Reprocessing of Suomi NPP CrIS SDR and Impacts on Radiometric and Spectral Long-term Accuracy and Stability

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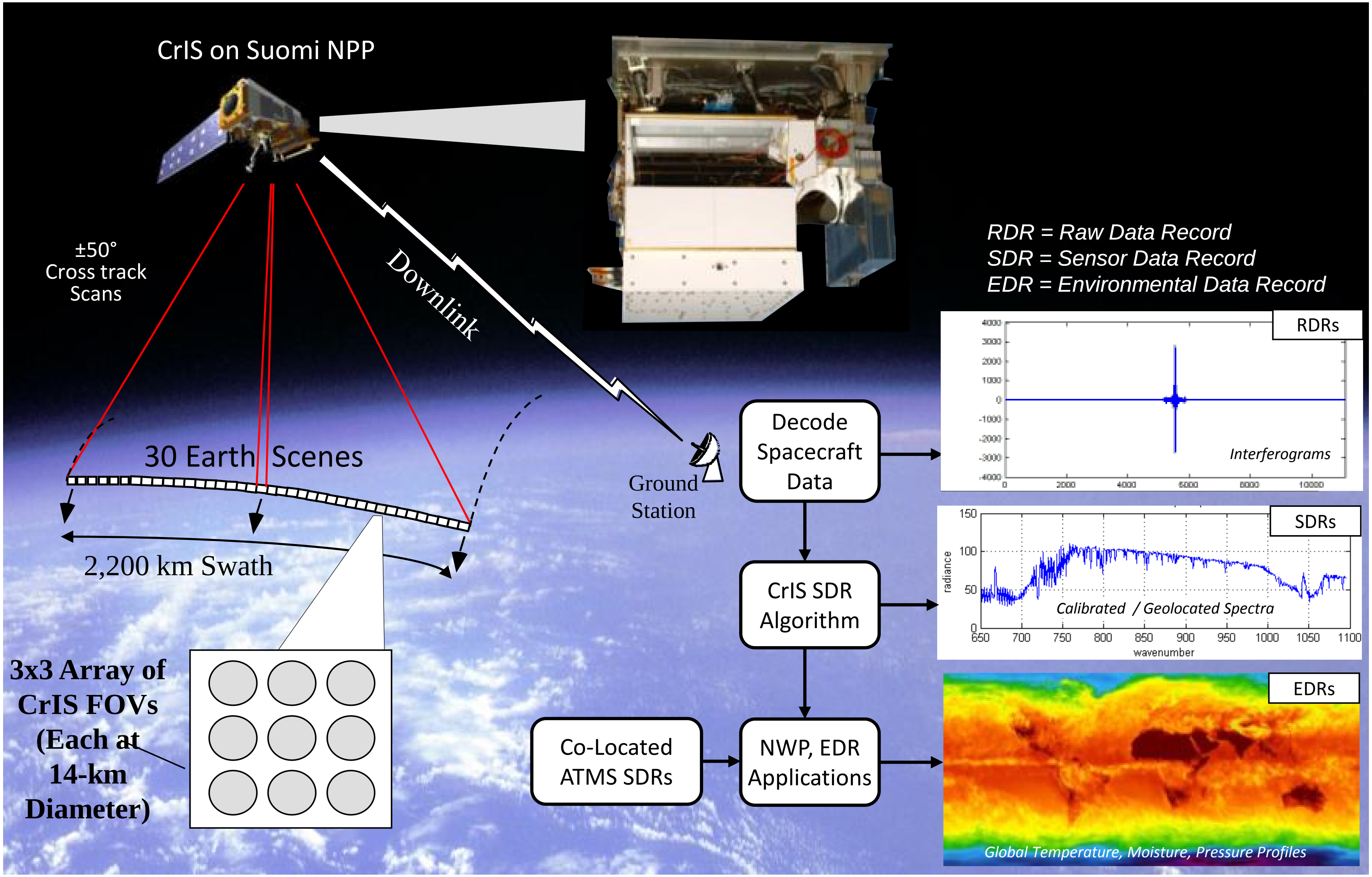
Outline

- CrIS operational concept and instrument long-term trending
- Importance of CrIS reprocessed SDR for inter-calibration and climate applications
- Reprocessed SDR long-term radiometric accuracy and stability
- Reprocessed SDR long-term spectral accuracy and stability
- Summary

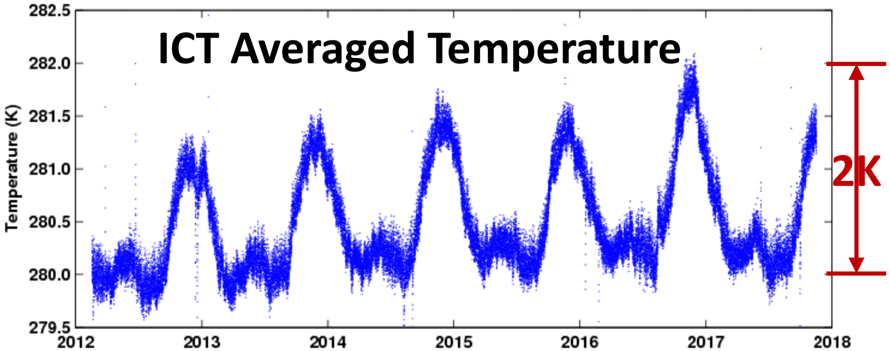
CrIS Operational Concept

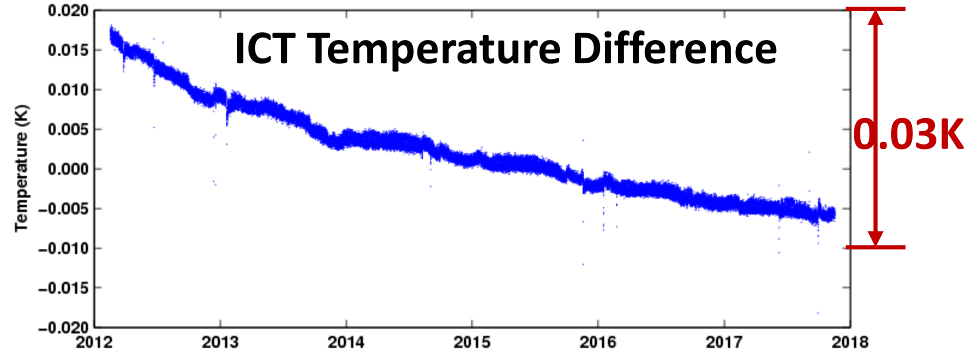


From Exelis/ABB

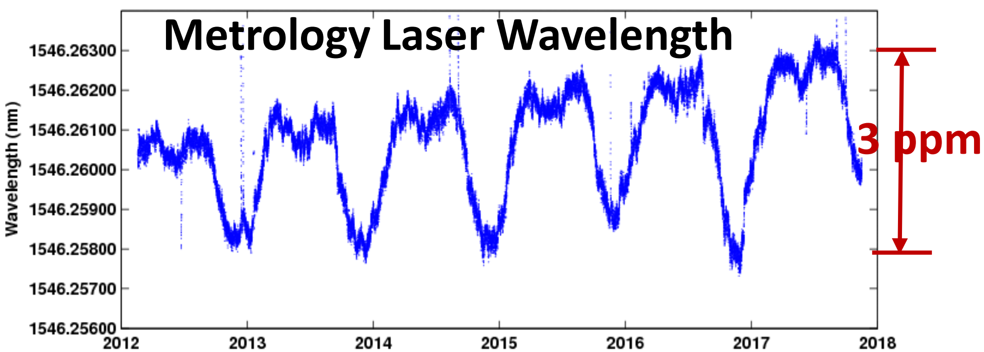
CrIS Instrument Long-term Trending

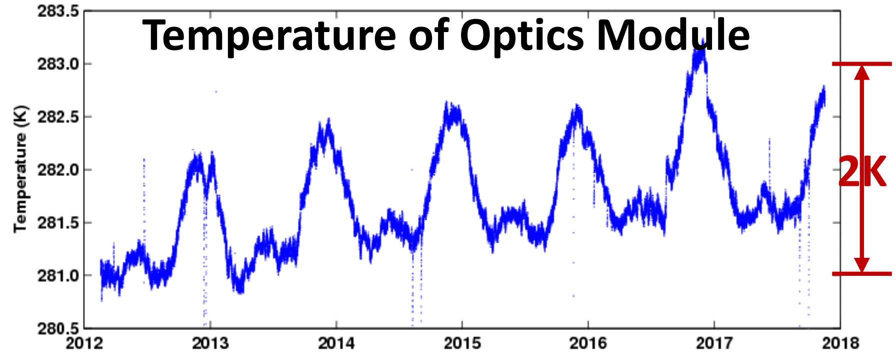
CrIS ICTs show seasonal variation, but the two ICTs are very consistent



