CrIS SDR Calibration and Cross-sensor Comparisons

Yong Han
NOAA Center for Satellite Applications and Research, College Park, MD, USA
and
CrIS SDR Science Team

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Outline

- CrIS SDR Science Team
- Data processing and Cal/Val process
- SDR product quality and calibration uncertainties
- Cross-sensor comparisons
- Summary

SDR: Sensor Data Record

JPSS CrIS SDR Science Team member & Cal/Val Process

CrIS SDR calibration and validation (Cal/Val) team members (Subject Matter Experts):

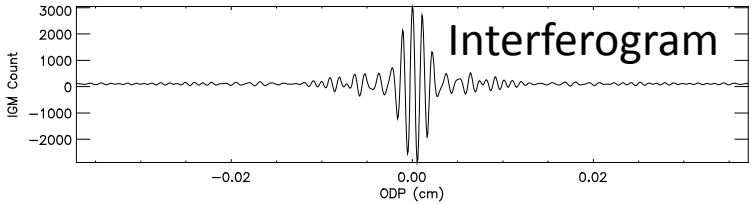
Organization	PI
NOAA Center for Satellite Applications & Research (NOAA/STAR)	Yong Han
University of Wisconsin (UW)	Hank Revercomb
University of Maryland Baltimore County (UMBC)	Larrabee Strow
Space Dynamics Laboratory/Utah State University (SDL)	Deron Scott
Massachusetts Institute of Technology/Lincoln Labs (MIT/LL)	Dan Mooney
Northrop Grumman Aerospace Systems	Degui Gu
Exelis-ITT	Mike Cromp
NASA	Dave Johnson
Raytheon	Wael Ibrahim

CrIS SDR Validation phases:

- Early Orbit Checkout (**EOC**), 18 January – 23 February 2012
- Intensive Calibration and Validation (**ICV**), 23 February 2012 – 20 December 2013
- Long-term Monitoring (**LTM**), remaining NPP mission

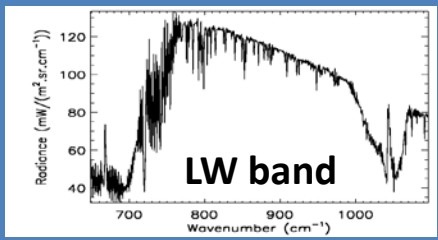
CrIS System

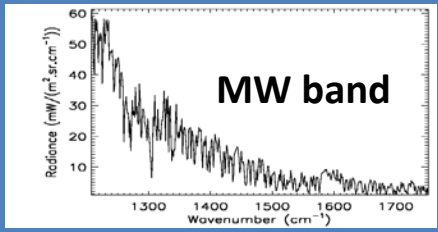
CrIS instrument provides interferograms & calibration data

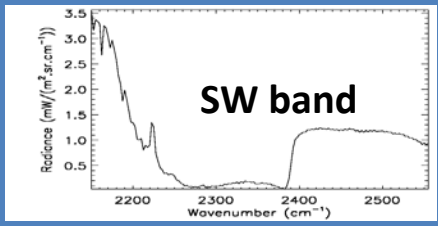


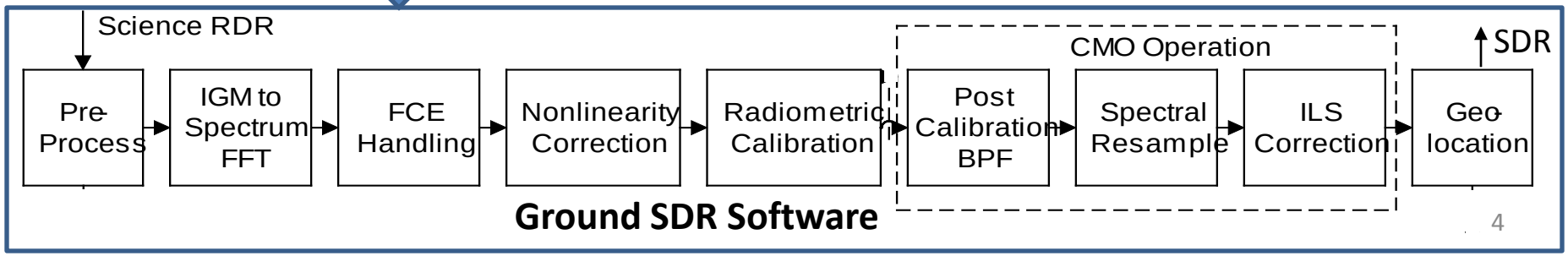
SDR Product

Radiance Spectra







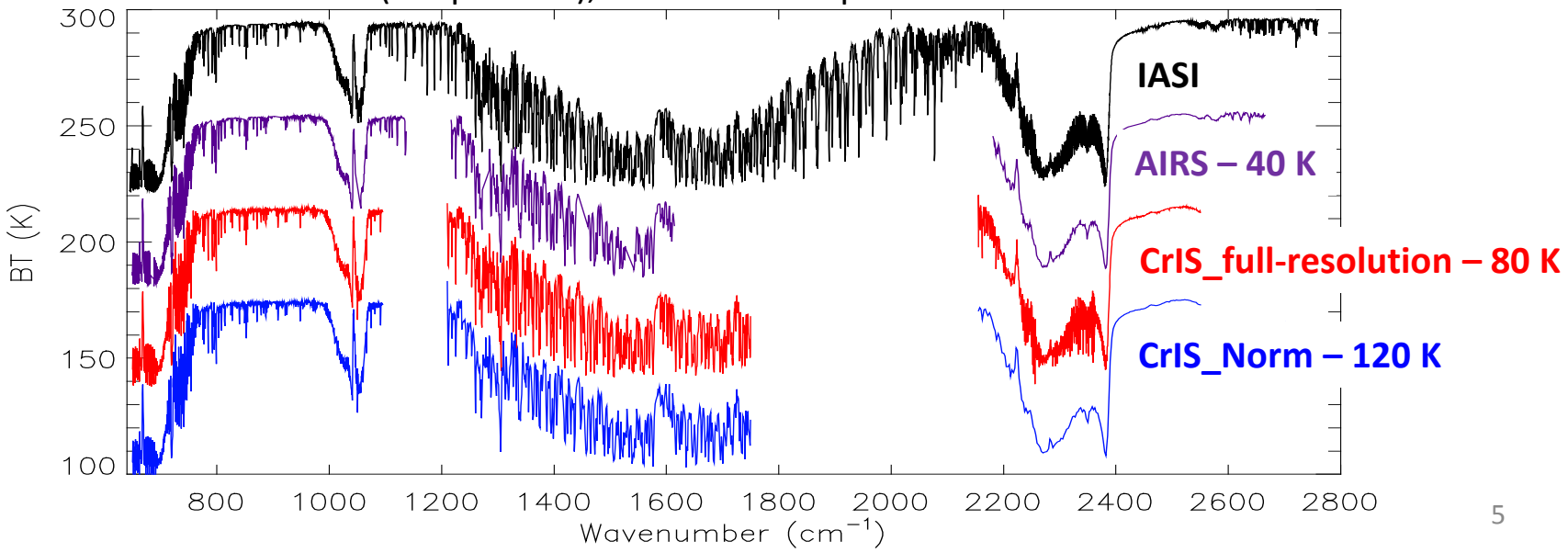


CrIS Spectral Parameters

Band	Spectral Range (cm^{-1})	Normal Mode		Full Resolution Mode*	
		Resolution (cm^{-1})	MPD (cm)	Resolution (cm^{-1})	MPD (cm)
LW	650-1095	0.625	0.8	0.625	0.8
MW	1210-1750	1.25	0.4	0.625	0.8
SW	2155-2550	2.5	0.2	0.625	0.8

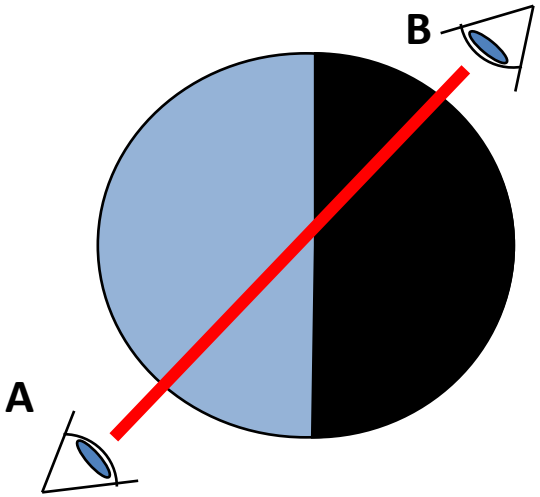
* NOAA intends to operate CrIS in full spectral resolution (FSR) mode in near future

