The Cooperative Institute for Meteorological Satellite Studies (CIMSS)

Quarterly Report for GOES Improved Measurements and Product Assurance Plan (GIMPAP)

for the period
1 January 2008 to 31 March 2008

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1. Development of GOES Single Field of View (SFOV) cloudy sounding product
Task Leader: Jun Li
NOAA Collaborator: Tim Schmit

1.1. Progress on GOES single field-of-view cloudy sounding algorithm development

A GOES single field-of-view (SFOV) cloudy sounding algorithm is being developed, and preliminary results are encouraging. Since the moisture forecast is often worse in cloudy situations than that in the clear skies, GOES SFOV cloudy soundings can improve the moisture forecast in some cloudy situations, for example, in thin or low clouds.

Unlike the operational GOES retrieval algorithm for clear skies, the GOES SFOV cloudy sounding algorithm (GCSA) starts with a synthetic regression technique. A GOES Sounder cloudy radiative transfer model accounting for molecular absorption, cloud absorption and scattering, has been adapted in the synthetic regression algorithm development for GOES cloudy sounding retrieval. The predictors include 1) the Tb (including the quadratic terms); 2) surface pressure; 3) local zenith angle; 4) observed surface air temperature and moisture if available; 5) the forecast profiles of temperature and moisture. The predictants include 1) profiles of temperature and moisture; 2) skin temperature; 3) cloud optical thickness (COT) at 0.55 µm; and 4) the cloud-top pressure (CTP). The cloudy training data sets are developed in ice and water cloudy situations, and the regression coefficients are generated for water and ice clouds separately.

Preliminary results are encouraging for GOES SFOV soundings in thin cloud situations. Since the GFS forecast model has been able to predict the temperature field well, we focused on cloudy moisture in term of relative humidity (RH) profile and 3-layer precipitable water (PW). The 3-layer PW are integrated precipitable water in Sigma coordinates. PW1 is from the surface to 0.9 (roughly 900 hPa), PW2 is from 0.9 to 0.7 (roughly 900 to 700 hPa), and PW3 is from 0.7 to 0.3 (roughly 700 to 300 hPa). A typical NCEP GFS forecast has a smaller RH root mean square error (RMSE) (around 20%) in the lower atmosphere than that in the middle atmosphere; the upper atmosphere has the largest RH RMS (around 50 %) and bias. Figure 1(a) shows GOES RH RMSE and bias under thin cloud situations. ARM Cart Site RAOBs and collocated GOES SFOV cloudy soundings are included in the statistics. It can be seen that the NCEP GFS forecast has better than average performance (this could be because the 4-times-a-day sounding data are assimilated into the GFS forecast model). Below 500 hPa, the GFS forecast has an RH RMSE around 15 %. Even in the upper atmosphere, the RMSE is around 35 %. The retrieval error pattern remains the same as the first guess except all the magnitude is reduced. At 250 hPa, the improvement of RMSE is largest, about 15 % smaller than the first guess. Going down to the surface, the improvement gets smaller.

Below 700 hPa, it is hard to see any improvement of the RH profile. Below 900 hPa, small improvement is seen again. Figure 1(b) shows the 3 layer PW in Sigma coordinate. As expected, PW3 is improved significantly; both the RMSE and the bias are reduced. PW1 has the same improvement although not as much as PW3. PW2 is not improved in both RMSE and bias.

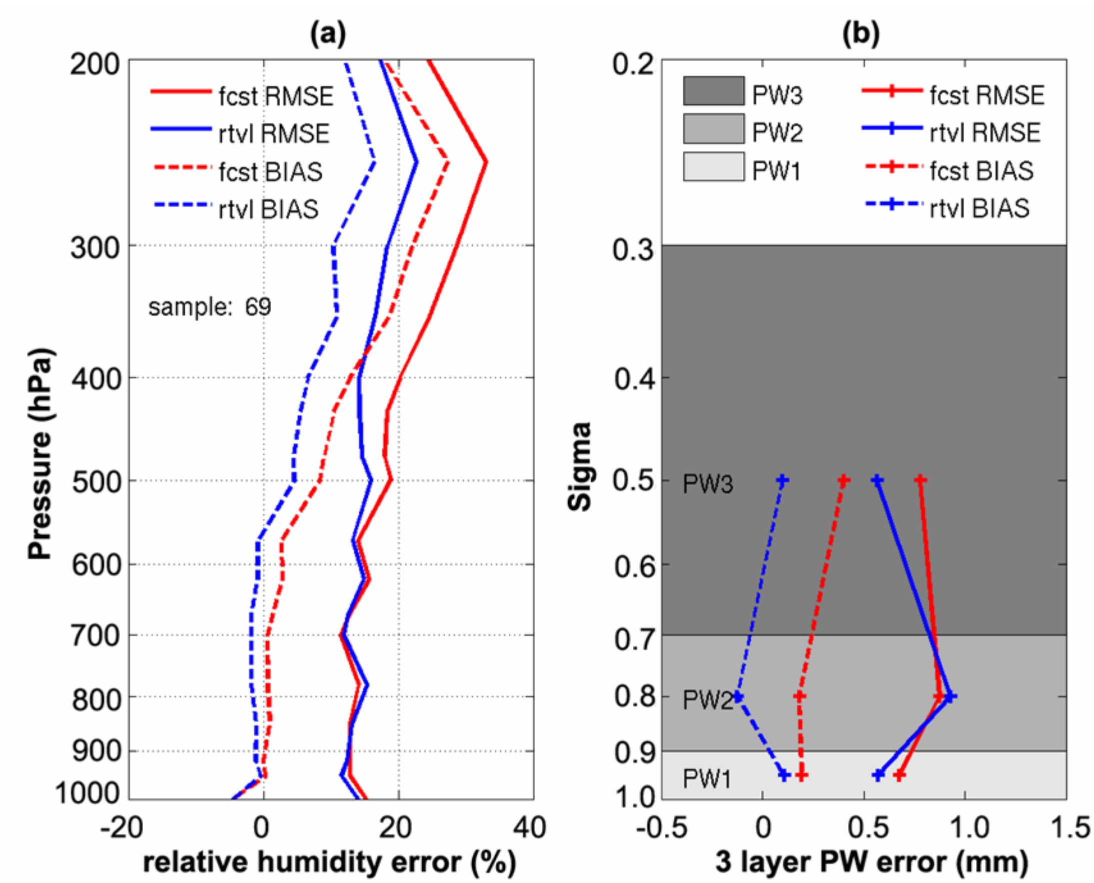


Figure 1. Error and bias profiles of (a) RH and (b) 3 layer PW for thin clouds with retrieved COT less than 2.0.

In this study, we choose the COT of 2.0 as the threshold to determine thin clouds for two reasons. First, our study indicates that when clouds have COT less than 2.0 the retrieval algorithm is able to improve over the forecast profile. Secondly, low water clouds with the same COT are more difficult to retrieve than high ice clouds. Whether the retrieval algorithm is sensitive to cloud parameters depends on the derivative of the radiance to the COT (COT Jacobian). If this value is too small, the COT change does not affect the radiance too much; the retrieval algorithm cannot determine whether the radiance change is due to the COT change or just the noise. Low clouds typically have small brightness temperature contrast between the surface and the cloud top. With the same COT, low clouds and high clouds have a significantly different impact on brightness temperature; usually the sounding retrieval in low cloud situations is less accurate than that in high cloud situations. So the COT of 2.0 is chosen to reduce the bias introduced by relatively thin low clouds.

