AIRS/MODIS combined retrieval products

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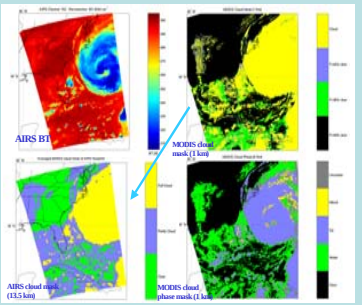
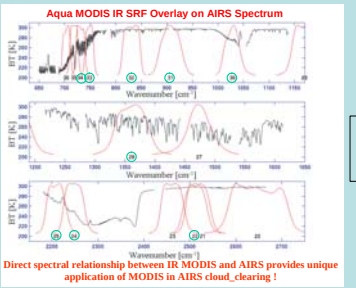
Thanks also to…
Elisabeth Weisz, CIMSS
Jinlong Li, CIMSS
Allen Huang, CIMSS
MODIS science team
AIRS science team
GOES-R team at CIMSS

The Atmospheric InfraRed Sounder (AIRS) onboard NASA's Earth Observing System's (EOS) Aqua spacecraft, with its high spectral resolution and radiometric accuracy, provides atmospheric vertical temperature and moisture sounding information with high vertical resolution and accuracy for numerical weather prediction (NWP) and climate prediction. Due to its relatively coarse spatial resolution (13.5 km at nadir), the chance for an AIRS footprint to be completely clear is small (less than 5%). However, the Moderate-Resolution Imaging Spectroradiometer (MODIS), also on the Aqua satellite, provides cloud mask, cloud phase mask, and clear radiances at several spectrally broad infrared (IR) bands with 1 km spatial resolution within many AIRS cloudy footprints. MODIS can

(1) provide AIRS sub-pixel cloud characterization (mask, amount, phase, layer information, etc.) within each AIRS footprint (Li et al. 2004a);
(2) provide background information on the retrieval of cloud properties such as cloud-top pressure (CTP), cloud optical thickness (COT), and cloud particle size (CPS) in radius with AIRS radiances (Li et al. 2004b; 2005a); and
(3) be used for AIRS cloud-clearing for partly cloudy AIRS footprints.

AIRS cloud-cleared radiance product using MODIS





MODIS/AIRS cloud-clearing approach for partial cloudy AIRS footprints

Optimal imager/sounder cloud-clearing Methodology

(Li et al. 2005; *IEEE trans. On Geoscience and Remote sensing, June issue*).

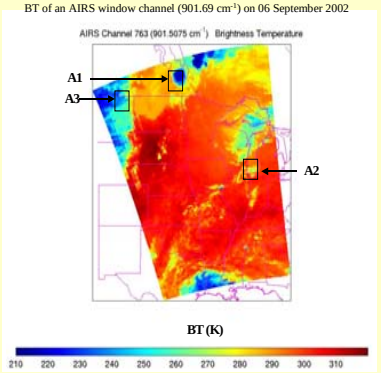
N^* then can be analytically solved from minimizing the cost function $\frac{\partial J(N^*)}{\partial N^*} = 0$

An extension of single band N^* method (Smith et al. 1968, 2004) !

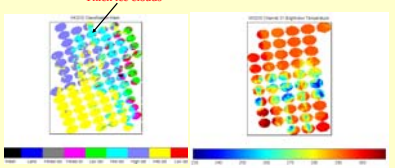
$$N^* = \frac{\sum_i \frac{1}{\sigma_i^2}[f_i(R_v^1) - R_{M_i}^{clr}][f_i(R_v^1) - f_i(R_v^2)]}{\sum_i \frac{1}{\sigma_i^2}[f_i(R_v^2) - R_{M_i}^{clr}][f_i(R_v^1) - f_i(R_v^2)]}$$

AIRS cloud mask product using MODIS

BT of an AIRS window channel (901.69 cm^{-1}) on 06 September 2002

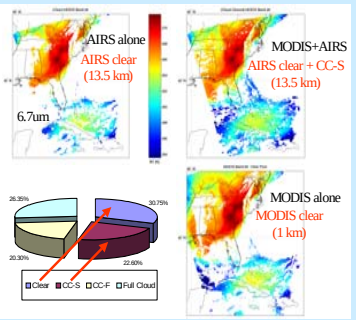


Thick ice clouds

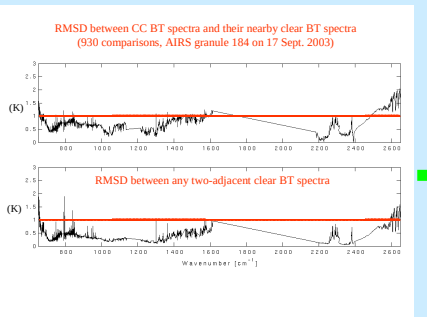


1 km MODIS classification mask superimposed to the small area A3.

