Monitoring, Observations, Predictions & Communications.
A Practical Guide

Activity 4

Task 4.1: Integration of observation results in a help decision tool

Task 4.4: Response Follow-up

Task 4.5: Provision of common decision support tools

ARCOPOL

The Atlantic Regions' Coastal Pollution Response

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EXECUTIVE SUMMARY

This document focuses on the information necessary to manage the crisis. Thus, in this document information will be that for having a map of the crisis, knowing the location of the spill and its future movement as well other geographical data rather than orders relating to command and managing.

DATA DURING THE RESPONSE

The objective of this document is to provide practical guidance on recommendations to synthesize communications in the process of creating useful information for managing a marine spill crisis.

During the course of a crisis, data is generated and is used, in conjunction with pre-existing data, to generate information necessary for spill crisis managers to make critical decisions.

The following paragraphs outline the principal elements of a crisis.

DATA TYPES

The data primarily provides:

OBSERVATIONS:

Observations are a type of data that are gathered during the spill crisis, whether there is a demand for it or not. Observational data is generally imagery collected from satellites, flights, boats, as well as from spill workers on the coastline. There are two common elements that should be recorded with all types of observational data: the location and the time of sighting (not to be confused with the time that the observation is generated at).

FORECASTS:

Whether it comes from models or extrapolations, the predictions of the movement of spills are another type of data that is generated during such a crisis. The way in which a forecast reports the prediction of the drift of a spill is varied, even when dealing with the same prediction. Outputs are generated primarily from the centre of mass trajectories, spillets (particles representing the parcels of the spill) or discharge concentration isolines. The predictions can be superficial and two dimensional or can be vertically integrated to be three dimensional.

In addition to the predictions of the movement of the spill, other variables that are modelled include currents, surface winds, salinity, water temperature, etc. This data has a spatial component and two dimensions. In contrast to the predictions of spills, data generated is describes in grids of values or in a raster format.

STATIC DATA:

Static data is defined as the geographic features necessary for the description of the overview of a spill crisis over time (or at least during the spill), which have been previously collected. These elements can be areas, lines, or points of special interest, such as waterfront, access areas, protected fishing regions, survey points, etc. This data, although it has a location, does not have an associated time as it is not necessary information.

INFORMATION & DATA FLOW

The flow of data during a crisis occurs between three types of people: Observers, Forecasters, and End-users.

OBSERVERS:

Observers cover all the elements that generate local information, specifically the location of the spill, although it is also possible that they refer to the flight plans, media location, boats, barriers, etc…

The knowledge of the location of the spills can come from satellites, surveillance flights, boats, observers on the coast, etc. Observations can also come from drifting buoys tracking dye effluents.

FORECASTERS:

Forecasters generate future predictions, whether they are the movement and drift of the spill in either the atmospheric or marine state.

Predictions, in this case, refer almost exclusively to numerical model predictions resulting from services performed by modelling experts.

END-USERS:

End-users are the personnel who are going to use the generated information, either from observations and/or predictions. This data can be combined with other data to produce value-added information. So, end-users become management people, local authorities, press, general public, etc.

Very important end-user during will be the Bureau of Crisis Management during a contingency. The information that reaches them must be accurate, but also summarize where to display only essential information, allowing an extension of information on demanding. .

Even among the crisis managers, very different situations can be found. Take for example the Monitoring and Forecasting Unit, who are usually located in facilities with internet, while there also must be an On-Scene Command located on vessels with communications by mobile phones and laptop computers. So, between the raw information and end-users exists another layer composed of GIS technicians who have a considerable amount of training and the ability to handle complex information. The GIS technicians map the crisis situation and then relay it to the general public, who need clear, concise, and updated information on the situation.

FLOW:

Each of these components must interact in a two-way manner with each other. Thus, end-users communicate with the observers and predictors for carrying out the necessary monitoring and modeling, as well as taking additional measures to track drifter release spills or simulations to specific areas.

Observers must communicate with the other two to report observations, by data and information surrounding the observations (metadata). Forecasters need observers to indicate the results of their predictions, whether to carry out further observations, such as the recovery of measuring instruments such as drifter buoys. Also, they should report their findings to the crisis managers and if applicable, to other end-users. This flow is summarized in the following figure:

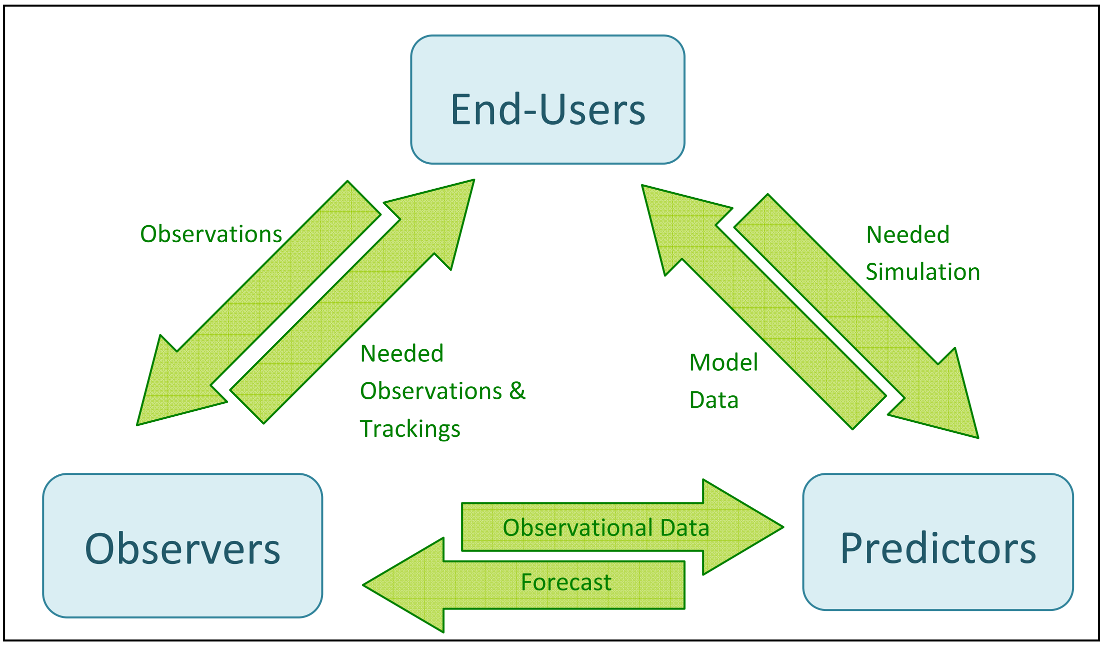


Figure 1. Information flow during a spill crisis.

Because this flow of information is going to be active during times of contingency, it is essential to have quick and accurate communication; in such a manner that most necessary information reaches is destination.

This document will be discussed as a guide, different standards protocols and technologies to facilitate accuracy, reliability, and faster communication are shown in Figure 1.

DATA SOURCES

OBSERVING SYSTEMS

This section is not intended as a detailed catalogue of the observers and the information, rather an approach to the types of observers, with a particular relevance to the format when transmitting the observations (depending each time on the type of observation).

TYPES OF OBSERVATIONS

SATELLITE

Nowadays, satellites are a common mean to sample the ocean frequently and on a global scale. Several remote sensors are used to detect oil slicks. Among them, one of the most important is the Synthetic Aperture Radar (SAR), since it provides wide area coverage and has the capability to detect oil slicks on the sea surface in both darkness and daylight hours and to see through the clouds.

Remote sensing radars are used to identify objects and landscapes through the transmission of pulsed microwave (radio wave) beams. The beams bounce off, and are altered by, objects and surfaces they come into contact with (termed backscatter). The backscatter is transmitted back to the satellite, and the strength and origin of these returning reflections is captured by sensors. The resulting data can be analysed to provide information of varying kinds, for example whether a sea surface area has an unusual texture which may be due to spilt oil. SAR sensors have enhanced capabilities for transmitting and receiving beams, and therefore produce higher quality images. Oil slick are detected in SAR images as black areas, since sea surface is flattened by the oil.

This technique is commonly used for the detection of illegal discharges. This should be complemented by other methods, such as aerial surveys, oil drift models in "backtracking", and in-situ measurements upon arrival in port.

Currently, the EMSA is conducting a service called "Clean SeaNet" http://cleanseanet.emsa.eurpoa.eu for the development and rapid dissemination of these satellite images and their use by Member States in the pursuit of violators.

The CleanSeaNet service uses radar images acquired by SAR sensors on polar orbiting satellites. Examples of SAR sensor satellites are ENVISAT and RADARSAT 1 and 2.

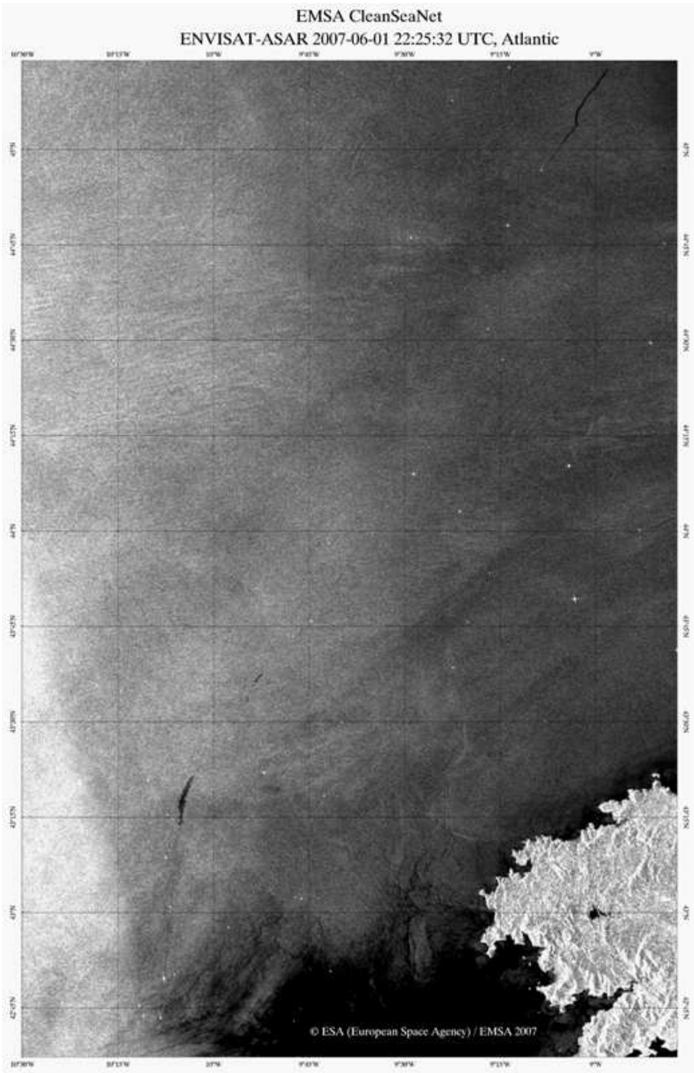


Figure 2. Illegal Oil Spill detected by SAR as represented by the dark, black spots; White spots are ships (ESA/EMSA 2007).

Besides SAR, Optical Sensors are also used. Optical sensors detect reflected sunlight, rather than microwaves. For this reason, they can only be used during daytime and in good weather conditions (free of cloud cover).

Thus, images are the primary object of this type of sensors (SAR and Optical ones), which must be geographically referenced. If these images are then processed to distinguish real from false positive spots (such as black areas produced by factors such as quiet areas, rather than waste), then the result of the process is usually a GIS object type shapefile or GML.

As a real example of a operating use of this kind of sensors and the dissemination of their results, Kongsberg Satellite Services (KSAT, www.ksat.no) runs a satellite based, near-real-time (30 min max delay), oil-spill detection service through the EMSA (European Maritime Security Agency) CleanSeaNet service. All content from this service is available as GML 3.1.1 for all data delivery (except the actual images) and for publishing of data to their customers. GML Schemas and some sample data files can been found at http://cweb.ksat.no/cweb/schema/ . The oil spill polygon schema and supporting documentation are concise and provide excellent examples of using GML to encode key content.

AIRBORNE

Aerial observations are generally made for two types of situations. The first being routine flights which aim to detect, locate, describe, and where possible, identify the source of pollution. In addition, aerial surveys are used in cases of accidents, to help recovery and spread of the spill. In both cases, the objectives of the aerial observations are to locate, describe as accurately as possible, and assist in the mapping of the situation. All of which is necessary for monitoring the pollution, adjusting the drift models that are used, as well as prepare a response for the coming days.

More information about this type of observation can be found in the "Operational Guide: Aerial Observations of Oil Pollution at Sea" published by Cedre, where the type of data available and the method of data transmission is discussed.

Several types of data must be taken into account in aerial surveillance, besides the obvious location of pollution, such as comments on the situation, the flight plan, photographs, and remote sensing. The method of exchanging this information is varied, from description by radio, fax, email, phone, or internet. To optimize the transmission, computer media should be prioritized over others. Thus, it is important to digitize as much information as possible and prioritize the transmission of real time information via the internet.

PHOTOGRAPHS:

With respect to photographs, as mentioned earlier, digital images should be the preferred media type in order to expedite processing. Images taken from planes can be either oblique or zenith. At the same time picture is taken, time and position must be written down as well as altitude and direction since these data allow to georeference the image. DRIFTER project developed a protocol to collect all these data and georeferenced in a GIS as a geotiff. After this process actual position, length and area of the slick were calculated from the picture.

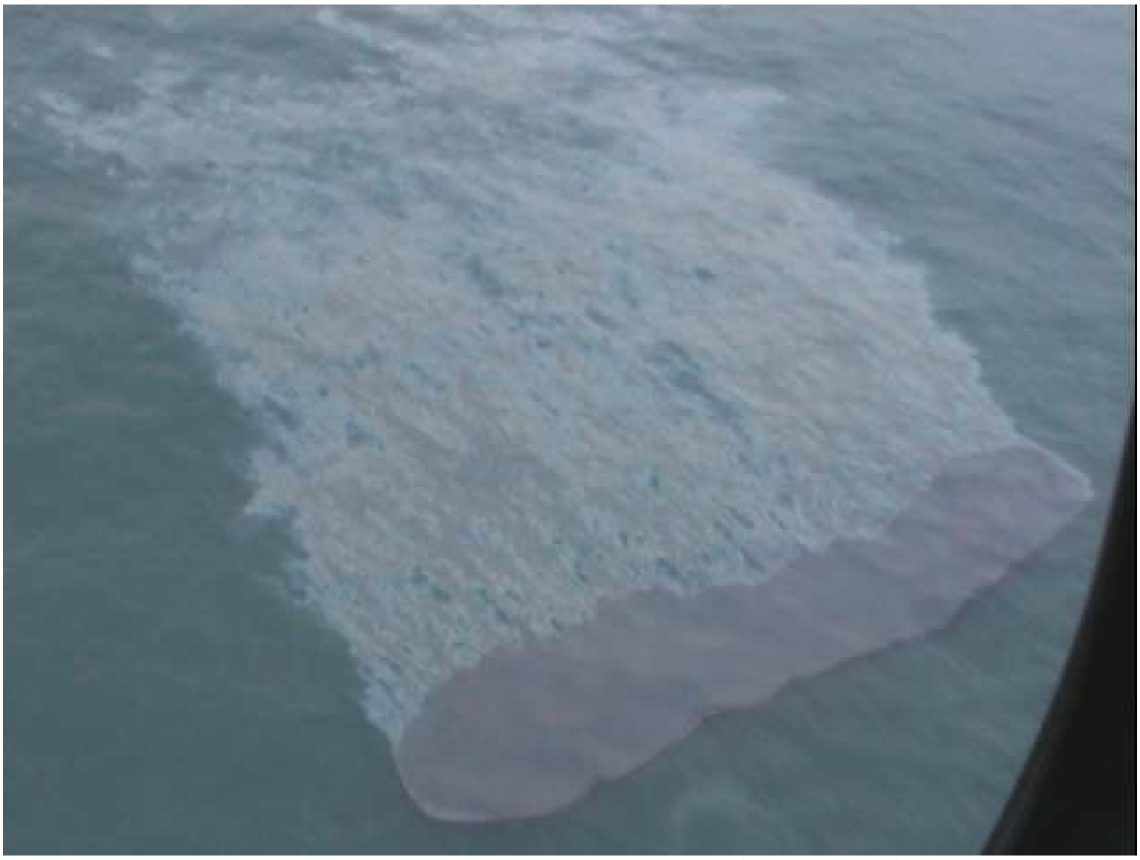


Figure 3. Slick picture from a Galician Coast Guard Helicopter during Prestige crises (INTECMAR, 2003).

When images are taken as visual observation to calculate the amount of spilled oil, colour codes are often used to relate the spots with the type of oil and the quantity of thickness. A new code, called the Bonn Agreement Oil Appearance Code (BAOAC) was established as the standard method for assessing the thickness of oil slicks. For more information, please see the Bonn Agreement Aerial Surveillance Handbook (www.bonnagreement.ord). The following table shows a summary of this code.

Appearance	Layer Thickness Interval (µm)	Litres per km^2
1. Sheen (silvery/grey)	0.04 - 0.30	40 - 300
2. Rainbow	0.30 - 5	300 - 5 000
3. Metallic	5 - 50	5 000 - 50 000
4. Discontinuous True Colour	50 - 200	50 000 - 200 000
5. Continuous True Colour	> 200	> 200 000

Table 1. Bonn Agreement Oil Appearance Code

OPTICAL SENSORS:

In addition to visual observations by cameras, there are other types of sensors that are used by special aerial means. These are:

Sensor	Description
Side-Looking Airborne Radar (SLAR):	Similar to SAR, SLAR detects dampening by wind and oil of capillary waves generated by the wind. During reconnaissance flights (from 1500 to 4000 ft), SLAR can detect oil 15 to 20 NM away, on either side of the plane.
Infrared Line Scanner (IR):	Detects thermal radiation with a wavelength in the band of 8 to 12 µm.
Ultra Violet Line Scanner (UV):	Detects the ultraviolet component of Light from the sun reflected by oily liquids.
Microwave Radiometer:	Similar to IR Line Scanner. It has the advantage of being able to measure the thickness, and therefore volume, of slicks detected.
Forward-Looking Infrared Scanner (FLIR):	Detects thermal radiation with a wavelength in the band of 8 to 12 µm. The range depends on the altitude of the plane and the field of view selected by the operator, as well as the hygrometry.

Table 2. Types of Aerial Sensors (from Cedre's Aerial Observation of Oil Pollution at Sea Guideline)

The images and data collected by these sensors are likely to be geographically referenced. In general, each sensor has its own software for image analysis, so that the transmission of data from the acquisition program to another with a different purpose, a GeoBase for example, depends on whether the former has this capability. It is desirable that all acquisition software and analysis of this data is able to be exported directly into a standard format (geotiff, GML, shapefile, KML …).

ADDITIONAL INFORMATION AND REPORTS:

In addition to the above information, information can also be transmitted through a slick Pollution report (POLREP), flight plans, and sea state.

Among the information collected, either manually or electronically, are:

1. The date and times of the flight.
2. The zone over flown.
3. The name of the observer and of the organization to which he belongs.
4. The type of aircraft used.
5. The meteorological conditions: cloud cover, colour of the sky and the se, the sea state.

This information is transmitted through electronic documents, radio, faxes, etc. If possible, all information should be transferred to an electronic format for the rapid ingestion of a system of maintenance.

VISUAL (FROM EITHER VESSEL OR COAST):

Similar to the previous case, visual information is transmitted through POLREP newsletters or is broadcasted by warnings through the radio, fax, etc.

Pollution Reports, or POLREP's, consist of reports that inform on spill events. There are different forms with various fields to be completed according to the system or country to give the POLREP report, but in general, all have the date, time, location, and short description of the incident. The most common transmission of a POLREP is to fill out a paper form and manually transcribe in electronically. Next image shows the first page of Galician CoastGuards POLREP as an example.

