Information service system based on GOOGLE graphical interfaces

Giuseppe M.R. Manzella

ENEA ACS, p.o. box 224, 19100 La Spezia, Italy

Corresponding author: tel +39 0187 978215; e-mail address giuseppe.manzella@enea.it

Abstract

An information system supporting the assessment of the marine environment and operational ocean weather forecast needs to access data, images, and general information from data bases residing in different servers located in different geographical areas. The general concepts of a such IT infrastructure is based on the following information content:

- **What;** Describing the objectives, and/or the content of the project
- **Why;** Explaining the reason and/or the status of art before the project
- **Where;** Describing the scientific and/or geographical area in which the efforts are concentrated
- **When;** Providing information on the temporal coverage
- **Who;** Describing the group of participants and/or the project participants and roles
- **How;** Providing information and links on themes and/or centers participating to the project

From the European Union INSPIRE directive the following services must be provided:

- **discovery services** allowing to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata;
- **view services** allowing, as a minimum, to display, navigate, zoom in/out, pan, or overlay viewable spatial data sets and to display legend information and any relevant content of metadata;
- **download services**, enabling copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly;
- **transformation services**, enabling spatial data sets to be transformed with a view to achieving interoperability;
- **services** allowing spatial data services to be invoked.

The **services** in support to assessment and operational forecast must be real time, delayed mode, on request, per application through service interface. All these services have been developed with a user friendly interface allowing a geographical, temporal, type of measure, parameter, campaign selection. The graphical selection of the area and the presentation and elaboration of data is operated on GOOGLE API maps. Also data residing in remote servers can be accessed through the catalog of the portal that is updated daily. In our application, about 13,000 CTD (i.e. temperature, salinity, oxygen, etc. data from automated probes(and XBT (i.e. temperature) profiles collected in the Mediterranean from 1999 are actually managed in a local server (ENEA La Spezia). Daily satellite images of sea surface temperature from 2006 residing in CNR-ISAC Rome are also accessed. Both in situ and satellite data can be displayed and comparison between data can be done. Once the data are selected, the user has access to metadata and data. He can create on the fly horizontal and vertical maps on profiles graphically selected with polylines or polygons tracked on GOOGLE maps. Data can be downloaded in different formats (spreadsheet or ASCII).

1. Introduction

One of the challenges of information systems is the accessibility of products residing in different remote servers and compose them to produce more complex information products. Problems in achieving this goal are related to legacy of different information systems that includes formats, applications, schemas, vocabulary, technologies. Furthermore, the products in electronic form are becoming fairly complex, consisting of files (ASCII, XML, HTML, Word, etc.), interactive animations (e.g. Macromedia Flash), sound, video, images or embedded programs (e.g. Java applets).

Four tiers can be seen as a base of a distributed system:

- **The product tiers**, formed by the servers containing the data; these could be in different formats, such as netCDF, HDF, ASCII, etc.
- **The product access and inventory tier**, the access being provided by servers such as HTTP, and the inventory by catalog services.
- **The product catalog tier**, allowing the selection of data.
- **The product presentation tier**, that is constituted by portals and must allow different services, such as visualization.

In the case of harmonized components, the architecture to access products in a distributed system can be easily defined. But in general the architectures of data management systems residing in the different places have a high heterogeneity. A 'transformation service' is important in a system allowing access to data residing also in other data management systems, in order to transform queries and data between different logical scheme.

Different approaches can be adopted to access data residing in different servers, solutions are linked to the existence of (*inter alia*) common data policy, schema, vocabularies. The approach selected to built the information system that will be presented in this paper, is based on the idea to have a *portal of portals*, in which the heterogeneity is maintained. The main portal will contain all the information on metadata of products residing in the other portals, but property and download services will remain in the '*product owner portal*'. Vocabulary can be different (within certain limits) in the different portals, but the main will contain a trans-coding table. Schema can be also different, it is only necessary to have access to particular final products. However, it is necessary to have a minimum common content in metadata, in order to allow queries by users. Format of metadata can be different, since it is transformed in central system. The disadvantage of a such approach is on the fact that the inclusion of new portals requires the implementation/adaptation of the 'transformation' software. The advantage is on the fact that the ownership of products remains in the original sites, and this does not create conflicts. Furthermore, the existing data management systems can be maintained. In operational sense, the 'federation' of different portals with their heterogeneity is effective since it assures the continuous update of portals content by local data managers, does not delay the response to queries, and assure the maximum profit both to data holders and users.

In this paper it is demonstrated that most of the problems to access products residing in different remote servers can be superseded in an effective way, using free software (PHP, MySQL, etc.) actually used in many information systems. The example is provided by the so called Mediterranean Operational Network (MOON) – Volunteer Observing Ship (VOS) Portal.

In September 1999, a Ship Of Opportunity Program was launched in the Mediterranean with the aim to provide data to the Mediterranean Forecasting System, i.e. the pre-operational model forecasting the 3D circulation, temperature and salinity of the Mediterranean Sea [1]. For this reason it was developed a portal for the access of data by users. During the last decade, the scope was enlarged in order to reach the need of a wider community of users: operational systems, climatic variability, research, public companies, students and the public [2]. Furthermore, the portal has been implemented to access also products residing in remote servers. Actually access to products deriving from *in situ* and satellite data is offered to users.

