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Intercalibration of Passive Microwave Radiometers in Preparation for TEMPEST-D

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The Temporal Experiment for Storms and Tropical Systems Technology Demonstration (TEMPEST-D) mission is meant to pave the way for high temporal resolution measurements of clouds and precipitation on a global basis with a constellation of closely spaced 6U-Class satellites carrying identical five-channel microwave radiometers. Such a constellation could make repeated observations of cloud systems as they develop and transition to precipitation, providing temporal context that is unachievable from existing passive microwave radiometer satellite instruments, and sensitivity to changes inside the clouds that is missing from geostationary visible and infrared measurements. During the TEMPEST-D mission, a single 6U-Class satellite carrying a cross-track scanning passive microwave radiometer operating at frequencies near 89, 165, 176, 180, and 182 GHz will be deployed from the International Space Station. One of the primary mission objectives is to demonstrate intercalibration between the TEMPEST-D radiometer and the Global Precipitation Measurement (GPM) Microwave Imager (GMI) and Microwave Humidity Sounder (MHS) instruments. GMI, which underwent extensive on-orbit calibration maneuvers designed to identify and correct for calibration anomalies, is believed to be very well-calibrated and stable. It could thus serve as a validation reference for the TEMPEST-D radiometer. MHS, which currently operates on board four polar-orbiting satellites, is similarly well calibrated with consistency between the four instruments and with GMI shown to be within 0.5 K for all five channels.

We outline a method developed to cross-calibrate the TEMPEST-D brightness temperatures (Tb) with either GMI or MHS. Near-coincident observations over non-precipitating oceans scenes are identified and a radiative transfer model is used to simulate Tb for each sensor configuration. A “double differencing” method is then used in which the difference in simulated Tb between the two sensors is subtracted from the difference in observed Tb to determine the overall calibration difference. Key to this intercalibration effort is a robust optimal estimation (OE) retrieval algorithm that translates Tb to geophysical parameters needed to implement the double difference method. We have developed such a scheme for non-precipitating ocean scenes that can be applied to both conically-scanning microwave imagers and cross-track scanning microwave sounders to retrieve water vapor profile information, vertically integrated amounts of cloud water and ice, and (for imagers) sea surface temperatures and wind speeds. By allowing the observational error covariance matrix to vary with Earth Incidence Angle, view-angle-dependent biases in the OE algorithm are almost entirely eliminated. The algorithm is used to retrieve geophysical parameters from the GMI and MHS observations. The algorithm output is then used to screen for scenes with precipitation or significant cloud contamination and to better inform the model used for simulating Tb about the atmospheric state. Examples will be presented that validate the MHS calibration to within 0.5K relative to GPM. The same process will be applied once TEMPEST-D is launched in late spring of 2018.