Our next task is to derive cloudy soundings in low cloud situations. Results from low cloud situations are expected in next quarterly report.

1.2. Manuscript on improved GOES soundings and applications published in Geophysical Research Letters

The manuscript on the GOES single field of view improved sounding algorithm and applications has been published in Geophysical Research Letters (GRL). The paper summarizes the improved GOES sounding algorithm recently implemented into the CIMSS merged retrieval system and the application of improved soundings on severe weather nowcasting.

1.3. Collaboration on using improved GOES clear sky SFOV soundings

In the latter part of 2007, NOAA scientist Dan Birkenheuer began acquiring TPW data produced over the eastern U.S. by the improved physical retrieval algorithm (Li et al. 2008) being run at CIMSS. He is currently comparing this TPW data with nearby Global Positioning System (GPS) TPW data, to ascertain its quality. The comparison information can be seen at: http://gpsmet_test.fsl.noaa.gov/cgi-bin/sat/modis.cgi (click the "data" tab).

1.4. Related presentations and publications during 01 January – 31 March 2008

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

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

2. GOES Atmospheric Motion Vectors (AMV) Research
Task Leader: Chris Velden

Background and Motivation

The CIMSS automated satellite-derived winds tracking algorithm is continuously evolving. In order to advance the software package, new science and research ideas need to be developed and tested at CIMSS in collaboration with winds research collaborators at NOAA/NESDIS and elsewhere. Innovations in the CIMSS automated wind derivation techniques and its applications often lead to improved wind information from GOES for operational and research use.

This research is being conducted to help mitigate the existing limitations of the GOES AMV product; directed at the two key areas of vector height assignment and quality confidence. The research strategies proposed are novel, and promise to improve on the product quality. AMVs are a fundamental variable observable from GOES, and can have a high impact in NWP data assimilation and prognoses. The two key outstanding issues of vector height assignment and quality confidence are what we aim to address in this research. The tasks build on a long and successful GIMPAP AMV research program at CIMSS. Both the national and international met communities have frequently cited the importance of GOES AMV products developed by CIMSS under NOAA GIMPAP support. We use this as motivation to continue to search out ways to improve GOES AMV product development.

Accomplishments over the past 3-months include (but are not limited to):
Proposal Task 1: Continue the exploration of new and improved techniques for GOES AMV height assignments (largest source of vector RMSE).
To accomplish this task we will employ two approaches:

1) Use the newly available active measurements of cloud tops from CALIPSO to evaluate current height assignments. If systematic biases are found, we will apply corrections to GOES AMVs and evaluate against radiosonde observations.
2) Continue research on GOES AMV representation in terms of the *layer* being tracked. The goal is to move away from the traditional *level* height assignment. Preliminary results are quite encouraging to lower vector RMSE. This should benefit data assimilation.

1) Previously we reported on some issues related to using CALIPSO to validate AMV height assignments. The collocation approach has now been implemented, and a qualitative comparison is underway. So far we have compared the AMV target altitude to: 1) the one CALIPSO pixel nearest in distance to the AMV target center; 2) the median of all available CALIPSO pixels, 3) the median of the heights from pixels showing cloud tops above the 25th percentile of all heights. This last idea is similar to how we choose what target pixels are to be used to assign a height to an AMV. Preliminary results from one CALIPSO orbital path (Fig. 2) are shown in Fig.3. Fig. 3 shows the Total Attenuated Backscatter at 532nm. The location of each studied AMV is shown by the red marks. In general, and as expected, most of the AMV assigned height fall below the CALIPSO-signified cloud tops. We hope to gain a better understanding of these biases by looking at additional cases, and quantifying the results.

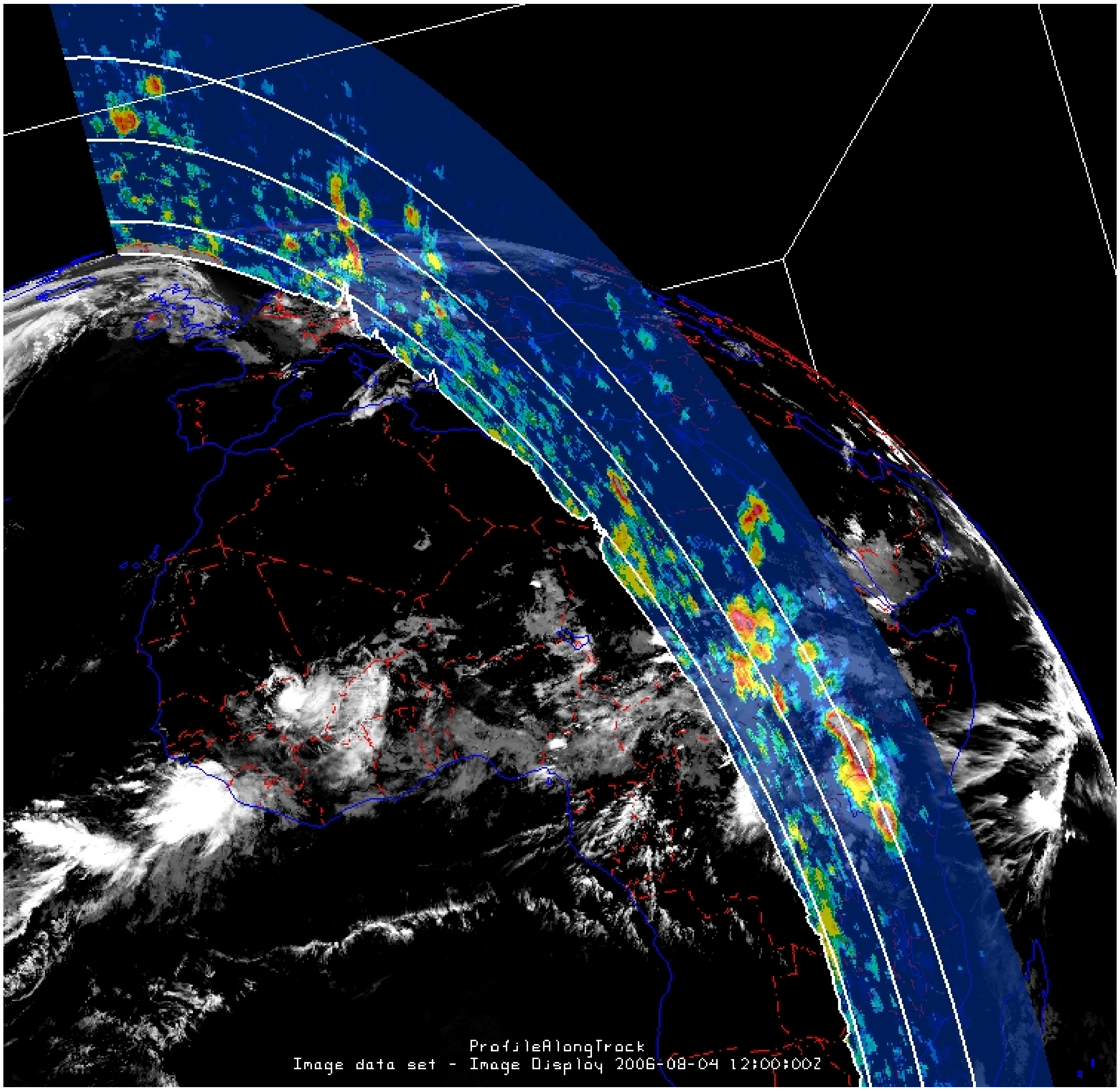


Figure 2. CALIPSO orbit overlain as a vertical plane of backscatter signal on a coincident SEVIRI image for the case examining the comparison of CALIPSO cloud heights with assigned SEVIRI cloud tracked winds altitudes.

