**MEMORANDUM FOR:** The Record

**FROM:**  Dr. Changyong Cao, VIRIS SDR Team Lead

 NOAA/NESDIS/STAR

**SUBJECT:** Suomi NPP VIIRS SDR Provisional status and public release

**DATE:**  02/19/2013

1. **Background**

The successful launch of the Suomi National Partnership Program (NPP) spacecraft on Oct. 28, 2011 with the Visible Infrared Imaging Radiometer Suite (VIIRS) ushers in a new generation of capabilities for operational environmental remote sensing for weather, climate, and other environmental applications. The VIIRS Sensor Data Record (SDR) product will be used for numerical weather prediction and for producing a large number of Environmental Data Records (EDRs). The VIIRS SDR team consists of experts from NOAA, NASA, The Aerospace Corp., University of Wisconsin, MIT/Lincoln Lab, and industry partners: Northrop Grumman and Raytheon. The team has been working intensively on the postlaunch cal/val tasks to evaluate and fine tune the VIIRS instrument performance.

The VIIRS 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, hosted by NOAA/NESDIS/STAR. The Review had more than 100 attendees including NPP/JPSS SDR Team members, Program and Project Scientists, Joint Center for Satellite Data Assimilation, and representatives from Numerical Weather Prediction (NWP) Centers. The purpose of this meeting was to assess the readiness of the VIIRS SDR data product maturity level to be declared “Provisional” by the AERB.

The VIIRS SDR team members presented progress since beta maturity, and EDR users also offered their independent assessments of data product quality based on their analyses. A total of 12 presentations were made and are attached in this CCR package. Through interactions with the data product users and discussions with review panel members, the SDR chairs and team collected feedback on recommended VIIRS SDR product improvements for future validated VIIRS SDR product.

After a thorough review, the VIIRS SDR team, EDR users, and the review panel members reached consensus that although the level of maturity differs in some aspects, the VIIRS SDR product overall has reached provisional status and therefore is recommended to be approved by the AERB, and made available to the public. Additional materials attached in the package include the agenda for the review meeting, and all presentation materials.

**1.1 Beta product**

VIIRS SDR product was declared to have reached Beta maturity level on May 2nd, 2012, following the successful execution of the 58 Cal/Val tasks by the team. A Readme file was provided to the Beta product users, which summarized the following product caveats:

1. The larger than expected instrument responsivity degradation centered near the 0.86 um band (primarily in bands M7, M6, M5, M8, I2, and I1): After a thorough investigation by the SNPP Anomaly Resolution Team (ART), it was concluded that this is due to the scan mirror contamination with tungsten and tungsten oxide or other coating error in the manufacturing process and subsequent on-orbit ultraviolet (UV) exposure which leads to the mirror darkening in those spectral bands. The VIIRS SDR team has developed a strategy to mitigate the effects of this degradation through more frequent update of the calibration lookup tables (LUT). A weekly LUT update is currently implemented which significantly reduces the impact of degradation but with a residual effect of 0.8% between weekly updates. A dynamic gain adjustment based on SD gain tracking on each orbit for solar reflected bands is currently being investigated. This will eliminate the calibration shift. The degradation is being closely monitored. Based on early studies, the current calibration update scheme makes the degradation impact negligible for most EDR products, except for more calibration sensitive products such as ocean color. It is also estimated that the signal to noise ratio for all bands should still meet the specification by the end of the mission, according to model predictions by the instrument vendor.
2. A-side vs. B-side electronics calibration differences: it is known that the B-side was better characterized and analyzed prelaunch than the A-side, and therefore the B-side is preferred for routine use. However, we find that the electronics B-side is having minor difficulties with 1394 communications interface and Spacecraft Computer anomalies. The Flight Project currently is assessing whether the A-side may be more stable for these performance matters, and so it is possible that VIIRS will be transitioned to the electronics A-side of the system at some time to test this hypothesis. The current VIIRS SDR “Beta” status is based on the B-side calibration and if the electronics side is switched to the A-side, then the ‘Beta Quality’ indicator will be removed until the data quality for the A side is verified to be Beat Quality..
3. M6 band radiance saturation and “fold-over”: during the postlaunch cal/val, it was found that when the M6 band saturates (Lsat), and scenes were observed with M6 radiance greater than Lsat, then the digital signal values would start to decrease with increased radiances. This situation creates the impression that the radiance is less than Lsat. While the impact of this behavior should be small because M6 is used for atmospheric correction for ocean color with low radiances, the saturated pixels are not flagged and users are advised to handle the data accordingly based on the radiance/reflectance values. Very high radiance values in M7 is one indicator that the M6 value may be the result for fold-over.
4. Early VIIRS SDR data: It is recommended that VIIRS SDR data before Feb. 6, 2012 should not be used for quantitative analysis due to issues with the LUT used in the ground processing system. Reprocessing of the all data before the implementation of the SD-based dynamic gain adjustments may be needed in the future if these data are to be used for research purposes.
5. Striping in some VIIRS bands: It is known that striping occurs in several VIIRS bands especially over uniform scenes. However, the magnitude of striping is either comparable or less than that of the MODIS. Residual effects of striping are currently being studied by the VIIRS SDR team.
6. Instrument and spacecraft maneuvers and tests: User’s should be aware that maneuvers and special tests are still being performed to VIIRS to better characterize instrument performance. These include but not limited to, the monthly lunar maneuver, blackbody WarmUp CoolDown (WUCD) tests quarterly. During such events, the data may not be optimal. Data users are encouraged to contact the VIIRS SDR team if any related issues arise.
7. Aerospace has tested a witness sample for the VIIRS NPP telescope mirrors and finds a UV exposure spectral degradation that has similar signal degradation rate to what we see in the VIIRS gain reduction observations using the solar diffuser. [See a) above for the description of the on-orbit behavior.] We advise our users that one hypothesis for this anomalous degradation is to treat this degradation as exclusively due to changes in sensor spectral throughput. We still are at work to correlate the Aerospace test data to the SD on-orbit observations. Users are encouraged to assess the differences in potential errors for their products when they use the at-launch (pristine) RSRs rather than the anomaly-degraded RSRs for their products, and we will provide further guidance in how to handle evolving RSRs for those users wishing to test their EDR performance against this hypothesis.

