Cyanophyte and algal composition of the 2015 CyanoHAB Bloom in Sandusky Bay, Lake Erie

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Growing Water Quality Concerns in Lake Erie

- ✧Reduce oxygen levels and cause unwanted taste, color, and odor
- ✧Researchers are looking for ways to monitor, assess, and predict algal blooms
- ✧Use Varimax-rotated PCA to unmix the signal

August, 2014

Grand Lake St Marys (photo J. Ortiz)

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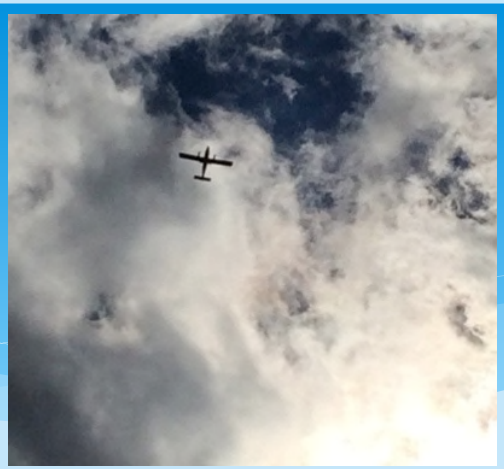
Mirror Based Atmospheric Correction or "White Reference" Calibration



- Use with NASA Glenn HSI2 images
- Provides basis for empirical calibration of radiance measurement from air-borne or space-borne assets
- Advantages that you obtain synchronous measurements of downwelling irradiance and upwelling radiance with the same sensor

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2015 SPARC Mirror Calibration in Sandusky Bay

- Deployed arrays of concave mirrors on floats or from land stations (Derived from Stephen Schiller's SPARC method)
- Concave mirrors reflect irradiance signature back to sensor without saturation
- Embeds a signal related to scene downwelling irradiance into the image

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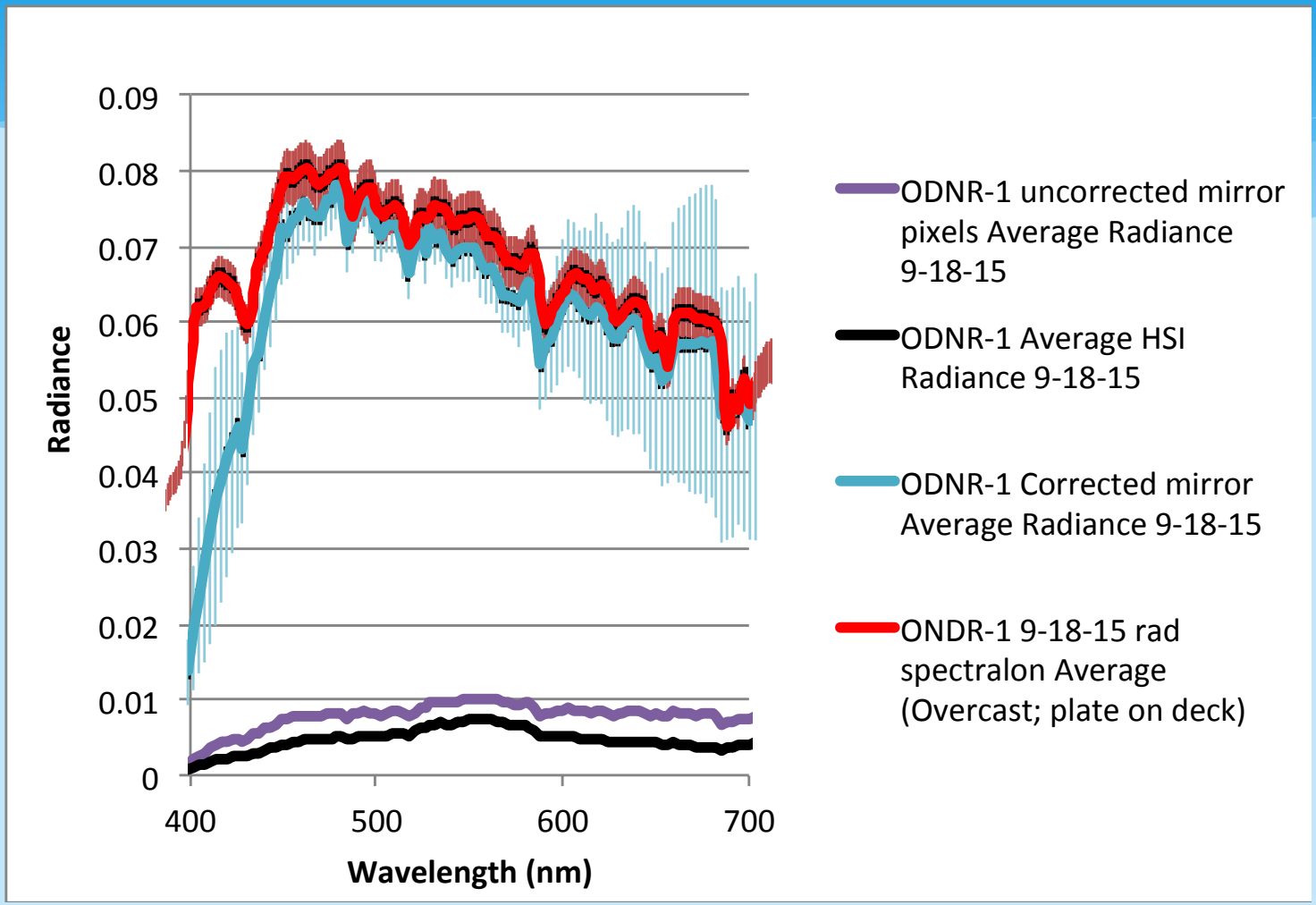
Verification of Empirical mirror gain function correction

- Results agree within 1-sigma from 430-700 nm
- Falloff below 430nm due to atmospheric scattering



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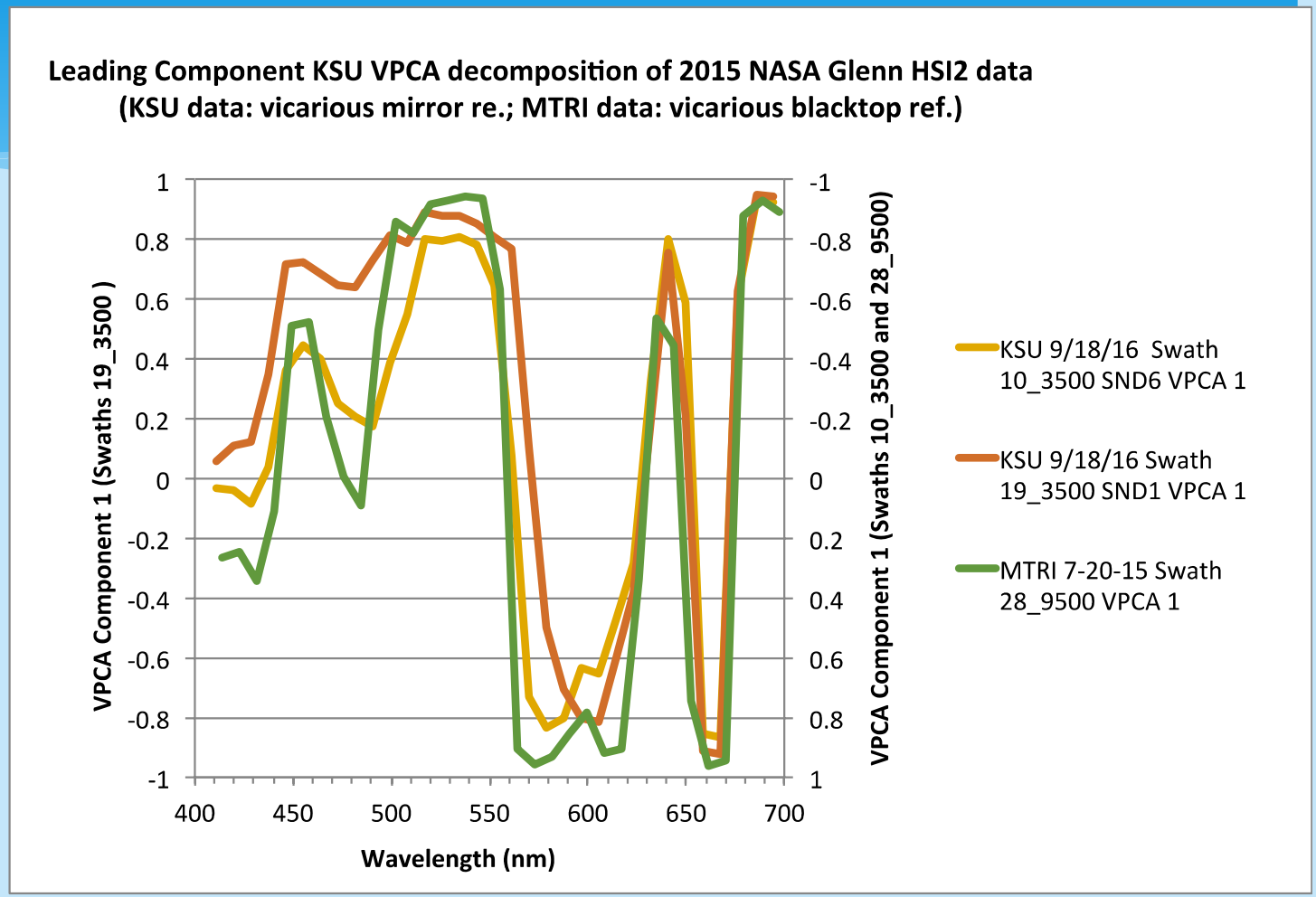
HAB-related signals from Sandusky Bay and Maumee Bay NASA HSI2 images



