SOFTWARE DEVELOPMENT TO EXPLOIT EARTH OBSERVATION DATA FOR HUMAN HEALTH: MONITORING HARMFUL ALGAL BLOOM

DESARROLLO DE SOFTWARE PARA EXPLOTAR LOS DATOS DE OBSERVACIÓN DE LA TIERRA APLICADOS A LA SALUD HUMANA: MONITOREO DE FLORACIONES DE ALGAS NOCIVAS

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ABSTRACT

A software tool aimed to create risk maps has been developed for monitoring intense proliferation of phytoplankton in the ocean through satellite imagery. This phenomenon, known as algal bloom, can cause severe poisoning in humans, and even death, due to ingestion of shellfish and other sea products contaminated with phytoplankton-produced toxins.Usingdata from the instruments MERIS and AATSR on board the European Space Agency ENVISAT satellite, it is possible to develop geo-referenced thematic layers with information closely related to the studied phenomenon such as sea surface temperature (SST), chlorophyll concentration, suspended sediments and other optical properties.This paper describes the design and implementation of a software tool highly friendly and configurable that allows anyone to analyse on line the environmental data obtained by remote sensing. In addition to the possibility of requesting risk maps with configurable thresholds, the users can process these data, according to their interests, through a matrix definition.

RESUMEN

Se desarrolló una herramienta de software con el objetivo de crear mapas de riesgo para el monitoreo de proliferaciones intensas de fitoplancton en el océano, a través de imágenes satelitales. Este fenómeno, conocido como floración de algas, pueden causar intoxicaciones graves en los seres humanos, e incluso la muerte, debido a la ingesta de mariscos y otros productos del mar contaminados por toxinas. Utilizando los datos de los instrumentos AATSR y MERIS a bordo del satélite ENVISAT de la Agencia Espacial Europea, es posible desarrollar capas temáticas geo-referenciadas con información estrechamente relacionada al fenómeno estudiado, tales como la temperatura superficial del mar (SST), la concentración de clorofila, sedimentos en suspensión y otras propiedades ópticas. En este trabajo se describe el diseño e implementación de una herramienta de software amigable y configurable, que permite que cualquiera usuario pueda analizar *on-line* los datos ambientales obtenidos a través de la teledetección. Además de la posibilidad de solicitar mapas de riesgo con umbrales configurables, los usuarios pueden procesar estos datos, según sus intereses, mediante álgebra de bandas.

Key words: algal bloom, SST, phytoplankton, risk maps, satellite image, geo-referenced thematic layers, ENVISAT, risk assessment.

Palabras clave: floraciones de algas, SST, fitoplancton, mapas de riesgo, imagen satelital, capas temáticas geo-referenciadas, ENVISAT, evaluación de riesgos.

INTRODUCTION

The microalgae are unicellular organisms constituting the phytoplankton and are responsible for major primary production in the marine food web (Hallegraeff, 2004). Extreme proliferations of marine microalgae are known as “algal bloom”. The impact of toxic phytoplankton blooms is particularly evident when they affect marine resources such as aquaculture and fishing. Some types of phytoplankton produce toxins which can be accumulated by molluscs and affect marine fauna and humans due to ingestion of shellfish.

Unfortunately, the detection of contaminated seafood is not immediate since shellfish do not show anomaly symptoms when accumulate the toxins in its organs. Neither fishermen nor consumers are able to determine whether the products are fit for consumption. Laboratory analysis is needed to determine the type and the concentration of toxins.

Algal blooms, which may or may not colour the water depending on the predominant species (Lagos, 1998), are a natural phenomenon that occurs frequently. During the last decades, the increased frequency, intensity and geographical distribution has impacted both the human health and economic activities, fishing and tourism (Erdner *et al.*, 2008; Graneli, *et al.*, 1998).

Among current techniques available for the detection and monitoring of "algal blooms", the remote sensors can measure the concentration of chlorophyll, a pigment that can be detected and quantified from space and that is proportional to the algal biomass (Astoreca *et al.*, 2009). Currently, there are several of these satellite instruments able to make the detected signal visible with radiometers, such as MERIS from ESA or MODIS Aqua and Terra from NASA. Unfortunately these instruments are not capable of obtaining information in sub-superficial seawater layers and in case of cloud coverage. In some cases and areas, like for example the coastal regions of Chile (Rodríguez *et al*., 2006), and Scandinavian and Florida coasts, it has been possible the early detection of spots in the sea and a real-time monitoring of the movement of these spots in the marine environment. Moreover, the monitoring of the sea surface temperature, enabling the performance of several oceanographic features (fronts, upwelling areas, eddies), is useful in formulating an early warning on the presence and evolution of the algal bloom facilitating an efficient management of the risk areas where these marine events occur. It is necessary to mention that this technology should be complemented with traditional oceanographic measurements *in situ* such as the determination of the algal species present in the seawater.

