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Short Communication

COMPARING THE REMOTELY SENSED CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) PRODUCT WITH IN-SITU CDOM IN THE NORTHERN BAY OF BENGAL

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ABSTRACT

Assessment of the role of estuarine-carbon fluxes is essential to improve the estimates of global carbon budget. Dissolved organic matter (DOM) plays an important role in aquatic carbon cycling. Chromophoric fraction of DOM (CDOM) is considered to be the major component of the dissolved natural organic matter (DNOM) in natural waters. CDOM also has many important effects on aquatic ecology and chemistry. Understanding the distribution and dynamics of CDOM thus is broadly important to monitoring, assessment and management of surface waters, and remote sensing is especially attractive for monitoring purposes because of its ability to make measurements at regional and even larger scales. The CDOM can be readily detected via in situ and remotely-sensed optical measurements. DOM properties, including CDOM absorption coefficient at 443 nm (aCDOM(443)) was examined in northern Bay of Bengal (nBoB), using in situ and satellite observations during February, 2015 - January, 2016. The aim of this study was to examine the relationship between in-situ measured CDOM and remotely sensed CDOM product in the nBoB. This is the first attempt to compare the remotely sensed CDOM product with in-situ CDOM in the northern Bay of Bengal. Present study revealed that remotely sensed CDOM product could be use after 50 km away from the shoreline in the nBoB.

Keywords: Remotely sensed CDOM product, in-situ CDOM, northern Bay of Bengal

1. INTRODUCTION

Coastal oceans represent transitional zones between terrestrial and marine environments [1]. Dissolved organic matter (DOM) derived from the terrestrial environment is an important source of dissolved organic carbon (DOC) to coastal oceans. DOM modified by biotic and abiotic processes during transport from terrestrial part to coastal waters [2]. In situ observations have been widely used, but they provide limited spatial and temporal coverage. Satellite remote sensing with its synoptic and repeated coverage over large regions has the potential to greatly enhance our ability to monitor the processes controlling aquatic DOC cycling of coastal and estuarine environments [3].

Chromophoric dissolved organic matter (CDOM) is an optically-active fraction of the DOM pool that is characterized by increasing light absorption towards the UV–visible wavelengths [4, 5]. The optical characteristics of CDOM (e.g., absorption coefficients and spectral slopes) are well-known proxies for variations in DOM molecular weight corresponding to DOM sources and photochemical history [6, 7]. Several studies have demonstrated the possible use of CDOM absorption coefficients to assess DOC concentration using a conservative CDOM-DOC relationship in a variety of coastal waters [8-12]. Numerous studies have proposed the use of ocean color sensors to assess CDOM in estuarine and coastal waters [13-15]. This has allowed us to link between satellite- estimated CDOM and in situ CDOM relationships, which can be used to elucidate DOC distributions and estuarine-scale processes in the context of global carbon reserves with high spatiotemporal resolution [15-19]. Furthermore, combining satellite remote sensing data with numerical hydrodynamic model results can be used to gain better insights on the linkages between physical processes and the distribution and transport of water constituents of interest in the coastal environments [20, 21].

The main aim of this study was to evaluate the applicability of remotely sensed CDOM product (MODIS) for monitoring CDOM and DOC concentrations in northern Bay of Bengal (nBoB), obtaining synoptic views of their distributions, potential sources, and transport mechanisms to shelf waters. For this purpose, CDOM absorption coefficient at 443 nm ($a_{CDOM}(443)$) was examined in nBoB, using in situ and satellite observations during February, 2015 - January,

2016. Whether the relationship between in-situ CDOM absorption coefficient at 443 nm ($a_{CDOM}(443)$) and MODIS CDOM product is statistically significant or not. If the relationship shows statistically significant relationship, MODIS CDOM product could be used for broader prospect.

2. MATERIALS AND METHODS

2.1. Study Area

This study region is located in the shallow continental shelf (<15 m bathymetry) off the coastline of the state of West Bengal, India. This area receives a substantial amount of freshwater dis-charge as well as suspended matter from the perennial River Hugli [22, 23]. Therefore, a substantial amount of terrestrial organic matter mixes in the present study region throughout the year. Previous studies also indicated that the region experiences a significant prevalence of organic matter [23, 24]. This region is characterized by semidiurnal tide of meso-macrotidal nature (2.5-7 m) [25]. Moreover, CDOM in this region was mainly found to be of allochthonous character and principally of river-borne source [26-28].

