CrIS Calibration and Validation

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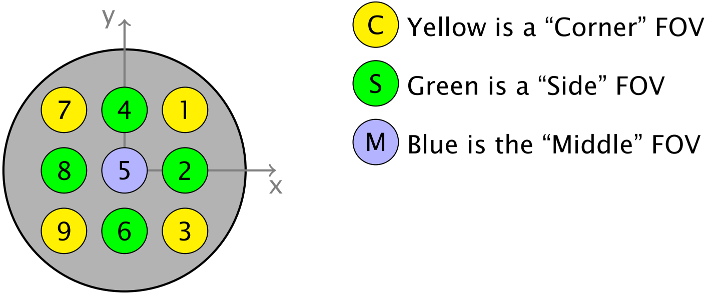
Thanks to ITT Excelis!

Overview

- Pre-launch spectral calibration
- Percent of observation “bad” (almost none)
- Neon calibration performance
- Post-launch spectral calibration
- Radiometric inter-consistency among FOVs
- SNOs, esp. versus scene temperature

Focal Plane Geometry: CrIS

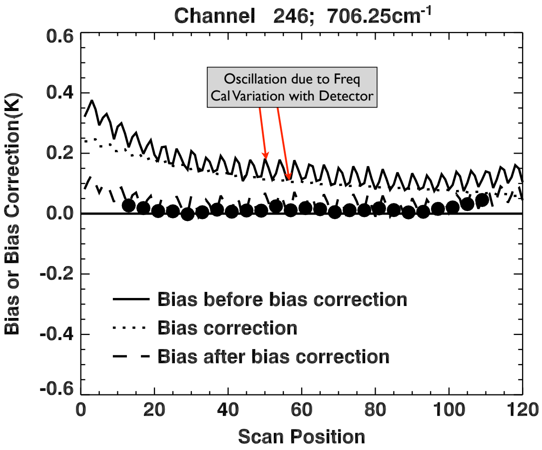


Off-axis FOV spectra are shifted by >500 ppm, etc. SDR algorithm adjusts these spectra back to effective on-axis measurements. At 1500 cm^{-1}, $\Delta\nu$ of 500 ppm = 6K in B(T).

Focal plane parameters will be written out using the above layout for FOVs.

Overview: ECMWF Bias Correction Stability

Plot from Collard and McNally, QJRMS 2009



- The curvature is some combination of RTA error and IASI radiometric and spectral error. The oscillation is differential spectral calibration among IASI FOVs.
- ECMWF decided to only use 1 detector our of 4 on each focal plane because of differential calibration.

NWP requirement for precision among FOVS is much lower (2 ppm?) than CrIS absolute spectral calibration requirement (10 ppm).

Basic Frequency Calibration Methodology

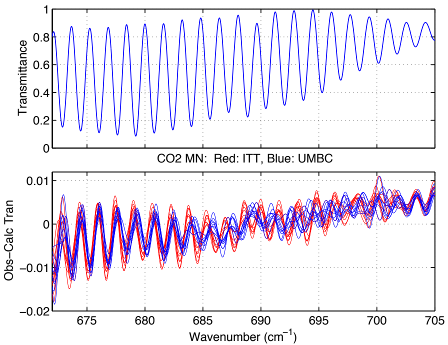
1. Record spectra (lab gas cell or upwelling radiances)
2. Frequency calibrate each of 9 FOVs

   Absolute: (a) Fit spectra to gas cell transmittance model, (b) Cross-correlate observed to computed up-welling spectra (clear)

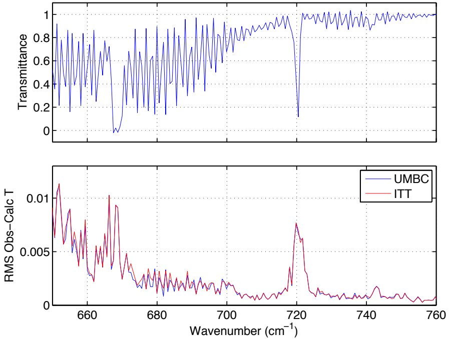
   Relative: Use uniform scenes (3x3) and determine frequency offsets relative to center FOV (#5).
3. Need absolute to get Neon calibration (maybe only FOV #5). Works best with in-orbit data in LW
4. But, relative calibration sufficient to find positions of each FOV relative to interferomter axis. Good performance in LW and MW.

