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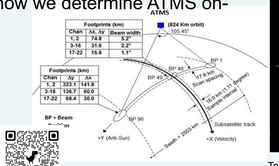
Contact: cheng-hsuan.lyu-1@nasa.gov

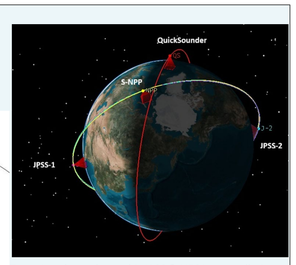
INTRODUCTION TO THE JPSS-2 ADVANCED TECHNOLOGY MICROWAVE SOUNDER (ATMS) GOVERNMENT CALIBRATION DATA BOOK (GCDB)

Cheng-Hsuan Lyu[1,7], Edward Kim[1], Hu Yang[1,9], Saji Abraham[1,2], Matthew Sammons[1,8], Quanhua Liu[9], James Fuentes[3], James Kam[3], Siena Iacovazzi[5,6], Flavio Iturbide-Sanchez[5], R. Vincent Leslie[4], Cooper Loughlin[4], Ninghai Sun[5,6]
[1]NASA Goddard Space Flight Center, [2]KBR Wyle, [3]Northrop Grumman, [4]MIT Lincoln Laboratory, [5]NOAA, [6]Entarian, [7]Morgan State University, [8]Fibertek Inc., [9]Science Systems and Applications Inc.

1. SCOPE

This poster is to help the science user to understand this J2 ATMS GCDB document, which provides information needed to interpret and process NOAA-21 ATMS science data. And we demonstrate how we determine ATMS on-orbit performance.
ATMS is a cross-track scanner, which has an Earth-viewing sector 105.45° wide with 96 beam positions (or 96 FOVs), plus Warm and Cold sectors for two-point calibration.



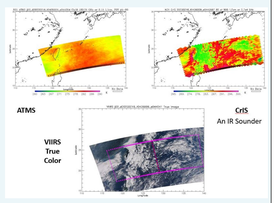


Tentative planned on-orbit JPSS & NEON constellation configuration of JPSS-2, JPSS-1, S-NPP & QuickSounder.

For public released J2 ATMS GCDB, click the link, https://www.star.nesdis.noaa.gov/jpss/ATMS.php

2. INTRODUCTION

With proper brightness temperature corrections, we show different observed physical conditions in one sample comparison of ATMS brightness temperature measurement to that of CrIS and the true color image of VIIRS, which are from 3 key instruments on-board the JPSS-2 mission. Note that the images shown in right figure are the derived brightness temperature (BT) of ATMS channel 18,183.31 GHz (6.11 1/cm) FOV # 4 – 93, the infrared derived brightness temperature of CrIS at 900 1/cm, or 2.7 x 10^4 GHz, and the corresponding true color image of VIIRS. Note also that ATMS channel 18 penetrates through the clouds so that it can detect the BT from the surface of the Earth.



On-orbit footprint projection map of J2 ATMS, CrIS Brightness Temperature images & the VIIRS true color image on the corresponding Earth surface

3. PRT SENSOR AND OTHER ENGINEER DATA

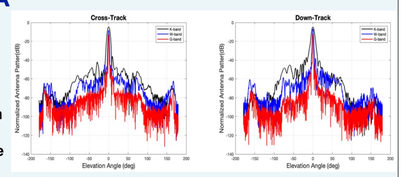
We have provided all the engineering and housekeeping data information –
Table 3.1: PRT Counts Conversion Parameters; Table 3.2: Coefficients for KAV Warm Target 4-Wire PRTs
Table 3.3: Coefficients for WG Warm Target 4-Wire PRTs; Table 3.4: Conversion of Calibration Parameters;
Table 3.5: Coefficients for Receiver Shelf 2-Wire PRT's; Table 3.6: Coefficients for Other 2-Wire PRTs;
Table 3.7: Voltage Scale and Offset Parameters; Table 3.8: Data Conversions for Scan Drive Engineering Telemetry;
Table 3.9: Passive Analog Temperature Telemetry Operational Warning Limits in Celsius;
Table 3.10: Housekeeping Telemetry Advanced Warning Operational Limits in Celsius;
Table 3.11: Flight Software Limits for Motor Currents

4. REFLECTOR POSITION DATA

Introducing the reflector position data --
Table 4.1: SPA EEPROM Scan Position MSW Definition;
Table 4.2: JPSS-2 ATMS Space View and Warm Load Reading Resolver Counts for Scan Profile 1

5. ANTENNA PATTERN DATA

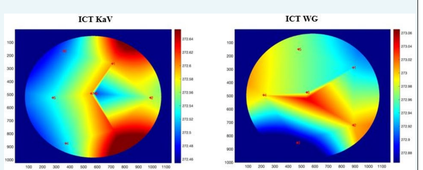
We have provided the users with the antenna pattern data information
Table 5.1: The calculated antenna parameters for the nadir scan position of FOV 1, 48, 96;
Table 5.2: The Euler angles for JPSS-2 ATMS antenna beam pointing offset in Satellite Coordinates;
Table 5.3: JPSS-2 ATMS Reflector Emissivity.



