Read-me for Data Users

MEMORANDUM FOR: The JPSS Program Record
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SUBJECT: NOAA-21 Product Validated maturity status
DATE: 03/28/2024

Validated maturity status declaration for J2 OMPS Nadir Mapper and Nadir Profiler SDR
Maturity Review Date: **03/28/2024**
Effective Date and Time: **03/28/2024 19:37:29 GMT**
Operational System: **MX 9 IDPS with At-launch OMPS LUTs and ADR 10360,10365, 10550, 10553, 10682, 10685,10686,10825**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the J2 OMPS NM and NP SDR products to the NOAA SDR/EDR cal/val users with a validated maturity level quality as of 04/06/2024 19:37:29 GMT (effective date and time), based on JPSS Validation Maturity Review held on 03/28/2024 (link to review artifacts).

1. **Background:**

The Joint Polar Satellite System-2 (JPSS-2) was successfully launch on November 10, 2022 and renamed NOAA-21 after reaching polar orbit. Ninety-one days after launch, on February 10, 2023, the NOAA-21 Ozone Mapper Profiler Suite (OMPS) started collecting operational non-global nominal science data. The first two days of global data were collected on February 17 and 18, 2023. With the same design as that of the Suomi NPP and NOAA-20 OMPS Nadir Suites, NOAA-21 OMPS consists of two spectrometers each with different spectral and spatial coverage. The nadir mapper (NM) has spectral coverage from 300nm to 380nm with 198 channels and 1.1nm bandpass. The nadir profiler (NP) has spectral coverage from 250nm to 310nm with 158 channels and 1.1 nm bandpass. The OMPS nadir suite provides global measurements of total ozone, ozone profile, sulfur dioxide, and an aerosol index. More importantly, the OMPS NM on NOAA21 enables us to detect, track and monitor atmospheric ozone UV-absorbing aerosols and other atmospheric gases important for air quality such as Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2) at better spatial resolution. Quantifying these atmospheric species is important for a variety of reasons including monitoring the Ozone Layer and its interactions with climate change, tracking volcanic SO2 and ash for air traffic safety, and identifying pollution sources and levels for general air quality health assessments.

The OMPS SDR team consists of experts from NOAA/STAR, University of Maryland/CISESS, NASA, GST Inc, SSAI., the Aerospace Corp., and industry partner Peraton**.** The team has been working intensively on post-launch instrument performance optimization, OMPS SDR pre- and post-launch calibration and validation.

2. **Validated maturity stage definition:**
    a. Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
    b. 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.
    c. Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
    d. Product is ready for operational use based on documented validation findings and user feedback.
    e. Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.
3. **Justifications for declaring OMPS NM and NP SDR data products validated maturity:**

After NOAA-21 OMPS NM and NP SDR data reached Provisional Maturity on April 14, 2023, OMPS SDR team members continued the analysis of OMPS science RDR, telemetry, SDR and GEO data products. The following assessments of the OMPS SDR products were performed prior to the Validated Review.

1) Conducted a large and wide range of representative conditions of the data quality for the NOAA-21 OMPS NM and NP in comparison with Suomi NPP and NOAA-20.
2) Improved the sensor wavelength registration algorithms for OMPS NM and NP.
3) Continued the analysis of NOAA-21 OMPS NM and NP dark current, gain and LED.
4) Assessed the geolocation accuracy of the OMPS NM data against VIIRS M1 band data.
5) Assessed the geolocation accuracy of the OMPS NP data against the NM data.
6) Analyzed the SNR performance of the OMPS NM and NP data.
7) Analyzed the NM intra-orbit wavelength shift feature analysis.
8) Evaluated the NP stray light effect and delivered an improved NP straylight table.
9) Evaluated the NM out-of-range (OOR) stray light effect and delivered a new NM OOR straylight table.
10) Continued the weekly dark rate LUT delivery since February 23, 2023.
11) Continued the biweekly NP solar and wavelength LUT delivery since March 21, 2023.
12) Analyzed and fixed an over-correction of the dark current.
13) Analyzed and delivered a short-term fast track correction for Solar Intrusion and a more comprehensive code change update for the solar intrusion.

In summary there were 9 ADR for both the NM and NP SDR since the provisional review.

1) ADR10360/6548: Straylight deficiency in NOAA-21 OMPS NM. TTO Nov 6, 2023.
2) ADR10365/6475: 0.03 nm difference in EV and Solar Irradiance wavelength scale. The wavelength shift calculation method was updated. TTO 11/06/2023.

3) ADR10550/6767: Solar Intrusion OMPS-NP fast-track straylight correction. The OMPS-NP instrument has a solar intrusion straylight error. This is similar to the NOAA-20 NP solar intrusion.

4) ADR10552/6773: Solar intrusion OMPS-NP code change. A new and improved version of the solar intrusion correction was implemented. This is related to ADR10550 but this DR delivered an improved correction and required a code change. In other words, the above ADR10550 can well address the requirement concern of the NP SDR data quality, although this new ADR can make the quality of NOAA-21 OMPS NP SDR data better. TTO April 18, 2024.

5) ADR10553/6799: OMPS-NP Hot and Transient pixel. One single CCD pixel began to exhibit unstable dark current background signal several months in to the mission. A flight table and ground table updates effectively disabled the transient pixel.

6) ADR10682: OMPS-NP Weekly Dark deliveries are scaled by an empirical factor to reduce the magnitude of the dark current correction. The basis for the correction is the power law.

7) ADR 10685/6951: An improved version of the OMPS-NP Straylight correction was derived. TTO 02/29/2024.

