Inter-Calibration of AIRS with IASI and CrIS

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Organization

Better title: **Can we, should we, build a hyperspectral infrared radiance climate data record (Hy-CDR) from the operational IR sensors?**

- Review of sensors and associated science
- Sensor stability
- Self consistency (multiple detectors, scan angle, etc.)
- Intercalibration of hyperspectral sensors
- Sensor accuracy (not really addressed)
- Theme: do we have the tools, and the instrument performance to create a Hy-CDR?

Time to Start on Hyperspectral CDR

Hyperspectral IR Observing Systems

- Need ~ 15 years for climate
- AIRS now 10 years
- AIRS -> CrIS will give 20+ years
- IASI now 5+ years, will give 15+, IASI-NG coming 30+
- All agree to ~0.1-0.2K level on “Day 1”; a good start

A Hyperspectral Climate Radiance/Data Record: Hy-CDR

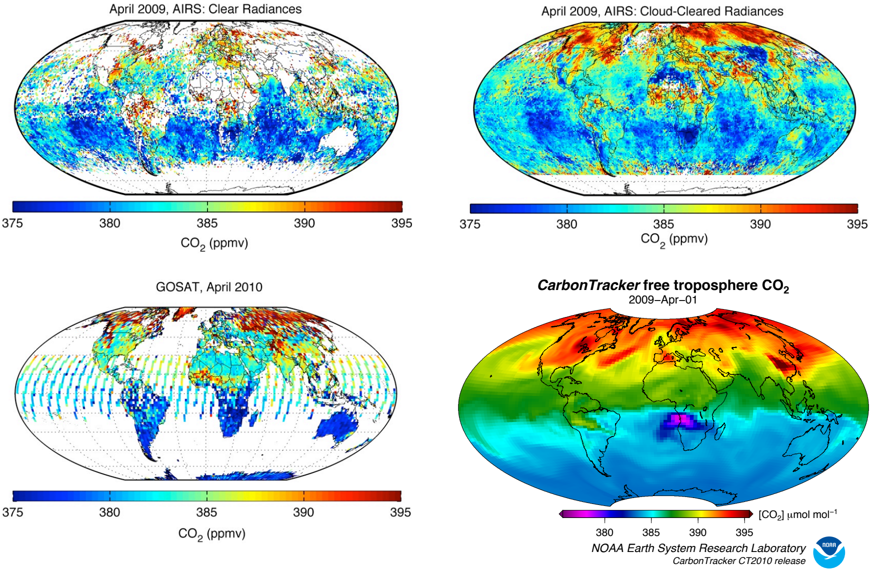
- CLARREO provides justification, with 0.1K 3-σ accuracy
- Operational data set richer than used for CLARREO justification
- This talk: Can we build a radiance CDR with AIRS+CrIS (A.M orbit) and IASI (P.M orbit)

Science Products

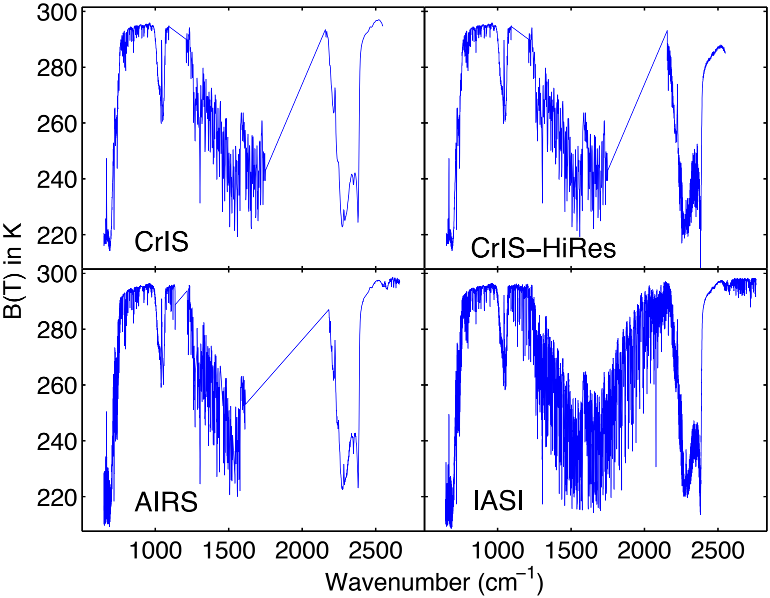
- CLARREO: climate feedbacks, model evaluation
- Spectral OLR
- Changes in cloud radiative properties and cloud types (cirrus, MBL cloud formation)
- Surface temperature and emissivity trends
- Changes in water vapor distribution (including HDO)
- Extreme events (like recent melting Greenland surface)
- Minor gas trends: O_3, CO, CH_4
- Mid-troposphere CO_2 and it's transport
- Volcanic eruptions (ash and SO_2)
- Nitrogen cycle via NH_3
- Dust climatologies and transport
- Atmospheric temperature (with other sensors: microwave, GPS, in-situ)