The portal is providing the services defined in the INSPIRE directive [3]: discovery, view, downloading, transformation. The implementation of the portal has been based on specific rules on mission, quality and business:

- *Mission*: definition of the general objectives; thematic information to be managed by the network; definition, implementation and maintenance of services;
- *Quality*: quality assessment and QC procedures for data, products and services;
- *Business*: specific data policy; pricing (if needed); ownership; use rules.

To facilitate the discovery service, a friendly user interface based on Google maps has been developed. This allow also to zoom on particular areas, maintaining the necessary geographical information.

In order to organize any information system, it is necessary *inter alia* to have additional definitions. In our case it is important to define ‘products’ and ‘services’:

- **product** is anything that can be offered to a client and that might satisfy a want or need (reference)
- **service** refers to a discretely defined set of technical functionalities.

The paper is organized in the following way. The motivation and description of the architecture is presented in Section 2. A demonstration of the efficiency and effectiveness of our framework using real-life queries and data sets is provided in Section 3. Discussion on lessons learned from our user study and further challenges to build the data retrieval integrated relational system is provided in section 4.

2. The architecture

Data retrieval (i.e. finding data from large databases) has become a serious problem as myriad databases have been brought online in the Web. Any user is obliged to navigate in the Web, using search engines and in some cases the search is frustrated by the lack of data for which the user was looking for. Thematic portal are under development in order to provide a unique entry point to access data residing in different servers. The possibility to access data ignoring the source of them, is only one component of an information system. The user is also interested on the ‘qualification’ of data, i.e. have information on position and date of collection, the conditions in which the data have been collected, and possibly view the data before download them. In other words, the users requires some minimum set of services that in Europe have been defined in the INSPIRE Directive [3].

Among the user requirements, there is also the long term maintenance of the services, the reliability of products provided, the use policy: mission, quality and business rules must be well described in the information system.

The architecture developed for the MOON-VOS portal is based on the idea that the software must be freely available in the net and the re-use must be assured in many fields of application. It includes the following elements: Bus, Right Management, Registry, Network Services.

The bus is the software allowing the connection of portals and applications, by means of ad hoc developed interfaces. In our case, two data bases are accessed: a local one containing *in situ* data and satellite data residing in a server located remotely. Both data were collected in the framework of the Mediterranean Forecasting System [1, 4].

The Right Management allows the management of authentication, authorization and logging.

Registry is based on a governance model (mission, quality and business) that allow the data maintenance, correct processing and interpretation.

The network services are the set of services provided to users, such as discovery, view, download, transformation. In particular, discovery allows the search of data through the metadata in catalogues, view allows to view at maps of data layers, download allows to access the data selected through the discovery service.

2.1 Information typology

The system allows the inclusion of numerical and alpha-numerical data, as well as images or multimedia files. The base element aggregating the information is the ‘station’, i.e. element containing meteo-marine parameters having a spatial and/or temporal variability. The ‘stations’ could be a vertical profiles (from CTD or XBT probes), temporal series (from sea level gauges, current meters, meteorological stations), geo-referenced images, model data outputs. Stations can contain any number of parameters and can reside in local or remote servers.

Station metadata contain the information on the sampling technologies and methodologies, quality control procedures, environmental compartment (e.g. water, sediment, biota), data owner, data manager name, accessibility, etc. In the metadata it is possible to include references to publications, internet links, images.

2.2 Organization of information

Information is included in a relational data base, with tables that can be schematized as in figure 1.

Metadata Tables:

- Parameters (Gf3)
- Roscop type
- Matrix and environ. compartment
- Quality flag decode

Administration Tables:

- User and permission
- Log table
- Utility tables
- Cache table

Data Tables:

- Table for X,Y,Z,T station limit
- Table for Cruise metadata (data protection included)
- Pivot table to control :
  - Table X,Y,T constant (Xbt i.e.)
  - Table X,Y,Z constant (current meter i.e.)
  - Table Z constant (drift i.e.)
  - Table generic (X,Y,Z.T variable)
  - Table for Image
  - Station parameter
  - Quality flag
- Table of header (to trace original header data)
- Table of note (comments)

Figure 1. The organization of the relational data base.

This scheme allows the organization of information in flexible way, extending the number of parameters in each station and optimizing the storage. This is done by the use of pivotal tables containing data having some similar characteristics. For example, the vertical profiles are constant in longitude, latitude and time, the table related to a such stations contains only the measured values of each parameter and their quality flags. The same procedure is applied for temporal series or other kind of stations. This procedure allows a faster response of the information system to queries.

Other tables or registries include
- the list of parameters and measurements type
- all units of measurement used
- all codelists / thesauri used in the application schema
- identifier namespaces
  - all feature catalogues
  - Metadata on dataset level will be available through catalogue services.
- registry for the management of right access

Data access is organized in three levels (public, limited, confidential) on the bases of wishes of the data owner. All ‘stations’ belonging to a defined ‘cruise’ have the same level of confidentiality.

