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CHARACTERIZATION OF QUICKSOUNDER ATMS AT INSTRUMENT LEVEL TVAC

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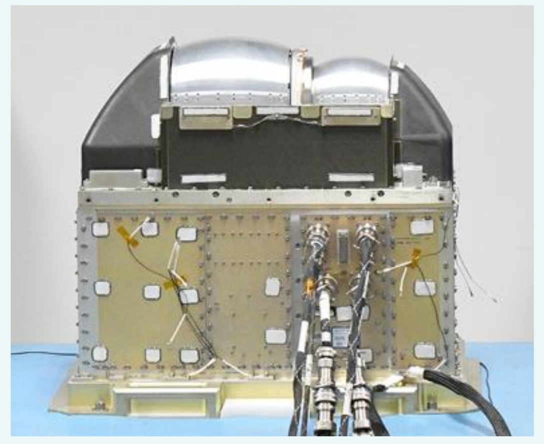
Overview

QuickSounder (QS) is the pathfinder space mission for the next generation of NOAA LEO environmental satellites in the NEON program, follow-on to the JPSS program. It is a collaborative initiative between NASA and NOAA to verify rapid and cost-effective delivery of small Earth observation satellites.

QuickSounder is focusing on mission elements other than science performance. In this context, an existing sensor, the refurbished ATMS EDU (Advanced Technology Microwave Sounder, Engineering Development Unit) was chosen as the QuickSounder payload.

This poster discusses the performances of QuickSounder ATMS during thermal vacuum (TVAC) calibration to ensure that QS ATMS is characterized and calibrated in the same manner as JPSS ATMS units, even though science performance attributes are not the priority of this mission.

Northrop Grumman built and refurbished ATMS EDU, and it has been integrated into a SwRI spacecraft bus using Firefly.



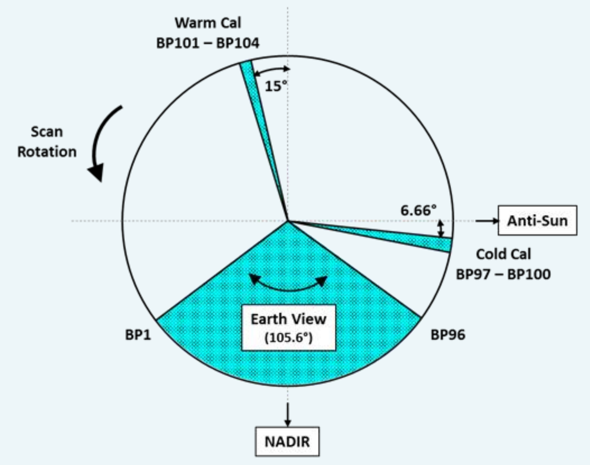
Calibration Parameters
- Sensitivity (NEΔT)
- Calibration Accuracy

Applications
- Weather forecasting
- Storm tracking
- Climate prediction models
- Precipitation, snow, and ice detection
- Temperature and humidity profile generation

