

GOES-R Progress Report for July September 2005
University of Wisconsin-Madison
Cooperative Institute for Meteorological Satellite Studies

Project Title: CIMSS Participation in GOES-R Risk Reduction
Principle Investigator: Steve Ackerman
Co-Investigators: Allen Huang, Chris Velden, Bob Knuteson
Program Manager: Tom Achtor
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FY2006 Funding: \$910,000 (budget period through February 2006)
Remaining Funds: \$200,000

Topics Summary

Task 1. Soundings Algorithm Development

Significant Inputs in the last three months

- ***Coordination and Management:***
 - New management and coordination activities were initiated where all scientists and software engineers provide monthly reports to program managers. Development of a quarterly statement of work (SOW) for each of the algorithm development staff was also established. These SOWs will be updated quarterly to reflect the evolving assignments and responsibilities and to give each individual a clear short term direction to make optimal progress.
 - Monthly algorithm development meetings were conducted to coordinate workload and optimize resources.
 - To improve communication and coordination, a dedicated GOES-R3 algorithm development web site and group e-mail address was set up. In this web site all announcements, meeting minutes, SOW of each individual, draft of ATBDs, and all other reports, documents, and publications will be available on-line. Any GOES-R3 Algorithm Development (AD) personnel will be able to post his/her report, and other related information to improve communication.
 - AD is further divided to several groups and group leaders have been identified to give direction and coordinate their peers. The group leaders will be responsible to provide inputs to the AD program managers for the quarterly report.
 - Task priority and project deadline are now well identified and announced.

- ***Algorithms:***
 - **Surface Emissivity Study & Modeling**
 In the last quarter we have reported that high spectral resolution emissivity contributes greatly to the retrieval sensitivity over desert and other land areas as well. Accurate treatment and modeling of emissivity with high spectral resolution will be a key factor for accurate atmospheric profile retrievals. Since then

progress in the surface emissivity study has resulted the distribution of version 1 of a global gridded emissivity database. This is a step beyond the ecosystem-based emissivity dataset.

For general and broad usage the dataset was converted to binary files and a Fortran subroutine was written to extract emissivity for a desired latitude, longitude grid. The code also interpolates emissivity for any wavelength between 3.7 and 14.3 microns. Both a wavelength version of the dataset for users who work with broadband instruments like MODIS, and a wavenumber version for the users of high spectral resolution instruments like AIRS were created. This global gridded emissivity database was beta released to CIMSS and the NOAA/NESDIS Joint Center (JCSDA). The two versions of the database are permanently located on the web, at:

http://thorpex-data.ssec.wisc.edu/UWSSEC/GLOBAL_EMIS/

or they can be direct access by users with an account from the computer barrage: /mnt/chasm/UWSSEC/GLOBAL_EMIS

The global gridded emissivity was applied to the SeaBor v3 training dataset and validated with the MODIS MOD07 total precipitable water product using the new gridded emissivity. Improvement was seen over the ecosystem based emissivity used formerly.

- **Synergistic Cloud-clearing Algorithm Development**

The viewing angle effects on the cloud-clearing performance was resolved. No explicate angle correction is required. The new processing scheme will use 8 adjacent pairs, same as the original, for cloud-clearing of those view angles that are smaller than 30 degree. For those viewing angles that are greater than 30 degree only the two alone track pairs will be used. As such, the yield will drop slightly, by about 5%. MODIS/AIRS cloud-clearing global statistics are in preparation. Preliminary results indicate interesting insight to the performance and will be detailed in the upcoming quarterly report.

- **Cloudy Sounding Retrieval Algorithm Development**

- **Sensitivity of water vapor profile retrieval under the opaque cloudy condition**

Preliminary study has shown that the information content of water vapor profiles under opaque cloudy conditions is limited, especially when cloud altitude is high. This is not surprising since most of the water vapor is concentrated in the lower part of the troposphere. The use of most of the water vapor channels becomes the center of the processing concept if complementary information from each individual channel can be fully utilized.

