**MEMORANDUM FOR:** The Record

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

**SUBJECT:** NPP ATMS SDR Provisional status and public release

**DATE:**  1/16/2013

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 the weather forecast and used by the CrIS and Microwave Sounder Suite (CrIMSS) algorithm to produce the 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, Exelis-ITT and Raytheon. The team has been working intensively for post-launch instrument performance optimization and ATMS SDR pre- and post-launch calibration and validation.

The Suomi-NPP SDR Provisional Status Review was held on October 23-24, 2012 at the NOAA Center for Weather and Climate Prediction (NCWCP) in College Park, Maryland, hosted by NOAA/NESDIS/STAR. The purpose of this meeting was to assess the readiness of the ATMS SDR data product maturity level to be declared “Provisional” by the Algorithm Executive Review Board (AERB).

ATMS SDR team members presented current Cal/Val progress since beta maturity, and CrIMSS group also offered their independent assessments of ATMS Temperature Data Records (TDRs) and Remapped SDR product quality based on their analyses. Data assimilation users from different Numerical Weather Prediction (NWP) centers, including NOAA Joint Center for Satellite Data Assimilation, MetOffice, and ECMWF, demonstrated impact study by assimilating ATMS data in their NWP models. A total of 9 presentations related to ATMS SDR were made and are attached with this CCR package.

**1.1 Beta Product**

ATMS TDR product was declared to have reached Beta maturity level on February 12th, following successful early CalVal work performed by the team, including updates of PCT table, optimal space view sector selection, and other 23 tasks by the team. A Readme file was provided to the Beta product users, which summarized the following product caveats:

1. ATMS SDR data products include both Temperature Data Record (TDR) and Sensor Data Record (SDR). The TDR product is the calibrated antenna temperatures obtained directly from the sensor antenna measurements of earth's outgoing radiation at the top of the atmosphere while the SDR product is the brightness temperature after applying a beam efficiency and scan position dependent bias correction to the TDR data. For beta maturity, no beam efficiency and scan position dependent bias correction has been applied to the SDR data product, so the antenna temperatures in the TDRs are identical to the brightness temperatures in the SDRs.
2. Not all ATMS TDR/SDR data product quality flags were implemented accurately in the beta release due to non-optimized data quality dynamic ranges, which include granule level and scan level quality flags. Users need to be aware of this when directly using the quality flags in the TDR/SDR data products for operational data quality evaluation.
3. Minor striping phenomena have been noticed at ATMS selected V-Band channels (channels 10 to 15) when compared against Numerical Weather Prediction models. The root cause is still under investigation, but the latest explanation is that the ATMS receivers have larger 1/f noise that the heritage sensors. Mitigation techniques are being investigated.

1. There is a strong indication that direct solar intrusion causes a slight heating (0.15 Kelvin) of the "WG" band (Chan. 16-22) internal calibration target (ICT) as the NPP satellite enters the eclipse. The "KAV" band ICT had no direct solar intrusion due to the sun shade and varied only ~0.05 Kelvin during these events. The worst-case temperature variation, however, is within the specified allowable temperature drift for the calibration target, and does not compromise calibration accuracy.
2. Some ATMS TDR/SDR data may not contain valid values due to spacecraft maneuvers and anomalies, which are listed below:
   1. 65 deg. ATMS (anti-sun side) roll maneuver: 12 Jan 2012 between 12:00 to 12:35 UTC
   2. 25 deg. ATMS (sun-side) roll maneuver: 12 Jan 2012 between 13:50 to 14:10 UTC
   3. Pitch maneuver: 20 Feb 2012 between 18:15 to 19:00 UTC
   4. NPP Spacecraft Anomaly: ATMS data loss from 21 Jun 2012 18:00 UTC to 22 Jun 2012 12:56 UTC
   5. Near monthly VIIRS calibration maneuvers will impact ATMS SDRs (approx. nine maneuvers a year). The monthly VIIRS calibrations consist of a 14 deg. anti-sun side roll maneuver with a dwell time of four minutes.

Another caveat is that the N\_Spacecraft\_Maneuver metadata in the ATMS data products is not working as expected during the maneuvers, and therefore it isn't correctly identifying maneuvers. A fix was implemented on 9 Aug. 2012.

1. Preliminary evaluation on ATMS geolocation accuracy did not show a significant problem in Beta release data.
2. The ATMS SDR remapped to the CrIS SDR is available starting on April 19, 2012 to match when the CrIS SDR became available on CLASS. A false positive "synchronization error" quality flag (QF4) was fixed after May 17th, 2012 by changing a ground look-up table parameter value.