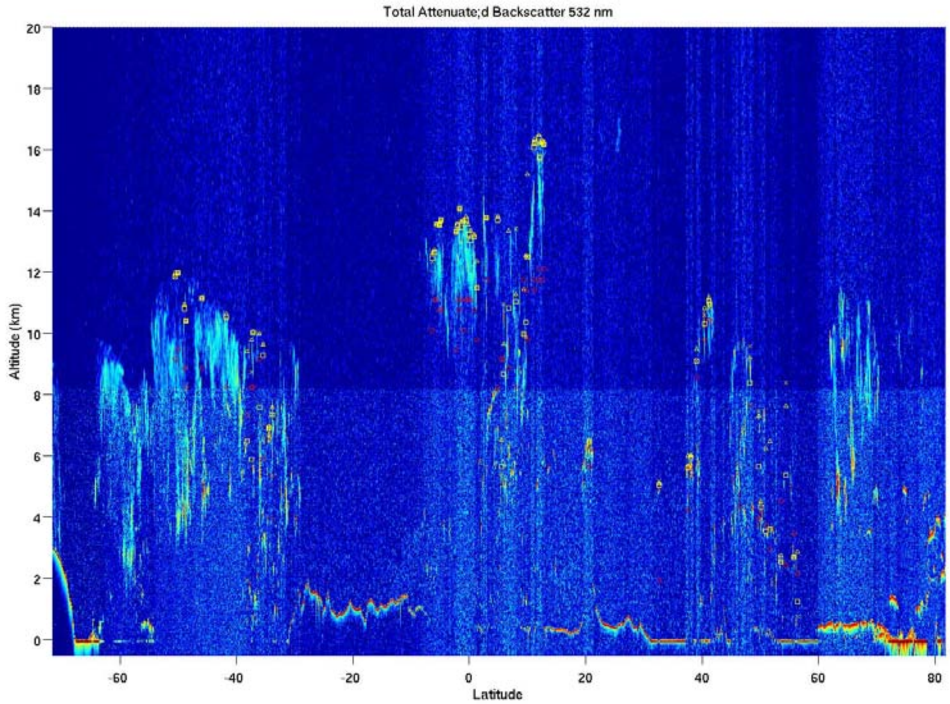


Figure 3. Illustration of CALIPSO total attenuated backscatter showing clouds, with AMV assigned heights (red marks). Yellow marks are estimates of CALIPSO estimated cloud top heights.

2) Using collocated rawinsonde and wind profilers, large samples of GOES AMV data sets were matched to the vertical wind profiles to identify a "layer of best fit" (minimization of RMSE between the two collocated datasets). Our results show clearly that the AMVs matched to rawinsonde ***layers*** yield significantly lower differences then the levels to which they were originally assigned. This work was recently accepted for publication in the Journal of Applied Meteorology, pending minor revisions. A paper on this study will be presented at the International Winds Workshop in mid April 2008, at which time the results will be discussed with data assimilation experts from NCEP and other international NWP centers.

Proposal Task 2: Continue the evaluation of improved quality indicators (QIs) for GOES AMVs.
Further testing of the "Expected Error" and "Correlated Error" QIs is necessary, but initial results show promise. The significance is: 1) Potential to improve data assimilation, and 2) Potential to replace cumbersome Auto Editor in the NESDIS operational AMV production algorithm.

We continue to test a new regression-based quality indicator referred to as the "Expected Error" (EE). This index is designed to attach to every vector record and indicate the confidence in the form of an expected vector RMSE. Our analyses suggest the EE is a better indicator of quality than the existing operational quality indicators. We continue to examine the skill of the EE in removing poor AMVs and comparing its skill to the auto-editor. As included in the last report, lowering the maximum expected error reduces the RMS vector difference. It also, however, reduces the average AMV speed of the dataset. As speed is one of the expected error predictors, high-speed AMVs tend to have higher AMVs than average. Therefore, it will be necessary to have a threshold that varies as a function of speed in order to prevent the unnecessary removal of high-speed AMVs. We are currently addressing this, and will report on preliminary finding at the upcoming International Winds Workshop.

Publications:

Velden, C., and K. Bedka, 2008: Identifying the Uncertainty in Determining Satellite-Derived Atmospheric Motion Vector Height Assignments. Conditionally Accepted in J. Appl. Meteor.

3. GOES Tropical Cyclone Applications Research
Task Leader: Chris Velden

Background and Motivation

This research is being conducted to help mitigate the existing limitations of GOES derived products as applied to Tropical Cyclones (TCs). The research strategies proposed are novel, and promise to improve on the product quality, and utilization. The tasks build on a long and successful GIMPAP TC research program at CIMSS. Both the operational and research communities have frequently cited the importance of GOES products developed by CIMSS under NOAA GIMPAP support. We use this as motivation to continue to *innovate and advance* GOES product development towards TC applications.

Accomplishments over the past 3 months include (but are not limited to):

Proposal Task 1: Continue the exploration of new and innovative methods for integration into the Advanced Dvorak Technique (ADT) to improve estimates of tropical cyclone (TC) intensity from GOES.

To accomplish this task, we will employ three approaches:

1) Explore the integration of other GOES channels (VIS, IR/WV differencing, SWIR). The current algorithm version only employs the GOES IR-Window.
2) Analyze and mitigate known biases in the ADT estimates. Example: ADT has difficulty with emerging EYE scenes.
3) Based on a request from NHC and SAB, explore extending the ADT scope of operations to pre-Depression, Subtropical, and Extratropical Transition stages. The current version only operates on purely tropical systems of at least Depression strength.

1) We are "dusting off" a potential technique first examined many years ago that uses a pixel differencing between collocated/coincident IR Window and WV channels to denote strong eyewall convection. We have just begun exploring if there might be useful information for the ADT in this method. There are no results yet to report.

2) Two of the identified biases in the ADT intensity estimates are being addressed. The first deals with the Shear scene type, which now includes an areal (size) check of the convective cluster coverage nearest the storm center. Performance testing of this modification is underway. The second bias occurs in emerging eye cases, where the ADT plateaus at an intensity that has been show to be too weak because the eye cannot be resolved adequately in the IR due to cirrus debris. Our mitigation strategy involves the incorporation of polar-orbiting microwave data to discern EYE scene types during obscuration in the IR. The microwave views through this debris to denote eye structure, and we are building in logic to over-ride the ADT IR-based scene typing if an eye is observed in the microwave data. Testing of this scheme is about to commence.

3) No efforts on this task were conducted during this period.

Proposal Task 2: Continue the development and evaluation of a new algorithm called SATCON, which yields a weighted consensus estimate of TC intensity from multiple satellite sources (incl. GOES/ADT).

