Inter-Comparison of NPP CrIS with Metop-A and -B IASI

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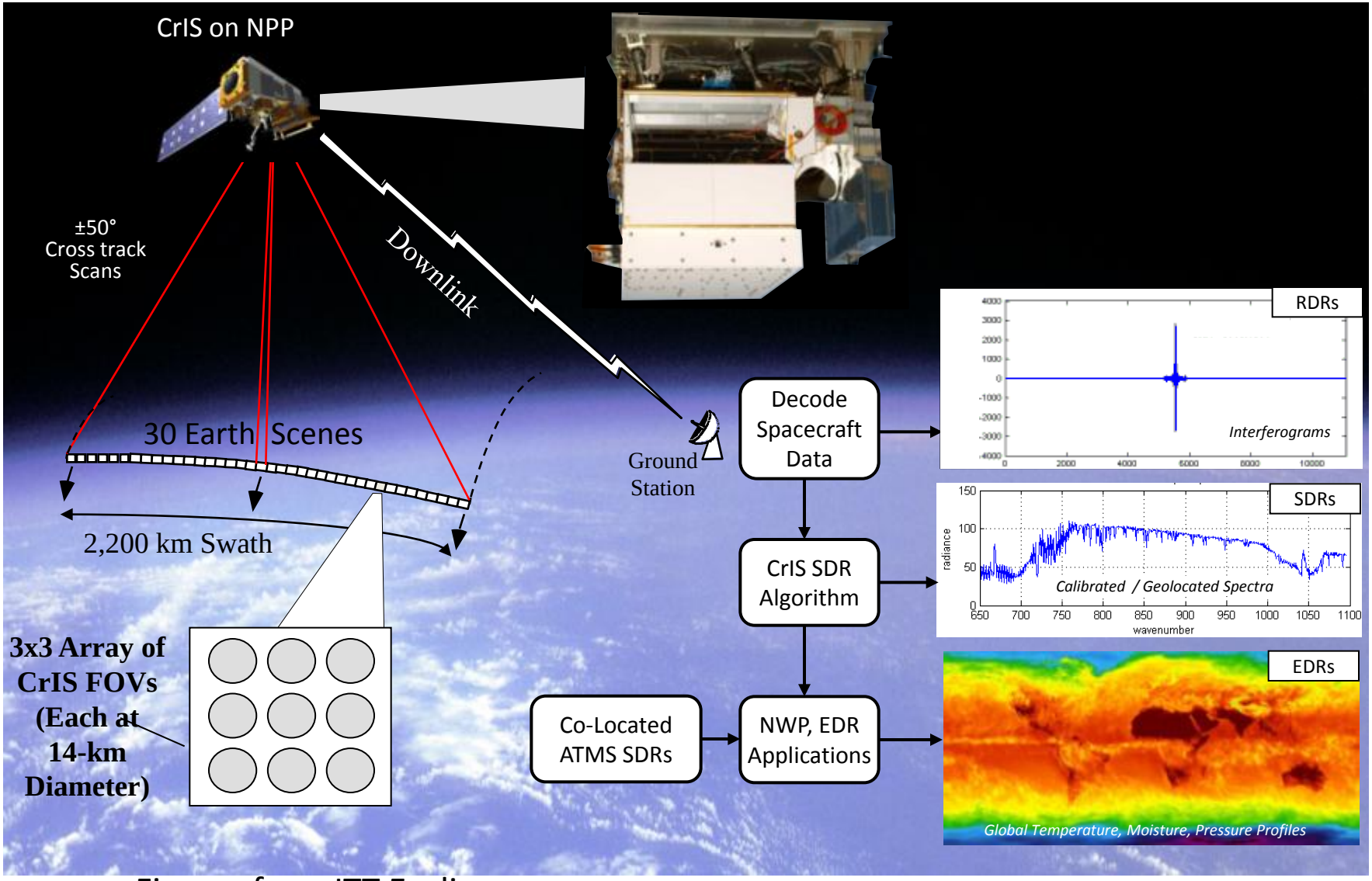
3rd IASI Conference, Hyères, France; 02/04/2013

Outline

- NPP/CrIS Post-launch Calibration
- Inter-sensor comparison
  - Direct comparison:
    - CrIS *versus* IASI
  - Indirect comparison:
    - Through the third sensor, CrIS-VIIRS *versus* IASI-VIIRS
- Conclusion remarks

CrIS Operational Concept

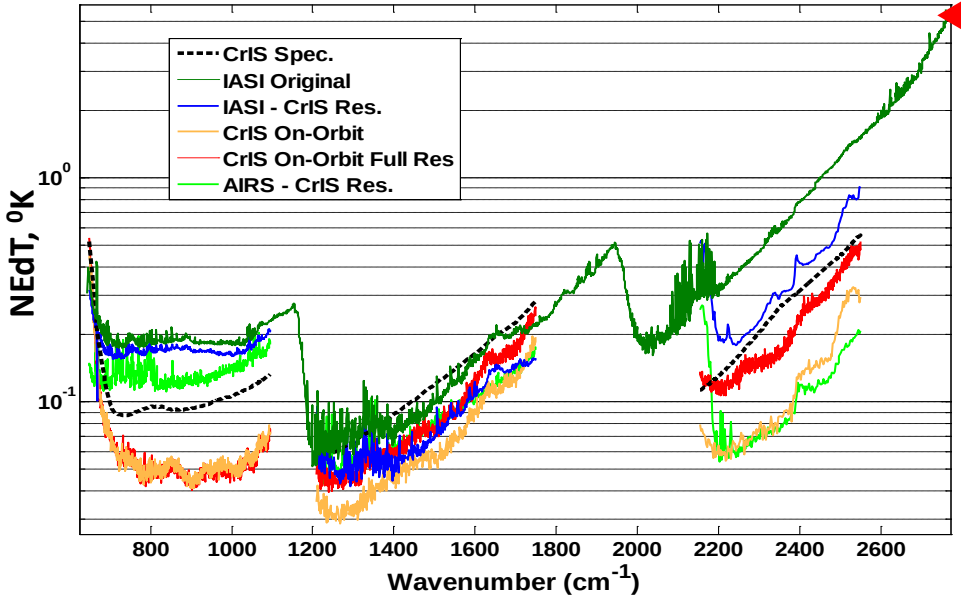


Figures from ITT Exelis

NPP CrIS Sensor Data Record
Calibration Uncertainty Specifications

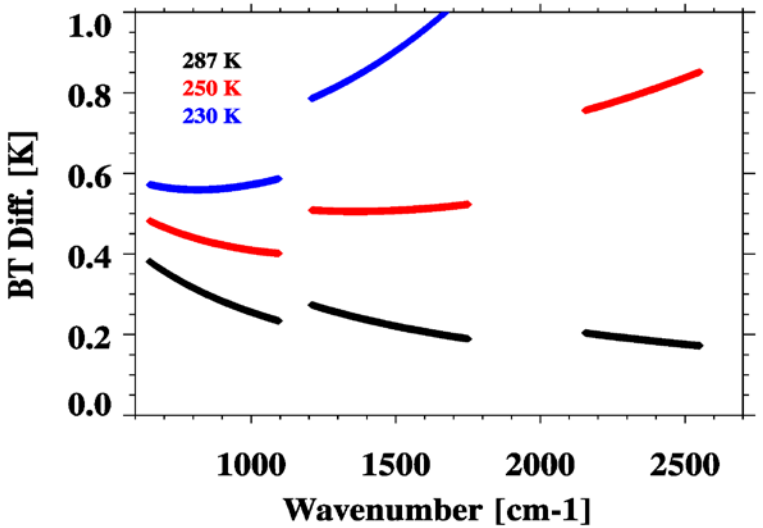
SDR Calibration Uncertainty

Band	Spectral range (cm^{-1})	N. of chan.	Resolution (cm^{-1})	FORs per Scan	FOVs per FOR	NEdN @287K BB $mW/m^2/sr/cm^{-1}$	Radiometric Uncertainty @287K BB (%)	Spectral (chan center) uncertainty ppm	Geolocation uncertainty km
LW	650-1095	713	0.625	30	9	**0.14**	**0.45**	**10**	**1.5**
MW	1210-1750	433	1.25	30	9	**0.06**	**0.58**	**10**	**1.5**
SW	2155-2550	159	2.5	30	9	**0.007**	**0.77**	**10**	**1.5**



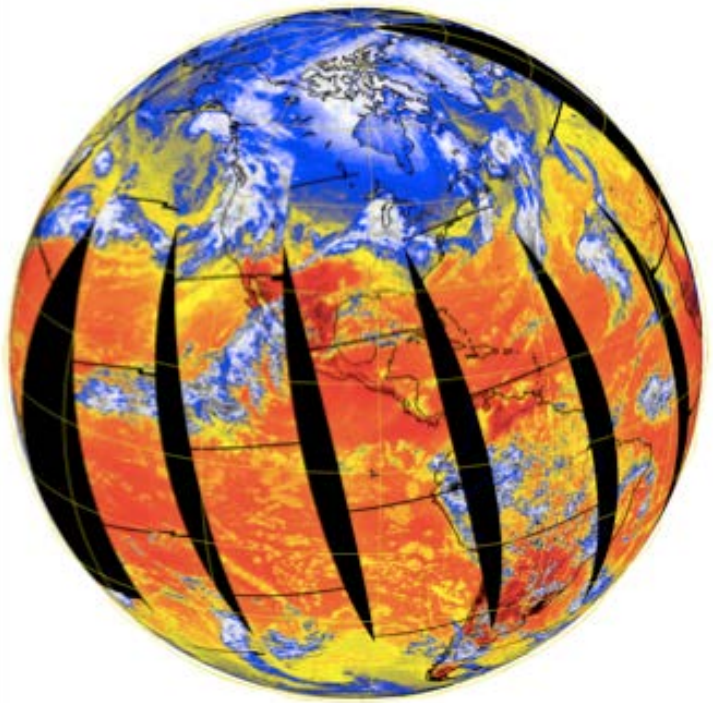
From Vladimir Zavyalov of SDL

Radiometric uncertainty specification converted to that expressed in



CrIS Cal/Val Milestones

- **January 18th 2012: CrIS was powered up; team started instrument checkout and optimization.**
- February 8th : Engineering packet v32 was uploaded (PGA setting and bit trim mask updates).
- February 22nd : Full spectral resolution RDRs (0.8 cm maxOPD for all bands) were collected.
- April 11th : Engineering packet v33 was uploaded (spectral calibration parameters, nonlinearity coefficients and ICT emissivity table updates).
- April 18th: A new FIR digital filter was uploaded to replace the corrupted one.
- May 15th : CrIS SDR product reached Beta maturity level .
- October 15th : CrIS Geolocation errors are fixed
- October 23rd , CrIS SDR Provisional Review
- Validated product: 2013



Jan. 25: First light image, 900 cm^{-1} BT 20-Jan-2012 12:54 to 23:57 UTC from CCAST SDR processing system from UW/UMBC