Simulated CrIS (unapodized), IASI and AIRS spectra

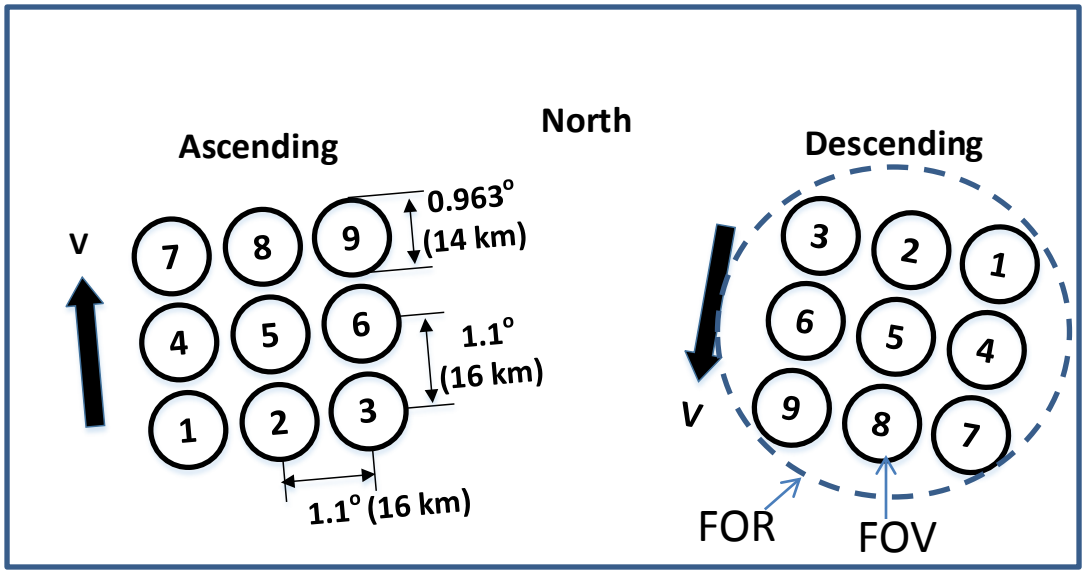


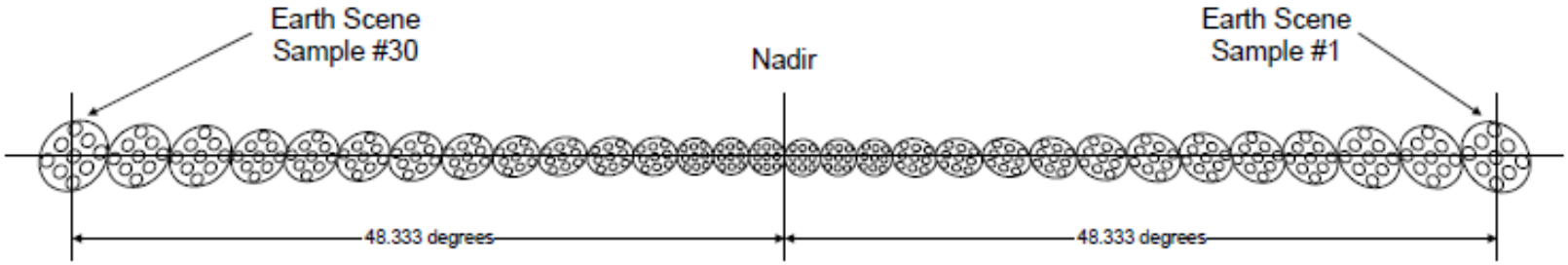
CrIS FOV, FOR and Scan

A - ascending **B - descending**



Nadir FOV footprints

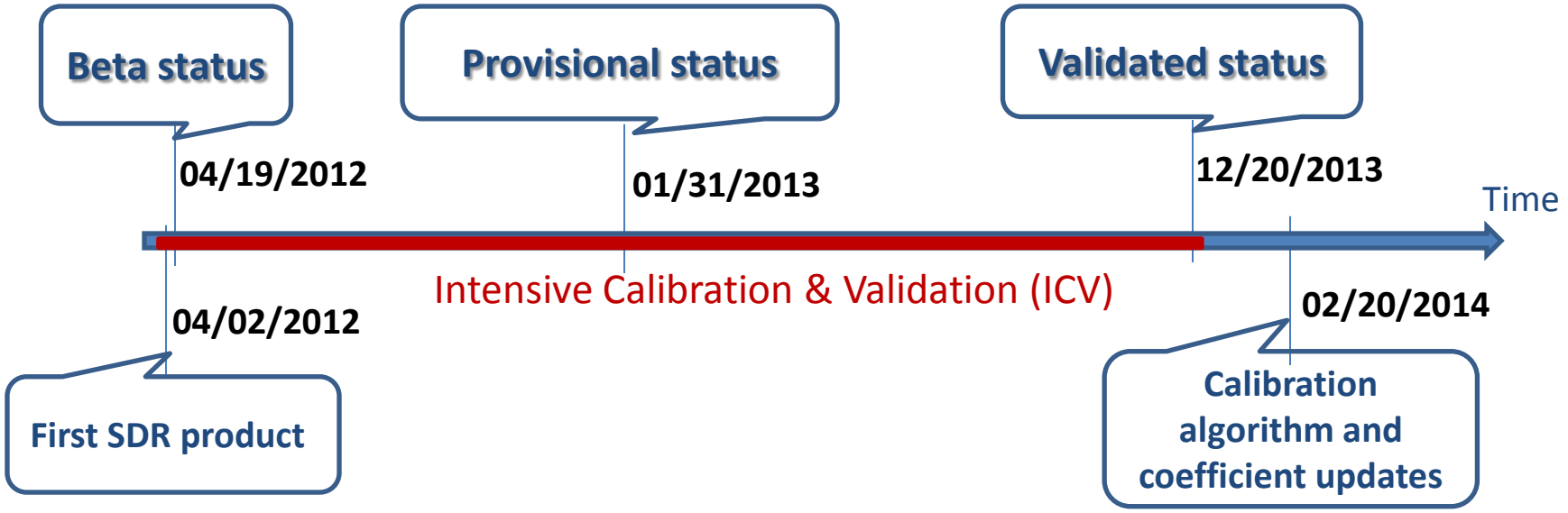




- Each scan has 30 Earth view Field of Regards (FORs)
- Each FOR has 9 Field of Views (FOVs)

CrIS SDR CalVal Milestones

SDR validated in three stages: Beta, Provisional, and Validated



- Major ICV activities
  - SDR algorithm and software improvement
  - CrIS performance characterization
  - Radiometric CalVal
  - Spectral CalVal
  - Geolocation CalVal
  - CrIS instrument and SDR trending and monitoring

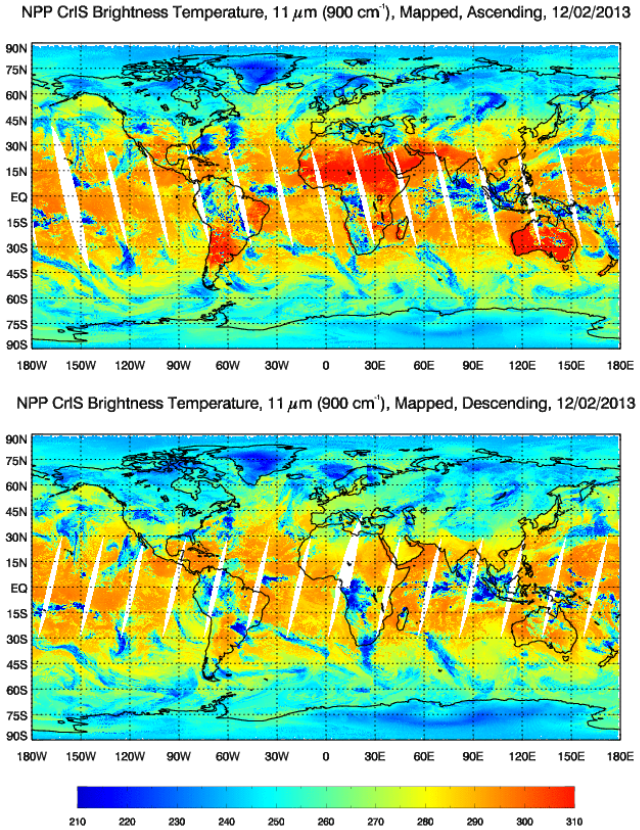
CrIS Data and SDR Software Available to Public

- CrIS Raw Data Records (RDRs) and Sensor Data Records (SDRs)
  - RDRs: interferogram measurements and calibration data (inputs of the SDR software)
  - SDR: radiance products (outputs of the SDR software)
  - **Data available at** http://www.nsof.class.noaa.gov/saa/products/welcome
- CrIS SDR software (ADL)
  - CrIS SDR software is a component of the Algorithm Development Library (ADL), which runs on Linux as well as some other computing platforms
  - ADL shares the same processing software as the operational software that runs on the Interface Data Processing Segment (IDPS)
  - **ADL software package available at**

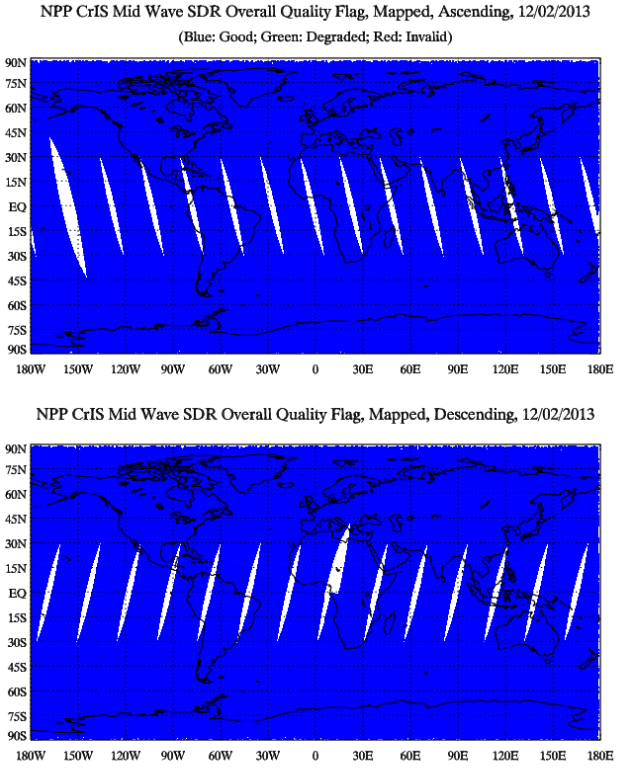
  https://jpss-adl-wiki.ssec.wisc.edu/mediawiki/index.php/ADL_Algorithm_Development_Library

Example of SDR Product Items

Radiance (900 cm^{-1})



Overall SDR quality flag (Blue – good)



CrIS SDR User's Guide: http://www.star.nesdis.noaa.gov/jpss/documents/UserGuides/CrIS_SDR_Users_Guide_1p0_TBD.pdf

CrIS data monitoring website: http://www.star.nesdis.noaa.gov/icvs/status_NPP_CrIS.php

CrIS Data Quality and Calibration Uncertainty Estimates

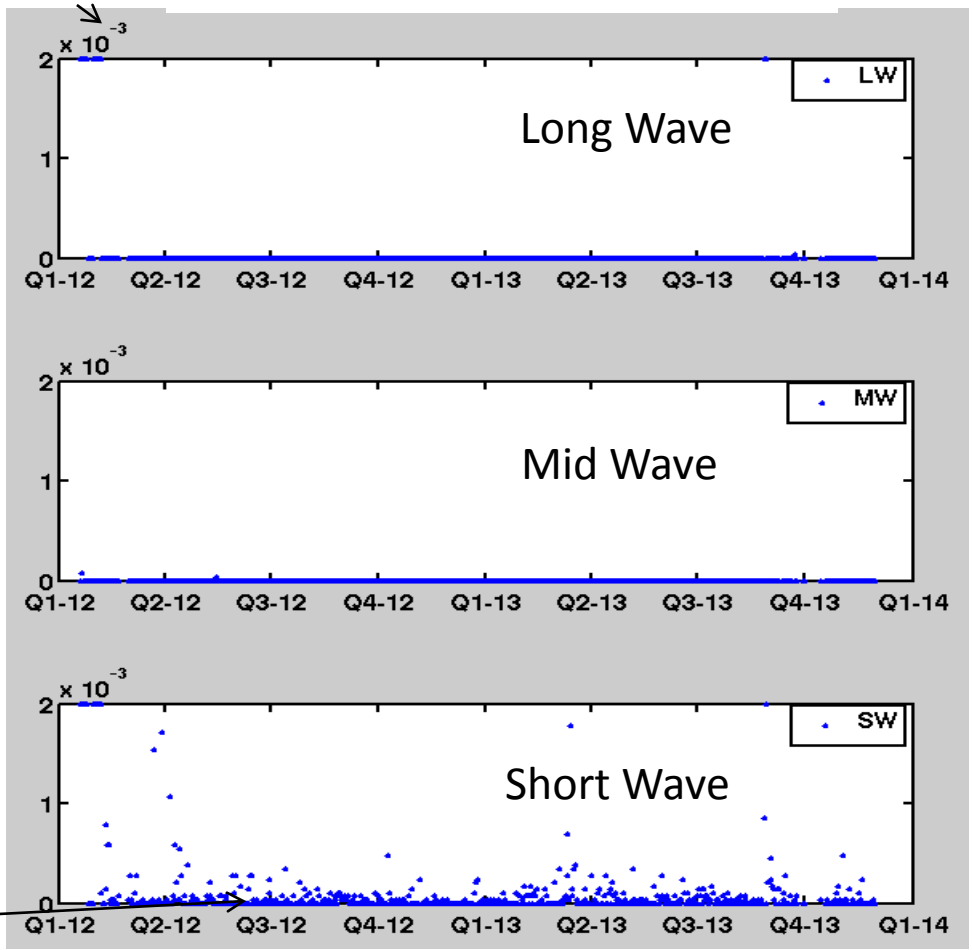
CrIS Data Quality

Daily occurrence of Good SDR spectra

LW	99.9817%
MW	99.9817%
SW	99.9816%

- **No ice contamination on detector so far**
- **No significant South Atlantic Anomaly (SAA) impact**
- **No Fringe Count Error (FCE) so far**