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2015 ASD FieldSpec HH Field Data Presented: Weekly 6-8-15 to 7-20-15 Additional samples until 10-9-15

ASD Field Spec HH measurement were collected along two 5-6 station transects

- Sandusky Transect
  - Inner bay from Muddy Creek to Outer Bay near mouth of Sandusky Bay
  - 0-25 km from Muddy Creek
- Central Basin Coastal Transect
  - Coastal samples generally <250 m offshore from Sandusky Bells toward Avon Point
  - 25- 150 km from Muddy Creek

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2015 Sandusky Bay and Central Basin Coastal Transect Stations

Figure 3. *Location of Sandusky Bay transect station sampled during summer 2015.*

Figure 4. *Location of the coastal zone transect stations eastward from Sandusky Bay.*

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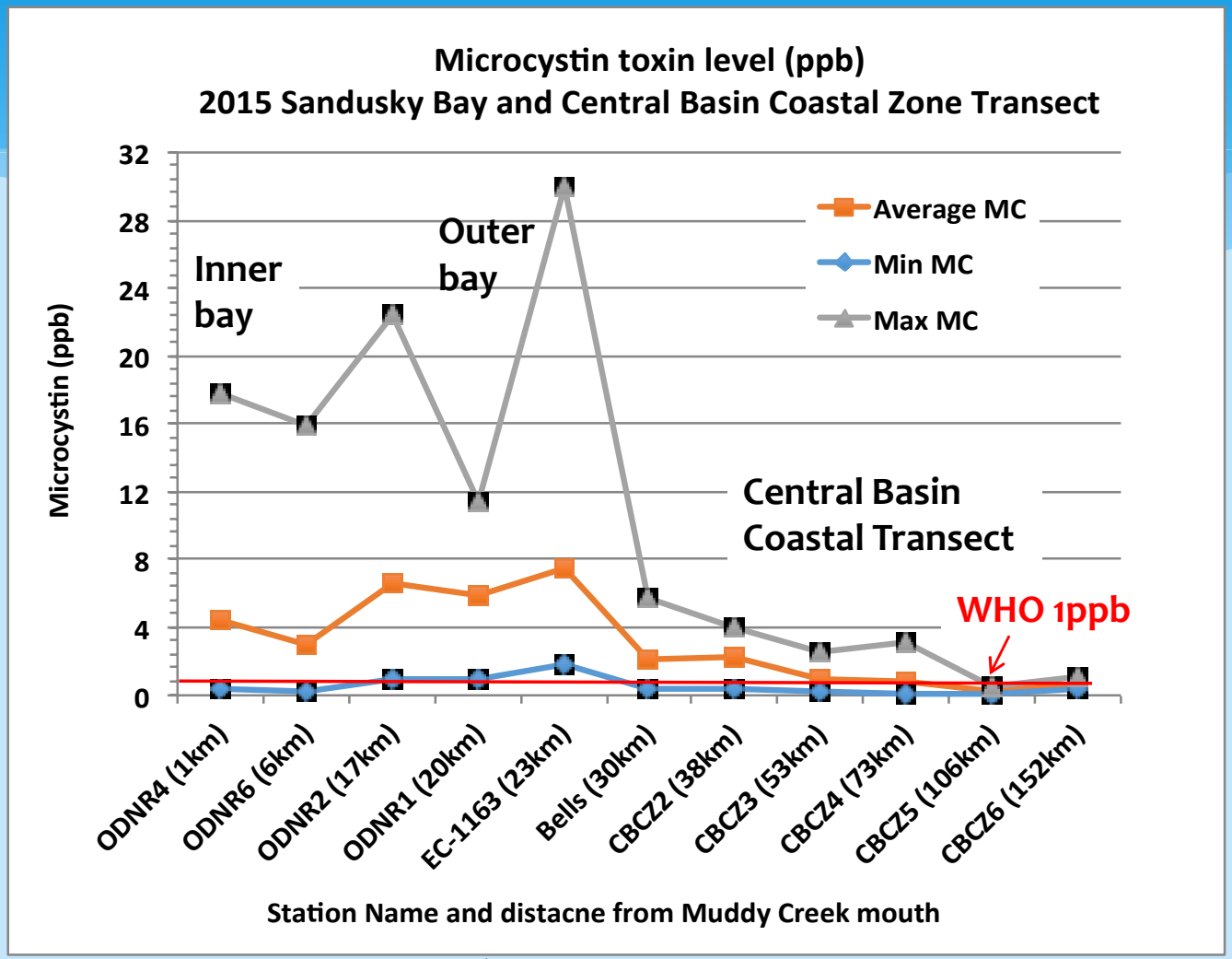
2015 Microcystin levels across the transects

- Microcystin was highest in the Outer bay
- Intermediate in the inner bay
- Lowest in the Central Basin
- Average MC of **4ppb** was above WHO **1ppb** limit 50-70 km from Muddy Creek