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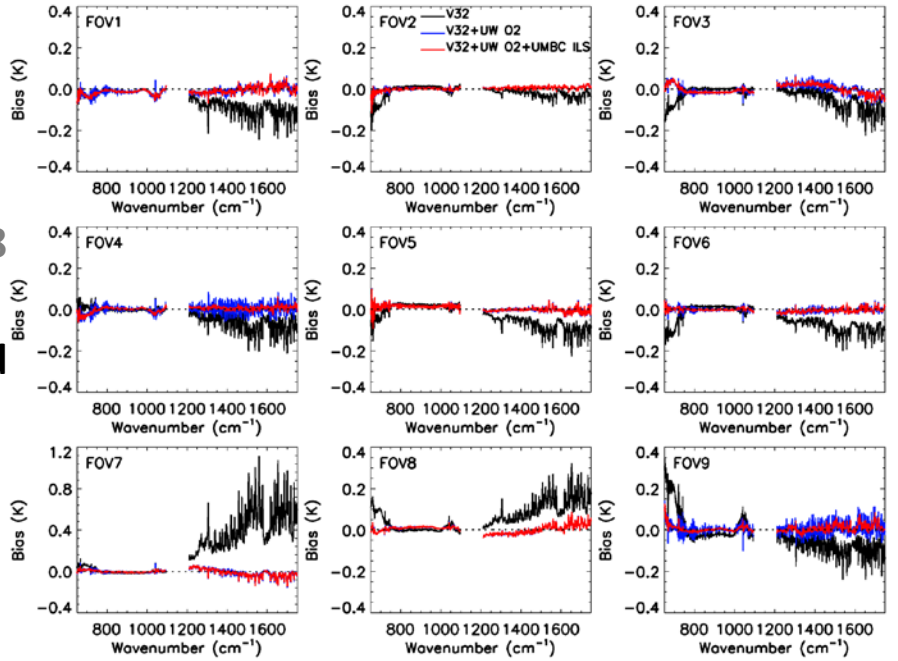
$$BIAS_{FOVi} = \overline{(Obs - CRTM)_{FOV_i}} - \overline{(Obs - CRTM)_{all}}$$



Black: before a2 and ILS parameter updates

Blue: after a2 updates but before ILS parameter change

Red: after both a2 and ILS parameter updates

Figure from Yong Chen of STAR CrIS Team

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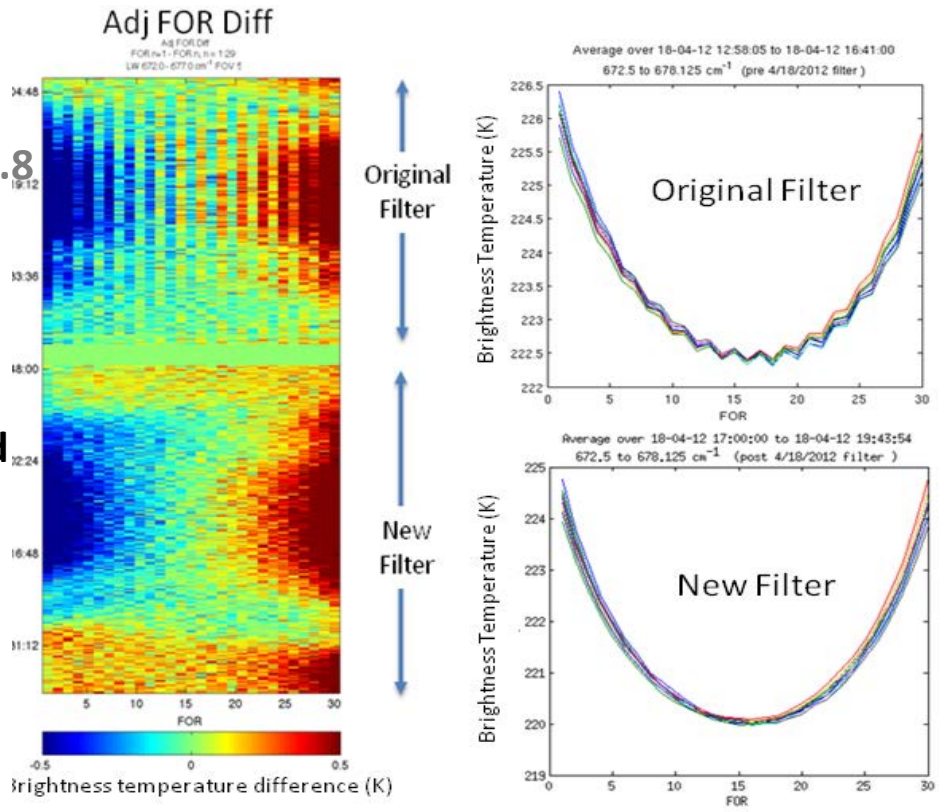

Figures from Dave Tobin of UW CrIS Team

CrIS Cal/Val Milestones

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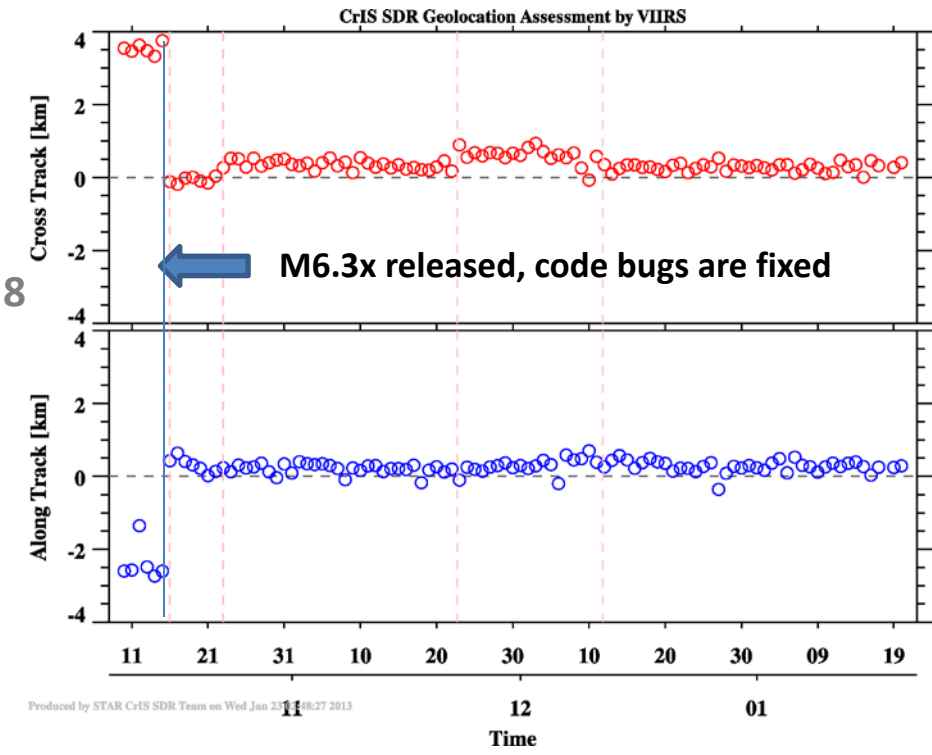
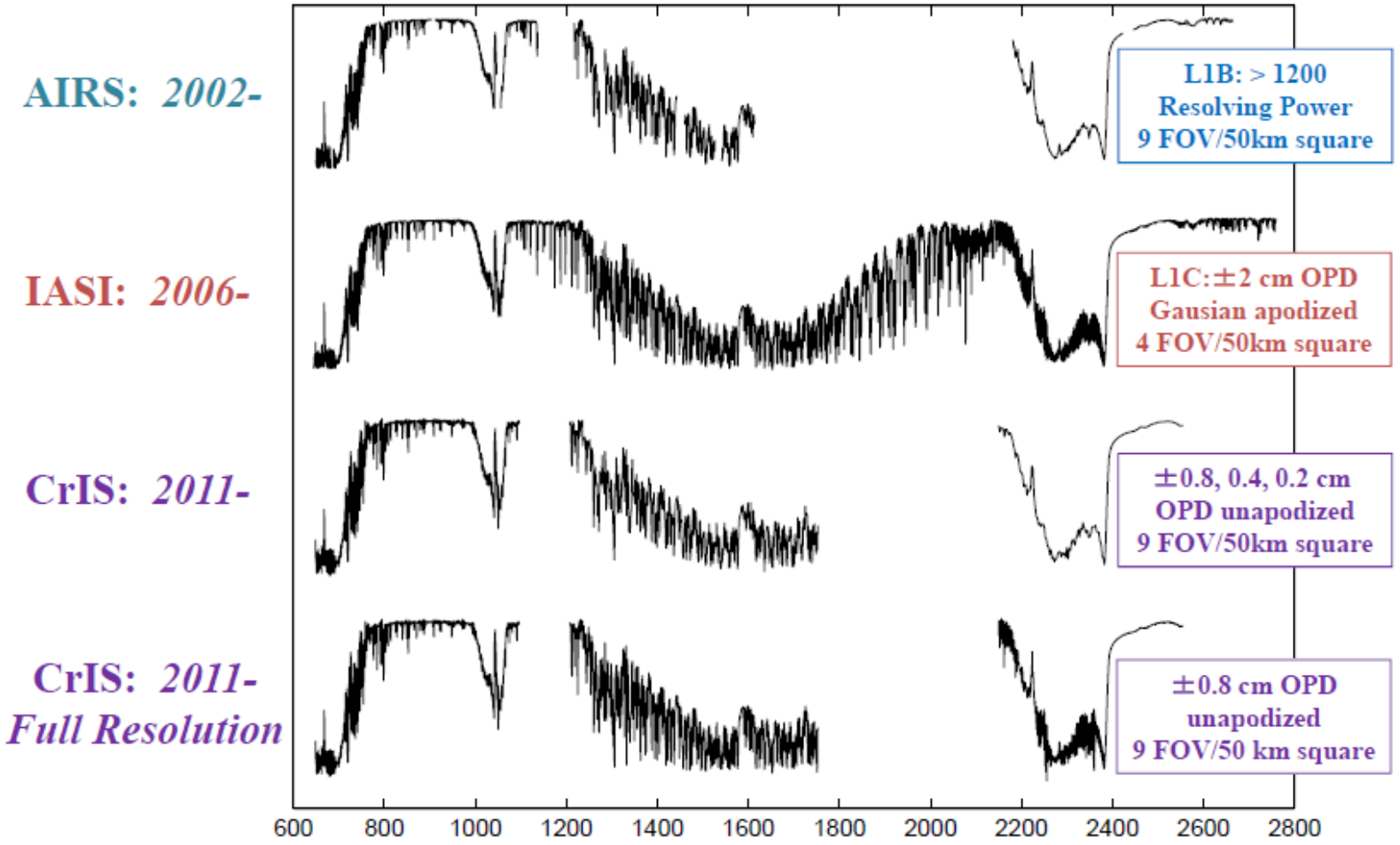


Geolocation error were caused by the code bugs in SDR processing software that applied IAR to SSMR rotation matrices twice.

