Harmful Algal Bloom Detection Using Hyperspectral and Multispectral Imagery

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INTRODUCTION

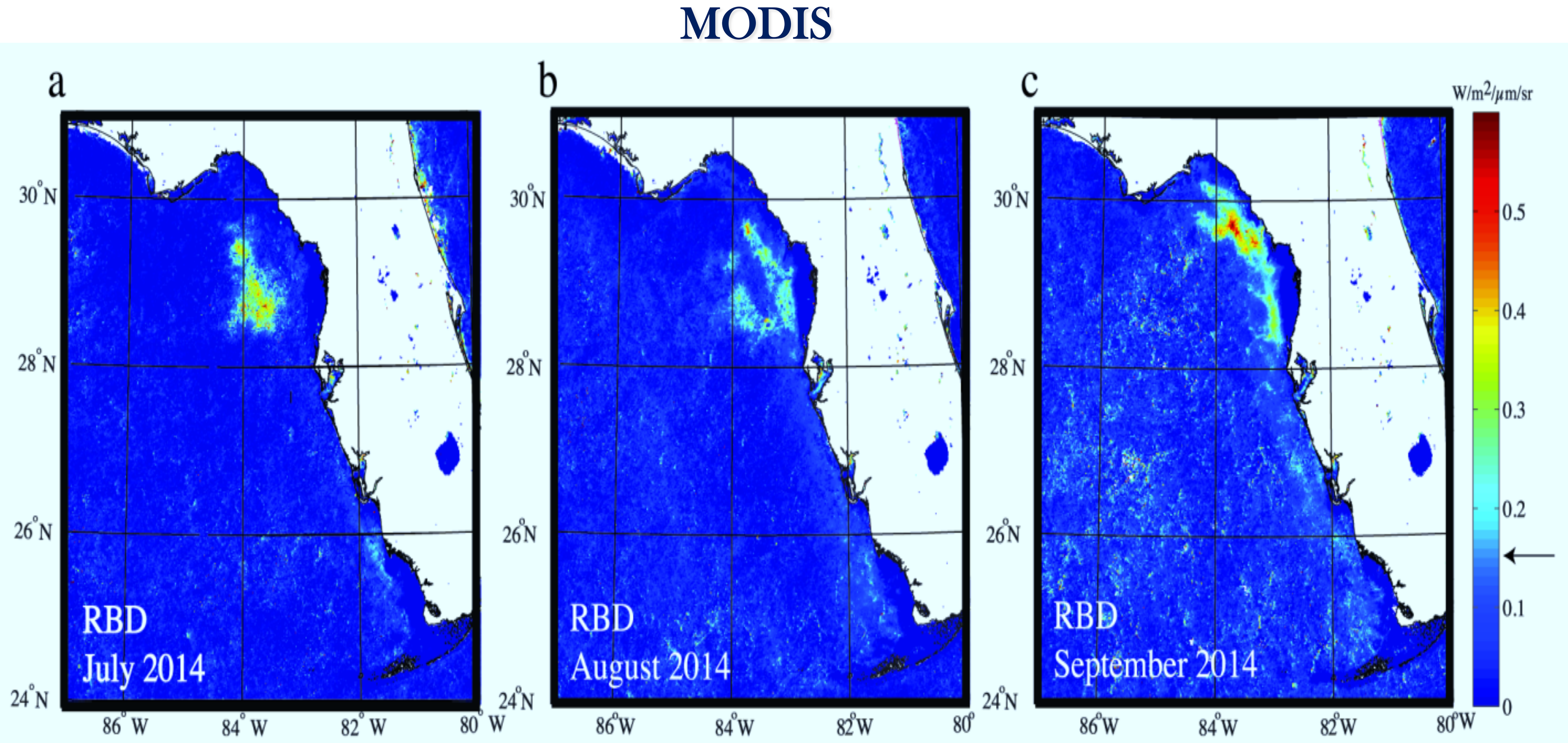
- Harmful Algal Blooms (HABs) have become a major threat to the coastal communities in recent years. In the United States, coastal HAB events have been estimated (conservatively, due to lack of information) to have economic impacts of $82 million/ year with the majority of impacts in the public health and commercial fisheries sectors [1].
- Approximately 50% of all red tide forming species and 75% of all HAB species are dinoflagellate [2]. Their motility provides a competitive advantage because they can migrate downward at night to acquire nutrients and to the surface during the day for photosynthesis. Their dense aggregations produce strong bio-optical signals that are detectable by satellite and airborne optical sensors.
- Detecting HABs in the coastal zone is very challenging due to the complexities of various water types and depths, dissolved and suspended organic and inorganic matters, and bottom reflectance. A hyperspectral imager records a contiguous spectrum from each pixel in the scene image and provides additional spectral information to exploit HABs from other bloom like features.