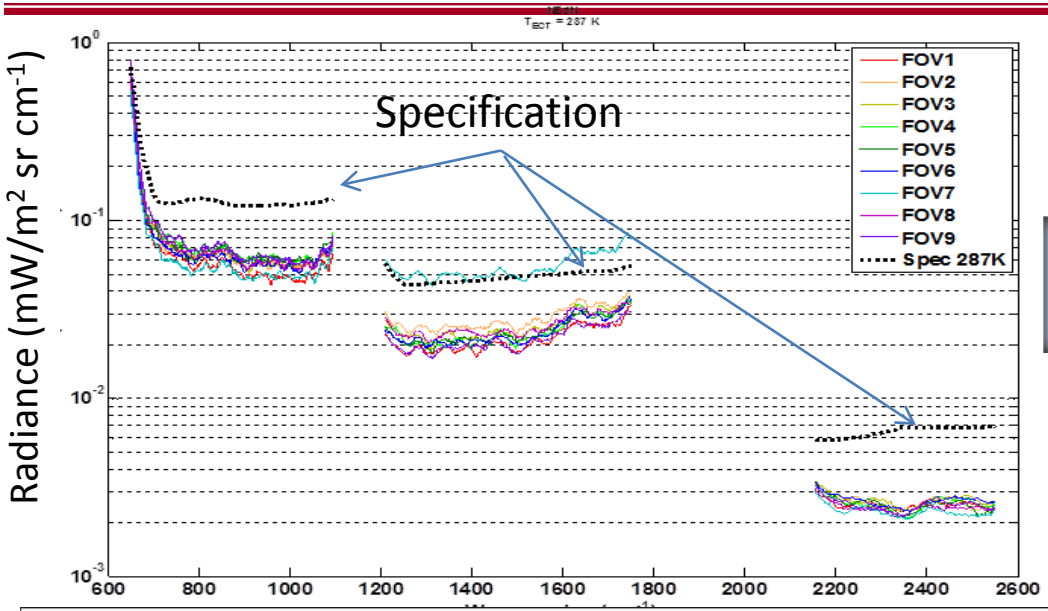
Daily Percentage of Invalid interferogram measurements



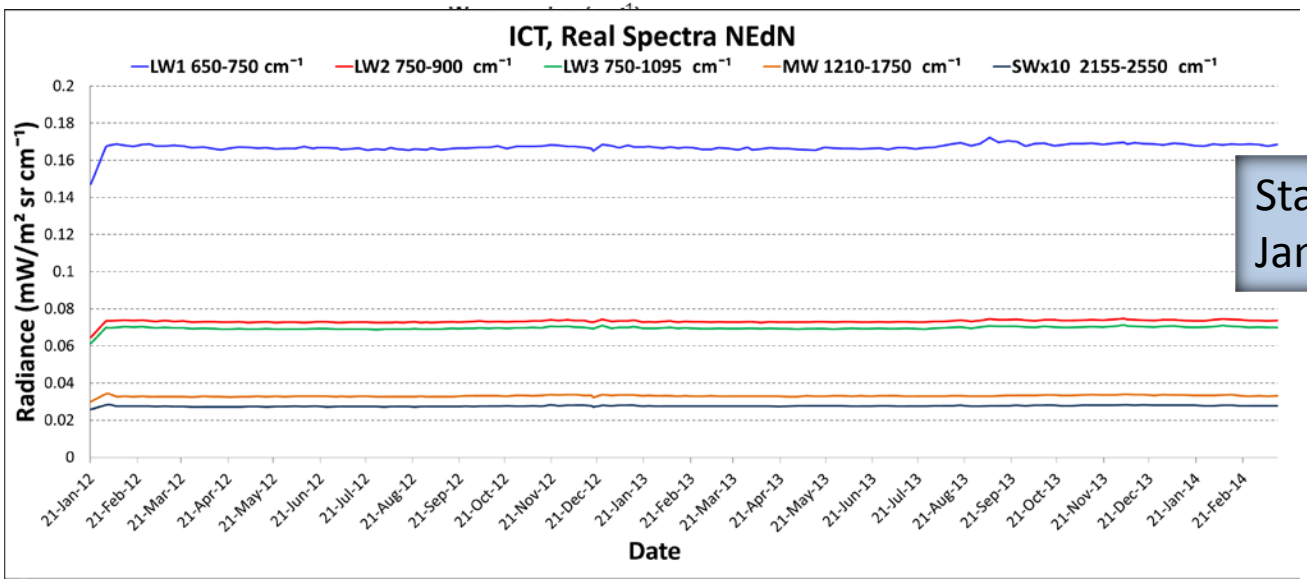
Mainly due to sun-glint saturation

Han et al. 2013, JGR

CrIS Noise (NEdN)



The noise levels substantially better than specification



Stable NEdN
Jan 2012 to Feb 2014

Zavyalov et al. 2013, JGR

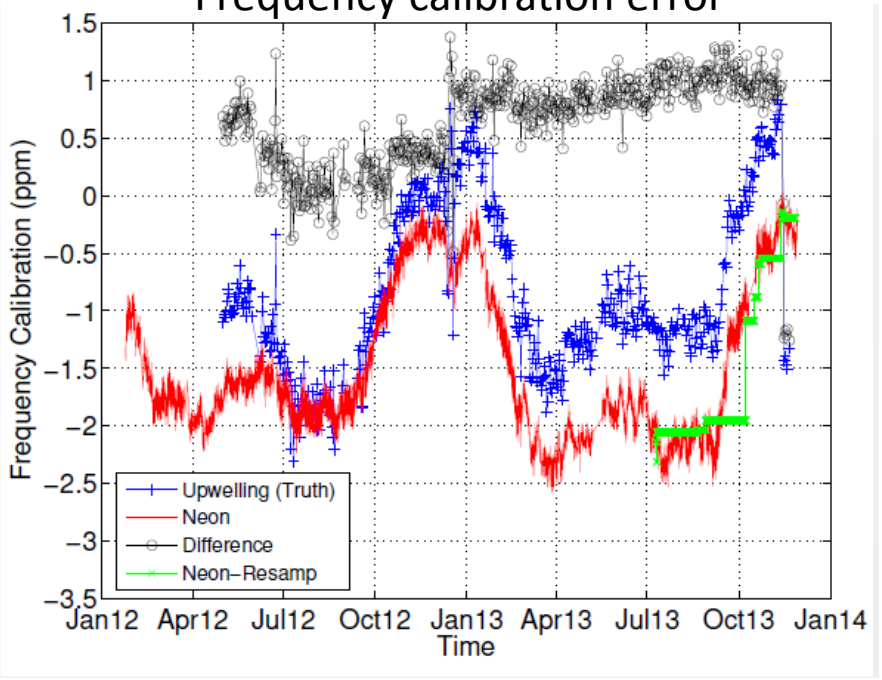
Spectral Calibration Accuracy

Spectral calibration accuracy (all FOVs & all bands):

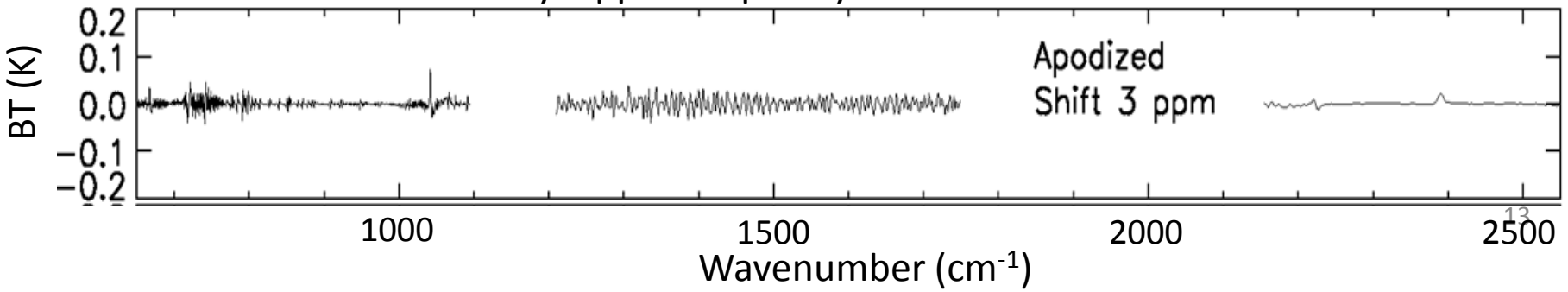
< 3 ppm

Strow et al. 2013, JGR

Frequency calibration error



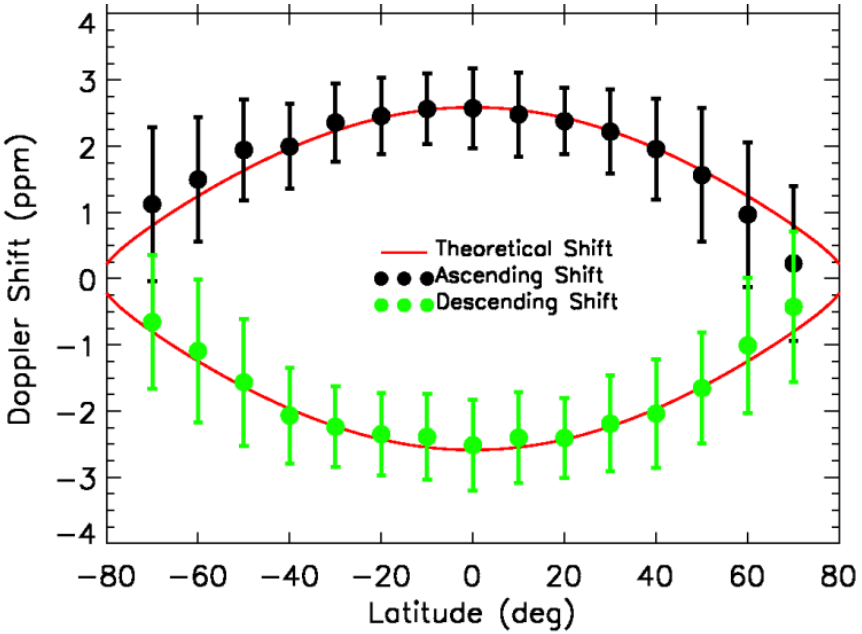
Radiance error caused by 3 ppm frequency error



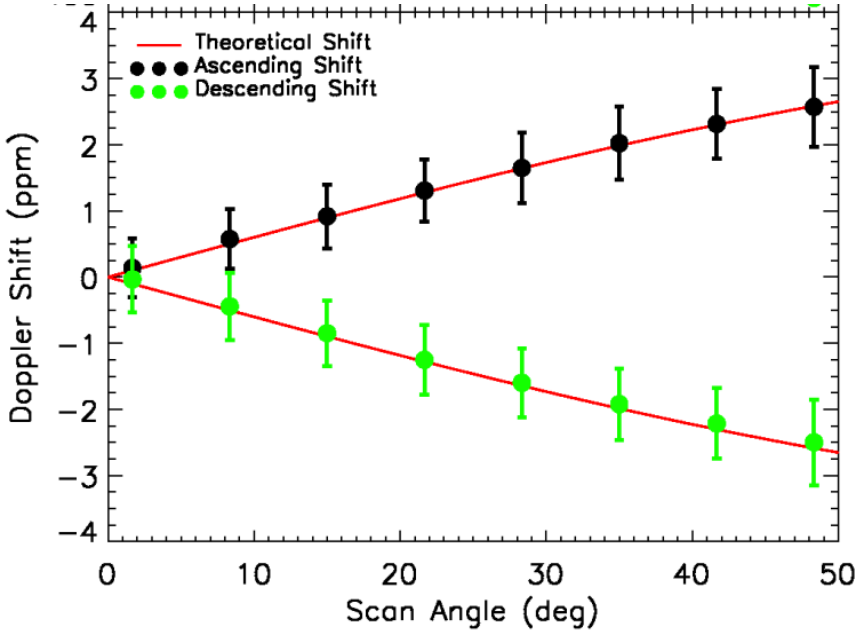
Earth-rotation Doppler Effect

- **Doppler frequency shift up to 1.25 ppm detected, which matches to the theory**
- **The shift is small and is not corrected**

