HIGH-RESOLUTION SIMULATION OF THE BLACK SEA DYNAMICS USING NEMO MODELING FRAMEWORK

Artem I. Mizyuk [1]*, Maxim V. Senderov [1] and Gennady K. Korotaev [1]
[1] Federal State Budget Scientific Institution, Marine Hydrophysical Institute of RAS, Sevastopol, Russia - artem.mizyuk@gmail.com

Abstract

High-resolution numerical modeling of the Black Sea circulation is carried out using parallel version of NEMO (Nucleus for European Modeling of the Ocean). Spatial variability of temperature reconstructed for 2005 – 2008 is analysed.

Keywords: Black Sea, Models, Mesoscale phenomena

During last two decades a large number of numerical ocean models were implemented for reconstruction of the Black Sea dynamics, e.g. [1 – 3]. Their simulations showed rather similar syn optical structures of general circulation, like RIM current and the main anticyclonic eddies. Recently studies of mesoscale phenomena in the ocean and seas became to be popular. They are carried out widely now due to availability of high performance computing. In the sense semi-enclosed shape of basin and relatively small sizes of the calculation domain make the Black Sea a good test bed for tuning the model physics to reproduce meso- and even submesoscale variability. High-resolution modeling is important for continuous development of the Black Sea Marine Forecasting System (BS MFC), which is still operating and remains the only one providing forecasting products for the region. The present study is an extension of previous works [4] aimed on implementation of NEMO modeling framework [5] in BS MFC. Two model setups with spatial resolutions 5 km (high) and 2.5 km (ultra-high) are used to study the effect of the calculation domain grid refinement. Simulations for both resolutions are produced using Moscow State University mainframe. Applying of the finer model grid allowed to obtain qualitatively new structure of the Black Sea circulation (figure 1, b, c), comparing to results reconstructed on a coarser grid (figure 1, a) which are rather smooth.

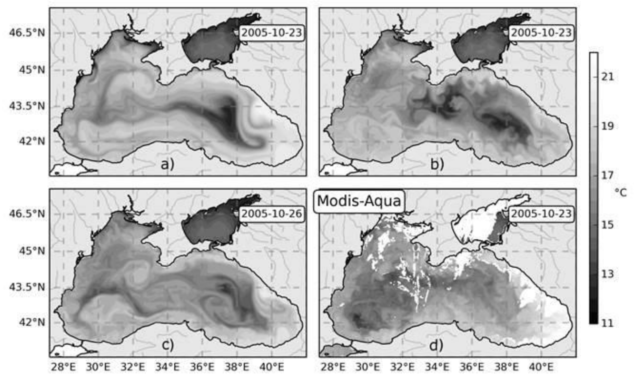

Fig. 1. Sea surface temperature (ºC): in simulations a) – with high-resolution model grid, b, c) – ultrahigh-resolution model grid; d) – from satellite (MODIS/Aqua).

Several model runs were carried out for ultra-high resolution making an attempt to reproduce spatial variability similar to high-resolution sea surface temperature derived from satellite images (figure 1, d). Analysis of the dynamics reproduced in ultra-high resolution simulations allowed to choose acceptable values of model lateral mixing. To compare simulated and observed spatial variability lagged correlation functions and spatial spectra are usually analysed. Analysis of spatial spectra from imagery is rather complicated due to inhomogeneity of observations (e.g., figure 1, d). In this work a product from Copernicus based on optimal interpolation of satellite images (OI SST) is also used for inter-comparison. Spatial horizontal scales obtained from modeling results and observations are rather close (comparing zero-crossing position).

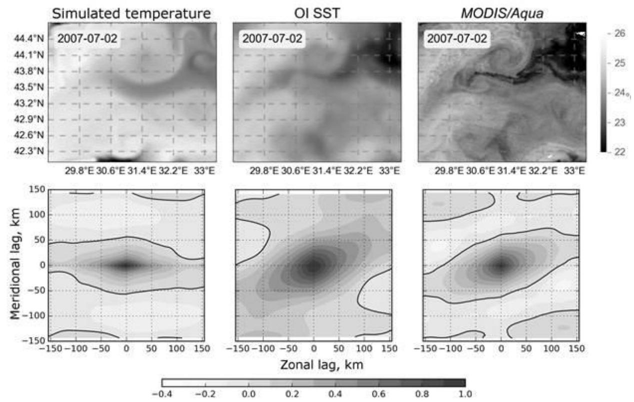

Fig. 2. Sea surface temperature (ºC) of the Black Sea western part (top) and corresponding lagged correlation functions (bottom) from simulation, MODIS/Aqua and OI SST.

Estimation of the spatial spectra slope for the reconstructed surface temperature showed values around 5, which is quite close to the theory of turbulent spectra of the upper ocean temperature [6]. The research leading to this results has received funding from Russian Science Foundation (project No. 15-17-20020).

References

1 - Demyshev S.G. and Korotaev G.K., 1992: C-grid numerical energy-balanced model of the baroclynic currents with rough bottom. In: Numerical models and results of calibration calculations of currents in the Atlantic Ocean circulation. (IVM RAN, Moscow, 1992), p. 163 – 231 (in Russian).
2 - Staneva J.V., Dietrich E.D., Stanev E.V., Bowman M.J., 2001: Rim current and coastal eddy mechanisms in an eddy-resolving Black Sea general circulation model. Journal of Marine Systems, 31, p. 137 – 157.
3 - Kubryakov A.I., 2004: Implementation of the nested grids for the monitoring system of the hydrophysical fields in the Black Sea coastal regions. Ecological safety of coastal and shelf zone and complex use of their resources (Marine Hydrophysical Institute, Sevastopol, Vol. 11, 2004), p. 31 – 50 (in Russian).
4 - Demyshev S., Knysh V., Korotaev G., Kubryakov A., Mizyuk A., 2010: The MyOcean Black Sea from a scientific point of view. Mercator Ocean Quarterly Newsletter, No. 39. p.16 – 24.
5 - Madec G. 2008: NEMO reference manual, ocean dynamics component // Note du pôle de modélisation, IPSL, France N°27 ISSN N. p.1288 – 1619.
6 - Saunders P. M., 1972: Space and time variability of temperature in the upper ocean. Deep-Sea Research, 19, p. 467 – 480.