Using HPC to enable coastal waters observatories

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Coastal systems are among the most productive ecosystems in the world, providing multiple resources and guaranteeing the resilience of the coastal communities. Climate change (e.g., sea level rise) represents a major threat to the world's coastal systems, via potential increases in salinity, acceleration in the nutrients cycling and disruption of aquatic ecosystems. Also, recent and predicted increases of nutrients loads to coastal systems may exacerbate these impacts.

Coastal waters observatories can support both the daily and the long-term management of coastal ecosystems, allowing the continuous surveillance of coastal zones and the establishment of adaptation measures. In the project UBEST the concept of coastal waters observatories is extended and demonstrated in two Portuguese coastal systems, the Tagus estuary and the Ria Formosa, to improve the global understanding of the biogeochemical buffering capacity of coastal ecosystems and their susceptibility to future scenarios of anthropogenic inputs and climate change.

The observatories developed in UBEST include several layers of information that integrate historical and real-time observations, forecasts, scenarios analysis and indicators in a comprehensive web-portal. The integration of all these layers provides information that covers different temporal scales, presented with different levels of complexity, enabling the end-users with more robust tools to support decision-making. However, the extension of the coastal waters observatories to integrate more layers of information brings several challenges, among them the requirement of more computational resources. In this context, High Performance Computing (HPC) is a powerful resource to enable the next generation of coastal waters observatories.

HPC, such as grid clusters, parallel computing or cloud computing, is used by the coastal modeling community to solve complex, very demanding problems. In UBEST, HPC is used at two levels: i) for high-resolution forecasts and scenarios simulations of the circulation and water quality dynamics in the two coastal systems, and ii) to provide computational power to process data and model results through predefined or user requests at the web-portal.

The simulations in the Tagus estuary and the Ria Formosa are performed with SCHISM, a parallelized model that uses the MPI (Message Passing Interface) paradigm. Daily forecasts of water levels and 3D currents, salinity, temperature and biogeochemical variables are deployed with the WIFF – Water Information and Forecasting Framework and the OPENCoastS service. The scenarios analysis provides long-term information of the biogeochemical buffering capacity of each system under present conditions and for scenarios of climate change (e.g. sea level rise) and anthropogenic pressures (e.g. wastewater discharges). The use of HPC allows both the timely production of daily forecasts and the generation of long-term simulations for the scenarios.

The UBEST web-portal, developed using Django, allows the access to all the data and model results through four dashboards: Data, Forecasts, Scenarios and Indicators dashboards. Several services and products are made available to the users, such as statistics of historical data, data on virtual sensors, and physical and water quality indicators.

The implementation of HPC in the UBEST water observatories was achieved using the INCD – the Portuguese National Infrastructure for Distributed Computing.