The Cooperative Institute for Meteorological Satellite Studies (CIMSS)

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

for the period
1 April 2007 to 30 June 2007

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1. Single Field-of-View (SFOV) Sounding Retrieval Science
Lead Scientist: Jun Li

1. GOES Sounder single field-of-view sounding and ozone improvement

GOES-12 Sounder improved single field-of-view (SFOV) soundings show very important nowcasting information for a Texas Tornado case which happened on 24 April 2007. The tornado killed 10 people and injured more than 120 persons. Severe convection developed ahead of a frontal boundary that was moving southward across the Rio Grande Valley region late in the day on 24 April 2007. This storm produced large hail (up to 2.75 inches in diameter), strong winds (up to 76 mph), and the EF-3 tornado. The hourly GOES-12 Sounder data are used to retrieve the soundings and lifted index (LI). The improved GOES Sounder single field of view method is used; the retrieved LI from new method is better than that produced from the legacy product, and much better than the forecast.

Figure 1 shows the forecast LI (upper left) and the GOES-12 Sounder LI retrievals (upper right) at 22 UTC on 24 April 2007. The NOAA-16 AVHRR image is also shown (lower panel). The storm is in a rapid development stage at 22 UTC. The LI index at 20 and 21 UTC from the forecast does not reflect any atmospheric instability in that region, while the GOES Sounder retrievals before and during the storm development show the important atmospheric instability information. Although the legacy LI also provided instability information for this case, it is not as good as new retrievals.

The CIMSS GIMPAP team contributed to the GOES-13 Sounder technical report. We found that the GOES-13 Sounder has striping noise for some spectral bands due to the calibration, and the striping noise can be removed by applying a noise filtering technique. Figure 2 shows an example of GOES-13 Sounder band 7 radiances, before the destriping (upper left), after the destriping (upper right), and the differences. The destriping will assure the quality of GOES-13 sounding and cloud-top products.

As part of the Global Earth Observation System of Systems (GEOSS)-America's capacity building, CIMSS delivered processing software to generate temperature and moisture profiles from GOES-10 Sounder data to Rodrigo Souza of Instituto de Pesquisas Espaciais (INPE, Brazil). The new algorithms and software provided to South American GOES-10 user community are developed under GIMPAP support. Luiz Augusto Toledo Machado, Chief of Satellite and System Division at INPE, has reported their GOES-10 sounding test results at the GOES-10 workshop held on 26 June 2007 in San Jose, Costa Rica.
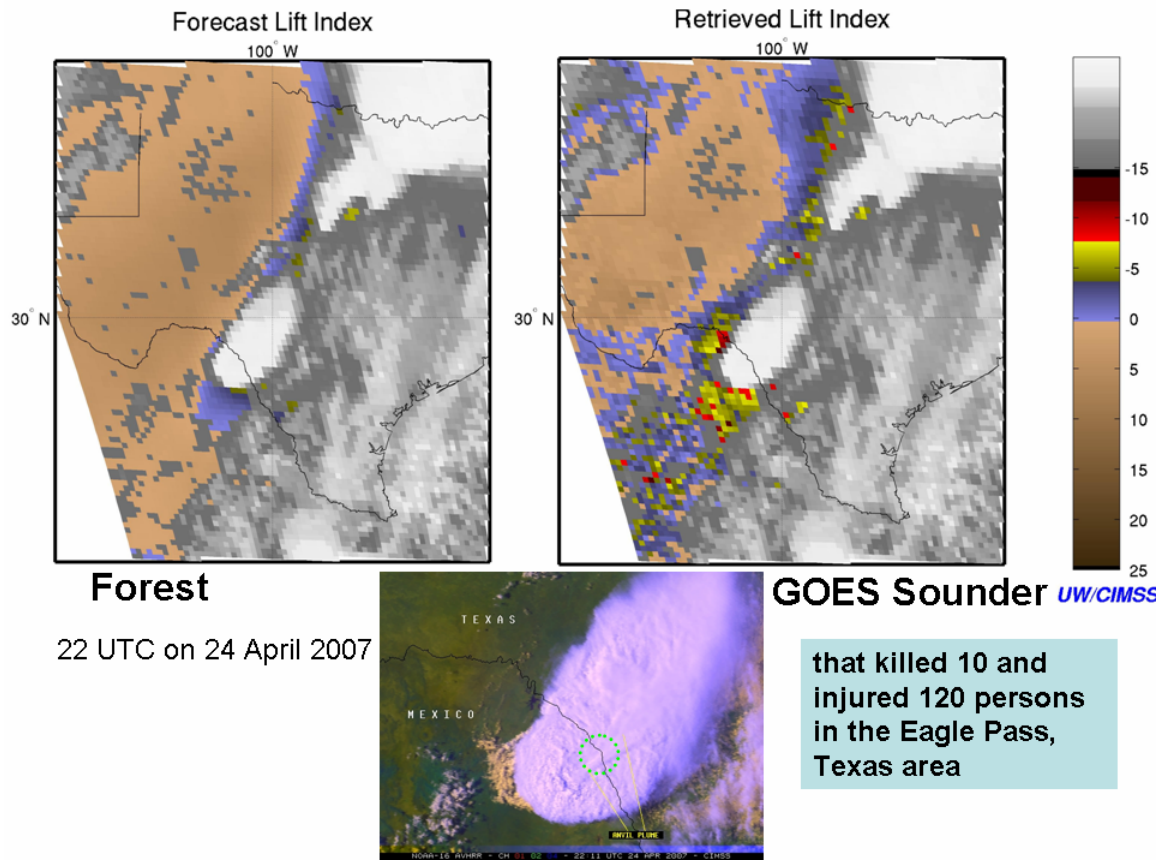
Figure 1: Forecast Lifted Index (LI - upper left) and the GOES-12 Sounder LI retrievals (upper right) at 22 UTC on 24 April 2007; AVHRR 1 km image (lower).

