Key, and Y. Liu, 2010: A thermodynamic model for estimating sea and lake ice thickness with optical satellite data. *J. Geophys. Res.*, Vol. 115, C12035, 14 PP., 2010, doi:10.1029/2009JC005857.

Liu, Y., J. R. Key, and X. Wang, 2009: The influence of changes in sea ice concentration and cloud cover on recent Arctic surface temperature trends. *Geophys. Res. Lett.*, doi:10.1029/2009GL040708, 2009.

Wang, X., J. R. Key, and Y. Liu, 2010: A thermodynamic model for estimating sea and lake ice thickness with optical satellite data. *J. Geophys. Res.*, Vol. 115, C12035, 14 PP., 2010, doi:10.1029/2009JC005857.

References

Key, J. and M. Haefliger, 1992: Arctic ice surface temperature retrieval from AVHRR thermal channels. *J. Geophys. Res.*, 97(D5), 5885-5893.

Wang, X., J. R. Key, and Y. Liu, 2010: A thermodynamic model for estimating sea and lake ice thickness with optical satellite data. *J. Geophys. Res.*, Vol. 115, C12035, 14 PP., 2010, doi:10.1029/2009JC005857.

16. VIIRS Cloud Studies for the Joint Polar Satellite System (JPSS)

CIMSS Task Leader: Richard Frey
CIMSS Support Scientist: Andi Walther
NOAA Collaborator: Andrew Heidinger

NOAA Strategic Goals

- Serve society's needs for weather and water
- Understand climate variability and change to enhance society's ability to plan and respond
- Support the nation's commerce with information for safe, efficient and environmentally sound transportation
- Provide critical support for the NOAA mission

CIMSS Research Themes

- Satellite Meteorology Research and Applications
- Satellite Sensors and Techniques

Proposed Work

The Joint Polar Satellite System (JPSS) will fly a Visible Infrared Imaging Radiometer Suite (VIIRS) instrument. VIIRS will serve as the primary meteorological vis/nir/ir imager on JPSS. The CIMSS cloud group supports the JPSS VIIRS Cloud Remote Sensing Program in many ways. The CIMSS group provides its expertise in the MODIS cloud detection to the VIIRS contractors (NGAS) as they develop the official VIIRS cloud mask (VCM).

The CIMSS cloud group is also undertaking efforts to develop alternative algorithms to those from NGAS. These are needed in order to validate the NGAS approaches in the context of the NOAA/NASA heritage methods. In addition these algorithms can also serve as backups if needed.

Lastly, the CIMSS team serves on the JPSS Cal/Val teams and offers leadership to the JPSS application teams. They play a large role in providing government and academia expertise in solving issues as they arise.

Summary of Accomplishments and Findings

Over the past year, this project has made the following notable accomplishments:

- Generated VIIRS Lookup Tables for the Daytime Cloud Optical and Microphysical Properties (DCOMP) which generates the cloud optical depth and particle size;
- Provided DCOMP tables to NGAS (the official VIIRS contractor);

- Developed VIIRS version of GOES-R ABI Cloud Height Algorithm;
- Developed VIIRS version of PATMOS-x Bayesian Cloud Mask;
- Implemented VIIRS algorithms on MODIS/AQUA;
- Made Prototype Google Earth visualizations (see Figure 16.1);
- Began global analysis and testing of NGAS VCM daytime tuned MODIS thresholds; and
- Participated in scene selection and manual analysis of test scenes for VCM nighttime threshold tuning exercise.

