

## 1. Objective

The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) on the GOES-R series will enable improved monitoring of the distribution and evolution of atmospheric thermodynamics and clouds. The HES will be able to provide hourly atmospheric soundings with spatial resolution of 4 - 10 km with high accuracy using its high spectral resolution infrared measurements. However, the presence of clouds affects the sounding retrieval and needs to be dealt with properly. The ABI will provide at high spatial resolution (0.5 - 2km) a cloud mask, surface and cloud types, cloud-top phase information, cloud top pressure (CTP), cloud particle size (CPS), and cloud optical thickness (COT), etc. The combined ABI/HES system offers the opportunity for atmospheric and cloud products to be improved over those possible from either system alone. The key step for synergistic use of ABI/HES radiance measurements is the collocation in space and time. Collocated ABI can (1) provide HES sub-pixel cloud characterization (mask, amount, phase, layer information, etc.) within the HES footprint; (2) be used for HES cloud-clearing for partly cloudy HES footprints; (3) provide background information in variational retrieval of cloud properties with HES cloudy radiances. The Moderate-Resolution Imaging Spectroradiometer (MODIS) and the Atmospheric Infrared Sounder (AIRS) measurements from the Earth Observing System's (EOS) Aqua satellite provide the opportunity to study the synergistic use of advanced imager and sounder measurements. The combined MODIS and AIRS data for various scenes are analyzed to study the utility of synergistic use of ABI products and HES radiances for better retrieving atmospheric soundings and cloud properties. ABI can also help HES for cloud-clearing of footprints in partial cloud cover. Currently there is an option that ABI and HES might be located on different satellites, this design will have impact on the ABI/HES synergism. In order to answer the question on what the impact will be on the ABI/HES synergism if the two satellites are separated by a distance of 1, 2.5, or 5.0 degree in longitude, a study is carried out to simulate the ABI BT differences within collocated HES footprints due to the two-satellite system for ABI and HES.

## 2. Fast Cloudy Radiative Transfer Model and Retrieval Schemes

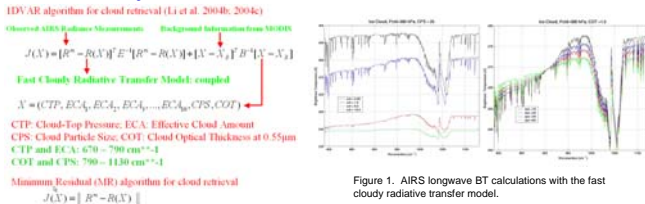


Figure 1. AIRS longwave BT calculations with the fast cloudy radiative transfer model.

## 3. Hyperspectral IR Sounder Cloud Properties Retrieval

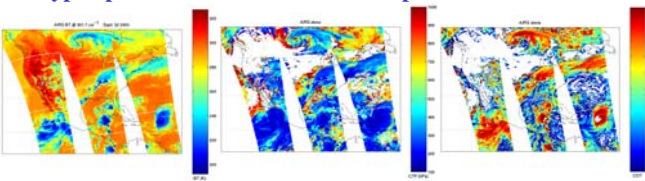


Figure 2. From left to right are (a) AIRS BT window image (03 Sept. 2003), (b) AIRS MR CTP, and (c) AIRS MR COT retrievals. In AIRS cloud property retrieval, MODIS cloud mask and cloud phase mask are used.

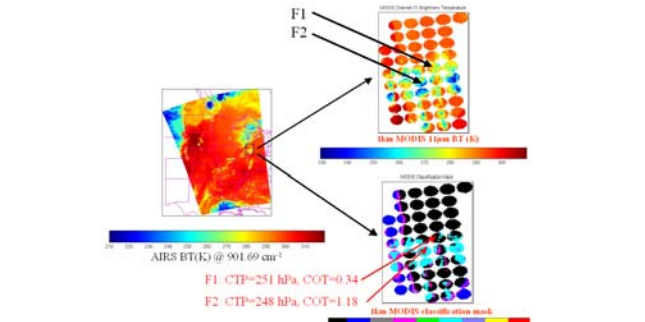


Figure 3. AIRS BT window image (06 Sept. 2002, upper left, AIRS granule 193), MODIS 1 km classification mask superimposed to AIRS footprints of a small area (upper right), and the AIRS observed and calculated (from retrievals) BT spectra for the two selected footprints (lower left and right).

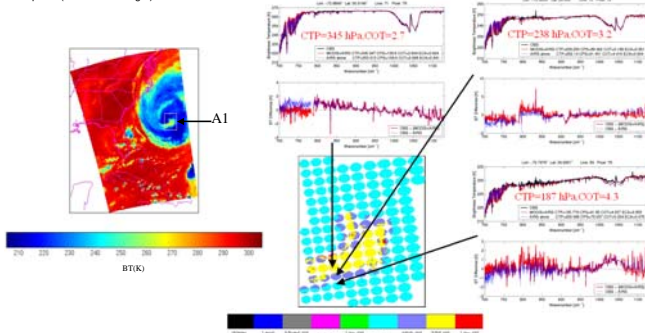


Figure 4. AIRS BT window image (upper) and the AIRS observed and calculated (from retrievals) BT spectra for the three selected footprints from the center of hurricane Isabel (AIRS granule 184, 17 September 2003) indicated by box A1 in upper panel.

