Summary

- Three-year (2009-2011) observations in highly turbid waters of the western Pacific from (MODIS) on the satellite Aqua are used to conduct this study. SWIR atmospherics corrections with band set of 1640 nm and 2130 nm is conducted to derive \( n_L(\lambda) \) at the red, near-infrared (NIR), and shortwave infrared (SWIR).
- NIR ocean reflectance spectral shape represented by reflectance ratio of \( \rho_{\text{sw}}(748)/\rho_{\text{sw}}(869) \) is highly dynamic in a large coverage of turbid waters.
- In turbid waters, ocean IOP modeling can be significantly simplified. It is feasible to analytically derive some IOP properties in turbid waters with combined visible-NIR \( n_L(\lambda) \) spectra data.
- IOP properties such as \( b_p(\lambda) \) can be derived from satellite \( n_L(\lambda) \) measurements in the NIR wavelengths. Backscattering spectral slopes can also be reasonably derived in the coastal turbid regions.
- This work is published in *Llimnology and Oceanography* (Shi and Wang, 2014).

West Pacific Highly Turbid Waters

The BS, YS, and ECS are the three major marginal seas in the western Pacific Ocean bounded by China, Korea, and Japan (Fig 1). They cover some of the most turbid waters in the world (Shi and Wang, 2010, 2012). Major rivers in this region such as the Yangtze River and Yellow River transport large amounts of sediments into the BS, YS, and ECS.

In the coastal region of the YS (Sta. 1, 2 in Fig. 1, Subes Shal of the YS (Sta. 3 in Fig. 1), Yangtze River estuary (Sta. 5 in Fig. 1), Hangzhou Bay (Sta. 6 in Fig. 1), and Lake Taihu (Sta. 7 in Fig. 1), normalized water-leaving radiance at the red band \( n_L(1645) \) can be over \(-5\) mW cm\(^{-2}\) 
\mu m\(^{-1}\) sr\(^{-1}\) in the winter season (Shi and Wang 2012; Wang et al. 2011). Normalized water-leaving radiance at 859 nm \( n_L(859) \) normally is also over \(-2\) mW cm\(^{-2}\) 
\mu m\(^{-1}\) sr\(^{-1}\) at these stations.

Three-year MODIS-Aqua observations from 2009–2011 are used to derive \( n_L(1645), n_L(748), n_L(859), n_L(869), \) and \( n_L(1240) \) using the SWIR atmospheric correction with the band set of 1640 and 2130 nm (Wang 2007).

Spectral Features of \( n_L(\lambda) \) in the Read, NIR and SWIR

- NIR reflectance spectral shapes represented with \( \rho_{\text{sw}}(748)/\rho_{\text{sw}}(869) \) is highly dynamic. It drops from \(-1.8-2.0 \) for moderately turbid water to \(1.1-1.2 \) for highly turbid waters.

\[ \rho_{\text{sw}}(748)/\rho_{\text{sw}}(869) \] vs. \( \rho_{\text{sw}}(869) \) at Different Stations

- Concept of NIR-based IOP Retrieval Modeling

<table>
<thead>
<tr>
<th>NIR-based Reflectance Modelling and IOP Retrievals</th>
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<tr>
<td>( \alpha(\lambda) ) = ( \frac{1}{\rho_{\text{sw}}(\lambda)} ) (reflectance at ( \lambda ))</td>
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<td>( \beta(\lambda) ) = ( \frac{1}{\rho_{\text{sw}}(\lambda)} ) (reflectance at ( \lambda ))</td>
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<tr>
<td>( b_p(\lambda) ) = ( \frac{1}{\rho_{\text{sw}}(\lambda)} ) (reflectance at ( \lambda ))</td>
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- NIR-based IOP Model Test with IOCG Synthetic Data

- NIRS-based IOP Retrievals in the Turbid Waters

- Backscattering Power Law Slope \( \eta \) vs. \( b_p(859) \)

- Conclusion Remarks

- This study quantifies and characterizes the normalized water-leaving radiance spectra \( n_L(\lambda) \) in wavelengths of the red, NIR, and SWIR in highly turbid coastal regions of the BS, YS, and ECS.
- NIR ocean reflectance spectral shape represented by reflectance ratio of \( \rho_{\text{sw}}(748)/\rho_{\text{sw}}(869) \) is highly dynamic in a large coverage of turbid waters.
- In turbid waters, ocean IOP modeling can be significantly simplified. It is feasible to analytically derive some IOP properties in turbid waters with combined visible-NIR \( n_L(\lambda) \) spectra data.
- We demonstrate IOP properties such as \( b_p(\lambda) \) can be derived from satellite \( n_L(\lambda) \) measurements in the NIR wavelengths. Backscattering spectral slopes can also be reasonably derived in the coastal turbid regions.
- SWIR atmospheric correction with the MODIS SWIR band set of 1240 and 2130 nm can be safely used for \( n_L(\lambda) \) retrievals for waters with \( n_L(859) \) less than \(-2.5 \) mW cm\(^{-2}\) 
\mu m\(^{-1}\) sr\(^{-1}\).
- Current existing algorithms for Chl-a, \( K_d(490) \), TSM, and IOPs using the ocean reflectance at the red band for coastal regions are all limited and cannot be applied to highly turbid waters with \( \rho_{\text{sw}}(859) > 0.05 \).

References


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