CrIS Early Orbit Checkout Review

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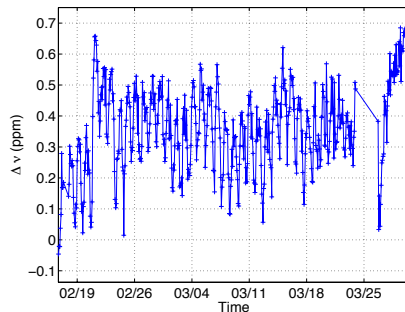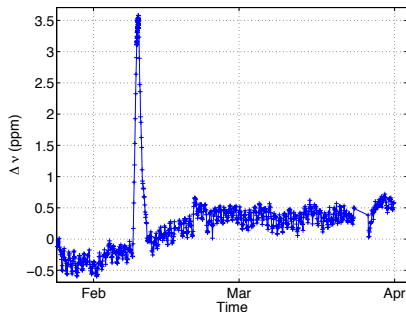
April 4, 2012

CrIS Task 6: Spectral Calibration: Introduction

- Relative spectral calibration among FOVs < 1 ppm
- Absolute longwave spectral calibration (Neon) < 1 ppm
- Neon and metrology laser both very stable < 1 ppm
- Liens
    - Midwave: absolute spectral calibration has 2 ppm variability. Suspect algorithm/code.
    - Shortwave: absolute spectral calibration not possible in normal mode. Work continuing using high-res data.

STATUS: Completed, but needs verification on IDPS output.
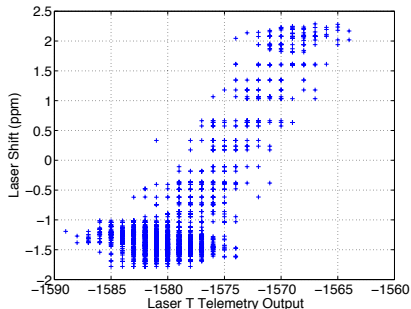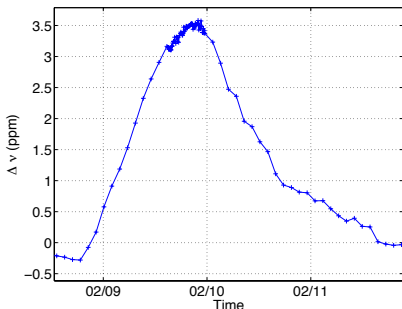
Neon Calibration Lamp Operation

- 2-month Neon/Metrology laser stability: 1 ppm (relative to each other)
- No evidence Neon is changing, but more work needed
- About 0.3 ppm daily cycling of metrology laser calibration. (Probably laser temperature.)

4-min Neon Firing Test

- Feb 9, Neon fired at 4-min interval for several hours
- Done after scan mirror fixed in place, so laser temperature varying, but stable enough.
- Absolute Neon calibration during 2.5 hours of 4-min firings was stable to 0.46 ppm (std). Offset due to laser temperature swings tracked by Neon to 0.7 ppm (limited by analysis using longwave upwelling).

The changing metrology laser temperature/wavelength during this test allowed an in-orbit measurement of the laser wavelength shift with laser temperature.

Frequency Calibration Overview

Methodology

- Measure ppm frequency offsets for each of nine FOVS using upwelling spectra compared to simulated spectra.
- Convert ppm offsets to radial movements of the detectors on each focal plane, and to absolute Neon calibration
- Verify with re-processed SDRs.

Final PPM Errors (LW)

0.08	-0.04	0.01
0.06	-0.61	-0.51
-0.76	-0.98	-0.39

Actual Approach

- Relative frequency calibration (but no Neon) using difference of FOV 5 upwelling to other FOVS (Tobin approach) more accuate for *all* bands.
- But, longwave absolute approach (using simulated spectra) agreed with Tobin approach to -0.12 ppm +- 0.46 ppm!
- This gives confidence in our absolute calibration of Neon using longwave (unchanged from TVAC!)
- Before ν-calibration errors were as large as 7 ppm.

