

Radiometric Intercomparisons of AIRS and IASI for Climate Monitoring Applications

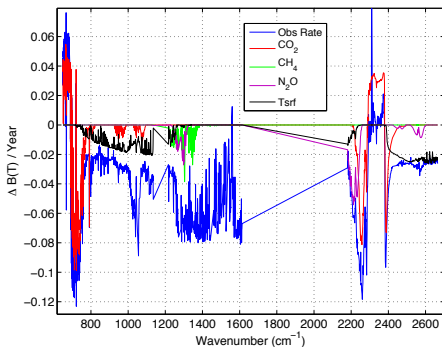
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Motivation

- IASI and AIRS are *extremely* stable. To 1 mK per year??
- Climate trending is possible. At present, maybe only using radiances directly?
- But systematic inter- and intra-instrument differences remain
 - Frequency calibration (AIRS: versus time, IASI: versus FOV)
 - Radiometric calibration differences between AIRS and IASI
- Hyperspectral IR could provide unique geophysical trending, but issues remain (CO_2 vs T, how to handle clouds, etc.)
- IASI may help diagnose AIRS SRF inaccuracies



- Blue curve: Observed radiance derivative ($\text{dB(T)}/\text{dt}$) for 5-years (± 30 deg. lat).
- Retrieval of minor gas rates (and $T(z)$, $Q(z)$) return very accurate geophysical rates.

Approach: Double Differences

Double-Differences between AIRS and IASI

- ECMWF forecast data better than in-situ sondes for CO₂ channels in mid- to lower-troposphere.
- **BUT**, Obs-Calc B(T) contains radiative transfer errors.
- **Instead**, examine double-differences (DD) of ECMWF bias:

$$DD \equiv \left(BT_{obs} - BT_{cal}(ECMWF) \right)_{AIRS} - \left(BT_{obs} - BT_{cal}(ECMWF) \right)_{IASI}$$

Advantages of *DD*

- *DD* removes inaccuracies in both the RTA and ECMWF
- Gives *quick* results: (Being developed for CrIS Cal/Val)
- Works best in tropics, where there are no SNO's

Disdvantages of *DD*

- Need identical radiative transfer for both instruments.

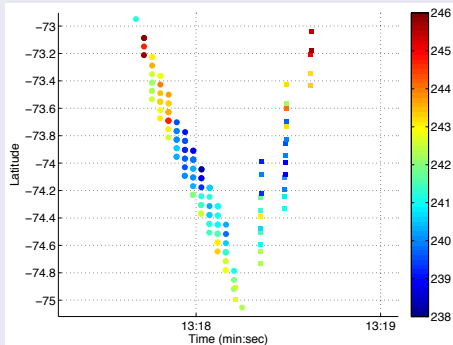
Approach: SNO's

SNO: Simultaneous Nadir Overpasses

SNO: This work

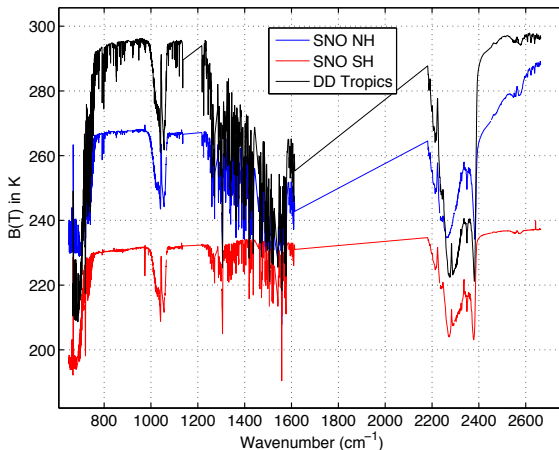
- SNO's created by NASA/JPL PEATE (preliminary product)
- Four months analyzed: (Jul/Dec 2008, Jun/Dec 2009)
- SNO details: $\Delta t = 10$ min, Δ distance = 20 km.
- Data averaged, no time series
- Dave Tobin will give SNO Details: Next Talk!

SNO Example



SNO vs DD Spectra

SNOs are at ± 73 degrees latitude. Our double-differences are in the tropics.

