COMBINATION OF CHEMICAL MEASUREMENTS AND REMOTE SENSING IN COASTAL WATER MONITORING. THE CASE OF EASTERN MEDITERRANEAN

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ABSTRACT

The main advantage from the use of Remote Sensing techniques in environmental research is the ability of large-scale monitoring of entire basins. On the other hand they are limited to surface waters and only few pollutants like phytoplankton pigments, suspended particulate matter and oil slicks are well detectable. Eastern Mediterranean sea is oligotrophic with occurring eutrophication phenomena, increased transportation of oil, bad coastal management, river discharges and hot spot areas. The development of Marine Chemistry research and monitoring projects based on both analytical measurements and remote data is a matter of priority for the sustainable management of the area. A marine pollution monitoring project that shall combine the large scale, sea surface results of parameters that can be measured by remote sensing techniques with in situ chemical analytical measurements of marine pollutants in the whole water column, shall be an effective tool for the environmental protection and sustainable management in the ecological sensitive area of the Eastern Mediterranean.

1. DISCUSSION

Coastal zones are important and sensitive ecological systems. They are also significant from an economic point of view as they are used for tourism, fishing, aquaculture and recreation. Unfortunately many times their significance is ignored and they are over exploited or subjected to intense environmental pressures. Large loads of land-based pollutants from industrial, urban and agricultural activities are disposed to coastal areas. Chemical, biological or thermal pollution can cause adverse effects to the marine environment and can even pose dangers for public health. Along with physical and geological alterations the previously mentioned environmental pressures can lead to ecological degradation or even destruction of the coastal habitats which in turns affects plant and animal life as well as the people who dwell there. In order to study the quality of the marine environment numerous in situ monitoring programmes are carrying on especially in hot spot areas. These monitoring programmes are multidisciplinary, and thus biological, chemical, physical and geological oceanographic studies are operating simultaneously on board research vessels manned by a large number of specialized scientists. Thus the main disadvantage of in situ programmes is the extremely high cost.

Remote sensing techniques have been utilized since the early 60's for various environmental applications. They can provide baseline information on coastal and offshore marine areas, measuring physicochemical parameters that have a direct effect on the optical properties of the examined water body. Such parameters are: Ocean Features (Sea Surface Temperature, Sea Level), Phytoplankton pigments, particularly chlorophyll-a, suspended particulate matter as well as marine pollutants mainly hydrocarbons. [1]

Various types of sensors have been used for the marine environment, such as optical, thermal, laser and radar. The main advantages of remote sensing are the possibility of long term, large scale monitoring of even entire basins. But there are also disadvantages, particularly the fact that not all the desired parameters of marine environment monitoring can be measured and the available measurements are limited to surface waters only and are more effective when high concentrations are involved (e.g. very soon after an oil spill has occurred). [2]

The coastal marine environment of the East Mediterranean is affected by economic development, population increase and changing in land use patterns. In situ monitoring programmes in the Eastern part of the Mediterranean are fewer compared to the West and with operational problems (spatial and temporal coverage). Furthermore the existing Remote Sensing results in the area are rather limited and mostly concern physical oceanography. [3], [4]

Another field of remote sensing applications has been primary production-chlorophyll-a and suspended matter monitoring since the eastern Mediterranean is oligotrophic with occurring eutrophication phenomena. There are also river discharges and coastal hot spot areas and influence from the Black Sea outlet through the Dardanelles and from the Western Mediterranean through the Straits of Sicily. This results in a west to east gradient of decreasing surface chlorophyll-a, that is readily seen from space, with the Eastern Mediterranean Levantine waters exhibiting highly oligotrophic conditions. [5], [6], [7]

In the case of marine pollution remote sensing has only been appropriate and applicable for oil spills. The sensors that have been used are video-photography (UV-VIS), optical sensors (UV-VIS-IR), thermal infrared imaging, laser fluorosensors and radar sensors (SAR). The advantage of radar sensors in comparison to optical ones is that they provide data under poor weather conditions and in the dark. Some remote sensing work of oil spill has been carried out in the Eastern Mediterranean due to the fact that there is increased transportation of oil products and accident occurrence. [8], [9]

The output of an improved algorithm used for oil spill detection from SAR images is presented in Figure 2. A significant issue that needs to be addressed in oil spill detection is the distinguishing between actual oil spills and other dark formations due to physical conditions. In this case, the algorithm depicted correctly the low probability of the dark objects to be oil spills. Furthermore, it assigned a high probability of 78% to the verified oil spill shown on the NW part of the image. Some efforts have also been undertaken for remote sensing of biota, such as seagrasses and fish stocks. [10], [11]

The applications mentioned above have not been able to lessen the efforts undertaken by marine scientists during in situ monitoring campaigns, because the measured parameters are only a small fraction of those that have to be studied in the marine environment and because the results of Remote Sensing techniques are less accurate than the results of in situ and laboratory measurements. In addition Remote Sensing techniques are limited to surface waters and have possible atmospheric interference and poor spatial resolution for certain applications.

A marine pollution monitoring project that would combine remote sensing techniques with chemical analytical measurements can be an effective tool for the environmental protection and sustainable management in this ecologically sensitive area.

