RAIA Observatory: Visualization of Oceanographic Data under INSPIRE Directive

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Abstract: One of the main goals of RAIA Project is to incorporate the requirements defined by the European Directive INSPIRE, which establishes an infrastructure for spatial information in Europe to support Community environmental policies and activities, in order to ensure that the spatial data infrastructures collected by the oceanographic observatory for the northwest Iberian Peninsula are compatible and usable. Through a single interoperable platform, RAIA Observatory will allow the public access to the information gathered by the oceanographic network. This platform is based on the use of solutions that implement standards defined by the Open Geospatial Consortium (OGC), such as WMS (Web Map Service), WFS (Web Feature Service) and WCS (Web Coverage Service). RAIA Project also includes other types of products that use specific protocols, such as OPeNDAP or Thredds, which are widely known and used by the oceanographic community.

Keywords: RAIA Observatory, INSPIRE, OGC, THREDDS, OPeNDAP, WMS, WFS, SOS, SDI.

1. INTRODUCTION

Oceans are dynamic and changing systems, source of resources and place for increasing human activities. Such activities can gain momentum if provided with accurate and timely information. Several agencies and public organizations operate systems for oceanographic observation and forecasting. Data outputs resulting from these systems are often not easily accessible due to the fact that they are neither shared in standard data formats, nor easily accessible in the scope of the environments where they currently exist. INSPIRE (Infrastructure for Spatial Information in the European Community) is a directive for strengthening the EU ability to share environment spatial information among public sector organizations and facilitate public access to spatial information across Europe. This directive (under its annex III) specifically addresses oceanographic and meteorological geographic features among its themes. Public organizations and governments must tackle this challenge and make it possible to discover, view and share in compatible and usable ways meteorological and oceanographic data. This situation requires the definition of common strategies in the scope of multi-organizational initiatives to implement Spatial Data Infrastructures (SDIs) enabling interoperable access to the spatial data themes under these categories. The Open Geospatial Consortium (OGC) plays an important role in the definition and adoption of a set of service implementation specifications and data encodings that constitute the building blocks of INSPIRE's proposed SDIs. Public commitment with OGC outputs made them *de facto* standards when dealing with geographic information. Actually a subset of OGC standards were incorporated in the ISO 19100 series. Table 1 presents some of the aforementioned standards, highlighting some of their advantages and weaknesses.

RAIA is an EU co-funded project joining 12 partners from Galicia (north-west Spain) and north Portugal to develop and maintain an ocean observatory for northwest Iberian oceanic region, an area where marine resources have a huge relevance to the socio-economic scope. The project involves partners with operational, technological and scientific background allowing them to consolidate previous works on ocean modelling and observation networks. Moreover, this heterogeneous collaboration allows the project to address scientific goals towards a better understanding of the ocean and to tackle technological and (data) governance barriers with the aim of producing results potentially applicable to a broad range of marine activities. The main technological goal is to develop an interoperability platform, supported on a SDI, according to the INSPIRE directive guidelines, ensuring that all data produced is publicly available in compatible and usable ways.

2. JOINING TWO WORLDS

One particular feature of this SDI is that it aims at bridging the gap between two communities: GIS community where OGC standards are widely accepted but mainly designed for static geographic information and Earth and Ocean Science (EOS)

Table 1. List of Main Protocols

Standard	Advantages / Uses	Weaknesses
OGC WMS Web Mapping Service	• Many technologies support WMS • Wide client side support • Good for server-side rendering of large datasets • ncWMS allows WMS implementation for gridded data managed with THREDDS	• Returns a "picture", no actual data • GetFeatureinfo spec does allow access to data but not widely implemented • Symbology and legends are complicated • Inconsistent projection implementation • Time specification is included in WMS but is still not widely supported by servers and clients
OGC WCS Web Coverage Service	• Useful for uniform rectangular grids	• Not widely supported on servers and/or clients • No support for unstructured and non-uniform grids
OGC WFS Web Feature Service	• Very flexible • Provides all relevant information for data • Allows for custom client-side rendering and analysis • Extensible	• Not practical for large amounts of data • Poor client support, not widely supported • Requires a sophisticated client application
KML Keyhole Markup Language	• Very flexible and practical • Provides all relevant information for data • Widely used, supported by Google Earth and Google Maps so easy to deploy	• Not practical for very large amounts of data • Creating KML for complex symbols (e.g. rotating vectors) not simple • Google Maps (thin client) support for KML is very weak so need to use Google Earth for full KML support • Not well supported by other GIS clients
OGC SOS Sensor Observation Service	• Growing adoption as part of Sensor Web Enablement (SWE) • Provides consistent methodology to share sensor data • Ideally suited for sharing data between sensor and data assembly center	• No widespread client support • Verbose so not practical for large amounts of data
OGC GML Geography Markup Language	• Consistent method to encode geographic information in an XML schema • Good client support, especially in open source mapping community	• Verbose so not practical for large amounts of data
Gridded data NetCDF, GRIB, HDF	• Served by OpeNDAP/Thredds so allows for subsetting and distribution • Very efficient for large data volumes • Expanding use for non-gridded data such as drifters • Wide client support in science community • Growing support in GIS community • ncWMS allows WMS support for the data	• Java library is very mature – C library is lagging behind • No support from mass market viewers (Google Earth etc.) • Support in ESRI tools is limited • No support for unstructured grids yet

