Evaluation of IASI and AIRS spectral radiances using Simultaneous Nadir Overpasses

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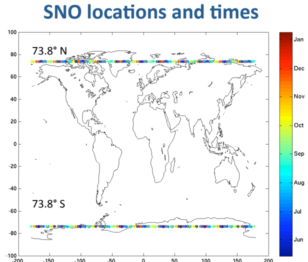
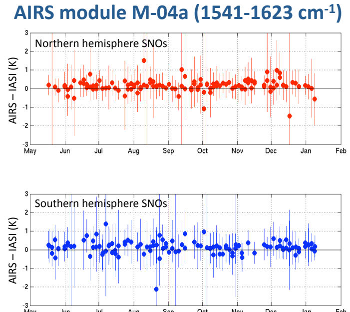
Motivation

- AIRS and IASI are high spectral resolution infrared sounders, designed primarily for weather applications and also currently serving as references for in-orbit infrared calibration.
- Previous studies performed for both AIRS and IASI suggest that the sensors are, in general, accurate to the 0.2 to 0.5 K (3-sigma) level.
- Direct comparisons of AIRS and IASI via Simultaneous Nadir Overpasses (SNOs) provide another way to assess the accuracies of the sensors.

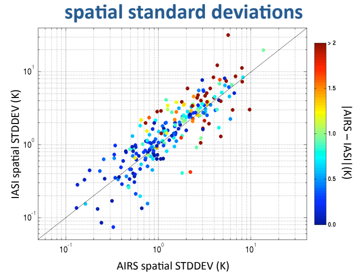
SNO locations and times



Sample time series plot: mean differences and uncertainties for channels within AIRS module M-04a (1541-1623 cm^{-1})



900.31 cm^{-1} channel differences as a function of IASI and AIRS spatial standard deviations



Analysis Approach

The locations and times of the SNOs for IASI and AIRS are computed, spanning 14 May 2007 to 10 Jan 2008, for SNOs for which the AIRS and IASI observation times are within 2 minutes of each other (N=284 cases).

For each SNO, the AIRS FOVs within 30 km of the SNO location are identified (typically 6 to 8 FOVs per SNO) and the mean (MN) and standard deviation (SD) radiance spectra are computed. The same is done for IASI (typically 3 to 4 FOVs per SNO).

For each SNO, the spectra are processed to have common spectral resolution and sampling (i.e. de-apodize the IASI L1C spectra and then convolve with the AIRS L1B SRFs, and convolve the AIRS L1B spectra with the de-apodized IASI L1C SRFs) and the difference between AIRS and IASI is computed (i.e. $\delta_i = MN'_{AIRS,i} - MN'_{IASI,i}$).

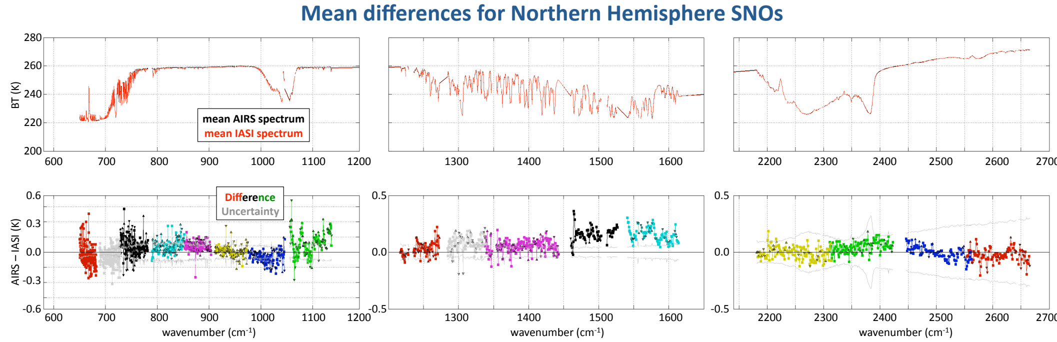
The resulting primary source of comparison error for each SNO case is due to the difference in the sparse sampling of the scene radiance provided by AIRS (nearly contiguous 3x3 FOVs) and IASI (non-contiguous 2x2 FOVs). The 1-sigma uncertainty for each SNO case is therefore computed as $\sigma_i = [SD'^{2}_{IASI,i} + SD'^{2}_{AIRS,i}]^{½}$.