**1.2 Major Cal/Val activities after the Beta review meeting**

Since the Beta Review Meeting, the VIIRS instrument has been relatively stable, and the VIIRS SDR team has focused on the following activities:

1. Implemented the scan-by-scan updates of the RSB radiometric calibration coefficients (F-factors) for a better mitigation of the RTA throughput degradation anomaly, with continued weekly updates of the look-up tables
2. Routine operational calibration LUT update to account for the RTA mirror degradation. The team has continued providing critical information to update the calibration LUT for the RSB to ensure the calibration accuracy of the VIIRS RSB bands.
3. The team continued inter-satellite/sensor comparisons, especially between VIIRS and Aqua/MODIS. A bias in M1 was resolved between VIIRS and MODIS which was found to be due to a calibration bias in MODIS collection 5. The bias disappeared when compared with MODIS collection 6 data. However, a new bias emerged in the summer of 2012 for the blue bands reported by the Ocean Color team and the root cause of the bias is currently under investigation.
4. The M6 roll over is now flagged with the implementation of the MX6.3/MX6.4.
5. The dual gain switching sequence anomaly was resolved with the implementation of the MX6.3/MX6.4.
6. The WUCD issue has been resolved through a LUT/software fix.
7. Updates to the SD and SDSM attenuation screens transmission look-up tables for improved offline derivation of the radiometric calibration coefficients
8. Updates of the radiometric gain coefficients for RSB and DNB
9. Continued longterm trending and monitoring
10. Continued monitoring the geolocation accuracy which is very stable.
11. VIIRS SDR quality flags are evaluated and confirmed.
12. Detector to detector performance evaluation was carried out.
13. Polarization correction was investigated and results look reasonable.
14. VIIRS stabilities are evaluated and presented. The following figure shows that M15 noise (in count) has been very stable since launch except for a few spikes due to bad data. The noise dropped in January 2012 after the cooler door was opened.



After the SD screen transmission is corrected, RSB F and H factors change smoothly, which indicate SD, SDSM, and the VIIRS sensor are normal as expected. There are no noticeable drift in the RVS. VIIRS and MODIS SNO comparisons further prove the VIIRS stability.

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

The VIIRS SDR Provisional Product Review Meeting was very successful. The VIIRS SDR team members presented results and progress on the 58 cal/val tasks. The review panel reached the following conclusions:

* The VIIRS SDR team has done an outstanding job, with significant amount of work since beta
* The VIIRS SDR team has demonstrated that the instrument performance is well within specification, with excellent geolocation
* VIIRS EDR teams are generally satisfied with the VIIRS SDR data quality
* All key VIIRS events are well documented
* VIIRS team (given in highlight chart) – clearly defined remaining issues and future plans
* Provisional maturity clearly achieved

More details can be found in the presentation package.