The CIMSS TC group continues to explore an integrated approach to satellite-based TC intensity estimation through a weighted consensus of satellite-based ADT, and AMSU methods derived at CIMSS and at CIRA. The approach (SATCON) has first identified the strengths and weaknesses of each individual method, which is then used to assign weights towards a consensus algorithm designed to better estimate TC intensity. A statistical analysis reveals the approach is superior to the independent algorithms evaluated alone. In this reporting period we have continued the investigation of a cross-platform approach that uses information derived from the estimate methods (CLW, AMSUB 89 GHz, ADT Eye temps and RMW) to make adjustments to the individual members. Once these adjustments are made we then apply the weighting scheme. This has resulted in an improvement in skill compared to simply weighting the members with no adjustments. The focus now is on displaying the information in a way that is most meaningful to the users and tweaking the real-time code. This new approach will be tested in near real time during the 2008 hurricane season. For more information, see: http://cimss.ssec.wisc.edu/tropic/satcon/satcon.html

Proposal Task 3: As part of public outreach and user utilization of GOES data, we propose to set up an on-line archive of GOES derived products developed and processed by the CIMSS TC group over the past decade.

GOES TC products are featured on the CIMSS Tropical Cyclones web site, which has become an extremely popular "public outreach" site for the general public, researchers, and forecasters during TC events. During this reporting period we have continued working on a new innovative web page site that will allow increased user interaction and visualization capabilities: http://cimss.ssec.wisc.edu/tropic2 . Also, GOES datasets and products are continuously requested and provided to the user community for expanding scientific research on TCs. Therefore, we have begun the development of an on-line GOES TC product archive. Data and products from several years are being uploaded from tapes to the on-line archive site. A graphical user interface will be designed for outside users of the GOES TC products.

Publication/Conferences

Herndon, D., and C. Velden, 2008: CIMSS Satellite Consensus (SATCON) Tropical Cyclone Intensity Estimation Algorithm. Presented at the 62nd Interdepartmental Hurricane Conference, Charleston, SC.

Velden, C. and T. Olander, 2008: Introducing the CIMSS new Tropical Cyclone web site. Presented at the 62nd Interdepartmental Hurricane Conference, Charleston, SC.

4. Analysis and Application of GOES IR Imagery Toward Improving Hurricane Intensity Change Prediction
Task Leader: Jim Kossin and Chris Rozoff

We are continuing our progress toward a Hurricane Rapid Intensification algorithm based on the Bayesian probabilistic model.

1) Following Kaplan and DeMaria (2006; hereafter KD06), we define rapid intensification as a 24 h period where maximum sustained surface winds increase at least 25 kts. We use predictors from the 1995-2003 SHIPS database, which are sea-surface temperature, the difference between the current and empirically derived maximum potential intensity, the 850-200 mb vertical shear and the 850-700 mb relative humidity, and the previous 12-h intensity change, and predictors derived from GOES infrared data, which are the percentage of area from 50-200 km radius containing brightness temperatures less than -30^{0}C and the standard deviation of brightness temperatures from 100-300 km radius.

- In the Atlantic basin, the Bayes model achieves a Brier Skill Score (B.S.S.) of 11.6% for the 2004 hurricane season compared to 9% found in KD06, 16.0% compared to 14% in 2005, and 14.1% compared to the 12% for the combined 2004/2005 seasons.
- On the other hand, in the Eastern Pacific, the algorithm achieves a B.S.S. of 25.5% for the 2004 season, which starkly contrasts to the 36% skill in KD06, the B.S.S. is not skillful for the 2005 season, just like in KD06, and the overall skill for the 2004/2005 seasons is 13.9% compared to 19% in KD06.
- A more robust leave one out cross validation for the 1989-2006 hurricane seasons provides B.S.S scores of 10% (0.4% false alarm rate) and 12.6% (0.5% false alarm rate) for the Atlantic and Eastern Pacific Ocean basins, respectively. KD06 limited their cross validation to the 2004 and 2005 only, so no comparisons can be made in this case.
- As a demonstration of the RI forecast scheme, Figure 4 shows an RI forecast for Hurricane Wilma (2005) using the above data and predictors.

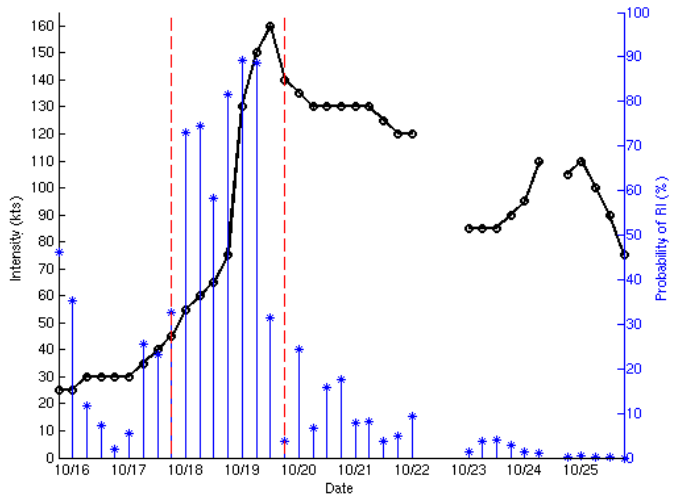


Figure 4: Performance of the RI algorithm in Hurricane Wilma (2005). The black curve shows the observed best track maximum sustained surface wind through time. Data are not plotted when the storm is located over land. The blue lines indicate the probability of RI and the red vertical lines bracket a period of RI. RI probabilities are enhanced during the period of RI. Except for the beginning of the period, the probability of RI during non-RI periods is lower than 30%.

2) It was found we can improve forecast skill substantially by using different predictors than those used by KD06. Using the principle components computed from azimuthally averaged GOES IR brightness temperatures, forecast skill can be improved by over 5% over the Atlantic. Such analysis is still being completed over the Eastern Pacific.

Milestones for this quarter are:

1. Completed validation of an RI forecasting scheme that uses the Bayes probabilistic model and environmental predictors from SHIPS and GOES IR brightness temperatures for both the Atlantic and Eastern Pacific Ocean basins during the period of 1989-2006. Compared results directly with other RI forecast schemes and completed a more robust "leave-one-out" cross validation technique, both of which showed the Bayes model to be skillful.

2. Optimally determined the most skillful predictors for each ocean basin and found predictability that exceeds currently published RI forecasting techniques.

3. Examined the forecast scheme for individual storms in the Atlantic and Eastern Pacific and the results help explain why the forecast scheme occasionally fails and illuminates how the scheme succeeds.

4. Used a principle component analysis of storm-centered, azimuthally averaged IR brightness temperature profiles and found added forecast skill in the RI forecasting scheme.

5. A more complete climatology of RI for the Atlantic and Eastern Pacific has resulted from these efforts, which has added new statistically significant information regarding the likelihood of RI.

5. Intercalibration
Task Leader: Mat Gunshor
NOAA Collaborator: Tim Schmit

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

NOAA participates in research promoting and advancing the knowledge of intercalibration techniques through the Global Space-Based Inter-Calibration System (GSICS). The primary goal of GSICS is to improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of the space component of the WMO World Weather Watch (WWW) Global Observing System (GOS) and Global Earth Observing System of Systems (GEOSS). This project supports NOAA's efforts with GSICS and also the NOAA Mission Goals of Climate and Weather and Water.