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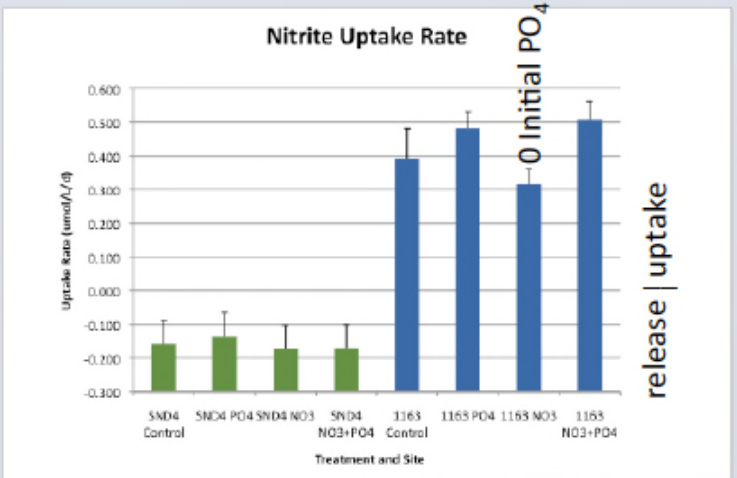
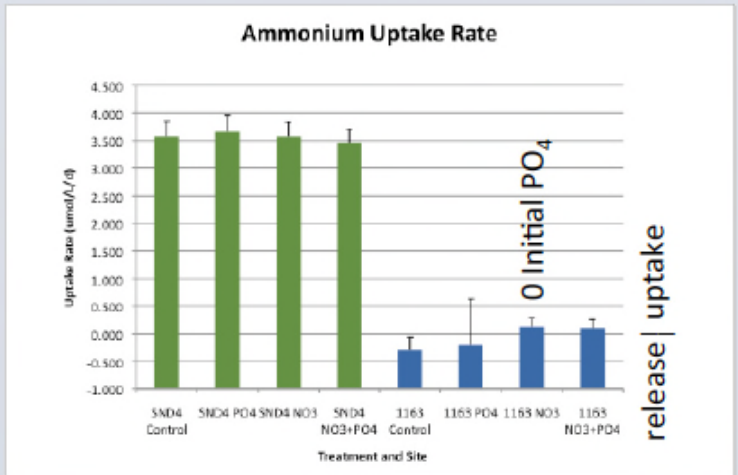
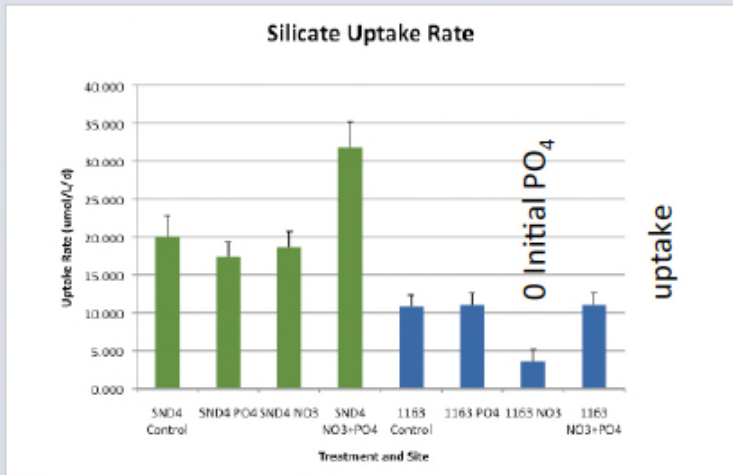
2015 Inner vs. Outer Sandusky Bay nutrient dynamics



Inner Bay Outer Bay



Inner Bay Outer Bay



Inner Bay Outer Bay

- Growth experiments at KSU REU by Kristen Slodysko document diatoms in Inner Bay and planktothrix in Outer Bay as late as June 28 2015
- Different nutrient dynamics in the inner (NH_4 & Silica uptake) and Outer Bay (Nitrite uptake)

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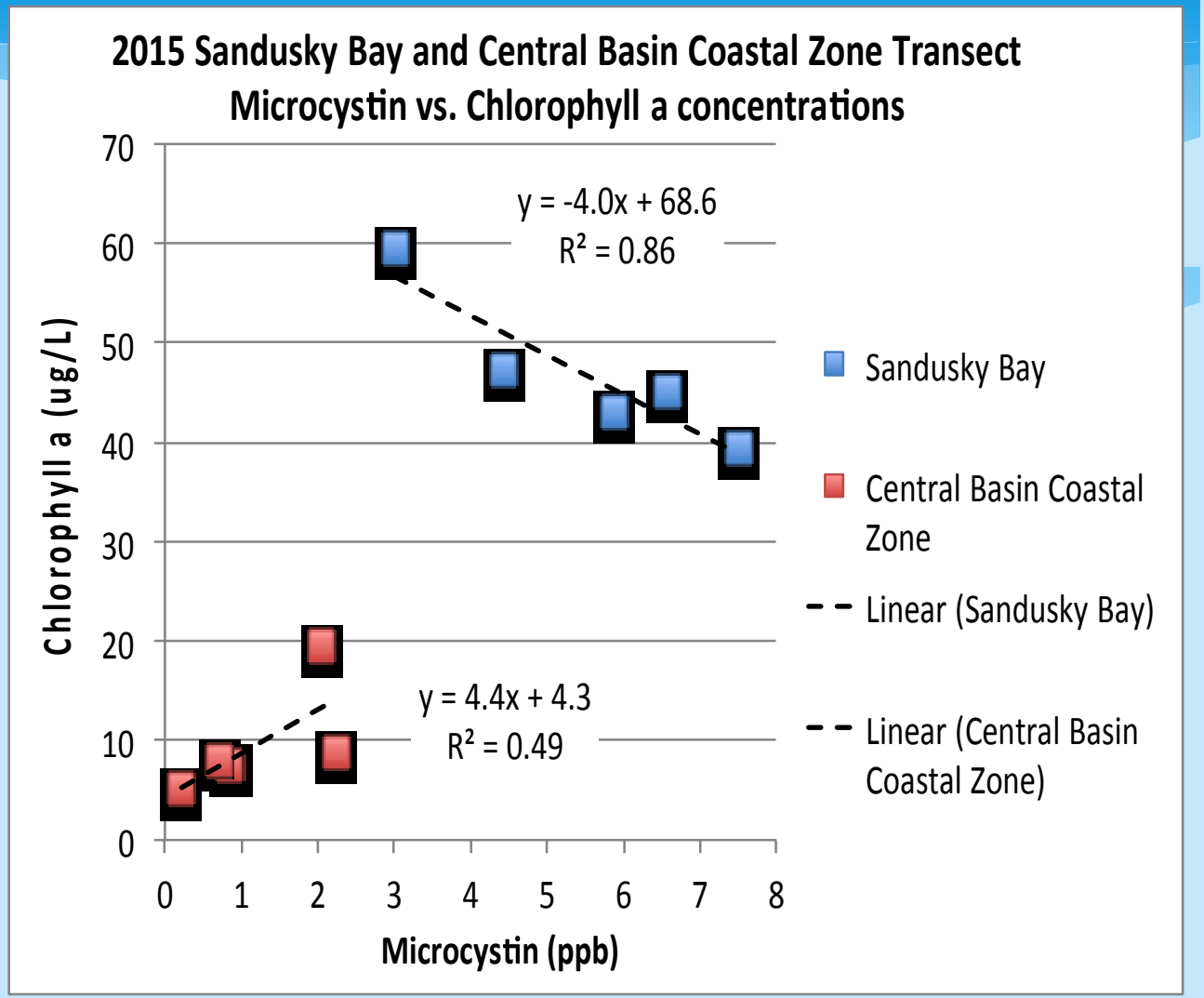
- ***Inverse relationship*** between chlorophyll a and microcystin in Sandusky Bay
  - Larger blooms were toxic
- ***Direct relationship*** between chlorophyll a and microcystin in Central Basin
  - Biomass in the central basin increases when plankton - some of which are toxic - are exported out of Sandusky Bay to the Central Basin