The remaining issues are not critical to the Provisional product

* RSB calibration updates need to be automated and implemented as part of IDPS: this will further improve the calibration and make the calibration update easier but is not essential to the provisional status.
* Cold M15 values when compared to CrIS: the bias is still being investigated and will be corrected once the root cause is identified.
* DNB stray light correction needs to be implemented in IDPS: the algorithm has been developed. The implementation in the IDPS is a matter of schedule. At the same time, offline correction can be performed on the case by case basis. This issue is not essential to reaching the provisional status.
* M1 bias emphasized by ocean color team needs to be addressed.
* Continue longterm monitoring of instrument parameters and observed radiances, intercomparison with MODIS, and at desert site
* Resolve moon vs. solar calibration discrepancies
* Continue closely monitoring the instrument degradation
* Further characterize detector to detector performance and striping
* Further quantify the polarization effects and impact on products
* Further study the A side vs. B side calibration differences
* Investigate novel methods for M13 low gain calibration
* Make effort to implement terrain correction for the DNB
* Support aircraft campaign as needed

IDPS VIIRS SDR processing has been stable since May 2012

Since MX6.3 and MX6.4 became operational, no critical issues and problems have been observed in VIIRS SDR processing.

Remaining DRs are not critical for the provisional status. Although there are still many DRs, none of them is critical for the provisional status. The following is a list of the most significant DRs documented during the October meeting.

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| DR# | Description |
| 7023  | Degraded geolocation from backup TLE |
| 5035 | Fall off in TOA Reflectance for edge detectors with scan dependence |
| 4971 | Modulation of VIIRS RSB RSR by RTA mirror reflectance degradation |
| 4924 | VIIRS DNB Terrain Correction is needed |
| 4911 | Moon in Space View of bounding granule for RSB calibration |
| 4894 | Unexpected high values of Satellite Zenith Angles |
| 4890 | VIIRS DNB geolocation residual error recommendation |
| 4780 | OBC BB thermistor weights need to be selectable by Band/Detector/HAM  |
| 4767 | HAM/RTA Sync Loss and Sector Rotation need to be flagged |
| 4742 | Erratic Solar Eclipse flag |
| 4716 | Day-Night Band stray light correction |
| 4710 | Warm-Up/Cool-Down tests need to be flagged |
| 4663 | Modified operational code for increased RSB calibration autonomy |
| 4589 | Improved SDSM screen transmission LUT |

1. **VIIRS Provisional SDR product caveats**

The followings are remaining known issues with VIIRS SDR which should be provided to the Provisional users for information:

1. RTA degradation

• RTA degradation anomaly challenged the RSB calibration team to maintain RSB calibration uncertainty and stability within requirements/desire.

• F-factor trend changes may carry some uncertainties

• Ongoing RTA degradation anomaly is modulating VIIRS VisNIR and SWIR RSR. Studies have been done and a set of modulated RSR is made available for evaluation.

1. RTA Scan Sync Loss occurs infrequently
2. DNB Stray light correction is not yet implemented in operations
3. Geolocation accuracy near spacecraft maneuvers is not as accurate and needs to be better understood
4. DNB geolocation needs to be terrain correction
5. M13 low gain calibration points
6. M1 bias emphasized by ocean color team needs to be addressed.
7. Resolve moon vs. solar calibration discrepancies
8. Further characterize detector to detector performance and striping
9. Further quantify the polarization effects and impact on products
10. Further study the A side vs. B side calibration differences
11. **Team assessment consensus**

 Before the SDR product review meeting held on Oct 23-24, the team lead sent the presentation “Suomi NPP VIIRS SDR Provisional Product Hightlight” to the team members for review. After a thorough review, the VIIRS SDR team, EDR users, and the review panel members reached consensus that although the level of maturity differs in some aspects, the VIIRS SDR product has overall reached provisional status and therefore is recommended to be approved by the AERB, and made available to the public and for operational evaluation.

 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 was that the VIIRS SDR overall has reached provisional maturity status after October 2012 in all three areas: geospatial, spectral, and radiometric. 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 VIIRS SDR team will continue the cal/val with the 58 tasks as planned to reach the calibrated/validated maturity status. This involves analysis of additional data over a longer time period. We also plan to more fully address the following performance issues such that the remaining issues will be either resolved or fully characterized. This includes but not limited to:

* Continue longterm monitoring of instrument parameters and observed radiances, intercomparison with MODIS, and at desert site
* Continue supporting the Maneuvers
* Make effort to implement the DNB straylight correction
* Make effort to implement terrain correction
* Make effort to implement the automated RSB band calibration
* Resolve moon vs. solar calibration discrepancies
* Reduce blue band radiometric uncertainties
* Continue closely monitoring the instrument degradation
* Further characterize and potentially resolve the cold scene bias for M15
* Further characterize detector to detector performance and striping
* Further quantify the polarization effects and impact on products
* Further study the A side vs. B side calibration differences
* Closely monitor geolocation anomalies
* Investigate novel methods for M13 low gain calibration
* Assess the reprocessing of early data sets
* Support aircraft campaign as needed
* Publish results in journals
* Update the SDR user’s guide with new releases
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