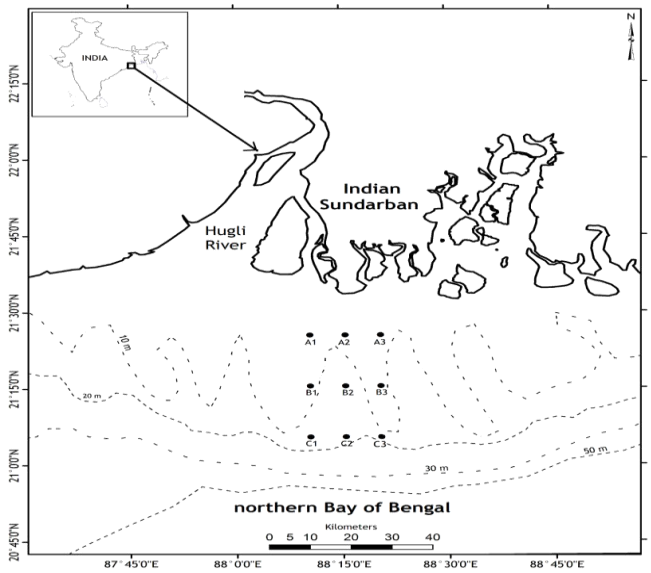

Fig. 1: Map of the study area showing the sampling stations.

2.2. Sampling Plan

The present survey was conducted at nine stations (Fig. 1) throughout one annual cycle (February 2015-January 2016). All the cruises were undertaken from Frasargunje Fishing Harbour (Lat. 21°34'45"N; Long. 88°15'05"E). During the study, a total of twelve sampling surveys were carried out. One survey was conducted in the first week of each month during day time only and one sample (mean of triplicate samples were considered for each parameter) was taken from each sampling point during all the surveys. CDOM was sampled according to Sasaki et al. [29].

2.3. Analytical Protocol

2.3.1. In-situ CDOM measurement

For CDOM absorption, the seawater samples were stored in amber colored glass bottles for four hours to equilibrate to room temperature. The samples were filtered through 47 mm Whatman GF/F filter to remove the coarse particles. The filtered seawater samples were again filtered through 47 mm Nuclepore membrane filter (pore size: 0.2 mm) to remove the fine particles. The absorption of CDOM was scanned in the range from 300 to 750 nm using 10 cm path-length cuvette with UV-VIS spectrophotometer (Shimadzu UV-Visible 1600 double-beam). Milli-Q water was used as a reference. The measured absorbance data were normalized to zero at 600 nm due to temperature-dependent artefacts [30] observed between 650 nm and 750 nm. A blank (Milli-Q water versus Milli-Q water) was subtracted from each wavelength of the spectrum. The CDOM absorbance was then multiplied by 2.303 to convert from $\log_{10}$ to $\log_e$ and by 10 to convert to a 1 m pathlength (Sasaki et al., 2005). The CDOM absorption coefficients were obtained by the following equation: $a(\lambda) = 2.303 \times (D(\lambda) / L)$, where λ is the wavelength and L is the cuvette length in metres. $a(\lambda)$ is the absorption coefficient at wavelength l, and $D(\lambda)$ is the absorbance at wavelength λ [29].

2.3.2. Remotely Sensed CDOM Data

Monthly composite of standard level-3 data of spatial resolution 9 km using MODIS (EOS-Aqua daytime) satellite of a_g (443) or a_{CDOM} (443), were downloaded from the website http://oceancolor.gsfc.nasa.gov/cgi/l3 from February 2015 to January 2016. A total of 12 months composite data were downloaded and analyzed in the present study using the software QGIS (version 2.14).

2.3.3. Statistical Analysis

The Pearson correlation coefficient (r) was computed and regression models were tested between in-situ $a_{CDOM}(443)$ and remotely sensed $a_{CDOM}(443)$.

3. RESULTS AND DISCUSSION

Available monthly average of $a_{CDOM}(443)$ (MODIS) and in-situ $a_{CDOM}(443)$ of the offshore stations (C1, C2 and C3) are documented in Table 1. Remote Sensing CDOM

data (monthly composite) were not available for the inshore stations (Fig.1, A1, A2, A3, B1, B2 and B3) in this study region during the present study period. We examined the regression equation established between in-situ $a_{CDOM}(443)$ with $a_{CDOM}(443)$ (MODIS) (Fig 2a, 2b and 2c) at off-shore sampling stations (C1, C2 & C3). The relationship is statistically significant ($p < 0.01$).