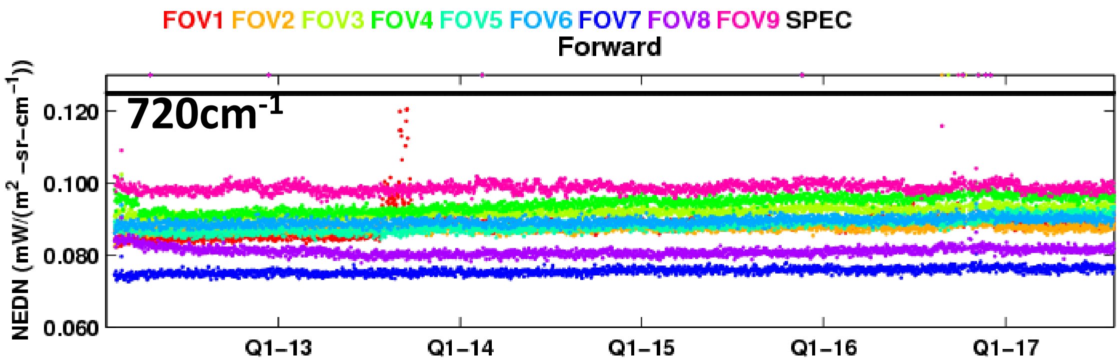


CrIS Spectral Cal sensitivity is < 2 ppm/ΔK of FTS





Stable NEdN



CrIS SDR CalVal Milestones

*Algorithm and software improvement
*CrIS performance characterization
*Radiometric CalVal
*Spectral CalVal
*Geolocation CalVal
*CrIS instrument and SDR trending and monitoring

Intensive Calibration & Validation (ICV)

10/28/2011
Launched

04/02/2012
First SDR product

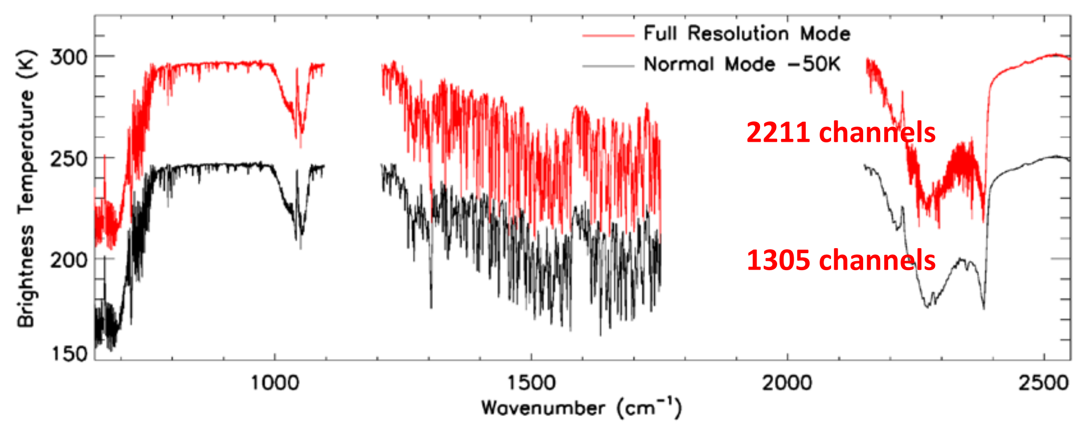
04/19/2012
Beta status

01/13/2013
Provisional status

02/20/2014
Validation status;
Calibration algorithm and coefficient updates (Mx8.1

12/04/2014
Full spectral resolution mode

3/08/2017
Block 2.0 Mx 1
FSR SDR operational

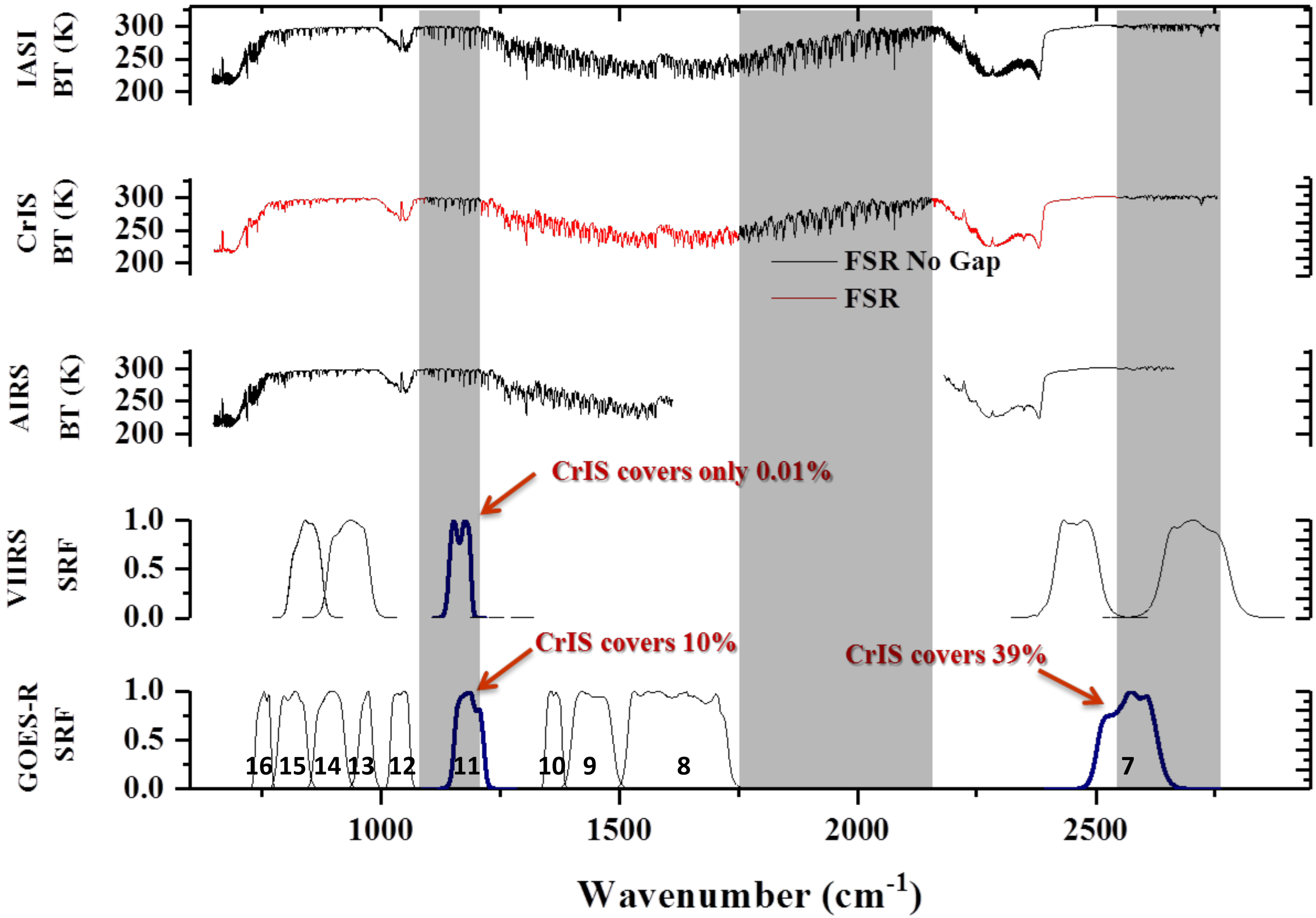


GSICS IR References – AIRS, CrIS, and IASI

- AIRS
  - **10% of 2378 channels degraded or dead**
  - **No follow-on sensor since Aqua/AIRS in 2002**
  - **Spectral gaps**
  - Reprocessing capabilities
- IASI
  - MetOp-A → -MetOp B → MetOp C → EPS NG
  - **Fully spectral coverage**
  - Reprocessing capabilities
- CrIS
  - SNPP → J1 →J2 → J2 beyond
  - **Spectral gaps (can be filled using PCA method)**
  - Reprocessing capabilities

life-long consistency of CrIS SDR spectral, radiometric, and geometric calibration is very important for inter-calibration and climate applications.

GOES-16 ABI Inter-Comparison with CrIS



From Hui Xu et al.