Observed minus Computed TVAC Gas Spectra: LW

Absolute Comparison



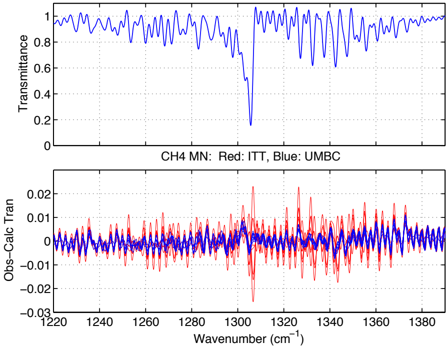
RMS of Obs-Calculated Spectra



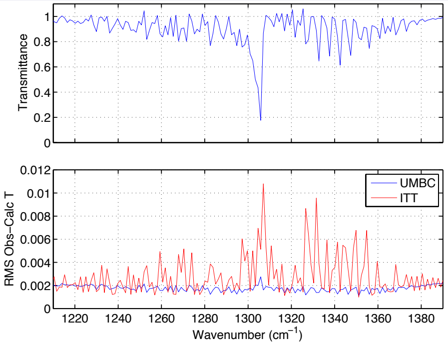
Differences are small, but noticeable. Good agreement partially validates each parties codes.

Observed minus Computed TVAC Gas Spectra: MW

Absolute Comparison



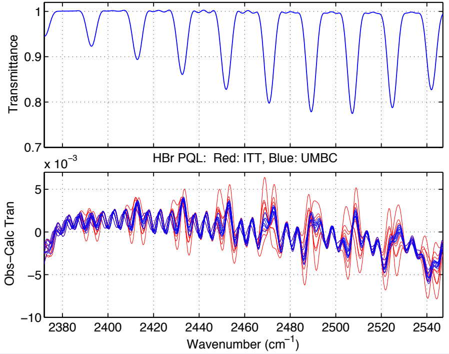
RMS of Obs-Calculated Spectra



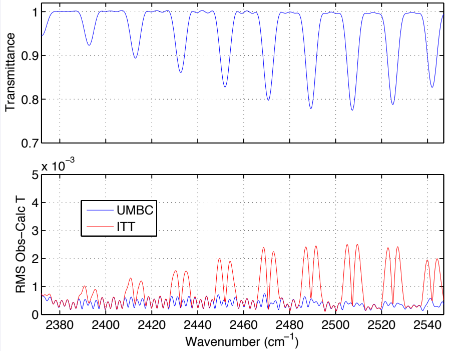
Differences are large. See later graph of differences in B(T) units.

