CIMSS Participation in the
GOES-R Risk Reduction Program

Quarterly Progress Report for
1 October – 31 December 2007

from the
University of Wisconsin-Madison
Cooperative Institute for Meteorological Satellite Studies (CIMSS)

Project Title: CIMSS Participation in GOES-R Risk Reduction

Principle Investigator: Steve Ackerman

Topics/Lead Investigators:
 1. Algorithms
  1.1 Sounding Algorithm Development - Jun Li, Allen Huang
  1.2 Winds – Chris Velden
  1.3 Ozone - Jun Li, Jinlong Li
  1.4 Radiative Transfer Modeling - Steve Ackerman, Tom Greenwald
  1.5 Surface Properties - Bob Knuteson
  1.6 Biomass Burning- Chris Schmidt, Elaine Prins
  1.7 SATCAST / CI - Wayne Feltz
  1.8 Tropical Cyclones - Jim Kossin
  1.9 Visualization (HYDRA integration) - Tom Rink, Tom Achtor
 2. Nowcasting - Ralph Petersen
 3. Data Assimilation / Simulations - Jason Otkin, Allen Huang
 4. Validation/Demonstration – Dave Tobin
 5. Ground System – Maciej Smuga-Otto, Bob Knuteson

Program Manager: Tom Achtor

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1.   Algorithms

1.1   GOES-R3 Sounding Algorithm Development and Risk Reduction
      Task Leads: Jun Li, Allen Huang
      Other contributors: Elisabeth Weisz, Jinlong Li, Xin Jin, C.Y Liu, Hal Woolf

1.1.1. Global map of hyperspectral IR emissivity spectra developed
Following the GOES-RRR TAC (Technical Advisory Committee) advice on using surface
emissivity from LEO (Low Earth Orbit) hyperspectral InfraRed (IR) radiances for ABI
(Advanced Baseline Imager) products, a global map of the AIRS (Atmospheric InfraRed
Sounder) emissivity spectra has been generated for demonstration. The hyperspectral IR
emissivity physical retrieval algorithm (Li et al. 2007 – Geophysical Research Letters) was used
for the emissivity product generation. A collocated operational MODIS (Moderate Resolution
Imaging Spectroradiometer) 1 km cloud mask product is used for AIRS sub-pixel cloud detection
(Li et al. 2004 – JAM), only radiances from clear sky AIRS fields-of-view (FOVs) are used for
surface emissivity retrieval. Figure 1 shows a global 8-day (01 – 08 January 2004) composite of
AIRS singe field-of-view (SFOV) retrievals at 8.21 µm (single channel). Figure 2 shows the
emissivity spectra over Arizona and Utah (right panel) which contains diversified surface types,
and the emissivity spectra show large spatial and spectral variations. The emissivity varies from
0.80 to 1.00 depends on the surface type and IR spectral region. This is a unique global
hyperspectral IR emissivity product that has not been seen before.

The study also show that the AIRS emissivity map at MODIS band center wavelength agrees
with the operational MODIS broadband emissivity product. Figure 3 shows the global emissivity
map from AIRS at 4.3 µm (single channel, upper panel) along with the operational MODIS
broadband emissivity product (lower panel). The two emissivity maps agree well. MODIS
provides a global emissivity product at 6 spectral IR bands, in order to better compare the AIRS
emissivity product (CIMSS) with the operational MODIS product, the MODIS spectral response
functions (SRFs) will be used to generate "Pseudo MODIS emissivity" from AIRS.

The same algorithm will be applied to process IASI (Infrared Atmospheric Sounding
Interferometer); unlike AIRS, IASI can provide an emissivity spectrum without spectral gaps,
which is ideal for GEO product processing.

Global AIRS emissivity map – CIMSS research product

AIRS emissivity (CH: 1265/8.21µm)

CIMSS/UW-Madison
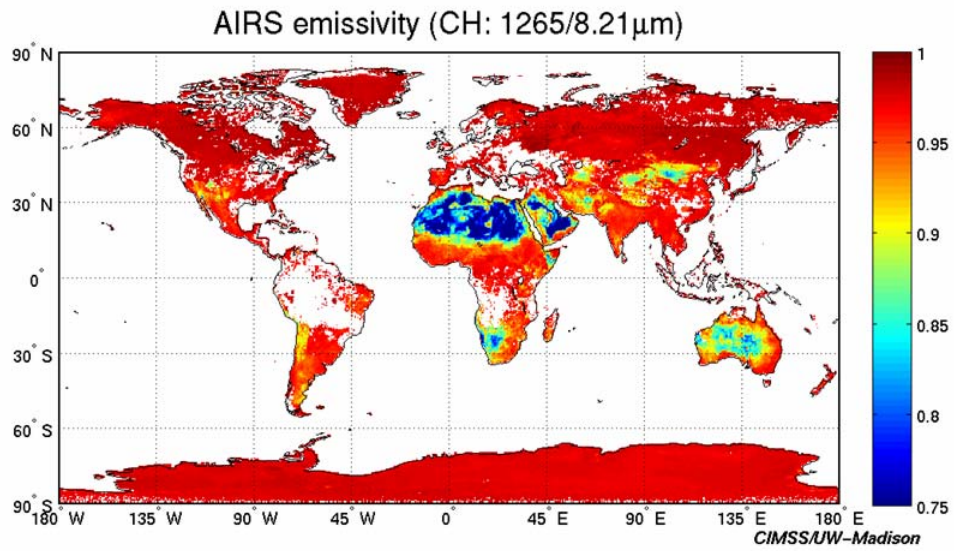
Algorithm can also be applied to IASI for global emissivity product

Figure 1. Global 8-day (01 – 08 January 2004) composite of AIRS singe field-of-view (SFOV) retrievals at 8.21 µm (single channel).
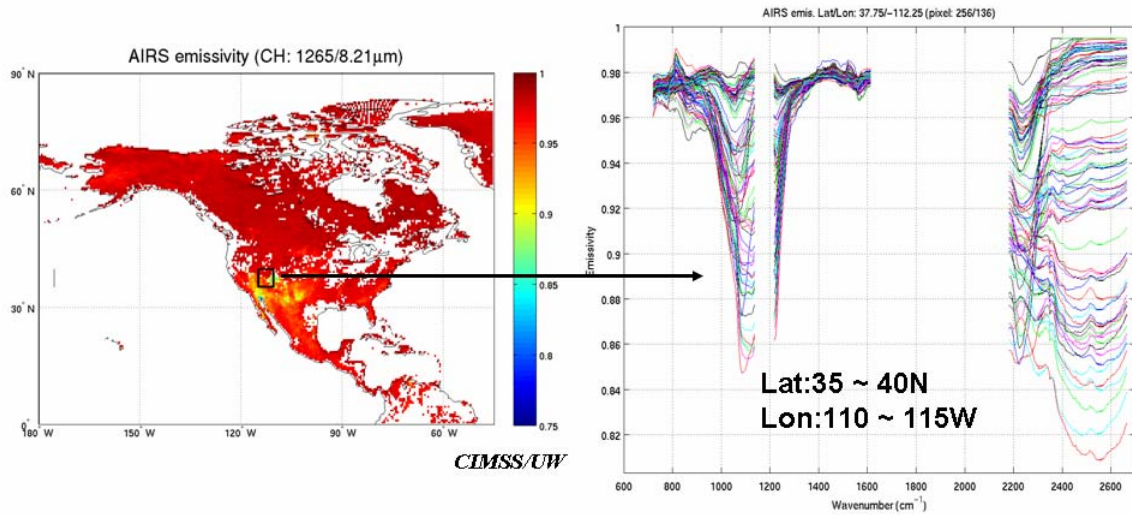
Figure 2. The emissivity spectra over Arizona and Utah (right panel) area which contains diversified surface types.
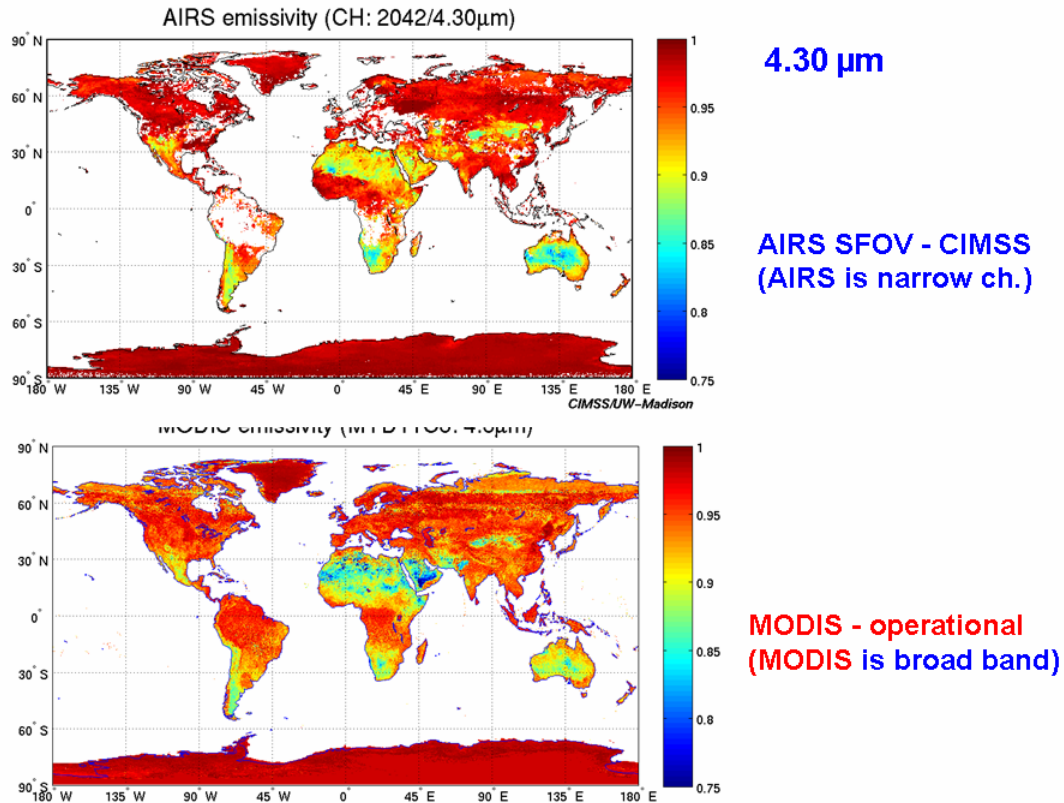
Figure 3. The global emissivity map from AIRS at 4.3 µm (single channel, upper panel) along with the operational MODIS broadband emissivity product (lower panel).

