**MEMORANDUM FOR:** The Record

**FROM:**  Dr. Christopher Barnet, CrIMSS EDR Lead

 NOAA/STAR

 *[with additional notes by Richard P. Cember,*

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**SUBJECT:** CrIMSS EDR provisional status

*[RPC: the product in question has*

 *Collection Short Name “CRIMSS-EDR”, and IDPS product*

 *identifier“REDRO”]*

**DATE:**  3/07/2013

The successful launch of the Suomi National Polar-orbiting Partnership (SNPP) Spacecraft on 28 October 2011 with the Cross-Track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) provides continuity of capabilities for operational environmental remote sounding for weather, climate, and other environmental applications. CrIS succeeds the NASA AIRS and EUMETSAT IASI with 1305 spectral channels covering wavelengths from 4 to 15 m. ATMS succeeds the NOAA AMSU-A and AMSU-B (or MHS) and provides 22 channels covering 20-183 GHz. Together these instruments provide data for the production of the Cross-Track Infrared Microwave Sounding Suite (CrIMSS) EDRs; the 42 layer Atmospheric Vertical Temperature Profile (AVTP), the 22 layer Atmospheric Vertical Moisture Profile (AVMP), the 32 layer Atmospheric Vertical Pressure Profile (AVPP). When cloud clearing is successful the EDR file contains the combined CrIS+ATMS retrieval; otherwise it contains the ATMS-only retrieval.

The product stream also contains a number of intermediate products including the 100 level ozone profile Intermediate Product (IP), the 100 level products for AVTP and AVMP derived from both the ATMS-only step as well as the final CrIS+ATMS retrieval, cloud cleared radiances, and infrared emissivities.

The CrIMSS algorithm utilizes all of the radiances from CrIS and ATMS within a CrIS field-of-regard (FOR) to produce a single sounding of the AVTP, AVMP. The FOR is derived from ~25 ATMS fields-of-view (FOV) that are optimally averaged along with an optimal spatial combination of the 9 CrIS FOVs (called cloud clearing). AVPP is derived from geopotential height computed from AVTP and AVMP. The CrIMSS EDRs are heavily dependent on the upstream SDRs as well as empirically derived bias corrections with respect to the CrIMSS forward model (called the Optimal Spectral Sampling or OSS model). As calibration of the CrIS or ATMS SDRs improves, so does the quality of the CrIMSS EDR. The ATMS and CrIS SDRs achieved beta status in February and April 2012, respectively.

We have evaluated the CrIMSS EDR with 4 focus days: Nov. 11, 2011, Feb. 24, 2012, May 15, 2012, and Sep. 20, 2012 as well as other samples of data in May and October. The majority of the evaluation is based on the May 15th focus day using our off-line version of the CrIMSS EDR (herein “Off-line-EDR”). The Off-line-EDR code allows us to evaluate the functionality of the CrIMSS EDR (it is a copy of the IDPS version that runs on LINUx) and it allows us to process a large volume of data in various configurations and has been shown to produce identical results as the Algorithm Development Library (ADL) which is maintained to reproduce the IDPS CrIMSS products. Preliminary results from the Off-line-EDR have been presented at AMS and IGARSS and show that the CrIMSS EDR is functioning very well, if optimization is done. See the provisional brief (Jan. 17, 2013) for a list of the changes that were made. A quick summary is presented here.

*[RPC: In the text below, “DR” refers to an Algorithm Discrepancy Report. “CCR” refers to a Configuration Change Request. These are internal JPSS program configuration control artifacts. The DR and CCR numbers are given here because they may be of interest and use to internal JPSS users. External users need not be concerned about these numbers.]*

Mx6.4 (Oct. 2012) We installed changes to allow empirical bias corrections for the ATMS (DR 4325, 474-CCR-12-472 and an update to the LUT for CrIS (DR 4334, 474-CCR-12-475) and an update to the emissivity climatology (DR 4335, 474-CCR-12-495).

