

ICOOE - A Virtual Lab boosting the exploration and integration of coastal ocean observations along Europe

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The coastal oceans are among the most complex and diversified marine regions of the Earth. They typically extend for a few tens of kilometers from shore, covering the continental shelves and transition to the open ocean. Driven by the atmosphere, by the continental inputs or by the open ocean influences, through a broad range of forcing mechanisms, they are profoundly affected by the presence of the coastal boundary and by topographic effects. These are also the areas where most of human activities related with the sea concentrate and through which the human societies receive the impacts of ocean's influences.

Understanding and forecasting the evolution of coastal ocean conditions is then of paramount importance to assure the safety of human life at sea, to support the Blue Economy, to manage marine resources in a sustainable way, to mitigate the loss of biodiversity and the impacts of accidents or extreme events. In a rapidly evolving scenario, where long term variability and climate changes trigger the development of highly variable extreme events, these challenges ask for a sustained capacity to observe the coastal ocean areas with the required time and spatial resolution.

Nowadays, increased efforts are taken by research institutes, academia and private operators to fulfill these requirements. Coastal ocean observations are collected by many different systems (e.g. permanent coastal stations and fixed platforms located offshore, ongoing systems installed onboard vessels, robotic systems, satellites and aerial vehicles) and complemented by numerical model results. This increasing amount of available data is being provided to users through a variety of data aggregators and service providers, such as EMODnet or Copernicus Marine Systems.

While coastal ocean observations become more and more available, the users interested in working with this data are frequently confronted with basic questions regarding how to handle the different datasets, how to extract from them the relevant information and how to combine them in an integrated analysis. Different observations are available with different structures and data formats and often require specific procedures for additional quality control or processing. All these difficulties can discourage many users to fully take advantage of the existing available observations.

The recognition of these difficulties lead to the development of a Virtual Laboratory specifically shaped to support the users in coping with these difficulties. The ICOOE (Integration of Coastal Ocean Observations along Europe) VLab is developed in the framework of Blue Cloud 2026, by a team gathering Instituto Hidrografico (IH - Portugal), the Balearic Islands Coastal Observing and Forecasting System (SOCIB- Spain) and the IEEE France Section (IEEE-France). It takes the full advantage of the Blue Cloud Virtual Research Environment and integrated expertise in coastal ocean processes gathered by the Joint European Research Infrastructure of Coastal Observatories (JERICO) community. ICOOE proposes three complementary thematic

services, providing a number of FAIR oriented tools and services that take advantage of globally accepted Ocean Best Practices and standards to explore key areas for the coastal ocean research and operational uses.

The Transboundary Transport and Connectivity Thematic Service explores the intrinsic nature of coastal ocean areas as waveguides for the long distance propagation of disturbances. A Dash python user interface allow users to select the geographical area of interest, the period of interest and the parameters of interest (surface and subsurface currents, temperature and salinity and sea surface height). Based on these choices, the service identifies the observations that are available for these options, from different data aggregators. After selection of the datasets of interest, these are downloaded to the VLab user area. The thematic service pre-processes the datasets to conform the specific requirements of the Thematic Service and presents a range of tools to support the users in the data exploration, integration and visualization. The thematic service is presently being demonstrated on the Iberian margin and for surface currents provided by the European HF Radar Node (HF radar observations) and by the Copernicus Marine Service (NEMO model results). Demonstration activities focus the transport of contaminants and invasive species and their impacts on offshore aquacultures, marine protected areas and coastal environments.

The Extreme Events Thematic Service focus on the assessment of extreme events and related impacts on the coastal ocean areas of Europe. Based on a user interface similar to the one describe above, this Thematic Service support users in the characterization of the conditions associated with extreme storms impacting the European coastal ocean and their effects on the bottom sedimentary cover.

The Ocean Glider Thematic Service aims to demonstrate the added value chain of glider missions from data acquisition to advanced products and visualisations for improved coastal information, integrating ocean state and variability derived from glider transects. The service offers a processing toolbox designed to generate interpolated profiles on a regular grid along the glider monitoring line, based on the vertical and horizontal resolution of the raw data. It includes vertical sections of key parameters such as potential temperature, practical salinity, potential density, and geostrophic velocity (meridional component only) within the Ibiza Channel. Additionally, the service provides software libraries and Jupyter notebooks for processing user data and facilitating data integration. An Advanced Data Viewer is used for enhanced data exploration and visualization. Demonstration activities for this service will focus the use of glider observation to derive environmental indicators boosting the understanding of the complex phenomena that affect marine ecosystems and of thermal variability and trends providing insight on how shifts in heat storage influence marine ecosystem structure and function over time.

ICOOE is presently being open to the community, as one of the Blue Cloud 2026 Virtual Labs. Interaction with the users will promote the fine-tuning of the available services as well as the rapid expansion of the installed capacities. An important component of the is the training of users on the VLab use and capacities, a goal that will be fulfilled through the participation in a hackathon or in webinars and by the preparation of training materials.