The Cooperative Institute for Meteorological Satellite Studies
(CIMSS)

Quarterly Progress Report
for
CIMSS Participation in the GOES-R Risk Reduction Program for 2008

for the period
1 January 2008 to 31 March 2008

submitted by:

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**1.   Improvement of Forward Models for ABI Simulations, Algorithm
        Development, and Radiance Assimilation
        Task Leaders: Allen Huang, Tom Greenwald, Bob Knuteson**

Proposed work:
This project seeks to enhance and verify the surface property databases and cloud/aerosol property databases used in generating simulated ABI proxy data sets. Because these properties are the least well-known parts of the forward radiative transfer modeling problem, it is expected that improving them will provide higher quality simulated ABI data sets for algorithm development and testing and radiance data assimilation experiments.

Acquiring improved surface properties and cloud/aerosol properties are considered outstanding issues by the GOES-R Algorithm Working Group. Better surface emissivity and surface reflectance data sets, especially over land, will have significant impacts on the performance of sounding and cloud products and on the broad use of clear sky radiances in data assimilation. Improved cloud particle absorption/scattering properties, particularly for ice, can provide more realistic tests of simulated ABI cloud products. More complex characterization of aerosol absorption/scattering properties, which depend on shape, size and composition, will also provide more realistic tests of ABI aerosol products used in air quality assessment and forecasts.

Accomplishments:
We acquired combined MODIS (Terra+Aqua) BRDF (Bidirectional Reflectance Distribution Function) Albedo Model products (MCD43B1) from the Land Processes DAAC. These products are at 1 km spatial resolution on a sinusoidal projection and contain 3D weighting parameters for the anisotropy models. The models support the spatial relationship and parameter characterization best describing the differences in radiation due to the scattering (anisotropy) of each pixel, relying on multi-date, atmospherically corrected, cloud-cleared input data measured over 16-day periods. Data sets starting on 13 August 2006 were selected to correspond to the 3-km WRF simulation performed over the MSG domain on 16 August 2006 for GOES-R AWG Proxy Data activities.

To derive the UW/CIMSS High Spectral Resolution (HSR) Emissivity Database, the HSR Emissivity algorithm and the input Baseline Fit (BF) global land surface IR emissivity data are required. In the first quarter of 2008 the beta testing of the UW/CIMSS High Spectral Resolution (HSR) Emissivity Algorithm was performed, the BF emissivity database and website was updated and the difference between collection 4 and the new collection 5 MODIS land surface products were investigated.

The UW/CIMSS HSR land surface IR emissivity database is derived from a combination of high spectral resolution laboratory measurements of selected materials, and the UW/CIMSS BF global infrared land surface emissivity database by using a principal component analysis regression. The algorithm is available in Fortran and Matlab languages. The beta version of the algorithm to extract a HSR emissivity from the UW/CIMSS BF emissivity dataset has been tested by scientists from EUMETSAT, Naval Research Laboratory, Monterey, Ca and CIMSS. The software is ready for release.

Because the BF emissivity data uses the MODIS MYD11 product as input, BF emissivity values will be affected by changes in the MYD11 algorithm. Beginning with January 2007 the NASA LP DAAC began processing the MYD11 data with the new collection 5 algorithm. The BF emissivity has now been computed using the new input MYD11 and is called version 3. Previously, version 2 BF emissivity was derived from the collection 4 MYD11 data.

BF emissivity derived from both collection 4 and collection 5 MYD11 data are now available at the UW/CIMSS emissivity website (http://cimss.ssec.wisc.edu/iremis). Version 2 BF data (MYD11 collection 4) is available for: Sept 2002 - Dec 2006 time period and Version 3 BF data (MYD11 collection 5) is available for whole year of 2003, 2004, 2006 and 2007. As collection 5 MYD11 data from other months and years becomes available on the NASA LP DAAC server, the BF database will be processed.

In this quarter, the comparison between collection 4 and 5 MYD11 products was also investigated. We noticed some significant differences with the new collection 5 of MYD11 products. The two most significant changes are the loss of variability in the long wave window channels (see bottom panels of Fig. 1 as an example) and an increase in the minimum emissivity for band 29 approximately 0.2 (see top panels of Fig. 1 as an example), especially over the desert and very arid areas. These changes are under further investigation, which also includes comparison with other independent IR land surface emissivity products like from AIRS and SEVIRI measurements. Due to the magnitude of the changes, we do not recommend use of version 2 and 3 BF emissivity data as a continuous dataset for the users.

In the next quarter a paper describing the UW/CIMSS HSR emissivity algorithm will be submitted, the HSR emissivity algorithm will be released on the website and as a routine task, UW/CIMSS BF emissivity data is processed as a new data becomes available on the NASA LP DAAC server.
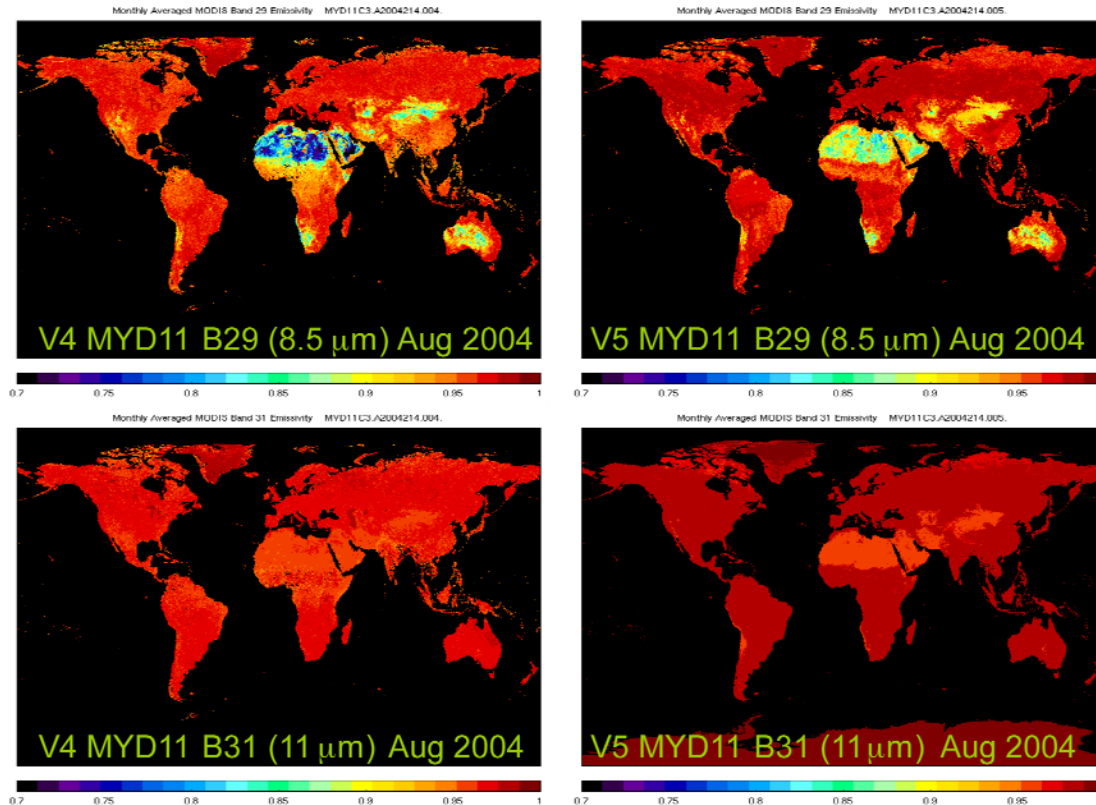
Figure 1: Comparison of collection 4 (V4) vs. collection 5 (V5) MODIS (MYD11C3) monthly land surface emissivity products at band29 (8.5 μm) and band31 (11 μm) for August 2004.

2. Study of the Efficient and Effective Assimilation of GOES-R Temporal/Spatial Measurement Information
Task Leaders: Jason Otkin, Allen Huang

This is a new project. Since funding has not yet arrived, there is nothing to report at this time.

3. GOES-R Atmospheric Motion Vector (AMV) Research
Task Leaders: Chris Velden, Steve Wanzong

Project Summary
GOES-R Risk Reduction work on AMVs at CIMSS focuses on exploring the applications of the AMV retrieval algorithm to expected GOES-R imagery and the estimation of tropospheric winds. It is important that this primary/traditional and important atmospheric variable derived from GOES satellites be measured with precision, and that new capabilities afforded from GOES-R (i.e. new spectral channels, better space and time resolution) be fully explored. This proposed work serves as a pre-requisite to the AWG AMV efforts, whereby algorithm research and development, demonstration, and testing is performed prior to AWG implementation activities.