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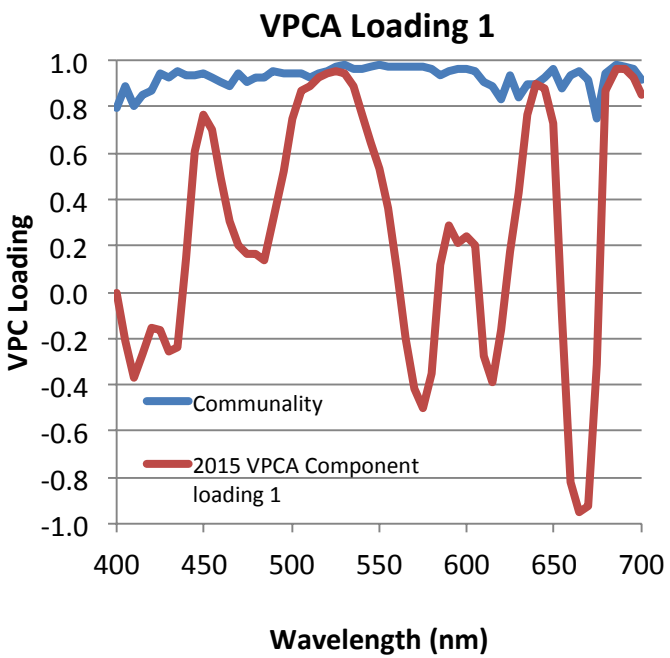
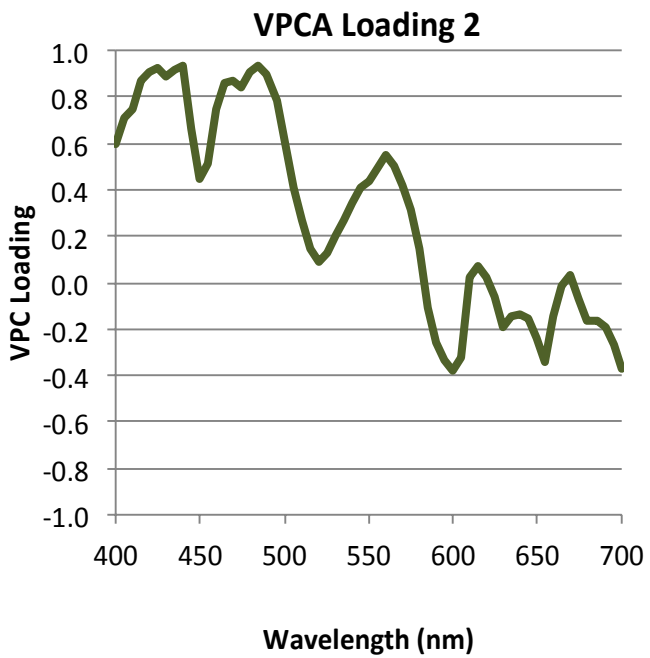
2015 ASD FieldSpec HH VPCA Components
CyanoHABs, algae and sediment

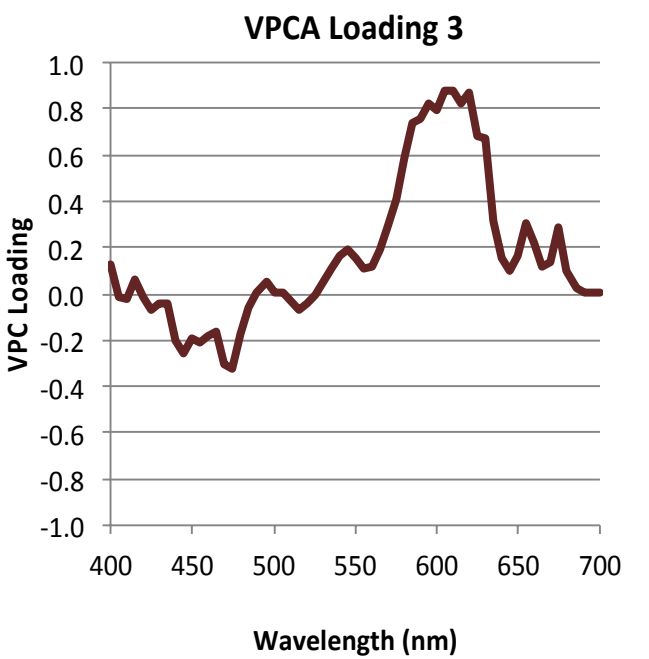
Cyanobacteria



Algae and Sediment



iron oxides



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- Both ***cyanobacteria*** *and* ***algae & sediment*** are present along the two transects
- ***Cyanobacteria*** decrease from Sandusky Bay to the Central Basin Transect
- ***Algae & sediment*** are in greater abundance in the Central Basin than in Sandusky Bay

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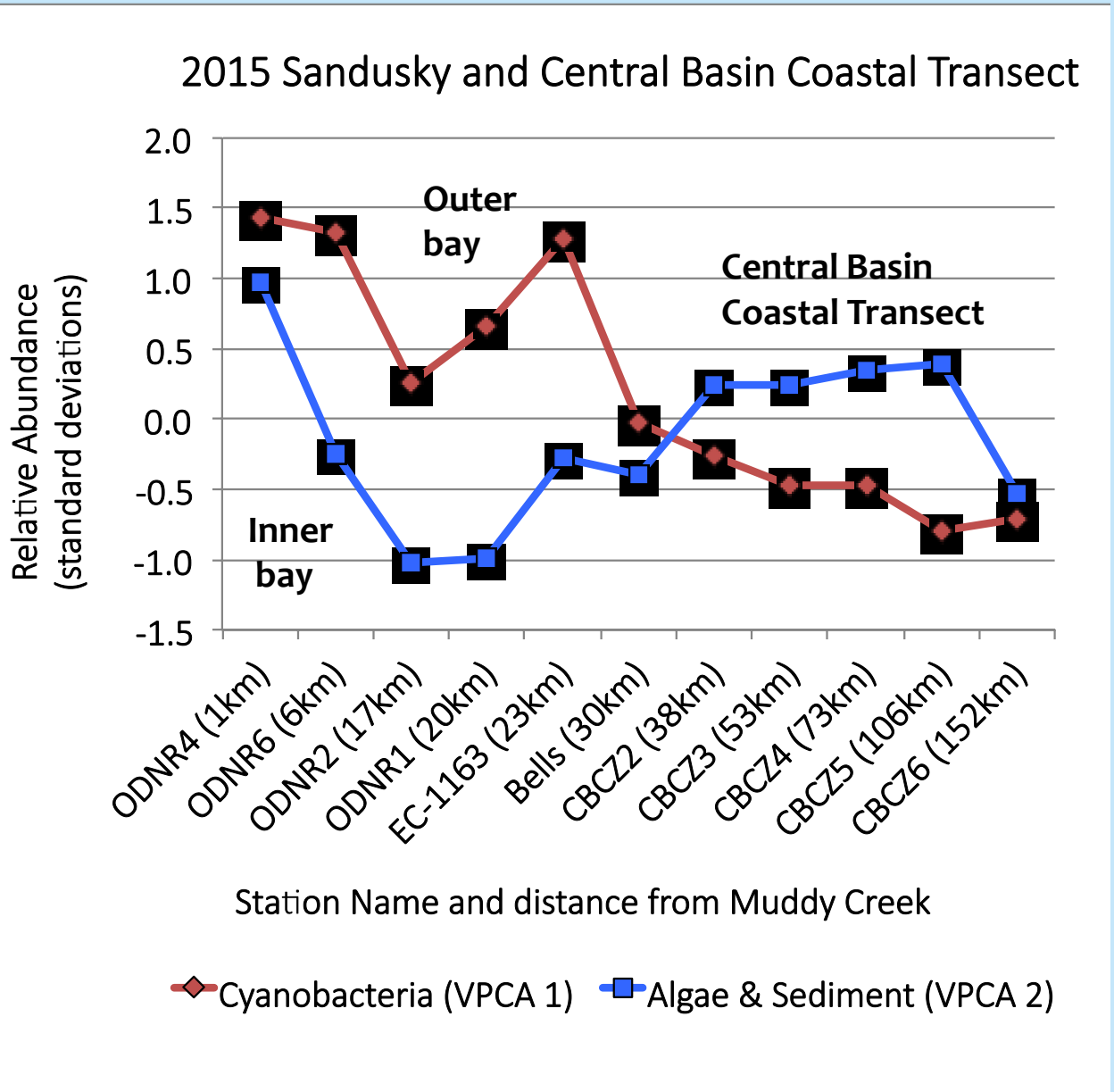
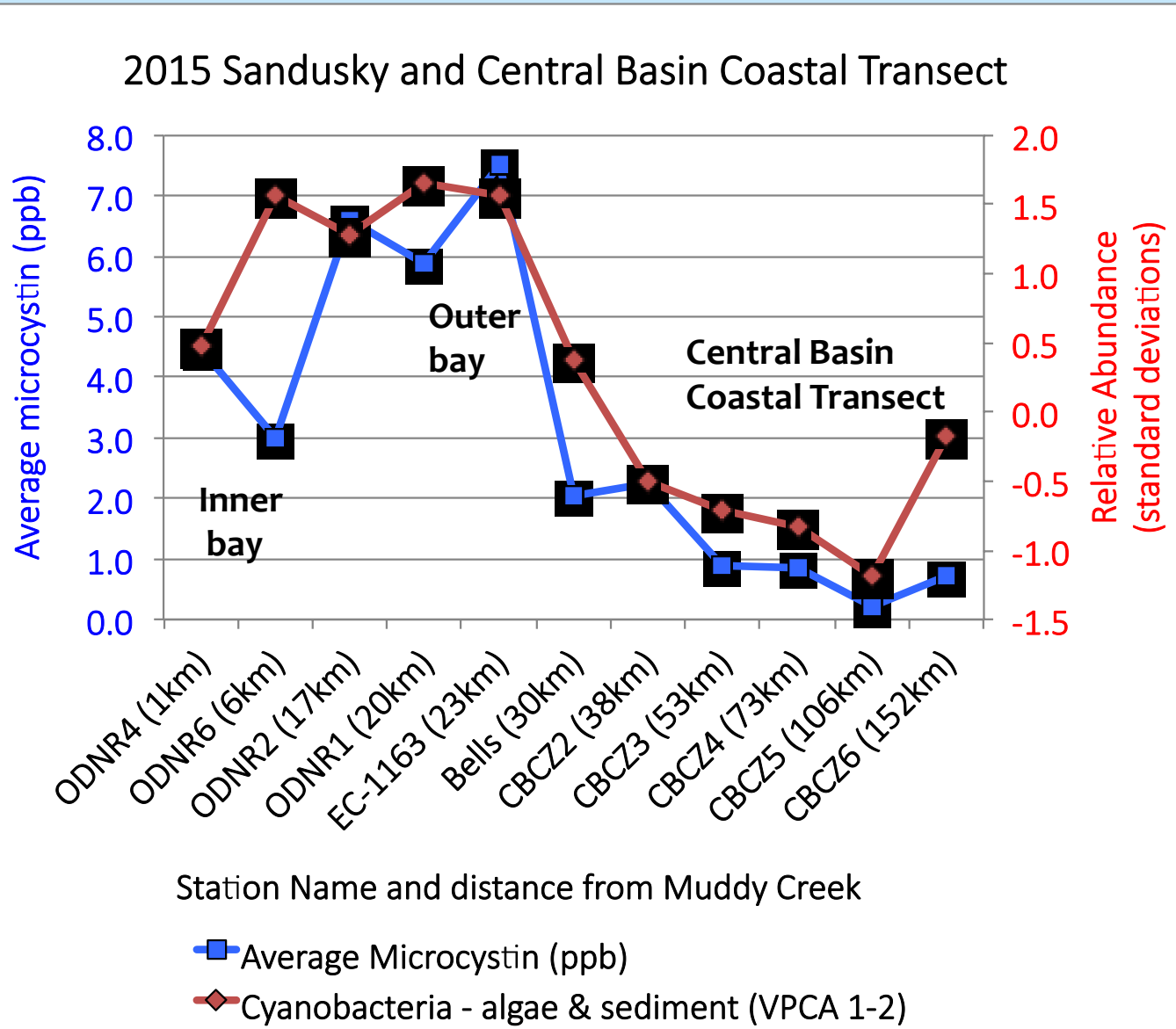


