

Title: Applications of All-Weather Dynamic Emissivity Estimation Algorithm for Snowfall Retrievals from GPM/GMI

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Introduction

The precipitation retrieval from passive microwave radiometers over land is a challenging task due to the effects of the surface on the observed brightness temperature (TB). At high latitudes, the surface evolves over time due to snow accumulation and melt, causing changes in the observed TB. Unaccounted changes in emissivity and skin temperature complicate the separation of surface effects from the observed signal, even when using climatology-derived surface parameters. In this study, the difference between observed TB and clear-sky TB (hydrometeor-free) is investigated as an indicator for near-surface snowfall occurrence. The usability of the emissivity estimated from the newly developed dynamic emissivity model for clear-sky TB estimation is also validated.

Data & Methods

The Surface Emissivity and Temperature Retrieval Algorithm (SETRAP) for GPM Microwave Imager (GMI) is proposed to address surface emissivity variability. It combines radiative transfer-based retrieval guided by the radiative transfer physics in clear-sky and neural network-based retrieval in semi-transparent atmospheres. The built-in transmittance-based threshold allows for the automatic switch between approaches. The generated surface emissivity atlases for GPM/GMI were used to simulate clear-sky TB at each swath location. For snowfall estimation, clear-sky TB was combined with observed TB and vertical profiles of pressure, temperature, and humidity in a deep neural network. The outputs consisted of the simultaneous retrieval of the snowfall presence and snowfall rates. The reference data for the emissivity model was constructed with matchups between the Tool to Estimate Land Surface Emissivity from Microwave to Submillimeter Waves (TELSEM2) atlas and GMI orbits in 2015. The ground truth data for snowfall was derived with the CloudSat CPR product from the CloudSat/GMI matchup dataset.

Results

Results show a low mean absolute error (MAE) of the retrieved emissivity across the first 11 channels (0.01 - 0.05) as well as skin temperature (3 K). The simulated TB using the obtained emissivity resulted in better alignment with the observed TB when compared with climatology-derived atlases, causing a decrease between simulation and observation of 10 K. The consistency of retrievals was validated, showing an average 5% difference in emissivity between consecutive orbits' overlaps. Snowfall retrievals with the new atlas showed improvement in both snowfall detection and estimation, leading to the HSS increase by 0.1 when adding clear-sky TB. Snowfall rate MAE finalized at 0.09 mm/hr relative to the CPR-derived estimates.

Conclusions

In summary, all-sky emissivity retrievals with the newly developed SETRAP model enable the incorporation of different surface conditions through time in the snowfall retrievals due to its physics-based and data-driven nature. Moreover, it was shown that the introduction of clear-sky TB leads to the performance improvement of the near-surface snowfall detection with neural network models. Future work can be focused on the detailed evaluation of emissivity and snowfall retrieval performance, as well as introducing physical consistency to the snowfall estimation module.