Improving the accuracy of the Black Sea Physics Analysis and Forecasting System in the framework of Copernicus Marine Service

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Abstract: This study will present the evolution of the Black Sea model physics in the framework of the Copernicus Marine Environment Monitoring Service, from EAS3 (current operational system) to EAS4 (operational from May 2021). Evolution in terms of modelling framework and prediction capacity will be detailed, describing the main results and skill score metrics.

Keywords: Black Sea, Numerical Ocean Modelling, Physics, Ocean Dynamics, Data Assimilation, Operational Forecasting

1. INTRODUCTION

The Black Sea Physics Near Real Time system (BS-PHY NRT) provides analysis and 10-days forecasts of the essential variables in the Black Sea basin. It is one of the components of the Black Sea Monitoring and Forecasting Centre (BS-MFC) which operates in the framework of the Copernicus Marine Environment Monitoring Service (CMEMS) since 2016.

In this contribution, we provide an overview about the main scientific numerical model upgrades of the Black Sea-PHYsics (BS-PHY) Near Real Time (NRT) system that achieved a higher product accuracy for analyses and forecasts. Modifications include the revision of the spatial domain and the horizontal and vertical resolution, the implementation of new open boundary conditions in the Marmara Sea and the improved representation of rivers and an upgraded data assimilation scheme.

2. THE BLACK SEA MODELING SYSTEM EVOLUTION

Reconstructing and predicting the Black Sea ocean state is a challenging objective that primarily concern the development of the numerical hydrodynamics to simulate the complex dynamics of this large estuarine basin. The current BS-PHY NRT system, herein referred as EAS3, is based on NEMO v3.4 (Madec et al., 2019) at 3 km horizontal resolution and 31 levels, online coupled to OceanVar (Dobricic and Pinardi, 2008; Storto et. al. 2011) scheme for the assimilation of insitu (T/S profiles) and satellite (SLA and SST) data. The model is characterized by a surface boundary condition at the Bosporus Strait, in terms of barotropic transport that is computed to balance the freshwater flux on monthly basis (Stanev and Beckers, 1999; Peneva et al. 2001). The main limitations of the current EAS3 system is the parametrization of the Bosporus Strait dynamics, and the parametrization of river inputs.

The new NRT system, so-called EAS4, has greatly improved the numerical model and the data assimilation system. The hydrodynamics core uses the new NEMO v4.0 (Madec et al., 2019), over the Black Sea basin including a portion of the Marmara Sea for the provision of the lateral open boundary conditions, following the results of Gunduz et al. 2020. The spatial grid is characterized by higher resolution in both horizontal and vertical (2.5 km and 121 z-star-levels, respectively). The new GEBCO bathymetry has been used together with a specific high resolution dataset for a better representation of the Marmara Sea box and the Bosporus Strait as in Gurses et al. (2016), Representation of the Danube River is improved by accounting for river branches - Chilia, Sulina and St. George - at their precise geographical locations are now specified and a new interannual historical monthly dataset was used to compute a new Danube runoff climatology. For the optimal interface between Mediterranean and Black Sea, a new high resolution unstructured grid-based model has been developed for the Marmara Sea (Ilicak et al., 2021), for the improved representation of Turkish Straits dynamics and to provide lateral open boundary conditions to the Black Sea through the Bosporus Strait. EAS4 is characterized also by a new implementation of OceanVar: it uses 45 empirical orthogonal functions (EOF) to describe the covariance of sea surface height and temperature and salinity in the water column, computed from a 10-year integration of the hydrodynamics model without assimilation.

3. QUALITY ASSESSMENT

The product quality framework is based on the standards from GODAE/OceanPredict and MERSEA/MyOcean (Hernandez et al., 2015): the EAS3 and EAS4 implement CLASS1-2-4 metrics in order to validate and verify the quality of the analysis and forecasting products. These standards are applied to both the analyses and to the misfits of temperature, salinity, sea surface temperature and sea surface height. Additionally, an independent validation is performed by comparing BS-PHY systems against mooring data (that are not assimilated) where available. A discussion about the main metrics and results will be provided in the extended abstract.

4. CONCLUSIONS

Within CMEMS, a new forecasting system, EAS4 is being developed - able to provide more accurate analysis and forecast products thanks to improvements in spatial resolution, boundary conditions and data assimilation improvements. It is based on a new numerical hydrodynamics model which is capable for the first time to better resolve the exchange with the Marmara Sea at the Bosporus Strait and the river runoff. The quality of the model and the products is strictly connected to the real time observing network and to larger computational resources available at CMCC.

Acknowledgements

This work was supported by CMEMS BS-MFC (Copernicus Marine Environment Monitoring Service – Black Sea Marine Forecasting Centre)

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