Integrated display and communication of information towards stakeholders. NAMIBIE: an application for the integrated management of the Thau lagoon and its watershed

L. Loubersac[1], S. Maraux[2] , A. Lemsanni[3] , A. Fiandrino[4] , M. Jouan[5] , D. Tellier[6] , J. Denis[7]

[1] *Dr, Laboratoire Environnement Ressources du Languedoc Roussillon / IFREMER, BP 171, 34203 Sète Cedex, France, lionel.loubersac@ifremer.fr*

[2] *Ing, ONDIM Bretagne, 34 Rue frédéric Le Guyader, 34000 RENNES, France, Maraux@ondim.fr*

[3] *Dr, Laboratoire Environnement Ressources du Languedoc Roussillon / IFREMER, BP 171, 34203 Sète Cedex, France, abdellah.lemsanni@ifremer.fr*

[4] *Dr, Laboratoire Environnement Ressources du Languedoc Roussillon / IFREMER, BP 171, 34203 Sète Cedex, France, annie.fiandrino@ifremer.fr*

[5] *Ing, Laboratoire Environnement Ressources du Languedoc Roussillon / IFREMER, BP 171, 34203 Sète Cedex, France, mathieu.jouan@ifremer.fr*

[6] *Ing, ONDIM Bretagne, 34 Rue frédéric Le Guyader, 34000 RENNES, France, Tellier@ondim.fr*

[7] *Dr, Laboratoire Environnement Littoral Provence, Azur, Corse/ IFREMER, Zone portuaire de Brégaillon BP 330, 83507 LA SEYNE-SUR-MER Cedex France, jacques.denis@ifremer.fr*

Abstract

NAMIBIE (a French acronym for Integrated Multimedia Navigator Within Coastal Environment Data Bases) is a specific tool which first concept has been established by Ifremer and has been developed by an association between research in the field of coastal environment, innovation in the field of new information and communication technologies and services in the field of coastal integrated management and impact studies.

The objectives of this tool is to facilitate research, direct access and display of relevant multimedia coastal integrated data and information according to an interactive, widely opened and play-full interface.

The principles are based upon the fact that sustainable decision making needs an optimised understanding of coastal processes and better consultation between actors. In this purpose the development of the tool has considered that the end user should and could be free to look after the data and the information he needs for a particular site or environment of interest and for a specific ICZM question according to easy navigation interfaces.

That is why the NAMIBIE concept is based upon :

- a coherent 3D representation of the coasts (i.e. from watersheds to continental shelf and deep sea), which consider a coherent DEM from land to sea and textural representation of the environment by using satellite imagery textural displays,
- a 3D navigator which allows the user to fly or dive over and within the coastal environment of interest,
- a multimedia database (text, graphs, image, maps, geographic objects, modelling results…) specific to the territory of interest,
- an interactive interface which helps in finding relevant information associated to specific questions

The technologies used include VRML data format, integration of standard GIS format (shp, grid, img) within the navigator, integration and display of modelling data. The production chain is realised in C++ and Java Scripts allow dialogue between web pages and 3D windows.

Applications are presented on the coasts of the Languedoc Roussillon region and the Thau lagoon area (French mediterranean border) in the framework of ICZM problematics.

1. INTRODUCTION

Communicating coastal environment information, understanding natural and human dredging forces that apply on the coastal system or delivering information on interactions between land (catchment area) and sea have been pointed out by numerous programs and working groups. Those goals have been identified as necessary conditions for a better participation and integration of actors in the decision processes. It is a fact that more and more questions are arising from the general public and there is a growing demand for delivering on line multimedia coastal environmental information.

ICZM processes (Communication of EU Parliament in 2002), European Water Directive on coastal waters (Directive 2000/60/EC; October 2000), various environmental crises (oil or chemical spills and other accidents at sea, impact of floods and storms, harm-full algae blooms etc…) or still national policies (as Loi Littoral in France for example) are enforcing a collaborative approach between actors which is based upon widely and adequate delivering and communication of information.

During the Info-coast meeting (Bridge L. ed 1999), which was boosting the needs of coherent coastal european information structures, P. Doody analysing the conclusions of the E.U. thematic study on information required for ICZM, underlined the needs of transforming data to information (i.e data + context) and then information to understanding (i.e. information + analysis).

