MEMORANDUM FOR:	The JPSS Program Record
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SUBJECT:	NOAA-21 ATMS TDR/SDR validate maturity status
DATE:	6/22/2023

Validated maturity status declaration for ATMS TDR/SDR

Maturity Review Date:	**6/22/2023**
Effective Date:	**May 12, 15:51:52 UTC 2023 Rev# 2601**
Operational System:	**IDPS with ATMS PCT 006**

1. Background:

The Joint Polar Satellite System-2 (JPSS-2) successfully lifted off from Vandenberg Space Force Base on Nov. 10, 2022 at 1:49 a.m. PST and was renamed NOAA-21. Eleven days after launch, on November 21, 2022, the NOAA-21 Advanced Technology Microwave Sounder (ATMS) was activated and started to collect science data.

Like the Suomi NPP ATMS and NOAA-20, NOAA-21 ATMS is a cross-track scanning radiometer with 22 channels at frequencies ranging from 23 to 183 GHz, permitting the measurements of the atmospheric temperature and moisture profiles under most weather conditions.

NOAA-21 will assume the primary role of the 1325 Local Time of Ascending Node (LTAN) (PM). NOAA-20 will have the required half-orbit separation behind NOAA-21. S-NPP is a quarter orbit in between NOAA-21 and NOAA-20.

The ATMS SDR team consists of experts from NOAA, NASA, MIT Lincoln Laboratory, and industry partners Northrop Grumman and Raytheon. The team has worked intensively for post-launch instrument performance optimization and ATMS SDR pre- and post-launch calibration and validation.

NOAA-21 ATMS data products were declared beta maturity level on November 30, 2022 after the preliminary data review and analysis. NOAA-21 ATMS data product reached provisional maturity on December 15, 2022 after continued instrument performance characterization and data quality improvement.

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 ATMS TDR/SDR data products validated maturity:

After NOAA-21 ATMS provisional maturity on December 15, 2022, ATMS SDR team members continued the assessment and analysis of both ATMS on-orbit normal scanning data and special Post-Launch Tasks (PLT) data, including ATMS science RDR, telemetry RDR, diagnostic RDR, TDR, SDR, and GEO data products. After more than six months of continuous study and monitoring of ATMS data, the following assessments of the ATMS instrument and data products are given:

1) Space view profile #1 was chosen as the optimal space view profile;
2) On-orbit NEΔT is well characterized and shows slightly better performance than S-NPP, while NOAA-21 G-band shows improvement over NOAA-20;
3) Temperature stabilization has been checked and demonstrates a relatively low orbital gain drift;
4) Effective FOV size, antenna pattern, and earth side lobe evaluations have been performed using roll & pitch over maneuver data;
5) Geolocation accuracy is assessed based on nearly six months on-orbit data and shows better accuracy than NOAA-20 (and therefore better than S-NPP);
6) Inter-comparison results between NOAA-21 and NOAA-20 ATMS indicate a relatively higher (but consistent) antenna temperature (TDR) in NOAA-21 using double difference technique;
7) Striping noise was evaluated and shows a significant improvement or equivalent compared to NOAA-20 (and much better than S-NPP);
8) Channel correlation assessment indicates a lower G-band correlation in NOAA-21 than on NOAA-20 (and much better than S-NPP across all channels)
9) Noise characterization data was analyzed and illustrated comparable results with pre-launch TVAC data;
10) PCT update (006) on 12-May-2023: a) turned on the calibration count upper and lower boundary checks to improve quality control, b) updated the TDR to SDR conversion coefficients to improve the SDR data quality, c) beam pointing correction, d) cold bias correction, e) reflector emissivity update. This PCT update successfully mitigates the ATMS cross scan asymmetry and further reduced the systematic difference between TDR and SDR.
11) Errors and artifacts in the data products, after provisional maturity, were documented;
12) NOAA-21 ATMS TDR data has been used in NOAA/NWS, UKMO, and ECMWF pre-

operational NWP system in May 2023.;

13) NOAA MIRS team has generated and analyzed NOAA-21 total precipitable water EDR products and is satisfied with the EDR accuracy.

A table at the end of this memo summarizes the ATMS channel center frequencies, polarization, NEΔT specification and on-orbit NEΔT values.

4. ATMS validated maturity TDR & SDR data product caveats

The following caveats are offered to the validated product users:

1) Like some heritage sensors, TDR/SDR data has noticeable striping in terms of NWP O-B field, particularly in temperature sounding channels. However, the NOAA-21 striping index is much lower than S-NPP and better than NOAA-20 in the G-band channels. Striping noise is attributed to flicker noise, which is a contributor to overall radiometric noise (NEΔT). NOAA-21 is still well within the ATMS NEΔT requirements, and the NOAA-21's flicker noise is lower than previous ATMS builds.
2) Due to the loss of SMD communication during early-orbit checkout, ATMS lost most of science data from 02:49 on December 16, 2022 to 23:09 GMT on February 1, 2023. During this period of time, only limited data near northern polar region were available.
3) ATMS SDR data before May 12, 2023 has relatively large cross track angular dependent asymmetry at V-band channels. Such asymmetry has been mitigated by the calibration coefficient update on May 12, 2023

5. Path forward

The team will move forward to improve ATMS TDR/SDR data product quality during the long-term monitoring (LTM) period after validated maturity. Here are some examples how:

1) Continue to monitor ATMS instrument stability and performance, as well as TDR/SDR data quality;
2) Develop and implement dynamic cold bias correction in IDPS (i.e., replace static Earth brightness temperature with a time-varying estimate)
3) Develop and implement satellite near-field contamination correction in IDPS to further reduce scan bias asymmetry
4) Implement band-dependent satellite zenith angle output in GEO data file
5) Further investigate an improved geolocation correction
6) Verify S-NPP & NOAA-20 antenna pattern correction based on lessons learned from NOAA-21 analysis

Additional information is available in the ATMS Algorithm Theoretical Basis Document (ATBD) and User's Guide, which can be accessed at:

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

NOAA-21 ATMS Spectral Response Function (SRF) Dataset and Calibration Data Book:

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

NOAA-21 ATMS On-orbit Events and Anomalies:
https://www.star.nesdis.noaa.gov/icvs/N21_Anomalies.php

NOAA-21 ATMS near real time status and performance monitoring is available at the following URL at:
https://www.star.nesdis.noaa.gov/icvs/status_N21_ATMS.php

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Ch.	Center Freq. (MHz)	Pol	NOAA-21 NEΔT Specification (K)	NOAA-21 NEΔT On-orbit (K)
1	23800	QV	0.7	0.22
2	31400	QV	0.8	0.27
3	50300	QH	0.9	0.30
4	51760	QH	0.7	0.21
5	52800	QH	0.7	0.20
6	53596±115	QH	0.7	0.22
7	54400	QH	0.7	0.20
8	54940	QH	0.7	0.21
9	55500	QH	0.7	0.22
10	57290.344(f_o)	QH	0.75	0.33
11	f_o± 217	QH	1.2	0.45
12	f_o±322.2±48	QH	1.2	0.49
13	f_o±322.2±22	QH	1.5	0.71
14	f_o±322.2±10	QH	2.4	0.99
15	f_o±322.2±4.5	QH	3.6	1.63
16	88200	QV	0.5	0.20
17	165500±925	QH	0.6	0.32
18	183310±7000	QH	0.8	0.25
19	183310±4500	QH	0.8	0.26
20	183310±3000	QH	0.8	0.36
21	183310±1800	QH	0.8	0.36
22	183310±1000	QH	0.9	0.50