**MEMORANDUM FOR:** The Record

**FROM:** X. Wu, OMPS SDR Team Lead, NOAA/NESDIS/STAR

**SUBJECT:** Justification for public release of Suomi NPP OMPS NM and NP EV SDR as Provisional Data

**DATE:** 03/07/2013

1. **Background**

The successful launch of the Suomi National Partnership Program (NPP) spacecraft on 28 October 2011 with the Ozone Mapper Profiler Suite (OMPS) ushers in a new generation of capabilities for operational environmental remote sensing for weather, climate, and other environmental applications. The OMPS Sensor Data Record (SDR) products are essential for the generation of OMPS Environmental Data Record (EDR) products that continue the ozone monitoring since 1980’s with significantly improved capability. This is a major contribution to the world and ensures the U. S. government to meet its treaty obligations. The OMPS SDR Team consists of government experts from NOAA and NASA and industry partners of Northrop Grumman, Aerospace, and Raytheon. The team has been working intensively to evaluate the OMPS instrument performance and fine-tune the OMPS instrument calibration for optimal OMPS SDR products.

The OMPS SDR Provisional Status Review Meeting was held on October 23-24, 2012, at the NOAA Center for Weather and Climate Prediction in College Park, Maryland. The Review was hosted by NOAA/NESDIS/STAR and was attended by more than 100 participants, including members of the NPP/JPSS SDR Teams, Program and Project Scientists, Joint Center for Satellite Data Assimilation, and representatives from Numerical Weather Prediction (NWP) Centers. The purpose of the Review was to assess the OMPS SDR products maturity for public release as “Provisional Product” by the AERB.

The OMPS consists of three instruments, a Nadir Mapper for total column ozone (NM or TC), a Nadir Profiler (NP), and a Limb Profiler (LP). The OMPS SDR Team is responsible for the nadir instruments only, each of which produces two types of SDR. The Earth View SDR is used to generate the EDR; and the Calibration SDR is used to support the OMPS EV SDR. In February 2011, due to issues associated with the IDPS Cal SDR table generation requirements, it was decided that IDPS at launch should use the Calibration SDR generated at the NASA Ozone Product Evaluation and Analysis Tools Element (PEATE), instead of the one in operations at IDPS. The Science Operation Center (SOC) was created at NASA for this purpose. In February 2012, SOC changed the calibration procedure to improve OMPS calibration, which also caused IDPS to cease generating CAL SDR after February 29, 2012, because it cannot adapt to the changed procedure. Currently only the OMPS NM & NP EV SDRs are subject to review. The long term strategy for the Cal SDR is the subject of other report and continued investigation. Six reports [1-6] related to OMPS SDR were presented to the Review on progress since the beta maturity; these and the agenda of the Review are included in this CCR package.

* 1. **Update since Beta Review**

OMPS NP EV SDR and the OMPS NM EV SDR were released as Beta Product on March 13, 2012, following the successful early Cal/Val work performed by the team (CCR 0328). A Readme file [7] was provided to the Beta product users. Since then, the OMPS SDR team has made the following improvements:

1. Regarding Beta caveat #1: Weekly update of DARKS has been implemented since 20 December 2013 for TC and since 6 February 2013 for NP.
2. Regarding Beta caveat #2: The solar spectral irradiance used for OMPS Beta products were synthetic proxies created from high-resolution reference solar spectra convolved with prelaunch bandpass measurements. These have been replaced with on-orbit OMPS-measured spectra, from preliminary analysis, on June 11, 2012 for NM (CCR 12-0411) and on July 17, 2012(CCR 12-0458). More accurate Day One solar spectra will be provided at a later date.
3. Regarding Beta caveat #3: The wavelength scale for the OMPS NM and NP for both Earth and Solar spectra are based on pre-launch measurements. This has been updated on May 7, 2012 with on-orbit measurements (CCR 12-0389). The adjustment is between -0.05 nm to -0.15 nm in most cases; these are larger than expected from pre-launch thermal analysis.
4. Regarding Beta caveat #4: While the OMPS NP South Atlantic Anomaly (SAA) flag is working well in identifying regions with higher frequency of charged particles, we have further characterized the SAA and its impact on OMPS products. We expect to improve the OMPS SDR performance over SAA as more results become available and are analyzed.
5. Regarding Beta caveat #5: Out-of-band stray light is present for the OMPS NM with levels increasing rapidly below 305 nm. While expected even before launch, this is not a major concern because these radiances are not used in total ozone retrievals. Stray light in this spectral region was characterized before launch and the EV SDR algorithm has an empty table that can be replaced with on-orbit determination of proper correction to mitigate the stray light effect. We are in the process of testing such a table before implementation in near future.
6. Regarding Beta caveat #6: The CCD smear corrections can be affected by charged particles (Transients). This has been observed to create a bias, albeit infrequently, in the smear corrections for an individual row. After the Beta review, more errors were found with smear, possibly because the dark has been subtracted incorrectly (DR 4818). We are developing corrections and screening to handle this complication.
7. Regarding Beta caveat #7: The nonlinearity corrections for OMPS Beta products were derived from the prelaunch characterization. One year monitoring of nonlinear correction with on-orbit measurements shows negligible changes. Update to these tables has not become necessary, although we continue to monitor.
8. Regarding Beta caveat #8: A limited amount of EV data with higher spatial resolution (smaller FOVs) has been collected in diagnostic mode for both NM & NP that can be processed in the G-ADA to analyze the results from these data.
   1. **Definition for Provisional Maturity**

