Submission Title:

A Comprehensive Forward Model for Spaceborne Radar Instruments

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Abstract

We present the development and validation of a comprehensive forward model designed to enhance remote sensing capabilities of spaceborne radar instruments. To overcome limitations in existing models, we integrated a Discrete Dipole Approximation (DDA) cloud scattering database into our Radiative Transfer Model (RTM), focusing on microwave frequencies. By simulating the optical properties of non-spherical frozen hydrometeors, the DDA technique effectively reduced discrepancies between simulated and observed values, surpassing traditional Mie tables. The evaluation of DDA lookup tables involved comparisons with a collocated dataset comprising short-term forecasts and satellite microwave data, providing evidence of their superiority.

Additionally, we address the challenges of assimilating active radar measurements, which offer vertically resolved insights into clouds and precipitation. We explored the assimilation of spaceborne radar measurements in Numerical Weather Prediction (NWP) models by integrating a forward radar model, along with its adjoint and tangent linear, into the data assimilation system. Evaluation using CloudSat measurements demonstrated promising agreement between simulations and observations, particularly when the input hydrometeor profiles aligned with the measured reflectivity profiles, showcasing the potential of the developed forward radar model. Moreover, we discuss other challenges in radar measurement assimilation within NWP models, including potential observation errors and biases.