S-NPP CrIS Sensor Data Record (SDR): Validated Maturity Level Product

Yong Han, Denis Tremblay, Degui Gu, Dan Mooney, Hank Revercomb, Deron Scott, Larrabee Strow

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Atlanta, GA
(4:15 Room C111, 2/04/14)
Outline

• CrIS SDR Science Team and Cal/Val process
• CrIS measurement and data processing
• CrIS SDR product
• CrIS SDR uncertainties
• CrIS SDR product documentation
• Summary
CrIS SDR calibration and validation (Cal/Val) team members (Subject Matter Experts):

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

• First operational SDR product, April 2, 2012
• Beta maturity status, review meeting on April 4, 2012
• Provisional maturity status, review meeting on October 23, 2012
• Validated maturity status, review meeting on December 18, 2013

The next calibration algorithm/coefficient updates scheduled on Feb. 17, 2014
  – Updates of instrument line shape and detector nonlinearity correction algorithms and corresponding coefficients
  – Up to 0.1 K radiance impact
CrIS System

CrIS instrument provides interferograms & calibration data

Interferogram

Ground SDR Software

SDR Product

Radiance Spectra

LW band

MW band

SW band

Science RDR

Pre-Process

IGM to Spectrum FFT

FCE Handling

Nonlinearity Correction

Radiometric Calibration

Post Calibration BPF

Spectral Resample

ILS Correction

Geo-Location

CMO Operation

SDR
Each scan has 30 Earth view Field of Regards (FORs)
Each FOR has 9 Field of Views (FOVs)
# CrIS Spectral Parameters

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral Range (cm⁻¹)</th>
<th>Normal Mode</th>
<th>Full Resolution Mode*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Resolution (cm⁻¹)</td>
<td>MPD (cm)</td>
</tr>
<tr>
<td>LW</td>
<td>650-1095</td>
<td>0.625</td>
<td>0.8</td>
</tr>
<tr>
<td>MW</td>
<td>1210-1750</td>
<td>1.25</td>
<td>0.4</td>
</tr>
<tr>
<td>SW</td>
<td>2155-2550</td>
<td>2.5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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

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Simulated CrIS (unapodized), IASI and AIRS spectra

![Simulated CrIS (unapodized), IASI and AIRS spectra](image_url)
CrIS SDR Product (1/2)

Radiance spectra

- LW band
- MW band
- SW band

Details in CrIS SDR User’s Guide

16 Data quality indicators (DQIs - integer or floating variables)

Examples of DQI:

- Imaginary radiance spectra
- NEdN spectra

LW band
MW band
SW band
18 Data quality flags (DQFs - 1 or 2 bits)

Details in CrIS SDR User’s Guide
CrIS SDR/RDR Monitoring System

Over 120 SDR as well as Raw Data Record (RDR) parameters are monitored with the Web-based monitoring system open to Public.

Real radiance
Near zero Imaginary radiance indicates good real radiance
Overall SDR quality flag
Blue - good

NPP CrIS Brightness Temperature, 11 μm (900 cm<sup>-1</sup>), Mapped, Ascending, 12/02/2013
NPP CrIS imaginary part radiance, 11 μm (900 cm<sup>-1</sup>), Mapped, Ascending, 12/02/2013
NPP CrIS imaginary part radiance, 11 μm (900 cm<sup>-1</sup>), Mapped, Descending, 12/02/2013
NPP CrIS Mid Wave SDR Overall Quality Flag, Mapped, Ascending, 12/02/2013
NPP CrIS Mid Wave SDR Overall Quality Flag, Mapped, Descending, 12/02/2013

-0.4 0.0K 0.4
Daily occurrence of Good SDR spectra from 2013-07-11 to 2013-11-24

<table>
<thead>
<tr>
<th>Wave</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW</td>
<td>99.9817%</td>
</tr>
<tr>
<td>MW</td>
<td>99.9817%</td>
</tr>
<tr>
<td>SW</td>
<td>99.9816%</td>
</tr>
</tbody>
</table>

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

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 Jan 2013

Zavyalov et al. 2013, JGR
Spectral Calibration Accuracy

Radiance error caused by 3 ppm frequency error

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

Apodized Shift 3 ppm
Radiometric Uncertainty (RU)

Distribution of 3-sigma RU for one orbit of data

 RU better than spec by approximately a factor 4

Uncertainty specification @287K blackbody

Tobin et al. 2013, JGR
FOV-2-FOV Radiometric Performance Difference

1-year LW (672-682 cm\(^{-1}\)) BT difference with respect to FOV5

FOV to FOV radiometric differences are well below 0.1 K

Tobin et al. (UW)
Clear-sky Observation-Calculation Analysis

Behavior of mean biases and standard deviation of obs-calcs are consistent with forward model and atmospheric state uncertainties, implying very good radiometric performance for CrIS

Example of obs-calc bias and std

Chen et al. (NOAA/STAR)
CrIS/IASI Simultaneous Nadir Overpass (SNO)

Metop-A

CrIS  IASI

CrIS-IASI

Metop-B

CrIS  IASI

CrIS-IASI

Wang et al. (NOAA/STAR)
Geolocation Accuracy Assessed with VIIRS

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

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

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

Wang et al. 2013, JGR
Summary of CrIS SDR Uncertainty

CrIS SDR uncertainties (blue) vs. specifications (black)

<table>
<thead>
<tr>
<th>Band</th>
<th>NEdN @287K BB mW/m²/sr/cm⁻¹</th>
<th>Radiometric Uncertainty @287K BB (%)</th>
<th>Frequency Uncertainty (ppm)</th>
<th>Geolocation Uncertainty (km) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW</td>
<td>0.098 (0.14)</td>
<td>0.12 (0.45)</td>
<td>3 (10)</td>
<td>1.3 (1.5)</td>
</tr>
<tr>
<td>MW</td>
<td>0.036 (0.06)</td>
<td>0.15 (0.58)</td>
<td>3 (10)</td>
<td>1.3 (1.5)</td>
</tr>
<tr>
<td>SW</td>
<td>0.003 (0.007)</td>
<td>0.2 (0.77)</td>
<td>3 (10)</td>
<td>1.3 (1.5)</td>
</tr>
</tbody>
</table>

* Within 30° scan angles

CrIS SDR meets all the requirements with the exception of the NEdN for MWIR FOV7.
Documentation and Data Download

• ATBD, User’s guide, and more science documentation are available at
  http://www.star.nesdis.noaa.gov/jpss/ATBD.php

• CrIS monitoring system located at
  http://www.star.nesdis.noaa.gov/icvs/status_NPP_CrIS.php

• CrIS SDR Data available at CLASS
  http://www.nsof.class.noaa.gov/saa/products/welcome
References
(JGR Special Issue)


Summary

• The CrIS instrument has been working very well since the beginning of the NPP mission

• CrIS SDR product has been validated, which meets the requirements with large margin

• A complete set of documentation on SDR product, SDR theoretical basis, and SDR calibration/validation results are available publicly