Observed minus Computed TVAC Gas Spectra: SW

Absolute Comparison

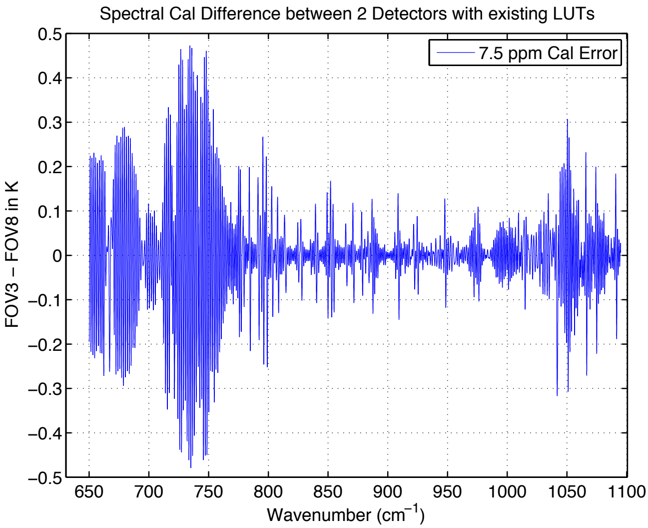


RMS of Obs-Calculated Spectra



Differences are relatively large

Band 1 B(T) Differences for a 7.5 ppm ν Cal Error



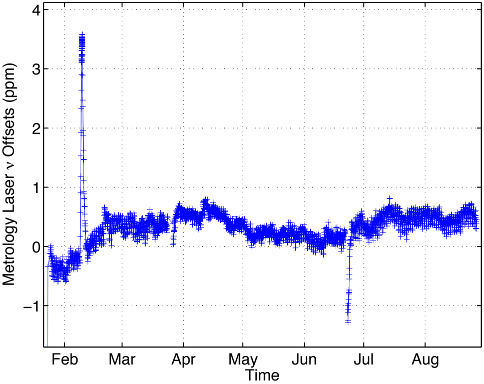
TVAC Summary

- Neon calibration, performed separately for each three bands, all agreed to better than 1 ppm!
- "Rigid" focal plane off by about 7 ppm
- Moved individual detectors to get to the 1 ppm or better range
- Results temperature dependent
- Shortwave band errors higher

In-Orbit Frequency Calibration Summary

- Absolute frequency calibration in-orbit with up-welling radiances showed that the Neon alignment was still good to <1 ppm!.
- The focal planes did move slightly (3 ppm max). Using relative calibration found that LW and MW focal planes shifted a little.
- In addition, the focal plane "contracted" a little, so each FOV needed slightly changed positions (max 4-5 ppm level).
- Maybe 0.8 ppm Neon shift from Feb. to June, at most!
- Frequency calibration is very stable
- AND, the metrology laser is also very stable (next slide)

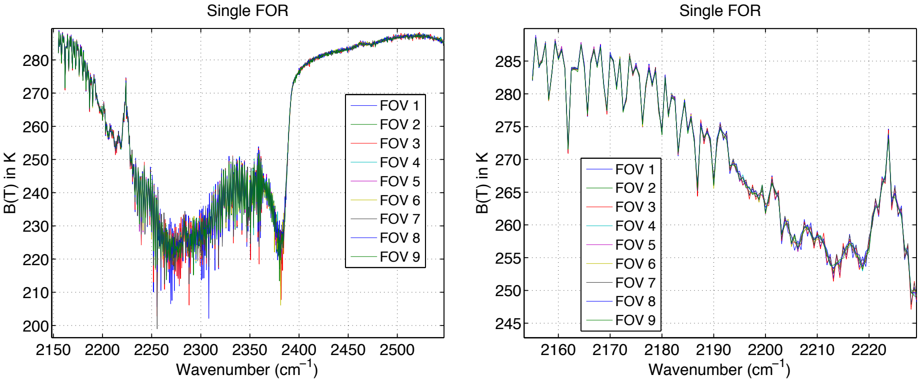
Neon Calibration of Metrology Laser



Neon measurement of metrology laser wavelength indicates 5+ month stability of better than 1 ppm! (Previous slide indicates Neon stable via analysis of up-welling spectra.)

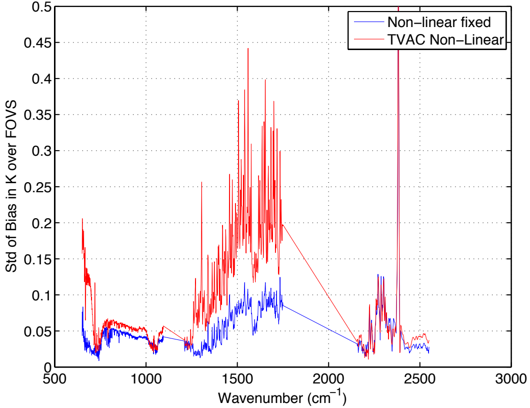
Spikes are due to know instrument testing, or spacecraft shutdowns.