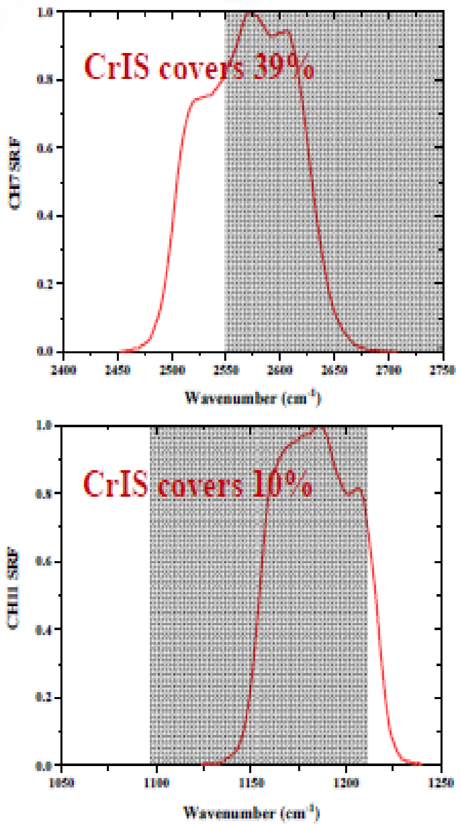
GOES-16 ABI Inter-Comparison with CrIS (with gap filled)

SNO selection: FOV distance : less than 7 km ; Time difference: less than 10 minutes ; Nadir: FOR 14, 15, 16 and 17

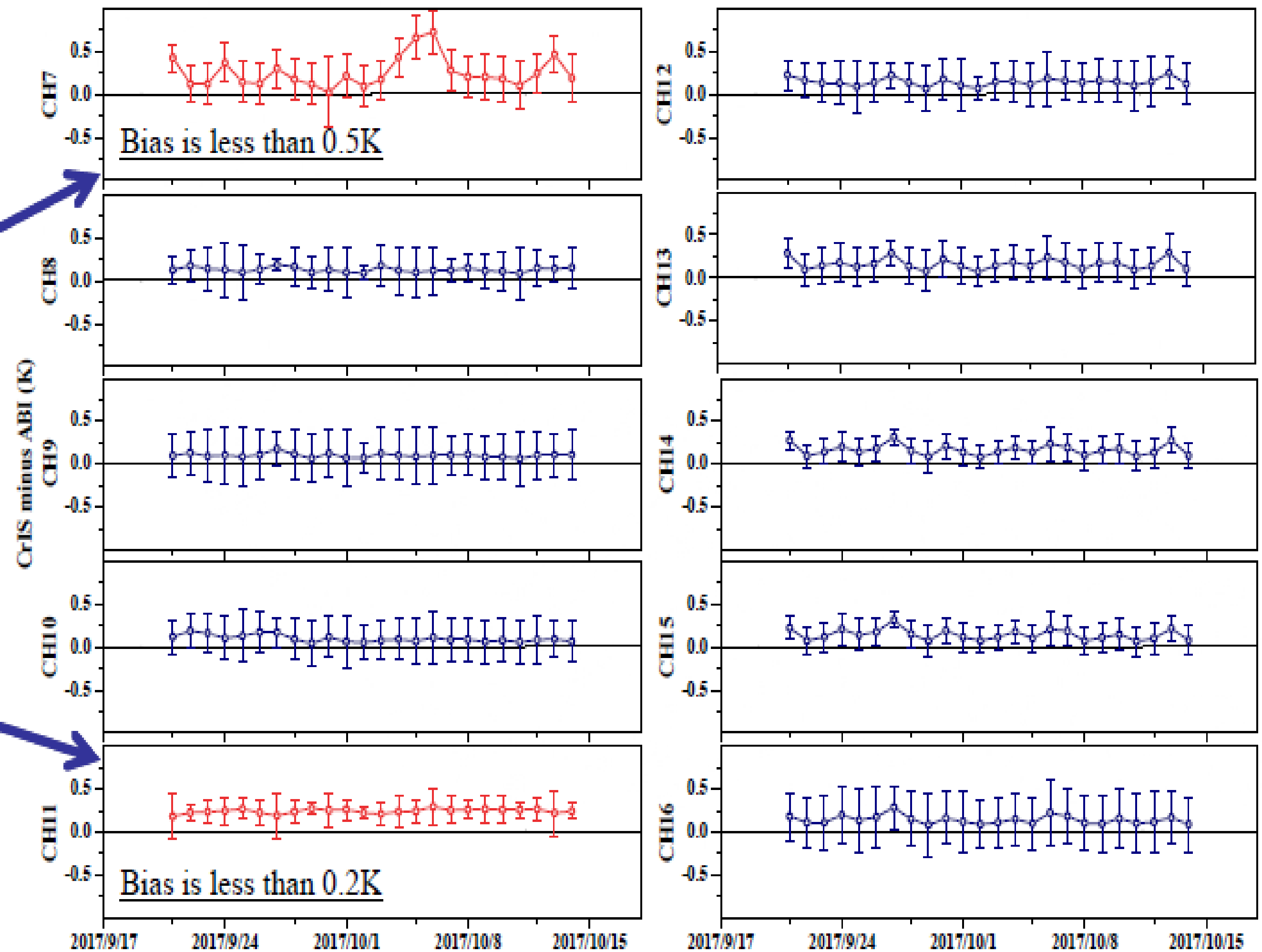
View angle difference: abs(cos(zen1)/cos(zen2)-1) less than 0.02; ABI CH14 : std(M16) / mean(M16) <0.01 ; ABI within CrIS are averaged

CrIS - ABI

Spectral response functions of ABI channel 7 and 11



After gap was filled



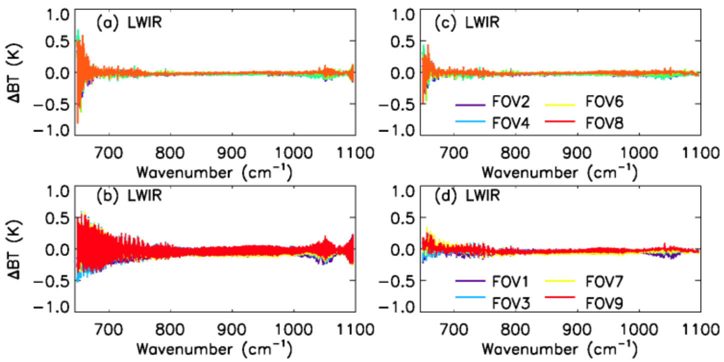
From Hui Xu et al.

Reprocessed CrIS SDR

- Reprocessed CrIS SDR data quality is improved for climate applications with its fine-tuning of calibration coefficients in NOAA reprocessing project.
- One specific code for CrIS SDR reprocessing was developed. This code was based on ADL5.3.1 PSAT16 with updates for calibration algorithm, non-linearity, and geolocation to improve the scientific results.
- The calibration coefficients are refined with the latest updates based on the work from CrIS science team, and are inserted in the Engineering Packet in the Raw Data Record (RDR) data stream.
- The resampling wavelength was updated based on the metrology laser wavelength and resulting in zero sampling error in the spectral calibration.
- All the SDRs are generated with the same calibration coefficients, resulting in improved consistency during the CrIS life-time mission.

Optimizing Calibration Equation

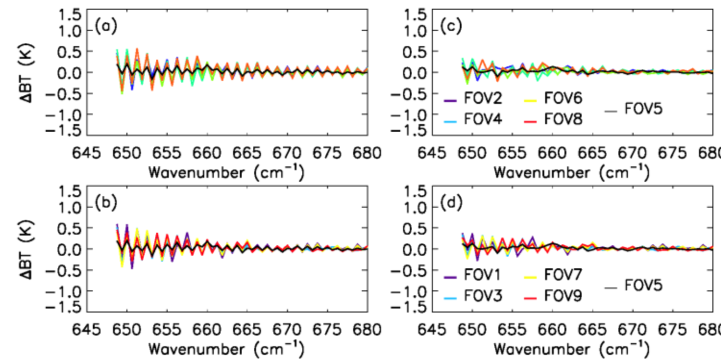
- Major changes include the calibration equation, self-apodization correction, resampling matrices, and calibration filter.
- Compared to the previous algorithm, the improvement reduces the calibration inconsistencies among the nine fields of view and between the forward and reverse interferometer sweep directions by up to 0.5 K, and the differences between observed and simulated spectra by up to 0.4 K.



