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

- **2,200 km Swath**
- **±50° Cross track Scans**
- **30 Earth Scenes**
- **3x3 Array of CrIS FOVs (Each at 14-km Diameter)**

**CrIS on Suomi NPP**

- **Decode Spacecraft Data**
- **CrIS SDR Algorithm**
- **Co-Located ATMS SDRs**
- **NWP, EDR Applications**

**Ground Station**

**RDR = Raw Data Record**
**SDR = Sensor Data Record**
**EDR = Environmental Data Record**

**From Exelis/ABB**
CrIS Instrument Long-term Trending

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

ICT Averaged Temperature

ICT Temperature Difference

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

Metrology Laser Wavelength

Temperature of Optics Module

Stable NEdN

FOV1 FOV2 FOV3 FOV4 FOV5 FOV6 FOV7 FOV8 FOV9 SPEC Forward

720 cm⁻¹
**CrIS SDR CalVal Milestones**

- **First SDR product**: 04/02/2012
- **Beta status**: 04/19/2012
- **Provisional status**: 01/13/2013
- **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

**Intensive Calibration & Validation (ICV)**

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

**Launch**
- 10/28/2011

**FSR SDR operational**
- 2211 channels
- 1305 channels
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
  – 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)

CrIS - ABI

Spectral response functions of ABI channel 7 and 11

CrIS covers 39%

CrIS covers 10%

Bias is less than 0.5K

Bias is less than 0.2K

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

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.
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.
Non-linearity Coefficient Changes

Longwave band

Middlewave band
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
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**

- **06/25/2013**
  - ECMWF IFS cycle cy38r2
  - Increasing vertical level from 91 to 137

- **11/19/2013**
  - ECMWF IFS cycle cy40r1
  - Increasing ENS vertical level from 62 to 91

- **03/08/2016**
  - ECMWF IFS cycle cy41r2

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\textsuperscript{-1}

\[ \Delta BT \text{ (K)} \]

\begin{align*}
\text{Month (2012–2016)} & \\
\end{align*}

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

IDPS SDR

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

MW, 1585-1610 cm\(^{-1}\)

**IDPS SDR**

**Reprocessed SDR**
**CrIS Radiometric Stability:**

**Daily Mean FOV-2-FOV Difference wrt FOV5**

**SW, 2500-2520 cm⁻¹**

[Graph showing ΔBT (K) against time from 2013 to 2016 for different FOVs with IDPS SDR and Reprocessed SDR highlighted.]

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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.
• 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://jldrdata.umd.edu/thredds/catalog.htm](http://jldrdata.umd.edu/thredds/catalog.htm)