

## **Integration of Hydrographic Data Products in a Global Web Based 2D and 3D GIS**

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### **Abstract**

Seafloor morphology is one of the main subjects of oceanographic research. However, currently there are some obstacles to the dissemination of this information. Web based GIS could play an important role in minimizing such problem, breaking some barriers between the potential users community and the data. Web-GIS can effectively maximize the hydrographic data potential, providing a set of information exploration tools, facilitating the dissemination of hydrographic products and, therefore, allowing users to add these products to their own georeferenced data.

This study intends to explore Web-GIS as a tool to promote hydrographic products distribution, particularly offshore seafloor data collected by the Portuguese Task Group for the Extension of the Continental Shelf (EMEPC) and the products generated including bidimensional and three-dimension data and information.

The main products generated are KML files, which can be visualized with global geographic information systems such as Google Earth or NASA World Wind. Supported by Web-GIS some links to other generated objects, such as Fledermaus objects, were also created, allowing for a new interaction with the data and making possible the exploration of their morphological characteristics.

Keywords: GIS, KML, Google Earth, Fledermaus, seafloor, hydrographic products

### **Introduction**

The study of seafloor morphology and its interaction with the surrounding environment is one of the central subjects of ocean research. This knowledge can be applied to a wide range of areas such as science, economy, resource management or politics and influences several other disciplines namely, biology, microbiology, geology, ocean circulation, water chemical composition, maritime transportation.

Seafloor topography also influences the general equilibrium of the planet, due to its role in ocean circulation and water mixture, which controls the Earth climate (Rahmstorf (2002)), biologic diversity and marine resources. Moreover, earth's geologic activity is recorded in the ocean bottom, and it is also there that spots rich in mineral resources and potential epicenters for earthquakes or tsunamis are located.

The significant role of seabed morphology to several areas has encouraged its research and characterization. Coastal states have been investing in geomorphometric data collection of its surrounding waters, which allows the study of the ocean bottom morphology. Those investments, mainly related with multibeam echo sounder systems, have generated a large amount of high quality data with significant potential.

However, this potential hasn't been fully explored due to some obstacles associated with the dissemination of this kind of information. The absence of a reference point that gathers all the

ocean data coupled with the non promotion of an efficient way to share that information results in a waste of the inherent potential of the data.

Web-GIS can thus have an important role as a reference point to centralize the diverse ocean data, from different sources, and simultaneously acting as tool to promote information exchanges between them and the general community. Therefore, it can be the key to break the barriers between the large community of users and the geographic information, promoting data integration and dissemination of the data and maximizing its potential.

This paper presents the use of WEB-GIS as a tool to share hydrographic information of the Portuguese offshore seafloor. The background section describes the scope of data collection and the methodology used to develop the WEB-GIS products, followed by the presentation of the products and their discussion in the Results section. The last section concludes and describes future research work.

## **Background**

The data used in the present work is owned by Task Group for the Extension of Portuguese Continental Shelf (EMEPC), and was collected using Portuguese navy hydrographic vessels equipped with multibeam echo sounder systems. EMEPC was created in January 2005 by government decision (Presidência do Conselho de Ministros (2005)) with the main objective of preparing the Portuguese proposal to extend its continental shelf, based on the 76th article of United Nations Convention on the Law of the Sea (UNCLOS) (United Nations (1982)). The proposal must be submitted to the United Nations until May 13th 2009.

Under the project scope a set of survey areas were defined to collect scientific data that allows the establishment of outer limit of the continental shelf beyond the 200 nautical miles. Multibeam echo sounders systems were the technology chosen to fully explore the planned hydrographic survey areas, since it is the most efficient equipment available (faster and with high quality standards) (US Army Corp of Engineers (2002)). Figure 1 represents the EMEPC surveyed area, which corresponds to more than 850.000 km<sup>2</sup>, defined by roughly 250 million depths positions.

