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Implementation of Black Sea numerical model based on NEMO and 3DVAR data assimilation scheme for operational forecasting

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This study describes a new model implementation for the Black Sea, which uses data assimilation, towards operational forecasting, based on NEMO (Nucleus for European Modelling of the Ocean, Madec et al., 2012).
The Black Sea domain is resolved with $1/27° \times 1/36°$ horizontal resolution ($\sim$3 km) and 31 z-levels with partial steps based on the GEBCO bathymetry data (Grayek et al., 2010). The model is forced by momentum, water and heat fluxes interactively computed by bulk formulae using high resolution atmospheric forcing provided by the European Centre for Medium-Range Forecast (ECMWF). The initial condition is calculated from long-term climatological temperature and salinity 3D fields. Precipitation field over the basin has been computed from the climatological GPCP rainfall monthly data (Adler et al., 2003; Huffman et al., 2009), while the evaporation is derived from the latent heat flux. The climatological monthly mean runoff of the major rivers in the Black Sea is computed using the hydrological dataset provided by SESAME project (Ludvig et al., 2009). The exchange with Mediterranean Sea through the Bosporus Straits is represented by a surface boundary condition taking into account the barotropic transport calculated to balance the fresh water fluxes on monthly bases (Stanev and Beckers, 1999, Peneva et al., 2001).
A multi-annual run 2011-2015 has been completed in order to describe the main characteristics of the Black Sea circulation dynamics and thermohaline structure and the numerical results have been validated using in-situ (ARGO) and satellite (SST, SLA) data.
The Black Sea model represents also the core of the new Black Sea Forecasting System, implemented at CMCC operationally since January 2016, which produces at daily frequency 10-day forecasts, 3-days analyses and 1-day simulation. Once a week, the system is run 15-day in the past in analysis mode to compute the new optimal initial condition for the forecast cycle. The assimilation is performed by a three-dimensional variational data assimilation system (3DVAR) that ingests all hydrographic profiles (mostly ARGO floats), sea level anomaly data from available altimetry missions and sea surface temperature measurements retrieved from infrared sensors on-board polar-orbiting satellites (Storto et al., 2014). All the data are taken from the CMEMS catalogue. The 3DVAR system implements a recursive filter to model horizontal correlations while vertical covariances are formulated through multivariate empirical orthogonal functions. The system produces hourly and daily means for temperature, salinity, currents and sea surface height with online validation against satellite observations for SST and in-situ ARGO measurements.

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