Before

After

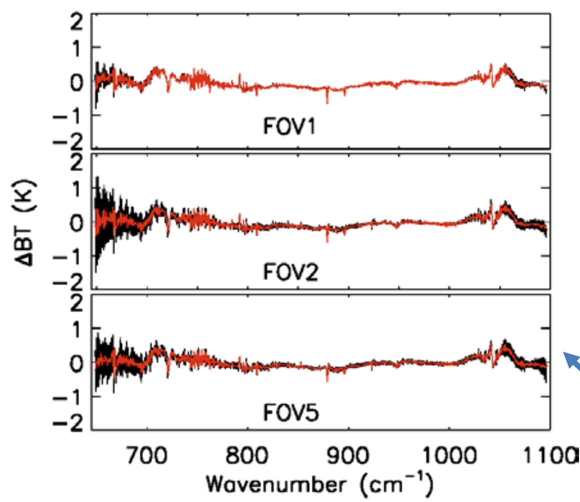
Nine FOVs consistency



Before

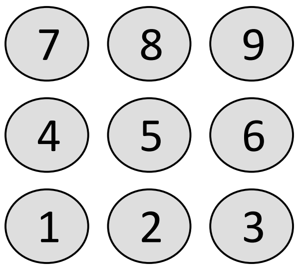
After

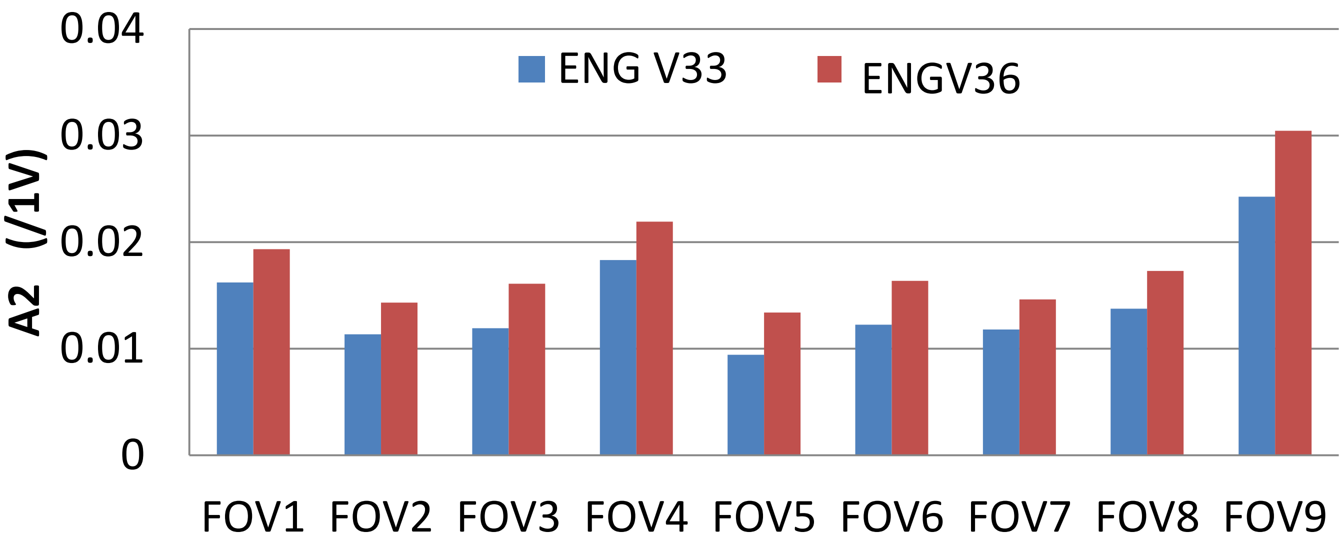
Sweep direction difference



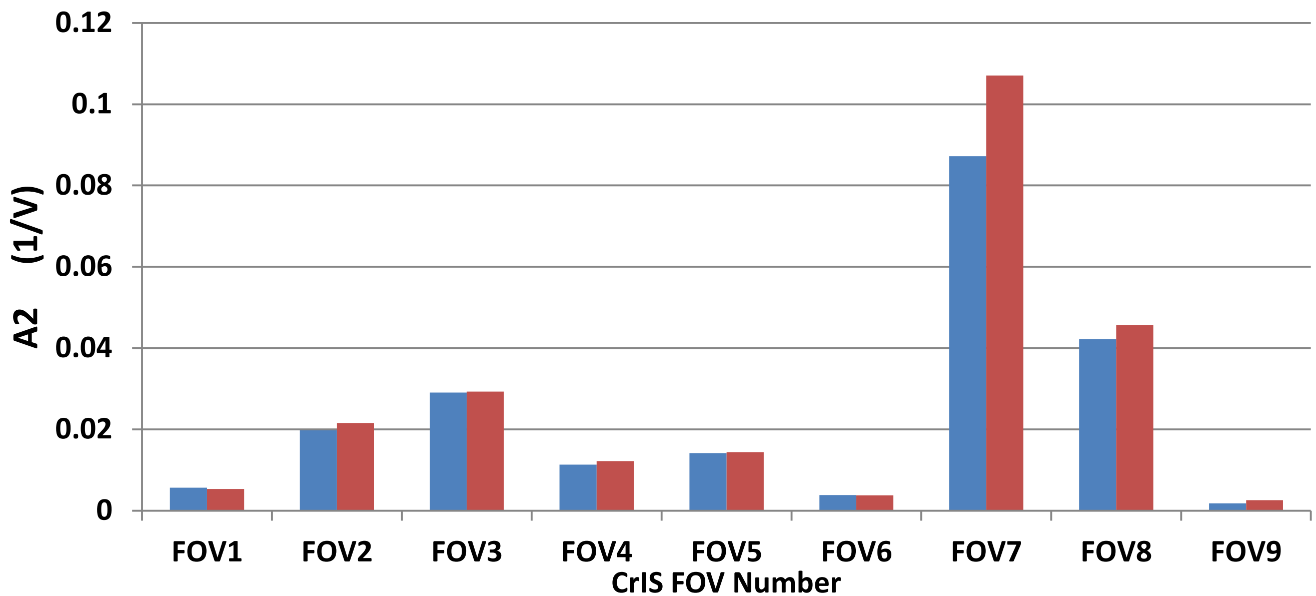
Comparison with LBLRTM simulation

Non-linearity Coefficient Changes



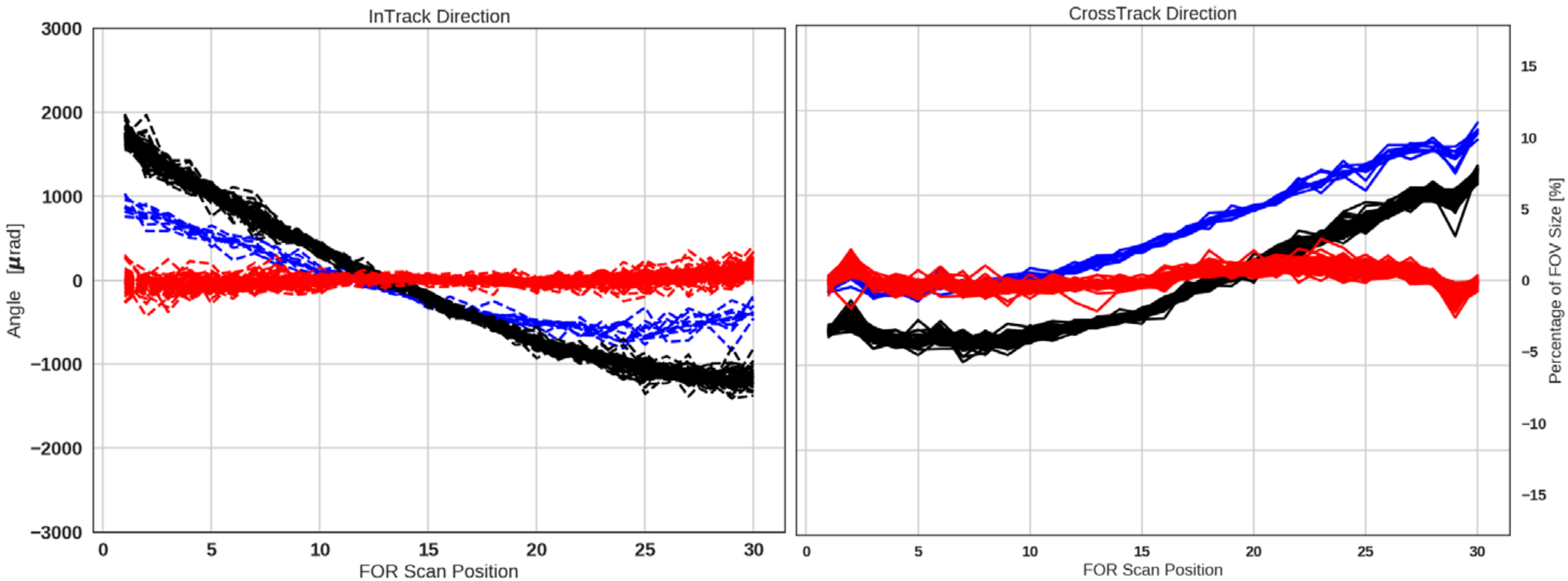


Longwave band



Middlewave band

Geolocation Accuracy Rrelative to VIIRS



Blue lines: Before the geolocation mapping parameters update

Red lines: After the geolocation mapping parameters update

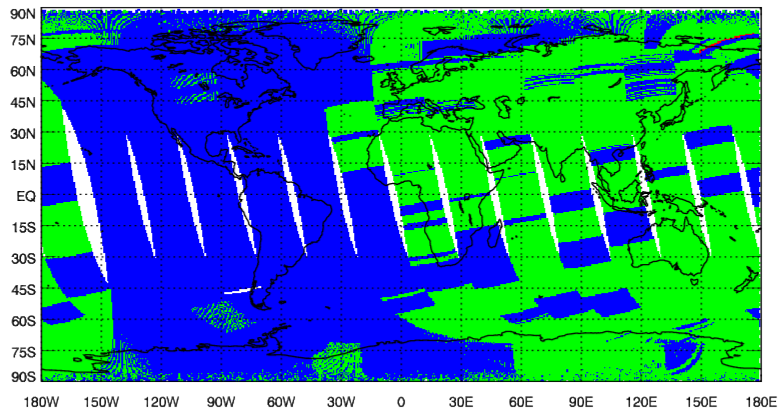
The FOV size is 16808 μrad, 1000 μrad ≈ 850 m at nadir

