Fusion of satellite SAR and passive microwave radiometer data for automated sea ice mapping and the expected impact of CIMR observations

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Title
Fusion of satellite SAR and passive microwave radiometer data for automated sea ice mapping and the expected impact of CIMR observations.

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Abstract (max. 500 words)
Manual ice charting from multi-sensor satellite data analysis has for many years been the primary method at the National Ice Services for producing sea ice information for marine safety. Ice analysts primarily use satellite synthetic aperture radar (SAR) imagery due to the high spatial resolution and the capability to image the surface through clouds and in polar darkness, but also optical imagery in clear sky and daylight conditions, thermal-infrared and microwave radiometer data from e.g. AMSR2. Ice analysts mention the spatial resolution of microwave radiometers as the primarily limitation to use the data.
The traditional manual ice charting method is time-consuming and limited in spatial and temporal coverage. Further, it is challenged by an increasing amount of available satellite imagery, along with a growing number of users accessing wider parts of the Arctic due to the thinning of the Arctic sea ice.
The automation of the time-consuming and labour-intensive sea ice charting process has potential to provide users with near-real time sea ice products of higher spatial resolution, larger spatial and temporal coverage, and increased consistency.
To automate the generation of sea ice information from satellite imagery we use a Convolutional Neural Network (CNN) designed for prediction of sea ice in Greenland waters. Automating the process on SAR data alone is challenging. SAR images show patterns related to ice formations, but backscatter intensities can be ambiguous, which complicates the discrimination between ice and open water, e.g. at high wind speeds. Our CNN model tackles the challenges by fusing Sentinel-1 active microwave (SAR) data with Microwave Radiometer (MWR) data from AMSR2 to exploit the advantages of both instruments. While SAR data has ambiguities, it has a very high spatial resolution, whereas MWR data has good contrast between open water and ice. However, the coarse resolution of the AMSR2 MWR observations introduces a new set of obstacles,

e.g. land spill-over, which can lead to erroneous sea ice predictions along the coastline adjacent to open water.
The CNN model has been trained with a large dataset of 461 ice charts manually produced by the ice analysts in the DMI Greenland Ice Service based on Sentinel-1 imagery. The dataset also contains the corresponding AMSR2 swath co-located with the ice charts and Sentinel-1 images. The sea ice training dataset (https://doi.org/10.11583/DTU.13011134.v2) has been co-produced in the ASIP and AI4Arctic (ESA) projects.
We will present the results of merging active and passive microwave data from Sentinel-1 and AMSR2 as input to a CNN and show how the input from the passive microwave data has a positive effect on the CNN performance. Furthermore, we will discuss the benefits and improvements that can be expected with the higher resolution CIMR observations and give inputs to the requirements for simulated CIMR test data in the context of CNN development.
The CNN model is in production at DMI and its ice products have been tested with users in the Fall of 2020.