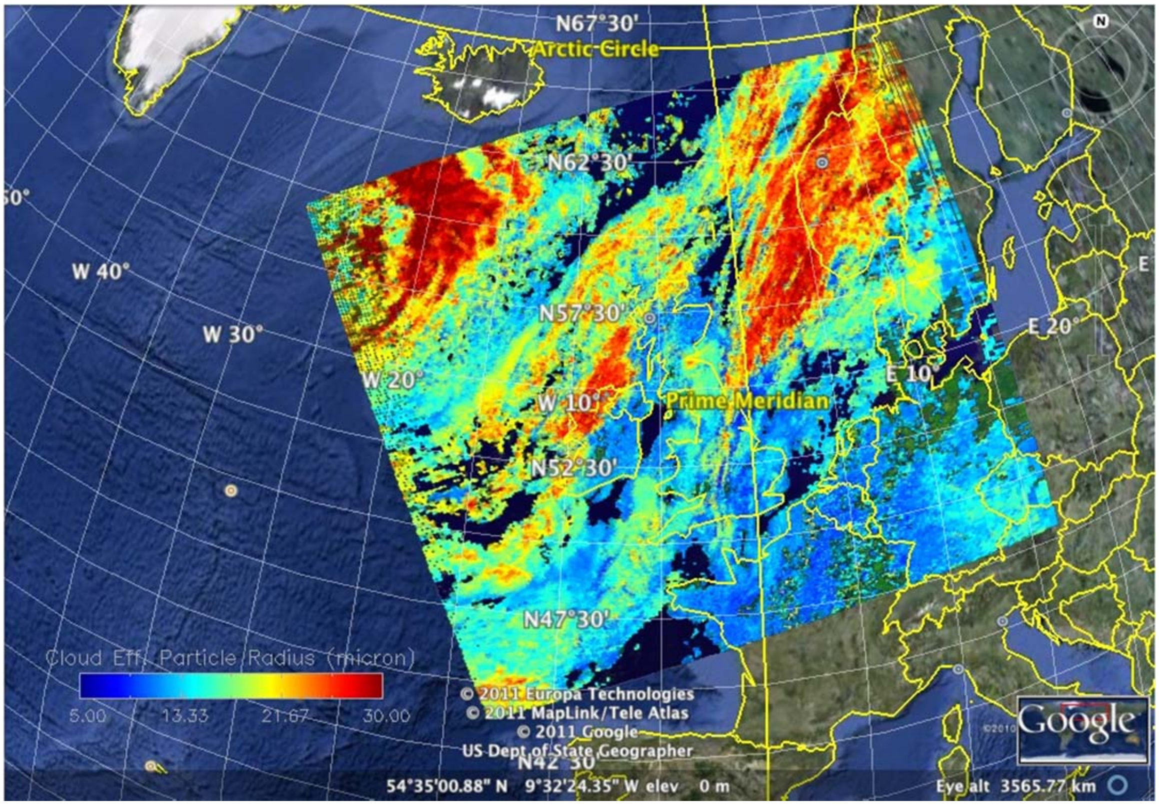


Figure 16.1. This image was generated by apply the NOAA-AWG VIIRS algorithms to data from the NASA AQUA/MODIS sensor. While MODIS provides more channels than VIIRS, only the channels that are present on MODIS are used. The product shown here is the Cloud Effective Particle Radius (micron) generated by the DCOMP algorithm. DCOMP was initially developed for GOES-R.

VIIRS Cloud Mask Testing and Development

Validation and testing of NGAS VIIRS Cloud Mask (VCM) daytime "tuned" thresholds was begun. The updated thresholds were implemented in the CIMSS LEOCAT version of the VCM science software and tested on a global day of MODIS proxy input data. The results were generally favorable; however, two areas of concern were noted, namely deserts and sun-glint regions. The VCM is designed to switch from a cloud test using 0.672 μm (M5) reflectances to one using 0.412 μm (M1) reflectances when moving from mostly vegetated to mostly non-vegetated surfaces. A top of canopy NDVI value of 0.2 is used to determine where the switch is made. This threshold may need adjusting as many sparsely vegetated areas have false cloudiness due to use of the M5 rather than the M1 test. In addition, a 3.7-4.0 μm (M12-M13) BTD test that should not be applied is causing false cloudiness in the same sparsely vegetated regions.

In many areas characterized by sun-glint, there is a noticeable decrease in detection of relatively warm, cumuliform clouds. This decrease may be mitigated to a certain extent by use of I-band variability tests that cannot be simulated using MODIS proxy data.

