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ON-ORBIT PERFORMANCE OF THE NOAA-21 ADVANCED TECHNOLOGY MICROWAVE SOUNDER (ATMS)

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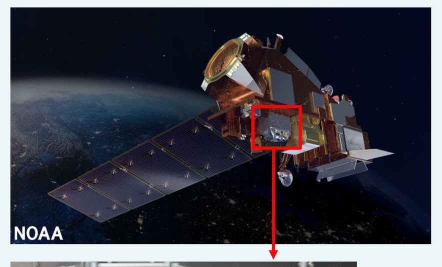
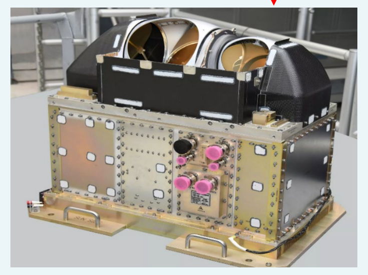
Overview

ATMS provides sounding measurements of Earth's atmosphere to collect temperature and water vapor data for NOAA's Joint Polar Satellite System (JPSS) program. ATMS is a total-power passive microwave radiometer with 22 channels spanning a frequency range from 22 to 183 GHz. This poster focuses on the on-orbit performance of the NOAA-21 (N21) ATMS, including comparisons to the S-NPP and NOAA-20 (N20) ATMS units, for select parameters.





Source (top): https://www.noaa.gov/news-release/noaas-newest-satellite-heads-toward-orbit;
Source (bottom): https://www.nesdis.noaa.gov/current-satellite-missions/currently-flying/joint-polar-satellite-system/advanced-technology

Launch and Commissioning

JPSS NOAA-21 was launched on November 10, 2022, from Vandenburg Space Force Base. NOAA-21 ATMS was activated eleven days after launch and transitioned to operational mode. From launch through handover to NOAA on Mar 30, 2023, ATMS was evaluated and characterized by analyzing data from nominal mission operations and post-launch test (PLT) activities.

Most PLTs required specific commanding for ATMS; PLTs were coordinated with Mission Operations Support Team. There were 13 ATMS-related PLTs performed. An example PLT is the Pitch Offset PLT, a spacecraft pitch maneuver that was used to characterize non-uniformities/biases in the instrument antenna field and evaluate instrument susceptibility to RFI from the Ka transmitter. All PLT data collects were successful.

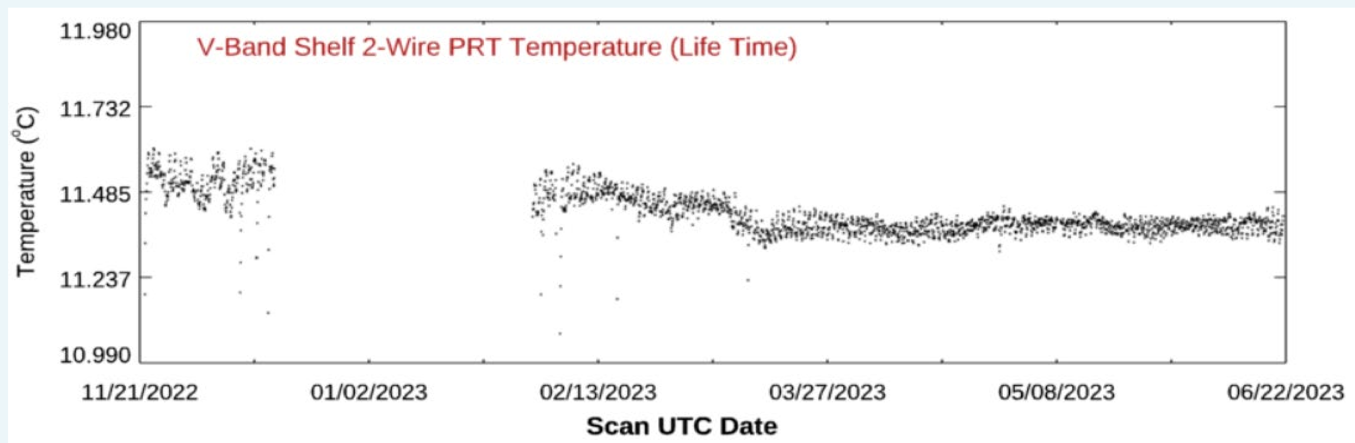
Source: https://www.noaa.gov/news-release/noaas-newest-satellite-heads-toward-orbit