- Average spatial pattern of the difference between the cyanobacteria, algae and sediment follows the microcystin trend
- Microcystin production appears linked to this proportional relationship
- As toxic proportion of algae increases, microcystin content increases



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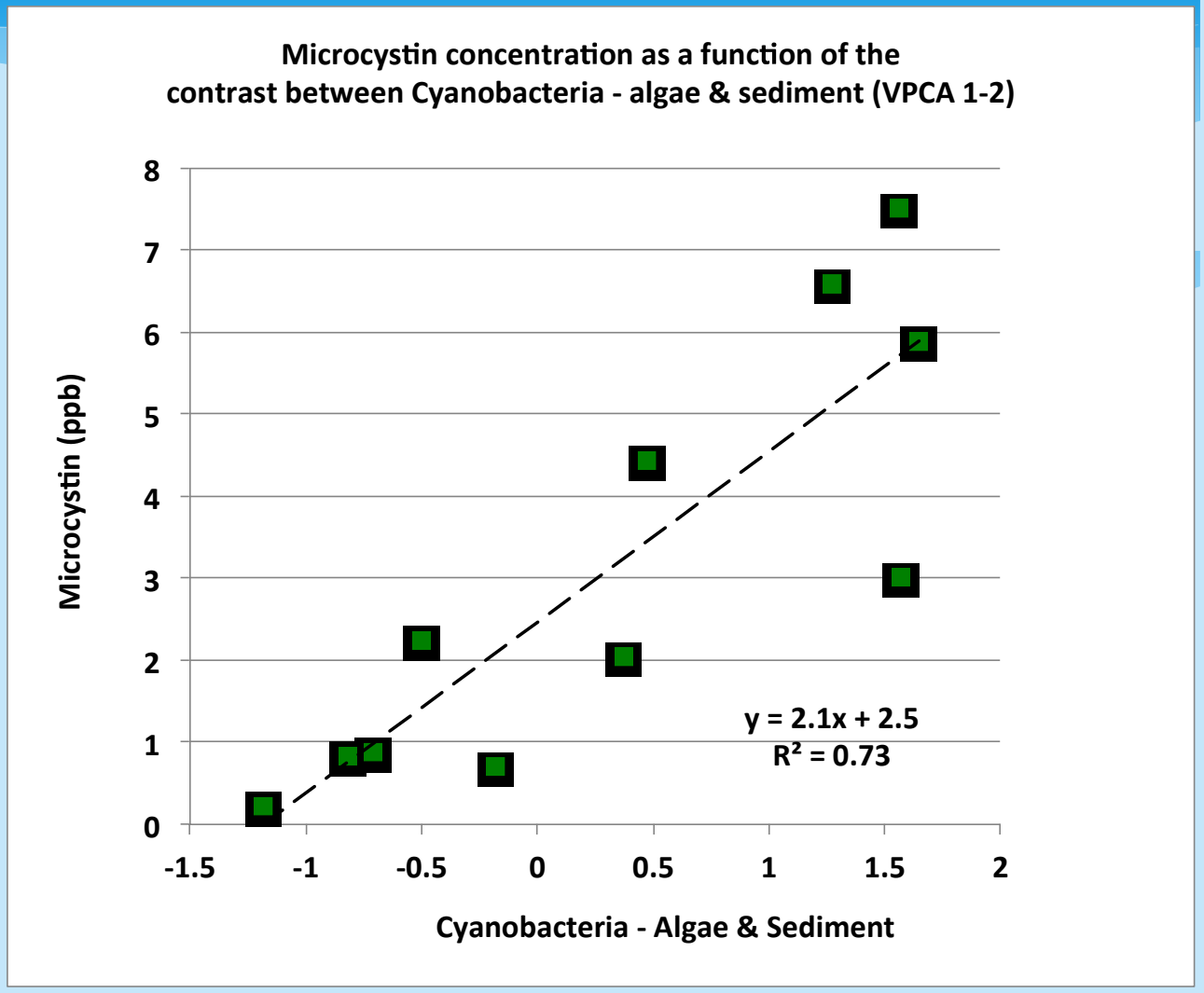
- Optical properties of the surface water measured by ASD spectroradiometers along the transects are statistically correlated with the microcystin content