Summary
The 3rd Conference of the GSICS Research Working Group (GRWG-III) was held in Camp Springs, MD 19-21 February 2008. CIMSS attended and presented "Recent AIRS-GEO intercalibration at UW-CIMSS." This presentation included intercalibration results from January 2006 through October 2007 comparing AIRS to the imagers on GOES-10, GOES-11, GOES-12, Meteosat-8, Meteosat-9, FY-2C, and MTSAT-1R. In addition, it highlighted the time dependence of results with regards to the difference between overpass times, the effects of GOES-12 decontamination in July of 2007, FY-2C "stray light" issues, and the GOES-13 13.3 micrometer band issues discovered during the GOES-13 post launch test. CIMSS raised the issue of which agencies should be responsible for informing users of calibration problems when they are discovered. The example given was at the beginning of 2006 Meteosat-8 went through a decontamination and before the instrument had fully recovered, data were sent out. In a comparison to AIRS it was shown that this data was off by approximately 8 K in the IR Window channel.

A manuscript is being edited by co-authors at the time of this report. It includes the material presented at the GSICS meeting as well as a more in depth presentation of the methods and analysis of the findings. It will be submitted to the Journal of Atmospheric and Oceanic Technology (JTECH).

6. Global Geostationary Fire Monitoring and Applications
Task Leader: Chris Schmidt

The UW-Madison CIMSS biomass burning team proposed four major tasks for GIMPAP in 2008. CIMSS proposed to continue the GOES WF_ABBA trend analysis throughout the western hemisphere to assess changes in biomass burning for the time period of 2000 – present. Also, CIMSS proposed to continue the collaboration with the user community in environmental applications of the WF_ABBA database. These collaborations include ongoing activities with the atmospheric modeling community to assimilate geostationary WF_ABBA fire products into aerosol/trace gas transport models. The third proposed task is to collaborate with Dr. R. Rabin (NOAA/NSSL) and Dr. P. Bothwell (NOAA/NWS, Storm Prediction Center) on developing and assessing applications of Rapid Scan GOES fire products for early detection of wildfires and agricultural burning and diurnal monitoring of fire variability. Finally, CIMSS proposed to continue to work with GTOS GOFC/GOLD, CGMS, and GEOSS to foster the development and implementation of a global geostationary fire monitoring network with international involvement.

Accomplishments:
During the first quarter of 2008 the CIMSS biomass burning team continued to collaborate with Dr. R. Rabin and Dr. P. Bothwell on applications of Rapid Scan GOES fire products for early detection of wildfires and diurnal monitoring of fire variability. CIMSS evaluated three case studies of time series of rapid scan observations of wildfire activity and ancillary information (local meteorological conditions and fire observations if available). These case studies included the Hayman, Colorado and Rodeo-Chediski, Arizona Fires in June 2002 and the Bugaboo-Scrub Fire, Georgia/Florida in April/May 2007. In addition, the southern California fires from October 2007 were included as an additional case study. The focus of this investigation was to determine the utility of providing time series of value-added information to fire weather forecasters for specific wildfires. This additional information might include a combination of time series of rapid scan observed and background brightness temperatures in the 3.9 and 10.7 micron bands, satellite derived products (such as power difference which is a proxy for fire radiative power), and meteorological information. Figure 5 shows a plot of time series of GOES-11 power difference (kW per unit area) and ASOS wind observations (Ramona, CA) for the Witch Creek fire over southern California in October 2007. For the Witch Creek case study, analyses indicate that there is a relationship between power difference and wind speed. In addition, there is a diurnal relationship of both power difference and wind speed. The Santa Ana winds were a major factor in the spread of this fire and as the wind speeds increased, the power difference increased as well. Figure 6 shows a plot of time series of GOES-11 power difference and ASOS dewpoint depression observations (Ramona, CA) for the Witch Creek fire. Analyses also indicate that there is a relationship between power difference and dewpoint depression. The higher dewpoint depression values often coincide with the larger power difference values and this seems to fluctuate in a diurnal manner, with higher values during the day. The other fire case studies indicated above had similar results.

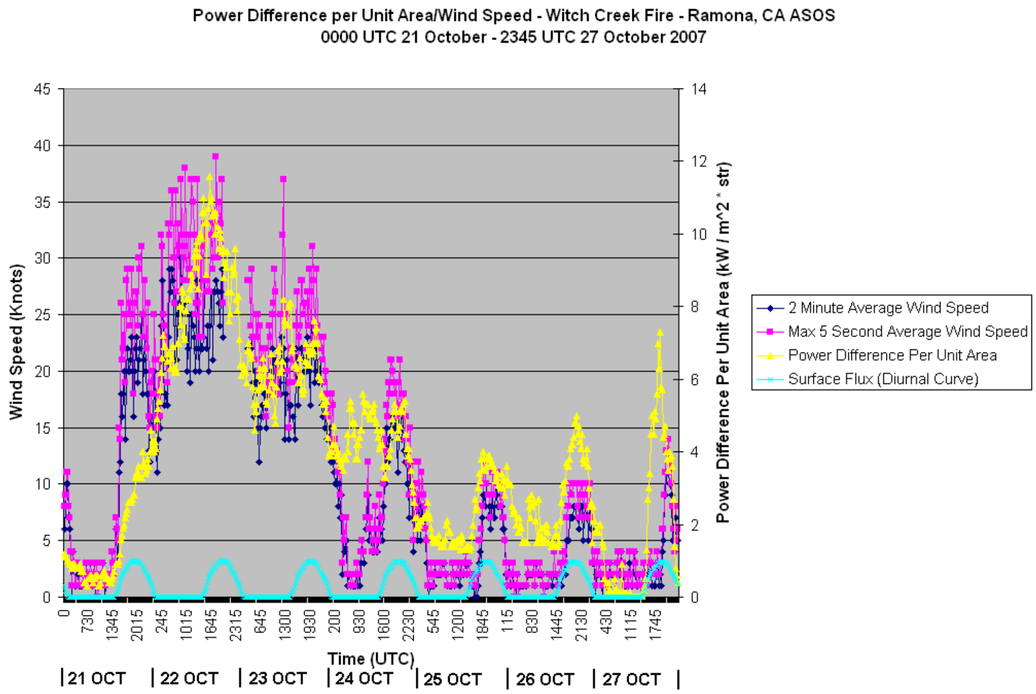


Figure 5. Time series of GOES-11 power difference (kW per unit area) and ASOS wind observations (Ramona, CA) for the Witch Creek fire over southern California in October 2007.