Acknowledgements

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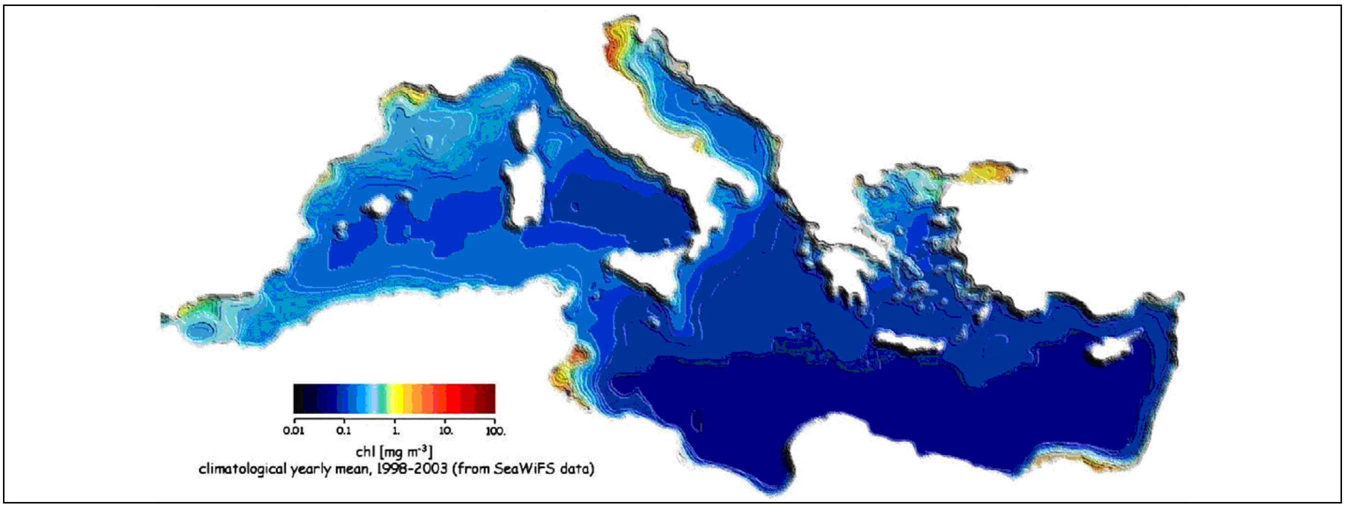

Figure 1: SeaWiFS-derived (1998–2003) climatological chl yearly mean, Mediterranean Sea (Barale 2008)

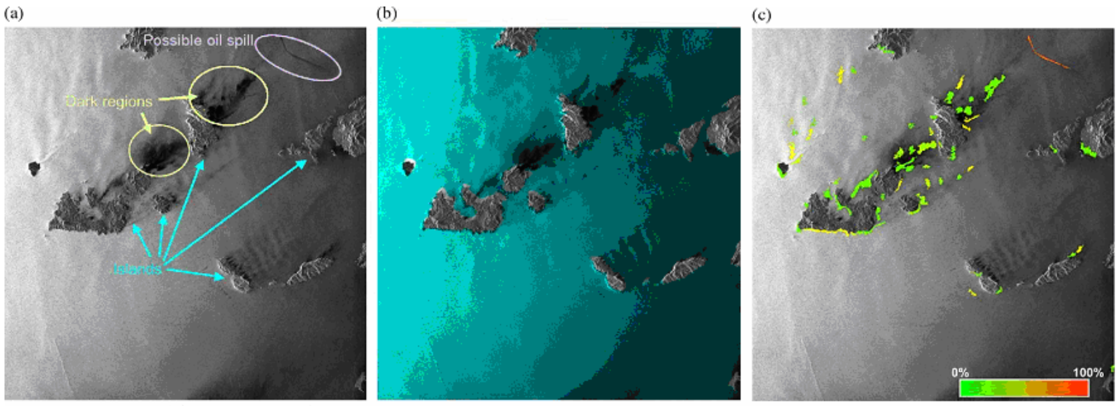

Table 2
Sample tabular output from scene depicted in Fig. 6(a)–(c)

Dark object on image	Number of objects around	Area (km^2)	Eccentricity	Land distance (km)	Longitude (°N)	Latitude (°E)	Probability to be an oil spill (%)
	2	0.811	2.750	0.081	24.88	36.63	23.107
	9	10.073	2.760	10.342	24.81	37.09	22.707
	2	1.169	2.650	0.357	24.96	36.60	23.110
	2	1.224	10.723	12.583	24.89	37.22	78.389
	2	2.679	20.210	14.792	24.97	37.19	76.606
	1	1.081	3.579	0.143	25.03	36.97	23.440
	1	1.169	2.596	0.311	25.15	36.72	23.187
	1	1.336	2.738	1.937	25.17	36.74	49.080
	1	5.199	2.915	1.057	25.13	36.98	22.460
	0	0.835	2.548	0.632	25.34	36.47	23.148

Figure 2: The SAR image over the islands Sifnos, Milos, Serifos and Paros presents a large number of dark regions especially close and between the islands and depicts only one verified oil spill. (a) original scene, (b) land masked image, and (c) output image with dark objects coloured according to their possibility to be oil spills (green is low, red is high), Table2: tabular output.