Using AIRS high spectral resolution spectra to assess MODIS TIR band calibration

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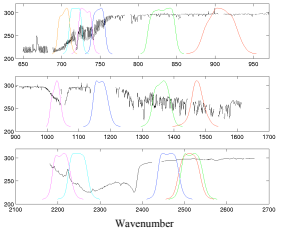
Introduction

- Comparisons of Atmospheric InfraRed Sounder (AIRS) and MODerate resolution Imaging Spectroradiometer (MODIS) radiance observations
  - Spatially uniform scenes collected on 6 Sept 2002 and 18 Feb 2004
  - Differences characterized as functions of scene temperature, scan angle, and solar zenith angle.
- Important for:
  - Climate studies utilizing data from one or both sensors
  - Understanding differences between AIRS products and MODIS products
  - Diagnosing calibration issues of either sensor
  - Development of applications utilizing data from both sensors (e.g. AIRS cloud-clearing using MODIS data, synergistic use of AIRS and MODIS for cloud property retrievals)

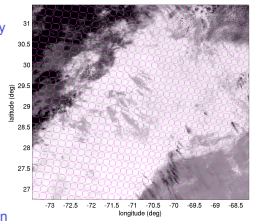
MODIS Spectral Response over an AIRS spectrum.

To match the MODIS spectral resolution, the AIRS spectra are convolved with the MODIS SRFs

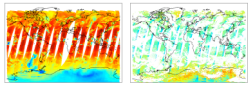


The 1 km MODIS is collocated with AIRS by representing the AIRS FOVs as slightly oversized circular footprints, and computing the mean MODIS value within those footprints for each band.

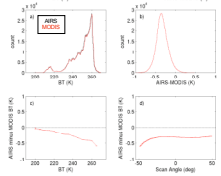
Spatially uniform scenes are selected by requiring the standard deviation of the MODIS data within each AIRS footprint to be 0.2K or less.



Example comparisons for band 34 (13.7 μm) on 6 Sept. 2002.



Evaluation includes a) brightness temperature (BT) and b) BT difference (AIRS-MODIS) histograms, c) BT difference as a function of scene temperature and d) of scan angle.

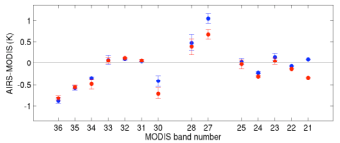


Overview: Combining AIRS and MODIS observations from Aqua offers an opportunity to enhance the performance and scientific harvest of each sensor. In this work, AIRS and MODIS observations are directly compared using global data on two different days to gain insight on L1B performance. The data are filtered to select uniform scenes. Two important findings are presented:

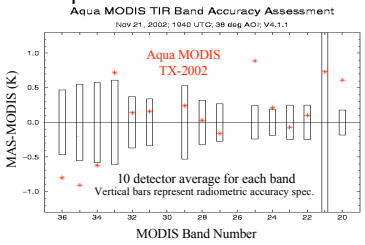
1. The AIRS-MODIS differences have an apparent scene temperature dependence for several bands, including CO2 sensitive bands and water vapor sensitive bands. The scene temperature dependence can be removed from MODIS CO2 bands 34-36 by adjusting the spectral position of these bands by 0.8, 0.8, and 1.0 cm-1 resp. This *suggests* a possible spectral characterization error in Aqua MODIS LWIR CO2 bands.
2. The AIRS-MODIS differences for LWIR bands 34-36 have an apparent dependence on scan angle of the swath. This *may* be caused by error in the MODIS response vs scan (RVS) characterization used in L1B to describe the MODIS scan mirror performance.

Scene Temperature Dependence

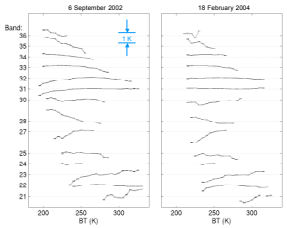
Mean brightness temperature differences and uncertainties for 6 September 2002 (blue) and 18 February 2004 (red).