FOR1 relative to FOR30 frequency shift as a function of latitude



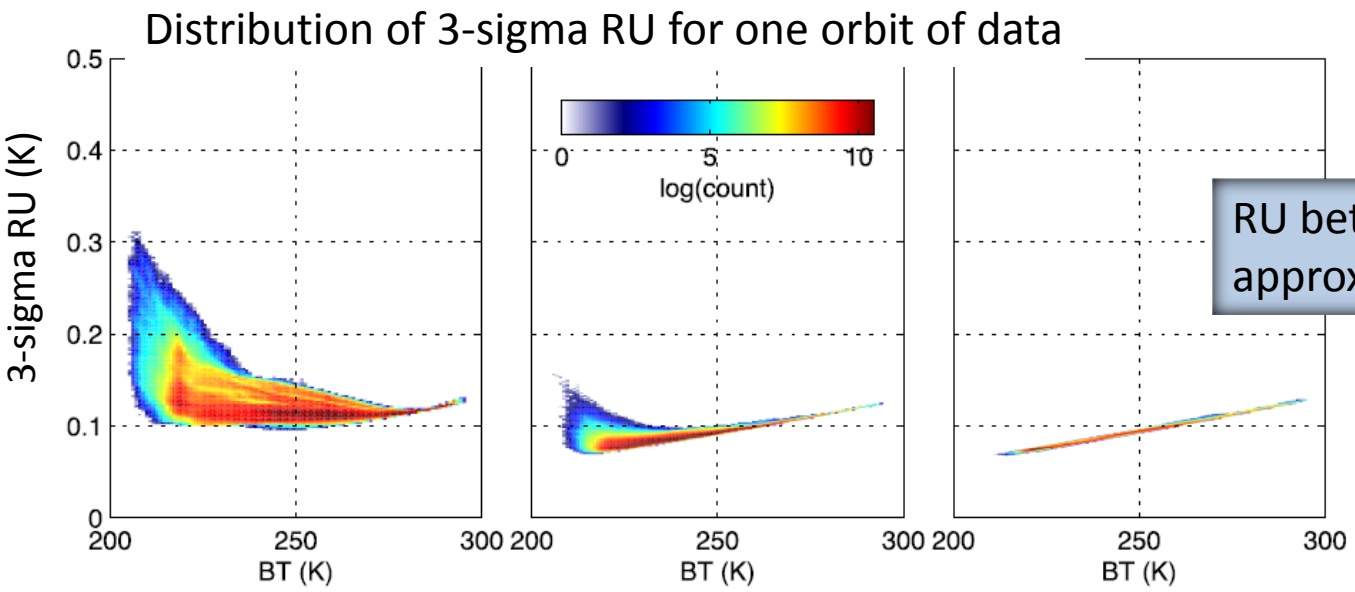
FOR(i) relative to FOR(31-i) frequency shift near Equator



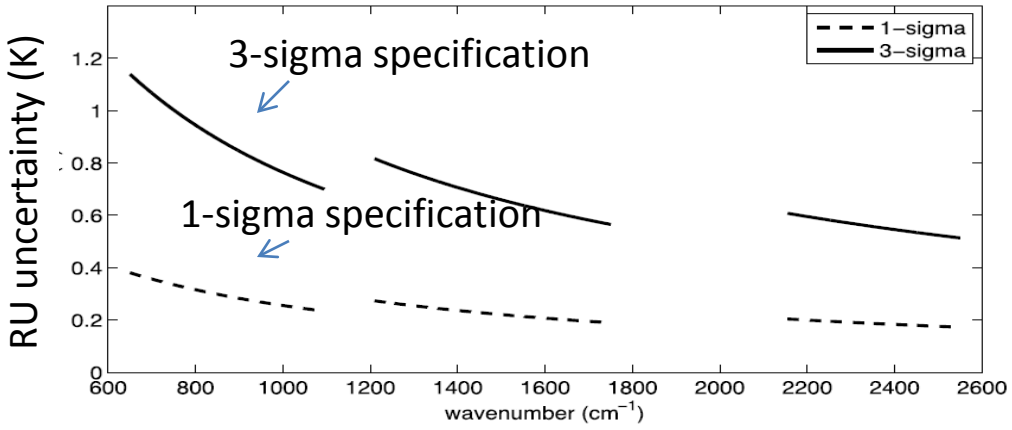
Black – ascending, Green – descending, Red - theory

(Chen, et al. 2013, AO)

Radiometric Uncertainty (RU)



RU better than spec by approximately a factor 4



Uncertainty specification @287K blackbody

Tobin et al. 2013, JGR

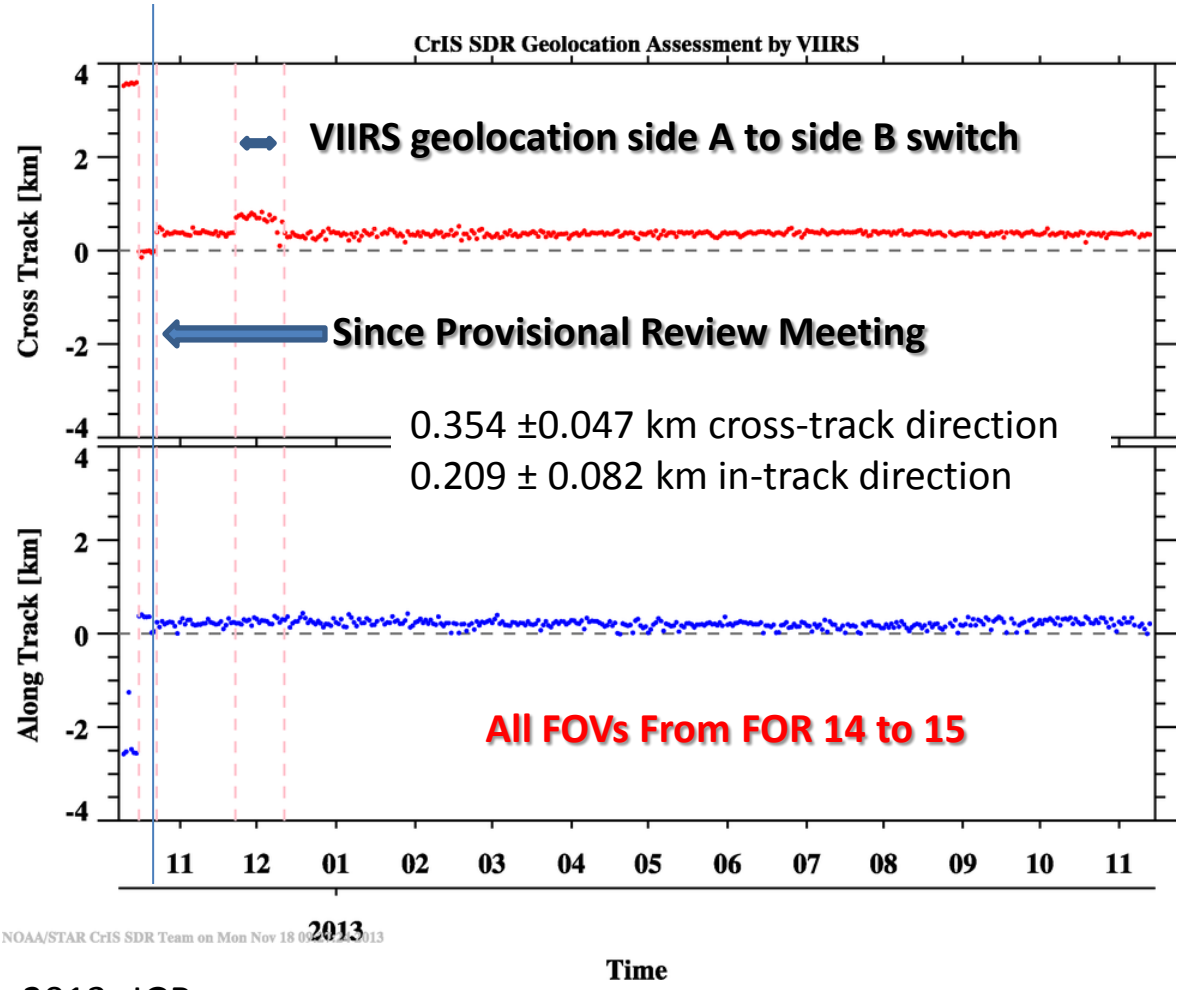
Geolocation Accuracy Assessed with VIIRS

VIIRS I5 band data (350m spatial resolution) are used to assess CrIS geolocation accuracy

Pixel geolocation accuracy:
< 0.4 km nadir
< 1.3 km (Zenith angle < 30°)

Due to VIIRS "bowtie deletion", this method does not apply to pixels with zenith angle larger than 30°