Time continuity was further studied during this quarter. We have tested a few approaches, the time continuity does show slight improvement compared to the single time step for soundings. After analysis, we think the time continuity might not be able to show significant advantages over the single time step method with current GOES Sounder data. The possible reasons might be: (1) the temporal resolution of GOES Sounder is not high enough to show advantage in time continuity for soundings, (2) GOES Sounder retrieval algorithm uses forecast as first guess and the forecast already contains time continuity information through dynamic processes, and (3) collocation between two time steps for the SFOV will create additional error. However, time continuity should be able to work well on surface emissivity and skin temperature retrieval. For example, by the assumption that emissivity is temporally invariable while surface skin temperature is temporally variable, radiance observations from more than two time steps can be used. We will investigate the time continuity approach for surface property retrieval.

We are also testing the single field of field cloudy sounding approach with the GOES Sounder data. The hyperspectral IR alone data showed advantages on cloudy single FOV soundings which is very important for severe weather forecasts. Since the GOES Sounder has limited spectral band information, forecast will be used together with cloudy radiances for sounding under broken clouds and low clouds conditions. By applying the cloudy sounding approach, the LI product can be derived with more spatial coverage.
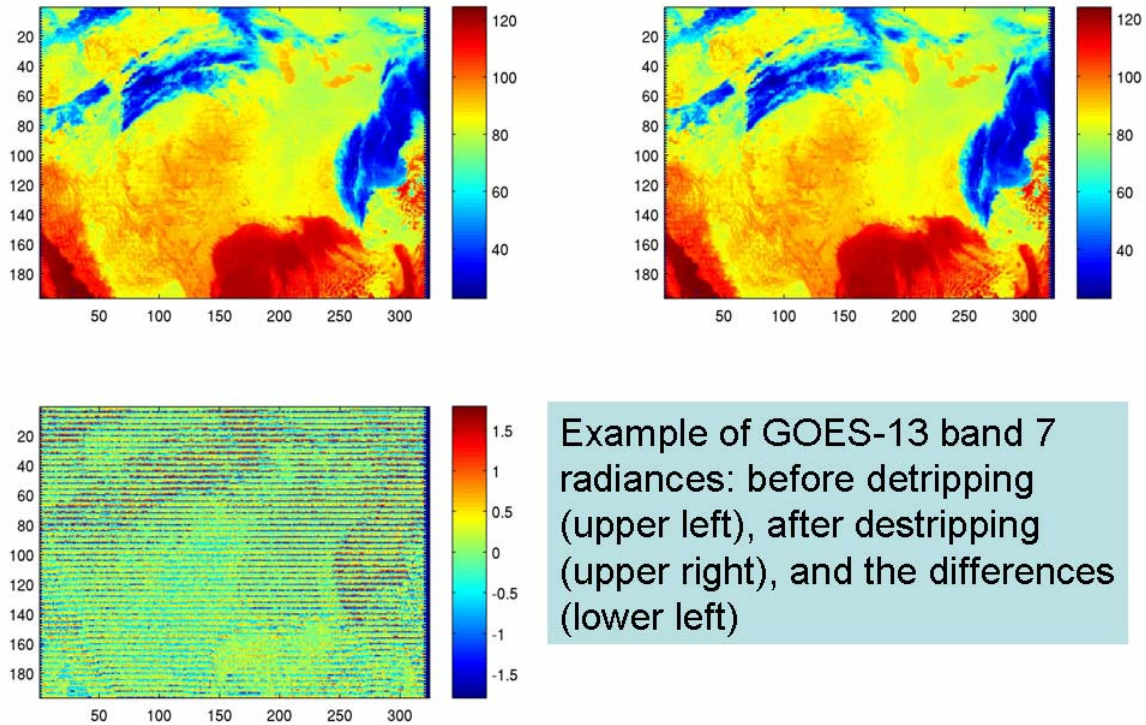
Example of GOES-13 band 7 radiances: before detripping (upper left), after destripping (upper right), and the differences (lower left)