Radiometric consistency between CrIS and IASI/AIRS

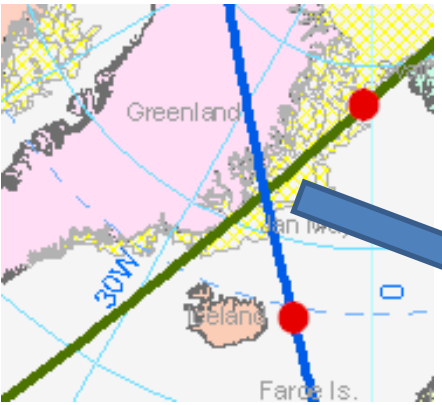
Spectral Coverage and Resolution of AIRS, IASI, and CrIS

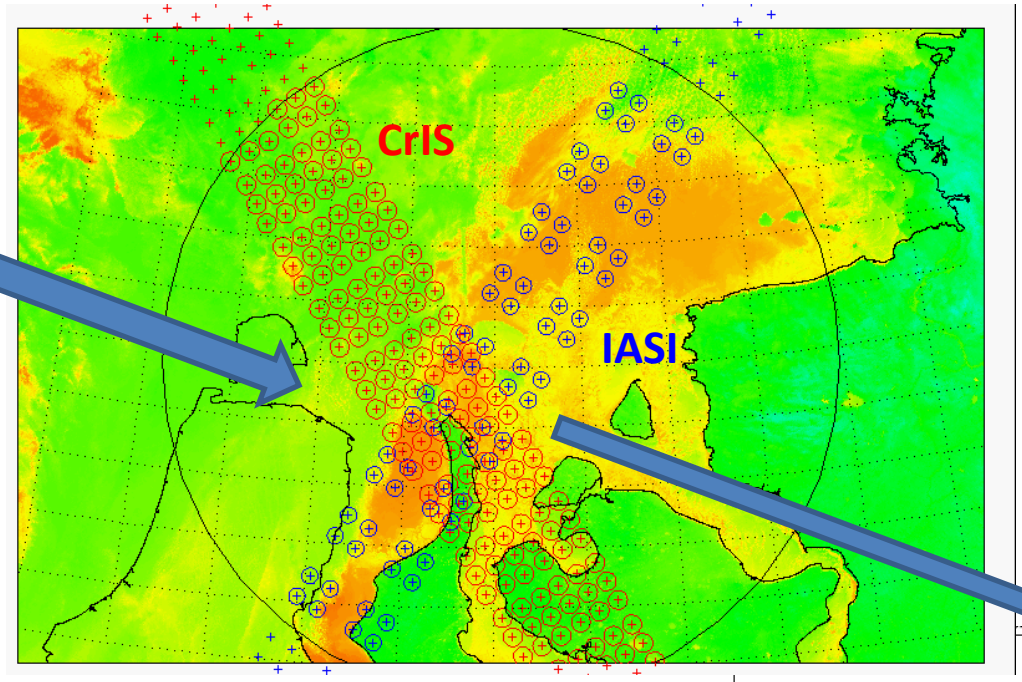


From Hank Revercomb

Simultaneous Nadir Overpass (SNO)

from 10/22-10/24 and 12/10-12/14: a total of 125 cases





Time Difference: <= 120 s

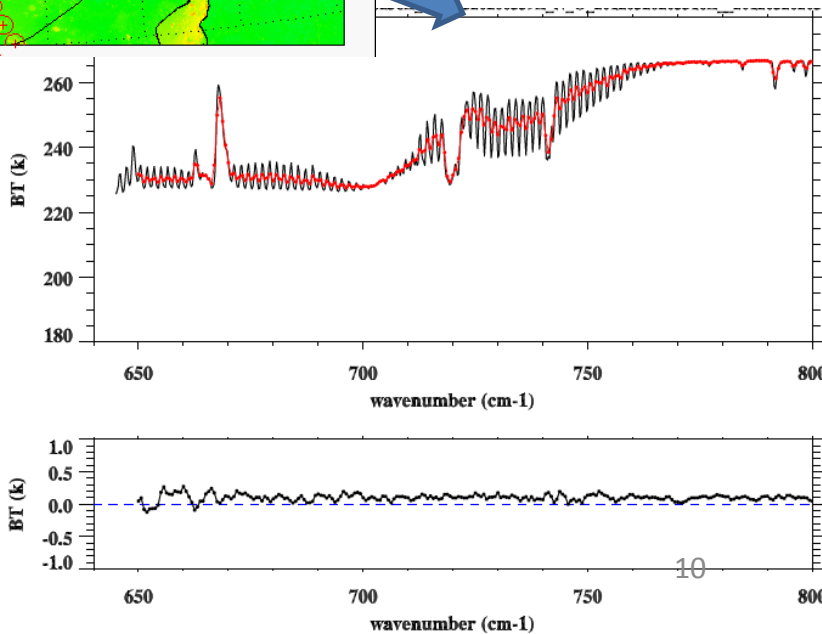
Pixel distance difference: <=(12+14)/4.0 km = 6.5 km

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

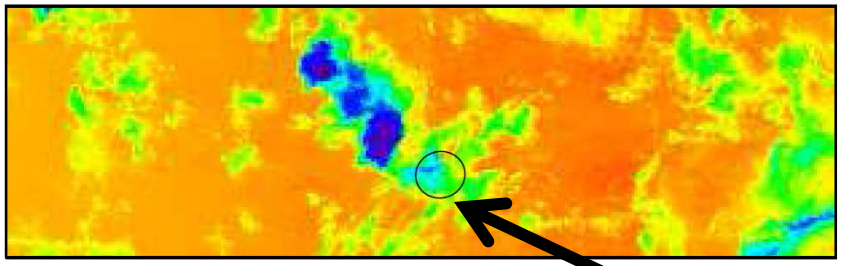
All data are from IDPS.

Only nadir and uniform scenes were selected.

Using the same collocation algorithms to collocate CrIS/IASI with VIIRS.