SDR Overall Quality Flag Improvement

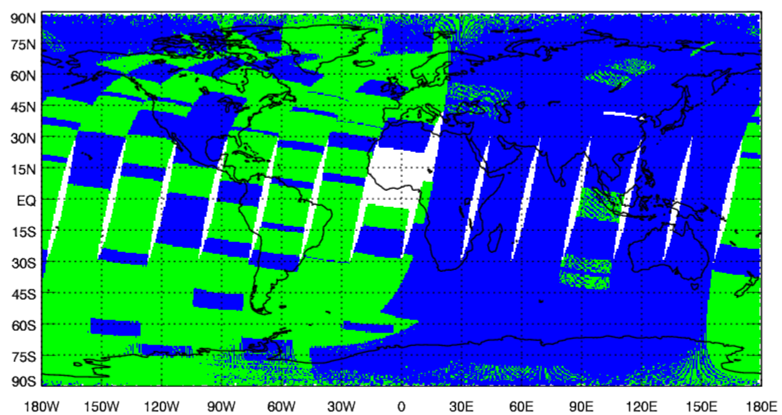
IDPS SDR

NPP CrIS Long Wave SDR Overall Quality Flag, Mapped, Ascending, 06/27/2012

(Blue: Good; Green: Degraded; Red: Invalid) Updated at Aug 10 22:48:06 2015 UTC



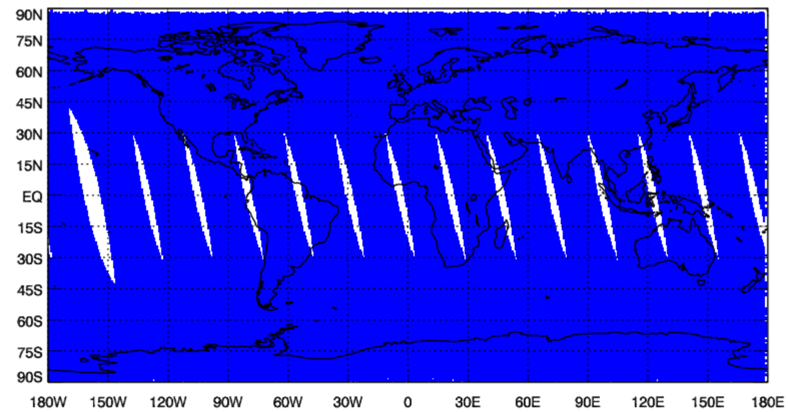
NPP CrIS Long Wave SDR Overall Quality Flag, Mapped, Descending, 06/27/2012



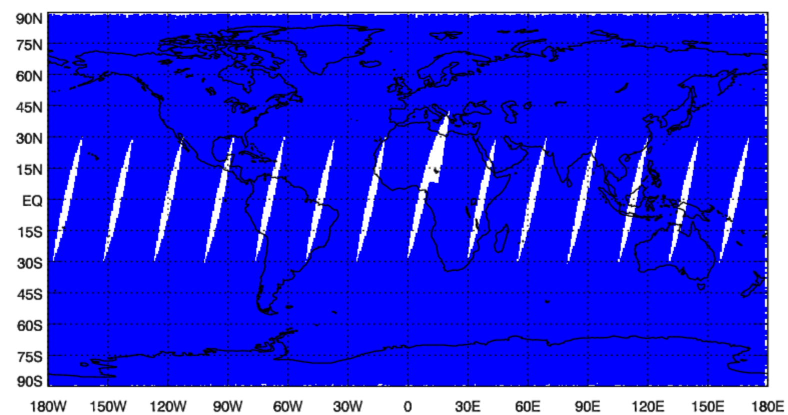
Reprocessed SDR

NPP CrIS Long Wave SDR Overall Quality Flag, Mapped, Ascending, 06/27/2012

(Blue: Good; Green: Degraded; Red: Invalid) Updated at Oct 7 17:34:09 2016 UTC



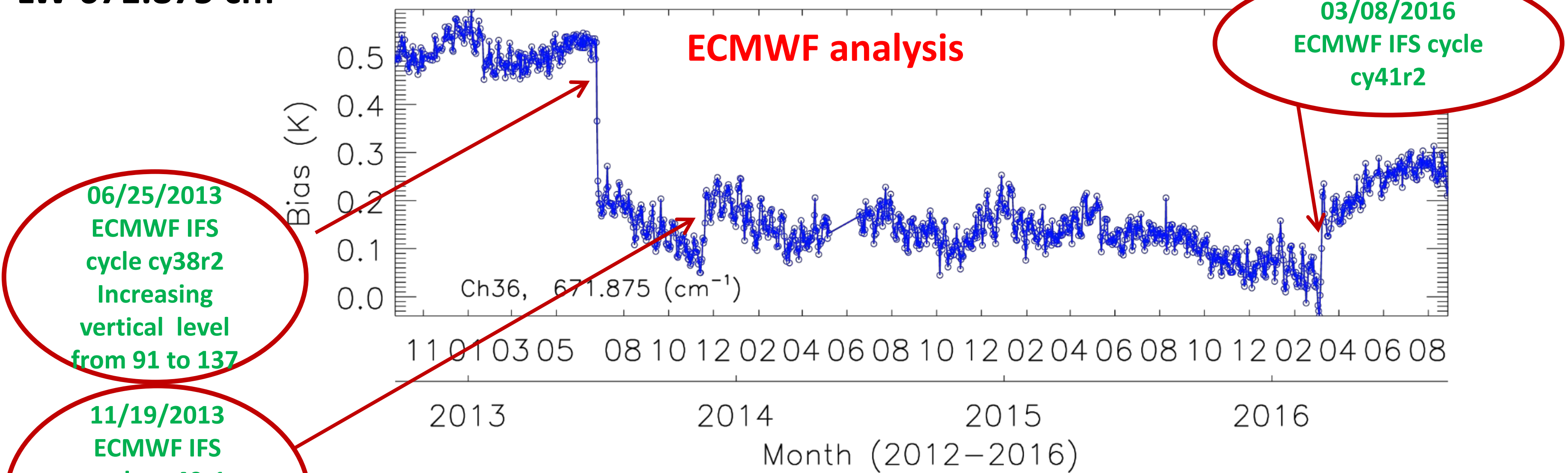
NPP CrIS Long Wave SDR Overall Quality Flag, Mapped, Descending, 06/27/2012

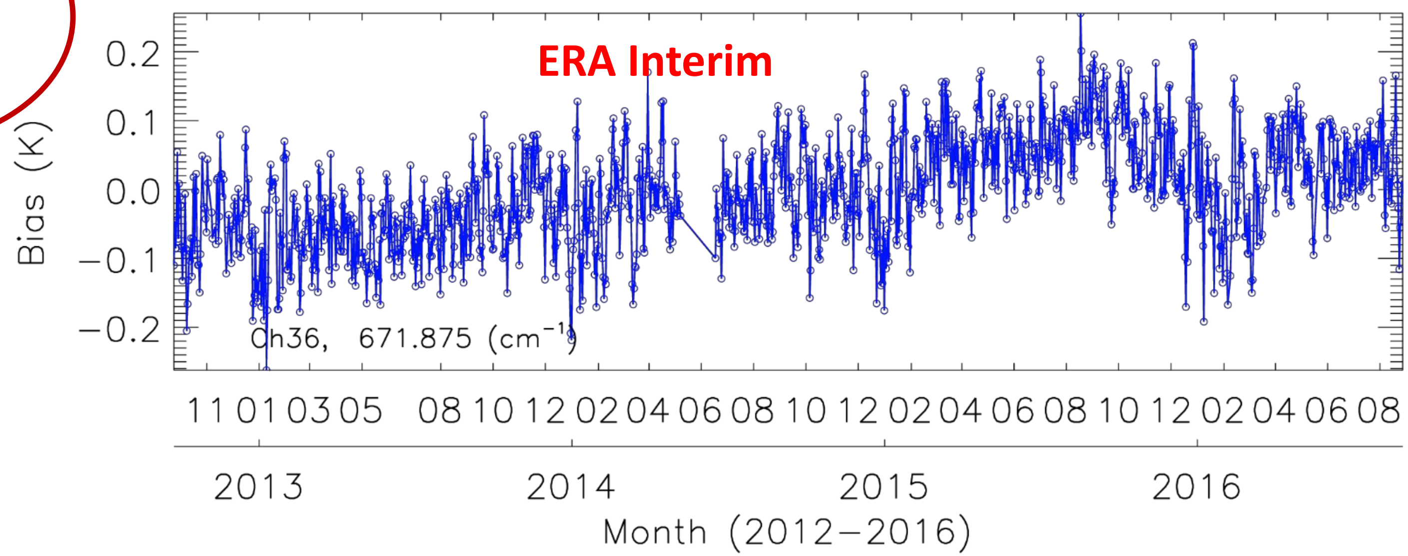


Overall quality flag has no degraded values after Temperature Drift Limits Updated in Eng Pkt

