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NPP ATMS Prelaunch Performance Assessment and Sensor Data Record Validation*

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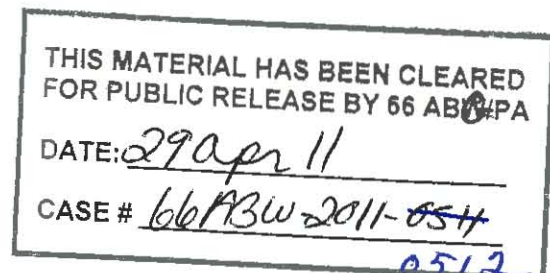
Abstract

A suite of sensors scheduled to fly onboard the NPOESS Preparatory Project (NPP) satellite in 2011 will continue the Sensor Data Records (SDRs) provided by operational and research missions over the last 40 years. The Cross-track Infrared and Microwave Sounding Suite (CrIMSS), consisting of the Cross-track Infrared Sounder (CrIS) and the first space-based, Nyquist-sampled cross-track microwave sounder, the Advanced Technology Microwave Sounder (ATMS), will provide atmospheric vertical profile information to improve numerical weather and climate modeling. The ability of ATMS to sense temperature and moisture profile information in the presence of non-precipitating clouds complements the high vertical resolution of CrIS. Furthermore, the ability of ATMS to sense scattering of cold cosmic background radiance from the tops of precipitating clouds allows the retrieval of precipitation intensities with useful accuracies over most surface conditions. This paper presents several assessments of the performance of ATMS and the geophysical quantities that are to be derived using ATMS measurements. Pre-launch testing of ATMS has characterized the principal calibration parameters and has enabled predictions of on-orbit performance with high levels of confidence. Also discussed is the planned on-orbit characterization of ATMS, which will further improve both the measurement quality and the understanding of various error contributions. This paper is organized as follows. An overview is given of the prelaunch radiometric calibration of ATMS. Key calibration parameters are discussed and plans for on-orbit characterization of ATMS to further improve SDR performance are presented.

Prelaunch Testing

An integral part of the CrIMSS (CrIS + ATMS) pre-launch cal/val activities is the testing of operational software that will be used to process raw data counts into scientific data products. To ensure a smooth transition after launch to the operational production of temperature, sensor, and environmental data records, pre-launch test data are passed through the software processing system to identify bugs and any unforeseen issues in the processing flow. It is important for the test data to be as authentic as possible; therefore, "proxy" data are used. The term "proxy" refers to observed data from an on-orbit sensor that are transformed spatially and spectrally to resemble, with some error, a future sensor. Atmospheric models may be inaccurate and incomplete, and therefore data simulated using only these models will be flawed. Alternatively, proxy data derived from actual radiometric observations of the atmosphere should preserve all of the meaningful meteorological features. The prelaunch radiometric calibration of ATMS consists of Compact Antenna Test Range (CATR); thermal vacuum chamber (TVac); vibration testing; and electromagnetic and radio frequency interference testing.

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Postlaunch Testing

Postlaunch calibration and validation consists of four phases: activation, functional evaluation and optimization, Intensive Cal/Val (ICV), and long-term monitoring. The ICV will end approximately 180 days after launch. This paper will describe the various calibration and validation tasks in the four phases and the team responsible. Some of the tasks include calibration target stare data collection to calculate each channel's power spectral density; optimal space view selection; geolocation accuracy evaluation; RFI evaluation and mitigation; simultaneous nadir overpasses of other microwave sensors; on-orbit spacecraft maneuvers; simulation comparisons with radiosondes and numerical weather prediction models; and aircraft underflights.

