Current Status and Future Improvements for ATMS On-orbit Absolute Calibration

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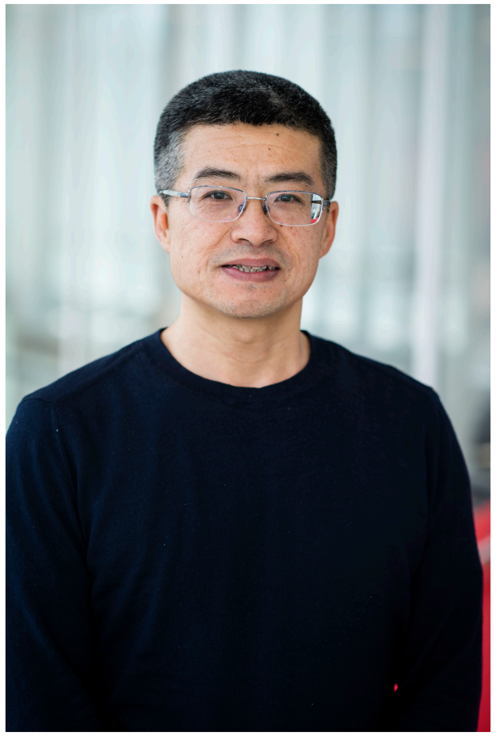


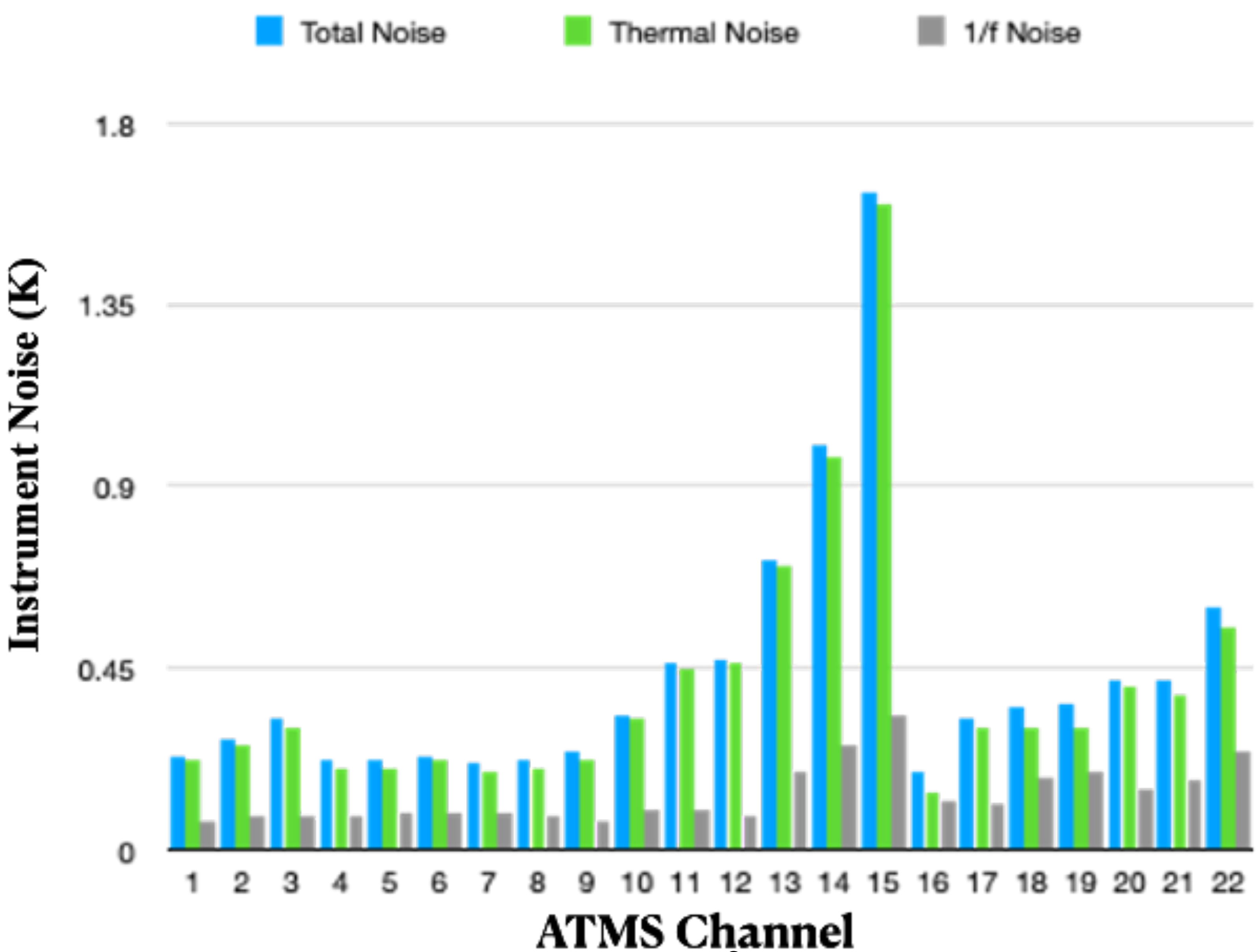
Outline

- ATMS radiance calibration algorithm updates and the current instrument performance
- Beam pointing/Geolocation error evaluation and its impact on bias evaluation
- The challenges and on-going work for future improvements