- **NWP Modeling for Geostationary hyperspectral resolution measurement simulation**

- The WRF model was used to generate a simulated atmospheric profile dataset for a case study referred to as the “FULLDISK” simulation. This simulation contains a 1580 x 1830 grid point domain with 8-km horizontal grid spacing that nearly covers the entire geographical region to be observed by GOES-R. The domain extends from the southern tip of South America northward into southern Canada with an east-west distance of $\sim 110^\circ$ degrees longitude. An hourly dataset was generated for a 6-hour period during this simulation.
- Jason Otkin and Bob Aune attended the WRF-NMM tutorial in Boulder, CO. The WRF-NMM is the NCEP version of the WRF model. Overall, it has some slight advantages compared to the WRF-ARW core (the NCAR version of WRF), but these advantages are outweighed at this time by the lack of sophisticated parameterization schemes. More importantly for our future work, WRF-NMM currently does not contain a data assimilation module. There was talk at the tutorial about releasing a data assimilation package sometime during the next year or two.

○ **Cloudy Forward Model Development**

We are continuing to leverage work under the MURI project in this endeavor. During this quarter the progress is summarized below:

- Continued to evaluate the performance of a two-layer cloud model in the framework of the GIFTS fast model (LY2G).
- Independent but parallel to the LY2G effort, is to conduct cloud property modeling and fast cloudy forward model development independently using SOI approach. In addition, we’ll develop a validation procedure to benchmark the performance of the fast model. The validation of fast cloudy model will include the use of LBLRTM and DISORT models to provide the “truth” to validate the radiances computed by the fast model. The fast model under developed will include analytic Jacobians, tangent linear, and adjoint for retrieval and data assimilation.

□ **Recent Publications:**

1. Wu, X., J. Li, W. P. Menzel, H. L. Huang, K. Baggett, and H. Revercomb, 2005: Evaluation **of AIRS cloud properties using MPACE data, *Geophysical Research Letters*.
2. Eva E. Borbas, Suzanne Wetzel Seemann, Allen Huang, Jun Li, Paul Menzel: Global profile training database for satellite regression retrievals with estimates of skin temperature and emissivity. ITSC 14 Poster paper.

Plans for Next Three Months

- Generate a 24-hour dataset of FULLDISK simulation using WRF model. The simulation contains a 1580 x 1830 grid point domain with 8-km horizontal grid

spacing that nearly covers the entire geographical region to be observed by GOES-R.

- Prepare a journal article that documents the WRF numerical modeling work in support of forward model and retrieval algorithm development.
- Continue to verify two-layer cloudy forward model performance and prepare article for publication.
- Continue analyzing cloud-clearing performance using one day of MODIS/AIRS global data.
- Continue to refine ATBDs and use latest ATBD to guide algorithm development and implementation.
- Expand the global gridded emissivity by including data from multiple years of MODIS (MOD11) observed land surface emissivities.
- Include the AIRS retrievals of emissivity in the derivation of the global gridded emissivity database.
- Implement CIMSS developed Hyperspectral IR CRTM for the efficient and accurate calculation of IR radiance spectra for sensors such as GIFTS, AIRS, CrIS, and HES that is consistent with microwave approach adopted by JCSDA.

Task 2. Preparation for Data Assimilation

Significant Inputs in the last three months

Work completed by Florida State University (FSU) under the supervision of Prof. X. Zou, our GOES-R3 subcontractor, during this quarter is summarized below:

- Channel selection for improved QPFs
- Development of the adjoint of a cloudy radiative transfer model
- Conduct OSSE

We completed a high-resolution simulation of the severe convective initiation that occurred on 12 June 2002 during the International H₂O Project (IHOP) intensive observing period to an extended the 4-km forecast domain, with 300 X 300 horizontal grid points and 54 vertical layers. Simple ice explicit moisture scheme (Dudhia scheme with no cumulus parameterization), MRF planetary boundary layer scheme and RRTM radiation scheme were used in the model integrations. Similar parameterization schemes have been used to simulate the same case by Otkin (2004) except the OSU land surface model scheme.

