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An effect of mesoscale and submesoscale eddies on sea ice processes in the Marginal Ice Zone

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The early study of eddy properties in the Marginal Ice Zone (MIZ) and of their influence on the ice regime in the Greenland Sea, based on the results of the MIZEX project (Johannessen et al., 1987), revealed that eddies may capture and transport a significant amount of ice, enhancing its ablation. Estimates suggest that eddies may provoke the ice edge retreat as fast as 1–2 km per day during summer. However, up to present, the mesoscale dynamics in polar regions, as well as the effect of eddies on ice edge ablation are poorly understood. This is due to sparse in situ observations and to an insufficient spatial resolution of numerical models, typically not resolving the mesoscale processes due to a relatively small Rossby deformation radius in polar regions.
This study aims to better understand the ways eddies affect the sea ice edge and their relative effect on the MIZ position in the East Greenland Current (75-78°N and 20°W-10°E). Pronounced local water temperature gradients and the importance of thermodynamics ablation in the ice dynamics in the Greenland Sea, derived in previous studies (Selyuzhenok et al., 2020), suggest a possibly strong eddy effect on the MIZ. This effect was noted in several case studies, when eddies were observed to trap and transport a significant amount of ice away from the MIZ (see, for example, von Appen et al., 2018).
We base our results on the output of the very high-resolution Finite Element Sea ice-Ocean Model (FESOM), tested against the remote sensing observations from ENVISAT. We investigate only the warm period of 2007, when ice is actively melting and during which period a data on eddies, detected in SAR data, is available. Comparison of the location and dynamics of the ice edge in FESOM, AMSR-E-based ice concentration products and ENVISAT ASAR data, as well as of eddy properties in FESOM and in SAR satellite images, suggest that the model is in good agreement with the observations and can be used to study mesoscale dynamics of the MIZ in the region.
The analysis showed that eddies affect the ice edge position through an enhanced horizontal exchange across the MIZ. The sea-ice is trapped by eddies and transported east, in the area of a warmer water, while the warmer water is entrained by eddies and transported west, towards the MIZ. Both effects contribute to the accelerated sea ice melt and destruction. The highest temperature gradients, as well as the largest concentration of eddies in the MIZ were detected in

the northern part of the study area, adjacent to the Fram Strait. Here eddies were found to play a particular important role in the MIZ dynamics.

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