A Unified Microwave Radiative Transfer Model with Jacobian for General Stratified Media: Extension and Numerical Results

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A unified microwave radiative transfer (UMRT) model is developed for rapid, stable and accurate level-centric calculation of the thermal radiation emitted from any geophysical medium comprised of planar layers of either densely or tenuously distributed, moderately sized spherical scatterers.

UMRT employs a rapid multistream scattering-based discrete ordinate eigenanalysis solution with a layer-adding algorithm stabilized by incorporating symmetrization of the discretized differential radiative transfer equations and analytical diagonalization and factorization of the resulting symmetric and positive definite matrices. The formulation includes both Mie and dense media radiative transfer (DMRT) theories, employs multilayer stack with refracting layers, couples the vertical and horizontal radiation intensities within each layer, allows the thermal radiation of a layer to be linear in height, compensates refracted fields by applying Snell's law and a cubic spline interpolation matrix.

Moreover, by incorporating the derivative chain rule using first-order perturbations of the eigenvalues and eigenvectors of a symmetric matrix, UMRT provides rapid numerical calculation of the associated Jacobians between the observed brightness temperature and all relevant radiative and geophysical parameters.

The development and validation of UMRT with Jacobian and the associated programs have been presented during the previous two years. This presentation focuses on further extending the Jacobian formulation to include several important geophysical parameters of snow (or ice), such as the snow thickness, snow volume fraction and the stickiness parameter defined within DMRT theory, and comparing results of the upwelling brightness temperatures over dry snow and ice from simulations with data from several field campaigns. Numerical results from the UMRT Jacobians including the derivatives with respect to the scattering and absorption coefficients, medium temperature, temperature lapse rate, and medium layer thickness are presented and discussed.