Aircraft Comparisons

Radiance observations from the NAST-M airborne sensor can be used to directly validate the radiometric performance of spaceborne sensors. NAST-M includes a total of four spectrometers, with three operating near the oxygen lines at 50-57, 118.75, and 424.76 GHz, and a fourth spectrometer centered on the water vapor absorption line at 183.31 GHz. All four feedhorns are co-located, have 3-dB (full-width at half-maximum) beamwidths of 7.5° (translating to 2.5-km nominal pixel diameter at nadir incidence), and are directed at a single mirror that scans cross-track beneath the aircraft with a nominal swath width of 100 km. We present results for two recent validation efforts: 1) the Pacific THORpex (THE Observing-system Research and predictability experiment) Observing System Test (PTOST 2003, Honolulu, HI) and 2) the Joint Airborne IASI Validation Experiment (JAIVEx 2007, Houston, TX). Radiance differences between the NAST-M sensor and the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sensor (MHS) were found to be less than 1K for most channels. Comparison results for ocean underflights of the Aqua, NOAA, and MetOp-A satellites are shown in Tables 1-3.

Table 1
AMSU-A PTOST Bias Estimates

Satellite Date GHz	NOAA-16 3/11/03		NOAA-17 3/12/03		Aqua 3/1/03		Aqua 3/3/03	
	μ	σ	μ	σ	μ	σ	μ	σ
50.3	4K*	±7K	-1.7K	±1.1K	-0.38K	±0.9K	-0.45K	±1.3K
52.8	2.2K*	±1.3K	1.1K	±0.2K	1.86K	±0.1K	2K	±0.3K
53.75	-0.6K	±0.3K	-0.5K	±0.1K	0.06K	±0.4K	0.37K	±0.2K
54.4	0.64K	±0.2K	0.6K	±0.3K	0.65K	±0.3K	0.52K	±0.3K
54.94	0.4K	±0.2K	0.36K	±0.3K	N/A†		N/A†	
55.5	0.2K	±0.3K	-0.8K	±0.1K	0.17K	±0.2K	0.01K	±0.3K

* This was a very cloudy day, which increases variation in window and humidity channel.

† Aqua channel 54.9GHz was disregarded due to excessive sensor noise

Table 2
AMSU-B PTOST Bias Estimates

Satellite Date GHz	NOAA-16 3/11/03		NOAA-17 3/12/03	
	μ	σ	μ	σ
183.3±1.0	4.2K*	±0.6K	-2.9K	±1.7K
183.3±3.0	1.2K*	±0.7K	-0.2K	±1.4K
183.3±7.0	2K*	±1.0K	-0.9K	±2K

Table 3

AMSU-A JAIVEx Bias Estimates

Satellite Date GHz	METOP-A 4/20/07	
	μ	σ
50.3	-0.8K	±0.4K
52.8	0.9K	±0.3K
53.75	-0.36K	±0.3K
54.4	-0.36K	±0.3K
54.94	-0.15K	±0.6K
55.5	-1.5K	±0.5K

MHS JAIVEx Bias Estimates

Satellite Date GHz	METOP-A 4/20/07	
	μ	σ
183.3±1.0	1K	±0.7K
183.3±3.0	N/A [§]	
183.3±7.0	1.4K	±0.4K

[§]NAST-M channel not operational for this flight

On-orbit Field of View Calibration

We review an approach for on-orbit FOV calibration of the ATMS satellite instrument using vicarious calibration sources with high spatial frequency content (the Earth's limb, for example, see Fig. 1). The antenna beam is slowly swept across the target of interest and a constrained deconvolution approach is used to recover antenna pattern anomalies (Fig. 2). Additionally, we present an overview of FOV calibration exercises being considered for ATMS, which will not only help to characterize the radiometric boresight of each ATMS channel, but could also potentially identify antenna sidelobe problems affecting similar passive microwave sensors that are presently operational.

