Inter-comparison of Hyperspectral Sounders Towards Establishing Hyperspectral Benchmark Radiance Measurements

Likun Wang[1*], Yong Han[2], Yong Chen[1], Denis Tremblay[3], Xin Jin[4]

1. CICS/ESSIC/University of Maryland, College Park, MD
2. NOAA/NESDIS/STAR, College Park, MD
3. Science Data Processing, Inc, Laurel, MD
4. Earth Resources Technology, Inc., Laurel, MD

*Email: wlikun@umd.edu

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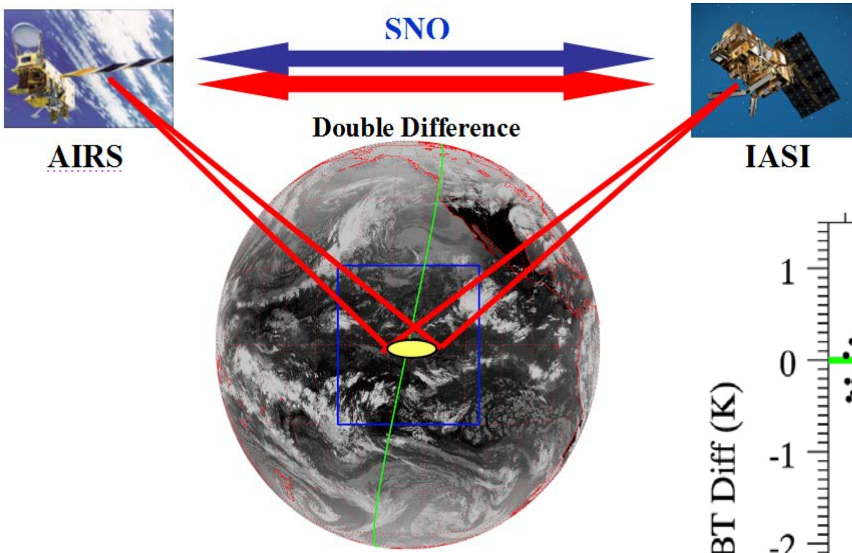
Outline

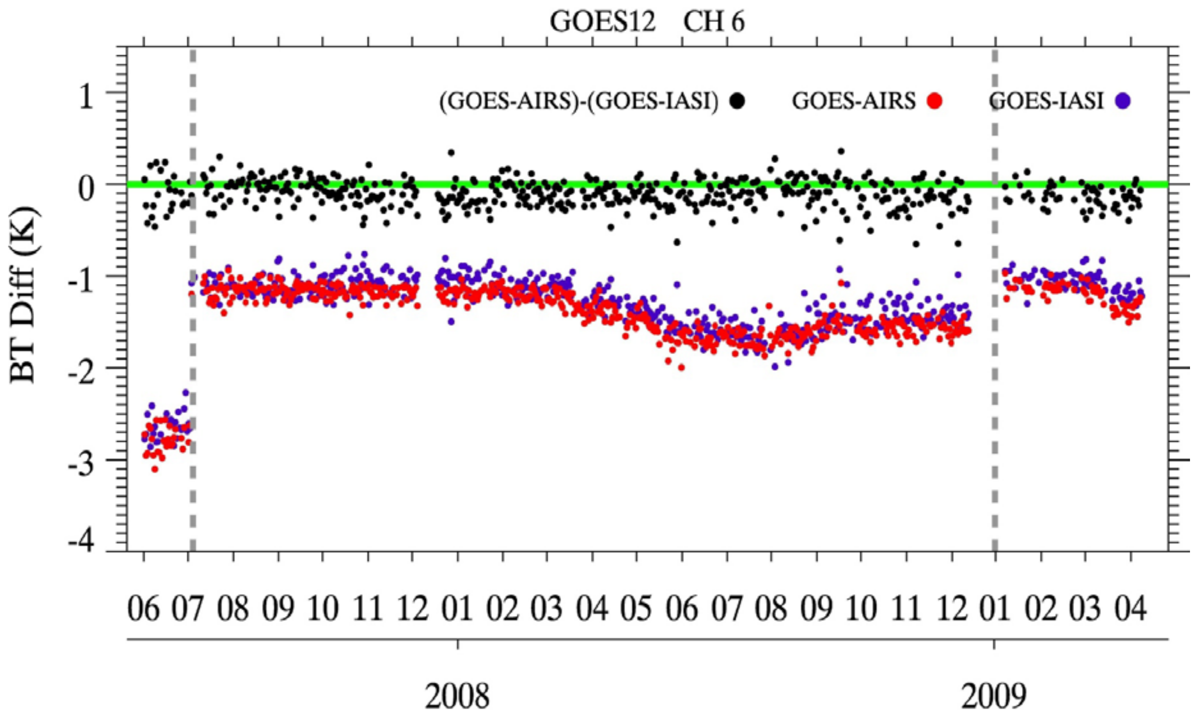
- Motivation
- Methodology
- Results
- Conclusion

Radiances Consistency of CrIS, IASI, and AIRS



Each Agency routinely uses AIRS/IASI to assess calibration accuracy of its own geostationary instruments

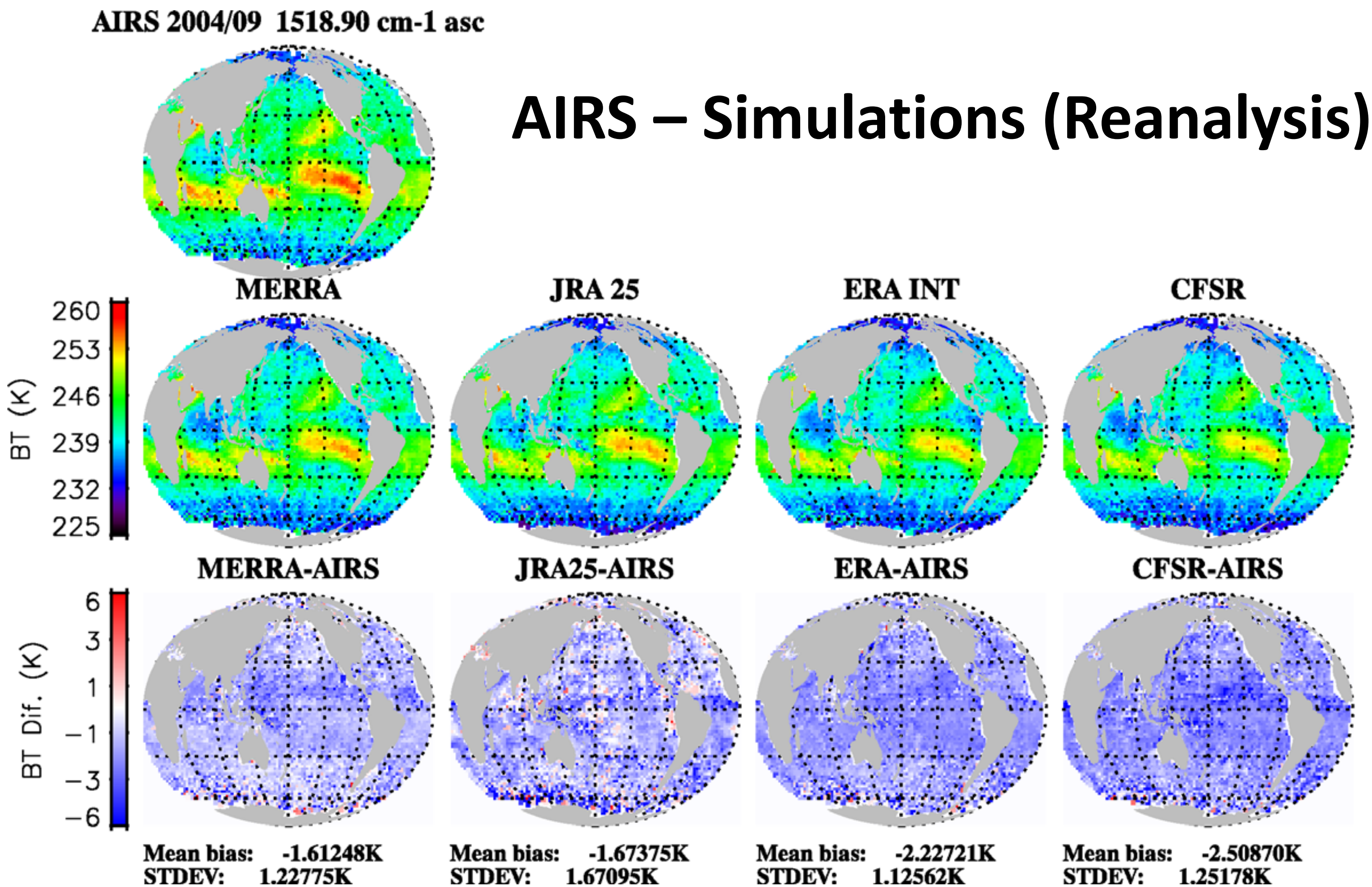
GSICS Framework:
Independent Calibration Assessment



Spectral and radiometric consistency among CrIS, AIRS and IASI is significant for GSICS community.

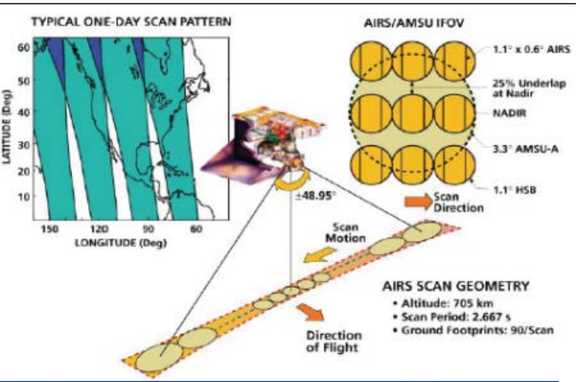
Model Verification

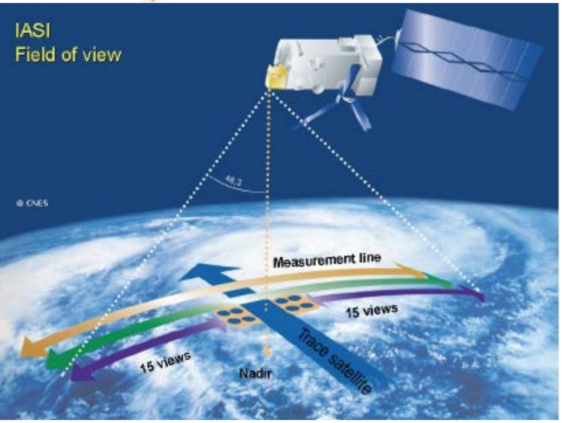
AIRS – Simulations (Reanalysis)

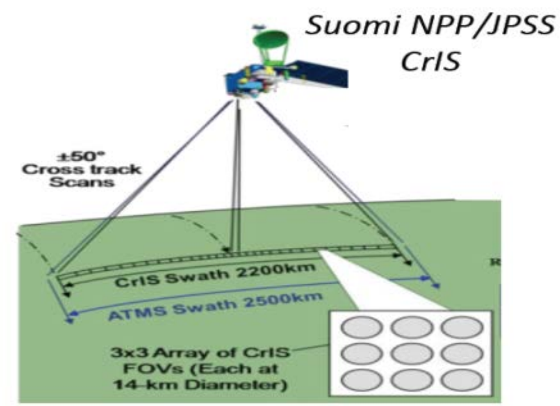


Hyperspectral radiance measurements can serve as a benchmark for model assessment, but the consistency is the key.