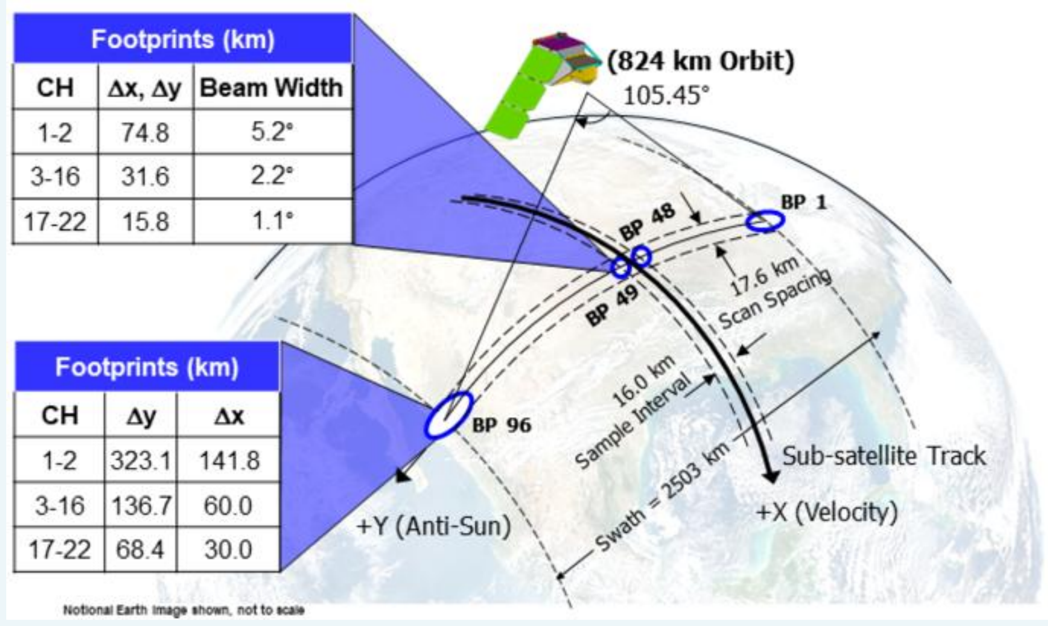
Source: NG and Firefly Aerospace

Operational Concept

- ATMS is the only science instrument on QuickSounder
  - Earth-viewing sector: 105.45°, 96 beam positions
  - Warm and Cold sectors for two-point calibration