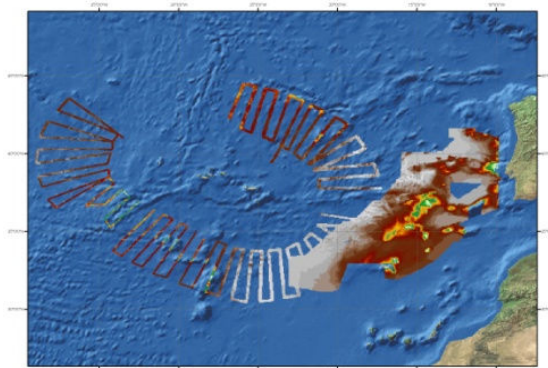


Figure 1 – Multibeam coverage data, collected until January 2008 by the Portuguese Continental Shelf Project.

## **InforM@r Project**

Even though hydrography is the main source of data for the continental shelf extension project, there are other kinds of data and information that need to be integrated. EMEPC created the InforM@r Project to integrate ocean data from different disciplines such as, hydrography, oceanography, geodesy, marine geology and biodiversity. Furthermore, in a near future,

InforM@r aims to establish a framework to assemble all the Portuguese ocean data, minimizing the problems related with information dispersion in several different institutions.

The development of InforM@r data model was based on Marine Data Model (ESRI (2007)), which was adapted to the identified custom requirements.

Figure 2 shows a simplified representation of the InforM@r data model, containing only the entities and relationships that interact with the hydrography area.