XUNTA DE GALICIA	PLAN TERRITORIAL DE CONTINXENCIAS INFORME SOBRE CONTAMINACION MARINA (POLREP)	

COMUNICANTE				DESTINATARIO
ORGANISMO:				DIRECCION XERAL DE PROTECCION CIVIL
OBSERVADOR (nºde axente):				SUBDIRECCIÓN XERAL DE ATENCIÓN ÁS EMERXENCIAS E CALIDADE DA PROTECCION CIVIL
EMBARCACION/VEHICULO:				
AERONAVE:				CENTRO DE ATENCION AS EMERXENCIAS 112 GALICIA
SINAL DISTINTIVA:				FAX: 981 541414 / 981 541455 / 981 541456
DATA:				TEL: 112 / 981 541400

CARACTERÍSTICAS DA CONTAMINACIÓN						
DATA E HORA LOCAL DA OBSERVACIÓN				EXTENSIÓN DA ÁREA AFECTADA		
DIA	MES	ANO	HORA	LONGO	ANCHO	SUPERFICIE

SITUACIÓN XEOGRÁFICA DO CENTRO DA MANCHA			
LATITUDE	LONXITUDE	DEMORA	DISTANCIA
DERIVA DA MANCHA:	RUMBO:	VELOCIDADE:	

APARENCIA DA MANCHA (1)	
A penas visible en excelentes condicións de luz	Visible coma unha pelicula prateada sobre a auga
Trazas de cor máis escuro	Bandas brillantes de cor laranxa, azul ou verde
Bandas mais escuras das mencionadas cores	Cor moi escuro

ASPECTO DA MANCHA (1)		
Superficie continua	Bandas lonxitudinais	Parches illados

NATUREZA DA CONTAMINACIÓN (1)	
Petróleo cru	Combustible / Aceite
Produtos químicos	Residuos sólidos
Materia orgánica	Descoñecida

Figure 4. First page of Galician Coast Guards Polrep.

Visual information and POLREP´s must be integrated into management information systems, it is advisable to send such information by electronic means and standard formats. A method to automate this process has been adopted by the EMSA, the European Directive 2002/59 calls upon Member States of the European Union participating in the European maritime information Exchange through a system called SafeSeaNet. Any Exchange of information between Member States and SafeSeaNet is done so through messages in an XML format. EMSA has published a guide for this type of message "SafeSeaNet Guideline Messages Incident Report", which specifies the format (XML) and the fields that should have these kinds of messages. Specifically, the POLREP, as introduced in the Counter Pollution Manual of the Bonn agreement (and employed for incident reports related to pollution in the SSN XML messaging guide) is noted as the most appropriate way of reporting spill events. EMSA also provides a guide for the construction of such a message in XML; an extract of these messages in given in Annex I.

DRIFTERS:

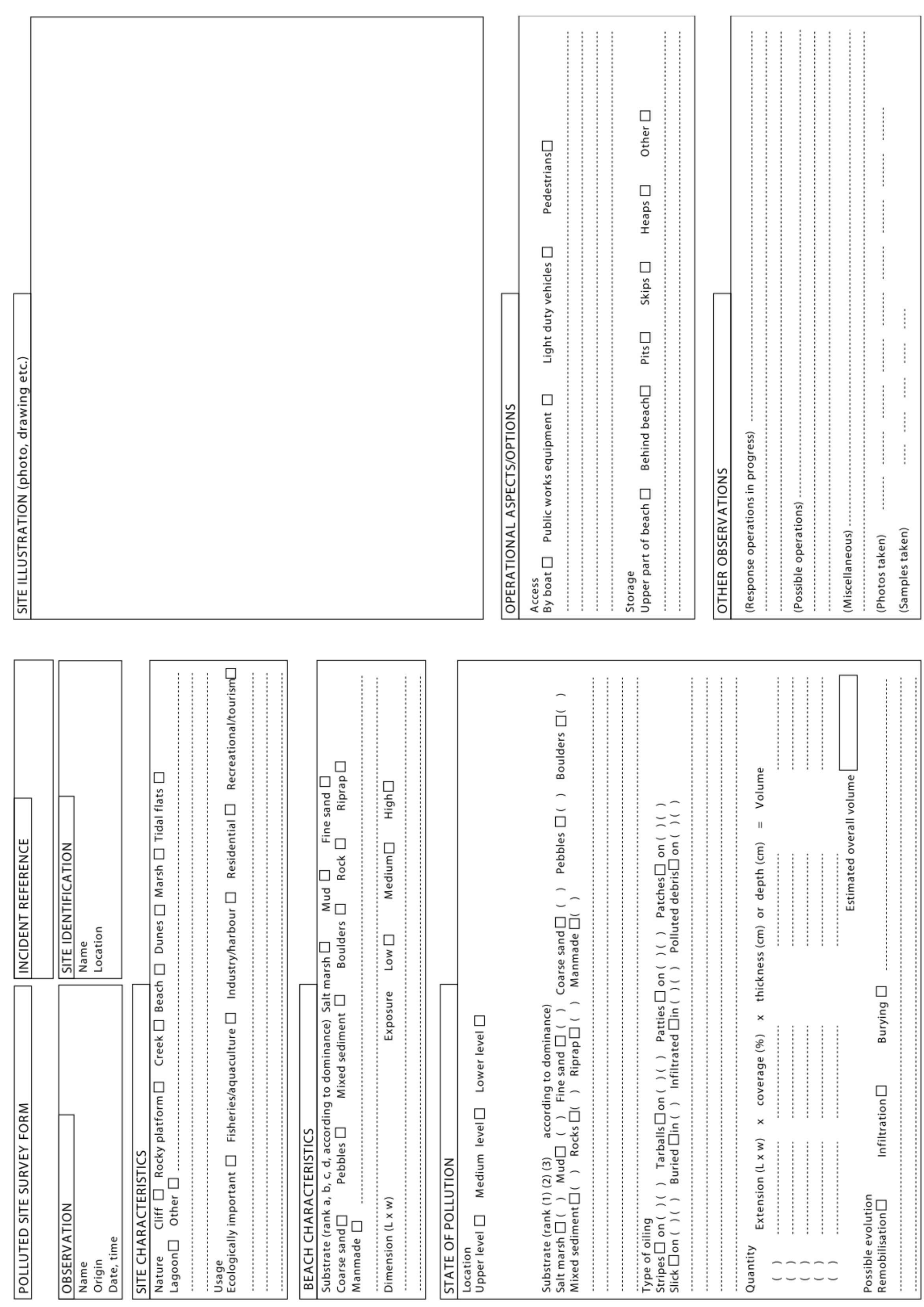
During a spill, drifter buoys are usually available that take position from time to time and send them through either a mobile phone or, more commonly, through a satellite. The primary information transmitted is the position of the buoys and the moment of position taking, therefore being a measurement of marine drift.

Several systems are used and they usually uses their own software to collect these data. However, they usually have compatible formats with the most common GIS as KML or Shapefile. Thus, little efforts used to be necessary to adapt their formats to a general GIS.

ONSHORE OBSERVATIONS AND SCAT:

If a spill has reached land, it is necessary to assess all possibly affected areas. In order to do so, various teams of prepared personnel record observations on the spill along the shoreline, with the intention of determining the amount and type of the received discharge, and thus inform the managers of cleaning. This technique is known at the Shoreline Cleanup Assessment Technique (SCAT). SCAT teams systematically survey the area affected by the spill to provide accurate and rapid geo-referenced documentation of the shoreline oiling conditions. More detailed information about SCAT can be found in "The UK SCAT Manual: A Field Guide to the Documentation of Oiled Shorelines in the UK" (UK Maritime & Coastguard agency, April 2007): http://www.coastguardrescue.org.uk/c4mca/lrgtxt/corp_118.pdf and in "Surveying Sites Polluted by Oil" (Operational Guide by Cedre): http://www.cedre.fr/en/publication/survey/survey.php .

The most conventional way of reporting on the spill is to fill out a form prepared for that purpose. An example of a standard form is shown below:



POLLUTED SITE SURVEY FORM

INCIDENT REFERENCE

OBSERVATION
Name
Origin
Date, time

SITE IDENTIFICATION
Name
Location

SITE CHARACTERISTICS
Nature Cliff ☐ Rocky platform ☐ Creek ☐ Beach ☐ Dunes ☐ Marsh ☐ Tidal flats ☐
Lagoon☐ Other ☐ ....
Usage
Ecologically important ☐ Fisheries/aquaculture ☐ Industry/harbour ☐ Residential ☐ Recreational/tourism☐

BEACH CHARACTERISTICS
Substrate (rank a, b, c, d, according to dominance) Salt marsh ☐ Mud ☐ Fine sand ☐
Coarse sand☐ Pebbles ☐ Mixed sediment ☐ Boulders ☐ Rock ☐ Riprap ☐
Manmade ☐ ....
Dimension (L x w) Exposure Low ☐ Medium☐ High☐

STATE OF POLLUTION
Location
Upper level ☐ Medium level☐ Lower level ☐

Substrate (rank (1) (2) (3) according to dominance)
Salt marsh ☐( ) Mud☐ ( ) Fine sand ☐ ( ) Coarse sand☐ ( ) Pebbles ☐ ( ) Boulders ☐( )
Mixed sediment☐( ) Rocks ☐( ) Riprap☐ ( ) Manmade ☐( )

Type of oiling
Stripes☐ on ( ) ( ) Tarballs☐on ( ) ( ) Patties ☐ on ( ) ( ) Patches☐ on ( ) ( )
Slick ☐on ( ) ( ) Buried ☐in ( ) Infiltrated ☐in ( ) ( ) Polluted debris☐ on ( ) ( )

Quantity
Extension (L x w) x coverage (%) x thickness (cm) or depth (cm) = Volume
( )
( )
( )
( )
( )
Estimated overall volume

Possible evolution
Remobilisation☐ Infiltration☐ Burying ☐

SITE ILLUSTRATION (photo, drawing etc.)

OPERATIONAL ASPECTS/OPTIONS
Access
By boat ☐ Public works equipment ☐ Light duty vehicles ☐ Pedestrians☐
Storage
Upper part of beach ☐ Behind beach☐ Pits ☐ Skips ☐ Heaps ☐ Other ☐

OTHER OBSERVATIONS
(Response operations in progress) ....
(Possible operations) ....
(Miscellaneous) ....
(Photos taken) -------- -------- -------- --------
(Samples taken) ----- ----- ----- -----

Figure 5. Example SCAT form (from Cedre's Surveying Sites Polluted by Oil).

The sections that a SCAT team covers are as follows:

Identification	◦ of the incident ◦ of the site ◦ of the survey ◦ of the observer
Environmental characteristics of the site (unusual or well known)	◦ physical ◦ ecological ◦ socio-economic
General characteristics of the beach (beach, essentially)	◦ types of substrates ◦ sizes
Characteristics of the pollutant and the spill	◦ colour, appearance, viscosity ◦ types of oil arrivals and location on the beach ◦ size, distribution, volume ◦ expected trend (viscosity, washed back out to sea...).
Operational characteristics of the site	◦ accessibility ◦ is the site easy to work on ◦ storage facilities for recovered waste

Table 3. Typical Information collected by the SCAT teams (from Cedre's Surveying Guide).

Once the observer has inspected all the relevant sites, he must submit his survey forms and a summary of the surveys he has conducted. The summary consists of one single map, if possible, that sums up all the information collected for the area in terms of estimated quantities of beached oil, the nature of the pollution (such as heavy emulsions, buried oil, arrivals of polluted seaweed, etc.).

In some instances, the information collected by observers can be entered into a GIS (Geographic Information System). In these cases, the use of IT through laptops, smart phones, or tablets with GPS, cameras, and wireless communications can facilitate the insertion of data into the GIS.

In this regard, the initiative ARCOPOL, led by Cedre, should be mentioned. ARCOPOL allows coastal pollution information and observations to be entered directly into a website. The following figure shows the ARCOPOL website for the introduction of observations.

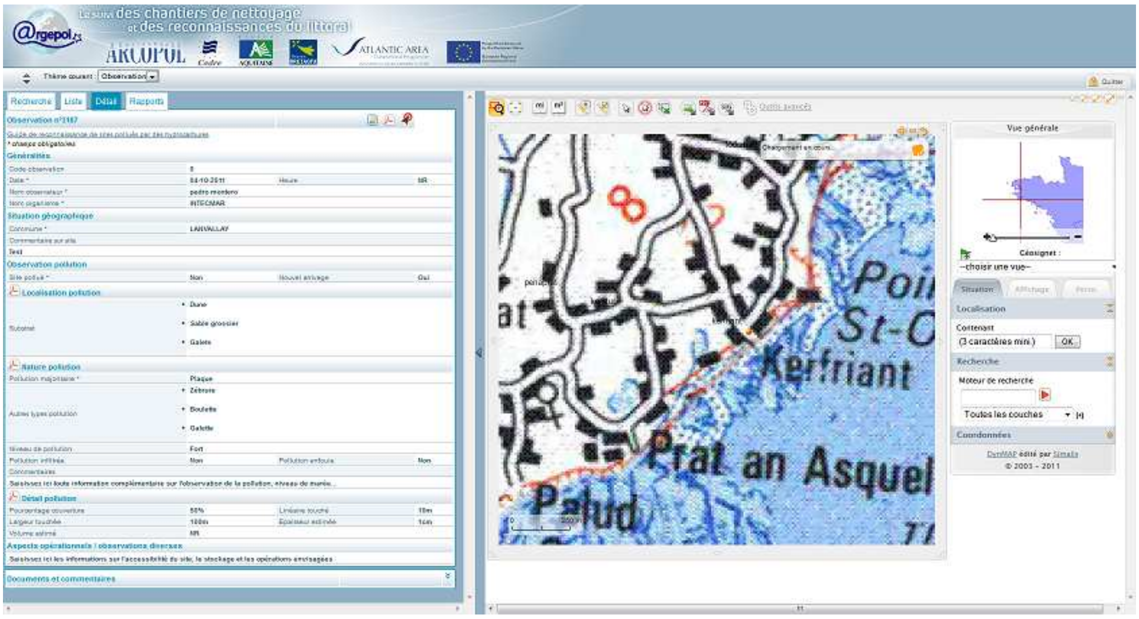


Figure 6. Screenshot of the ARCOPOL website.

Another interesting initiative is the NOAA Marine Debris (http://marinedebris.noaa.gov/). Although this program is aimed at collecting data about debris on beaches, the originality of the system is the use of platforms such as iPhone or Android smartphones for data collection. The following figure shows a screen with the data collection application on a mobile phone.

Figure 7. Example of a mobile phone data collection application

PREDICTIONS SYSTEMS

TYPE OF PREDICTIONS

The standard method to predict the movement of spills is through the results of drift models. These are mathematical models capable of numerically predicting the position of spills at a future time starting from an initial position forced by wind, wave, and current fields. These fields are often predicted by numerical models developed for such a purpose.

The drift models can be classified as either Eulerian or Lagrangian. The first models the dynamics of the concentration of a substance, while the second uses a relatively large number of particles, known as Lagrangian cells, to represent the substance. The concentration of the substance is then calculated from the number of particles (or its represented mass) per unit area. In the case of spills, most of the models used are typically Lagrangian.

It should be noted that when compared with meteorological, current, and wave models, drift models are relatively light and quick. However, the quality of the predictions of these depends on the accuracy of the predictions of the forcings used and therefore, the atmospheric and hydrodynamic models.

Thus while drift models are often run on demand, once the location of the accident or the position of the observations of discharges are known, hydrodynamic and atmospheric models are often run routinely to results available.

Although the models are run for future situations, they can also be used to analyze past situations, running the timeline backwards. This technique is often called backtracking and is frequently used to discover the emitting source of a spill, especially in the case of oil spills.

TYPES OF INFORMATION

Hydrodynamic, atmospheric, and wave models provide fields for currents, temperature, winds, and waves (wave height, period, and frequency) for several forecasted times. This data is usually arranged in a two-dimensional grid for the atmosphere (only used on the surface) and the waves and two-dimensional or three-dimensional hydrodynamic models. This grid can be structured or unstructured. Whether considering 2-D or 3-D data, the main feature is often quite large, so tools have been developed for quick and easy handling. In addition, it should be noted that they have a temporary dimension and that winds and currents must be represented by vectors.

Drift models are commonly represented with three types of figures: a representation on a map of the spillets themselves, the path of the centre of mass of the spill over time, and the field of discharge concentration represented by the particles. However, data derived from Lagrangian models are very different in size and shape tan data from hydrodynamic models.

The data formats used for exchanging data from atmospheric, hydrodynamic, and wave models were conceived by the Earth and Ocean Sciences (EOS) community. Several formats are commonly used, such as GRIB (Gridded Binary) , HDF(Hierarchical Data format) and NetCDF.

Regarding the data derived from models, there is currently no definitive format for the different resulting features (spillets, lines, concentration, etc). The CF convention, in its latest version, supports several ways to deal with the data, but many prefer to use other formats such as ESRI Shapefiles, KML, or simply ASCII files.

INFORMATION FOR END-USERS

End-users, specifically the managers, will need to handle specific parts of the information quickly and securely. Moreover, the information needed is not all the information generated, rather only that of which is important for decision making. However, this does not mean that at some point additional information will not be required, so it is necessary to have it readily available. Finally, all data generated must be stored for later use or simply for keeping a record of the situation during the spill crisis.

As one can see, most of the information have the ability to be geo-referenced, i.e. prepared on a map. End-users will utilize this mapped information on to gain a general idea of the situation. In addition to this information, the end-users will create reports.

Therefore, a tool for the end-user must:

- Display fast, accurate, and secure results on a map
- Mix different information on a map
- Generate reports, graphs, and drawings that can be inserted into reports
- Be user-friendly
- Store data in one or more databases

TOWARDS A GLOBAL SCHEMA

The following schema summarizes the different combination of data types and communication formats between each group.

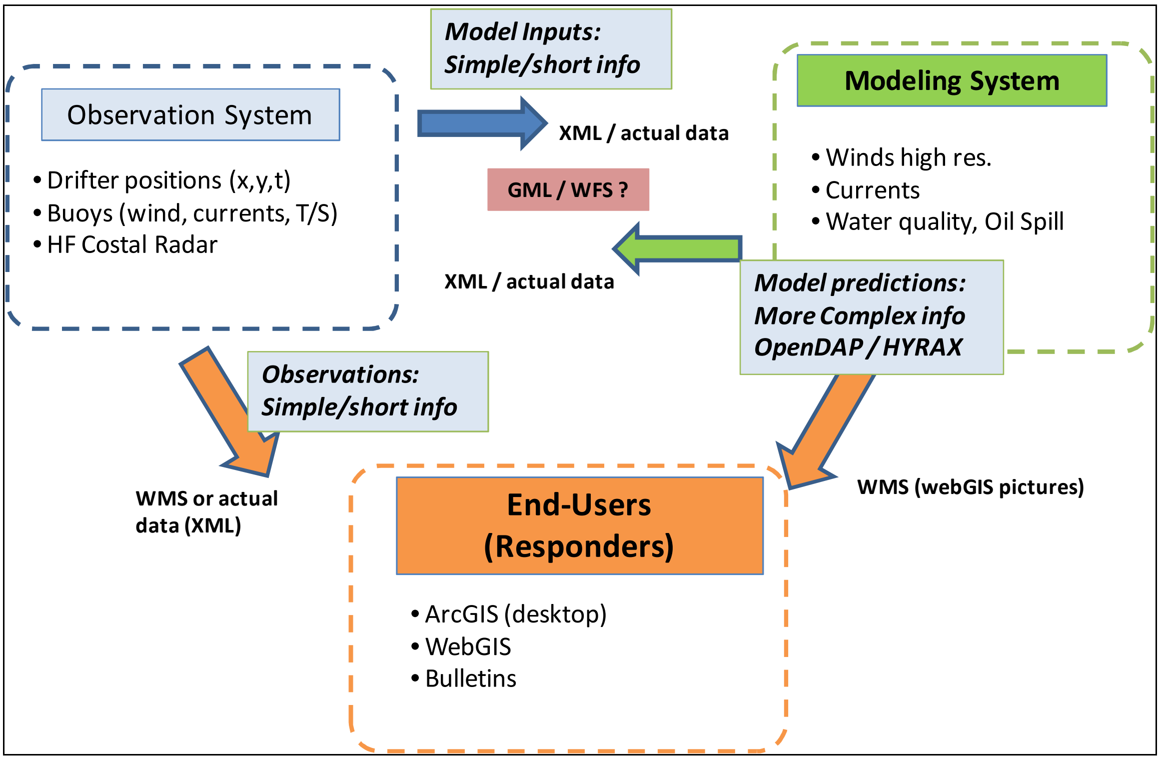


Figure 8. Flow of data types & communication formats between different groups.

