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Mediterranean and Black Sea tidally forced ocean model: investigation of nonlinear effects of tides on the basin circulation

Maria Vittoria Struglia, Andrea Bargagli, Adriana Carillo, Roberto Iacono, Ernesto Napolitano, Massimiliano Palma, Giovanna Pisacane, and Gianmaria Sannino

ENEA, SSPT-MET-CLIM, Rome, Italy (mariavittoria.struglia@enea.it)

A high-resolution forecasting model of the circulation of the Mediterranean Sea-Black Sea system has been developed, which includes the effects of the main diurnal and semidiurnal astronomical tides. The model, based on the Massachusetts Institute of Technology general circulation model, has a uniform horizontal resolution of 1/48° (about 2 km) over most of the domain, except in the Straits of Gibraltar, Dardanelles and Bosphorus, where resolution is further increased, up to few hundred meters, to correctly resolve the local dynamics.

The tidal dynamics of the model has been validated through comparison with the results of a tidal inversion software, with reference experimental data, and with tide gauge measurements. A first validation of the model circulation and hydrology has then been performed, comparing the results of a 40 days run (19 March-30 April 2018) with available in situ and satellite observations. After one month of simulation, during which no assimilation or relaxation was applied, the model circulation and the sea surface temperature distribution were still found to be in good agreement with the observations, proving the capability of the model to follow the evolution of the system in a period - beginning of spring -characterized by complex dynamics and significant changes in the surface heat fluxes. Tides have been found to induce an important modulation of the transport not only across the Strait of Gibraltar and the Sicily Channel, as expected, but also across the Corsica Channel and the Otranto Strait. Tidal effects also appear to modify relevant features of local circulation inside the basin; an example is the diurnal rotation of the flow patterns found over some shallow bathymetric features, such as the Adventure Bank, in the Sicily Channel. Spectral analysis of the mean kinetic energy in the Sicily and Corsica Channels has revealed the presence of spectral peaks corresponding to periods of about 8 and 6 hours, which can only be interpreted as harmonics of the diurnal and semidiurnal tidal components, generated through nonlinear interactions, questioning the widespread assumption that tidal effects in the Mediterranean can be linearly superimposed to the basin circulation.