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Satellite Intercalibration and Evaluation of Climate Trends and Variability

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A realistic and reliable assessment of climate trends and variability requires long-term, accurate, and homogeneous time series of climate data. Microwave radiometers provide the most accurate remote sensing measurements over the ocean of several essential climate variables crucial for the water cycle, including surface wind speed, vertically integrated water vapor, cloud water, and rain rate. We are approaching the point of having a 30-year long record of Earth observations by microwave radiometers. This long-term record requires the combination of time series measured by several different radiometer designs orbiting on a dozen different satellites, including 6 SSM/I, 3 SSMIS, TMI, AMSR-E, and WindSat. To obtain an accurate and homogeneous data record, the systematic differences due to radiometer design must be taken into account, otherwise biases specific to one satellite or another will introduce artificial shifts in the time series. These shifts can have a huge impact on the results of climate analysis, especially those of climate trend analysis. Satellite intercalibration provides the needed bias-correction and homogenization to ensure accurate time series.

We will present our physically-based satellite intercalibration technique and evaluate the long-term trends and variability of the intercalibrated time series. Our technique has been designed to ensure a consistent and traceable calibration starting from raw sensor counts. There are many potential sources of error in sensor calibration, but we have found four primary sources dominate the error budget. First is error in pre-launch determination of the antenna spillover. The spillover is part of the familiar antenna pattern correction, which is the crucial conversion from antenna temperature to brightness temperature. Second is error due to specifying the effective hot load temperature on orbit. The design of the hot load for F16 SSMIS, for example, allows sunlight to enter, either via directly or via a single reflection. This introduces significant thermal gradients that decorrelate the temperature measured by the embedded thermistors from the effective radiating temperature of the load. Third is error due to direct emission from the antenna. This error is difficult to handle, but it only affects the TMI and SSMIS sensors. Fourth is error due to the spacecraft and calibration targets entering the field of view during a scan. This error is easily corrected because it is a systematic error that repeats every scan. All of these errors, in addition to many other minor errors, are removed using our intercalibration technique that is based on comparing satellite observations to a common radiative transfer model.