Seasonal and interannual variability of the Black Sea circulation
Numerical modelling

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Deep and intermediate waters in the Black Sea are strongly influenced by the variability in the Bosphorus an rivers inflow, buoyancy fluxes at the sea surface and the momentum flux. The analysis of meteorological data illustrates their seasonality and the strong interannual signals. The response of the sea to the forcing changes includes variations in the intensity of the general circulation, formation of quasi permanent sub basin gyres and changes in the total heat content in the cold intermediate layer. Major physical problems are the interplay between the large variety of forcing factors, the mechanisms of the formation of vertical stratification and the energetics. The lack of experimental data motivates us to try to understand how the Black Sea works using numerical models with improved forcing. So far the numerical models are forced with climatic annual mean or seasonally varying boundary conditions. Such forcing functions do not include enough variations in the atmospheric signal. Its amplitude is drastically reduced which could result in underestimation of the sea response to the atmospheric signal. In the present work we address the problem of the role of high frequency variability for the ocean circulation on the example of the Black Sea model.

The numerical model used in this study is the well known GFDL Princeton Ocean General Circulation Model (OGCM). Horizontal resolution is $\Delta\lambda = 1/3° \ \Delta\varnothing = 1/4°$. The vertical structure is approximated using 11 levels with vertical resolution varying from 20 m in the surface layer to 980m in the deepest part of the basin. Bottom relief and coastal line are specified from bathymetric map in the horizontal grid points.

The model is initialized with annual mean temperatures and salinity. Small area including the Strait of Bosphorus is relaxed to the climatology in order to maintain the exchange with the Mediterranean Sea. After the model fields adjust to the initial forcing and topography the integration continues with time variable forcing.

Forcing functions are calculated in the model from the NMC 12 hours atmospheric analysis including air temperature, humidity and winds at the sea surface. Sea surface salinity is relaxed to monthly mean data. All forcing functions are interpolated linearly at each time step. The model is run for 9 years and the analysis of the simulated results is presented in this paper. The emphasis is given to the processes which form the sea surface heat fluxes, intermediate water formation, variability of the circulation patterns and to the net role of the short period atmospheric variability for the general circulation. The comparison of the simulated results obtained for each year manifests the fundamental role of the interannual atmospheric variability for the Black Sea circulation.