community that uses a diverse collection of data formats and sources and its own set of tools to display and analyse information.

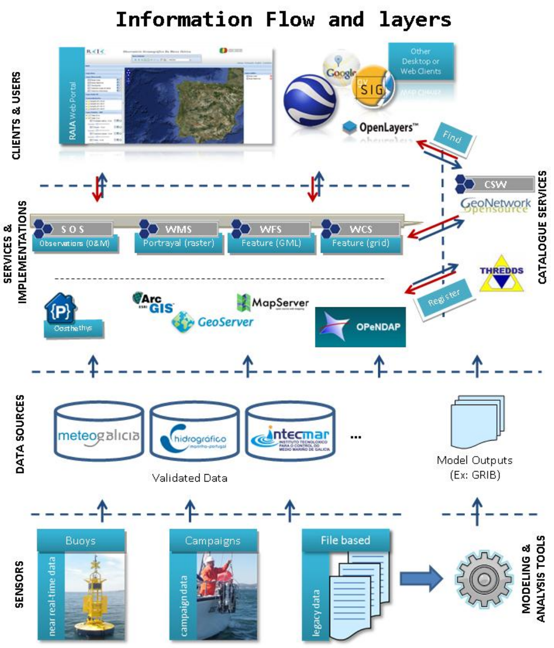

Figure 1.Information flow and layers in RAIA project.

Most common protocols to share scientific data are OPeNDAP Data Access Protocol (DAP) and THREDDS Data Server (TDS) which is the catalogue service of choice for the EOS community. The TDS can catalogue and harvest the OPeNDAP, and provides access to datasets in any of the Unidata's Common Data Model (CDM) supported formats: GRIB, NetCDF, and HDF, among others (through the OPeNDAP protocol). Also, given the efforts of convergence between both communities, most recent implementations of TDS provide a subset of OGC standard implementations for data access, namely WMS and WCS, which could then be catalogued by means of an OGC Catalogue Service (CSW).

Besides these efforts, experience demonstrated that the task of cataloguing and automatic harvesting TDS datasets is not trivial due to the form how these are provided (as Web Accessible Folders) and respective metadata contents in the TDS.

3. ORGANIZATION

RAIA project also has among its objectives to develop an interoperability platform which disseminates the data collected by several real-time sources, such as mooring buoys, HF Radar maps, and satellite maps.

From the system architecture perspective this platform, as can be depicted in Figure 1, can be divided in several layers:

1. Layer of "sensors", comprising near-real time data, campaign data and other kinds of file based data.
2. Layer of data sources, where each provider stores and maintains its own data.
3. Layer of services. This layer depicts the standard interfaces used to find and serve data (mainly georeferenced information) and some

of the implementations of the standards actually used in the project.

4. Layer of clients. Client software is used to find, query and portray data. RAIA portal (www.observatorioraia.org) is currently the main client user interface tool used to reach and assemble georeferenced oceanographic information from the Web that is available in the context of the Observatory. However, since the services layer provides data through standard interfaces, other clients can likewise access, integrate and query the provided data.

Layer separation allows a clear assignment of responsibilities among system components. Furthermore, heterogeneous data sources can be merged together in the same geographic view, simplifying analysis by contributing to an enhanced perception of ocean dynamics.

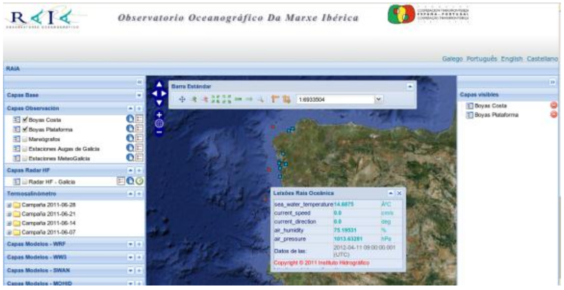

Figure 2. Request to SOS data.