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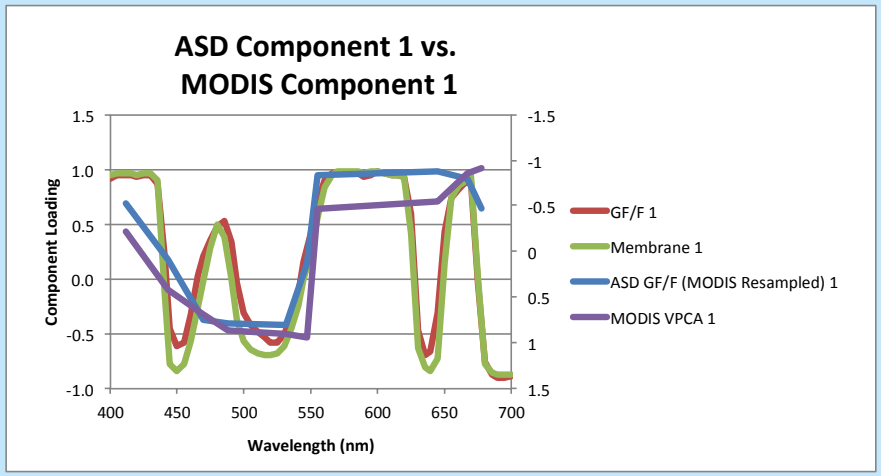
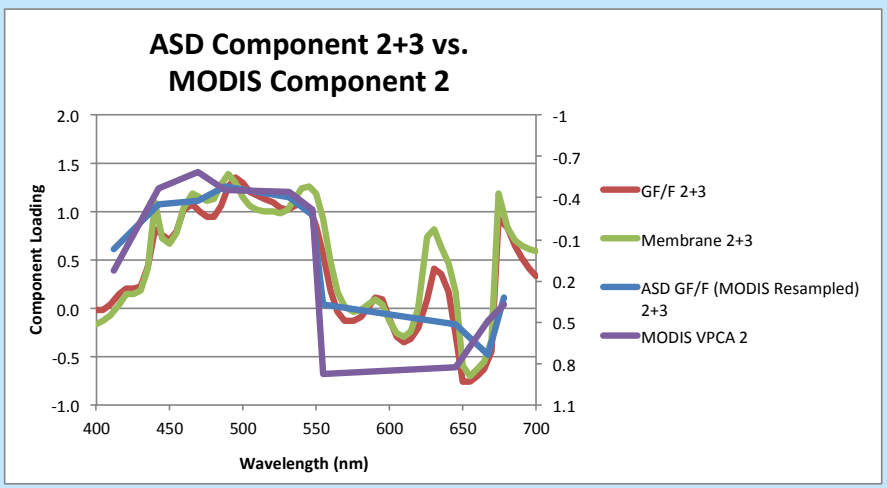
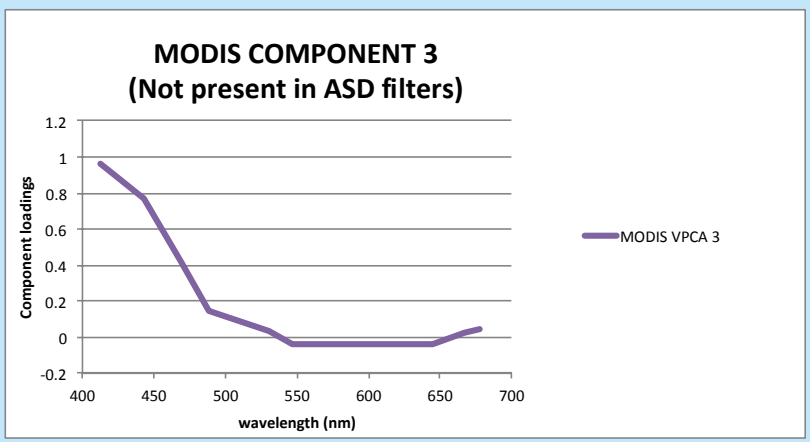
VPCA of Derivative Reflectance Spectra
MODIS Components vs ASD Components





- ASD Labspec and Fieldspec data pull more components than MODIS, although MODIS extracts a CDOM related component not present in the filtered Labspec results (Avouris et al., 2015)
- Leading MODIS component is cyanobacteria; 2nd component is algae and sediment; 3rd component is CDOM
- Accounts for 98.6% of the variance in the MODIS images



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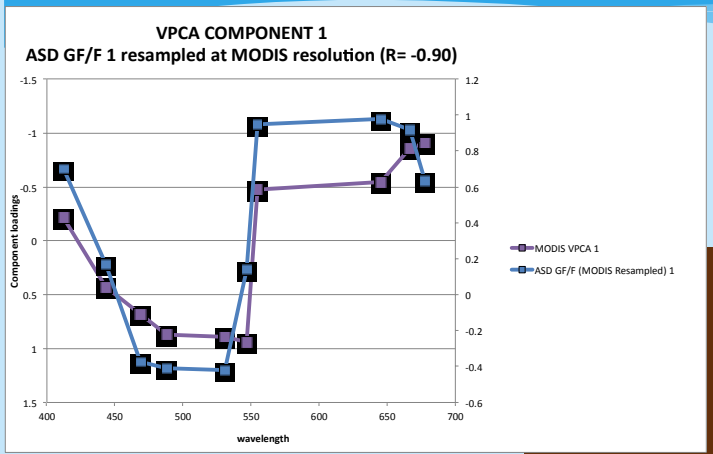
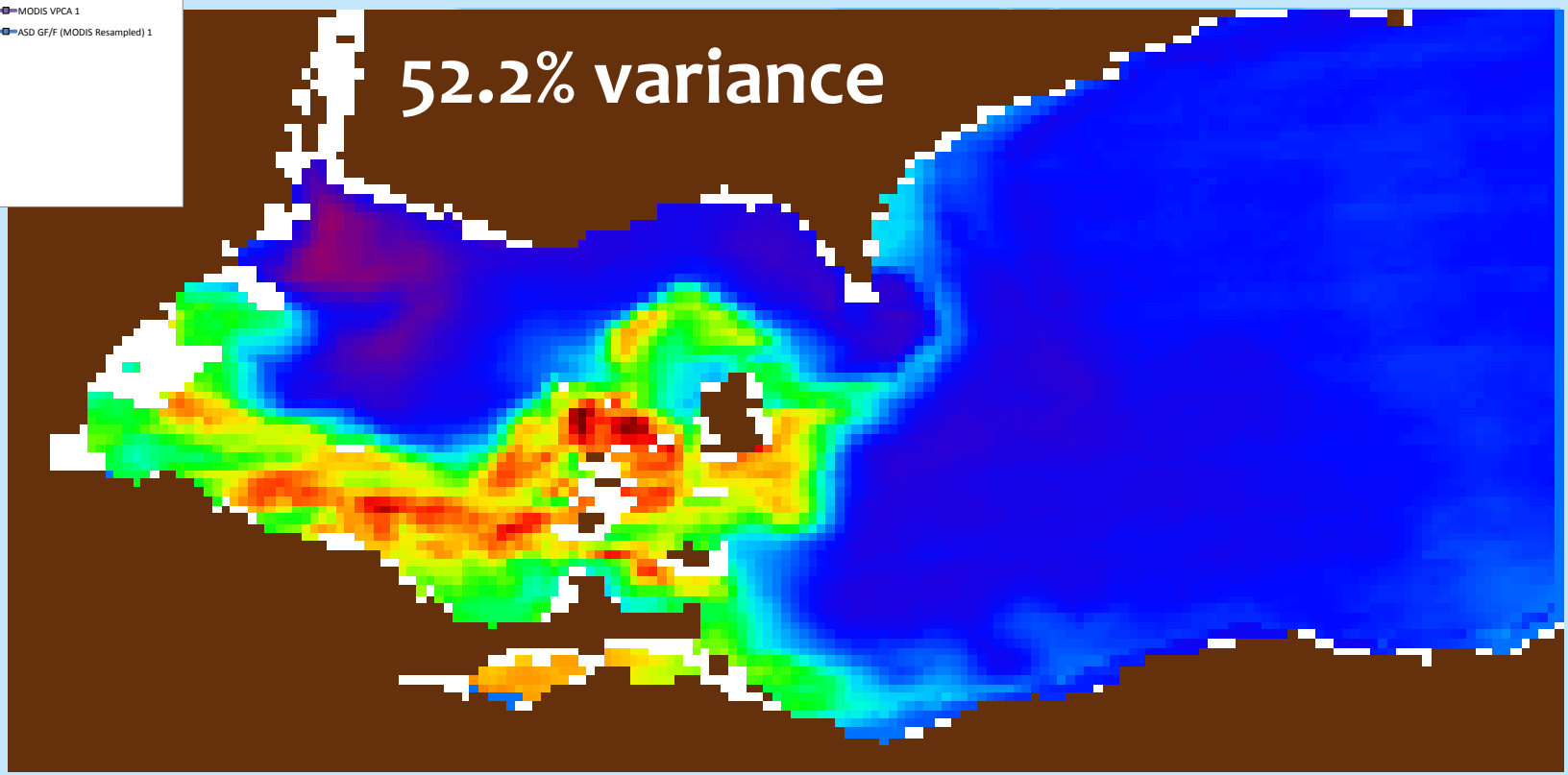
28 July MODIS decomposition
MODIS Component 1: Cyanobacteria





