THE IOSMOS PROJECT: A MULTI-DISCIPLINARY APPROACH FOR IONIAN SEA WATER QUALITY MONITORING

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ABSTRACT

Coastal zones are for their intrinsic properties very dynamic and complex ecosystems which deserve multi-scale and multi-disciplinary monitoring system. South-eastern Basilicata region (Italy) coastal areas, in the gulf of Taranto (Ionian sea) show typical features of costal ecosystems: a wide range of different habits, an increasing level of anthropization, different potential sources of pollution, etc... IOnian Sea water quality MOnitoring by Satellite data (IOSMOS) is a European Transnational Cooperation co-financed by the Operational Program ERDF Basilicata 2007-2013, with the main aim of supporting Basilicata Region in monitoring Ionian sea water quality status by developing and implementing advanced satellite data products. By performing a long term investigation (up to 15 years), based on a general methodology for multi-temporal satellite data analysis, the Robust Satellite techniques (RST) approach, the project aims at providing a description of the sea water status in terms of standard bio-optical parameters, such as Chlorophyll-a (Chl-a) and Coloured Dissolved Organic Matter (CDOM). IOSMOS will study also the suspended sediment material (SSM) phenomena occurring in the area and the Sea Surface Temperature (SST) variations. The main objective is to provide information about the area with the highest level of degradation and the areas at highest potential risk. In addition, by performing specific in situ and airborne measurement calibration campaigns, the opportunity to develop original satellite products will be investigated. In this paper, first activities and preliminary results of IOSMOS project will be presented and discussed.

INTRODUCTION

Estuaries and coastal zones are among the most productive ecosystems in the world, with both high ecological and economic values (1). They provide a wide range of economic benefits to many sectors, including fishing, industrial complexes and amenity services such as tourism and recreation. However, estuaries and coastal zones, being made up of a wide range of different habitats, are very dynamic and complex ecosystems (2). The growing level of anthropization, the irrational exploitation of resources, together with natural hazards and the climate changes are causing a strong modification of the coastal areas, representing a continuous threat to the biodiversity of these zones. As a consequence, safety, health, and economic of the human population living in the coastal zones (3). This is why coastal water bodies are also of interest under the Water Framework Directive 2000/60/EC (WFD) (4). The WFD establishes a framework for the protection of all surface waters (rivers, lakes, transitional and coastal) and groundwater at EU level and aims to achieve a good ecological and chemical status (or a good ecological potential for heavily modified water bodies) by 2015. According to the WFD, the coastal water deterioration should be prevented and the aquatic ecosystem status protected and enhanced.

Remote sensing data can give relevant information in this context, offering the capability to provide the spatial distribution of water constituents over large areas with high temporal rates and at

relatively low costs. In particular, Ocean Color (OC) satellite sensors have already demonstrated to be useful in providing reliable information about a few of the Essential coastal marine ecosystem state and pressure variables (3), such as water leaving radiances, chlorophyll-a (chl-a), total Suspended Sediment Material (SSM), Colored Dissolved Organic Matter (CDOM), and diffuse attenuation coefficient. Satellite measurements have been also used to retrieve information about the space-time variability of other sea surface parameters, such as temperature (SST); height (SSH); salinity (SSS), etc... A study of these parameters and of their evolution in the space-time domain may furnish useful indications on the overall quality of the sea water for a specific area, offering, in addition the baseline necessary for identifying significant changes (possibly induced by anthropogenic pressure) in the coastal environment.

In this context, the main aim of IOSMOS (IOnian Sea water quality MOnitoring by Satellite data) - a Project for European Transnational Cooperation co-financed by the Operational Program ERDF Basilicata 2007-2013 – is the development of advanced and exportable satellite products for measuring the above mentioned bio-optical coastal water parameters as well as for timely identifying short-medium term changes, potentially dangerous for the environment and/or human health. To reach this aims, a long term multi-year (up to 15 years) satellite data analysis has been already performed. Specifically, the Robust Satellite Techniques (RST – (5,6)) approach has been applied on historical series of OC Earth Observing System – Moderate-Resolution Imaging Spectroradiometer (EOS-MODIS) products, in particular chl-a has been already investigated, while CDOM, SSM and SST will be studied in the next future. In addition, the potential of RST in developing original sea water quality products will be also assessed, exploiting several in situ and airborne measurement calibration campaigns carried out during the 24 months (01/06/2012-31/05/2014) of project activities. The main Area of the Interest (AoI) investigated by the project is the Ionian sea water off the coasts of Basilicata region, in the gulf of Taranto (figure 1, red box), but the study will be performed also for the sea water of the western part of the Crete island (Greece - figure 2, blue box).

