Oceanographic data management at the Balearic Islands Coastal Ocean Observing and Forecasting System (SOCIB)

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Abstract

The Balearic Islands Coastal Ocean Observing and Forecasting System (SOCIB, http://www.socib.es), is a multi-platform Marine Research Infrastructure that provides data from the near-shore to the open sea. According to SOCIB principales, data are discoverable and accessible, freely available, quality-controlled standardized and interoperable.

With these objectives in mind, the Data Centre manages the different steps of data processing: from sensors to visualisation by users: 1) the acquisition using SOCIB platforms (gliders, drifters, HF radar, …), numerical models (hydrodynamics, waves, …), or even information generated by other divisions, such as the Division of Strategic Issues and Applications for Society; 2) the archiving and processing, in order to guarantee the data quality; 3) the distribution through dedicated web applications; 4) the dynamic visualisation through SOCIB website or through applications designed for mobile devices.

This paper describes the data processing chain and presents some of the web applications developed in order to improve their visualisation and access. Applications for smart-phones have been also developed to enhance the data access by the general public.

Keywords: multi-platform system, ocean forecast, glider, HF radar, marine research infrastructure.

1. Introduction

The Balearic Islands Coastal Ocean Observing and Forecasting System, is a multi-platform Marine Research Infrastructure located in the Mediterranean Sea (Tintoré et al., 2013). It responds to a paradigm shift in the field of oceanic and coastal observations: instead of single-platform systems, the central element of which is the research vessel, new systems rely on a variety of platforms to provide free, open and quality-controlled data from near-shore to the open sea. SOCIB objectives follow three main lines: scientific priorities, technological developments and response to societal needs. The system is made up of three major infrastructure components: 1) a distributed multi-platform observing system, 2) numerical forecasting system, and 3) a data management and visualization system. To collect the necessary data, the SOCIB system is made up of: a research vessel, a high-frequency (HF)

radar system (Lana et al., 2014), weather stations, tide gauges, moorings, drifting buoys, ARGO profilers, and gliders (autonomous underwater vehicles, Heslop et al., 2012; Cusi et al., 2013). In addition, the system has recently begun incorporating oceanographic sensors attached to sea turtles. High resolution model provides ocean forecasts in the western Mediterranean Sea (WMOP, Juza et al., 2015) and waves (SAPO based on the SWAN model). The variety of platforms, instruments and sensors provides data of various types (grid, time series, trajectory, mesh, point, images) related to ocean (temperature, currents, traffic, ...), atmosphere (air pressure, rainfall, …) and land (coastline, erosion, …) as well as in different formats (comma-separated values, NetCDF, JSON, …) makes it essential to have a scalable and integrated data system. In addition to the information provided by the observing platforms and numerical model, the Strategic Issues and Applications for Society (SIAS) division constitutes another source of data that has to be specifically taken into account, for instance for displaying cartographic data.

2. SOCIB DATA CENTER

One of the main challenges for the SOCIB Data Centre (DC) is to deal with this variety of data (i.e., in terms of sources, typologies and formats) and also allow users (scientists, technicians, and the general public) to access the data of interest and to visualize the corresponding information in an easy and attractive way. According to SOCIB principles, data should be: discoverable, accessible, freely available, interoperable and standardized. For these reasons, the data management system implemented aims to meet international standards for quality assurance and interoperability. The system's main components are: 1. An instrumentation application to manage all platforms through a web interface. 2. A processing application to deal with all collected data, performing data calibration, derivation, quality control, and standardization. 3. A data server to provide metadata and data access through standard and open web services (e.g., OPeNDAP, OGC services, HTTP, ncISO). 4. A layer of RESTful web services to ease the development of both internal and external applications, such as web or mobile applications. 5. A set of tools for data visualization and real-time monitoring.

The data management system is implemented using various open source solutions. The data comes from different sources, and according to them, different procedures are applied, employing applications in Java, Matlab, R, Python or geographic information system (GIS). Data from observing platforms or numerical models are stored in NetCDF, while vectorial data are stored in databases implemented in PostGIS. For the metadata, an internal application (see Section 3.1) allows their management and registration into the NetCDF files. The rest of the metadata are edited and stored using Geonetwork application (http://geonetwork-opensource.org/). Data distribution and access is facilited by OGC services, such as Web Map Service (WMS) carried out in Thematic Real-time Environmental Distributed Data Services (Thredds) or Geoserver (http://geoserver.org) applications. Furthermore, DC developed a RESTful web services, *DataDiscovery,* with the objective to make easier the data integration either by internal applications or by a third party, thus providing interoperability to the system.