CrIS Radiometric Stability: Obs-Simulation Time Series

LW 671.875 cm^{-1}

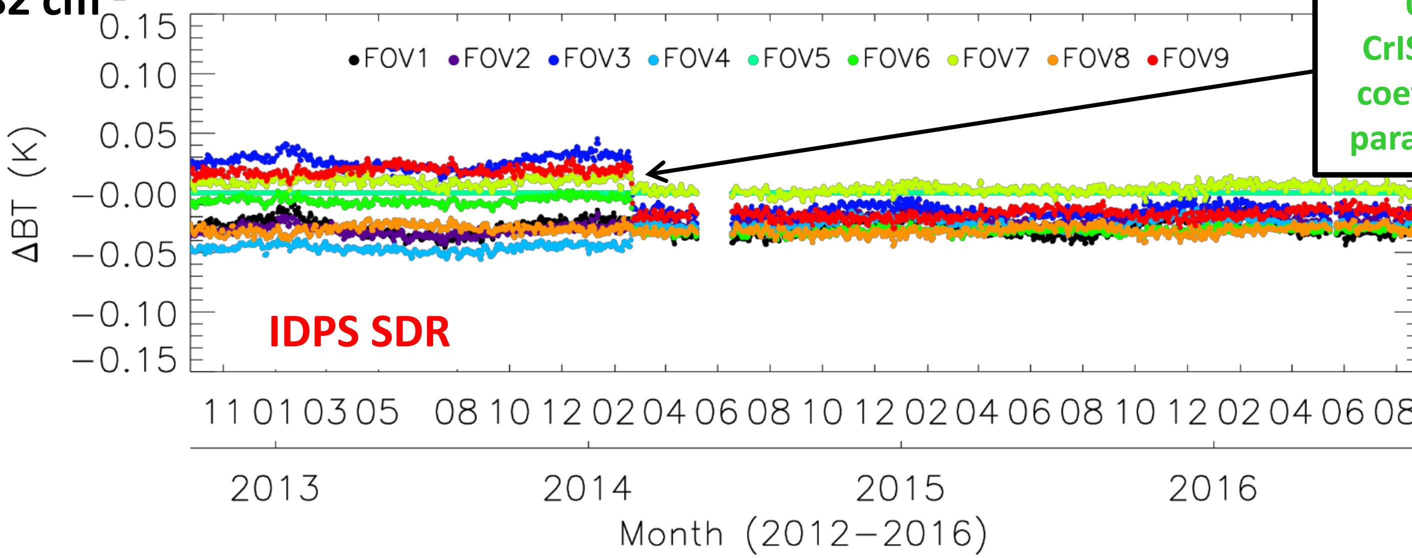




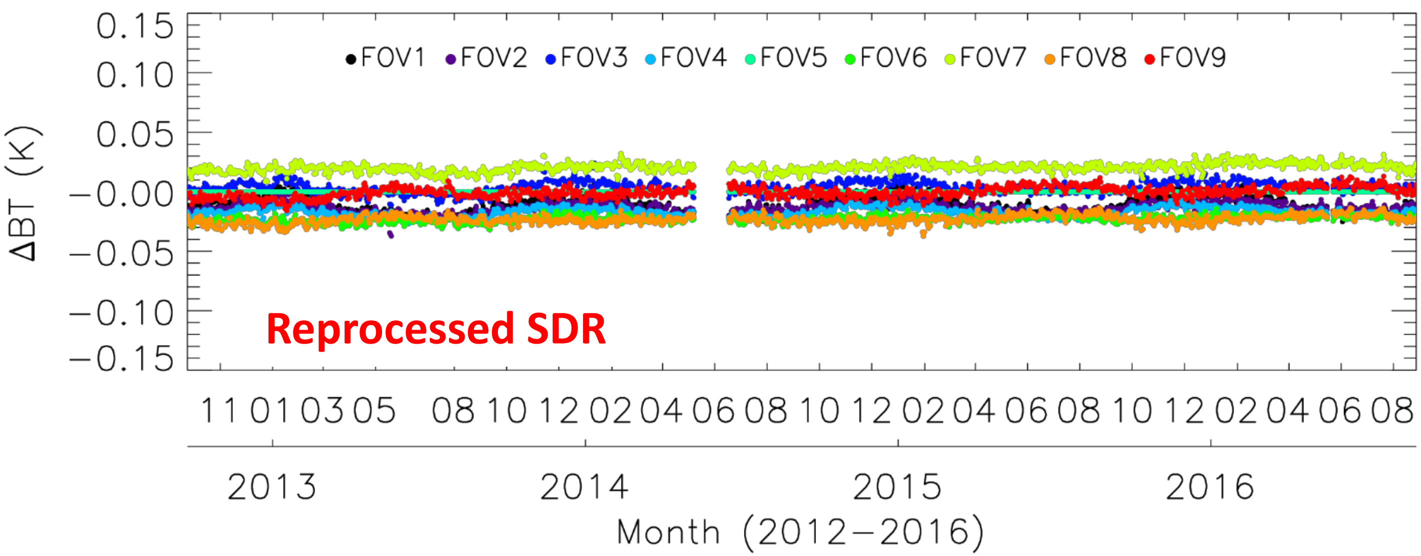
The data gap from May 8, 2014 to June 16, 2014 is due to loss of ECMWF analysis data

