Remote Sensing of Water Properties Using the SWIR-based Atmospheric Correction Algorithm

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Atmospheric Correction: SWIR Bands

(Wang & Shi, 2005; Wang, 2007)

- At the shortwave infrared (SWIR) wavelengths (>~1000 nm), water has much stronger absorptions. Thus, atmospheric correction (Gordon & Wang, 1994) can be carried out for coastal regions with the **black pixel assumption at the SWIR bands**.
- Water absorption for 869 nm, 1240 nm, 1640 nm, and 2130 nm are 5 m^{-1}, 88 m^{-1}, 498 m^{-1}, and 2200 m^{-1}, respectively.
- MODIS has three SWIR bands at **1240, 1640,** and **2130 nm**, designed for atmosphere and land applications.

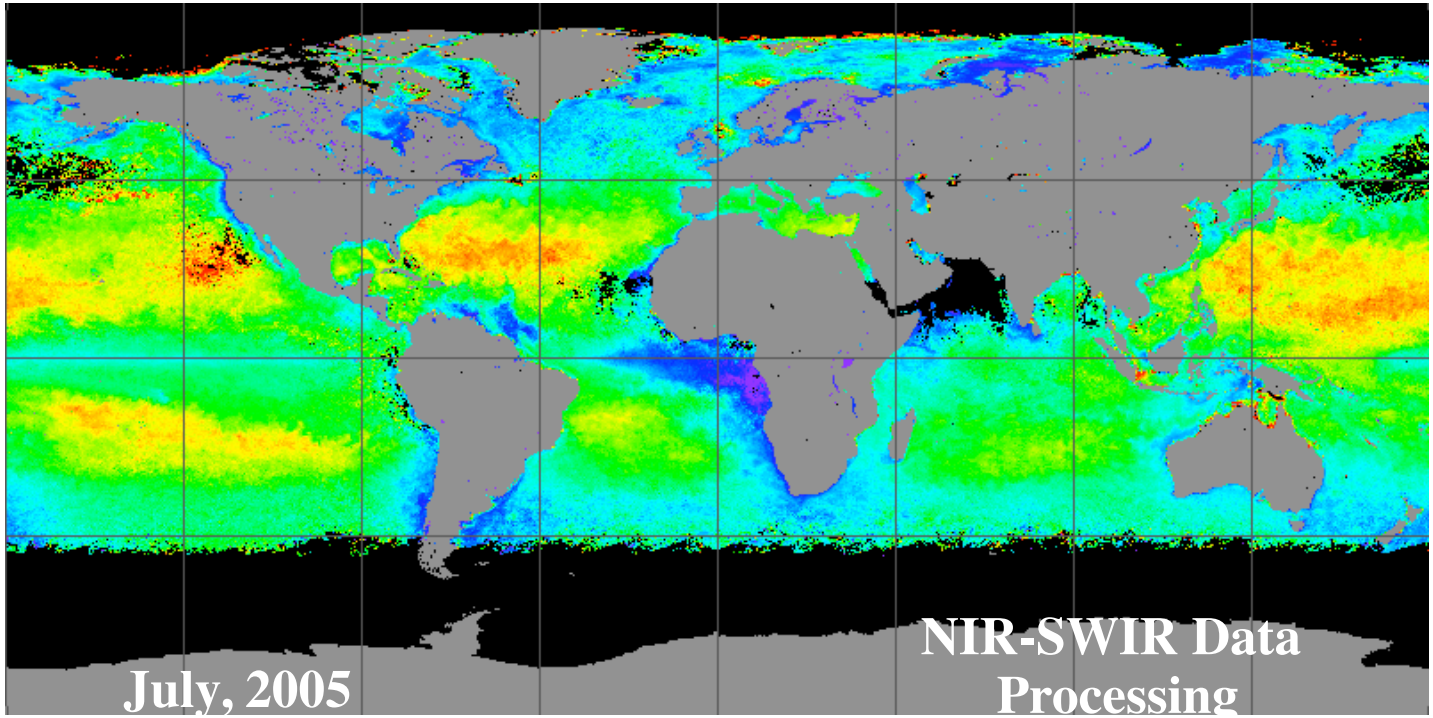
➢ We use the SWIR band for the cloud masking. This is necessary for coastal region and inland lake waters.

✓ Require sufficient **SNR** characteristics for the SWIR bands and the SWIR atmospheric correction has slight larger noises at the short visible bands (compared with those from the NIR algorithm).

nLw(443)

Scale: 0.-3.0

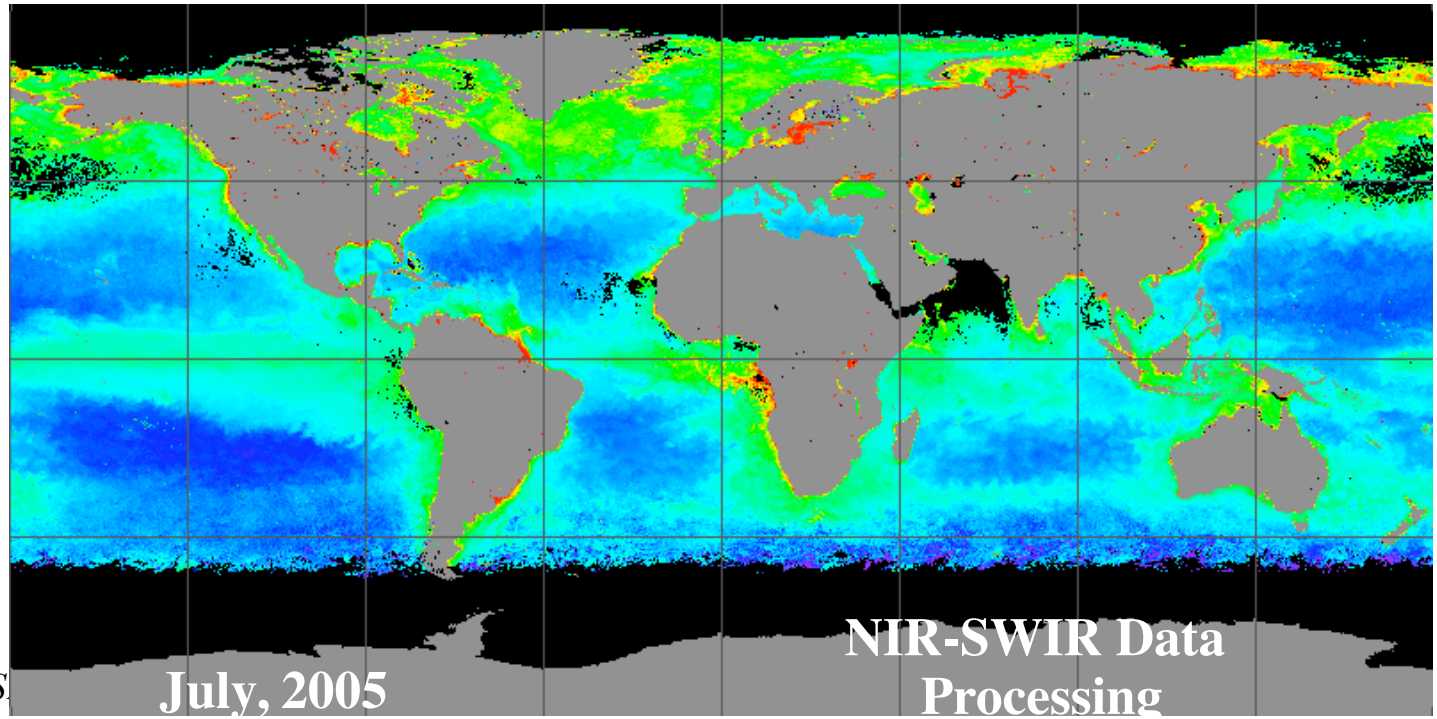
(mW/cm^2 μm sr)



Chlorophyll-a

0.01-10 (mg/m^3)

(Log scale)



Wang, M., S. Son, and W. Shi (2009), "Evaluation of MODIS SWIR and NIR-SWIR atmospheric correction algorithms using SeaBASS data," *Remote Sens. Environ.*, **113**, 635-644.