CIMSS VCM science software has been submitted to the Atmosphere PEATE that will process four complete months of MODIS proxy data. Collocation with CALIOP cloud mask data will be used to assess seasonal dependencies and detection of systematic errors that may not be apparent in a one-day analysis. This data will also be useful for validation of the daytime tuned thresholds.

Publications and Conference Reports

Walther, A., A. K. Heidinger and M. J. Foster, 2011: Application of DCOMP in the PATMOS-x dataset. Submitted to *JAMC*, March 2011.

Appendices

Appendix 1: List of Awards to Staff Members

2011

Andrew Heidinger: NOAA Employee of the Month for the first delivery of an externally-generated climate data record to NCDC as part of their CDR program

Justin Sieglaff: NOAA-CIMSS Collaboration Award "For providing near real-time volcanic ash information in the critical period following the eruption of the Eyjaafjallajokull volcano"

William Straka III: NOAA-CIMSS Collaboration Award "For developing an enhanced production system for satellite-based real-time radiation data from NOAA’s operational geostationary satellites"

2010

Thomas Achtor and Wayne Feltz: 2010 University of Wisconsin Police Department Community Service Award for Providing Weather Forecasts for Special Events in Camp Randall Stadium

Steven Ackerman: NASA Exceptional Public Service Medal

Steven Ackerman and Tom Whittaker: Finalist in NSF International Science and Engineering Visualization Challenge

Scott Bachmeier: NOAA Team Member of the Month for his efforts to improve public awareness of NOAA satellite applications, both for the general public and for NOAA

Kaba Bah: Best Poster Presentation at the 35th National Weather Association Annual Meeting for “Preparation for use of the GOES-R Advance Baseline Imager (ABI)”

Jordan Gerth: Wisconsin Space Grant Consortium Graduate Fellowship Award

Andrew Heidinger: Department of Commerce Bronze Medal: “For developing an enhanced production system for satellite-based, real-time radiation data from NOAA's operational geostationary satellites”

Michael Pavolonis: Department of Commerce Bronze Medal: “For providing near real-time volcanic ash information in the critical period following the eruption of the Eyjafjallajökull volcano”

Appendix 2: Publications

The tables below show the number of papers on which CIMSS and ASPB scientists were first author (Table 1) or contributors (Table 2) to peer reviewed journal articles and non-reviewed articles. Note that data for 2011 is incomplete.

A separate listing of publications of the Advanced Satellite Products Lab (ASPB) is available at: http://library.ssec.wisc.edu/resources/aspb/aspb.php .

Table 1:
Peer Reviewed and Non Peer Reviewed journal articles having CIMSS and/or NOAA lead authors, 2009-2011.* Publications are categorized by Institute, NOAA and Other Lead Author.

	Institute Lead Author			NOAA Lead Author			Other Lead Author		
	2009	**2010**	**2011***	**2009**	**2010**	**2011***	**2009**	**2010**	**2011***
Peer Reviewed	16	19	5	7	8	0	44	30	8
Non Peer Reviewed	1	3	0	1	0	0	0	1	0