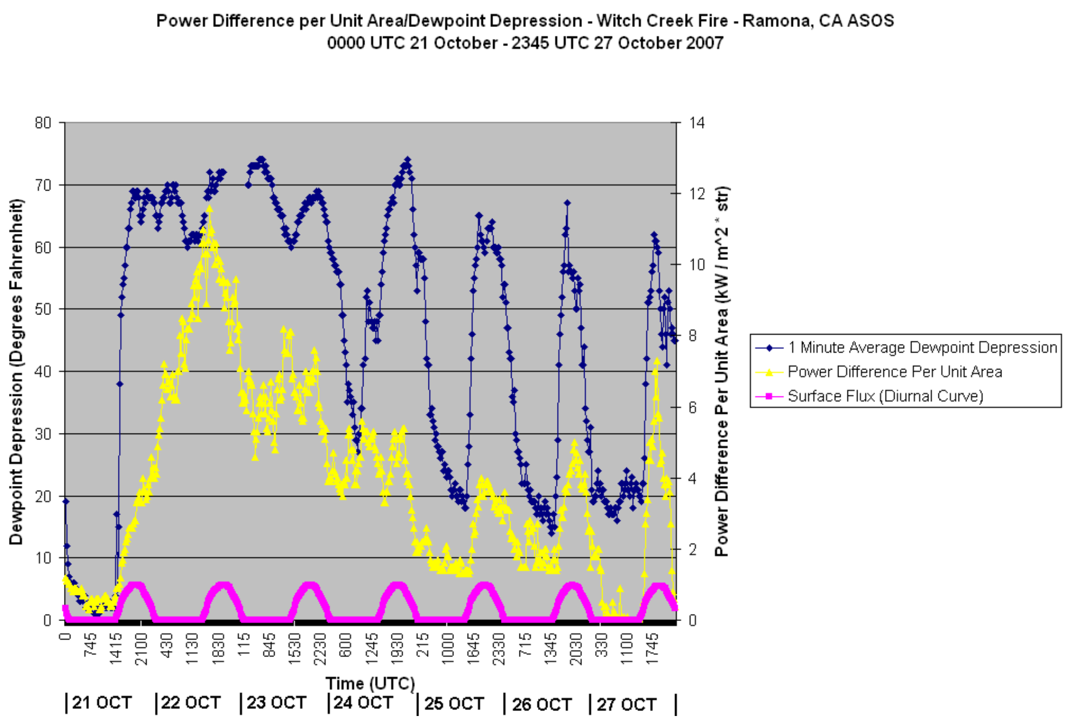


Figure 6. Time series of GOES-11 power difference (kW per unit area) and ASOS dewpoint depression observations (Ramona, CA) for the Witch Creek fire over southern California in October 2007.

F. Patadia from UA-Huntsville inquired about the onset of the fire season in Brazil in 2003 and the magnitude of burning in 2004. In response to this request CIMSS is working on time series plots for 2000-2007. Preliminary analyses indicate that the WF_ABBA identified fewer fires in the 2003 fire season with a slight increase late in the fire season. In 2004 the WF_ABBA observed elevated fire activity earlier in the season and higher than average fire activity throughout the season.

During the first quarter CIMSS responded to several inquiries regarding CEOS actions for 2008 that support corresponding Group on Earth Observation tasks. These efforts were primarily in preparation for the CEOS Strategic Implementation Team (SIT) meeting in April and the first meeting of the newly formed CEOS Disaster SBA Team to be held in Quebec in April. In support of GOFC/GOLD Fire Team requests and the NOAA/NESDIS global geostationary fire monitoring effort, UW-Madison CIMSS is coordinating the following tasks under CEOS Category 1 Disaster Action DI-06-13:

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

7. Automated Volcanic Ash Detection and Volcanic Cloud Height and Mass Loading Retrievals from the GOES Imager
Task Leader: Justin Sieglaff
NOAA Collaborator: Mike Pavolonis

This program is a new start, and since funding has not yet arrived, work has not started on this project.

8. Improvement and Validation of Convective Initiation and Mesoscale Wind Applications
Task Leaders: Wayne Feltz, Kris Bedka, Justin Sieglaff

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

flooding potential. SAB precipitation estimates are provided directly to National Weather Service Forecast Offices and Regional Forecast Centers and contribute to forecasts disseminated to the general public.

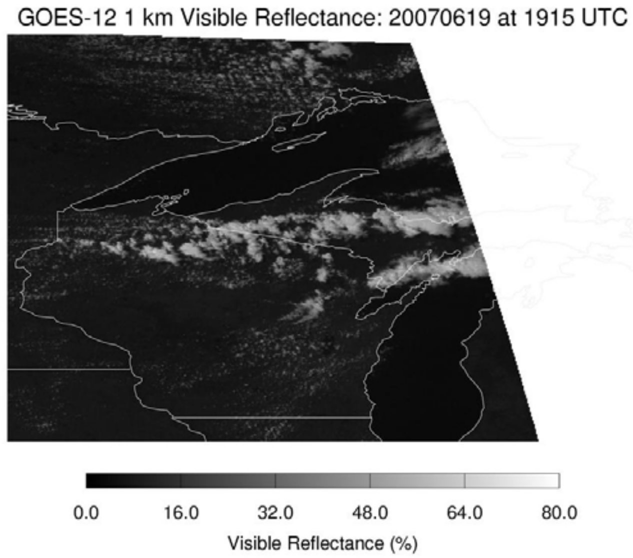
The UW-CIMSS Satellite Nowcasting Aviation Applications (SNAAP) proposes to support further refinement to experimental convective initiation algorithm implemented at NOAA/NESDIS (SAB precipitation team) and AWIPS relayed products to Sullivan, La Crosse, and Green Bay NWS offices. Preliminary product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

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

Accomplishments

1) Implement optimal parallax correction to products

Progress has been made on implementing a parallax corrected convective initiation product. Figure 7 demonstrates about a southward 20 km shift in cloud location after a simplistic assumption of a uniform 9km cloud height. More refined parallax methodologies will be tested.



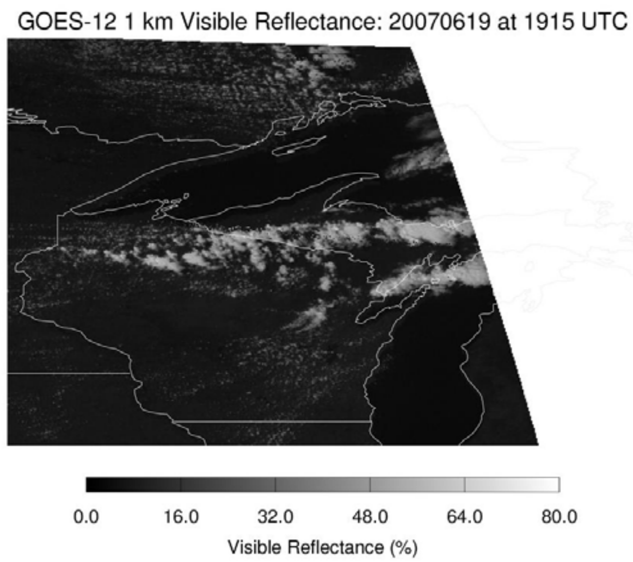


Figure 7: GOES-12 visible image before parallax correction (top) and after (bottom) using an assumed uniform 9km cloud height.

2) Use validation study to improve cooling rate signal and reduce FAR

Lightning and radar data are currently being used for a validation study to improve cooling rate signal and reduce FAR. A framework has been developed to build relationships between GOES-12 box-averaged satellite cloud-top cooling rates and future radar reflectivity changes. Radar reflectivity fields are remapped to the GOES-12 1 km Visible satellite resolution and GVAR navigation. Satellite observations have been parallax-corrected based upon a constant height assumption (20 kft) to better match the satellite cloud observations with their underlying radar signals. The challenge will be to ensure we are accurately matching past and current satellite signals to radar reflectivity changes 30 min to 1 hour in the future, accounting for the cloud and echo motion that can occur during this time period. Emphasis will first directed toward evaluation of "best-case scenarios", where rapid convective cloud growth and rainfall development occur with near stationary clouds during the 30 min-1 hour validation time period. A list of case events have been already identified for further processing which exhibit these characteristics.

Collaboration has recently evolved between UW-CIMSS and the South African Weather Service (SAWS), where SAWS has provided UW-CIMSS with cloud-to-ground lightning strike locations and radar reflectivity across the entire South African observation network for several convective initiation events. Though South Africa is only observed by the MSG SEVIRI instrument, comparisons between satellite convective cloud growth indicators and lightning/radar can provide insight into the potential accuracy of GOES-based nowcasting products.