Figure 2: GOES-13 Sounder band 7 radiances, before the destriping (upper left), after the destriping (upper right), and the differences (lower).

Related presentations and publications during 01 April – 30 June 2007

Li, Jun, Timothy J. Schmit, Jaime Daniels, Jinlong Li, Zhenglong Li, W. Paul Menzel, and James J. Gurka, 2007: GOES infrared sounders - the current applications and future needs, *Proceeding of 32nd International Symposium on Remote Sensing of Environment*, June 25 - 29, 2007 , San José, Costa Rica.

Schmit, T. J., 2007: The GOES-10 Sounder, GOES-10 Workshop, 26 June 2007, San José, Costa Rica.

2.   **Global Observing System Studies - Intercalibration**
         Lead Scientists: Mat Gunshor, Tim Schmit

2.1   Global Observing System Studies

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). This proposal covers research into new/improved methods, testing new satellite instruments, diagnosing problems on existing instruments, and the analysis and presentation of results.

Summary
Research into improving methods of filling AIRS spectral gaps continues. The latest efforts include investigations into using AIRS spectral response functions (SRFs), and mock-SRFs in AIRS gaps, to more accurately average a calculated hyperspectral atmosphere to use in filling AIRS gaps. In addition, an error-analysis method to estimate the amount of error introduced by this method of gap-filling has been devised. Initial tests with this error-analysis method led to changes in the gap-filling code as well as the convolution code. The gap-filling function was rewritten based on what was learned.

By creating AIRS-like gaps in a calculated hyperspectral atmosphere, the gap-filling technique can be tested. A spectrum calculated from the U.S. Standard Atmosphere is the calculated spectrum used in the gap filling method. It is believed that by convolving several calculated hyperspectral atmospheres with GOES and METEOSAT SRFs before and after introducing AIRS-like spectral gaps to them, an approximate error for the gap-filling method can be calculated.

A rough draft has been completed of a manuscript detailing the AIRS/GEO intercalibration method, including the method for compensating for AIRS spectral gaps. The process of writing the rough draft is what led to the need for reevaluating the application of the methods. A poster presentation and accompanying paper addressing the finished portions of this work are planned to be presented at the SPIE Conference "Atmospheric and Environmental Remote Sensing Data Processing and Utilization III: Readiness for GEOSS" in San Diego, CA, August 27-28, and 30, 2007.

2.2   *Intercalibration of GOES and POES*

Background
Calibration and instrument intercomparison are the main methods by which individual instruments can be validated against one another between the geostationary and polar orbiting platforms. Routine automated intercalibration provides information on how operational geostationary environmental satellites around the globe compare radiometrically. CIMSS has been intercalibrating satellite instruments routinely since 1999 and the methodology is documented in the research journal literature (Gunshor et al. 2004). Research into new/improved methods, testing new satellite instruments, diagnosing problems on existing instruments, and the analysis and presentation of results are covered under the broader CIMSS GIMPAP proposal topics. This proposal covers the routine production of results, the routine posting of results on the World Wide Web, software maintenance, and the implementation of knowledge gained from the research done under the broader CIMSS GIMPAP proposal (Global Observing System Studies).

