Optical Models for Estimating Colored Dissolved Organic Matter Absorption in Poyang Lake

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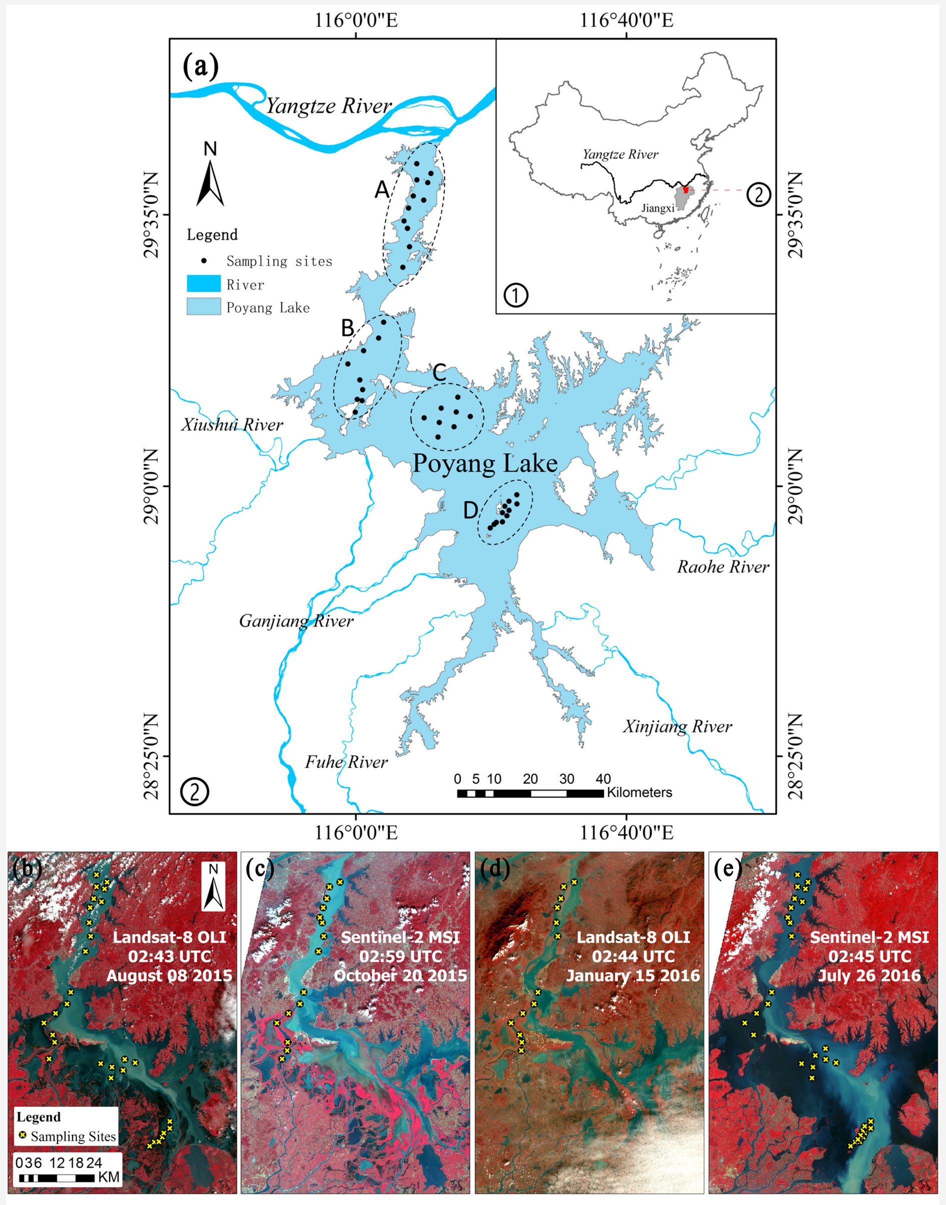
Introduction

Colored dissolved organic matter (CDOM), the key component in aquatic environment, plays an important role in biogeochemical processing. The optical characteristics of CDOM potentially permit remote sensing of CDOM. However, retrieval of CDOM for inland turbid water is challenging because of CDOM absorption at blue spectral range overlapped by the absorption caused by chlorophyll a and amounts of total suspended matter contained in turbid water. CDOM inversion algorithms developed and applied to specific regional locations may not be directly applicable for other water environment. Moreover, various CDOM sources present distinct CDOM absorption characteristics spatially and spectrally. In this study, in situ reflectance and water samples were used to develop models for estimating CDOM absorption in a complex freshwater environment in Poyang Lake, China.