1.1.2. Study on the best LEO soundings for GEO/LEO synergy

Polar orbiting environmental satellites have multiple imaging and sounding instruments. For example, EOS Aqua contains MODIS, AIRS and AMSU-A; MetOp-A carries AVHRR, IASI and AMSU; while NPOESS will have VIIRS, CrIS and ATMS. Producing the best soundings derived from LEO imager/sounder/microwave instruments is very important for GEO/LEO synergy. The goal is to have the best soundings at the LEO IR sounder footprint using combined imager, IR sounder and microwave sounding measurements. MODIS/AIRS/AMSU are being used for this study; currently two approaches are being studied, using MODIS/AIRS and AMSU/AIRS. The goal is to derive the best soundings from combined MODIS/AIRS/AMSU for this GEO/LEO synergy study. Some results are expected in next quarterly report. SEVIRI will be used as an ABI proxy in this study.

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

1.1.4. Conference presentations from 01 October 01 to 31 December 2007.

Jun Li attended the first IASI conference, held in Anglet, France from 13 to 16 November 2007, and gave an oral presentation entitled "Single footprint sounding, surface emissivity and cloud property retrievals from hyperspectral infrared radiances under all sky conditions".

1.2   GOES-R Winds Work Summary
         Task Lead: Chris Velden

Previous GOES-RRR winds work concentrated on demonstrating the ability to target and track features from WRF model moisture fields and simulated moisture retrievals. The ATReC and Ocean Winds datasets were used to successfully demonstrate the concept.

The next dataset being investigated (FULLDISK) dwarfs the previous two cases in the number and size of files. WRF simulations run on a full-disk domain simulating the expected GOES-R coverage are broken up into "cubes" to simulate HES sounding blocks. These cubes are written as Unidata network Common Data Form (NetCDF) files. Each NetCDF file contains the moisture field information. New data staging code using Matlab and McIDAS stitches the cubes together into a McIDAS AREA file as preparation for the winds retrievals.

Accomplishments in the last three months
Results from the FULLDISK simulation were presented at the Joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th Satellite Meteorology & Oceanography Conference of the American Meteorological Society. This conference was held from 24-28 September 2007 in Amsterdam, Netherlands. Please see the following link for a copy of the poster:

http://www.ssec.wisc.edu/meetings/jointsatmet2007/pdf/wanzong_sim_datasets.pdf

The UK Met Office has expressed interest in a similar simulation. They will use their high resolution (1.5km) mesoscale model with RTTOV to simulate the MTG-IRS spectra. They have been in contact with CIMSS hoping for some guidance in their work.

1.3   Ozone
         Task Lead: Jun Li, Jinlong Li

No activity in this quarter due to the limited funding ($20 K) on GOES-RRR ozone. Radiative transfer model impact on ABI ozone will be investigated in next months. RTTOV8.7 and PFAAST models will be used in the study; results are expected in the next quarterly report.

1.4   Radiative Transfer Modeling
         Task Leads: Tom Greenwald, Steve Ackerman

Proposed work:
The main goals of this task are to expand on our previous GOES-R Risk Reduction RTM activities by extending cloudy sky RT calculations into the solar spectrum, and by developing a "unified" RTM that is applicable from the solar through the microwave. Developing fast

methods for computing solar radiance is needed for simulating ABI channels 1-7. A unified RTM will provide a simpler and more consistent framework from which to compute radiances in support of the development of ABI proxy data and other multi-spectral applications. Comparative tests will also be undertaken between the SOI RTM and the FIRTM-AD in the thermal infrared.

Accomplishments:
Development of the solar version of the SOI radiative transfer model was completed. The model also underwent significant testing.

The IR version of the SOI model was compared to the FIRTM-AD model. As a test case, an ice cloud with an optical depth of 1 and effective particle diameter of 30 microns was located at 168 hPa in the FIRTM-AD model and between 162.23 and 175.23 hPa in the SOI model. Both models used 32 streams in the calculations. The differences between the models were within 0.25K in the window region between 800 and 1400 cm-1. These differences were most likely due to difficulties in exactly matching the vertical location of the clouds in the two models.

The SOI model was found to be about 3-4 times slower than the FIRTM-AD model. This is due to the SOI model explicitly computing the cloud reflection/transmission properties while the FIRTM-AD model is based on a lookup table approach.

1.5   Surface Properties
     Task Lead: Bob Knuteson
     Other contributors Leslie Moy, Eva Borbas, Allen Huang, Suzanne Seemann

(Note – this report is for the entire year, January to December 2007)

Proposed Work
The CIMSS GOES-R Risk Reduction activity in 2006 related to land surface properties was focused on the development of a global gridded high spatial resolution multi-year infrared emissivity database for use by 1) the AWG proxy data team for simulation of realistic Earth emitted radiation, 2) the sounder team for temperature and water vapor retrieval algorithm development, and 3) for data assimilation in Numerical Weather Prediction models. A paper was submitted in late 2006 to the Journal of Applied Meteorology and Climate (JAMC) by lead author Suzanne Wetzel-Seemann that describes the methodology used to create this database from a combination of MODIS observations and laboratory measurements. This development was conducted in collaboration with the MODIS land products team and has been used for the comparison of against AIRS products produced by NOAA STAR. We proposed to continue this work in 2007 with an emphasis on deriving land surface temperature and surface emissivity for the ABI sensor. Our approach is to collaborate with the EUMETSAT Land Satellite Applications Facility (LAND SAF) in Portugal, esp. Dr. Isabel Trigo, in an algorithm for using the temporal change of the SEVIRI instrument measurements to determine infrared emissivity for the SEVIRI infrared channels. We will create a prototype algorithm for ABI that takes advantage of the time change of surface temperature to separate surface temperature and surface emissivity. We will apply this algorithm to the SEVIRI observations over Africa and Europe for a case study. The independent emissivity product created from the SEVIRI infrared channels will be used to validate the UW/CIMSS emissivity database. This UW/CIMSS database is being used by the EUMETSAT Climate SAF in the profile retrieval of temperature and water vapor over land. We

will collaborate with R. Bennartz (UW-AOS) on the impact of improvements in the land surface emissivity on profile retrievals SEVIRI as a proxy for ABI.

Accomplishments in 2007
Two accomplishments can be reported under this GOES-R risk reduction task in 2007; 1) an assessment of land surface emissivity from SEVIRI observations, and 2) an extension of the MODIS-based UW/CIMSS BF database to high spectral resolution. Both results have been presented at conferences (see reference list). Unfortunately the planned development of a land surface temperature and emissivity separation algorithm was not possible due to what appears to be significant calibration errors in the SEVIRI observations. These are apparent in the comparison of derived emissivities from SEVIRI when compared to results derived from MODIS and AIRS observations. This result is unexpected and requires further investigation. An update to the SEVIRI calibration is expected in 2008 from EUMETSAT. This work shows the importance of the sensor radiometric calibration requirement for the ABI in the GOES-R program in that it suggests that the full information content of the observations will not be exploited unless the relative and absolute calibration of each of the infrared channels is fully characterized.