Shortwave High Spectral Resolution SDRs



- CCAST (CrIS SDR Matlab testbed) modified to produce Hi-Res spectra using full radiometric model. Significant filter work to remove ringing.

Observed Variability of Radiances over CrIS 9 FOVs

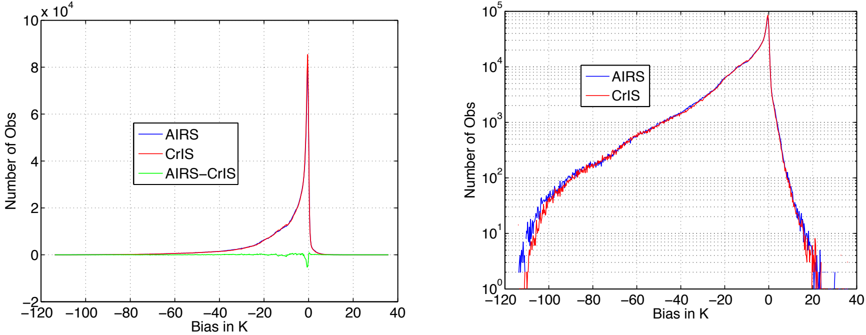


Clear ocean scenes. Compute B(T) bias vs NWP simulated radiance. Take STD over FOVs.

Dramatic decrease in STD after U.Wisc. determination of in-flight changes to non-linearity from TVAC values.

CrIS vs AIRS Counts: 1231 cm^{-1} Channel

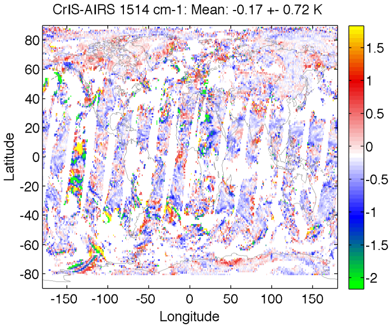
Compare “radiance” counts. Use bias from NWP, ocean, night to account for scene differences. Cold tails are cloudy scenes.

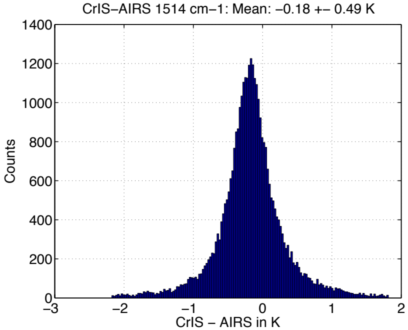


Agreement is spectacular, especially at the cold/hot ends.

CrIS vs AIRS Global: 1514 cm^{-1} Channel

Examine global map of bias differences. Use relatively deep water channel. Only include scenes where NWP bias of window channel (1231 cm^{-1}) = $\pm$4K max to avoid high clouds.



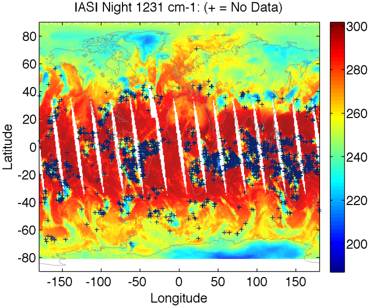


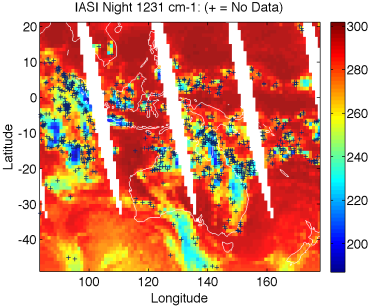
Histogram has outliers >3 STD removed.

Agreement is excellent, -0.17K $\pm$ 0.72K (1 σ).