While some data can be simply transferred as (geo-referenced) images, other applications may require the actual data (metadata and its content). Typically the modelling system component requires having a more “intelligent” data server to provide data on-demand.

The challenges faced in integrating the different users and data communications could be characterized in the following topic areas:

- Data Management communities
- Sharing input information/data with the model and common operational picture
- Delivering data to the model(s)
- Sharing/publishing the model results
- Building user applications

RESPONSE SYSTEM FRAMEWORK:

REQUIREMENTS & PROPOSALS

Since the visualization of data in maps is an essential element in providing an overview of the spill crisis, as well as the computerization of the maps, it is necessary that the crisis management tools use applications from or with the participation of Geographic Information Systems (GIS).

On the other hand, it should be noted that location of crisis workers can be varied, such as the unit for monitoring and prediction who have high capacity networks, as well as GIS specialists, in contrast to an operator in the spill area, with low-bandwidth communications and without anybody high specialized in geographic information. Therefore, it should be ensured that tools are able to work without an internet connection.

Additionally, these users may be using different software to manage the spill crisis, such as an ESRI ArcGIS tool or a geographic visualization tool like Google Earth.

Since data and information is generated by multiple agencies and institutions, the platforms needs to allow for interoperability with other data servers, i.e., must ingest various data formats without major changes and if possible using transmission of the requests over the internet.

Building a platform that seeks to have scalability in the future should include the following capabilities:

- Ability to use a lot of sources of information without major changes of formats, and possibly using network services.
- Ability to use different tools or software for the management of the crisis, with the end user to choose which should be used, regardless of the information used. The platform should not impose a client tool.

BACKGROUND

The following sections will be a brief introduction to Geographic Information Systems (GIS) and the interoperability of these systems, based on the explanation of an IDE as a platform for distributed geographic data, such as the various services that exchange geographic data over the internet. These services are standardized by an international organization known as OGC (Open Geospatial Consortium), and are used by most GIS software, which allows the exchange of information between them.

GIS & SDI

A Geographic Information System (GIS) is an organized integration of hardware, software, and geographic data, methods, and trained personnel designed to capture, store, manipulate, analyze, and display geo-referenced information in order to solve complex problems of planning and management in all its forms. A GIS can be also defined as a model of part of reality referred to a ground coordinate system and built to meet specific information needs. In the strictest sense, a GIS is any information system capable of integrating, storing, editing, analyzing, sharing, and displaying geo-referenced information. In a more general sense, GIS are tools that allow users to create interactive queries, analyze spatial information, edit data, maps, and present the results of these operations.

GIS functions as a database with geographic information (alphanumeric data) that is associated with an identifier common to graphical objects on a digital map. GIS data represents the objects in the real world (roads, soil use, altitude, etc). There are two ways of storing data in a GIS:

- Raster: A raster data type is, in essence, any digital image represented in tights. Divides the space into regular cells where each of them represents a single value. Aerial photographs are a commonly used form of raster data. Raster data are stored in different formats, from a standard file structure based on the TIFF, JPEG, etc. large binary objects.

- Vector: In a GIS, geographical features are often expressed as vectors, keeping the geometric characteristics of the figures. Each of these geometries is linked to a row in a database that describes their attributes. Digitally modelling real world entities using three geometric elements: point, line and polygon. Vector layers are usually stored in Shapefile format or simply SHP.

A Spatial Data Infrastructure (SDI) is a computer system composed of a set of resources (catalogues, servers, software, data applications, websites,…) dedicated to managing geographic information (maps, orthophotos, satellite images, names,…) available online, that meet certain conditions for interoperability (standards, specifications, protocols, interfaces,…) that allow a user, using a simple browser, to use them and combine them according to their needs.

The justification for the establishment of an SDI is linked to two fundamental ideas:

- The need for easy, comfortable, and efficient use of existing geographic data. Geographic data, thus far, has been a source of costly productions and difficult access for several reasons: formats, models, distribution policies, lack of information, etc.

- The opportunity to reuse the generated GIS in a Project for other different purposes, given the high cost of production.

In this sense, the EU encourages interoperability between SDIs local, regional and national building an SDI via the European INSPIRE initiative.

WHAT IS INSPIRE?

In Europe a major recent development has been the entering in force of the INSPIRE Directive in May 2007, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.

The INSPIRE directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019.

The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organizations and better facilitate public access to spatial information across Europe.

A European Spatial Data Infrastructure will assist in policy-making across boundaries. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes.

INSPIRE is based on a number of common principles:

- Data should be collected only once and kept where it can be maintained most effectively.
- It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.
- It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.
- Geographic information needed for good governance at all levels should be readily and transparently available.
- Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

(from http://inspire.jrc.ec.europa.eu)

OGC STANDARDS

Standards and agreements constitute an essential substrate which makes it possible for necessary coherence, compatibility, and interoperability so that the data services and resources of an SDI and can used, combined, and shared.

The Open Geospatial Consortium (OGC) is an international voluntary consensus standards organization, originated in 1994. Its purpose is to define open standards and interoperable solutions within the web and GIS. Seeking agreements between different companied of the sector to enable interoperation of geoprocessing systems and facilitate the exchange of geographic information for the benefit of users. It was formally known as Open GIS Consortium.

Examples of OGC specifications are:

- Geography Markup Language (GML): It is an XML grammar for expressing geographical features.
- Web Feature Service (WFS): provides an interface allowing requests for geographical features across the web using platform-independent calls.
- Web Map Service (WMS): produces maps of spatially referenced data, dynamically from geographic information.

NETCDF AND SCIENTIFIC STANDARDS

As we have mentioned above, currently, model outputs are gridded fields with 3 spatial dimensions and one temporal dimension which results in very huge data files. Thus, it is hard to deal with those them. In order to overcome this problem, some data formats were created as NetCDF, which has been greatly expanded in recent years as format for exchanging gridded scientific data.

WHAT IS NETCDF?

NetCDF (network Common Data Form) is a set of interfaces for array-oriented data access and a freely-distributed collection of data access libraries for C, Fortran, C++, Java, and other languages. The netCDF libraries support a machine-independent format for representing scientific data. Together, the interfaces, libraries, and format support the creation, access, and sharing of scientific data.

NetCDF data is:

- SELF-DESCRIBING. A netCDF file includes information about the data it contains.
- PORTABLE. A netCDF file can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.
- SCALABLE. A small subset of a large dataset may be accessed efficiently.
- APPENDABLE. Data may be appended to a properly structured netCDF file without copying the dataset or redefining its structure.
- SHARABLE. One writer and multiple readers may simultaneously access the same netCDF file.
- ARCHIVABLE. Access to all earlier forms of netCDF data will be supported by current and future versions of the software.

The netCDF software was developed by Glenn Davis, Russ Rew, Ed Hartnett, John Caron, Steve Emmerson, and Harvey Davies at the Unidata Program Center in Boulder, Colorado, with contributions from many other netCDF users. It is safe to say that NetCDF4 is going to be and is in fact the most common format for the Exchange of scientific data. NetCDF was also named the OGC standard in 2011.

In consideration to NetCDFs, for their readability, there are several conventions for the unification of metadata that have been created. Among them, the most commonly used is the CF, NETCDF Climate and Forecast Metadata Convention (http://cf-pcmdi.llnl.gov/). This convention uses a series of standard names and attributes as the units for a large number of measures that can be performed in the air and ocean.

As mentioned above, the model output files are considerable in size and therefore, their distribution over the internet creates technological problems. For this reason, in addition to the usual protocol for the exchange of files like FTP or http, a special protocol has been designed for this type of file known as OpeNDAP, or Open-source Project for a Network Data Access Protocol.

DATA MANAGEMENT COMMUNITIES / USER GROUPS

The ability to build successful marine crisis software architecture requires bridging the gap between different communities, primarily the Earth and Ocean Sciences (EOS) community that uses a suite of scientific data formats and standards and the GIS community that uses a set of tools, formats and standards with a traditional focus on static geographic information.

The EOS community typically use a set of binary data formats, often in grids, that are typically HDF (satellite data), GRIB (meteorology data), and NetCDF (gridded meteorology and oceanographic data). These categories are general, as other formats are also used. For in-situ observations, buoys and drifters, there historically has been less consistency, with data stored and shared in a wide variety of formats including ASCII, relational databases and other custom binary formats. The science community have a wide set of tools to manage this type of data.

The GIS community typically uses a different set of data standards, driven by the commercial GIS vendors (ESRI and others) and the open-source community encapsulated by the OGC (Open Geospatial Consortium). The data in the GIS community can be generally categorized into two main classes, vector (features) and grids (rasters). Features are generally stored in file structures (eg. SHP, KML) and relational databases (Postgres, Oracle, SQL Server) where there have been a lot of improvements to manage spatial data, The GIS community is very advanced in using web services to share data. Traditionally, the GIS community has not provided strong support for time-varying data.

SHARING INPUT INFORMATION/DATA WITH THE MODEL AND COMMON OPERATIONAL PICTURE

The data that needs to be managed can be classified as:

- **Non-geospatial information**: photos, video, reports, contingency plans, etc. The evolution of Web 2.0 technologies has made this class of data readily manageable. Data is available in a wide number of files such as HTML, PDF, AVI, MOV, etc., that are readily consumable by web browsers and searchable using search technologies such as Google.

- **Gridded Data**: As described previously, the EOS community use a set of grid formats. A number of technologies have evolved to make access to these data sets neatly seamless. Many of these data providers make this data available via OpenDAP (Data Access Protocol). An OPeNDAP server can serve an arbitrarily large collection of data. Compared to ordinary file transfer protocols (e.g. FTP), a major advantage using OPeNDAP is the ability to retrieve subsets of files, and also the ability to aggregate data from several files in one transfer operation. There are two main flavours of this server THREDDS Data Server (TDS) managed by Unidata and OpenDap/Hyrax managed by Opendap Inc. TDS (http://www.unidata.ucar.edu/software/tds/) is a web server that provides metadata and data access for scientific datasets using OPeNDAP, OGC WMS and WCS, HTTP, and other remote data access protocols. In addition to distributing data, catalogue files to facilitate your search. Next figure shows the relationship between formats, servers, catalogs, protocols and applications.

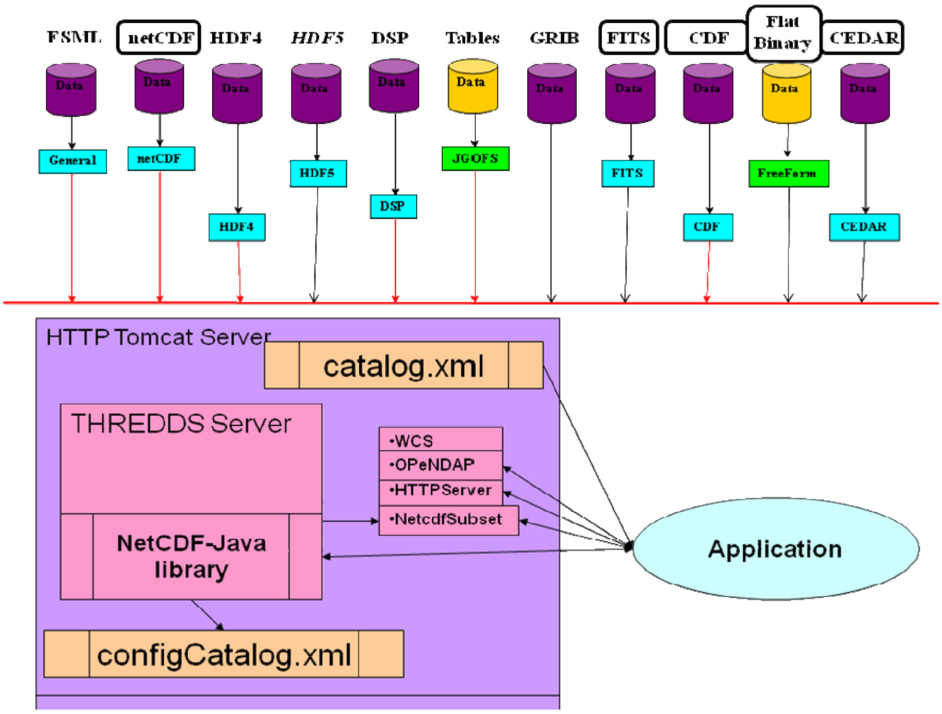


Figure 9. Schema of a THREDDS Server.

Currently, there is an initiative to provide geospatial NetCDF data through a WMS to display model outputs. This initiative is known as ncWMS (http://www.resc.rdg.ac.uk/trac/ncWMS/)and is an add-on that is coupled to the OPeNDAP server.
An Application Programming Interface (API) is available (NetCDF Java library) that allows developers to use one interface to access the gridded data whether it is stored in NetCDF, GRIB, HDF, or other data formats.

- **Non-Gridded met-ocean data –** For data that comes from other platforms such as AUV's, drifters, in-situ buoys, there is some movement to use one of the formats traditionally used for grids to manage this data and some progress has been made to use NetCDF for these data types. However, this is still immature and there has been a lot of development to standardize the use of the Sensor Observation Service (SOS), an XML-based protocol for sharing point observations. This is still evolving and there continues to be a lack of client support for SOS so it may be viewed that SOS will be used to share data between the sensor and a central data assembly center (DAC) where the data may be stored in relational databases. Once centralized, it can be made available to the end user applications using different methodologies, including KML and SHP files. There is also evolution of the SOS implementation so that the data return may be available in a variety of formats including simple CSV, GML and JSON which is very popular with the web development community as it is efficient and easily integrated.

- **Geospatial Features**: For features such as points (e.g spill location, last known position, vessel locations, etc.), polygons (observed slick, dispersant zones, exclusion zones, etc.) and polylines (boom locations, vessel paths, etc.), the GIS community has been managing and transferring these types for data for decades, so data available as SHP, KML or some XML-based standard such as GML makes this data readily consumable by a variety of desktop and web geospatial applications. The time-varying aspect of data is still a challenge but there is evolving support for time-based GIS in ArcGIS 10 and support for time-varying data in KML

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	Growing adoption as part of Sensor Web Enablement (SWE) Provides consistent methodology	No widespread client support Verbose so not practical for large amounts of

Sensor Observation Service	to share sensor data Ideally suited for sharing data between sensor and data assembly centre	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 sub setting 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

Table 4. Advantages and weakness of most used standard formats.

ARCHITECTURE OF THE SYSTEM

INTRODUCTION

After the above, it should now be understood that there are several different players involved in marine spill crisis, but one must differentiate between those who populate the databases of information and those who collect such information.

There are several tools and specialized software for managing a contingency. One way to use this information for crisis management is the use of monolithic software where all the bases and management tools are not physically or logically separated.

However, there are several problems associated with this kind of approach.

- The information generated by other institutions must be sent to the computer of the institution is in charge, create a local copy and converted to the proper format to be used by the software used. In addition to time spent on shipping and reformatting, problems can arise in the integrity of data every time you review the source data.
- Conversely, any information generated by the distributed system must be sending copies of this information. The recipients of this information should change this to use with your software.
- If different software with different input formats is used, they must transform again and again to be used by them.

Ultimately, capacities of distributing information, both for sending and receiving are reduced by the use of different software and communications.

When faced with this problem, take into account that, on one hand there are several institutions that provide information and on the other hand, that different users with software tailored to their needs, it is advisable to use client-server architecture in three layers:

1. Databases or data generated containers: The logical layer where the data and information to be used during the crisis is stored, either because it has been collected previously or because it was generated during the contingency. This layer will contain data from GIS layers, text files, databases, files of results of the models. In a distributed architecture, there would be a single server, but each institution or agency data generator possess one or more servers to serve your information, or if that could not be used the other alternative.
2. Interfaces or Services Layer: Layer logic that would provide interoperability services for the above data. For these services, OGC standards are chosen, such as WMS to serve maps, features and WFS to serve NetCDF OPeNDAP or combined with services to serve Thredds modelling data. You can also use the WFS, WFS-Transfer or to insert information in the GIS database.

3. Customers: the layer of tools that use data from the first layer available through online services. These software tools can be management, visualization, GIS clients or models that would use data from observations as initial conditions.

The following figure shows a schematic summary of the above.

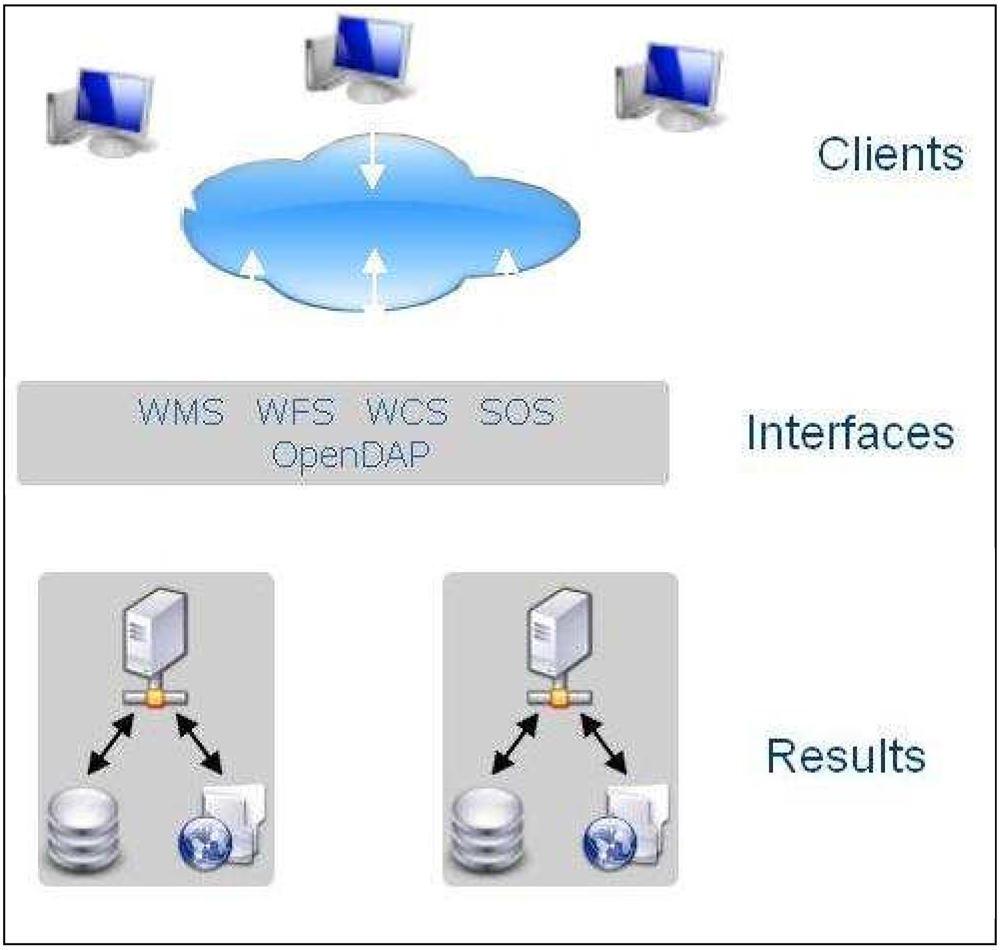


Figure 10. Client-server architecture layers.