Assessment of Land Surface Emissivity from SEVIRI
Diurnal signatures of land surface emission were investigated using SEVIRI data from August 2006. The diurnal change of observed brightness temperature is shown for seven sites near the Eastern Mediterranean in Figure 4. These geostationary observations can be used to develop an inversion method for obtaining land surface emissivity from the SEVIRI data that takes advantage of the time variation of the measurements. The data were obtained from M. Pavalonis using GEOCAT. The observed top of atmosphere radiation is the sum of atmospheric, surface, and reflected contributions. Using an RTM to make calculations for each term of the RTM we can easily evaluate the TOA radiation assuming any given surface emissivity. We compare these calculated radiances to observed SEVIRI radiances for an evaluation of the different emissivity products.

The atmospheric state is described by ECMWF model runs for August 18, 2006 at 00UTC. The radiative transfer model (LBLRTM by AER, Inc.) was used to calculate the TOA radiation given by the atmosphere, the surface, and reflected terms in a 1x1 degree grid over North Africa. The calculations were then interpolated onto the finer SEVIRI grid, and convolved to the SEVIRI spectral resolution (see Figure 5). We assumed the surface temperatures used by LSA SAF, and the surface emissivities given by: LSA SAF, UW/CIMSS MODIS BF, and NASA L2 AIRS. The LSA SAF emissivities are daily averages for August 18, 2006, the UW/CIMSS MODIS BF emissivities are monthly averages, and the AIRS Level 2 emissivities are for August 16, 00UTC values (August 18th was not available). Results are presented in Figures 6 and 7.
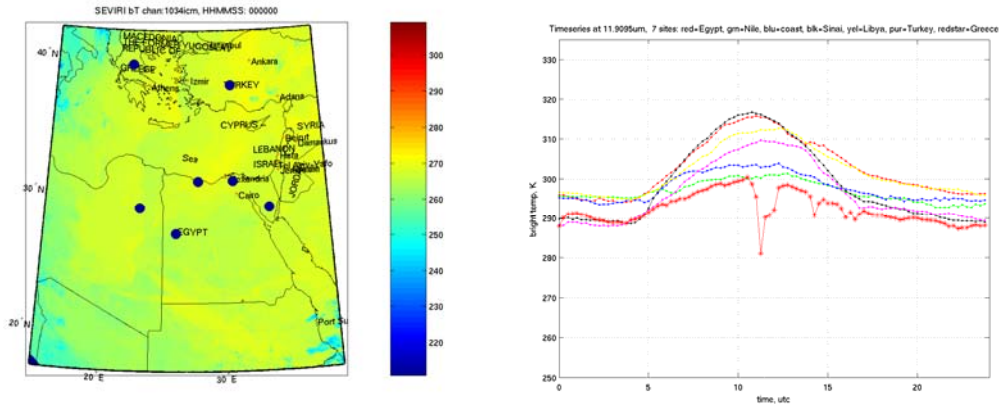
Figure 4. Diurnal change in the observed SEVIRI brightness temperature (right) at the seven sites shown as dots on the map (left) representing a range of land cover types.
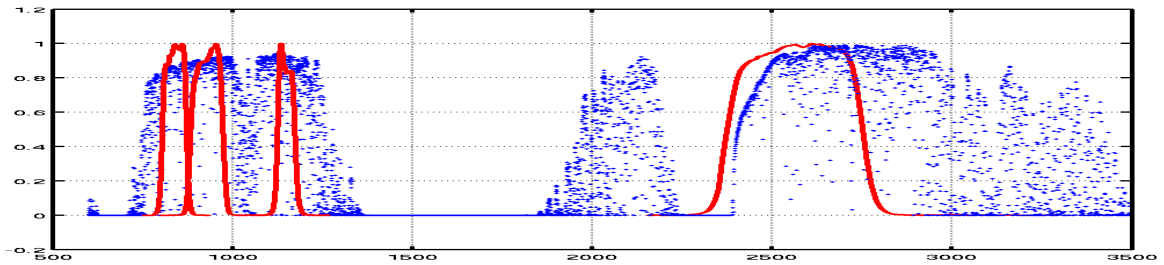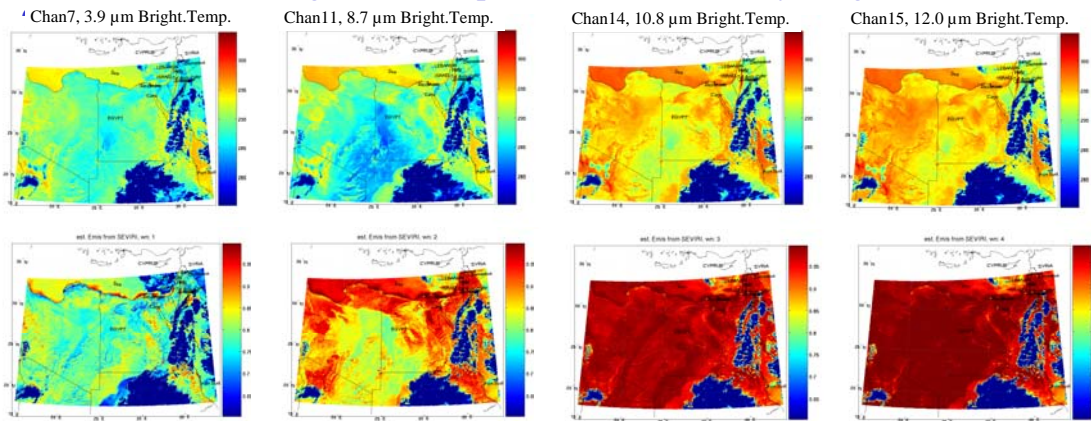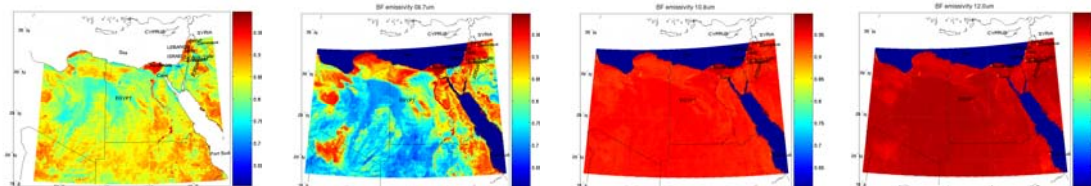

Figure 5. The four IR SEVIRI filter functions overlaid on a transmission calculation.

SEVIRI observed Brightness Temperature and Emissivity, Aug. 18, 2006

Chan7, 3.9 µm Bright.Temp.   Chan11, 8.7 µm Bright.Temp.   Chan14, 10.8 µm Bright.Temp.   Chan15, 12.0 µm Bright.Temp.

Emissivity from UW MODIS BF, monthly average Aug. 2006

Emissivity from LSA SAF, Aug. 18, 2006 00UTC

LSA SAF 3.9 µm Emissivity | LSA SAF 8.7 µm Emissivity | LSA SAF 10.8 µm Emissivity | LSA SAF 12.0 µm Emissivity
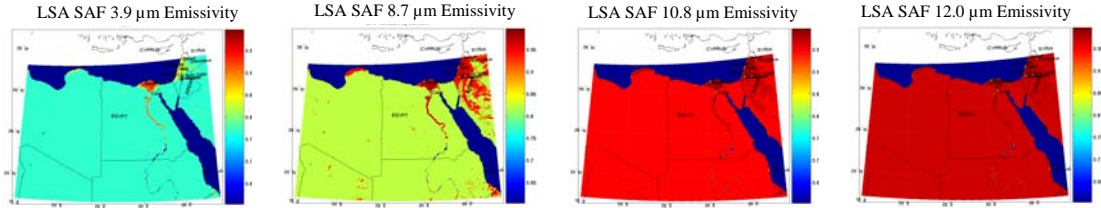
Emissivity from AIRS L2, Aug. 16, 2006 00UTC

AIRS L2 3.9 µm Emissivity | AIRS L2 8.7 µm Emissivity | AIRS L2 10.8 µm Emissivity | AIRS L2 12.0 µm Emissivity
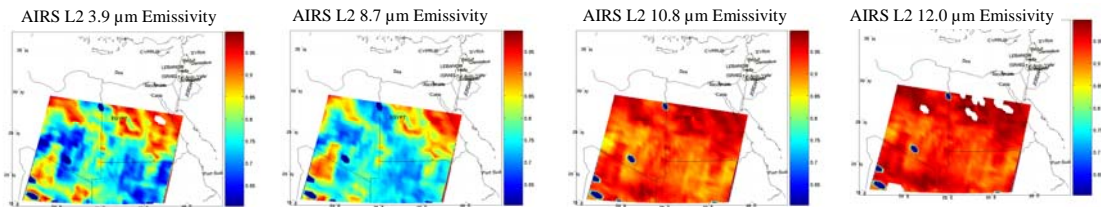
Figure 6. The top two row of panels are the observed SEVIRI brightness temperature and the emissivity derived from the same observations using a surface temperature obtained from the EUMETSAT Land SAF (courtesy of Trigo). Comparison to MODIS emissivities for the same time (third row of panels) however show large discrepancies at 8.5 microns and smaller discrepancies at 3.9 and 10.8 microns. The actual spatial variation is much more realistic than that used by the Land SAF however (fourth row). The bottom row shows results from the AIRS L2 product for reference.
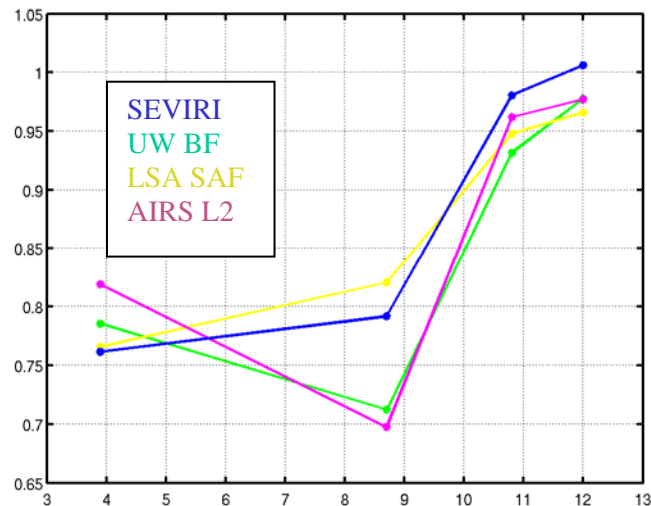

