Title: Calibration of Small Satellite Microwave Radiometers using the Community Radiative Transfer Model (CRTM)

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Abstract:

Miniaturized instrument payloads on small satellite and nanosatellite platforms that are deployed in low Earth orbit are demonstrating cost effective weather monitoring platforms with increased temporal and spatial resolution compared to larger weather satellites. The NASA Earth Decadal Survey [1] states that improving the revisit time of microwave radiometers would significantly improve weather forecasting. Radiometers such as the Advanced Technology Microwave Sounder (ATMS) on Suomi National Polar-orbiting Partnership (Suomi-NPP) and the Joint Polar Satellite System-1 (JPSS-1), now NOAA-20, provide an average revisit rate of 7.6 hours; however, a constellation of six CubeSats in three orbital Low Earth Orbit (LEO) planes with microwave radiometers such as the Time-Resolved Observations of Precipitations structure and storm Intensity with a Constellation of Smallsats (TROPICS) mission would provide a refresh rate of better than 60 minutes. In order to effectively use CubeSats in a constellation as a weather monitoring platform, calibration must be used to provide measurements consistent with state of the art measurements, such as ATMS that has a NeDT at 300K of 0.5-3.0K [2].

In this work, we use the Joint Center for Satellite Data Assimilation (JCSDA) Community Radiative Transfer Model (CRTM) to simulate brightness temperatures (https://www.jcsda.noaa.gov/projects_crtm.php), which are used to assess miniaturized microwave radiometer radiometric biases. CRTM is a fast radiative transfer model that uses Fortran functions, structure variables, and coefficient data of the modeled sensor to simulate radiances. The user inputs surface characteristics, scan angles, and atmospheric profiles from sources such as radiosondes, Numerical Weather Prediction (NWP) models, and Global Positioning System Radio Occultation (GPSRO) measurements. The output of CRTM is a simulated brightness temperature that is used to correct radiometric biases in order to meet required instrument NeDT performance. We use radiosonde, GPSRO, and NWP ERA-5 atmospheric profiles in CRTM and compare the results to ATMS brightness temperatures and find an average difference in brightness temperature of 1.95 K, which is comparable to ATMS Integrated Calibration/Validation System (https://www.star.nesdis.noaa.gov/icvs/status_NPP_ATMS.php) reports which show channel bias variations of up to 2 K. We take a similar approach to provide calibration for the Micro-sized Microwave Atmospheric Satellite-2A (MicroMAS-2A), a 3U CubeSat that was launched on January 11th, 2018. MicroMAS-2A carries a 1U 10-channel passive microwave radiometer that provides imagery near 90 and 206 GHz, temperature sounding near 118 GHz, and moisture sounding near 183 GHz. We develop an approach for comparing MicroMas-2A brightness temperatures to radiosonde, GPSRO, and NWP ERA5 atmospheric profiles. Due to the scarcity of GPSRO and radiosonde profiles near the MicroMAS-2A data segments, we determine that NWP models will be the best option for radiance validation. After the next stage of calibration

of MicroMAS-2A is completed, we will compare CRTM simulated radiances from ERA profiles to the initial sensor data, with expected results of channel bias variations of <2 K.

[1] *National Research Council, Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond., Washington, D.C.: The National Academies Press, 2007.*

[2] *Kim, E., C.-H. J. Lyu, K. Anderson, R. V. Leslie, and W. J. Blackwell (2014), S-NPP ATMS instrument prelaunch and on-orbit performance evaluation, J. Geophys. Res. Atmos., 119, 5653–5670, doi:10.1002/2013JD020483.*