IMPLEMENTATION: INTECMAR EXAMPLE

The following section will explain the specific implementation of this architecture in INTECMAR. The specific objectives of this system are:

- Creating a management tool that could be used by the Galician Coast Guard and INTECMAR, with the ability to ingest data from other institutions as well as static information that existing in GIS format. The platform must be able to insert and manage information from various observations and models.
- Use this system as a test bed for the flow of information as well as example for the development of similar tools.

- Produce a code and a knowledge that can be valid and transferable to similar tools and projects.
- The conditions that must be met are:
    - Build on existing tools and developments, such as APIs and development project produced by the RAIA.
    - Ensure scalability and therefore, the future development as well as distribution and interoperability of information regardless of the final tool.

Para la construcción de la herramienta se parte de la metodología multicapa, con las 3 capas lógicas anteriormente relacionadas.

Multilayer methodology with 3 logic layers mentioned above is using in order to build this tool.

The layers of servers use the following applications;

- OPeNDAP Server with NcWMS plug-in: is mainly used for the distribution of gridded data and outputs from atmospheric, hydrodynamic, and wave models, as well as data from Radar-HF.
- GeoServer: This server is used primarily for geo-referenced data in vector format. In contrast to other servers, GeoServer supports WFS-T.
- MapServer: It supports vector formats such as ESRI shapefiles and GML's, in addition to raster formats, such as geotiffs and ECW's, the latter of which is used to serve the orthophotos and nautical charts.

In the layer of interfaces, the most commonly used are:

- OGC-WMS (WebMapServer): This protocol is used for rendering maps and layers of different servers as well as timely response data associated with these layers. OGC-WFS (Web Feature Service): This service is used, in our case, to respond to requests for data itself; less frequently used than the previous one. OGC-WFS-T (Web Feature Service):. Used to insert features from the client to the server.
- OPeNDAP/NcWMS: OPeNDAP services are used to return large data requests.

Regarding on layer of clients:

Any software that can interact with the above protocols can be contained in this layer. In particular, commercial and open-source software as ESRI ArcGIS, CarbonCopy GAIA, GvSIG, or Google Earth as well as own GIS solutions are able to display layers WMS. In addition, custom clients can use existing libraries, prepared to interact to these protocols such as OpenLayers can develop.

Three similar clients were created in the implementation of the INTECMAR, but each with specifications to collect three types of main users: Observer, modeller, and managing user. For each of them a custom web-viewer has been developed. Each of these is very similar to the others but has certain tools and features depending on the type of user.

Thus, the observer is able to insert comments into the geodatabase using WFS-T Protocol. The modeller is able to collect the information of the comments stored in databases through WFS and transform them into inputs for the models. Once these are executed, the results of the models can be inserted in the database through OGC-WFS-T protocols for storage. The use of the observations for both the inclusion of the results in the database, models need to develop specific procedures for the transformation of formats. Finally, the end user is able to collect information inserted by the previous observer and modeller, as well as other servers, to be viewed quickly and draw up reports on the situation.

It should be noted that not all information is likely to be transferred efficiently using these protocols; so far, certain kinds of information for example, geographically referenced images, must be sent using another kind of protocols (FTP, http) and manually inserted in the geodatabase. Even so, it is expected that the future is to automate also this kind of interoperability.

The final outline of the implementation of the system can be summarized in the following figure:

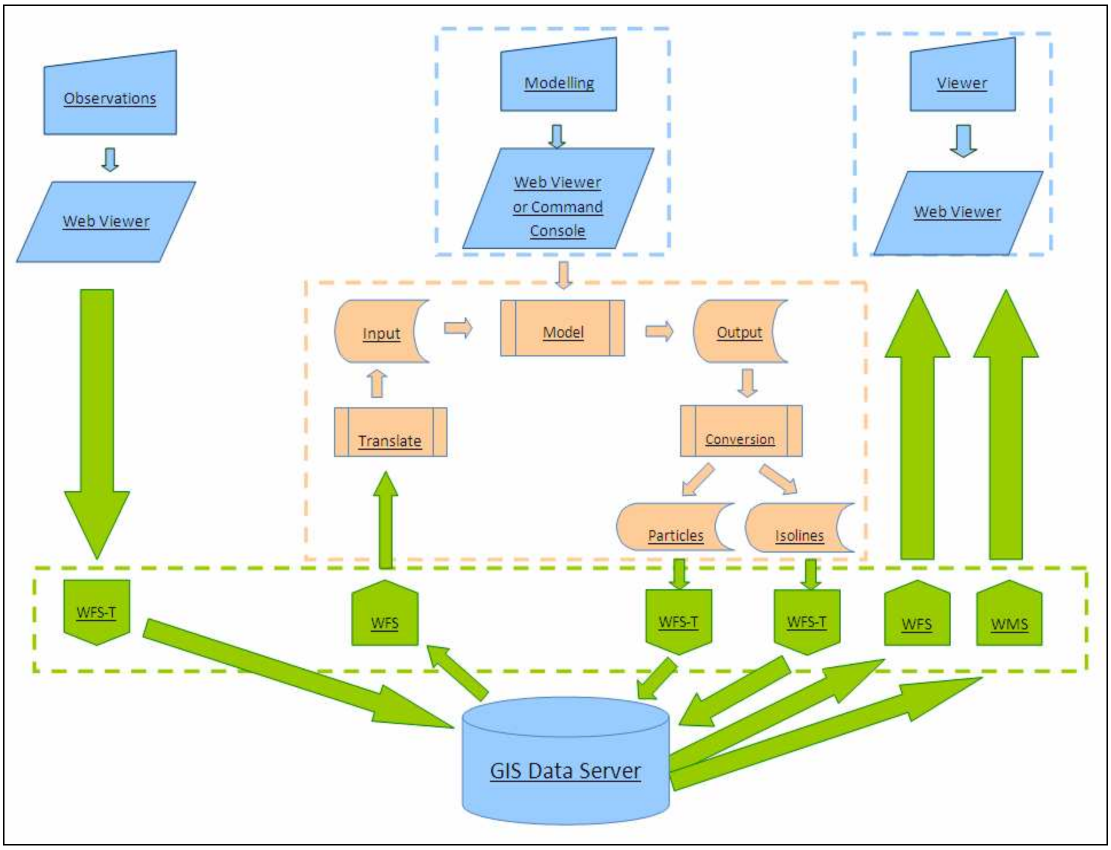


Figure 11. Implementation of the system. Client layer is in blue, protocols are in green, and model client in orange.

ARCOPOL WEB TOOL:

The following is a brief explanation of the use of ARCOPOL, using INTECMAR as an example, and its mode of development for clients. Logically, these clients have a use of their own for ARCOPOL, but INTECMAR is shown as an example. However, its implementation and development can help to build future viewers.

The display is based on an adaptation of the generic viewer application developed in the RAIA Project, funded by POCTEP through the ERDF (http://www.observatorioraia.org).

The basic viewer (http://ww3.intecmar.org/arcopol/viewer.html) is a web application consisting of four distinct regions

1) The map showing the information
2) A layer tree (left of page)
3) A toolbar
4) A table containing the active layers

The following figure shows the general appearance of this page:

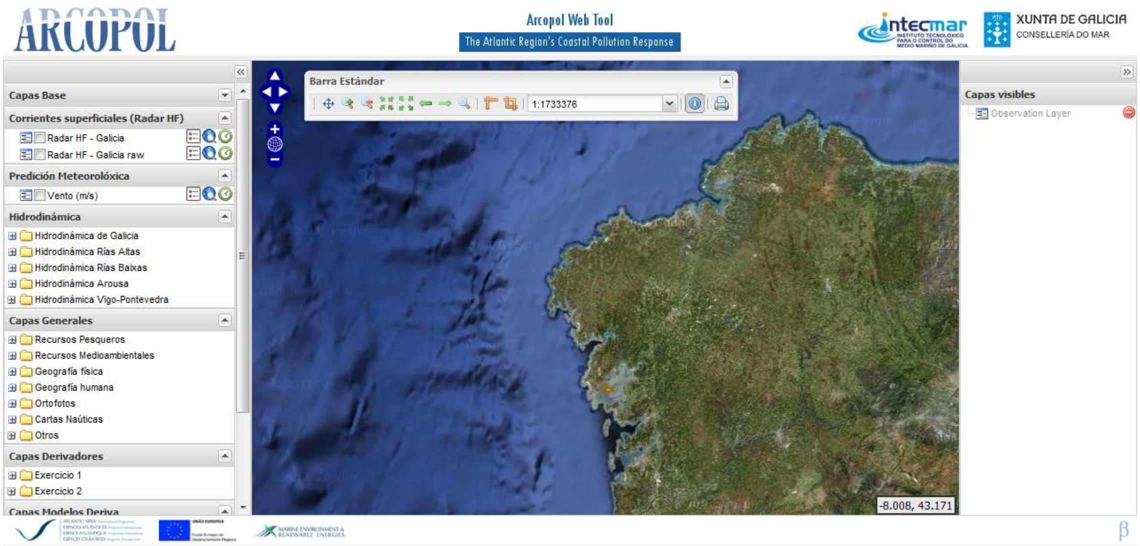


Figure 12. Screenshot of the ARCOPOL web client with layers tree on left

Any of the viewers is based on this provision, with their differences in layers that are accessible through the viewfinder and attached tools for manipulating the map.

Next figures show the capability of manager web client to display several kind of data as environmental data, fisheries areas, model outputs and navy charts. All of these layers are storede in GIS Servers and they are retrieved when selected.

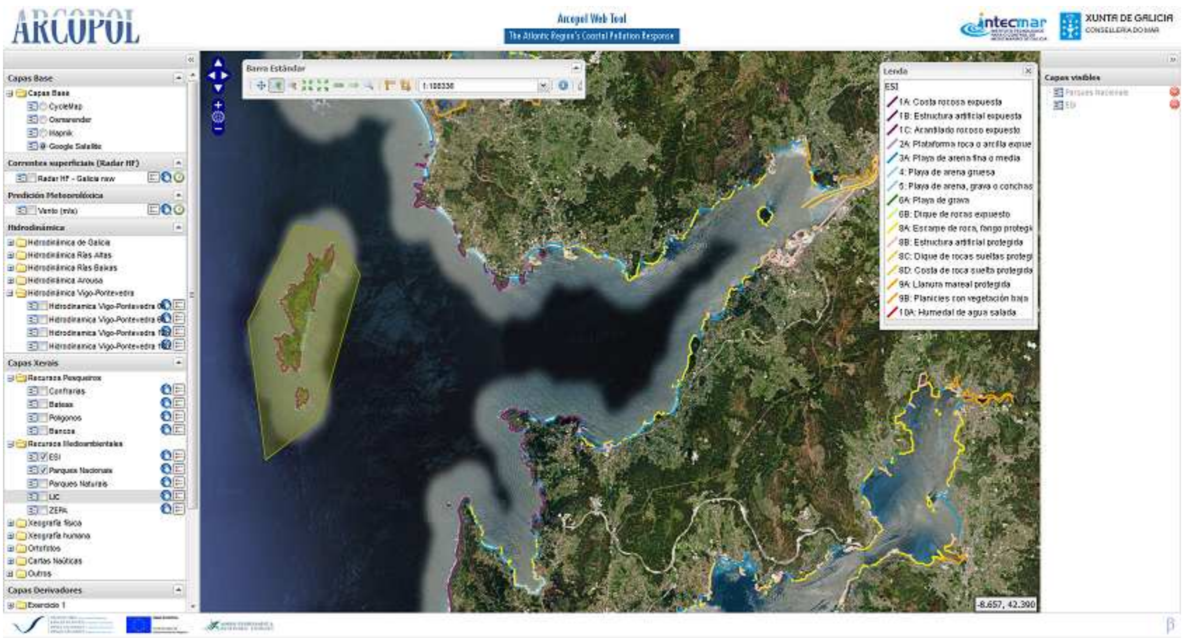


Figure 13. Web client with ESI line and National Parks layers activated.

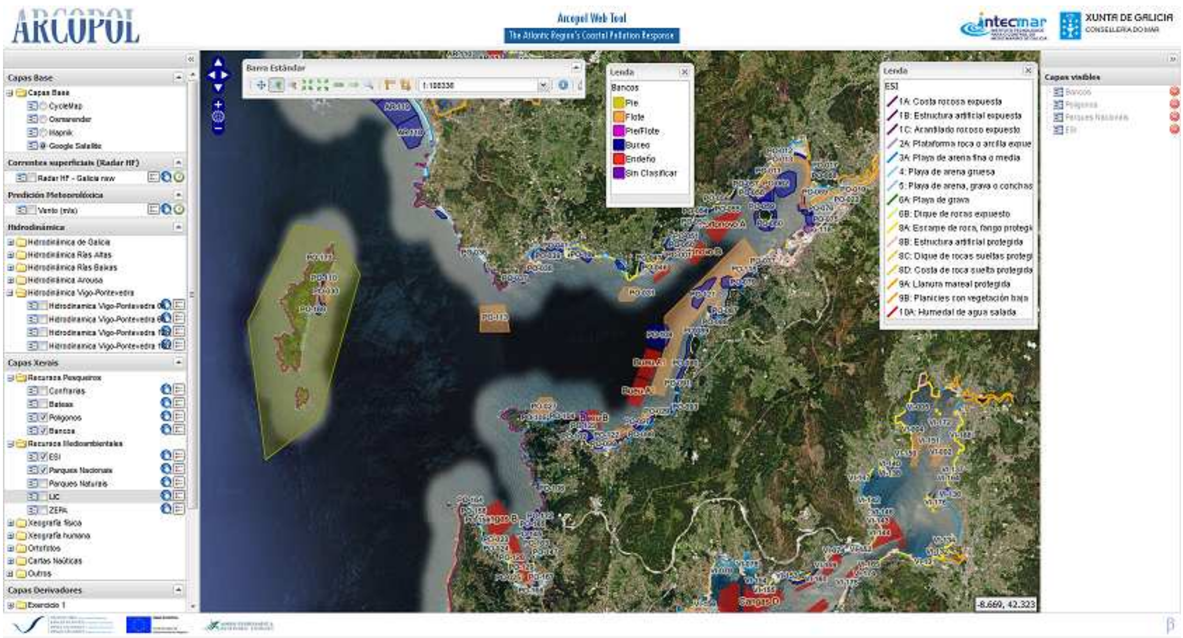


Figure 14. Former web client with fisheries and aquaculture areas added.

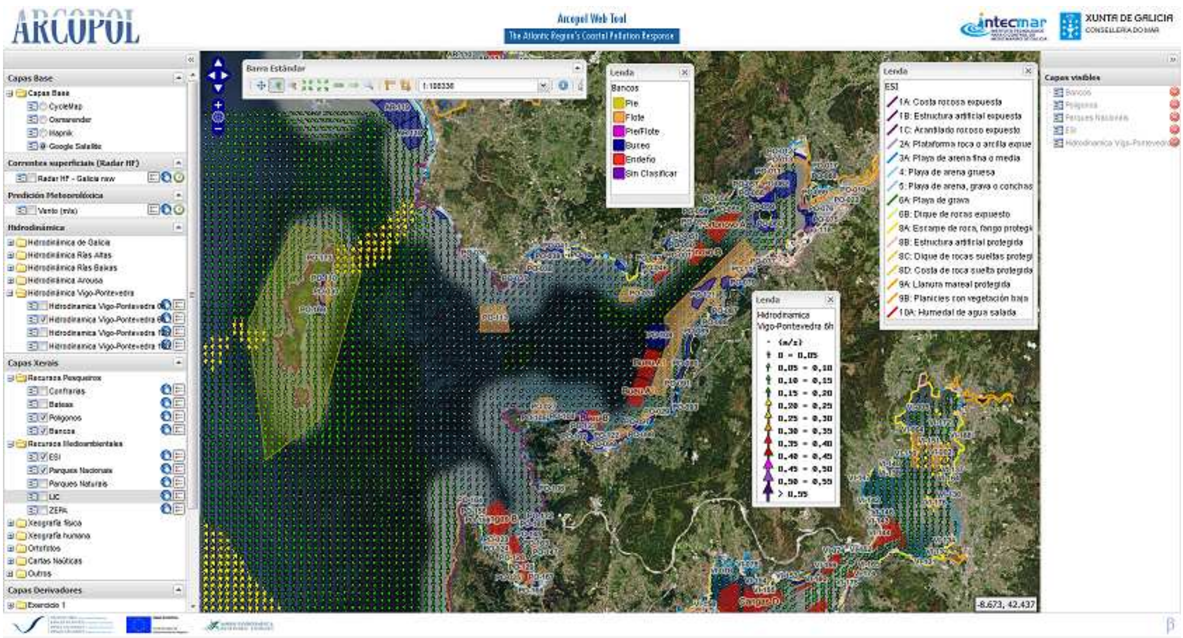


Figure 15. Former web client with currents output model added.

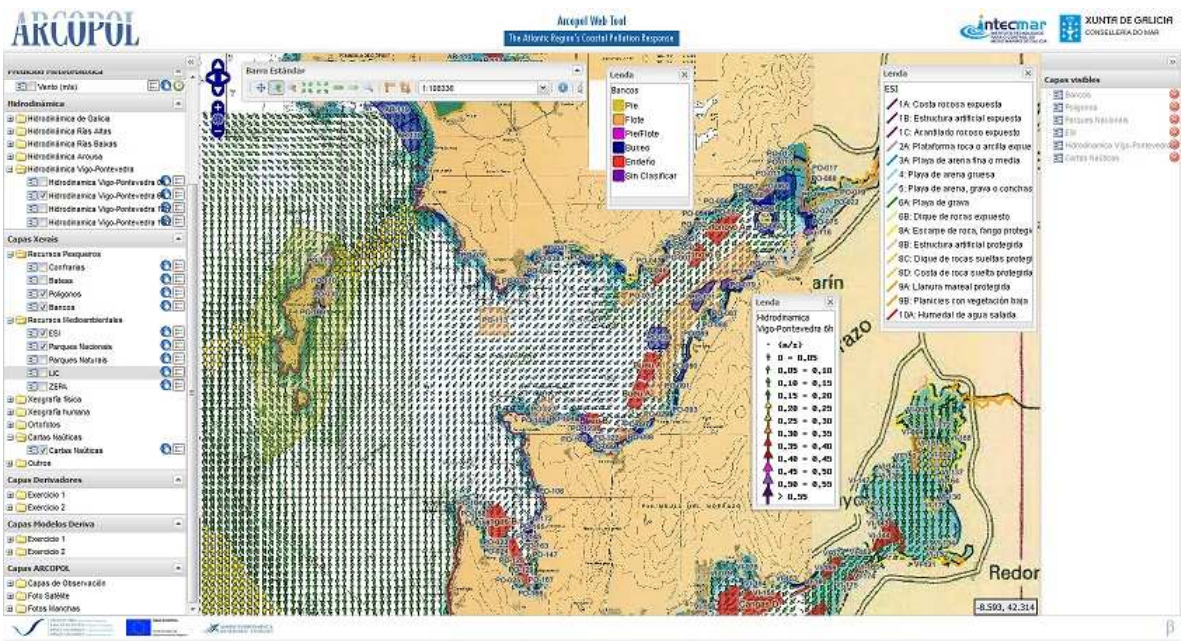


Figure 16. Former web client with the marine chart added.

Next figure shows the results of a real exercise, conducted by Galician Coast Guards. Drifter were released and a lagrangian model was run to simulate their tracks. Blue dots are the locations of the drifters in several times. Red dots are the lagrangian model output forced by wind. Yellow dots are the lagrangian model ouput forced by wind and currents. All of them were simulated with MOHID model developed by Maretec. External forcings came from MeteoGalicia.