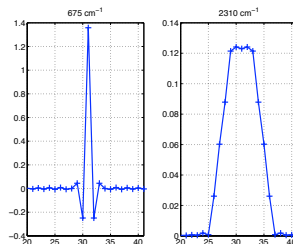
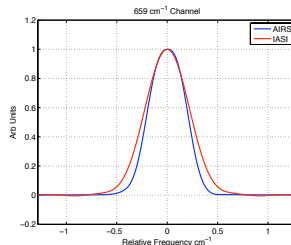


IASI vs AIRS Spectral Response

- Must try to handle different spectral responses of AIRS and IASI
- Longwave: AIRS slightly higher spectral resolution.
- Midwave, Shortwave: IASI significantly higher spectral resolution
- I am more interested in diagnostics of individual AIRS channels, so:
- Approach
 - 1 Frequency calibrate *each* instrument
 - 2 Shift IASI to AIRS channel center ν_i . (Hard to shift AIRS!)
 - 3 Transform IASI to AIRS SRFs (imperfect in Longwave)
- This approach partially resolves difficulty in interpolating AIRS since it is not quite Nyquist sampled.

Convert IASI SRF to AIRS

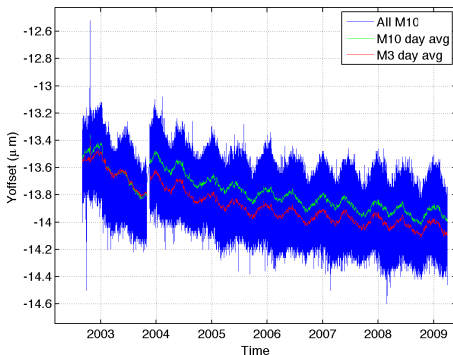
- Conversion operator = $\text{FFT}(\text{AIRS SRF}) / \text{FFT}(\text{IASI SRF})$
- Operator not defined past 2 cm OPD
- So, cannot produce AIRS from IASI in long-wave
- Applied in spectral space



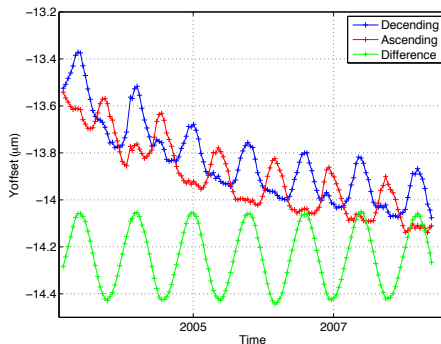
AIRS Spectral Calibration

Complicated, but is well characterized

ν per Granule



Tropical Latitude ν Calibration

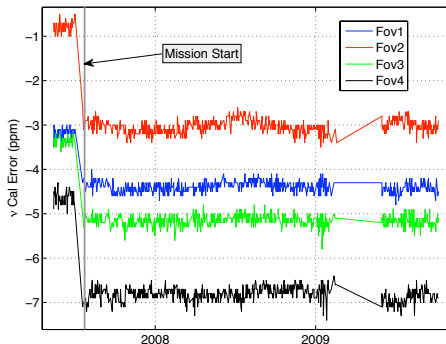


Maximum B(T) change during mission $\sim 0.2\text{K}$.
A Level 1C radiometric product is planned.

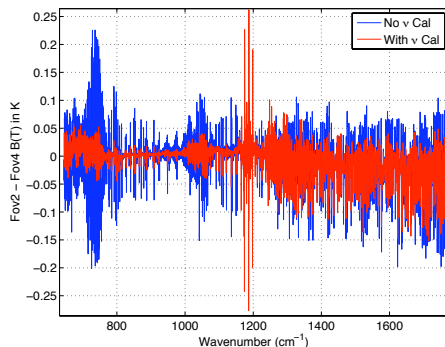
IASI Spectral Calibration

Use large statistical set of observations and compare FOV B(T)'s

ν Calibration vs Time



Calibrated vs Un-calibrated Radiances



Frequency calibration very stable.

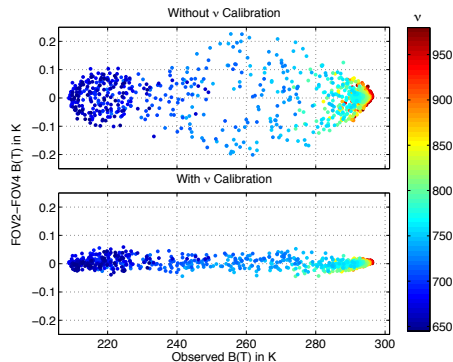
Calibration fix should be very simple. Easily done by the user if needed.

Spectra near band edges have a different frequency calibration.

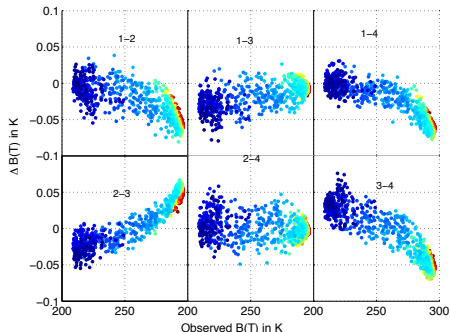
IASI Radiometric Calibration Among FOVs

Slightly off topic.

