Read-me for Data Users

MEMORANDUM FOR: The JPSS Program Record
SUBMITTED BY: JPSS CrIS Team, Flavio Iturbide-Sanchez, Yong Chen, Denis Tremblay, Likun Wang, Andrew Wald
CONCURRED BY: JPSS Algorithm Management Project Lead Arron Layns
JPSS STAR Program Manager Lihang Zhou
APPROVED BY: JPSS Program Scientist Mitch Goldberg

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SUBJECT: NOAA-20 CrIS SDR Validated Maturity Status and Public Release
DATE: 10/02/2018

Validated maturity status declaration for CrIS SDR
Maturity Review Date: **10/02/2018**
Effective Date: **08/14/2018**
Operational System: **IDPS with Engineering Packet (EP) v115**

1. Background:

The Joint Polar Satellite System-1 (JPSS-1) was successfully launched on November 18, 2017 and renamed NOAA-20 after reaching polar orbit. Forty-eight days after launch, on January 5, 2018, the NOAA-20 Cross-track Infrared Sounder (CrIS) started collecting science data. With the same design as Suomi NPP CrIS, NOAA-20 CrIS provides global hyperspectral infrared observations twice daily for profiling atmospheric temperature and water vapor, critically needed information for improving weather forecast accuracy out to seven days. CrIS also supplies information used to retrieve greenhouse gases, land surface and cloud properties. CrIS measures infrared spectra in three spectral bands: the long-wave IR (LWIR) band from 650 to 1095 cm^{-1}, mid-wave IR (MWIR) band from 1210 to 1750 cm^{-1} and short-wave IR (SWIR) band from 2155 to 2550 cm^{-1}. Normal spectral resolution (NSR) and full spectral resolution (FSR) operational modes provide a total of 1305 and 2211 radiance channels, respectively.

The CrIS SDR team consists of experts from NOAA, NASA, University of Maryland/CICS, University of Wisconsin/SSEC, University of Maryland at Baltimore County, Utah State University/SDL, MIT Lincoln Laboratory, Harris, Logistikos, and Raytheon. The team has been working intensively on post-launch instrument performance optimization and CrIS SDR pre- and post-launch calibration and validation.

The NOAA-20 CrIS SDR data product was declared Beta Maturity on January 17, 2018. After one-month of intensive Cal/Val activities, the NOAA-20 CrIS SDR data product was declared Provisional Maturity on February 16, 2018.

2. Validated Maturity Stage Definition:

1. Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
2. Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions

and severity level.

3. Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
4. Product is ready for operational use based on documented validation findings and user feedback.
5. Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

3. Justifications for Declaring NOAA-20 CrIS SDR Data Products Validated Maturity:

After NOAA-20 CrIS SDR Provisional Maturity on Feb 16, 2018, CrIS SDR team members continued the assessment and analysis of both CrIS on-orbit data and special post-launch tasks (PLT) data, including CrIS science RDR, telemetry RDR, diagnostic RDR, SDR, and GEO data products. Based on more than six months of continuous intensive evaluation and monitoring of CrIS data, the following assessments of the NOAA-20 CrIS instrument and data products are given:

1. NOAA-20 CrIS SDR performance has been demonstrated globally for more than six months, since Provisional Maturity.
2. Comprehensive documentation of instrument status and product performance exists, including: ICVS reports, Algorithm Theoretical Basis Document (ATBD), Operational Algorithm Description (OAD), ReadME file, Cal/Val plan and regular validation reports.
3. On-orbit NEdN: all FOVs and bands are within the specification (MW FOV9 is out of family). NOAA-20 CrIS SDR noise holds comparable performance against S-NPP CrIS SDR.
4. Spectral uncertainty: spectral offsets, relative and absolute, for all three bands are all within ±2 ppm.
5. Radiometric uncertainty: radiometric uncertainty given as a percent of the 287 K blackbody radiance is 0.19%, 0.21% and 0.37% for the long-, mid- and short-wave infrared band, respectively. Radiometric FOV2FOV consistency for LW and MW bands are within 0.1 K.
6. Geolocation uncertainty: geolocation uncertainty is within 220 meters for all FORs using VIIRS as the geolocation reference.
7. Radiometric differences between SNPP and NOAA-20 are within ±0.1 K for the majority channels. The estimated differences were derived from the simultaneous nadir overpass (SNO) double-difference approach using MetOp-B/IASI as a transfer radiometer and double-difference from radiative transfer calculations as a transfer target.
8. NOAA-20 CrIS SDR has shown long-term noise, spectral and geolocation stability.
9. The NOAA-20 CrIS SDR data is sufficient for use on qualitative and quantitative assessments, as well as for operational use.
10. NOAA-20 CrIS SDR data has been utilized in NOAA/NCEP operational NWP system since May 30, 2018, and September 11, 2018 in ECMWF.
11. NOAA NUCAPS team has generated and analyzed NOAA-20 trace gases, temperature, water vapor and other EDR products and is satisfied with the EDR accuracy. NUCAPS NOAA-20 temperature and water vapor products are being distributed to users after reaching the provisional maturity level on June 15, 2018.
12. No major concerns have been identified in the SDR software or in the SDR data. To ensure product validation, quality assurance and algorithm stewardship, the CrIS SDR team maintains

the algorithm and product validation, continues to improve algorithm performance, and continues monitoring the instrument health and product quality.

Table 1 summarizes the on-orbit NOAA-20 CrIS SDR performance against specifications.

Table 1. The NOAA-20 CrIS FSR SDR uncertainties (blue) vs. specifications (black).