Figure 7. A single pixel at the Egypt One validation site illustrates the spectral discrepancies among the SEVIRI, MODIS (UW/CIMSS BF), Land SAF, and AIRS L2 products.

The calculated brightness temperature using the three different emissivity products is in good agreement with SEVIRI observations at 12.0 µm; about +0.1 K, +0.1 K and -0.4 K respectively for UW/CIMSS MODIS BF, LSA SAF, and AIRS Level 2. At 10.8 µm the agreement is good also; approximately +0.4, +0.6, and -0.02 K respectively. However all the emissivity models lead to a disagreement with SEVIRI observations of about +3 K at 8.7 µm, and between +2.3 to +2.9

K at 3.9 µm. The use of 12.0 and 10.8 µm for the determination of land surface temperature appears to be valid however. UW/CIMSS MODIS BF and AIRS L2 emissivities are in generally good agreement with each other while the LSA SAF emissivity is limited by its lack of spatial detail.

Extension of the UW/CIMSS MODIS BF database to High Spectral Resolution (HSR)
In 2007 an algorithm has been developed to derive a high spectral resolution (HSR) IR land surface emissivity from 3.6 to 14.3 µm for a given month, for every latitude/longitude point globally at 0.05-degree spatial resolution. The HSR emissivity is derived from a combination of high spectral resolution laboratory measurements of selected materials, and the UW/CIMSS Baseline Fit (BF) global infrared land surface emissivity database (Seemann et al, 2007) by using a principal component analysis (PCA) regression. The beta version of the algorithm to extract the high spectral resolution emissivity database from the UW/CIMSS BF emissivity dataset is available for testing.

The HSR emissivity is derived from a statistical regression. The first Principal Components (PCs, eigenvectors) of 123 selected laboratory spectra (in this study the wavenumber resolution between 2-4cm^{-1}, at 416 wavenumbers) were regressed against the 10 hinge points (3.6, 4.3, 5.0, 5.8, 7.6, 8.3, 9.3, 10.8, 12.1, and 14.3 μm) of the monthly UW/CIMSS BF emissivity (available at *http://cimss.ssec.wisc.edu/iremis/*). After calculating the PCA coefficients, the high spectral resolution emissivity values are determined at the same MYD11 latitude and longitude point given in the BF data. The accuracy of the new HSR emissivity data is dependent upon the input BF emissivity data and the MODIS monthly MYD11 measurements.

In the PCA technique, the first PCs with highest eigenvalues represent real variations in the data while the last, least significant PCs most often represent random white noise. The number of PCs allowed is 10 due to the number of spectral points of the input BF emissivities, however using the maximum number or close to the maximum number of PCs makes the solution unstable. Some tests (see Borbas et al., 2007) indicate that the optimal number of PCs is 6. The number of PCs is an input to the algorithm. An example creating high spectral resolution emissivity spectra using the land profiles of the SeeBor training database over two IGBP types is shown on Figure 8.

Comparison of the UW/CIMSS BF and UW/CIMSS HSR emissivities at 10 different locations of the Earth can be seen on Figure 8. The comparisons indicated that the largest differences occur around at 13, 10.2-9.7, 8.5, 7.8 and 4 μm for arid and semi arid regions and the HSR emissivity data can capture the quartz-reststrahlen band with the peak around 8.5 μm.
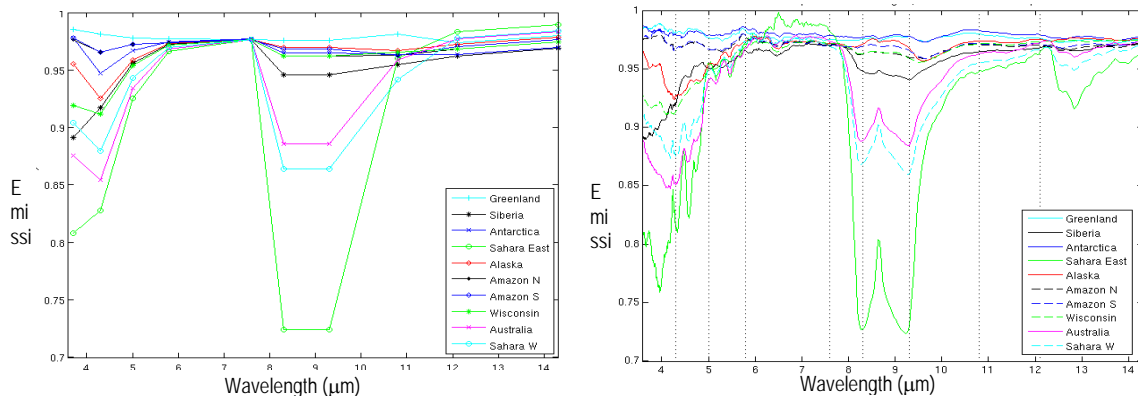

Figure 8: Emissivity spectra for August 2003 at 10 different locations created by the BF (right) and PCA regression method (left).

For assessment of the importance of emissivity on retrieved atmospheric temperature, moisture, ozone profiles and land surface products, and on use in data assimilation, a sensitivity analysis of forward model calculated IR brightness temperatures (BT) is performed for the high spectral resolution AIRS spectral channels. The impacts of varying the emissivity on the calculated top-of-atmosphere BT across the infrared spectral regions are examined, then an analysis of the effects of a change in emissivity on retrieved temperature and moisture profiles is presented.

The pCRTM transmittance model was used to calculate BT for 8583 clear sky land profiles from the SeeBor training dataset. Average differences of calculated BT using BF emissivity and HSR emissivity are plotted for some selected IGBP ecosystem types on Figure 9. The largest differences between BT calculated with these two emissivities occur around at 13, 10.2-9.7, 8.5, 7.8 and 4 μm for the IGBP barren/desert land classification.
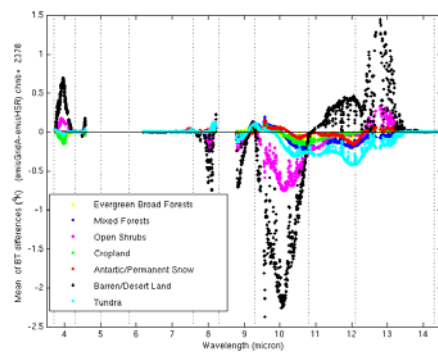

Figure 9: Averaged differences of BT calculated with BF emissivity minus those calculated with HSR emissivity. Each point represents a forward model calculation for one profile, and the colors indicate the land cover classification of the profile location, as defined by the IGBP categories.