Pre- vs Post-Launch

Post-launch characterization has overlap with pre-launch characterization, but some post-launch characterization activities are unique to the on-orbit evaluation and don't have a pre-launch equivalent. Pre-launch performance characterization is primarily performed at the instrument vendor's facility in Azusa, CA. Certain parameters measured during pre-launch testing were re-evaluated on-orbit in order to compare the pre- and post-launch behavior. The on-orbit data shows good agreement with the pre-launch data.

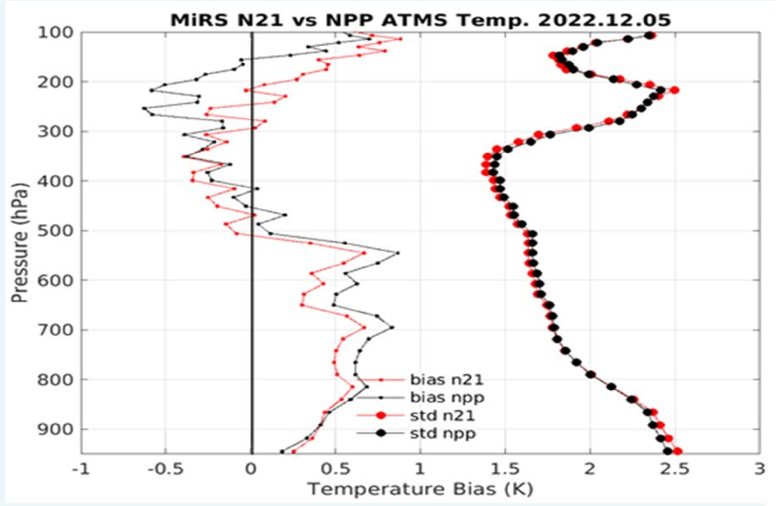
Thermal Stability

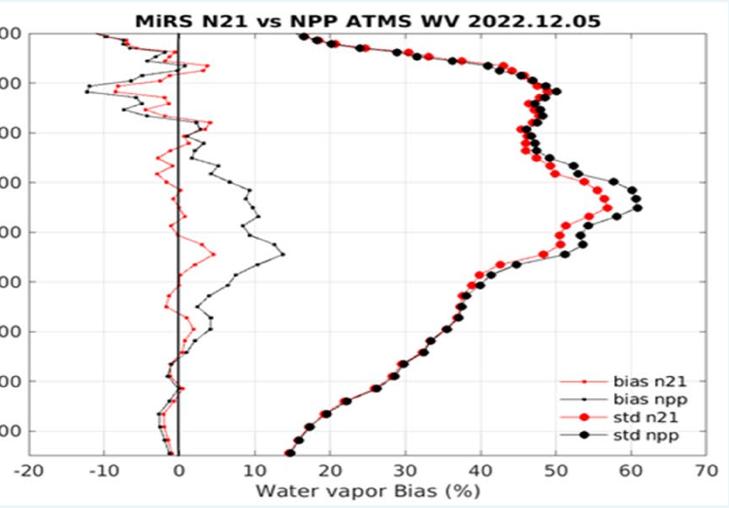
The NOAA-21 ATMS shows satisfactory thermal stability throughout the mission life. Platinum Resistance Thermometer (PRT) temperature sensors on the ATMS receiver shelves, as shown in the figure below, demonstrate that the temperature is stable. Note that data gap is due to NOAA-21 SMD data unavailability.



Radiometric Bias and Stability

Temperature and water vapor bias estimated from NOAA-21 measurements. The relatively lower noise in the G band channels presents improved water vapor retrieval performance compared to SNPP.