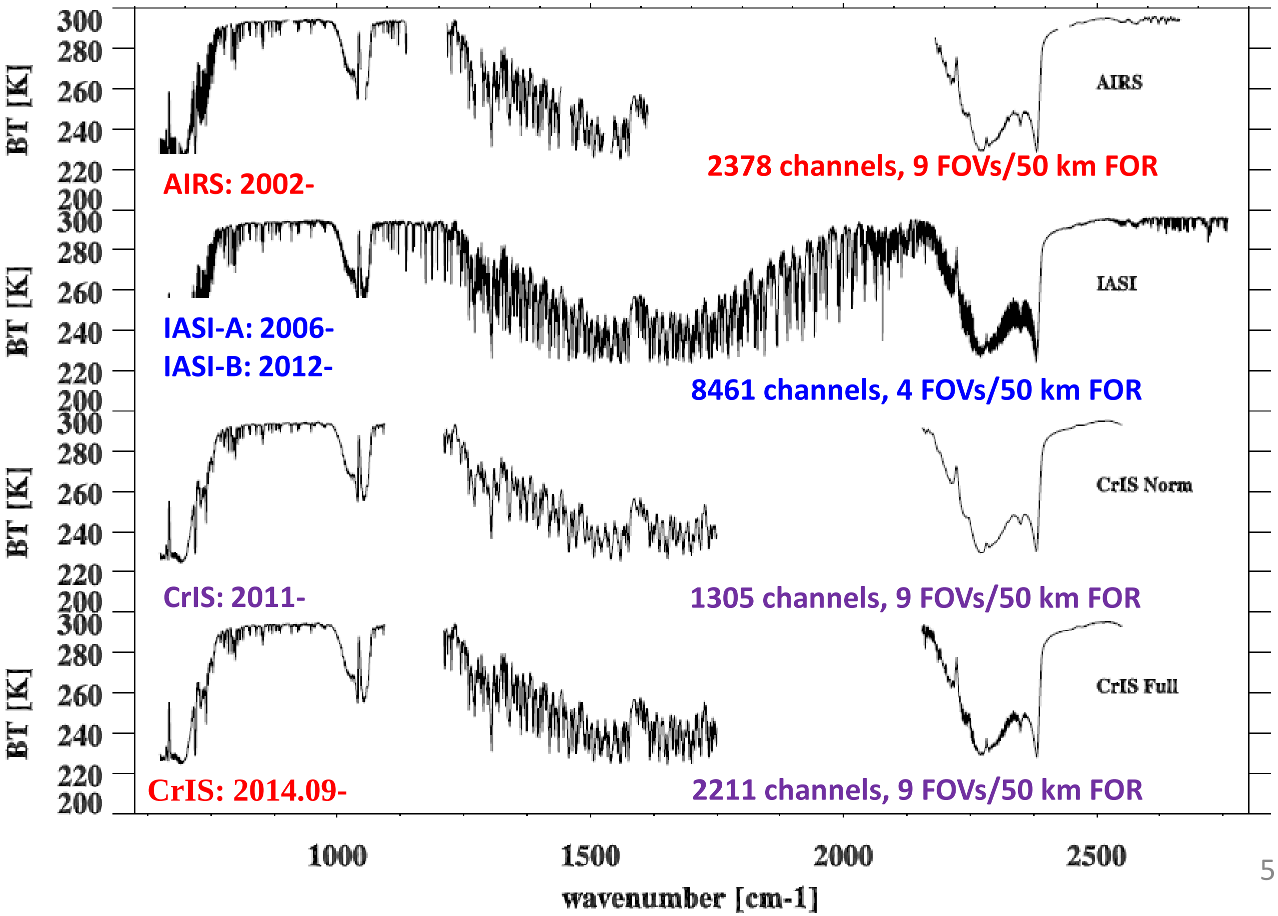
Instrument and Spectral Characteristics



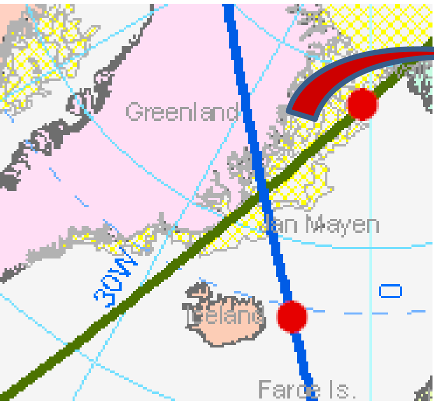




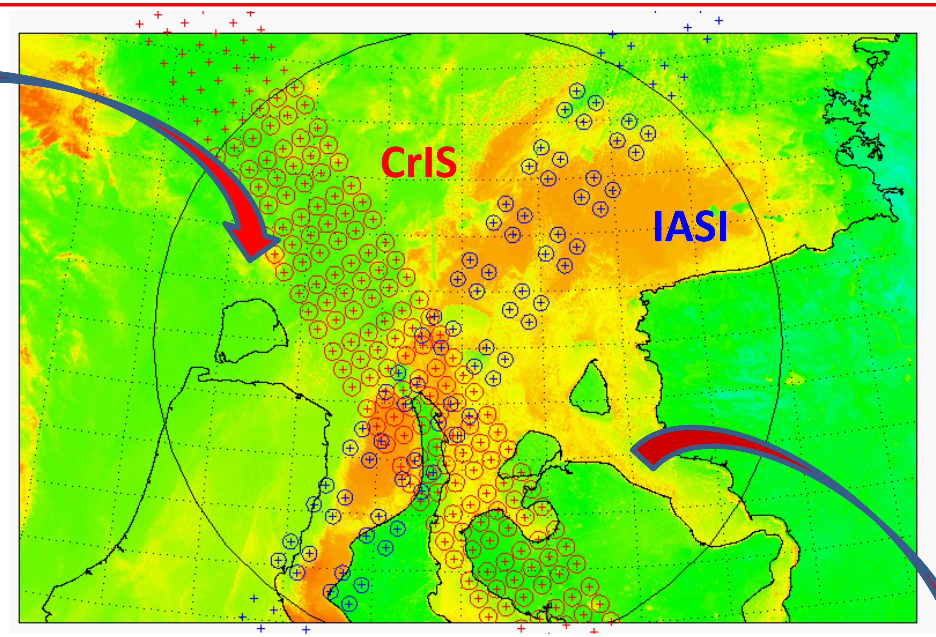
Spectral Coverage and Resolution of AIRS, IASI, and CrIS



Simultaneous Nadir Overpass (SNO)