The primary purpose of the intercalibration project is to compare the infrared window, water vapor, and 13.3 micrometer CO_2-absorption band channels on geostationary instruments (e.g. GOES, Meteosat) by using the same spectral bands on polar-orbiting instruments (e.g. NOAA AVHRR and HIRS). This task is accomplished by making multiple comparisons at the geostationary sub-satellite points and finding an average brightness temperature difference between the geostationary and the polar orbiter spectral bands.

Comparison of satellite radiances leading to an improved knowledge of calibration is important for various global applications of satellite data where data from more than one instrument are combined for a single purpose. The CGMS (Coordination Group for Meteorological Satellites) has requested satellite operators to regularly perform satellite intercalibration. The World Meteorological Organization (WMO) has initiated a global intercalibration project called the

Global Space-based Intercalibration System (GSICS) with NOAA/NESDIS as a lead agency. This intercalibration work directly supports this international collaboration among satellite providers.

Summary
Regular oversight of the automated features of this task was the primary function this quarter. The data collection and processing results were monitored as well as the output generated for the internet.

3.   GOES Winds
Lead Scientist: Chris Velden

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

1) The data assimilation community continues to struggle with effective integration of satellite-derived winds into current variational analysis schemes. As a result, observing system experiments show the winds offer only a modest positive impact on NWP forecasts. During this quarter we continued 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 QI (Quality Indicator). We are in the process of examining this new EE for data assimilation screening properties, and possibly for the replacement of the cumbersome auto-editor and recursive filter quality flag.

2) We have taken a fresh look at GOES winds height assignments. Instead of treating the winds as vectors representing discrete levels, our analysis has focused on tropospheric layers. Using collocated rawinsonde and wind profilers, GOES winds are matched to the vertical wind profiles and a "layer of best fit" (minimization of RMSE) is identified. Our results of this analysis have found that the layer matches are superior to the levels of best fit. The matches have been broken down by wind type and height assignment method to better characterize the height assignment traits by layers. We expect a journal publication of the final results to be completed by the next reporting period.

4.   GOES Tropical Cyclone Applications
Lead Scientists: Chris Velden (4.1), Jim Kossin (4.2)

4.1   *SAL, ADT and Integrated Intensity Algorithms*
Lead Scientist: Chris Velden

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

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

often based on community/user feedback. During this reporting period we have continued working on a new innovative web page site that will allow increased user interaction and visualization capabilities. Also, GOES datasets and products are continuously requested and provided to the user community for expanding scientific research on TCs. Therefore, we are scoping the development of an on-line GOES TC product archive.

2) We continue to conduct basic research and upgrade the Advanced Dvorak Technique (ADT) algorithm, which is now used by several NOAA and DoD tropical cyclone analysis centers. The algorithm upgrades have focused on a statistical evaluation of the performance in specific cases to better understand the behavior and areas of weakness. We are working to ensure (through G-PSDI funding) that the latest versions are available to NESDIS/SAB and NOAA/TPC and CPHC. More information can be found at: http://cimss.ssec.wisc.edu/tropic/adt/

3) 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 investigated a cross-platform approach that uses information derived from the estimate methods (CLW (Cloud Liquid Water), AMSU-B 89 GHz, ADT Eye temps and RMW (Radius of Maximum Winds)) 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 fundamental error sources of the methods have not changed with the latest upgrades of the members so the original weighting decision tree remains and the weights themselves have not been changed (at least not yet). The focus now is on displaying the information in a way that is most meaningful to the users and adjusting the real-time code. This new approach will be tested in near real time during the 2007 hurricane season. For more information, see:
http://cimss.ssec.wisc.edu/tropic/satcon/satcon.html

4) We continue the application of the geo satellite-based Saharan Air Layer (SAL) detection technique. We will continue to build SAL cases via the satellite-derived product to study the association between TC intensity behavior with SAL interaction.

Publications:

Olander, T., and C. Velden, 2007: The Advanced Dvorak Technique (ADT): Continued development of an objective scheme to estimate tropical cyclone intensity using geostationary satellite IR information. *Wea. and Fore.*, 22, 287-298.