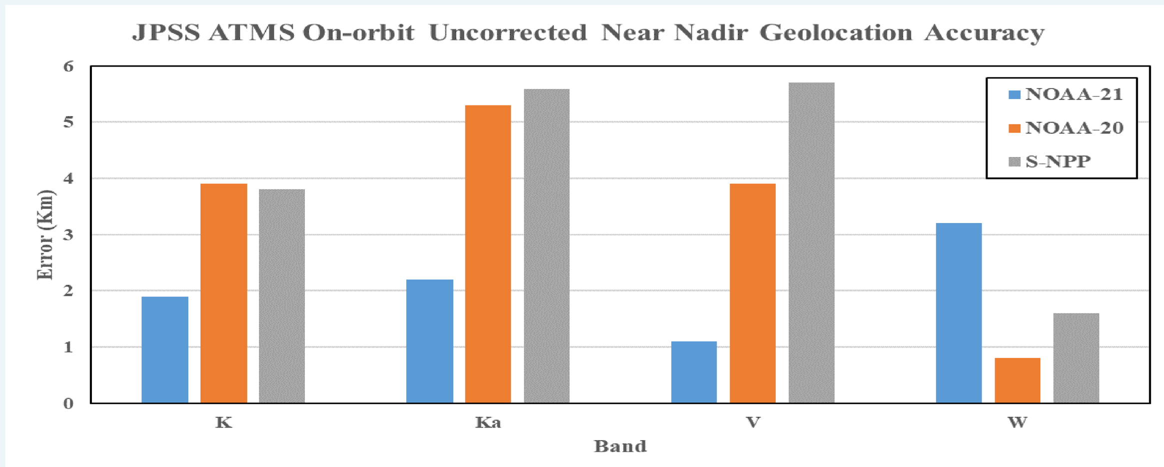


Geolocation Accuracy

Geolocation accuracy is produced using the coastline inflection point (CIP) method, which utilizes data from coastline crossings and compares them to the location of actual coastlines defined in the Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG). Note that this method is only viable for ATMS surface channels that can observe a large Tb difference between land and ocean; as such no G-band geolocation accuracy is presented.

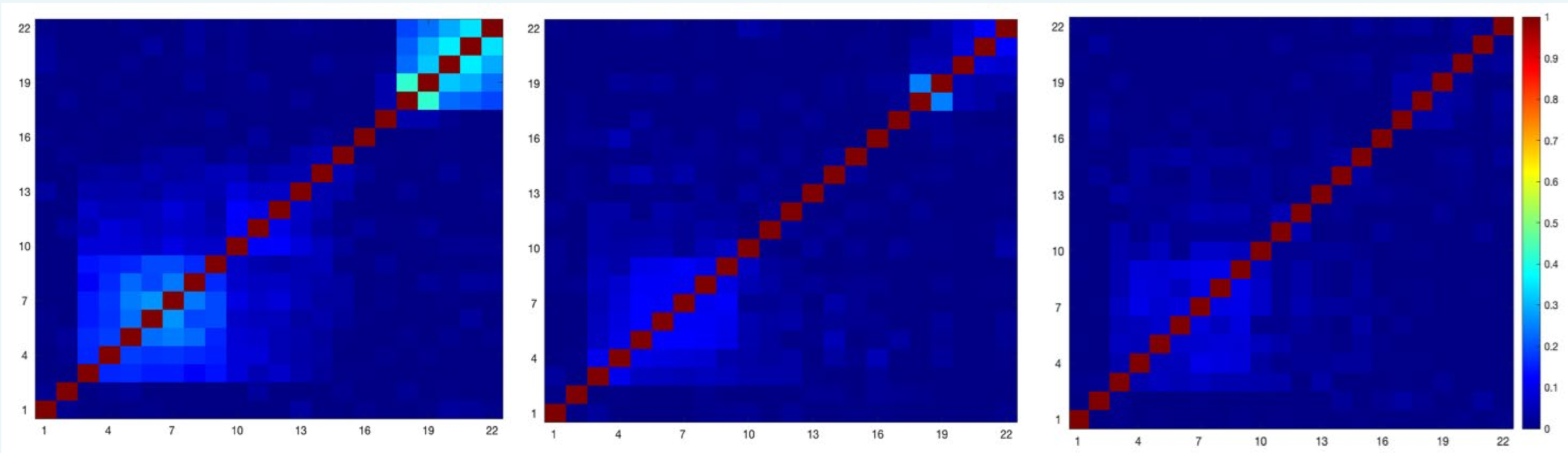
Band	S-NPP Nadir Error (Km)	NOAA-20 Nadir Error (Km)	NOAA-21 Nadir Error (Km)
K	3.8	3.9	1.9
Ka	5.6	5.3	2.2
V	5.7	3.9	1.1
W	1.6	0.8	3.2