Antenna pattern measurements at the nadir scan position for K-, W- and G- band.
Left is for cross-track (0-degree azimuth angle) and right is for down-track (90 degree azimuth angle)

6. IN-FLIGHT HOT CALIBRATION

We demonstrated how to perform hot target BT corrections data
6.1 Warm Target Correction: Radiance Calibration;
6.2 Warm Target Correction: Brightness Temperature Calibration;
6.3 Warm load Emissivity Correction;
6.4 Warm load temperature error correction;
6.5 Coupling Error Correction
6.6 Reflector Thermal Emission Correction



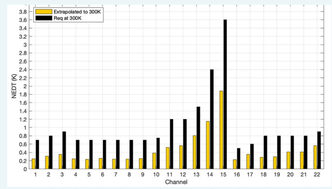
On-orbit temperature gradient in JPSS-2 ATMS KaV and WG internal calibration targets (ICT).

7. IN-FLIGHT COLD CALIBRATION

In this chapter, we demonstrated how to perform cold target BT corrections information
7.1 Earth and Spacecraft Contamination Correction;
7.2 Lunar Intrusion Correction; 7.3 Reflector Thermal Emission Correction.

8. RADIOMETRIC PERFORMANCE AND CALIBRATION

Here we provided J2 ATMS on-orbit performance data
Table 8.1: JPSS-2 ATMS On-Orbit NEdT;
Table 8.2: Instrument Redundancy Configurations (RCs);
Table 8.3: Worst-Case Non-Linearity and Residual Uncertainties;
Table 8.4: JPSS-2 ATMS Nonlinearity μ Parameters for DB User;
Table 8.5: Worst-case calibration accuracies and non-linearity uncertainty errors (K);
Table 8.6: Worst-case calibration accuracies for cold, mid, and hot scene temperatures..



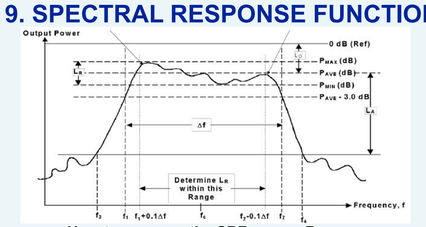
JPSS-2 ATMS Maximum On-Orbit NEDT

Radiometric performance of the JPSS-2 ATMS SN 304 instrument can be assessed through on-orbit measurements, thermal vacuum (TVAC) testing, and mathematical modeling. In this chapter, the instrument's radiometric performance is characterized by temperature sensitivity, non-linearity, and radiometric accuracy. Temperature sensitivity, reported as noise equivalent delta temperature (NEDT), is obtained via on-orbit measurements of the warm internal calibration target (ICT) and cold space views. Non-linearity is measured during TVAC. Radiometric accuracy is determined by measurements taken during TVAC and a mathematical model of the sensor performance which accounts for multiple sources of error.

JPSS-2/NOAA-21 ATMS Gov Cal Data Book Content

CHAPTER	Content
1	SCOPE
2	INTRODUCTION
3	PRT SENSOR AND OTHER ENGINEERING
4	REFLECTOR POSITION DATA
5	ANTENNA PATTERN DATA
6	IN-FLIGHT HOT CALIBRATION
7	IN-FLIGHT COLD CALIBRATION
8	RADIOMETRIC PERFORMANCE AND CALIBRATION
9	SPECTRAL RESPONSE FUNCTIONS
10	RADIOMETRIC COUNTS DYNAMIC RANGE
11	RADIOMETRIC SHORT-TERM GAIN STABILITY
12	STRIPING INDEX
13	ON-ORBIT PROCESSING PCT TABLES
14	INTRODUCING NOAA ICVS WEBSITE AND SERVICES
15	REFERENCE, NOTES, APPENDIX

9. SPECTRAL RESPONSE FUNCTIONS



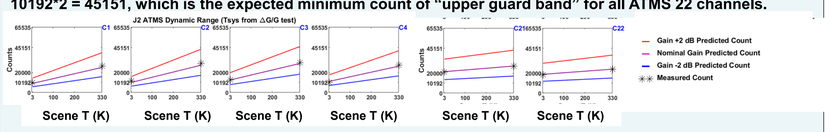
How to measure the SRF versus Frequency

P_{MAX} : max power ($f_{roll\ off\ low}$ to $f_{roll\ off\ high}$)
P_{MIN} : min power ($f_{roll\ off\ low}$ to $f_{roll\ off\ high}$)
P_{AVE} : $(P_{MAX} + P_{MIN})/2$
L_0 : passband insertion loss (dB)
L_A : out-of-band rejection (dB)
Passband : f_1 to f_2
Stopband : $f < f_3$ and $f > f_4$
f_{CENTER} : $(f_1 + f_2)/2$
Bandwidth : $\Delta f = f_2 - f_1$
L_R : passband ripple

The JPSS-2 ATMS SRF data can be found in Appendix F.