4.2   *GOES Imager Applications to Hurricane Intensity Change*
Lead Scientist: Jim Kossin

Project Description:

The goal of this research is to extract more information from GOES IR imagery that is related to hurricane intensity change, and apply this information to increasing intensity forecast skill through modification of the SHIPS model. Previous work has demonstrated that information gleaned from GOES IR imagery about the state of the hurricane inner core can also be related to

intensity change. This was shown by the addition of GOES IR-based predictors to the existing environment-based predictor suite of SHIPS, which increased skill. The GOES data in these previous studies comprised imagery only back to 1995. Our first goal was to extend this dataset back in time.

Accomplishments in the last three months
Our accomplishments for this quarter are similar to last quarter, and are entirely data-related. The dataset was updated during this quarter in collaboration with Ken Knapp at the NOAA NCDC – this update includes extending the data back to 1981 and forward to 2006, and manually fixing erroneous data in the GOES imagery that was identified by users of the first dataset release. We then reprocessed the data and executed the algorithms constructed in last quarter to extract the required SHIPS predictors. After execution of the algorithms, the predictors were made available to our collaborators in the NOAA/NESDIS RAMM-B Team at CIRA/CSU (DeMaria and Knaff). This constitutes a significant extension of the GOES data for inclusion in the SHIPS model, and the major benefits of our efforts will be realized when the SHIPS model is updated to include these. We hope to actively participate in this analysis portion of the project.

5.   Biomass Burning Research
Lead Scientists: Elaine Prins, Chris Schmidt

The UW-Madison CIMSS burning team proposed four major tasks for 2007. CIMSS proposed to continue the GOES WF_ABBA trend analysis throughout the western hemisphere to assess changes in biomass burning and collaborate with the user community in environmental applications of the WF_ABBA data base. These collaborations include ongoing activities with the atmospheric modeling community to assimilate geostationary WF_ABBA fire products into aerosol/trace gas transport models. A new effort in collaboration with Dr. R. Rabin (NOAA/NSSL) and Dr. P. Bothwell (NOAA/NWS, Storm Prediction Center) focuses on 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:
The CIMSS biomass burning team continues to collaborate with the international aerosol/emissions modeling and data assimilation communities. During the past quarter most of our interactions have been with NRL-Monterey and FNMOC and the air quality transport modeling team at INPE/CPTEC in Brazil. Collaborators at INPE/CPTEC published a manuscript in Atmospheric Chemistry and Physics titled, "Including the sub-grid scale plume rise of vegetation fires in low resolution atmospheric transport models." CIMSS served as a co-author on this manuscript.

In collaboration with Dr. R. Rabin (NOAA/NSSL) and Dr. P. Bothwell (NOAA/NWS, Storm Prediction Center) CIMSS continued to evaluate 3 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 include the Westside Fire in southern California in December 2006, the East Amarillo Complex Fire in March 2006, and the Hayman and Rodeo Chediski Fires in June 2002. The focus of this investigation is 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, fire radiative power, and meteorological information. Figure 3 shows plots of time series of GOES-12 rapid scan observed and background 3.9 and 10.7 micron brightness temperatures (K) as well as derived power (kW per unit area) and ASOS winds observations (Borger, TX) for the East Amarillo Complex fire in March 2006. Preliminary analyses seem to indicate that observations of fire radiative power in conjunction with other meteorological information may be useful to evaluate fire intensity and diurnal variability.

