**MEMORANDUM FOR:** The Record

**FROM:**  Dr. Yong Han, CrIS SDR Team Lead

NOAA/NESDIS/STAR

**SUBJECT:** NPP CrIS SDR Provisional status and public release

**DATE:**  11/6/2012

1. **Background**

The successful launch of the Suomi National Partnership Program (NPP) spacecraft on October 28th, 2011 with the Crosstrack Infrared Sounder (CrIS) ushers in a new generation of capabilities for operational environmental remote sensing for weather, climate, and other environmental applications. The CrIS Sensor Data Record (SDR) product will be assimilated by the NWP models to significantly improve the weather forecast and used by the CrIS and Microwave Sounder Suite (CrIMSS) algorithm to produce the Environmental Data Records (EDRs). The CrIS SDR team consists of experts from NOAA, NASA, University of Wisconsin, Space Dynamic Laboratory (SDL), MIT/Lincoln lab, University of Maryland Baltimore County (UMBC), and industry partners Northrop Grumman, Exelis (formely ITT), and Raytheon. The team has been working intensively for instrument performance optimization and CrIS SDR calibration and validation.

**1.1 Beta product**

CrIS SDR product was declared to have reached Beta maturity level on May 15th, following successful early CalVal work performed by the team, including updates of PGA setting and bit trim masks in Engineering packet v32 uploaded to NPP CrIS on Feb. 8, updates of ILS parameters and nonlinearity coefficients in Engineering packet v33 uploaded on April 11th 2012, a new onboard FIR filter uploaded on April 18th 2012, and critical SDR software bug fixes.

A Readme file was provided to the Beta product users, which summarized the following product caveats:

1. The CrIS Overall data quality flag (DQF) is not reliable. The user is advised to look at the imaginary part of the spectrum to assess the quality of the radiance.
2. The CrIS Overall DQF may have a value of 3. This is due to a coding error that is planned to be fixed for declaring the provisional maturity level.
3. Less than 0.1% of the interferograms contains ‘filled’ values. It is believed that they were corrupted during the transmission on the ground. The current CrIS SDR code does not check for the presence of these filled values and processes the IFGM as valid. A code fix is planned and is needed for declaring the provisional maturity level.
4. The fringe count error (FCE) detection and correction algorithm has been disabled because it was found to be defective. The lack of the FCE detection and correction module currently does not pose a problem, since FCE is a rare event.
5. The geolocation accuracy has been assessed at the first look level (crude). Precise assessment will be performed during the upcoming intensive calibration and validation (ICV) phase.

**1.2 Major CalVal activities after the Beta review meeting**

Since the Beta Review Meeting, the CrIS SDR team has focused on the following activities:

1. Spectral and radiometric uncertainty characterization
   1. Inter-satellite/sensor comparisons
   2. Observation vs. radiative transfer model comparisons
   3. Gain analysis: orbital dependence, channeling and stability
   4. Internal consistency check: FOV-2-FOV comparisons, FOR-2-FOR comparisons, component correlation analysis and PCA
   5. Calibration algorithm analysis: spectral ringing and proposal for improvement
   6. Full resolution data analysis for SW spectral calibration
2. Geolocation validation
   1. Uncertainty analysis using VIIRS data and near coastline CrIS data; an erroneous offset of 4.5 Km was found and the software code has now been fixed
3. Algorithm improvement and code fix
   1. New data quality flag based on imaginary part of radiances
   2. New algorithm for checking temperature limits
   3. Engineering packet updates from v33 to v34 and v35
   4. Code fixes for geolocation and handling missing packets

**1.3 Provisional maturity definition**

The definition of the Provisional maturity level is given in Table 2 in Section 2.5.