Presently, at european, national and regional levels, various approaches have been identified and various tools are under development : i.e. metadata architectures, national and regional information networks, exchange hubs, etc… The Namibie project has been developped within these frameworks and contexts.

2. BASICS OF THE TOOL

The basics of this tool can be resumed as follow :

. integrated, i.e. supporting information from various sources representing various disciplines and themes,

. interactive and play-full, i.e. very accessible to the end user and leading to pleasure and curiosity,

. multimedia as coastal information possesses various forms (text, graphs, tables, maps, images, animated objects….),

. multi-scale as coastal problematics encompass local, regional, national and international questions,

. as close to reality as possible, i.e. offering to the end user a representation of the coastal territory (land, coast and sea) as it is,

. 3D as to represent land, coast and sea in their volume dimensions and as to offer to the end-user the capability of looking at the land/sea landscapes from any point of view,

. trans-frontiers between land and sea as between air and sea,

. evolutive in order to be easily updated and adapted to new questions, new types of data and information,

On a technical point of view the main challenges were the following :

. to solve a 3D continuous representation of land-sea continuum (topography - depth) from regional to local scales,

. to represent the coastal region considered thanks to new sources of satellite and underwater remote sensing techniques,

. to facilitate interactive navigation over/on/in, even under the land-sea territory considered,

. to integrate zoom in – zoom out possibilities,

. to manage directly GIS data native formats (geographic objects and attributes) into the 3D navigator,

. to offer display capabilities of mathematical modelled data (hydrodynamism for example)

. to facilitate to the end user the display of chosen objects including spatial indicators and the direct retrieving of associated information

3. INTEGRATION OF TOOLS : A "TRIPOD CONCEPT"

NAMIBIE facilitates access and display of integrated information referring to a specific coastal area and the land territories which influence its behaviour (i.e. watershed, employment basins …). This integrated information results from three main sources: in situ monitoring, spatialisation and simulation, specific tools (statistics, GIS, Digital Image Processing, numerical modelling) being attached to each of them (see fig 1).

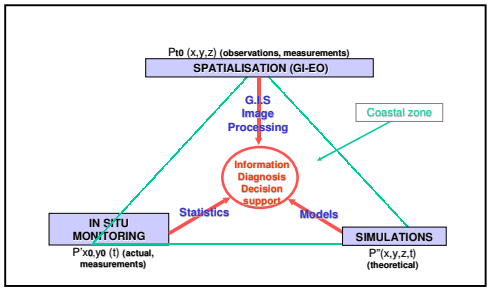

Fig 1 : the "tripod concept" : three main sources of information for coastal zone representation, diagnosis and decision support.

In situ monitoring sources offer actual data (measurements) with discrete geographic representation and in general long term series which for example offer statistic analysis of trends.

Spatialized data offer continuous spatial representation in x, y and z dimensions. Discrete times series exist (Remote sensed data sources for example). Digital image processing and GIS tools are favorites.

Simulated data sources offer access to the x, y, z and t dimensions. Models benefit now from high computer power and reach high resolution in

those four dimensions. Results are here theoretical.

4. MATERIALS AND METHODS

In this paragraph are described data types, data processing techniques and software solutions.

4.1 Data types and data processing

4.1.1 Digital Elevation Model

As to offer a 3D continuous representation from land to sea, an integrated Digital Elevation Model has been set up. This DEM has been built from four main sources of data.

For the land representation two primary DEM have been used :

. one, from IGN source (Institut Geographic National - BD Alti) interests the entire Languedoc Roussillon Region with a 50 meters mesh and a 1 meter resolution in z,

. the second one, from SPOT Image source, interests the zooming zone of the catchment area of the Thau lagoon (Sète and Agde regions). It results from the processing of a SPOT image couple acquired (15/1/1999 and 24/1/1999) with a 20 meters mesh (Spot Image 2004).