One Example: Spatial Distribution of CO_2

CO_2 Scale in B(T) Units: ±0.3K!



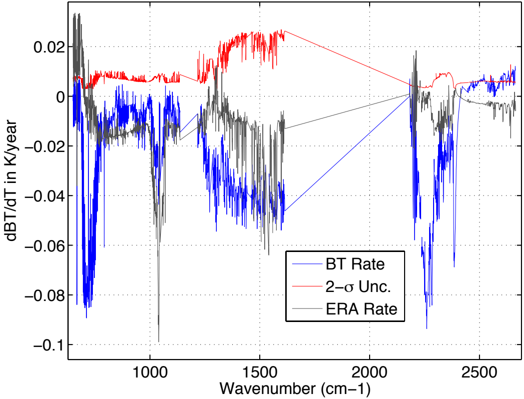
AIRS/IASI/CrIS Spectral Radiance Comparisons



Sensor Stability: AIRS

Comparisons to SST and CO_2 < 0.005K/yr stability

AIRS 9-Year Clear Scene B(T) Rates, Tropics



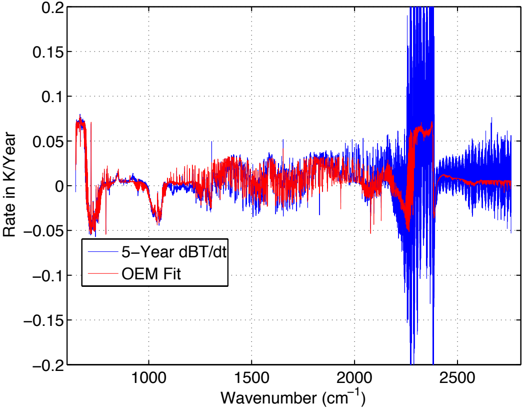
Slightly higher rates in shortwave. True? More scattering?

Temperature channels dominated by CO_2. Science payoff is H_2O, clouds, surface??

Sensor Stability: IASI

Comparisons to CO_2 imply < 0.005K/yr stability

IASI 5-Year Clear Scene B(T) Rates, Tropics



OEM Fit

IASI Fit CO_2 = 1.99 ppm/yr;
In-situ = 1.96 ppm/yr

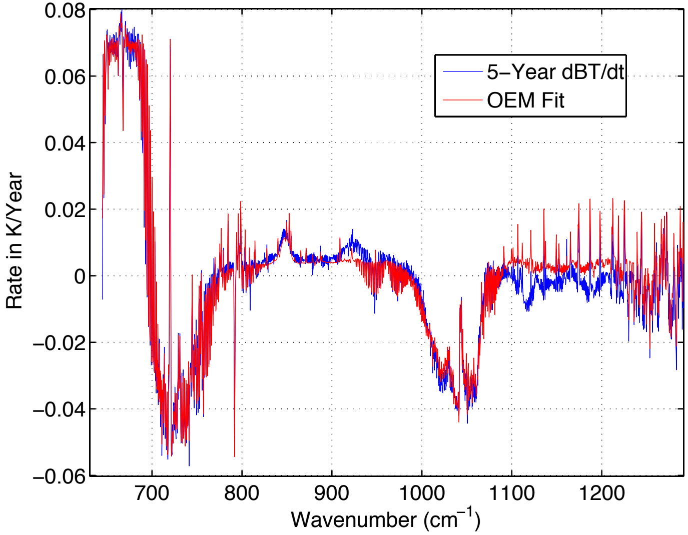
IASI Fit N_2O = 7.7 ppb/yr;
In-situ = 7.8 ppb/yr