1. **Justification for promoting the CrIS SDR maturity level from Beta to Provisional**

On October 23-24, 2012, the CrIS SDR Provisional Product Review Meeting was held at NOAA NCWCP. All the PIs of CrIS SDR team attended the review meeting. The purpose of this meeting was to assess the readiness of the CrIS SDR data product maturity level to be declared “Provisional” by the Algorithm Executive Review Board (AERB). The CrIS SDR team members presented results and progress on the 48 cal/val tasks. CrIS SDR users, representatives from NWP data assimilation centers (NCEP, ECMWF and UKMO) and the CrIMSS team lead provide their assessments to the CrIS SDR product. In the end of the review meeting, the review panel provided the following assessment to the CrIS SDR team and product:

1. Outstanding – significant amount of work since beta
2. No major issues
3. Instrument well within specification
4. Team should analyze trends very carefully to assess stability
5. Need to ensure data quality flags are working
6. Need to assess CrIS saturation at the cold end – important for climate
7. Need to use CrIS to validate VIIRS
8. CrIS team – clearly defined remaining issues and future plans
9. Provisional maturity clearly achieved

The justifications for promoting the CrIS SDR from Beta to Provisional maturity level are summarized in the followings and the supporting materials [1] – [12], presented in the SDR Provisional product review meeting by the CrIS SDR team and users.

**2.1 The SDR product has met the specifications**

The following table lists the SDR specifications in black color and the corresponding CalVal values the SDR team derived from the in-orbit data in green color. The SDRs are well within the specifications. These CalVal values in the table are derived with rigorous methods on the data collected over the past 10 months. The NEdN values are estimated from spectra of the deep space (DS), internal calibration target (ICT) and Earth scenes (ES). Not only the NEdN spectra are evaluated but also its stability with time and the noise correlation between channels, which are all in excellent status. The radiometric uncertainty is estimated with inter-FOV comparisons, inter-satellite/sensor comparisons and the bias analysis with the radiative transfer models (RTM). The radiometric uncertainty in brightness temperature is around 0.1 K or better and has been very stable over the past 8 months. The spectral calibration uncertainty is estimated through spectral correlation analysis between FOV-i (i = 1, 2, 3, 4, 6, 7, 8 or 9) and FOV-5 and between the observed spectra and RTM simulated spectral, based on the knowledge that the spectral positions of the atmospheric absorbers are precisely known. The geolocation uncertainty is estimated by comparisons of collocated CrIS and VIIRS IR radiance observations, taking the advantage of that these VIIRS channels have a spatial resolution of 750 m and a geolocation uncertainty of less than 100 m. The details of the uncertainty assessments and results can be found in the attached team member presentations [1] – [8].

Table 1. CrIS SDR specifications (black color) and corresponding CalVal values (green color)

|  |  |  |  |
| --- | --- | --- | --- |
| **Band** | **LW** | **MW** | **SW** |
| **Spectral Range (cm-1)** | 650-1095 | 1210-1750 | 2155-2550 |
| **Number of Channels** | 713 | 433 | 159 |
| **Resolution (cm-1)** | 0.625 | 1.25 | 2.5 |
| **FORs Per Scan** | 30 | 30 | 30 |
| **FOVs Per FOR** | 9 | 9 | 9 |
| **NEdN @ 287K BB mw/m2/sr/cm-1** | 0.14(**0.05**) | 0.06(**0.02**) | 0.007(**0.002**) |
| **Radiometric Uncertainty @ 287K BB (%)** | 0.45 (**0.3**) | 0.58 (**0.2**) | 0.77 (**0.2**) |
| **Spectral (Channel Center) Uncertainty ppm** | 10 (**3**) | 10(**3**) | 10 (**3 \***) |
| **Geolocation Uncertainty (km)** | 1.5(**1.0 \*\***) | 1.5(**1.0 \*\***) | 1.5(**1.0 \*\***) |

**\*Relative to FOV5; \*\*Within 30o scan angles**

**2.2 The remaining issues are not critical to the Provisional product**

The followings are the issues identified by the team. None of them are critical to the SDR product.