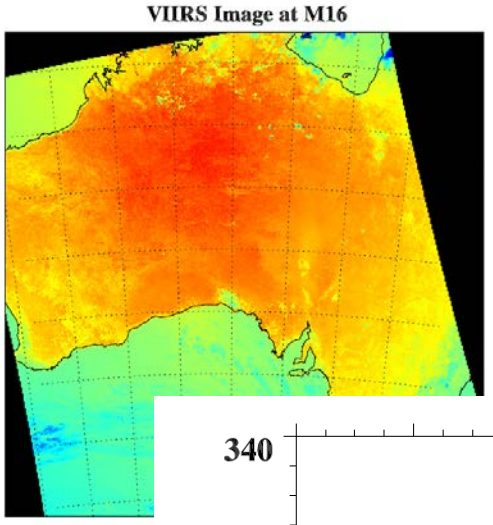
Nadir geolocation accuracy time series



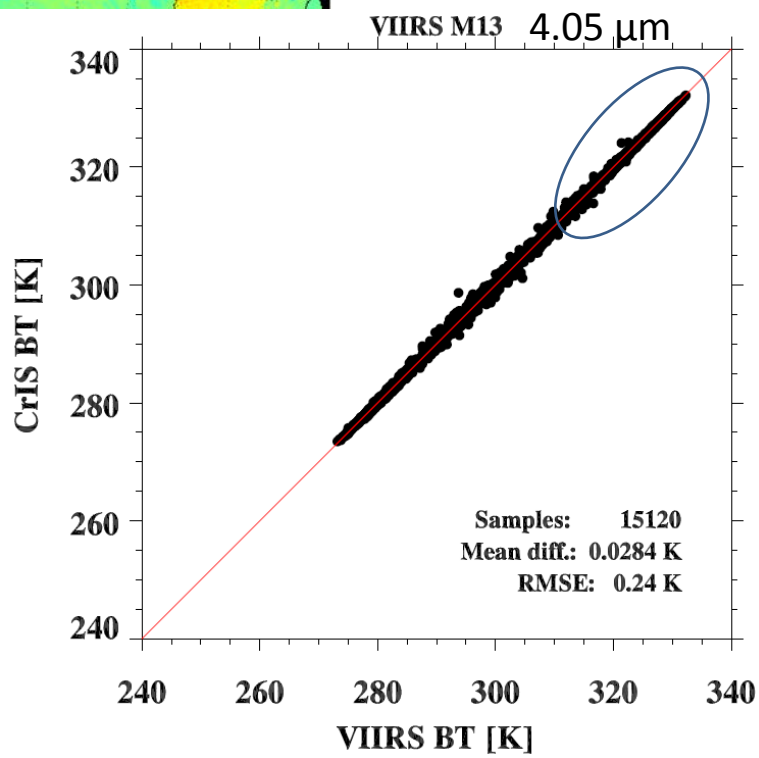
Wang et al. 2013, JGR

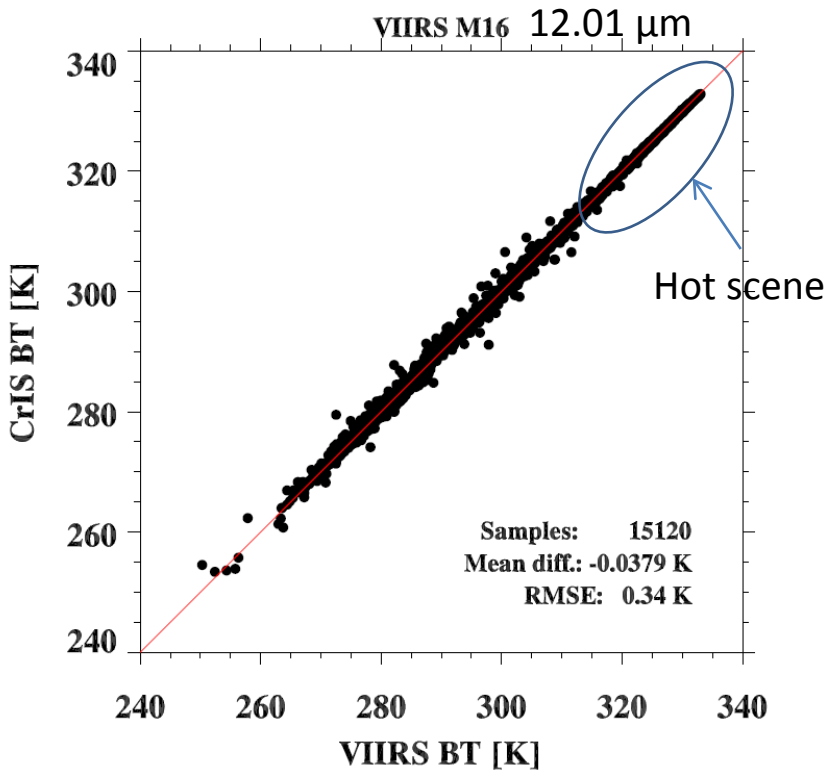
Cross-sensor Comparisons

Hot Scene CrIS/VIIRS Comparison



Australian Desert,
Jan. 29, 2013

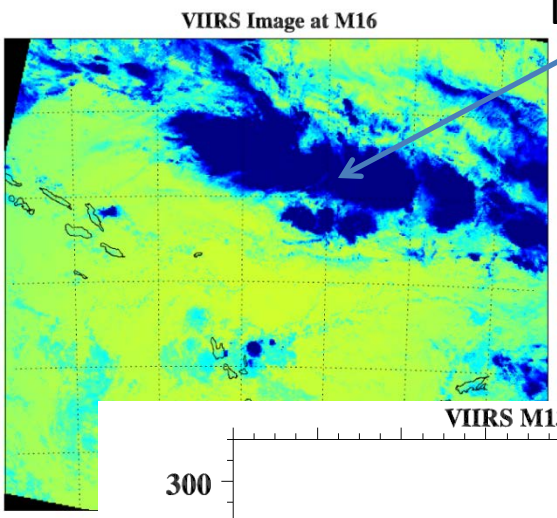




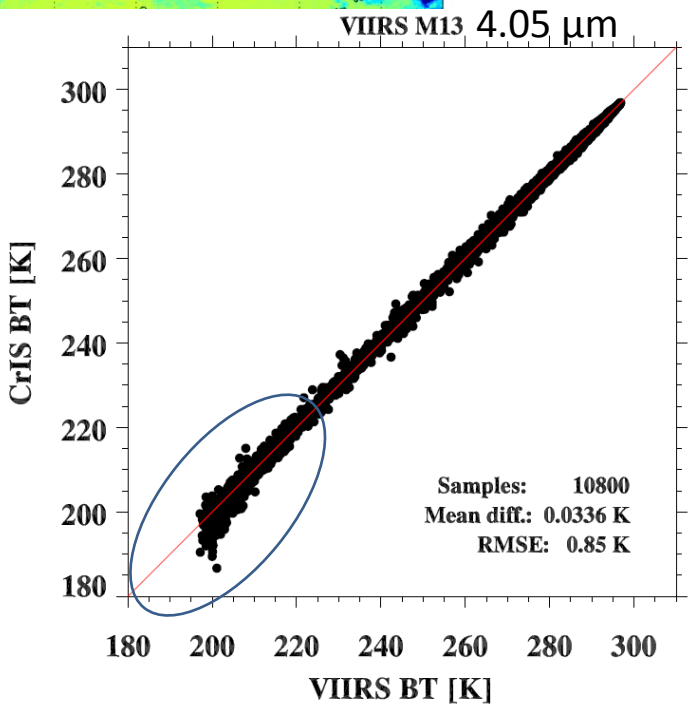
Good agreement in the entire region
(no data points were excluded)

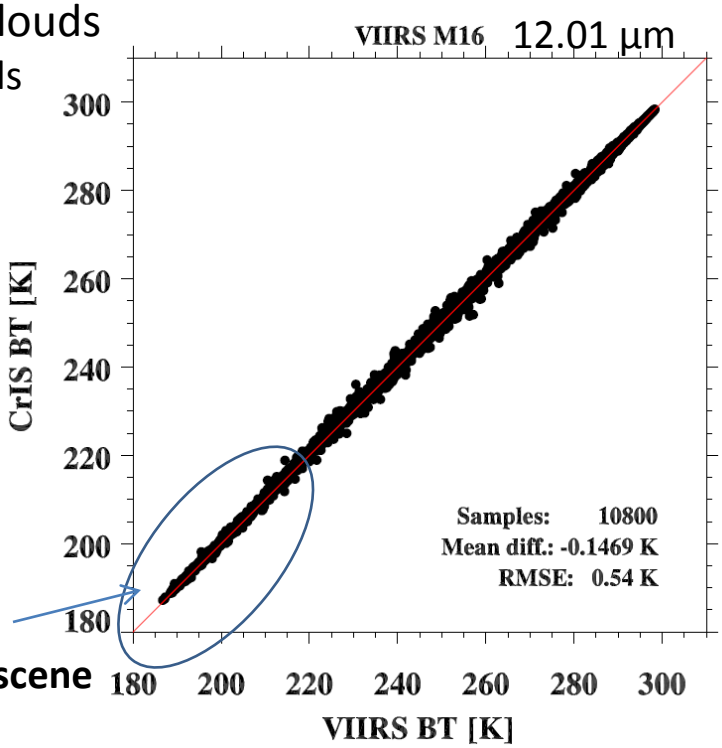
(see backup slides for CrIS – VIIRS figures)

Cold Scene CrIS/VIIRS Comparison



Deep Convective Clouds
near Solomon Islands
Feb. 5, 2013



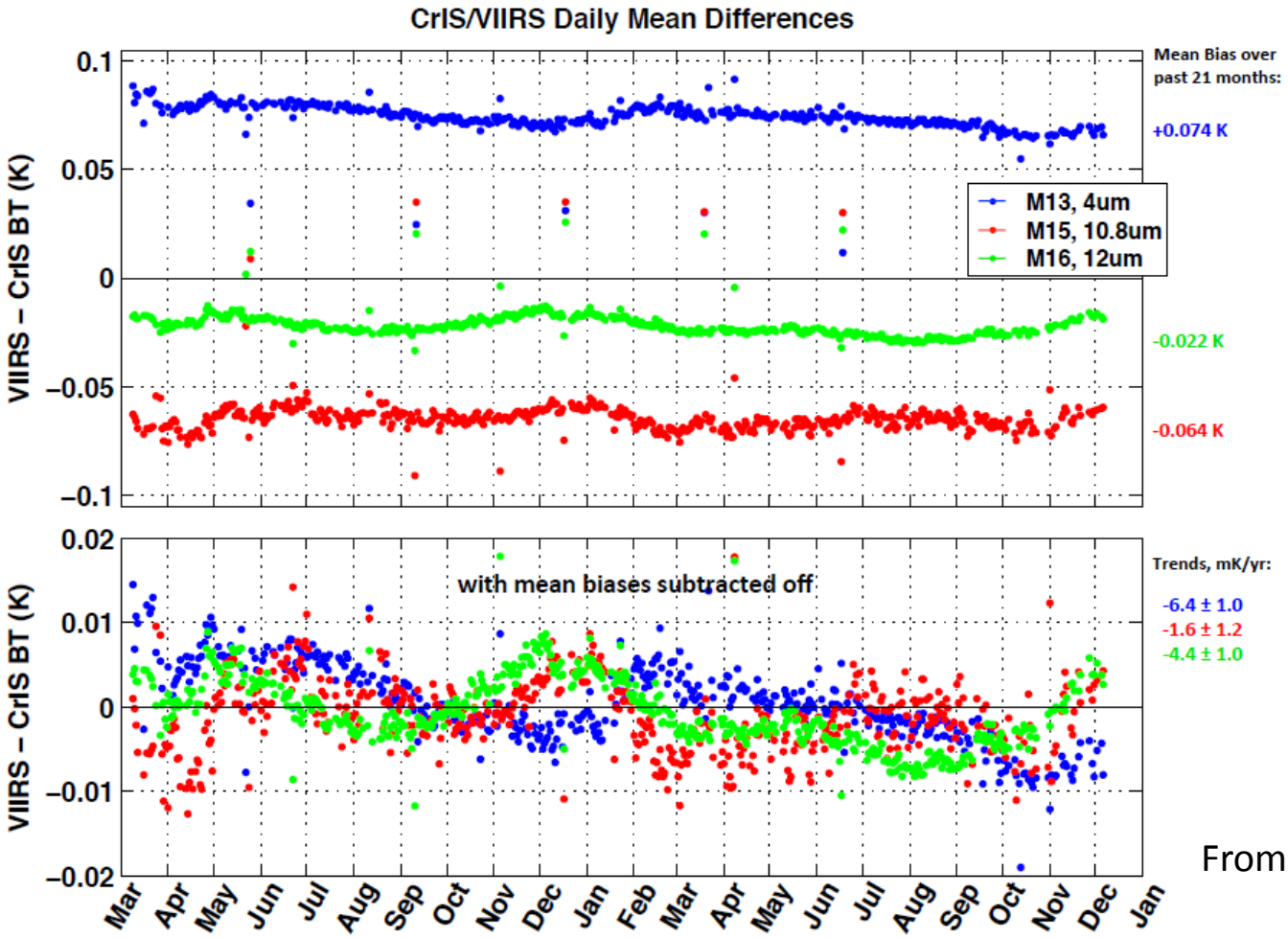


Cold scene

- **Good agreement in the LW channel**
- **VIIRS M13 lost sensitivity below 200 K**

(no data points were excluded)

