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Sea ice thickness retrieval in the Baltic Sea using SMOS

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The Soil Moisture and Ocean Salinity (SMOS) mission is the first space mission measuring brightness temperatures at 1.4 GHz (L-band). Additionally to its main fields of application, soil moisture and ocean salinity, it seems possible to retrieve sea ice thickness globally from space using SMOS data. The penetration depth in ice at 1.4 GHz restricts a possible ice thickness retrieval to thin ice.

We have developed a three layer (ocean-ice-atmosphere) dielectric slab model describing ice thickness as a function of the observed brightness temperature. In this model the dielectric properties of ice depend on the relative brine volume which can be described as a function of the bulk ice salinity and temperature. There are two different ways of using the model. Either auxiliary information on salinity and temperature is used as input to the model, or it is run using tie-points obtained for the considered region and season from the data itself.

This study contributes to the development of algorithms that could possibly be used for operational retrieval of thin sea ice thicknesses with SMOS data. We validate the model by comparing it to available ice thickness data sets. Besides, we aim to further improve the model. Instead of a bulk ice temperature a temperature gradient can be implemented. Furthermore, the surface roughness and the thermal insulation effect by a snow cover shall be included in the model set-up. Another task is to determine the model's restrictions and error characteristics. According to the model calculations the ice thickness sensitivity depends on the ice conditions (temperature and salinity) and thus varies with the region considered. Above a certain ice thickness value the modeled brightness temperature shows saturation. The corresponding maximum ice thickness can be considered as a lower boundary.

Here, we show the model's applicability to sea ice formed in the Baltic Sea. Sea ice conditions in the Baltic Sea are characterized by relatively warm temperatures and low salinities. The mean water salinity amounts to about 7. For these conditions the maximal ice thickness that is retrievable has a magnitude of 1 m. As a first attempt we applied our model to SMOS data recorded in the Baltic Sea in March 2010 and compared our results to EM Bird ice thickness measurements. The comparison shows that the ice thicknesses retrieved with SMOS are in the expected range. Some of the observed deviations could be explained by effects caused by Radio Frequency Interference (RFI). As some major RFI sources have been switched off after the launch of SMOS, more emphasis is placed on the ice thickness retrieval in the following winter season. We show ice thickness maps for the Baltic Sea derived with SMOS data in the winter season 2010/2011. These are compared to ice thickness charts based on SAR and MODIS images. The Finnish Meteorological Institute (FMI) is developing these charts that estimate ice thickness categories for both level and deformed ice fields in fine spatial resolution (1 km). Additionally, the SMOS ice thickness maps are compared to manual ice charts and maps from the German Federal Maritime and Hydrographic Agency showing ice thickness minima and maxima. These comparisons give an estimate of the accuracy and the retrievable ice thickness range of our method for sea ice in brackish waters like the Baltic Sea.