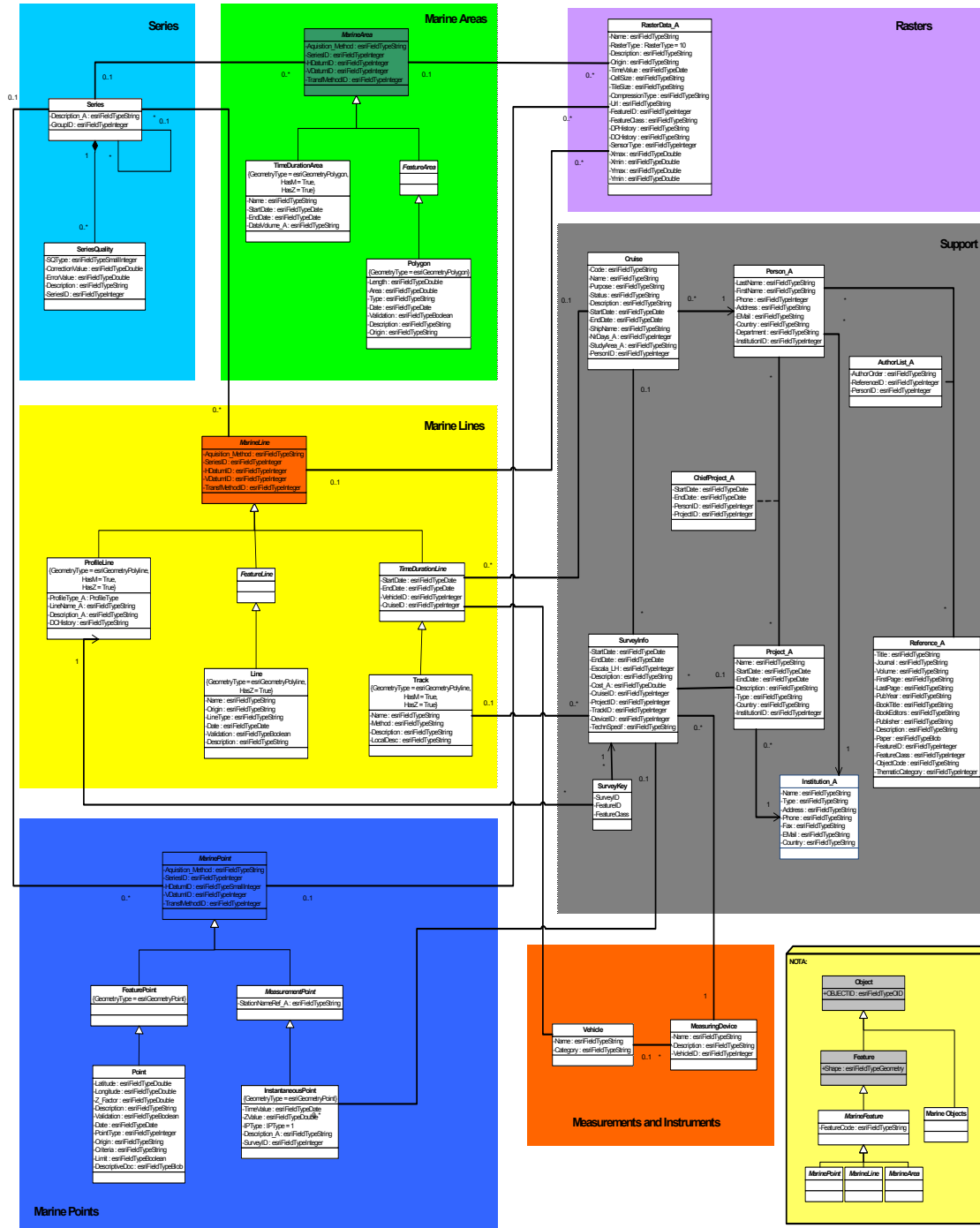


Figure 2 – InforM@r Domain Model - simplified view regarding the hydrographic data.

### **Hydrographic Products**

Concerning the EMEPC data sharing policy, the InforM@r website was created to make available some of the ocean data collected by the institution. As a future step in InforM@r website development, it was decided to include bathymetric mapping information and link it to other complementary platforms with privilege relations with the general public, in order to distribute that data.

Once numerous ocean phenomenon show a deep vertical structure, influenced by the morphology of the sea bed, it was decided to make available not only bidimensional, but also tridimensional products. These value-added products will bring more realistic views, which will influence other elements combined with it, allowing more interesting simulations and analysis.

The two types of products (bidimensional and tridimensional) allow the users to choose the representation system more adapted to their goals.

To make the information available, the following approaches were considered as data dissemination platforms:

- Local geographic information viewer, namely ArcIMS, which supports the InforM@r web site;
- Global geographic information viewers, e.g. Google Earth, NASA World Wind or Microsoft Virtual Earth;
- Dedicated software to visualize and explore geographic datasets.

### **Results**

The product generation for different survey areas follows a similar approach. Therefore, this paper will focus in just one survey area to illustrate the process (Figure 3).

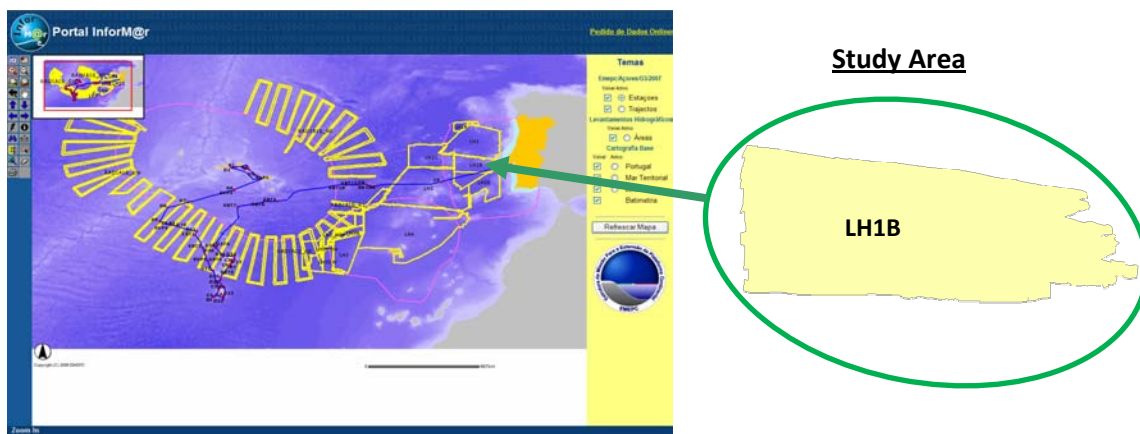


Figure 3 – Study area.

In terms of spatial resolution and data quality, the main objective of the products created is to offer a geographic dataset better than other public data available for the region.

Looking for the public data to this region, we can find the ETOPO 2 grid (NGDC (2006)), with, as the name indicates, 2' grid spacing and the General Bathymetric Chart of the Oceans (GEBCO) (NGDC (2007)), 1' grid spacing.

Using multibeam echo sounders with seafloor total coverage is, just by itself, a guarantee of quality improvement when compared with such grids. Moreover, considering the grid resolution, it was defined a reference spacing between depth information of 30'', respecting the initial

objective i.e. offer the best bathymetric dataset corresponding to a substantial improvement in seafloor morphology representation, not only in terms of data quality used to generate it, but also in terms of data density.