2.3 Distribution/management of information

The information system is organized on a Client/Server structure on three levels:

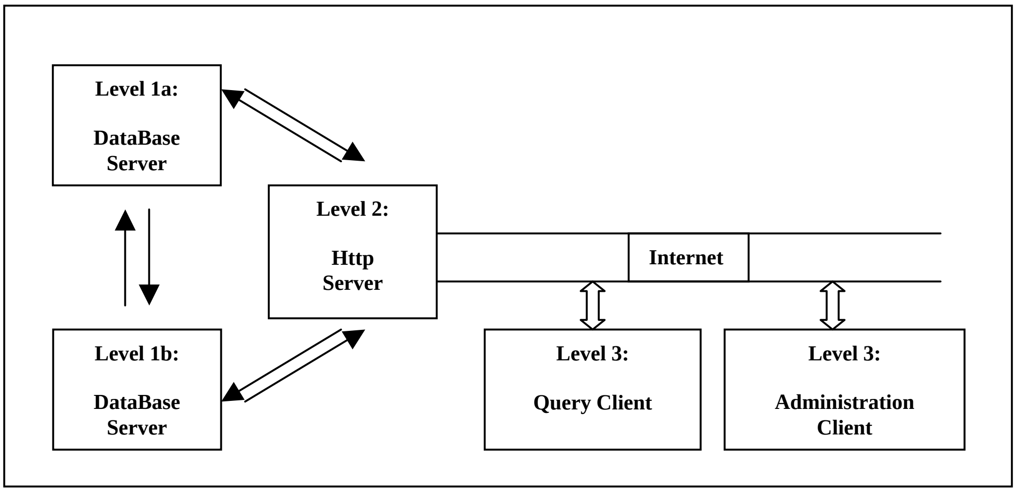


Figure 2. Organization of the client/server structure

The data base is linked to http servers that can reside locally or remotely. PHP procedures in the http server have two main functions:

- manage the data base, and tables content by the system administrator
- provide discovery, view and download services

2.4 Software implementation

Procedures "server-side" have been developed in PHP Version 5.1.4 [6] with graphical components GD (Version 2.0.28). The database is implemented in MySQL Version 4.0.18 [7]. The server http is provided with Apache/2.0.49.

The client-side maps are implemented with Google Maps Api that are shaped parametrically through PHP, in a way that markers and images can be overlaid. Additional functions for navigation and selection have been implemented in JAVA script.

Some algorithms have also been implemented to speed up the marker representations when stations are greater than 5000 (cluster method – [reference 8]).

The maps are produced using Ferret [9], an analysis tool for gridded and non-gridded data. The files necessary to Ferret are prepared with PHP procedures and as well as the results of the Ferret graphics are included in html pages or as overlays of the Google maps.

The operative system of the server is SUSE LINUX Enterprise Server 9 (i586). Details on the server hardware are provided in table 1.

Processors	4
Model	Intel(R) Xeon(TM) CPU 3.06GHz
Chip MHz	3062.06 MHz
Cache Size	512 KB
System Bogomips	24363
PCI Devices	0000:00:09.0 VGA compatible controller: ATI Technologies Inc Rage XL 0000:00:0f.1 IDE interface: Broadcom CSB5 IDE Controller 0000:02:08.0 Ethernet controller: Broadcom Corporation NetXtreme BCM5703X Gigabit Ethernet 0000:05:03.0 RAID bus controller: Adaptec ServeRAID Controller 0000:09:06.0 Ethernet controller: Broadcom Corporation NetXtreme BCM5703X Gigabit Ethernet
IDE Devices	hda: HL-DT-ST CD-ROM GCR-8482B
SCSI Devices	IBM SERVERAID (Direct-Access) IBM SERVERAID (Processor) IBM 02R0962a S320 1 (Processor) BNCHMARK DLT1 (Sequential-Access)
USB Devices	Linux 2.6.5-7.276-smp ohci_hcd OHCI Host Controller 0000:00:0f.2

Table 1. Server hardware and components

3. Discovery, selection and view interfaces

The development framework is done to achieve user-friendliness by allowing users to express intuitively their preferences in ordering products. The logical hierarchy of the information system is taking into consideration that the users is starting his queries by selecting geographical and temporal windows. He wants to look at the products available in that area and their temporal distribution, to know what parameters are included in the products, possibly have a look at them and finally download the products. This logical hierarchy has been used to develop the interfaces that allow the discovery, selection and view of products.

The functional scheme is shown in figure 3.