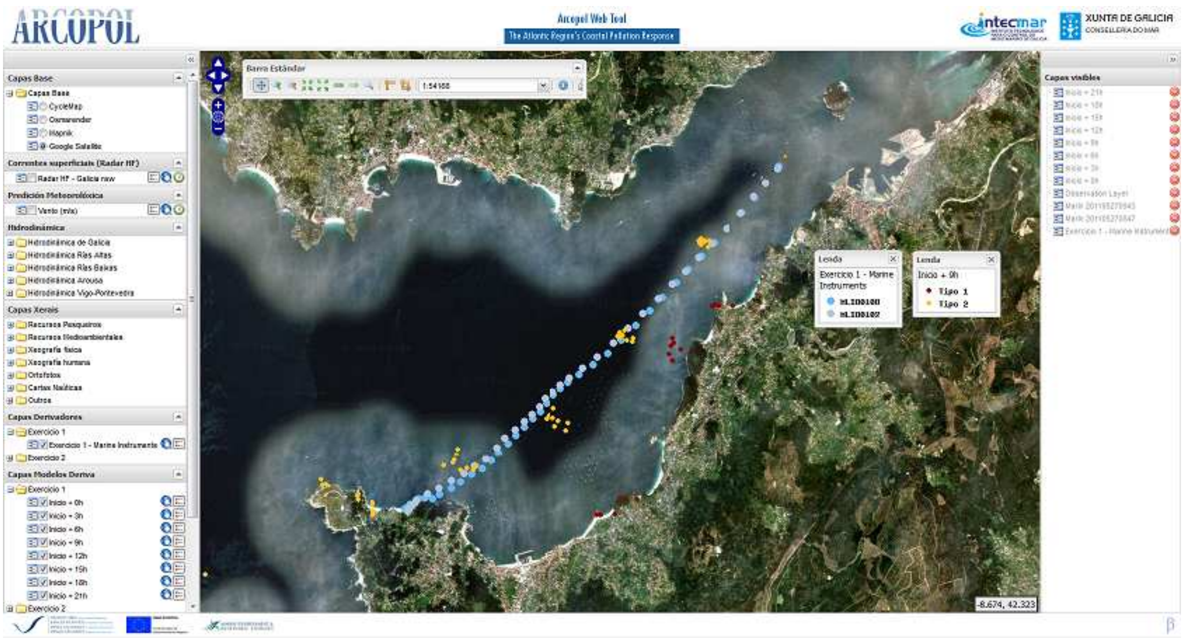


Figure 17. Web client showing drifter tracks (blue dots) and lagrangian model outputs (yellow and red dots).

Next figures show the capability of the observation web tool to create shapes from georeferenced images and insert in a GIS database to be used by modelers and managers. During a Galician CoastGuard exercise, a fluoresceine spill was released. Following a procedure developed in DRIFTER Project, zenital pictures were taken and georeferenced as geotiff images. Then, they were inserted into INTECMAR GIS database and retrieved by ARCOPOL web tool. Since they were georeferenced, these images are correctly located and oriented and with their right size.

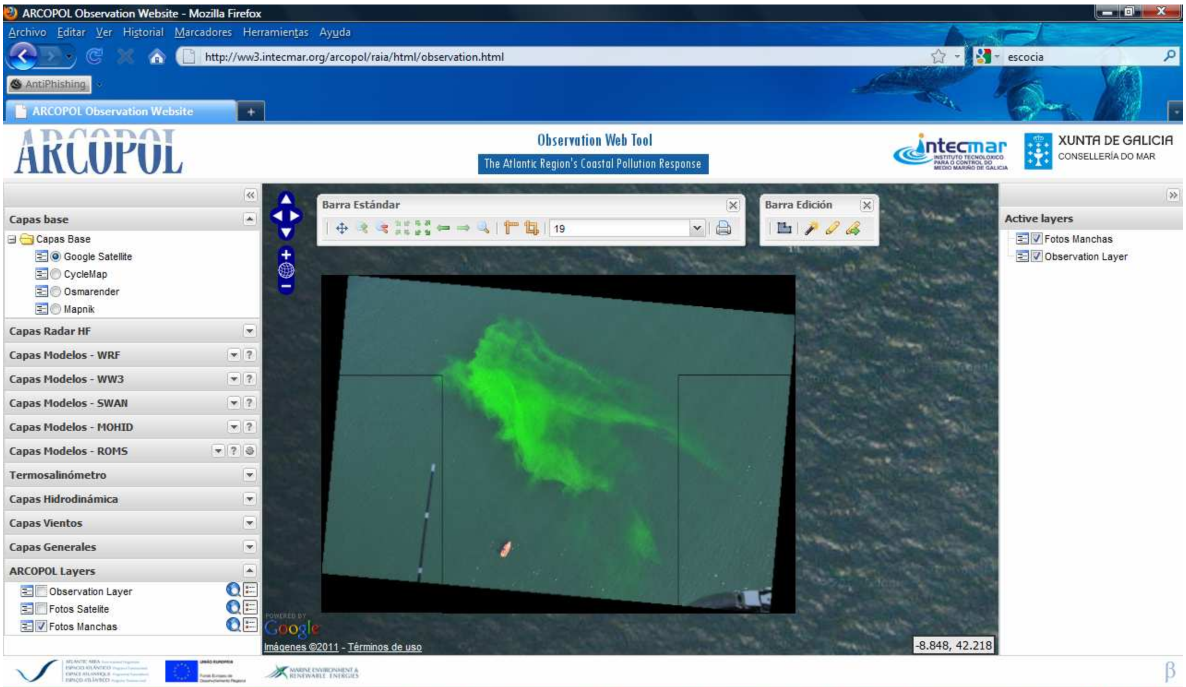


Figure 18. Web client showing a georeference image of fluoresceine slick.

Observer web viewer has got an inserting tool, with the capability to mark the boundaries of this image, and insert as a vector shape in the GIS database as well to add it some keywords as the observation time, type of spill, name of the observer, etc. All of these data as well as the location and shape of the spill can be used for managers as well as modelers as an input of a spill model.

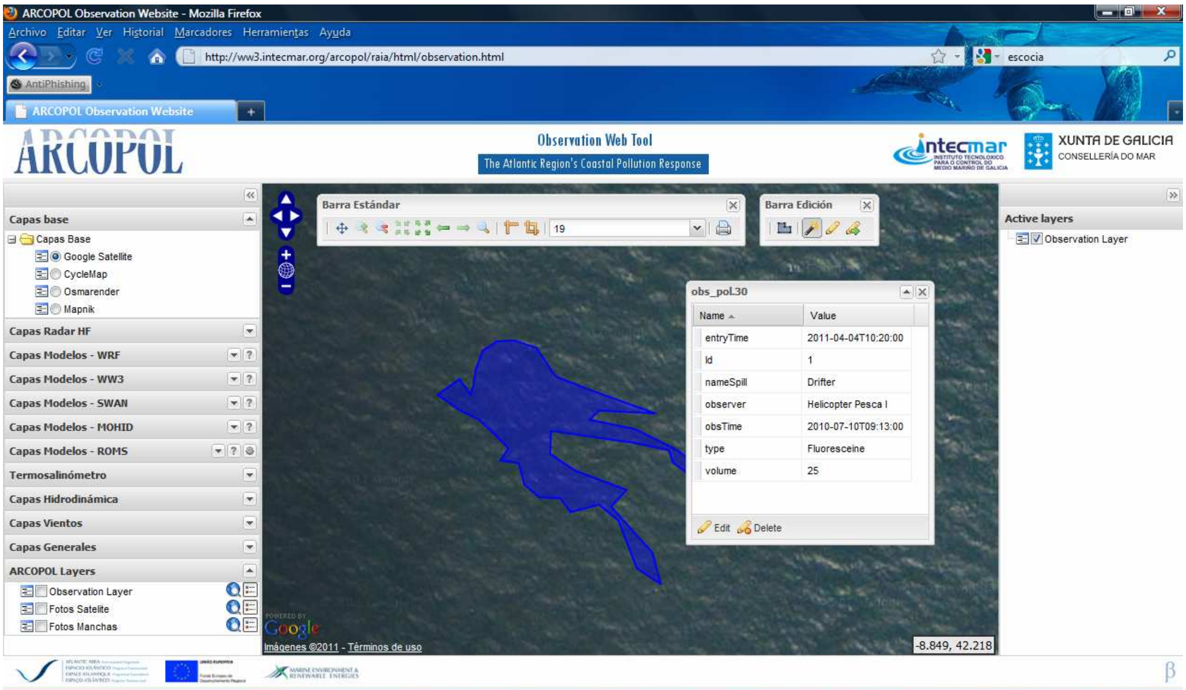


Figure 19. Vectorized slick and dialog window to add data. Next step will insert this shape in a GIS database.

Since the system is based on standards, all geographic features can be retrieved not only by custom web GIS but by another ones using the same protocols. Thus, next image shows the web client with a forecasted slick from a model (red spots). This output can be merged with other as fisheries areas to obtain add value information.

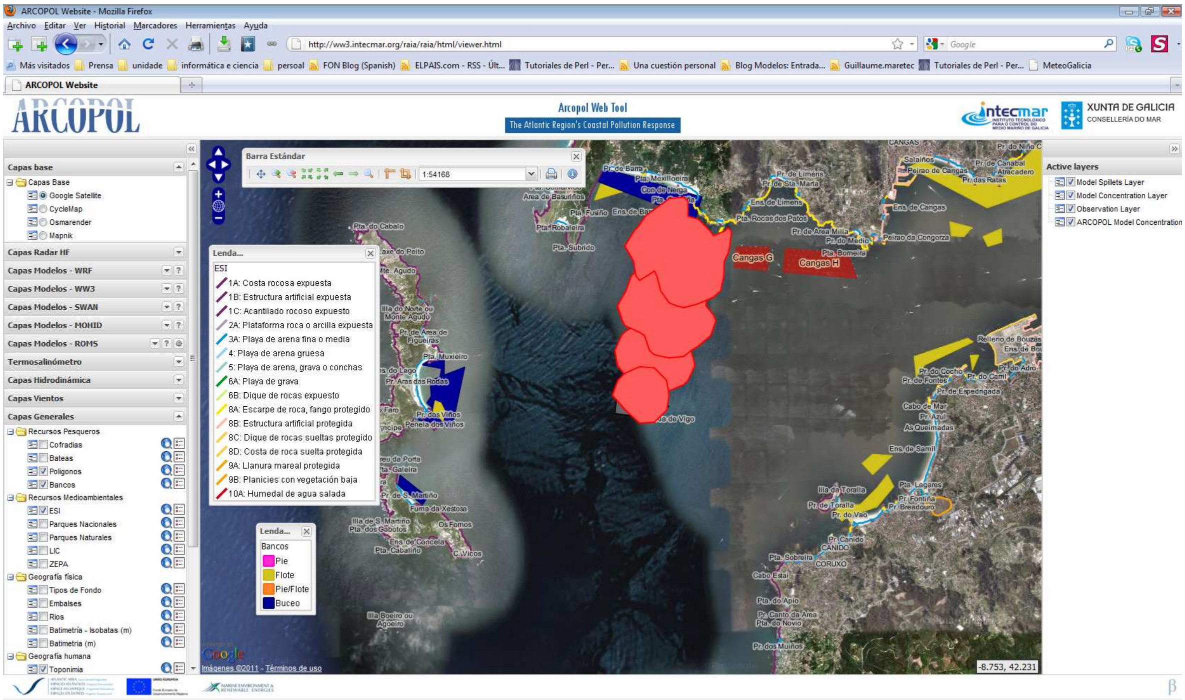


Figure 20. Web GIS showing a slick forecasted by a model output.

Since this geography feature (modeled slick) is in a GIS database and serve by standard methods, it can be showing with other GIS client, as Carboncopy Gaia or Google Earth.

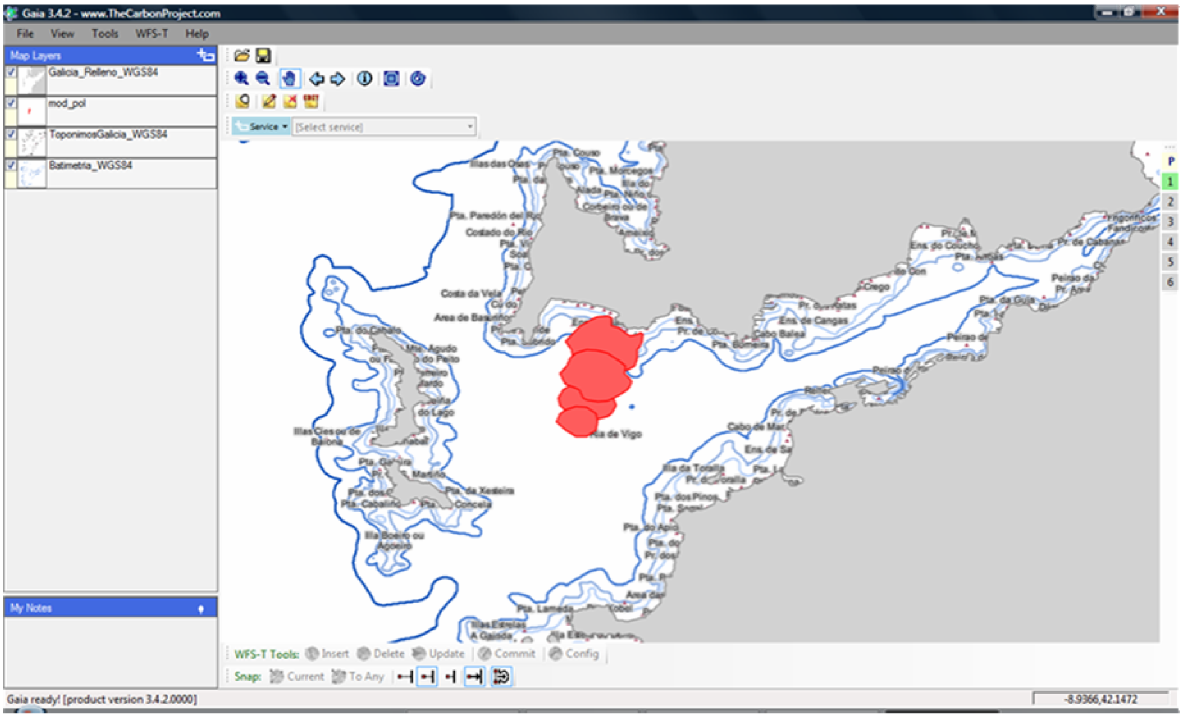


Figure 21. Same forecasted slick displaying on CarbonCopy Gaia GIS Client

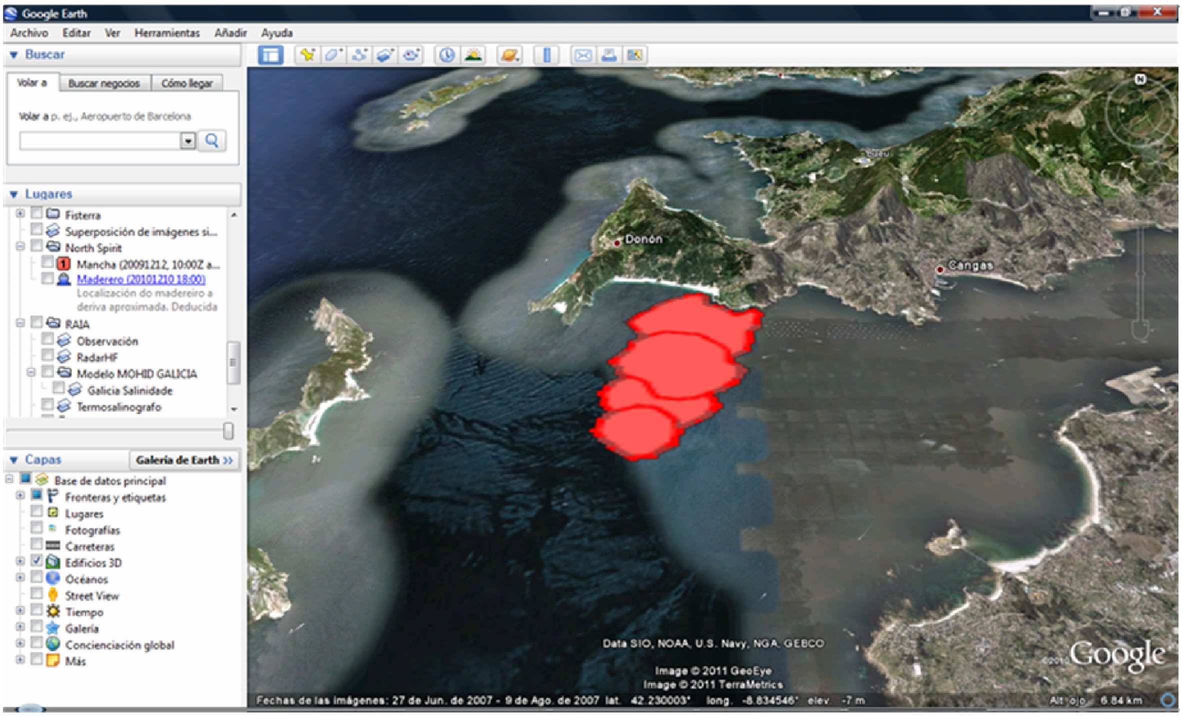


Figure 22. Same forecasted slick displaying on GoogleEarth.

This very ability is very interesting since information will be generated just once but will be able to be consulted by a different software solution depending on end user and his preferences, necessities or skills.

DISCUSSIONS ON MODEL DATA EXCHANGE

Currently there are many numerical prediction models of discharges and in addition, many of them have associated software for data integration and visualization of results. To do this, they often use own ways of data exchange and storage. The advantage of such programs is the integration data ingestion, model outputs and data analysis and displaying into a whole. However, in most cases, in order to input data, the user must adapt them to the software custom format. Thus, it means to rewrite the received information into the modeling software format. Similarly, from the point of view of end-users, most of these outputs are hardly used by other displaying programs or GIS.

The objective of this section is to provide a series of recommendations for data exchange between observation and software that predicts the movement of the spill, so that in the future this software can exchange data input and output, naturally with other programs, either because it contains all necessary information or because it uses widely accepted standards.

DATA EXCHANGE

One of the main issues in the exchange of data is traceability. That means since information is generated from an observation, it will continue to flow where these data will be treated to generate some predictions that in turn will be analyzed. Throughout this process, any information generated should contain the origin on either the data or metadata. This is critical, bearing in mind, that the observer of the spill, the modeller, and the end-user of the prediction are normally not the same person and might not even have the capability of contacting to each other.