Background
Previous GOES-R Risk Reduction work on AMVs concentrated on demonstrating the ability of the AMV algorithm to target and track features found in WRF modeled moisture fields and simulated

moisture retrievals. The ATReC and Ocean Winds data sets were used to successfully demonstrate the feasibility of the concept of altitude-resolved vectors from the derived retrieval constant-pressure moisture analyses.

Based on the recent decisions to delay the HES and descope it from GOES-R, combined with TAC guidance, our focus on GOES-R winds research in 2008 will be on the ABI. We have completed the effort to demonstrate the concept of deriving tropospheric winds from retrieved moisture analyses provided by hyperspectral sensors, which was the focus of previous risk reduction wind derivation studies. However, since a sounder of some kind is still being considered for GOES-R, we will continue to demonstrate the potential of this novel approach using the existing GOES sounder (per TAC guidance).

Accomplishments over last three months include:
The following are *specific tasks we proposed to accomplish*, followed by progress in last 3 months:
- *Refine and optimize the baseline winds algorithm for expected ABI inputs*
  The QI code was rewritten to the GEOCAT framework and tested.
- *Identify potential algorithm risks and propose solutions to reduce risks*
  We employed input data provided by the AWG proxy data team in the form of WRF model-generated simulated cloud and moisture fields representing selected ABI channels. CIMSS made use of these "ABI-like" fields by transforming them into AMV algorithm-friendly input images. From a time sequence of these images, we tracked features to retrieve AMV fields. Using the GRAFIIR system, we introduced various forms of noise to the original TOA fields to assess the potential impact on the AMV fields. The results of this risk reduction analysis will be presented at the International Winds Workshop in mid April 2008.
- *Update ATBD describing baseline winds algorithm*
  Discussions began on the content for the winds ATBD, which will be used to reflect any identification of potential algorithm risks, as well as proposed solutions to reduce the risks.
- *Continue the investigation of applying the baseline winds algorithm to GOES sounding moisture fields*
  No new research results for this reporting period.

Publication/Conferences
Genkova, I., S. Wanzong, C. S. Velden, D. A. Santek, J. Li, E. R. Olson, and J. A. Otkin, 2008: GOES-R wind retrieval algorithm development. 5th GOES Users Conf., AMS Annual Meeting, New Orleans, LA.

**4.   Hurricane Wind Structure and Secondary Eyewall Formation
        Task Leaders: Jim Kossin, Matt Sitkowski**

We're continuing our progress toward an algorithm that utilizes environmental analyses and GOES infrared imagery to objectively diagnose and forecast hurricane secondary eyewall formation. Our accomplishments for this quarter are:

1) Sitkowski presented our results at the AMS Annual meeting in New Orleans, LA.
2) Kossin presented our results at the 62nd Interdepartmental Hurricane Conference in Charleston, SC.
3) The secondary eyewall database was expanded further through searches of the Vortex Message archive at the National Hurricane Center.

3) Further modifications were made to the Bayes classification algorithm to increase skill.
4) Additional information was extracted from the GOES imagery using Principal Component Analysis. Two-dimensional infrared brightness temperature fields were azimuthally averaged about the storm center to form temperature profiles, and the leading EOFs were calculated. The leading expansion coefficients (PCs) were found to increase the algorithm performance when added to the existing GOES-based predictors from the SHIPS model.
5) A rigorous cross validation of the algorithm was performed. We applied a "leave-one-season-out" method, which provides a good barometer of the skill expected in an operational forecasting setting.
6) We further explored various ways to assess skill, including Brier Skill Scores, Confusion Matrices, Attributes Diagrams, and Receiver-Operating Characteristic (ROC) curves. We are achieving Brier Skill Scores of around 21%, and the area under the ROC curve is giving a probability of ~84% that the algorithm will distinguish between events and non-events. The Attributes Diagram for the cross-validated algorithm performance is shown in Figure 2.
7) We have begun looking at the cross-validated performance of individual storms. An example is shown in Figure 3.
8) We are completing a manuscript documenting the new algorithm. This will be submitted shortly as a peer reviewed article, probably to Monthly Weather Review.
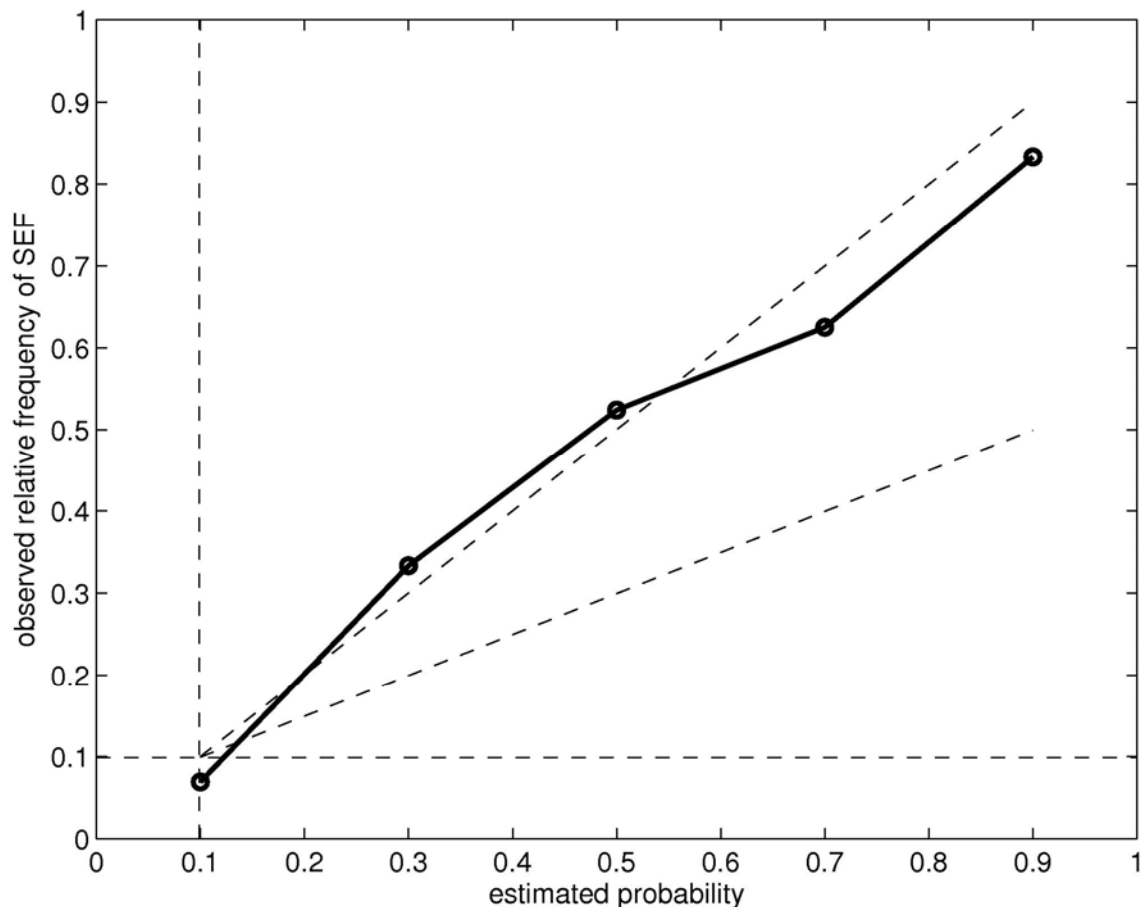

