Geophysical Research Abstracts
Vol. 16, EGU2014-1174, 2014
EGU General Assembly 2014

Numerical simulation of inter-annual variations in the properties of the upper mixed layer in the Black Sea over the last 34 years

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The Black Sea is a nearly land-locked basin where a combination of salt and heat budgets results in a unique thermohaline water mass structure. An important feature of the Black Sea is that oxygen is dissolved and rich sea life made possible only in the upper water levels. This is due to a strong pycnocline which cannot be mixed even by strong winds or winter convection (Shapiro, 2008). The upper mixed layer (UML) with a nearly uniform temperature profile and a very sharp seasonal thermocline at its lower boundary develops during the summer season (Sur & Ilyin, 1997). The deepening of the UML has an important effect on the supply of nutrients into the euphotic upper layer from the underlying nutrient-rich water mass. The temperature of the UML at any given location is dependent on the surface heat flux, horizontal advection of heat, the depth and the rate of deepening of the UML.

In this study we use a 3D ocean circulation model, NEMO-SHELF (O'Dea et al, 2012) to simulate the parameters of the UML in the Black Sea over the last 34 years. The model has horizontal resolution of $1/12 \times 1/16$ degrees and 33 layers in the vertical. The vertical discretization uses a hybrid enveloped s-z grid developed in Shapiro et al. (2012). The model is spun up from climatology (Suvorov et al., 2004); it is forced by the Drakkar Forcing Set v5.2 (Brodeau et al., 2010, Meinvielle et al., 2013) and river discharges from 8 major rivers are included. For each year the model is run from 1st January and the data for the period April to October are used for analysis. The sea surface temperature produced by the model is compared with satellite data (Modis–Aqua, 2013) to show a good agreement. The model simulations are validated against in-situ observations (BSERP-3, 2004; Piotukh et al., 2011). The analysis is performed for the deep basin where the depth of the sea is greater than 1000m. It clearly shows the inter-annual variations of both the SST and the depth of UML. The depth of UML is calculated using the method by Thomson (1976). It is highly dependent on the meteorological forcing, in particular the wind speed. The correlation between the variations of parameters of UML, the weather patterns, buoyancy fluxes and the kinetic energy of the UML circulation is analysed.

This study was supported by EU FP7 PERSEUS and EU FP7 MyOcean2 projects.

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