Instrument NEdT

Xun Yang and Hu Yang, 2021, "A New Algorithm for Determining the Noise Equivalent Delta Temperature of In-orbit Microwave Radiometers", IEEE Transaction on Geoscience and Remote Sensing, in review

- New method to quantify instrument thermal noise and 1/f noise separately
- Separate PRT variation from calibrated warm load Tb to reduce the impact of orbit oscillation
- Split warm counts for independent calibration gain calculation and variance calculation to avoid pseudo f^{2} noise



Updates on TDR Calibration Algorithm

Hu Yang et al., 2021, "ATMS Radiance Data Products Calibration and Evaluation", IEEE TGRS, in review

The ATMS radiometric calibration for antenna brightness temperature is derived as

$$R = R_c + (R_w - R_c)\left(\frac{C_s - \overline{C_c}}{\overline{C_w} - \overline{C_c}}\right) + Q$$

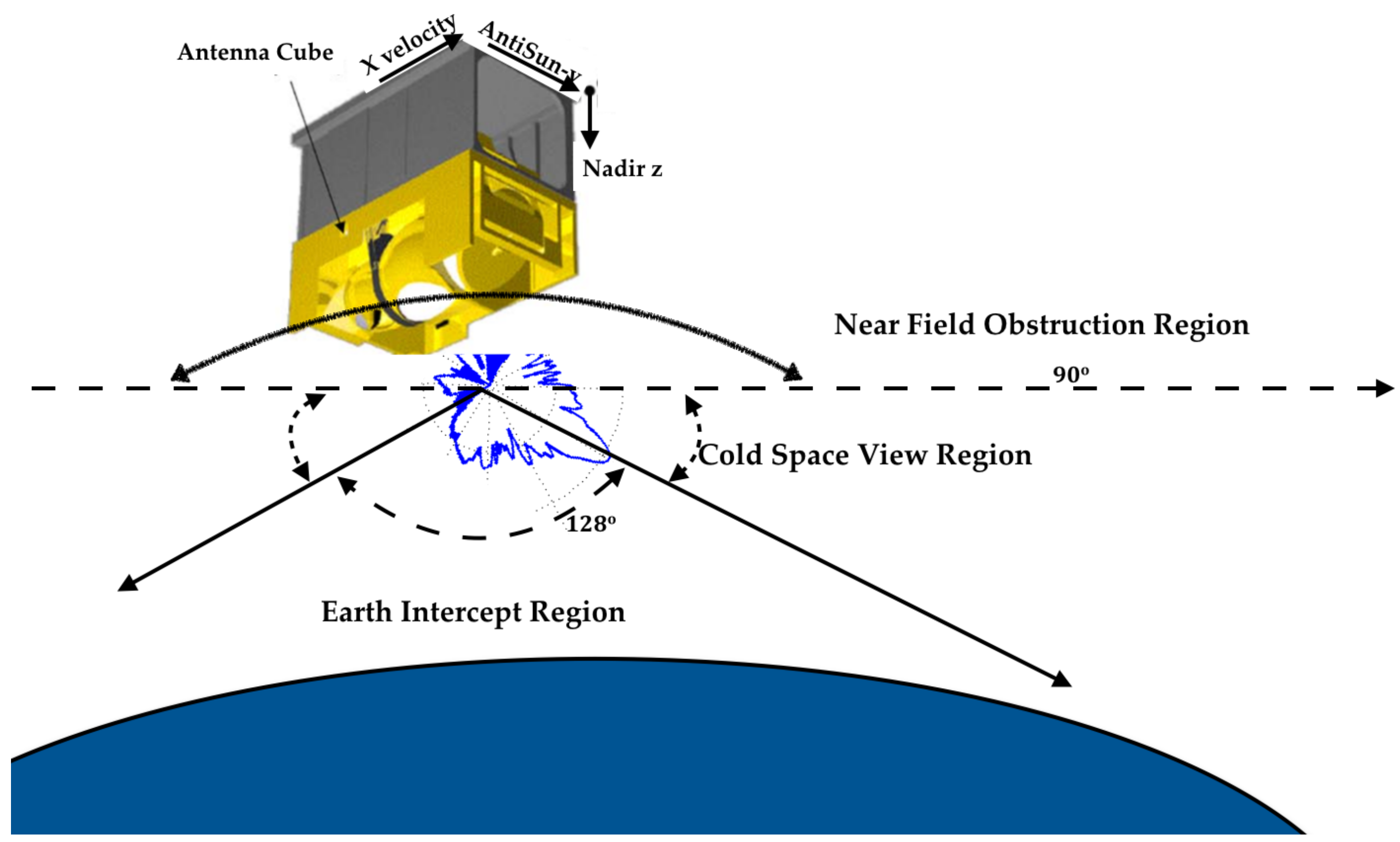
Q is the calibration non-linearity term

$$Q = \mu (R_w - R_c)^2 \frac{(C_s - \overline{C_w})(C_s - \overline{C_c})}{(\overline{C_w} - \overline{C_c})^2} = 4Q_{\max}(x - x^2)$$

