ON-ORBIT SPECIAL TESTING OF NOAA-20/JPSS-1 ATMS

Edward Kim (1), Vince Leslie (2), Joseph Lyu(1,3), Lisa McCormick(1,4), Craig Smith(1,5), Idahosa Osaretin(2), Quanhua (Mark) Liu(6), Ninghai Sun(6), Hu Yang(6), Lin Lin(6), Kent Anderson(7), Mark Hernquist(7), James Fuentes(7), Elliot Stiglic(7), and Michael Replan(7)*

(1) NASA Goddard Space Flight Center; (2) MIT Lincoln Laboratory; (3) IMSG at NASA/GESTAR; (4) Fibertek, (5) SGT; (6) NOAA/STAR (7) Northrup Grumman

ABSTRACT

The second Advanced Technology Microwave Sounder (ATMS) recently launched November 2017 on the Joint Polar Satellite System-1 satellite (JPSS-1), now re-named NOAA-20. It joins the first ATMS flight unit aboard the Suomi NPP (S-NPP) satellite, as well as older sounders—the Advanced Microwave Sounding Units A & B (AMSU-A/B) and Microwave Humidity Sounder (MHS)--on polar-orbiting operational weather satellites. Together, these sounders provide critical all-weather temperature and humidity profile information for Numerical Weather Prediction (NWP) models.

This paper presents results from a number of special post-launch tests used to characterize the instrument and provide unique calibration information. These special tests—long stares, alternate techniques for lunar intrusion mitigation and geolocation, spacecraft maneuvers, special scan modes, comparisons with NWP models--require non-standard modes of operation or data analysis, and can only be conducted during commissioning, prior to the start of regular forecast observations.

Index Terms— microwave, radiometer, sounder, satellite, weather

1. INTRODUCTION

The Advanced Technology Microwave Sounder (ATMS) is the newest generation of microwave sounder in the international fleet of polar-orbiting operational weather satellites, replacing the Advanced Microwave Sounding Units A & B (AMSU-A/B), which first entered service in 1998, and the Microwave Humidity Sounder (MHS), which succeeded the AMSU-B in 2005 [1].

ATMS provides 22 channels of temperature and humidity as well as cloud sounding observations over a frequency range from 23 to 183 GHz [2]. These microwave soundings provide the highest impact data ingested by operational Numerical Weather Prediction (NWP) models, and are the most critical of the polar-orbiting satellite observations, particularly because microwave sensing can penetrate clouds [3] and due to the frequent global coverage and consistent calibration.

The first ATMS launched aboard the Suomi NPP (S-NPP) satellite in October 2011 and is still in operation. The second ATMS launched November 2017 on the Joint Polar Satellite System-1 satellite (JPSS-1), now re-named NOAA-20. N-20 will eventually replace S-NPP.

2. SPECIAL VS. ROUTINE TESTS

During the first 90 days following launch, a number of routine and special tests are conducted as part of the extensive on-orbit commissioning schedule. The routine tests are ones in which ATMS operates essentially in normal operational mode, and the data are analyzed. These tests are able to characterize parameters such as housekeeping variables (temperatures, voltages), scan drive performance, radiometric sensitivity and accuracy, certain noise characteristics, and geolocation [4].

The special tests are those which involve modes of operation or data analysis not used for regular observing. These include long stares, changes of scan profiles, mitigation of lunar intrusion, active geolocation, environmental characterization, spacecraft maneuvers in roll and pitch as well as yaw, and comparisons of observations vs. NWP model predictions. These special tests are the focus of this paper.

Comparisons of on-orbit performance vs. pre-launch performance are very valuable for both the routine tests as well as for the special tests. Ideally, they should be nearly identical. When differences exist, corrections may be necessary to the Temperature Data Record (TDR) or Sensor Data Record (SDR) data products, or both. These comparisons will also be discussed where applicable.

3. LONG STARES

Long stares are used to gather data for characterization of the noise power spectrum of each channel as well as inter-channel correlation. This is a special test since it involves halting the normal scan rotation and staring at a target of known brightness temperature—cold space or the internal hot load.

The noise power spectrum includes both white and pink noise components, corresponding to the NEDT and 1/f characteristics of each channel. The latter is a key factor driving the amount of "striping" seen in the brightness temperature data—a concern for NWP users. Correlations between channels is another key concern for NWP users.