For the sea representation two primary Digital Depth Models have been considered :

. the first one encompasses the whole Lion Gulf area, from Marseilles in the North-East down to the Spanish border. It has a 100 meters mesh and a depth resolution of 1 meter. It results from the digital processing of sounding points from SHOM source (Service Hydrographic et Océanographique de la Marine) for the area between 0 and 150m of depth and of multi beam sonar data for depths greater than 150 meters acquired during IFREMER oceanographic campaigns, (Berné & al 2001, Berné & Satra 2002).

. the second one interests the Thau lagoon and results from the processing (krieging) of sounding points. Its mesh is 10 meters.

Those four models have been first resampled with a 20 meters mesh and a 1 meter resolution in z. They have been merged, according to "Lambert II étendu" projection, in the logic order as follow : first marine DEM, second land DEM, third lagoon DEM using specific masks for sea, land and lagoon.

The resulting model (figure 2) lies from 2902 meter at Mount Carlit in the eastern Pyrenean mountains, down to -2585 meters in the depths of the Lion Gulf (Golfe du Lion).

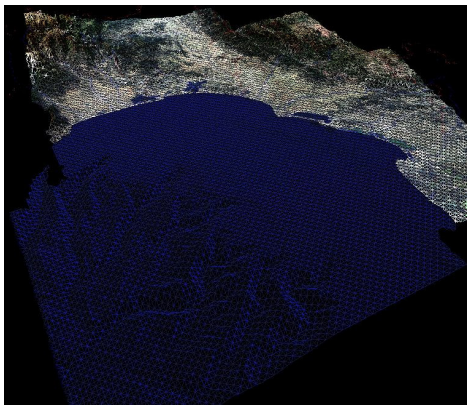

Figure 2 : general Tin DEM of the whole region from sea (foreground) to land (background), view to the NW direction.

4.1.2 Image texture

Textural information has been applied to the DEM as follow :

. the pixels textural information of a Landsat TM image (true colour) has been used for land and for general views of the entire region,

. for land and for zooming views of the Thau area a SPOT 10 meter resolution pseudo-true colour image texture has been applied,

. for sea and lagoon bottoms, the marine texture has been obtained through a hill-shade processing with exaggerating the depths of the lagoon.

Association of the textural information of land (true colour satellite source) and of sea bottom (blue hill-shade) has been performed according to grid transformation, merging processes, and composition in three band image using digital image processing software (figure 3).

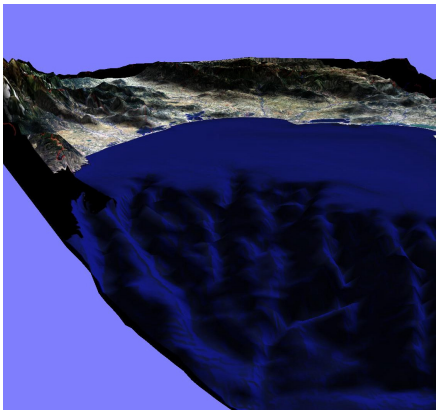

Figure 3 : 3D view of the underwater and land texture applied to the general DEM from deep sea (foreground) to coast and land (background), view to the NW direction, Pyreneans at the left border of the figure.

4.1.3 Geographic data

Considering the technical challenge which consisted in importing and displaying geocoded data throught the Namibie interface a set of geographic information layers has been prepared. This set includes points, lines, polygons and associated tables as follow :

. points : coastal environment quality monitoring network sampling stations (National and regional networks : RNO, REMI, REPHY, RSL), infrastructures (as water-treatment plant, lighthouses and beacons…),

. lines : coastline, hydrographic network, catchment area limits, administrative limits…,

. polygons : municipality areas, aquaculture zones and oyster beds…,

Those geographic information data have been elaborated according to the projection standard adopted for the experiment.

4.1.4 Modelling results

Mars 3D, a three-dimensional numerical model developped by Ifremer to solve primitive equations using finite difference method and dedicated to coastal and shelf sea has been used to provide new sets of data to be transfered to the Namibie tool. Mars model calculates the currents, temperature, salinity and free surface elevation under Boussinesq, hydrostatic and incompressibility approximation. The model is based on the splitting mode technique (Blumberg et Mellor, 1987). The external two-dimensional free surface mode reproduces gravity waves (ADI scheme) and is coupled with the three-dimensional mode that calculates the 3D current and salinity/temperature fields (river plumes, seasonal variation, or passive tracer). Boundary conditions can be directly calculated (tidal forcing) or provided by a larger model (Garnier et Garreau, 2002).