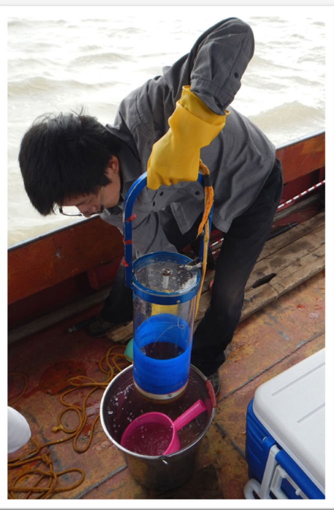
Objectives

The objectives of this study are to: (1) characterize and analyse CDOM absorption and water reflectance spectra of Poyang Lake to obtain sensitive spectral band ratios potentially applicable for remote sensing implementation; (2) establish and evaluate different algorithms based on simulated Sentinel-2 and Landsat-8 spectral bands for estimating the lake's CDOM; and (3) examine their potential capability for retrieving CDOM in floodpath lakes and wetlands.



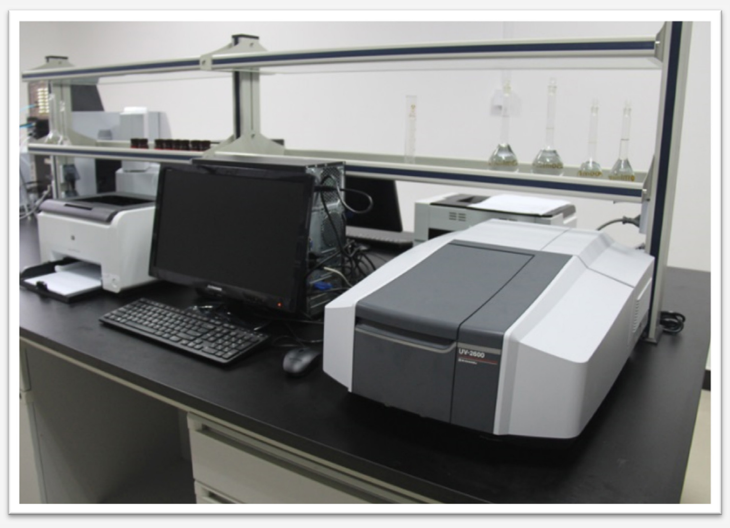
(a) Study areas and sampling sites in Poyang Lake; (b-e) Pseudo color displays of Landsat-8 OLI and Sentinel-2 MSI images that illustrate the landscape of the study area approximately to the time of field samplings.