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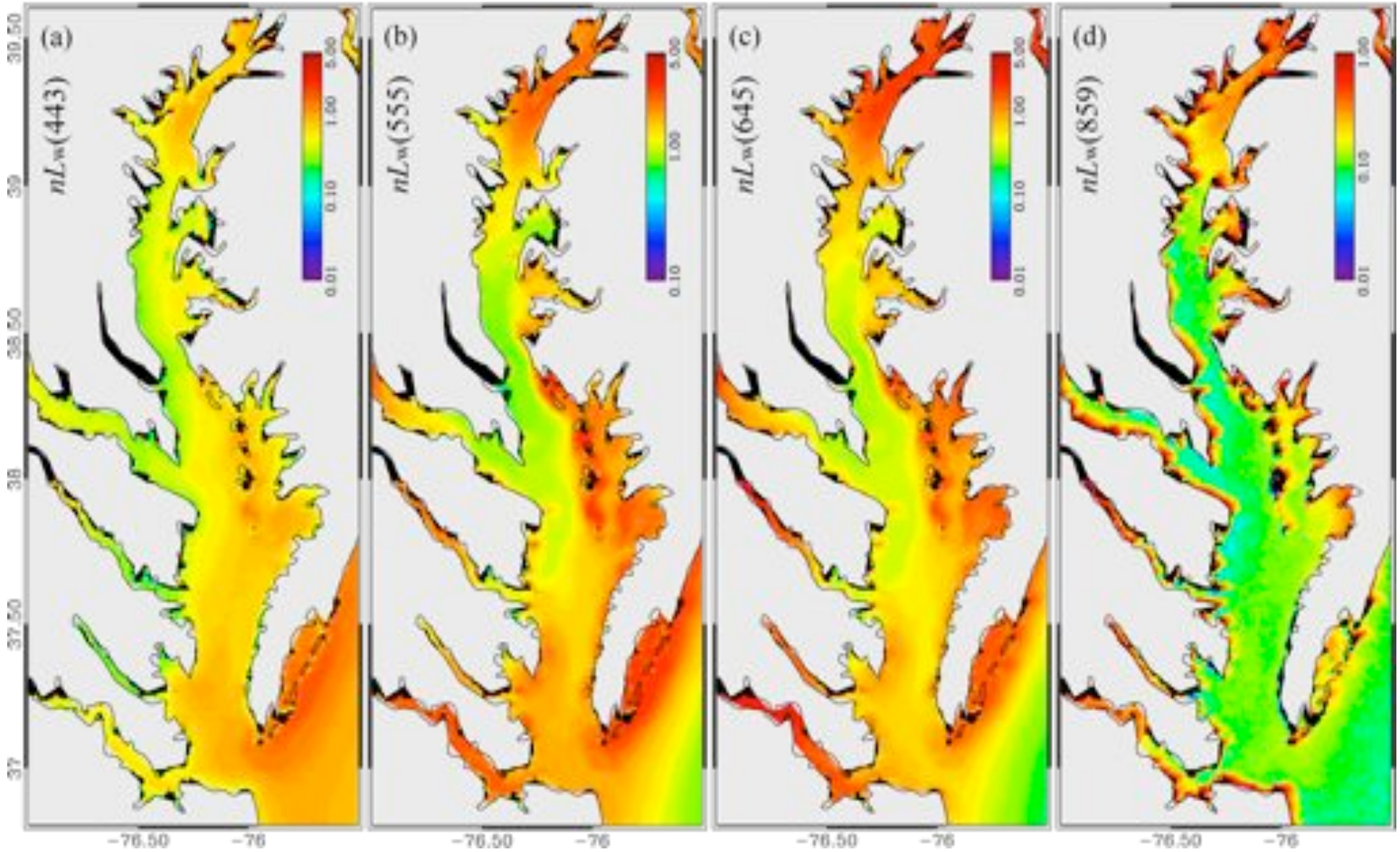
Climatology (Jul 2002-Dec 2010) Images of MODIS NIR-SWIR nL_w



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Results from Inland Lake Taihu

Using the **SWIR** algorithm, we have derived the water optical properties over the Lake Taihu using the **MODIS-Aqua** measurements during the spring of 2007 for monitoring a **massive blue-green** algae bloom, which was a major natural disaster affecting several millions residents in nearby Wuxi city.

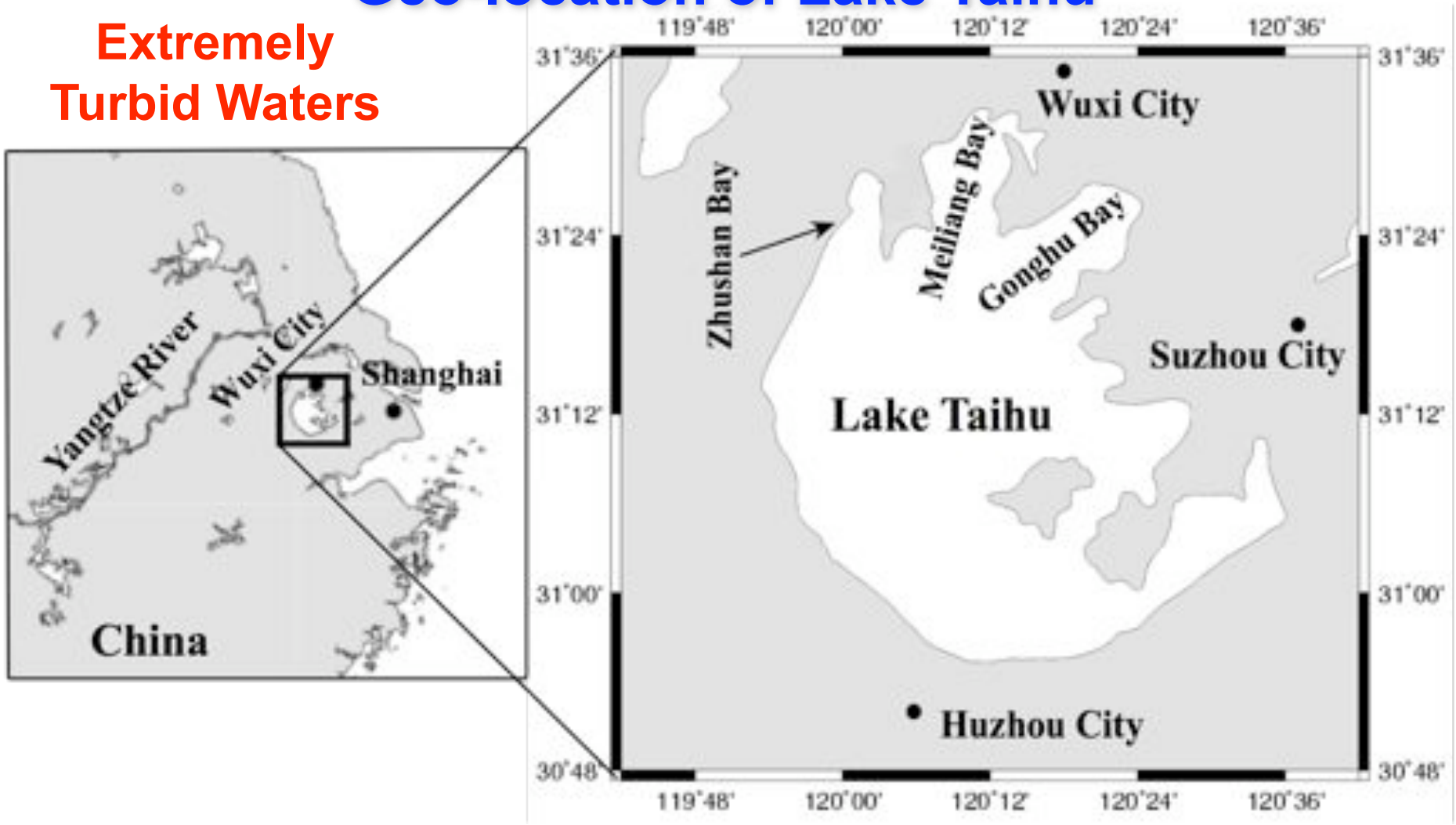
Wang, M. and W. Shi (2008), "Satellite observed algae blooms in China's Lake Taihu", *Eos, Transaction, American Geophysical Union,* **89**, p201-202, May 27.