Figure 1: the Investigated sites.

In this paper, first activities and preliminary results of IOSMOS project will be presented and discussed, starting from the those achieved by the long-term OC products records analyses.

DATA AND METHODOLOGY

The first planned IOSMOS activity concerned the acquisition of historical series of standard OC product for the two AoI. Among the possible sources of such products, MODIS one have been selected, because it ensures both a long term series of data (Terra satellite has been flying since 1999) and is still operational. NASA provide daily global MODIS OC Level 2 products (http://oceancolor.gsfc.nasa.gov/cgi/algorithms.cgi/). These outputs, distributed in Hierarchical

Data Format (HDF) at spatial resolutions up to 1 km, provide information about different parameters: chlorophyll-A (Chl-a) concentration, diffuse attenuation coefficient at 490 nm, CDOM index, ecc... About 22000 OCLevel 2 data covering the two investigated sites have been acquired since 2003 to 2012, then the whole Chl-a dataset has been generated for the two AoI, in particular for Basilicata coast an area of 221 pixels x 171 lines (Corners: UL 40.7N16.4E; LR 39N18.6E) has considered, while the Crete Island one if of 400 pixels x 300 lines (Corners: UL 37N23E; LR 34N27E), both re-projected WGS84. Then, the Robust Satellite Techniques approach has been implemented on these two datasets.

RST is a general change-detection scheme that has been already largely applied with satisfactory results for studying several environmental processes, also involving sea surface (7,8,9). By investigating long-term series of satellite data/products homogeneous in the spatial-temporal domain, RST is able to identify at pixel level the expected behaviour as well as the natural variability of the investigated signal for a specific condition of observation. A multi-year monthly window is used to identify these two reference signals, usually expressed in terms of temporal mean and standard deviations. These values are finally compared with the signal measured for a specific image acquired under similar condition of observation looking for significant statistical signal excess which are flagged as anomalous values. For its construction, RST will allow us for the long term trend analysis investigation useful for the identification of any possible critical situation, as well as for the short-term changes identification.

RESULTS

In the framework of the IOSMOS activities, we firstly investigated the MODIS OC Level 2 Chl-a concentration (10). Following RST prescriptions, for both the AoI we computed the Chl-a monthly average (and the relative standard deviation signal) collecting together all the data acquired for the same calendar month in the whole 2003-2012 period. This means that the February monthly average maps in figure 2 have been generated collecting together all the data acquired in February 2003, February 2004,…, February 2012. These two specific February datasets where composed of 772 imagery for Basilicata area and of 772 for Crete, while about 11000 imagery for each of the AoI where used for the total analysis.

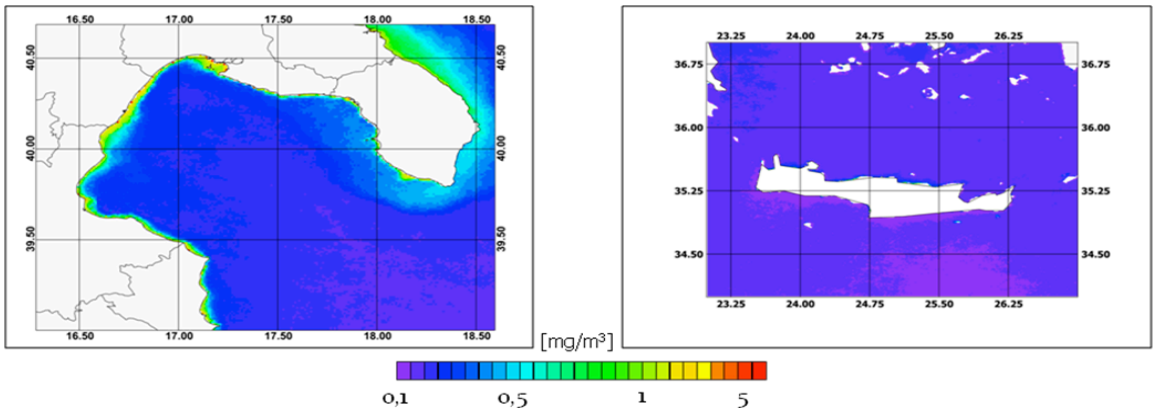

Figure 2: Multi-year (2003-2012) February Chl-a maps for Basilicata and Crete island.