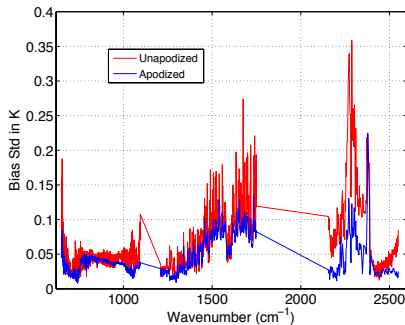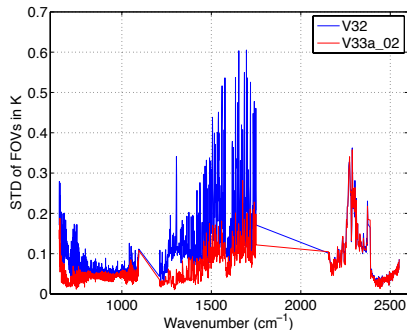## Frequency Calibration Details

- Relative ν calibration gave same x,y offset for both longwave and midwave focal planes. Similar for shortwave. These offsets used to move all detector positions for ENGR packet V33.

- Absolute calibration of midwave varies by about 2.5 ppm with FOV. Needs work. FOV 5 offset = -0.97 ppm. However, in TVAC showed Neon calibration using longwave is correct for midwave and shortwave.

- Summary: (1) Small launch related focal plane shifts, and (2) Scene "contracted" a little, implying small shift of telescope focal length (Excelis states within specification.)

- Improvements with new ENGR V33 ILS parameters on observed spectra are shown in next section, combined with improvements due to updated non-linear coefficients by UW.

CrIS Task 15: CrIS Residual Analysis

- Concentrate on Feb. 25, ADL output (from UW), AIRS, IASI
- Two data sets (both with NWP clear-scene radiances from UMBC SARTA RTA)
    - Clear, ocean scenes
    - All scenes
- Performance issues studied:
    - Improvements of ENGR 33 vs ENGR 32
    - Scan direction biases
    - Clear tropical ocean NWP biases, and vs AIRS/IASI
    - Cloudy scene comparisons vs AIRS

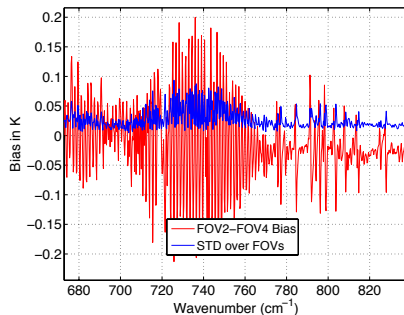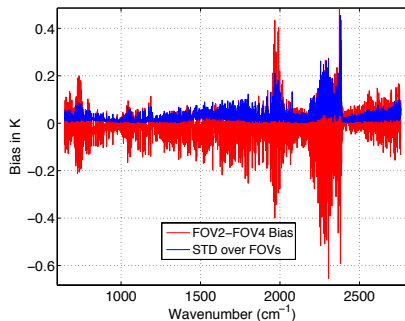STATUS: On-track, awaiting IDPS, V33 ENGR, new on-board filters.

Improvement in NWP-Bias STD over 9-FOVs

This shows that the variability in radiometric and spectral calibration among the nine FOVS is close to NWP nominal requirements of < 0.1K. Higher values in the water band are likely NWP co-location errors.
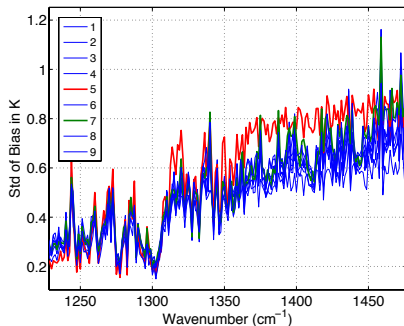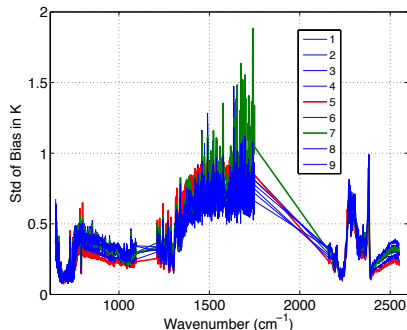
IASI NWP-Bias STD over 4-FOVs

Data from Feb. 25, 2012

Two IASI FOVs (2,4) are quite different due to spectral calibration errors producing errors of ± 0.15K. Essentially stopped ECMWF and other centers from using all IASI FOVs.