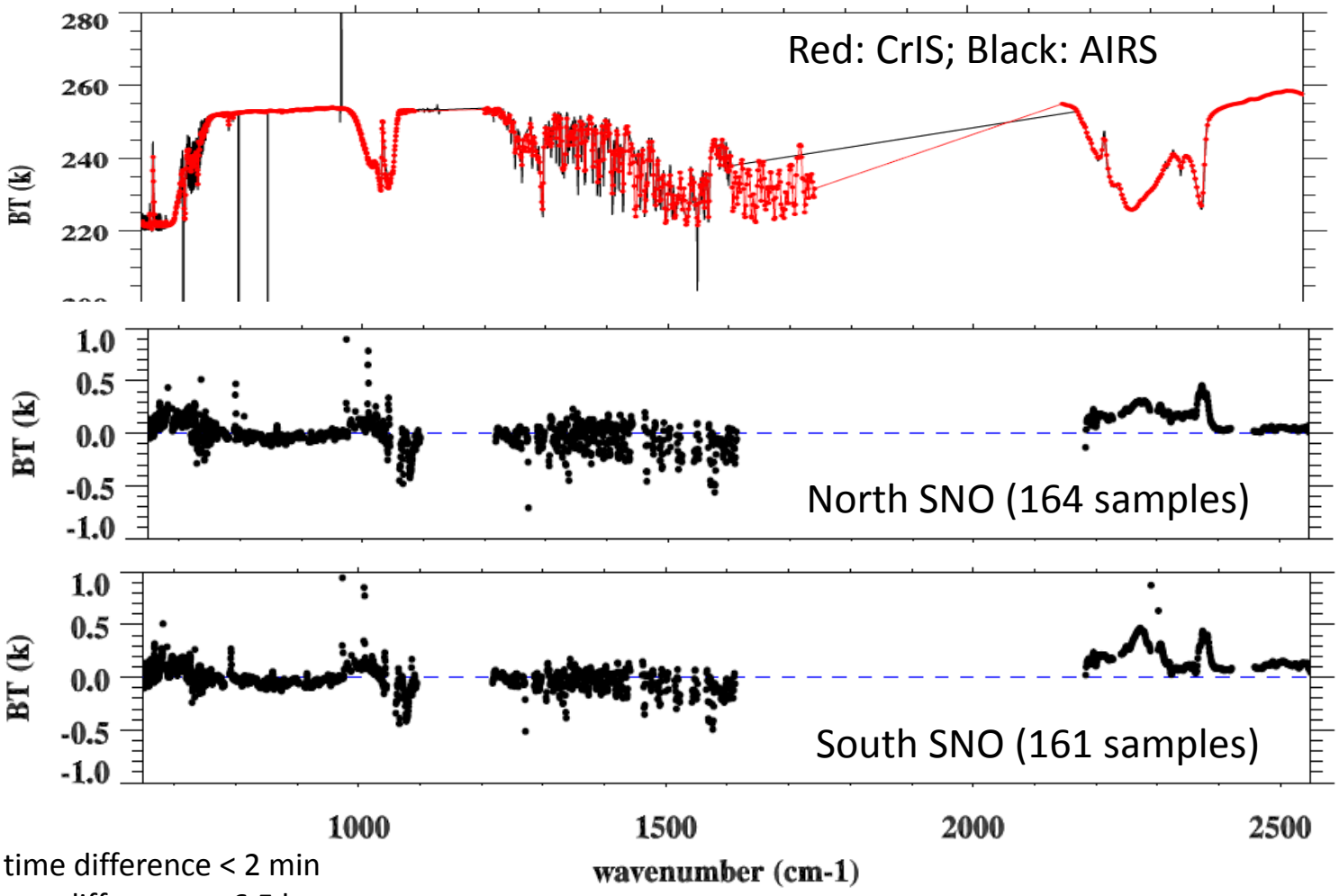
Time Series of CrIS/VIIRS Comparison



From D. Tobin, UW

CrIS/VIIRS daily mean difference are < 0.1 K and trends are < 10 mk/yr

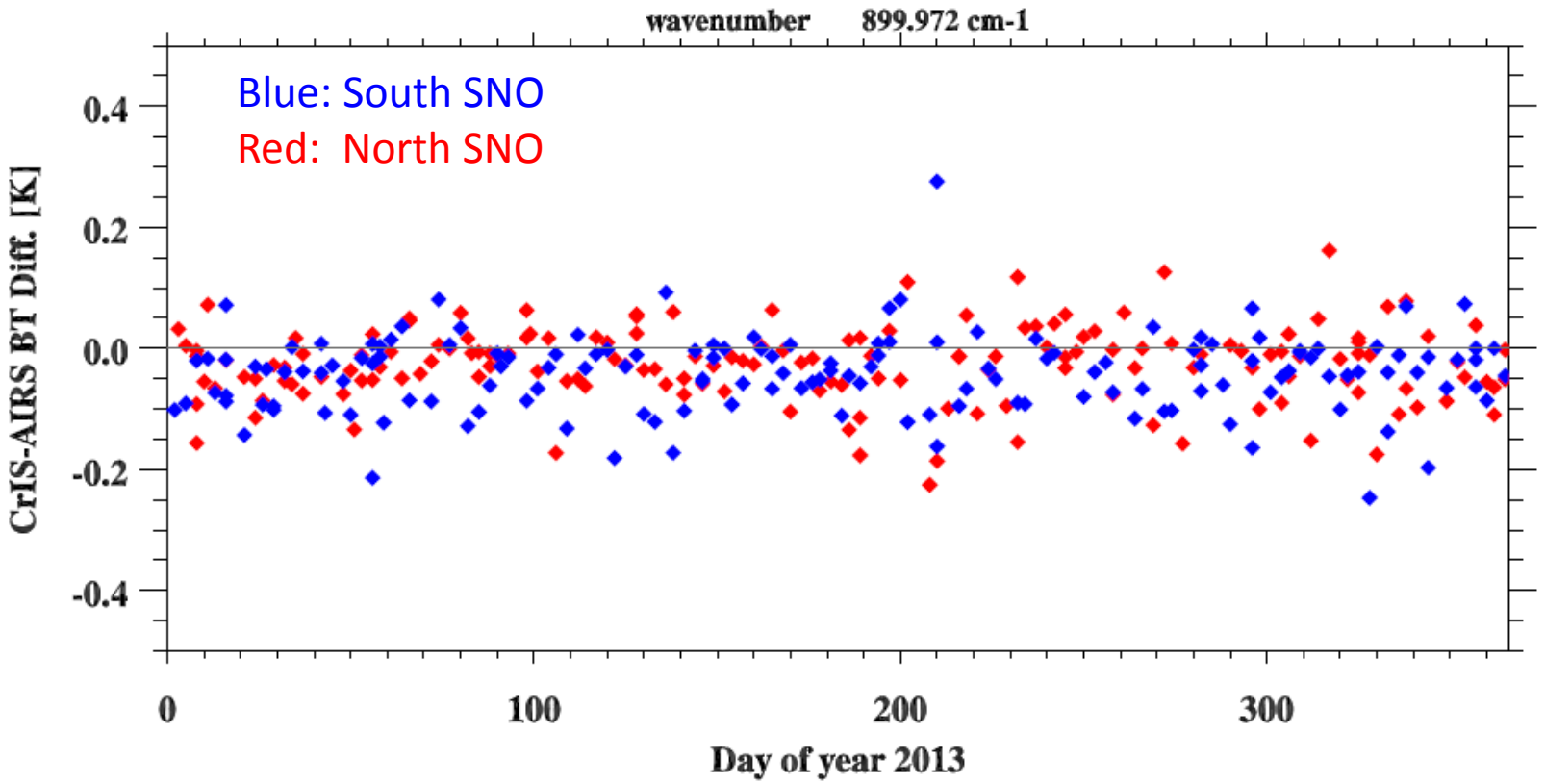
CrIS/AIRS SNO Comparisons



SNO time difference < 2 min
Distance difference < 6.5 km

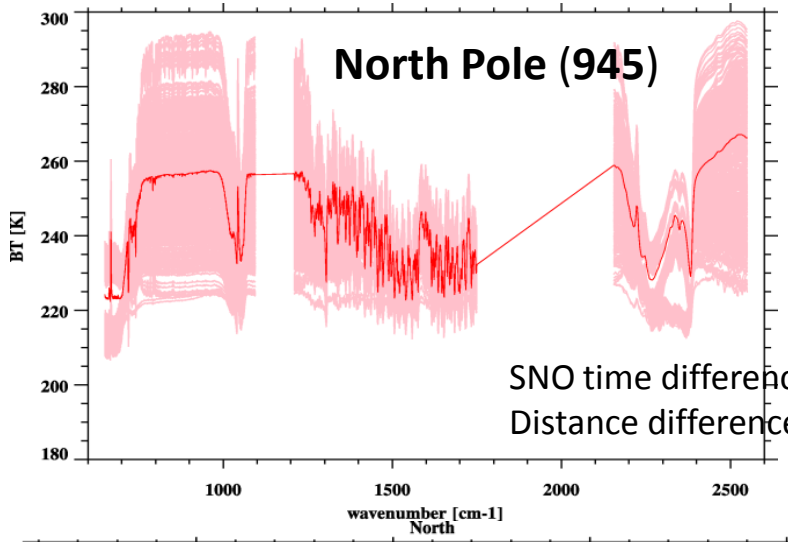
From L. Wang, NOAA/STAR

CrIS/AIRS SNO Time series at 899.97 cm^{-1}



From L. Wang, NOAA/STAR

CrIS/IASI(Metop-A) SNO Results from Feb. to Dec. 2013



SNO time difference < 2 min
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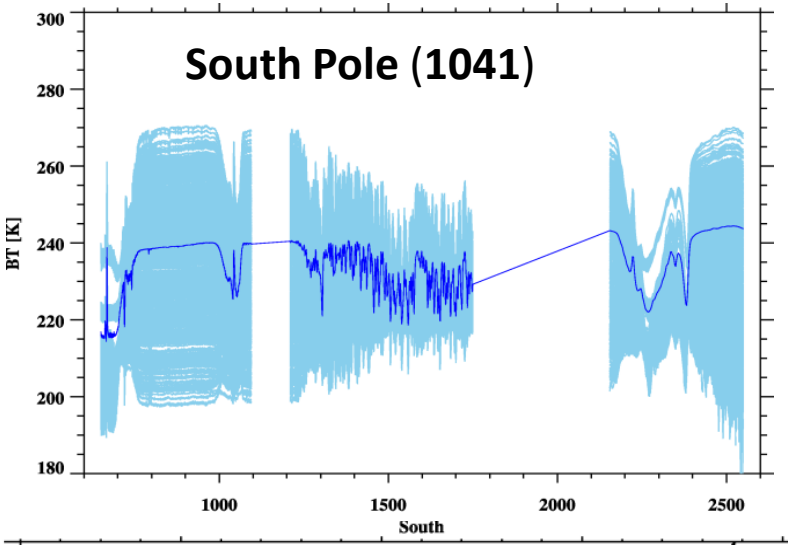
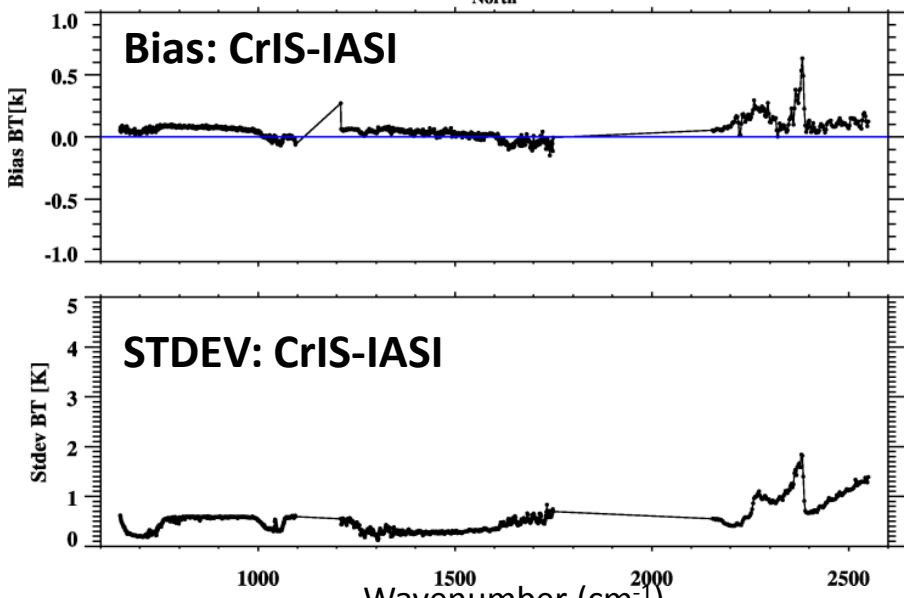
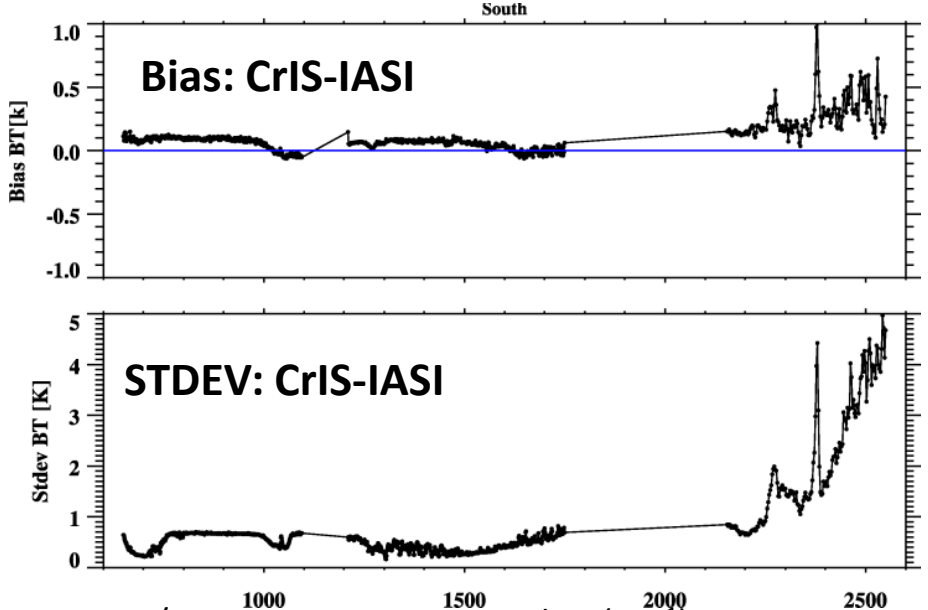
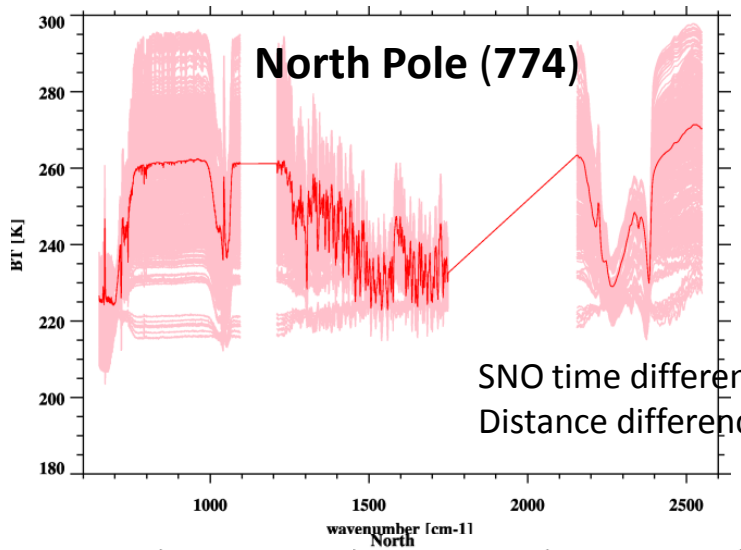