Materials and Methods

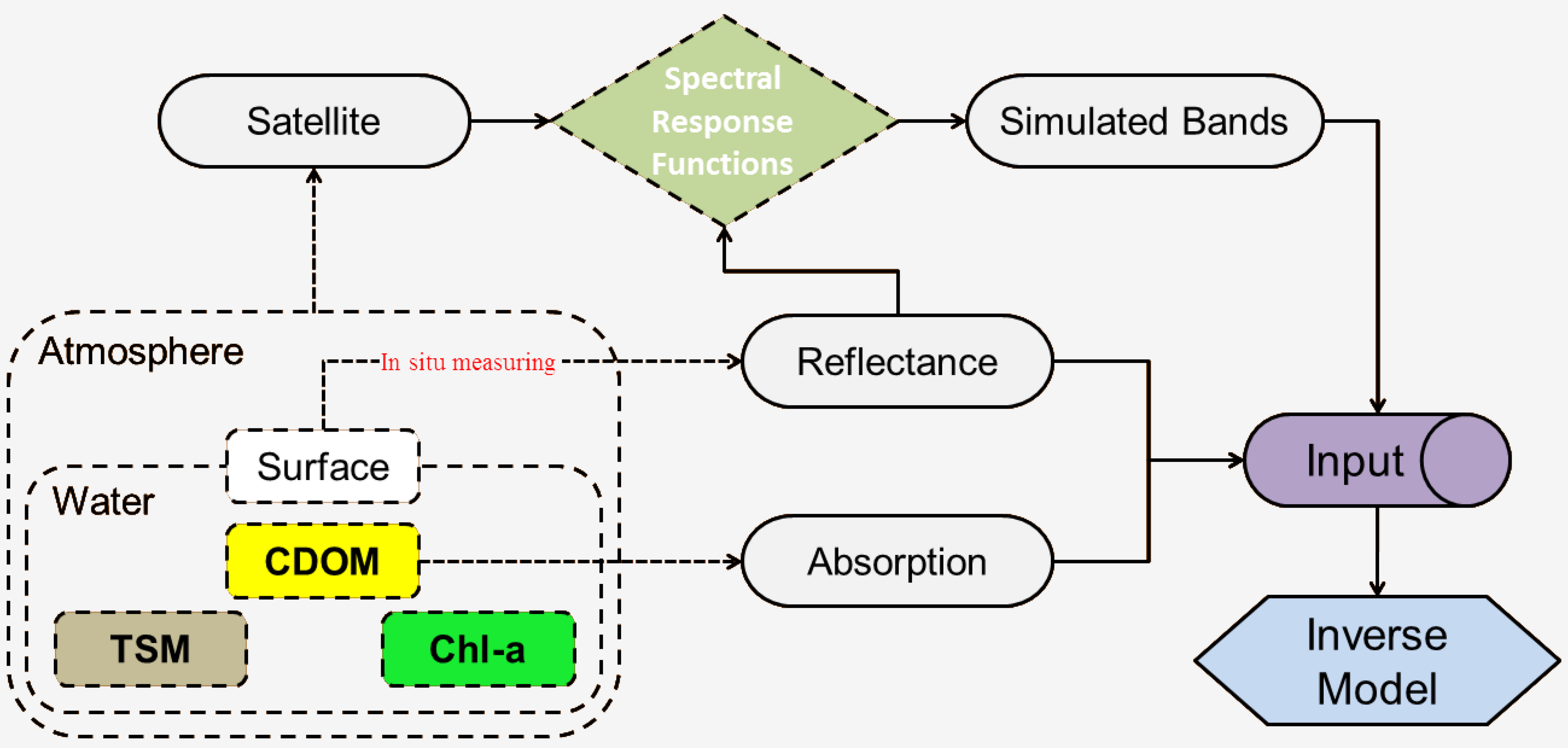


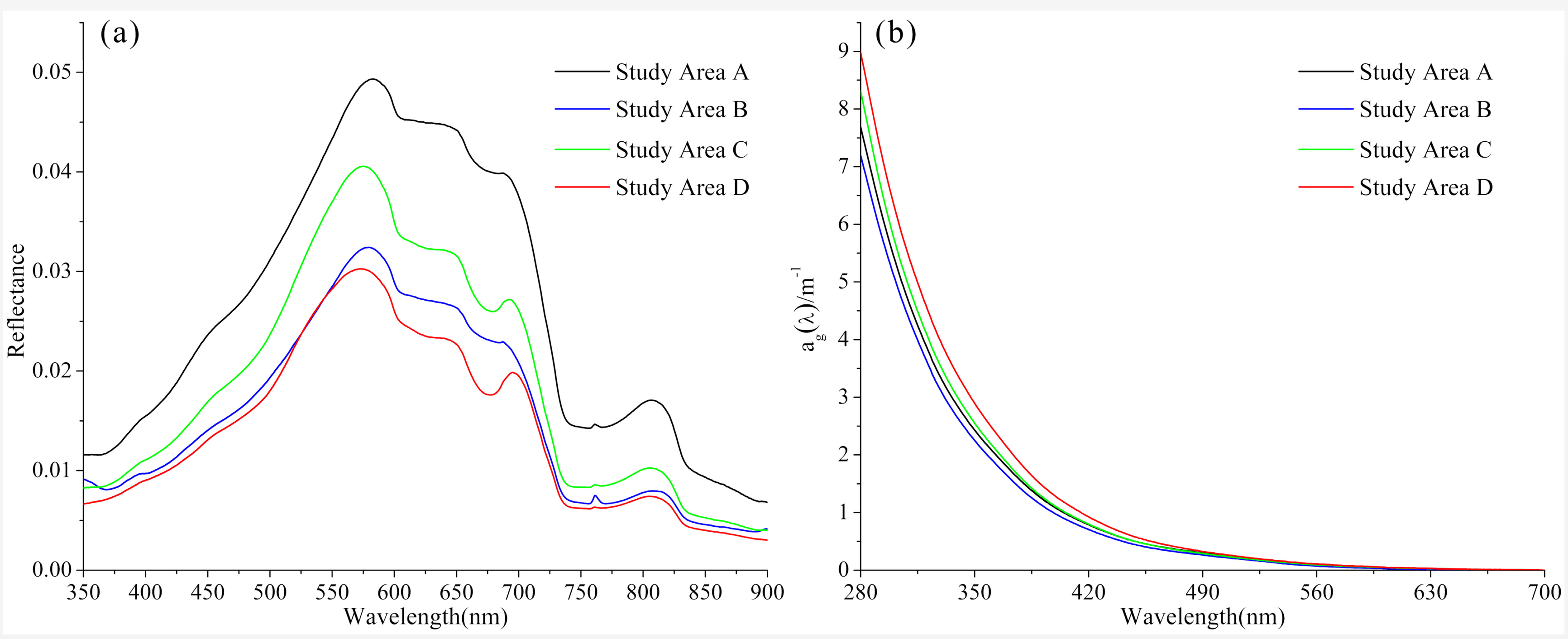
Water Sampling

Reflectance Spectral Measurement



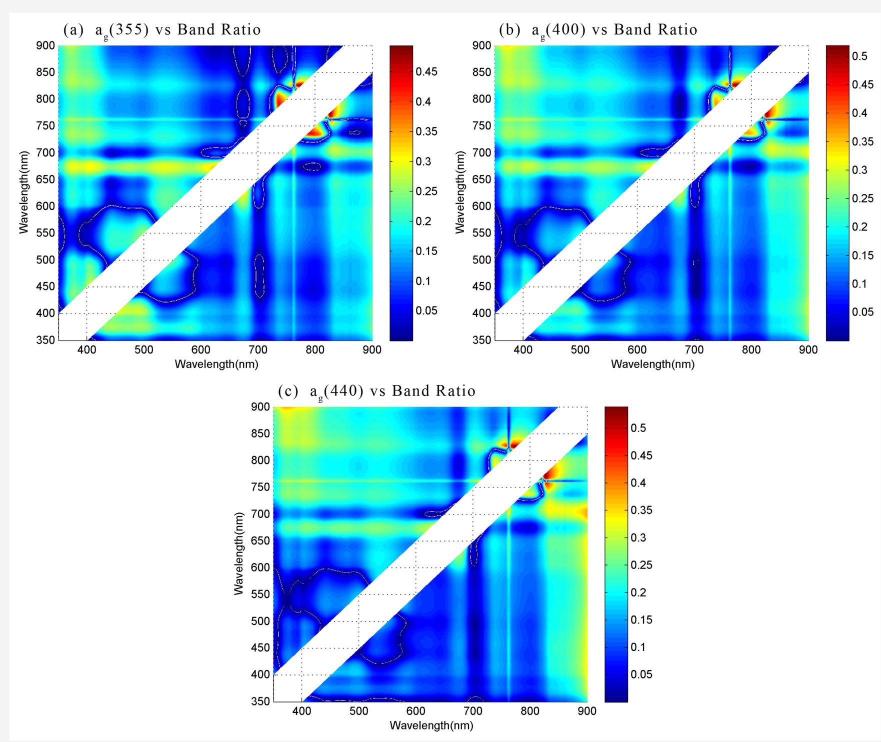
CDOM Measurement



