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Uncertainty characterization of sub-mm and MW in all-sky radiative transfer

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Nowadays, satellite microwave (MW) observations are gaining weight in weather and climate applications. The upcoming Ice Cloud Imager (ICI) mission covering frequencies between 183 and 670 GHz aims at improving the representation of cloud ice in models. Ultimately, ICI will extend the scope of MW assimilation. In stand-alone retrievals and data assimilation, several simplifications are still employed. Particularly, particle size distributions (PSDs) and particle models (PM) of ice hydrometeors are poorly considered and three-dimensional (3D) radiative transfer is ignored. Thus, an assessment of these simplifications was conducted by means of ARTS (Atmospheric Radiative Transfer Simulator). A framework was developed, employing the ARTS scattering database and generating synthetic scenes based on CloudSat observations over Tropics. Firstly, we evaluated the performance of different PMs and PSDs to model observations by GMI (GPM Microwave Imager) and the impact to the derived ice water content is assessed. At frequencies between 186 and 190 GHz and above 180 K, the simulated brightness temperature is fairly insensitive to PM. However, at lower temperatures, large discrepancies are found, with no clear indication which PM performs best. Of tested PSDs, McFarquhar and Heymsfield (1997) provides the best agreement to GMI. The analysis was extended towards the highest frequencies of ICI (above 328.65 GHz) and revealed a higher sensitivity to the assumed PM with great potential for constraining ice properties. Secondly, an effort was conducted to quantify the errors induced by neglecting 3D effects, i.e., horizontal photon transport (HPT) and beam-filling (BF), at mm/sub-mm wavelengths of current and proposed satellite instruments. The analysis reveals a small HPT effect introducing mostly random errors and an overestimation (below 1 K), while a substantial BF effect that increases with frequency and footprint size. Overall, the BF effect can be up to 4 and 13 K at 183.6 and 668 GHz, respectively.

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