Wang, M., W. Shi, and J. Tang (2011), "Water property monitoring and assessment for China's inland Lake Taihu from MODIS-Aqua measurements", *Remote Sens. Environ.,* **115**, 841-854.

- The work was featured in the NASA 2008 Sensing Our Planet (http://nasadaacs.eos.nasa.gov/articles/2008/2008_algae.html)

Geo-location of Lake Taihu

Extremely Turbid Waters



- ✓ The third largest fresh inland lake in China (~2,250 km^2).
- ✓ Located in one of the world's most urbanized and heavily populated areas.
- ✓ Provide water resource for several million residents in nearby Wuxi city.

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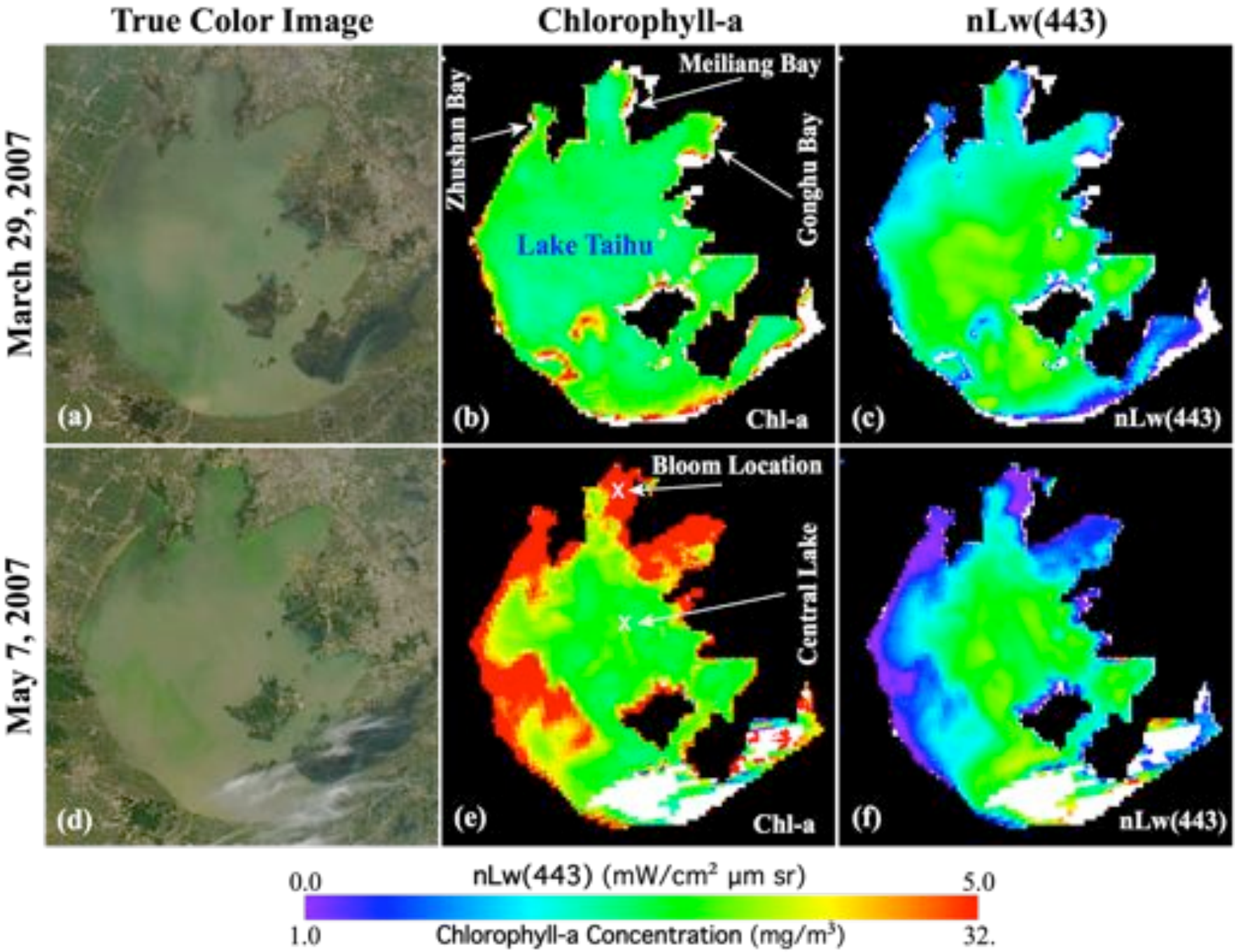
Methodology (1)

- The SWIR atmospheric correction algorithm (Wang, 2007; Wang & Shi, 2005) is used for the water property data processing.
- Since MODIS 1240 nm band is not always black for the entire Lake Taihu, we have developed three-step method in the data processing for each MODIS-Aqua data file:
  - ✓ First, regions for the black of 1240 nm band are determined using the SWIR data processing.
  - ✓ Second, a dominant aerosol model from the region with black of 1240 nm band is obtained, and
  - ✓ Finally, with the derived aerosol model, the SWIR atmospheric correction algorithm is run using only 2130 nm band (with fixed aerosol model).
- The Lake Taihu water property data are then derived.

Wang, M., W. Shi, J. Tang (2011), "Water property monitoring and assessment for China's inland Lake Taihu from MODIS-Aqua measurement," *Remote Sens. Environ.,* **115**, 841-854.



(*Wang and Shi*, 2008)