The averaged (over all uniform scenes) AIRS-MODIS differences are similar to averaged MAS-MODIS differences (red stars at right) computed from an underflight of Aqua by a NASA ER-2 aircraft on Nov. 19, 2002.

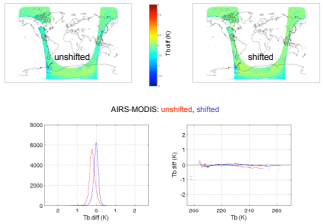


Brightness temperature differences as a function of scene temperature.

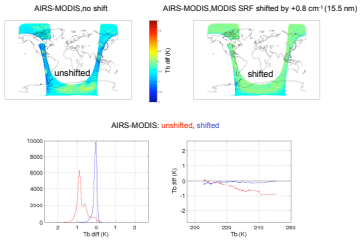


The AIRS-MODIS differences show dependence (slope) on the scene temperature, especially for LWIR CO2 sensitive bands 34-36, and water vapor sensitive bands 27 and 28. The dependence is similar (though not the same) on both days.

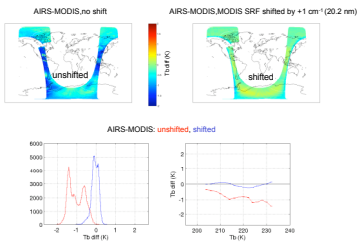
MODIS Band 34 (13.7 μm)



MODIS Band 35 (13.9 μm)

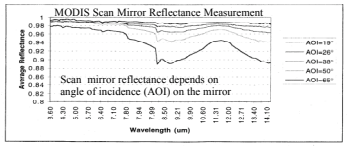


MODIS Band 36 (14.2 μm)

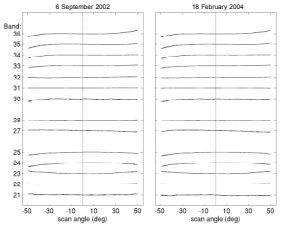


Band 34 (13.7 μm), 35 (13.9 μm), and 36 (14.2 μm) brightness temperature differences for one orbit of data on 6 Sept 2002 using the nominal MODIS unshifted SRF (red) and using the MODIS SRF shifted by +0.8 cm^{-1}, +0.8 cm^{-1}, and +1.0 cm^{-1} (blue), resp. Shifting the spectral position of these bands effectively removes the scene temperature dependence in the AIRS-MODIS differences.

Scan Angle Dependence

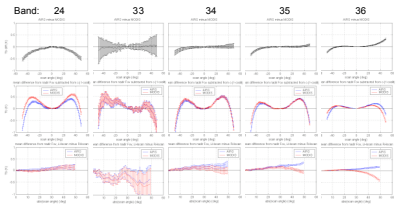


The MODIS scan mirror reflectance (above) is dependent upon the angle of incidence (AOI) of the upwelling radiance on the scan mirror. Error in the characterization of the scan mirror response vs scan (RVS) in L1B production causes scan angle dependent biases in the MODIS L1B radiances and L2 science products. The AIRS-MODIS comparisons (below) demonstrate that such biases exist, and are likely due to MODIS since the AOI of the light on the AIRS scan mirror does not change with scan angle.



Brightness temperature differences as a function of scan angle.

The charts below show the departure in the MODIS and AIRS across track profiles by band. In the spectral region of MODIS B24, the scan mirror reflectance is nominally flat with AOI. There is good agreement between AIRS and MODIS across track profiles (bottom row of the daytime and nighttime charts) for B24; at longer wavelengths (B33-36) the MODIS scan mirror reflectance varies markedly with scan angle. For B34-36, the MODIS across track profile departs from that of AIRS going towards the end-of-scan side of the swath. This systematic behavior suggests that MODIS RVS characterization inaccuracy is causing a scan angle dependent bias between MODIS and AIRS.



Aqua AIRS / MODIS differences as a function of scan angle