Nominal ATMS Scan Profile

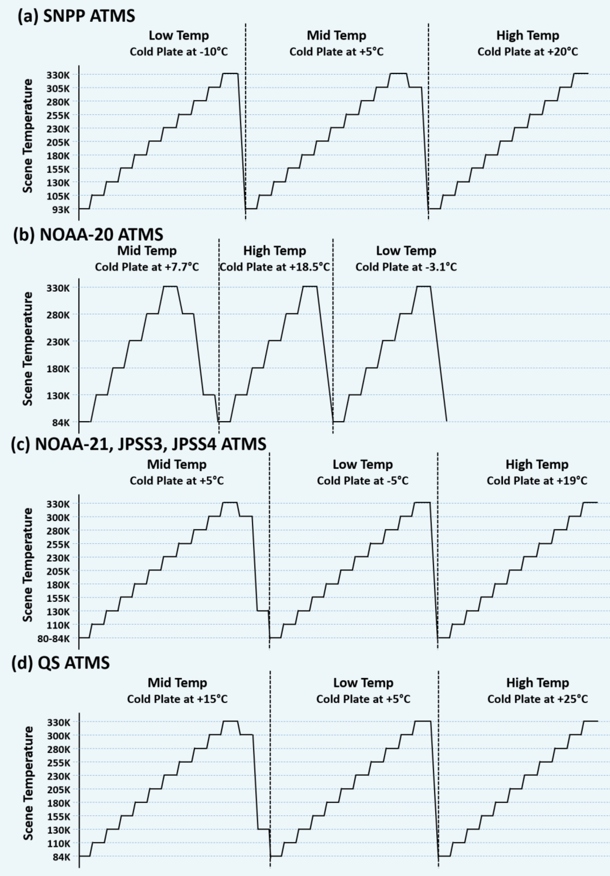


Source: NASA

QS ATMS Scanning

Ground Calibration

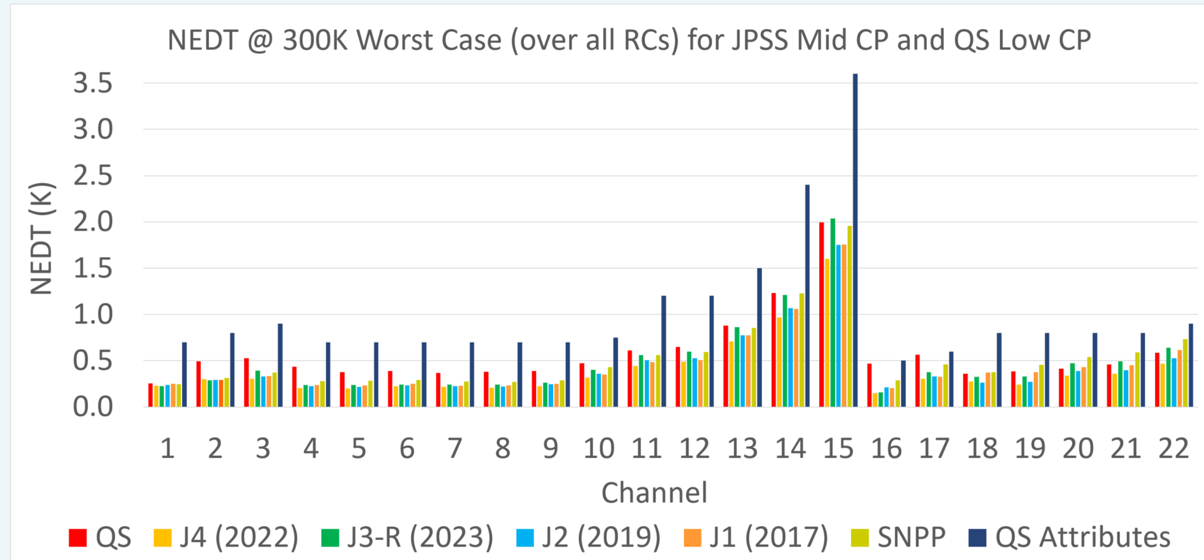
- Calibration was performed at instrument level during Thermal Vacuum (TVAC) testing. Tests performed at 3 instrument temperatures
  - External targets observed at 11 scene temperatures (SNPP, JPSS2, JPSS3, JPSS4 and QS) and 6 scene temperatures (JPSS1 regression test)
- Data used to determine and verify sensitivity (NEΔT) and characterizes transfer function non-linearity, to be used in Sensor Data Record (SDR) correction algorithms



Test profiles are compared among ATMS builds

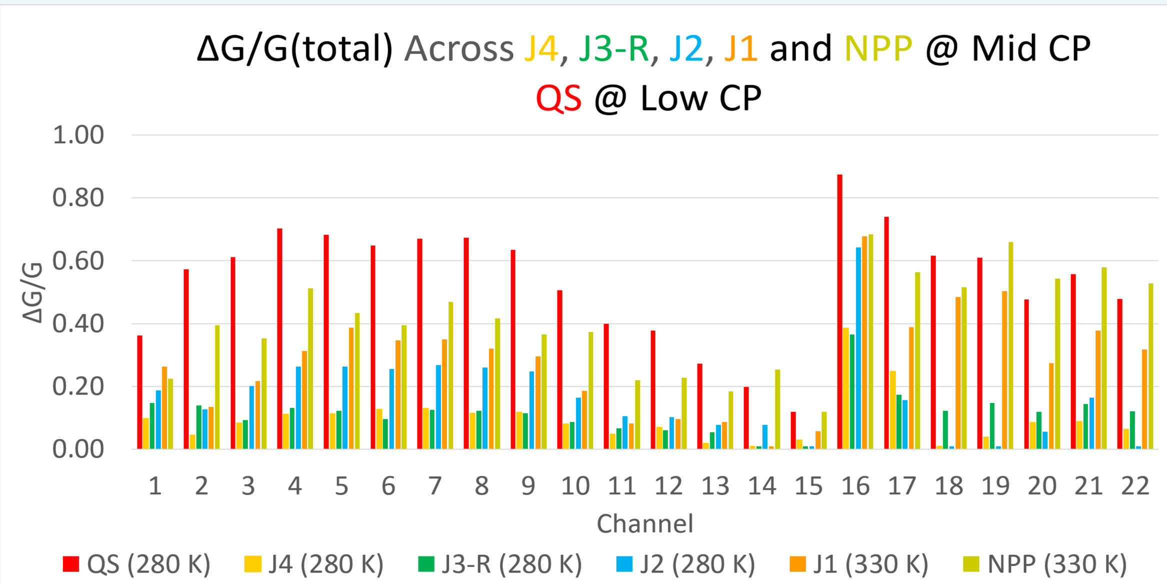
Sensitivity (NEΔT)