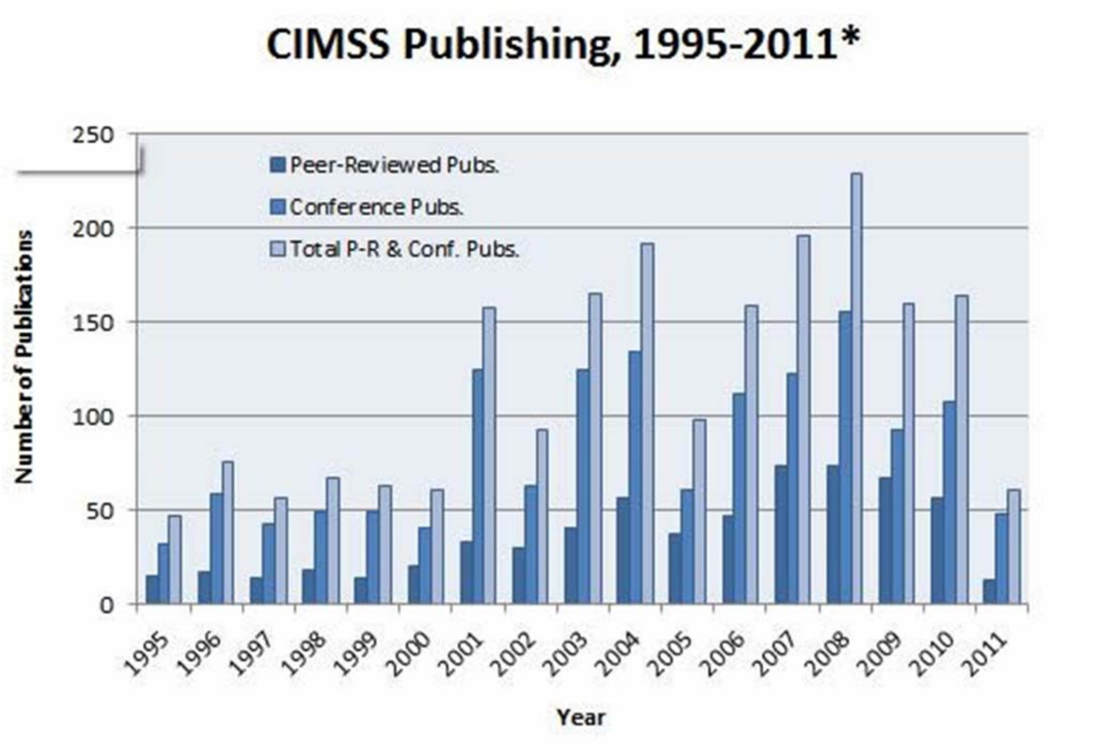
*2011 incomplete: does not include papers submitted for publication, accepted for publication, or those in review.

Table 2:
Peer Reviewed and Non Peer Reviewed journal articles having one or more CIMSS and/or NOAA Co-Authors, 2009-2011.

	Institute Co-Author			NOAA Co-Author		
	2009	**2010**	**2011***	**2009**	**2010**	**2011***
Peer Reviewed	52	39	14	20	19	4
Non Peer Reviewed	2	0	0	0	0	0

*2011 incomplete: does not include papers submitted for publication, accepted for publication, or those in review.

Table 3:
CIMSS Publishing History, showing peer reviewed and conference publications.



*2011 incomplete: does not include papers submitted for publication, accepted for publication, or those in review.

Appendix 3: Employee Information

CIMSS Staff and Student Hours on NOAA Cooperative Agreement Projects

July 2010 through March 2011

Name	Title	Hours	% Time
Jung, James	Scientist I	1,312.0	100%
Foster, Mike	Researcher I	1,156.0	88%
Stettner, David	Researcher I	884.0	67%
Vasys, Egle	Executive Assistant	723.0	55%
Pasowicz, Daniel	Student, Undergrad	702.1	53%
Bachmeier, Anthony	Researcher II	672.0	51%
Oo, Min Min	Scientist, PostDoc	613.3	47%
Borbas, Eva	Asst. Scientist	612.0	47%
Dengel, Russell	Computer Programmer III	582.0	44%
Plokhenko, Youri	Researcher III	532.4	41%
Frey, Richard	Computer Programmer III	454.2	35%
Gerth, Jordan	Graduate Student	450.0	34%
Brunner, Jason	Researcher I	448.0	34%
Park, Chang Hwan	Researcher I	448.0	34%
DeSlover, Daniel	Researcher II	444.0	34%
Schreiner, Anthony	Researcher III	400.0	30%
Sieglaff, Justin	Researcher I	379.0	29%
Monette, Sarah	Student, Graduate	360.0	27%
Smith, Nadia	Researcher I	336.0	26%
Sorce, Ashley	Student, Undergrad	335.0	26%
Jasmin, Tommy	Computer Scientist II	314.0	24%
Cureton, Geoffrey	Computer Scientist II	304.0	23%
Liu, Yinghui	Researcher I	304.0	23%
Strabala, Kathleen	Researcher III	304.0	23%
Cronce, Lee	Researcher I	288.0	22%
Hoffman, Jay	Researcher I	281.0	21%
Gumley, Liam	Researcher III	280.0	21%
Moeller, Christopher	Scientist I	280.0	21%
Smalley, Mark	Student, Graduate	270.0	21%
Mindock, Scott	Computer Scientist II	264.0	20%
Weisz, Elisabeth	Researcher II	256.0	20%
Baum, Bryan	Scientist II	242.0	18%
Schmidt, Christopher	Researcher III	233.5	18%
Hartung, Daniel	Researcher I	224.0	17%
Zheng, Jing	Scientist, PostDoc	216.0	16%
Borg, Lori	Researcher I	195.6	15%
Wang, Xuanji	Scientist, PostDoc	193.3	15%
Li, Jun	Scientist II	172.0	13%
Huang, Bormin	Scientist I	167.0	13%