Provisional Products for Suomi NPP are expected to have the characteristics outlined in Table 1.

**Table 1: Provisional product maturity definition**

|  |
| --- |
| Product quality may not be optimal |
| Incremental product improvements are still occurring as calibration parameters are adjusted |
| Version control is in effect |
| General research community is encouraged to participate in the QA |
| Users are urged to consult the SDR product status documents prior to use of the data in publications |
| Ready for operational evaluation |

1. **Justification for OMPS NP and NMEV SDR to be Provisional**

At the Review, users and SDR Team members concluded that the OMPS instrument performance is excellent; however the OMPS EV SDRs from IDPS need to resolve a few critical DRs in order to take full advantages of that performance. One of the key issues is the interface between PEATE and IDPS, i.e., the implementation of PEATE-generated LUTs in IDPS, and going forward this should be STAR’s responsibility. The Review Panel recommended a follow-up meeting, which was held on November 13, 2012, and attended by X. Wu, M. Goldberg, J. Gleason, H. Kilcoyne, F. Weng, B. Guenther, L. Zhou, and others. At the meeting the panel recognized the importance for STAR to acquire the capability of CAL SDR support for IDPS, however, that should not be a prerequisite for the OMPS EV SDRs to achieve the Provisional status as long as the impacts of the existing caveats are small. It is thus recommended that the OMPS NP and NM EV SDR be approved by the AERB as Provisional products and made available to the public. Justifications for promoting the OMPS NP and NM EV SDR from Beta to Provisional are summarized in this memorandum and the supporting materials [1-6].

* 1. **The OMPS Instrument Met the Specifications**

There is no explicit specification for the OMPS SDRs, other than to support the OMPS EDR to meet its specifications. Instead the specified requirements for the OMPS instruments are used to evaluate the OMPS performance. As can be seen from Table 2, OMPS met all its requirements, often with significant margin. There are no specifications requirements on the OMPS NP except to be of the same or better quality than SBUV/2.

**Table 2: OMPS NM SDR specifications and performance**

|  |  |  |
| --- | --- | --- |
| Requirements | Specification or Prediction | On-Orbit Performance |
| Non-linearity Knowledge | **< 0.5%** | **~0.1%** |
| Non-linearity | **< 2% full well** | **< 0.46%** |
| On-orbit Wavelength Calibration | **< 0.01 nm** | **average ~0.01 nm RMS** |
| Stray Light NM | **≤ 2** | **average ~± 2%** |
| Intra-Orbit Wavelength Stability | **<0.02 nm** | **< 0.013 nm** |
| SNR | **>1000** | **> 1000 from SV and EV** |
| Inter-Orbital Thermal Wavelength Shift | **<0.02 nm** | **<0.013 nm** |
| CCD Read Noise | **<60 –e RMS** | **< 25 –e RMS** |
| Detector Gain | **>46** | **~42** |
| Absolute Irradiance Calibration Accuracy | **< 7%** | **5%** |
| Absolute Radiance Calibration Accuracy | **< 8%** | **< 5%** |

* 1. **Review of Critical Issues for Provisional product**

At the Review, three issues were identified as critical for the OMPS NP and NM EV SDR. One is to update the dark current, which has been implemented (ref. 1.1.1) so it is no longer an issue.

The second issue is that the smear has appeared to be error. It was suspected that the incorrect dark current correction was the root cause, which has been partially vindicated when most of the anomalous smear disappeared after weekly darks update was implemented. Recently we found that SAA\_DARKS are still in error, which is being aggressively corrected. We believe the remaining smear error is also cause by the dark error that will be removed after the SAA\_DARKS is corrected.