Mx6.6 (Mar. 2013): NGAS discovered during testing for Mx6.4 that the indexing for CrIS channels for the non-LTE correction and the ozone channel selection was offset by 22 channels in the IDPS code. DR 4922/CCR-0707 repaired this code error. Primary effect was to increase the number of accepted cases for the CrIS+ATMS retrieval in daytime cases.

Mx7.1 (June 2013): A number of enhancements and code fixes were installed to complete the provisional maturity system. These changes have all been implemented off-line and also tested within the ADL environment. Two CCRs were written that each contain a number of DRs. Once these changes are implemented into the Mx7.1 system within IDPS the product will be considered provisional. Here is a summary of those CCRs.

CCR0739 incorporates DR4926, DR4942, DR4945, DR4946:

* DR4926: fix handling of forward model errors. Atmospheric noise and sensor noise need to be combined for the inversion of state parameters and evaluation of convergence criteria. Current ops code has errors in computing the total error in radiance residuals (either from RTM forward simulation or sensor error). It’s proposed to modify the code to correct the errors in order to achieve optimal CrIMSS EDR performance. This change impacts scenes that are determined to be cloud-free. No changes to the ATBD are required (this change makes the code compatible to the current ATBD)
* DR4942: Code modification for tighter clear scene detection. The current CrIMSS code identifies scenes as clear when the scene is actually partly cloudy. This results in both lower yield and poor performance in those scenes incorrectly identified as clear. The proposed code modification below will utilize two tests to ensure the indentified clear scenes are, in-fact, clear (tests are channels ith high enough thermal contrast and number of cloud formations). Having these two tests should provide a more conservative identification of clear scenes. ATBD: This change is consistent with the current ATBD.
* DR4945: Modify surface air temperature constraint over daytime land. During the daytime over land the temperature difference between skin temperature (Tskin) and surface air temperature (Tair) can be very large. The current CLIM LUT has a very tight constraint with regards to these two parameters which leads to a large warm bias of the retrieved air temperature near surface. We have relaxed the constraint and a-priori based on the analysis of the ECMWF field and obtained better EDR performance; however, a better solution is to modify the code to relax the constraint during daytime (current algorithm does not stratify day versus night). This would allow a tighter constraint during nighttime (when Tair and Tskin are more tightly coupled) and a looser constraint over daytime. Technically this change is consistent with the current ATBD; however, we recommend adding the following sentence to the end of section 4.3 in the CrIMSS EDR ATBD: “During post-launch testing it was determined that the skin temperature constraint (departure from air temperature, Tair-Tskin) during daytime was too tight over land cases. The prior covariance for daytime cases over land (land fraction > 0.1) overrides the value set in the covariance LUT and is set to 5.0.”
* DR4946: Optimize the climatology LUT. For ocean scenes the CrIMSS EDR should select an appropriate climatology covariance (warm versus cold ocean). The current IDPS code selects the warm ocean covariance based on either retrieved ATMS Tskin greater than 290 K or delta emissivity (between channel 22 and channel 1) is greater than 0.1. This logic will lead to the selection of warm covariance matrix even when we are close to polar region (there are some ice emissivity with positive delta Emissivity listed above). We propose to modify the code (make the logic Tskin > 273K and delta Emissivity > 0.2 instead of the logic above). Caption for Fig. 38, page 126 of ATBD needs to be changed to indicate that the logic has been changed to include the logical or of Tskin < 273K or delta emissivity < 0.2 will select the cold ocean covariance, otherwise the warm ocean covariance is selected. Delta emissivity is defined as the retrieved emissivity difference between ATMS channel 1 and 22. (NOTE: the logic here was reversed to be consistent with the way the ATBD is written - a logical "and" for selecting the warm condition is equal to a logical "or" when selecting the cold condition)

CCR 740 included all LUT modifications for provisional maturity. It incorporates DR4943, DR4958