- Sensitivity of microwave radiometer is quantified by the Noise Equivalent Differential Temperature (NEΔT), which measures the smallest detectable temperature difference in the instrument's output
- NEΔT is defined as standard deviation of inferred brightness temperatures when viewing stable calibration target at 300 K
- QS NEΔT at Low CP (Cold Plate) is compared with JPSS NEΔT at Mid CP because of comparable CP temperatures
- The instrument level TVAC shows QS met science performance attributes except for Channel 16.
- The QS NEΔT are higher than JPSS ATMS builds for channels 2-17, and comparable to JPSS ATMS for the channels 1, 18-22



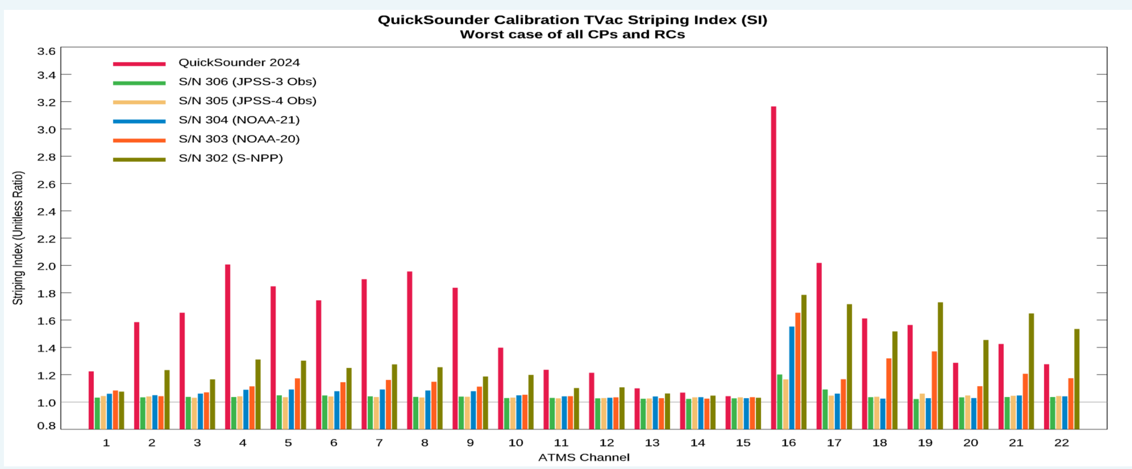
Gain Stability

- NEΔT is comprised of thermal noise (ideal radiometer performance) and flicker noise ($1/f^{\alpha}$) contributions
  - ❖ Thermal noise (white noise) is broadband with constant power per hertz due to thermal and shot process and has flat spectrum
  - ❖ Flicker noise is due to electronic system imperfections and temperature effects, and power spectral density decreases with frequency and quasi-gaussian in nature
- The noise contributions from gain instability results in unwanted "striping" in radiometric data
- Analysis takes NEΔT as the RSS of thermal and $1/f^{\alpha}$ contributions to extract gain stability
- SNPP thru JPSS4 showed a steady decline in $1/f^{\alpha}$ noise, but increased in refurbished ATMS EDU for QS, especially in channels 1 through 17 (except CH14) and comparable for the channels 18 through 22 with SNPP



Striping Index

- Striping index is the ratio of variance in brightness temperature along-track and cross-track
- Striping is caused by gain instability noise, as indicated in previous panel. Reduction in gain instability noise is supported by corresponding reduction in striping index



Beam Pointing, Beamwidth and Beam Efficiency Comparison

- Beam pointing accuracy is deviation from intended vector
- Beamwidth is the half power beamwidth
- Beam efficiency is the ratio of main lobe to total energy

