Microwave emission of sea ice - of variabilities and uncertainties
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Passive microwave sensors onboard satellites have been observing the polar regions since the 1970s. Many different algorithms for the retrieval of various sea ice properties such as ice concentration, snow depth, ice type, and ice thickness have been developed and evolved over time. Most of the retrievals used today are empirical, i.e., are trained by other observational or model based data. The primary observed quantity is the emission comprising contributions from the surface (snow, ice, water) and atmosphere. The main reasons for the absence of physical retrievals are the lack of: firstly, physical constraints, and secondly, understanding of microwave interaction with snow/sea ice.

Layer based microwave emission models for snow such as MEMLS (Microwave Emission model of Layered Snowpacks) and SMRT (Snow Microwave Radiative Transfer) require knowledge about many input parameters for each layer, like grain size, permittivity, and temperature to determine the emitted radiation at horizontal and vertical polarization. In addition, these radiative transfer (RT) models employ certain approximation to simplify the otherwise complex calculations. The permittivities of the snow/ice/water mainly determines the emitted radiation. While the permittivity of snow in the microwave regime is well measured and can be theoretically described, for sea ice the permittivity has a much larger variability spanning over an order of magnitude. Salinity, temperature, and geometry variations of the brine inclusion in the ice are the main causes of uncertainty. We address this variability of permittivity for low microwave frequencies (< 10 GHz) using a Monte Carlo exploration of the permittivity space, based on dielectric mixture models (Sihvola, 2000) for sea ice as a brine/ice/air composite. This allows us also to quantify the uncertainty of sea ice permittivity.

One approximation of current microwave emission model is the assumption of strict layer boundaries to calculate the transmissivity through layer interfaces simply using the Fresnel equations ignoring potential soft interfaces (i.e., gradual permittivity changes) and corresponding coherence effects. By using a fully coherent RT model, we investigate the interface transmissivity as a function of thickness of transitional layers and frequency. Comparing coherent and incoherent RT through interfaces reveals a major discrepancy between the two methods and suggest a careful handling of layer discretizations when employing RT models.