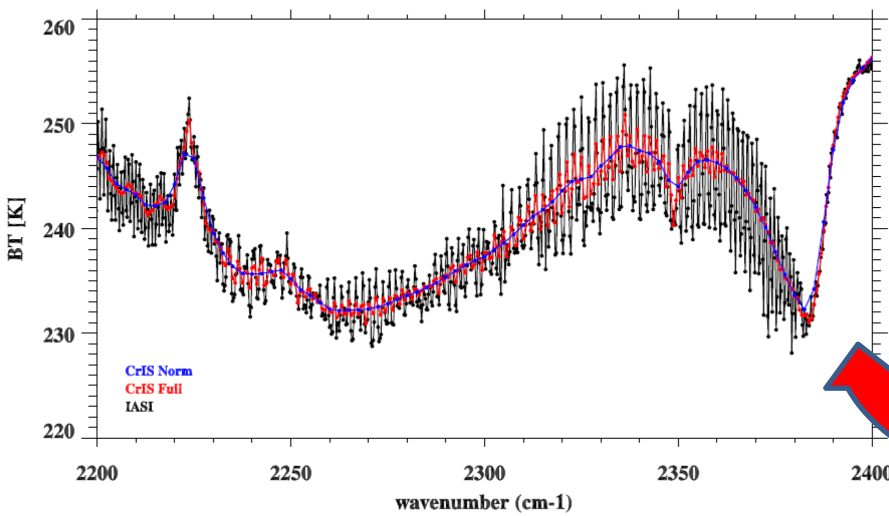
From Changyong Cao

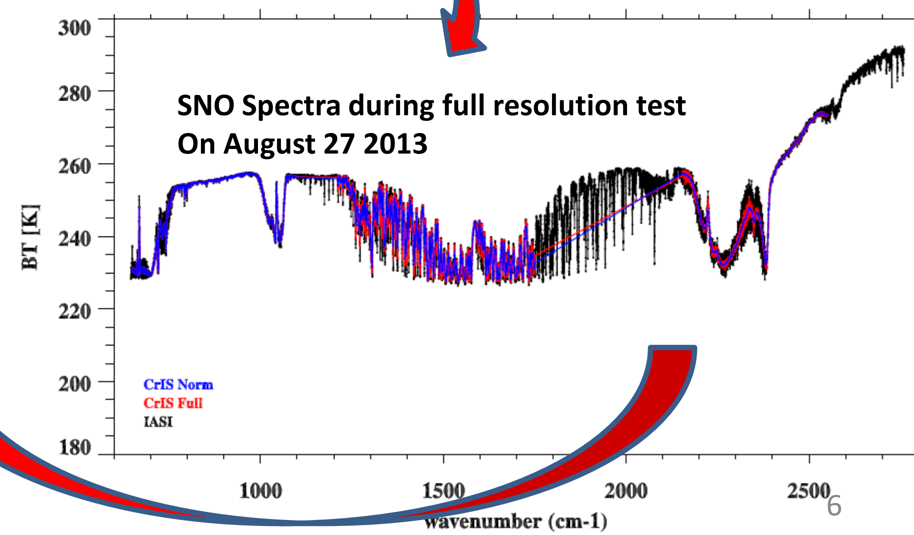


Time Difference: <= 120 Sec

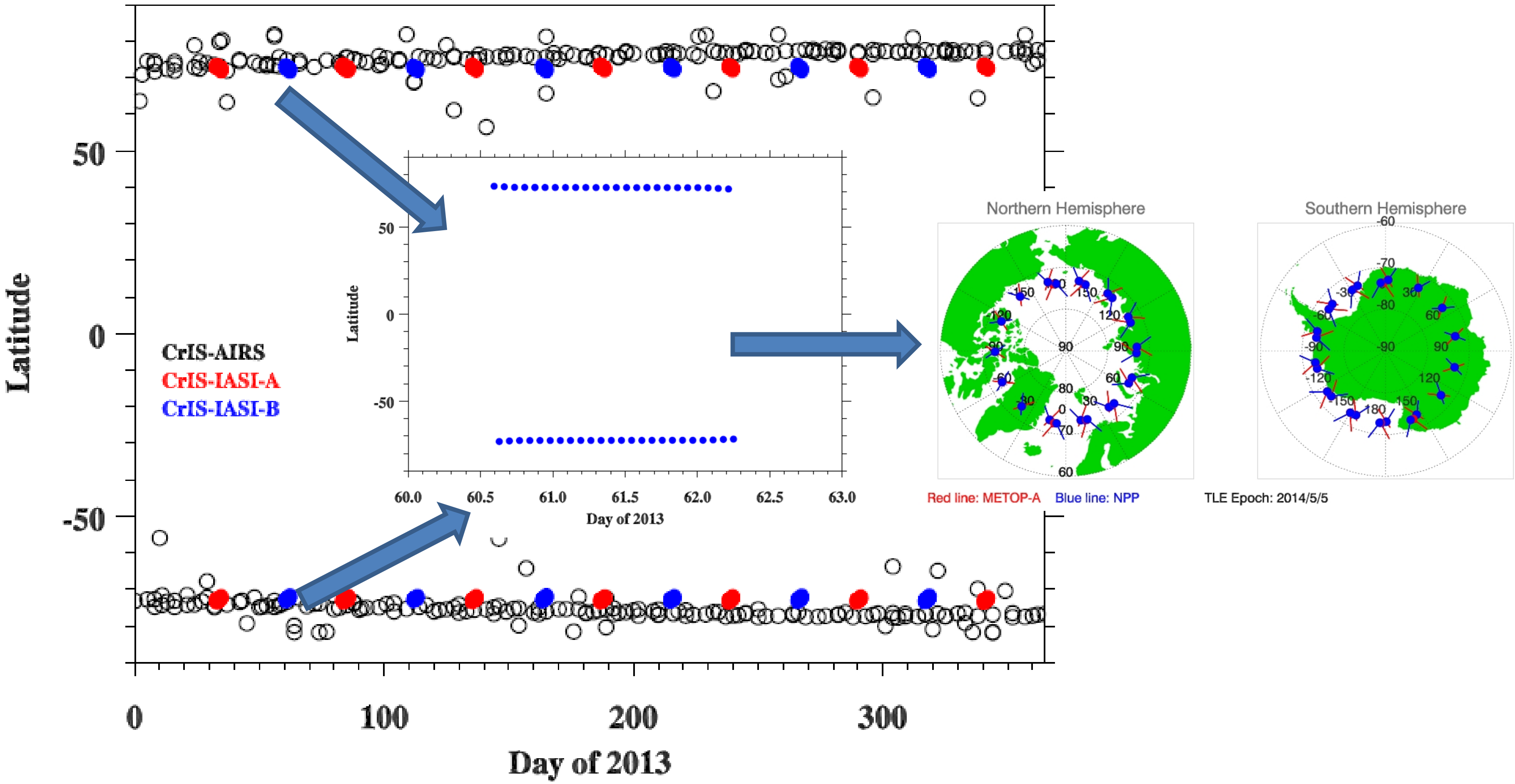
FOV distance difference: <=(12+14)/4.0 km = 6.5 km

Angle Difference: ABS(cos(a1)/cos(a2)-1) <= 0.01



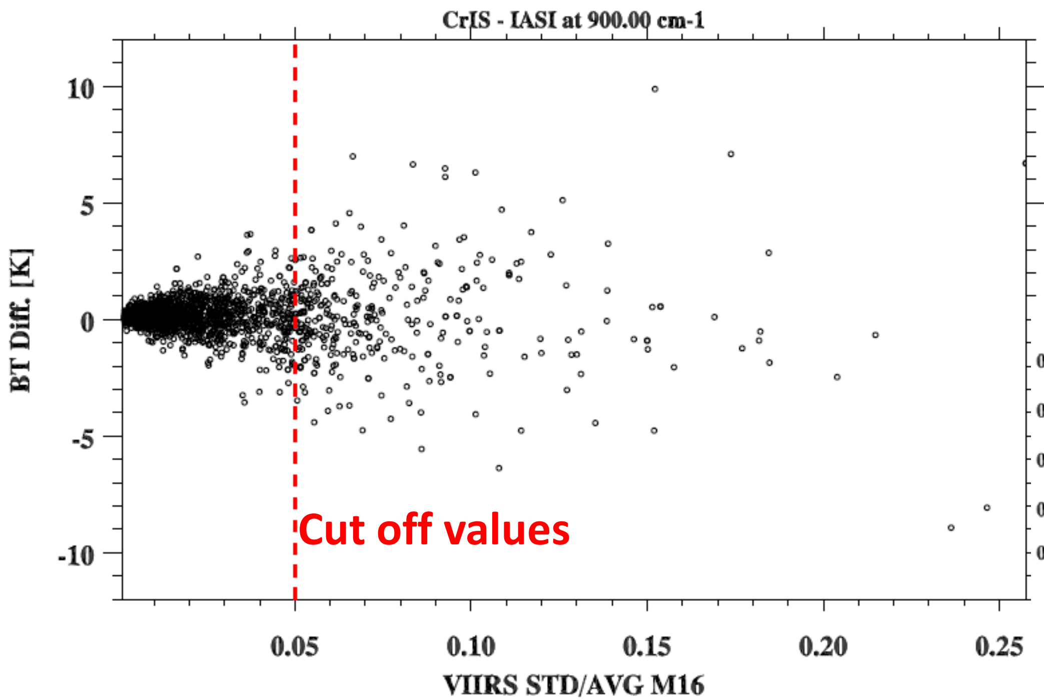


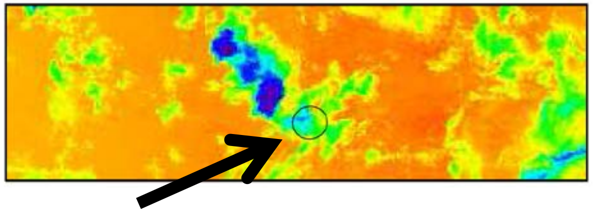
SNOs Latitude Distribution Time Series



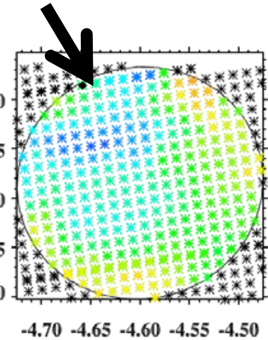
The SNOs between SNPP and Aqua occurred every 2-3 days.
the SNOs between MetOp and SNPP occurred every 50 days.
Fortunately, once an SNO event occurs, their orbits will continuously cross each other every orbit.

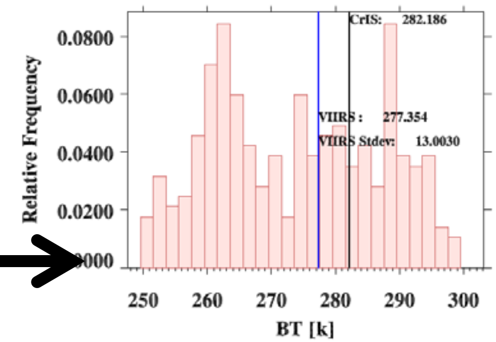
Scene Uniformity Effects



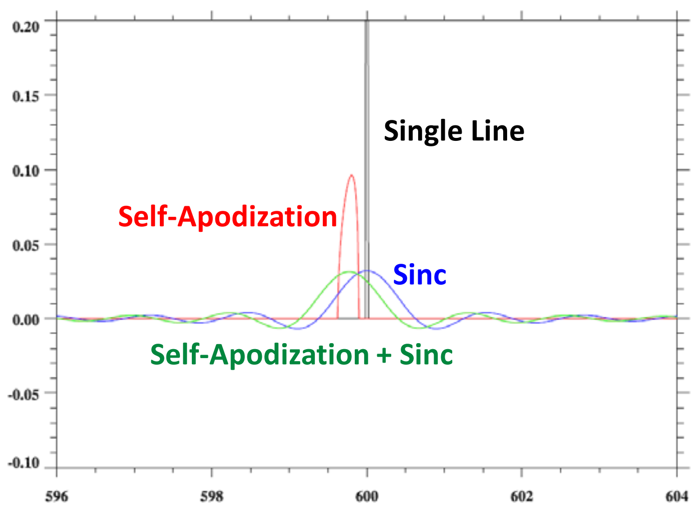


CrIS FOV footprint





Histogram of VIIRS radiances

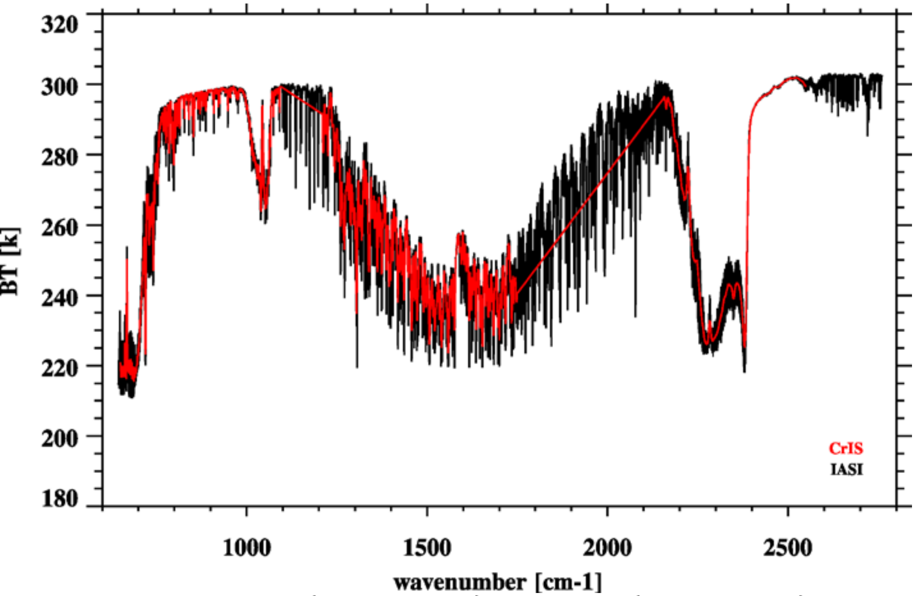


Radiance nonuniformity within the instrument's FOV affects ILS associated with each true wavenumber

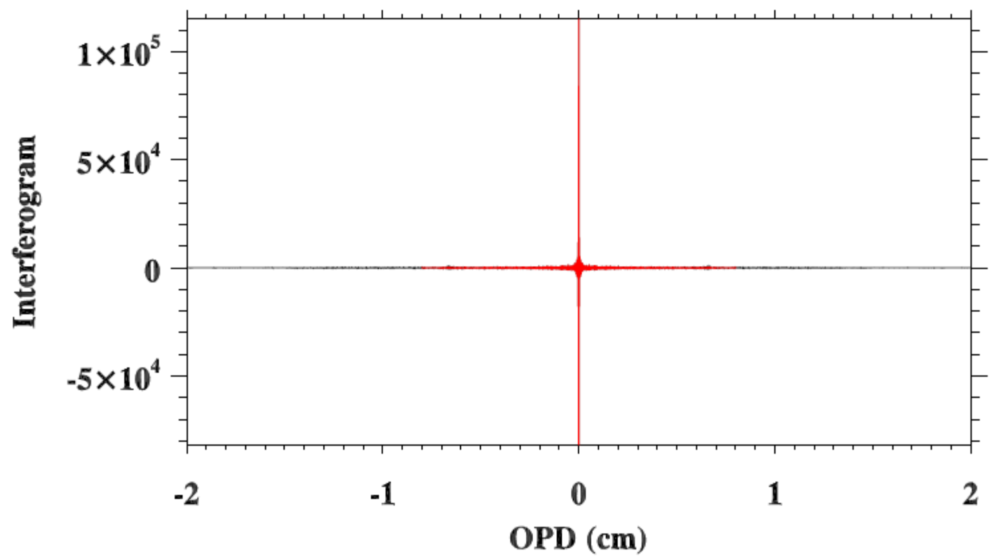
Inhomogeneous scenes can introduce spatial collocation uncertainties.

The standard deviation to mean ratio of the VIIRS radiances in band 16 is used to select uniform scenes.

