Sea ice concentration and type analysis from ASAR and MODIS images in the Baltic Sea

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Sea ice extent in the Baltic Sea can vary from 10% on mild winters to 90% on cold winters. Studies related to sea ice have been performed for several decades in the Baltic Sea, mainly motivated by the development of winter shipping. Finland and Estonia are the only nations in the world where all harbours freeze every winter (Jevrejeva and Leppäranta, 2002). In average winters, the ice covers the Bothnian Sea, the Archipelago Sea, the Gulfs of Finland and Riga as well as the northern part of the Baltic Proper. In severe winters, the Danish Straits and the southern Baltic Proper are also covered with ice. Locally ice formation usually starts within sheltered bays and skerries and the ice edge moves outward from the coasts as the winter progresses. Ice forms first in the inner skerries and bays where the water is often fresher and shallower. The land-fast ice cover usually extends to the outer skerries, where the water depth is typically between 5 and 15 m. Further offshore the ice cover is highly dynamic (Leppäranta, 1981).

Availability of different types of sensors opens new possibilities in ice type determination procedures. SAR and optical remote sensing images data enable to describe more accurately sea ice extent and ice type in Baltic Sea. For test data we used ASAR (Advanced Synthetic Aperture Radar) and MODIS (Moderate Resolution Imaging Spectroradiometer) images that were recorded at the same dates on 17.02.2006 and 11.03.2006 in the Baltic Sea. Also ice concentration maps from MODIS data were calculated for winters 2006 and 2007.

Histogram analysis was performed on MODIS 250m resolution images to obtain ice concentration maps. For classification a subset from MODIS image was chosen where a wide range of reflectance values were representing different ice concentrations. The histogram was calculated from all pixels reflectance values within the subset. The smallest reflectance representing water was defined as 0% ice concentration (open water) and the highest reflectance was 100 %. Different ice concentration regions were also characterized spectrally using data from MODIS 1km resolution images. Our previous studies have shown that spectral remote sensing data can be used for distinguishing different ice types (ridged ice, fast ice etc.). The analysis of SAR data was carried out using histogram analysis as described previously in case of MODIS data analysis. Ice concentrations maps were distinguished from Normalized Radar Cross Section (NRCS) data.

The MODIS and SAR with the calculated ice concentration were compared. Analysis showed that the ice concentration data was in general similar on both images. On SAR image the influence from atmosphere is excluded but on MODIS the histogram analysis give more accurate results in the region were the subset for analysis was chosen but in distant areas the ice concentration data is influenced by atmosphere. In general our results showed that MODIS data with 250m resolution gives us high resolution ice concentration data on cloudless days and can be used for different applications.

Jevrejeva and M. Leppäranta, Ice conditions along the Estonian coast in a statistical view, Nordic Hydrology 33 (2002), pp. 241–262.
Leppäranta, 1981 M. Leppäranta, On the structure and mechanics of pack ice in the Bothnian Bay, Finnish Marine Research 248 (1981), pp. 3–86