Otkin, Jason	Researcher II	164.0	12%
Vinson, Kenneth	Student, Graduate	150.0	11%
Tobin, David	Scientist I	144.0	11%
Straka, William	Researcher I	132.0	10%
Knuteson, Robert	Scientist I	124.0	9%
Mooney, Margaret	Outreach Specialist II	115.2	9%
Nelson, James III	Researcher III	104.6	8%
Holz, Robert	Researcher II	104.0	8%
Huang, Hung-Lung	Scientist III	101.1	8%
Achtor, Thomas	Scientist III	100.0	8%
Garcia, Raymond	Computer Scientist III	100.0	8%
Antonelli, Paolo	Researcher II	95.3	7%
Lim, Agnes	Graduate Student	90.0	7%
Rink, Thomas	Computer Scientist I	88.0	7%
Hudson, Rebecca	Student, Undergrad	81.0	6%
Smith, William, Sr	Scientist III	75.0	6%
Martin, Graeme	Computer Scientist I	71.0	5%
Parker, David	Computer Scientist I	69.5	5%
Bearson, Nicholas	Researcher I	68.0	5%
Whittaker, Thomas	Computer Scientist III	58.0	4%
Olander, Timothy	Researcher II	54.0	4%
LaPorte, Daniel	Researcher III	50.0	4%
Bellon, Willard	Data Manager II	46.0	4%
Feltz, Wayne	Scientist I	40.0	3%
Roman, Jocola	Student, Undergrad	30.0	2%
Sitkowski, Matthew	Student, Graduate	30.0	2%
Garms, Elise	Student, Undergrad	29.5	2%
Baggett, Kevin	Computer Programmer II	28.0	2%
Santek, David	Scientist I	20.0	2%
Gjermo, Britta	Student, Undergrad	14.5	1%
Revercomb, Henry	Scientist III	12.0	1%
Spangler, Roseann	Data Center Specialist	10.0	1%
Ratcliff, Douglas	Data Center Specialist	8.0	1%
Ackerman, Steven	Scientist III	7.5	1%
Nolin, Scott	Technical Computing Specialist	7.0	1%
Kohrs, Richard	Researcher II	4.0	0%
Moeller, SzuChia	Researcher II	4.0	0%
Avila, Leanne	Documentation Specialist II	3.0	0%
Smith, Justin	Student, Undergrad	2.0	0%
Lalande, John	Technical Computing Specialist	1.0	0%
	Total Labor Hours	14,289	
	Equivalent full time employees	10.9	

Research Topics of Current CIMSS Graduate Students and Post-Doctors

NOAA Funded Graduate Students

Jordan Gerth
Research studies the impact of varied initial conditions and lateral forcings on numerical weather prediction forecasts, and works heavily on research to operations exercises supporting future National Weather Service use of the Geostationary Operational Environmental Satellite R-Series (GOES-R) as part of a proving ground effort. The goal is to produce better operational forecasts through integrating geostationary satellite imagery and products, particularly indicative of clouds and moisture, into the forecast process.

