Validation of IASI L1c Radiances using ECMWF Model Fields

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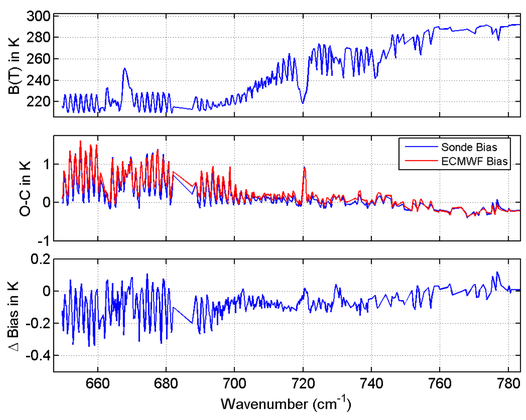
1 Introduction

- IASI and AIRS
  - IASI: Interferometric sounder on METOP, 8461 channels with spectral resolution of 0.5 cm^{-1} from 645-2760 cm^{-1}. 9:30 am/pm orbit. Regular data collection began in 2007.
  - AIRS: Grating spectrometer sounder on EOS-AQUA, 2378 channels with spectral resolution ~0.5-2.0 cm^{-1} from 650-2665 cm^{-1}. 1:30 am/pm orbit. AIRS operational for 5 years, intensively validated.
- Goals
  - Validate IASI for numeric weather prediction applications
  - Cross-validate IASI with AIRS for climate applications
  - Use AIRS + IASI to improve our radiative transfer codes (RTA's) for both instruments.
- Approach
  - AIRS Experience: ECMWF model fields as good as radiosondes for mid-latitude tropospheric temperatures
  - Subset IASI (and AIRS) to clear, ocean-only FOVs, compute radiances using RTAs *with identical spectroscopy*.
  - Convolve AIRS with IASI SRFs (Spectral Response Functions) and convolve IASI with AIRS SRFs. Near zero differences in the ECMWF biases using these two observations should cross-validate IASI with AIRS. AIRS validated to the ~0.1 - 0.2 level. RTA errors largely drop out.

2. AIRS: ECMWF and RS-90 Biases Very Similar

- ECMWF tropospheric $T(z)$ strongly pinned to radiosondes (even after major updates)
- Only consider CO_2 channels with little stratospheric component
- Validation using ECMWF can be done in months, not years.
- Highlights issues with minor gases (CO_2, HNO_3, CCl_4, etc.)

Graph Shows AIRS Biases for (1) Large set of RS90 sondes and (2) ECMWF (± 40 Deg Latitude)



Channels below ~700 cm^{-1} peak too high for ECMWF validation, but for 700-780 cm^{-1} sondes, ECMWF agree to ~0.1K

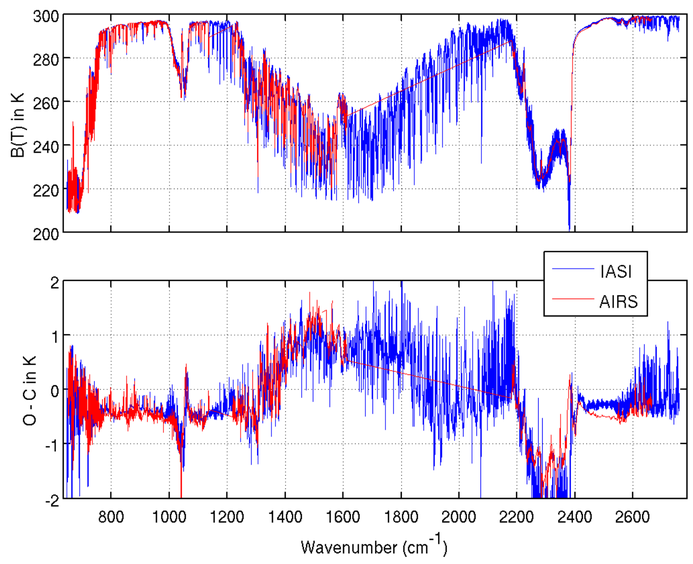
3. Subset IASI and AIRS Data for Clear/Ocean

- Accurate radiance calculations can only be done for clear scenes
- We receive all IASI data from NOAA/CLASS
- Our subset algorithm starts with a uniformity filter that looks at variability in the IASI IR imager, and the IASI 2x2 FOV spectral radiances. Only ocean scenes have been examined.
- This subset is subsequently filtered using "spectral" tests between channels that are sensitive to cloud contamination.
- We also force observed SST to agree to ECMWF SST to within 5K (stratus filter).
- Time Period: May 17 - June 24, 2007
- AIRS clear filter is similar, but only uses uniformity in the AIRS 3x3 FOV spectral radiances. Also, the nighttime AIRS "spectral" filter uses shortwave channels that are too noisy to use on IASI.