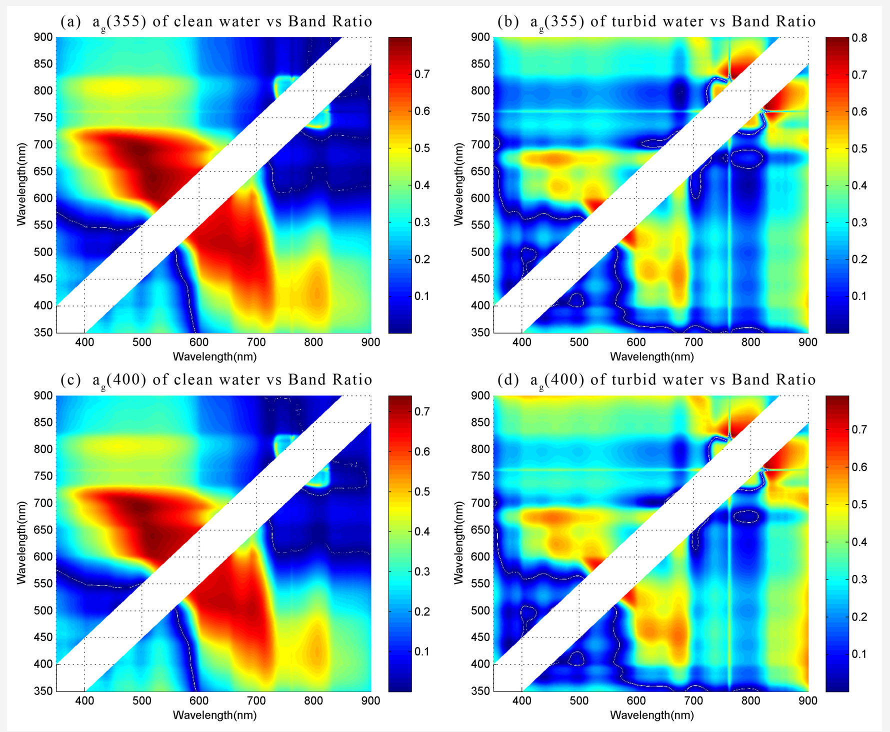


(a) Mean reflectance spectral of water surface from each study area; (b) Mean absorption spectral of CDOM in each study area.

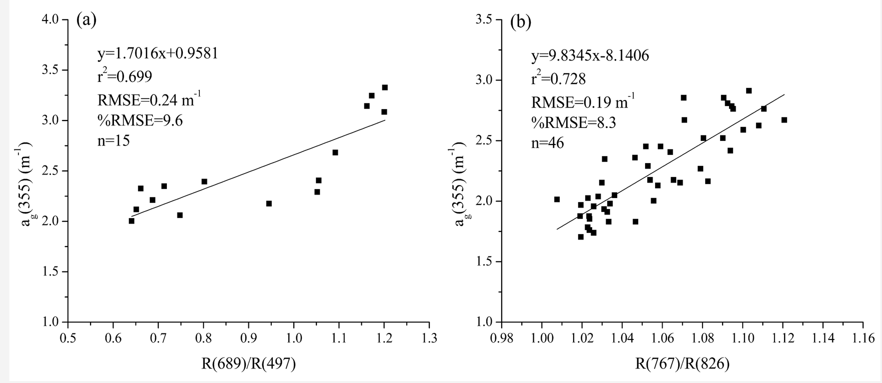
Results and Discussion