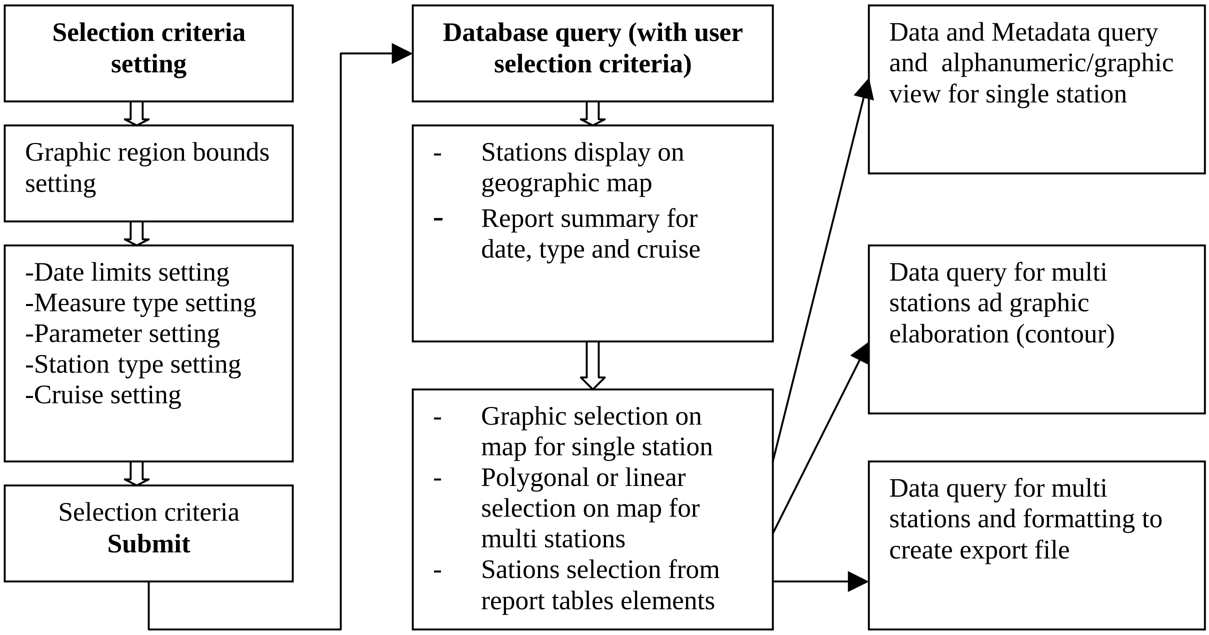


Figure 3. The functional scheme for discovery, selection and view of products

The functions are viewed by the users through a Internet browser. The graphical interface is divided in frames allowing (figure 3):

- the selection of the stations on the base of cruises, parameters, geographical location, time,
- the response frame providing the view of the selected stations; the selection can be refined in this frame;
- display of selected stations by query;
- other links and title frames.

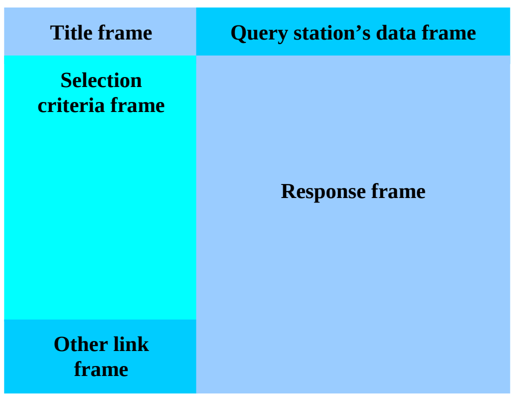
User interface	**Logical frames of the interface**
	

Figure 4. The schematic frames of the query system.

The geographic region can be selected through Google Maps API (Google Maps embedded in web pages with JAVA script; the API provides a number of utilities for manipulating maps [5]). The selected area appears in the 'response frame' with the number of stations contained in that area.

The response to the queries are shown in a Google map together with a table with a temporal distribution of selected stations. In the 'query stations data frame' appears a table from which it is possible to look at the metadata, profiles or data numbers.

Other view services developed for the users are the horizontal and vertical maps that can be done 'on the fly' respectively with polygons or polylines.

Finally data can be exported in two formats: ASCII MedAtlas and ODV spreadsheet. The ENEA information system is also starting to produce data in netCDF format.

View and download services are provided under the data policy decided by products' owners.

4. Conclusions

The Web has facilitate the exchange of products and services. One of the challenges of the information systems is the accessibility of different products residing in different remote servers and compose them to produce a more complex information product. The aim of the paper is to show how relatively simple how relatively simple systems, with software freely available in the net can be used to implement an information system having the possibility to access files in local as well as remote servers (portal of portals). Data must be represented on maps providing useful geographic information. The use of Google is proven to be very effective, since provide detailed maps and zooming facilities.

The approach does not operate a data harmonization process, but assure that spatial data are stored, made available and maintained at the level of product producer. It is possible to combine spatial data from different sources in a consistent way and share them between several users.

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[8]
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The colleague Franco Reseghetti (ENEA) is continuing the monitoring of the Mediterranean, assuring a flow of data allowing the assessment of the status of the Mediterranean climate. Emanuele Bohm and Cristina have provided the access to satellite images and data in the CNR ISAC server. They are operationally producing Sea Surface Temperature maps in the Mediterranean area. Authors acknowledge also the cooperation provided by Rosalia Santoleri (CNR ISAC) and Salvatore Marullo (ENEA). The development of the MOOV/VOS portal has been financially supported by contracts supporting different projects: DG Research MFSPP by the European Commission, Adricosm Ext and Adricosm Star by the Italian Ministry of Environment and Territory, I3 SeaDataNet by the European Commission, PRIMI by the Italian Space Agency (ASI).

Appendix

Setting selection criteria (left frame)

Google maps API:

Functions:

- Zoom, Pan
- Lat, Lon cursor position on screen
- Rectangular Zoom
- Map, Satellite, Hybrid chart
- Dynamic bounds View
- Navigation area menu

User select the geographic area. Every time the rectangular window is moved, the number of stations appear in the left frame.

