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On the ability of OMIP models to simulate the seasonal cycle of the ocean mixed layer depth in pan-Arctic Seas

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In this study, we assess the ability of the ocean-sea ice general circulation models that participated in the Ocean Model Intercomparison Project (OMIP) to simulate the seasonal cycle of the ocean mixed layer depth in pan-Arctic seas. We focus on the central Arctic Ocean, Beaufort, Chukchi, East Siberian, Laptev, Kara, and Barents Seas. All models underestimate the mixed layer depth by about 15m on average during summertime compared to the MIMOC (Monthly Isopycnal/Mixed layer Ocean Climatology) observational data. In fall and winter, differences of several tens of meters are noticed between the models themselves, and between the models and the observational data. Some models generate too deep mixed layers, while others produce too shallow mixed layers. The magnitude of these inter-model variations differs depending on the sea under consideration.

In almost all the seas, OMIP models with similar ocean stratification compared to MIMOC observational data display the best mixed layer depth at the end of the winter. Furthermore, all models simulate more or less the same sea ice mass balance and thus salt flux into the ocean during sea ice freezing. We argue that the discrepancies between models are not so much linked to the surface salt balance but rather to the accuracy with which those models reproduce the ocean stratification. To substantiate this behavior, we apply a simple conceptual model, which simulates the fall/winter month-to-month evolution of the mixed layer depth in ice-covered regions. In almost fully sea ice-covered regions such as the central Arctic Ocean, Beaufort, and Chukchi Seas, this simplified dynamics captures very well the behavior of the general circulation models, and this highlights that the main difference between the models is the ocean stratification. At the same time, in the East Siberian, Laptev, and Kara Seas, inter-model variations are not explained by the differences in ocean stratification, even though they contain a significant concentration of sea ice. In not fully sea ice-covered regions, such as the Barents Sea, the mixed layer depth dynamics is different: the retreat of the ice cover during summer is more significant than in fully covered regions, hence favoring exchanges with the atmosphere.