Multispectral Bloom Detection

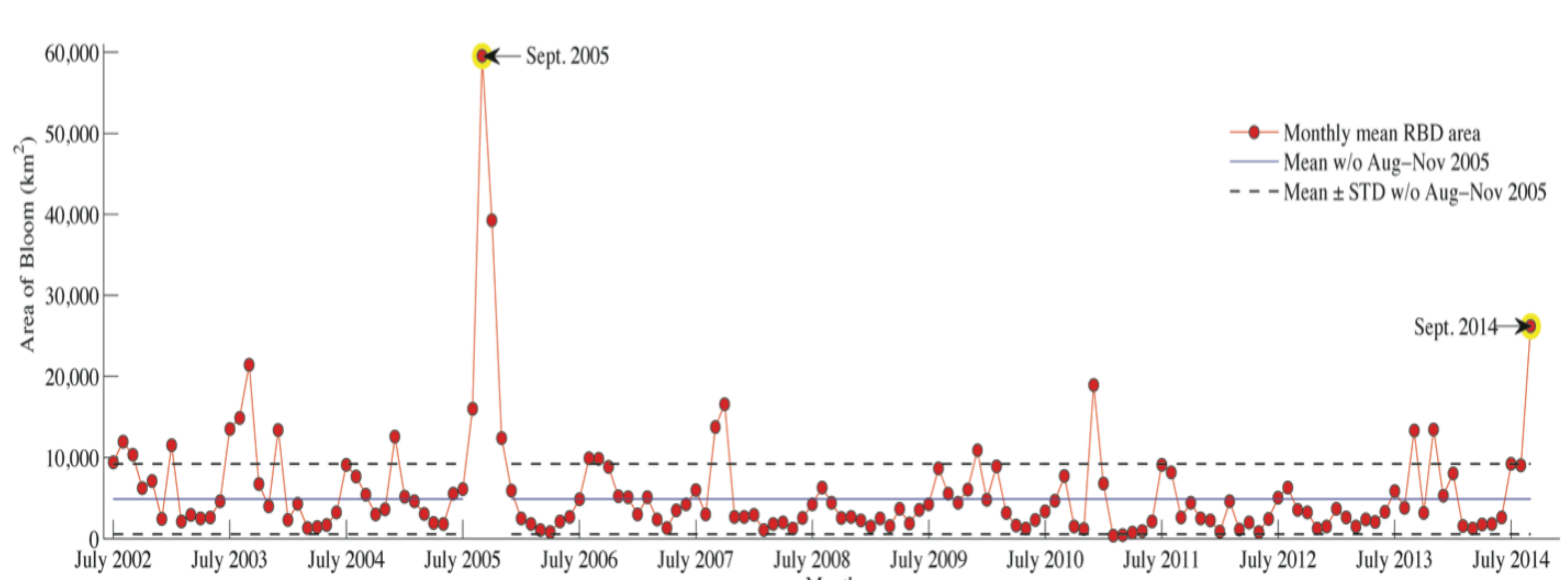
The Red Band Difference (RBD) Algorithm: $RBD = nLw(\lambda_2) - nLw(\lambda_1)$

where $nLw(\lambda)$ is normalized water-leaving radiance; λ_1 represents MODIS band 13 (667 nm), MERIS band 7 (665 nm), and GOCI band 5 (660 nm); λ_2 represents MODIS band 14 (678 nm), MERIS band 8 (681 nm), and GOCI band 6 (680 nm)