The product development guidelines adopted were:

- Use EMEPC web page as the central platform for distribution;
- Use a global geographic information viewer in the product distribution, allowing the users to combine EMPEEC information with their own geographic data;
- Develop solutions that aloe for a higher interaction between the users and the geographic information through basic exploration tools;
- Develop bidimensional and tridimensional products, increasing the flexibility for the users.

Regarding these principles, a group of 4 different products were defined, in a bidimensional or tridimensional format, oriented to distinct platforms as represented in Figure 4.



Figure 4 – Visualization platforms of created products.

The ArcGIS Desktop 9.2 from ESRI and Fledermaus Professional were used to process the original data. Figure 5 shows the processing diagram for each product.

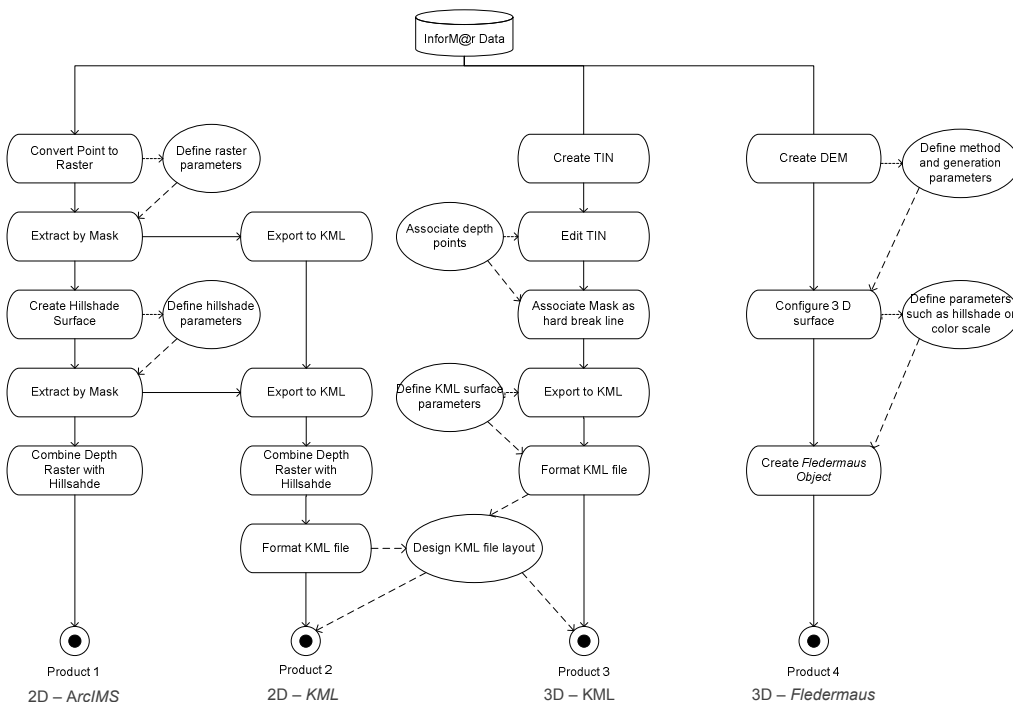


Figure 5 – Generic product generation's workflows.

**Product 1 – InforM@r portal (ArcIMS)**

The initial step of product development was to generate a hydrographic product focused on the InforM@r portal. Because ArcIMS works in a bidimensional base a 30 minutes resolution raster was created. Each cell value was defined as the average depth of all contained sounding points.

A shaded relief surface for the same area was also created. Through the overlaying of such surfaces, and setting some transparency to the front layer, it was possible to get a tridimensional appearance in a 2D surface (Figure 6).

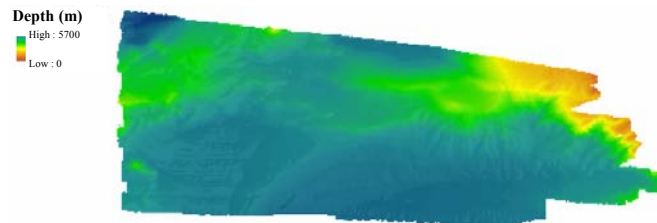


Figure 6 – Overlay of raster surface with shaded relief surface

Figure 7 shows the surface mentioned before integrated in InforM@r Portal.