CrIS NWP Biases: Standard Deviations

Tropical ocean bias standard deviations are well within expectations. FOV 7 in midwave larger due to detector noise. Minor issue: FOV 5 higher STD in water band than other detectors.

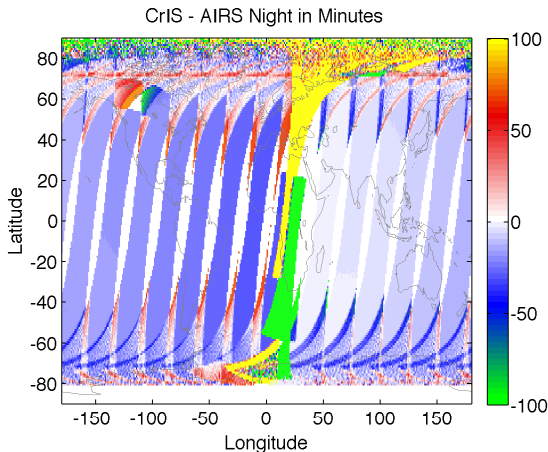# CrIS Task 4: Bit Trim and Impulse Mask Checks
CrIS Task 17: SNO Cross Calib. with AIRS and IASI

Task 4: Mostly done by SDL. Histogram counts of B(T) observations shown here support this task.
STATUS: On-track.

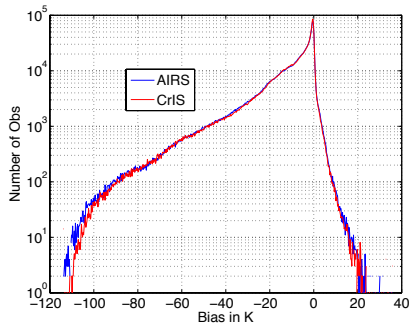Task 17: SNO work just starting, requires AIRS to CrIS ILS conversion.
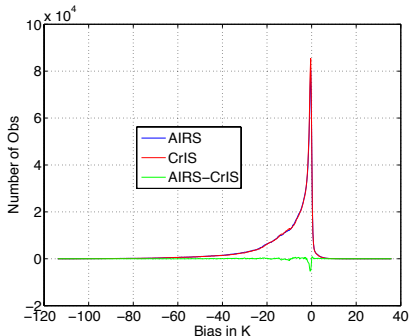STATUS: On-track.

CrIS Dynamic Range: Clear+Cloudy Scenes

- Compare CrIS to AIRS statistically w/o SNOs (see below)
- Check high/low radiance counts (relative to AIRS)
- Check "many global" scenes for CrIS vs AIRS using high-water channel

CrIS - AIRS Night in Minutes

CrIS vs AIRS Counts

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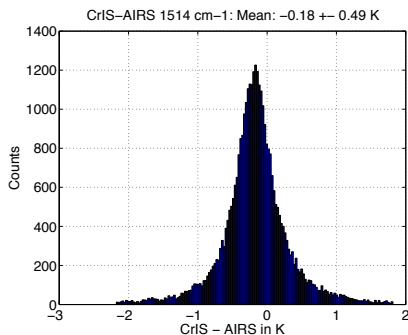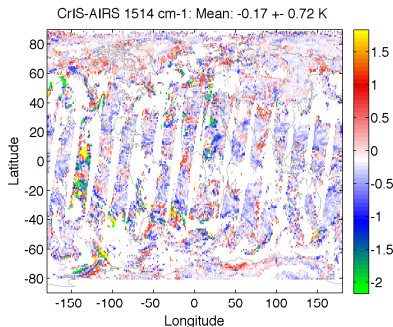

Agreement is spectacular, especially at the cold/hot ends.

Between -80K and +10K almost all AIRS and CrIS counts agree to within ±8%. During daytime we find CrIS sees "hotter" glint radiances than AIRS, which is good.

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.
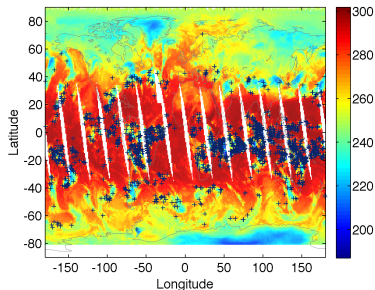

CrIS-AIRS 1514 cm-1: Mean: -0.17 +- 0.72 K

CrIS−AIRS 1514 cm−1: Mean: −0.18 +− 0.49 K

Histogram has outliers >3 STD removed.

