Optical characterisation and classification of water types in the southern South China Sea and Straits of Malacca

ABSTRACT

We describe the characteristics of surface water spectral reflectance variability and identify reflectance-based optical water types that are present in the southern South China Sea (SSCS) and the Straits of Malacca (SoM). Simultaneous measurements of in-water hyperspectral remote sensing reflectance (Rrs), particulate backscattering coefficient (bbp) and in-water constituents were conducted at 473 stations from May 2009 to March 2019 during different monsoon seasons at both coastal and oceanic waters. Empirical orthogonal function (EOF) and hierarchical cluster analysis (HCA) were performed to determine the spectral variability of Rrs and group the homogenous optical water type regimes. The results indicate that monsoons and regional hydrodynamic conditions have great influence on the optical properties. The SSCS exhibited strong seasonal patterns with maximum values of all the bio-optical parameters during the northeast monsoon and minimum values during the spring inter-monsoon. In contrast, the SoM waters are subjected to strong influence of freshwater discharges, thus resulting in optically complex water regimes. The EOF analyses clearly revealed two dominant modes of optical variability, with each mode corresponding to the optical conditions of SSCS and SoM, respectively. The correlation between EOF amplitude factors and optical parameters indicated that the Rrs variability in SoM was primarily driven by the particulate backscattering and secondarily by light-absorbing components, while it was only minimally influenced by the absorption coefficients in SSCS. Hierarchical clustering revealed the presence of five distinct optical water types, which varied considerably according to the concentration of biogeochemical and optical properties. Classes 1 and 2, which were only found in SSCS waters, were defined by high magnitudes within the blue spectral region with very low concentrations of in-water constituents, indicating clear waters. Class 3 represents the optically transitional waters between coastal and open oceans, characterizing by a well-defined Rrs peak at the blue-end of the spectrum with no single dominant constituent. Classes 4 and 5 are most representative of waters influenced by riverine plumes, particularly in the SoM, with the highest Rrs magnitudes in the green and a well-defined absorption peak in the blue spectral region. Our findings confirmed that the performance of global Chl-a algorithms varied with the optical conditions present in the study area with the retrieval uncertainties increasing substantially from Class 1 to Class 5 water types. This finding will contribute significantly to the development of regional class-specific bio-optical models.