Adjoint sensitivity analysis

We continue to access the relative sensitivity of radiance to temperature and water vapor mixing ratio at different vertical levels by way of GIFTS forward model and its adjoint model. Figure 1 gives an example showing the relative sensitivity of radiance at channel 533 (892.5818 cm⁻¹) to the temperature and water vapor mixing ratio profiles. It is noted that the sensitivities of radiance to temperature are much larger than the sensitivities of radiance to water vapor mixing ratio. This actually is true for all absorb channels including the water vapor channels. It is also noted that the maximum values of relative sensitivity profiles are found in the low troposphere. The IR window channel observes

the surface radiance (temperature) for the clear-sky atmosphere, and therefore contains useful information about the location and initiation of the severe precipitation area. Vertical oscillations of maximum sensitivity and variations of radiance sensitivity to mixing ratio at hourly time scales are also noted in Fig. 1. Although the vertical level of maximum value of sensitivities of radiance is consistent with the maximum weighting function (figure omitted), the advantages of adjoint sensitivity study are the abilities of (i) separating sensitivity to temperature from that to water vapor as well as (ii) providing profile-dependent maximum sensitive regions.

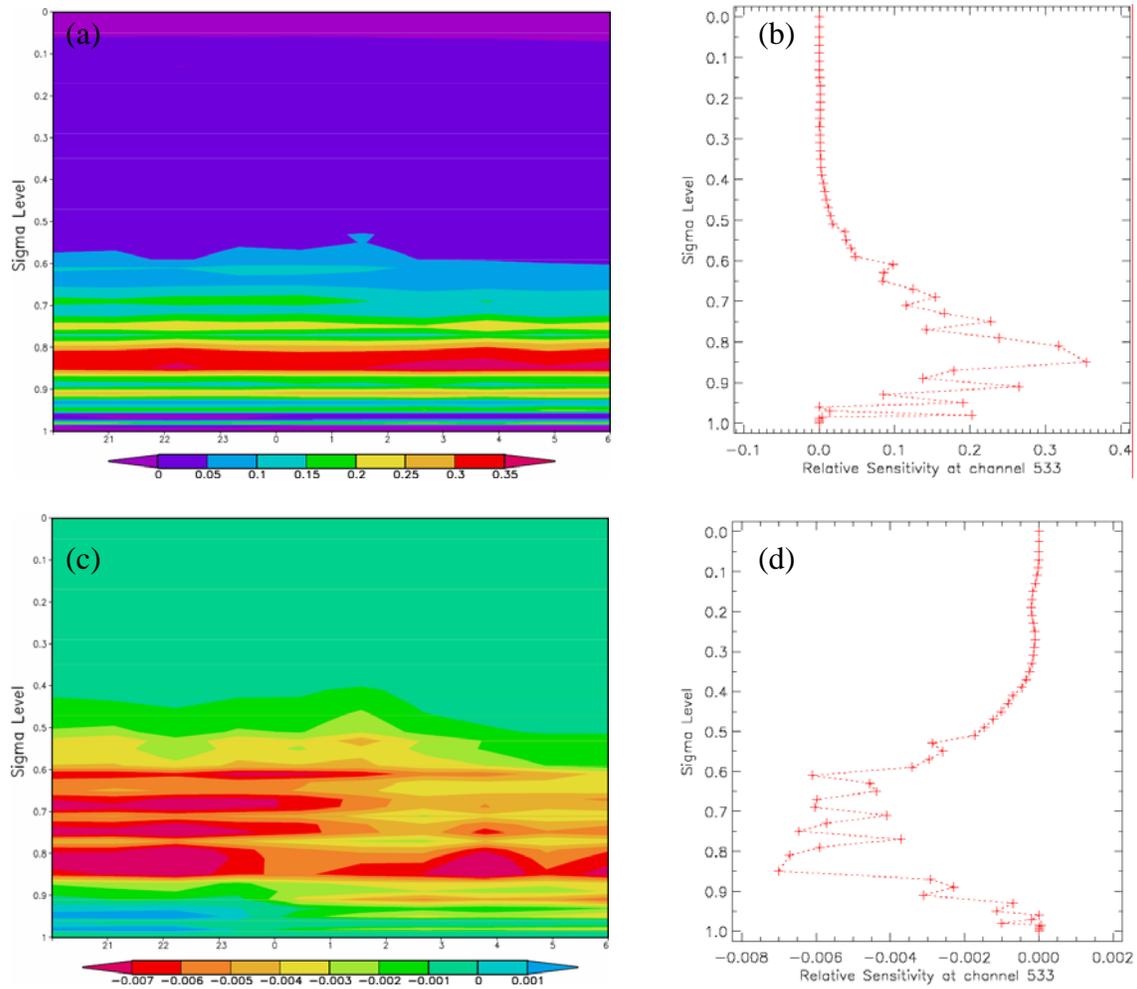


Figure 1. Relative sensitivities (left panels) and average relative sensitivities (right panels) for the 533 channel (wavenumber 892.5818 cm^{-1}) to (a-b) temperature and (c-d) mixing ratio at a clear-sky point for the period from 2100 UTC 12 June to 0600 UTC 13 June.

- *Publications:*
N/A

Plans for Next Three Months

Prof. Zou of FSU will continue to perform the following activities during the next quarter:

- Channel selection for improved convective QPF - one way to optimize data assimilation approaches for HES;
- Development of the tangent linear and adjoint operators of a cloudy radiative transfer model (RTM); and
- Observing system simulation experiments (OSSEs) (e.g., data assimilation using simulated HES data), aiming at assessing full information content of HES for NWP data assimilation by taking advantage of time continuity of HES, and identifying risks and potential problems associated with assimilation of HES data.

Task 3: GOES R Winds

Project Title: GOES-R3 Winds

Principle Investigator: Velden