A version of MARS 3D is running on Thau Lagoon. The mesh grid has a resolution 100x100 m in longitudinal and transverse directions. The Thau lagoon model is forced by tidal elevation at the open sea boundary (Sète channels), river discharges and meteorological data (wind stress, atmospheric pressure, heat fluxes, …). The hydrodynamic model can be coupled to biological one to simulate bacterial contamination for example around the shellfish breeding area. A trajectory module is also implemented using the « lagrangian particle tracking » approach. During the prototypes implementation (see paragraph 4.), particles figuring toxic phytoplancton cells have been released from a precise area (assumed as bloom starting area) to follow water masses. The same technique can also be used for estimating « transit time » and « residence time ».

This model has provided current fields and trajectories of particles released from a specific area of the lagoon for a period of one month. The output model data have been transformed from Netcdf format to Esri shape and/or grid formats as input data for the Namibie tool according to a specific method (Loubersac and *al*. 2000, Populus and *al*. 2003).

4.2 Software solutions

Technical solutions have been derived from research in the field of representing 3D information issued from GIS (De Cambray 1994, De La Losa 2000). They also have taken in account surface simplification algorithms methodologies (Garland and Heckbert 1997) and virtual reality.

Other constraints considered in the software solutions are :

. to integrate a pre-processing chain as to easily transform data coming from geographic databases to 3D accessible information,

. to use a display interface with a personalised navigation mode,

. to be compatible with Internet solutions as online consultation of data should be possible through local networks or new generation Internet solutions.

The pre-processing chain is based on the use of free software libraries as VTK (3D and images processing) or GDAL (as to directly import Esri GIS format data : vector/raster geographic objects and attributes).

Other tools (some import/export modules as processing ones) have been developed within the project.

Output products are 3D files (point, lines, polygons), the colour and the legend of which can be easily modified and from which various links can be established with web pages.

The Namibie platform integrates also grid formats adapted to modelling results displays (currents fields, salinity…) as animated objects (particles trajectories).

3D visualisation and interactive 3D navigation is performed through VRML (and future MPEG4) formats. A navigator (Blaxxun Contact 5.1) has been chosen as free software with extensions allowing personalised navigation modes. 3D eye bird views are easily accessible and a 2D map allows the user various position modifications and quick transfers and movements from one site to an other.

Java Scripts have been developed for interfacing the user into the 3D world as for developing specific data menus.

5. EXPERIMENTAL SET-UP AND PROTOTYPES

Two prototypes have been presently developed.

The first prototype (Namibie version 1) has been focused on the access and display of the information acquired by the regional monitori-

network (RSL) dedicated to the evaluation of the quality of regional mediterranean coastal lagoons. It considers the general DEM introduced in part 3.1.1, the Landsat and sea bottom textures introduced in part 3.1.2 and permits the display of geographic objects within two scale levels, the regional one and a more detailed one adapted to the lagoon complexes (figure 4).

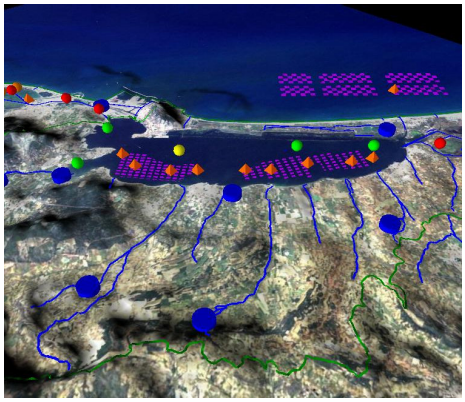

Figure 4 : 3D representation of the Thau lagoon and its catchment area (Landsat TM texture) with 3D display of geographic objects.

The Namibie interface allows also the retrieving of information linked to a specific 3D geographic object : attributes, web page…(figure 5).