Data flow is envisioned to be as follows (see schema below):

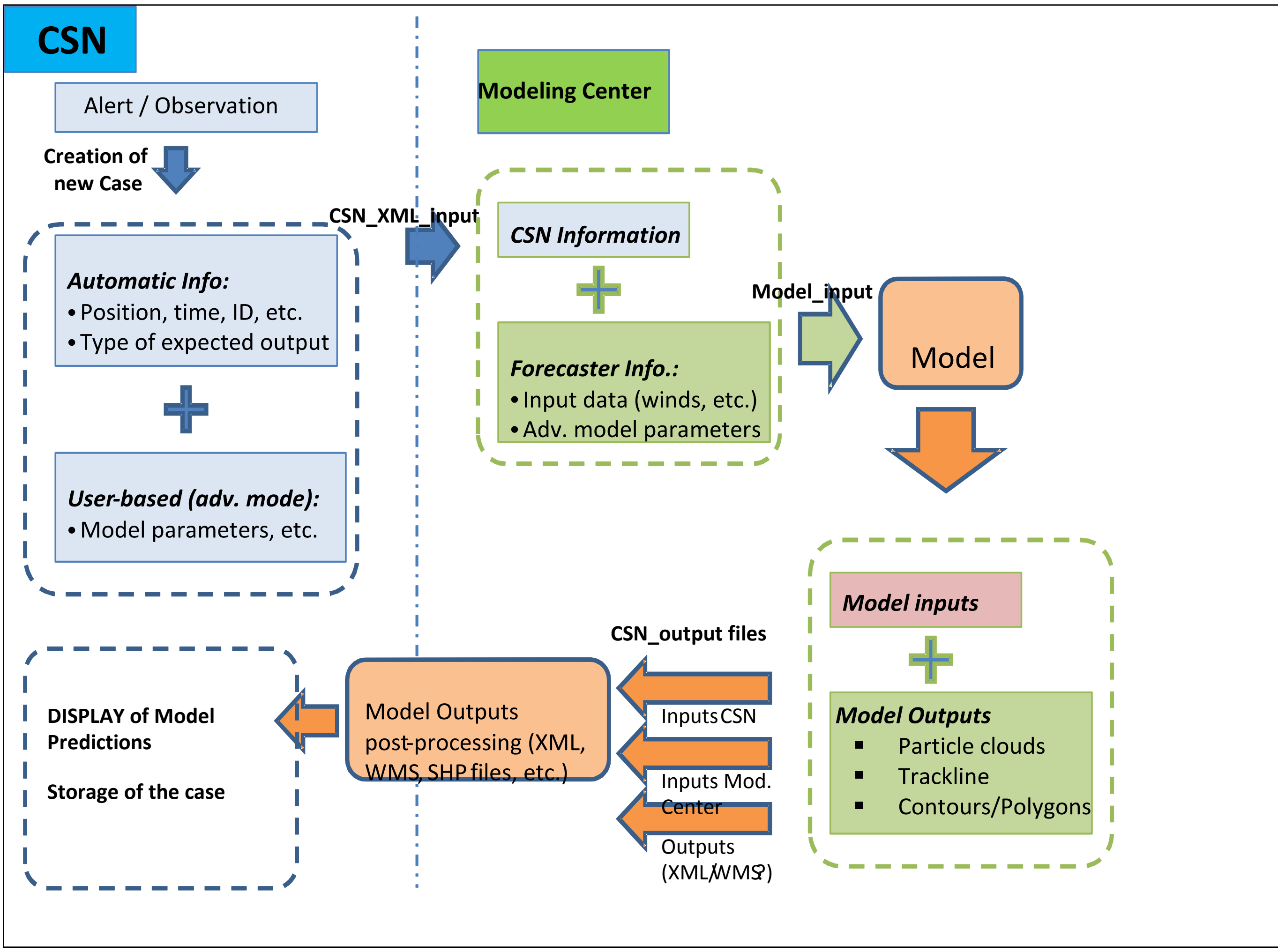


Figure 23. Schema for the generation of INPUT/OUTPUT between an operational webGIS portal

1) The webGIS server generates an alert based on a captured satellite image, observed oil slick, etc. A specific GIS object is automatically created, e.g. a polygon of an observed oil slick. This information has a spatial (geographic) and time component.

2) Other additional inputs are automatically gathered by the webGIS system and/or collected from the user request (triggering an online request to perform a remote simulation). This information would probably NOT have time/space component. An oil spill scenario is created based on an initial oil spill observation alert and this particular information (eg: "case generated by Mr/Ms XX, date, request made to…").

3) By sending all previous info, a prediction request is sent to a Modelling Centre (Operator / host of an operational oil spill modelling system). That could be exchanged via a simple XML with some spatial component.

4) Forecaster (or an automated process) reads the CSN_xml_input and includes some additional information, specific to the case (inputs) or to the oil spill model (model parameters). This includes a key component such as winds and currents files. Since this information is exchanged internally, most likely the file format will be proprietary. All info is provided to the oil spill model (OSM).

5) Once model results are available, those will be forwarded to the webGIS server. Depending on the type of OSM, i.e. its degree or ability post-processing the model outputs, several components are potentially available for display (see following page)

   All information has a spatial & time component. Depending on how each component is provided, XML (ASCII) format can lead to very large files, making difficult the on-line exchange.

INPUT DATA GUIDELINES

Whichever format is used, the information needed to run a prediction model depends on the complexity of the model and simulation. However, there is always minimum necessary information such as time and location of the spill, and so on. In addition to this information, it is also, while not necessary, useful to keep the traceability of the simulations, such as the agency that generated the request for prediction.

In the next section, a basic data model gathering geographic data involved during a contingency will be developed. This data model is currently used by INTECMAR. Nevertheless, this data model was shown as a guideline of a future model and not a finished one. It will be created, intending to be updated to the future standards arising from CleanSeaNet or SeSafeNet initiatives.

Some data objects or entities were created to put the information during a contingency in order:

Episode: means the crisis or the contingency itself. Examples of episodes are Prestige Crisis or Urquiola spill.

Spill: Each episode is composed by one or more spills. Spill object is distinguished from other one because release time, or type of substance or focus are different. As an example, during Prestige crisis, there was an initial spill, when the ship broke down, and then, there was another spill when the ship sank. A similar case happened during Urquiola episode, first there was a spill of combustible and then another of crude. Each spill has associated a type of substance, which can be oil, HNS or inert. Depending of each kind of substance, it has different associated properties describing its substance.

Feature: means any item with associated time and location. Feature can be several slicks representing by polygons or contamination sources spilling during some time. These features could be actual ones and come from an observation or hypothetical and simply being used to characterize simulation input data. The attribute called trace identifies several features of a same slick. It can be used when a same slick is observed several times: they will be different features but with a same trace property.

Thus, in the suggested data model, each simulation needs the existence of former three elements, since any feature needs to be associated to one spill and this one to an episode.

If a feature comes from an observation, observation object will be associated to it. This object can be linked to files of pictures, polrep, etc,… Observations are performed during a survey, which gathers the main properties of an observation plan. The fact to distinguish observations from features is necessary since there will be some hypothetic features without observation. Per example, what happened if that ship would sink that date in that location?

When a feature has been established, it can be modeled leading to one or more simulation objects.

Simulation objects gather in addition to feature, the properties of simulation, as simulation time, backtracking mode or not, etc. A simulation has one or more outputs. Outputs will be described in the next section.

Next figure shows a complete UML diagram of data classes using in the suggested data mode. This data model can be translated to a XML or GML data model.

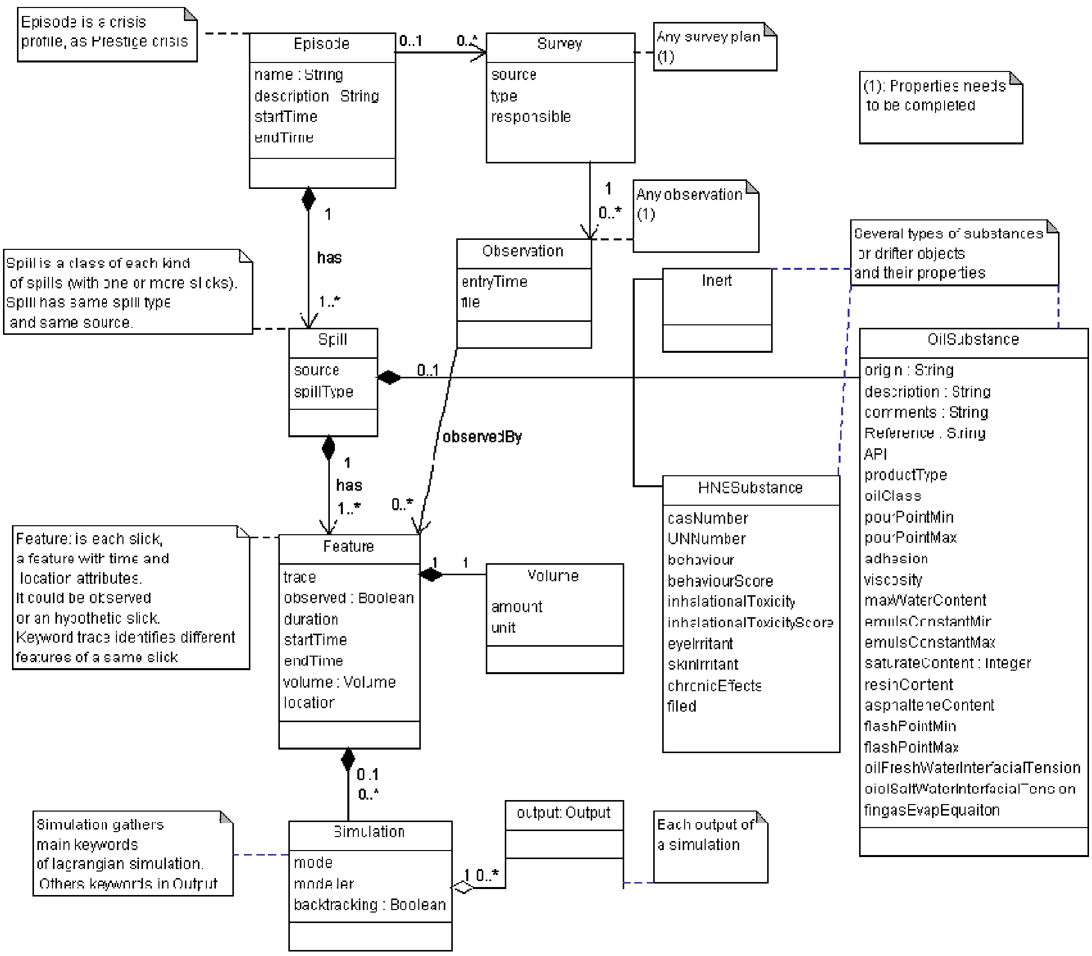
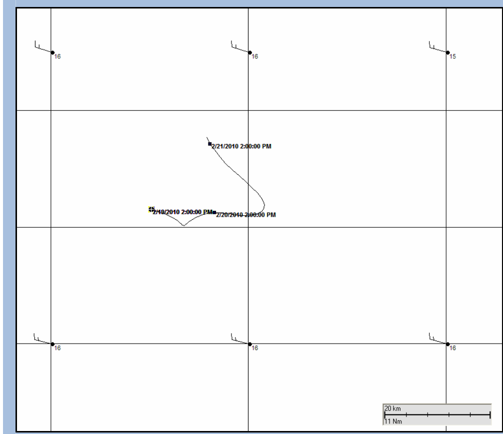
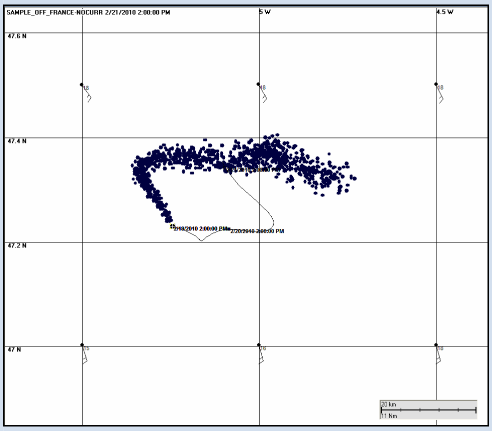


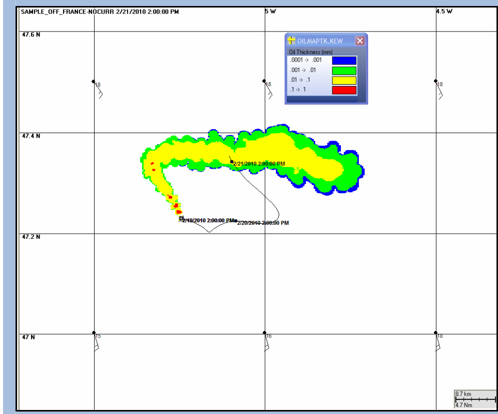
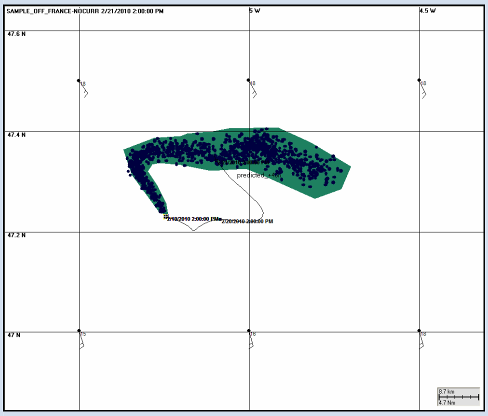
Figure 24. UML Diagram with objects of the model data.

OUTPUT DATA GUIDELINES

In terms of output data, we are referring to the data generated by forecast models. Models results can be provided in different formats or presentations. Some presentations may require an additional post-processing, other are straight outputs results from the model. For example, many chemical models simulates the dispersion of the pollutant in the water column providing results as 3D time-varying information; however, this may be difficult to be represented in 'standard' presentation methods like paper report, 2D maps, etc.; 3D animated visualization requires extensive model outputs post-processing.

Next table is a summary of the main ways to display an output of a lagrangian spill model:

Type of information	Description	Example
Track-line - 2D	The Track-line represents the centre-line of the pollutant slick over time, indicating some intermediate positions (e.g. every 6hours) It requires minimal processing and provides a sense of the main drifting direction. Good for oil and other type of spills when the transport is predominant over dispersion/dissolution.	
Cloud of particles > 2D/3D	In the lagrangian models, the spill is represented by a cloud of individual particles (not real slicks but ideal entities). Each particle represents certain amount the total oil/chemical spilled. Each particle moves independently to each other, following local winds, currents, and the "turbulence" of the environment. Particles can be located in different compartments (air, surface, etc.) and thus may degrade differently. This corresponds to the raw model output. The closer the particles, the more product is to be found.	

Contour lines > 2D	For each compartment (air, surface, water column, sediments), model can calculate the concentration of the pollutant. This is represented by means of concentration bands or iso-contours at different layers and at different time intervals. This is obtained by assessing the concentration of particles in a specific grid. For example, on the water surface, the number of particles per grid cell is used to obtain the thickness of a floating oil slick. This implies a post-processing of the lagrangian models, potentially delaying the release of results.	
Contour lines / Swept area > 2D	By post-processing the raw model results and generating the envelope of all the positions of the particles during the entire simulation, it provides the "swept" area or volume. It provides an overall idea where the oil "can be located" during the entire simulation. When compared to previous result, it is overestimating the chemical spill footprint.	

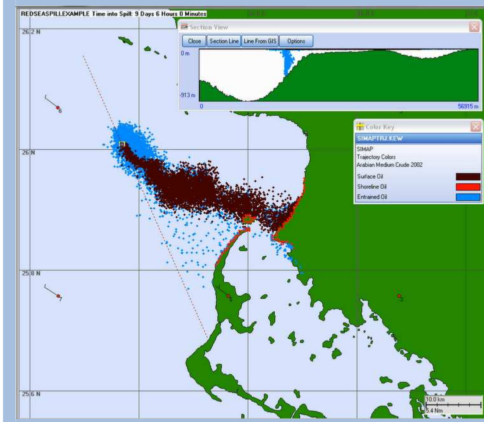
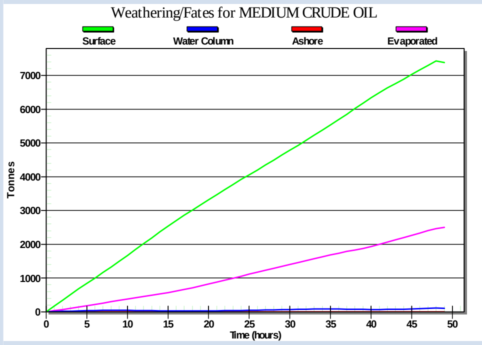
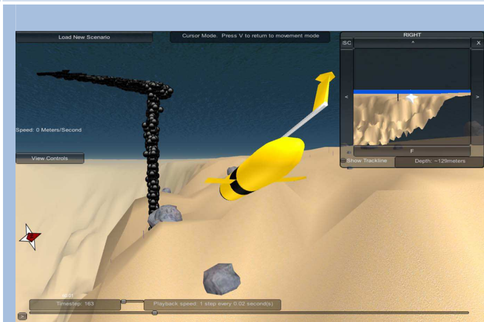
Cross sections > 2D/3Ds	3D modelling systems can provide outputs of the pollutant being transported in the air or within the water column. However, it may be challenging to represent this information in a 2D plot. A simple way is to present cross sections of the vertical distribution of the pollutant (particles or concentrations). Other type of 3D visualizations may require an intensive post-processing of the model output, and may not be operational. Thus, vertical cross sections need to be provided in combination of plan views.	
Weathering data > 1D	The pollutant transport models typically reproduce also the weathering or behaviour of the spilled product once released in the environment. For example, the mass balance graph provides information of how much product has been transfer between compartments (air, surface, entrained). Other variable may change over time; it is the weathering process for the oil spills.	
Animated 3D Views	By means of extensive model output post-processing and 'virtualization', the user can have a complete 3D, time-varying, presentation of the pollution.	

Table 5. Typical outputs of a spill modelling system.

This data should be available in formats that can be blended seamlessly with previous data, which give meaning to the information generated by the models and add value to it. Due to the complexity of all of these kinds of displaying data, this study will focus on those results of the models refereed to the prediction of the trajectories of discharges and especially to the mapping of these.

Figure 24 representing output uml diagram shows the output object. Each output has a meteoocean data object associated, which gather information about the forcings used to generate that output. Moreover, there exist several outputs type objects representing several kinds of result of table 5. All of them inherit the main characteristics from an abstract Output object.

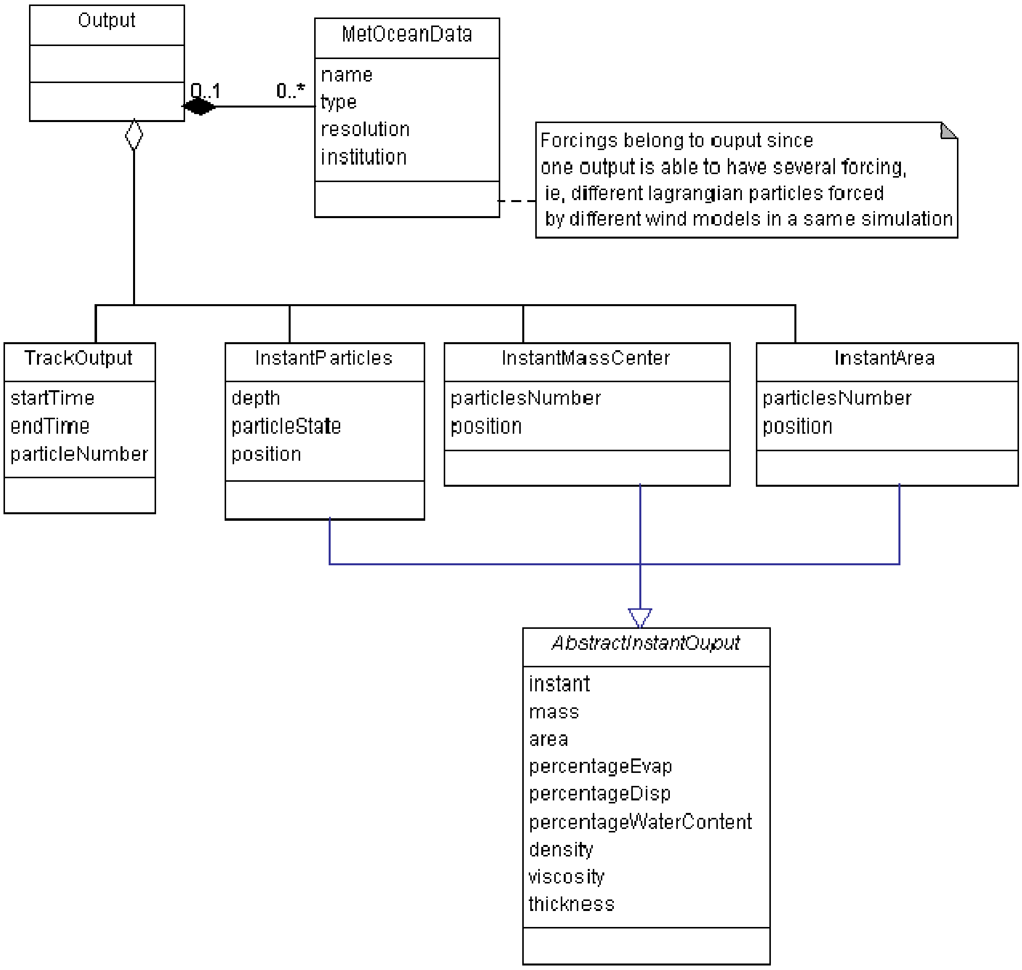


Figure 25. Modeling output UML diagram

Whichever format is used, the information needed to run a prediction model depends on the complexity of the model and simulation. However, there is always minimum necessary information such as time and location of the spill, type of spill, etc. In addition to this information, it is also, while not necessary, useful to keep the traceability of the simulations, such as the agency that generated the request for prediction.