MODIS

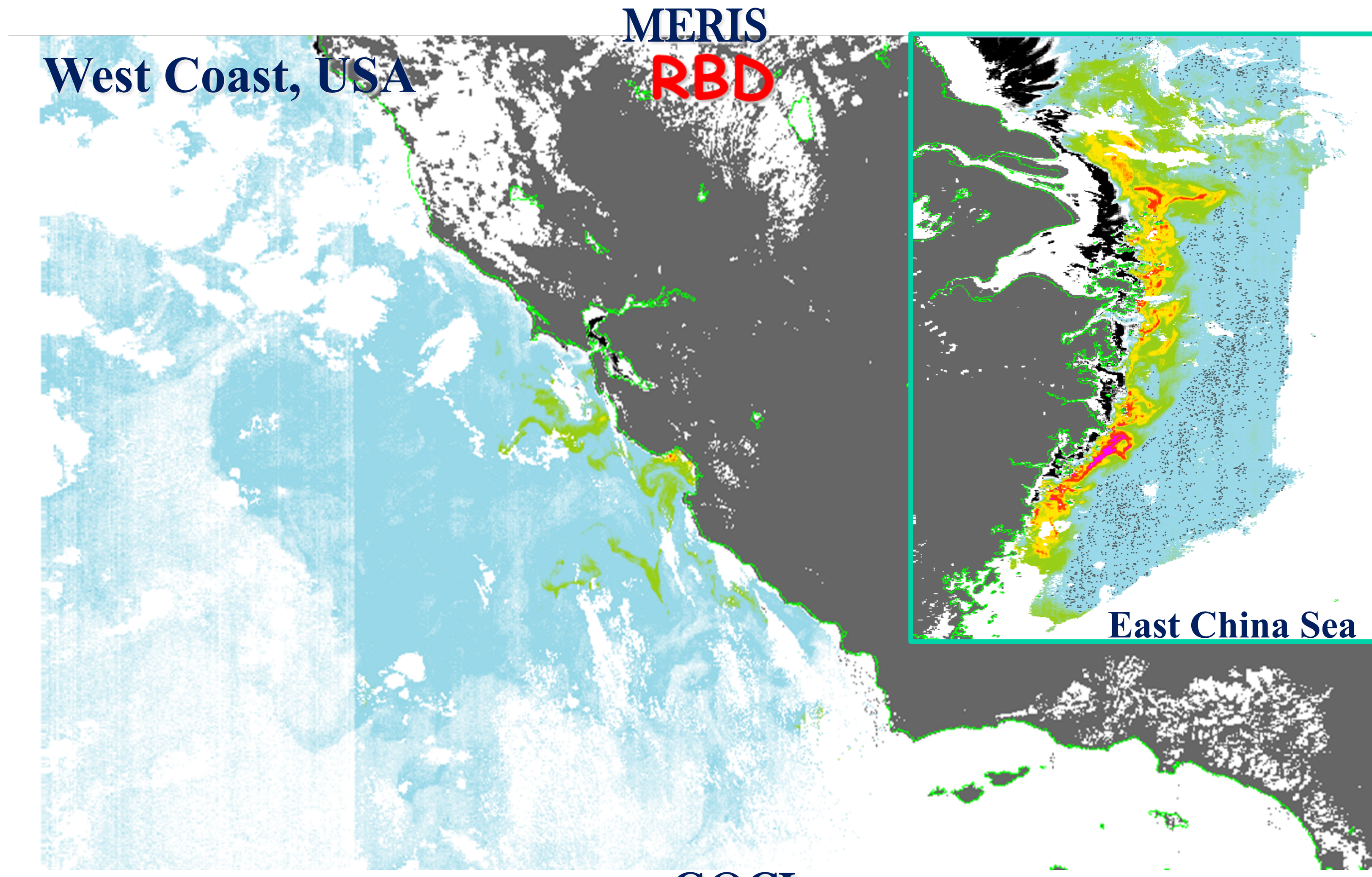


Progression of the 2014 *K. brevis* bloom on the WFS using the RBD technique: July-2014 (a), August-2014 (b), and September-2014 (c). The arrow on the colorbar indicates the RBD threshold.

