Geophysical Research Abstracts
Vol. 13, EGU2011-1931, 2011
EGU General Assembly 2011

Modelling of salinity and temperature variation in the Baltic Sea during the last two decades

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Various investigations have been made to estimate the impact of the inflow events on the physical, chemical, and biological status of the Baltic Sea. The present study is an attempt to perform realistic model simulations of the Baltic Sea in order to quantify temperature and salinity variations in different Baltic Sea Basins as a consequence of inflow events with different extent and origin. The used 3D hydrodynamic model is the General Estuarine Transport Model (GETM) (http://getm.eu) code which is implemented for the whole Baltic Sea including the Kattegat. Hourly sea level data is prescribed at the open boundary (57.74 N). The sea level is reconstructed from gauge data in the Kattegat (http://www.dmi.dk/dmi/tr07-09 and http://www.ioc-sealevelmonitoring.org/). The simulated time period covers the years from 1989 until 2009. Model bathymetry is based on realistic bottom topography data of the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) (http://www.io-warnemuende.de/topography-of-the-baltic-sea.html). Adaptive terrain-following vertical coordinates are applied to reduce pressure gradient errors and numerical mixing. Temperature and salinity initial conditions are interpolated from monthly climatology while boundary conditions are estimated from the observation data of the Baltic Environmental Database (BED) (http://nest.su.se/bed). Simulations are forced with surface meteorology from the ECWMF Interim Reanalysis Project ERAINT (http://www.ecmwf.int/). Also the freshwater inflow of 42 rivers of the Baltic catchment area is considered (data is collected from different sources). Therefore, free public numerical code and data are used to describe the physical conditions of the Baltic Sea during last two decades. During the whole integration period neither relaxations towards observations nor temperature and salinity nudging are utilized.

Simulation results are scrutinized against observational data of BED and IOW for the basins of the Baltic Sea which are mostly affected by the inflow events. The computed time series is consistent with observed variation in salinity and temperature. However, the simulated seasonal variation of salinity and temperature is more pronounced than in the data. This is partially due to the lack of regular observations and model limitations. The timing and the size of the inflow events have been simulated with acceptable accuracy. The occasional decrease/increase of the near-bottom temperature due to the winter/summer inflow events is well represented. Based on the model results details of the effect of exceptional inflow events on the dense bottom currents in Arkona, Bornholm and Gotland Basins are analysed. Simulations show that all types of inflow events are important for the ventilation of the intermediate and deep Baltic waters.

The model predicts an increase in the surface temperature during the last decade in the central Baltic Sea. Soon after the major barotropic inflow in 2003 leading to a significant drop in the bottom temperature, near bottom temperatures have found to exceed the long term mean values as a consequence of more frequent baroclinic inflow events. The formation of mesoscale eddies in the Baltic Sea and their role in deepwater mixing are discussed.