Major Updates:

- Replaced the R-J approximation with full radiance based calibration in linear calibration and nonlinearity correction
- Applied antenna reflector emission correction for both calibration targets and the Earth scene
- Implemented the revised lunar intrusion correction scheme and correction model

Updates on SDR Correction Algorithm



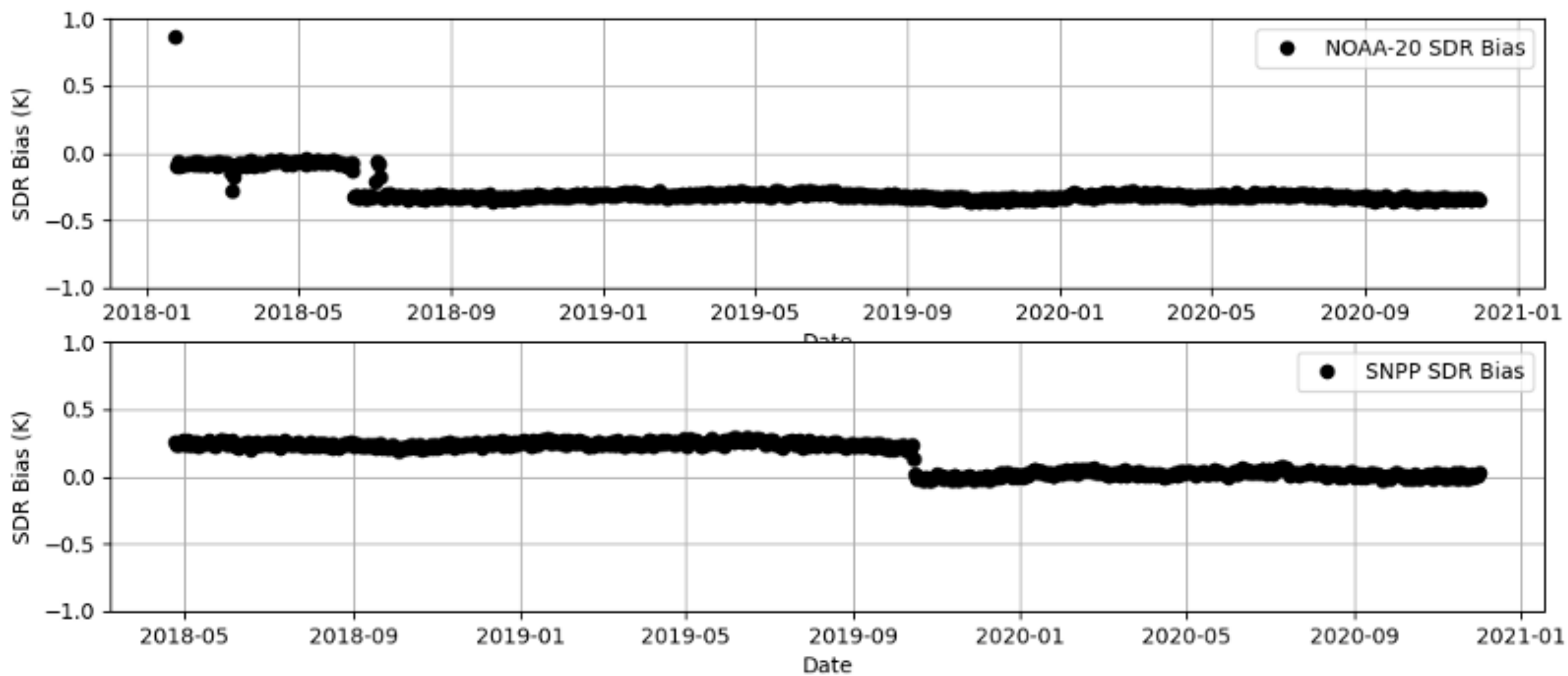
Major Updates

- Use hyper-antenna pattern to generate the APC coefficients
- Revised algorithm to account for FOV inhomogeneity
- Side lobe spill-over correction based on post-launch special scan