4. LUNAR INTRUSION MITIGATION

Approximately, half a dozen times per year, the moon intrudes into the cold space view sector used for the scan-by-scan cold calibration. This lunar intrusion is flagged and the current operational algorithm replaces contaminated observations with data from a lunar intrusion model. This approach is passive; it does not require changing from normal operational mode. Like all techniques, this has certain limitations.

One of the special tests for N-20 ATMS involves testing an active mitigation technique that changes the scan profile to avoid lunar intrusion. One potential benefit is obtaining real (uncontaminated) observations vs. using model fill values. This technique also has limitations. Results from this first-time on-orbit testing of this alternative mitigation technique will be presented, along with a discussion of the pros and cons of the two mitigation techniques.

5. ACTIVE GEOLOCATION

Similar to the lunar intrusion case, there are two techniques for ascertaining ATMS geolocation. Both involve analyzing data from coastline crossings. The current operational technique is passive; no special modes are required. However, some time is required to accumulate sufficient data for an accurate geolocation determination.

An alternative, faster, technique requires halting the scan and staring during a selected set of coastline crossings. One of the special tests for N-20 ATMS will test this technique. Results from this first-time on-orbit testing of this alternative geolocation technique will be presented, along with a discussion of the pros and cons of the two techniques.

6. SPACECRAFT MANEUVERS

A major commissioning activity for all spaceborne microwave radiometers is characterizing antenna sidelobe contributions and scan angle-dependent biases. ATMS is no exception, and two types of spacecraft maneuvers—rolls and a complete "backflip" in pitch—are used to provide essential data for these.

The clear view of cold space across the entire Earth view sector provided by the backflip is essential for quantifying the scan bias, whether due to reflections from other components on the spacecraft, or due to polarized reflector emissivity that varies with scan angle.

The Earth limb as seen during both roll and pitch maneuvers is also useful to perform on-orbit verification of the antenna patterns.

Results from the two maneuvers used to assess scan bias and antenna patterns will be shown and discussed.

7. OTHER SPECIAL SCAN PROFILES

In addition to reflections from other components on the spacecraft, reflections from parts of ATMS itself can potentially create unwanted "stray light" leading to scan angle dependent biases. One way to check for this is to use a special scan profile that takes observations beyond the normal Earth view and space view sectors.

This also has implications for the choice of the exact pointing used for cold space calibration. Again, special scan profile tests are the answer.

Results from these special scan profile tests will be presented and discussed.

8. COMPARISONS VS. NWP MODELS

As a source of critical NWP input data, imperfections in ATMS observations impact forecasts. One important diagnostic for detecting and quantifying any such imperfections are comparisons between ATMS observations and NWP forward radiance model predicted signatures. Results from these so-called "O minus B" analyses will be shown and the implications on ATMS will be discussed.

9. CONCLUSIONS

Both routine and special tests are part of the toolkit used to characterize ATMS flight units post-launch. As the special tests involve non-standard operating modes or data analysis, they are conducted during the 90-day commissioning period after launch, prior to the start of regular NWP operations.

Results from recently-completed special tests on the newest ATMS flight unit—the one on NOAA N-20—will be presented and discussed. These include long stares for noise spectrum and channel correlation determination; tests of alternative lunar intrusion and geolocation techniques; spacecraft maneuvers to characterize scan bias, reflector emissivity, and to verify antenna patterns; alternate scan profiles to characterize the local environment; and comparisons of observations with NWP model predictions.

10. REFERENCES

[1] H. Aumann, et al, AIRS/AMSU/HSB on the AQUA Mission: Design, Science Objectives, Data Products, and Processing Systems, *IEEE Trans. Geosci. Remote sens.*, *41*(2), pp. 253–264, 2003.

[2] C., W. Muth, A. Webb, W. Atwood, and P. Lee, “Advanced Technology Microwave Sounder on the National Polar-Orbiting Operational Environmental Satellite System,” Int’l Geoscience and Remote Sensing Symposium, *2005 IGARSS Proceedings*, 2005.

[3] C. Cardinali, “Monitoring observation impact on short-range forecast,” *Q. J. R. Meteorol. Soc*., pp. 135, 239–250, 2009.

[4] E. Kim, , C.-H. J. Lyu, K. Anderson, R. V. Leslie, and W. J. Blackwell, “S-NPP ATMS instrument prelaunch and on-orbit performance evaluation,” *J. Geophys. Res. Atmos*., 119, pp. 5653–5670, 2014.