To analysis of the effects of a change in emissivity on retrieved temperature and moisture profiles clear sky AIRS retrievals were compared to the ECMWF analyses on September 2, 2003. The UW-Madison IMAPP single FOV AIRS algorithm was used for getting temperature, moisture and ozone retrievals. A constant emissivity of 1.0, the UW/CIMSS BF emissivity, and the UW/CIMSS HSR emissivity were each assigned to the SeeBor training dataset and subsequently used to derive the synthetic regression coefficients for the AIRS retrievals. The MODIS MYD35 cloud mask products were used for finding the clear sky scenes. Bias and rms differences between the differently derived AIRS retrievals and ECMWF analyses at low latitudes (between ± 30°) are shown on Figure 10.
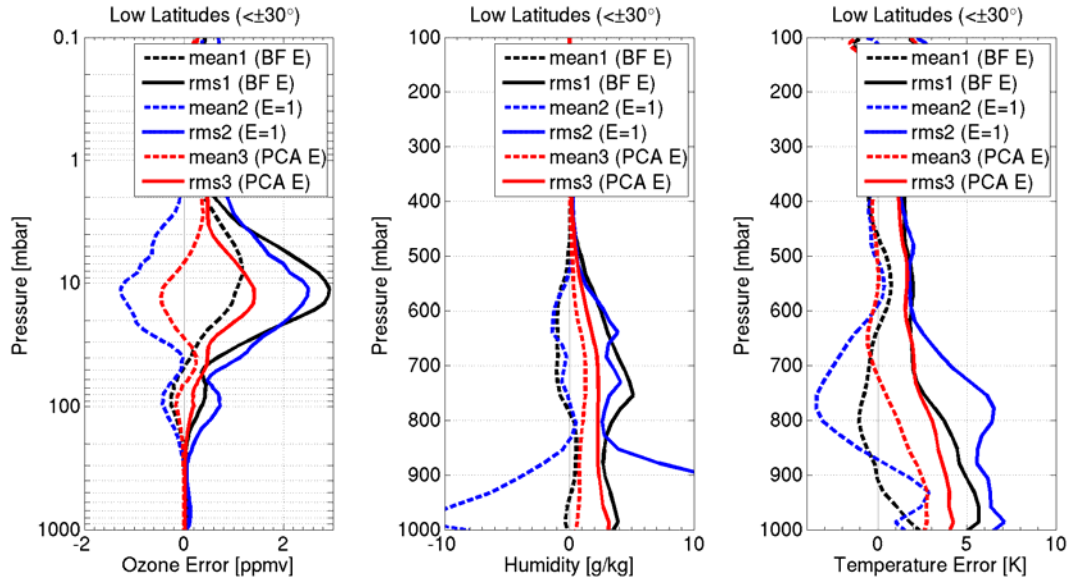
Figure 10: Profiles of mean and rms differences between ECMWF analyses and AIRS ozone (left), moisture (middle) and temperature (right) retrievals for law latitudes (between 30 S and 30 N) calculated using emissivity=1 (blue), the UW/CIMSS BF emissivity (black) and UW/CIMSS HSR (PCA) emissivity (red) assigned to the training profiles for clear sky scenes on September 2, 2003.

Using the HSR emissivity data in the IMAPP AIRS algorithm showed a positive effect on temperature, moisture and ozone retrievals when compared with using a constant emissivity or the BF emissivity data. This case study also indicated that the HSR emissivity data could better capture the emissivity spectra in the ozone absorption band.

Publications:
Borbas, Eva; Moy, L.; Seemann, S.; Knuteson, R.; Trigo, I.; Antonelli, P.; Li, J. and Huang, H. L.. A global infrared land surface emissivity database and its validation. Symposium on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface, 11th, San Antonio, TX, 14-18 January 2007 (preprints). American Meteorological Society, Boston, MA, 2007, Paper P2.7. Call Number: Reprint # 5285. .
http://ams.confex.com/ams/pdfpapers/119572.pdf. (poster presentation + conference paper)

Borbas, Eva E.; Knuteson, Robert O.; Seemann, Suzanne W.; Weisz, Elisabeth; Moy, Leslie and Huang, Hung-Lung. A high spectral resolution global land surface infrared emissivity database. Joint 2007 EUMETSAT Meteorological Satellite Conference and Satellite Meteorology and Oceanography Conference, 15th, of the American Meteorological Society, Amsterdam, the Netherlands, 24-28 September 2007. Proceedings. European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), Darmstadt, Germany, 2007, Unpaged. Call Number: Reprint # 5563. (poster presentation + conference paper)

Moy, Leslie; et al., Comparison of Land Surface Emissivity from MODIS, AIRS, and SEVIRI, Joint 2007 EUMETSAT Meteorological Satellite Conference and Satellite Meteorology and Oceanography Conference, 15th, of the American Meteorological Society, Amsterdam, the Netherlands, 24-28 September 2007. Proceedings. European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), Darmstadt, Germany, 2007,

Seemann, S.W., E.E. Borbas, R.O. Knuteson, G. R. Stephenson, H.- L. Huang: A global infrared surface emissivity database for clear sky atmospheric sounding retrievals from satellite-based radiance measurements. *Journal of Applied Meteorology and Climatology,* accepted April 2007, DOI:10.1175/2007JAM1590.1,Volume 47.

**1.6   Biomass Burning-
            Task Leads: Chris Schmidt, Elaine Prins**

GOES-R ABI biomass burning research and development activities for 2007 focuses on active fire detection and sub-pixel characterization utilizing simulated and current global geostationary multi-spectral data. CIMSS is investigating application of the dynamic Baseline Emissivity dataset 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. Collaborations will 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:
CIMSS has updated and refined the technique for generating ABI proxy data from MODIS data. MODIS has two 3.9 µm channels, bands 21 and 22. Band 21 has higher radiometric noise than 22 but also saturates at a higher temperature. The modified technique now utilizes band 22 unless it has saturated, in which case band 21 is substituted. This allows a more accurate simulation of the ABI dynamic range.   This technique was then applied to the Southern CA fires of 2007 (23, 24, and 26 October). CIMSS now has 8 such MODIS to ABI case studies representing fires in North, Central, and South America. In the process of refining this remapping technique a more direct comparison was made between remapped data with the Point-Spread Function (PSF) applied and that without, and it was confirmed that simple remapping produces virtually useless data.

CIMSS also continued to work with CIRA on generating model-simulated ABI fire proxy data. The two groups jointly worked out the correct way to simulate the FRP that ABI should be able to detect given simulated viewing conditions using a simplified Gaussian bivariate PSF. CIMSS also provided current GOES WFABBA fire location and characterization data to use as inputs to the second model-generated case, this time simulating fires over Central America.

**1.7   SATCAST / Convective Initiation
            Task Lead: Wayne Feltz**

Work Proposed
This research task seeks to adapt a GOES imager infrared cooling rate and convective initiation algorithm for use with MSG SEVIRI imager radiance data in anticipation of application on the GOES-R ABI imager. The CIMSS Satellite Nowcasting and Aviation APplications (SNAAP) team conducts this research.

We proposed to take advantage of the current Convective and Orographically-induced Precipitation Study (COPS) being conducted in Southern Germany and Eastern France in the Summer of 2007. Collaboration is currently underway between CIMSS, Dr. Volker Gaertner (EUMETSAT), Dr. Marianne Koenig (EUMETSAT), and Dr. Volker Wulfmeyer (U of Stuttgardt) and transitioning the SNAAP/ASAP convection initiation and mesoscale atmospheric motion vector applications to using SEVIRI radiance inputs has been accomplished. This experiment has ended but it has provided an opportunity to use a current imager containing more ABI channels than currently possessed by GOES imager. New radiance channels can be used to optimize the convective initiation algorithm.

Accomplishments
GOES imager convective diagnostic products have been produced for the past COPS experiment in the summer of 2007. Results from this activity were presented at the EUMETSAT/AMS Satellite conference in Amsterdam, Netherlands in September 2007. This activity has spawned a new collaboration with the South African government meteorological agency which has a fairly dense radar network. SEVIRI convective diagnostic products are being produced and provided in a near real-time manner for weather decision support for S. Africa. The additional SEVIRI radiance channels (as compared to the GOES imager) is allowing spectral and temporal optimization of the algorithm for future GOES-R ABI use. New FY2008 GOES-R3 convective cooling rate, convective initiation, and mesoscale wind research have been outlined and accepted for continued progress.

1.8   Tropical Cyclones
         Task Leads: Jim Kossin
         Other contributor: Matthew Sitkowski

We're continuing our progress toward an algorithm that will utilize environmental analyses and GOES infrared imagery to objectively diagnose and forecast hurricane secondary eyewall formation. During this quarter, we made a number of significant steps toward our goals.

We constructed a new secondary eyewall formation (SEF) index based on environmental features from the SHIPS-model developmental dataset applied to a Bayesian classification scheme. Utilizing the SHIPS dataset allows for a very simple merging of our index with the annular hurricane index being developed by our CIRA/NESDIS collaborators, which also uses the SHIPS developmental dataset. Some of our earlier results of this quarter are shown in Fig. 11. The Bayes classifier considers climatological probability of SEF in concert with probabilities based on the storm environment. For example, if we had no environmental information at all, we would simply assign a probability of SEF based on previously documented frequencies of occurrence. For storms of intensity greater than 100kt that did not just complete an eyewall replacement cycle, the climatological probability of SEF in the following 12 h is around 30% on average.

A very noteworthy step was achieved later in this quarter with the inclusion of the GOES infrared-based features in the SHIPS developmental dataset. The improvement of the algorithm when the GOES data is included is shown and described in Fig. 12. This figure also reflects improvements (compared to Fig. 11) made through our continuing analysis of the SHIPS environmental features, and modifications to our SEF climatology based on the inclusion of new data. Table 1 shows the "confusion matrices" for our algorithm. To create this, we reduce our probability predictions to a simple classifier by using 50% as a threshold between predicting SEF and non-SEF. The skill beyond climatology and the improvement due to the inclusion of the

GOES features are clearly demonstrated. These preliminary results are very encouraging, and we're presently looking more deeply into how to optimize the GOES-based improvements to our model.

We have also made progress toward a more flexible climatology to apply to the Bayes classifier. For example, we have enough cases now to stratify the classes (SEF and non-SEF) by current intensity, which has a significant effect on the climatological probability of SEF. We will continue to pursue this into the next quarter.