Erik Janzon
The OSSE (Observing System Simulation Experiment) was conducted to assess the impact a network of ground-based remote sensing profilers would have when assimilated into a NWP model. Current research using the OSSE dataset has been conducted in order to assess the effect of the assimilation on mid-level frontogenesis during a wintertime convective event.

Agnes Lim
Ph.D. Thesis title: "Study of Convective Initiation through Hyperspectral Data and their Assimilation." The aim of this study is to access the impact of assimilating clear and cloud-cleared AIRS radiances at its original resolution. Better quality control on the AIRS data will be developed to check the AIRS data prior to their assimilation. The improved analyses and forecasts will be used to study convective initiation and identifying new indicators for detecting the onset of convective initiation.

Chian-Yi Liu
Ph.D. Thesis title: "Remote Sensing of the Upper Tropospheric State of Storms Using Space-Borne High Spectral Resolution Infrared Measurements". This study addresses the use and handling of clear and cloudy high spectral resolution AIRS IR radiances, and the application of retrieved atmospheric profiles before the genesis of convective storms. The cloud-removal technique, alone with both clear and cloudy sounding retrievals algorithms in AIRS single field-of-view spatial resolution is developed to increase the algorithm capability in pre-storm environment. It is found that a tropospheric low stability is frequently occurred 3- to 6-hour before the convective storm developing, and the use of brightness temperature difference for detecting of tropospheric penetrating convection is effective in detection of deep convection.

Sarah Monette
Current research examines operational uses for an objective overshooting top detection algorithm. Presently working on the employment of an objective overshooting top detection algorithm to various stages of a tropical cyclone, mainly genesis and intensification. In addition, the algorithm has been applied to the likelihood of an airplane experiencing turbulence.

Kathryn Mozer
Research involves the PATMOS-x satellite dataset (1982-2009) created by Andrew Heidinger and comparing low cloud fraction (over the eastern South Pacific) from PATMOS-x, NCAR/ CCSM3.0 (20th century and SRESa1b experiments),and GFDL/CM2.0 (20th century and SRESa1b experiments)to lower tropospheric static stability as described in Klein and Hartmann 1993, calculated from the models and NCEP Reanalysis data. The goal is to determine how well the models compare to the satellite and if LTS is indeed an appropriate diagnostic for low cloud in this region.

Matthew Sitkowski

Ph.D. Thesis title: "The Dynamics and Prediction of Secondary Eyewall Formation." This study utilizes flight-level aircraft data to develop a climatology of intensity and structure changes associated with eyewall replacement cycles. The flight-level data is also used to explore dynamic and physical processes that occur within the inner-core of a hurricane during the formation of a secondary eyewall. An environmental and GOES-based Bayesian algorithm is also developed to predict the likelihood of secondary eyewall formation and the subsequent eyewall replacement cycle that follows.

Students Funded on other projects than NOAA

Brent Maddux

Ph.D. Thesis title: "Analyses of the MODIS Global to Regional Cloud Properties and Uncertainty." This study analyzes the MODIS global and regional cloud property data records. Cloud property histograms and statistics are utilized to characterize the global cloud property fields and attribute systematic errors and biases to their source. In conjunction with the GEWEX Cloud Climatology Comparison working group, this effort will help characterize the MODIS data records for future improvement and potential merger with other satellite data records.

Aronne Merrelli

Ph.D. Thesis title: "Far Infrared Radiation and Cirrus Clouds." This research investigates the potential of high spectral resolution far infrared measurements (100 - 600 1/cm) for ice particle property retrievals, and thus explores a new method for remote sensing of cirrus clouds. Line by line and discrete ordinates radiative transfer codes are used to model ice clouds, and an optimal estimation algorithm is used to evaluate the retrieval and the information content of the infrared spectra.