NOAA-21 K, Ka, and V bands show smaller error when compared to N20 and SNPP; N21 W band error is larger that N20 and SNPP.



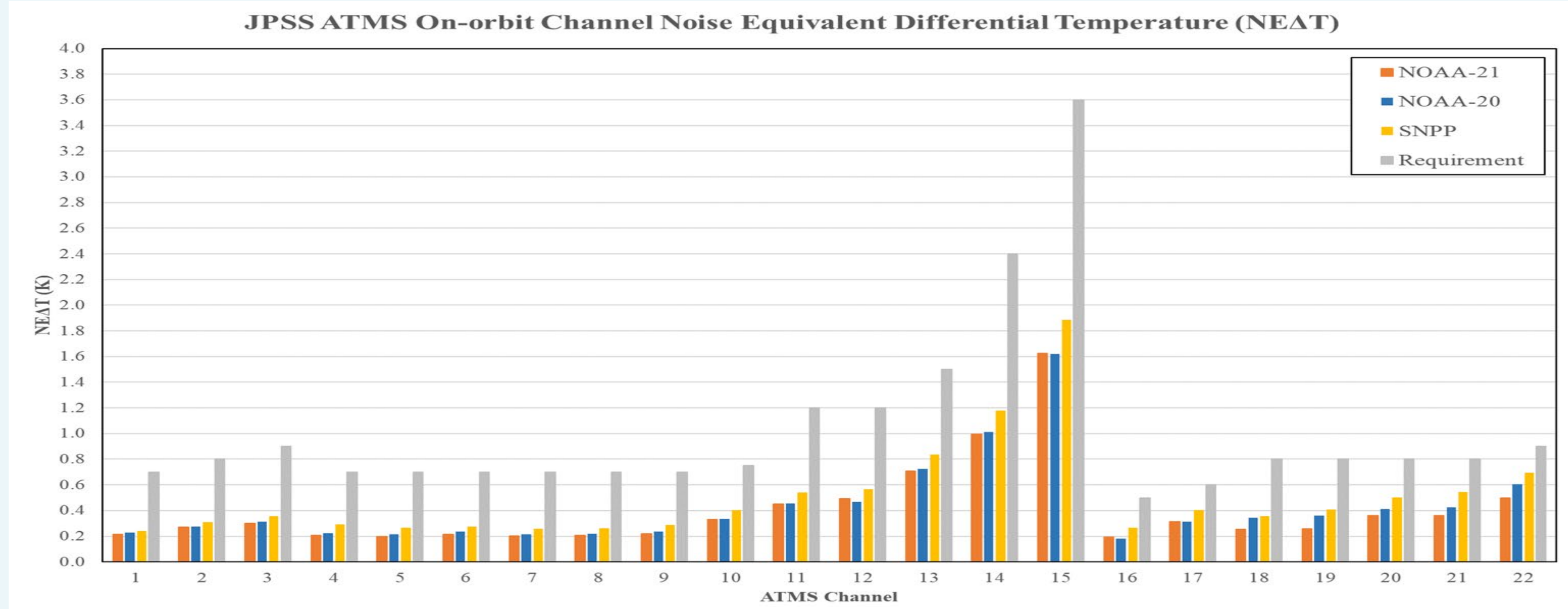
Inter-channel Noise Correlation

Measure of random noise correlation across channel pairs (0 = no correlation, ideal. 1 = perfect correlation). NOAA-21 shows improvement in G-band inter-channel noise correlation compared to NOAA-20, and general improvement compared to SNPP.