8) ADR10686/6956: The OMPS-NM straylight table was lacking the OOR component of the straylight correction. New coefficients were derived. TTO 03/21/2024.

9) ADR10825: Assess calibration errors in NOAA-21 OMPS NM and NP solar flux relative to S-NPP. The solar flux differences in NOAA-21 OMPS NM and NP have been identified by comparing S-NPP day-1 and synthetic spectra.

Overall, the NOAA-21 OMPS NM and NP instrument performs well with stable CCD gain, nonlinearity and dark rate performance after the launch. The corresponding SDR data show a reasonable quality with a good agreement with SNPP and NOAA-20. They are in a family with SNPP and NOAA-20 OMPS. Below is a summary the NOAA-21 OMPS data quality performance.

i. On average, the SNR meet the requirements
ii. Geolocation accuracy meets the requirement
iii. NM and NP data consistencies in the range from 302 to 310 nm are mostly within ±2%.
iv. OMPS NM SDR data agree with both SNPP and NOAA-20 typically with margins of ±3 % for the channels above 305nm.
v. OMPS NP SDR data agree with both SNPP and NOAA-20 typically with margins of ±5 %.

The NOAA STAR EDR team has successfully used the NOAA-21 OMPS SDR data in total ozone and ozone profile retrievals. The results demonstrated that the products are of good quality with a few known/unknown concerns, which are generally consistent with the SDR calibration problems and caveats summarized in this readme. The detailed justifications for declaring OMPS SDR validated maturity is provided in the attached presentation.

4. NOAA-21 OMPS SDR validated maturity caveats

The following caveats are provided to the validated product users. ADR 10825 still needs to be delivered to IDPS as fast track look-up tables.

1) Uncertainties exist in the currently derived NOAA-21 OMPS NM and NP solar 'day-1' data set. These discrepancies will be resolved with new fast-track solar datasets to IDPS under ADR 10825. The solar activity impact correction is not currently done for OMPS NM and NP. This has an affect for some shorter channels in OMPS-NP.
2) The NOAA-21 OMPS NM radiance shows a relatively large discrepancy with NOAA-21 OMPS NP in the range from 300 to 302 nm. The cause is thought to be the calibration coefficient lookup table. Data below 302nm should be used with caution or not at all.
3) The SNR performance of the NOAA-21 NM and NP data is not well quantified in the dichroic range from 300 to 310nm by using the current algorithm. An improved SNR algorithm is desirable to better capture the SNR performance there.
4) There are certain inter-sensor radiance differences between the NOAA-21 OMPS NM and the SNPP/NOAA-20 radiance. Further investigation is needed to better quantify the inter-sensor radiometric calibration biases.
5) The correction of the solar intrusion, which is only applicable for the OMPS NP SDR data over Northern Hemisphere with solar zenith angles higher than 58 degree, is using an empirical look-up table until the MX10 TTO expected on May 17, 2024. With the implementation of this empirical table, solar intrusion has been significantly corrected toward meeting the requirement. However, the new and improved version of the solar intrusion correction associated with the code change via ADR10552/6773 can further improve the performance of the solar intrusion correction particularly for NP wavelengths below 255nm.
6) The calibration accuracy of the NOAA-21 NM and NP data at short wavelengths (e.g., below 255nm for NP and below 303nm for NM) need to be further quantified. Improved radiative transfer modeling is expected to better quantify the calibration radiometric errors.
7) The data in the dichroic range from 300 to 305nm are known to be problematic. It is expected that further analysis will lead to improvements in both solar irradiance and radiance for this region.
8) The OMPS NM SDR data below 300nm is not validated, which is beyond the requirement. Even so, this deficiency is expected to be fixed in the future by delivering new OMPS-TC-CALCONST lookup tables to IDPS in future.

5. Path Forward

The OMPS SDR team continues long-term monitoring of the calibration, quality, and algorithm stewardship after achieving the validated maturity, throughout the lifetime of the instrument. The path forward includes:

1) Deliver the ADR10825 Solar Flux update LUTs to resolve the solar flux discrepancies relative to reference solar datasets.
2) Continue the following analyses
    i. Regular deliveries for the NOAA-21 NM/NP dark and NP wavelength LUTs
    ii. NOAA-21 OMPS NM and NP wavelength registration accuracy improvement.
    iii. SNR calculation method improvement.
    iv. Geolocation accuracy continuing monitoring of NOAA-21 OMPS NM/NP data
    v. Solar intrusion effect for NOAA-21 NP
    vi. Stray light correction performance.
3) Further quantify the NOAA-21 data quality towards the scientific requirements using multiple methods
    i. NM and NP SDR data quality consistency
    ii. Inter-sensor radiometric calibration uncertainties (e.g., JPSS instruments, Tempo, TropOMI, GEMS)
    iii. RTM simulations
4) Improve the simulation accuracy of the CRTM for OMPS NP and NM in coordination with the STAR CRTM team
5) Assess impact of a different solar reference spectrum (e.g., GSICS-recommended one) on NOAA-21 SDR data quality
6) Continue to update the OMPS SDR ATBD.

Additional information is available in the OMPS algorithm theoretical basis document (ATBD) and validated maturity review briefing, which can be accessed at:
https://www.star.nesdis.noaa.gov/jpss/Docs.php

NOAA-21 OMPS near real time status and performance monitoring is available using the following URL at:

https://www.star.nesdis.noaa.gov/icvs/status_N21_OMPS_NP.php

https://www.star.nesdis.noaa.gov/icvs/status_N21_OMPS_NM.php

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