MEMORANDUM FOR: The Record

FROM: Dr. Fuzhong Weng, JPSS ATMS SDR Team Lead

SUBJECT: S-NPP ATMS SDR Validated status and public release

DATE: 1/7/2014

Validated status declaration for S-NPP ATMS SDR and TDR
Effective IDPS Build: Mx 8.3
Collection Short Names: ATMS-TDR and ATMS-SDR

1. Background

The successful launch of the Suomi National Partnership Program (NPP) spacecraft on Oct. 28, 2011 with the Advanced Technology Microwave Sounder (ATMS) ushers in a new generation of capabilities for operational environmental remote sensing for weather, climate, and other environmental applications. The ATMS Sensor Data Record (SDR) product has been assimilated by the NWP models to improve weather forecasts, and is used by the Cross-Track Infrared and Microwave Sounder Suite (CrIMSS) algorithm to produce its Environmental Data Records (EDRs). The ATMS SDR team consists of experts from NOAA, NASA, MIT Lincoln Laboratory, Space Dynamic Laboratory (SDL), 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.

The Suomi-NPP SDR Validated Status Review was held on December 18-20, 2013 at the NOAA Center for Weather and Climate Prediction (NCWCP) in College Park, Maryland, hosted by NOAA/NESDIS/STAR. The purpose of the meeting was to assess the readiness of the ATMS SDR data product maturity level to be declared "Validated" by the Algorithm Executive Review Board (AERB).

ATMS SDR team members presented current Cal/Val progress since provisional maturity. Data assimilation users from different Numerical Weather Prediction (NWP) centers, including NOAA National Centers for Environmental Prediction (NCEP), UK MetOffice, European Centre for Medium-Range Weather Forecasts (ECMWF), and Naval Research Laboratory (NRL), demonstrated the impact of assimilating ATMS data in their NWP models. A total of 10 presentations related to ATMS SDR were made and are attached with the Validated-Maturity CCR package.

1.1 Provisional Product

ATMS TDR product was declared to have reached Provisional maturity on February 6th, 2013, following successful early CalVal work performed by the team, including updates of the PCT table, optimal space view sector selection, and 23 other tasks by the team. A Readme file was provided to the Provisional product users, which summarized the following product caveats:

1) TDR data present noticeable striping in terms of NWP O-B field (DR 4813) but the striping magnitude is still within the requirement of ATMS channel noise (NEΔT).

2) SDR brightness temperature data is the same as TDR brightness temperature data. Currently, the beam-efficiency and scan-bias coefficients for the linear TDR-to-SDR conversion are set to one and zero, respectively. It is found that the current SDR products are still within the ATMS accuracy specification [1]. At the ATMS provisional product review, it was also shown by user community that NWP O-B for most of the upper air sounding channels are generally less than 1.0K. There were discrepancies in beam efficiency coefficients among NOAA/STAR, NGES, and MIT-LL calculations. However, the ATMS SDR team has reached an agreement to produce a beta version of beam efficiency and scan bias correction coefficients for preliminary evaluation.

3) Quality flags should be stable now. But the maneuver flag was not set correctly.

4) Reflector emissivity impact analyses were performed on NPP ATMS pitch maneuver data. However, additional assessment is needed before concluding that reflector emissivity impacts earth scene radiances.

5) The Lunar intrusion flag was set correctly but lunar intrusion correction was not implemented.

1.2 Major Cal/Val Activities after the Provisional Version

Since the Provisional Review Meeting on October 23, 2012, the ATMS SDR team has focused on the following activities:

1) SDR Calibration Analysis
   a. Developed theoretical expressions for ATMS TDR-to-SDR conversion
   b. PCT table update for antenna pattern and scan bias correction
   c. Lunar intrusion detection and correction
   d. Inter-satellite/sensor comparisons
   e. SDR bias characterization using GPS Radio Occultation data
   f. TDR striping analysis and mitigation plan discussion
   g. Scan profile contingency plan discussion and proxy data generation
   h. ATMS SDR ATBD update
   i. ATMS data user guide preparation

