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Predicting the Black Sea state at weather and climate scales

The Black Sea is the largest euxinic basin in the world ocean. Oxygen is only present in the first 80-120 m and below that depth, the basin contains huge pools of hydrogen sulfide and ammonia. Since several decades, the equilibrium of the Black Sea vertical structure has been affected by eutrophication and warming with the progressive disappearance of the Cold Intermediate Layer and the rising of the main oxycline. These changes will potentially significantly affect the Black Sea physics, biogeochemical cycles and biology over the next decades

We use the BiogeochemicAl Model for Benthic and Hypoxic Influenced areas (BAMHBI), coupled to the hydrodynamic model NEMO and to the regional atmospheric model (MAR) to predict the Black Sea physical and biogeochemical state at weather and climate time scales.

The NEMO-BAMHBI-data assimilation prediction system is used to daily forecast the Black Sea biogeochemical state in the frame of the Black Sea marine forecasting center of the marine Copernicus service. Climate projections are also performed until the end of the century under two scenarios of changes (SSP1, SSP5). A trait-based distribution model based on neural network is developed to connect the environmental conditions predicted by NEMO-BAMHBI with benthic biodiversity and functions and to explain the Black Sea state recovery after eutrophication and hypoxia.

We also present results from a stochastic version of the NEMO-BAMHBI prediction system extended with a radiative transfer model to assimilate satellite reflectance. This ensemble version is obtained by considering the uncertainty on inherent optical properties. Satellite reflectance are then assimilated using an ensemble Kalman filter.

Finally, a model emulator based on deep learning (diffusion models) is tested as an economic alternative of the physical-law based NEMO BAMHBI model. In particular, we test the capacity of the AI- based model to simulate the oxygen state and bottom hypoxia when assimilating earth observations provided by satellites.