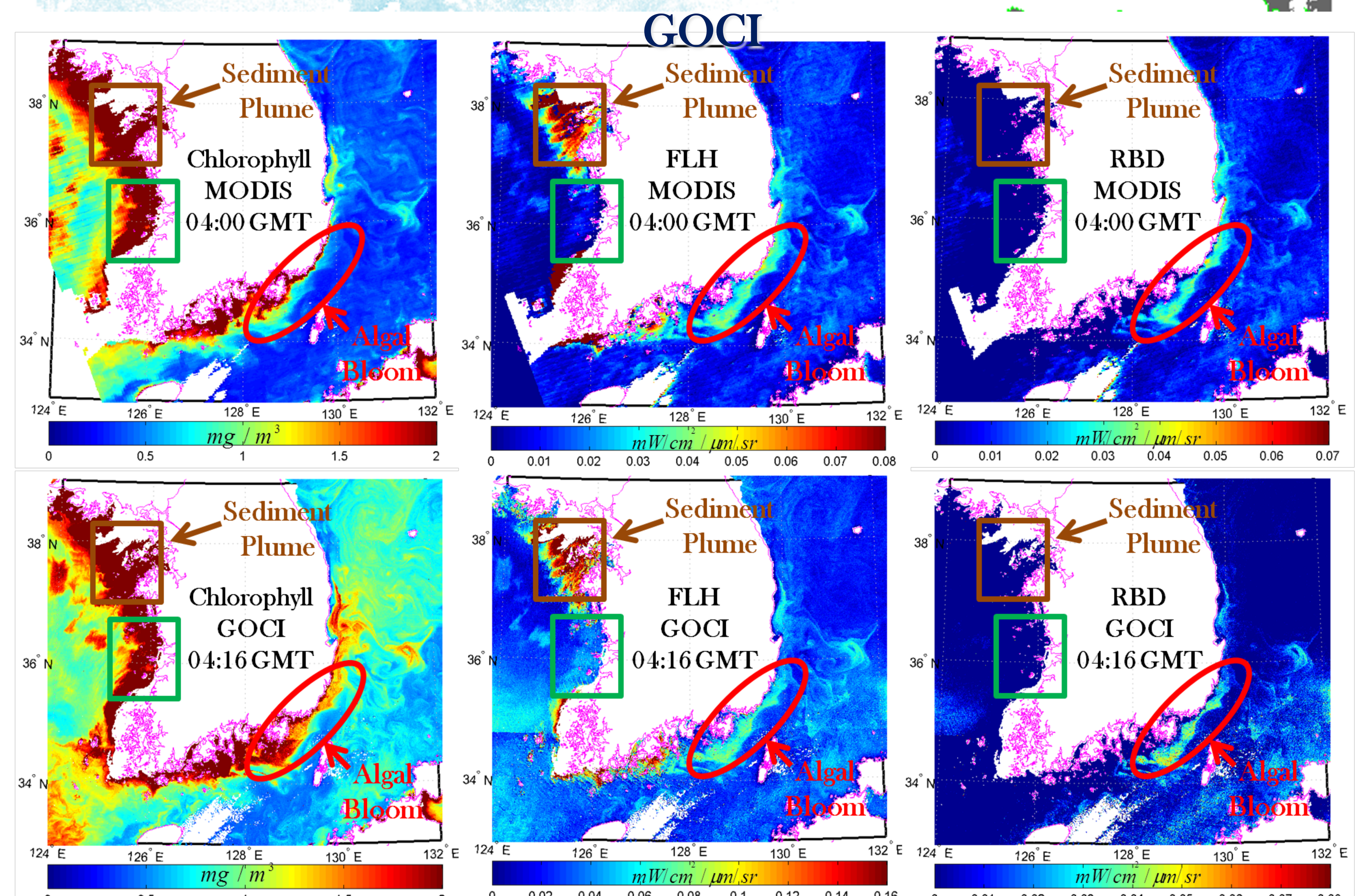


The monthly mean *K. brevis* bloom extent (km^2) was estimated using the RBD for the entire MODIS Aqua record (July 2002 to September 2014). *K. brevis* blooms occur almost every year between August and March and occasionally at other times. This trend is clearly seen in the time series plot where the striking event of 2005 and the more recent event (July-September 2014) are particularly evident. Since the 2005 bloom was exceptionally large relative to the rest of the years, it was excluded from the mean and standard deviation calculations (4,892 km^2 and 4,317 km^2, respectively).

