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Decadal trends in simulated oxygen dynamics and hypoxia in the Baltic Sea

S. Miladinova, A. K. Stips, and G. Lessin
Joint Research Centre, Water Resources Unit, Italy (adolf.stips@jrc.ec.europa.eu)

Over the last century hypoxia is increasing in large parts of the Baltic Sea. Inflowing salt water brings new supplies of oxygen to the bottom water however is at the same time enhancing stratification and thereby creating favourable conditions for hypoxia. Moreover, it is the increased flux of organic material to the bottom water and sediments due to nutrient enrichment, which has disrupted the balance between oxygen supply through physical processes and oxygen consumption from decomposition of organic material. The aim of the present work is to explore the oxygen availability in the Baltic Sea on the base of the 3D numerical model GETM (General Estuarine Transport Model, http://getm.eu). The model is implemented for the whole Baltic Sea including the Kattegat and is forced with realistic sea-level and meteorological data. The simulated time period covers the years from 1960 until the end of 2010. The oxygen removal is assumed to be independent of the content of oxygen in the Baltic Sea and has been simply parameterized. Despite the simplistic approach taken for describing oxygen, the modelled oxygen concentrations agree well with independent observational data. This implies that the realistic modelling of the long term evolution of oxygen is requiring an accurate description of the physical circulation. The adequate accordance between simulations and data indicates that the time evolution of surface oxygen is mainly determined by the gas exchange at the surface. We find that bottom oxygen in the Kattegat is mainly controlled by the oxygen saturation. In the Baltic Proper however long-term inflow variations determine the bottom oxygen concentration. For example, in the Bornholm Basin the increase of the near bottom oxygen usually corresponds to a sudden increase in salinity due to an inflow whereas the oxygen dynamics in the deep waters of the Gulf of Finland has a seasonal behaviour. We confirmed that the major factors controlling the oxygen dynamics in the Baltic Sea are natural physical factors, like the magnitude of the vertical turbulent mixing, wind speed and the variation in temperature and salinity.
Thorough statistical evaluation of the time series for anoxic and hypoxic areas in the Baltic Sea resulted in overall non-significant increasing trends during the last 50 years. Contrary to the non-conclusive trend evaluation the time series have a significant structural break point (changing from negative to positive trend) at about 1975-1980.