CrIS vs IASI: Almost no “bad” CrIS Observations

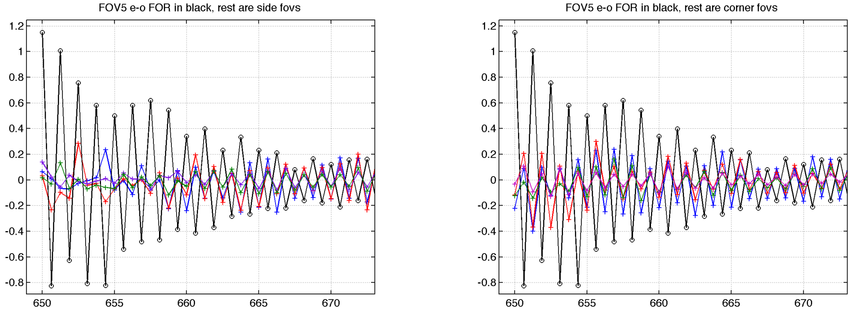
IASI has 0.2-0.3% of scenes flagged bad due to inability to find ZPD in-orbit. CrIS doesn’t lose fringes (1/4 wave plates in cal channels)!





This design feature of CrIS ensures that scene averaging for climate studies will not be aliased.

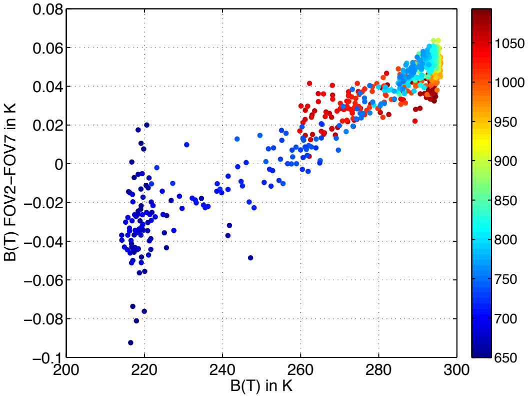
Scan Biases vs FOV



Differences in NWP *biases* with interferometer scan direction. Note that FOV 5 stands out.

CrIS Internal Consistency

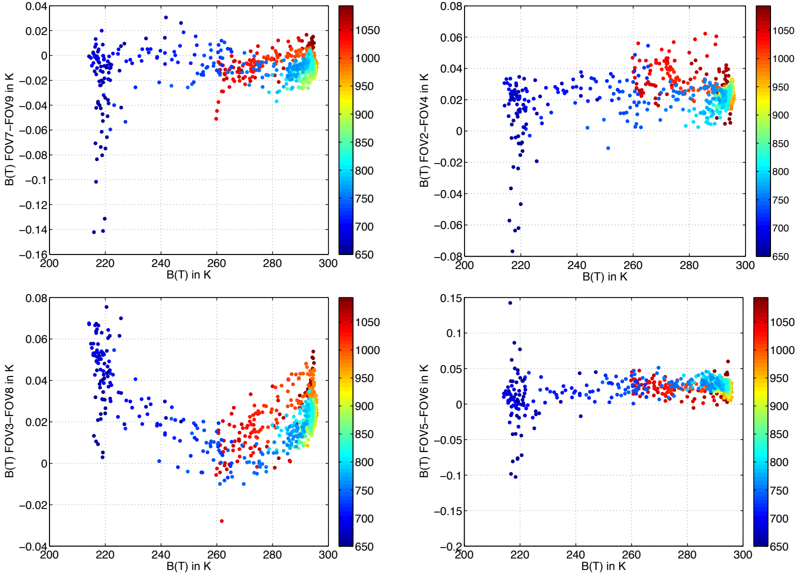
B(T) difference FOV2 vs FOV7. Note scale!!



CrIS FOV to FOV radiometry is very good, can be improved. Data from one month tropical ocean clear scene NWP bias data.