For ensembles of SNOs, the spatial sampling differences are assumed to be random from case to case. The mean differences between AIRS and IASI and their uncertainties are computed using weighted mean differences using the spatial standard deviations to compute the weights for each case (i.e. $\omega_i = 1/\sigma_i^2$, $\Delta = \sigma_\Delta^2\,[\Sigma_{i=1:N}\,\omega_i\,\delta_i]$, and $\sigma_\Delta = [\Sigma_{i=1:N}\,\omega_i]^{-½}$).

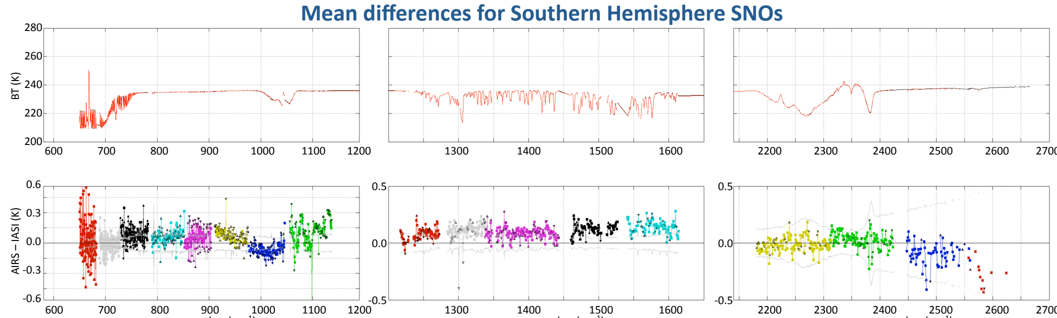
Summary, Conclusions, Questions

- Although the agreement between AIRS and IASI observed radiances is very good on one level, the SNO comparisons reported here reveal some fundamental measurement differences which can potentially impact both weather and climate applications.
- **Specific findings include:**
  - The comparisons show no significant long term (8 months) trends versus time.
  - Significant differences, on the order of 500 mK, are observed between the longwave differences from the northern to southern latitude SNOs, particularly for AIRS detector array M-12 (649-681 cm^{-1}). Further analyses and comparisons with L. Strow's spectral shift analyses suggests that these differences are due primarily to orbital variations of the AIRS spectral centroids, which is not included in production of the AIRS L1B product. SNO comparisons with IASI should be performed again after production of the AIRS L1C climate products, which are expected to include knowledge of these spectral shift variations.
  - AIRS A-B state related differences are observed within some detector arrays, most notably within array M-08 (851-903 cm^{-1}) with differences of approximately 400 mK between A-side only and B-side only channels.
  - For upper level water vapor channels, mean differences on the order of 200 mK are observed for AIRS detector arrays M-04a (1541-1623 cm^{-1}) and M-04b (1460-1527 cm^{-1}), while the mean differences for neighboring arrays are approximately zero, suggesting that these differences are due, at least partially, to AIRS.
  - IASI shortwave channels are very noisy for the very cold southern latitude SNOs. Optimal random noise filtering and/or wavenumber averaging should be used to improve the comparisons for these cases.
- **Resulting questions:**
  - Are the differences reported here for relatively cold scenes representative of differences for warmer scenes ?
  - To what degree have the observed differences been *absorbed*, correctly or not, into forward model parameterizations and/or retrieval bias functions and/or derived climate products ?
  - What calibration refinements can be implemented to account for the observed differences ?

Mean differences for Northern Hemisphere SNOs



Mean differences for Southern Hemisphere SNOs



International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.