Figure 2: Attributes Diagram for the cross-validated algorithm. Points on the X=Y diagonal represent perfect algorithm reliability. The horizontal dashed line represents climatology (zero recognition). The algorithm is exhibiting good reliability at all estimates of probability.
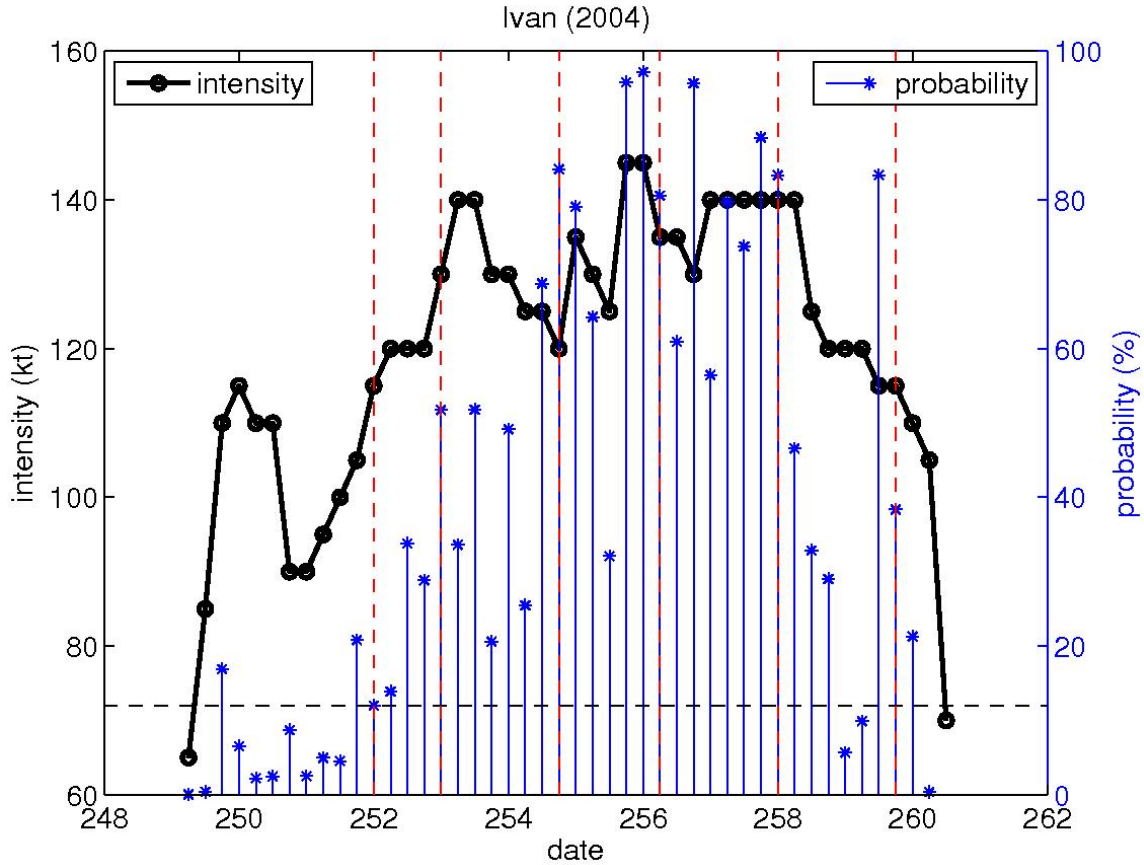
Figure 3: Evolution of the Hurricane Ivan's intensity (black curve) and the probability of secondary eyewall formation provided by our algorithm (blue points). Actual secondary eyewall formation events are identified by the dashed red lines. The performance is based on the cross-validated probabilities and provides a realistic measure of expected operational performance.

5.   GOES-R Ozone Product Risk Reduction Study
   ## Task Leader: Jinlong Li

Study on the impact of clouds on ABI total ozone retrieval
A Total Column Ozone (TCO) retrieval algorithm using ABI infrared radiances has been developed (Jin et al. 2007 - IEEE TGARS); the algorithm is for clear sky ABI radiances only. Since the ozone weighting function peak of 9.7 µm ABI spectral band is above the cloud-top in most cloudy situations, it is possible to derive the ozone product under some cloudy skies. In order to develop ABI cloudy ozone retrieval algorithm, a cloudy radiative transfer model for ABI infrared radiance calculations under cloudy situations has been developed. The input cloud parameters are cloud-top pressure (CTP), cloud particle size (CPS) and cloud optical thickness (COT) at 0.55 µm. Radiance sensitivity to the cloud parameters were studied, we found that the 9.7 µm band is sensitive to the cloud optical thickness (COT) when COT is greater than 1.0, while it is less sensitive to CPS, especially for ice clouds. Figure 4 shows the simulated top of atmosphere (TOA) ABI 9.7 µm band brightness temperatures as a function of cloud optical thickness for various cloud particle sizes, for ice clouds (upper panel) and water clouds (lower panel), respectively. According to the results, CPS effects can be easily accounted into brightness

temperature calculations. Therefore, COT and CTP are the major parameters that need to be considered in the development of cloudy training data set for ABI TCO retrieval in cloudy situations. We will report the progress on cloudy training dataset development in our next quarterly report.
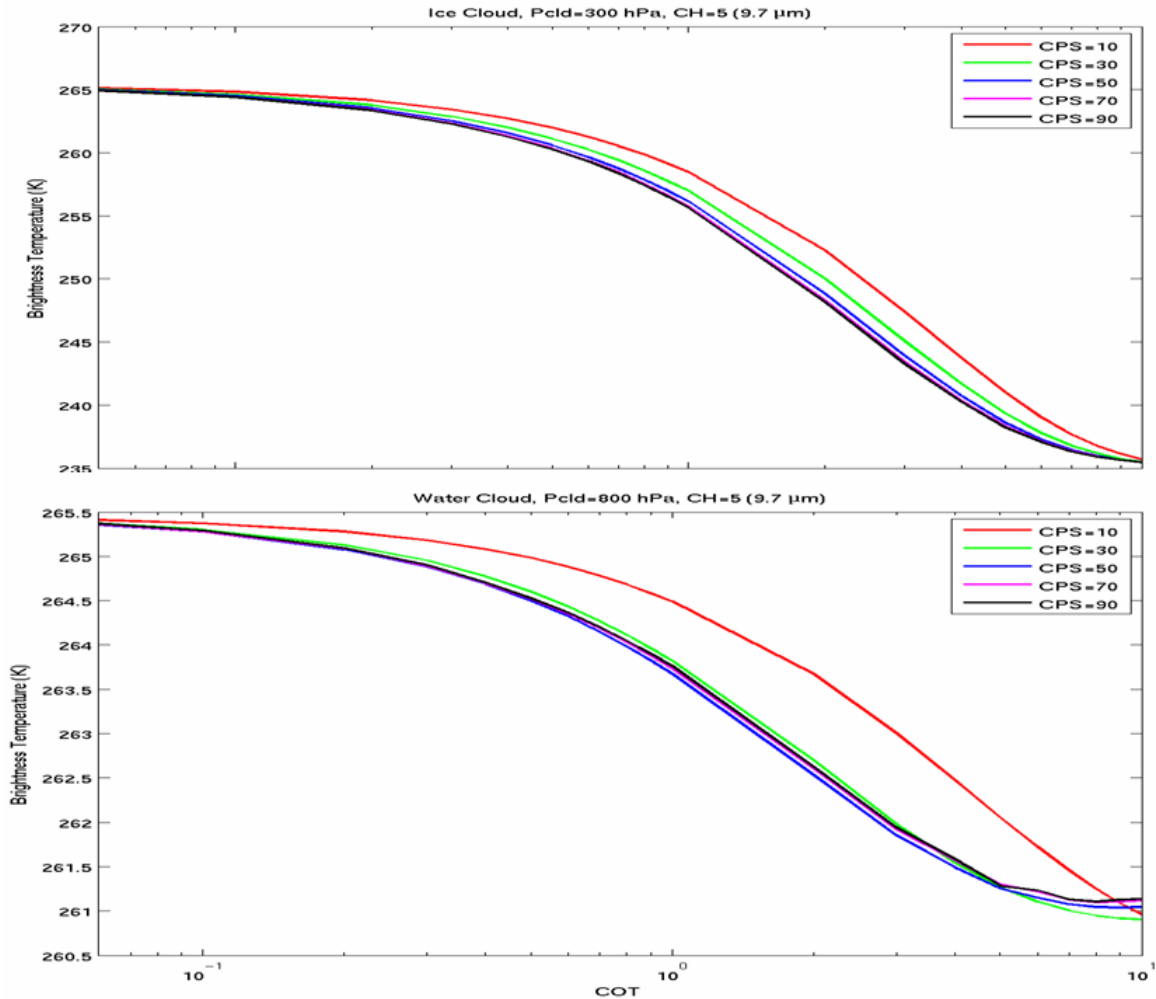

Figure 4. The simulated top of atmosphere (TOA) ABI 9.7 µm band brightness temperatures as a function of cloud optical thickness for various cloud particle sizes, for ice clouds (upper panel) and water clouds (lower panel), respectively.