Impacts of Algorithm Updates on SDR products

NOAA ICVS website: https://www.star.nesdis.noaa.gov/icvs/status_N20_ATMS.php

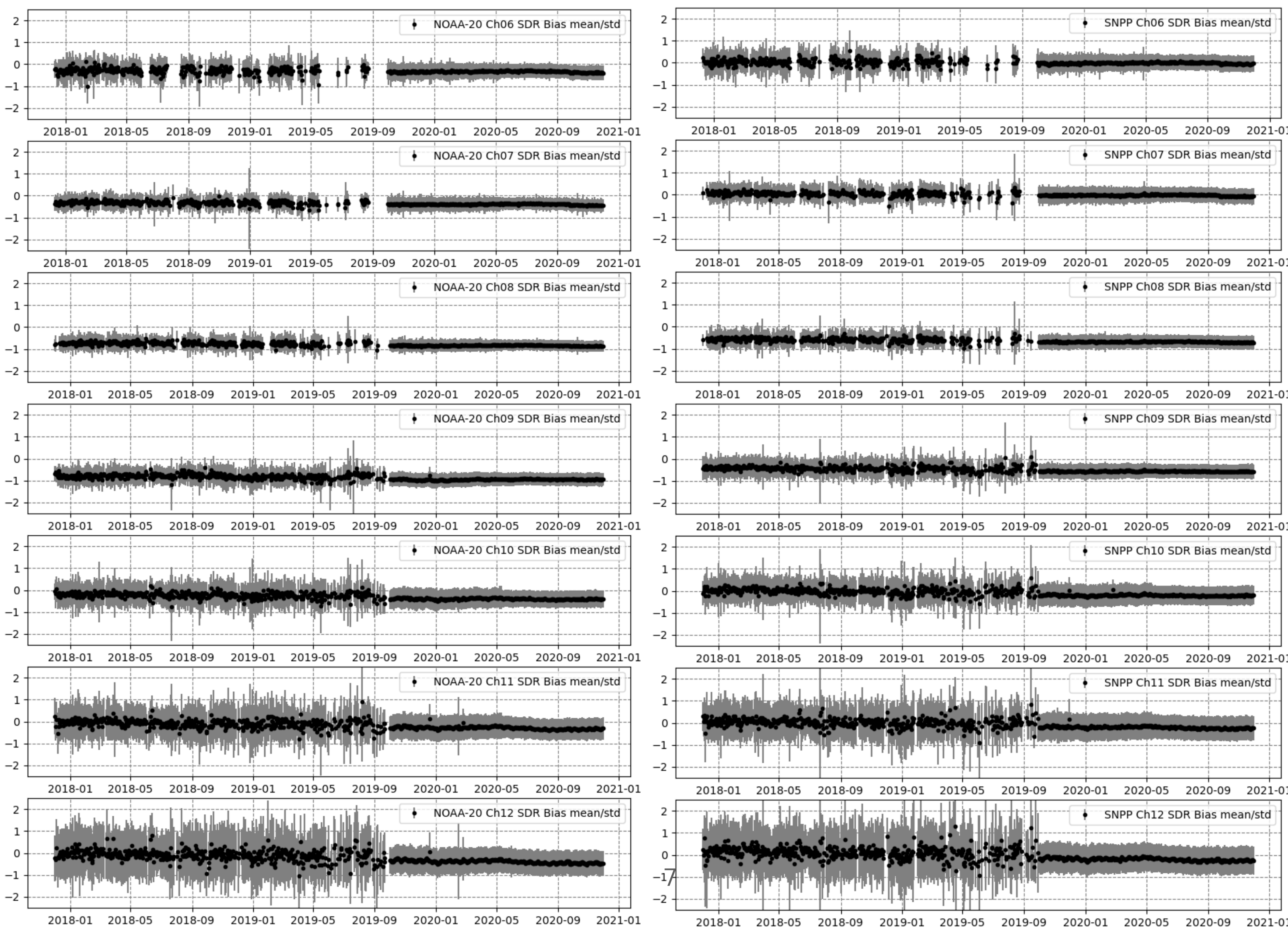
- Update on March 7th, 2017, ATMS calibration algorithm was switched to a full radiance-based algorithm from the Rayleigh-Jean approximation temperature-based algorithm. The calibration coefficients, such as nonlinearity correction coefficients and antenna pattern correction coefficients, in the associated Processing Coefficients Table (PCT) were also updated to match the change of calibration algorithm accordingly.
- Update on June 15th, 2018, updated antenna pattern correction coefficients were applied based on the post-launch on-orbit data analysis after about 6 months from N-20 launch. This led to visible changes in the SDR data associated with this instrument.
- Update in S-NPP and NOAA-20 on October 15th, 2019, both the antenna reflector emission correction algorithm and updated antenna pattern correction coefficients were applied in the IDPS