Selection of data:

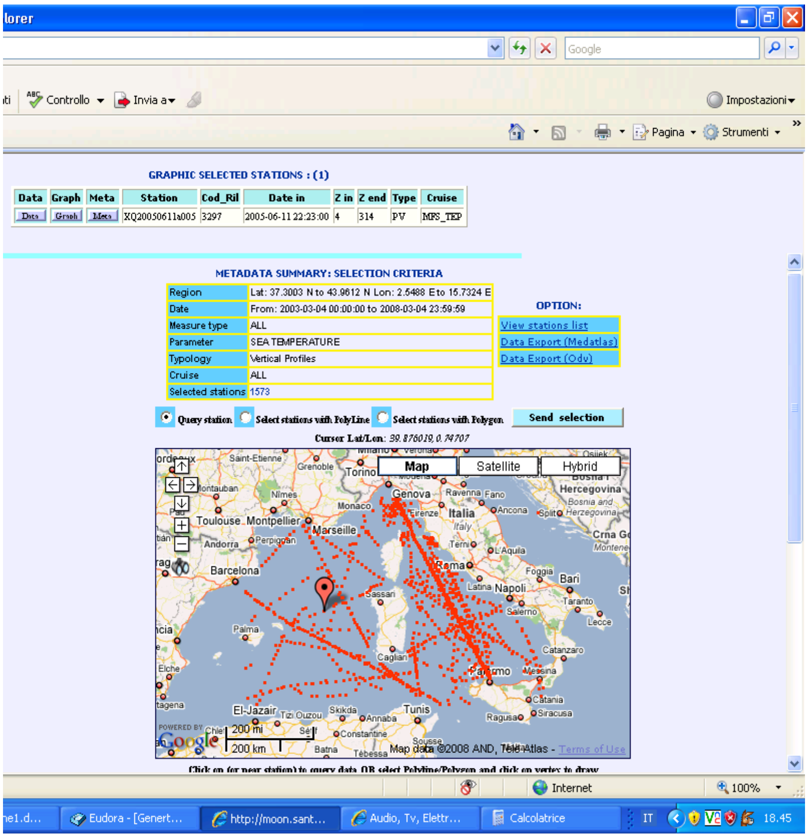
Function:

- Temporal interval: a window of 20 years is provided by default: dates can be changed by the users
- Measure type, Parameter, Typology, Cruise: are listed only options for which there are link with the data base.
- Operation type: two choices are possible, view the number of stations or display position and temporal table.

All query conditions are considered as AND. In the case option is left ALL, this will not used for the selection. In the case of selection of CRUISE, only this option will be considered in the stations selection.

After selection, the user can have a look at temporal distribution of stations and cruises to whom stations belong clicking on **View NUMBER of selected stations**.
Or can have also a Google Map showing the spatial distribution clicking on **View SUMMARY for selected stations.**

Response to query (right frame)



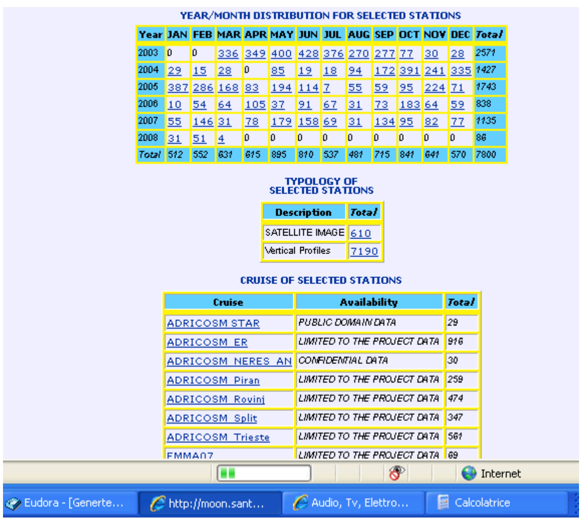
The SQL query defined with the selection criteria is sent to he database through the http server. The response to the query is shown on the right frame. In the upper part the defined criteria are reported. In the center the position of selected stations are shown in a Google map. In the lower part the yearly and monthly distribution of station is shown in a table.

The user can navigate on the map using the Google Map Api functionalities. Can select a station and in this case

The user ca use the typical Google Map API functions to navigate on the map. Furthermore can click on a station whose attributes will appear in the upper frame. Three commands are available here:

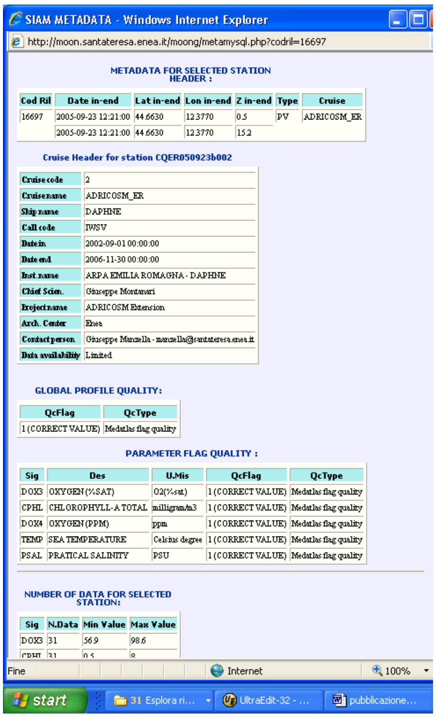
"**Meta**": allows the visualization of metadata.
"**Graph**": allows the graphical visualization of products (vertical profiles, time series, images)
"**Data**": allows to view the alpha-numeric values of products in table form.