IASI Fit CFC = -10 ppt/yr;
In-situ = -3 ppt/yr

IASI Fit SST: +0.006K/yr

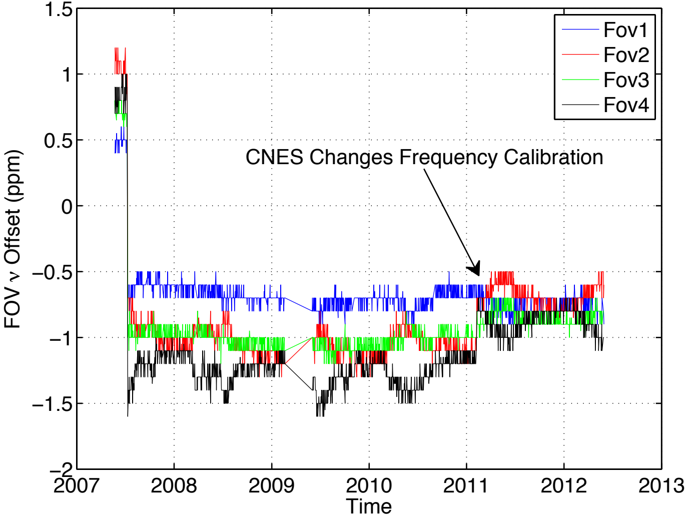
Shortwave ringing dominated by CNES “Day-2” algorithm changes.

IASI 5-Year Clear Rate: Zoom



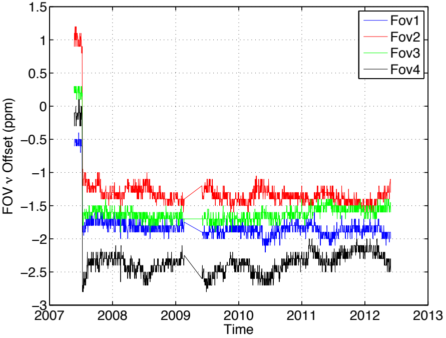
Missing a CFC, minor gases past 1100 cm^{-1}

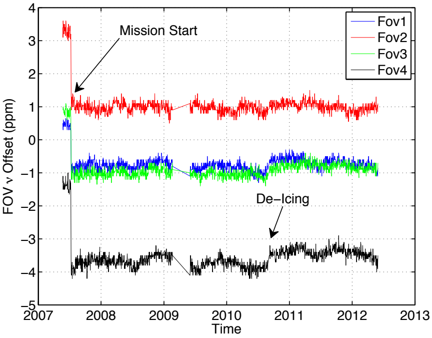
IASI: Spectral Calibration + Stability: SW



CNES made change when EUMETSAT complained about CO retrieval varying with FOV ID.

IASI: Spectral Calibration + Stability: LW, MW





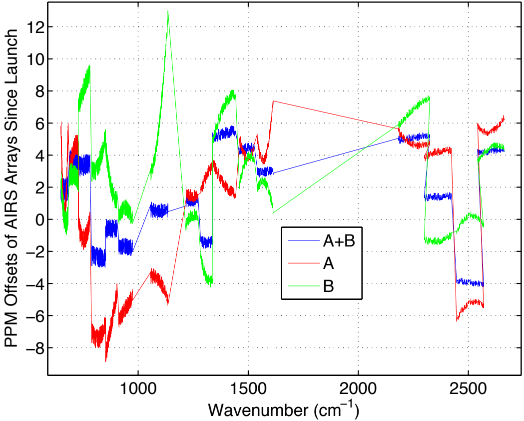
They forgot longwave and shortwave!

This causes up to ±0.2K errors between IASI FOVs

Longwave spectral calibration is robust using either CO_2 line or H_2O line (as we do for CrIS)

AIRS: Spectral Calibration Stability

AIRS has it's own problems: ±0.3K BT drift due to ν calibration (but fixable in L1c)

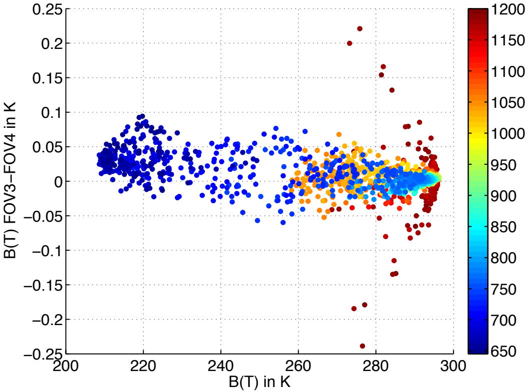


These are changes in AIRS spectral calibration from mission start to May 2012. Larger then IASI AIRS. Will fold into L1c.