CIMSS continues to work with the GTOS GOFC/GOLD Fire Implementation Team. An executive summary of the 2nd GOFC/GOLD Workshop on Geostationary Fire Monitoring and Applications held at EUMETSAT in Darmstadt, Germany (4-6 December 2006) was completed and is available on-line at http://gofc-fire.umd.edu/implementation/Events/meetings/past.asp. A list of presentations can also be found at this web site.
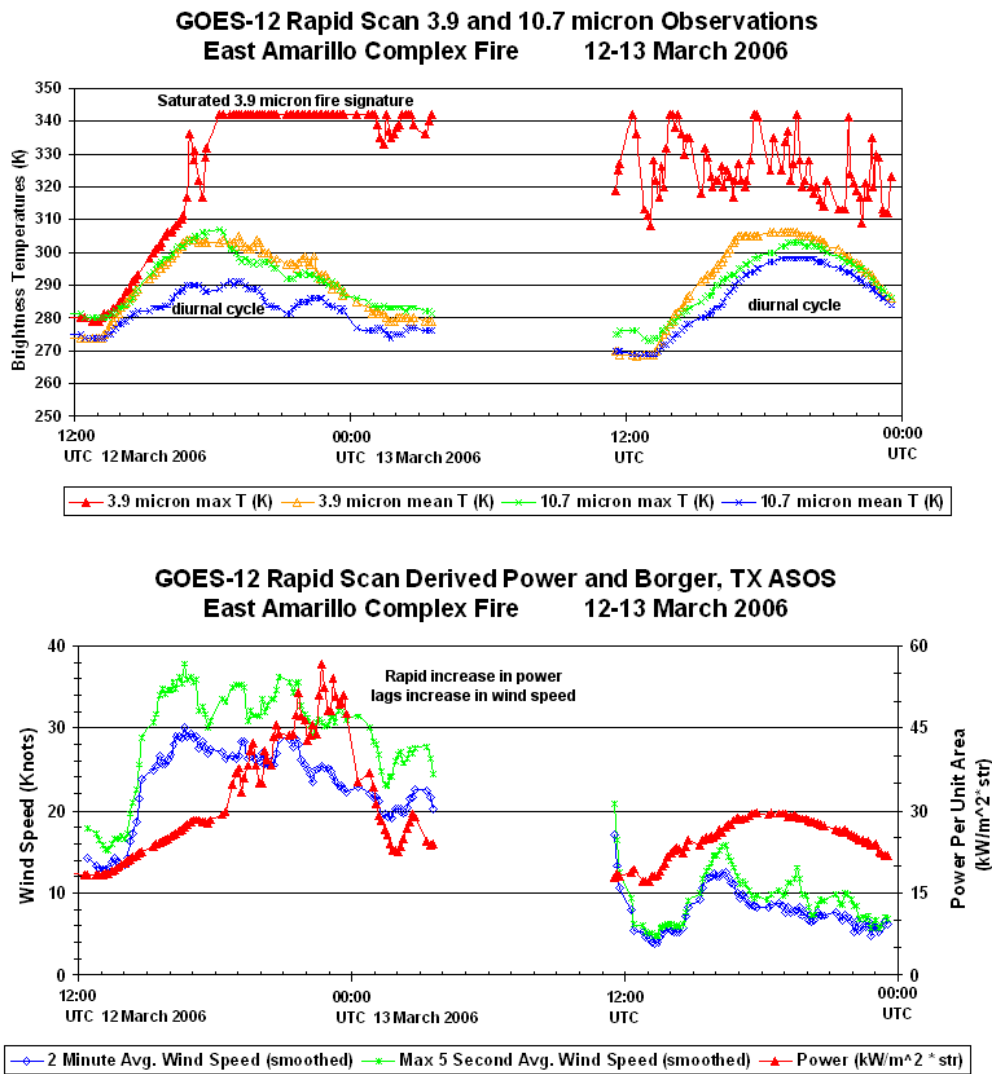

Figure 3. Time series of GOES-12 rapid scan observed and background 3.9 and 10.7 micron brightness temperatures (K) as well as derived power (kW per unit area) and ASOS winds observations (Borger, TX) for the East Amarillo Complex fire in March 2006.

Peer-Reviewed Publications:

Freitas, S.R., K. M. Longo, R. Chatfield, D. Latham, M.A.F. Silva Dias, M. O. Andreae, E. Prins, J. C. Santos, R. Gielow, and J. A. Carvalho Jr., 2007: Including the sub-grid scale plume rise of vegetation fires in low resolution atmospheric transport models, Atmospheric Chemistry and Physics, 7, 3385-3398.

Reports:

Prins, E. M., Y. Govaerts, I. Csiszar, 2007: GOFC/GOLD Fire Monitoring and Mapping Implementation Team 2nd Workshop on Geostationary Fire Monitoring and Applications – Executive Summary, EUMETSAT, Darmstadt, Germany, December 4 - 6, 2006.

**6.   GOES Imager SATellite Convection AnalySis and Tracking (SATCAST) System Product Evaluation by NOAA/NESDIS Operations
Lead Scientists: Wayne Feltz, Kris Bedka**

Background

CIMSS, in collaboration with the University of Alabama - 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 use of geostationary satellite imagery provides a clear advantage over operational NWP model guidance for short-term convective weather forecasting, as satellites observe the true state and evolution of a convective event at high temporal/spatial resolution, whereas NWP models often incorrectly simulate the timing and location of convective storm development. Satellite-derived products also have an advantage over WSR-88D radar products in that convective storm initiation is observed in satellite imagery before precipitation echoes are detectable by radar, providing valuable lead time for operational forecasters.