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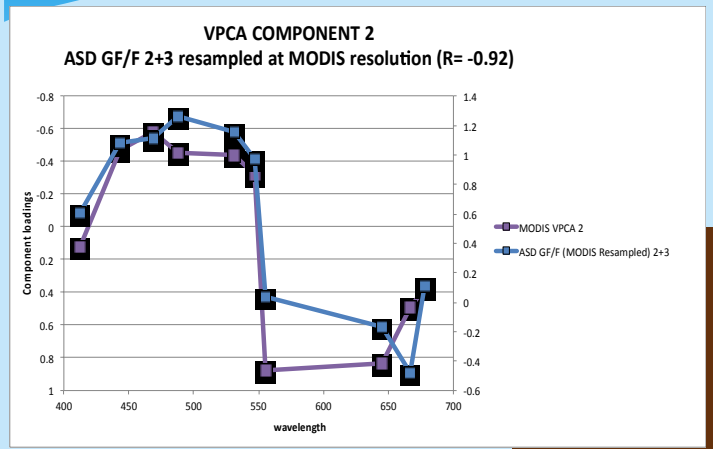
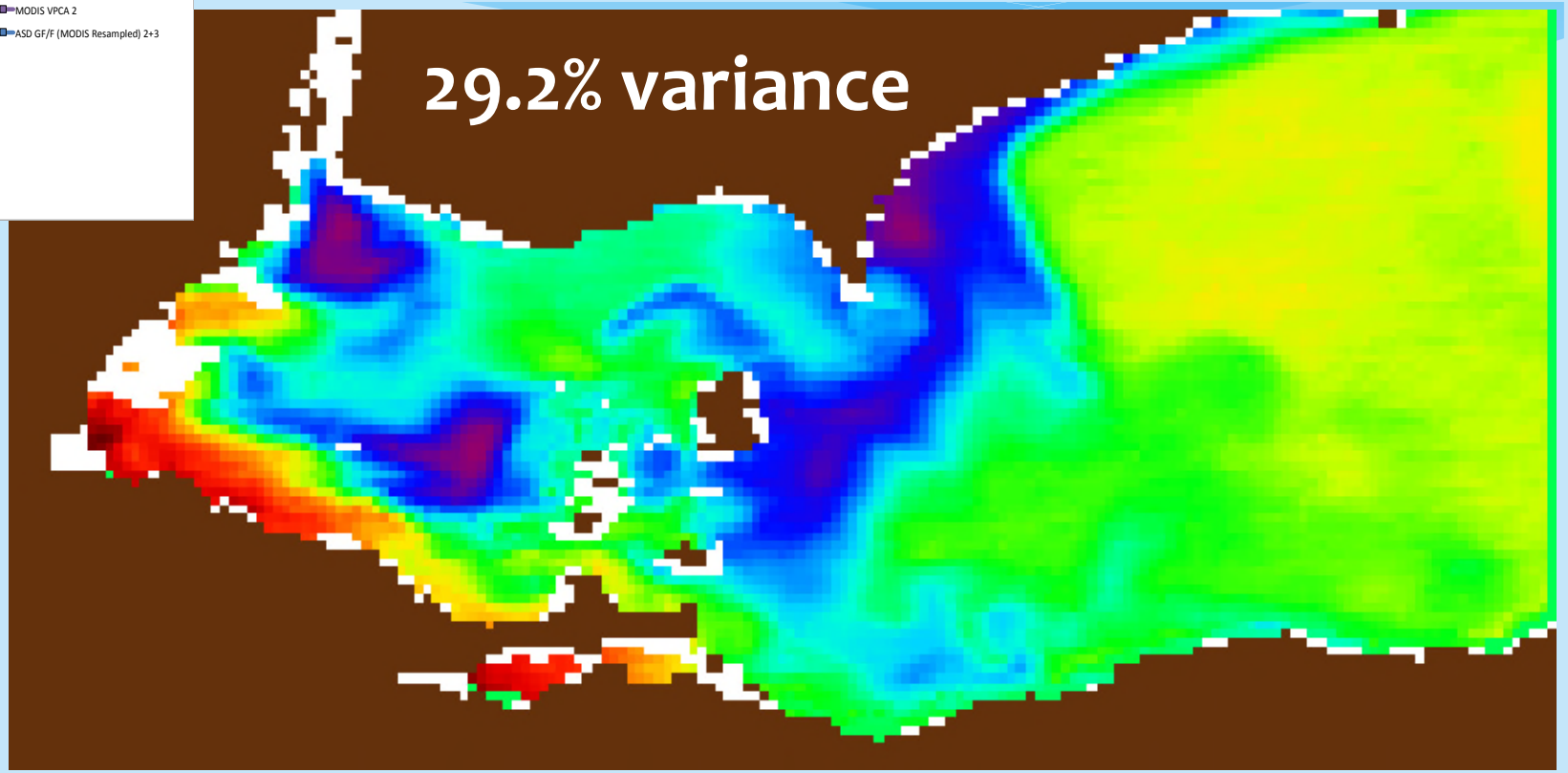
28 July MODIS decomposition
MODIS Component 2: Algae & sediment