Other future goals include a more thorough cross-validation of our algorithm so that we can get a better idea of what to expect in an operational setting. We are also looking at ways to objectively measure skill beyond the application of confusion matrices, which is a method for quantifying the skill of classifiers but does not utilize the additional information of probabilities that our algorithm provides (beyond, for example, a linear discriminant method). We would like to extend this to measure the skill of our assigned probabilities. We are also looking at ways to reduce the effect that the storms themselves have on the SHIPS environmental features. The storms tend to contaminate a large surrounding region, making it difficult to measure the true storm environment. Using reanalysis fields, we are looking at variance maps to determine whether measuring the environment at a location some time before the storm arrives is a reasonable proxy for the environment at the time of the storm's arrival at that location.
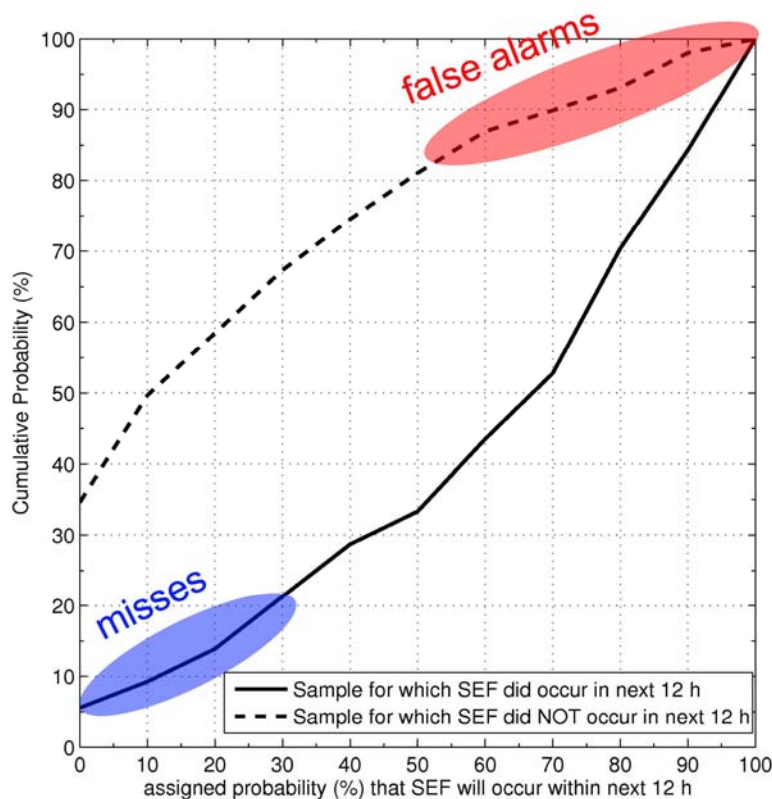

Figure 11: Cumulative probability of the probability that secondary eyewall formation (SEF) will occur within the next 12 h, as assigned by our new SHIPS developmental dataset-based algorithm. Solid line: probability of SEF assigned to storms that did undergo SEF. Dashed line: probability of SEF assigned to storms that did not undergo SEF. The algorithm is skillful, assigning higher probability than the climatological probability (of around 30%) in 80% of SEF cases. This is analogous to a success rate of

80%. The algorithm also assigns a probability of SEF that is greater than 50% in about 20% of non-SEF cases. This is a subjective measure of our false-alarm rate.
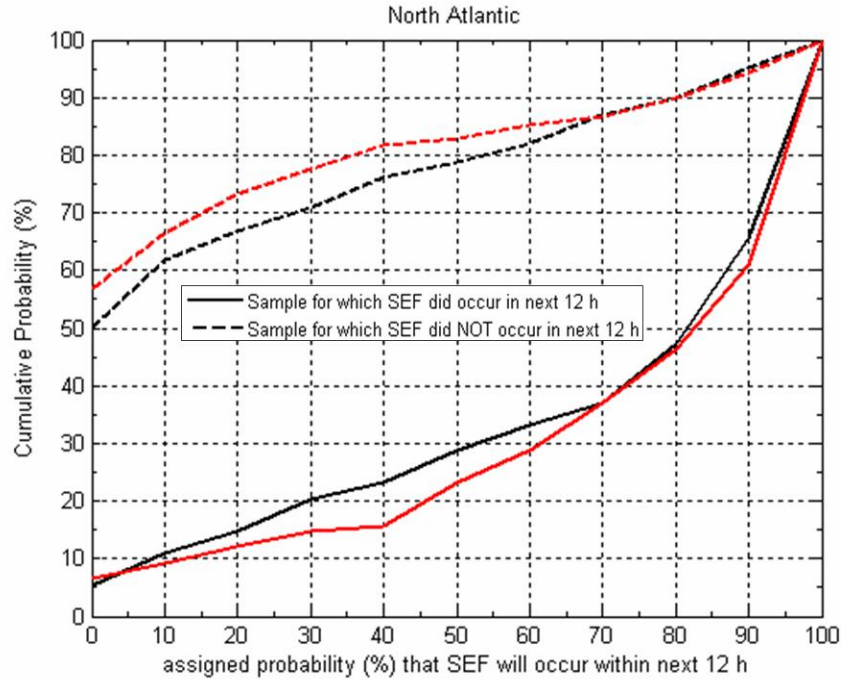

Figure 12: Similar to Fig. 11, but with modifications to the algorithm, and with the inclusion of the SHIPS GOES-based features. The black lines show the algorithm performance in the North Atlantic without the GOES-based features, and the red lines show the improvement with the GOES-based features. Our assigned probabilities for both the SEF and non-SEF cases improve measurably and there is consistent improvement (no degradation of skill). For example, the probability of assigning a low probability of SEF (P < 30%) to non-SEF cases increases from 70% to roughly 80%. The probability of assigning a high probability of SEF (P > 30%) to SEF cases increases from 80% to 85%.

Table 1: Confusion matrices resulting from climatology (green) and for the algorithm without the GOES features (red) and with the GOES features (blue). The two columns represent instances of the *predicted* class and the rows represent instances of the *observed* class. For the case of climatology, we would simply always predict no SEF (we would be correct about 70% of the time and would miss all actual SEF (30% of cases)). The skillfulness can be seen with the inclusion of the environmental features, and again with the further inclusion of the GOES information.

	SEF-YES (predicted)	SEF-NO (predicted)
SEF-YES (actual)	**0% (success)**	100% (missed)
SEF-NO (actual)	0% (false alarm)	**100% (success)**
SEF-YES (actual)	**72% (success)**	28% (missed)
SEF-NO (actual)	22% (false alarm)	**78% (success)**
SEF-YES (actual)	**77% (success)**	23% (missed)
SEF-NO (actual)	16% (false alarm)	**84% (success)**

1.9   Data Analysis and Visualization: HYDRA integration
          Task Lead: Tom Rink, Tom Achtor

The goal of this project is the development of an interactive analysis and visualization system capable of fusing geo-science data including satellite (Hyper-Spectral, Multi-Spectral), as well as, in-situ observations and NWP.

New development also includes class extensions for data sources and controls specific to hyper-spectral radiances (Level 1B, Level 1C), which have been mostly completed and tested on AIRS and IASI data. Excellent cooperation with Unidata on the data storage format issues will enable Java access to HDF5 and HDF4 file formats. Testing is underway now using the HDF5 format IASI Level 1C available from the Eumetsat archive system.   This is important from a more technical standpoint, in that the current libraries in HYDRA for accessing HDF4 via Java are difficult to maintain, and will be replaced by the new Java-NetCDF library.

Progress continues to be made in employing data and display software components to add HYDRA-type functionality to the McIDAS-V architecture. Figure 13 is a McIDAS-V display of IASI spectra and imagery demonstrating the interactive capability to investigate all IASI spectral bands. In addition to hyperspectral data support, work is progressing on the incorporation of CALIPSO and CloudSat data into McIDAS-V, as well as, several MODIS products. Work in the upcoming quarter will focus on incorporating analysis capabilities found in HYDRA into McIDAS-V, building on the work completed so far.