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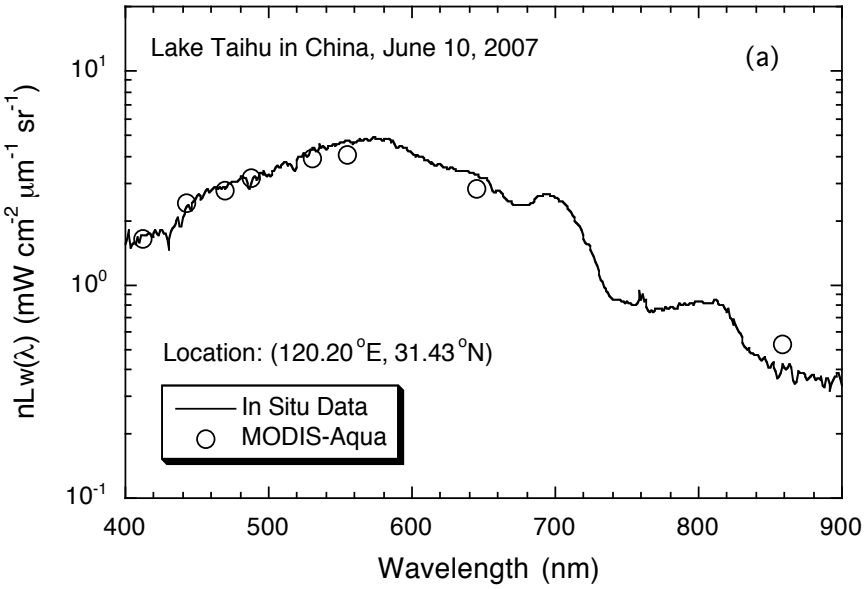
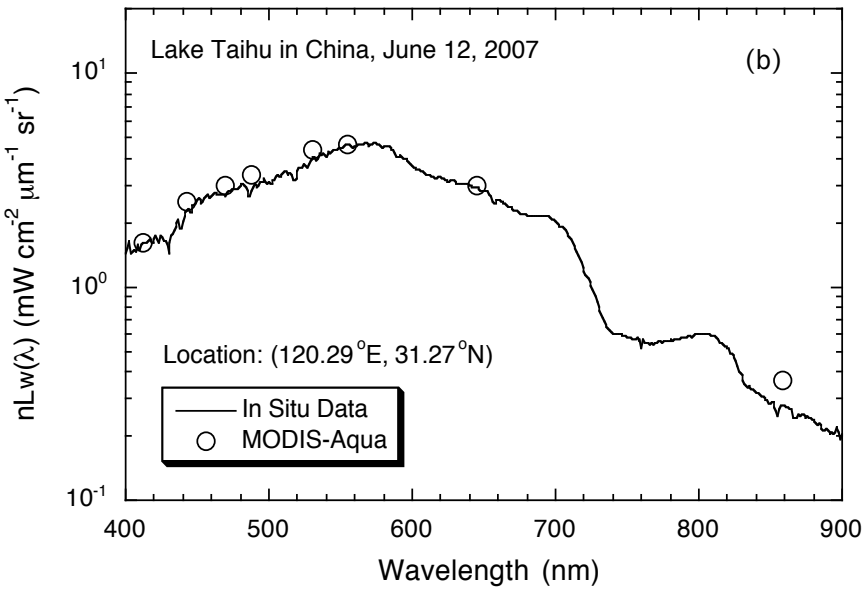
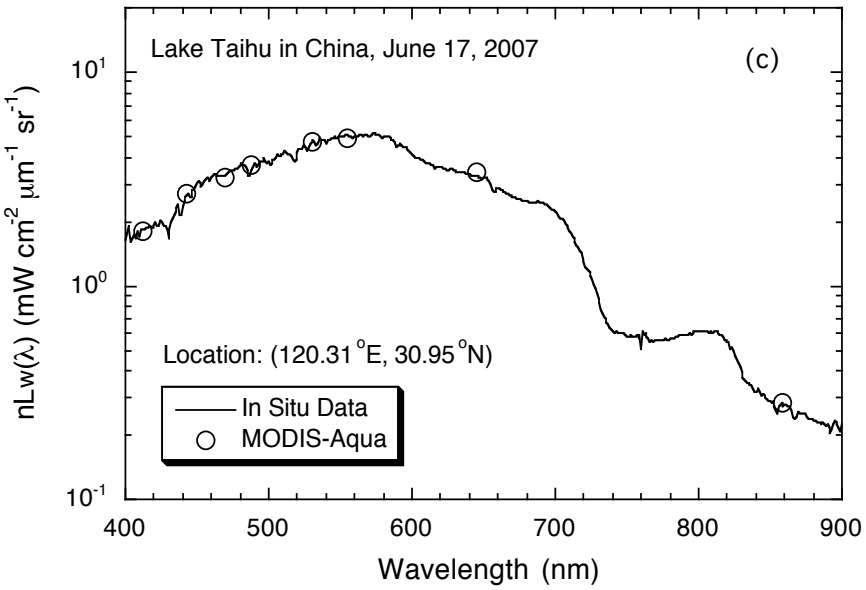
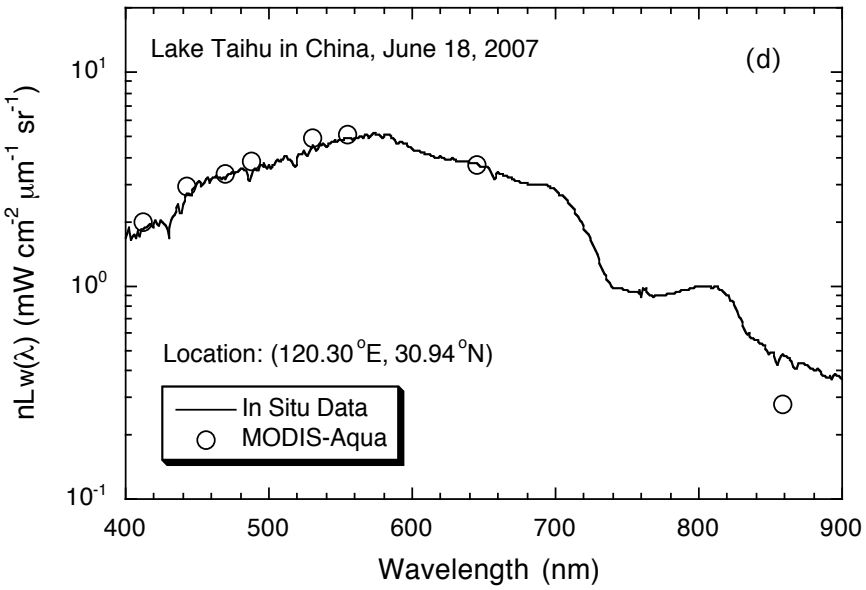
Validation Results for MODIS-derived Water-leaving Radiance Spectra