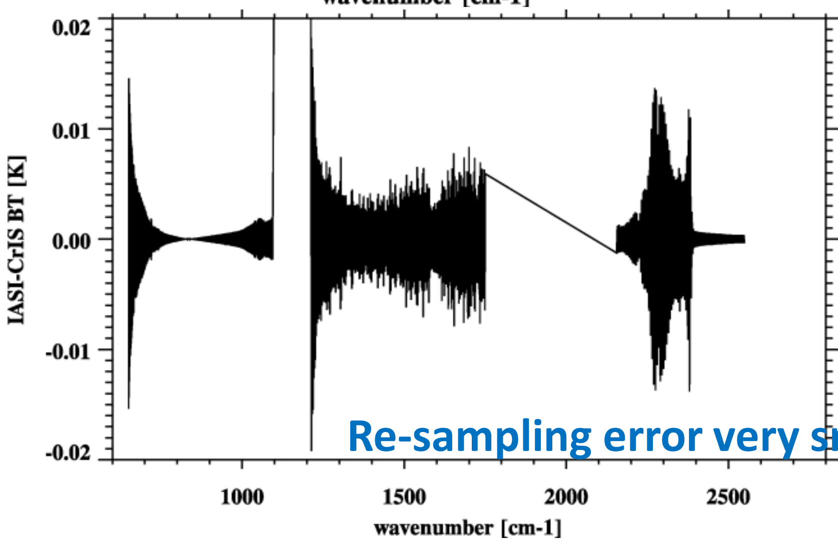
Resample IASI to CrIS



Fourier Transform



1) De-Apodization of IASI spectra
2) Truncation of IASI spectra
3) Apodization using CrIS Hamming Apodization function

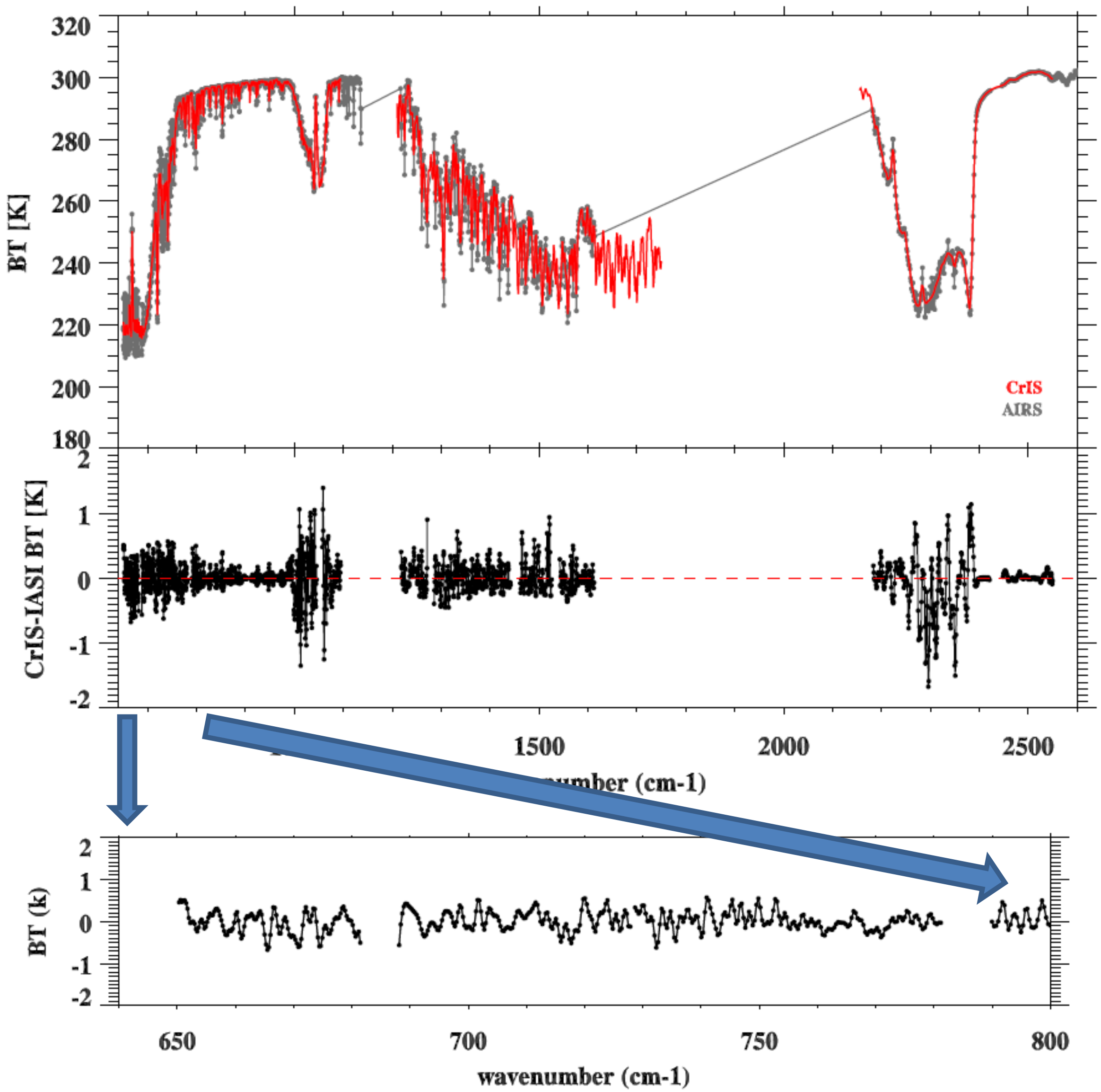


Re-sampling error very small

Inverse Fourier Transform

CrIS versus AIRS: The best we can do without reducing the spectral resolution

- AIRS Spectrum is convolved with CrIS SRFs (three bands) at each AIRS spectral grid
- Resembling CrIS into high-resolution data (e.g. 2^15) and they are convolved with AIRS SRFs
- After that, they are at the same spectral grid
- The results should be carefully interpreted with cautious.



Updates on CrIS SDR Calibration Parameters and Software

Provisional status since Jan 31, 2013

To be done

Mx6.3/6.4
2012-10-15

- Geo bug fixed
- Imgy rad. DQF implemented
- Stage2cooler drift limit lifted
- EngPktV35

Mx7.1/7.2
2013-07-10

- MW Imgy limit lifted to 0.88
- Time stamp fix for monthly shift
- Full-res truncation module inserted
- **Bit-trim table stored in CMO file**
- FIR coefficients are updated
- **Handling Missing pixel/scan**
- Handling short granule
- Handling invalid Geolocation
- **Re-tasking procedure changed**

Mx8.0
2013-11-14

- **Re-sampling laser wavelength for initial CMO saved in CMO file**
- **Time stamp overflow bug fixed**

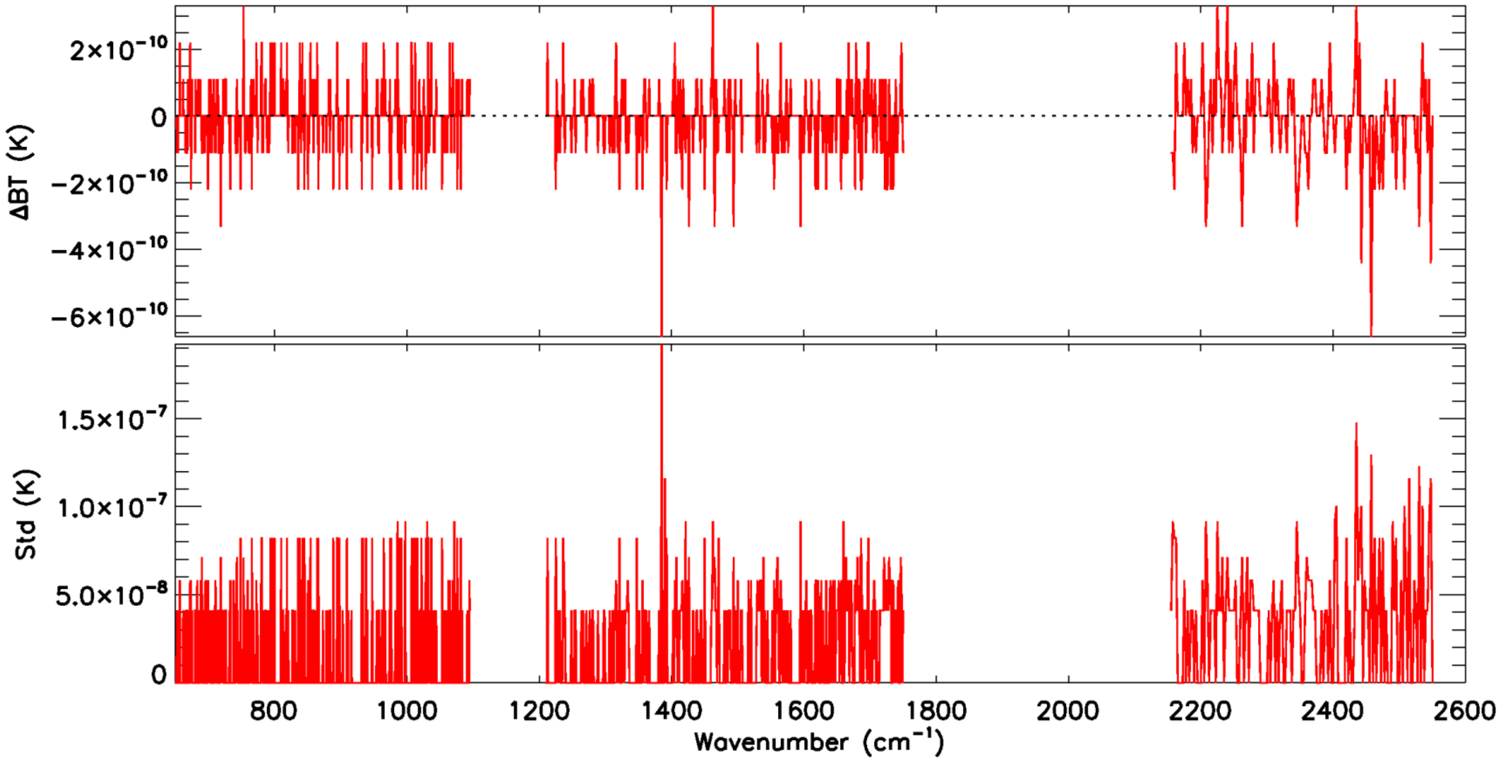
Mx8.1/8.2
On 2014-02-17

- FOV5 ILS equation error
- Non-linearity equation format change
- Lunar intrusion flag bug
- RDR impulse noise count data type
- One-scan shift of reference window

The data used in this study were reprocessed using ADL4.0 (comparable to Mx8.1/8.2) with EP36.

