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TITLE: Stratification Has Strengthened in the Baltic Sea ? An Analysis of 35 Years of Observational Data

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ABSTRACT:

Stratification of the water column, consisting of the three layers (upper, intermediate, and deep layer), is an important factor for the functioning of the brackish Baltic Sea. In the present work, changes in the vertical structure of temperature and salinity, as well as heat content, salt mass and stratification conditions were estimated on the basis of in-situ and remote sensing data in 1982-2016. The seasonal thermocline and the halocline have strengthened in most of the sea by a rate of 0.33 ? 0.39 kg m-3 and 0.70 ? 0.88 kg m-3, respectively, during 35 years. The upper layer has warmed by 0.03 ? 0.06 °C year-1 and sub-halocline deep layer 0.04 ? 0.06 °C year-1 in most of the sea. The total warming trend in the whole Baltic has been 1.07 °C for 35 years, being approximately twice higher compared to the upper 100 m in the Atlantic Ocean. Average upper layer warming of the sea from May to September has been 0.07 ? 0.08 °C year-1 while in winter, trends were mostly statistically not significant. More rapid warming during summers has occurred in shallower, closed-end areas of gulfs. Possible reasons for high warming there might be shallow depths and limited water exchange, stronger stratification, and/or higher turbidity. Sea surface temperature trends estimated by in-situ and satellite data agree well. Trends of freshening (-0.005 to -0.014 g kg-1 year-1) of the upper layer and increasing salinity (0.02 to 0.04 g kg-1 year-1) in the sub-halocline deep layer were detected. Increased salinity in the deep layer is likely caused by the increased lateral import of saltier water from the North Sea. Changes in the upper layer salinity might not be related to the accumulated river runoff only, but decadal changes of vertical salt flux might also contribute. The vertically distinct changes cancel each other and no significant trend in the mean salinity of the Baltic Sea was detected. No remarkable changes have occurred in the cold intermediate layer. In conclusion, different dominating processes have caused distinct long-term trends in the three layers of the Baltic Sea.

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