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty (km)	Radiometric Uncertainty @287K BB (%)	Radiometric Stability @287K BB (%)
LWIR	650-1095	0.625	713	0.086 (0.14)	2 (10)	0.22 (1.6)	0.19 (0.45)	0.27 (0.40)
MWIR	1210-1750	0.625	865	0.0315 (0.084)	2 (10)	0.22 (1.6)	0.21 (0.58)	0.30 (0.50)
SWIR	2155-2550	0.625	633	0.00766 (0.014)	2 (10)	0.22 (1.6)	0.37 (0.77)	0.52 (0.64)

The detailed justifications for declaring NOAA-20 CrIS SDR validated maturity is attached in the presentation.

4. NOAA-20 CrIS Validated Maturity SDR Data Product Caveats

The following caveats are offered to the NOAA-20 CrIS SDR validated product users:

1. The MWIR FOV 9 has high NEdN and is out of family. However, the noise performance of this FOV is within specifications and was expected since prelaunch measurements.
2. Due to the flight software update performed on NOAA-20 from 12:07 on February 2, 2018 to 15:59 on February 3, 2018, CrIS data are lost for this period. All instruments were set in safe mode during the flight software update.
3. Due to the incorrect default bias tilts values for Dx and Dy in the flight software, CrIS SDR data have higher NEdN at SWIR (some FOVs increasing 20%, but still meet the specification) compared to pre-flight software update. This issue was corrected around 18:38 GMT on February 16, 2018 when the EP v114 was uploaded and the interferogram (IM) configuration commanding were performed in the flight software. This problem occurred after the flight software update performed during the February 2-3, 2018 period (caveat 2).
4. On July 24, 2018, the CrIS SDR Team informed the Flight Software Working Group (FSWWG) about potential errors in the instrument configuration associated with incorrect bias tilts, after an anomaly experienced on July 19, 2018. Although still meeting the specifications, this increased the NEdN at SWIR channels. The FSWWG confirmed the CrIS SDR team about errors on the bias tilts. On July 26, 2018 at 18:45 UTC the proper instrument configuration (correct bias tilts) and setup commands were uploaded to avoid future incorrect bias tilts occurring after the instrument is set on safe mode (caveat 3 and 4).
5. Due to a software bug affecting the determination of the interferometer sweep direction (forward and reverse), the data quality indicators and quality flag with explicit dependence on sweep direction are impacted. Affected indicators and flags are: DS_WindowSize, ICT_WindowSize, DS_SpectralStability, ICT_SpectralStability, ICT_TemperatureStability, ICT_TemperatureConsistency, NumberOfValidPRTTemps, and quality flag QF2_CRISSDR. Overall data quality flag (QF3) and radiance products are not impacted. This caveat was fixed after 09/24/2018, when Block 2.1 Mx 3 went into operations (DR 8629).
6. There are several anomalies related to missing RDR packets for NOAA-20 CrIS SDR. Earth Scenes (ES) SDRs are found to have bad quality flags and FILLED values on the radiance and Lat/Lon fields. However, corresponding RDRs are not corrupted, when the cross granules (4 before and after of the center granule) have missing ES RDR packets. Another anomaly occurred

when Internal Calibration Target (ICT) packets are missing in a moving window. In this case, the SDR radiances are labelled as 'degraded' as a result of excessive thermal drift due to the error to handle the missing ICT packets. These anomalies were fixed in IDPS software on May 24, 2018 (DR 8653) by implementing the out-of-cycle LUTs for j01 CrIS-FS-SDR-FILL-PACKET-LUT and CrIS-SDR-FILL-PACKET-LUT.

5. Path forward

The team will work diligently to continue with the following planned Cal/Val tasks after the Validated Maturity of the NOAA-20 CrIS SDR data product. :

1. Continue to monitor the instrument long term stability and performance (NEdN, responsivity, geolocation, radiometric and spectra accuracy), as well as SDR data quality.
2. Continue to inter-compare the NOAA-20 CrIS instrument with other sensors (IASI, VIIRS, and ABI), and provide the radiometric uncertainty.
3. Implement the polarization correction in IDPS. When and how to turn on this implementation depends on users' request.
4. Reprocessing NOAA-20 CrIS data before EP v115 (August 14, 2018), using the same calibration coefficients and the latest IDPS software to improve the data consistency for the whole mission.
5. Assess the impact of the operational spike detection and correction algorithm on the quality of the CrIS SDR data.
6. Assess the impact of the sweep direction indicator and Quality Flags improvements on the quality of the CrIS SDR data.
7. Include the lunar intrusion algorithm in IDPS Block 2.1 MX4 (12/17/2018) and assess its impact on the quality of the CrIS SDR data.
8. Investigate further the non-linearity of the NOAA-20 CrIS MWIR FOV9.
9. Investigate the potential refinement of the NOAA-20 CrIS ICT Environmental Model.
10. Continue the characterization of the instrument performance following the NOAA-20 CrIS Calibration/Validation Plan.
11. Lessons learned from NPP and NOAA-20 CrIS are being integrated into J2 CrIS by using the developed methodologies and procedures for the characterization and calibration of J2 CrIS. As part of the Polar Follow-ON (PFO) planned activities, the CrIS SDR Team is moving toward future higher spatial resolution IR hyperspertral observations by discussing the implementation of a 7 km CrIS FOV size for J4.

Additional information is available in the CrIS Algorithm Theoretical Basis Document (ATBD) and Maturity review briefings, which can be accessed at:
https://www.star.nesdis.noaa.gov/jpss/Docs.php
https://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php

Pre-operational NOAA-20 CrIS near real time status and performance monitoring password protected web page is available using the following URL at:
https://www.star.nesdis.noaa.gov/icvs/status_N20_CrIS.php

Point of Contact:
Name: Flavio Iturbide-Sanchez
Email: flavio.iturbide@noaa.gov
Phone: 301-683-3572