The last issue is stray light correction for NM (DR 4907) and NP (DR 4823), which were expected before launch but were not considered a major issue. The effect on NM was below 305nm, where radiances were not used in total ozone retrievals. The effect on NP can be soft calibrated. Some of the stray light effects were characterized before launch. EV SDR algorithm has an empty table that can be replaced with on-orbit determination of proper correction to mitigate the stray light effect. We are in the process of testing such a table before implementation in near future. We now believe that the OMPS NP and NM EV SDR can become Provisional before all stray light effects are completely corrected.

* 1. **Open Discrepancy Reports**

In 2012, 42 SDR related DRs were submitted and **nearly 30** were closed, including those submitted in previous years. Currently there are **20** SDR related open DRs and all have expected completion dates. None is critical for either the OMPS NP or NM EV SDR to become Provisional.

**Table 3: Open DRs**

|  |  |
| --- | --- |
| DR # | Short Description |
| 7010 | TC SDR Dark update # 0007 |
| 5034 | OMPS Version Reference Document |
| 5032 | NP Darks Table update |
| 5008 | NP SDR (and EDR) fails for Sample Table with extra pixel column |
| 5000 | OMPS TC and NP SDR provisional status |
| 4978 | TC EDR fails for Sample Table with extra pixel column |
| 4927 | FT document 474-00181 need update |
| 4907 | TC needs Stray light correction |
| 4823 | The NP stray light needs to be corrected. |
| 4818 | Smears in error - Smears show negative and unexpected values |
| 4799 | Inconsistent structure between OAD and EV SDR |
| 4749 | OMPS darks have negative values |
| 4693 | Cal SDR strategy study |
| 4676 | Radiance error associated with aggregation |
| 4673 | Correction for different linearity slope Tup for CCD2 |
| 4672 | Linearity correction update for xml file |
| 4671 | OMPS Data quality threshold tables non existence for SDR |
| 4627 | Quantization introduced by linearity correction error - Cal SDR |
| 4615 | Transient filter issue |
| 4602 | Spatial pixel mismatch in Cal SDR |
|  |  |

* 1. **Stable Processing of OMPS EV SDR at IDPS since March**

The OMPS EV SDRs processing at IDPS resulted in incorrect values in February 2012 due to an error in handling the leap year. After that, the processing has been stable and smooth. In particular, the implementation of Mx6.2 in August included a major revision to severe the link between the EV and CAL SDR at IDPS, and that went through smoothly without incident. The software used at IDPS and SOC to process the NP and NM EV and CAL SDRs has always been version controlled.

1. **OMPS EV SDR Caveats**

OMPS SDR Release, Provisional Data Quality

Recommended Cautions for Data Users (to be used as a readme file)

The JPSS Algorithm Engineering Review Board has reviewed the OMPS Earth Viewing Sensor Data Record products and set the Data Quality attribute to Provisional, effective March 1, 2013. Provisional quality is defined as:

* Product quality may not be optimal
* Incremental product improvements are still occurring as calibration parameters are adjusted
* Version control is in effect
* General research community is encouraged to participate in the QA
* Users are urged to consult the SDR product status documents prior to use of the data in publications
* Ready for operational evaluation

The Board recommends that users be aware of certain specific data product characteristics. The product caveats for OMPS at this time are:

1. After the implementation of weekly update of dark current, it was found that the dark correction over SAA is occasionally in error. This is being investigated aggressively and should be corrected by the end of March 2013.
2. The CCD smear corrections have appeared to be in errors. Incorrect dark current correction was suspected as the root cause, which has been partially vindicated when most of the anomalous smear disappeared after weekly darks update was implemented. Recently we found that SAA\_DARKS are still in error, and that is being corrected. We believe the remaining smear error is also cause by the dark error that will be removed after SAA\_DARKS is corrected.
3. The spectral solar irradiances have been updated with on-orbit measurements for both NM and NP. Further analysis and update of Day One solar irradiance may be provided in the future. These preliminary and additional updates of Day One solar have been planned before launch as part of normal calibration update.
4. The wavelength scales for the OMPS NM and NP for both Earth and solar spectra have been updated with on-orbit measurements. The adjustments were somehow larger than expected from pre-launch thermal analysis. The wavelength scale will be monitored and re-evaluated periodically.
5. While the OMPS NP South Atlantic Anomaly (SAA) flag is working well in identifying regions with higher frequency of charged particles, the OMPS SDR performance over SAA is to be improved.
6. Out-of-band stray light was found for wavelength less than 310 nm for the OMPS NM. The impact can be significant, up to 5%, for wavelength less than 305 nm. While expected even before launch, this is not a major concern because these radiances are not used in total ozone retrievals. Stray light in this spectral region was characterized before launch and the EV SDR algorithm has an empty table that can be replaced with on-orbit determination of proper correction to mitigate the stray light effect. We are in the process of testing such a table before implementation in near future.
7. Out-of-band stray light has also been noted for NP. Its characterization and correction are the subject of future research.
8. OMPS NM SDR product dimensions allow for a future change in the horizontal resolution to much smaller FOVs. Currently only the first 35 cross-track by 5 along-track cells are used to store actual measurements. The OMPS NP SDR products allow for a future change in the horizontal resolution as well. Currently only the firs cross-track by first along-track cell contains and actual measurement. Thus, users should continue to find that, most of time, only a small portion (less than 5% in some case) of the data in the HDF files are valid (not zero or other fill values), as explained in Beta readme file [7].
9. In August 2012, the NM geo-location occasionally mismatched that of NP by 10-15 km in longitude when NM calculated ephemeris using the interpolated Two-Line-Element (TLE) and NP using the spacecraft diary. This mismatch affects the NM geo-location only, for part of Mx6.2 only (in operation between 8/10/12 and 10/15/12 when Mx6.3 entered in effect). This mismatch has been corrected since Mx6.3 was implemented, which no longer uses TLE for NM.