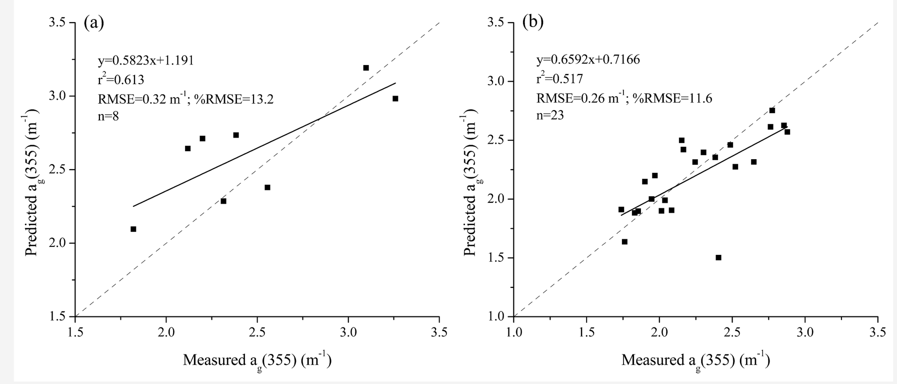
Correlation coefficient between band ratio combinations (Y-axis / X-axis wavelength reflectance) versus CDOM (a) $a_g(355)$, (b) $a_g(400)$ and (c) $a_g(440)$ based on all field samples.



