



Detection of harmful algal blooms in the Strait of Hormuz using satellite data

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Harmful algal blooms (HABs) can adversely affect coastal activities, marine aquaculture, and economy of the affected waters. The Strait of Hormuz at the east part of the Persian Gulf is highly prone to the HAB because of receiving considerable nutrients either from its coastal regions or from pollutant currents from Oman Sea. Early detection of HABs is of high importance in this strategic region. This study aims at identifying key variables affecting the formation and expansion of HABs in the Strait of Hormuz and its detection using satellite data. Three main events were studied between September 2008 to December 2014, each lasting for more than a month. MODIS satellite data based models of chlorophyll-a (Chl-a) concentration, sea surface temperature (SST), sea surface salinity (SSS), aerosol optical thickness (AOT), and Photosynthetically Active Radiation (PAR) were used together with in-situ wind data and analyzed before, during and after the formation of HABs. Then, to delineate the HAB areas four algorithms were applied including Red Band Difference (RBD), Chlorophyll Anomaly (CA), Backscattering Detection and Floating Algal Index (FAI). Finally, the Classification and regression tree (CART) model was implemented to detect the red tide formation and its warning state ($\text{chl-a} > 5 \text{ mg/m}^3$).

Correlation analysis between environmental variables and Chl-a concentration showed that there is a meaningful positive and negative correlation between Chl-a and SSS & SST, respectively. However, temporal analysis of the maps indicates that the formation and development of the bloom occur within the specific ranges of temperature (19-26 C) and salinity (36-39 psu), which are well consistent with the results of experimentally determined thresholds for the peak density population of dominant cyanobacteria. Furthermore, with regard to identifying the HAB events, the RBD algorithm outperformed (having a Probability of Detection=0.67 and False Alarm Ratio=0) other techniques when compared to the in situ data. Results revealed that the CART model can successfully recognize the red tide affected areas (overall prediction accuracy of 92%) and perfectly indicate the Chl-a hotspots (warning condition), respectively. Findings of this study can provide promising results to develop a satellite-based early alarm system for this region, which can prohibit the expansion of the harmful algal bloom and its negative and costly consequences.

Keywords: Harmful algal blooms, MODIS data, the CART model, Environmental variables, Ocean color