Table 1: MODIS monthly (9 km) (a_{CDOM} (443) m^{-1}) and in-situ CDOM data of the following sampling points (C1, C2 and C3) of the study region during study period.

	a_{CDOM} (443) m^{-1} (MODIS)			a_{CDOM} (443) m^{-1} (in-situ)		
	C1	C2	C3	C1	C2	C3
Feb, 2015	0.1908	0.2187	0.1954	0.2222	0.2211	0.2205
Mar, 2015	0.1518	0.1563	0.148	0.1075	0.1059	0.1075
April, 2015	0.1082	NA	NA	0.1055	0.1033	0.1069
May, 2015	NA	NA	NA	0.1011	0.1012	0.1011
June, 2015	NA	0.0934	0.0934	0.1591	0.1064	0.1084
July, 2015	NA	NA	NA	0.1711	0.1714	0.1704
Aug, 2015	NA	NA	NA	0.2178	0.2195	0.2178
Sep, 2015	0.2432	NA	NA	0.2522	0.2562	0.2522
Oct, 2015	0.1855	NA	0.2211	0.1232	0.1294	0.2069
Nov, 2015	0.1631	0.2215	0.1637	0.1051	0.2058	0.1085
Dec, 2015	0.1233	NA	NA	0.1031	0.1019	0.1022
Jan, 2016	0.1862	NA	0.1822	0.2016	0.2011	0.2101

NA=Not Available

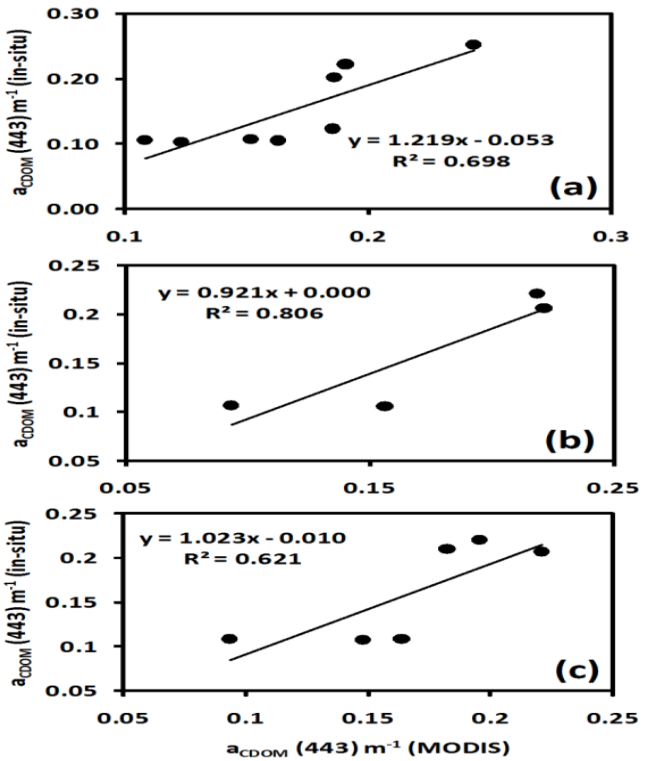

Fig. 2: Relationship between in-situ CDOM and remote sensing CDOM (MODIS) product at sampling point C1 (a), C2 (b) and C3 (c) respectively.

Present study wanted to inspect the relation and compare the in-situ CDOM data obtained from this study and the remotely sensed CDOM data. An R^2 value of 0.698, 0.806 and 0.621 ($p<0.001$) were found to exist between the remotely sensed data and the in-situ data in station C1, C2 and C3 respectively (Fig. 2), which implies that the remotely sensed data was fairly in parity with the in-situ observed data for the offshore area. These offshore stations are ~55 km away from the shoreline. From the present annual survey, we can conclude that remotely sensed CDOM data could be used after 50 km away from the shoreline in the present study zone. Moreover, this is the first approach to compare the remotely sensed CDOM product with in-situ CDOM in the nBoB. Present study can be helpful to developed regional carbon budget by means of remote sensing in near future in the northern Bay of Bengal. However, we are unsure whether such a strong relationship would also hold true for the rest of the part of nBoB or not.

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