Agreement is excellent, -0.17K $\pm$ 0.72K (1 σ). Statistical uncertainty of mean *much* smaller if Gaussian errors (by x200).
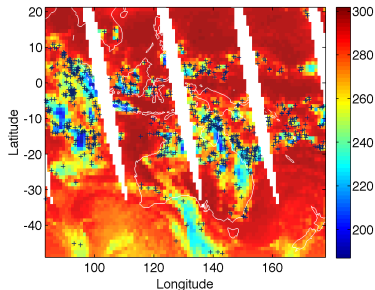
CrIS vs IASI: CrIS Means Unbiased!

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)!
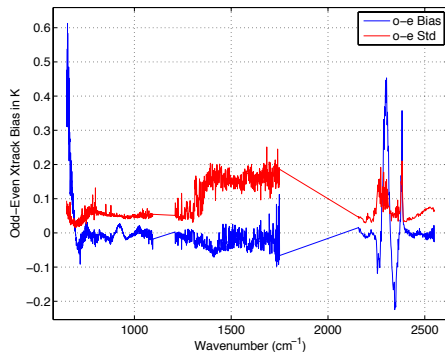

CrIS may lose some data *if* fringe count errors cannot be corrected. However, fringe count errors near zero and they can often be corrected if they exist. Note in zoom that IASI errors are "near" colder scenes.
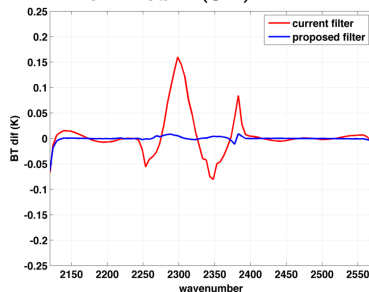
This design feature of CrIS ensures that scene averaging for climate studies will not be aliased.

Interferometer Scan Direction Striping Errors

This issue covered by others. Here we show the magnitude of this problem via NWP bias errors, plotting (bias odd FORS) minus (bias even FORS) averaged over +-50 deg. latitude ocean, clear scenes.
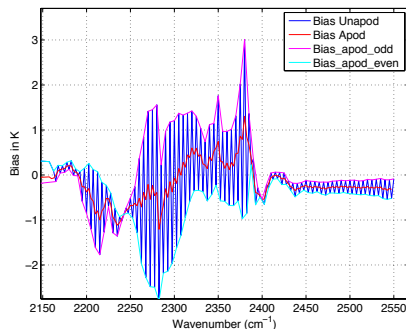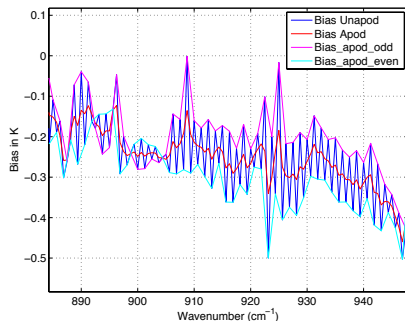

From Tobin (UW)

This approach will provide a good diagnostic of the new pre-decimation filter.

CrIS Excessive Sinc Ringing

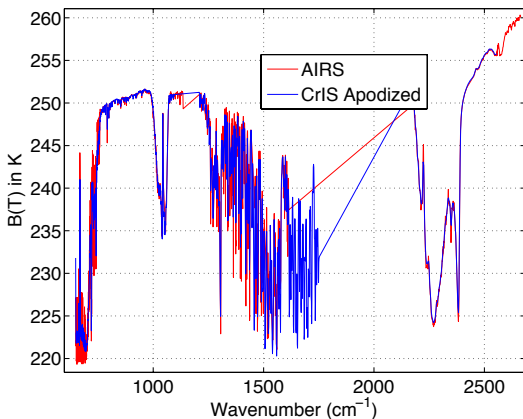(Note: bottom 2 legends should say "Bias_unapod*", not "Bias_apod*".)

Conversion of Hamming apodized SARTA forward model to unapodized is robust. Here we show the CrIS exhibits excessive ringing in both the longwave (0.1K extra) and in the shortwave (up to 3K extra).