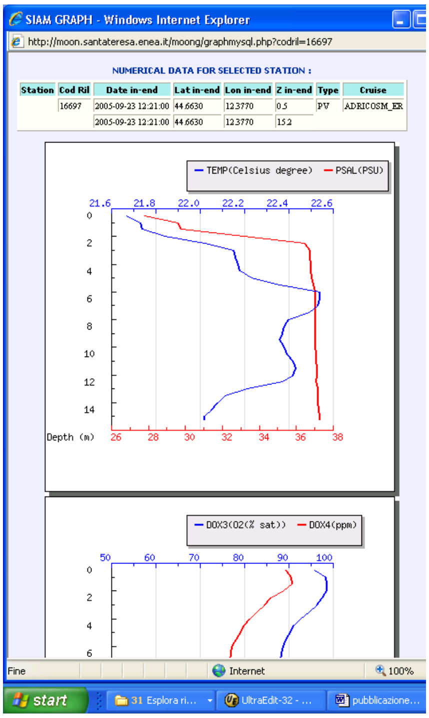
Furthermore, other services have been added.
Polygon: allows the selection of stations in a certain area in order to produce horizontal maps. These will be presented overlayed on Google Map.
Polyline: allows the selection of stations to produce vertical sections.

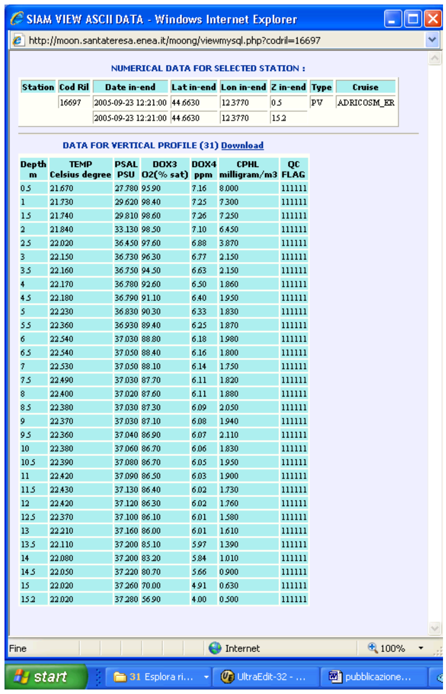


Below the Google Map it is provided a table with the temporal distribution of stations in years and months. Another table provides the list of cruises to whom the stations belong. Numbers and cruises in the two table can be selected by clicking on them.