On top of the described services, SOCIB DC has been developing various applications, as detailed in the next section, allowing users to visualise, access and use the data.

3. APPLICATIONS

Several specific applications have been designed in order to facilitate the access to the data by a wide range of users. The most relevant applications are described in the next sections.

3.1 Applications for data acquisition and processing

Two main applications are used in the first steps of the data cycle. First, the "*Instrumentation*" application, in which all the information related to the platforms managed by SOCIB are registered. Secondly, a "*Processing*" application that performs a series of operations of the data from the considered platforms. These successive operations are : 1) the data ingestion, which requires the knowledge of the data access method and the format ; 2) the data calibration based on the information indicated in *Instrumentation* ; 3) the generation of new data, which requires the method to derive the new variables (for instance, the salinity computed from the conductivity and temperature provided by the instrument) ; 4) the data quality control, based on criteria provided by the facility responsible for the instrument.

3.2 Applications for data acquisition and processing

The Deployment Application (DAPP, http://apps.socib.es/dapp/) displays all the active and completed deployments on a map, with the possibility to obtain the measurements or the data files themselves in one click. For example, on November 27, in addition to the research vessel, 2 gliders, 38 drifters, 6 Argo profilers, 2 moorings, and 2 turtles were deployed. Additional information, such as bathymetry, numerical model results or satellite images, can be provided in the form of additional layers served through a web map service (WMS) interface. A click on the deployment icons opens a window showing basic information (time, positions, speed…) and according to the platform type, links to images generated with the latest data. Direct links to the thredds catalog are also available. The main technologies for this applications are: J2EE, GXT, OpenLayers, GeoJSON and THREDDS (ncWMS).

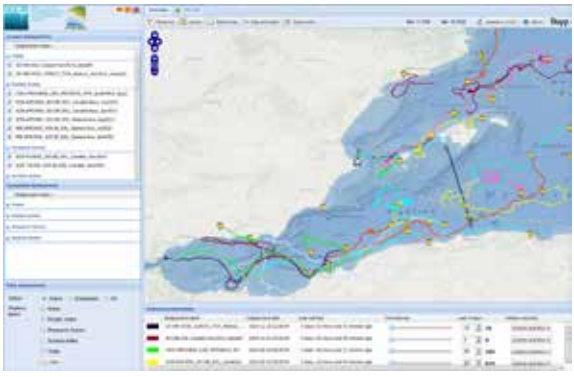

Figure 1 The Deployment Application (DAPP) provides access to both the active and archived deployments of the mobile platforms: surface drifters, profilers, gliders, research vessel and animals (turtles).

The *Lightweight for NetCDF viewer* (LW4NC2, http://thredds.socib.es/lw4nc2/?m=radar, for HF radar in this case) is web client that allows users to browse through gridded fields (numerical model results, HF radar velocities, satellite data) by variable or date, through requests to a web map service such as the ncWMS integrated in the THREDDS server. Additional functionalities of the tool include the extraction of time series at selected locations or along a section drawn on the map, or the animation of layers. The style is easily customisable by modifying these elements: colormap, vectors, minimal and maximal displayed values. The main technologies underneath LW4NC2 are: Ext JS 3, OpenLayers, THREDDS (ncWMS).

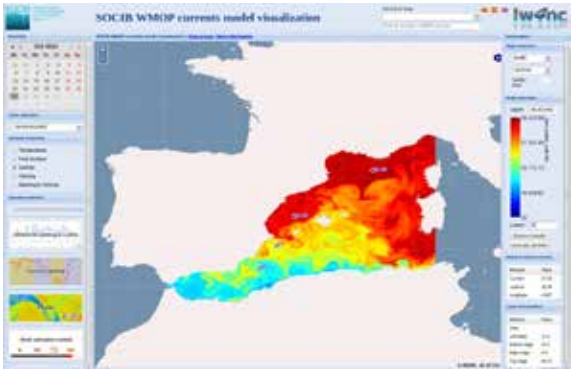

Figure 2 Salinity generated by the hydrodynamic model in the Balearic Sea, viewed through the LW4NC.