Thus, in order to safe the interoperability between models and visualization tools, some objects otuputs can be to standardise. Here, a guideline to achieve this task is suggested:

One output object must have unique characteristics and a unique line trajectory; then, it should include groups of sub-layers per instant – these groups of sub-layers are different ways to visualize the evolution of the spill (using averaged-mass centre points, polygons, or simple particles /points). Next table summarize the main keywords:

Output Data	Level	Keywords (mandatory in bold)
Output characteristics	1 per output	Metadata of one output must add all the properties of former objects (episode, spill, feature and simulation) as well as forcings in order to characterize the output
Track (line)	1 per output	particlesNumber startTime endTime
InstantArea (polygon)	1 per instant	**instant** **mass** area percentageEvap percentageDisp percentageWaterContent density viscosity thickness particlesNumber
InstantMassCenter (point)	1 per instant	**instant** **mass** percentageEvap percentageDisp percentageWaterContent density viscosity thickness particlesNumber
InstantParticles (points)	1 per instant	**instant** **mass** percentageEvap

		percentageDisp percentageWaterContent density viscosity thickness **depth** particle_state: • surface • water column • evaporated • ashore

Table 6. Outputs layers and keywords.

Volume is not used in the published results, because mass is more commonly used in the showing results

ANNEX I: XML FILES

POLREP SEASAFENET FORM:

Extracted from SafeSeaNet XML Messaging Reference Guide Version 2.06, provided by EMSA

MESSAGE DESCRIPTION

The following table describes the XML message used for the transaction.

Elements		Attributes	Occ
Header			***1***
		Version	1
		TestId	0-1
		MSRefId	1
		SSNRefId	1
		SentAt	1
		From	1
		To	1
		StatusCode	1
		StatusMessage	0-1
Body			***0-1***
	SearchCriteria		**1**

Elements	Attributes	Occ
	IncidentType	1
	SentAt	1
	IMONumber	0-1
	MMSINumber	0-1
IncidentDetails		***0-1***
WasteAlertInformation		***0-1***
VesselIdentification		***1***
	IMONumber	0-1
	MMSINumber	0-1
	CallSign	0-1
	ShipName	0-1
	Flag	0-1
NonComplianceInformation		***1***
	WasteDeliveryDuePort	1
	ETD	1
	InspectionReason	1
InspectionInformation		***0-1***
	Deficiencies	1
	ActionTaken	1

Elements	Attributes	Occ
InspectionAuthority		***1***
	Name	1
	Coordinates	1
AuthoritiesNotified		***0-1***
	NextPortOfCall	0-1
	OtherAuthorities	0-1
SITREPAlertInformation		***0-1***
VesselIdentification		***0-1***
	IMONumber	0-1
	MMSINumber	0-1
	CallSign	0-1
	ShipName	0-1
VoyageInformation		***1***
	PortofDeparture	1
	PortOfDestination	1
	TotalPersonsOnBoard	1
ShipPosition		***1***
	Longitude	1
	Latitude	1

Elements					Attributes	Occ
			CargoManifest			***0-1***
				UrlDetails		***1***
					Url	1
					DocType	1
			SITREPInformation			***1***
					SITREPId	1
				A_CasualtyIdentification		***1***
					Name	1
					CallSign	1
					Flag	1
				B_Position		***1***
					Longitude	1
					Latitude	1
				C_Situation		***1***
					MessageType	1
					NotifiedAt	1
					Nature	1
					D_NumberOfPersons	1
					E_AssistanceRequired	1

Elements	Attributes	Occ
	F_CoordinatingRCC	1
	G_CasualtyDescription	1
	H_WeatherOnScene	1
	J_InitialActionsTaken	1
	K_SearchArea	1
	L_CoordinatingInstructions	1
	M_FuturePlans	1
	N_AdditionalInformation	1
POLREPAlertInformation		***0-1***
VesselIdentification		***0-1***
	IMONumber	0-1
	MMSINumber	0-1
	CallSign	0-1
	ShipName	0-1
VoyageInformation		***0-1***
	PortOfDeparture	1
	PortOfDestination	1
	TotalPersonsOnBoard	1
ShipPosition		***1***

Elements						Attributes	Occ
						Longitude	1
						Latitude	1
			CargoManifest				***0-1***
				UrlDetails			***1***
						Url	1
						DocType	1
			POLREPInformation				***1***
				POLWARN			***1***
						P1_DateTime	1
						P3_Incident	1
						P4_Outflow	1
						P5_Acknowledge	1
					P2_Position		***1***
						Longitude	1
						Latitude	1
				POLINF			***1***
						P40_DateTime	0-1
						P41_PollutionPosition	1
						P42_PollutionChars	1

Elements						Attributes	Occ
						P43_PollutionSource	1
					P44_Wind		***1***
						Speed	1
						Direction	1
					P45_Tide		***1***
						Speed	1
						Direction	1
					P46_SeaState		***1***
						WaveHeight	1
						Visibility	1
					P47_PollutionDrift		***1***
						DriftCourse	1
						DriftSpeed	1
						P48_PollutionEffectForecast	1
					P49_ObserverIdentity		***1-99***
						Name	1
						HomePort	1
						Flag	1

Elements						Attributes	Occ
						CallSign	1
						P50_ActionTaken	1
						P51_Photographs	1
					P52_InformedStateOrg		***0-99***
						Name	1
						P53_OtherInformation	0-1
						P60_Acknowledge	1
				POLFAC			***1***
						P80_DateTime	0-1
						P81_RequestForAssistance	1
					Assistance		***1***
						P82_Cost	1
						P83_PreArrangements	1
						P84_Delivery	1
					P85_InformedStateOrg		***0-99***
						Name	1
						P86_ChangeOfCommand	1
						P87_ExchangeOfInformation	1
						P88_OtherInformation	0-1

Elements						Attributes	Occ
						P99_Acknowledge	1
		LostFoundContainersAlertInformation					***0-1***
			VesselIdentification				***0-1***
						IMONumber	0-1
						MMSINumber	0-1
						CallSign	0-1
						ShipName	0-1
			VoyageInformation				***0-1***
						PortOfDeparture	1
						PortOfDestination	1
						TotalPersonsOnBoard	1
				ShipPosition			***1***
						Longitude	1
						Latitude	1
			CargoManifest				***0-1***
				UrlDetails			***1***
						Url	1
						DocType	1
			LostFoundContainersInformation				***1***

Elements							Attributes	Occ
							P1_ReportType	1
					P2_ShipIdentification			***1***
							IMONumber	0-1
							MMSINumber	0-1
							CallSign	0-1
							ShipName	0-1
					ContainerInformation			***1***
						P3_ContainerPosition		***1***
							Longitude	1
							Latitude	1
							P4_NumberOfContainers	1
							P5_TypeOfGoods	1
						Containers		***1-99***
							Description	1
							CargoLeaking	1
						Wind		***1***
							Speed	1
							Direction	1
						Tide		***1***

Elements						Attributes	Occ
						Speed	1
						Direction	1
					SeaState		***1***
						WaveHeight	1
						Visibility	1
					ContainersDrift		***1***
						DriftCourse	1
						DriftSpeed	1
		OtherAlertInformation					***0-1***
			VesselIdentification				***0-1***
						IMONumber	0-1
						MMSINumber	0-1
						CallSign	0-1
						ShipName	0-1
			CargoManifest				***0-1***
				UrlDetails			0-1
						Url	1
						DocType	1
				ContactDetails			***0-1***

Elements					Attributes	Occ
					LastName	1
					FirstName	1
					LoCode	1
					Phone	0-1
					Fax	0-1
					EMail	0-1
			OtherInformation			***1***
					Details	1

BUSINESS RULES

The following table describes the XML message used for the transaction and the applicable business rules. The detailed definition of the attributes is included in the original document.

Item	Occ	Description
Header	**1**	**Header node**
Version	1	none
TestId	0-1	none
MSRefId	1	The MSRefId must be unique.
SSNRefId	1	The SSNRefId is unique.
SentAt	1	Format "YYYY-MM-DDThh:mm:ssTZD" Where TZD = time zone designator (Z or +hh:mm or -hh:mm).
From	1	none
To	1	none
StatusCode	1	none
StatusMessage	0-1	none
Body	**0-1**	**Body node (only optional when *StatusCode*="InvalidFormat")**
SearchCriteria	**1**	From incoming *SSN2MS_Alert_Req.xml* request
IncidentType	1	From incoming *SSN2MS_Alert_Req.xml* request
SentAt	1	From incoming *SSN2MS_Alert_Req.xml* request
IMONumber	0-1	From incoming *SSN2MS_Alert_Req.xml* request
MMSINumber	0-1	From incoming *SSN2MS_Alert_Req.xml* request

IncidentDetails	0-1	*IncidentDetails* element node. Not allowed if *StatusCode* <> OK
WasteAlertInformation	0-1	*WasteAlertInformation* element node (if incident type = Waste)
…		
SITREPAlertInformation	0-1	*SITREPAlertInformation* element node (if incident type = SITREP)
…		
POLREPAlertInformation	0-1	*POLREPAlertInformation* element node (if incident type = POLREP)
…		
LostFoundContainersAlertInformation	0-1	*LostFoundContainersAlertInformation* element node (if incident type = LostFoundContainers)
…		
OtherAlertInformation	0-1	*OtherAlertInformation* element node (if incident type = Others)
…		

ANNEX II: ARCOPOL WEB TOOL: TUTORIAL AND INSTALLATION

The following is a brief explanation of the use of ARCOPOL, using INTECMAR as an example, and its mode of development for clients. Logically, these clients have a use of their own for ARCOPOL, but INTECMAR is shown as an example. However, its implementation and development can help to build future viewers.

The viewer is based on an adaptation of the generic application developed in the RAIA Project, funded by POCTEP through the ERDF (http://www.observatorioraia.org).

The basic viewer (http://ww3.intecmar.org/arcopol/viewer.html) is a web application consisting of four distinct regions

5) The map showing the information

6) A layer tree (left of page)

7) A toolbar

8) A table containing the active layers

The following figure shows the general appearance of this page:

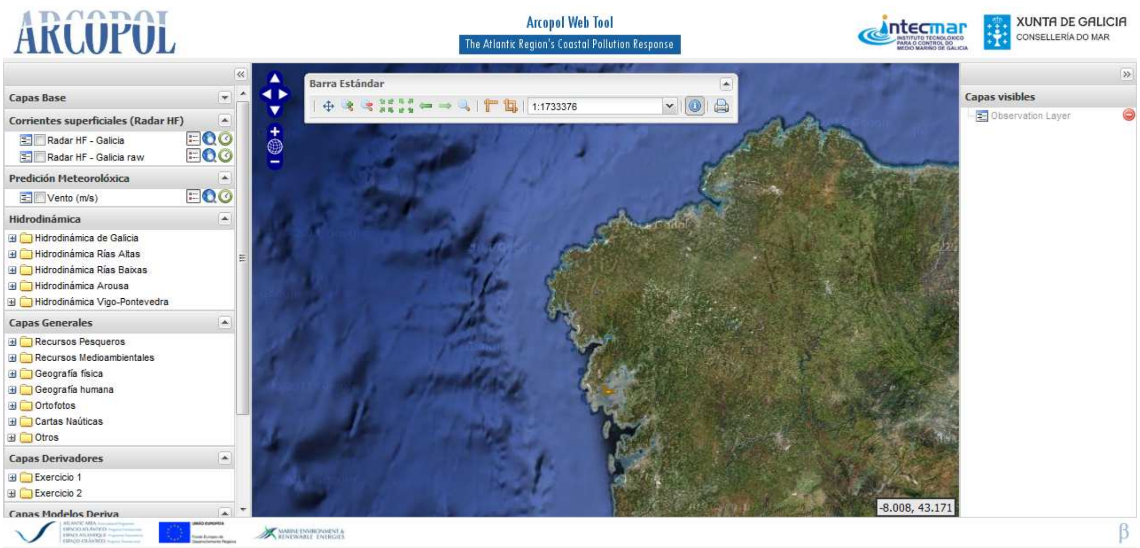


Figure 26. Screenshot of the ARCOPOL web client with layers tree on left

Any of the viewers is based on this provision, with their differences in layers that are accessible through the viewfinder and attached tools for manipulating the map.

As previously explained, this kind of viewer consists of the following elements:

1. **Toolbar.** Basic toolbar buttons carry out one of these functions: navigation, pan and drag on map window, zoom, measure, print page…

Figure 27. Toolbar

2. **Main Panel**. Shows base layer, active layers (called overlays), one mouse position box (it displays geographic coordinates of the mouse pointer, as it is moved about the map) and a navigation toolbar embedded into the map.

3. **Available layers panel**. It is placed on the left of the main panel. The different types of layers are grouped under different tabs in an accordion layout. The first tab contains all the possible base layers. Prediction and HF RADAR layers are grouped under the following two tabs; finally, you can find the general layers (Fishing and Environmental resources, Physical and Human geography, nautical maps…) and finally ARCOPOL specific layers.

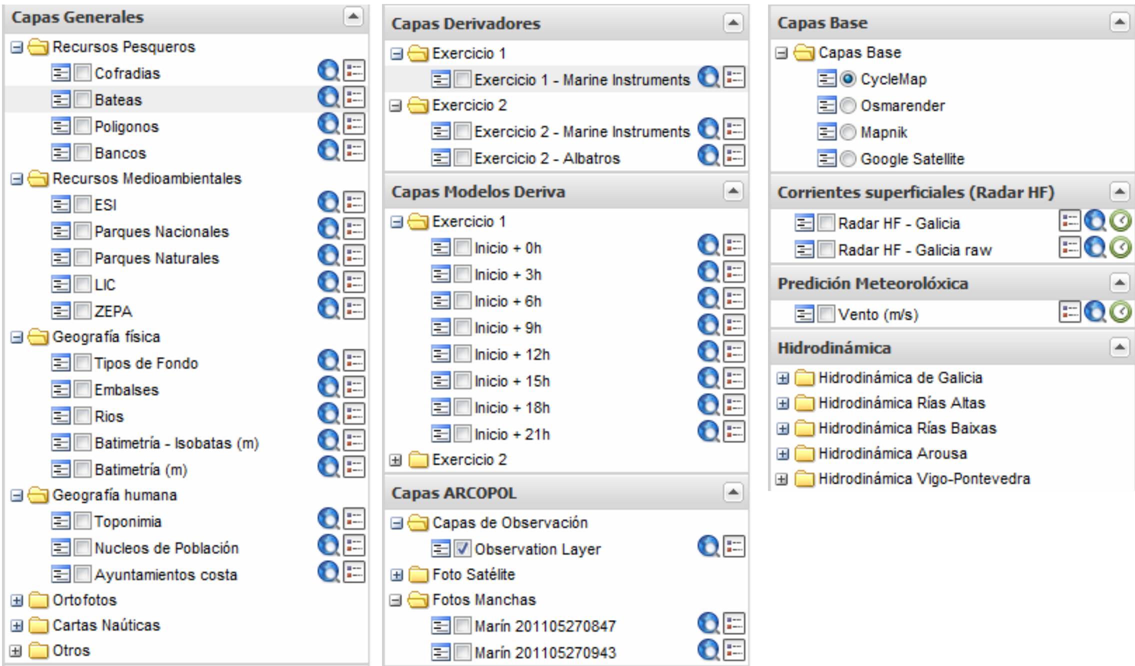


Figure 28. Layers tree

4. **Visible layers panel.** This panel is located to the right of the main panel. These layers are sensitive to be moved up and down. They can also be deleted.

In conclusion, we can say that this viewer allows the visualization of all this kind of information into one single map for one crisis management.

Next figure shows the same viewer but with several active layers:

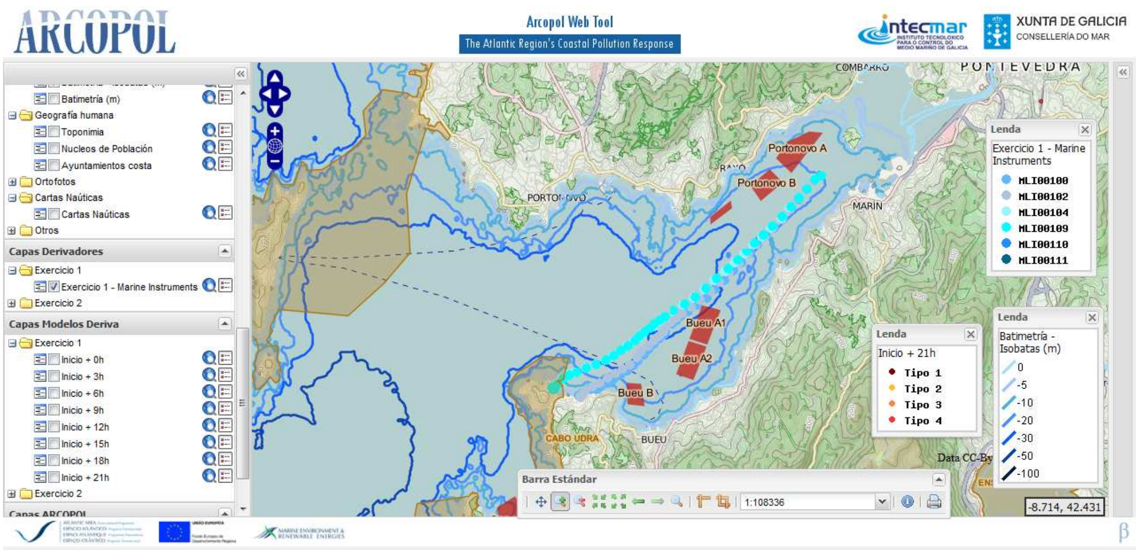


Figure 29. Same viewer with some active layers (see layers tree on the left) and some legends on the map

GEOGRAPHIC SERVERS

The layers displayed in this web client are stored in different type of geographic servers:

GEOSERVER

GeoServer is an open source software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards.

GeoServer allows you to display your spatial information to the world. Implementing the Web Map Service (WMS) standard, GeoServer can create maps in a variety of output formats. OpenLayers, a free mapping library, is integrated into GeoServer, making map generation quick and easy. GeoServer is built on Geotools, an open source Java GIS toolkit.

There is much more to GeoServer than nicely styled maps, though. GeoServer also conforms to the Web Feature Service (WFS) standard, which permits the actual sharing and editing of the data that is used to generate the maps. Others can incorporate your data into their websites and applications, freeing your data and permitting greater transparency.

GeoServer can display data on any of the popular mapping applications such as Google Maps, Google Earth, Yahoo Maps, and Microsoft Virtual Earth. In addition, GeoServer can connect with traditional GIS architectures such as ESRI ArcGIS.

GeoServer forms a core component of the **Geospatial Web**.

The GeoServer License is a GNU Public License (GPL) version 2.

DOCUMENTATION

- http://geoserver.org/

SERVER REQUIREMENTS

It is difficult to say since it depends on the size of datasets and web traffic. In any case it should have enough RAM to avoid swapping (2GB are usually more than enough) and a fast CPU and disk if a large amount of data is going to be served.

OS

Linux, Windows.

USE AT INTECMAR

AIM

Currently, GeoServer is used for geo-referenced data in vector format. As this is an open-source server certified by the OGC, it is also used to derive GIS layers by several OGC Services: WFS, WMS, WCS.