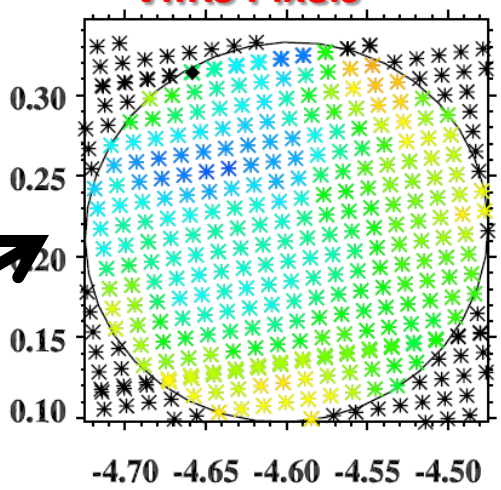


Collocate VIIRS with CrIS/IASI

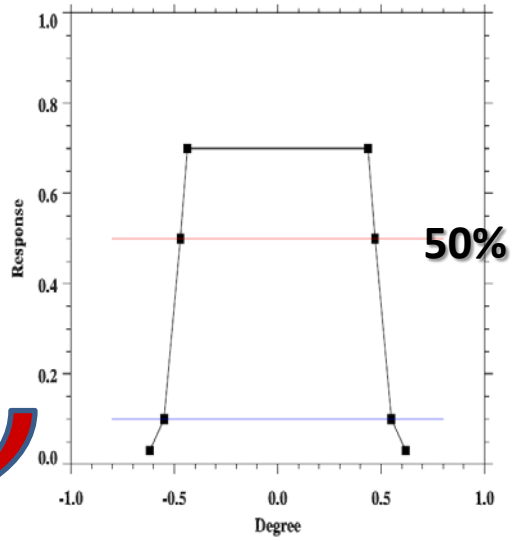


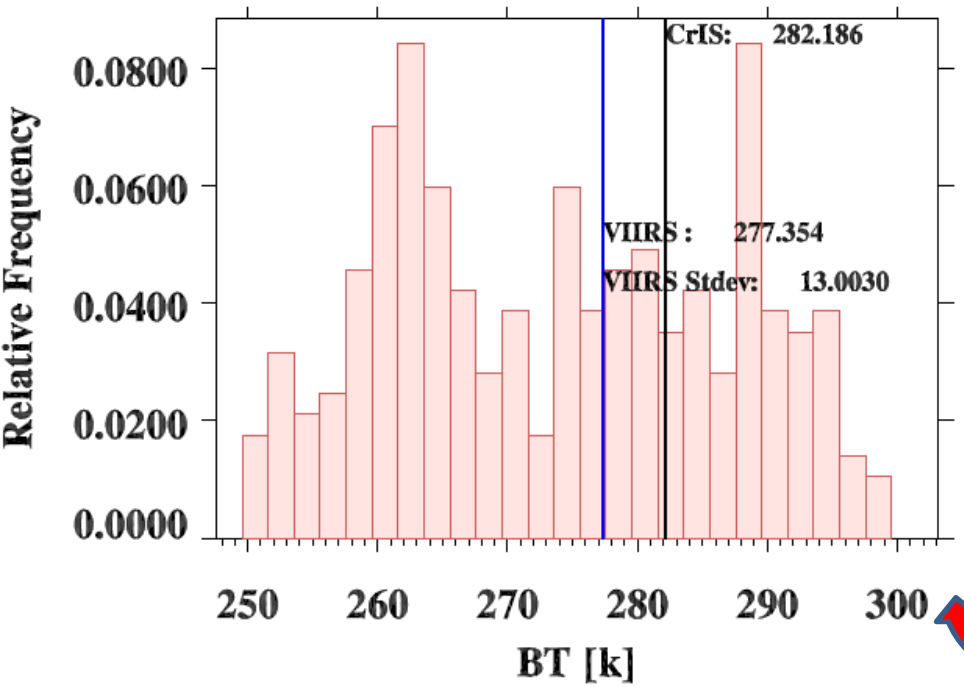
CrIS FOV footprint

VIIRS Pixels



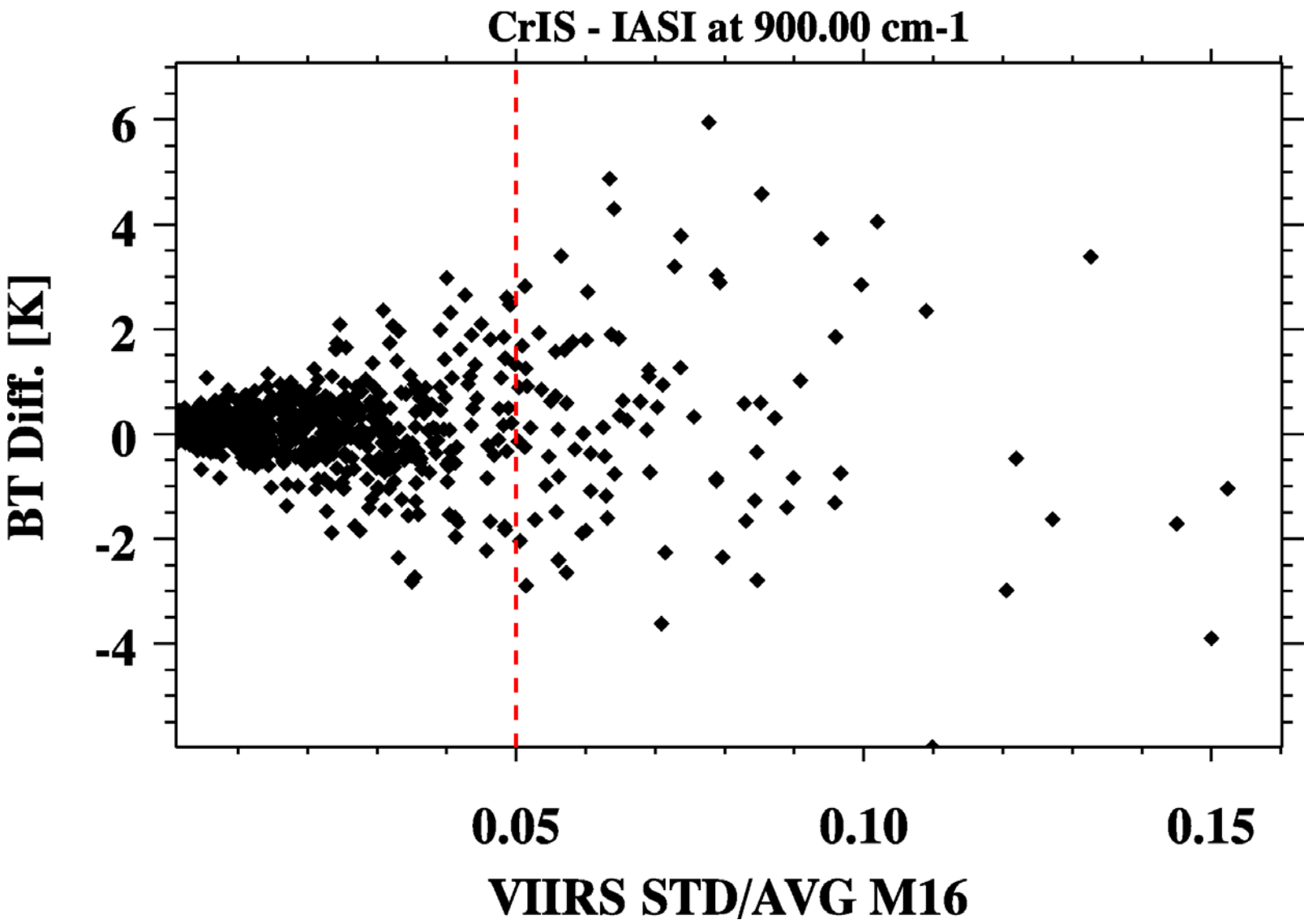
CrIS/IASI FOV Spatial Response



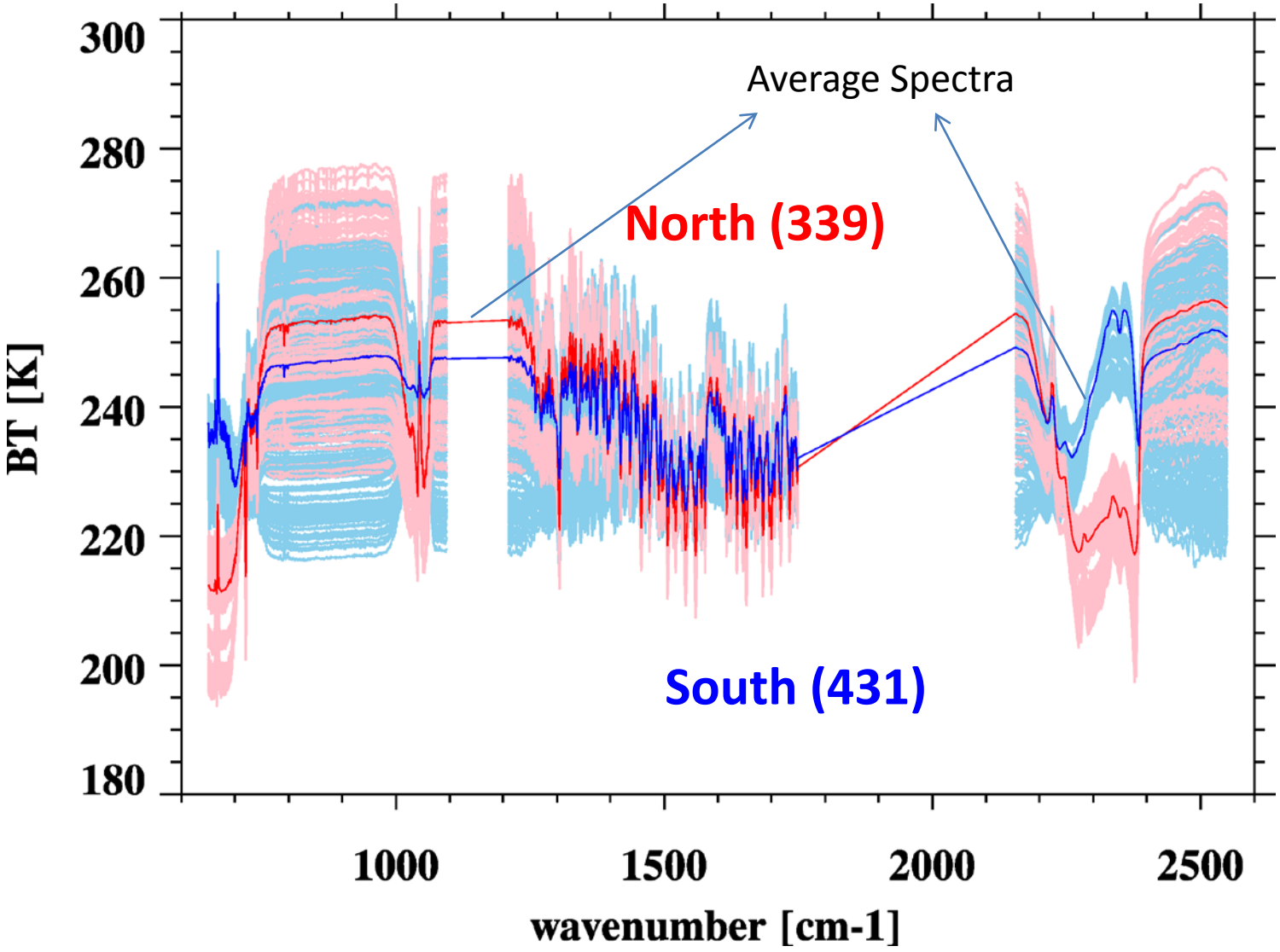


Histogram of VIIRS M16 radiances in CrIS FOV

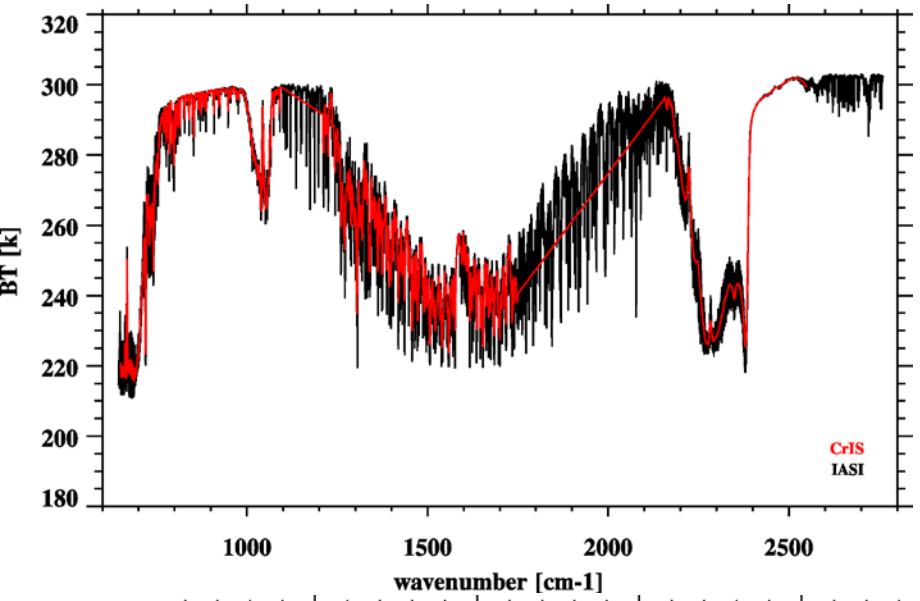
Scene Uniformity

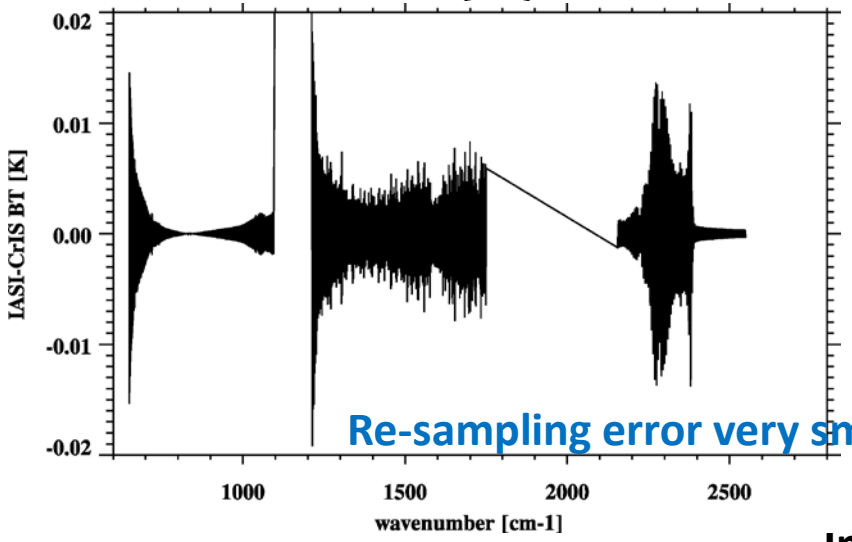


SNO Spectra: 770 Pairs