John Sears

M.S. Thesis title: "Investigating the Role of the Upper-Levels in Tropical Cyclogenesis." Recent studies on genesis have been primarily focused on the lower portions of the troposphere. Utilizing a unique satellite wind data set from a recent field study, this research focuses on the upper level dynamics behind tropical cyclogenesis and seeks to determine the role of the upper levels in facilitating lower level development.

Mark Smalley

M.S. Thesis title: “Effects of spectral response function uncertainties on cloud height retrievals using CO_2 slicing.” The 30 year record of HIRS and MODIS cloud heights has the potential to create a true cirrus cloud climatology. However, inter-instrument biases in retrieved cloud heights due to differing spectral response functions must be addressed when assessing trends or cycles throughout the cloud height record. To estimate these biases in cloud heights retrieved with CO_2 slicing techniques, cloud heights for HIRS and MODIS instruments have been simulated using high spectral resolution measured radiances from AIRS.

William Smith, Jr.

Ph.D. Thesis title: "Using Satellite Data to Improve the Representation of Clouds and their Effects in Numerical Weather Analyses and Forecasts." New cloud products derived from CloudSat and CALIPSO data form the basis for a technique developed to retrieve the vertical distribution of cloud water from passive satellite observations. The technique is applied to GOES data over North America and adjacent oceans and the cloud products ingested into the NOAA Rapid Update Cycle (RUC) assimilation system. The impact of the satellite data on RUC model analyses and forecasts is assessed.

Kenneth Vinson
M.S. Thesis title: "Constraining Predicted Trends in Arctic Methane Release using Satellite Observations." There is a great deal of methane stored in the Arctic, mainly in the form of underwater methane clathrate ices and in frozen peat bogs in areas with permafrost. Predicted warming trends may release a large amount of methane from these sinks. Elevated methane release in the Arctic may already be underway. Measurements from polar-orbiting satellites, in-situ stations, and aircraft campaigns will be used to evaluate recent trends in arctic methane release and to help constrain climate model predictions.

Tim Wagner
Ph.D. Thesis title: "A method for retrieving the cumulus entrainment rate from ground-based observations." An algorithm has been developed to retrieve the cumulus entrainment rate from observations taken by the suite of instruments at the ARM Southern Great Plains site. This enables the development of a robust dataset of entrainment rates that is unconstrained by the limitations of aircraft observations. Analysis shows that the entrainment rate tends to increase throughout the day.

Post Doctors funded on other projects than NOAA

Giuseppe Baldassarre
Ph.D. Thesis title: “A performance analysis of advanced MSG-SEVIRI fire detection algorithms (WF_ABBA and RST_FIRES) over Italy.” Research activities consist of comparing WF_ABBA (Wildfire Automated Biomass Burning Algorithm) and RST_FIRES (Robust Satellite Techniques Fires) fire products with the fire ground truth provided by the Italian State Forestry Department and see the performances of this two satellite techniques.

CIMSS Students and/or Staff hired by NOAA during this period

Jessica Staude, NOAA/NESDIS/ESRL (contractor)

Kathryn Mozer -Short & Associates (working for) Dick Reynolds on NOAA funded work

Appendix 4. CIMSS Subcontracts summary

None.

Appendix 5. CIMSS publications for 2010-2011

Publications of the Cooperative Institute for Meteorological Satellite Studies, 2010-2011* Reviewed and Gray Literature

2011 Reviewed Publications

Bi, Lei; Yang, Ping; Kattawar, George W.; Hu, Yongxiang, and Baum, Bryan A. Diffraction and external reflection by dielectric faceted particles. Journal of Quantitative Spectroscopy and Radiative Transfer v.112, no.2, 2011, pp163-173.

Chen, Xiuhong; Wei, Heli; Yang, Ping; Jin, Zhonghai, and Baum, Bryan A. An efficient method for computing atmospheric radiances in clear-sky and cloudy conditions. Journal of Quantitative Spectroscopy and Radiative Transfer v.112, no.1, 2011, pp109-118.