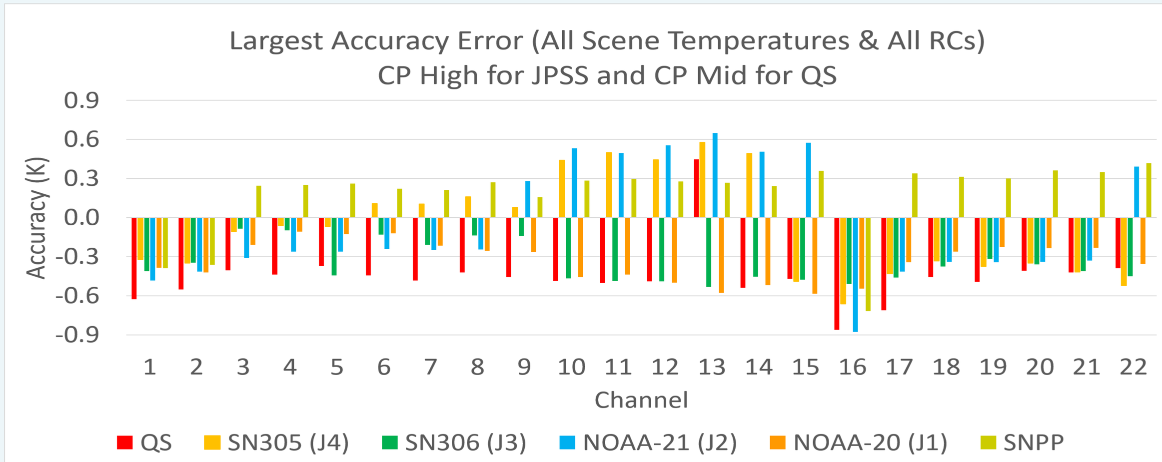
Beam Pointing Accuracy (degrees)						
Band	SNPP	NOAA-20	NOAA-21	JPSS-3	JPSS-4	QuickSounder
K	0.133	0.067	0.111	0.198	0.164	0.140
Ka	0.204	0.120	0.089	0.163	0.147	0.146
V	0.143	0.115	0.133	0.152	0.138	0.147
W	0.068	0.124	0.070	0.060	0.173	0.132
G	0.094	0.184	0.078	0.061	0.107	0.127

Beamwidth (degrees)						
Band	SNPP	NOAA-20	NOAA-21	JPSS-3	JPSS-4	QuickSounder
K	5.4	5.5	5.3	5.4	5.3	5.4
Ka	5.5	5.6	5.5	5.6	5.5	5.7
V	2.3	2.3	2.3	2.3	2.3	2.3
W	2.2	2.2	2.2	2.2	2.2	2.2
G	1.2	1.2	1.1	1.2	1.2	1.2

Beam Efficiency (%)						
Band	SNPP	NOAA-20	NOAA-21	JPSS-3	JPSS-4	QuickSounder
K	96.2	96.0	96.1	96.2	96.3	95.0
Ka	97.1	97.0	97.3	97.2	97.5	95.0
V	96.8	97.0	97.0	95.4	97.2	96.0
W	95.7	97.0	96.2	96.9	96.4	96.0
G	95.0	94.0	95.7	95.9	95.5	92.0