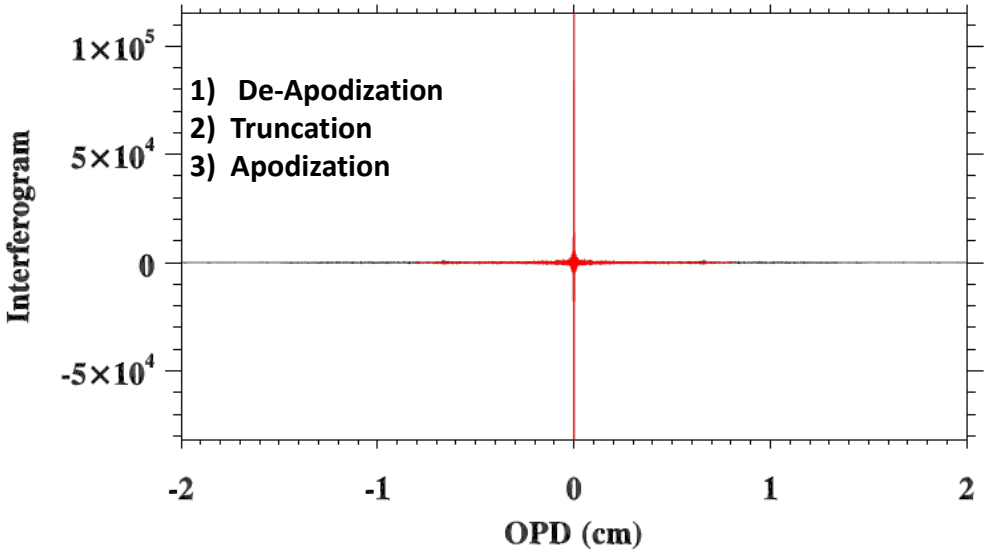
Resample IASI to CrIS





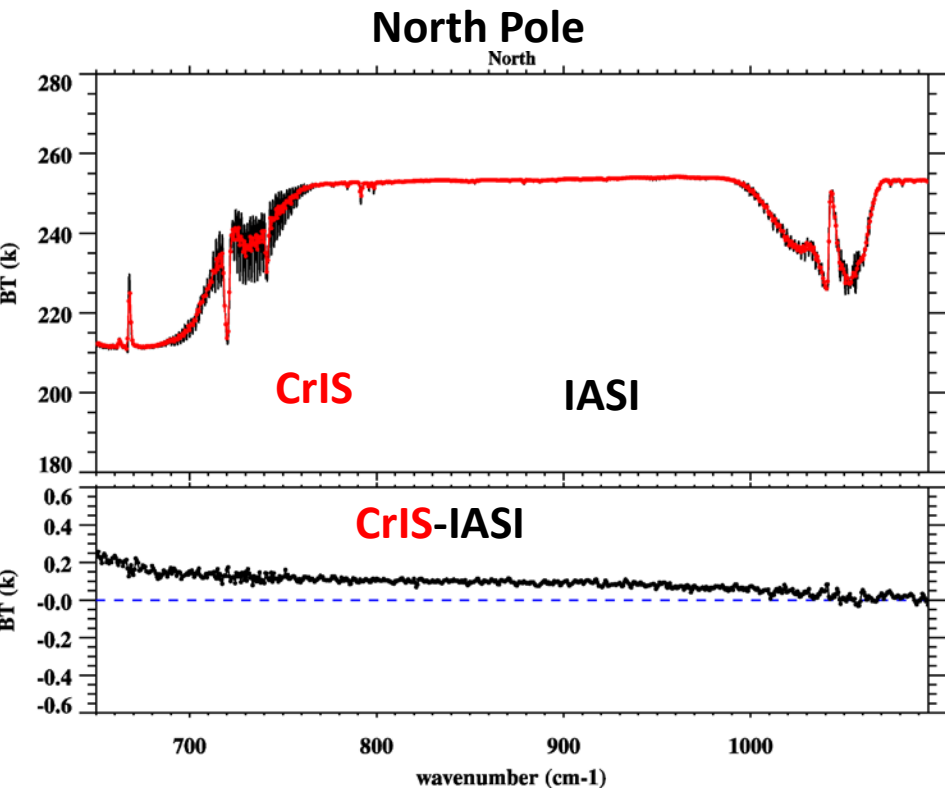
Re-sampling error very small

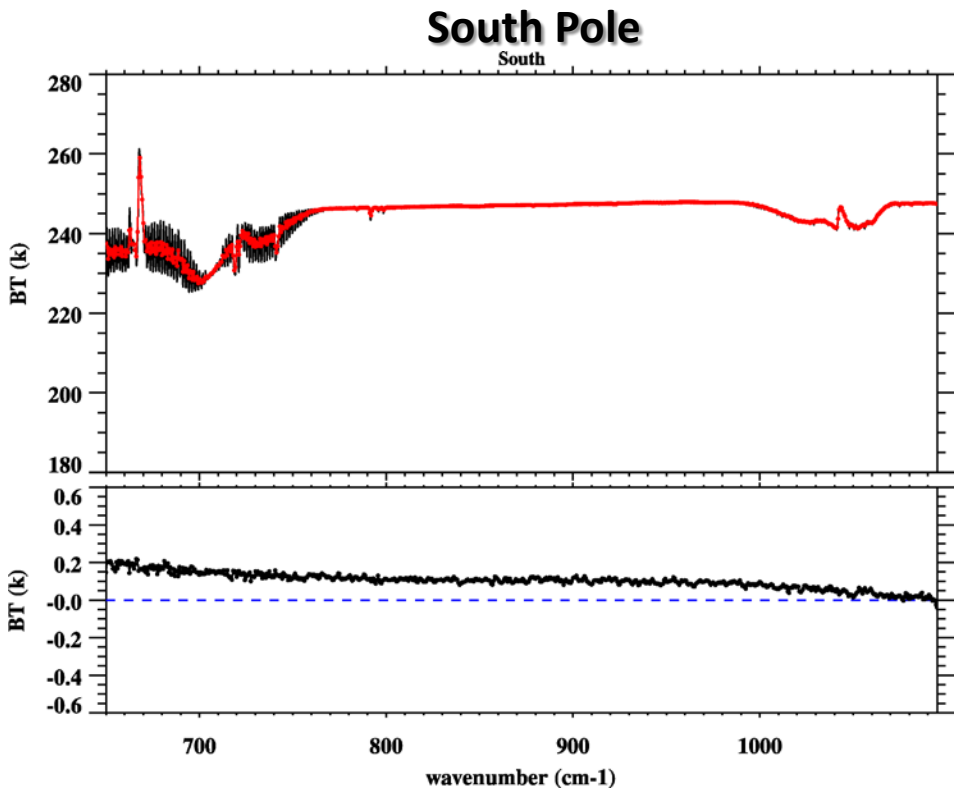
Fourier Transform



Inverse Fourier Transform

CrIS vs. IASI: CrIS Band 1

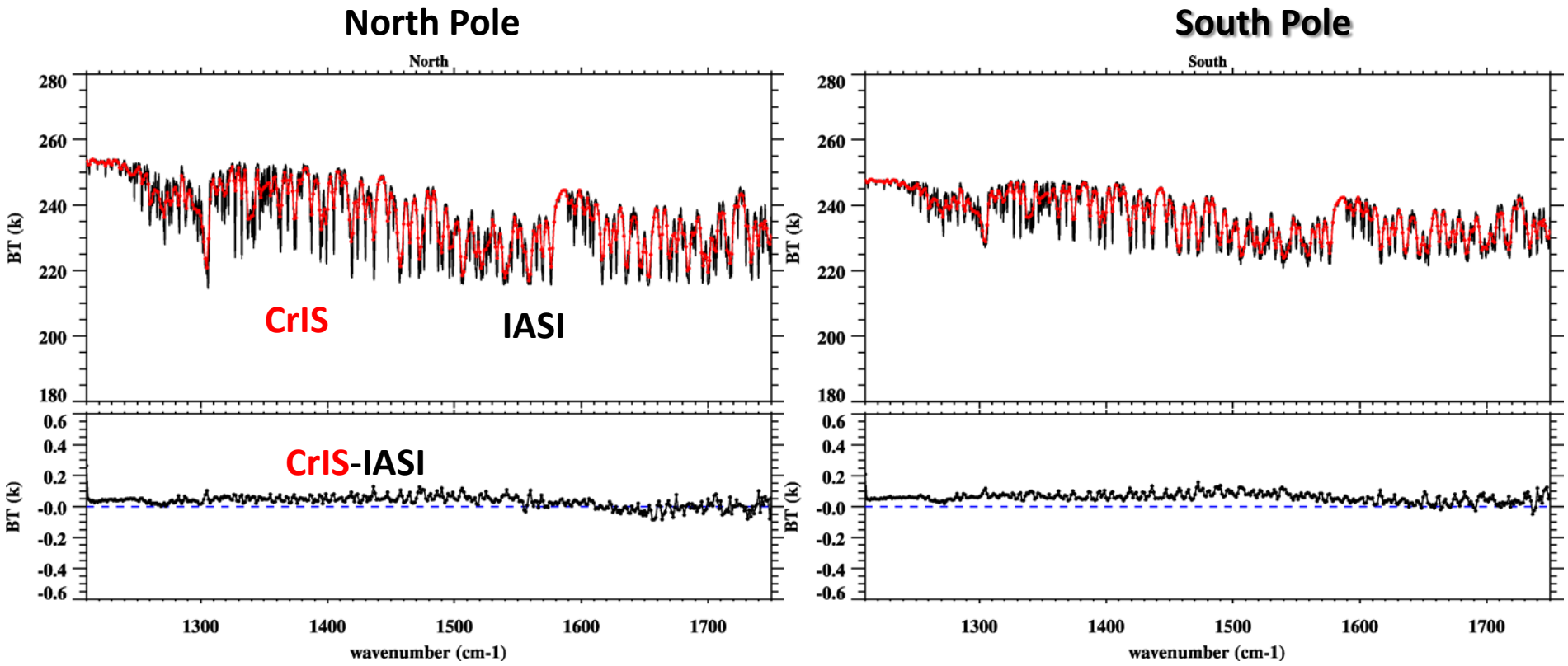




At band 1, CrIS is slightly warmer than IASI.

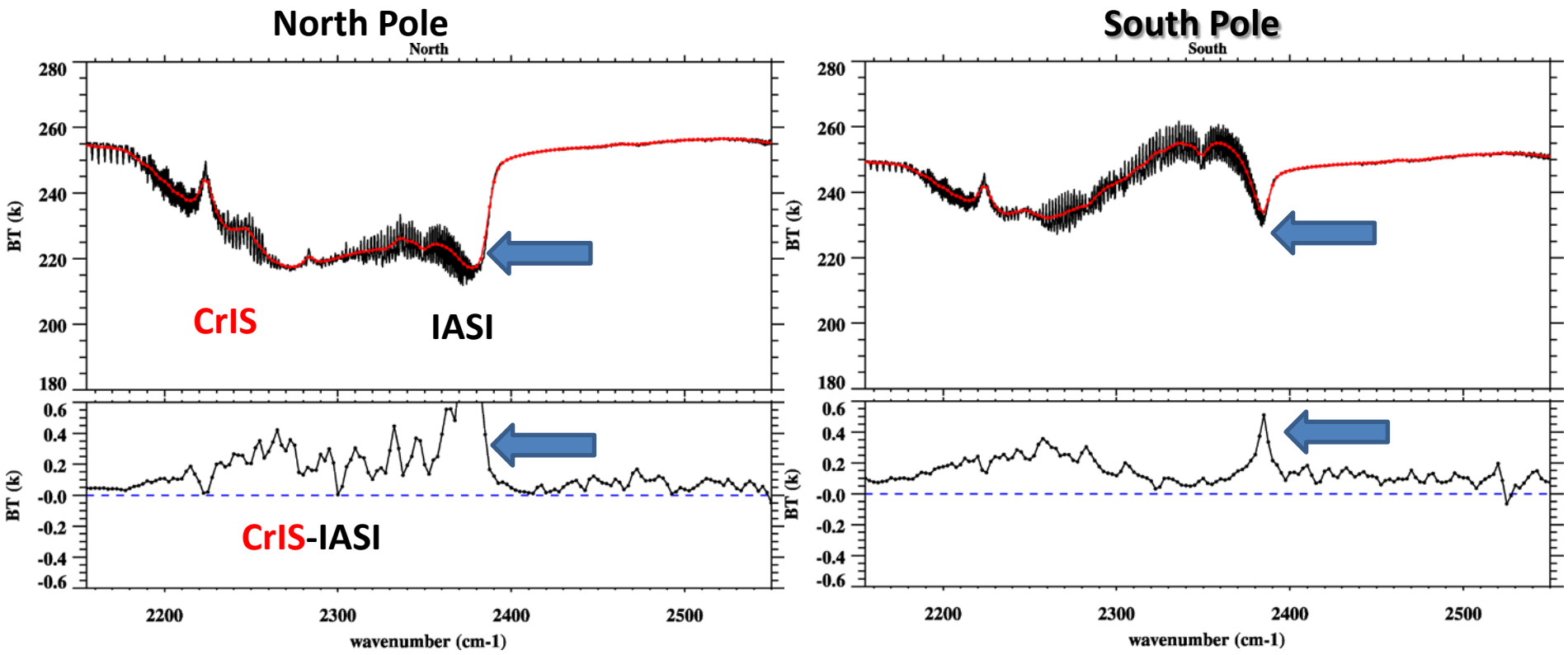
CrIS-IASI BT differences show the slope feature and BT differences decrease with wavenumbers.