10. RADIOMETRIC COUNTS DYNAMIC RANGE

The ATMS end-to-end system gain is expected to vary by no more than ± 2 dB over the life of the instrument. Thus, for a 16-bit A-to-D conversion, the radiometric count maximum, Cmax = 65535 – 2 dB = 65535 – 10192*2 = 45151, which is the expected minimum count of "upper guard band" for all ATMS 22 channels.



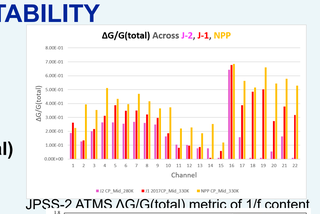
JPSS-2 ATMS Channels 1, 2, 3, 4, 21, & 22 dynamic range, model prediction versus measured counts.

11. RADIOMETRIC SHORT-TERM GAIN STABILITY

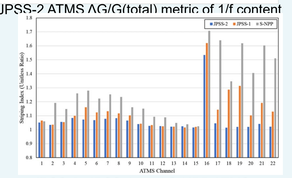
From the ATMS short term gain stability ΔG/G tests, one can use ΔG/G(total) as another gauge of ATMS striping issues. Comparing JPSS-2 to previous JPSS ATMS builds JPSS-1 and SNPP, one can find significantly reduced striping noise in the ATMS data, see right figure. This is because the smaller ΔG/G(total) is, the less striping will be found in the ATMS data.

12. STRIPING INDEX

To evaluate the striping effect, JPSS ATMS Cal/Val team proposed a new Striping Index (SI) to indicate the scale of striping effect. SI is defined as the ratio of down-track variance to cross-track variance of the observed brightness temperatures. See right figure.



JPSS-2 ATMS ΔG/G(total) metric of 1/f content



JPSS-2, JPSS-1, and S-NPP ATMS instrument TVAC CP-Mid SI comparison

13. ON-ORBIT PROCESSING PCT TABLES

The implementation and improvement of calibration results are applied to raw observations through Processing Coefficients Table (PCT) in the operational Interface Data Processing Segment (IDPS) in order to generate user friendly brightness temperature. The PCT is binary data including both satellite dependent and independent coefficients derived from both pre-launch TVAC and Post-Launch Test (PLT) on-orbit data analysis results. We have provided this PCT sample table contents in this JPSS-2 ATMS GCDB.

14. INTRODUCING NOAA ICVS WEBSITE AND SERVICES

NOAA has developed a website https://www.star.nesdis.noaa.gov/icvs/ dedicated to providing near real time environmental satellite performance and scientific data quality monitoring. This website hosts an operational Integrated Calibration and Validation system (ICVS) Long-Term Monitoring (LTM) (ICVS-LTM) System which allows to visualization and comparison of data related to all operational satellite instruments from Suomi National Polar Orbiting Partnership (SNPP), the JPSS missions, NOAA legacy Polar Operational Environmental Satellites (POES), and Geostationary Operational Environmental Satellites (GOES). ATMS operational data products are also made available on the STAR JPSS website.
The NOAA-21 ATMS user guide (user guide) is hosted on the NOAA Institutional Repository. This document describes the operational ATMS science data products such as the antenna temperature data record (TDR), the sensor data record (SDR) and the geolocation. Information about the processing of the data and the generation of these products is also detailed in the user guide.

15. REFERENCE, NOTES, APPENDIX

Besides all the important quoted references and notes, we include also the following Appendixes.
Appendix A – Contains 'ADDITIONAL INTRODUCTION' document;
Appendix B – Contains 'THE JPSS-2 ATMS ANTENNA PATTERN COEFFICIENTS CORRECTION DATA' ;
Appendix C – Contains 'CALIBRATION ACCURACY DATA';
Appendix D – Contains 'NON-LINEARITY DATA IN BRIGHTNESS TEMPERATURE';
Appendix E – Contains 'NON-LINEARITY DATA IN RADIANCE';
Appendix F – Contains' THE JPSS-2 ATMS SPECTRAL RESPONSE FUNCTIONS DATA' with additional notes;

JPSS-2 ATMS Instrument (Photo courtesy of Northrop Grumman in Azusa, CA)

Concluding Remarks

The contents of the JPSS-2 ATMS GCDB data book incorporate results from pre-launch subsystem-level and instrument-level testing as well as post-launch testing performed during instrument commissioning. Major milestones include instrument thermal vacuum (TVAC) testing in 2019 and observatory TVAC testing in 2022. JPSS-2 was launched on November 10, 2022. To learn more about when JPSS-2 was declared operational, please go to https://www.noaa.gov/news-release/noaa-21-satellite-is-now-operational

To help the general users to understand how JPSS-2 ATMS collects the science data, we have presented the following aspects about ATMS –
ATMS Design; Radiance Calibration based on Planck Function; Temperature Calibration based on Modified Rayleigh-Jeans Approximation; and Additional ATMS Information compared to other key instruments on-board JPSS-2 mission. Please note that similar documentation planned for future ATMS builds, J3, J4 & QS. Since there is publicly available CDB for J1, we may skip creating a GCDB for J1.
If users have any questions about this JPSS-2 ATMS GCDB, please contact us via Ed.kim@nasa.gov