6.   GOES-R Sounding Algorithm Development and Risk Reduction
Task Leaders: Jun Li, Allen Huang
NOAA Collaborator: Tim Schmit

Global map of hyperspectral IR emissivity comparison with MODIS
In our last quarterly report, a hyperspectral IR global emissivity map was produced from 8-day global Atmospheric InfraRed Sounder (AIRS) radiance measurements using an algorithm developed by the CIMSS sounding team (Li et al. 2007 - GRL). In order to further analyze the reliability of hyperspectral IR emissivity map from AIRS, the operational MODIS (collection 4) broad-band emissivity product is used for the comparisons. The MODIS spectral response functions (SRFs) are used to convolve the AIRS hyperspectral IR surface emissivity (from

CIMSS single field-of-view algorithm) into the MODIS spectral coverage. Figure 5 shows the AIRS convoluted 8-day (01 – 08 January 2008) emissivity retrieval at 8.55 µm (upper left panel), the operational MODIS 8-day composite emissivity map (collection 4, lower left). The two types of emissivity agree very well in both pattern and magnitude.
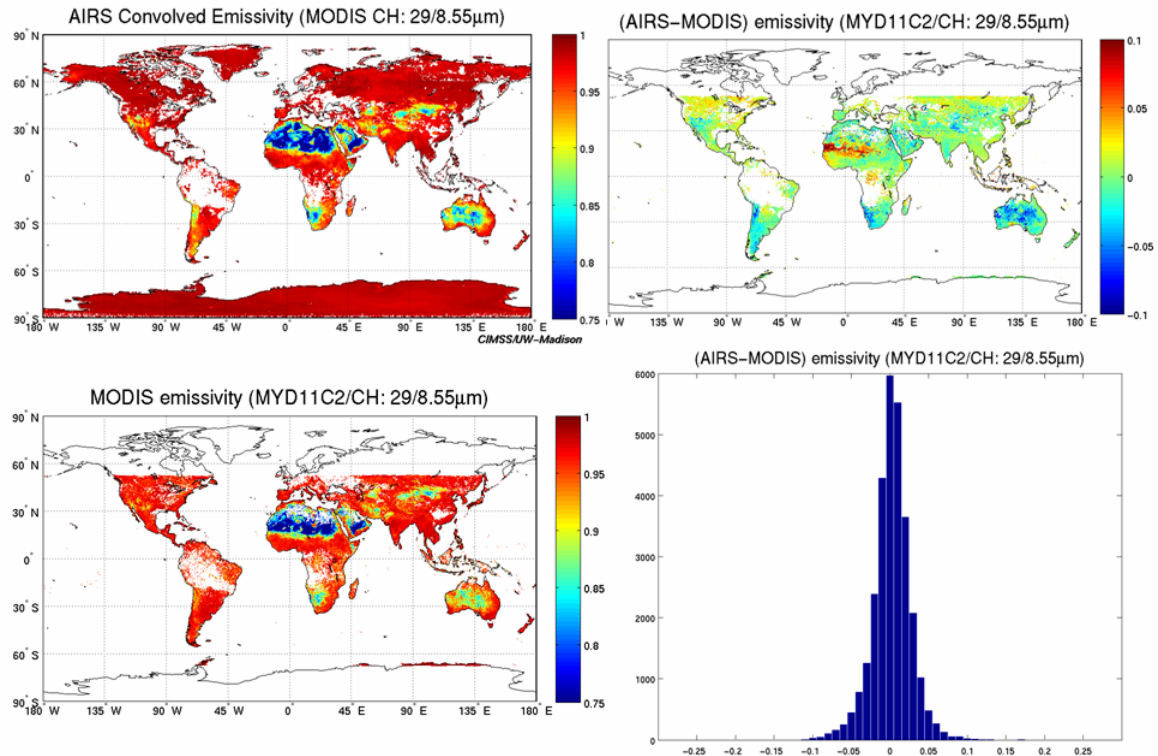

Figure 5. The AIRS convoluted 8-day (01 – 08 January 2004) emissivity retrieval at 8.55 µm (upper left panel), the operational MODIS 8-day composite emissivity map (lower left), the difference image between AIRS and MODIS (upper right), and the histogram of the emissivity differences.

The emissivity difference map from the two instruments is also shown in the upper right panel of Figure 5; the histogram of the differences is indicated in the lower right panel. Most pixels have the differences less than 0.05 for MODIS 8.55 µm band. Some pixels (over Saharan region) show a little large differences (greater than 0.05), indicating the possibility of large uncertainties in both emissivity products for 8.55 µm IR spectral region.

GEO/LEO Synergy Study
For GEO/LEO synergies we have used MODIS as proxy for GEO (geostationary earth orbit) ABI and AIRS for LEO (low earth orbit) hyperspectral IR data. Collocated MODIS clear sky radiances and AIRS radiances are used to derived the soundings at AIRS single footprint resolution. In AIRS partial cloud cover, MODIS clear radiances within the AIRS footprint help the AIRS cloudy sounding. Figure 6 shows the composite true color using Aqua MODIS reflectance from bands 1, 4, 3 as red, green, and blue, respectively from 1935 to 1945 UTC on 09 May 2003 (panel (a)), the relative humidity (RH) vertical cross section alone the green line in (a) from MODIS clear alone retrievals (panel (b)), AIRS alone retrievals (panel (c)), and the combined AIRS and MODIS retrievals (panel (d)) for AIRS granule 196 on 09 May 2003. Black solid lines are corresponding radiosonde location used for sounding validation. Temperature and moisture soundings from AIRS cloudy radiances alone and the combined MODIS clear radiances

and AIRS cloudy radiances are compared with radiosonde at ARM CART site, MODIS clear radiances improve AIRS soundings in cloudy skies (not shown). In Figure 6, although AIRS alone method can retrieve a moist layer approximately at 550 hPa between latitudes 34.5° and 35.5°, the synergistic AIRS and MODIS method can retrieve a more prominent feature at the same cross section latitudes, which can be identified as broken clouds from MODIS true color image.
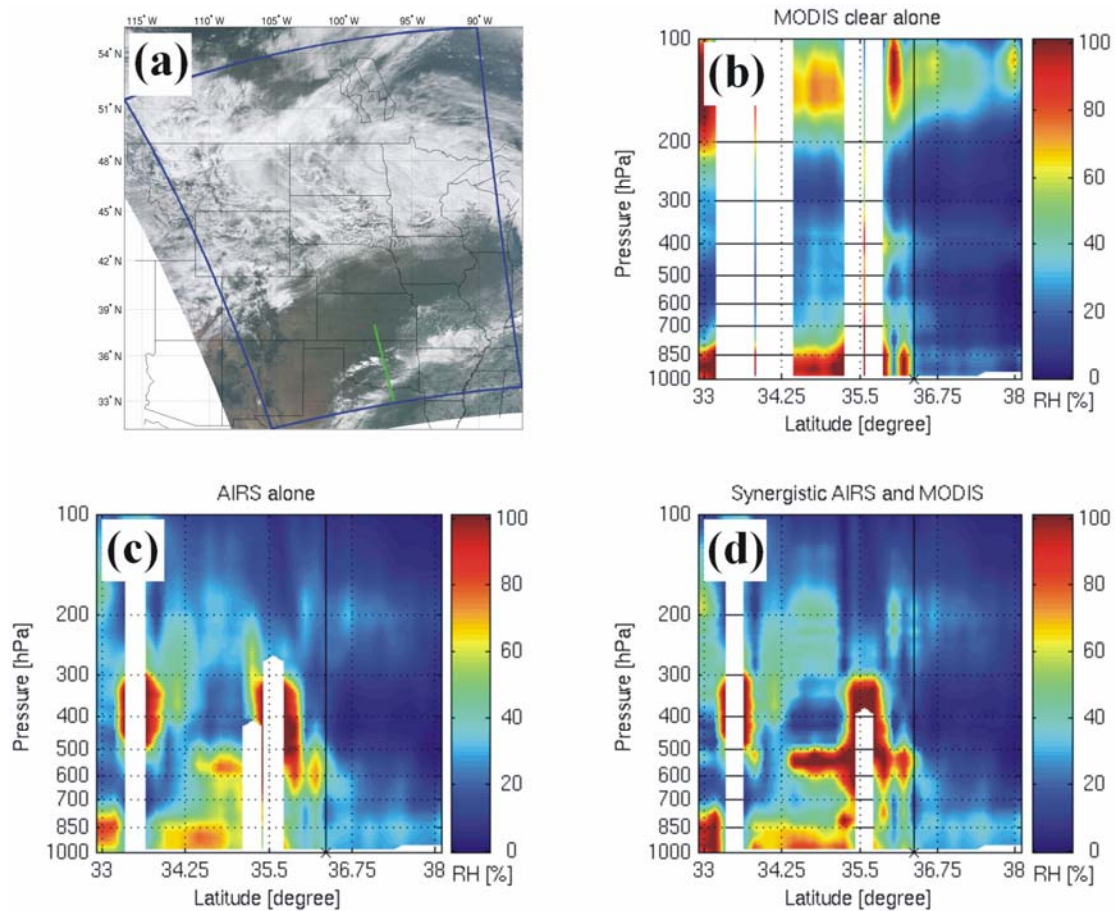

Figure 6. (a) Composite true color using Aqua MODIS reflectance from bands 1, 4, 3 as red, green, and blue, respectively from 1935 to 1945 UTC on 09 May 2003; the relative humidity vertical cross section alone the green line in (a) from MODIS clear alone retrievals (b), AIRS alone retrievals (c), and the combined AIRS and MODIS retrievals (d) for AIRS granule 196 on 09 May 2003. Black solid lines are corresponding to the radiosonde location used for validation.