Of the caveats listed above, #1 & #2 will be resolved soon. #3 – #8 have been expected before launch; they are given a status update here. #9 is not expected to occur again.

1. **Path Forward Toward Validated Maturity Level**

The central task for the OMPS SDR team is to provide science support for the stable production of OMPS NP and NM EV SDR at IDPS, and to improve its quality. This includes the support for IDPS with PEATE CAL SDR products (generation of tables needed as inputs by the EV SDRs) in short term; and the transfer of PEATE CAL SDR capability to STAR in long term. The OMPS SDR products can advance to the next level of maturity (Validated) only when both EV and CAL SDR products are mature, consistent, and sustainable. The team will move forward to perform the following work:

1. Continue the Cal/Val activities as planned for the ICV and LTM.
2. Document the capability being developed and transferred.
3. Prioritize and resolve the remaining and new DRs, in particular the caveats noted above.
4. **References:**
5. X. Wu (NOAA/STAR), “Suomi NPP OMPS EV SDR Provisional Product Review”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
6. C. Pan (NOAA/STAR), “Provisional Suomi-NPP OMPS SDR”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
7. C. Seftor (NASA/SSAI), “OMPS Examples”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
8. G. Jaross (NASA/SSAI), “Evaluation of OMPS Sensor and EV SDR Performance”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
9. M. Grotenhuis, and X. Wu (NOAA/STAR), “OMPS SDR Data Quality via Satellite Integrated Calibration and Validation System (ICVS)”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
10. C. Long (NOAA/NWS), “OMPS Products Applications”, Suomi NPP SDR Product Review Meeting, October 23-24, 2012.
11. OMPS SDR Beta ReadMe – Please see CCR 474-12-0323, DR 4564. This file is also attached to this CCR and should have been part of the CLASS OMPS SDR beta assignment
12. C. Pan (NOAA/STAR), “Performance and calibration of the nadir Suomi-NPP Ozone Mapping Profiler Suite from early-orbit images”, IEEE JSTAR (submitted), January 2013.
13. M. Haken (NASA/SSAI): “Dark current monitoring and correction for OMPS”, AGU Meeting, December 3-7, 2012.
14. **Responses to Comments**

On 13 February 2013, AERB considered but deferred a decision to release the OMPS EV SDR as Provisional Products. Following are some of the related comments and our responses.

Mitch Goldberg and Jim Gleason requested further details on the status, impact, and path forward regarding the three critical issues identified at the review. These were presented in 2.2 and have been updated.

Bruce Guenther raised several issues about CAL SDR:

1. Calibration be validated: We have shown that the OMPS instrument performs very well, as expected. See Slides #8, #9, and #13-#19 of [1]; Slide #5-#18 of [2]; and Slides #1-#11 of [4], for example. While we agree that all products (including calibration products) may not have been fully validated, that is not required as Provisional Product.
2. Calibration be available: Calibration SDR are available from the SOC system for C/V team member. A study of how this will be modified for J1 is being investigated and is part of the Cal SDR J1 path forward resolution.
3. Calibration be transparent: We agree and have started to document the SOC activities such as the improved calibration procedure. Additionally, a process is being worked on to ensure that future changes that impact the product will be notified ahead of time to Ground. This will be part of a modified ConOps

Bruce Guenther also requested at the AERB Review that Users’ Guide be provided. We agree to understand the needs and scope of the Users’ Guide and provide it at a mutually agreed time.