To implement the management of risks and emergencies by using early warning systems based on satellite data is one of the main objectives of the Gulich Institute, a research and educational centre managed by CONAE (Argentine National Space Agency) and UNC (University of Cordoba). There is emphasis on research in computer science and its applications, specially related to the operational use of space technology on health. In this context, the objective of this study was to develop a tool facilitating the monitoring, analysis and prediction of the algal bloom development and evolution with the idea of anticipating its appearance to reduce the risk to human health and economic activities associated. This kind of techniques aim to focus economic efforts, as for example water sampling procedures, of operational groups involved in human health risk assessment.

MATERIALS Y METHODS

The developed tool has been adapted to monitor algal bloom in the coastal regions of Argentina (Figure 1), but it should be noted that the program can be applied in other areas if some basic parameters are changed in the command lines. The approach to monitor ocean parameters using remotely sensed data was carried out using ENVISAT images obtained by the radiometers MERIS (Medium Resolution Imaging Spectrometer) and AATSR (Advanced Along-Track Scanning Radiometer). The main bands selected for this study were the following:

a. Algal index (algae I and II) corresponding to the pigment concentration in coastal and offshore waters obtained throughout different algorithms.
b. Suspended matter.
c. Yellow substance.
d. Photosynthetically Active Radiation (PAR).
e. Surface temperature (SST).

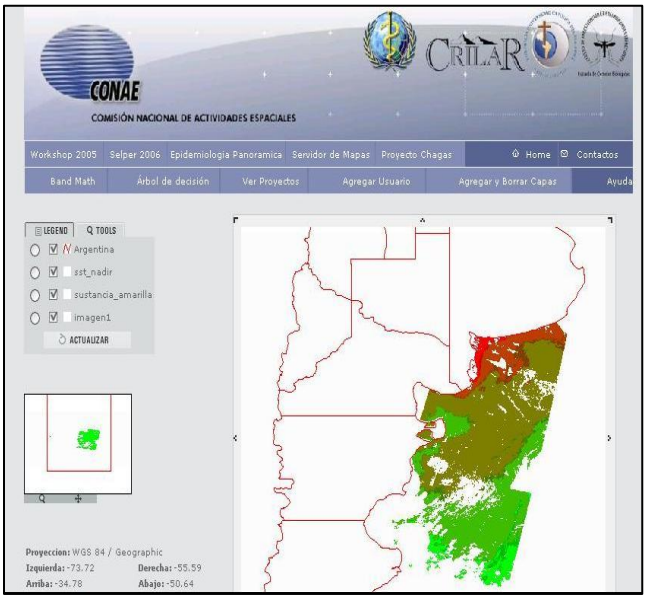

Figure 1. Map server (server raster images and vector images).

Figure 2. Selection of bands where the processing will be carried out.

The ENVISAT data were analyzed using the software BEAM (Basic ENVISAT Toolbox for ATSR and MERIS) developed by ESA to facilitate the visualization and processing of the data downloaded from the ENVISAT instruments, MERIS and AATSR. In this study it has been also developed a Map Server with the aim of providing real time maps through a client web.

RESULTS AND DISCUSSION

The tool works with projects, each project being constituted of a set of layers. The users can produce their own projects and manage all layers, adding or eliminating new layers depending of their needs. The following figures show some print screen of the software describing several steps and options available during the processing.

Figure 2 shows the step in which the band of the ENVISAT product is selected to applied arithmetic procedures. The software enables the users to carry out the mathematics operations needed to applied afterwards thresholds to define parameters and elaborate risk maps (Figures 3 and 4).

A set of functions are provided to the users to navigate through the maps products to get the data of interest from the sites or areas to be monitored (Figure 1).

Figure 3. Band Math.

Figure 4. Decision tree allowing the storage, editing and deletion of equations as well as the recovering of those previously used.

The software allows the user to navigate, measure distances and zooming as is typical of map servers and geographical information systems. It is also possible to get information from a specific pixel with different kinds of information associated in the areas of interest. With the optional tools it is possible to get the scale of the map, to determine the projection of the current view and to select the print options of the products. In this section it is available the export tool which facilitate the user exporting of the products in several formats such as .jpeg, .gif and others.

The maps are served in near-real time and without the need of downloading the original images in the local computer as the whole processing is carried out in the server.

CONCLUSIONS

The implemented technology, capable of obtaining important information in real time, integrates satellite data and allows early detection of changes in the environment that favours the proliferation of algae. It also facilitates the generation of risk maps in order to anticipate the possible coastal phenomena, which could be harmful, with the aim of mitigating its effect in the population. The above mentioned tool is easy to use because it provides a friendly interface for the user and can be accessed via web.

The described tool provides benefits to the citizen through the exploitation of remotely sensed data and computer technology and has also an interesting potential in other activities such as the fishing industry.

The developed system mediates the integration of remotely sensed data and its applications to analyze natural phenomena which impact several economic activities and human health. One of the main goals of the project was to exploit this tool for risk management in case of harmful algal bloom.

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