Improved MODIS Chlorophyll for Satellite Detection of Red Tides in Ariake Bay, Japan

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Ariake Bay, a semi-enclosed sea in Japan, has severely sufferred from red tides. Especially, great economic loss of Nori (Porphyra) culture, covering nearly half of the Japanese production, has been caused by the red tides. Ocean color satellite chlorophyll (Chl-a) is expected to use as an important variable for identifying red tide areas and the movements. However, the validation of MODIS Chl-a revealed that the error was large, and the two possible factors of the causes were atmospheric correction and in-water algorithm.

The accuracy of MODIS remote sensing reflectance (Rrs) was firt examined by comparing with in situ Rrs; negative Rrs was observed at blue bands indicating the problem of the atmospheric correction. To improve MODIS Rrs, the Rrs correction method by Hayashi et al. (2015) was modified and adopted. Our results showed that MODIS Rrs was much improved after Rrs correction. As a consequence, the OC3M Rrs band ratio was also significantly improved after Rrs correction as manifested by the decreasing RMSE from 55% to 38%.

Furthermore, MODIS standard in-water Chl-a algorithm, OC3M, was evaluated using in situ Rrs data. Much underestimation was observed for the estimated Chl-a. Light absorption characteristics of water constitutes were analyzed to understand the variability of OC3M Rrs ratio against Chl-a. Based on the ratio of light absorption of phytoplanktion, non-phytoplankton particle, and colored dissolved organic matter at 443 nm, water types were discriminated. Relation between Rrs ratio and Chl-a was similar to OC3M for phytoplankton and CDOM dominated waters except that some data from phytoplankton dominated waters were a little far from OC3M; however, the water dominated by non-phytoplankton particles showed small change of the Rrs ratio by the change of Chl-a. The data were separated into the two groups by an index of turbidity using Rrs at 667 nm, and non-turbid and turbid empirical algorithms were developed with 4th order and sigmoid functions, respectively, for the switching algorithm. The switching algorithm and OC3M were compared through estimated Chl-a and our results showed that the switching algorithm was much better than OC3M since the RMSE of estimated Chl-a decreased from 0.41 to 0.29.

The switching algorithm was applied to the corrected MODIS Rrs, and the RMSE of Chl-a decreased from 0.61 to 0.28. Moreover, the combined Rrs correction and switching algorithm were validated by data of the Fisheries Research Institutes and the corrected Chl-a were also much improved ini terms of RMSE from 0.41 to 0.33.

Keywords: Ariake Bay, MODIS Chl-a, light absorption, switching in-water algorithm, atmospheric correction