Performance of Reprocessed SDR Products

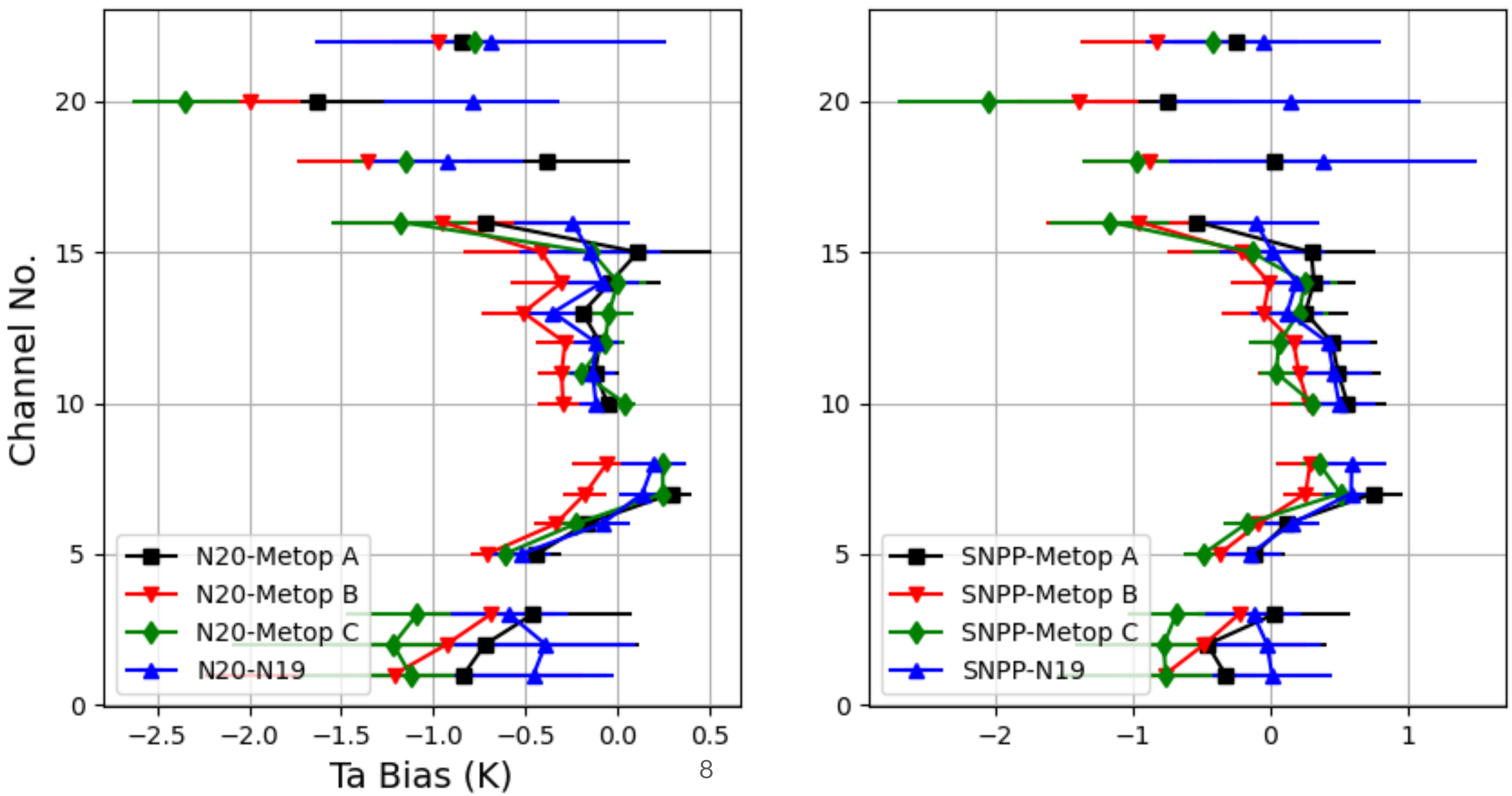
- The Mean and std. of O-B for S-NPP and N-20 ATMS channel 6 to 12 were calculated with GNSS RO profiles from COSMIC-1/KOMPSAT-5 between December 2017 and November 2020, and COSMIC-2 from October 2019 to November 2020 as RTM inputs
- ATMS instruments performance are stable for both S-NPP and N-20, the changes in performance around Oct.2019 are due to the inconsistency of RO profiles between COSMIC-1 and COSMIC-2

