The Black Sea Nowcasting and Forecasting System Development

Petr N. Mikheev

Hydrometeorological Research Center of the Russian Federation,
Bol. Predtechesky per., 11-13, 123242 Moscow, Russia
E-mail: pmikheev@gmail.com

The Black Sea is a unique nearly landlocked sea basin characterized by strong density stratification. As a result of it, the permanent deep-water anoxic layer occupies 87% of the Black Sea volume. Human-induced changes in the Black Sea environment create an acute need for a research and development program designed to study different aspects of nonequilibrium ecosystems of the sea through a wide cooperation of the Black Sea countries in the field of observations, modeling, and analysis of sea variables.

The European Union funded project "A Regional Capacity Building and Networking Programmer to Upgrade Monitoring and Forecasting Activity in the Black Sea Basin" (ARENA) is one of such cooperative programs aiming at regional capacity building in close collaboration with regional and other relevant organizations. In the context of this project at the Hydrometcenter of Russia, Princeton Ocean Model (Mellor, 2003) and its version ECOMSED (Blumberg, 1996) are used for the extensive calculations of the Black Sea water circulation, temperature and salinity. Princeton Ocean Model (POM) is a sigma coordinate, free surface, primitive equation ocean model, which includes a turbulence sub-model developed in the late 1970's by Blumberg and Mellor, with subsequent contributions from other people (Mellor and Yamada, 1982). POM uses an orthogonal curvilinear coordinate system, which greatly increases model efficiency in treating irregularly shaped coastlines and in meeting requirements for high resolution at desired locations. The model has been successfully used in modeling estuaries, coastal regions, and open oceans. The latest version of POM is the ECOMSED model including three main sub-models. These are hydrodynamic module, sediment transport module, and wind induced wave module. The sediment transport module is of great importance in modeling water ecosystems.

Research in 2005 was focused on the adaptation of the models (POM and ECOMSED) to the Black Sea, upgrading of the computational model grids to high resolution, and near-real time data assimilation. The entire system can be separated into four main components: (1) the model's module; (2) the generation of the computational grids; (3) the generation of the temperature and salinity fields (initial conditions); (4) the atmospheric forcing (boundary conditions).

Fine grids are required for the Black Sea hydrodynamic model applications even if the computational time may greatly increase. The generation of the computational grids using the computer graphics methods is an example of such module (Mikheev, 2005). Grid cells are determined by the boundaries and by the number of grid junctions along each latitude and longitude. The land-sea mask taking into account the irregularly shaped coastline is produced by the Weiler and Atherton algorithm (Weiler and Atherton, 1977). Then the 2-Minute Gridded Global Relief Data (ETOPO2, Boulder World Data Center for Marine Geology & Geophysics) are interpolated into this grid. The longitudinal and latitudinal resolution varies between 6 and 14 km, thus, better describing the Black Sea coastline. The maximum model depth is 2200 m and there are 31 vertical sigma levels.

The module of the generation of initial conditions uses the MEDAR/MEDATLAS temperature and salinity annual and monthly distributions interpolated at 25 horizontal levels and objectively analyzed to produce grided climatological fields. The goal of the MEDAR/MEDATLAS II project is to rescue, safeguard, and make available a comprehensive data set of oceanographic parameters collected in the Mediterranean and Black Sea through a wide cooperation of the Mediterranean and Black Sea countries. The atmospheric forcing is based on the analyses received daily from the Global medium-range weather forecast model developed in the Hydrometcenter of Russia or from the National Center for Environmental Prediction (NCEP), Washington.

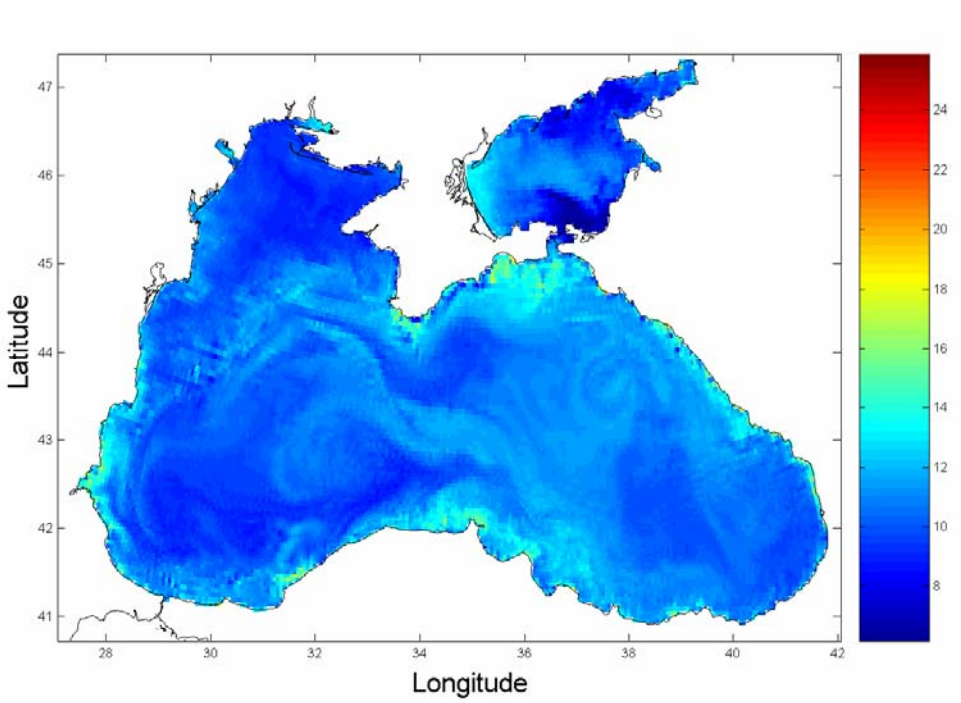

Figure 1. An example of model results: sea surface temperature distribution for February.

The model capacity to represent specific Black Sea physical properties (cyclonic Rim current, presence of the permanent cold intermediate layer in the temperature field, seasonal intensification of the cyclonic circulation) is shown by the comparison of model results with satellite and observational data and with published results from other models for the Black Sea area with similar configuration. Figure 1 shows the February temperature distribution obtained with our configuration of POM.

It is planned to advance this system in the nearest future. Until present, the interconnected Black Sea - Mediterranean Sea basin systems has been poorly addressed in numerical model studies. The exchange flows between the seas are not well studied yet. Many questions exist about the impact of the Kerch and Bosphor Straits on physical characteristics of the Black Sea. There are great uncertainties in values of the horizontal and vertical eddy viscosity and vertical diffusivity coefficients. We are going to investigate these questions in our further studies. It is planned to compare the modeling results with the altimeter data in order to improve the monitoring of the Black sea circulation. This prototype of the Black Sea nowcasting and forecasting system is regarded as a first stage to further develop the Black Sea operational marine forecasting and research system at the Hydrometcenter of Russia.

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