Very complicated since "A/B" detector choices for some channels have changed over time.

AIRS/IASI/CrIS Internal Consistency: Here IASI

Need to fix internal inconsistencies before intercalibration.

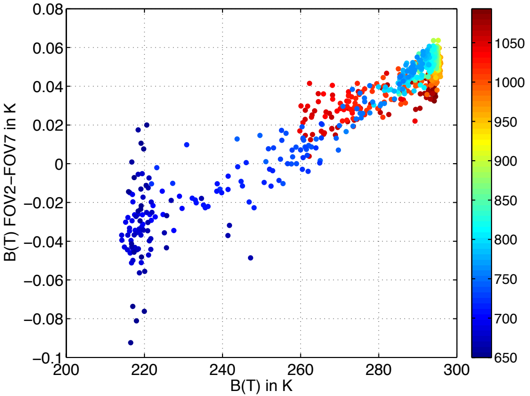


IASI FOV to FOV radiometry quite good. Data shown **frequency shifted by UMBC**.

Channels near 1200 cm^{-1} off due to CNES smoothing between bands with incorrect frequency calibration.

AIRS/IASI/CrIS Internal Consistency: Here CrIS LW

B(T) difference FOV2 vs FOV7. Note scale!!

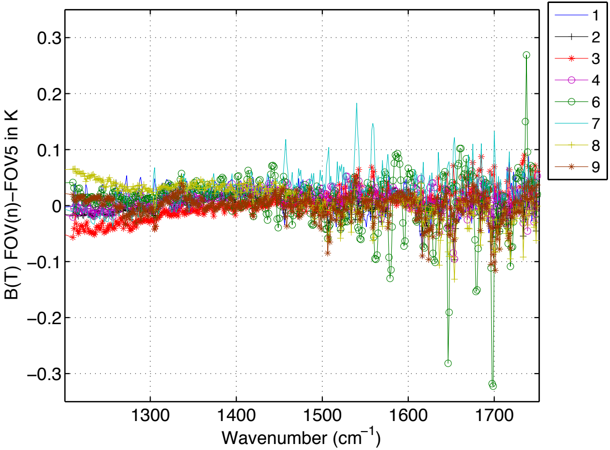


CrIS FOV to FOV radiometry also very good. But, we can improve it!

Cold channels are near end of band and need work.

AIRS/IASI/CrIS Internal Consistency: Here CrIS MW

B(T) difference FOV5 minus FOV(n).



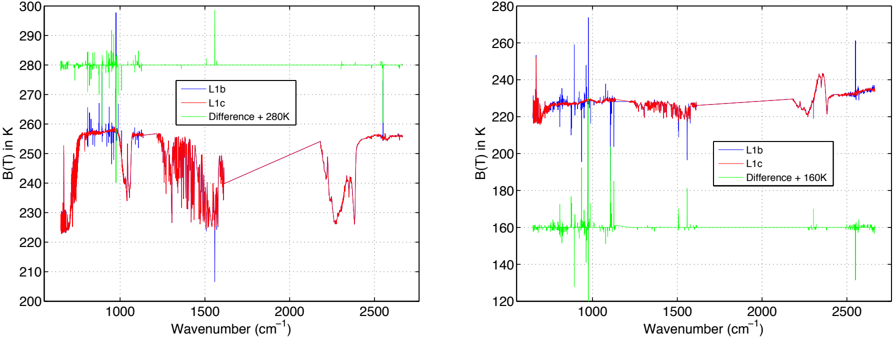
Uncertain issue with FOVs 6 and 7 versus FOV 5.

Small issues at band edge

AIRS/IASI/CrIS Internal Consistency: AIRS

AIRS channels “POP”, go bad.

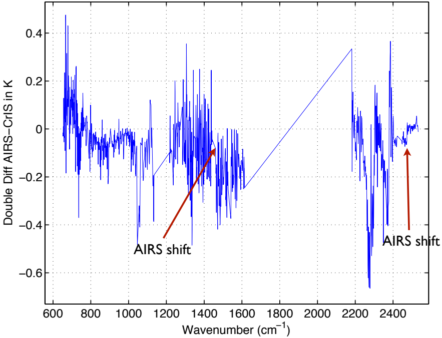
AIRS occasional “band channels” make the data painful to work with. JPL L1c algorithm (with UMBC frequency calibration) should make AIRS data easier to use.