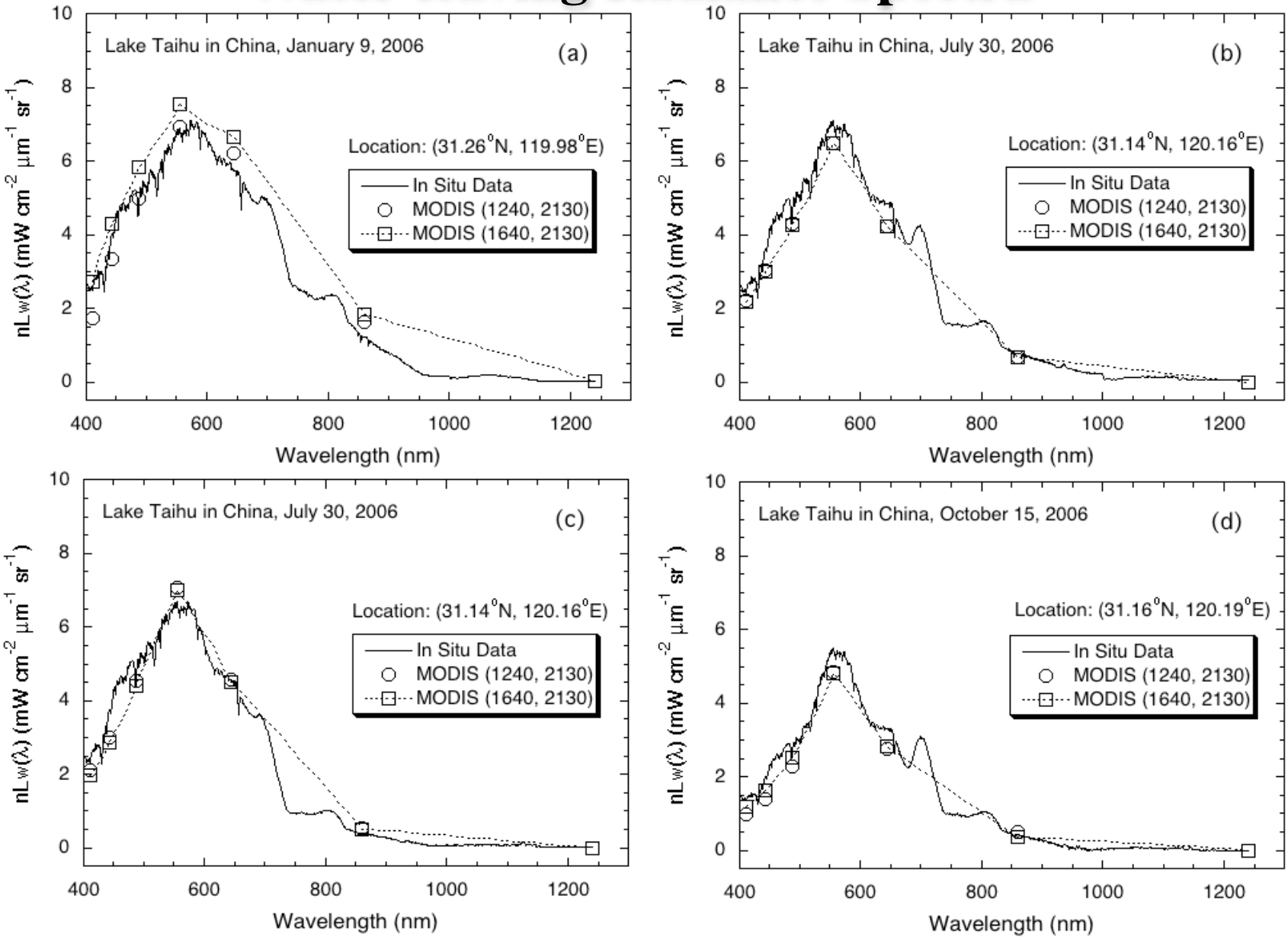




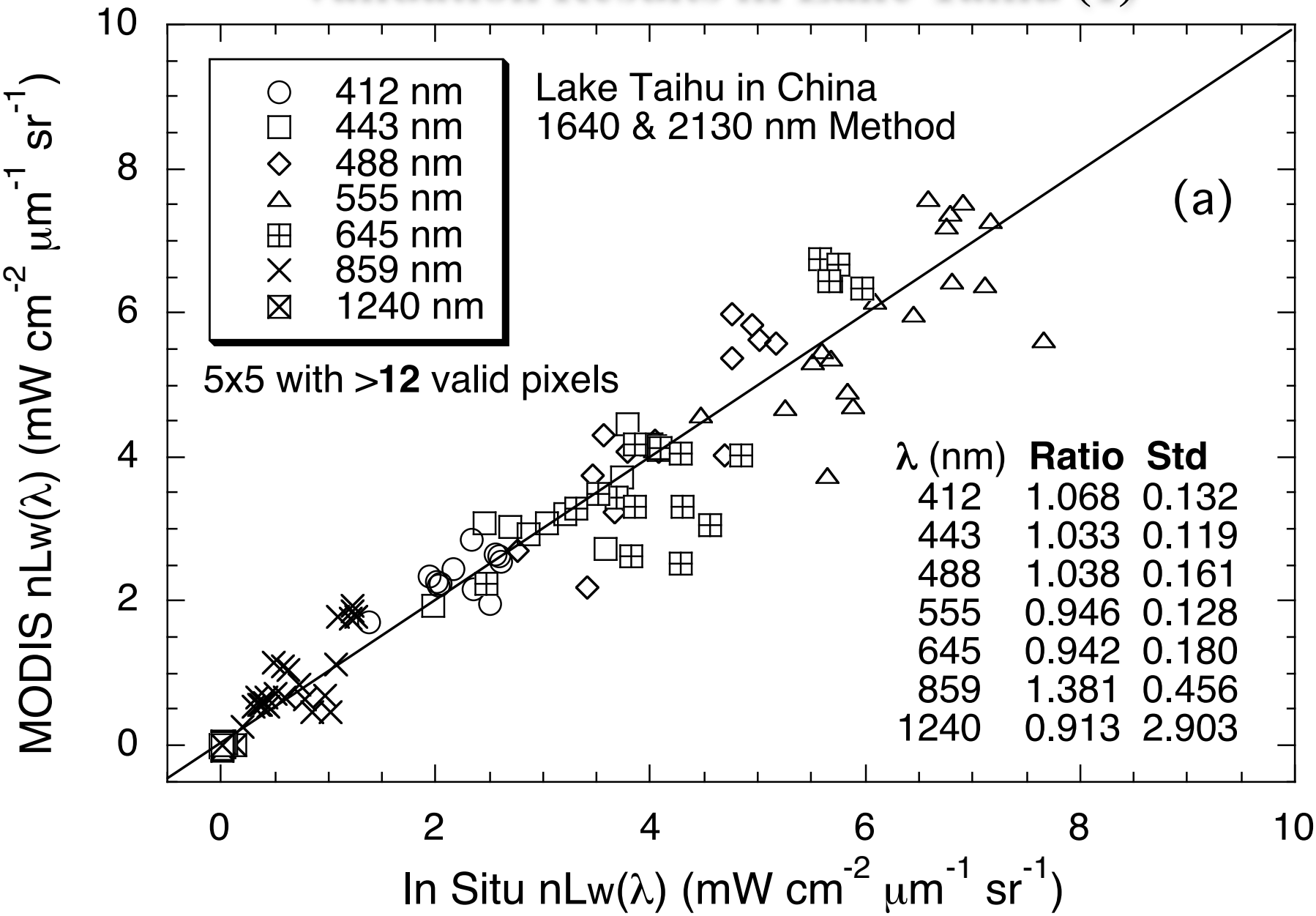
Methodology (2)

- Black pixel assumption at the SWIR 1640 and 2130 nm is generally valid for Lake Taihu.
- The SWIR atmospheric correction algorithm using bands 1640 and 2130 nm (Wang, 2007) can be used for the water property data processing.
- However, for MODIS-Aqua, four out of ten detectors for the SWIR 1640 nm band are inoperable (dysfunctional).
- We focus on deriving seasonal results for the lake using the SWIR 1640 and 2130 nm atmospheric correction algorithm.
- More in situ data (five seasonal cruises in 2006-2007 in the lake) are also available to us now.

Validation Results for MODIS-derived Water-leaving Radiance Spectra



Validation Results in Lake Taihu (1)



