COMBINING SATELLITE-DERIVED CHLOROPHYLL-A DATA AND HIGH-RESOLUTION DUBAISAT-1 DATA TO DETECT AND MONITOR RED TIDE OUTBREAKS IN THE ARABIAN GULF

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1. INTRODUCTION

Red tide is a common name for a phenomenon known as an algal bloom, an event in which estuarine, marine, or fresh water algae accumulate rapidly in the water column, or "bloom". Red tide outbreaks are the result of an influx of a type of toxic algal bloom turning the water to a reddish color which can devastate marine plant and animal life. Red tide may cause a number of negative effects including the spread of bad smell in the air resulting from the organic decomposition of dead plant algae, death of large quantities of fishes and crustaceans, disturbance of fishing operations and suspending desalination plants operations. Recent red tide outbreaks have caused the closure of a number of beaches and have severely affected the fishery industry in the UAE.

The objective of this project is to develop evaluate the potential of combining chlorophyll measurements derived from MODIS with multispectral data from Dubaisat-1 satellite for real time monitoring of red tide in the Arabian Gulf. In addition to chlorophyll measurements, visible and thermal measurements provided by MODIS sensors on board of Terra and Aqua satellites will be used in this project. Moderate resolution data of MODIS will be complemented with very high resolution data from the newly launched satellite DubaiSat-1 (DS-1).

Satellite measurements have been widely used for monitoring water color and quality in the last three decades. CZCS and SeaWiFS, which were launched in 1978 and 1997 respectively, were the first two earth observation satellites devoted to water quality monitoring and measurement. The long gap between launching the two instruments proofs that the lack of suitable sensors has limited the use of remote sensing in the past [1]. MODIS multi-spectral data has been used to measure different water quality parameters including color, phytoplankton (chlorophyll-*a*), total suspended matter (TSM), colored dissolved organic matter (CDOM), turbidity and temperature.

Figure 1: Red tide approaching Dubai beaches (Source: REUTERS)

2. LITERATURE REVIEW

250-m resolution data of MODIS has been used by Miller and McKee (2004) to detect color changes and to map TSM concentrations in the Northern Gulf of Mexico. The authors have found more than 90% correlation between the first band of MODIS (645 μm) and in situ measurements of TSM [2]. The ability of MODIS optical data in estimating chl-*a* was compared with SeaWiFS data by Dall'Olmo et al. (2005). Both Red and Near-Infrared bands were used in this study. The authors have found that MODIS Red and NIR bands provide the most accurate prediction of chl-*a* compared to SeaWiFS optical bands [3].

MODIS data has also been used in monitoring water quality in the Middle East region (Red Sea and Arabian Gulf). Nasr et al. (2007) estimated chl-*a*, TSM and Sea Surface Temperature (SST) in the Red Sea. OC4 algorithm was used to estimate chl-*a* and other two empirical algorithms were used for estimating TSM and SST. The derived and the measured chl-*a* and SST were very well correlated (RMSE= 0.13 and 0.37) respectively. While the concentration of TSM needed an offset for satisfactory correspondence (RMSE= 4.86) [4]. In another study, Reza (2008) has developed an algorithm for retrieving Suspended Sediment Concentration (SSC) from MODIS spectral radiance over the northern coast of the Arabian Gulf. He developed an algorithm based on the relationship between the measured concentrations and different combinations of MODIS optical channels. The resulting correlation was varying between 0.75 and 0.85. The developed approach has shown more sensitivity to SSC variation and was recommended for turbid estuaries and coastal waters monitoring [5].

3. RESEARCH METHODOLOGY

This research will be centered on an interface between two distinct areas: water quality analysis and satellite data processing. As first step, historical field data have been collected from different local and regional organizations that are active in red tide monitoring. EIAST has recently initiated separate collaboration agreements with these organizations:

- The UAE Federal Marine Resources Research Center (MRRC) in Umm Al Quwain
- The environmental department at Dubai Municipality.
- Regional Organization for the Protection of the Marine Environment (ROPME).

The figure below shows red tide coverage map produced by ROPME in February 2008. Similar data for red tide outbreaks occurred since 2008 have been provided for by the MRRC. A complete statistical and numerical analysis has been performed on this data in order to categorize major red tide outbreaks in terms of location, coverage, duration, and toxicity level.

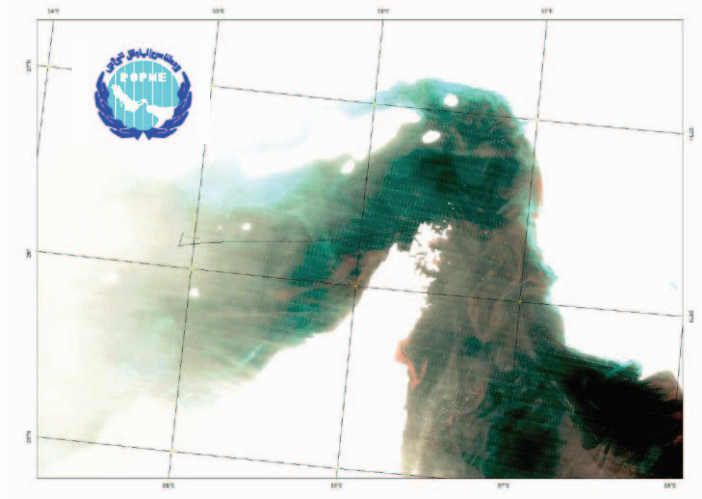

Figure 2: Red tide outbreak in the Gulf and Sea of Oman acquired in February 2008

Satellite images covering the affected areas acquired during red tide outbreaks have been collected and analyzed. New satellite data will be also collected from MODIS and DS-1 to cover new outbreaks of red tides that will occur in 2010. The preliminary analysis of satellite data have focused on corroborating the measured signal from space with the physical characteristics of red tide outbreaks measured in the field.

The detection tool will be based on monitoring water color, water temperature, and water chlorophyll concentration. The produced maps will show the spatial extent of red tide areas and “hopefully” an estimation of

their toxicity level. The UAE tourism industry as well as fishery industry will be main beneficiary of the final product. For this kind of applications, there are some potential difficulties in filtering out the contribution of land pixels to measured reflectances over water. This risk exist for MODIS data due to their low resolution (250 m to 1 km) which creates mixed land and water pixels on the coastal line. This confusion will reduce the accuracy in detecting red tide outbreaks near the shore line. Such confusion can be reduced by adding higher resolution data of DS-1. However, DS-1 data has lower temporal resolution compared to MODIS. By relying the red tide detection and monitoring tool on both MODIS and DS-1 will reduce the time response of the operational tool. To overcome this limitation, two separate approaches will be applied, one for deep water (based on MODIS) and one for near-shore water (based on both DS-1 and MODIS). The deep water approach will be complemented by DS-1 data (when they are available) to have a detailed picture of red tide spatial coverage.

11. REFERENCES

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