Evaluation of the COWVR+TEMPEST Channel Set for Estimating Precipitation Structure over a Variety of Surface Conditions

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While precipitation is a continuous process evolving in 3-D extent, all global precipitation products provide periodic updates of the 2-D near-surface precipitation rate. We describe adaptations to an existing passive microwave (MW) inversion framework for estimation of vertical structure variables (V) from passive MW observations collected by the Compact Ocean Vector Winds Radiometer (COWVR) and the Temporal Experiment for Storms and Tropical Systems (TEMPEST). The COWVR+TEMPEST duo was delivered to the International Space Station (ISS) in December 2021, situated in the Japanese Experiment Module Exposed Facility (JEM-EF). COWVR is a conically-scanning (890 km swath) microwave polarimeter providing fore and aft imaging at 18.7, 23.8 and 33.9 GHz (full Stokes parameters), while TEMPEST provides near simultaneous cross-track (1400-km swath) imaging at 89, 166, 176, 180 and 182 GHz. With three scheduled years of operations from the ISS asynchronous orbit, the COWVR fore/aft conical scan and the 18-183 GHz channel diversity offer diurnal sampling of global precipitation, and potentially contribute to shorter global passive MW revisit in the mid/lower latitudes.

The inversion is based upon a transformation applied to the observed brightness temperatures (TB) into a set of orthogonal principal components, themselves derived from physical conditions that most influence the measured TB, including the surface emissivity. Since COWVR+TEMPEST data are unavailable at this current time, existing ATMS and GMI data are used as proxies for the COWVR+TEMPEST channel set to evaluate the utility of COWVR's polarized low-frequency channels in separating precipitation over different surface types. As precipitation begins to enter the satellite field of view, these relationships (being derived from non-precipitating conditions) begin to deviate and gradually transform themselves into terms that separate precipitating and non-precipitating conditions.

These passive MW sensors are sensitive to the vertical distribution of condensed water from the top of the cloud down to a depth D – high frequencies (i.e., TEMPEST channels) are not sensitive to the condensation below the top-most layers of the cloud (small D), while the low frequencies (i.e., COWVR channels) are (larger D). The estimation of V from a large set of a-priori data depends upon the definition of the distance that quantifies how close or different two sets of observations are, and the kernel (typically assumed to be Gaussian) that is used to infer V from the observed TB. We present results that examine the optimal transformation of the TB and the corresponding norm in the transform space, and the derivation of an optimal kernel.