MERIS



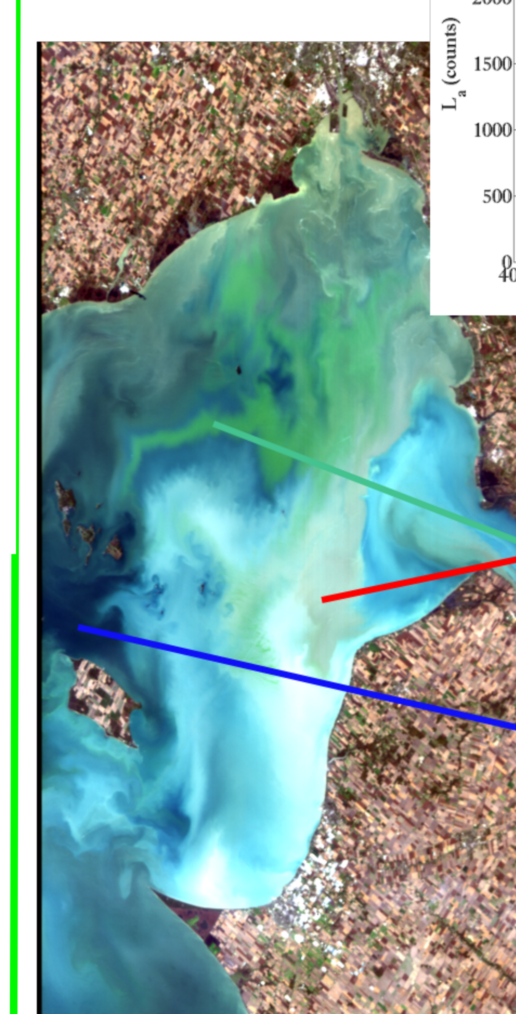
GOCI

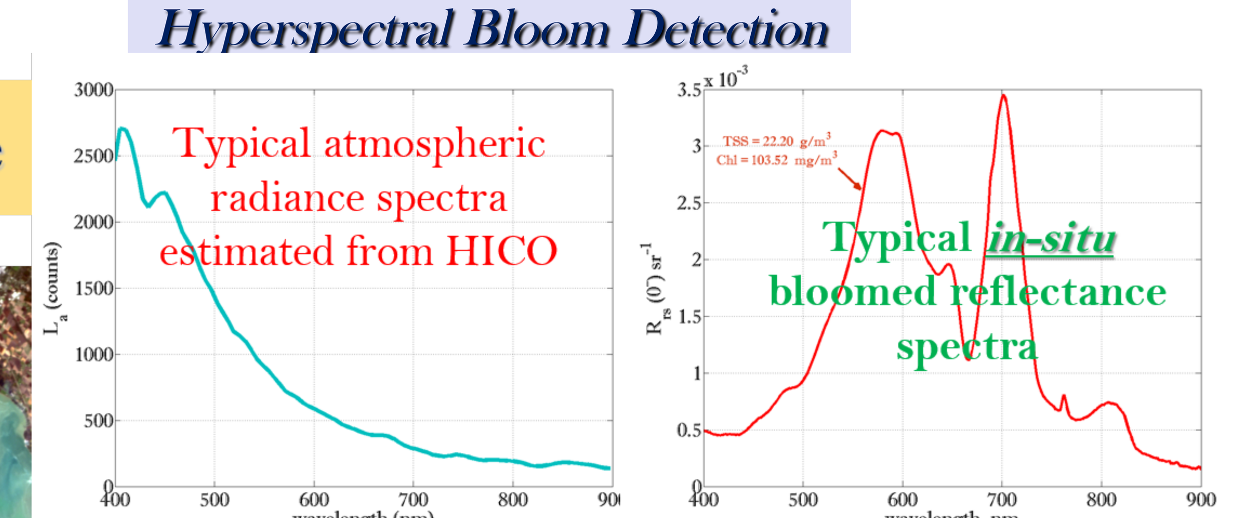


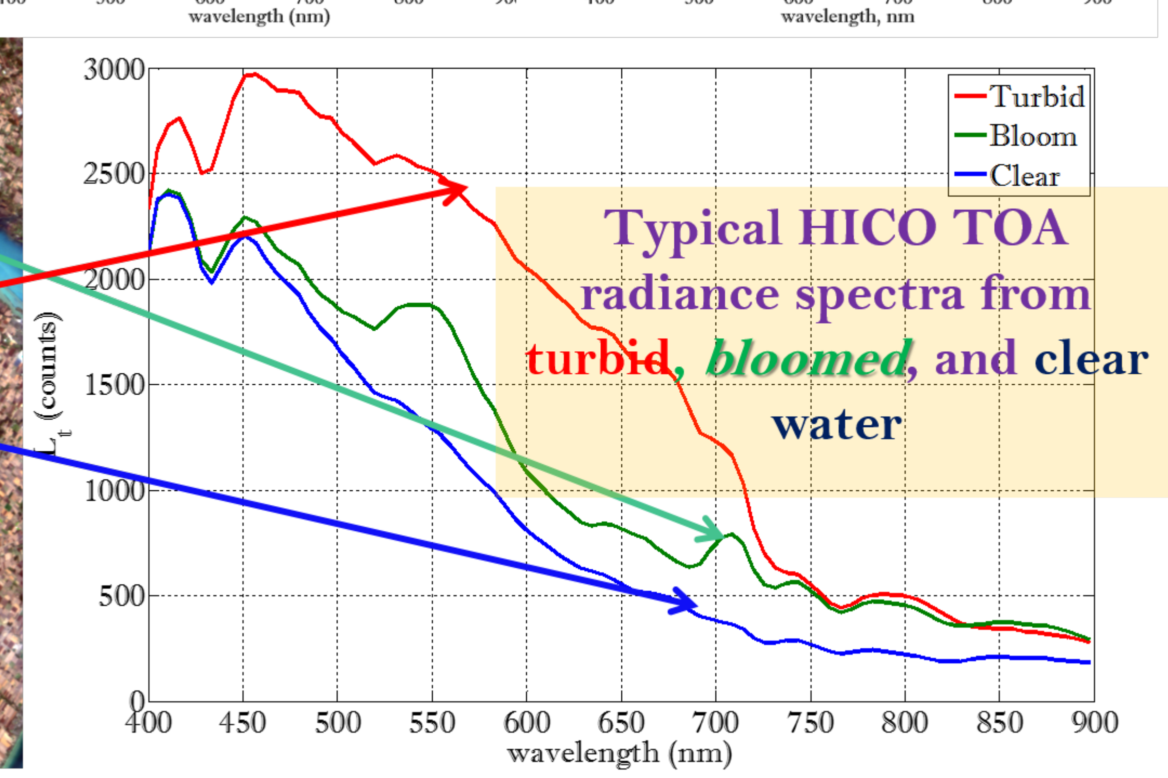
MODIS ocean color products from April 5, 2011, acquired at 04:00 GMT: chlorophyll image, fluorescence line height (FLH) image, and red band difference (RBD) image. GOCI ocean color products (data processed with GOCI data processing system GDPS) from April 5, 2011, acquired at 04:16 GMT: chlorophyll image, FLH image and RBD image. Sediment rich region (red box), false high chlorophyll region (green box), and the algal bloom region (red circle).