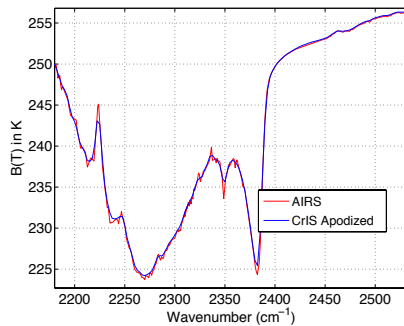Since most users apodize the radiances, this is not a large issue (Bill Smith likes unapodized??)
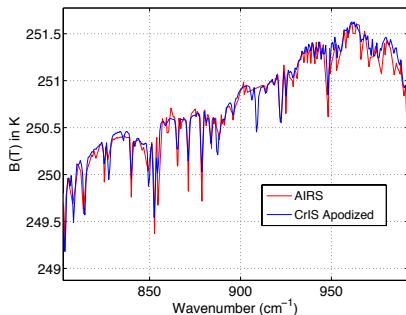
CrIS-AIRS SNOs

First look at CrIS-AIRS SNOs produced by the NASA Atmospheres PEATE, for Feb 25. No filtering done, max 10-minute time difference, ± 1-deg spatial. No conversion of AIRS to CrIS SRFs yet.

Agreement looks very good, especially in windows where SRF/ILS is unimportant.
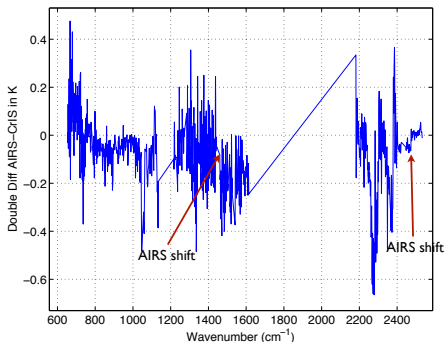
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SNO's: Zoom

Agreement appears to be in the 0.1K or better range. STD and better statistics awaits conversion of AIRS to CrIS SRF/ILS.

CrIS Task 16: CrIS Double-difference Cross Comparisons with AIRS and IASI

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.
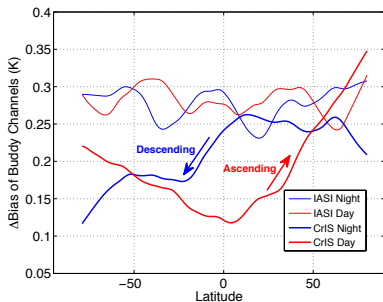

Arrows denote boundaries between two sets of AIRS detector arrays. These offsets relative to AIRS have been seen with IASI DD's and SNOs.

Excellent agreement in the window regions.

STATUS: On-track.

CrIS Task 9: ICT External Environmental Radiance Model Assessment and Tuning (Preliminary)

Lien: Latitude poor proxy for orbit phase

Need ADL run w/o thermal model

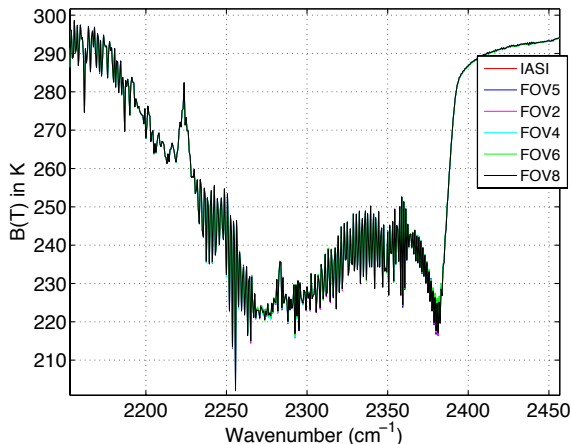STATUS: On-track.

Scan Baffle Issue

- CrIS ICT emissivity relatively low past 1700 cm^{-1}
- Makes radiometric calibration more sensitive to scan baffle temperature, which varies over the orbit.
- Thermal model used to correct radiances for scan baffle emission.