Very little work was done on GOES-R winds in this reporting period. A new dataset was recently provided by the algorithm group for the ATReC case that includes AIRS cloud-cleared or flagged retrievals. The winds group will attempt to re-derive AIRS winds with these new retrieved moisture fields in the next quarter.

Significant Accomplishments in the last three months

None this quarter

Plans for Next Three Months

The new set of cloud-cleared AIRS retrieval moisture fields for the ATREC case study completed in the last reporting period will be used to re-derive the height-resolved winds and assess the quality.

Task 4: GOES-R Ground System Design and Studies

Significant Accomplishments in the last three months

Proposed activities for the third quarter of 2005 involved development of the toolset for automatic generation of processing code, along with a final development push for the various algorithms making up a demonstration GIFTS pipeline, resulting in prototype testing runs of the pipeline using early versions of a simulated GIFTS dataset.

Work during this quarter focused on updating and finalizing the architecture and design of the processing pipeline, and on writing updated versions of the individual algorithms. Much of the work focused on fleshing out the metadata associated with the processing, a

task which was begun in the previous quarter. This involved more research into metadata formats, as well as selection of technologies and prototyping of code for handling the metadata as it passes through the processing system. Specific tasks included adapting a data dictionary architecture, previously successfully employed in other SSEC interferometer processing programs, to the GIFTS processing system. Also, the various capsules written in earlier stages of the project were updated to reflect the most recent state of the interfaces.

Unit and functional testing of both the interfaces and of the assembled pipelines were performed throughout.

During this reporting period, results from the above research were presented at the poster session of the 25th anniversary symposium held by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) in Madison, Wisconsin on July 14. An in-depth poster was also presented at the Earth Systems X session of the SPIE meeting in San Diego, on July 31-August 1. A companion manuscript, "Data Processing Suite for GIFTS Testing" was published in the Proceedings of SPIE, volume 5882. Figure 1 shows details of the new capsule design that was described in that manuscript.