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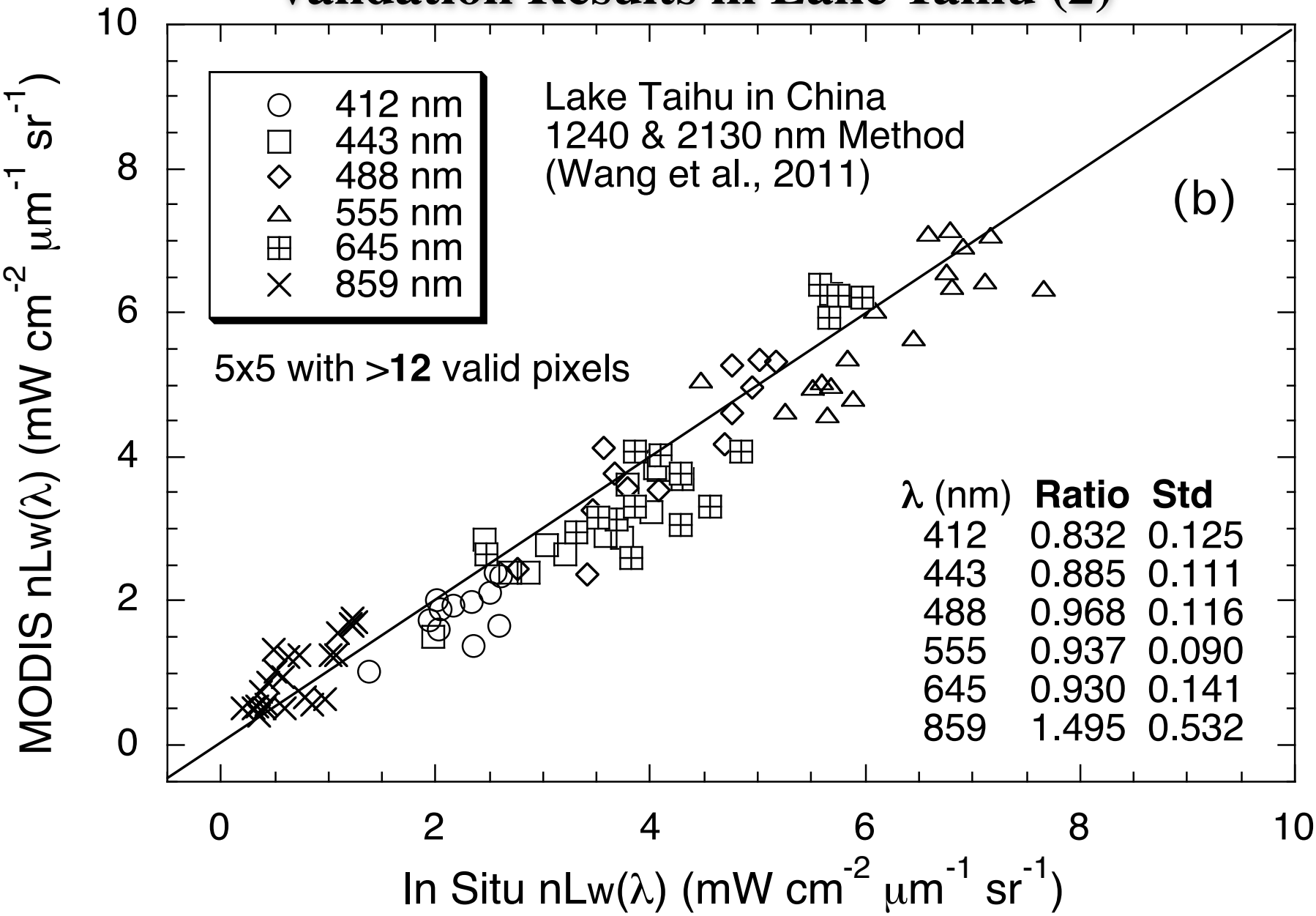
Validation Results in Lake Taihu (2)



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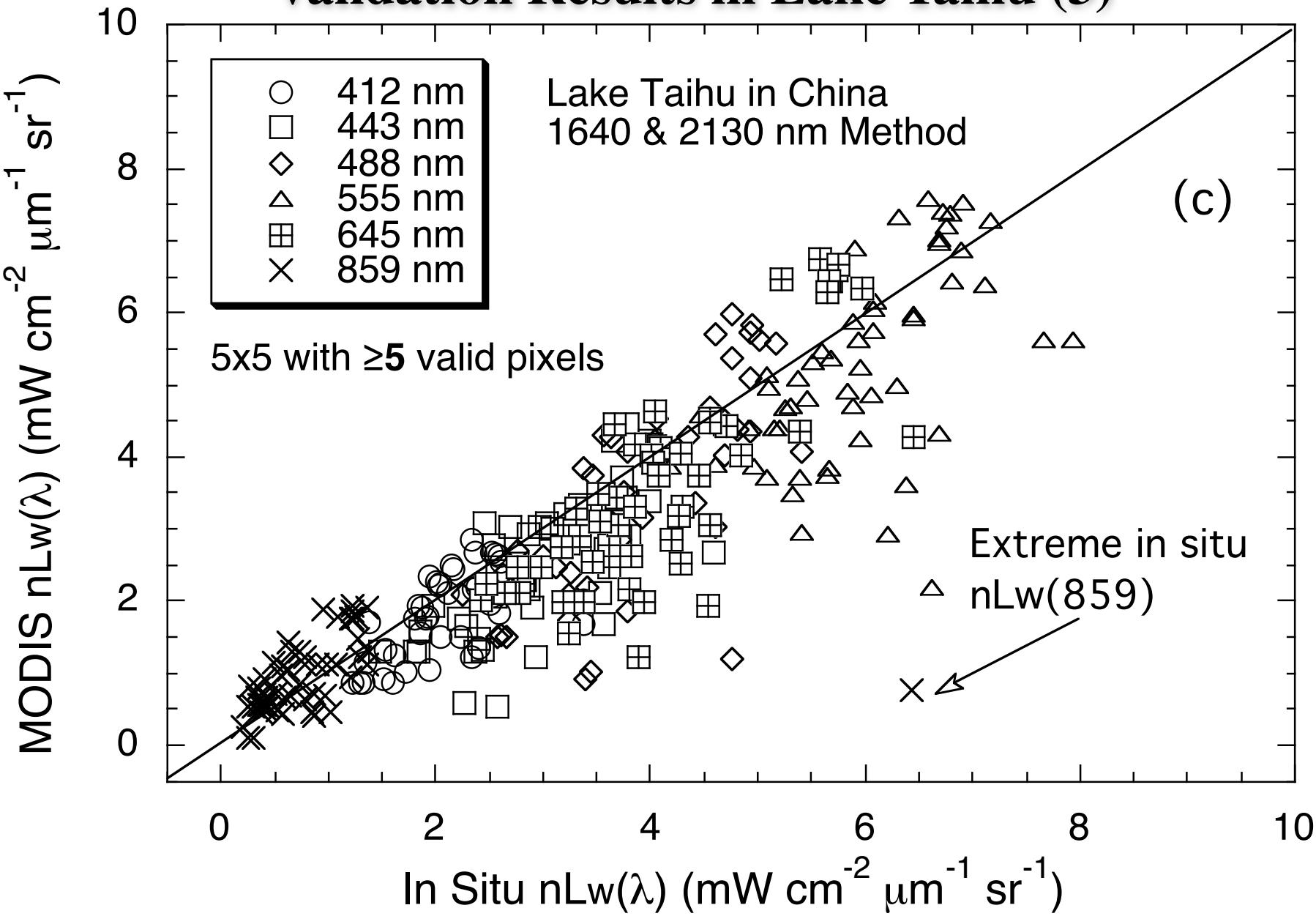
Validation Results in Lake Taihu (3)