Approach to Evaluate Scan Baffle Model

- Choose two nearly identical channels: ch1=1513.75 and ch2=1745.00 cm^{-1}.
- 1513.75/1745.00 cm^{-1} channels insensitive/sensitive to scan baffle
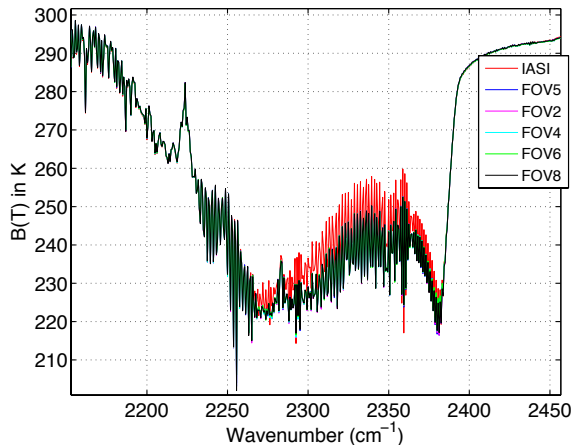- Plot (NWP Bias Ch1 - NWP Bias Ch2) versus latitude (proxy for orbit phase).

Hi-Res SW Apodization Corrections

- SA matrix condition number: 10 (normal), 65 (hi-res sides), 5×10^5 (hi-res corners)
- More filtering needed for application of SA^{-1}. (SDR done with CCAST; UW/UMBC SDR Testbed Code)
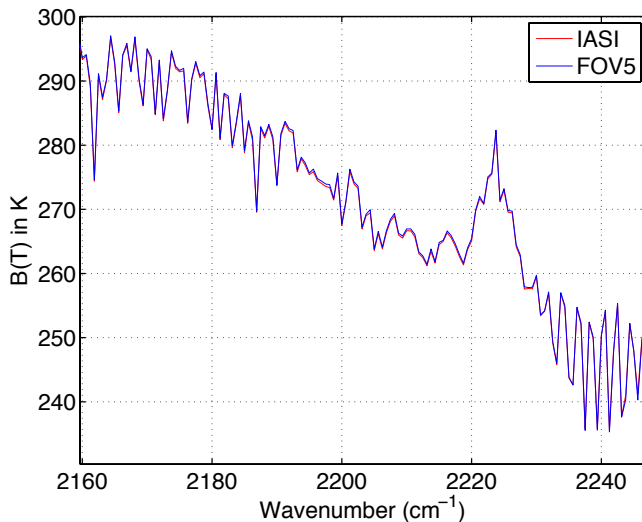
Hi-Res SW Comparison to IASI

- Picked tropical ocean granule, mostly clear. Removed cloud scenes.
- Converted IASI to CrIS hi-resolution boxcar ILS.

CrIS too cold for low radiance channels. Our radiometric cal *very* basic. Single ICT emissivity, no scan baffle corrections, etc.
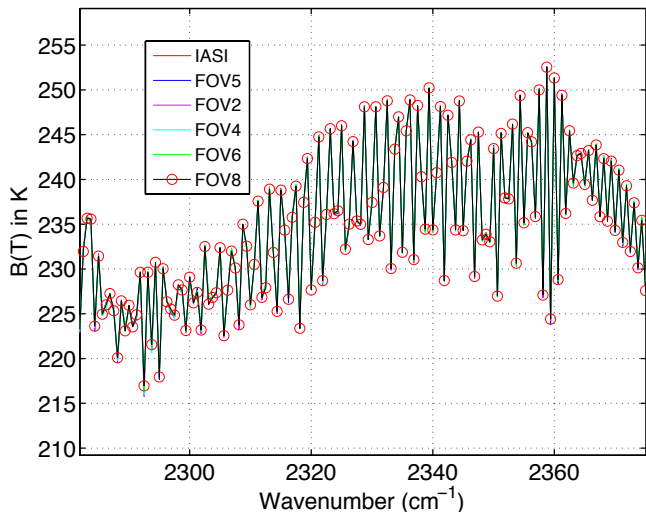
Comparison to IASI: Zoom

In many spectral regions agreement is excellent.

Comparison to IASI: Zoom

Center of band shows spectral structure (not just ringing) needed for absolute frequency calibration.

Hi-Res Summary

- High resolution data looks very good.
- More work needed in CCAST to fully calibrate high resolution data
- May need another high-resolution data collection using updated on-board digital filter!