Temporal Morphing of X-Band SAR Sea Ice Classification

We aim to predict the dynamical development of regional sea ice cover by morphing TerraSAR-X synthetic aperture radar (SAR)-based sea ice classification results using sea ice drift forecast data.

Ship travel in ice-covered waters is challenging, even for ships with high ice classes and icebreakers. Also, since sea ice is drifting, the location and extent of thicker sea ice and more easily navigable open leads is constantly changing. An operationally available route suggestion through sea ice would help ships to find the safest route through the ice.

For this new morphing application, we use sea ice classification results obtained during the MOSAiC expedition (Kortum, Singha, and Spreen, 2022). The classification applies robust machine learning techniques on TerraSAR-X Dual-pol StripMap (HH, VV) data on a 17.5m grid. Each grid cell of the classification result is tracked forward in time with vector-based Lagrangian tracking. Our approach uses an inverse distance weighting variant of Runge-Kutta 4th-order developed starting from Vennell et al. (2021). The forecast data accessed for morphing is procured from CMEMS (Copernicus Marine Environment Monitoring Service). We use sea ice drift forecast data included in the TOPAZ4 (CMEMS, 2015) and neXtSIM-operational (CMEMS, 2020) products. The forecast models are computed on a grid spacing of 12.5 km and 10 km, respectively. The tracking algorithm operates on a Lagrangian grid with floating point number resolution. This combines different spatial scales together in one product. We try to provide additional information to ice pilots by adding predicted deformation to the morphed sea ice classification results.

The sea ice drift forecast data is evaluated regarding its usability for morphing with Sentinel-1-based sea ice drift data. For this, sea ice drift vector fields are obtained with a phase correlation method that operates in the Fourier domain and uses a hierarchical pyramid method (Frost et al., 2018). The result of morphing highly depends on the forecast data. We try to find a use-case-depending best solution for the utilization of the forecast products for finding optimal shipping routes.

References CMEMS, 2015, TOPAZ4: Arctic Ocean Physics Analysis and Forecast: European Union - Copernicus Marine Service, http://dx.doi.org/ 10.48670/moi-00001. CMEMS, 2020, NeXtSIM: Arctic Ocean Sea Ice Analysis and Forecast: European Union - Copernicus Marine Service, http://dx.doi.org/ 10.48670/moi-00004. Frost, A., S. Wiehle, S. Singha, and D. Krause, 2018, Sea Ice Motion Tracking from Near Real Time Sar Data Acquired During Antarctic Circumnavigation Expedition, in, 2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS): IEEE, 2338-41, http://dx.doi.org/ 10.1109/IGARSS.2018.8518249. Kortum, K., S. Singha, and G. Spreen, 2022, Robust Multiseasonal Ice Classification From High-Resolution X-Band SAR: IEEE Transactions on Geoscience and Remote Sensing, 60, 1-12, http://dx.doi.org/ 10.1109/TGRS.2022.3144731. Vennell, R., M. Scheel, S. Weppe, B. Knight, and M. Smeaton, 2021, Fast lagrangian particle tracking in unstructured ocean model grids: Ocean Dynamics, 71, 423-37, http://dx.doi.org/ 10.1007/s10236-020-01436-7.