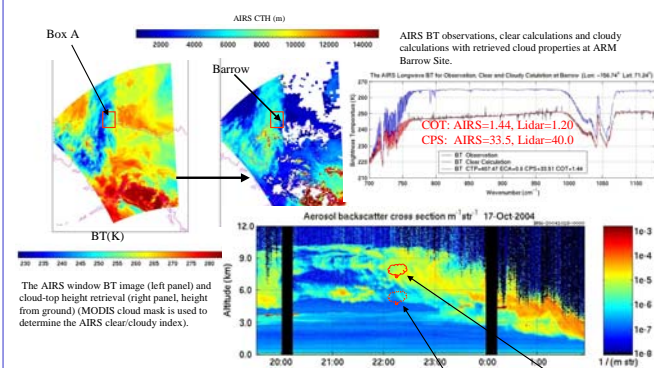


Figure 5. AIRS and MODIS CTHs overlapping with Aerosol backscatter cross section, MODIS assigns clouds lower than AIRS at ARM North Slope of Alaska Barrow site.

## 4. Imager/Sounder cloud-clearing

An optimal imager/sounder cloud-clearing method is developed (Li et al. 2005, IEEE Transaction on Geoscience and Remote Sensing, June issue). MODIS/AIRS data are used for verifying the algorithm.

$$N^* = \frac{\sum_i \frac{1}{\sigma_i^2} [f_i(R_i^c) - R_{i0}^c] [f_i(R_i^c) - f_i(R_i^*)]}{\sum_i \frac{1}{\sigma_i^2} [f_i(R_i^c) - R_{i0}^c] [f_i(R_i^c) - f_i(R_i^*)]} \rightarrow R_i^{cc} = \frac{R_i^c - R_i^* N^*}{1 - N^*}$$

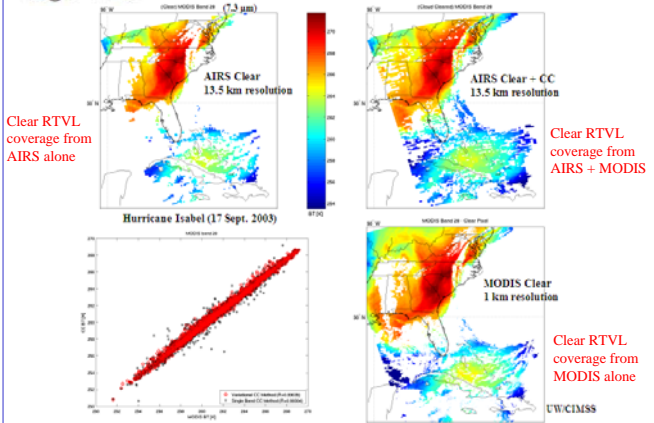


Figure 6. AIRS convolved 7.3 um clear BT (upper left), clear + cloud-cleared BT (upper right), and MODIS clear BT (lower right). The scatterplot between AIRS CC BT and MODIS clear BT is also shown (lower left).

## 5. GOES-R Design Impact on ABI/HES synergism

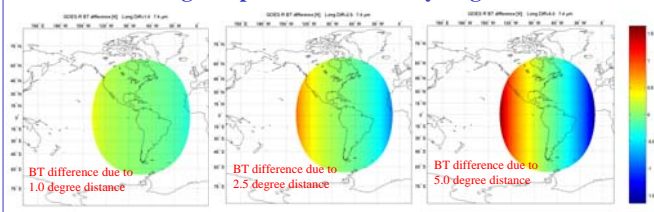


Figure 7. 7.4 um brightness temperature differences due to two-satellite system for ABI and HES. From left to right is 1.0, 2.5, and 5.0 degree distance between two satellites (e.g., two GOES-R East), respectively.

## 6. Summary

- HES sub-pixel cloud characterization using ABI mask products (cloud mask, cloud phase mask, cloud classification mask) is very important for HES cloud property retrieval.
- ABI and HES data provide cloud properties (CTP, ECA, COT, CPS) during both daytime and nighttime.
- IDVAR and MR algorithms give similar cloud products from HES, but IDVAR is more efficient.
- Combination of ABI/HES is very useful for cloud property retrieval and AIRS cloud-clearing.
- Two-satellite system for ABI and HES has significant impact on ABI/HES synergism, especially in East and West limb sides. A small distance between two satellites is very important for the synergy.

## References

[1] Li, J., C.-Y. Liu, H.-L. Huang, T. J. Schmit, X. Wu, W. P. Menzel and J. J. Gurka, "Optimal cloud-clearing for AIRS radiances using MODIS", *IEEE trans. On Geoscience and Remote Sensing*, vol. 43, 2005  
 [2] Li, J., W. P. Menzel, F. Sun, T. J. Schmit, and J. Gurka, "AIRS sub-pixel cloud characterization using MODIS cloud products", *J. Appl. Meteorol.* Vol. 43, pp. 1083 - 1094, 2004a.  
 [3] Li, J., W. P. Menzel, W. Zhang, F. Sun, T. J. Schmit, J. J. Gurka, and E. Weisz, "Synergistic use of MODIS and AIRS in a variational retrieval of cloud parameters", *J. Appl. Meteorol.*, vol. 43, pp.1619 - 1634, 2004b.  
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 [5] Schmit, T. J., M. M. Gunshor, W. Paul Menzel, J. Li, S. Bachmeier, and J. Gurka, 2004: Introducing the next-generation advanced baseline imager (ABI) on Geostationary Operational Environmental Satellites (GOES)-R. *Bull. of AMS* (in press)

## Acknowledgement

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