

Sea ice in the Baltic Sea during 1993/94–2020/21 ice seasons from satellite observations and model reanalysis

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General comments

In this paper the authors investigated the sea ice characteristics of the Baltic Sea using Copernicus satellite and model reanalysis data products. Primary focus was on assessing the performance of the model reanalysis product in estimating ice season evolution compared to the satellite dataset. The specific objectives as stated by the authors were (a) finding the sea ice fraction threshold to bias correct the model reanalysis dataset for Sea Ice extent (SIE) and comparing ice thickness statistics between the model and SAR & ice charts–based datasets; (b) comparing Baltic Sea reanalysis product’s sea ice season evolution characteristics with satellite dataset; (c) analyzing the characteristics and changes of ice extent and thickness in during 1993/94–2020/21; (d) providing trend analysis of the sea ice season parameters and sea ice thickness. It was found that a sea ice fraction threshold of 0.20 for the model dataset provides the most optimal match against the satellite data 0.15 threshold, minimizing bias and root mean square error for the temporal evolution of sea ice extent over the study period. The model estimates an earlier start to the ice season, but it generally matches satellite data regarding the season’s end. It was found that the model tends to overestimate ice thickness compared to ice chart-based data. Across the Baltic Sea, declining trends for the sea ice were observed. The sea ice characteristics during the recent period (2007-2021) compared to preceding one (1993-2007) show decreased sea ice fraction and thickness. The decrease in the sea ice thickness was over 50 % in some areas during the melting phase (March to May). In general, there was uniform pattern towards shorter ice seasons, reduced sea ice extent (SIE) and reduced mean ice thickness.

While methodology and results in the paper are properly presented and discussed, I have some questions and remarks on the used datasets and some other major comments below. Satellite data sea ice fraction was taken Copernicus SST product. According to product documentation this sea ice fraction comes from the ice chart in which it based on manual analysis. Thus, sea ice fraction does not come from any automatic algorithm, which must mentioned in the paper.

Sea ice thickness seems to be taken from Copernicus Marine Baltic Sea–Sea Ice Concentration and Thickness Charts product dataset with product id SEAICE_BAL_SEAICE_L4_NRT_OBSERVATIONS_011_004. This dataset is the manual ice chart, and ice thickness is level ice thickness, and that is why you likely observed model overestimating ice thickness; more off-shore than near the coasts where there is level landfast ice. You refer ice thickness as the SAR & ice chart based product, but ice thickness in the ice chart is based on in-situ data from coastal stations and icebreakers. Or is there an error in the text and you in reality use Baltic Sea - SAR Sea Ice Thickness and Drift, Multisensor Sea Ice Concentration product which has sea ice thickness dataset where ice thickness from the ice chart is spatially enhanced using SAR imagery?

Section 4 should be under Section 5 ‘Results’, and Section 5 could start with short introduction of the section contents.

The sea ice fraction threshold for calculating sea ice extent from the model data was tuned against the satellite data SIE. How do you know here that the satellite data SIE is more accurate than the model SIE? Possible that satellite data needs bias correction not model data?

In Section 4.2 explain how corrected ice thickness was calculated, diving by 1.814?

How results of the trend analysis would change if you use different time intervals, e.g. five or ten years?

Paper by Ronkainen et al. “Interannual sea ice thickness variability in the Bay of Bothnia”, *The Cryosphere*, 12, 3459–3476, 2018, may have results relevant to your study.

Specific comments

line 7: “recent period (2007–2021)”

Definition of this recent period here is vague without defining what is the preceding period.

Figure 1 is not introduced and discussed in Section 1. Same color is used for Bothnian Sea and Danish Straits.

l. 28: BACC II Author Team, 2015

This reference is missing from reference list.

Discussion on Baltic Sea ice in Introduction could include some figures on typical thickness of level ice and thickness of ridges.

l. 42: “Remote sensing techniques have evolved to enhance the efficacy of ice information services”

Include here some newer references, e.g. papers by Karvonen et al.

l. 55: ice state over previous model products (QUID_REAN).

Explain QUID_REAN, or give reference.

l. 71: spell out SMHI and FMI when first time used.

l. 80: “The system is forced by ECMWF ERA5 meteorology (ref).”

give reference

l. 123: “the dataset (the lm function from R)”

explain this lm function from R

l. 131: “The quality information document (QUID) ...”

Give reference for the QUID document, it is not Karvonen et al. 2007.

Figure 3 is introduced in the text after Figure 4.

Figure 8: very difficult to see black contour lines.

Table 3: maybe SIT data with 0.1 cm accuracy