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Abstract: **Assessing the Long-term Stability of ATMS through Cross-Calibration**

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The long-term performance of Suomi NPP ATMS including its calibration stability and accuracy has been assessed from 2011-2016. ATMS is the latest generation of microwave sounder onboard current and future NOAA polar-orbiting satellites for Earth environmental measurement and weather forecast. As ATMS has a designed mission life of five years, it is critical to review and examine its post-launch calibration stability, accuracy, and possible drift. Rather than using the conventional O-B approach, where a radiative transfer model (RTM) works as the reference, we use independent microwave radiometers as a reference through cross-calibration. By doing so, the bias between observation and simulation is reduced and pseudo drift due to RTM and sampling issues can be eliminated. Overall, ATMS has demonstrated stable performance without noticeable drift, where the change of cross-calibration accuracy is below 0.1 K. However, pseudo drifts as large as 0.5 K are found in O-B, which indicates that O-B can be problematic in cross-calibration. Whereas ATMS shows no significant seasonal and annual variability, some diurnal difference is found, which is likely due to simulation that cannot capture the diurnal variability. A periodic oscillation is found in cross-calibration. It depends on the spacecraft orbit characterization and can be explained by a recently-reported orbit model. In addition to the primary oscillation, a secondary oscillation with smaller magnitude but a doubled period is also revealed. These oscillations are due to the change of geographic areas of cross-calibration collocation and biases in RTM rather than the instrument. As we have used conical-scanning instruments including TMI and GMI in cross-calibration, the study shows the usefulness of cross-calibration between conical and cross-track scanning instruments.