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MODIS-Aqua Data based Detection and Classification of Algal Blooms along the Coast of India using RLS Classifier

M Jocelyn Babu[a,*], P Geetha[a], K P Soman[a]

[a] *Centre for Computational Engineering and Networking (CEN), Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, Amrita University, India*

Abstract

In the field of marine biology, researches reveal that there exists a constant increase in Algal bloom (AB) count, along the coast of India. This work aims at detecting and classifying six most frequently appearing algal blooms in this region (viz.:*Trichodesmium erythraeum, Noctiluca scintillans/miliaris, Cocholodinium ploykrikoides, Chattonella marina* and *Karenia mikimotoi* blooms). The uniqueness of ocean's optical properties such as remote sensing reflectance (R_{rs}) and normalized water leaving radiance (nL_w) during bloom period serve as the underlying features on whose grounds classification is performed. These parameters are acquired from Aqua/MODIS sensor measurements and Regularized least squares classifier is used in GURLS library for classification. An overall classification accuracy of 94.37% is obtained using both R_{rs} and nL_w features, which is superior to the previously conducted studies for monitoring ABs using optical properties of water. Given a MODIS image, a map is developed wherein the pixels with ABs are highlighted and the causative species is recognized. A MODIS image is available every two days and hence frequent generation of AB moitoring maps is possible, which is of great significance in the fisheries industry.

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Keywords: Algal bloom; R_{rs}; L_w; MODIS Aqua; RLS classifier; India

1. Introduction

Studies in marine biology indicate a growth in frequency of occurrence of Algal Blooms (AB) along the coast of India[4]. Though not all these blooms are harmful, their decomposition consumes dissolved oxygen in water resulting in a hypoxic condition that poses as a threat to marine life. Hence several studies are focused on detecting and classifying ABs, introducing vast variety of algorithms for the same, especially with the availability of large number of ocean related satellite data. Advances in research based on remote sensing techniques overcome the bottleneck that arises in traditional methods and allows more frequent study across wide geographies.

Over the past decades, a number of remote sensing technique based algorithms have been introduced to detect and monitor ABs. One of the common approaches include detection using optical methods which comprises of

* Corresponding author. Tel.: +91-9790446474.
E-mail address: joce207@gmail.com

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examining water discoloration, concentration of chlorophyll and absorption spectra[12]. In case I water (where optical properties are solely determined by phytoplankton), optical methods such as water discoloration is effective, however in case of turbid water (case II water), discoloration is dependent on the interaction between backscattering of light by phytoplankton and that by sediments. But in the case of cyanobacterial blooms, water discoloration is adequate even in turbid water[10]. A second approach involves monitoring ecological parameters such as sea surface temperature and density[12] associated with ABs. For example, in temperate zones, transient upwelling actions exists which may lead to the development of SST patterns that initiate blooms. Several algorithms based on these techniques are developed for remote identification of blooms. *Shanmugam et al.*[9] proposes an algorithm to accurately compute the chlorophyll a (Chl-a) values based on the ratios of water leaving radiance (L_w) along with ABI (algal bloom index) using three bands in the visible region. Algorithm is generated using data from SeaWiFS sensor and is later fine-tuned to be applied to MODIS data. In another work,[5] reflectance signatures of several blooms were recorded using a hand-held spectrometer. Reflectance values for SeaWiFS and MERIS sensors were simulated using the collected data and the types of blooms were classified based on the SVD algorithm. When compared to the classification accuracies obtained using SeaWiFS and MERIS sensor reflectance values, this technique proved to be superior. *Park et al.*[7] developed a threshold map which is compared to MERIS and MODIS Chl-a data to detect bloom occurrences. Compute RedTide Index that can pin point regions of HAB from SeaWiFS image. The optical properties of water is used by *Amin et al.*[2], a technique for detection of blooms with low backscattering characteristics known as RBD is introduced. A multi-algorithm technique for classification of bloom and no-bloom regions based on an Empirical Approach and a Bio-optical Technique is proposed by *Carvalho et al.*[3]. Uniqueness of the spectral signatures of different blooms are exploited to generate a band ratio algorithm for classification of four species of algae by *Simon et al.*[11].

The spectral reflectance curve for each species of phytoplankton is unique, and with adequate information of the L_w values (and thereby the remote sensing reflectance values) over different wavelengths in the visible and near infra-red region, it is possible to study a pattern in the reflectance curves pertaining to each species. The technique for detection and classification of ABs presented here is based on this observation. Monitoring of blooms is based on data obtained from MODIS/Aqua images in waters of the Arabian sea and Bay of Bengal. Regularized least squares (RLS) algorithm is utilized for classification with the aid of GULRS library.

The remainder of this paper proceedes in the following structure: Section 2 states the importance of the selected study area and explains the technique through which the data set is acquired. The significance of the features upon which classification is based is justified in Section 3. The classifier used and the proposed methodology is also mentioned in this section. The classification results obtained along with the AB monitoring maps is presented in Section 4 and discussed in Section 5. The work is concluded in Section 6.

2. Materials

An explanation for why this study focuses on the bloom occurrences along the coastline of India is given in this section. The basis on which the six specific algae species are considered for classification are mentioned and the source of the data products are stated.

2.1. Region of Study

AB usually tend to occur in regions with high nutrient content like stagnant waters, generally in land-locked seas. But, despite the exposure to winds and currents of the Indian Ocean, AB reports reveal bloom dominance along the coast of India, especially along the south west coast. AB counts reach their peak values during the pre-monsoon and withdrawal of the south−west monsoon periods. Figure 1 shows the AB count in waters around India recorded for over a century, which was documented by *D'Silva et al.*[4]. The two types of phytoplankton that dominate blooms in this water, dinoflagellate and cyanobacteria are considered in this figure. An analysis of the ABs reported in the last five decades reveal that the most commonly occurring species of phytoplankton along the coast of India are *Trichodesmium erythraeum, Noctiluca scintillans/miliaris, Cocholodinium ploykrikoides, Chattonella marina* and *Karenia mikimotoi*[4].