Accomplishments

1) We are collaborating with NOAA/SAB analysts in the optimal display, interpretation, and use of CIMSS satellite-derived convection diagnostic and nowcasting products. NOAA/SAB officially announced availability of these products to several NWS offices. SAB is currently evaluating SATCAST products and communication is ongoing.

2) A training PowerPoint presentation has been constructed and provided to interested users, including the NOAA NESDIS SAB team.

3) The software has been optimized to operate on larger real-time domains. The CI domain will operate in two modes. First over Storm Prediction Center (SPC) convective risk domains and

second over the upper Midwest in support of local forecast offices. SATCast is now operating over the AWIPS Upper Midwest "States" domain. Cooling rate and convective initiation results are being evaluated locally at CIMSS prior to distribution to local NWS office. A new cooling rate technique using radiance box averaging has been developed to improve product temporal latency and reduce false alarm rate.

4) We are working with local NWS offices (Milwaukee-Sullivan, Green Bay, and La Crosse) to acquire user feedback and improve upon products where necessary. The SATCast mesoscale winds and convective initiation work was presented to forecasters at the Milwaukee-Sullivan and La Crosse NWS offices. They have expressed strong interest in receiving mesoscale wind fields via AWIPS. Distribution of Mesoscale winds commenced in May 2007 via AWIPS to the Milwaukee-Sullivan and La Crosse NWS offices, and a feedback survey is being constructed. Local science operations officers are excited about the mesoscale wind product. Visits to offices to provide information about how to use winds will occur in July and August 2007 (the mesoscale winds web site is at: http://cimss.ssec.wisc.edu/~jordang/awips-goes/meso/).   Figure 4 shows an example of mesoscale winds in AWIPS. We are also on agenda to present the GOES satellite-derived mesoscale winds and convective initiation work at NWS Great Lakes Operational Meteorologist Workshop Sept 5-7, 2007. Green Bay NWS has invited us to visit in October 2007 to present this work.

5) We are coordinating with scientists at NSSL and CIRA on CIMSS aviation activities. A seminar at CIRA will be conducted in Fall or Winter 2007.
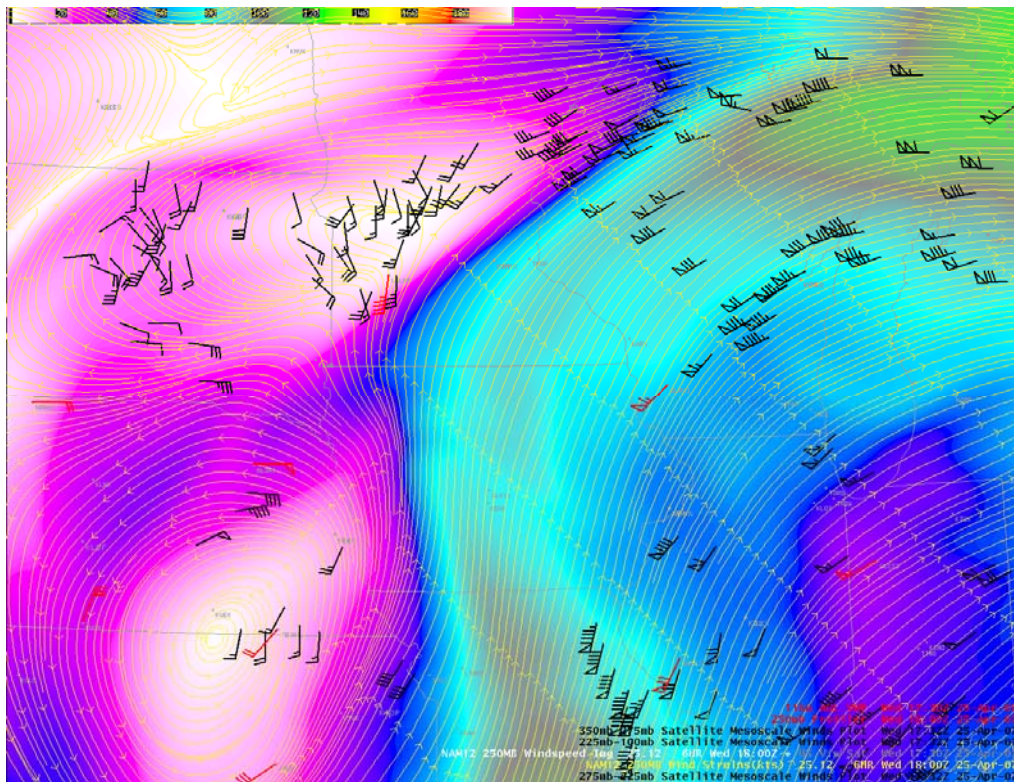