Long-term GPS RO Bias



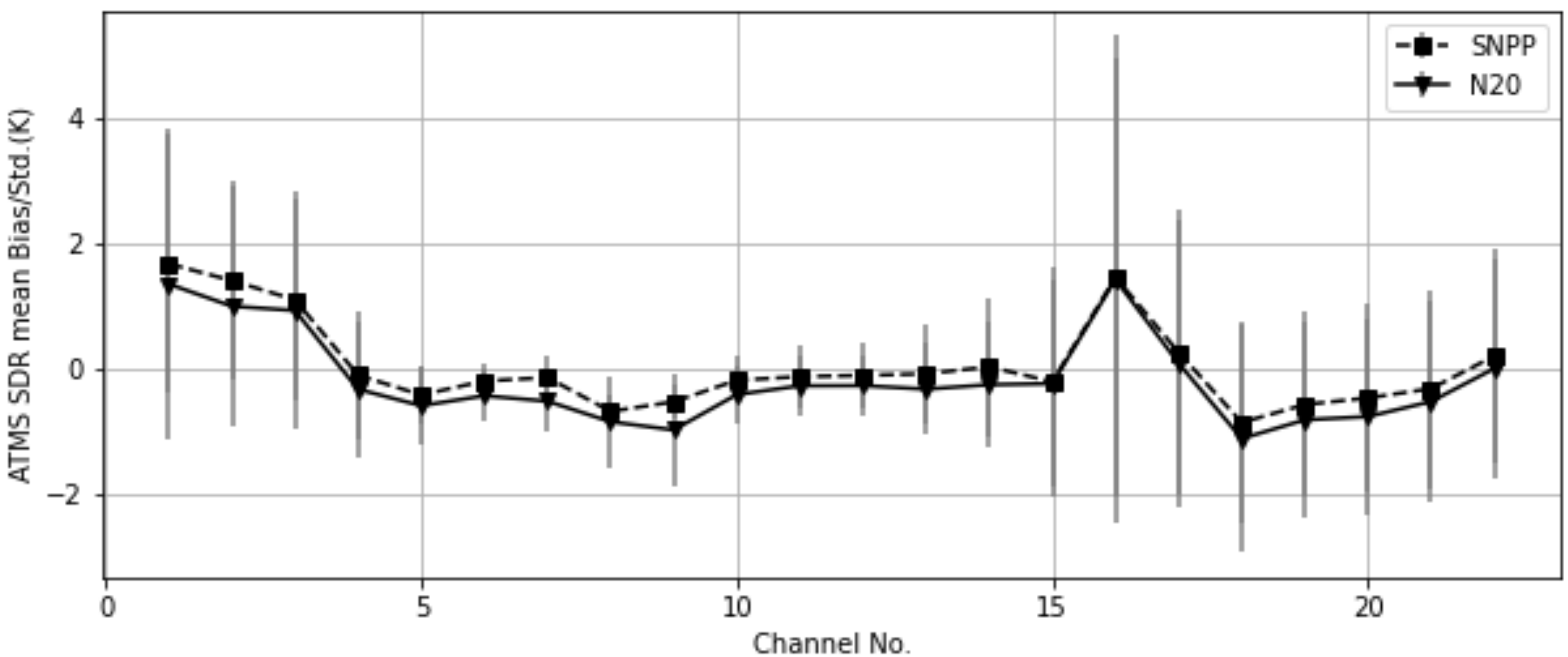
SNO Comparison Results

- The simultaneous nadir overpass (SNO) method was explored to investigate the calibration difference between S-NPP/NOAA-20 ATMS and AMSU/MHS onboard Metop-A, B, and C and NOAA-19
- For sounding channels 5 to 15, the calibration are more consistent between ATMS and AMSU/MHS, the differences are around ±0.5 K
- For window channel and 183 GHz channels, larger calibration differences are observed between ATMS and AMSU/MHS, and among AMSU/MHS onboard different satellites



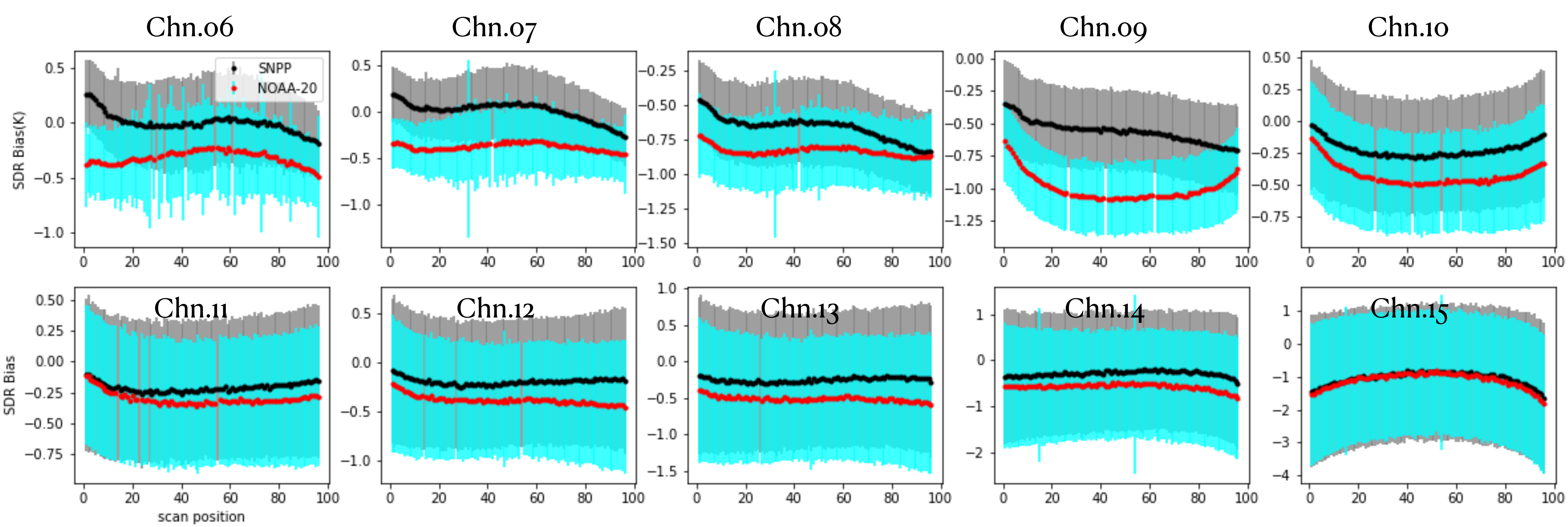
Global Mean Bias for Nadir Position

Channel average O-B bias shows better consistency between observations and simulations for temperature sounding channels, and relatively large difference for surface and G band channels