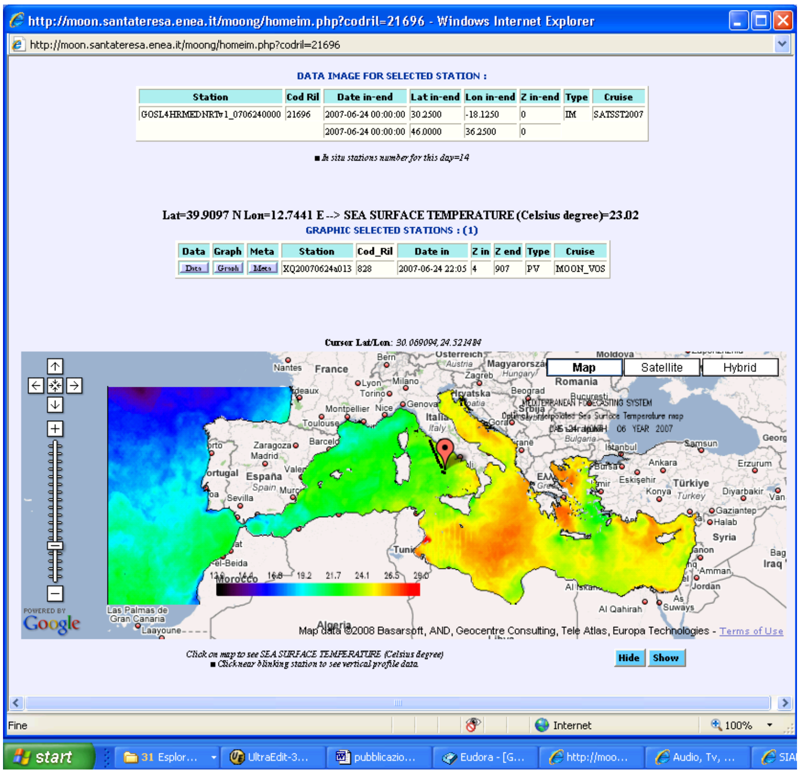
Example: Data View







Metadata View **Graph View** **Data View**

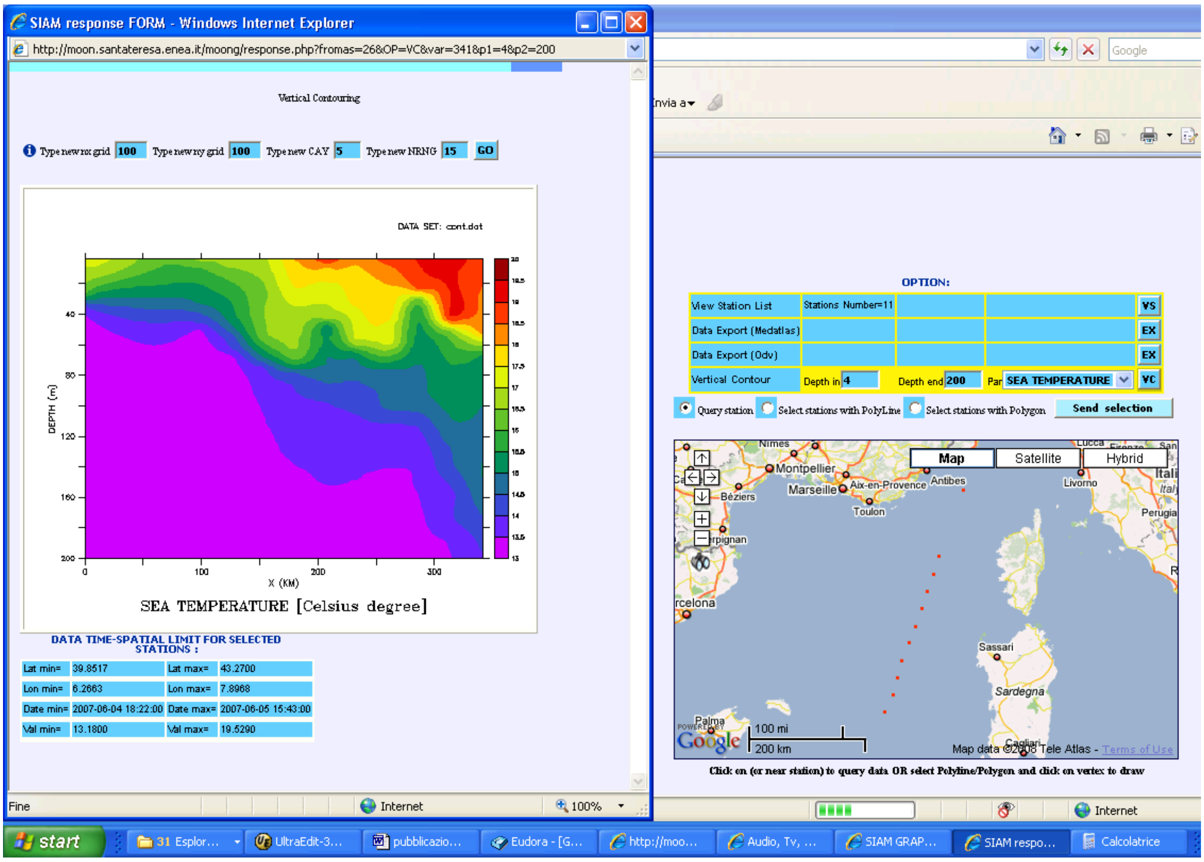


Graph Satellite View (SST)

A click on each pixel of the image in overlay on Google map will provide the value of the SST in that point. This is done by accessing the corresponding Netcdf file.

If in situ stations are also available in the day of the satellite image, they are viewed in the map. The stations can be selected and viewed as metadata, graphs, data. In this case it is possible to compare satellite and in situ data.