2) Algorithm improvement and code fix
   a. Code fixes for TDR/SDR maneuver flag

   b. Code update for lunar intrusion correction

   c. PCT update for TDR-to-SDR conversion

2. Justifications for Promoting ATMS TDR/SDR/RSDR Products from Provisional to Validated Level

The ATMS SDR Validated Product Review Meeting was very successful. After presenting progress results by all investigators on remaining tasks after provisional, the review panel provided the following assessment of the ATMS SDR products:

1) On-orbit NEΔT is well characterized and meets specification

2) On-orbit SDR bias is well characterized using different data

3) All the important quality flags are checked and updated

4) Calibration coefficients from TDR-to-SDR conversion for K/Ka/V bands are updated, and only scan biases are updated for W/G bands

5) Lunar intrusion correction is tested and DR is submitted for update

6) ATMS and AMSU-A inter-sensor biases are well characterized, and ATMS TDR data are more consistent with AMSU-A data.

7) Very solid root-cause analysis for striping using TVAC, pitch-over maneuver data, and earth scene analysis.

8) STAR ICVS-LTM can provide long-term monitoring of ATMS instruments

9) Good documentations including updated ATBD, publications, error budget analysis, etc

10) All the Cal/Val science results have been published through peer-reviewed process

11) NWP users have demonstrated positive impacts of ATMS TDR on global medium-range forecast models

12) ATMS SDR products have reached the validated maturity level. The data is ready for use by the operational center and scientific publications.

The detailed justifications for promoting the ATMS SDR from Provisional to Validated maturity level are summarized in the following and the supporting materials [1] – [15], presented in the SDR validated product review meeting by the ATMS SDR team and data product users.

<u>The products have met the specifications</u>

The following table lists the SDR specifications in black color and the corresponding on-orbit Cal/Val values the SDR team derived from the data in red color.   The SDRs calibration

results are well within the specifications. These Cal/Val values in the table are derived with rigorous methods on the data collected since the launch of S-NPP. The NEΔT values are estimated from Space View Count, Warm Target Count, and PRT temperatures. Not only is the NEΔT evaluated but also its stability with time, which is very stable as shown in the ICVS-LTM products. The TDR global bias has been estimated at each FOV by the radiative transfer models (RTM) with ECMWF forecast background. The details of the uncertainty assessments and results can be found in the attached team member presentations [1] – [15].

Table-1. ATMS SDR specifications (black) and the on-orbit values from ICVS (Red)

#	Channel Freq. (MHz)	Calibration Accuracy (K)	Nonlinearity Max. (K)	NEΔT (K)	3-dB BW* (deg)	Equivalent AMSU-A/B/#
1	23800	1.0	0.3	0.7(0.24)	5.2	AMSU-A2/1
2	31400	1.0	0.4	0.8(0.30)	5.2	AMSU-A2/2
3	50300	0.75	0.4	0.9(0.35)	2.2	AMSU-A1-2/3
4	51760	0.75	0.4	0.7(0.28)	2.2	NA
5	52800	0.75	0.4	0.7(0.26)	2.2	AMSU-A1-2/4
6	53596±115	0.75 (0.2)	0.4	0.7(0.27)	2.2	AMSU-A1-2/5
7	54400	0.75 (0.2)	0.4	0.7(0.26)	2.2	AMSU-A1-1/6
8	54940	0.75 (0.4)	0.4	0.7(0.25)	2.2	AMSU-A1-1/7
9	55500	0.75 (0.5)	0.4	0.7(0.28)	2.2	AMSU-A1-2/8
10	f_o=57290.344	0.75 (0.3)	0.4	0.75(0.40)	2.2	AMSU-A1-1/9
11	$f_o \pm 217$	0.75 (0.3)	0.4	1.2(0.52)	2.2	AMSU-A1-1/10
12	$f_o \pm 322.2 \pm 48$	0.75 (0.3)	0.4	1.2(0.55)	2.2	AMSU-A1-1/11
13	$f_o \pm 322.2 \pm 22$	0.75 (0.1)	0.4	1.5(0.80)	2.2	AMSU-A1-1/12
14	$f_o \pm 322.2 \pm 10$	0.75	0.4	2.4(1.13)	2.2	AMSU-A1-1/13
15	$f_o \pm 322.2 \pm 4.5$	0.75	0.4	3.6(1.82)	2.2	AMSU-A1-1/14
16	88200	1.0	0.4	0.5(0.27)	2.2	89000 (A1-1/15, B16)