**1.2 Major Cal/Val Activities after the Beta Version**

Since the Beta Review Meeting in January 13, 2012, the ATMS SDR team has focused on the following activities:

1. SDR Calibration Analysis
   1. Roll/Pitch Maneuvers data analysis
   2. Theoretical explanation for Quasi-Vertical/Quasi-Horizontal polarization channel measurements
   3. Inter-satellite/sensor comparisons
   4. Observation vs. radiative transfer model comparisons
   5. Update PCT table to improve data quality flag accuracy
   6. ATMS SDR remap to CrIS FOR, including updating synchronization time in PCT to eliminate QF false alarms TDR stripping analysis
2. Geolocation validation
   1. Compared with high resolution geolocation digital datasets and verify that the near nadir and off nadir geolocation are within specification.
3. Algorithm improvement and code fix
   1. Code fixes for QF false alarms
4. **Justifications for Promoting ATMS TDR/SDR/RSDR Products from Beta to Provisional Level**

The ATMS SDR Provisional Product Review Meeting was very successful. After presenting progress results by all PIs on 25 cal/val tasks, the review panel provided the following assessment to the ATMS SDR products:

1. ATMS SDR team has showed that the instrument performance is well within specification and the Backus-Gilbert remap SDR has a quality similar to AMSU-A data
2. NWP users have demonstrated positive impacts of ATMS TDR on global medium-range forecast models
3. Team should analyze ATMS on-orbit performance trends carefully to assess its stability
4. Continue to ensure that the data quality flags are working well
5. Need to implement an algorithm for correcting the scan-angle dependent bias
6. Need to determine the root cause of TDR stripping issues and develop an algorithm to mitigate the striping.
7. ATMS team (given in team highlight presentation) – clearly identified the remaining issues and future plans
8. ATMS TDR/SDR/RSDR products have reached the provisional maturity level.

The detail justifications for promoting the ATMS TDR/Remapped SDR from Beta to Provisional maturity level are summarized in the followings and the supporting materials [1] – [10], presented in the SDR Provisional product review meeting by the ATMS SDR team and data product users.

The products have met the specifications

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 over the past 12 months. The NE∆T values are estimated from Space View Count, Warm Target Count, and PRT temperatures. Not only is the NE∆T evaluated but also its stability with time, which is also very stable as shown in the ICVS-LTM products. The calibration accuracy and bias analysis are estimated at each FOV with the radiative transfer models (RTM) with ECMWF forecast background. The geolocation uncertainty is estimated by comparisons of ATMS FOV along coast and high resolution geolocation digital datasets. The details of the uncertainty assessments and results can be found in the attached team member presentations [1] – [6].

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 | 0.83 | 0.1 | 0.5(0.24) | 5.2 | AMSU-A2 |
| 2 | 31400 | 0.83 | 0.1 | 0.6(0.30) | 5.2 | AMSU-A2 |
| 3 | 50300 | 0.67 | 0.075 | 0.7(0.35) | 2.2 | AMSU-A1-2 |
| 4 | 51760 | 0.67 | 0.075 | 0.5(0.28) | 2.2 |  |
| 5 | 52800 | 0.67 | 0.075 | 0.5(0.26) | 2.2 | AMSU-A1-2 |
| 6 | 53596±115 | 0.67(0.2) | 0.075 | 0.5(0.27) | 2.2 | AMSU-A1-2 |
| 7 | 54400 | 0.67(0.2) | 0.075 | 0.5(0.26) | 2.2 | AMSU-A1-1 |
| 8 | 54940 | 0.67(0.4) | 0.075 | 0.5(0.25) | 2.2 | AMSU-A1-1 |
| 9 | 55500 | 0.67(0.5) | 0.075 | 0.5(0.28) | 2.2 | AMSU-A1-2 |
| 10 | fo=57290.344 | 0.67(0.3) | 0.075 | 0.75(0.40) | 2.2 | AMSU-A1-1 |
| 11 | fo ± 217 | 0.67(0.3) | 0.075 | 1.0(0.52) | 2.2 | AMSU-A1-1 |
| 12 | fo ±322.2±48 | 0.67(0.3) | 0.075 | 1.0(0.55) | 2.2 | AMSU-A1-1 |
| 13 | fo ±322.2±22 | 0.67(0.1) | 0.075. | 1.5(0.80) | 2.2 | AMSU-A1-1 |
| 14 | fo ±322.2±10 | 0.67 | 0.075 | 2.2(1.13) | 2.2 | AMSU-A1-1 |
| 15 | fo ±322.2±4.5 | 0.67 | 0.075 | 3.6(1.82) | 2.2 | AMSU-A1-1 |
| 16 | 88200 | 0.95 | 0.1 | 0.3(0.27) | 2.2 | 89000 |
| 17 | 165500 | 0.95 | 0.1 | 0.6(0.40) | 1.1 | 157000 |
| 18 | 183310± 7000 | 0.95 | 0.1 | 0.8(0.36) | 1.1 | AMSU-B |
| 19 | 183310± 4500 | 0.95 | 0.1 | 0.8(0.43) | 1.1 |  |
| 20 | 183310± 3000 | 0.95 | 0.1 | 0.8(0.51) | 1.1 | AMSU-B |
| 21 | 183310± 1800 | 0.95 | 0.1 | 0.8(0.55) | 1.1 |  |
| 22 | 183310± 1000 | 0.95 | 0.1 | 0.9(0.70) | 1.1 | AMSU-B |