From Xin Jin/STAR

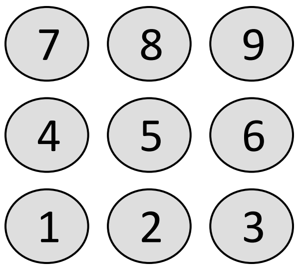
Comparison between ADL and IDPS

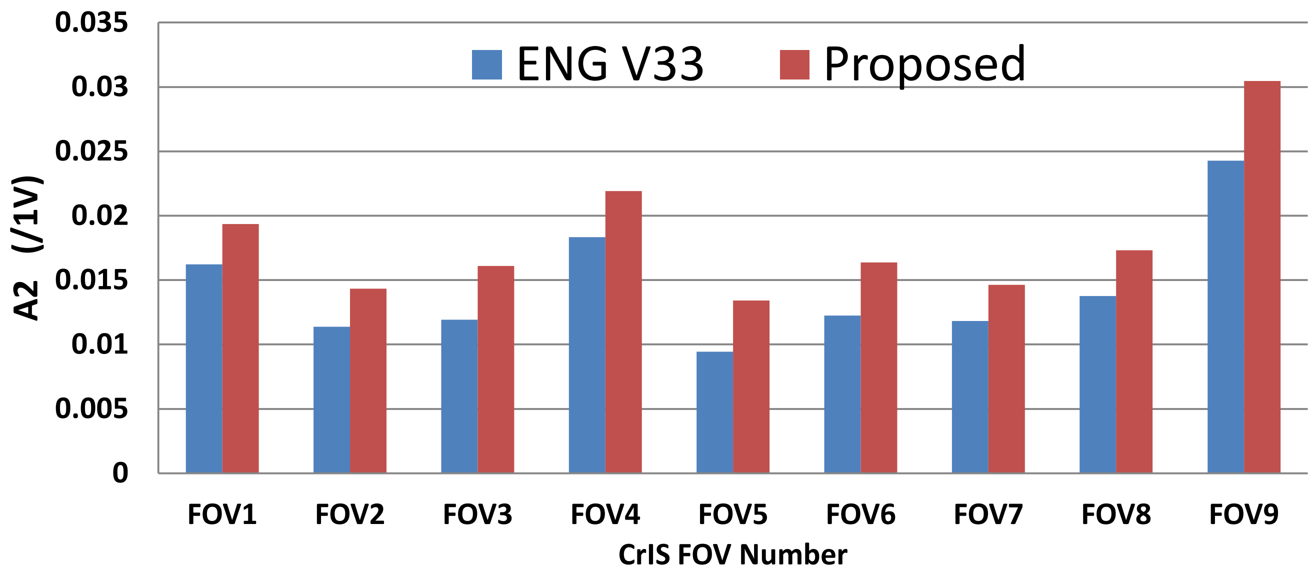


The differences between ADL and IDPS are negligible.

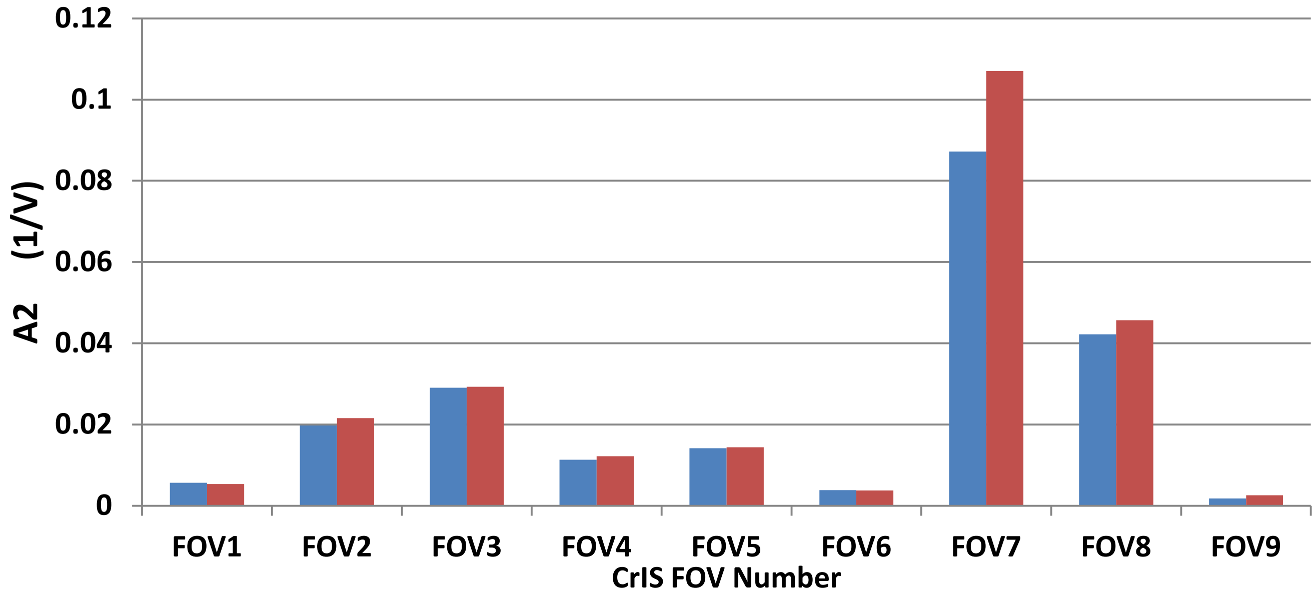
From Xin Jin/STAR

Non-linearity Coefficient Changes



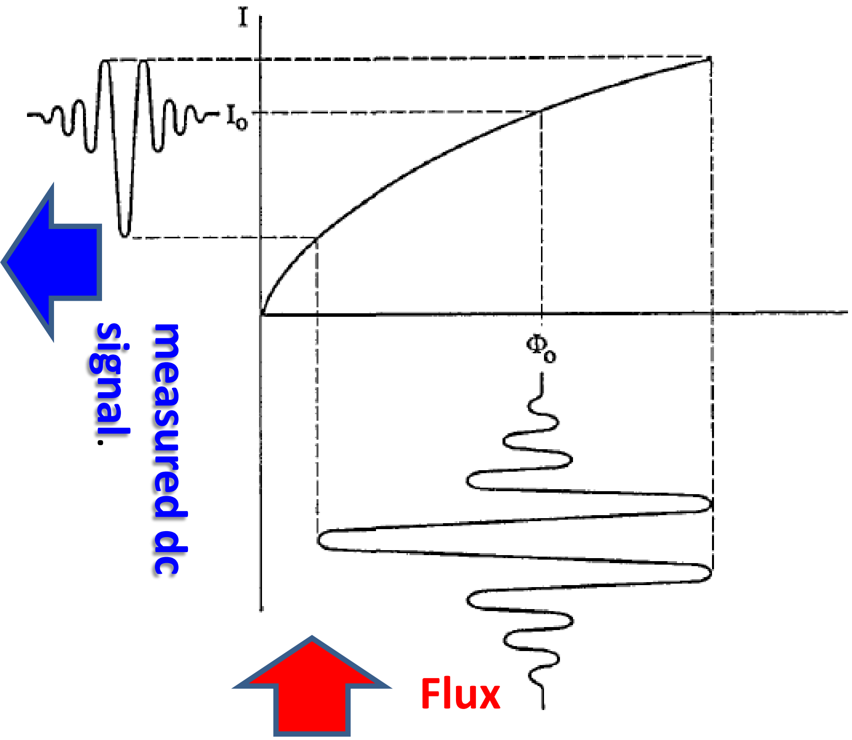


Longwave band

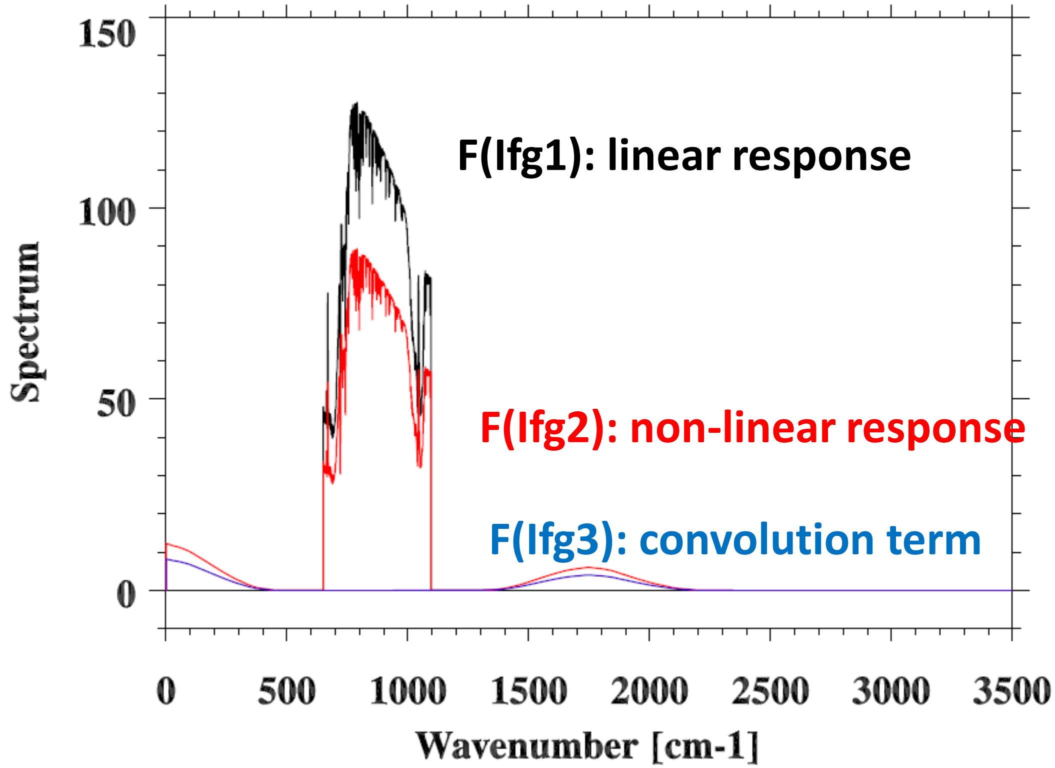


Middlewave band

For a non-linear detector



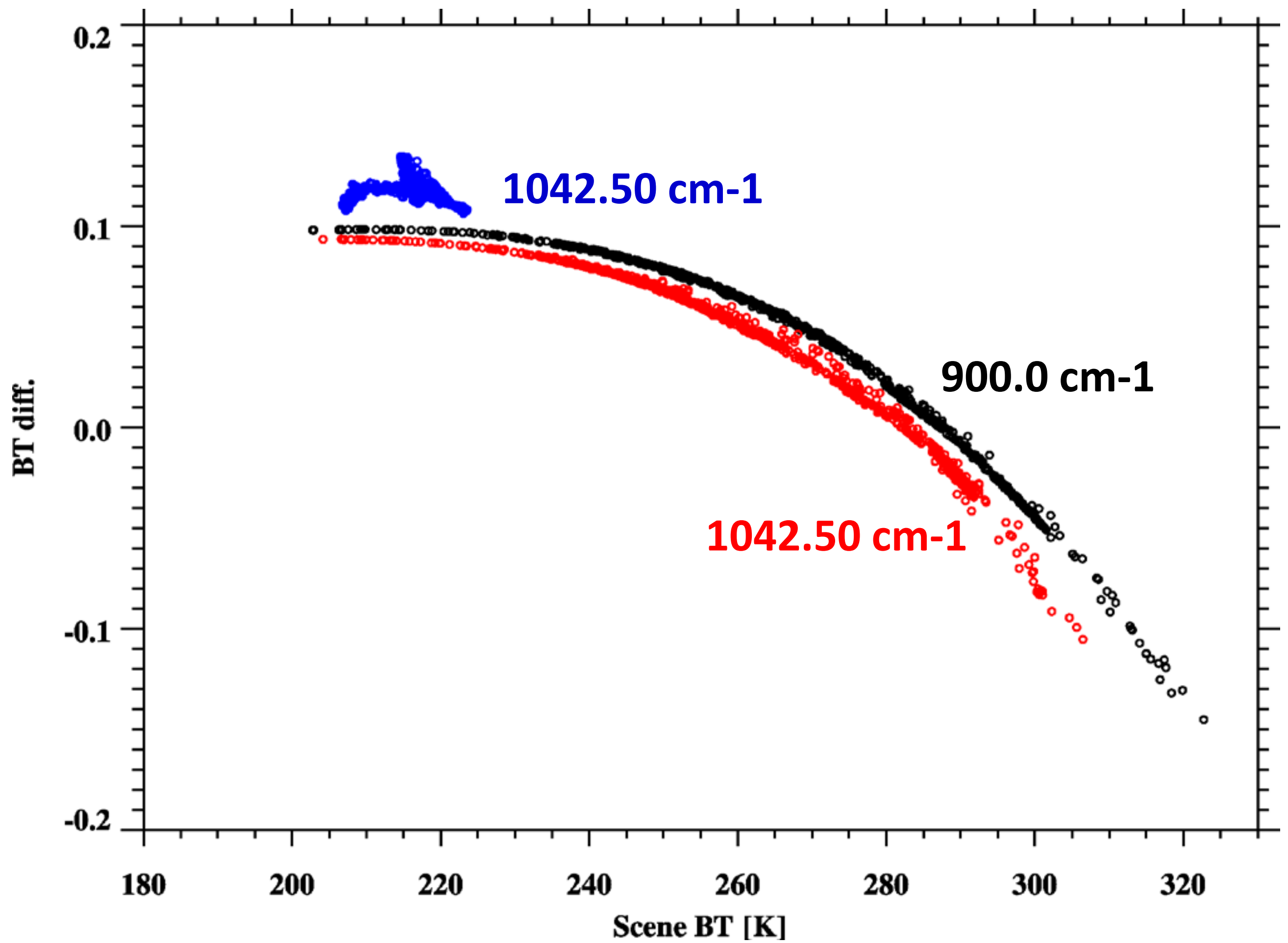
Hypothetical detector-response curve exhibiting nonlinearity. The horizontal axis represents the absolute magnitude of the photon flux and the vertical axis represents the measured dc signal.



