An analysis of MODIS algorithms for colored dissolved organic matter and dissolved organic carbon in northwest Florida estuaries

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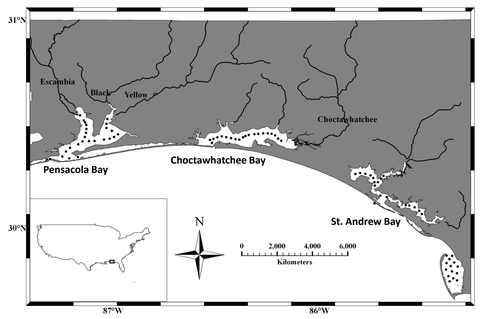
Introduction

- Satellite remote sensing may provide the synoptic and frequent monitoring of water quality parameters in estuaries to assist in the development of effective management strategies.
- Water clarity in NW Florida estuaries is influenced by colored dissolved organic matter (CDOM), chlorophyll-*a*, suspended solids, and bottom reflectance.
- Traditional Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite water quality algorithms were developed for the open ocean and do not transfer to these optically-complex estuarine waters.
- CDOM absorption was derived from a MODIS band-ratio algorithm in NW Florida estuaries.
- Satellite-derived CDOM absorption was used as a proxy to estimate DOC - a parameter that cannot be directly measured by satellite - thus enabling remote estimation of the standing stock of DOC and the carbon cycle in NW Florida estuaries[1].

Objectives: i) Validate the CDOM algorithm using an independent data set and ii) test an approach to estimate concentrations of DOC from MODIS-derived CDOM measurements.

Methods

- Discrete surface water samples were collected over a 20-month period, from September 2009 to May 2012.



- Surface water samples were filtered through combusted 47mm GF/F filters. CDOM absorption was measured in a dual-beam spectrophotometer from 200-700nm. Absorption at 412nm was used for algorithm development. DOC concentration was measured using a Shimadzu TOC-$_{VC}$SN Analyzer.
- Measures of *in situ* remote sensing reflectance (R_{rs}) were collected with a Hyperspectral Surface Acquisition System (HyperSAS).
- MODIS data were obtained from the NASA ocean color website. The MODIS R_{rs} band ratio 667nm/488nm was used in the CDOM algorithm (Fig. 2).
- Linear regressions were performed between *in situ* variables (i.e. HyperSAS R_{rs} vs. $CDOM_{ag(412)}$ and $CDOM_{ag(412)}$ vs. DOC) in order to obtain the slope (m) and y-intercept (b) coefficients for use in the CDOM and DOC algorithms, correspondingly (Fig. 2 and 4).
- Data collected from January 2003 to June 2011 by the Florida Department of Environmental Protection (FL DEP) were used as an independent data set for validation of the CDOM algorithm.

Fig. 1) *in situ* R_{rs} vs. *in situ* CDOM

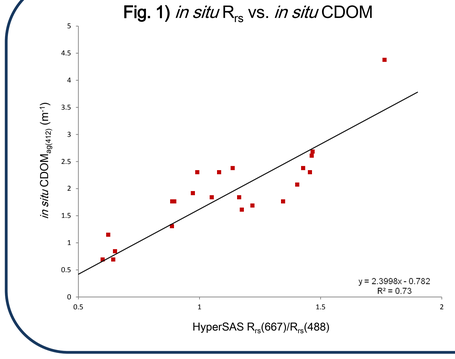
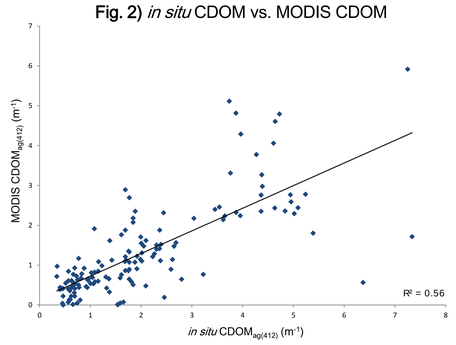


Fig. 2) *in situ* CDOM vs. MODIS CDOM



- The *in situ* R_{rs} values were significantly correlated to *in situ* CDOM, signifying the regression coefficients (m and b) could reliably be used in the CDOM algorithm (Fig. 1).
- CDOM absorption in NW Florida estuaries was successfully derived from MODIS R_{rs} using the CDOM algorithm, as shown by the significant regression in Figure 2 (t-test assuming unequal variances, p-value<0.0001).