Figure 7 – Product developed to InforM@r portal.

**Product 2 – KML 2D**

In addition, a 2D product designed to integrate bathymetric information in a global geographic information system was also developed. The format adopted was KML, created by Keyhole, Inc. and currently associated with Google Earth (Google Inc. (2007)). Because of the generalization of KML use, this format became a standard, used not only by Google Earth but also in many other geographic information applications.

The KML product generation was based on the product 1 created including raster depth surface and the correspondent shaded relief. Combining those two images and making them available in other platform allows users to further combine this data with their own geographic information. A third element was also added to KML, containing the screen overlay with the legend of the raster, date of product generation, among other metadata.

Figure 8 shows the generated product with all its components (raster with depth values, shaded relief and screen overlay).

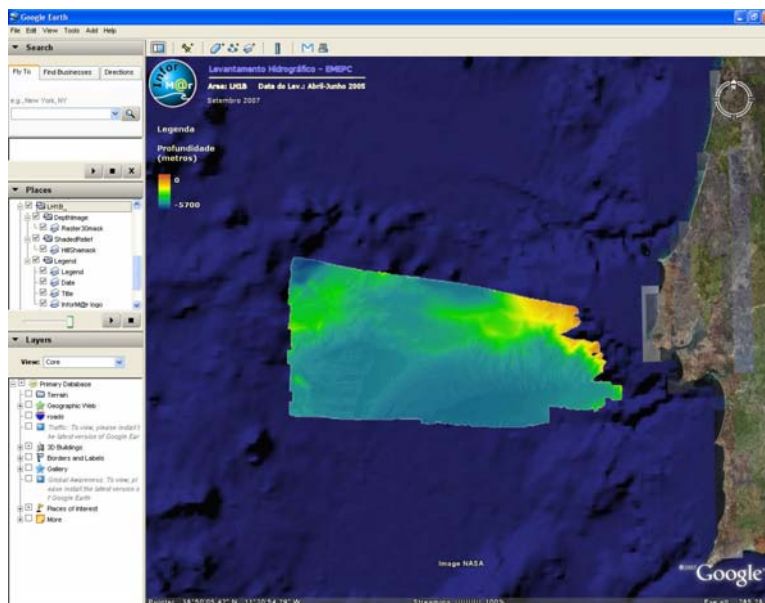


Figure 8 – Final result obtained in KML 2D file generation.

### **Product 3 – KML 3D**

As a complement to the 2D KML product, a tridimensional surface, also in a KML format, was created. An ArcGIS tool was developed, using Visual Basic for Applications, which exports tridimensional surfaces from Triangulated Irregular Network (TIN) to KML files. This ArcGIS tool has the ability to apply a vertical exaggeration or an offset to the surface.

Creating a TIN from multibeam high density data with such an amount of information and exporting it to a KML file would originate a file too big and overdetailed. Therefore, before the TIN creation, the sounding points of the study area were resampled, to obtain a depth information dataset with approximately 1000 meters spacing.

The resampling was performed using a Gridder tool associated with the Hydrographic Data Warehouse – HDW (Campos, A., Pimentel, F., Abreu, M. (2007)), implemented in EMEPC data management structure.

The TIN surface was developed from such subset of points. The polygon obtained for the surveyed area was applied as a mask to hide the triangles built outside the study area (Figure 9).

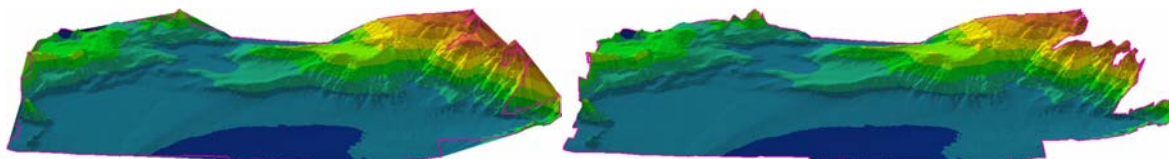


Figure 9 – TIN surface before (on left) and after (on right) mask application.