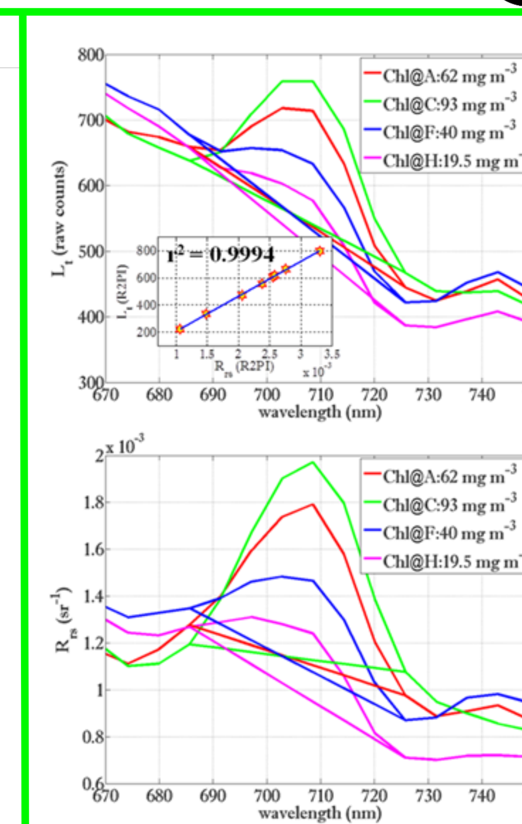
Hyperspectral Bloom Detection

HICO Image

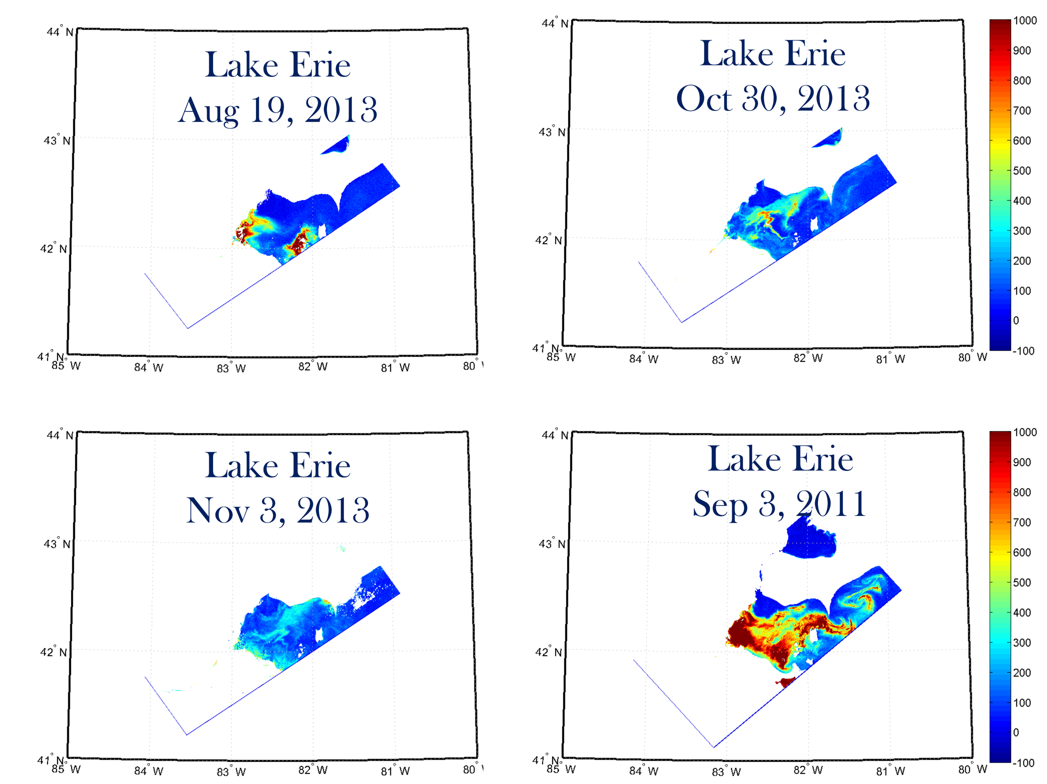








Red-NIR peak is observable on the TOA radiance or raw digital counts and can be used as an indicator of the bloom. Due to the shifts in the spectral minima and maxima, we use minima at the left and right side of the peak to create a baseline. When the baseline is subtracted from the peak, background signal gets removed automatically. Thus it does not require any atmospheric correction.



CONCLUSION

- This study complements previous studies using the RBD technique and shows that the RBD technique is indeed an effective detection tool for dinoflagellate blooms such as *K. brevis*.
- This study also shows that blooms can be detected directly from the hyperspectral raw digital counts or radiance at sensor's attitude. This results in minimal errors from imperfect atmospheric corrections or calibration.
- This study also demonstrates the value of including the chlorophyll fluorescence channel in future satellite sensors such as those being planned for the NASA's hyperspectral Pre-Aerosol-Cloud-Ecosystem (PACE) and Hyperspectral Infrared Imager (HyspIRI)) missions.

ACKNOWLEDGEMENTS

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