CrIS Radiometric Stability: Daily Mean FOV-2-FOV Difference wrt FOV5

LW, 672-682 cm^{-1}

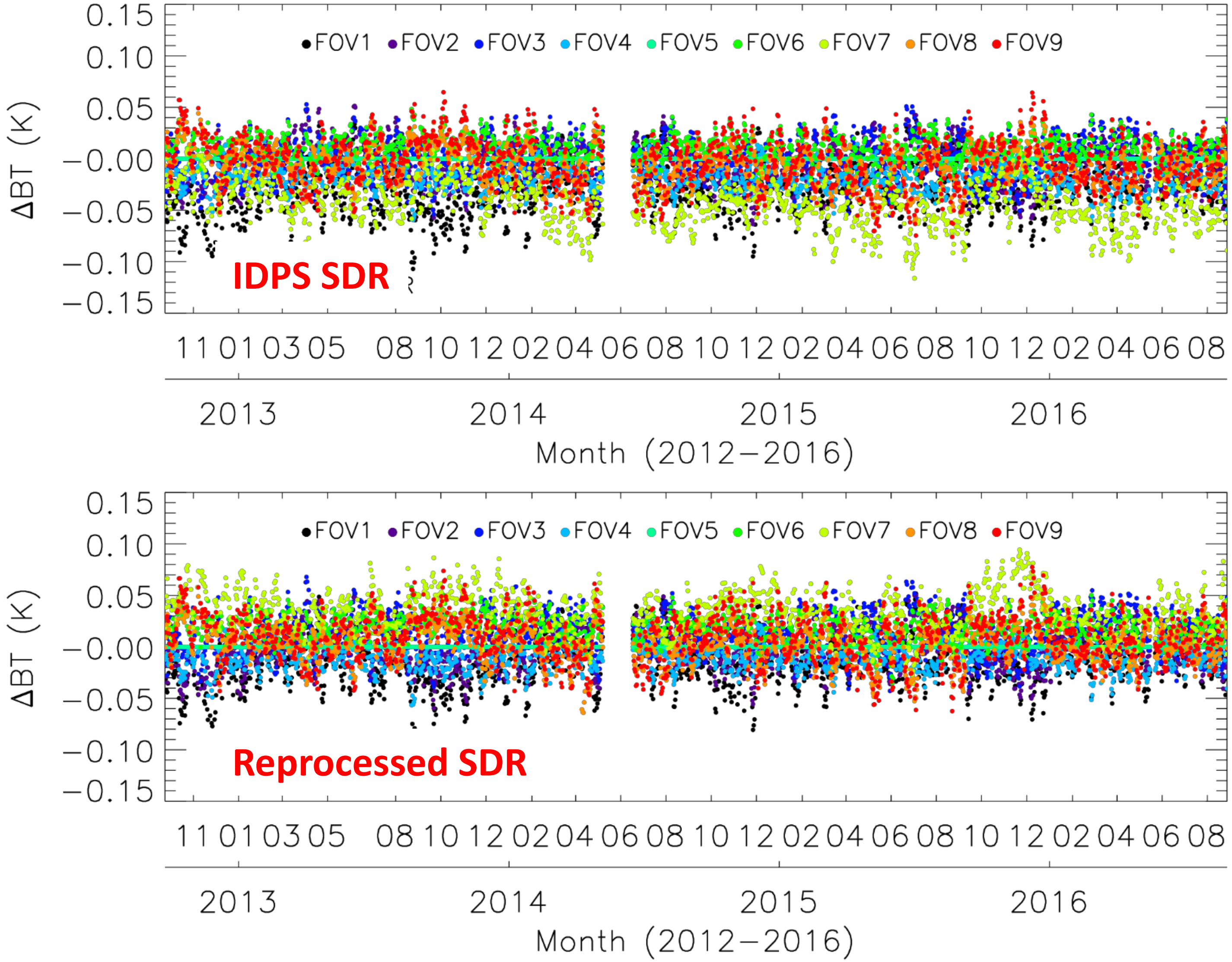


02/20/2014
CrIS non-linearity coefficient and ILS parameters update



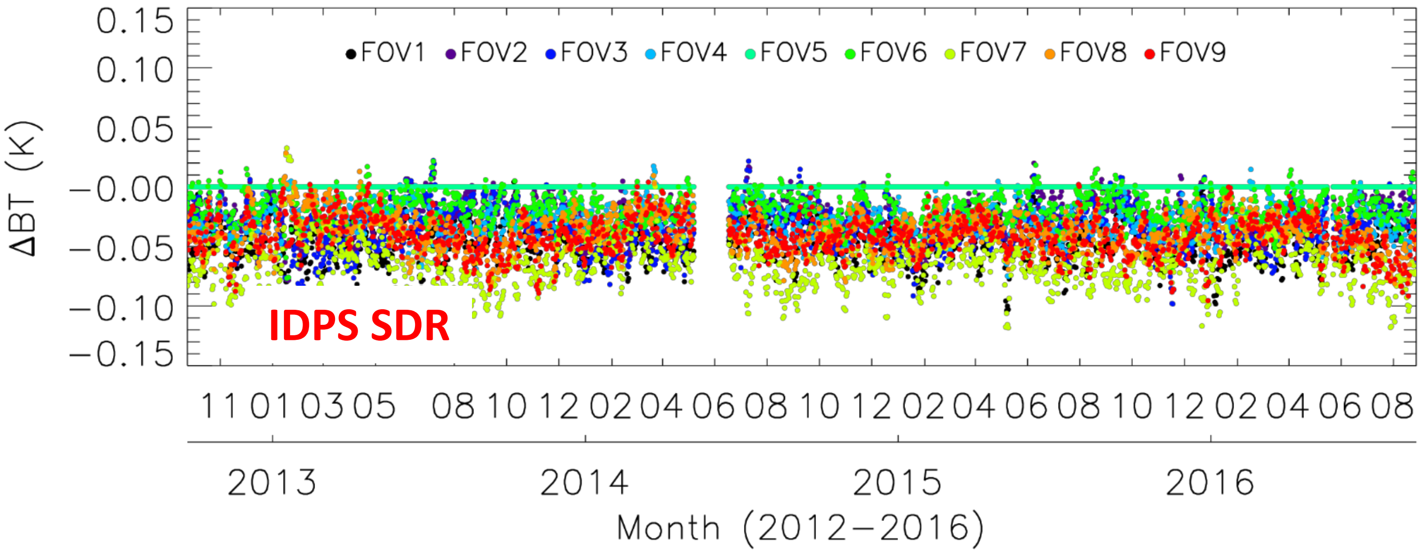
CrIS Radiometric Stability : Daily Mean FOV-2-FOV Difference wrt FOV5