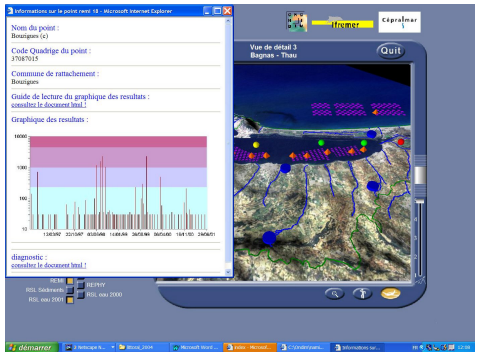

Figure 5 : result of a request on a geographic object : microbiological results at a specific monitoring network point : REMI

The second prototype (Namibie version 2) has been developed in the framework of a project (AGIL) dedicated to the setting up of information tools for ICZM.

It inherits from the previous software developments and integrates two more levels of geographic zooming as to pass from the 30 meters resolution of Landsat TM to the SPOT 10 meters resolution texture (figure 6).

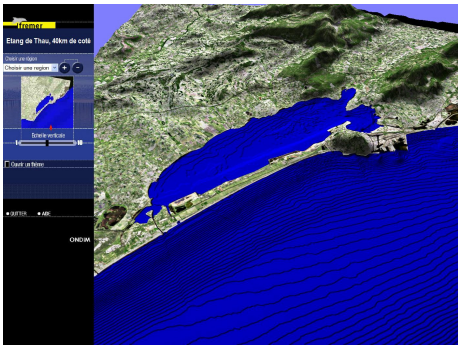

Figure 6 : new interface of Namibie 2 version and high resolution display of the Thau lagoon region : Spot 10 m. resolution texture and lagoon/sea 3D depth model.

The second prototype development has also been focused on the integration and display of modelling results.

Specific work has been dedicated to the access to current fields, trajectories and animated water particles in the Thau lagoon as to the display of the area of influence of a specific discharge or to the behaviour of water masses (figure 7)

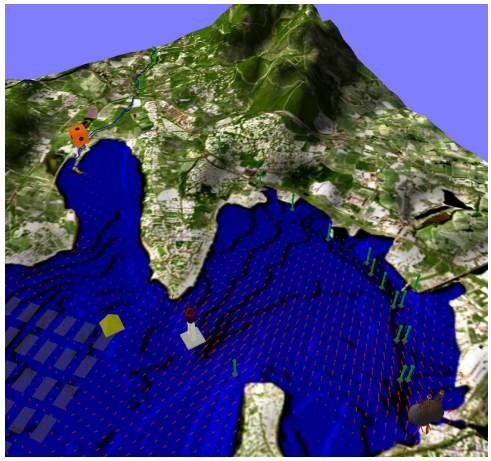

Figure 7 : detail of the north part of Thau lagoon depicting current field (red), various lighthouses and beacons, water treatment plant (dice), Oyster beds (grey rectangles), REMI monitoring network point (yellow).

6. RESULTS, PROSPECTS AND CONCLUSIONS

On the technical point of views the two prototypes have made the demonstration that the main challenges related to 3D inter-activity, import/export of 3D GIS data, retrieving and display of associated multimedia information, integration of mathematical modelling results can be achieved.

Nevertheless two main technical bottlenecks are still to be solved :

. management and display of coherent 3D complex polygons,

. advanced simplifications of 3D surfaces in order to gain in data volume as in loading time through Internet access.

On the practical point of view the two prototypes have been presented to various potential end-users.

The main interests lie in the potential offered by the tool to let decision makers, stakeholders as coastal professionals visualising their own territories of interest in their 3D as in their multidisciplinarity dimensions.

Within the framework of various integrated projects as AGIL and others, typical future developments have been identified :

. integrating very high satellite resolution (on the order of the meter) or digital air photography as to offer more precise spatial representation of coastal phenomenons and questions as urbanism development, coastal infrastructures establishment, tourism impact, coastal erosion…

. diversifying applications related to main coastal management questions by developing an integrated interface derived from hierarchic models of the considered territories (Prelaz Droux 1995),

. enforcing the coupling with modelled data as to enter in the 4D dimension, to offer better understanding of relations between catchment area and marine zones as better representation of high frequency modifications of the marine response under continental waters management, land uses changes or climatic events.

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