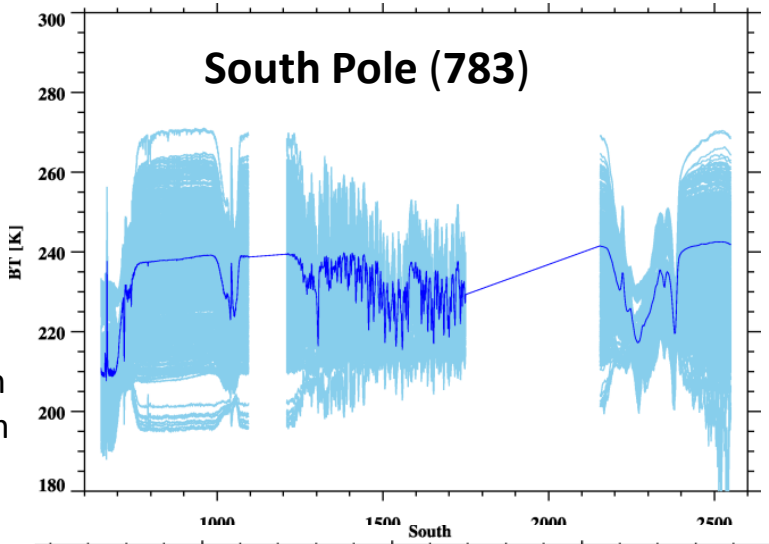


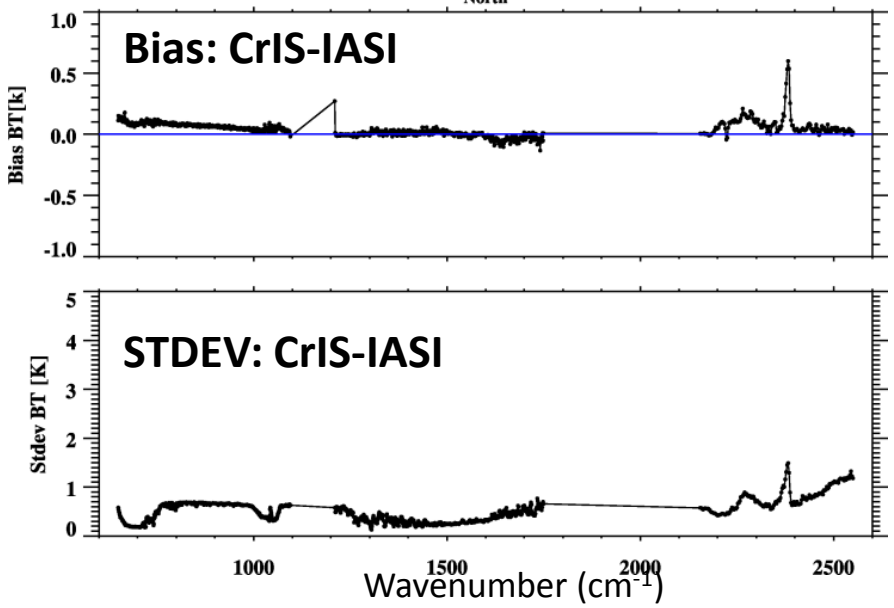
From L. Wang, NOAA/STAR

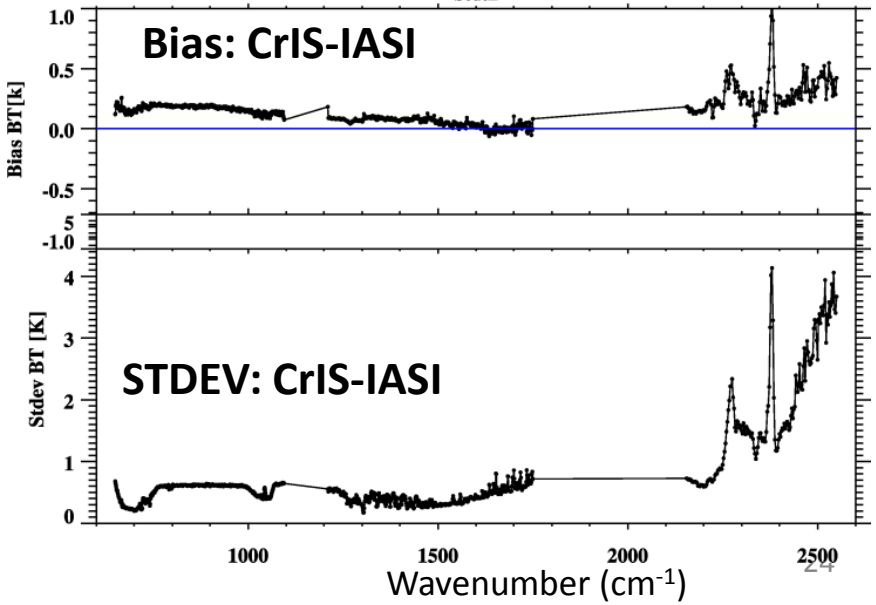
CrIS/IASI(Metop-B) SNO Results from Feb. to Dec. 2013



SNO time difference < 2 min
Distance difference < 6.5 km



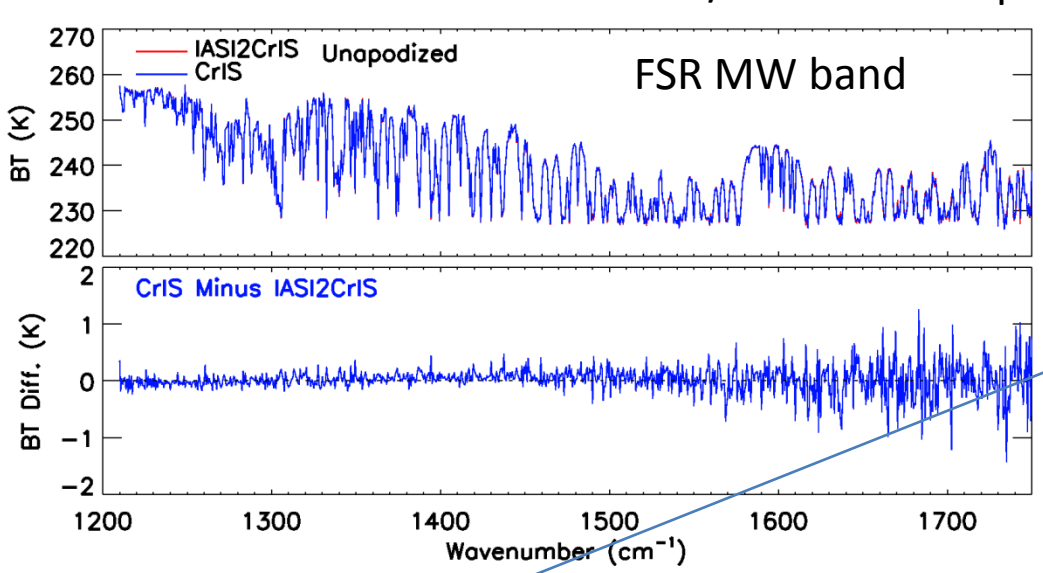


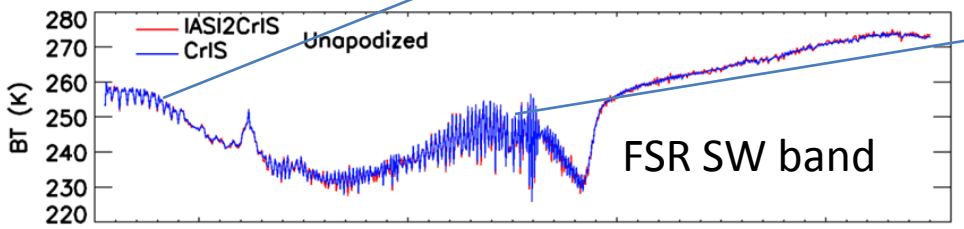


Preparing for Full Spectral Resolution Mode Operation

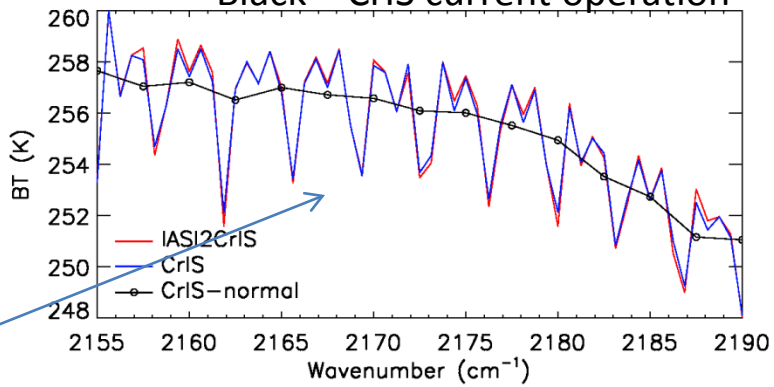
- S-NPP CrIS has so far turned on the FSR mode three times for testing
- Preparation is ongoing for FSR mode operation some time this year