* DR4943: Upgrade to sensor and forward model noise LUTs. The sensor noise files and the forward model error estimate for CrIS contain pre-launch values. In both cases these LUTs contain conservative values to ensure algorithm stability during early phases of instrument activation. The cal/val team has updated these files for the at-launch performance of these instruments and comparisons of the OSS forward model with observations. Analysis of on-orbit data indicated the OSS RTM is performing well and, as a result, this LUT needs to be updated to fully exploit CrIS data and improve CrIMSS EDR product quality. The ATBD does not require any updates due to this change. The LUTs we would like to update are: NP\_NU-LM0230-003, CrIS sensor NOISE and NP\_NU-LM0230-002, CrIS forward model (OSS) NOISE.DR4958: Optimize CrIMSS EDR QC thresholds. CrIMSS EDR data products are produced by IDPS from either the first stage MW-only or the second stage CRIS+ATMS combined retrievals based on a number of chi-square tests. If the second stage CRIS+ATMS combined retrieval doesn’t pass the tests, the retrieved profile will be ignored and the first stage MW-only retrieval will be used to generate the EDR products. However, examination of EDR quality vs. chi-square values has shown that a good number of high-quality CRIS+ATMS retrievals are thrown away based on the current chi-square threshold values. It’s recommended to refine the chi-square test threshold values in CrIMSS PCT file to retain as many as possible CRIS+ATMS combined retrieval results to improve the overall quality of the CrIMSS EDR data products. The file to be updated is the CrIMSS EDR algorithm processing coefficient table (collection-short-name: CrIMSS-EDR-AC). Only one parameters in the file is changed as a result of this investigation: chiSqMw2Max (second stage MW chi-Square) - currently set to 2 - proposed to relax to 4. This DR requires an update to the ATBD and should be synchronized with DR 4943. ATBD section 5.6.3, end of 1st paragraph should be changed from "larger than 2" to "larger than 4"

Provisional maturity is defined as:

* Product quality may not be optimal
* Incremental product improvements are still occurring
* Research community is encouraged to participate in the QA and validation of the product.
* Ready for operational evaluation.

This provisional justification is based on the current operational IDPS EDR products that are on the 22 AVMP layers and 42 AVTP layers. Even without optimization we feel that the CrIMSS IDPS-EDR products should be made publically available given that they are reasonably accurate and robust and we feel that it is appropriate for users to gain experience with the product characteristics.

The Board recommends that users be informed of the following product information and characteristics when evaluating the CrIMSS EDR:

1. Precipitation flag is using an out of date code and AMSU coefficients (DR 4068 and 4079). Preliminary analysis shows this flag is functioning but has a large number of false positives and false negatives. A solution has been developed (R. Ferraro, STAR) and this will be addressed in the stage.1 validated product (scheduled for Dec. 2014)
2. Amplification factor and residual values (chi^2) are not written properly into the EDR file when an ATMS-only retrieval is performed. Technically, these values should not exist (be NaN’s) when the CrIS+ATMS retrieval is rejected and replaced with the ATMS-only in the EDR file. What is occurring now is that the last successful CrIS+ATMS value in the system is written into the file. If the 1st retrieval in the granule is ATMS-only then it is invalid (-9999) and if the ATMS-only occurs after a successful CrIS+ATMS retrieval has been performed then that value is repeated until another successful CrIS+ATMS retrieval occurs. This error can be detected by monitoring the QC parameters in the file; however, it would be better if these values reflected the case-by-case value (i.e., NaNs for ATMS-only). Also, the value of amplification factor and chi^2 should exist for each and every CrIS+ATMS retrieval performed (whether selected for the EDR or not) in the AVTP and AVMP IP files. *[RPC: This is DR 7116.]*
3. When a spacecraft maneuver occurs and the satellite is not pointing at nadir (that is, the CrIS pointed at the center of FOR 15/16 is not at zero satellite zenith angle) but the CrIS and/or ATMS are still pointing at the Earth a retrieval is still performed. Technically, if the GEO file is correct and the proper satellite zenith angle is computed a retrieval could be performed; however, the code uses the view angle to select the proper coefficients for the local angle adjustment (where the 9 FOV’s of CrIS are adjusted to be the radiance at the center FOV satellite zenith angle). This correction will be in error when the spacecraft is not at nadir and will cause small errors in all the retrievals within that scanset. These retrievals should be marked as degraded. *[RPC: This is DR 7117.]*
4. We have noticed odd vertical shapes in the water vapor profiles and believe this is due to a threshold for supersaturation that is applied for independent vertical levels. When this threshold is crossed it produces kinks in the AVMP product. This will be explored and repaired in the stage.1 validated system. *[RPC: This is DR 7118.]*
5. The EDR algorithm’s scene selection module decides which profiles are clear, partly cloudy, and cloudy.  The vast majority of profiles are partly cloudy and are cloud cleared before running the combined retrieval.  Clear cases are not cloud cleared, but still undergo the combined retrieval.  Cloudy cases are stopped before the combined retrieval and the ATMS-only retrieval is used within the EDR. The current decision tree has the following faults: 1) Highly heterogeneous scenes (whether the clustering algorithm sees one highly variable cluster (i.e, ncldfm=0 and nccl>=9, happens about 1.2% of the time), or many small clusters (i.e., ncldfm>=4, happens about 0.4% of the time) are marked as cloudy, but still act as partly cloudy profiles in the algorithm; 2) In cases where there are not enough valid fields of view, the algorithm treats these profiles as cloudy, but may mark them as clear, partly cloudy, or cloudy; and 3) If CrIS data is present but turned off, then it is reported as a clear profile but treated as a cloudy profile.  Solutions to these issues are currently in progress. Generally #2 and #3 have not occurred.  However, these are possible in instances of bad data. *[RPC: This is DR 7119.]*
6. DR4923: The CrIMSS EDR team has discovered that the surface pressure ancillary input to the CrIMSS EDR appears to have large errors and sometimes (10's of cases per day) exceeds reasonable values. Relative to an off-line calculation using our own DEM there are large differences, mostly over land. The fact that the ocean cases are reasonable we feel that the NWP component of surface pressure is probably computed properly. We suspect (but cannot prove) that there is some kind of error related to the computation of terrain altitude within the IDPS system on the CrIMSS field of regard. Large differences tend to be positive (IDPS values exceed our calculation by 50 mbar 0.1% of the time) and sometimes these differences are unreasonable (~20 cases greater than 1050 mbar in 0.1% of the time, 2 cases on 5/15/2012 exceed 1100 mbar) and occur in locations that are not low terrain). In extreme cases this causes the AVTP and AVMP to have derived values below the surface. The impact of this error on AVTP and AVMP is small; however, it does directly impact the AVPP product, which is a delivered EDR. Also, the EDR reporting layers are derived from surface pressure and in many cases this leads to unreasonable profile shapes in CrIMSS KPP products (the retrieval constrains top of atmosphere radiance and, as such, an error in surface pressure forces the retrieval to assign AVTP and AVMP to the wrong pressure levels). This is related to DR4008 but this DR is explicitly concerned with the unreasonably large values and accuracy of the surface pressure ancillary product. It may also be related to DR4865 (OMPS Psurf > 1.1). The CrIMSS EDR ATBD describes the desired science-code calculation; however, this computation was moved to a higher level within the operational code. We are not certain exactly what was implemented at the system level in the IDPS. We need assistance from Raytheon to understand where (and how) this calculation is done and how to fix it. We have prepared a discussion of what we have learned with our off-line calculation and suggest that the CrIMSS team holds a TIM with Raytheon to determine how to proceed to solve this issue.
7. There has been a request by the NASA PEATE to include the entire atmospheric state into the EDR file so that radiances can be computed from the EDR that would agree with those radiances minimized by the retrieval process. At this time many of those state parameters are written into the IP files; however, some state parameters are missing (i.e., liquid water and microwave emissivity derived in the ATMS-only step). At this time, the CrIMSS EDR team does not plan to implement these changes because: (a) there is no operational requirement to do so and (b) for validation and product evaluation the off-line or ADL can be easily modified to write these variables into a file.

*[RPC: This README is dated March 7, 2013. That is the date of its composition. JPSS Algorithm Engineering Review Board approval was received on March 27, 2013. The currently scheduled date for transition to operations of IDPS Release Mx7.1 is June 27, 2013; this is the date forward from which the products received for archiving at CLASS will be of provisional maturity.]*

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