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Sea Ice Thickness Retrieval based on Predictive Regression Neural Networks using L-band Microwave Radiometry Data from the FSSCat mission

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Several approaches have been developed to yield Arctic sea ice thickness based on satellite observations. Microwave radiometry operating at L-band is sensitive to sea ice properties and allows to retrieve thin sea ice up to ~ 0.5 m. Sea ice thickness retrievals above 1 m can be successfully derived using sea ice freeboard data from satellite altimeters. Current inference models are build upon empirically determined assumptions on the physical composition of sea ice and are validated against regionally available data. However, sea ice can exhibit time-dependent non-linear relations between sea ice properties during the process of formation and melting, which cannot be fully addressed by simple inversion models. Until now, an accurate estimation of sea ice thickness requires specific conditions and is only viable during Arctic freeze up from mid-October to mid-April. Neural networks are an efficient model-based learning technique capable of resolving complex systems while recognizing hidden links among large amounts of data. Models have the advantage to be adaptive to new data and can therefore reflect seasonally changing sea ice conditions to make predictions based on the relationship between a set of input features. FSSCat is a two 6-unit CubeSat mission launched on September 3, 2020, which carries the FMPL-2 payload on board the 3Cat-5/A, one out of two spacecrafts. FMPL-2 encompasses the first L-band radiometer and GNSS-Reflectometer on a CubeSat, designed to provide global brightness temperature data suitable for soil moisture retrieval on land and sea ice applications.

In this work a predictive regression neural network was built to predict thin sea ice thickness up to 0.6 m at Arctic scale based on FMPL-2 observations and ancillary data including sea ice concentration and surface temperature. The network was trained based on CubeSat acquisitions during early Arctic freeze up from October 15 to December 4, 2020, using existing maps of daily estimated sea ice thickness derived from the Soil Moisture and Ocean Salinity (SMOS) mission as ground truth data. Hyperparameters were optimized to prevent the model from overfitting and overgeneralization with the best fit resulting in an overall mean absolute error of 6.5 cm. Preliminary results reveal good performance up to 0.5 m, whereas predicted values are slightly

underestimated for higher thickness. The thin ice model allows to produce weekly composites of Arctic sea ice thickness maps. Future work involves the complementation of the input features with sea ice freeboard observations from the Cryosat-2 mission to extend the sensitivity range of the current network and to validate the findings with on-site data. Aim is to apply the model trained on Arctic data to retrieve full-range Arctic and Antarctic sea ice thickness maps. The presented approach demonstrated the potential of neural networks for sea ice parameter retrieval and indicated that data acquired by moderate-cost CubeSat missions can offer scientifically valuable contributions to applications in Earth observation.