FOV2-FOV4 $\Delta B(T)$ vs $B(T)$



All Fov Intercomparisons

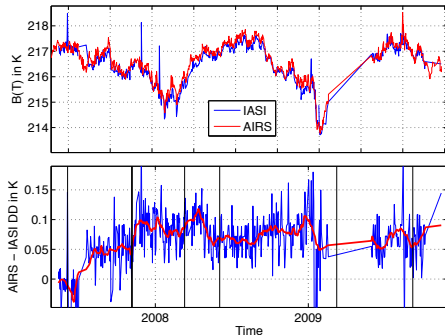


Slight radiometric differences among FOVs.

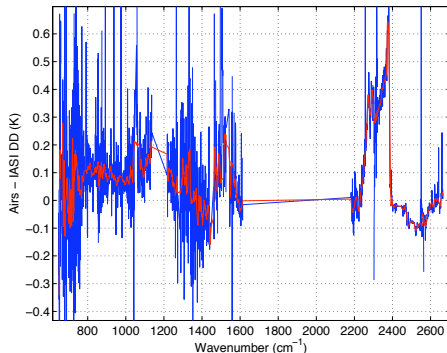
Some concern if lose one FOV and climate record mixes FOVs.

Double-Difference Results

$\nu=698 \text{ cm}^{-1}$ DD vs Time



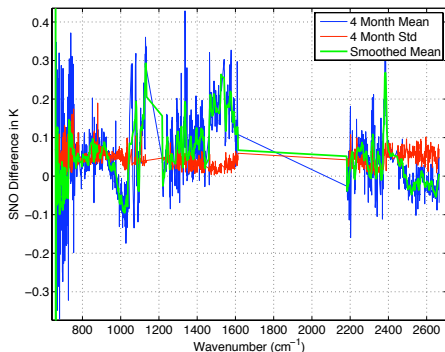
Average DD vs ν : Red is smoothed vs ν



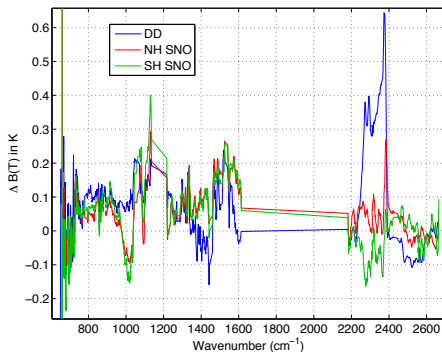
Double difference has slight dependence on ECMWF
Large DD errors in longwave partially due to methodology!
Significant differences on order 0.1 K with AIRS module imprint.

Double-Difference versus SNOs

SNO Results



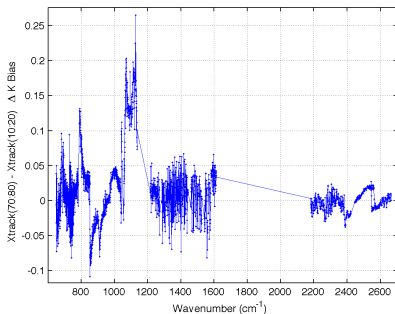
Smoothed SNO and DD



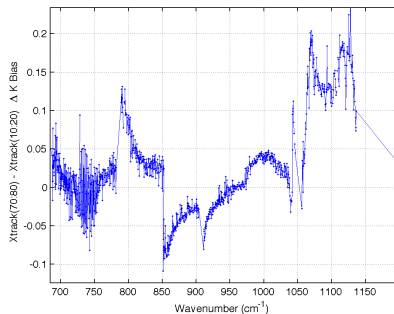
Longwave SNOs smaller than DD, DD spectra have more contrast
SNO and DD agree to $\sim 0.1\text{K}$ or better *except* near 1000 cm^{-1}
 1000 cm^{-1} disagreement may be AIRS scene dependent polarization

Could AIRS Polarization be an Issue?

Change in Bias vs Scan Angle



Zoom of Figure to Left



Asymmetry shown here is an average for ± 60 degrees latitude
Module boundaries easily seen. Expect ability to correct some of this.
Differences between SNO and DD may be increased polarization, but not a great match.

Conclusions

- AIRS and IASI agree extremely well, far beyond specifications.
- We clearly have close to climate-quality instruments, especially with regard to stability.
- Frequency calibration needs improvement for both instruments
- AIRS radiometric calibration needs to be made more consistent among modules.
- Longwave channel comparisons remains difficult. More work needed.
- Instrument calibration deserves more attention. Users are pushing the envelope, especially with CO₂ retrievals.
- AIRS recently went down, we will work to bring it back up with the spectral calibration unchanged.