Correlation coefficient between band ratio combinations (Y-axis / X-axis wavelength reflectance) versus $a_g(355)$: (a) 23 samples with TSM < 10 mg/L, and (b) 69 samples with TSM ≥ 10 mg/L; and versus $a_g(400)$: (c) 23 samples with TSM < 10 mg/L, and (d) 69 samples with TSM ≥ 10 mg/L.



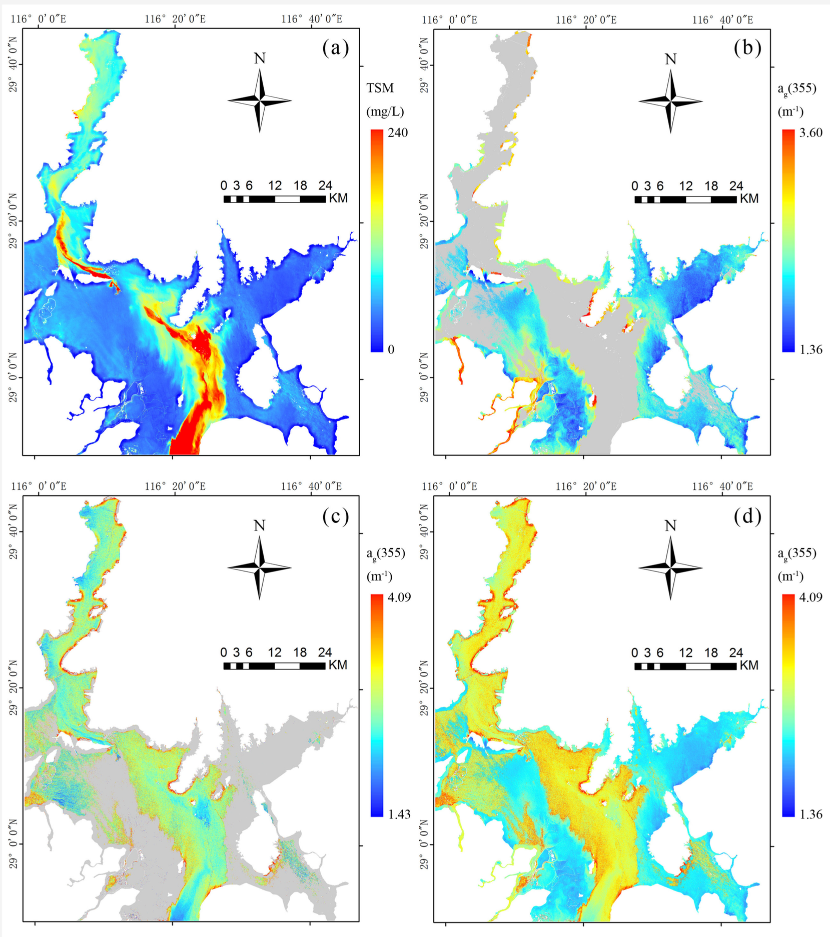
Calibration models for (a) samples of clean water; (b) samples of turbid water based on band ratio model based on in-situ data.



