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Analysis of Vertical Dynamics in the Northern Baltic Sea based on 3D Modelling and Data from Shallow-Water Argo Floats

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Vertical mixing is a challenge for ocean models. 3D hydrodynamic models often produce considerable errors in mixed layer depths and vertical temperature structure that can be related to the vertical turbulence parameterisation. These errors can be pronounced in areas with complex hydrography. In the Baltic Sea, for example, there are high horizontal and vertical salinity gradients. Furthermore, thermocline and halocline are located at different depths. This produces stratification conditions challenging for all ocean models.

We studied vertical mixing with modelling experiments and new observational data. NEMO 3D ocean model has been set up at Finnish Meteorological Institute (FMI) for the Baltic Sea, based on the NEMO Nordic configuration. The model has been discretized on a Baltic Sea - North Sea grid with 2 nautical mile resolution and 56 vertical layers, using FMI-HIRLAM atmospheric forcing.

The observational data for Baltic Sea off-shore areas is sparse and new methods are needed to collect data for model validation and development. FMI has been testing Argo floats in the Baltic Sea since 2011 in order to increase the amount of observed vertical profiles of salinity and temperature. This is the first time Argo floats have been successfully used in the brackish, shallow waters of the Baltic Sea. This new data set is well suited for evaluating the capability of hydrodynamic models to produce the vertical structure of temperature. It provides a time series of profiles from the area of interest with good temporal resolution, showing the structure of temperature in the water column throughout the summer.

We found that NEMO was able to reproduce the general features of the seasonal temperature variations in the study area, when meteorological forcing was accurate. We ran the model with different vertical turbulence parameterisations. The k-ϵ and k-ω schemes showed clear differences, but neither proved superior. While sea surface temperature was better simulated with the k-ω scheme, thermocline depth was better with the k-ϵ scheme. Further tuning of the mixing parameterisations for the Baltic Sea is needed to better simulate the vertical temperature structure. We found the autonomous Baltic Sea Argo floats valuable for model validation and performance evaluation.