4. SST Comparisons (warm channels)

IASI and AIRS Biases (±20 Deg. Lat.)

Mean SST differences derived, including diurnal corrections

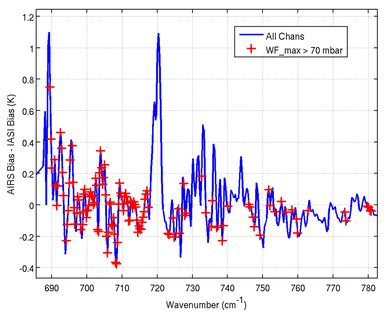


- Day: SST_{AIRS} - SST_{IASI} = 0.11K ± 0.1K
- Night: SST_{AIRS} - SST_{IASI} = 0.25K
- Day results gives agreement to 0.11K, while AIRS is 0.25K warmer at night.
- AIRS result uses shortwave channels for clear detection at night that are less sensitive to clouds due to Planck function, expect AIRS night (shortwave derived clear scenes) to be ~0.1K warmer.

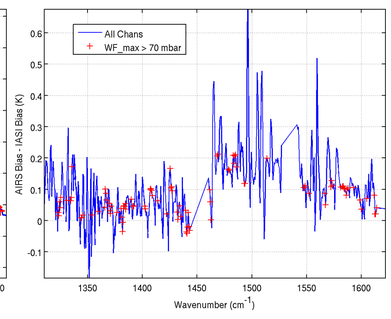
5. Mid-Tropospheric Comparisons (colder channels)

- Use clear subset, but fit for SST for each observation, and use these fitted values instead of the ECMWF SST. This reduces effect of incorrect SST (and cloud contamination) in the 765-755 cm^{-1} region.
- Convolve AIRS with IASI, IASI with AIRS SRFs
- Subtract Biases and examine CO_2 channels (1) peaking at altitudes below 70 mbar - where ECMWF is good, and (2) in-between lines where small spectral resolution differences are minimized.
- Main limitation: Are there any differences due to ECMWF for this 3-hour difference? We use the closest ECMWF forecast/analysis to either AIRS or IASI.

Mid-Trop CO_2 Channels



Mid-Trop H_2O Channels



CO_2, 690 - 755 cm^{-1}: AIRS-IASI Bias = -0.01K ± 0.15K

H_2O, 1300-1650 cm^{-1}: AIRS-IASI Bias = -0.07K ± 0.06K

H_2O, 1300-1450 cm^{-1}: AIRS-IASI Bias = -0.04K ± 0.04K

H_2O, 1450-1650 cm^{-1}: AIRS-IASI Bias = -0.11K ± 0.06K

The right-hand figure above suggests some small (~0.1K calibration differences between AIRS arrays).

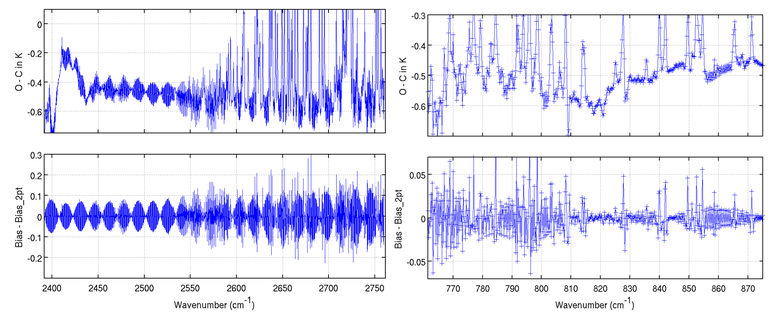
6. Spectral Calibration

We cross-correlate observed clear scene spectra with spectra computed from ECMWF. The frequency calibration is perturbed until the cross-correlation is maximized. Offsets shown below are ppm offsets relative to the reported IASI frequencies. Computed errors are *very small* (well within specification) A 3 ppm error translates to maximum errors of ±0.1K in Band 1. Std. Dev. are over latitudes.