1. Software issues still appearing

With the progress of the CrIS SDR CalVal work, software issues, although still occurring, become less and less critical to the SDR products, especially after MX 6.2 and MX 6.3. Many SDR data problems originated from the mishandling filled packets and missing packets in the SDR code were fixed in MX 6.2. A new quality flag based on the imaginary part of the spectra was added to MX6.3. The team anticipates that software issues if occur that cause data quality problems can be effectively picked up by this QC quality flag set as Invalid. The team will then fix the root causes.

1. Significant SW cold scene FOV differences

In the regions where the scenes are cold, some of the SW band channels exhibit significant FOV-to-FOV difference in the order of 0.2 K, which is still well within the specification. The reason for the difference is under investigation.

1. Spectral ringing

Spectral ringing about 0.1 – 0.2 K was detected at the channels near the beginning of the un-apodized spectra. The issue is under investigation. The ringing can be reduced well below the 0.1 K level if apodization is applied. Since most of the users such as the NWP data assimilation centers and CrIMSS all use the apodized spectra, there will be no issue in using the SDR data.

1. FCE module currently turned off

Currently the fringe count error (FCE) detection and correction module has been turned off due to the software bugs and algorithm problems. The turn-off of the FCE module has not been a problem since so far no FCE event has been observed. Even if the FCE occurs, the new QC algorithm implemented in MX6.3 will be able to catch it and flag the SDR as Invalid.

1. Calibration coefficients not optimal

Recent analysis indicates that the geolocation calculation and radiometric and spectral calibrations may be improved by further adjustment of the geolocation mapping parameters and calibration coefficients. These CalVal activities will make the SDR product better than that presented during the October SDR review meeting.

**2.3 The Discrepancy Reports in Open status are not critical to the Provisional product**

There are a total of 87 DRs registered on CasosNOSA, 72 of which have been closed or rejected. The rest 16 DRs are still open, but not critical to the SDR product, which was the conclusion at the DR review meeting for CrIS SDR provisional product organized by DPA. Among these DRs, 4 DRs (#3563, #4937, #4661, #4232) are being closed, 2 FCE-related DRs (#4508, #4481) will be fixed in future together with the algorithm fix. Five DRs (#3081, #4198, #4253, #4774, #4812, #4407) will be handled in the future, 3 DRs are minor code issues which will be fixed for the Validated product and 2 DRs (#4868, #4090) will be fixed in MX7.0.

There are 2 new DRs since the Provisional review meeting. DR # 4963 (Missing packet shall be flagged as invalid) was created for the issues occurred before MX6.3 became operational on Oct 12. If the missing packet issue occurred after Oct 12, the SDR will be flagged as Invalid by the imaginary QC algorithm implemented in MX6.3. A fix to the issue is still needed in the SDR software at a early processing stage to flag the missing packet. DR #4964 (Avoid division by zero) has a very low priority, since the possibility of division by zero in the calibration equation is near zero. It happened once in February when IDPS was not stable and at the stage of IDPS code initialization. Even if this case happens today, it will not affect the SDR quality. However, adding a check to the denominator in the calibration equation is a good thing to do, as this DR suggests.

**2.4 IDPS CrIS SDR processing is stable since July**

Since MX6.2 became operational, no critical issues and problems have been observed in CrIS SDR processing.

**2.5 Checklist of CrIS SDR maturity status against the Provisional definition**

In Table 2, the left and middle columns list the items of the Provisional status definition and the CrIS SDR maturity status, respectively. The comments on the right column summarize the rationale behind the CrIS SDR Provisional status.

Table 2. Provisional product maturity definition and CrIS SDR maturity status

|  |  |  |
| --- | --- | --- |
| **Provisional Product Maturity Definition** | **SDR Status** | **Comments** |
| Ready for operational evaluation | True | See section 2.1 and the user presentations [9]-[12]. CrIS SDR meets specifications and has positive impact on weather forecast. |
| Product quality may not be optimal | True | See section 2.2 and 2.3. CrIS SDR still have issues, but are not critical to the product. |
| Incremental product improvements are still occurring as calibration parameters are adjusted | True | See section 5. |
| Version control is in affect | True | The calibration coefficients are all in Engineering packet, which has a version; the SDR product currently is in version control with the IDPS build. |
| General research community is encouraged to participate in the QA | True | CrIS SDR data are available on CLASS for the public; the team has been responding to the QA issues from the users since the product was released to the public. |
| Users are urged to consult the SDR product status documents prior to use of the data in publications | True | A Readme file will be provided accompanying the SDR data; the readme file will include the caveats. |