NEDT

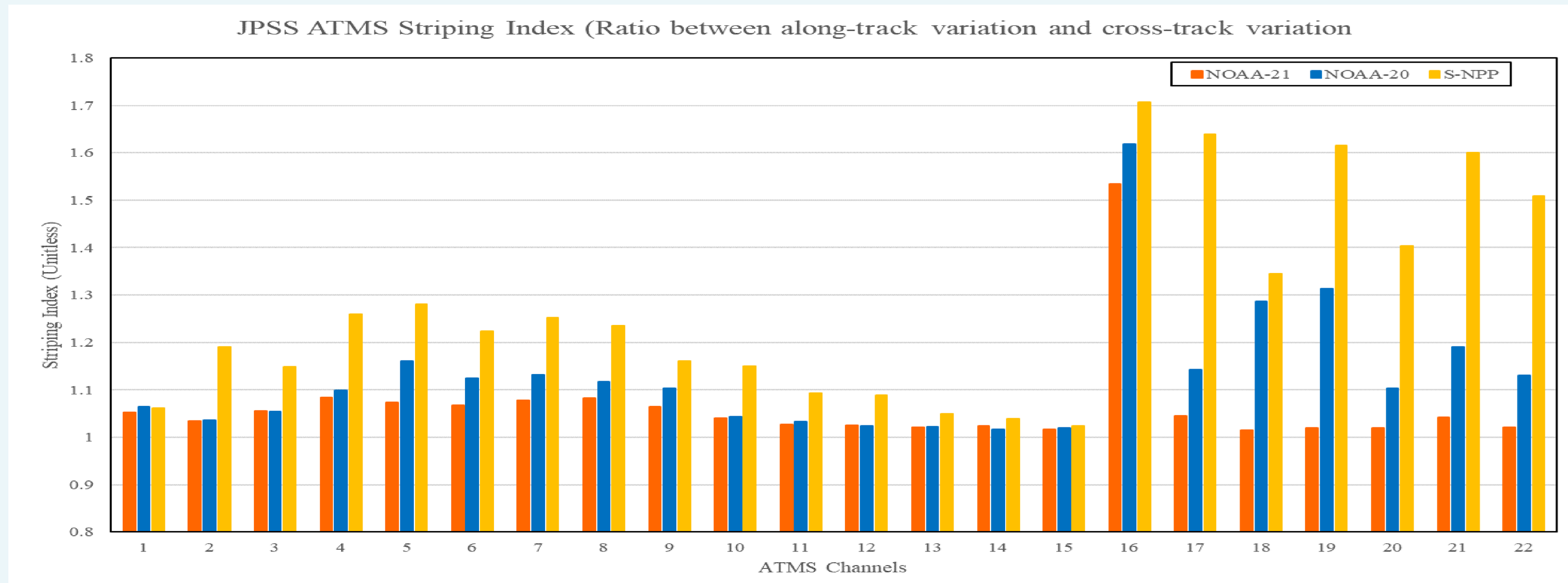
Noise Equivalent Delta Temperature (NEDT) is a way to represent the radiometric sensitivity and noise of the instrument. NOAA-21 on-orbit NEDT met the requirements with margin. NOAA-21 is comparable to NOAA-20 for K, Ka, V, and W bands and shows improved performance for the G-band. Similarly, NOAA-20 and NOAA-21 NEDT are better than SNPP for all channels.



Striping Index

The striping index (SI) is defined as the ratio between the along-track and cross-track variation in observed brightness temperatures. The SI index of 1 indicates no striping.

NOAA-21 ATMS has improved striping over NOAA-20 and SNPP, most prominently in G band.