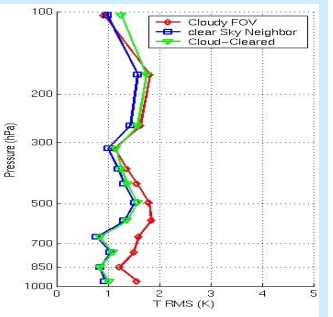
1 km MODIS 11μm BT superimposed to the small area A2.



The BT images of MODIS band 28 (7.3 μm) convoluted from the AIRS clear footprints (upper left), the AIRS clear plus successful cloud-cleared footprints (upper right), and the MODIS clear BT observations with 1 km spatial resolution (lower right).

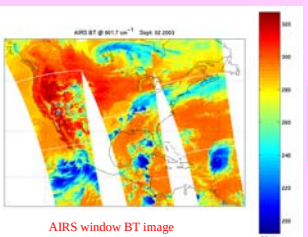


Assessment of AIRS cloud-cleared BT spectra.



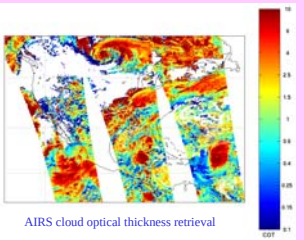
Temperature RMS difference between AIRS retrievals and the ECMWF analysis, ~ 250 thin cloudy footprints are included in the statistics.

MODIS/AIRS combined cloud property product

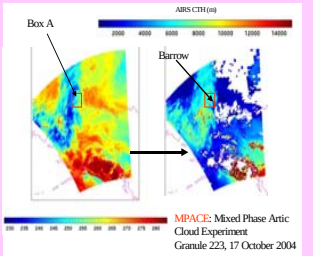


AIRS window BT image

With help of MODIS cloud mask and cloud phase mask, single footprint bade CTP, CPS in radius and ,COT can be retrieved from AIRS (Li et al. 2004b; 2005b).

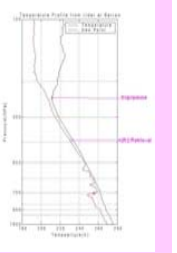


AIRS cloud optical thickness retrieval

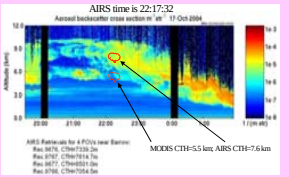


MPACE: Mixed Phase Artic Cloud Experiment Granule 223, 17 October 2004

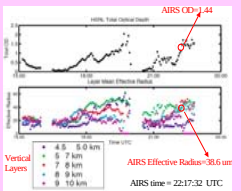
AIRS window (11 μm) BT (left) and retrieved cloud-top height (m) (right) during MPACE.



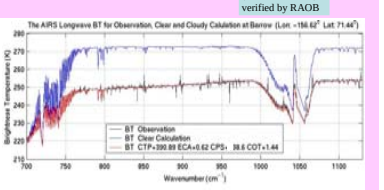
AIRS CTP retrieval (7.6 km, 390 hPa) verified by RAOB



AIRS CTP retrieval (7.6 km, 390 hPa) verified by Lidar (lidar data from SSEC lidar group)



AIRS COT (upper) and CPS (lower) verified by Lidar (lidat data from SSEC lidar group)



AIRS BT spectra from clear calculation, observation, and calculation with retrieved CTP, ECA, CPS and COT at ARM Barrow site.

Summary

Three types of MODIS/AIRS combined products can be derived: (1) AIRS single footprint cloud mask and cloud phase mask product using MODIS, (2) AIRS single footprint cloud-cleared radiance product using MODIS, and (3) AIRS single footprint cloud property product using MODIS.

References

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