MEMORANDUM FOR:	The JPSS Program Record
SUBMITTED BY:	JPSS VIIRS SDR Team, Changyong Cao, Slawomir Blonski, Wenhui Wang, Xi (Sean) Shao, Taeyoung Choi, Khalil Ahmad and others.
CONCURRED BY:	JPSS STAR Program Lead, Ingrid Guch (Acting) JPSS Product Lead, Lihang Zhou
APPROVED BY:	JPSS Program Scientist, Satya Kalluri

Read-me for Data

SUBJECT: ŇOAA-21 VIIRS SDR validated maturity status and public release

DATE: 8/3/2023

Validated maturity status declaration for VIIRS SDR

Review Date: 8/3/2023

Effective Date: 6/23/2023

Operational System: Algorithm version: IDPS Block 2.3 Release Mx7 (until 7/13/2023) and Mx8 (thereafter)

Version of LUTs used: at-launch LUT versions with the following updates effective on the dates shown below

- F-PREDICTED LUT on 1/12/2023 (VNIR only), 3/23/2023 (adds SWIR), 4/20/2023 (adds SWIR degradation correction), 5/11/2023 (adds SWIR bias corrections for I3, M8, M10, M11), 6/1/2023, 6/23/2023 (adds SWIR bias correction for M9), 7/27/2023
- GEO-DNB/IMG/MOD-PARAM LUTs on 1/12/2023 (post-lunch mounting matrix)
- DNB Onboard Offset Tables (ID 5 & 33-35) on 3/17/2023 (using spacecraft "backflip" pitch maneuver)
- DNB DN0 and GAIN-RATIOS LUTs on 3/9/2023, 3/30/2023, 4/27/2023, 6/1/2023, 6/29/2023, 7/27/2023, and continuing monthly after each new moon
- DNB STRAY-LIGHT-CORRECTION LUTs on 3/30/2023, 4/27/2023, 6/1(2)/2023, 6/29/2023, 7/27/2023, and continuing monthly after each new moon during the first year on orbit
- RVF (RVS) LUT on 6/7/2023 (TEB LWIR only, using spacecraft "backflip" pitch maneuver)
- RSBAUTOCAL-HISTORY file on 6/8/2023 (re-initialized RSBautoCal calculations)

The JPSS Algorithm Maturity Readiness Review Board approved the release of the NOAA-21 VIIRS SDR to the public with a Validated Maturity level quality as of 6/23/2023, 13:42 UTC (effective date, with F-PREDICTED LUT update for M9), based on JPSS Validation Maturity Review held on 08/03/2023.

1. **Background:**

The Joint Polar Satellite System-2 (JPSS-2) was successfully launched on November 10, 2022 and renamed NOAA-21 after it reached its final polar orbit. Twenty-five days after launch, on December 5, 2022, the NOAA-21 Visible Infrared Imaging Radiometer Suite (VIIRS) started collecting science data. With the same design as that of the Suomi NPP and NOAA-20 VIIRS, NOAA-21 VIIRS is a cross-track scanning radiometer with 22 channels at wavelengths ranging from 0.41 to 12.5 μm, enabling global measurements of clouds, ocean and land surface, detection of aerosols and fires, as well as low light from human settlements at night.

The VIIRS SDR team consists of experts from NOAA, Protech Sensor Contractors, University

of Maryland/CISESS, NASĂ, The Aerospace Corp., University of Wisconsin, and instrument vendor Raytheon. The team has been working intensively on post-launch instrument performance optimization and VIIRS SDR pre- and post-launch calibration and validation.

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 VIIRS SDR data products Validated Maturity:

After NOAA-21 VIIRS SDR data reached Provisional Maturity on March 30, 2023, VIIRS SDR team members continued intensive analysis of VIIRS science RDR, telemetry RDR, and SDR radiometric and geolocation data products. Based on additional 4 months of study and evaluation of the VIIRS reflective solar bands (RSBs), Thermal Emissive Bands (TEBs) and the Day/Night Band (DNB) SDRs, the following assessments of the VIIRS SDR products are summarized:

1) All four major categories (RSB, TEB, DNB and GEO) have been verified through a large and wide range of representative conditions (global and limited seasonal) dataset analysis. No significant anomalies have been found affecting data quality.
2) On-orbit instrument noise (NEdT and SNR) has been characterized; On-orbit SDR biases and stabilities were characterized based on comparisons with NOAA-20 VIIRS, lunar, Deep Convective Cloud (DCC), and validation site observations, as well as TEB comparisons with NOAA-21 CrIS.
3) All calibration related parameters, and major SDR/GEO quality flags were checked.
4) Errors and artifacts in the data products were documented. Solutions have been proposed and evaluated (not all are necessarily implemented).
5) Feedback from NWS and VIIRS EDR teams including Fire, Imagery and Ocean Color, are positive about the data quality based on their assessments.
6) Based on documented validation findings and user feedback, all VIIRS SDR data products have met the validated maturity requirements, are ready for operational use, and can be used for full qualitative and quantitative assessment for downstream products.