Improvement on hyperspectral IR alone SFOV cloudy sounding algorithm
The statistical algorithm for hyperspectral IR sounding retrieval in both clear and cloudy skies has been developed (Weisz et al. 2007). An advanced physical retrieval algorithm for simultaneously retrieval of atmospheric temperature and moisture profiles, cloud-top pressure, cloud optical depth and cloud particle size is being developed. The coupled clear sky radiative transfer model called SARTA developed by UMBC and cloudy scattering model developed through the joint effort of University of Wisconsin and Texas A&M University are used for cloudy radiance calculations. The cloudy sky Jacobians for temperature and moisture profiles as well as cloud parameters are also developed for physical retrieval. Figure 7 shows the water vapor mixing ratio (in term of logarithm) Jacobians with ice cloud optical thickness of 0.0 (clear), 1.0, and 2.0 respectively. Three IASI water vapor absorption channels are selected to represent upper (left

panel), middle (middle panel), and lower (right panel) atmospheric levels. It can be seen that ice clouds (if not very thick) have less impact on high level water vapor absorption channels, while they have impact on middle and lower level water vapor channels. Cloudy sounding improvement from the physical retrieval algorithm using the cloudy radiative transfer model and accompanying Jacobians over that from the regression technique is expected and will be included in the next quarterly report.
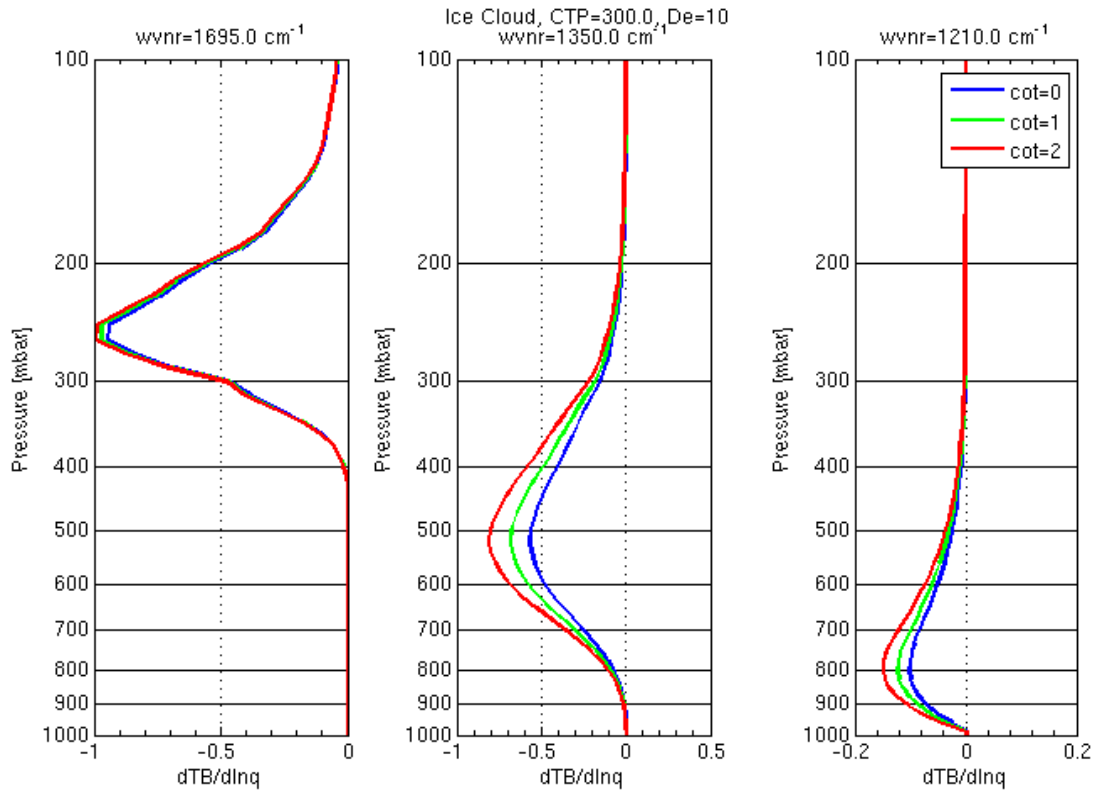

Figure 7. Water vapor mixing ratio (in term of logarithm) Jacobian with ice cloud optical thickness of 0.0 (blue line for clear sky), 1.0 (green line), and 2.0 (red line), respectively. Three IASI water vapor absorption channels are selected to represent upper (left panel), middle (middle panel), and lower (right panel) atmospheric levels

Peer-reviewed journal publications from 01 October to 31 December 2007.
Schmit, T. J., J. Li, J. J. Gurka, M. D. Goldberg, K. Schrab, Jinlong Li, and W. Feltz, 2007: The GOES-R ABI (Advanced Baseline Imager) and the continuation of GOES-N class sounder products, *J. of Appl. Meteorol. Cli.* (Accepted)

Jin, X., Jun Li, T. J. Schmit, et al. Retrieving Clear Sky Atmospheric Parameters from SEVIRI radiance measurements and simulated ABI radiances, submitted to *Journal of Geophysical Research* - Atmosphere

7.   CIMSS Cal/Val Efforts in Support of GOES-R
Task Leader: Dave Tobin

Proposed tasks for this effort include participation in GSICS (Global Space-based Inter Calibration System) meetings, participation in GOES-R Cal/Val planning, analyses of benchmark aircraft validation datasets in support of GSICS, simulation studies to estimate uncertainties in satellite sensor intercalibrations, and characterization and analysis of ARM site data for atmospheric sounding validation.

During this period, two key analyses have been performed, including the evaluation of AIRS and IASI spectral radiances using direct comparisons of the two using Simultaneous Nadir Overpasses, and the creation and evaluation of five years of global Aqua AIRS/MODIS radiance comparisons. These are described briefly below.

An example of a recent GSICS related study is shown in the Figure 8, where comparisons of AIRS and IASI for Simultaneous Nadir Overpasses (SNOs) are shown. The top panel shows the mean difference between AIRS and IASI from 9 months of northern latitude SNOs. The bottom panel shows the southern latitude SNO comparison. The spectral differences are color coded for the AIRS detector arrays. The comparisons are very useful for GSICS because they help to quantify the accuracy of the benchmark observations used for assessment of the other Geo and Leo satellite observations. While the mean differences are very small (on the order of < 0.1K for 20 wavenumber averages, typically), some larger differences are also observed, and the root causes of these differences are under investigation.
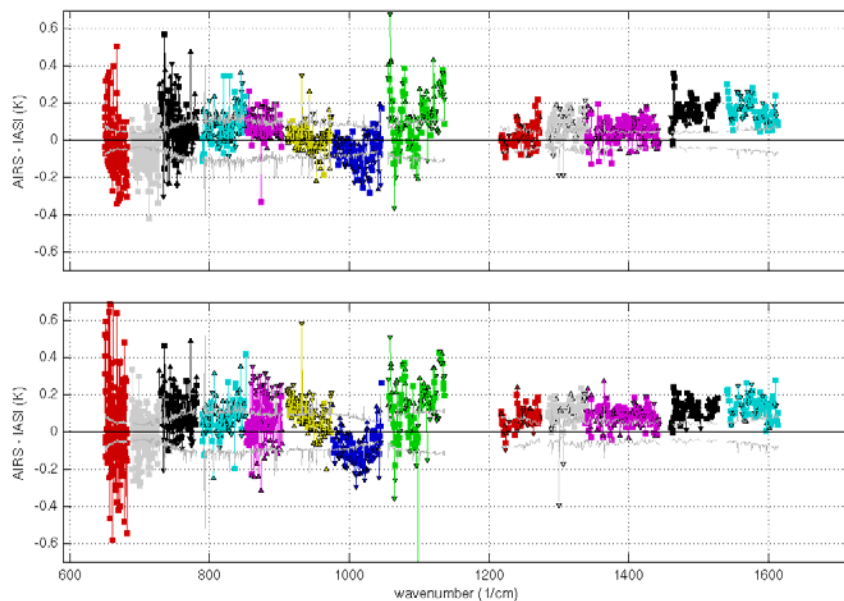
Figure 8. Mean brightness temperature differences between AIRS and IASI for Simultaneous Nadir Observations (SNOs) collected between April 2007 and January 2008. The top panel is the mean difference for northern latitude SNOs and the bottom panel is the mean difference for southern latitude SNOs, and the spectral curves are color-coded for the AIRS detector arrays. The statistical uncertainty in the mean difference is also included as the grey curves.