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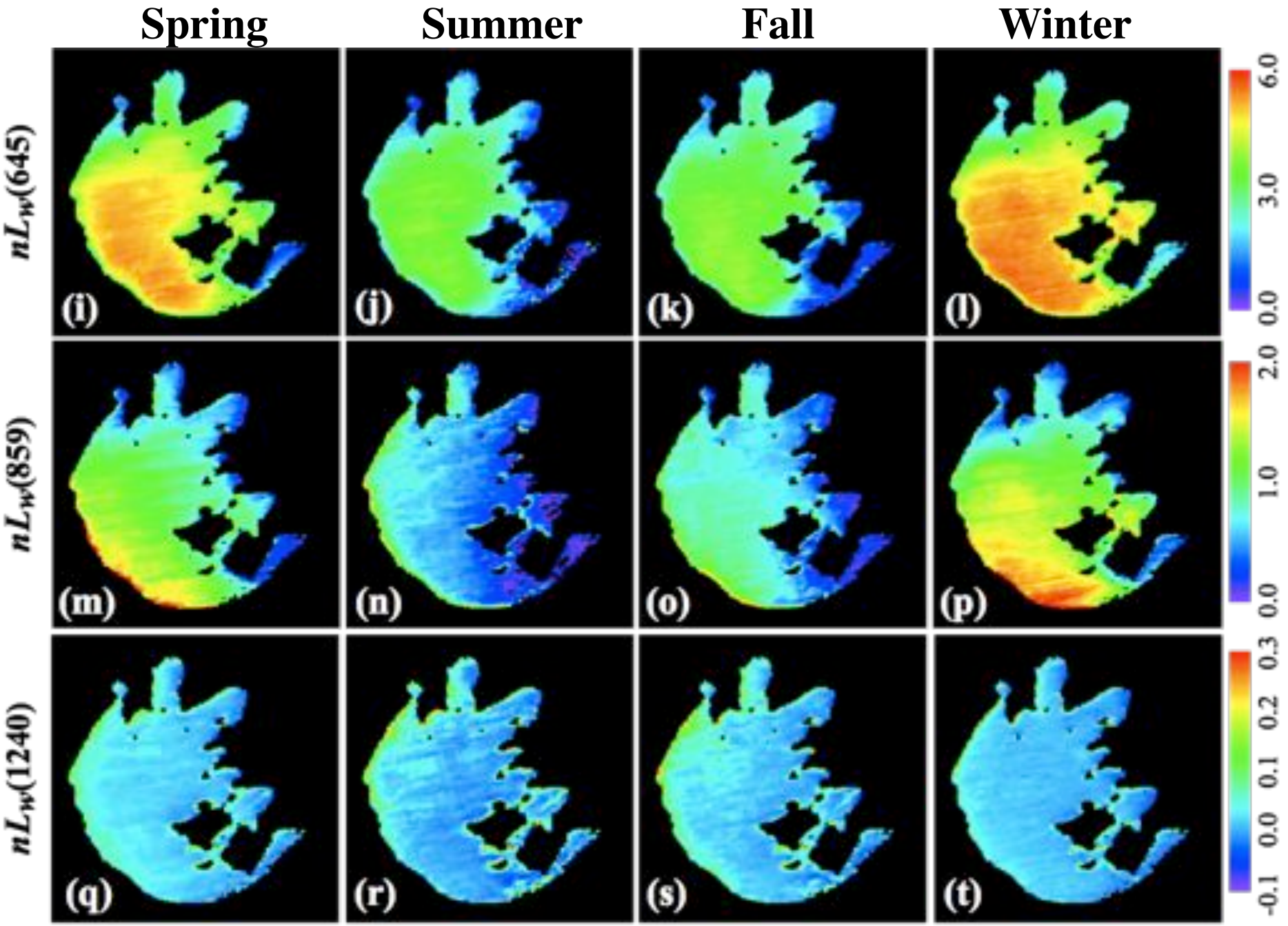
Spatial Non-uniformity in Lake Taihu



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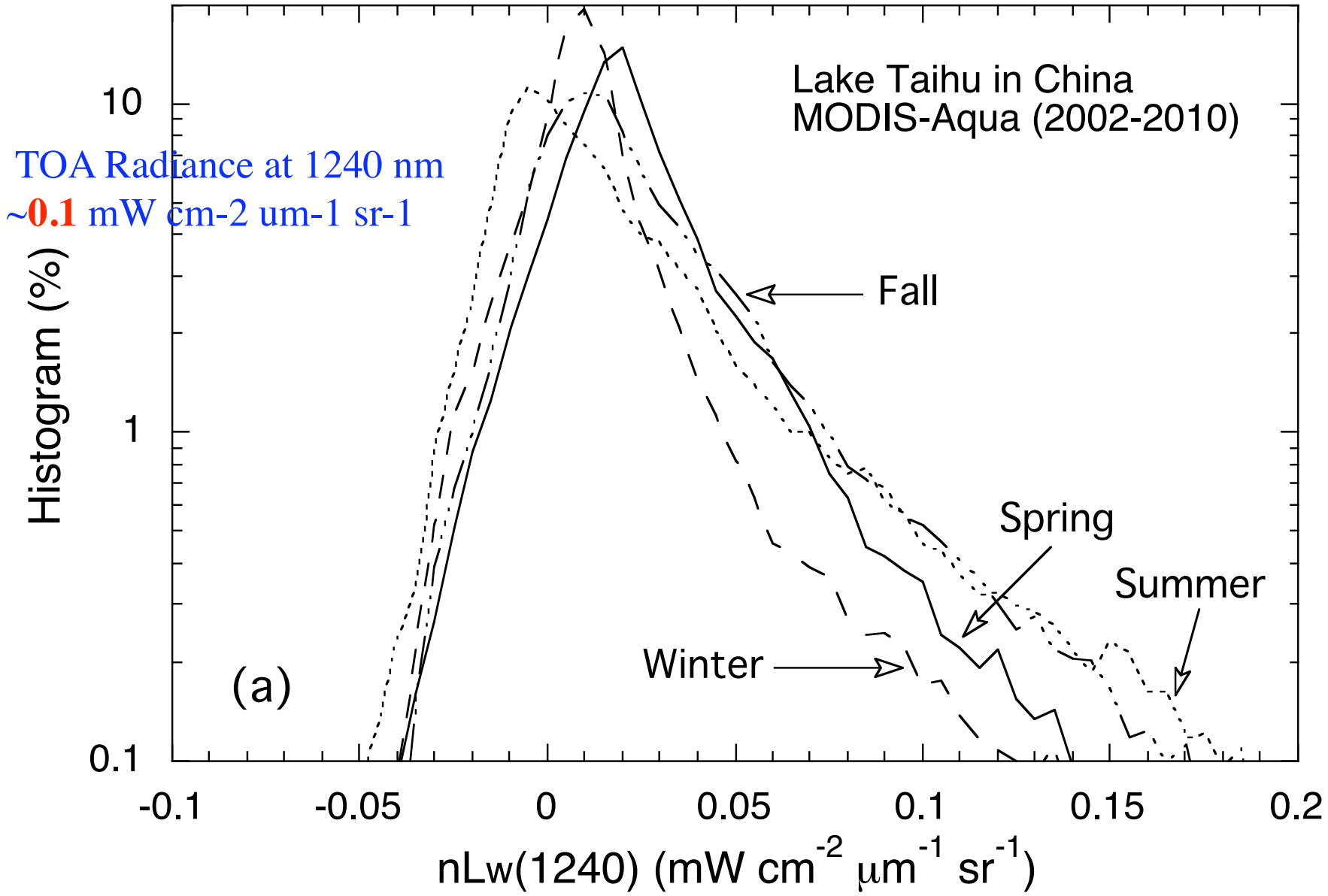
Seasonal Histograms in $nL_w(1240)$