Plans for Next Three Months

Work will focus on the large-scale data simulation effort, with the intent of finishing the generation of 24 hours worth of simulated GIFTS radiances from a near-full disk scan pattern.

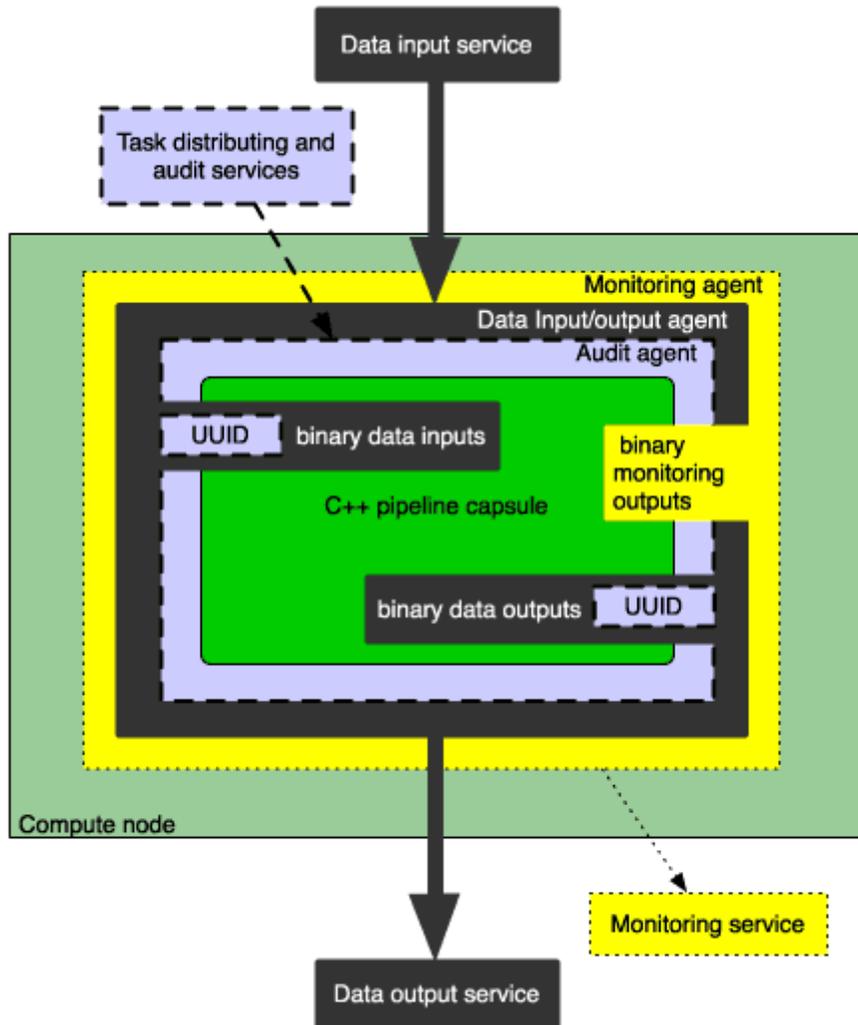


Figure 1. Capsule environment and interfaces, GIFTS processing system, August 2005 version.

CIMSS Finances Summary: GOES-R Funding and Spending Plan

GOES R Risk Reduction Funding

Through 2/2004	\$1,270K
Through 2/2005	\$ 750K
Through 2/2006	<u>\$ 910K</u>
Total funding to date	\$2,930K

GOES R Risk Reduction Spending

Through 2/2004	\$1,299K
3/2004 - 2/2005	\$ 880K
3/2005 – 6/2005	\$ 318K
July 2005	\$ 77K
August 2005	\$ 86K
September 2005	<u>\$ 70K</u>
Total spending thru 9/30/05	\$2,730K

For the next three months, spending is estimated to be:

October 2005	\$50K
November 2005	\$50K
December 2005	\$40K

end