The TIN was then exported using the ArcGIS VBA Tool, assuming 4 and 25 000 as vertical exaggeration and offset export parameters, respectively. The offset applied to the surface is crucial to enable the visualization of KML file in Google Earth. Otherwise the created surface would be positioned in its real position, under the geoid opaque surface.

Combining the support information with the KML generated surface, the final KML file results (Figure 10).

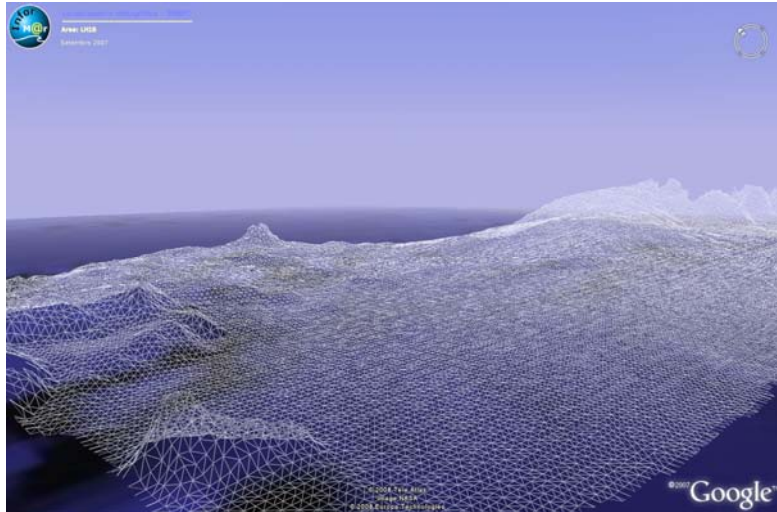


Figure 10 – KML 3D product.

#### **Product 4 – Fledermaus**

In addition to the 3D KML file a product providing extra tools for bathymetry exploration to the potential users was considered. Fledermaus (IVS 3D (2007)) was used allowing the user to have a tridimensional model associated with a viewer that allows for a higher interaction with the geographic data (Figure 11). The user can, for instance, change the vertical exaggeration applied to the surface, emphasizing some geologic structures that are hardly visible without this manipulation.

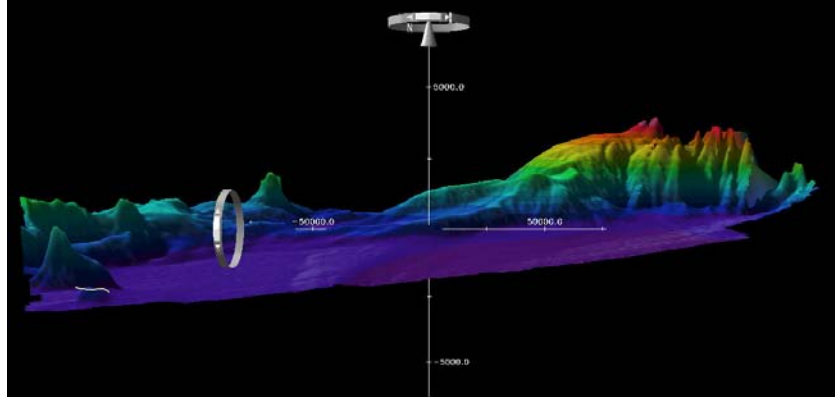


Figure 11 – Fledermaus product surface.

### **Conclusions**

Because there is not a unique bathymetric product that satisfies all the requirements of a single user, it was decided that a diversification of readily available products was needed.

Regarding the bidimensional products, the one developed for ArcIMS allows the combination of bathymetry with all InforM@r data; the 2D KML represents a solution to overlay bathymetric data with user's geographic datasets.

The tridimensional surfaces can, on the other hand, satisfy other user needs, allowing a much better representation of reality. The KML solution was chosen to integrate such representation within a global geographic information viewer, where, like in the 2D case, the users can integrate



its own geographic data. The Fledermaus product represents a solution where the users have a higher interaction with the ocean bottom surface data.

All together, these products intend to respond to different user needs, taking full advantage of bathymetric data, on different areas that interact with ocean topography.

As future work the combination of other kinds of geographic data with the developed surfaces can be explored, namely 3D products. Using a 3D base surface in technical analysis can bring an important increase in ocean environment representation, contributing to better perceptions of reality and consequently to the development of scientific knowledge.

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