Fig. 3) *in situ* CDOM vs. *in situ* DOC, all seasons

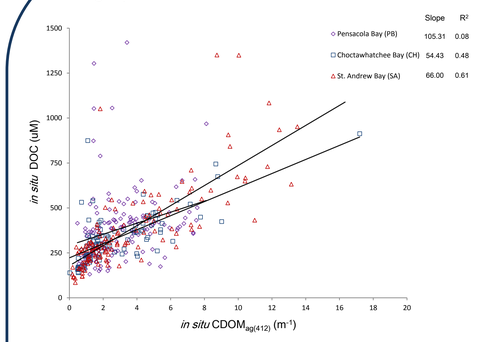


Fig. 4) SA *in situ* DOC vs. MODIS DOC

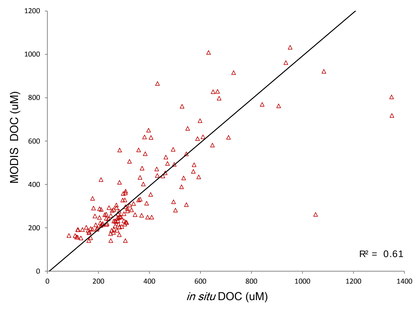
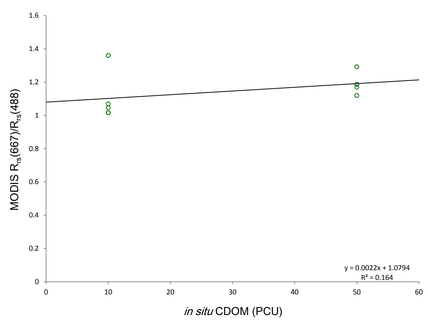


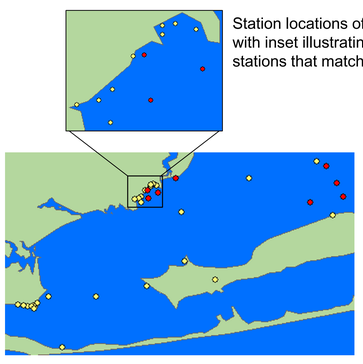
Table 1. Slope (m) and R^2 values resulting from seasonal regression analysis between *in situ* DOC and MODIS-estimated DOC, for each bay.

	Winter (Dec-Feb)	Spring (Mar-May)	Summer (Jun-Aug)	Fall (Sep-Nov)
Choctawhatchee Bay (CH)	m=0.86 R^2=0.78	m=0.77 R^2=0.55	**m=0.49 R^2=0.33**	m=0.79 R^2=0.62
Pensacola Bay (PB)	m=0.85 R^2=0.72	**m=-0.51 R^2=0.24**	m=0.48 R^2=0.47	**m=0.55 R^2=0.30**
St. Andrew Bay (SA)	m=0.87 R^2=0.90	m=0.89 R^2=0.76	m=0.75 R^2=0.64	m=0.85 R^2=0.73

- As indicated by the varied slopes and R^2 values for all seasons combined, all bays required individual DOC algorithm(s), potentially based on season (Fig. 3).
- Seasonal algorithms were used to derive DOC from MODIS for each bay. Although the R^2 values were low for CH in Summer and PB in Fall, the regression was significant. The Spring DOC data for PB only contained 10 samples, resulting in an inadequate range of DOC concentrations, thus causing the negative slope for that season (Table 1).
- SA has reduced river dominance compared to PB and CH, which was reflected by similar slopes across the seasonal DOC regressions (Table 1). Due to this similarity, one DOC algorithm was sufficient for estimating DOC from MODIS for SA (Fig. 4).

Fig. 5) FL DEP *in situ* CDOM vs. MODIS R_{rs}





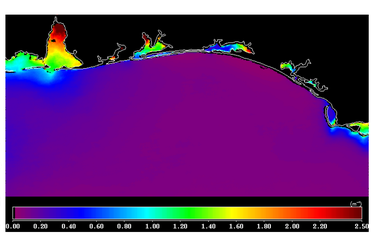
Station locations of FL DEP Pensacola Bay (PB) survey, with inset illustrating proximity to shore. Red points indicate stations that matched up with MODIS measurements.

- The MODIS match-up with PB Survey CDOM data for further validation of the CDOM algorithm was inconclusive due to an insufficient amount of corresponding MODIS data (Fig. 5). Most stations were too close to shore for the satellite to obtain measurements. Straylight contamination and bottom reflectance caused error masking during match-ups.

Summary

- The CDOM algorithm successfully derived CDOM from MODIS R_{rs} in northwest Florida estuaries.
- Seasonal algorithms successfully estimated DOC from satellite-derived CDOM measures.
- Preliminary validation of the CDOM algorithm using an independent data set was inconclusive. Further validation is needed.

The Aqua platform of the MODIS satellite used to measure R_{rs} and ocean color.



Example of a MODIS ocean color image, showing the 2011 annual CDOM absorption in northwest Florida estuaries .

Acknowledgements

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- [1]Tehrani, N.C., E.J. D'Sa, C. Osburn, T.S. Bianchi, and B.A. Schaeffer. Chromophoric dissolved organic matter and dissolved organic carbon from SeaWiFS, MODIS and MERIS sensors: case study for the northern Gulf of Mexico. *In Progress.*