The *Environment Sensitivity of the Coastline* (SACosta, http://gis.socib.es/sacosta/composer) is a web-based map viewer for the display of cartographic data related to the environmental sensitivity of the coastline of the Balearic Islands. The spatial data were obtained in 2005-2006 via a formal agreement between the Department of the Interior of the Government of the Balearic Islands and the University of the Balearic Islands. The data have been revised and updated by SOCIB. The viewer was developed to be a decision-making tool to support responses to potential oil spills. The categorization of the coastline is based on the standards defined by Petersen et al. (2002) and is made up of three main components: 1) geomorphological classification of the coast; 2) biological resources (coastal protected areas); and 3) human use (i.e., infrastructures, services, cultural and historic resources). The SACosta tool complies with OGC interoperability standards and the criteria of the INSPIRE directive. The data can be accessed directly through the map viewer, via Google Earth (metadata window), or via a WMS. The descriptions of the data are available in the metadata catalogue of SOCIB (http://gis.socib.es/geonetwork). Recently, a tool has been added to obtain the environmental sensitivity within a polygon selected by the user in the area. A detailed analysis describing the type of coastline with the corresponding length, as well as photographs of the concerned beaches, is automatically generated in the form of a report. The main technologies used for SACosta are PostGIS, Geoserver, GeoExt, Geonetwork,

Flask, d3.js.

3.3 Applications for general public

Figure 3 SACosta tool applied to the northeastern coast of Mallorca: an automatic report of the coastline sensitivity and its degree of protection is generated for the shaded polygon drawn by the user.

he applications presented in the previous sections are of particular relevance for scientists and other stakeholders. In order to build the bridge between ocean data and the general public, more specific tools were designed. They aim to present the same data, but in a more user-friendly way.

The SeaBoards (http://seaboard.socib.es/) consist of dashboard visualizations of real-time and forecast ocean data. Seaboards have been primarily designed for the tourism sector and are now installed in several collaborating hotels, providing useful information about the ocean and coastal state in real-time, as well as weather and wave forecasts. Other SeaBoards have been developed, for instance for the HF radar system (http://seaboard.socib.es/galfi) or for the SOCIB research vessel (http://seaboard.socib.es/vessel). Therein, the vessel trajectory and the last data measured by the thermosalinometer (temperature, salinity, fluorescence) and by the weather station (temperature, pressure, wind) are displayed and updated every 10 seconds. Overall, the SeaBoards fulfil the will to enhance public knowledge about science-based beach management and environmental preservation, while providing realistic and consistent measurements in real-time. The SeaBoards are implemented in Django and Dashing widgets, along with the SOCIB RESTful web services.

Figure 4 SeaBoard located in Son Bou (Menorca). Along with real-time images of the nearby beach, swimming and weather conditions and forecast are displayed.

With the increasing use of smart-phone by the general public, the development of applications specific to this support was a quite natural step. The main goal was the capability to provide an easy and quick access to all the platforms and data managed by SOCIB. Concretely, SOCIB App allows users to visualize the information provided by all the observational systems (Figure 6, top panel) or the numerical forecast models (Figure 6, top panel). The general concept of "*Data in one click*" used in the SOCIB web is also applied for the application. Once the app is launched, the user should be able to navigate between the different platforms and find data of interest. Up to now, the app runs under Android (https://play.google.com/store/apps/details?id=com.socib&hl=en) and iOS (https://itunes.apple.com/us/app/socib/id482542716?mt=8). The technologies used for these applications are : Objective-C, MapKit, YAJL, along with the RESTful web services, in particular "*DataDiscovery*" (http://apps.socib.es/DataDiscovery/index.jsp), which provides information and data of SOCIB platforms.

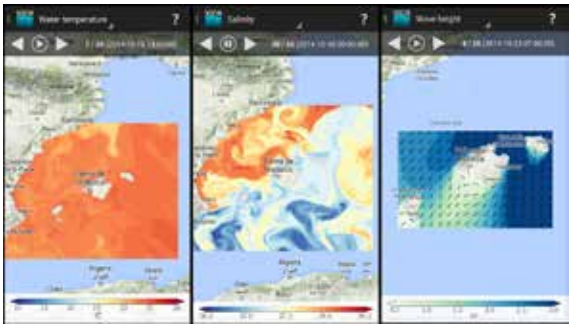

Figure 5 Smart-phone application (Android version): the first four screens show from letft to right: the Glider, Lagrangian platforms, Fixed station and HF radar data. The last three screens shows information related to numerical models: sea surface temperature, salinity and wave height.

4. Conclusions and future work

Over the last years, SOCIB Data Centre has developed several applications aimed at different types of users, ranging from scientists to the general public. In keeping with the objective of bringing relevant data to all kinds of users in a free and easy way, the future plans include the redesign of the applications to improve the user experience, along with the creation of applications specific to different groups of users, including tourists, sailors, surfers, and others. A specific application programming interface (API) is also under construction, with the objective of improving the data access to developers of applications.

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