Ding, Shouguo; Yang, Ping; Weng, Fuzhong; Liu, Quanhua; Han, Yong; van Delst, Paul ; Li, Jun, and Baum, Bryan. Validation of the community radiative transfer model. Journal of Quantitative Spectroscopy and Radiative Transfer v.112, no.2011, pp1050-1064.

Foster, Michael J.; Bennartz, Ralf, and Heidinger, Andrew. Estimation of liquid cloud properties that conserve total-scene reflectance using satellite measurements. Journal of Applied Meteorology and Climatology v.50, no.1, 2011, pp96-109.

Hiley, Michael J.; Kulie, Mark S., and Bennartz, Ralf. Uncertainty analysis for CloudSat snowfall retrievals. Journal of Applied Meteorology and Climatology v.50, no.1, 2011, pp399-418.

Huang, Bormin; Mielikainen, Jarno; Oh, Hyunjong, and Huang, Hung-Lung Allen. Development of a GPU-based high-performance radiative transfer model for the Infrared Atmospheric Sounding Interferometer (IASI). Journal of Computational Physics v.230, no.6, 2011, pp2207-2221.

Li, J.; Li, J.; Otkin, J.; Schmit, T., and Liu, C. Warning information in a preconvection environment from the Geostationary Advanced Infrared Sounding System-A Simulation Study using the IHOP case. Journal of Applied Meteorology and Climatology, v.50, no.3, pp776-783.

Li, Jun; Li, Zhenglong; Jin, Xin; Schmit, Timothy J.; Zhou, Lihang, and Goldberg, Mitchell D. Land surface emissivity from high temporal resolution geostationary infrared imager radiances: Methodology and simulation studies. Journal of Geophysical Research v.116, no.2011, ppdoi:10.1029/2010JD014637.

Otkin, J.A.; Hartung, D.C.; Turner, D.D.; Petersen, R.; Feltz, W.F., and Janzon, E. Assimilation of surface-based boundary layer profiler observations during a cool season weather event using an observing system simulation experiment: Part 1: Analysis impact. Monthly Weather Review

Pandya, Rajul; Smith, David; Ackerman, Steven A.; Brahma, Priti P.; Charlevoix, Donna J.; Foster, Susan Q.; Gaertner, Karl Volker; Lee, Thomas F.; Hayes, Marianne J.; Mostek, Anthony; Murillo, Shirley T.; Murphy, Kathleen A.; Olsen, Lola; Stanitski, Diane M., and Whittaker, Thomas. A summary of the 18th AMS Symposium on Education. Bulletin of the American Meteorological Society v.92, no.1, 2011, pp61-64.

Sieglaff, Justin M.; Cronce, Lee M.; Feltz, Wayne F.; Bedka, Kristopher M.; Pavolonis, Michael J., and Heidinger, Andrew K. Nowcasting convective storm initiation using satellite-based box-averaged cloud-top cooling and cloud-type trends. Journal of Applied Meteorology and Climatology v.50, no.1, 2011, pp110-126.

Xie, Yu; Yang, Ping; Kattawar, George W.; Baum, Bryan A., and Hu, Yongxiang. Simulation of the optical properties of plate aggregates for application to the remote sensing of cirrus clouds. Applied Optics v.50, no.8, 2011, pp1065-1081.

Zhou, Daniel K.; Larar, Allen M.; Liu, Xu; Smith, William L.; Strow, L. Larrabee; Yang, Ping; Schlussel, Peter, and Calbet, Xavier. Global land surface emissivity retrieved from satellite ultraspectral IR measurements. IEEE Transactions on Geoscience and Remote Sensing v.49, no.4, 2011, pp1277-1290.

2011 Gray Literature (Conference papers, presentations, reports, books, book chapters)

Achtor, Thomas; Rink, T.; Jasmin, T., and Whittaker, T. McIDAS-V - Accessing, visualizing and analyzing multi and hyperspectral environmental satellite data. Conference on Interactive Information Processing Systems (IIPS), 27th, Seattle, WA, 23-27 January 2011. Boston, MA, American Meteorological Society (AMS), 2011.

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