Drawing upon additional computing resources from the NPOESS Preparatory Project (NPP) Product Evaluation and Test Element (PEATE) at UW-Madison, we have compared Aqua AIRS and MODIS infrared radiances for the first day of every month for the life of the Aqua mission. The comparison process is described in Tobin D. C., H. E. Revercomb, C. C. Moeller, T. S. Pagano (2006), *Use of Atmospheric Infrared Sounder high–spectral resolution spectra to assess the calibration of Moderate resolution Imaging Spectroradiometer on EOS Aqua*, J. Geophys. Res., 111, D09S05, doi:10.1029/2005JD006095. Sample results are shown in Figures 9 and 10. Figure 9 shows the time series of the comparisons for MODIS band 32 (12 µm). The blue crosses are mean AIRS observed brightness temperatures for each day and the red squares are mean MODIS observed brightness temperatures for each day, for spatially homogeneous FOVs, and in the bottom panel, the black circles differences. The global mean differences for each day are less than 20 mK over the entire five year period and show no discernible long term trend versus time, but with a very small but repeatable pattern every year. This type of agreement is outstanding.
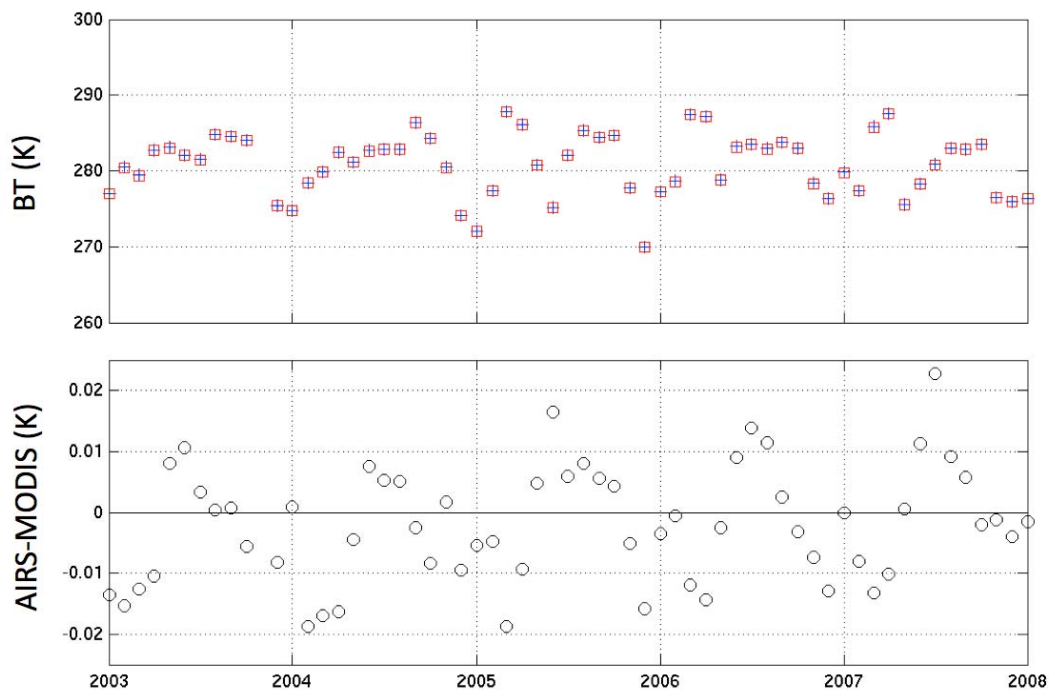

Figure 9. Five years of global AIRS/MODIS radiance comparisons for MODIS band 32. See the text for details.

As described in Tobin et al. 2006 there are significant differences between AIRS and MODIS for the MODIS LW bands, and one hypothesis is that these differences are due to inaccurate specification of the MODIS SRF positions. Figure 10 shows the comparison of AIRS and MODIS for MODIS band 35 (13.9 µm) as a function of AIRS brightness temperature and latitude for the first day of every month for the year of 2003. The figure shows the comparisons with the nominal MODIS SRF position and with the SRF shifted by 0.8 cm^{-1}. Without the shift, the biases exhibit a complicated behavior which varies with location on the globe and scene brightness temperature; with the proposed shift, the differences are reduced to near zero for all times and locations. The same behavior is observed for other years of the study and similar improvements are found for the other LW bands.

AIRS minus MODIS, Band 35
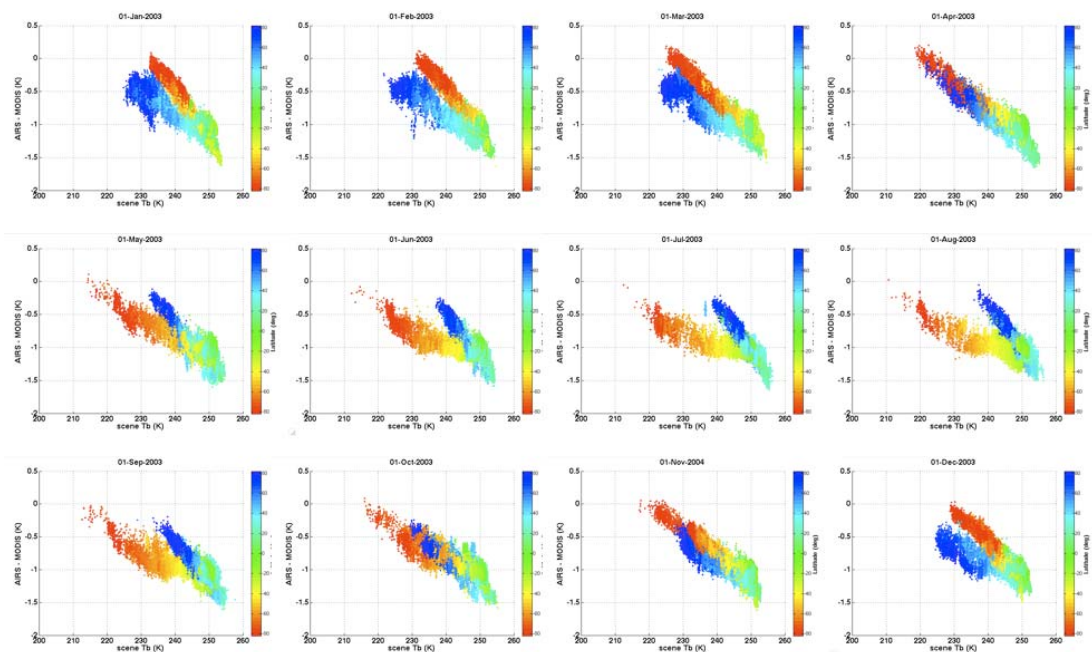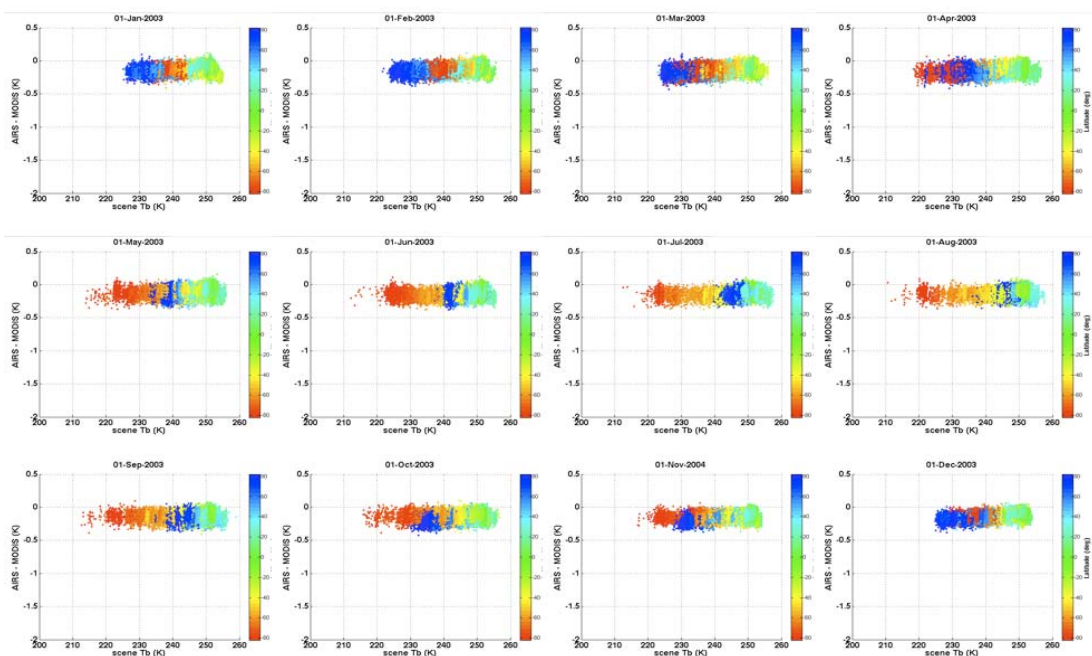
AIRS minus MODIS, Band 35, with 0.8 cm⁻¹ SRF shift

Figure 10. Comparisons of AIRS and MODIS brightness temperatures for MODIS band 35 (13.9 μm) as a function of time, scene brightness temperature, and latitude. The comparisons are shown with the nominal MODIS Band 35 SRF and with the SRF shifted by 0.8 cm⁻¹.