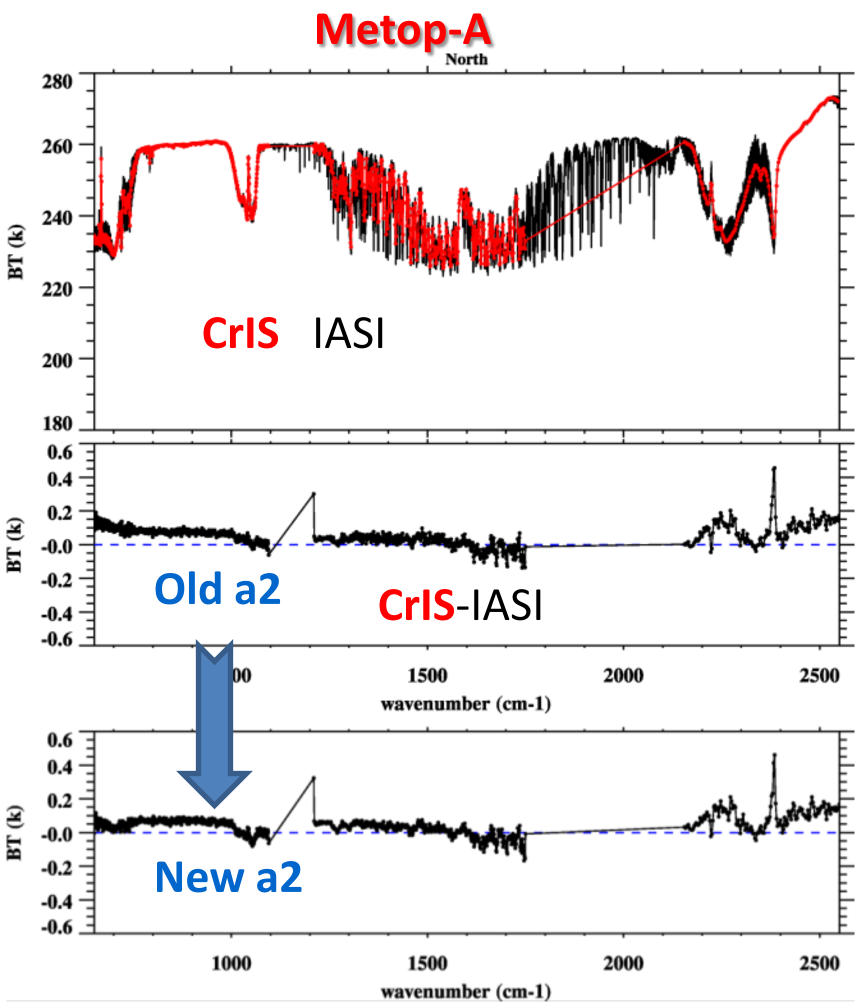
Non-linearity responses in spectral domain.

