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Observing convergent and divergent sea ice motion fields using spaceborne SAR image time series: Validation of a drift retrieval algorithm with buoy data

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Sea ice is almost constantly in motion. It is mainly driven by winds and ocean currents and can change significantly just within hours. When an ice sheet is exposed to winds and ocean currents from opposite directions, it fractures, and new open water leads appear. When convergent forces act on the ice sheet, it may collapse. Then, ice pieces either pile up randomly one over another, forming an uneven surface, or are pushed vertically into a wall called pressure ridge.

Synthetic Aperture Radar (SAR) satellites are well suited to observe large-scale motions in the sea ice. In this work, we developed a software processor for estimating high resolution sea ice drift vector fields from sequential, co-located SAR images. The estimated drift fields reveal local variations in the ice motion, e.g. diverging and converging movements.

The core of our processor is a phase correlation technique, executed in a hierarchical motion estimation framework. In principle, phase correlation implies the determination of maximum value location in a two-dimensional cross-power spectrum, which is generated from an image pair. In our work, we determine the maximum value location in sub-pixel space. This allows estimating drift vectors with accuracy higher than the input image resolution.

In this study, we quantify the accuracy of our drift processor by comparison with drift buoy data provided by Environment Canada. Our study deals with TerraSAR-X images taken in different orbits and incidence angle ranges off Northeast Greenland coast. The images have a resolution of 34 m. They show close drift ice, very close drift ice, and fast ice. 44 image pairs are used for the validation. We found an average displacement of 15.4 m between the real drift recorded in the buoy data and the estimated drift vector from our processor; the standard deviation is 8.6 m. These numbers prove the operational reliability of our sub-pixel motion estimation. The displacement is independent of the drift vector magnitude, though the absolute drift of sea ice between two SAR acquisitions has to be within the image margins to be recognizable by the processor. In ongoing work, we expand the test by analyzing more image pairs and ice regimes.

Derived sea ice drift vector fields may provide the basis for improving and validating sea ice models, for estimating ice volume export, and for predictions on climate change. Furthermore, sea ice motion is an important parameter for ship navigation in arctic waters and offshore activities. Hence, reliable information on sea ice motion is essential for safe operations in the Arctic.