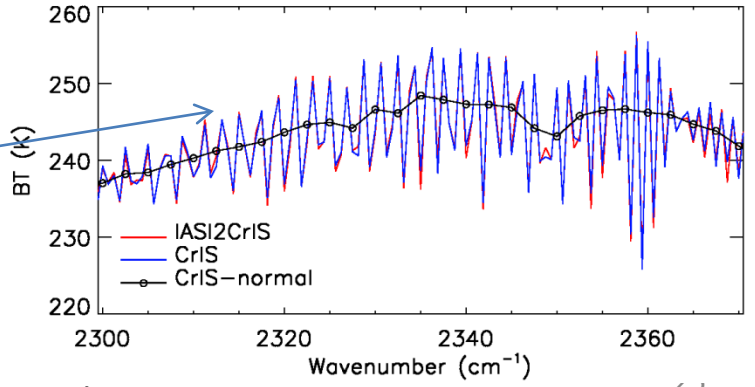
CrIS-FSR/IASI SNO Comparisons





Black – CrIS current operation





Time difference < 2 min
Distance difference < 6.5 km

From Y. Chen, NOAA/STAR

References
(JGR Special Issue)

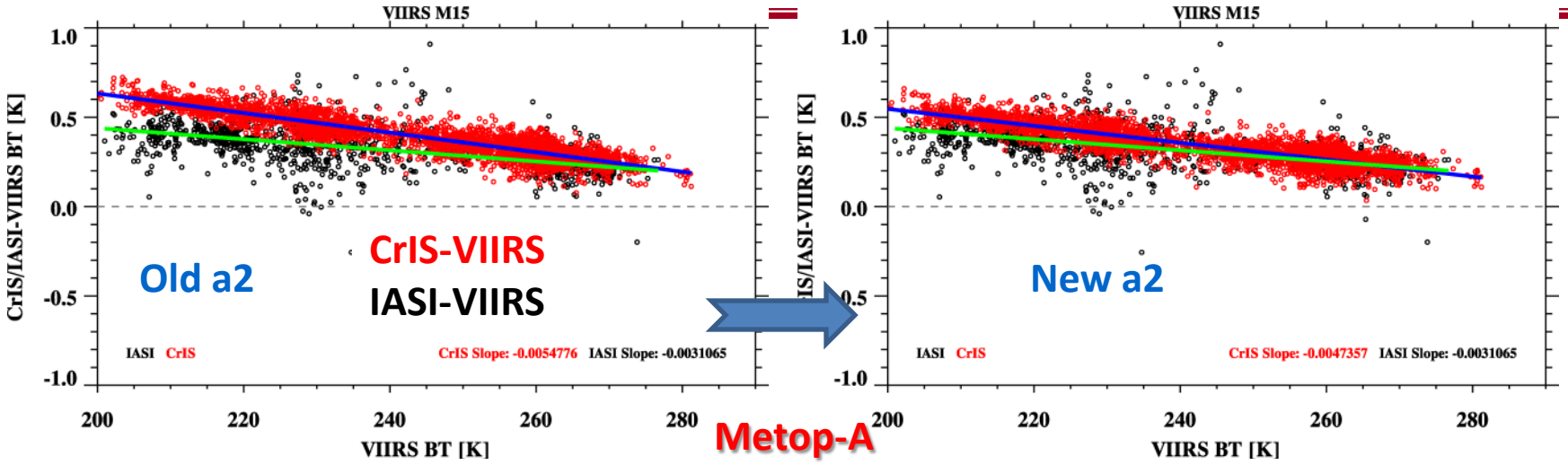
- Han, Y., *et al. (*2013*),* Suomi NPP CrIS measurements, sensor data record algorithm, calibration and validation activities, and record data quality, J. Geophys. Res. Atmos., 118, *doi:*10.1002/2013JD020344
- Tobin, D., *et al. (*2013*),* Suomi-NPP CrIS radiometric calibration uncertainty, J. Geophys. Res. Atmos., 118, 10,589–10,600, *doi:*10.1002/jgrd.50809
- Strow, L. L., H. Motteler, D. Tobin, H. Revercomb, S. Hannon, H. Buijs, J. Predina, L. Suwinski, *and* R. Glumb *(*2013*),* Spectral calibration and validation of the Cross–track Infrared Sounder (CrIS) on the Suomi NPP satellite, J. Geophys. Res. Atmos., 118, *doi:*10.1002/2013JD020480.
- Zavyalov, V., M. Esplin, D. Scott, B. Esplin, G. Bingham, E. Hoffman, C. Lietzke, J. Predina, R. Frain, L. Suwinski, Y. Han, C. Major, B. Graham, L. Phillips (2013), Noise performance of the CrIS instrument, J. Geophys. Res., doi: 10.1002/2013JD020457
- Wang, L., D. A. Tremblay, Y. Han, M. Esplin, D. E. Hagan, J. Predina, L. Suwinski, X. Jin, *and* Y. Chen *(*2013*),* Geolocation assessment for CrIS sensor data records, J. Geophys. Res. Atmos., 118, *doi:*10.1002/2013JD020376.

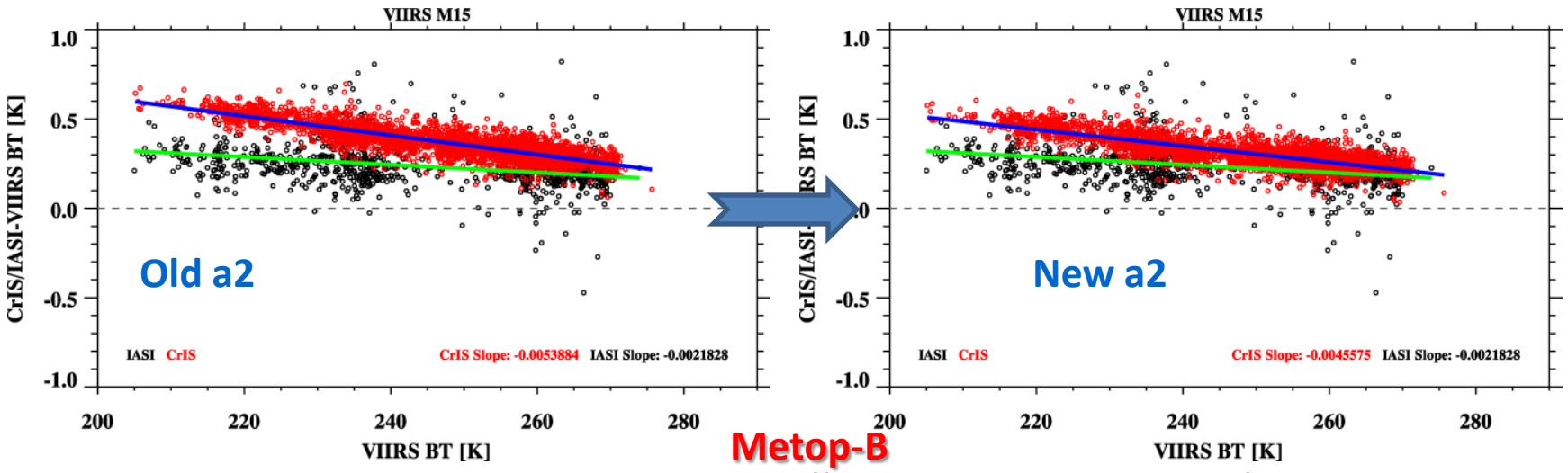
Summary

- The CrIS instrument has been working very well and stable since the beginning of the NPP mission
- CrIS SDR product has been validated, which meets the requirements with large margin
- Instrument performance and SDR calibration/validation are well characterized and documented
- The differences between CrIS and IASI/AIRS/VIIRS are in general within 0.1-0.2 K

Backup Slides

IASI/CrIS vs. VIIRS M15

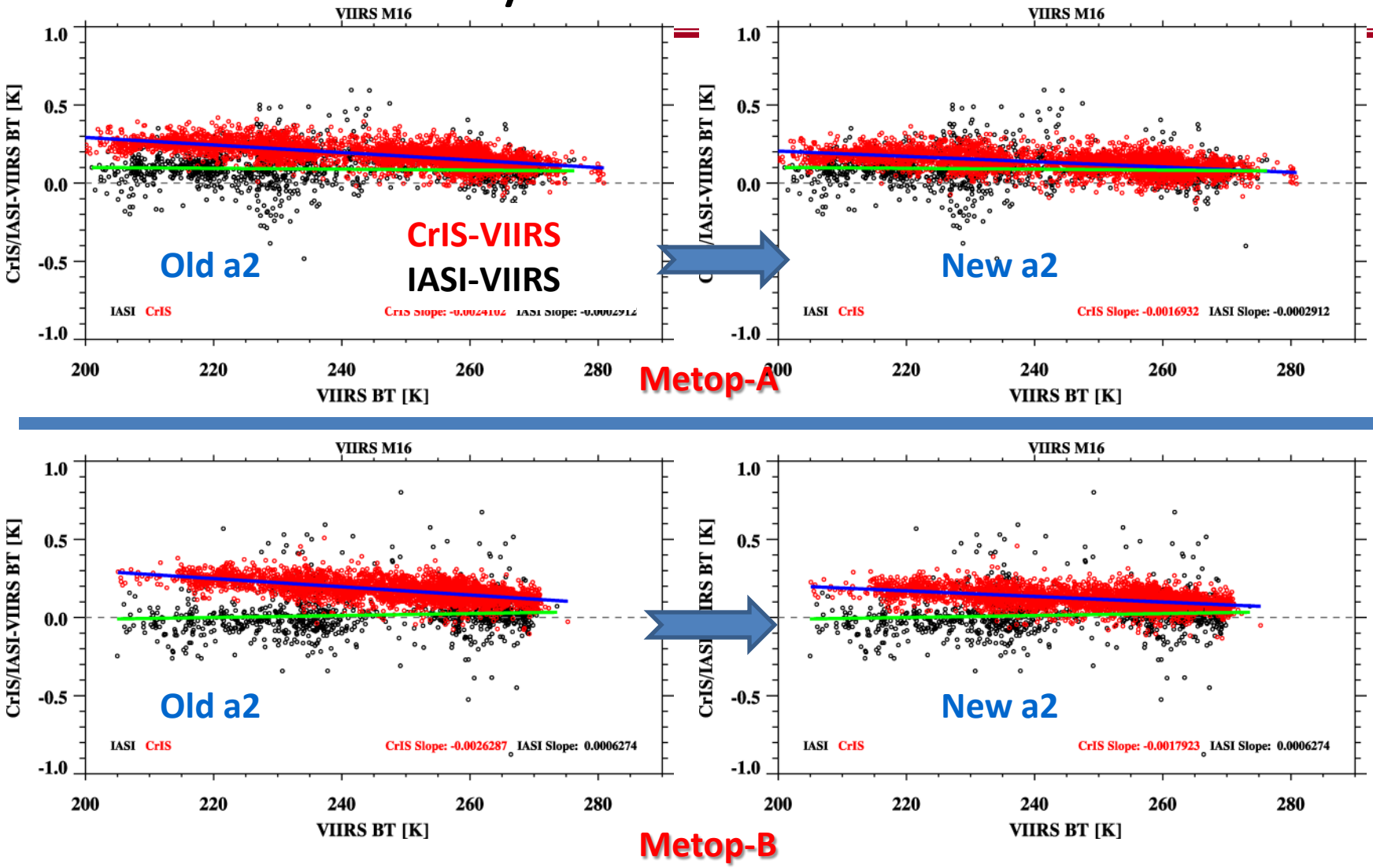




New a2: updated nonlinearity correction coefficients used in operation after Feb. 20, 2014

Old a2: nonlinearity correction coefficients used before Feb. 20, 2014

IASI/CrIS vs. VIIRS M16



New a2: updated nonlinearity correction coefficients used in operation after Feb. 20, 2014

Old a2: nonlinearity correction coefficients used before Feb. 20, 2014