Modelling of water circulation and thermohaline variability in the Southern Baltic by the Princeton Ocean Model

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Abstract

Results of numerical experiments with an application of the Princeton Ocean Model - code (cf. Blumberg and Mellor, 1987; Mellor, 1993) to investigate circulation and variability of thermohaline fields in the Southern Baltic Sea are presented.

POM is based on a standard formulation of the conservation equations for momentum and mass, utilizing the hydrostatic and the Boussinesq approximation. The model uses Smagorinsky (1963) parameterization for the horizontal mixing (turbulent exchange). To calculate the vertical eddy viscosity and diffusion coefficients a second turbulence closure scheme (Mellor and Yamada, 1974; 1982) is applied.

The model domain (8 ^{o} 50' E - 30 ^{o} 00' E; 53 ^{o} 50' N - 65 ^{o} 50') comprises the whole Baltic Sea with the Gulf of Bothnia, the Gulf of Finland and the Gulf of Riga as well as the Danish Straits and Kattegat and Skagerrak, simplified boundary conditions (radiation type) are applied. Bottom topography of the Baltic Sea used in the model is based on data from Seifert and Kayser (1995).

Two variants of horizonta model resolution are considered - with space step of 10 km and 5 km, respectively. Both model variants with vertical resolution of 24 σ - levels allow to simulate basic features of water movements and hydrology in the Baltic Sea.

Model is forced by realistic wind fields and by heat and salinity fluxes and/or climatological forcings. The river runoff rates are assumed as monthly means.

The three-dimensional fields of the seawater temperature T and its salinity S in August, constructed from the monthly mean (multi - year averaged, climatic) maps presented in Bock's (1971) and Lenz's (1971) atlases, were used in the model runs as initial fields of T, S and as climatological forcings.

The climatological forcings were coupled to the model by means of the so-called method of 'relaxtion towards climatology' (Oey and Chen 1992, Lehmann 1995, Svendsen et al. 1996).

Wind field is estimated from atmospheric surface pressure charts and surface heat fluxes at the sea surface are calculated with standard bulk formulae.

In order to test the capabilities of the model to simulate the characteristic hydrographic features of the the Baltic Sea, the prognostic hindcast calculations were performed for PIDCAP'95 - period.

Model runs, starting with climatological montly means of temperature and salinity were carried out for the period of August to October 1995. For this simulation the model was forced with 3-hourly atmospheric data (pressure, air temperature, specific humidity and the wind - field) derived from the Europa Modell of DWD (supplied by Dr. A. Lehmann from IfM in Kiel).

A comparison of computed and measured temperature and salinity shows (cf. Fig. 1) that the model reproduces the vertical structure of seawater temperature and salinity in a good agreement to the in situ observations. The discrepancy (mean value in the vertical profile) between the calculated and observwd temperature and salinity was equal to 1-2 ^{o} C and 1-2 psu, depending on location of the hydrographic station.

Next prognostic hindcast was performed for September 1989, when an intensive upwelling in some regions along the southern coast of the Baltic was well documented by Malicki and Mietus (1994).

In these calculations model was forced by realistic wind fields estimated from atmospheric surface pressure charts taken from (BED, 2000) and by climatological forcings.

Time evolution of the calculated seawater temperature in surface layer reproduced well time history of observed surface temperature at Kolobrzeg and Wladyslawowo measuring stations.

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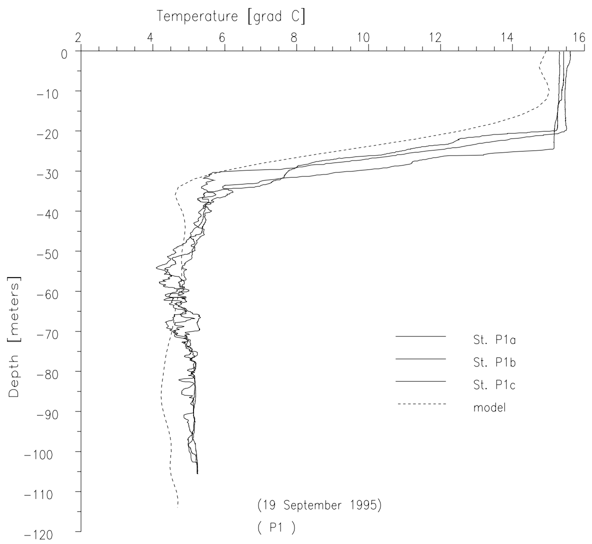

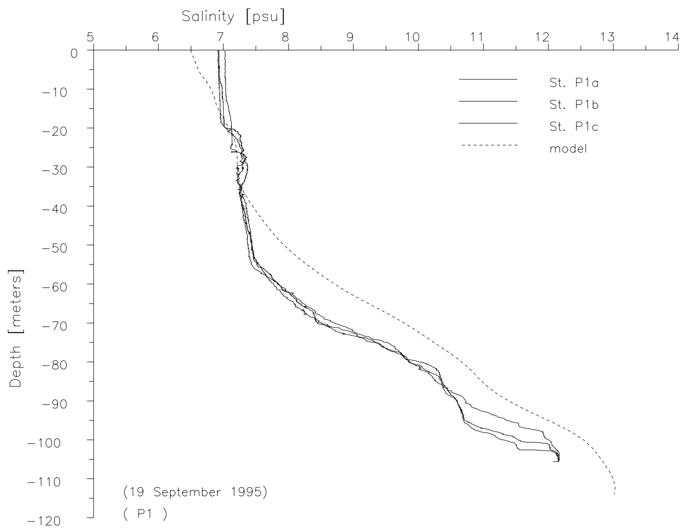

Figure 1. Calculated and measured profiles of sea water temperature (left figure) and salinity (right figure) in vicinity of hydrographic station P1 (Gdańsk Deep)