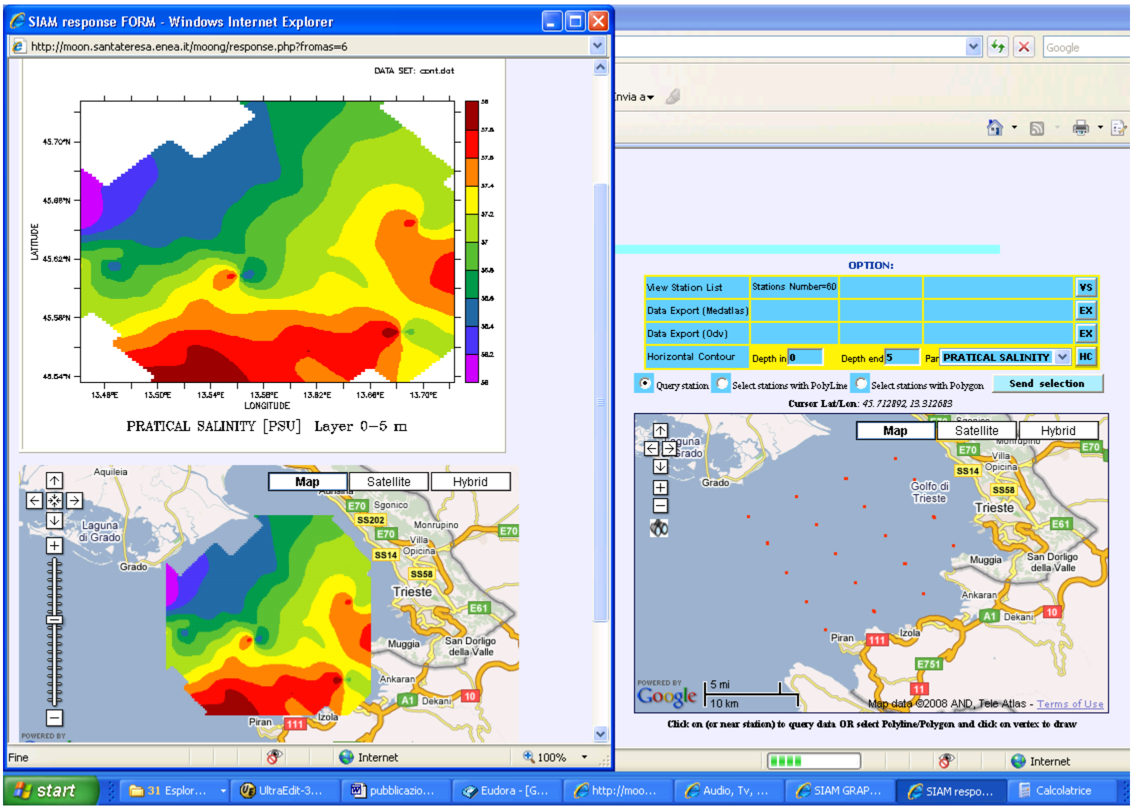
Example: Vertical contour



Using “**Select station with polyline**” it is possible to select stations. After clicking on Send selection, they will be viewed in the Google map. It is possible to select a vertical interval, a parameter and click on VC button. A section map will be produced.

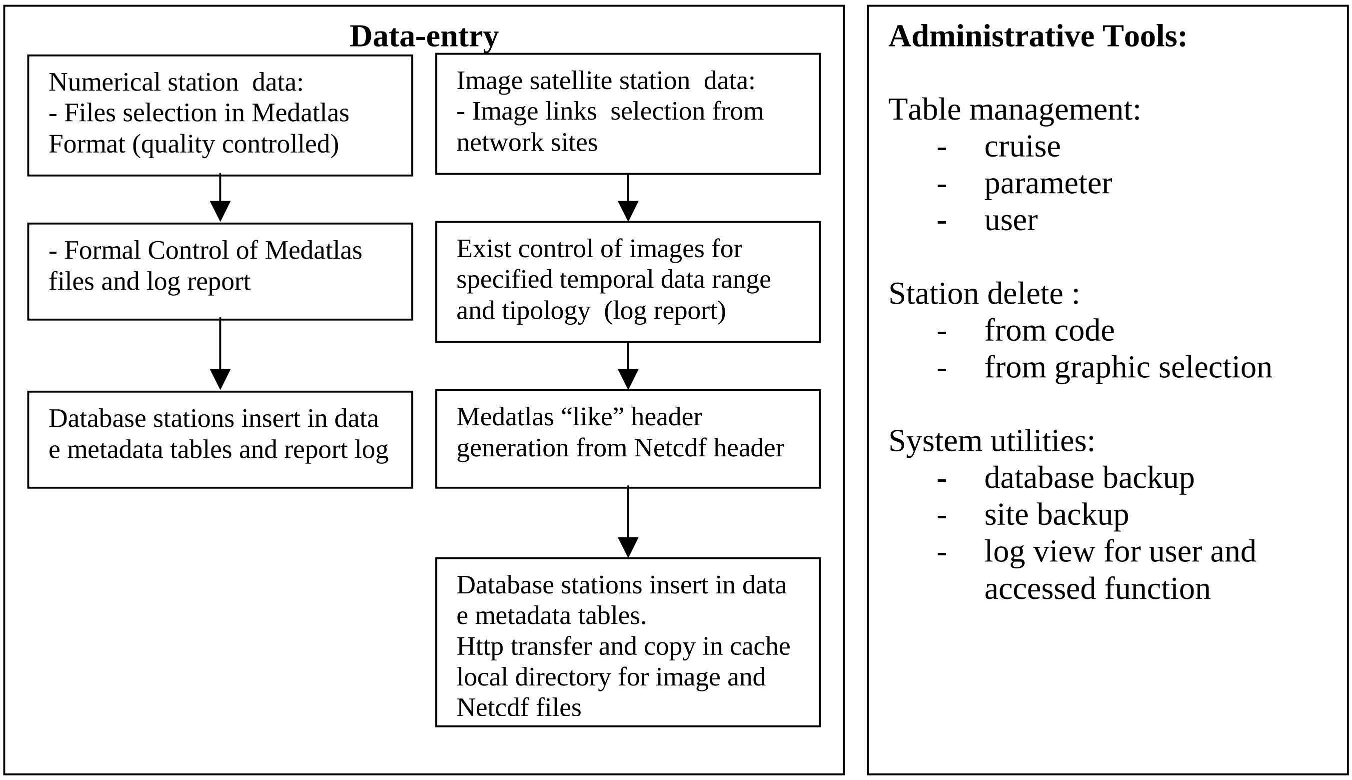
The interpolation parameters of the graph can be changed by the user.

Example: horizontal contour



“Select station with polygon” allows the selection of a polygonal area. All station inside the polygon are selected (Send selection). User can choose the depth interval and the parameter to be mapped and clink on HC (Horizontal contour). The horizontal map is overlayed on a Google map. The user can change the parameters of interpolation.

Data-entry and Administative Tools:
logic – functional schema:



The functions are presented to the user in an internet browser (Explorer, Mozilla, Netscape) .

The frame on the left is showing the available functions. The frame on the right is used to include parameters and visualize log files.

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