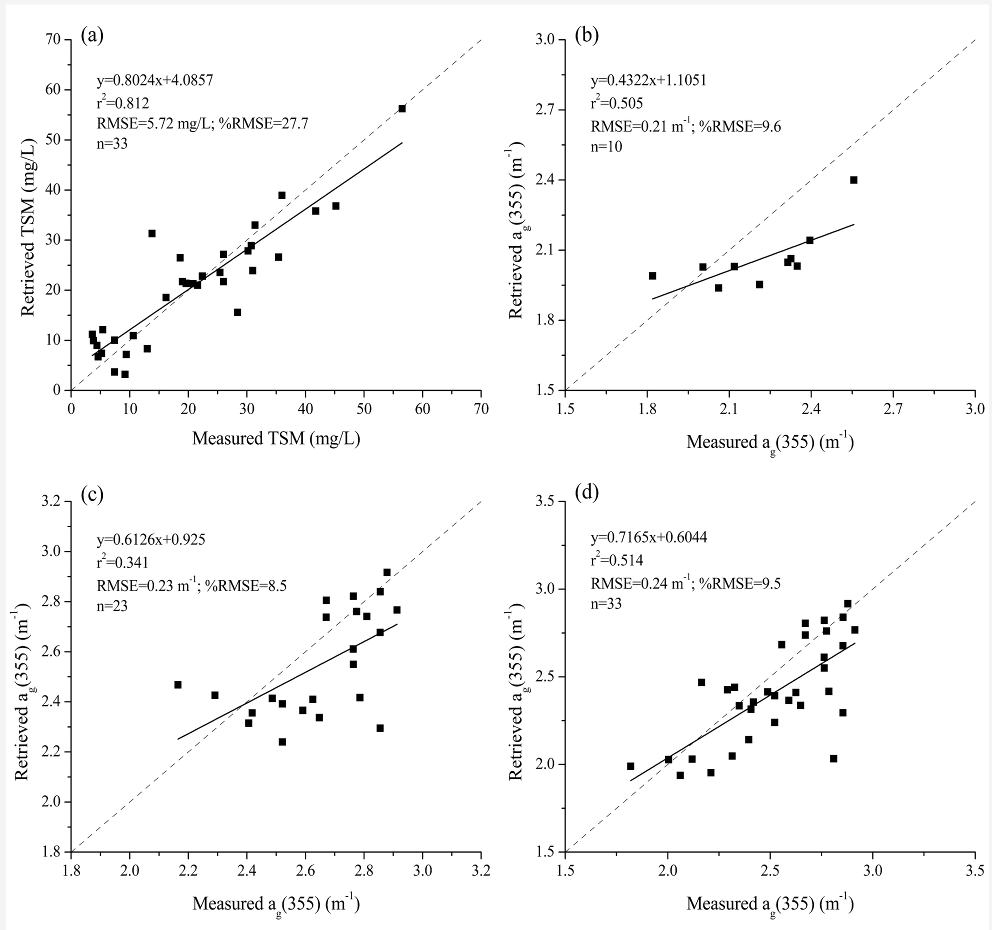
Validation results of band ratio models based on in-situ data (a) clean water; (b) turbid water.

Satellite	Dataset	Band Ratio	Calibration Model	r^2	n
Sentinel-2A	Clean water	B4 / B2	y=1.3439*exp(0.6851x)	0.700	15
Sentinel-2A	Turbid water	B7 / B8	y=3.4556x-2.0356	0.336	46
Landsat-8	Clean water	B4 / B2	y=1.3338x+1.0426	0.624	15
Landsat-8	Turbid water	B4 / B5	y=0.4468*ln(x)+1.4605	0.130	46

Satellite	Dataset	Band Ratio	Validation Model	r^2	RMSE	%RMSE	n
Sentinel-2A	Clean water	B4 / B2	y=0.5233x+1.314	0.544	0.338	13.7%	8
Sentinel-2A	Turbid water	B7 / B8	y=0.417x+1.3039	0.452	0.264	11.7%	23



TSM concentrations and CDOM absorption retrieved from Sentinel-2 image (July 26, 2016), (a) TSM concentrations; (b) $a_g(355)$ of clean water; (c) $a_g(355)$ of turbid water; (d) $a_g(355)$ of clean and turbid water.



Scatter plots of retrieved against measured values of TSM and CDOM, (a) TSM concentrations; (b) $a_g(355)$ of clean water; (c) $a_g(355)$ of turbid water; (d) $a_g(355)$ of clean and turbid water with the regression line (solid) and the 1:1 line (dashed).

Conclusions

This study demonstrated that the modeling approach based on band ratios performed well for estimating $a_g(355)$ with differentiation of water turbidity levels. The band ratios of R(689) / R(497) and R(767) / R(826) performed the best retrieval of $a_g(355)$ in clean water (TSM < 10 mg/L) and in turbid water (TSM ≥ 10 mg/L) with r^2 = 0.70, and r^2 = 0.73, respectively. The evaluation results indicated that Sentinel-2 performed better than Landsat-8 for estimating $a_g(355)$ especially for turbid water. The findings from this study provide algorithms foundation for monitoring spatial and temporal dynamic of CDOM in Poyang Lake using remote sensing.