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# Sea Ice Data for Shipping Routes


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## Introduction

What are the properties of local sea ice cover and how do they change? For finding optimal shipping routes, we compile a sythetic aperture radar (SAR)-based data basis that include sea ice information in tens of meters resolution on hourly basis.

Ship activities are increasing in polar regions. Hence, solutions for navigating in sea ice are demanded. As an improvement of previous algorithms such as the predicted ice image application (PRIIMA) [5], we are able to provide irregular distributed point clouds containing sea ice type information with a temporal component.

## Data and Methods

We apply operational-ready sea ice drift forecast data, i.e. TOPAZ4 [2] and neXtSIM [3] (neXtSIM-operational) in connection with sea ice type classification from SAR [9].

For this, we have implemented a vector data model for processing to gain high flexibility and floating-point number resolution. To speed up our object-oriented implementation we apply spatial indexing, hashing and a topology. For particle tracking, e.g. [12], we use an inverse distance weighting (IDW) version of Runge-Kutta 4th-order (RK4). RK4 requires continuous data in space and time. We interpolate sea ice drift in every grid point with cubic splines in the time dimension. In the space dimension, we then interpolate with IDW.

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## Morphing of Sea Ice Type Classification

The knowledge about horizontal sea ice cover and its temporal change is a valuable information for navigation in ice infested waters. Sea ice is constantly moving and deforming. Our algorithm is able to track irregular distributed points identified in sea ice type information images into the future using sea ice drift forecast data.

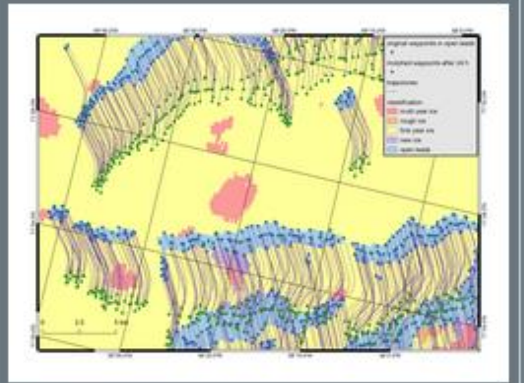

Figure 2: Forward tracking of irregular distributed routing waypoints containing sea ice type information. The classification result is derived from Sentinel-1 SAR-scenes.

We derive sea ice type classification from Sentinel-1 SAR scenes. The result is used to generate sea ice type polygons. From the corners of the polygons, Voronoy diagrams are derived. The resulting nodes of the Voronoy diagrams and the corners of the polygons are used as waypoints for navigation, e.g. [9]. We assign sea ice type information to the waypoint instances and track them forward in time (morphing). In Figure 2, only trajectories of waypoints in open leads are shown. One dataset derived from one Sentinel-1 SAR-scene-based sea ice type classification result contains around 500 000 waypoints.

## Evaluation

In our evaluation we analyze how sea ice drift and sea ice deformation are represented in the sea ice drift forecast data. Our SAR based ground truth was validated with buoy measurements. We measured a sigma error of 132 m at 10 km sea ice displacement and 235 m at 20 km [6].

For the evaluation of sea ice drift, we analyze the distribution of the distances between endpoints of SAR-based sea ice drift vector fields and sea ice drift forecast model-based trajectory fields (RMS separation distance) in relation to the observed sea ice drift.


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## Conclusions

We were able to implement a proof of concept of morphing of sea ice type classification. The value-added use of the sea ice drift forecast models TOPAZ4 and neXtSIM-operational in connection with sea ice type classification is possible. Nevertheless, some restrictions have to be made. In our study, we find that the fractality of deformation is not represented in the sea ice drift forecast data at navigational scale. Also, neXtSIM-operational has a much higher error of sea ice drift than stated in the model quality information.


The presented work is done in the framework of the mFUND funded project FastCast-2. Currently, we are preparing to support the navigation of RV Polarstern at the PS 144 expedition in August 2024. In near future, we want to support research and supply vessels by connecting morphed sea ice information with sea ice deformation.


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