In October 2007 the first alpha release of McIDAS-V was made available to the McIDAS Users Group. The software is now freely available to all, and can be found at
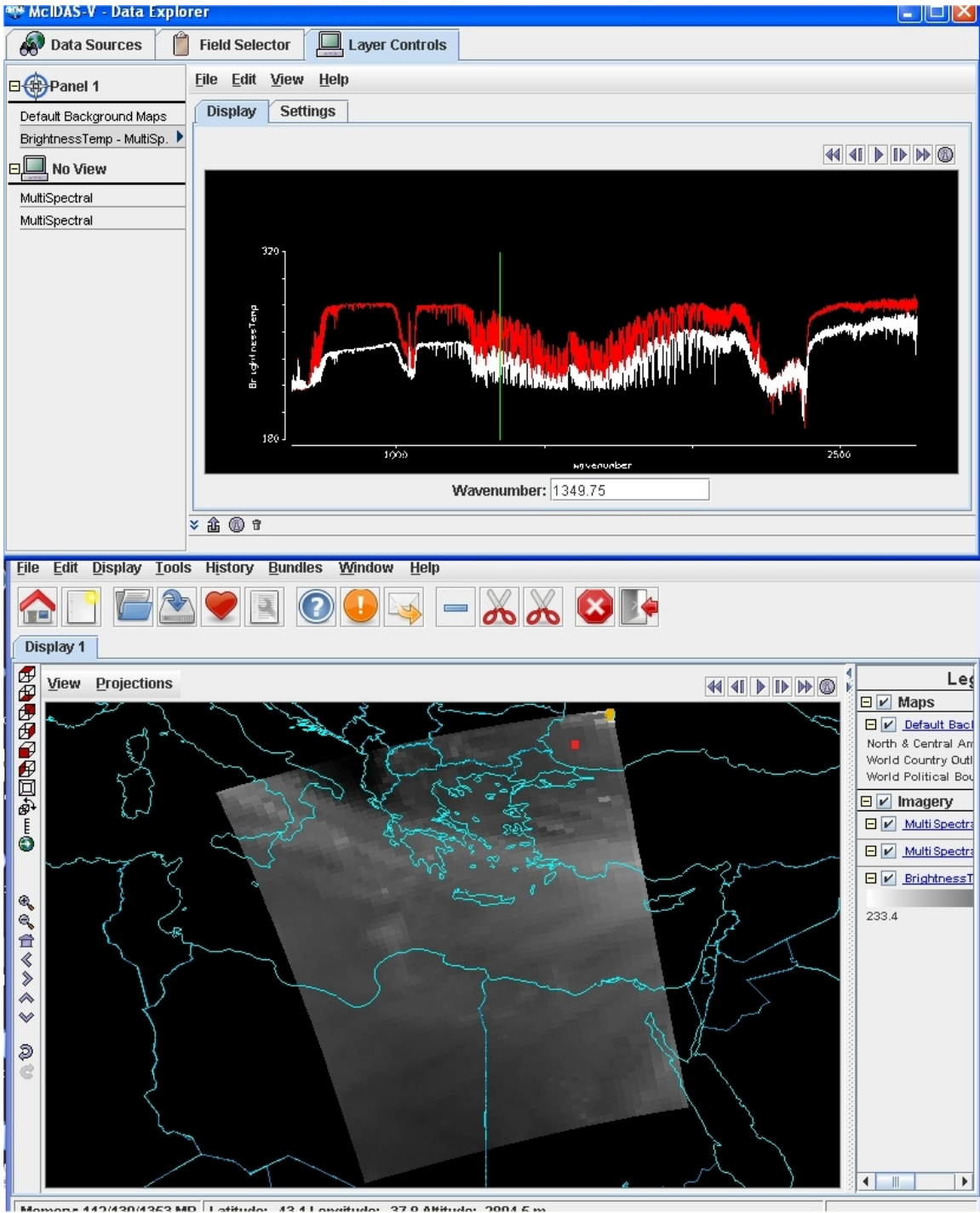http://www.ssec.wisc.edu/mcidas/software/v/

Figure 13. McIDAS-V display of IASI spectra (top) with slider bar to display spectral bands (bottom). The user can select points in the image and display the spectra for that pixel, or select the spectral band and display the image.

2.   Nearcasting
**   Task Lead: Ralph Petersen**

The overall goal of this project is to provide and test new tools to identify areas of convective destabilization 1-6 hours in advance of storm development using moisture data from current and future GOES satellites. Because the term "Nowcasts" is being heavily used to describe 0-1 hr projections made by extrapolation of radar observations, these slightly longer-range products based primarily on satellite data are being called "NearCasts".

Efforts this quarter have focused primarily on preparing for real-time assessment in several NWS WFOs. The transfer of the code and data ingest systems to a fully automated Linux computer is being completed. Output from the system will be provided in GRIB-II, thereby allowing the data to be ingested and displayed directly in the WFOs on AWIPS, as requested by forecasters. This system will also be transferred to CCNY-CREST. It should be noted that this effort was hampered during several weeks by the need to develop and test contingency GEOS-DPI products during the temporary lose from GOES-East due to lose of the satellite during maneuvers.

The most important work done during this period has involved the development of materials for both educating and training forecasters on the concept and use of the Lagrangian GOES NearCasting. The objective of this effort is to improve forecasts of the timing and location of hard-to-predict isolated thunderstorms, and will test the utility of the DPI predictions of both 'event' and 'non-event' forecasts. Preparation for training and data display in WFOs is continuing, with a training session scheduled for GRB in January 2008.

Presentations/Publications: Oral presentation abstracts have been accepted for AMS Aviation Conference and a poster has been accepted for the GOES-R User's Workshop in New Orleans in January 2008.

3.   Data Assimilation / Simulations
**   Task Leads: Jason Otkin, Allen Huang**

In an effort to more thoroughly characterize the realism of proxy ABI radiance datasets derived from numerical model output, a large-scale, high-resolution Weather Research and Forecasting (WRF) model simulation was performed at the National Center for Supercomputing Applications (NCSA). The simulation was initialized at 18 UTC on 15 August 2006 using 1° Global Data Assimilation System (GDAS) analyses and then run for 30 hours on a single 5950 x 5420 grid point domain covering most of the Meteosat viewing area with 3-km horizontal resolution. The geographical domain was chosen in order to leverage the high spatial and temporal resolution of the many ABI-like channels on SEVIRI. Over 16 TB of model data was produced during the simulation. The data is available every 5 minutes from 09 UTC until 15 UTC and every 15 minutes during the remainder of the simulation. So far, simulated SEVIRI brightness temperatures have been generated every 30 minutes using the Successive Order of Interaction (SOI) forward radiative transfer model. Fig. 14 shows a representative example of the simulated SEVIRI data. A detailed validation of the simulated datasets is currently underway.
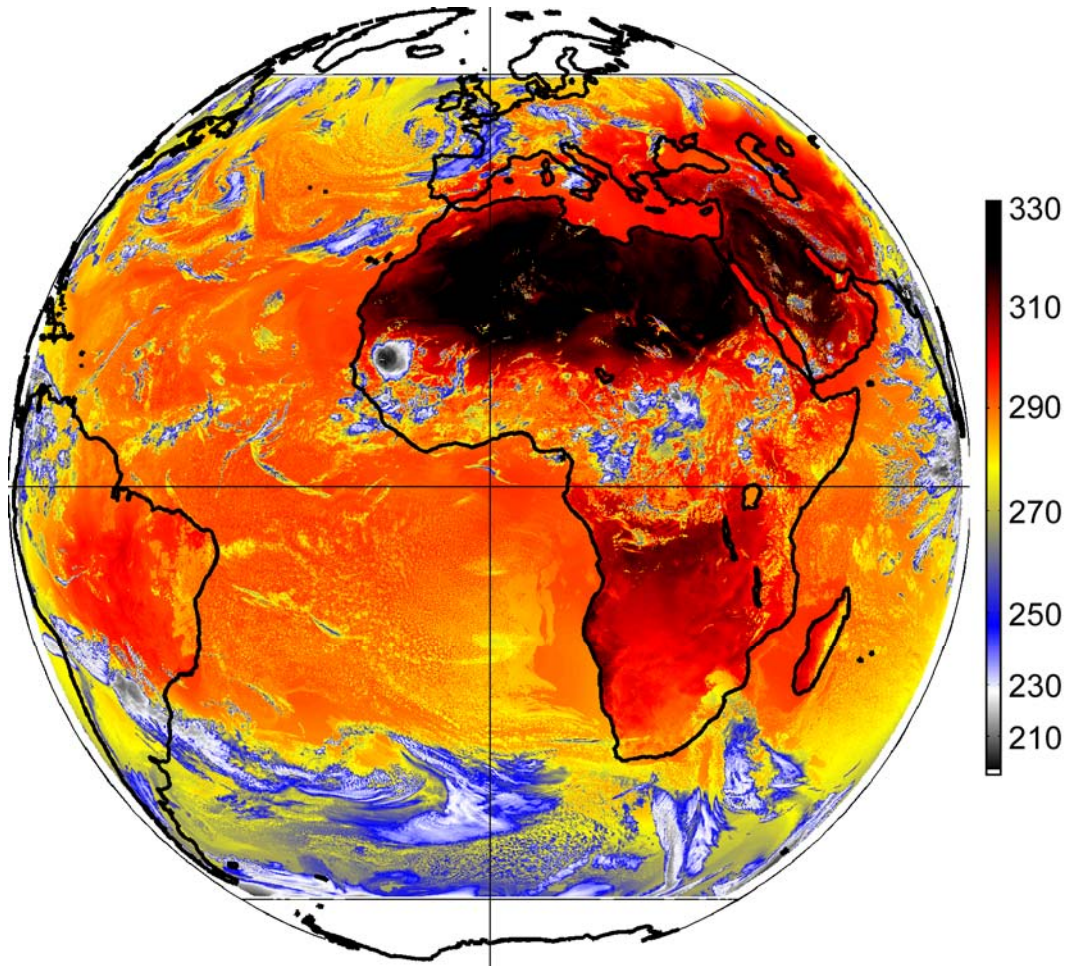
Fig. 14. Simulated SEVIRI 10.8 μm brightness temperatures (K) valid at 1200 UTC on 16 August 2006.