L1c needed to convert AIRS to CrIS (or eventual Hy-CDR resolution) since AIRS channel interpolations are needed.

Preliminary: AIRS vs CrIS using Bias Double-Diffs

Difference of AIRS NWP Bias and CrIS NWP Bias for tropical clear scenes. (a) Using a *very* appoximate AIRS to CrIS ILS operator, (b) the AIRS radiances have *not* been frequency corrected, se.



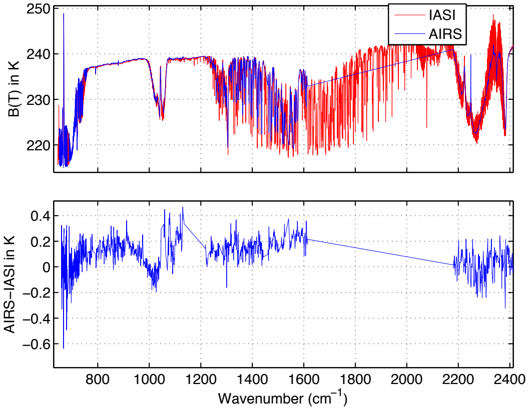
Arrows denote boundaries between two sets of AIRS detector arrays. These offsets relative to AIRS have been seen with IASI DD's and SNOs.

Excellent agreement in the window regions.

CrIS 9 FOVs ILS corrections agree to the 0.03-0.04K level (after in-orbit calibration).

AIRS and IASI SNOs (JPL Sounder PEATE)

Convert IASI to AIRS: Work in MW, SW

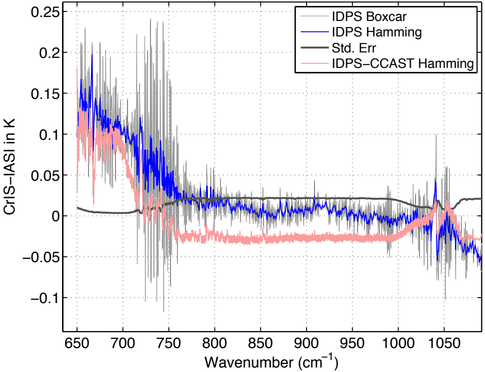


Operator to convert IASI to AIRS (SRFs) developed in Fourier space. Cannot be done perfectly for LW because AIRS has higher spectral resolution!

Working on AIRS to CrIS operator (should work). IASI to CrIS trivial.

CrIS and IASI SNOs: Data for May 2012 (LW)

Trivial to convert IASI to CrIS

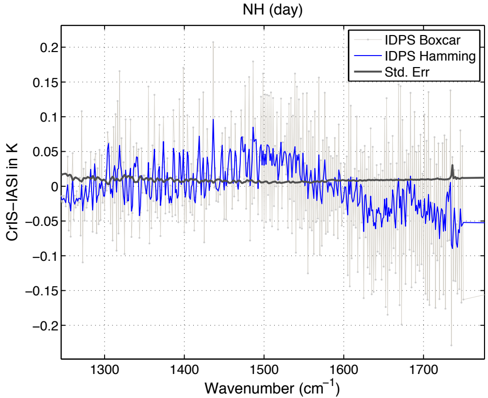


CrIS-IASI boxcar apodization has large ringing. Uncertain to cause, used all 4 IASI FOVs, all 9 CrIS FOVs for now.

Significant (for climate) offset in the longwave!

Red curve is CrIS from CCAST (UW/UMBC Matlab SDR testbed algorithm). CCAST much closer to IASI, but more work needed.

CrIS and IASI SNOs: Data for May 2012 (MW)



CrIS-IASI boxcar apodization again has ringing.

Very good agreement. Can we determine interconsistency below 0.05K?

Conclusions

- AIRS/IASI/CrIS in-orbit performance suggests a hyperspectral radiance climate data record may be possible
- Climate community cannot deal with too much complexity! May want a diurnal average.
- Need data providers to continue to improve raw L1b/c/SDR products.
- More work to assess accuracy
- This CDR requires in-orbit overlaps. Potential problems:
  - CrIS JPSS-1 (FM2) *might* not overlap with NPP.
  - IASI FM2 on METOP-2 will not have SNO's with IASI FM1!
- Semi regular aircraft underflights (S-HIS/NAST-I) may be critical if in-orbit instrument overlaps do not occur.