Scan Angle dependent Bias

- Scan angle dependent bias were observed in both S-NPP and N-20 ATMS SDR. The scan bias in sounding channel 6 to 15 were evaluated by O-B with GPS RO profiles as model inputs
- The observed scan bias are consistent between S-NPP and N-20. For high level sounding channels, magnitude of the scan bias increase with channel hight

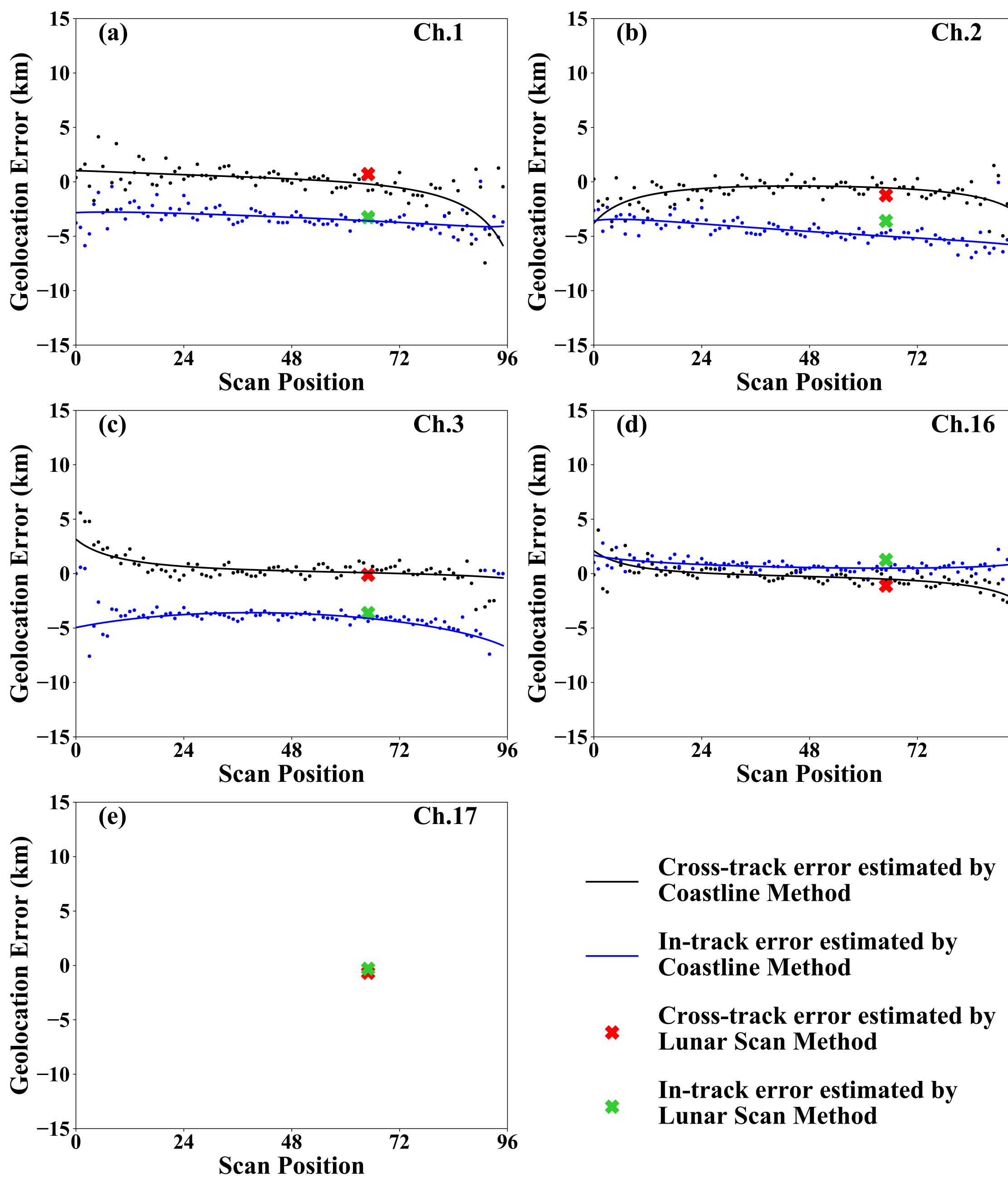


Beam Pointing offset Angle and Ground Geolocation Error

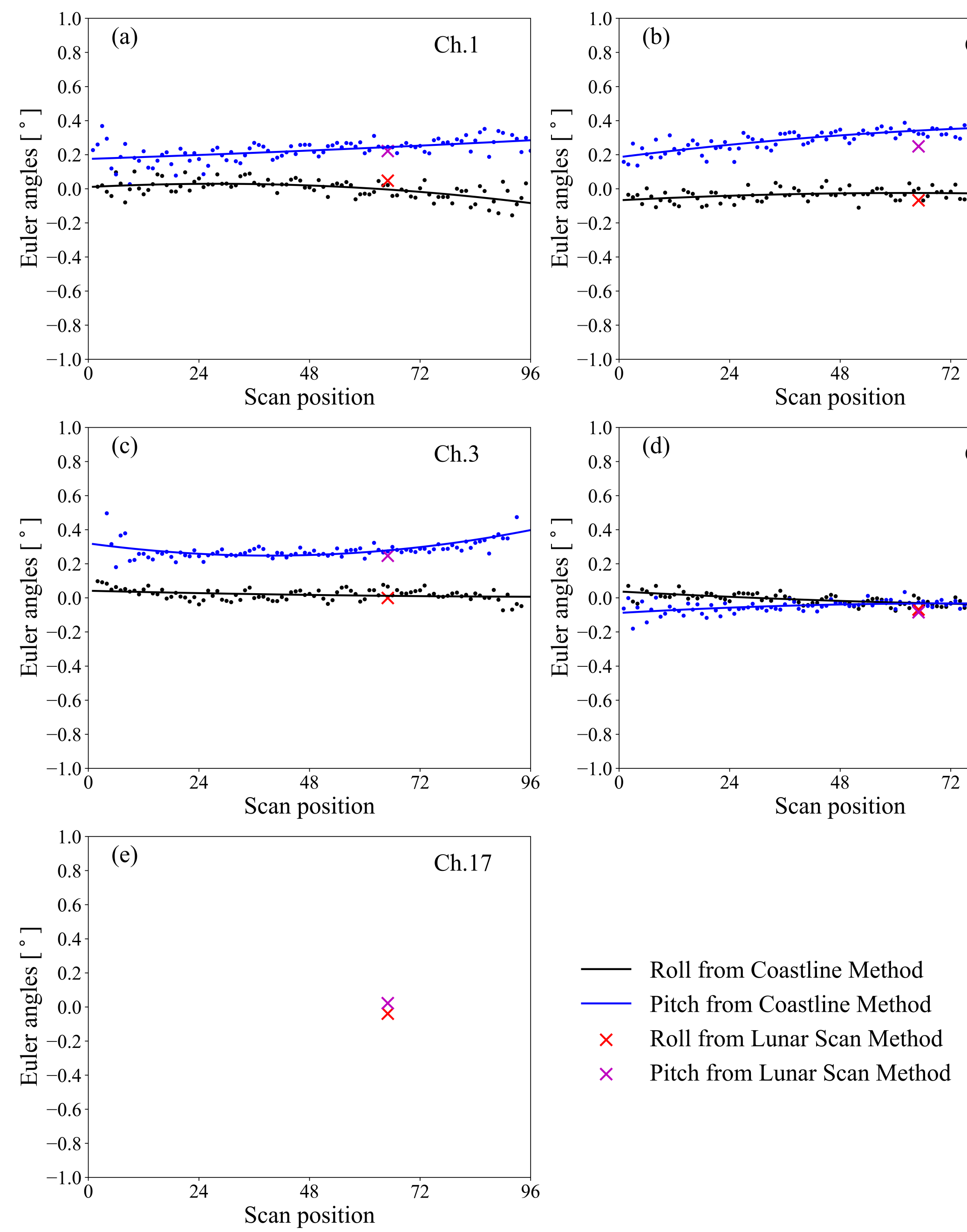
*Zhou, J. and **Yang, H***., "A study of a two-dimensional scanned lunar image for Advanced Technology Microwave Sounder (ATMS) geometric calibration", Atmospheric Measurement Techniques, vol. 12, no. 9, pp. 4983–4992, 2019. doi:10.5194/amt-12-4983-2019*

Two different methods were developed to evaluate the ATMS beam pointing offset and ground geolocation error for different scan position: coast line inflection point for surface channel geolocation error evaluation, and lunar observations for roll and pitch beam pointing offset at all channels

Ground Geolocation Error



Beam Pointing Error



Challenges: Mitigate the Calibration Difference between N20 and SNPP

- Comprehensive calibration process to reduce the uncertainties in TVAC tests and re-derive the nonlinearity parameters
- Include the corrections for stray-light contamination from satellite platform and instrument in SDR correction algorithm
- Correction for beam pointing error to reduce differences

Summary of the Work

- Comprehensive on-orbit calibration validation results are derived based on three different methods: SNO inter-satellite calibration, O-S with input profiles from GPS RO and NWP forecast.
- Results show that the overall calibration error for SNPP and N20 ATMS are comparable to or better than heritage NOAA microwave sounding instruments. The long-term error is stable and no degradation was found in TDR/SDR products.
- The calibrated Ta/Tb of N20 ATMS is systematically colder than SNPP, for all channels and over different scene targets. The potential root causes is under investigation, possible error sources include error in calibration target, nonlinearity and antenna pattern corrections.