CrIS vs. IASI: CrIS Band 2



For band 2 at water vapor absorption region, CrIS and IASI are well consistent and the BT difference is less than 0.1 K

CrIS vs. IASI: CrIS Band 3



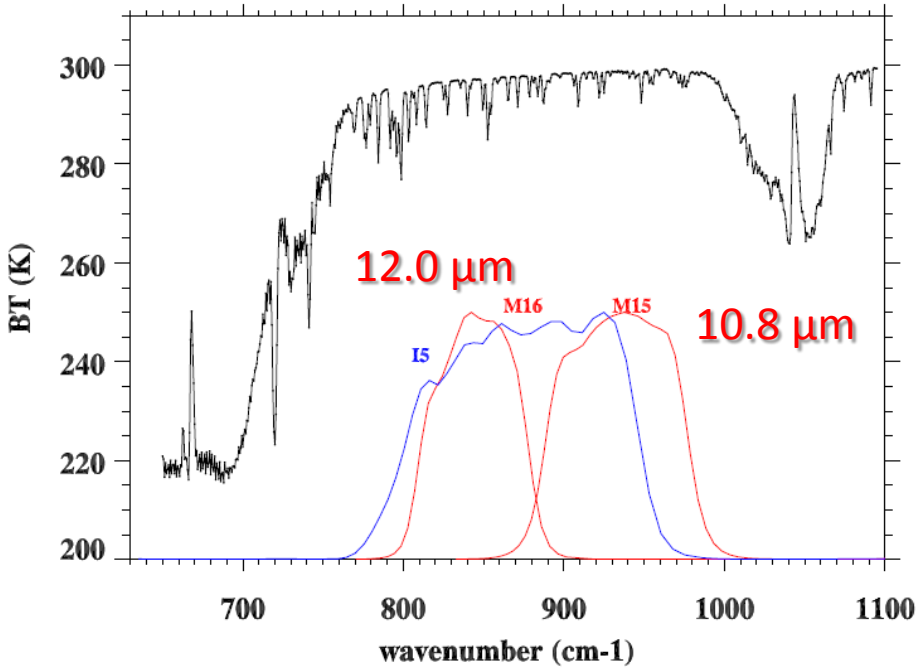
At band 3, CrIS is warmer than IASI .

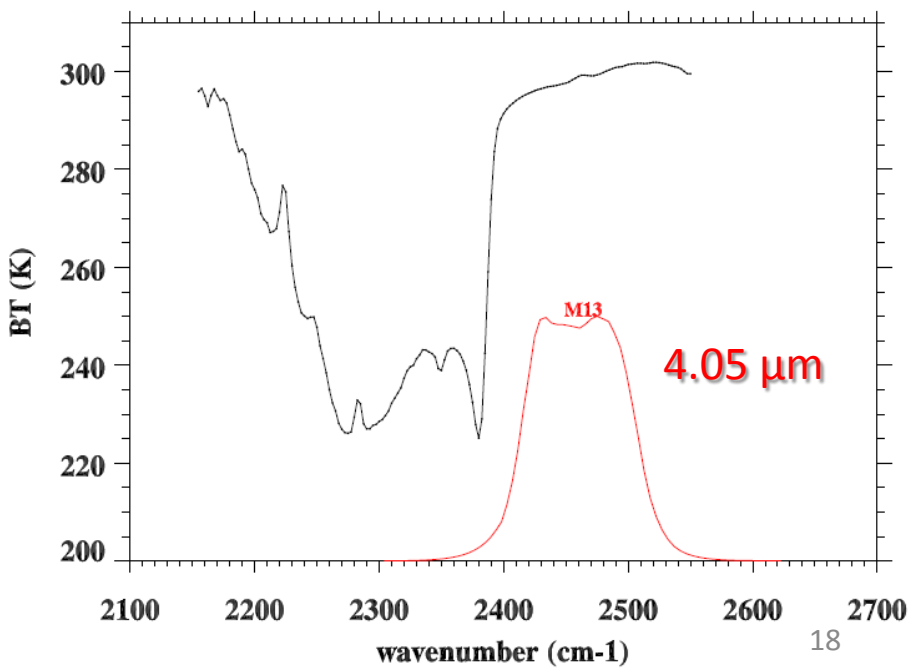
BT differences are large at the spectral transition region (~2380 cm^{-1})

How about CrIS/IASI versus VIIRS?

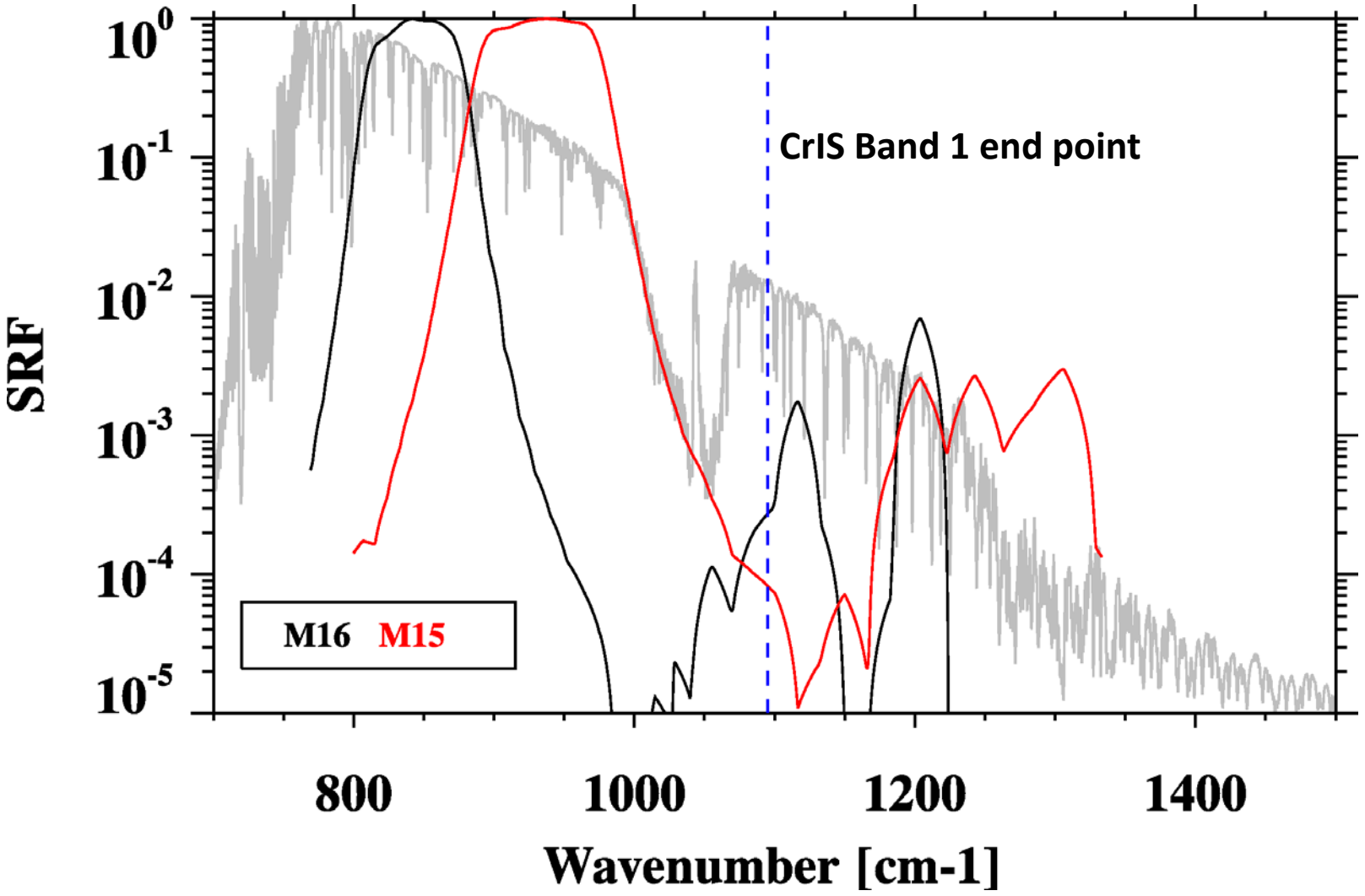
CrIS/IASI spectra are overlapped with VIIRS SRFs for M13, M15, and M16, and I5

$$L_i = \frac{\int_{\nu_1}^{\nu_2} R(\nu) S_i(\nu) d\nu}{\int_{\nu_1}^{\nu_2} S_i(\nu) d\nu}$$



