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Sea ice and snow parameter retrieval from low frequency passive microwave remote sensing

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Sea ice is a crucial component in the Earth's climate system and information about sea ice parameters are highly demanded for process studies, climate modeling and prediction. 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 and ice type have been developed and evolved over time. At lower frequencies like L-band (1–2 GHz), the current passive microwave-based missions SMOS (Soil Moisture Ocean Salinity) and SMAP (Soil Moisture Active Passive) are used to retrieve ice thickness of thin sea ice. Numerical modeling of the microwave emission of sea ice reveals that the emitted microwave radiation is sensitive to many more parameters, e.g. temperature, salinity and geometry of brine inclusions in the sea ice, especially at microwave frequencies below 10 GHz. We explore these sensitivities for the microwave emission at frequencies of 0.6, 1.4, and 6.9 GHz in horizontal and vertical polarizations using a physical forward model. In this frequency range the influences on the emission are quite versatile; Firstly, the permittivity of brine is strongly frequency dependent suggesting that simultaneous observations at different frequencies contain information about the brine content. Secondly, the effect of interference of radiation is very different at the scales from 4.3 cm (6.9 GHz) to 50 cm (0.6 GHz) wavelength. Therefore, sea ice with thin and thick snow cover appear similar in 6.9 GHz while for thicker snow covers, the emissions are higher at lower frequencies compared to ice covered with thinner snow. Also, growing sea ice shows increasing microwave emission with increasing ice thickness, which effect is increasing with decreasing frequency.
The potential inversion of a physical forward model will be discussed with an outlook on the expected quality of a potential retrieval of sea ice salinity, thickness of snow and ice, temperature and geometry of brine inclusions. In near future (approx. 2025), the CIMR satellite mission (Copernicus Imaging Microwave Radiometer) will provide simultaneous microwave measurements at 1.4, 6.9, 10.6, 18.7, and 36.5 GHz and therefore will be a prime candidate for snow and sea ice retrievals based on our findings.