The remaining issues are not critical to the provisional product

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

1. Beam efficiency and scan angle dependent bias correction

The ATMS SDR team is reaching a consensus on the coefficients that convert antenna temperatures to brightness temperatures (TDR to SDR). The team noticed an unexpected scan bias during the NPP pitchover maneuver, which lead NGES to theorize that the rotating flat reflector was more emissive than expected. This hypothesis is still under investigation and the correction is being formulated. The team is also working on a correction factor based on the antenna pattern measurements and possibly the NPP maneuvers.

1. TDR/SDR stripping problem

The NWP community noticed a striping artifact in their comparison of ATMS observations minus NWP background, which is not found in the heritage data. The team presently believes the striping is due to higher 1/f or flicker noise. While ATMS is still within specifications, the team is investigating techniques to mitigate the striping artifacts.

1. Calibration coefficients not optimal

The team will continue to evaluate fine-tuning of the calibration parameters. For example, the emissivity correction could impact the non-linearity correction factors and internal and space view correction factors.

IDPS ATMS TDR/SDR processing is stable since February

Since MX6.2 became operational, no critical issues and problems have been observed in ATMS SDR processing.

There are still many DRs, none of them is critical for the provisional status. The following is a list of the most significant DRs.

|  |  |
| --- | --- |
| DR# | Description |
| 4813 | TB striping |
| 4687 | New DQN for Time sequence error |
| 4593 | DQM turn on with updated DQTT |
| 4811 | PRT Consistency check turn on |
| 4521 | Maneuver flag |
| 4752 | Update NPP MDFCB |
| 4806 | Scan bias correction |

1. **ATMS Provisional SDR Product Caveats**

The followings will be written into the Readme file for the Provisional users:

1. TDR data present noticeable stripping in terms of NWP O-B field (DR 4813) but the stripping magnitude is still within the requirement of ATMS calibration accuracy.
2. SDR brightness temperature data is the same as TDR brightness temperature. Currently, the slope and intercept coefficients for TDR to SDR conversion are set to one and zero. It is found that the current SDR products are still within the ATMS accuracy specification [14]. At the ATMS provisional product review, it is also shown by user community that NWP O-B for most of upper air sounding channels are generally less than 1.0K. There were some discrepancies in computing ATMS antenna gain efficiency from different groups. However, ATMS SDR team is still investigating the resulting difference in the slope and intercept.
3. Quality flags should be stable now. Please report any false alarms.
4. It is also proposed by NGES that the ATMS reflector may have some emission. The emissivity has scan-angle dependence and may also produce the scan-angle dependent bias. But, the antenna side lobe can also produce a similar effect. The scan-angle dependent bias resulting from the antenna emission and side-lobe is manifested in the current TDR data [15].
5. **Path forward toward Validated maturity level**

The team will move forward to perform the following work:

1. Continuation of Cal/Val as planned in the OPSCON for the remaining ICV and LTM
2. Update ATMS beam efficiency and scan angle dependent bias correction coefficients for TDR to SDR conversion using ATMS antenna pattern measurements and NPP maneuver data
3. Work with NGES to better characterize ATMS antenna patterns, including side-lobe, cross-polarization spill-over, polarization twist angle, for J1/J2 mission
4. Algorithm improvements, including revision of ATMS radiometric calibration in full radiance instead of approximation, and possibly a TDR correction to the flat plate emissivity.
5. Develop channel dependent stripping reduction algorithm
6. Close off all remaining and new DRs
7. Implement Data Quality Threshold Table (DQTT) for Data Quality Notification (DQN)
8. Documentation, including ATMS SDR product user guide
9. Continue to monitor ATMS instrument stability and performance.
10. **Reference**

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[13] Weng, F., H. Yang, X. Zou, 2012: On Convertibility from Antenna to Sensor Brightness Temperature for Advanced Technology Microwave Sounder (ATMS*), IEEE Geosci. Remote. Sens. Letter,* 10.1109/LGRS.2012.2223193

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