Monitoring and predicting coastal dynamics for management, conservation and restoration: the MER Italian high-resolution modeling system

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Abstract

Coastal areas are highly dynamic environments in which physical and biogeochemical processes interact over multiple spatial and temporal scales. Monitoring and predicting these processes is crucial for effective management, conservation and restoration of marine ecosystems, but presents both scientific and technological challenges. The transitional nature of coastal areas -between land and open sea- requires modelling systems capable of capturing its strong variability, including coastal phytoplankton blooms, eutrophication gradients, marine heat waves, river plume and frontal dynamics, and pollutant dispersion. Furthermore, the development of high-resolution regional downscaling tools needs careful integration of various products (and their dependencies), such as open sea boundary conditions, river discharge, high-resolution atmospheric forcing, satellite observations and in situ coastal data (including wastewater treatment plant inputs).

In this context, we present a novel high-resolution physical-biogeochemical modelling system for the Italian coastal areas developed in the framework of the MER (Marine Ecosystem Restoration) project, funded by the NextGenerationEU program (investment M2C4 - I3.5). The reanalysis and forecasting system features the coupled MITgcm-BFM model and includes data assimilation of satellite-derived sea surface temperature and chlorophyll ocean color, as well as in situ coastal nutrient measurements. It downscales physical and biogeochemical products from the Copernicus Marine Service, improving the resolution from 4.5 km to 500 m. In addition, it integrates river discharge data from the EFAS system (Copernicus Emergency Management Service) with nutrient and carbon inputs, and it is forced by local ICON atmospheric fields at 2.2 km resolution and ECMWF data at 10 km resolution.

The modelling system is designed for operational purposes and provides both real-time analyses and five-day short-term forecasts. Moreover, we are producing a 10-year reanalysis dataset (2011-2020) and a 5-year hindcast (2021-2025) that will allow the assessment of both coastal-open ocean dynamics and temporal variability at fine scales. Model validation follows the Copernicus Marine skill performance framework and ensures a robust assessment of both past simulations and short-term predictions.

In this presentation, we describe the technological advancements and benefits of this relocatable forecasting system, and we show some preliminary results of the physical and biogeochemical hindcast simulations for the Italian coastal waters.