The detailed justifications for declaring VIIRS SDR Validated Maturity are attached in the presentations. The following is a table summarizing the VIIRS on-orbit SNR/NEdT and specification. For comparison purposes, S-NPP and NOAA-20 VIIRS noise values are also listed. The calibration bias characterization results of all VIIRS channels are provided in the presentations as well.

Band No	Center Wavelength (µm)	Band Gain	Ltyp or Ttyp (spec)	Spec SNR or NEdT (K)	On-orbit SNR or NEdT (K)		
					NOAA-21	NOAA-20	S-NPP
	VisNIR						
M1	0.412	H	44.9	352	653	631	588
		L	155	316	1063	1102	1045
M2	0.445	H	40	380	599	564	572
		L	146	409	1065	998	1010
M3	0.488	H	32	416	714	693	628
		L	123	414	1030	1061	988
M4	0.555	H	21	362	595	549	534
		L	90	315	913	848	856
I1	0.640	S	22	119	198	225	214
M5	0.672	H	10	242	360	385	336
		L	68	360	635	774	631
M6	0.746	S	9.6	199	408	417	368
I2	0.865	S	25	150	286	286	264
M7	0.865	H	6.4	215	540	532	457
		L	33.4	340	717	715	631
	S/MWIR						
M8	1.240	S	5.4	74	226	321	221
M9	1.378	S	6	83	234	297	227
I3	1.610	S	7.3	6	156	180	149
M10	1.610	S	7.3	342	557	673	586
M11	2.250	S	1.0	90/10*	186	199	*22 (Ltyp: 0.12)
I4	3.740	S	270	2.5	0.4	0.4	0.4
M12	3.700	S	270	0.396	0.15	0.12	0.12
M13	4.050	H	300	0.107	0.04	0.04	0.04
		L	380	0.423			
	LWIR						
M14	8.550	S	270	0.091	0.04	0.05	0.06
M15	10.763	S	300	0.07	0.02	0.02	0.03
I5	11.450	S	210	1.5	0.35	0.42	0.4
M16	12.013	S	300	0.072	0.02	0.03	0.03

*Note: SNPP M11 SNR Spec. was 10. On-orbit SNR was 22.

4. NOAA-21 VIIRS SDR Validated Maturity caveats (updated)

Mitigation of two issues identified in the Provisional Maturity review:

1) SWIR band radiometric bias uncertainties

Mitigation: SWIR band (M8-M11 and I3) bias corrections were fully applied as of June 23, 2023. Radiometric biases of SWIR bands relative to NOAA-20 VIIRS are within 2%. Further monitoring using multiple calibration methods such as lunar observations, vicarious targets, deep convective clouds and SNO-based calibration will be continuously performed.

2) DNB waiver (RDW-VIIRS-W208) "tail" in the line spread function

Conclusion: Closely monitored its impacts on DNB spatial resolution and geolocation accuracy. The impact is assessed to be small and no user concerns were reported. No mitigation is needed.

The following caveats remain in the validated products:

1) SWIR band gain changes are faster than expected

Mitigation and continued action: Continued close monitoring of these changes for all SWIR bands is required. Monthly updates of SWIR band radiometric calibration coefficients have been performed and the radiometric performance of SWIR bands meets the specs. In the meantime, preparation to automate SWIR band calibration is underway. In addition, potential mitigation of SWIR band gain change by the JPSS Flight Project will be supported.

2) MWIR band gain changes are faster than expected

Action: Impacts on NEdTs and SDRs of MWIR are negligible so far. Continued close monitoring of the responsivity degradations for MWIR bands and its impacts on calibration accuracy are needed. Potential mitigation of MWIR band gain change by the JPSS Flight Project will be supported.

5. Path Forward

The team continues VIIRS SDR long term monitoring, calibration, quality assurance, and algorithm stewardship after achieving the validated maturity and throughout the lifetime of the instrument.

1) Develop and deliver 12 monthly DNB stray light correction tables in a year
2) Continue to closely monitor and mitigate SWIR/MWIR band degradation
   - – Automate radiometric calibration for SWIR band
   - – Support potential outgassing operation by working with the JPSS Flight Project.
3) Analyze lunar calibration data to independently characterize solar diffuser degradation
4) Further evaluate NOAA-21 pre-launch waiver related issues and address them as appropriate
5) Continue monitoring VIIRS instrument stability and performance, as well as SDR data quality
   - – Update LUT to address TEB bias during warm up cool down
   - – Continue to prepare and submit LUT updates to implement improved calibration and error correction coefficients in the operational ground processing system
6) Explore the generation of images with alternative spatial resolutions to meet user needs

Additional information is available in the VIIRS Algorithm Theoretical Basis Document (ATBD) and validated maturity review briefing package, which can be accessed at:

https://www.star.nesdis.noaa.gov/jpss/Docs.php

NOAA-21 VIIRS near real time status and performance monitoring are available at the following URL:

https://www.star.nesdis.noaa.gov/icvs/status_N21_VIIRS.php

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