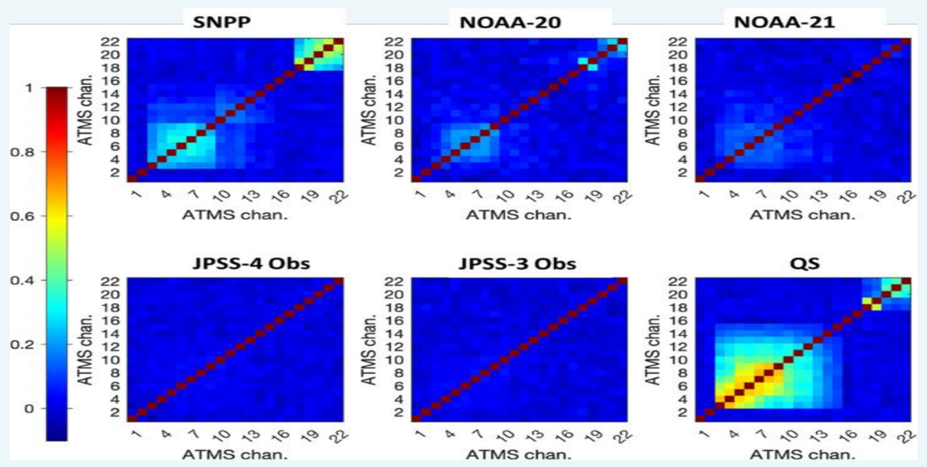
Calibration Accuracy

- Calibration accuracy of ATMS from SNPP to JPSS4 and QS is derived from calibration equation parameter uncertainties determined during TVAC



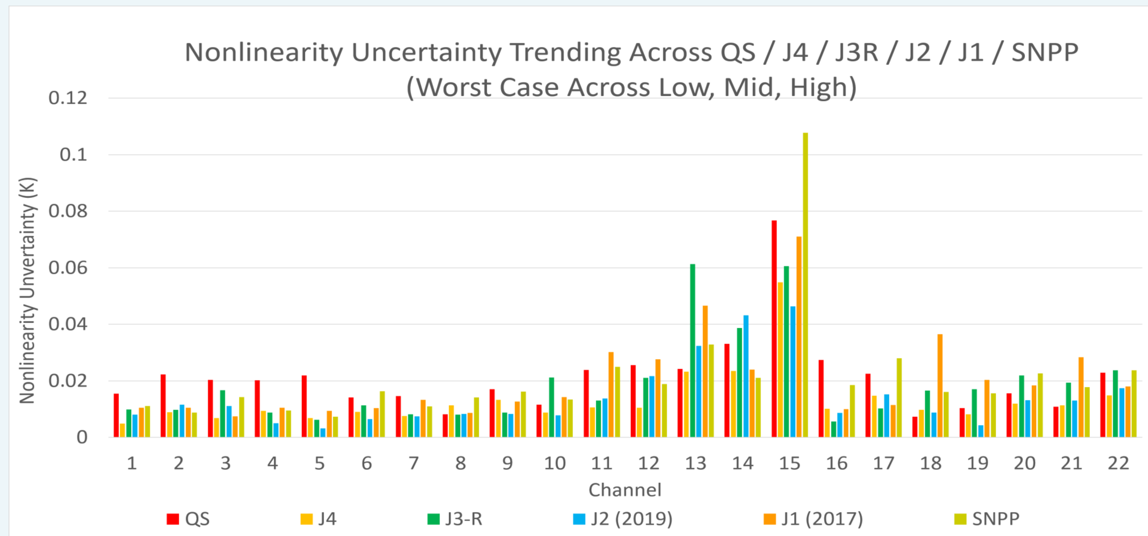
Inter-channel Noise Correlation

- Measure of random noise correlation across channel pairs, 0 = no correlation (ideal), 1 = perfect correlation



Nonlinearity Uncertainty

- Measure of nonlinearity uncertainty characterization for a given channel over tested scene temperatures



Conclusion

- ATMS Characterization was successfully performed at instrument level TVAC. Data analysis showed that performances of calibration parameters are consistent with previous ATMS builds and to the expected level of QuickSounder performance attributes, except for Channel 16.
- The QuickSounder NEΔTs are consistent to JPSS for the channels 1 and 18-22, but it is higher for channels 2-17.
- Striping index is larger in QuickSounder TVAC except G band. Inter-channel correlations are also greater for V and G bands compared to heritage ATMS, because the QuickSounder ATMS hardware has higher flicker noise compared to JPSS ATMS.