Conclusion

The NOAA-21 ATMS was successfully launched and commissioned. The on-orbit performance is satisfactory, meeting requirements and specific parameters show improvement over prior builds.

Highlights include:

- Good agreement with pre-launch characterization data
- Stable thermal characteristics
- Reduced geolocation error in K, Ka, and V bands; larger in W bands
- Improved G band NEDT
- Improved V band and G band striping
- Improved G band inter-channel noise correlation
- Improved water vapor retrieval performance

NOAA-21 ATMS Temperature Data Record/Sensor Data Record achieved Algorithm Validated Maturity Status on May 12, 2023 (review passed June 22, 2023).

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The Advanced Technology Microwave Sounder (ATMS) instrument provides sounding measurements of Earth's atmosphere to collect temperature and water vapor data for NOAA's Joint Polar Satellite System (JPSS) program. ATMS is a total-power passive microwave radiometer with 22 channels spanning a frequency range from 22 to 183 GHz. A general description of the ATMS instrument is detailed in [1].

Three ATMS units are currently on-orbit. The Suomi National Polar-orbiting Partnership (SNPP) unit was launched in 2011 and the NOAA-20 (previously JPSS-1) unit was launch in 2017. Both SNPP and NOAA-20 ATMS units are currently operational and the data is used for numerical weather prediction (NWP) models. The NOAA-21 (formerly JPSS-2) ATMS unit was launched on November 10, 2022 from Vandenberg Space Force Base in California [2]. The ATMS instrument began generating radiance data on November 21, 2022. At the time of this abstract NOAA-21 ATMS is currently completing on-orbit commissioning and checkout activities; it is expected that the commissioning activities will be complete by the IGARSS 2023 conference.

This paper will focus on the on-orbit performance of the NOAA-21 ATMS instrument based on measurements and activities from the commissioning period. Comparisons will be made to specifications and to expected performance based on pre-launch test activities. Pre-launch JPSS-2 (NOAA-21) ATMS performance is detailed in [4]. Additionally, the NOAA-21 performance will be compared to the on-orbit performance of the SNPP and NOAA-21 ATMS units. The post-launch performance of SNPP ATMS is detailed in [1][5][6][7]. The post-launch performance of NOAA-20 ATMS is detailed in [5][7][8].

On-orbit performance is evaluated through data collects from nominal mission operations as well as specific post-launch tests and spacecraft maneuvers. Nominal mission operations can be used to evaluate parameters such as instrument thermal stability, Noise Equivalent Delta Temperature (NEDT)/radiometric sensitivity, geolocation, inter-channel noise correlation, striping, and radiometric bias and stability. Shortly after instrument activation, the instrument thermal stability as measured from onboard temperature sensors is evaluated to demonstrate stable and steady-state behavior. Methods for computing NEDT are described in [9][10][11]. Passive geolocation measurements are performed using the coastline inflection point (CIP) method, described in [8][12]. The striping index, used as a metric to quantify striping, is the ratio of along-track variance to cross-track variance of the observed brightness temperature [4][8][14]. Inter-channel noise correlation has been previously reported for SNPP and NOAA-20 [1][8].

Dedicated post-launch tests and spacecraft maneuvers are utilized during the commissioning phase for further evaluation of on-orbit instrument performance. These activities provide information on the optimal space view selection, noise power spectral density (PSD), gain stability, scan bias, interference from onboard transmitters, reflector emissivity, active geolocation, and radiometric bias and stability detection methods. The optimal space view selection is used to determine which of ATMS space view sectors is preferred for minimizing contamination of the space view [1]. Point and stare testing is used to generate noise PSD and gain stability information, as described in [1][8]. Spacecraft roll and pitch maneuvers allow the ATMS to view different zones, including deep space, and the data can be used to provide information on scan biases and antenna sidelobe contamination [1][8]. The pitch maneuver can also be used to assess interference from onboard Ka-band transmitters and reflector emissivity [8]. Active geolocation is evaluated as a method for geolocation, described in [15].

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