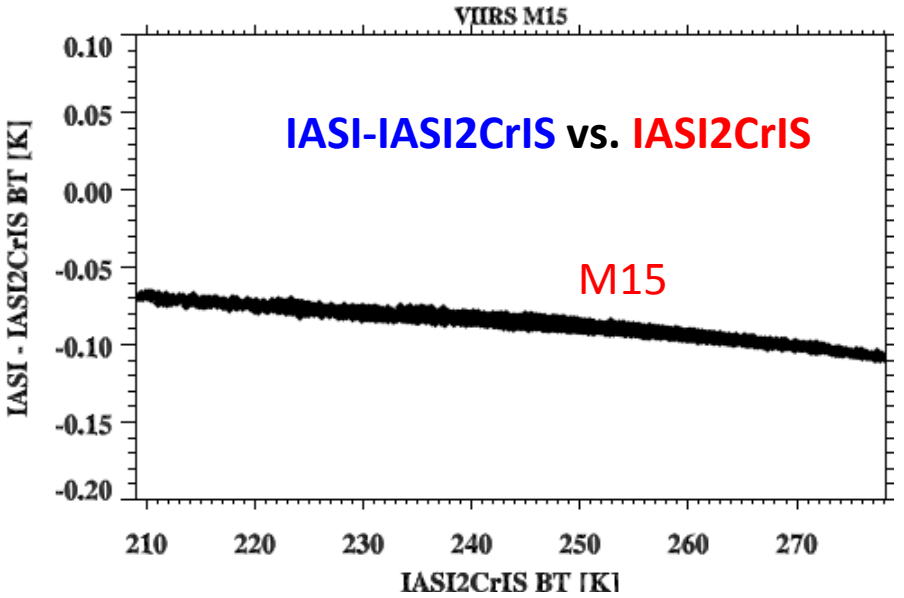


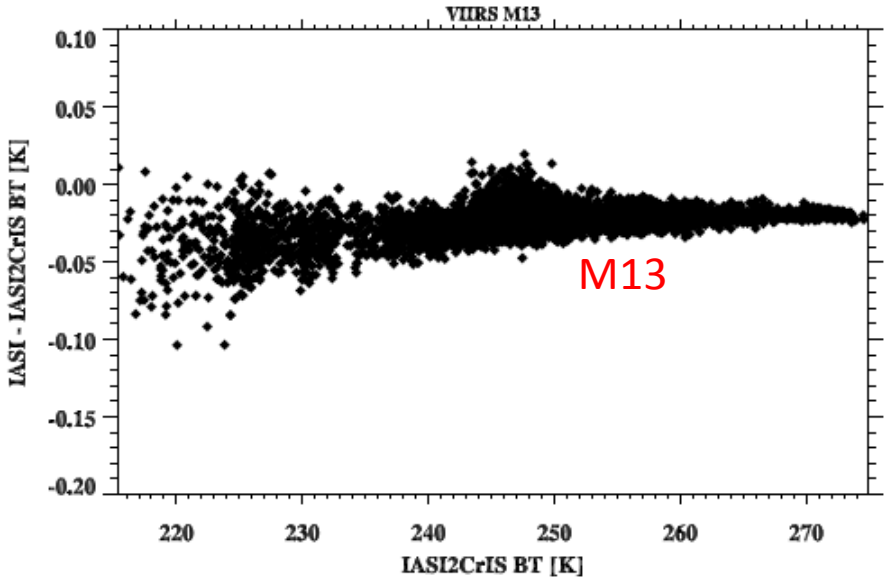
Be careful for out-of-band response!

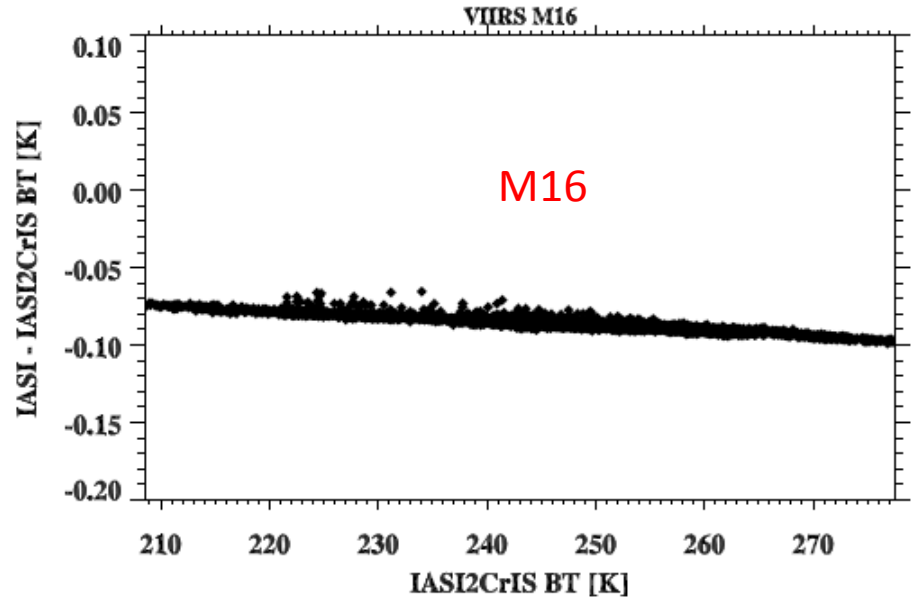


Center wavenumber and band correction coefficients are calculated using the above SRFs.

OOB effects in BTs

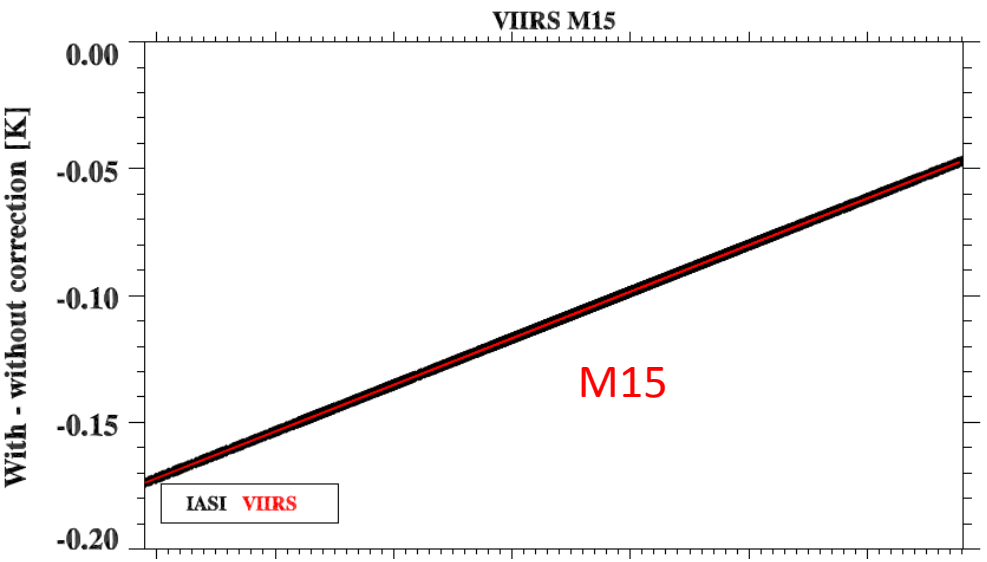


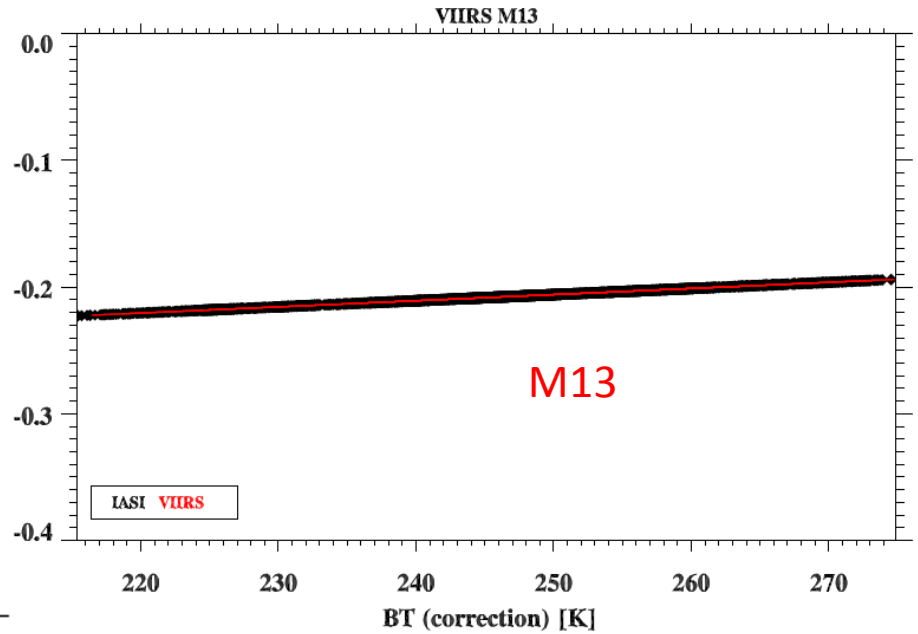


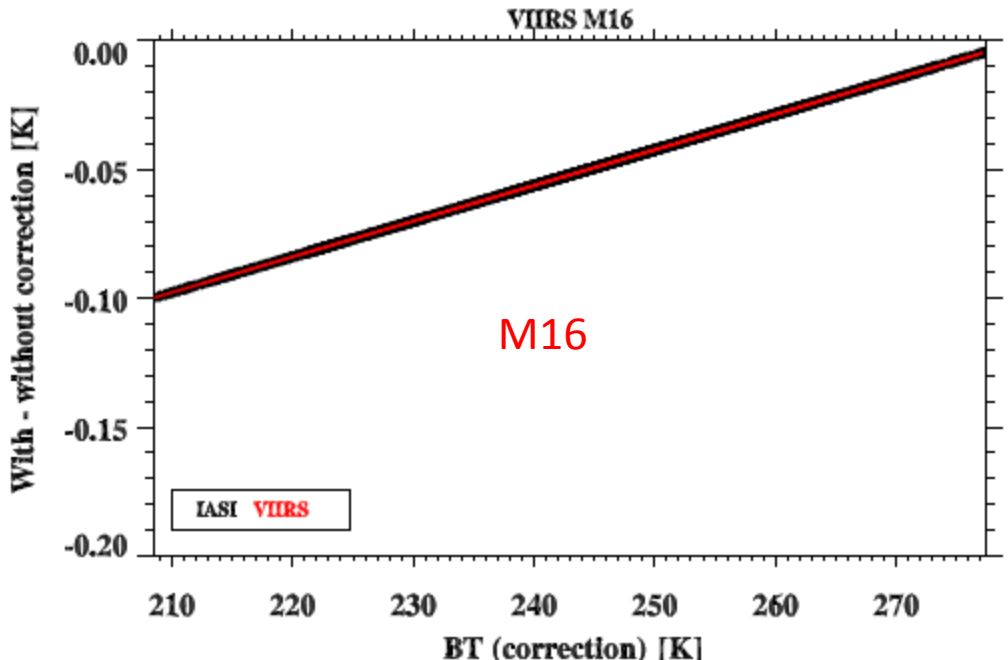


This relationship is used to compensate CrIS convolution results.