4. Validation/Demonstration
Task Lead: Dave Tobin

Proposed tasks for this effort included 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, key accomplishments include:
1. Performed simulation studies using real MODIS data to assess the ability of a proposed infrared climate benchmark sensor (CLARREO) to intercalibrate operational sounders (Holz, R. E., F. Nagle, D. C. Tobin, R. O. Knuteson, S. Dutcher, H. E. Revercomb, An investigation of the capability of CLARREO to calibrate operation sounders with a focus on both spatial and temporal sampling uncertainties, (2007), *Eos Trans. AGU, 88* (52), Fall Meet. Suppl., Abstract A31B-0313.)
2. Performed global intercomparisons of Aqua AIRS and MODIS infrared radiance observations over five years to assess the calibration accuracy and trends of the observations

3. Performed intercomparisons of METOP-A IASI and Aqua AIRS infrared spectral observations using Simultaneous Nadir Observations over the METOP-A mission time period.
4. Performed quality control on ARM dedicated radiosonde launch data collected in the Fall of 2007 for METOP-A and Aqua overpasses of the ARM sites.

5. Ground Systems
Task Leads: Maciej, Smuga-Otto, Bob Knuteson

In 2006 CIMSS demonstrated a lightweight web-oriented system for distributed processing, management and visualization of hyperspectral data, nicknamed Origami. Extensions to Origami proposed for 2007 involved integration of new algorithms to the Origami framework, the packaging of Origami for distribution across multiple projects, and development of the infrastructure itself to make the Origami framework more robust.

In 2007, several candidate algorithms slated for integration into Origami were moved to an XML (eXtensible Markup Language)-based interface description standard, and tools were developed to generate Origami-compatible source language interface files from this XML description. This makes it easy to automatically generate a new source language (C/C++, Fortran, Java, etc.) interface file for an algorithm. The algorithms in question, used for calibration Level 1 of raw data from potential hyperspectral imaging sounder, already had well-established interfaces to very specific coding frameworks within which they were developed, and needed to be adapted to Origami. The XML interface files provided the cleanest way to do this, as they assured the least coupling between the algorithm code and the surrounding environment. The flexibility of this approach was demonstrated when this approach was adapted, with few changes, in deploying Level 2 candidate algorithms for Advanced Baseline Imager (ABI) work under separate funding. The GEOCAT development framework is being used as the application testbed for this GOES-R risk reduction demonstration of interactive computing.

In addition, the distributed science workflow components of Origami were integrated into the McIDAS-V visualization environment being developed at the SSEC/CIMSS. In the integrated workflow, the scientist searches for datasets and orders distributed computations of intermediate products (such as reprocessing calibrated data) directly from the visualization software interface, without having to cut and paste between different applications. A demonstration of this integration architecture was built, using prototype IASI processing code as the computational load (see Fig. 15) .

The re-scoping of Origami as a component for integration into other applications prompted a rethinking of high-level design for science applications dealing with large volume datasets. The restructured design allows for component-by-component determination of whether to build a new solution or to adopt an existing one. A diagram of the new design as it relates to Origami is shown in Figure 16.
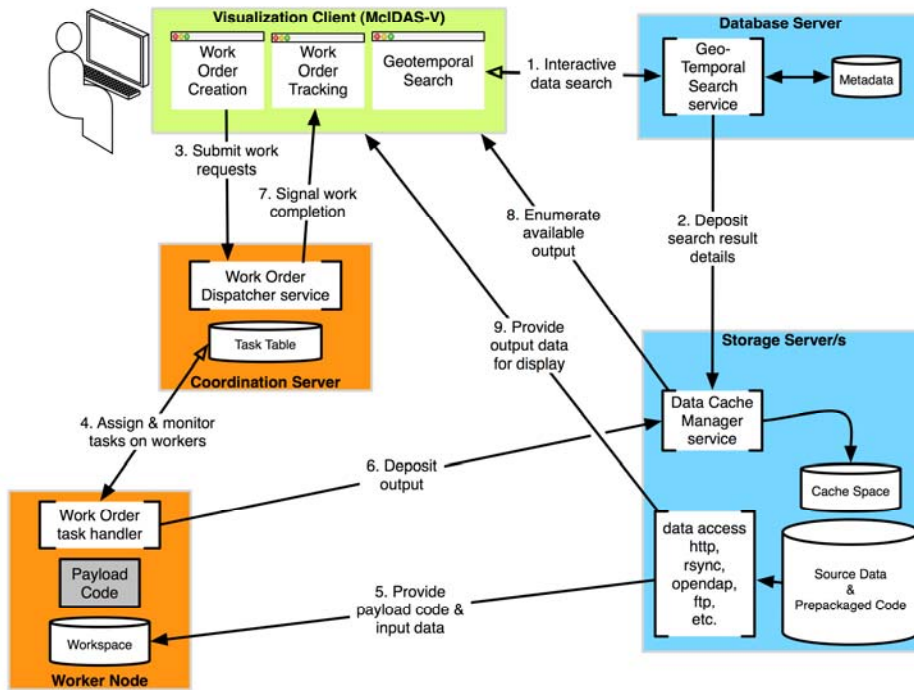
Work Order System Activities

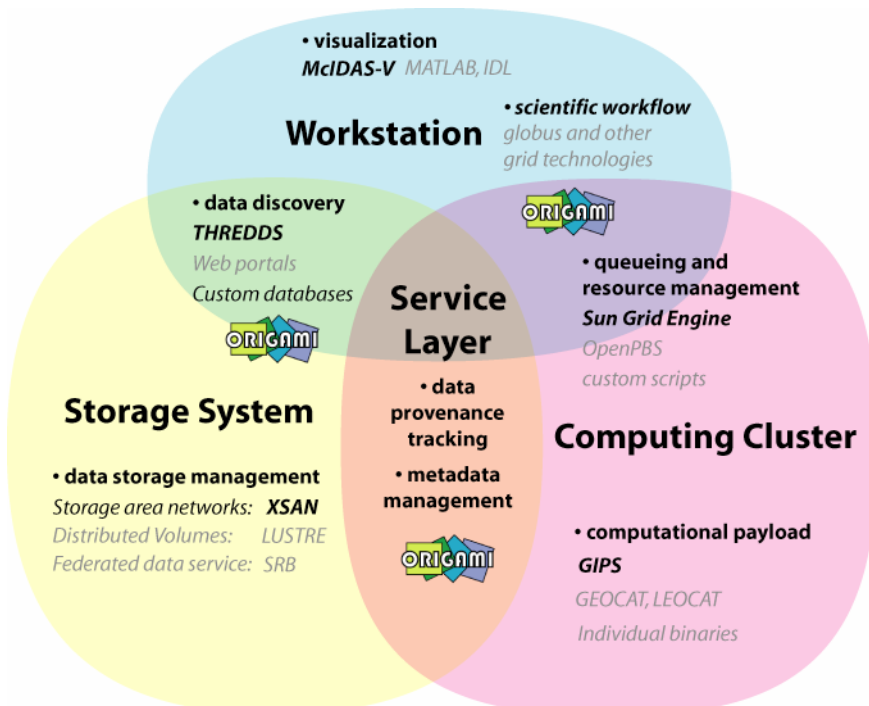Figure 15. Revised Origami architecture, integrated with the McIDAS –V visualization environment.

Figure 16: High level design of a distributed science workflow application for dealing with high volume datasets.

The Origami project is on track for integrating the GEOCAT algorithm testbed in 2008.

References:

Smuga-Otto, Maciej; Garcia, Raymond; Martin, Graeme; Flynn, Bruce and Knuteson, Robert. Origami and GIPS: Running a hyperspectral sounder processing system on a lightweight on-demand distributed computing framework. Joint 2007 EUMETSAT Meteorological Satellite Conference and Satellite Meteorology and Oceanography Conference, 15th, of the American Meteorological Society, Amsterdam, the Netherlands, 24-28 September 2007. Proceedings. European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), Darmstadt, Germany, 2007, Unpaged. Call Number: Reprint # 5582

Raymond K., Bruce M. Flynn, Robert O. Knuteson, Thomas Whittaker, Thomas Rink, Thomas Achtor, Scott Mindock, Steven T. Dutcher, Maciej J. Smuga-Otto, Graeme D. Martin, Tools For Integrating Distributed Computing With Interactive Visualization In McIDAS-V, 88th American Meteorological Society Annual Meeting, 24th Conference on IIPS, New Orleans, LA, January 2008. (http://ams.confex.com/ams/88Annual/techprogram/paper_134920.htm)