Figure 2 indicates that for February both the areas are characterized by eutrophic conditions, even if the Basilicata area shows a Chl-a concentration fluctuation higher than those observed for Crete island. As told before, the analysis was performed for the whole investigated period. Figure 3 summarize the preliminary results achieved, showing the spatially averaged Chl-a values trend computed for all the calendar months for both the areas. Also the natural variability values is shown in such a graph.

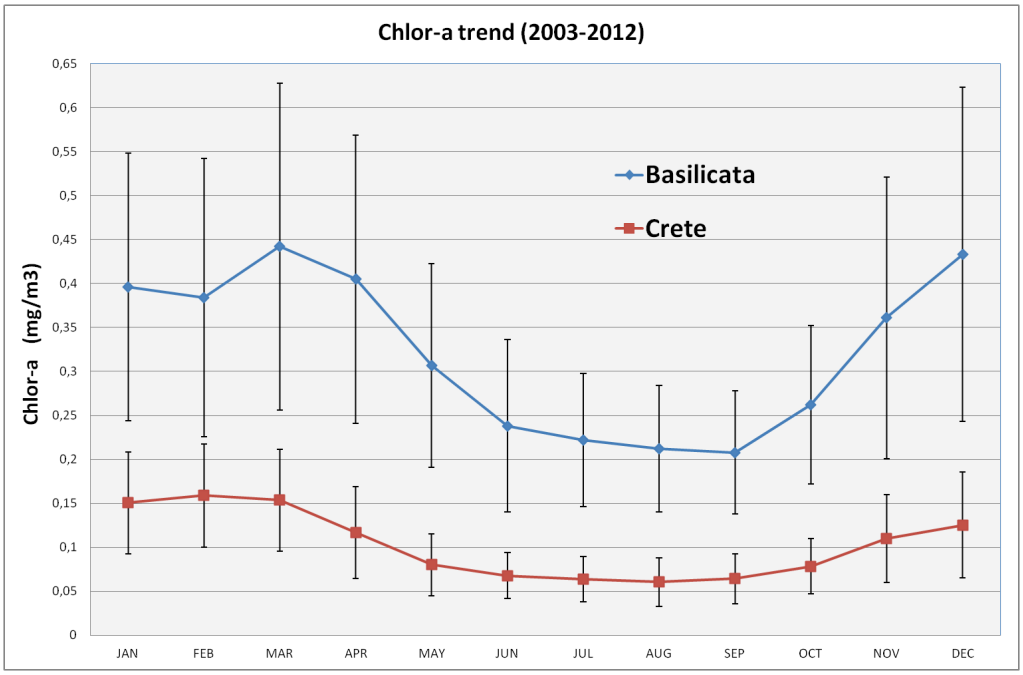

Figure 3: Multi-year (2003-2012) Chl-a trend for Basilicata and Crete island.

The analysis of the graph confirms the previous indications: both the areas are characterized by low Chl-a concentration values, even if they are lower and less variable for the Crete island AoI. In both the areas, a seasonal trend is easily observable, with an increasing of phytoplankton during the winter months, due to an higher nutrient contribution by rivers as well as an higher vertical instability. The higher variability in the signal measured for Basilicata region AoI, might be justified for several reasons: i) the closer shape of Gulf of Taranto; ii) the higher annual rain rate; iii) the larger number of the rivers present in the area.

Anyway, the achievements here shown are only the first preliminary results achieved in the framework of the IOSMOS project. Other parameters are under investigation, yearly and monthly analysis will be performed, and finally, the in-situ calibration campaign are in progress at this time.

CONCLUSION

Coastal ecosystems deserve monitoring system able to guarantee large temporal and spatial scale observation, as well as timely identification of any significant change in the ecosystem state and pressure variable. IOSMOS project aim is the assessment and developing of advanced satellite products concerning Ionian sea water quality status. The first period of activity has been dedicated to the multi-temporal analysis, based on the Robust Satellite Techniques (RST) approach, of standard Ocean Color Modis Level 2 products. Preliminary results achieved, here shown, have demonstrated the potential of such an approach to identify long term trend of the chlorophyll-a concentration in both the investigated regions, confirming their eutrophical conditions. Further analysis are now in progress, which will help in better characterize the sea water status for both the sites.

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