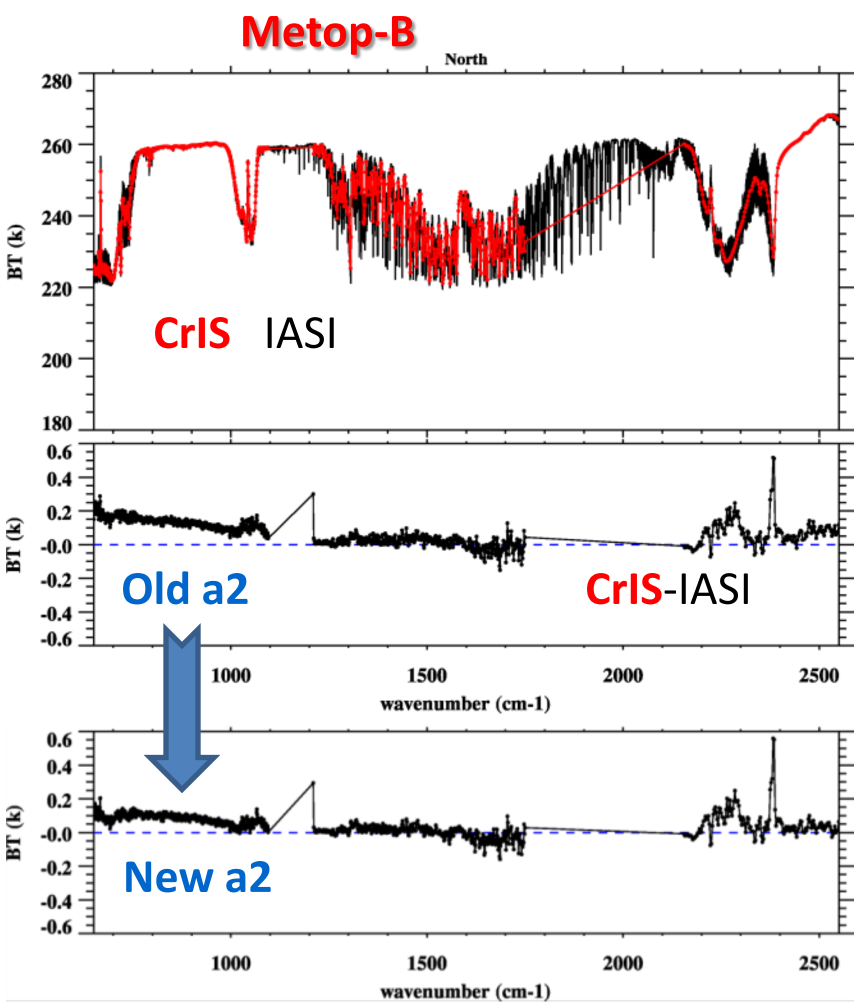
From Abrams et al. 1994

Longwave FOV 5
BT changes: Old a2 – New a2



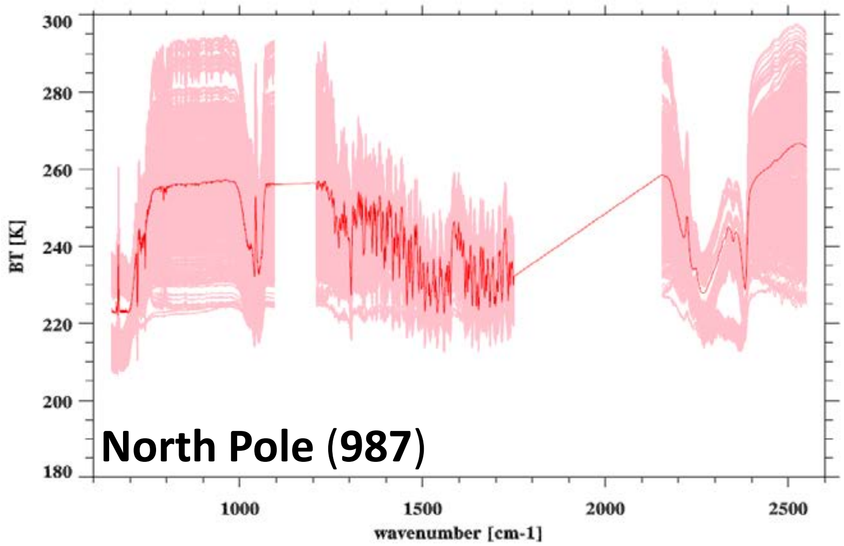
CrIS-IASI with New a2 values

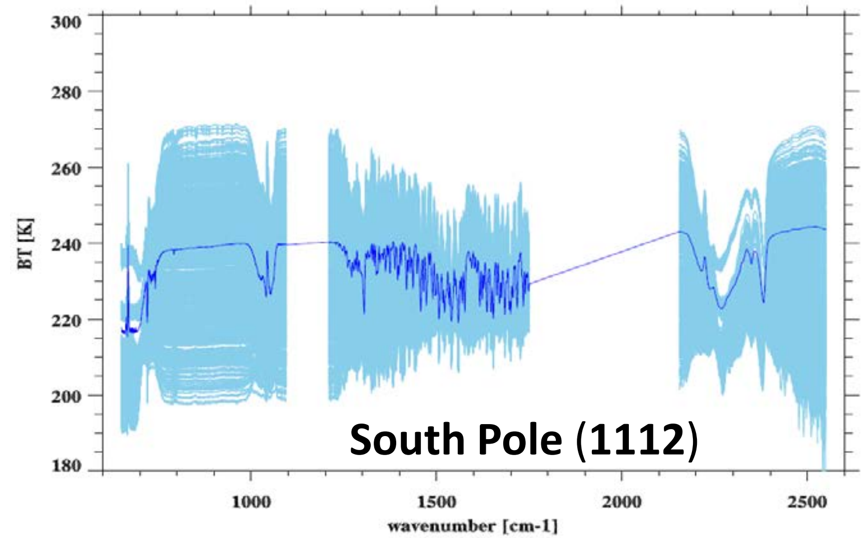


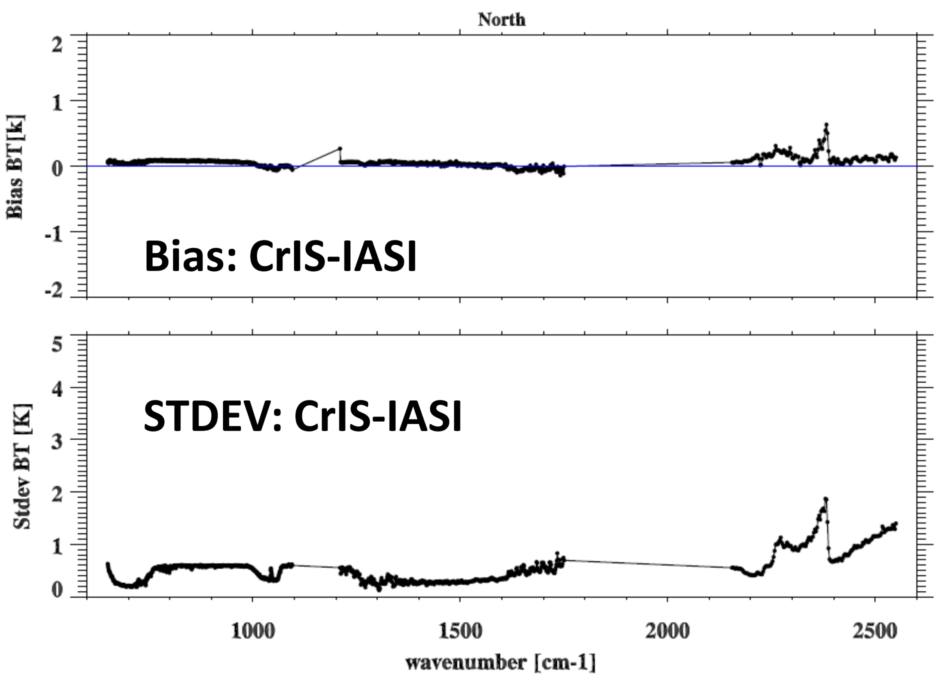


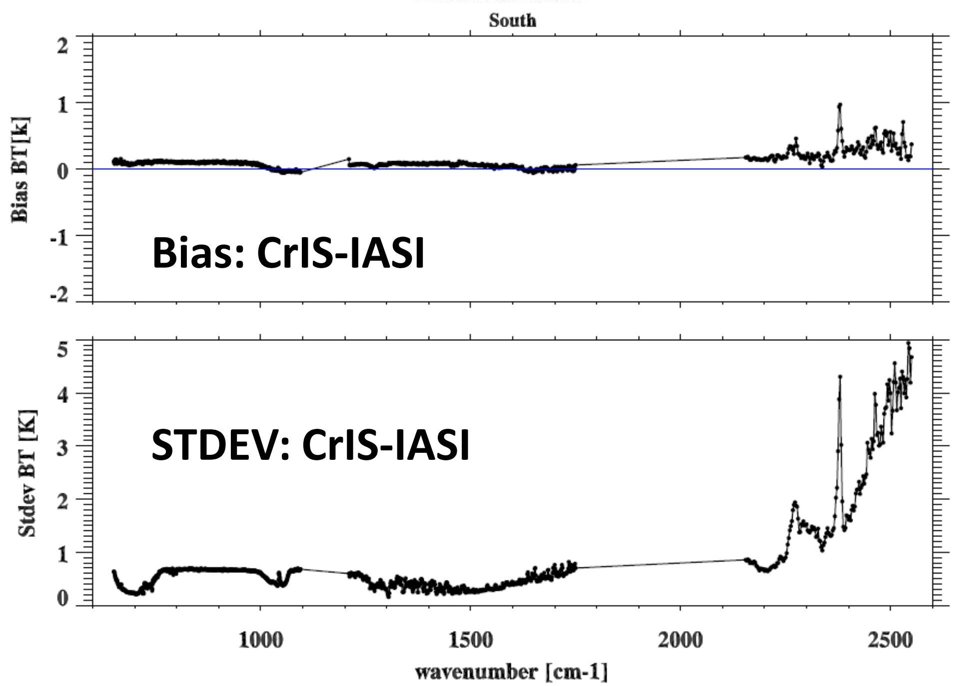
The differences between CrIS-IASI is reduced at LW bands with new a2 values.