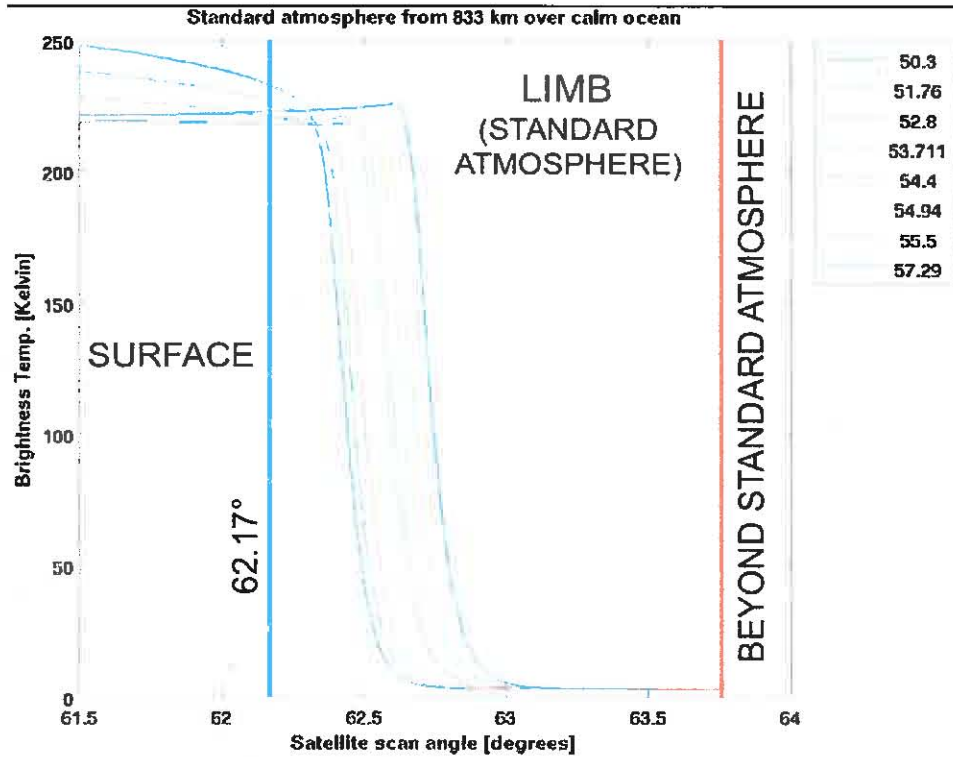


Figure 1. Atmospheric "source functions" are convolved with (unknown) antenna patterns.

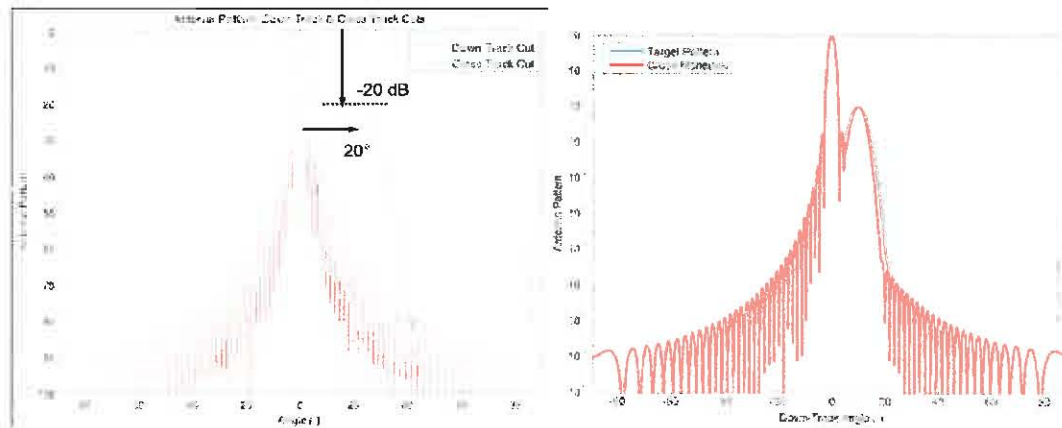


Figure 2. Target and recovered antenna pattern sidelobe using 2-D deconvolution technique.

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