17	165500	1.0	0.4	0.6(0.40)	1.1	150000 (B/17)
18	183310± 7000	1.0	0.4	0.8(0.36)	1.1	AMSU-B/20
19	183310± 4500	1.0	0.4	0.8(0.43)	1.1	NA
20	183310± 3000	1.0	0.4	0.8(0.51)	1.1	AMSU-B/19
21	183310± 1800	1.0	0.4	0.8(0.55)	1.1	NA
22	183310± 1000	1.0	0.4	0.9(0.70)	1.1	AMSU-B/18

<u>The remaining issues are not critical to the validated product</u>

The following are the issues identified by the team. None of them are critical to the SDR product for validated maturity status.

1) Beam efficiency for W/G-Band channels

The ATMS SDR team is reaching a consensus on the coefficients that convert antenna temperatures to brightness temperatures (TDR to SDR). However, due to the inconsistence on G-band beam efficiency coefficients derived from antenna pattern measurements by different team members, no beam efficiency correction has been applied in TDR to SDR conversion at W/G-band channels. The team continues working on the antenna pattern analysis for W/G-band beam efficiency and will update the processing coefficient table for IDPS once a consensus on the analysis method and beam efficiency is reached.

2) TDR/SDR striping mitigation

The NWP community noticed a striping artifact in their comparison of ATMS observations minus NWP background simulations, which is not found in the heritage AMSU-A data but in AMSU-B/MHS data. The striping noise is shown as 1/f or flicker noise in the power spectrum of warm counts. While overall ATMS noise is still within specifications, the team continues investigating techniques to mitigate the striping artifacts.

3) Scan drive contingency plan assessment

The team will continue to evaluate if ATMS is configured to a new scan profile (96 FOV to 48 FOV) whether RDR data can be processed at IDPS system into a normal data stream for NWP users.

3. **ATMS Validated SDR Product Caveats**

The following caveats are offered to the validated-product users:

1) TDR data present noticeable striping in terms of NWP O-B field, particularly in temperature sounding channels, but the striping magnitude is still within the requirement of ATMS channel noise (NEΔT).

2) SDR brightness temperature data for W/G-band channels does not contain beam efficiency corrections because of the uncertainty in W/G-band beam efficiency coefficients derived from antenna pattern measurements. Scan angle dependent bias has been corrected for all channels in the beta version correction coefficients.

3) Spacecraft maneuver quality flag is not set correctly.

4) It is also proposed by NGES that the ATMS reflector may have some self-emission. The emissivity has scan-angle dependence and may also produce additional scan-angle dependent bias. However, no pre-launch reflector emissivity data is available for analysis. Best estimates and proposed additional corrections will be added in the updated processing coefficient table.

4. Path forward after Validated maturity level

The team will move forward to perform the following work:

1) Continue to monitor ATMS instrument stability and performance, as well as TDR/SDR data quality

2) Update ATMS beam efficiency correction coefficients for TDR-to-SDR conversion in G-band channels

3) Update ATMS scan-angle-dependent bias coefficients for TDR-to-SDR conversion accounting for reflector emissivity

4) Work with NGES to better characterize JPSS-1 ATMS antenna patterns, including side-lobe, cross-polarization spill-over, and polarization twist angle

5) Implement the lunar intrusion correction algorithm in IDPS

6) Update spacecraft maneuver flag handling in TDR/SDR data

7) Develop channel-dependent striping mitigation algorithm

8) Study impact on ATMS products of scan drive contingency plan

5. References

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