8.   GOES-RRR Fire Detection, Monitoring, and Characterization
**   Task Leaders: Chris Schmidt, Elaine Prins**

GOES-R ABI biomass burning research and development activities for 2008 focus on active fire detection and sub-pixel characterization utilizing simulated and current global geostationary multi-spectral data. CIMSS continues to apply the dynamic Baseline Emissivity data set which contains monthly estimates of spectral band emissivities derived from MODIS data to improve sub-pixel fire characterization. CIMSS will utilize 15-minute MSG SEVIRI data and the MSG WF_ABBA product over Africa to investigate how to exploit high temporal data to identify and monitor small fast-burning agricultural and grass fires. CIMSS will continue to investigate fire characterization using both Dozier estimates of instantaneous sub-pixel fire size and temperature and fire radiative power (FRP) as derived from both MODIS simulated ABI data and other sensors as appropriate. CIMSS also is examining the use of additional channels for fire detection and characterization, investigating the potential of GLM lightning data to improve the fire products, and testing different techniques to address atmospheric attenuation and solar reflectivity. Collaborations continue with NRL-Monterey and NESDIS on emission studies and data assimilation into the NAAPS model. These risk reduction activities will ensure enhanced future fire detection, monitoring and characterization.

Accomplishments:
The first quarter of 2008 primarily saw progress on proxy data generation and proxy data testing. In January a data set of simulated fires over Central America was received from the proxy data team at CIRA and the ABI WF_ABBA was applied to it, leading to further examination of the minimum detection thresholds for fires. This case and the previous Kansas model case, also from CIRA, suggest that fires must have a minimum FRP of 75 MW in order to be detected, though this value can vary due to the surface types and viewing conditions involved. 75 MW represents a relatively small difference in temperature between fire pixel and background, or roughly a couple of degrees Kelvin difference in the 3.9 µm brightness temperature.

The generation of ABI proxy data from MODIS was advanced another step by further refining the point-spread function (PSF) technique as well as modifying the existing "simple remap" (nearest neighbor) code to work properly with ABI, which had not been the case previously. Once the data was generated the "simple remap" images were run through the ABI WF_ABBA and the results were not as good as the PSF technique, which had been expected. Visual inspection of "simple remap" images showed that fires would be far more difficult to detect properly.

Investigation of the impact of sensor properties on fire detection capabilities has continued, though it has been somewhat hampered by a lack of high-resolution, high-quality simulations of the impacts of sensor components (CIMSS is seeking these from ITT through the proper channels). The degree of diffraction present was varied within the WF_ABBA to estimate the impact of that quantity, and it was found that inaccurate estimates of diffraction, as well as scenarios where substantial diffraction is present, were dramatically impacting fire characterization. FRP was the least impacted, followed by instantaneous fire temperature and with instantaneous fire size showing by far the largest impact of the three fire characteristics. Fire area is important in emissions research, so this impact must be characterized. The relatively low diffraction loss (relatively high amount of energy within the nominal footprint) for ABI will have a small impact on characterization quality, but final instrument values for diffraction will be needed to assess it completely.

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

9. Nearcasts - Filling the Gap Between Observations and NWP Using Dynamic Projections of GOES Moisture Products
Task Leader: Ralph Petersen
NOAA Collaborator: Bob Aune

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

Results this Quarter
Much of the effort during this quarter focused on providing training and getting user feedback, although some efforts have been made to ensure that the NearCasting system can be expanded to include other indicators of potential for other hazardous weather events (e.g., LI, CAPE, etc.).

All milestones for this quarter were met, including: Completed real-time NearCasting system and Met with WFOs for training and to determine user needs/preferences. Efforts have focused on preparations necessary to assure reliable and useful delivery of real-time products, rather than major scientific advances. Details follow.

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

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

Training materials are being collected into PowerPoint presentations that can either be used either by the SOOs at the WFOs to train bench forecasters or by CIMSS personnel in VISITView

sessions. These materials will be presented in GRB in conjunction with the availability of the web-based NearCasts.

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

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

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

Papers also accepted for Special Aviation Session at SPIE meeting in San Diego in August and at Eumetsat Conference in Germany in September. The latter trip will also be used to foster testing of the NearCasts using Meteosat data.

10. **ABI Proxy Data Studies: Regional Assimilation of SEVIRI Total Column Ozone**
    Task Leader: Todd Schaack
    NOAA Collaborator: Brad Pierce

This is a new project. Since funding has not yet arrived, there is nothing to report at this time.

11. **Optimization of Convective and Mountain Wave Turbulence Detection in Support of GOES-R Aviation Requirements**
    Task Leaders: Wayne Feltz, Tony Wimmers, Kris Bedka

Work Proposed
The 2007 funding primarily focused on transition of current Convective Initiation (CI) methodology to SEVIRI; with the additional SEVIRI radiance information, microphysical transitions need to be investigated along with taking advantage of the high temporal resolution of future ABI sensor.

New techniques will be investigated to provide improved convective initiation, overshooting top, thermal couplet detection techniques for GOES-R Aviation AWG. The methodologies will take advantage of higher temporal image resolution to monitor microphysical changes (from GOES-R Cloud AWG) and cooling rate magnitude to detect convective initiation and storm maintenance. This research will work toward GOES-R pre-convective, initiation, and mature convective

product suite which would be used by aviation, hydrology, and weather nowcasting interests. Coordination with Cloud AWG to use imager derived microphysics product and Hydrology AWG provide infrared cooling rate as input to precipitation estimation will occur.

Research toward adapting satellite-derived mountain wave turbulence interest fields toward GOES-R turbulence application will be conducted. Specifically, the research will provide pathway to take advantage of the additional water vapor channel information that should help diagnose the vertical extent and interference pattern prone to be highly correlated with commercial airline mountain wave turbulence encounters.

Accomplishments
Convection
1) Optimize 10.7 um cooling rate product using special 1-min GOES imager checkout data sets (GOES-10 and GOES-12) which is directly correlated to convective initiation through leveraging the high temporal rate of infrared imagery availability.
No significant new progress

2) Use COPS 5-minute SEVIRI data to identify microphysical transitions which provide confidence for proper convective initiation identification
We have started work with MSG SEVIRI imagery toward the use of the GOES-R Cloud Algorithm Working Group (AWG) 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 geostationary satellite observations. Figure 11 shows MSG SEVIRI 10.8 micron IR window imagery, the aforementioned IR-only cloud phase product, and the cloud-top cooling rate product using the box-average approach accumulated every 15-minutes over a 5-hour period for an event with widespread convective development over central Africa. Several events with 5-minute SEVIRI imagery during the COPS experiment have been identified and these will be a focus of future work.