Band	Mean (ppm)	Std.Dev. (ppm)
1	0.05	0.8
2	0.03	0.77
3	-0.11	0.53

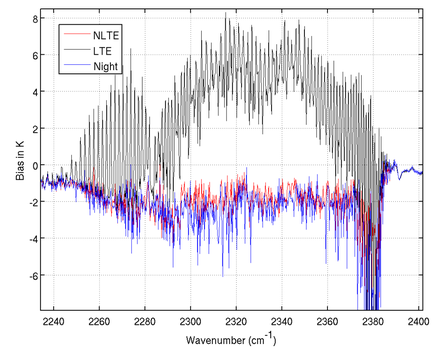
7. Fringing

- IASI radiances contain *minor* fringing, esp. in the shortwave
- May have some impact on climate applications
- As per suggestion of CNES IASI Team, average every other point to reduce fringing, good solution for climate applications?
- Graphs show IASI bias vs ECMWF in top panels. Bottom panels is (IASI bias) - (IASI bias with 2-point average, interpolated back to standard IASI frequencies.)



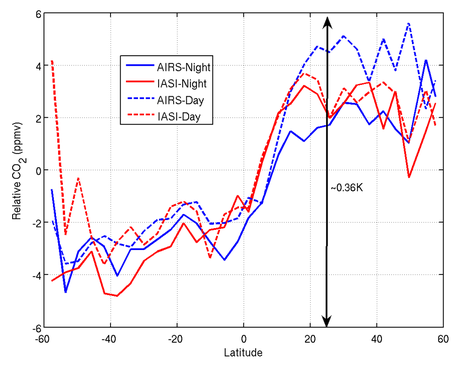
8. Non-LTE

- Daytime IASI radiances contain non-LTE emission in the shortwave
- Our AIRS non-LTE algorithm appears to work quite well with IASI
- Std. Dev. of biases similar for day, night



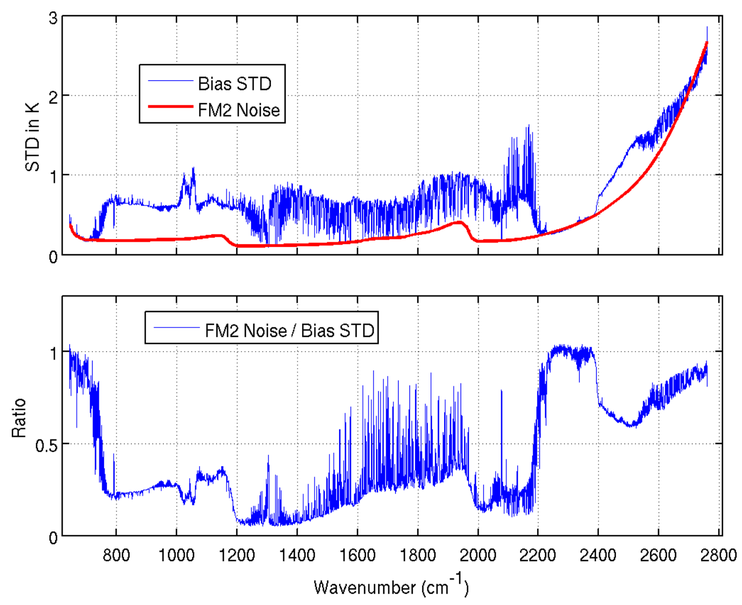
9. AIRS and IASI CO_2 vs Latitude

- Variation of 791.7 cm^{-1} channel bias with latitude gives mid-trop CO_2 estimate
- IASI and AIRS give similar results
- Results *preliminary*, limited quality control



10. IASI Noise Estimates

- IASI noise can be estimated from the ECMWF bias standard deviations, for temperature channels that are well characterized by ECMWF
- Window and H_2O channels have Std. Dev. dominated by model errors (SST, H_2O)
- Note close correspondence between stated IASI noise and ECMWF bias Std. Dev. in the longwave band



11. Conclusions

- IASI and AIRS radiances agree to the ~0.1K level.
- IASI radiances and frequencies appear to be very stable
- Validation to continue using cloud-cleared radiances that are used in NOAA/NESDIS added-value products (M. Goldberg, C. Barnet)