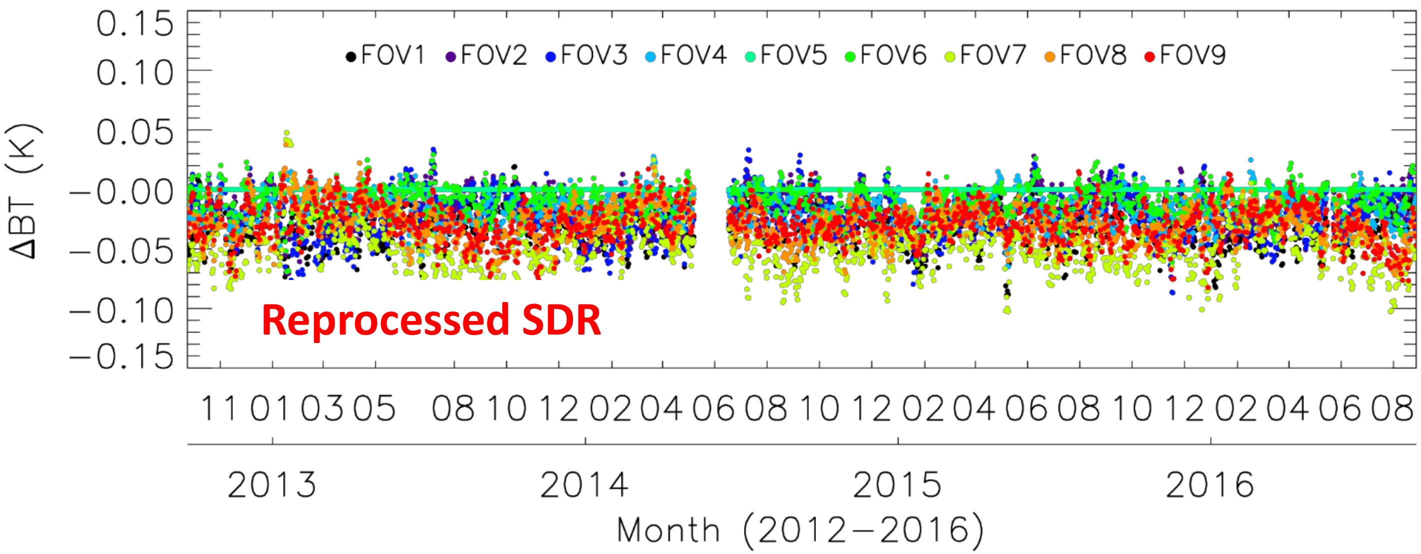
MW, 1585-1610 cm^{-1}



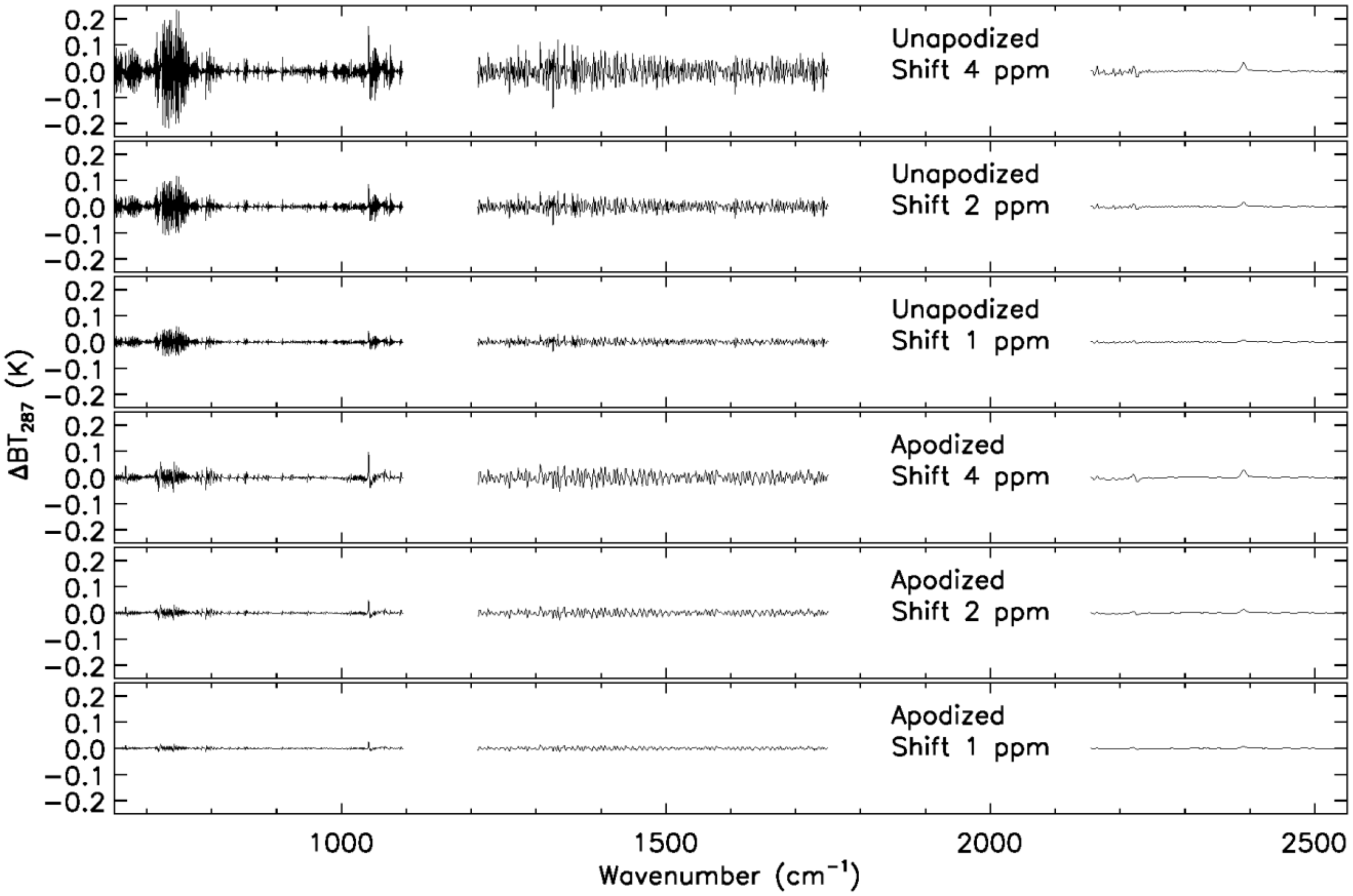
CrIS Radiometric Stability : Daily Mean FOV-2-FOV Difference wrt FOV5

SW, 2500-2520 cm^{-1}



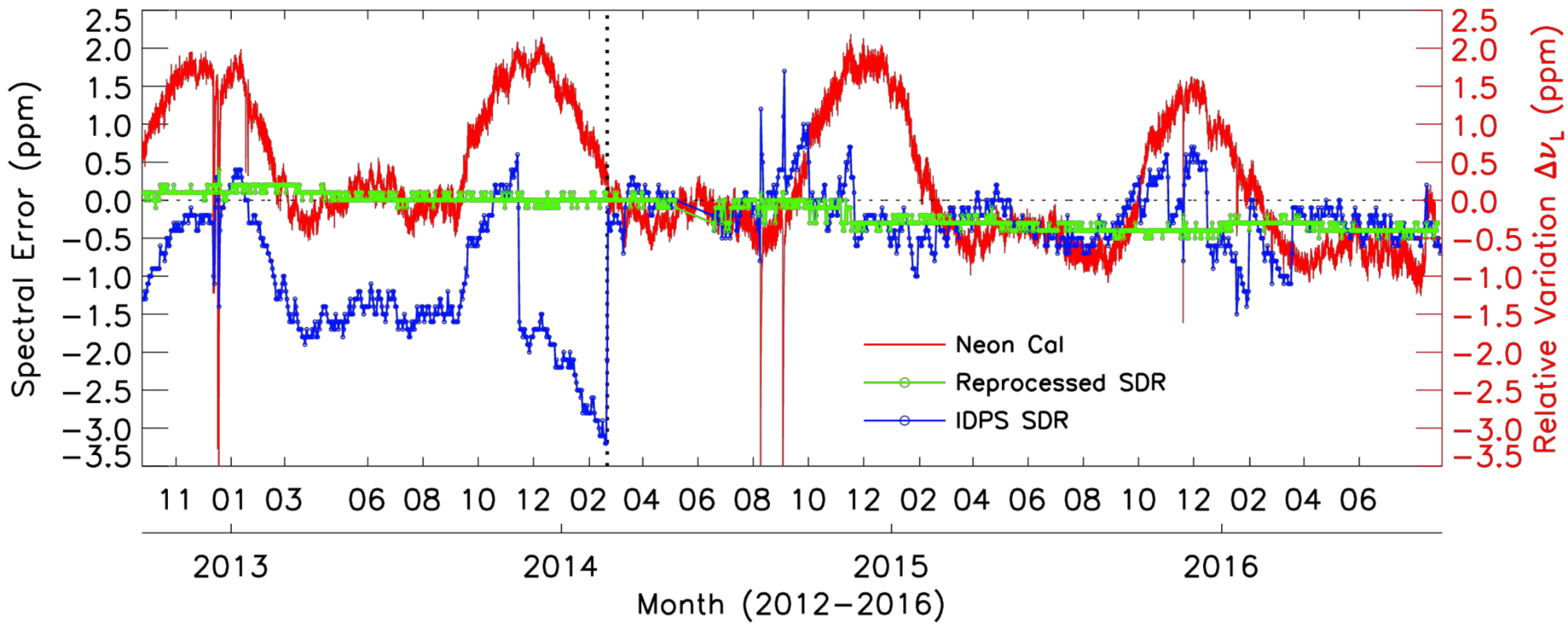


Spectral Accuracy Impact on Radiometric Accuracy



Impact of spectral accuracy on radiometric accuracy in terms of brightness temperature difference for a typical warm scene with respect to an effective BT of 287 K for three different spectral shifts (1 ppm (parts per million), 2 ppm, and 4 ppm) at CrIS three bands for both unapodized and apodized spectra.

CrIS SDR Long-Term Spectral Accuracy and Stability



- Comparison of the Neon subsystem spectral calibration versus calibration using the upwelling radiances for IDPS and reprocessed SDRs from September 22, 2012 to August 31, 2016.
- The upwelling calibration has been offset by -0.6 ppm.
- The Neon zero shift time is determined by the Correction Matrix Operator (CMO) update on December 19, 2012. The several sharp spikes in the December 19, 2012, August 9, 2014, and September 2, 2014 are due to NPP spacecraft issues, not CrIS malfunctions.
- The upwelling calibration is for the daily average of FOV5 at nadir (FOR 15 or 16), descending orbit over clear tropical ocean scenes.
- **Absolute calibration uncertainty is < 1 ppm**

Summary

- In this study, the accuracy of CrIS radiometric and spectral calibration and its stability are assessed using the reprocessed SDR and compared to the operational SDR data.
- Overall radiometric biases (O-S) are small and stable over time, FOV-2-FOV differences are less than ~0.1 K, and much better than that from the operational SDR.
- It is shown that CrIS metrology laser wavelength varies within 3 ppm as measured by the Neon calibration subsystem. The reprocessed SDR have spectral errors less than 0.5 ppm, is much better than the operational SDR with about 4 ppm.
- Reprocessed CrIS SDR will benefit GSICS inter-calibration capabilities and climate applications, in terms of better radiometric and spectral calibration accuracy and stability based on the same software and calibration coefficients

Access to Suomi-NPP SDR Reprocessing Data

- Website: **http://jlrdata.umd.edu/thredds/catalog.htm**


jlrdata.umd.edu/thredds/catalog.html

JPSS Life-Cycle Reprocessing

Catalog

http://jlrdata.umd.edu:81/thredds/catalog.html

Dataset	Size	Last Modified
S-NPP ATMS Data		--
S-NPP_ATMS_TDR/		--
S-NPP_ATMS_SDR/		--
S-NPP_ATMS_GEO/		--
S-NPP CrIS Data		--
S-NPP_CrIS_SDR/		--
S-NPP_CrIS_FSR_SDR/		--
S-NPP_CrIS_GEO/		--
S-NPP VIIRS Data		--
S-NPP_VIIRS_I-Band_SDR/		--
S-NPP_VIIRS_I-Band_Terrain_Corrected_GEO/		--
S-NPP_VIIRS_M-Band_SDR/		--
S-NPP_VIIRS_M-Band_Terrain_Corrected_GEO/		--
S-NPP_VIIRS_DNB_SDR/		--
S-NPP_VIIRS_DNB_GEO/		--
S-NPP OMPS Data		--
S-NPP_OMPS_NP_SDR/		--
S-NPP_OMPS_NP_GEO/		--
S-NPP_OMPS_TC_SDR/		--
S-NPP_OMPS_TC_GEO/		--