1. **CrIS Provisional SDR product caveats**

The followings will be written into the Readme file for the Provisional users:

1. The value of the ESZPDMMagnitude field may not be corrected due to an inconsistency between the internal data types (DR 4389).
2. The fourth scan of the SDR granule generated from a short RDR granule (3 scans) is not valid (filled with fillvalue), but labeled as Valid.
3. **Team assessment consensus**

Before the SDR product review meeting held on Oct 23-24, the team lead sent the presentation “Suomi NPP CrIS SDR Provisional Product Hightlight” to the team members for review. The presentation was given during the review meeting. The team members all agreed with the assessment written in the presentation: the CrIS SDR has reached the Provisional status.

In the weekly team telecon meeting following the SDR product review meeting Oct 23-24, the team reviewed the Panel assessment and the remaining issues/work described in the highlight presentation given during the SDR product review meeting. Again, the consensus is that the CrIS SDR has reached the Provisional maturity level and the remaining issues are not critical to the product. The team agreed to address these issues in the next phase of CalVal.

1. **Path forward toward Validated maturity level**

The team will move forward to perform the following work:

1. Continuation of CalVal as planned for the remaining ICV and LTM
2. Fine adjustment of spectral and radiometric calibration parameters and geolocation mapping parameters
3. Understand and address the issues of the spectral ringing, SW cold scene FOV-2-FOV difference and cold scene CrIS/AIRS difference
4. Algorithm and software quality control improvements (FCE detection/correction, self-apodization correction and code fix)
5. Close of all remaining and new DRs
6. Aircraft campaigns
7. Documentation, including SDR product user guide
8. Algorithm and code enhancement for handling full resolution RDRs
9. Continue to assess stability, work together with the VIIRS team to study M15/CrIS scene dependent bias.
10. **Reference**

[1] Y. Han (NOAA/STAR), “Suomi NPP CrIS SDR Provisional Product Highlight”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[2] L. Suwinski, J. Predina and Laura Jairam (Exelis), “CrIS SDR Provisional Readiness Review”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[3] D. Tobin, H. Revercomb, J. Taylor, B. Knuteson, D. DeSlover and Lori Borg (UW), “UW CrIS SDR Status Report”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[4] L. Strow, H. Motteler, P. Schou, B. Lmbiriba and S. Hannon (UMBC), “CrIS SDR Product Review UMBC Validation Status”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[5] M. Esplin, V. Zavyalov, M. Greenman, B. Esplin, D. Scott, K. Grant., B. Graham, C. Mayor and L. Phillips (SDL), “SDL CrIS Provisional SDR Status Review”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[6] D. Mooney (MIT/LL), “MIT/LL Cal/Val task status”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[7] L. Wang, C. Wang, D. Hagan and D. Gu (NGAS), “NGAS CrIS SDR Cal/Val Activity and Highlights”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[8] Y. Han, D. Tremblay, X. Jin, L. Wang and Y. Chen, “STAR CrIS SDR CalVal Task Performance”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[9] A. Doherty, N. Atkinson, A. Smith and B. Bell (Met Office), “Evaluation of ATMS and CrIS at Met Office: Data Quality Assessment and Assimilation Experiments”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[10] N. Bormann, T. McNally, A. Fouilloux, B. Bell and M. Dahoui (ECMWF), “Evaluation of ATMS and CrIS data at ECMWF, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[11] C. Barnet (NOAA/STAR), “Suomi NPP SDR Product Review from CrIMSS EDR Team”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.

[12] A. Collard, J. Derber, R. Treadon, D. Kleist, “Assimilation of CrIS and ATMS in the NCEP Global Model”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.