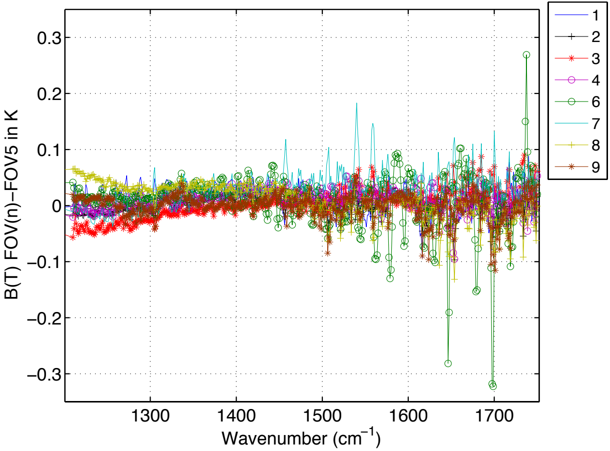
Cold channels are near end of band and need work.

Other CrIS FOV-dependent Differences



CrIS MW FOV Differences

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

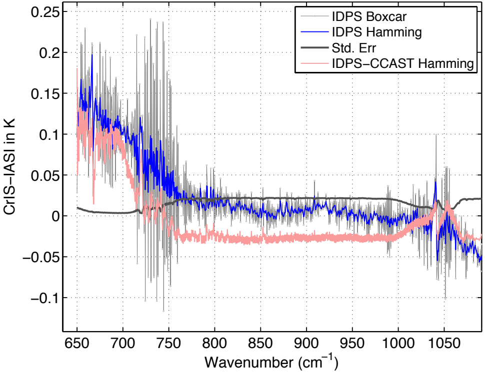


Uncertain issue with FOVs 6 and 7 versus FOV 5.

Small issues at band edge (seen in EDR residuals.)

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

From JPL Sounder PEATE: 10 min, 8 km windows

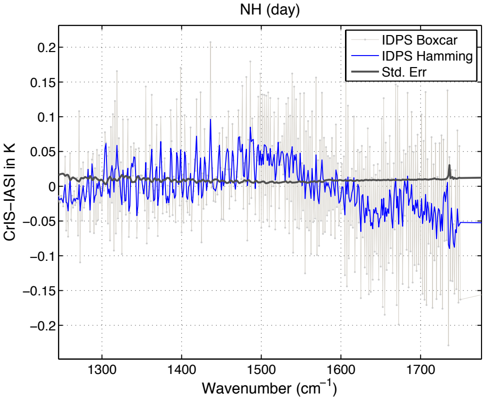


CrIS-IASI boxcar apodization has large ringing. Uncertain to cause, used all 4 IASI FOVs, all 9 CrIS FOVs for now.

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)

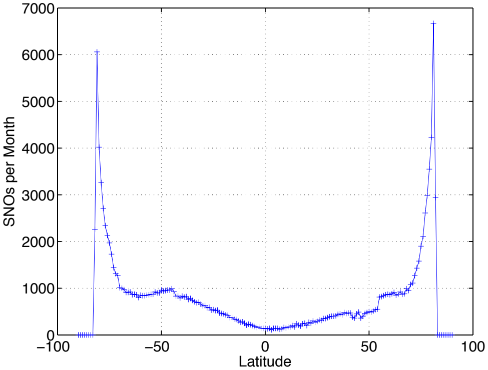


CrIS-IASI boxcar apodization again has ringing.

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

CrIS-AIRS SNOs Locations

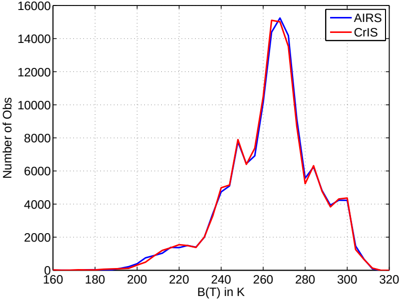
With 10-min,8 km window obtain full latitude range!