The following results evaluate the error characteristics of satellite-based lightning initiation (LI) nowcasts using two differing methods, a newly developed box-averaged method and an AMV-based method (Mecikalski and Bedka, 2006), to compute cloud-top time trends. The nowcast criteria used within the box-averaged method are based upon the results of Roberts and Rutledge (2003), where they show that rapid cloud-top cooling rates coupled with a recent drop to below freezing IR window temperatures (273 K) occur 30-45 mins ahead of significant radar reflectivity echoes. The specific criteria used within the box-averaged framework to identify LI nowcast pixels consist of:

-8 K/30 minute cloud-top cooling rate
A drop from above to below freezing IR window T_B within the most recent 15 min period
Current IR window T_B between 253 and 273 K

The Mecikalski and Bedka (2006) AMV-based method utilizes these criteria plus several other spectral channel T_B differences and difference trends. LI nowcast pixels in this framework meet 6 of the 8 nowcast criteria defined by Mecikalski and Bedka.

We now focus on the evaluation of false alarm rate (FAR) from these two LI nowcast methods. Specifically, we are trying to answer the question "how often does a lightning initiation nowcast correspond to lightning activity at least 15 mins in the future?" We analyze data over three convective events, 19-21 February 2008, over the Free State of South Africa.

The FAR analysis over these 3 case events indicates that the FAR for the box-averaged method is 22%, meaning that no lightning occurs at a 15 min or greater lead time in association with 22% of all nowcast pixels. The FAR for the AMV-based method is significantly greater at 35%. The box-ave method also provides a much greater number of nowcast pixels as well (4092 vs. 2387).

In order to evaluate the probability of detection (POD), we must first identify all occurrences of lightning initiation so that we can determine the frequency of detection by the two time trend methods. For this analysis, lightning strike data is binned in .25

degree resolution boxes and the time behavior of the lightning activity is analyzed. A box is flagged for lightning initiation if the number of lightning strikes increases from below to above 3 strikes within the box over a 15 min period. A larger box (.40 degrees) is also analyzed to eliminate situations where an electrically active storm moves into the smaller .25 degree box within this 15 min period. For the three cases described above, 367 lightning initiation occurrences are identified from which we can produce POD statistics. The box-average method provided at least 15 mins lead time for 40% of the cases (147/367), whereas the AMV-based method provided 15 min lead time for 27% (100/367) of the cases.

These statistics provide a baseline for product performance to improve upon with future work. They show that the box-averaged method provides a more reliable nowcast with increased information content and fewer false alarms. IR-based nowcast criteria can be adjusted and tested within the validation framework above. We plan to extend these results to U.S. cases and GOES-12 imagery, using WSR-88D to identify "convective initiation" and NLDN to identify "lightning initiation".

3) Prototype nocturnal convective cooling rate methodologies

Progress has been made to prototype nocturnal convective cooling rate methodologies. The current research path is to use cloud products which are or will be operational via GEOCAT and CLAVR-X to provide an infrared only day-night convective cloud mask and retire the daytime only UAH statistically based unsupervised clustering convective cloud mask method which highly relies on visual texturing. The new convective cloud mask has several advantages, 1) physically based on cloud microphysical properties, 2) 24 hour convective cloud mask, 3) uses operational datastreams, 4) algorithm logic is applicable to all geostationary sensor although optimal results are obtained when more radiative information is present (SEVIRI vs GOES) and high temporal resolution is available. We have started work with MSG SEVIRI imagery toward the use of a IR-only cloud microphysical phase product to identify newly developing convective storms. This phase product will serve as a surrogate to a daytime-only satellite VIS+IR convective cloud mask which has been developed at the University of Alabama in Huntsville (UAH), which will extend out nowcasting capability to the nighttime hours. We believe that monitoring the phase change from liquid and supercooled water to ice cloud tops is a key indicator of convective initiation that we can exploit from satellite observations. We are using the GEOCAT framework to produce the cloud-top phase product, which allows for flexibility in the spectral channels used as input to the algorithm. We plan to examine the impact of reducing the spectral information supplied to the algorithm on the resulting convective cooling rate product, as GOES has far fewer IR channels than MSG SEVIRI. This should help us to understand the feasibility of using phase information from current GOES in the nowcast process.

4) Collaborate with NOAA SAB and local NWS office to provide iterative avenue for product improvement and future path to operation

Collaborations with NOAA SAB and local NWS office to provide iterative avenue for product improvement and future path to operations have continued. Wayne Feltz presented a talk on future satellite-based aviation and nowcasting products titled "Convective Initiation and Future Nowcasting Related Products" to Green Bay and Marquette National Weather Service offices on January 10, 2008. Mesoscale atmospheric motion vectors are now provided to La Crosse, Sullivan, and Green Bay NWS offices with convective cooling rate/CI forthcoming this spring. Future collaborations are expected to occur in May 2008 with the Aviation Weather Center (AWC) and Central Region NWS in Kansas City.

9. Using GOES Imager Cloud Products to Study Convective Storm Evolution
Task Leader: Justin Sieglaff
NOAA Collaborator: Andy Heidinger

Brief Description of work proposed

With the advent of the GOES-R Algorithm Working Groups, NOAA has begun to develop consensus prototype algorithms for GOES-R. Particularly, the cloud application team has developed a prototype system for testing cloud algorithms applied to geostationary imager data (GEOCAT). GEOCAT can process geostationary imager data from GOES, MSG/SEVIRI and MTSAT. Beyond the cloud height and effective cloud amount product from the GOES-12 imagers and the cloud mask from Clear-sky Brightness Temperature (CSBT), NOAA makes no other operational cloud products from the GOES imager. Most of the proposed GOES-R cloud products can in fact be produced from the current GOES imagers albeit with reduced accuracy. We propose therefore to implement GEOCAT applied to the GOES imager data in real-time at CIMSS and to make cloud products available to all interested users for evaluation and comment.

Summary of Results for Past Quarter

This quarter we continued to focus on improving the real-time GOES processing and introduce a website to display the products as they become available. The GOES-R cloud algorithms have been adjusted so they can be run with the current GOES platforms and ingested into the real-time processing. Producing the cloud mask, cloud phase, daytime optical properties and height data on a full disk requires about five minutes. GEOCAT has proven to be a reliable system for controlling and running the cloud (and other GOES team) algorithms. Due to storage requirements there is currently no archive for the real-time products, however, a webpage has been created to display a running 3-day period of the real-time GOES-11 full-disk products (http://cimss.ssec.wisc.edu/geocat/viewer.php). The website allows the community to view an animated loop of a single product, or compare several algorithms using a multi-panel feature (2 or 4 panels – see figure 8). Web features also provide zoom and roaming capabilities for the images. New computer hardware recently received will allow the real-time processing to be expanded to produce GOES-R cloud products using better-suited MeteoSat Second Generation (MSG) - SEVIRI data.

Now that the GOES-NOP versions of the algorithms are running in real-time, we intend to apply them to case studies to explore their utility for studying convective storms. We have obtained a data-set of 1-minute GOES-10 data that will serve as our initial test-bed.

An example from that data set is shown in Figure 8 below. The cloud type/phase product shows great promise for detecting cumulus cloud top glaciation and estimating cirrus anvil areas. Analysis of other cloud products is underway.