Turbulence
1) Gather in situ and satellite observations for turbulence validation studies:
The NCAR Turbulence Product Development Team has delivered to CIMSS objective EDR observations of turbulence from United Airlines B757 aircraft during the Jan. '05 to Jun '07 time period. MODIS and GOES observations have been collected for mountain wave events with a high number (> 3 SD above the seasonal mean) of moderate to severe turbulence observations. These events will be the starting point for further study.
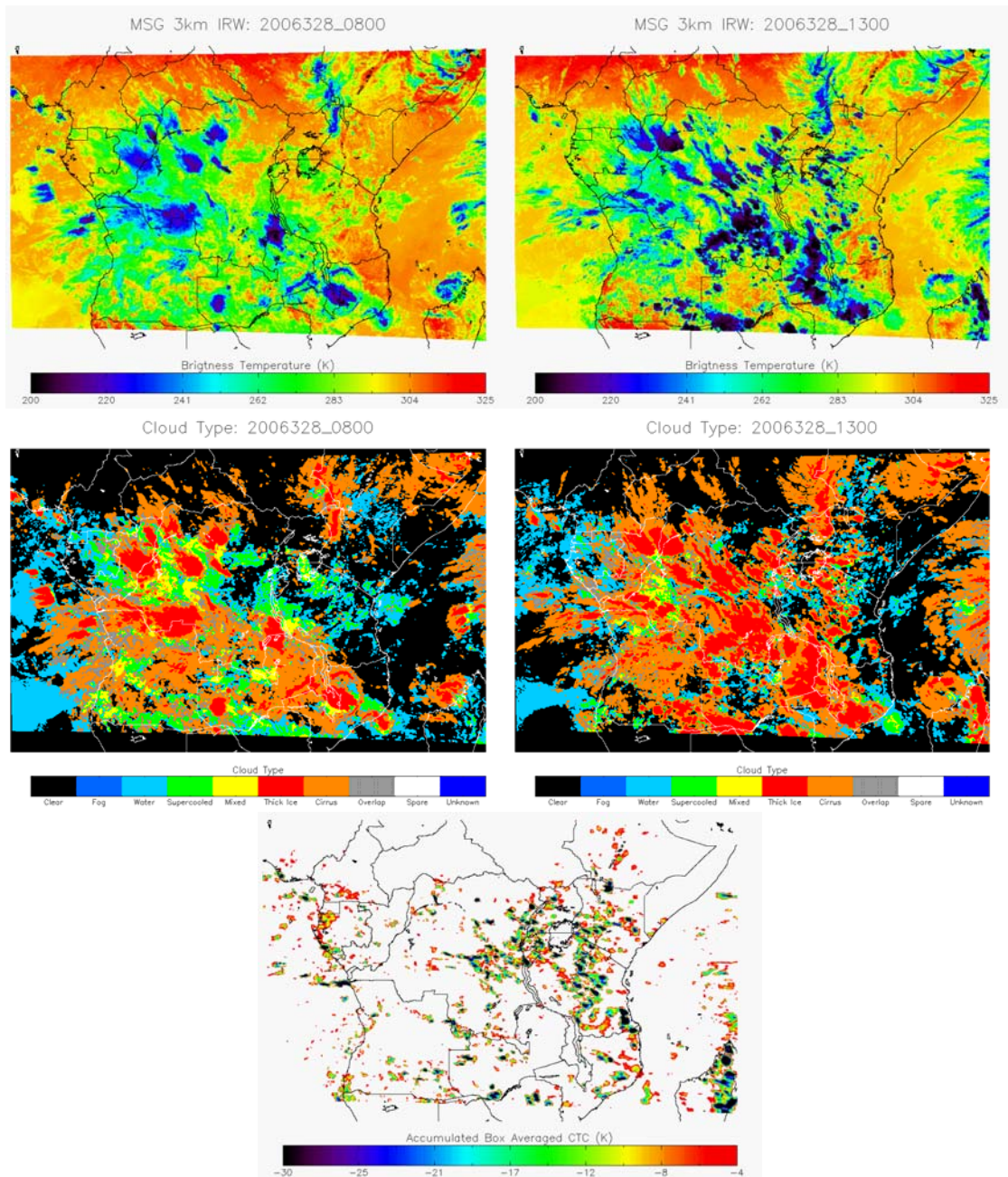
Figure 11: (top) MSG SEVIRI 10.8 µm brightness temperatures at 0800 (left) and 1300 UTC (right) on 03/28/2006, showing the widespread convective development that occurred during this event. (middle) An IR-only cloud-top phase product from the GOES-R Cloud Algorithm Working Group (AWG) at 0800 (left) and 1300 UTC (right). (bottom) 10.8 micron IR window cloud-top cooling rates accumulated every 15 min over the 0800-1300 UTC period shown above using the GOES-R Cloud AWG cloud phase product. For example, a cooling rate is computed at each cloud pixel between the 0815 and 0800 UTC images. The cooling rates between the 0830 and 0815 UTC is then added to that from 0815-0800. This process is done through the entire 0800-1300 UTC period. The greatest cooling rates correspond to locations of convective storm initiation.

2) Use current MODIS imagery to optimize water vapor imagery MWT feature pattern recognition technique:
A climatology of mountain wave events over the Colorado Rockies region in MODIS imagery has recently been completed for the October-April 2005-06 and 2006-07 time periods. This was done to identify both the frequency of occurrence and the varying morphology of mountain waves that occur over this region, such that pattern recognition techniques can be developed and optimized. The results show that some evidence of mountain waves was present in MODIS imagery over this region for 302 out of 442 days (68%) with good MODIS overpasses during the two 7-month periods. The EDR turbulence observations mentioned above will be studies for these 302 events to identify MODIS imagery characteristics for events with significant moderate to severe turbulence versus those producing little to no turbulence.

3) Apply to higher spatial resolution SEVIRI data so geostationary wave structure can be tracked
No significant new progress

12. Investigation of Daytime-Nighttime Inconsistencies in Cloud Optical Parameters
Task Leader: Bryan Baum

This is a new project. Since funding has not yet arrived, there is nothing to report at this time.

13. Improving Ice Thickness and Age Estimation With the ABI
Task Leader: Xuanji Wang
NOAA Collaborator: Jeff Key

Work Proposed:
To meet the GOES-R Mission Requirements Document (MRD) requirements and accomplish the goals outlined in the GOES-R Risk Reduction Activity Plan, this project will evaluate, improve, and develop sea and lake ice thickness and age retrieval algorithms for application with GOES-R ABI. Ice thickness and age are important parameters in the surface energy budget and mass balance of the global cryosphere, and also an important indicator of global climate change.

The GOES-R Mission Requirements Document (MRD) requires, at the Threshold level, that ice-free areas be distinguished from first-year ice. The Goal requirement is to distinguish not only ice-free from first-year ice areas, but also to distinguish between the following types of ice: nilas, grey white, first-year medium, first-year thick, second-year, multiyear smooth, and multiyear deformed, commonly called ice age. In this work, the efforts focus on improving the algorithms and developing new algorithms, when necessary, for use with GOES-R ABI to estimate sea and lake ice thickness and age. The work proposed here will result in quantitative measures of the performance of the improved/developed algorithms for ice thickness and age. AVHRR, MODIS, SEVIRI, and other satellite data such as ICESat data will be used as proxy data for the purpose of testing and validating the algorithms. This activity will ensure enhanced future geostationary cryosphere applications in the GOES-R era.

Accomplishments and Findings for this quarter:
This is a new project with no previous funding. Work began in January 2008. A variety of current experimental ice thickness and age estimation algorithms has been surveyed and evaluated, including the NPOESS/VIIRS sea ice thickness algorithm, a tracking algorithm for sea

ice age, a cluster algorithm for sea ice age, and a sea ice slab model for sea ice thickness. Some complex sea ice models, such as the Community Sea Ice Model (CSIM), the Los Alamos sea ice model (CICE), and the Parallel Ocean and Ice Model (POIM) that can simulate sea ice thickness over 1 meter thick have been surveyed as well. In terms of accuracy, availability of forcing data, and computational efficiency, we find that it is necessary to develop a new algorithm to be able to retrieve sea and lake ice thickness between 0 and potentially up to 3 meters and to be efficient computationally, especially for GOES-R ABI applications, based on the comparisons between current experimental algorithms and ground measurements. We will build a one-dimensional Thermodynamic Ice Model (OTIM) that is based on the surface energy balance at thermo-equilibrium, containing all components of the surface energy balance to estimate sea and lake ice thickness. Then based on the knowledge of ice thickness, ice can be classified into open water, new/fresh ice, grey ice, grey-white ice, thin first year ice, medium first year ice, thick first year ice, multi-year ice. Improvement and development of the algorithms to retrieve ice properties is an evolutionary process, especially for ice thickness and age with the changes as input data and information improve, and in response to the results of validation studies.

14. Algorithm Development, Data Analysis and Visualization Capabilities for the GOES-R Program
Task Leaders: Tom Rink, Tom Achtor, Ray Garcia

We've added extensions to the McIDAS-V system framework to support visualization of METOP IASI Level1C radiances from the Eumetsat HDF5 archive format. This includes display controls to examine spectra at various geographic locations, as well as, a roaming display readout of image values at a given wavenumber. The file adapter software could be used as the back-end of a server in addition to its role as a local file reader. Image context subsetting has been added in a matter consistent with the HYDRA application so that subsets of high spatial resolution data can be visualized with coincident, high spectral resolution data. Data adapters and specialized display controls have been developed for certain CALIPSO and CloudSat Level 1 products. These can be geographically subsetted as well, important especially for the CALIPSO instrument which makes approximately 50,000 along-track by 500 vertical samples.

The focus of the next quarter effort will be implementing and expanding HYDRA's interactive visual display analysis of multi-/hyper-spectral instruments. This will include arbitrary channel combination tool combined with an interactive scatter display similar to HYDRA.

15. GOES-R Education and Public Outreach
Task Leader: Steve Ackerman

Proposed work
We proposed to update the CIMSS Satellite Meteorology for grades 8-12 (CD and web-based resources) educator resource guide to address key topics that support understanding of satellite meteorology and the role of the next generation weather satellites – GOES-R Advanced Baseline Imager (ABI). We will develop a module that describes the ABI and the science it brings to weather forecasting. To make the material relevant, we will demonstrate ABI capabilities with current MODIS and SEVIRI observations. The project will contribute to teacher workshops where we will seek feedback through formative evaluation methods. Lessons are usually field tested at teacher summer workshops at UW-Madison.

Accomplishments:
Under separate funding, we completed an in-depth assessment of an on-line remote sensing course for middle school and high school teachers conducted by an independent evaluator. To summarize those findings as they relate to this activity:

1) Highlight the key ideas using both illustrations and audio (or text), minimizing extraneous details.
2) Present material in clear structure that allows for easy visualization.
3) Present text/audio and illustrations in ways that are familiar to the teachers and relevant to past experiences and in ways that make them more memorable.
4) Think creatively about how to do assessment in an interactive and challenging way.

We have reviewed that evaluation report and the teacher recommendations are using that experience to design activities that demonstrate the GOES-R ABI.