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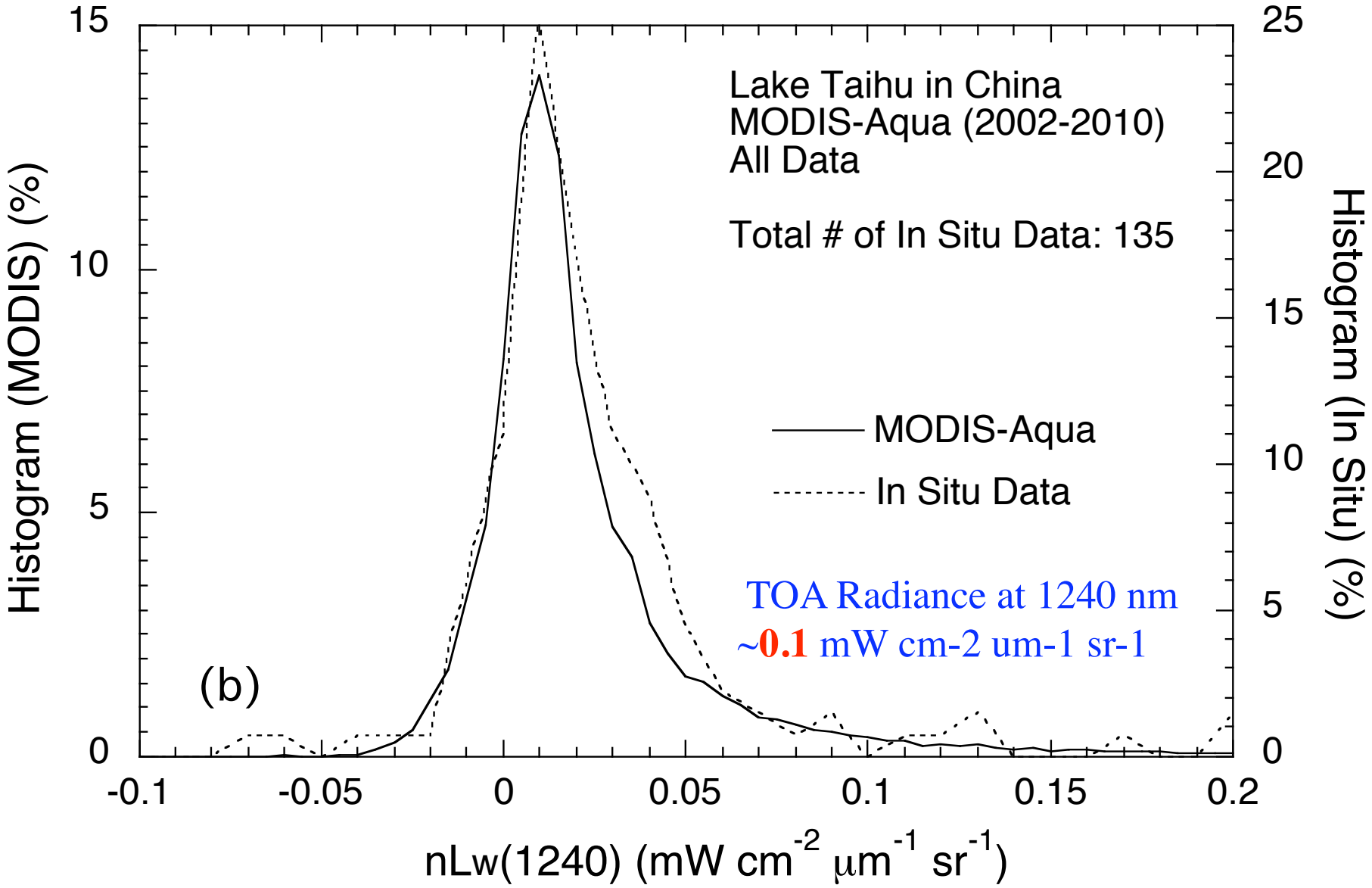
Climatology Histogram in $nL_w(1240)$



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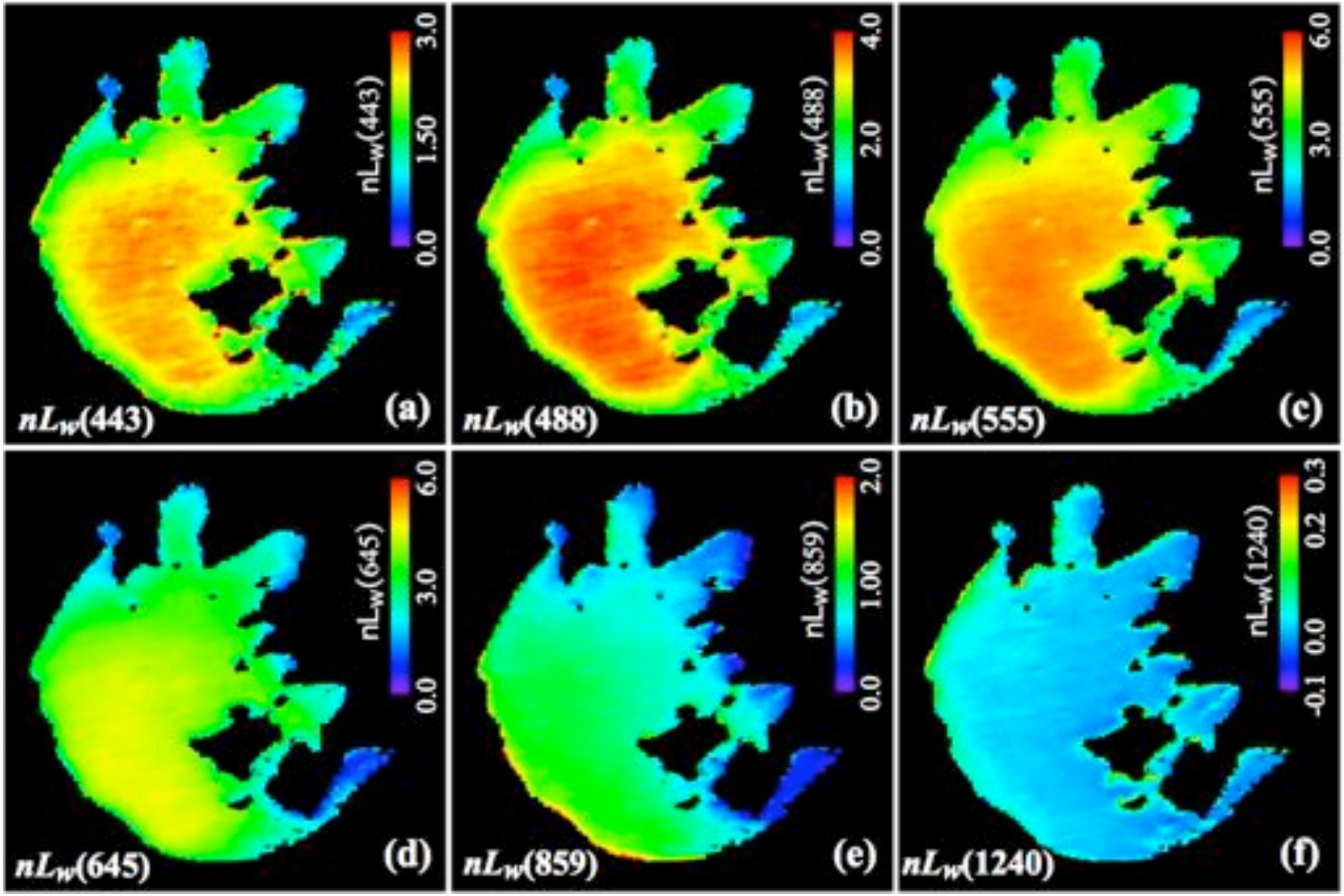
MODIS-Measured Climatology Water Optical Property for Lake Taihu



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Conclusions

- For the turbid waters in coastal regions and inland lakes, it has been demonstrated that the **SWIR** bands can be used for atmospheric correction.
- Future ocean (water) color satellite sensor needs to include the **SWIR** bands with **sufficient SNR** values for cases with turbid waters.

Thank You!

Comparisons Between MODIS and In Situ (SeaBASS) Data

Product	Data #	NIR-SWIR Method				
		Slope	Int†	R‡	Mean Ratio*	Medium Ratio&
$nL_w(412)$	116	0.827	0.198	0.873	1.120	1.084
$nL_w(443)$	128	0.952	0.073	0.891	1.040	1.025
$nL_w(488)$	104	1.057	-0.050	0.951	0.997	1.015
$nL_w(531)$	32	1.066	-0.069	0.961	1.018	1.040
$nL_w(551)$	116	1.106	-0.046	0.968	1.047	1.055
$nL_w(667)$	97	0.822	0.014	0.727	1.296	1.129
Overall $nL_w(\lambda)$	593	0.998	0.024	0.935	1.090	1.030
$nL_w(443)$/ $nL_w(551)$	43	1.021	0.025	0.879	1.052	1.032
$nL_w(488)$/ $nL_w(551)$	43	1.034	-0.023	0.953	1.017	0.996

†Intercept for line fit ‡Correlation coefficient

*Mean ratio of MODIS vs. in situ data &Medium ratio of MODIS vs. in situ data