Band Correction





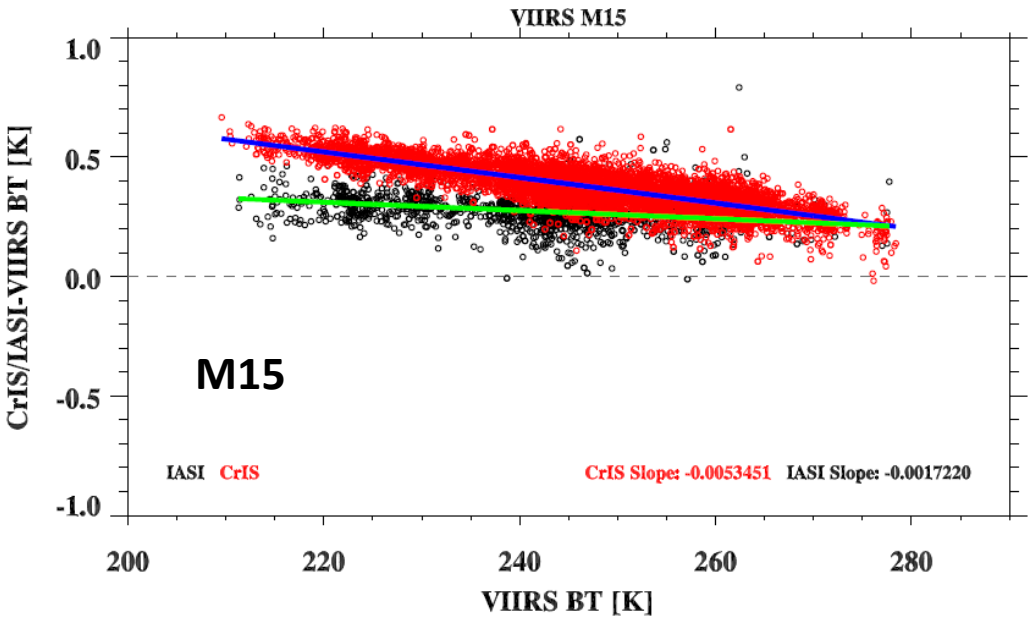


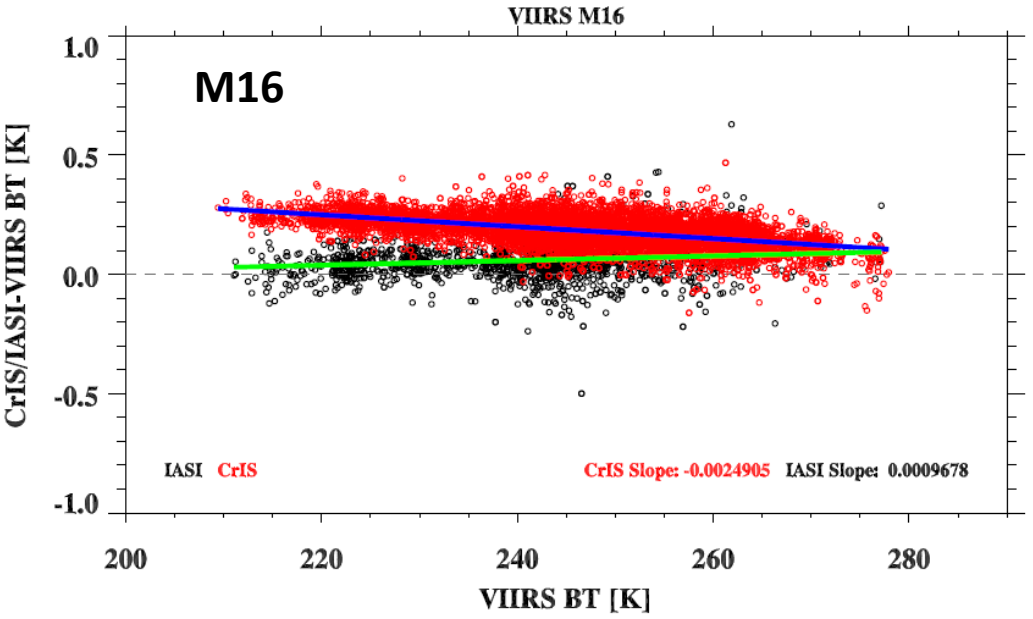
From VIIRS radiances to BTs
Unit: [W m^{-2} sr^{-1} µm^{-1}]

From CrIS/IASI radiances to BTs
Unit: [mW m^{-2} sr^{-1} cm^{-1}]

Band correction on BT domain should give identical values.

CrIS/IASI versus VIIRS

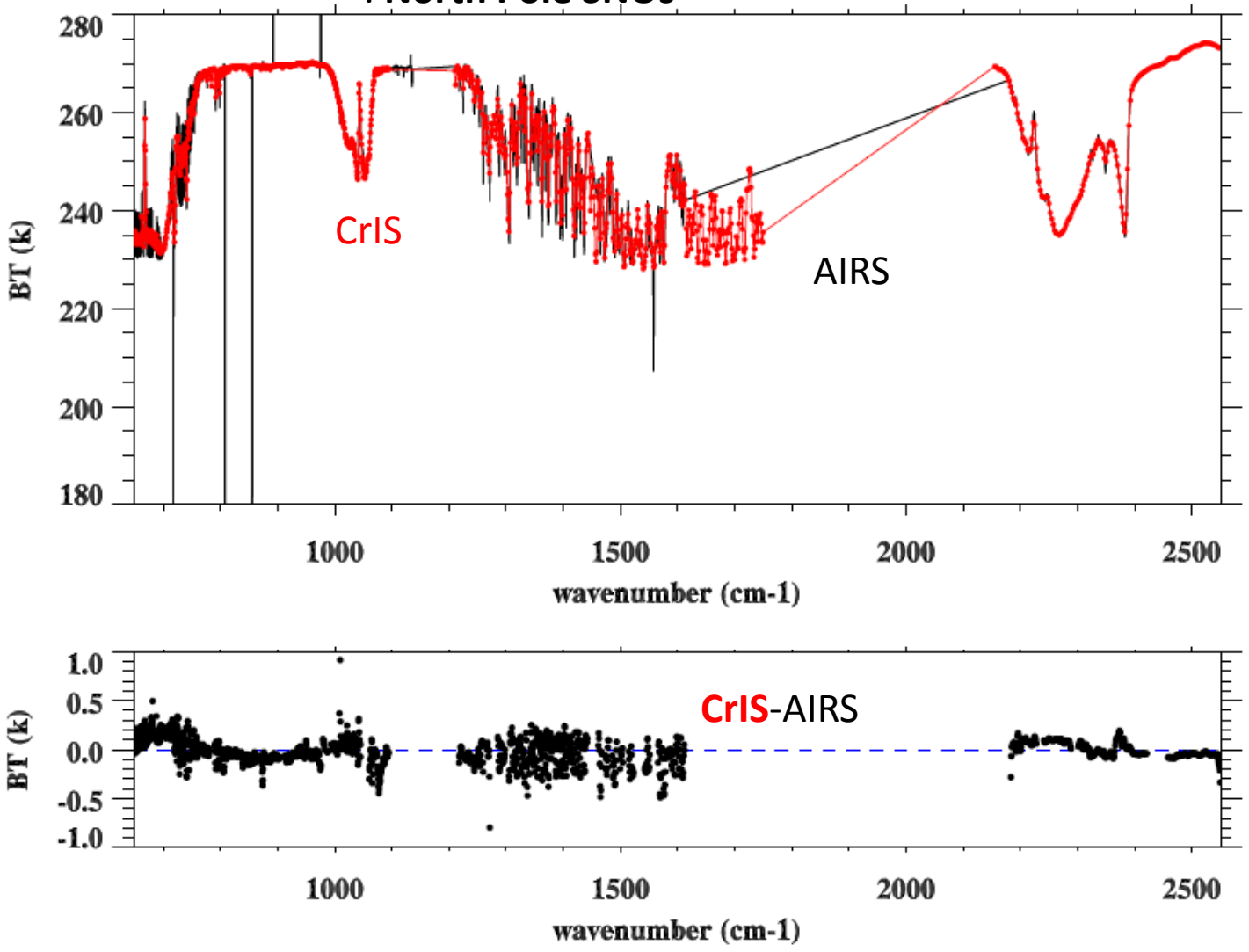




- CrIS is warmer than all sensors; CrIS-VIIRS at Band 15 has larger scene-dependence than M16
- IASI seems close to VIIRS and does not show scene dependence features.
- Using VIIRS as a reference, CrIS is warmer than IASI , especially for cold scenes.

AIRS vs. CrIS

: North Pole SNOs



Conclusion Remarks

- Inter-comparison of CrIS with IASI indicate that the consistency between CrIS and IASI is around 0.1-0.2 K at most spectral regions.

- Given current consistency level (0.1-0.2 K), it is very hard to find the root causes of the differences. However, in order to generate long-term climate data records, some issues still need further investigation:
  - CrIS is warmer than IASI at the longwave band, especially for cold scenes
  - CrIS-VIIRS scene-dependent features at M15
  - Spectral inconsistency for shortwave sharp transition regions between CrIS and IASI

- Looking forward: we really need **MetOp-B IASI** data to join in inter-comparison, which will facilitate the diagnosis.

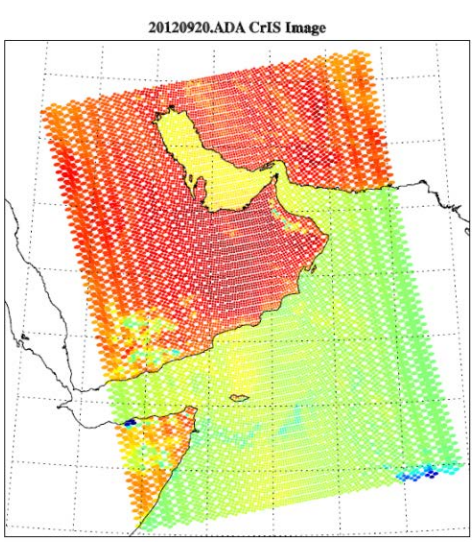
Thank you

Before and After correction

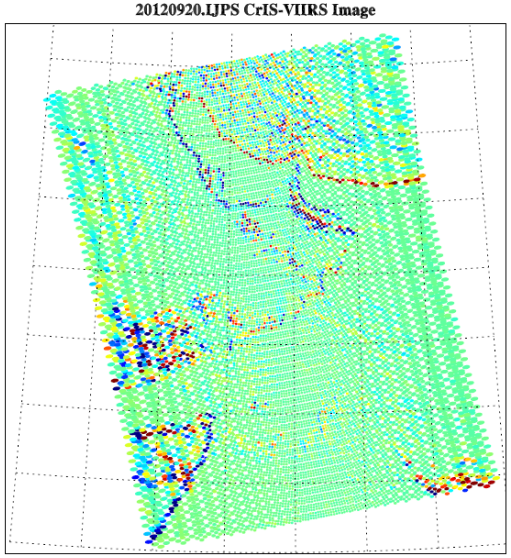
- Software bug was discovered in the operational code.
- Code fix was engineered by STAR and delivered to IDPS for implementation.

Without correction

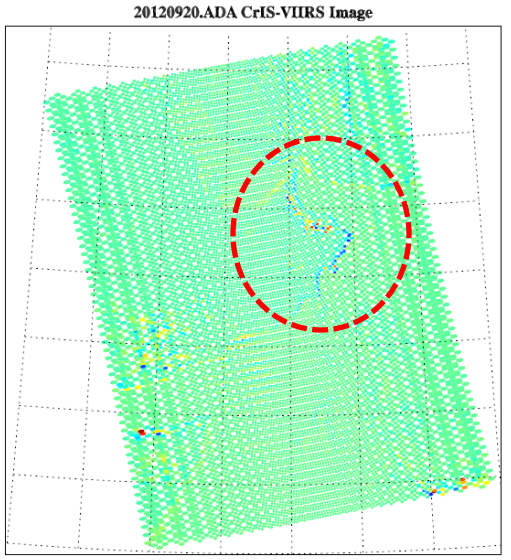
With correction



CrIS



CrIS-VIIRS



CrIS-VIIRS

- Geolocation code has been fixed and implemented in MX6.3 (10/16/2012)

- Geolocation accuracy is estimated to be 1.0 km within 30° scan angles.