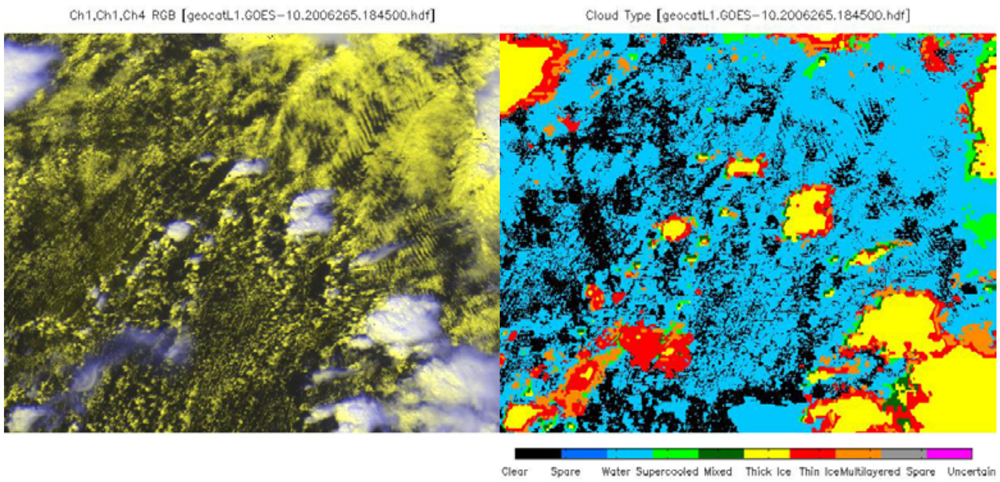


Figure 8: GOES-10 1-minute data taken near the Missouri Valley on September 22, 2006. The cloud type product on the right shows that several towering cumulus clouds were starting to glaciate. Many of these storms later produced high wind, hail, and tornados. The time it takes a cumulus cloud to glaciate is related to updraft velocity and hence storm strength.

10. Using AWIPS to expand use of GOES imager and sounder products in National Weather Service Forecast Offices

Task Leaders: Scott Bachmeier
NOAA Collaborator: Gary Wade

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

The following activity goals have been achieved or significantly advanced during this quarter.

(1) In-person training was successfully conducted on 10 January 2008 at the Green Bay, WI (GRB) NWS Forecast Office (FO). Several staff from the GRB FO, as well as a couple from the Marquette, MI (MQT) NWS FO, were in attendance. G. Brusky, the GRB Science and Operations Officer (SOO), was the contact who helped arrange the

visit. There was good discussion between the researchers and the forecasters; a number of products were received with interest. The PowerPoint presentations, by CIMSS and NWS staff, are available at http://cimss.ssec.wisc.edu/~garyw/nws-visits/grb-2008/.

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

(3) The next in-person training event is being actively planned for 29 May 2008 at the Kansas City NWS complex. The complex includes the NWS Central Region (CR) Headquarters, the NWS Aviation Weather Center (AWC), and the NWS Training Center (NWSTC), as well as, is within an hour’s drive of the Pleasant Hill, MO (EAX) and Topeka, KS (TOP) NWS FOs. G. Noonan (CR Scientific Services Division) has been the contact person as this visit has been arranged. Added emphasis is being put on aviation applications.

(4) A total of 7 live teletraining sessions of the VISIT lesson “Water Vapor Imagery and Potential Vorticity Analysis” were given during the period, with 17 NWS forecast offices participating in the training. This lesson demonstrates the utility of the GOES imager water vapor channel and the GOES sounder total column ozone product to diagnose important upper tropspheric dynamical structures (see Fig. 9).

(5) Twenty GOES-related entries were posted on the CIMSS Satellite Blog (http://cimss.ssec.wisc.edu/goes/blog/) to demonstrate a wide variety of examples of applications of GOES satellite products to a number of different weather analysis and forecasting tasks. The CIMSS Satellite Blog is becoming a popular satellite training resource for NWS forecasters.

(6) The CIMSS Warning Event Simulator (WES) was upgraded to Version 8.1, in preparation for work on creating WES training cases.

Lastly, another on-going effort remains the compilation of any AFD (Area Forecast Discussion) message that contains specific (named) references to any of the CIMSS-provided products in the AWIPS data stream at any participating FO.

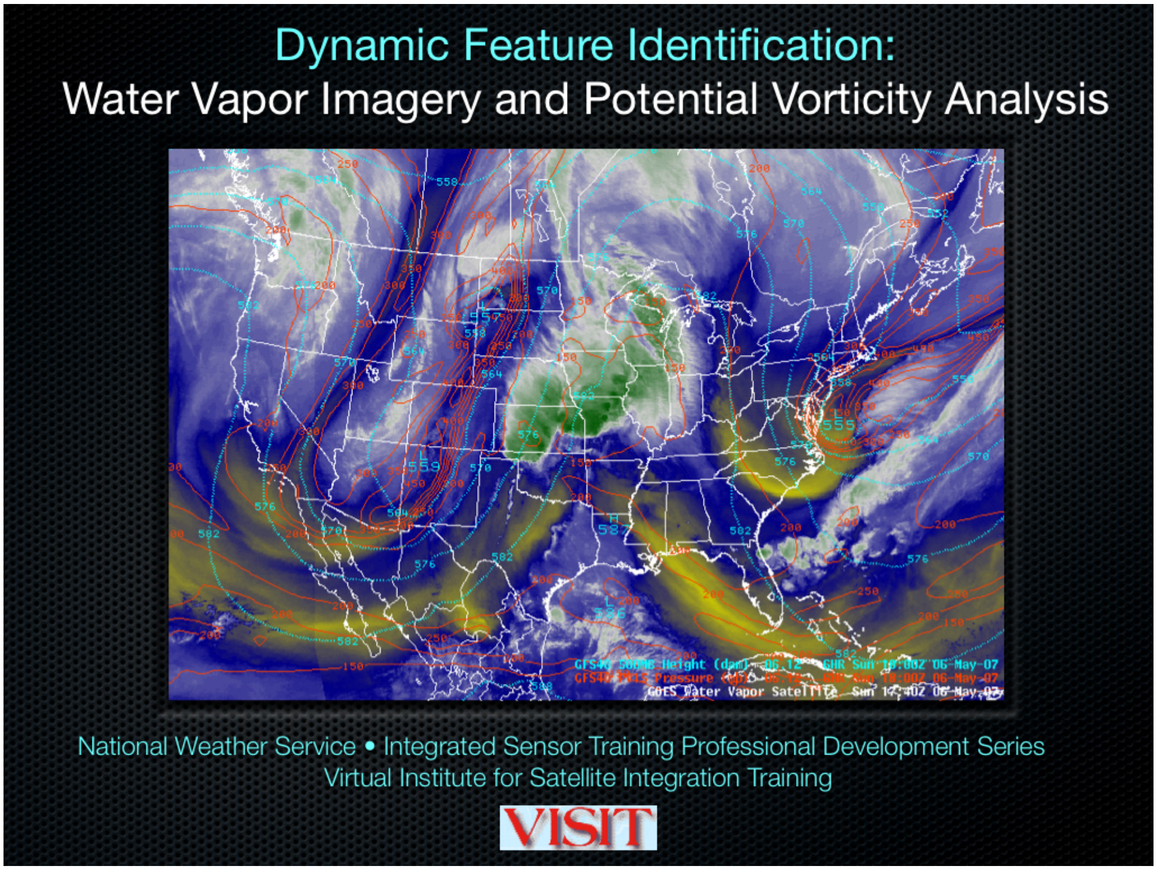


Figure 9: Title slide from the "Water Vapor Imagery and Potential Vorticity Analysis" VISIT lesson.