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Lead orientation derived from Advanced Microwave Scanning Radiometers

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Leads are linear openings in the sea ice cover. They originate from the wind field and ocean surface currents acting on the sea ice cover. High heat and moisture fluxes occur at the air-ocean interface in leads. Thus, new ice grows at a high rate in leads especially in winter. Leads also influence sea ice mechanics. An additional application is to use leads as natural route options for ships. We investigate this possibility in the framework of the IRO-2 (Ice Route Optimization - 2) project. The scope of the IRO-2 project is to develop a system for ship route forecasts.

Observations of lead occurrence can be obtained from optical sensors, altimeters, and Synthetic Aperture Radar. Optical sensors often have a higher resolution than passive microwave sensors but they are limited by cloud conditions. From altimeter track profiles alone it is not possible to estimate the lead orientation. Synthetic Aperture Radar has a high spatial resolution but the temporal coverage is not continuous. Here, we present an approach for detecting leads that is based on daily AMSR-E (Advanced Microwave Scanning Radiometer for EOS) satellite observations for the time period from 2002 to 2011.

When the sea water freezes in winter, nilas is formed as the first consolidated type of thin ice. Nilas shows a high emissivity near 19 GHz and 89 GHz. Here, we apply additionally an edge detecting filter on the AMSR-E brightness temperature maps to estimate thin ice in leads. We grid the resulting thin ice occurrence in cells of 6.25 km in length. Leads in the thin ice occurrence maps are often interrupted and mixed with noise potentially created by small scale leads that are not resolved in the thin ice occurrence. We apply the Hough transform on maps with thin ice occurrence to detect lead structures from the background noise. The Hough transform is an image analysis technique to detect line structures like leads and their orientation in images. In order to detect leads the Hough transform takes the minimal line length into account. We compare lead positions obtained from different minimal line lengths to the thin ice occurrence at the same location for each day. The minimal line length is chosen that matches the underlying thin ice occurrence best. A further problem is that the Hough transform detects certain lead positions several times. Therefore, we cluster the neighboring lead positions to one resulting lead position.

We analyze the orientation of leads Arctic wide and compare the orientation of leads to the shear orientation of the sea ice drift. We compare our results to wide swath mode Synthetic Aperture Radar observations of Arctic sea ice. Furthermore, we validate the automatic detection of leads with manually detected lead positions and their orientation.