One of the most interesting advantages is that GeoServer can serve WFS-T, i.e., GeoServer permits somebody to insert features on a layer.

COMPUTING RESOURCES

- OS Host: Windows 2003 Server running under a virtual machine
- Hardware: One blade with an Intel Xeon 3000 processor, 4 Gb RAM.

DERIVED LAYERS

Layers are introduced as shapefiles and geotiff files.

MAPSERVER

MapServer open source web mapping

MapServer is an Open Source development environment for building spatially-enabled web mapping applications and services. It is fast, flexible, reliable and can be integratated into just about any GIS environment. Originally developed at the University of Minnesota, MapServer is now maintained by developers around the world.

MapServer runs on all major operating systems and will work with almost any web server. MapServer features MapScript, a powerful scripting environment that supports many popular languages including PHP, Python, Perl, C# and Java. Using MapScript makes it fast and easy to build complex geospatial web applications.

MapServer has a X/MIT License, which is a free software license originating at the Massachusetts Institute of Technology (MIT).

Main characteristics:

- Supports industry standard data formats and spatial databases.
- On-the-fly feature classification.
- Sophisticated rule-based labelling.
- On-the-fly projection for both raster and vector data such as TIFF/GeoTIFF, EPPL7, and many others via GDAL o ESRI shapefiles, PostGIS, ESRI ArcSDE, Oracle Spatial, MySQL and many others via OGR.
- Provides a wide variety of spatial and attribute-based queries
- Supports popular Open Geospatial Consortium (OGC) standards including WMS (client/server), WFS (client/server), WMC, WCS, Filter Encoding, SLD, GML, SOS, OM.
- Leverages best-of-breed open source geospatial technologies such as GDAL/OGR, PostGIS and PROJ.4.
- Integrates with popular front-end environments such as ka-Map, Chameleon, Mapbender, MapBuilder and Cartoweb.

DOCUMENTATION

- http://mapserver.org/

SERVER REQUIREMENTS

It is difficult to say since it depends on the size of datasets and web traffic.

Regarding necessary software, a working and properly configured Web (HTTP) server, such as Apache or Microsoft Internet Information Server, is needed on the machine on which you are installing MapServer. OSGeo4W contains Apache already, but you can reconfigure things to use IIS if you need to. Alternatively, MS4W can be used to install MapServer on Windows.

OS

Linux, Windows.

USE AT INTECMAR

AIM

It is used to serve the orthophotos and nautical charts. Information displayed by the server is stored in shapefiles and available as PNG, GIF or JPEG's.

COMPUTING RESOURCES

- OS Host: Windows 2003 Server running under a virtual machine
- Hardware: One blade with an Intel Xeon 3000 processor, 4 Gb RAM.

DERIVED LAYERS

Layers are introduced as shapefiles and geotiff files.

OPENDAP / HYRAX

Hyrax is the next generation server from OPeNDAP (Open-source Project for a Network Data Access Protocol).

This server uses the Java servlet mechanism to hand off requests from a general web daemon to DAP format-specific software. This results in higher performance for small requests.
The servlet front end, called the OPeNDAP Lightweight Front end Server (OLFS) looks at each request and formulates a query to a second server (which may or may not on the same machine as the OLFS) called the Back End Server (BES).

OPeNDAP is released under LGPL-2.1 (GNU Lesser General Public License).

Main characteristics:

- The servlet architecture is faster, more robust, and more secure than CGI invoked Perl scripts.
- A single installation can handle multiple data representations (hdf4, hdf5, netCDF, etc.)
- Thredds catalog functionality.
- A prototype SOAP interface for OPeNDAP data services.

DOCUMENTATION

- http://opendap.intecmar.org/opendap/docs/
- http://www.opendap.org/download/hyrax.html

SERVER REQUIREMENTS

It is difficult to say since it depends on the size of datasets and web traffic.

OS

Hyrax is supported on Linux (preferably CentOS distribution).

USE AT INTECMAR

AIM

At present Hyrax is used to serve gridded data (HF radar and oceanographic data).
http://opendap.intecmar.org/opendap/data/

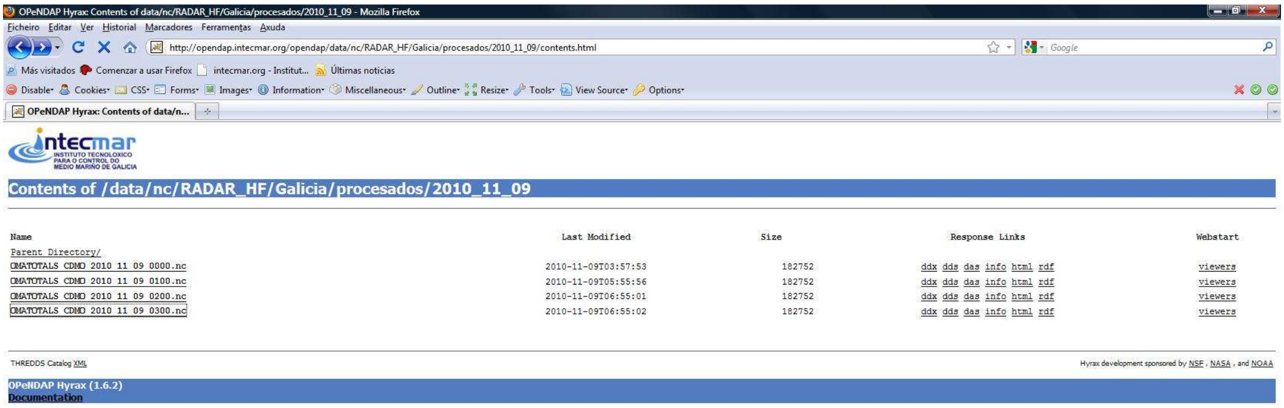


Figure 30. Intecmar Hyrax Server screenshot

COMPUTING RESOURCES

- OS Host: CentOS running under a virtual machine
- Hardware: One blade with an Intel Xeon 3000 processor, 4 Gb RAM.

HYRAX INSTALLATION INSTRUCTIONS

Intecmar has installed **Hyrax 1.6.2** (released 15 September 2010).

In order to get the basic Hyrax 1.6.2 server running, the following software is needed:

- Java 1.6
- Tomcat 6.x

To run the Hyrax server, the following packages (better from source) must be downloaded:

- OLFS (which is a Java binary and runs on any computer with Java 1.6)
- libdap
- BES
- General Purpose Handlers (aka dap-server)
- For Intecmar: HDF5 and NetCDF handlers.

THREDDS DATA SERVER

The THREDDS Data Server (TDS) is a web server that provides metadata and data access for scientific datasets, using OPeNDAP, OGC WMS and WCS, HTTP, and other remote data access protocols. It can also be used to serve data archives.

The THREDDS Data Server is implemented in 100% Java, and is contained in a single war file, which allows very easy installation into a servlet container such as the open-source Tomcat web server. Configuration is made as simple and as automatic as possible, and we have made the server as secure as possible. The library is freely available and the source code is released under the (MIT-style) netCDF library license.

DOCUMENTATION

- http://www.unidata.ucar.edu/projects/THREDDS/

SYSTEM REQUIREMENTS

- Java 1.6 or above.
- Tomcat 5.5 or above, recommend the latest version of Tomcat 6.x.

USE AT INTECMAR

AIM

Thredds is used to serve gridded data (HF radar and oceanographic data). http://opendap.intecmar.org/thredds

NCWMS

ncWMS is a Web Map Service for geospatial data that are stored in CF-compliant NetCDF files. The intention is to create a WMS that requires minimal configuration: the source data files should already contain most of the necessary metadata.

Reading e-Science Centre

ncWMS is developed and maintained by the Reading e-Science Centre at the University of Reading, UK.

It is implemented in Java as a web application. To install ncWMS you simply place the WAR (Web ARchive) file in your application server of choice (e.g. Tomcat).

It relies heavily on the Java NetCDF interface from Unidata. This library does a lot of the work of metadata and data extraction. In particular the GridDatatype class is frequently used to provide a high-level interface to gridded geospatial NetCDF files. The library will also read from NetCDF files on HTTP servers and from OPeNDAP servers.

ncWMS has now been integrated with the THREDDS Data Server.

It is released under BSD License.

DOCUMENTATION

- http://www.resc.rdg.ac.uk/trac/ncWMS/

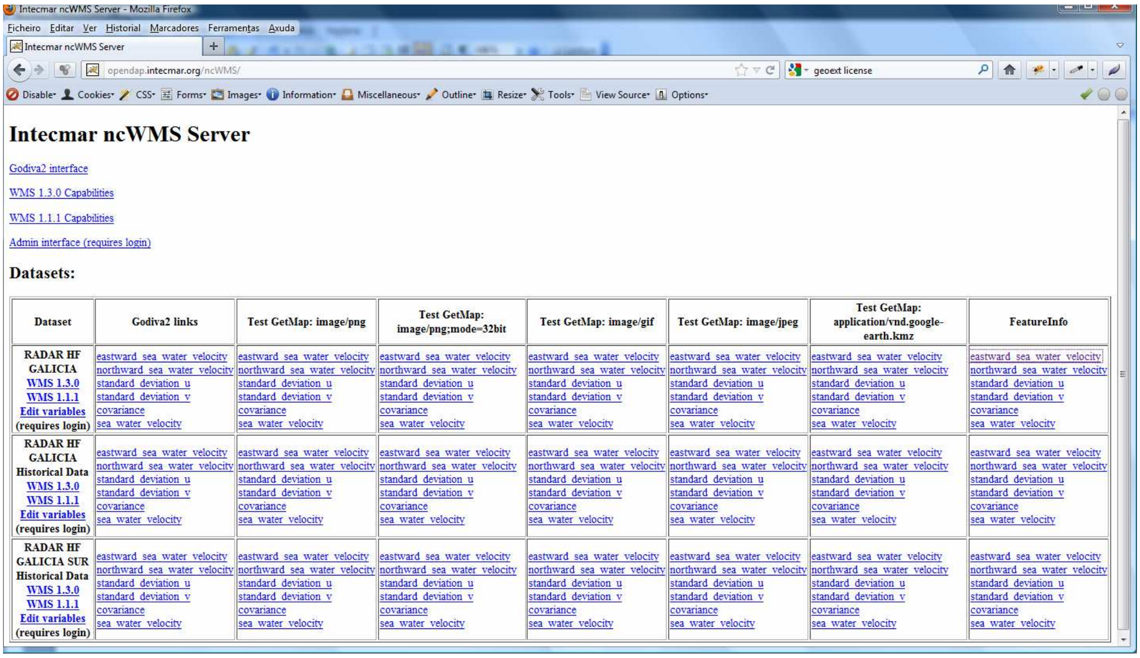
SYSTEM REQUIREMENTS

- Java 1.6 or above.
- Tomcat 5.5 or above, recommend the latest version of Tomcat 6.x.

USE AT INTECMAR

AIM

ncWMS is used to serve HF radar data.
http://opendap.intecmar.org/ncWMS



Intecmar ncWMS Server

Godiva2 interface

WMS 1.3.0 Capabilities

WMS 1.1.1 Capabilities

Admin interface (requires login)

Datasets:

Dataset	Godiva2 links	Test GetMap: image/png	Test GetMap: image/png;mode=32bit	Test GetMap: image/gif	Test GetMap: image/jpeg	Test GetMap: application/vnd.google-earth.kmz	FeatureInfo
RADAR HF GALICIA WMS 1.3.0 WMS 1.1.1 Edit variables (requires login)	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity
RADAR HF GALICIA Historical Data WMS 1.3.0 WMS 1.1.1 Edit variables (requires login)	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity
RADAR HF GALICIA SUR Historical Data WMS 1.3.0 WMS 1.1.1 Edit variables (requires login)	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity	eastward sea water velocity northward sea water velocity standard deviation u standard deviation v covariance sea water velocity

Figure 31. Intecmar ncWMS server screenshot

PROGRAMMING LANGUAGE

The GUI was programmed in ***JavaScript***. This language is characterized by its portability, which facilitates the joint programming with other teams.

ASP.NET is the Web application framework chosen for the development of this web tool. INTECMAR uses this programming environment for developing their applications.

Besides, we have employed *Sencha* (former *Ext.js*), *OpenLayers* and *GeoExt* libraries.

SENCHA

Sencha (former Ext.js) is a JavaScript library for building interactive web applications using techniques such as Ajax, DHTML and DOM scripting. Build rich, sustainable web applications faster than ever.

Sencha includes a set of GUI-based form controls (or "widgets") for use within web applications:

- text field and textarea input controls
- date fields with a pop-up date-picker
- numeric fields
- list box and comboboxes
- radio and checkbox controls

- html editor control
- grid control (with both read-only and edit modes, sortable data, lockable and draggable columns, and a variety of other features)
- tree control
- tab panels
- toolbars
- desktop application-style menus
- region panels to allow a form to be divided into multiple sub-sections
- sliders
- flash charts

Many of these controls are able to communicate with a web server using Ajax.

It also includes web application support with features such as:

- modal dialog boxes
- interactive user-input validation prompts
- state management

Other features include a DOM selector class allowing operations to be performed on elements within the page, data stores that can be used to manage data, and classes to create and manage data in JSON and XML formats.

Sencha has a Dual License (GPL3 / Commercial).

DOCUMENTATION

- http://www.sencha.com/products/js/

USE AT INTECMAR

Part of the Web project is developed with ExtJS:

- Panels.
- Tool bars and buttons.
- Dialog boxes...

OPENLAYERS

OpenLayers™

OpenLayers is an open source JavaScript library for displaying map data in web browsers, with no server-side dependencies. It provides an API for building rich web-based geographic applications similar to Google Maps and Bing Maps.

One of the OpenLayers' advantages is that it makes it easy to put a dynamic map in any web page. It can display map tiles and markers loaded from any source and has been developed to further the use of geographic information of all kinds.

Furthermore, OpenLayers implements industry-standard methods for geographic data access, such as the OpenGIS Consortium's Web Mapping Service (WMS) and Web Feature Service (WFS) protocols. Under the hood, OpenLayers is written in object-oriented JavaScript, using components from Prototype.js and the Rico library.

OpenLayers has been released under the 2-clause BSD License (also known as the FreeBSD).

DOCUMENTATION

- http://www.openlayers.org/

USE AT INTECMAR

Part of the Web project is developed with OpenLayers:

- Add layers (Google, WMS, Vector...)
- Controls (navigation, drawfeature, panpanel...).
- Information about the layers...

GEOEXT

GeoExt is a JavaScript library that provides a groundwork for creating rich web mapping applications. It combines the web mapping library OpenLayers with Extjs, "a cross-browser JavaScript library for building rich internet applications."

GeoExt provides a suite of customizable widgets and data handling support that makes it easy to build applications for viewing, editing, and styling geospatial data.

- A library of widgets specialized for mapping applications.
- Parsing utilities and storage components for handling geospatial data.

The *GeoExt* source may be distributed with a BSD *license*.

DOCUMENTATION

- http://www.geoext.org/

USE AT INTECMAR

Part of RAIA project is developed with GeoExt:

- Map Panel.
- Legend Panel.
- Layer Tree.
- Buttons...

CODE STRUCTURE

As discussed previously, ARCOPOL website uses part of the code developed in the RAIA Project (http://www.observatorioraia.org). So its structure is similar to the website of this project, which is available on the next page: http://trac.intecmar.org/raia/

The code for this project is organized as follows:

Figure 32. ARCOPOL code organisation

1. **arcopol/**. This folder contains the code specifically programmed for the ARCOPOL viewer (definition and organization of the layers), as well as logos and images.

2. **cgi-bin/**. Contains Web proxy.
3. **lib/**. Definition of the libraries mentioned above: Sencha (ExtJs) GeoExt and OpenLayers.
4. **visor/**. This folder contains some code that is common to all viewers, such as definition of new modules, utilities, resources, etc.

BASE CLASSES

Of the libraries mentioned above are mainly used two base classes:

- Openlayers.Control: it is used as the basis for the controls which interact on the maps.
- Ext.Observable: base class for interface elements.

The aim of using these two classes is to take advantage of event management, both for OpenLayers and for ExtJS when implementing controls, modules ...

OpenLayers controls are used for actions that require interaction with the "map", and ExtJS or GeoExt components in the interface elements.

CLASSES EXTENSION

For extending one class, we can use one of the following mechanisms:

- En el caso de extender un control de OpenLayers usamos OpenLayers.Class con la clase OpenLayers.Control como base.
- In case of extend from Ext.Observable, we use ExtJS extending mechanism:
  - Using Ext.extend, with Ext.util.Observable class or some derived from it as a base class
  - Creating a constructor method.

Example:

```
RAIA.mod.Module = Ext.extend(Ext.util.Observable, {

        ....
        constructor : function(config){
           Ext.apply(this, config);
           RAIA.mod.Module.superclass.constructor.call(this);
                }
)};
        ....
```

NAMESPACES

VISOR is used as root namespace for all classes. It is segmented according to the namespace directory structure and the objects in the directory ***visor/mod*** will have the namespace VISOR.mod

Namespaces are declared using Ext:

```
   Ext.ns('VISOR.mod');
```

In the case of creating specific modules for the viewer, the name of the namespace will be the one of the module:

```
   Ext.ns('ARCOPOL.mod');
```

CODE STRUCTURE

The principal directories are described at the beginning of this section

The folder named **visor** contains all the files needed to develop the viewer with the four distinct regions. These files are grouped in different subdirectories:

- **control**: its functions perform specific requests, such as netcdfsubset or longitude-latitude requests.

- **core**: it contains the central class of the viewer, which initializes the other modules and positioned them into a Ext.Panel.
- **language**: files for multilingual support.
- **mod**: contains modules designed to work and interact with a given set of layers.
- **plugin**: plugin para añadir un parámetro extra (nodo de una capa) al controlador de eventos.
- **resources**: under this directory are the images, the style sheets and a file containing the path of all files needed to load the viewer.
- **util**: this directory is intended for those utilities commonly used in the viewer, as the tree layers and the toolbar; each of these utilities has its own subdirectory, which contains the definitions of the different modules
- **widget**: contains the function responsible for raising a popup with OGC SOS service information.

The directory called **arcopol** contains three subdirectories under which are display-specific resources, such as the definition of layers, logos, internationalization, etc

- **html:** in this subdirectory you can find the homepage of the web site, along with references to the viewer's own scripts and dependencies; here is where you create an OpenLayers map object, set the layer to be used and also the components to be displayed.
- **language**: the viewer already has files of internationalization, but for the translation of specific terms of the project new files are added to this folder
- **resources**: files used for the code minimizatio

DOWNLOAD

ARCOPOL viewer is still in beta, that is, it is still being developed and improved.

If you want to download the code, it is in a SVN repository, which can be accessed via the following link:

- `svn+ssh://trac.intecmar.org/REPOSITORIO/arcopol/trunk`
- `User: InvitadoSVN`
- `Pass: 1nv1t4d0#SVN`

Take into account that the code can be subject to periodic changes, which will be duly documented through SVN[1].

[1] Subversion (often abbreviated SVN) is a software versioning and a revision control system distributed under a free license.

ANNEX III: REFERENCES

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Lake, Ron, 2004. *Geography mark-up language (GML):Foundation for the geo-web.* John Wiley and Sons. 388p.

NOAA. 2000. *Shoreline Assessment Manual, Third Edition.* HAZMAT Report 2000-1. Seattle: Office of Response and Restoration, National Oceanic and Atmospheric Administration. 54 pp. + appendices.

Some web pages in addition to the other ones listed above:

OGC: Open Geospatial Consortium. http://www.opengeospatial.org/

Clean SeaNet homepage: http://cleanseanet.emsa.europa.eu/

SeaSafeNet homepage: http://www.emsa.europa.eu/operations/maritime-surveillance/safeseanet.html

Spanish Spatial Data Infrastructure: http://www.idee.es/