CrIS versus IASI/MetOp-A

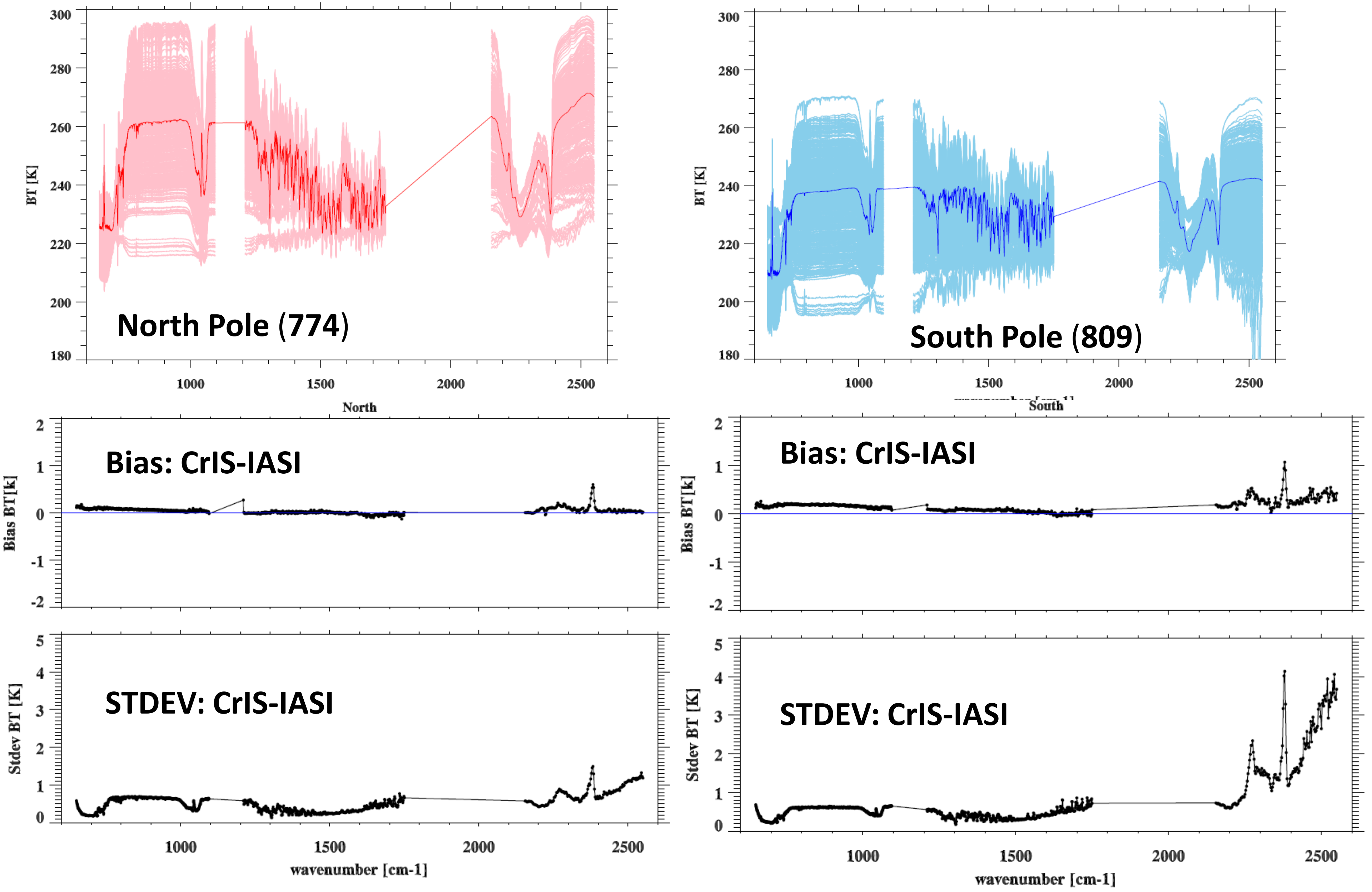




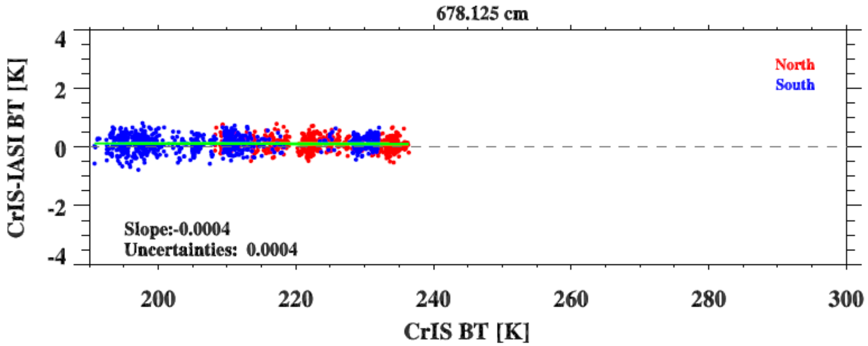


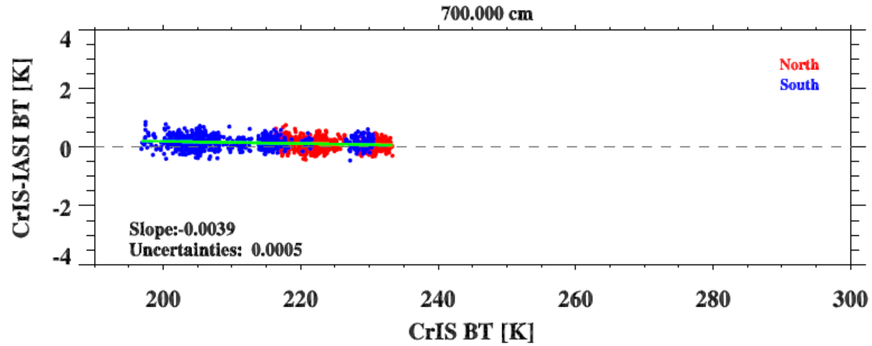


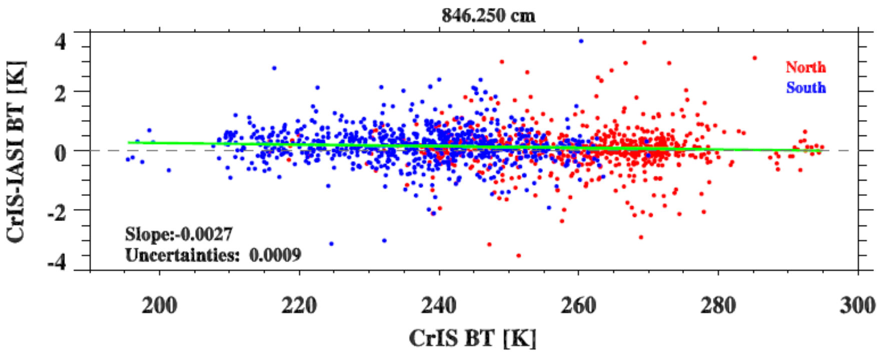
CrIS versus IASI/MetOp-B

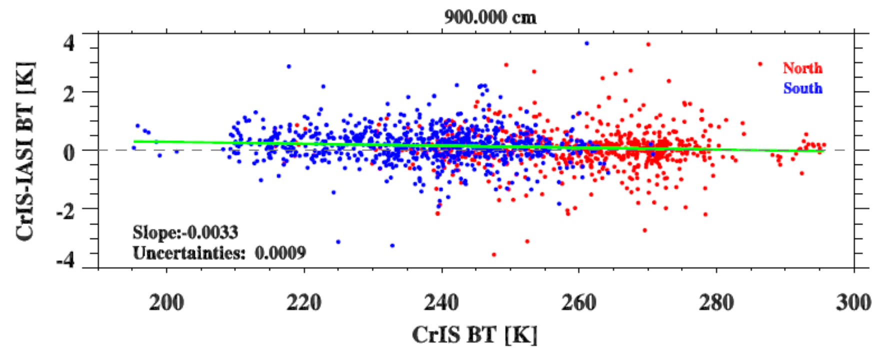


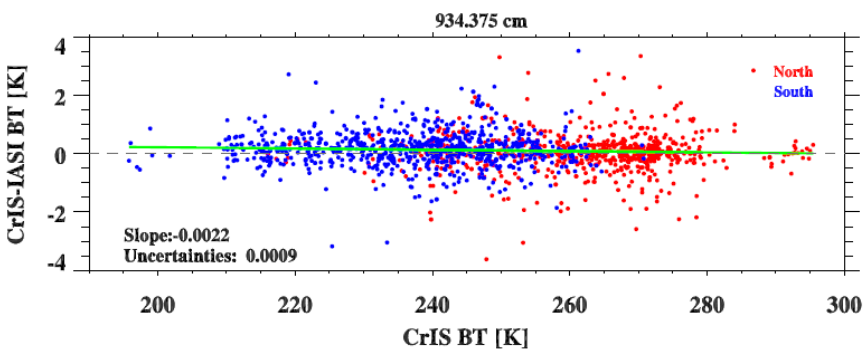
Scene-Dependent Bias

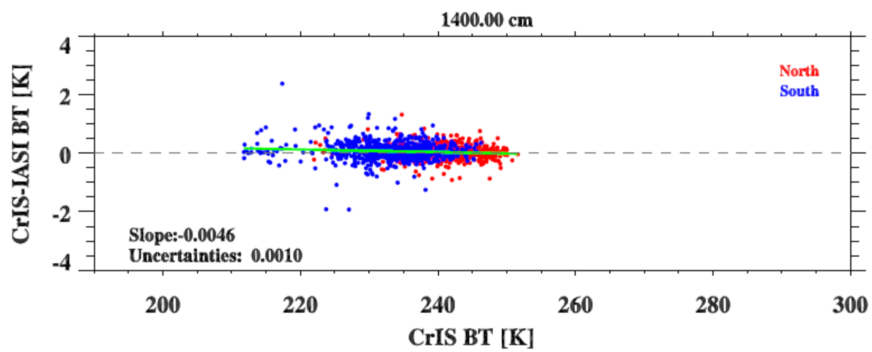




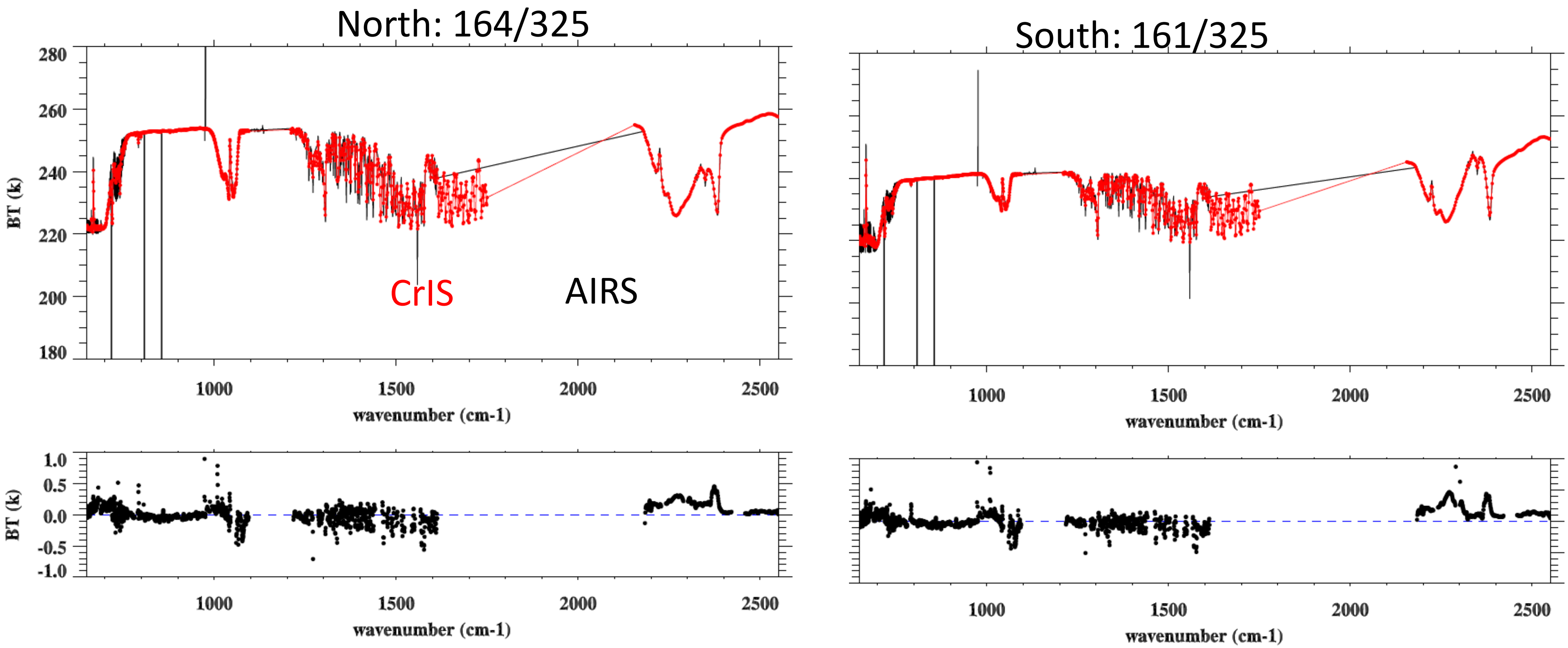






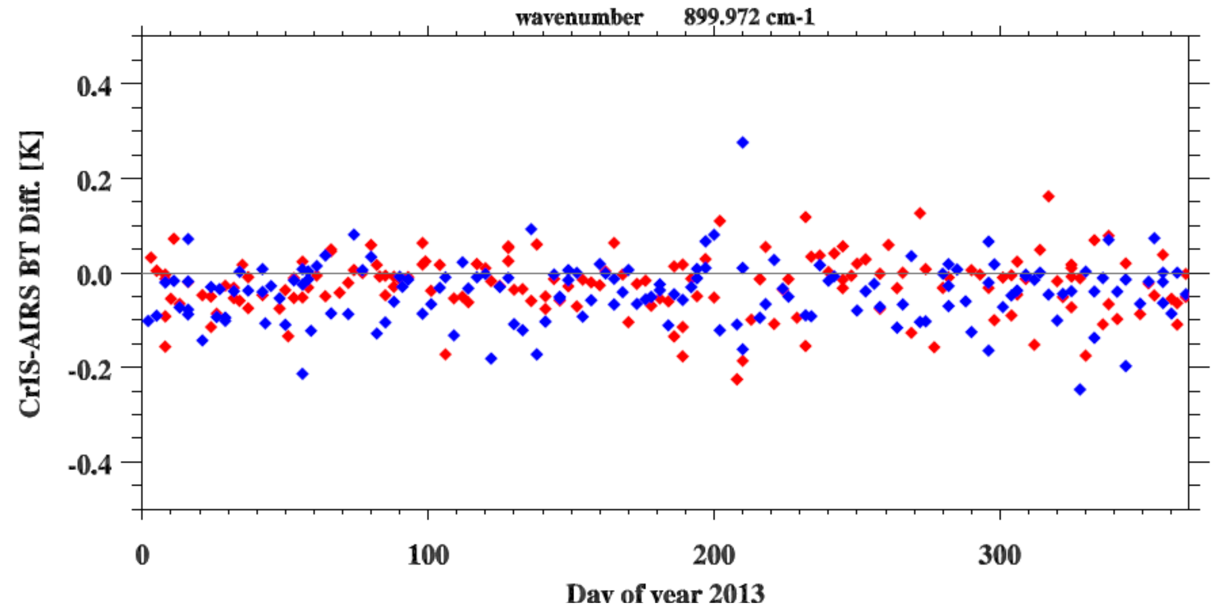


CrIS versus AIRS
Daily averaged SNO observations

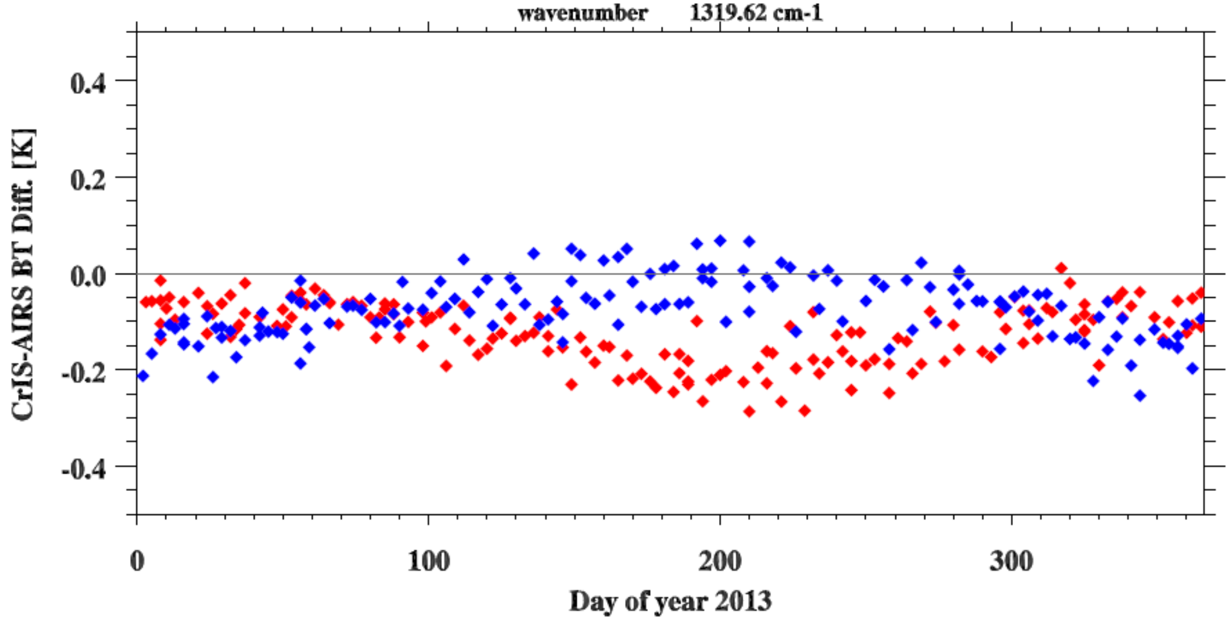


Large spread could be due to the resampling uncertainties and AIRS band channels

Time Series of CrIS-AIRS



Atmospheric Window



Water Vapor Window

Conclusion

- Radiometric and spectral consistency of four IR hyperspectral sounders is fundamental for GSICS and climate application.

- Inter-comparison of CrIS with IASI/Metop-A, IASI-Metop-B, and AIRS have been made for one year's of SNO observations in 2013.

- CrIS vs. IASI
  - CrIS and IASI well agree each other at LWIR and MWIR bands with 0.1-0.2K differences
  - No apparent scene dependent bias
  - At SWIR band, a sharp increases can be clearly seen at spectral transition region. The reason is still under investigation.

- CrIS vs. AIRS
  - Resampling errors still remain when converting AIRS and CrIS onto common spectral grids.
  - CrIS and AIRS well agree each other at LWIR and MWIR bands within 0.4 K differences
  - At SWIR band, a sharp increases can be clearly seen at spectral transition region.
  - A weak seasonal variation can been seen for CrIS-AIRS at water vapor absorption region.

- Lessons learned for JPSS CrIS: Non-linearity play an important role for CrIS radiometric accuracy and should be carefully evaluated during the prelaunch test.

- The comparison will be continued until end of sensor mission, which will provide fundamental information about consistency of hyperspectral sounders to the community.