4. RAIA PROJECT ACHIEVEMENTS

In the early stages of the project general guidelines to implement data integration technologies were supplied to all project members enabling them to provide data access through OGC and TDS protocols. Besides, the implementation of the interoperability platform required the design of a robust and flexible multi-tier architecture where all members' data services had to fit. After two years of development outstanding data integration implementations have already been developed and deployed:

- Several project partners provide numerical forecast data, both oceanographic and atmospheric, through THREDDS and OPeNDAP servers.
- Radar HF data and imagery are available through OPeNDAP and WMS protocols.
- Collected data from research vessels alongside the Galician coast can be requested through WMS and WFS.
- Data from moored buoys is available through OGC Sensor Observation Service (SOS) and different XML web services (see Figure 2).
- An OGC Catalogue Service (CSW) is also available to provide a common interface to discover, browse and request metadata about the platform services and datasets.

Several of these services are released under an open source license and all are accessible through the RAIA Observatory website.

Specific requirements for data storage and sharing were studied, such as observations made with sensors attached to mooring buoys. Some of these requirements were the capability of simultaneously observing the same phenomenon with different equipment and, eventually, at the same height (or depth); the existence of observations of the same phenomenon, with the same equipment, made simultaneously at different depths (or heights), as an example the multi-sampling of observation along a column of water; the existence of composite phenomena, i.e. the conceptual aggregation of several variables to one single phenomenon; the ability to dynamically reflect changes introduced during campaigns to equipment attached to buoys, maintaining the coherence of new observations with previously stored data collections; and the ability to optionally integrate a validation value, resulting from the observation procedure, to each observation stored.

A Sensor Observation Service (SOS) was implemented to respond to such requirements. This SOS was built upon the work from an open source initiative and, among others, most important implementations were made at the physical model of the relational database and to the conceptual scheme of the SOS offerings and observations.

Although the OGC Observations and Measurements (O&M) standard encoding contains the generic structure to accommodate the structure of observations in any domain, it lacks community-specific semantics. Specific profiles such as the WaterML for the hydrological community may help increasing the adoption of this standard

Other initiatives such as the BODC Parameter Ontology Project are also contributing to bridge this gap by linking the BODC Parameter Discovery Vocabulary, the CF Standard Names and the GCMD Science Keywords

The development of a general web application (depicted in Figure 3) is also an achievement of this project that lets the end user discover, visualize and download data directly from distributed and heterogeneous data sources provided and maintained by project partners. This web application provided a basic tool for the development of sectorial web applications that enable the creation of added-value information directed to the specific communities.

The availability of all those services facilitates the development of tailored products for specific activities and end users.

A tool for ports and fishers' organisations (http://www.meteogalicia.es/web/tablasMaritimas/index.action) produces daily sea-forecast reports for their main activity spots. The goose barnacle fishers' application (ww3.intecmar.org/percebeiros) is a support decision tool which allows catchers to monitor current sea conditions and forecast for the next hours and days.

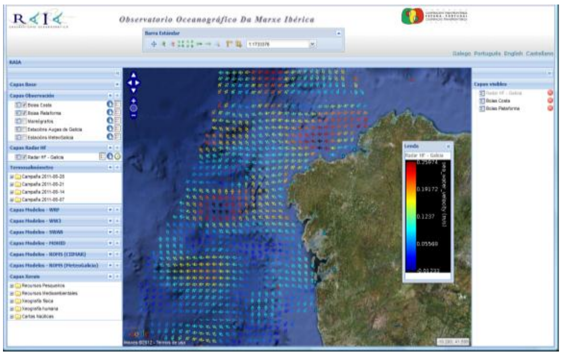

Figure 3. Screenshot of www.observatorioraia.org.

These tools proof the direct impact of RAIA Observatory in human activities on the sea, and show that the platform interoperability is an invaluable asset in local economies.

5. FUTURE WORKS

Despite the amount of services and tools developed, RAIA still faces many challenges. Some of them come from identified inefficiencies of the OGC protocols when dealing with scientific data and the dynamism of those protocols in order to adapt to the EOS community needs. But the primary challenge is to deliver an actual base of services, tools and knowledge allowing general public to use and understand the large quantities of data produced and collected within the project. To sum up, provide society a better approach of how our ocean works.

In fact, the project RAIA.co is launched as a follow-up of RAIA project in 2011. It will last until the end of 2013 and its main aim is to consolidate operational oceanography on the Iberian margin and the coast of the Euroregion North of Portugal – Galicia. For this, it will increase and enhance the services offered up to now by the RAIA observatory.

Specifically, the new version of the project's website (http://www.marnaraia.org) will provide a friendlier and more intuitive environment. It will allow the users to register and to customize the search queries according to group profiles of final users potentially concerned who belong to different social and economic sectors (e. g. scientific, sports, fishing profiles). Every profile will load predefined modules and layers in the views which may be considered more useful for the sector it belongs to.

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