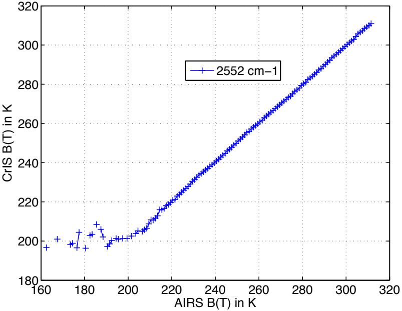


Unlike IASI-AIRS or IASI-CrIS, wide latitude range of SNO's.

This allows very detailed inter-comparisons as a function of scene type. Here we examine SNO differences with scene temperature for one channel in each band.

2552 cm^{-1} SNOs for AIRS, CrIS

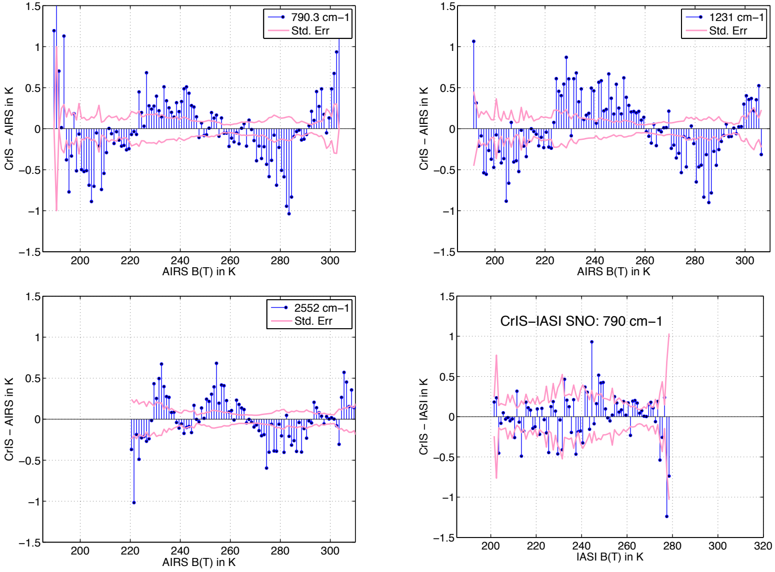




Good number of SNOs over a large range of B(T)'s

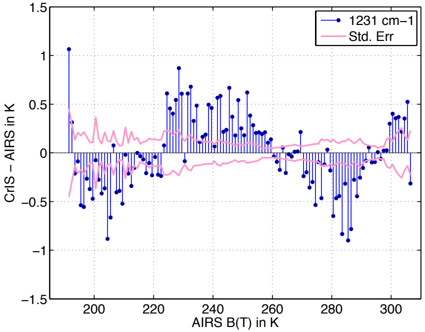
CrIS hits a B(T) floor around 200K.

2552, 1231, 790 cm^{-1} SNOs for AIRS, CrIS +IASI

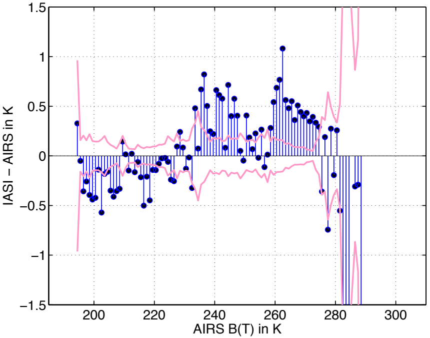


1231 cm^{-1} SNOs AIRS/IASI vs AIRS/CrIS

CrIS-AIRS SNO



IASI-AIRS SNO



Conclusions

- CrIS is working very well!
- Neon lamp stable: SDR algorithm using “at-launch” apodization correction operators.
- FOV-to-FOV spectral and radiometric differences are small
- Calval diagnostics show we can do better
- Interferometer scan direction biases need work
- Boxcar apodization “sinc” ringing varies too much with FOV
- Data provisionally ready for NWP use.