Figure 4: GOES-12 upper-tropospheric mesoscale winds (black) plotted on top of NAM model wind streamlines (yellow lines), NAM model wind speed (color shaded), and time/height matched WSR-88D and Wind Profiler wind barbs (red) within the AWIPS software. Plots such as these allow us to evaluate the quality of these mesoscale winds in a framework that NWS forecasters can relate to.

7.   Cloud Products
Lead Scientists: Mike Pavolonis, 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 make cloud products available to all interested users for evaluation and comment.

Summary of Results for Past Quarter
We still have not initiated work on this project. All of our efforts this quarter, as was the case last quarter, are on developing GEOCAT and imbedding the cloud algorithms into it. This quarter has seen the implementation of the daytime cloud properties algorithm (see Figure 5) and the cloud typing algorithm. This work has been done under the GOES-R AWG project. GEOCAT is now fully functional as GOES processing system and we have demonstrated its robustness by running one month of MSG data through it and generating Level-1 files. Our next goal is to generate cloud height and infrared cloud microphysical products. We are working towards a transfer of these algorithms to STAR in October, 2007. At this point, we will implement them in real-time on GOES data at CIMSS and displaying the results online.   We expect by the fourth quarter of 2007 to conduct the real-time implementation of GEOCAT proposed in this GIMPAP project.
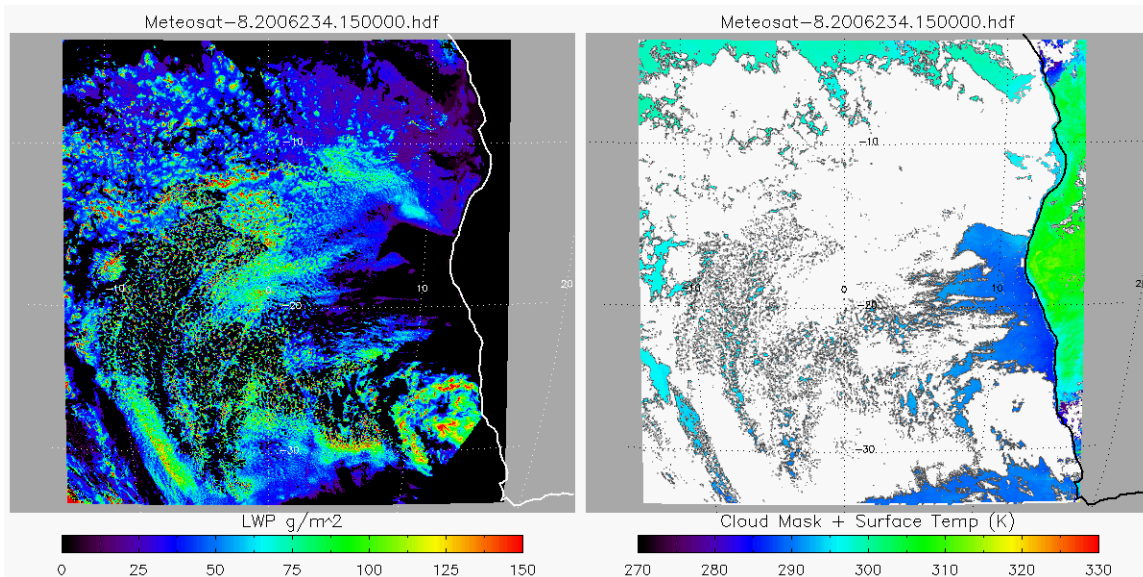

Figure 5 Example of the current GOES-R AWG cloud properties derived from MSG/SEVIRI. Image on the left is the cloud liquid water path and image on the right is the cloud mask overlaid on top of a surface temperature field. Data is from the South Atlantic Ocean off the Coast of Angola.