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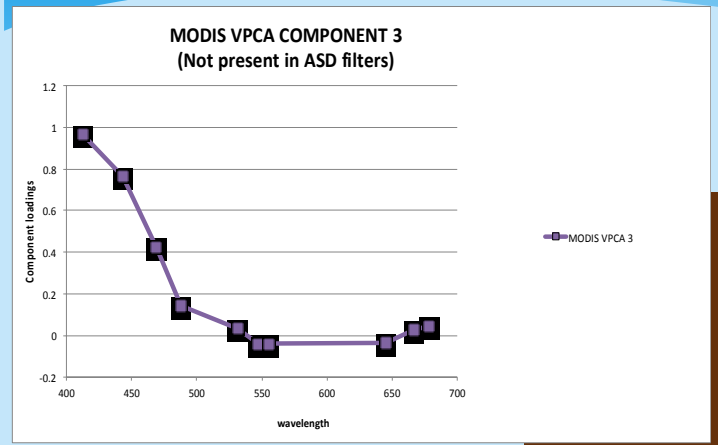
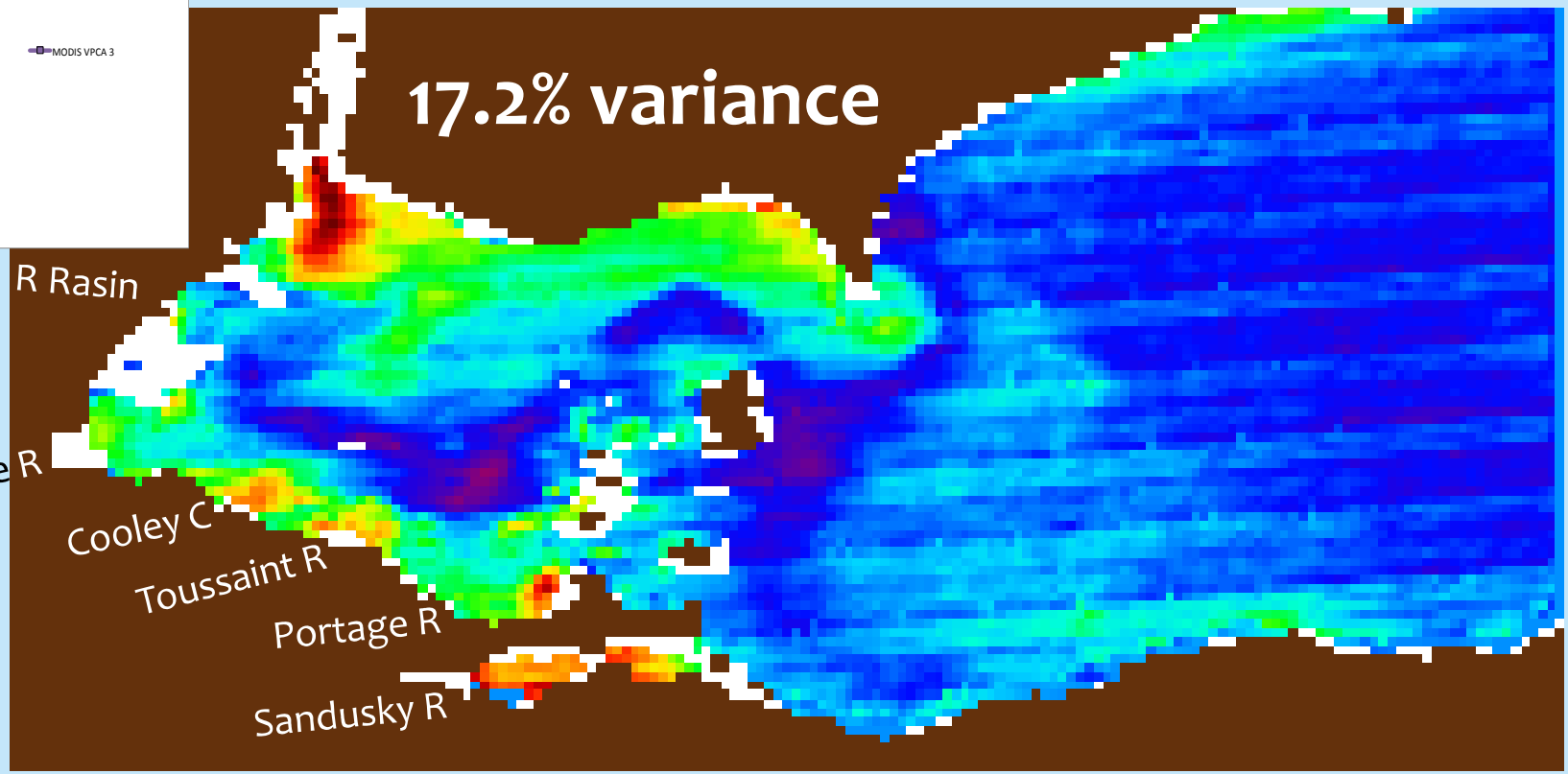
28 July MODIS decomposition
MODIS Component 3: CDOM



Detroit R.



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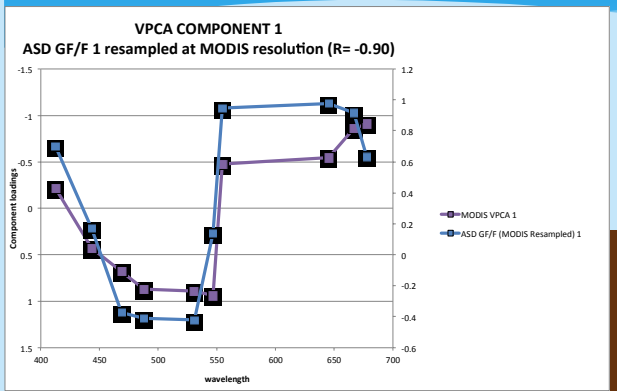
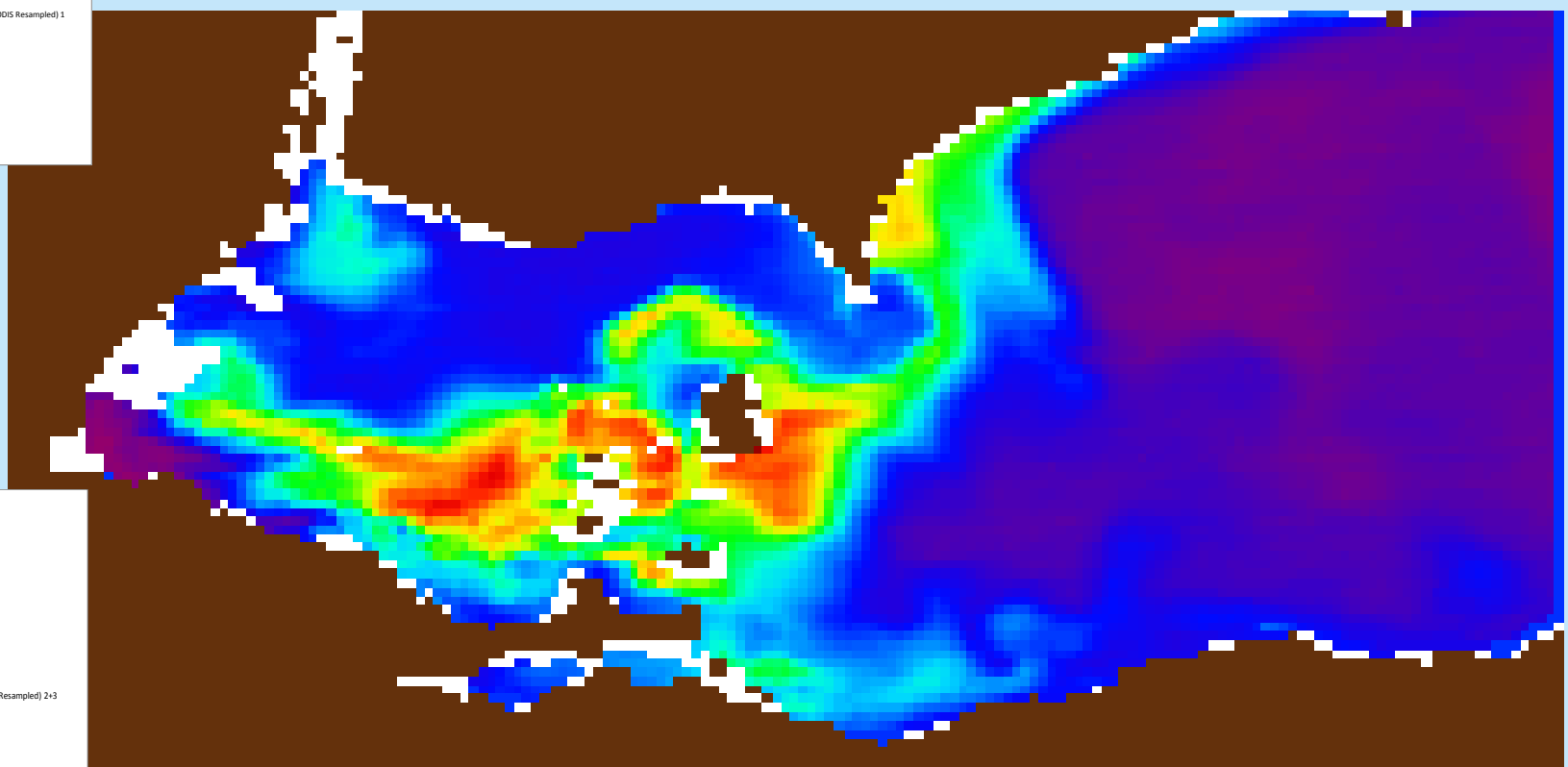
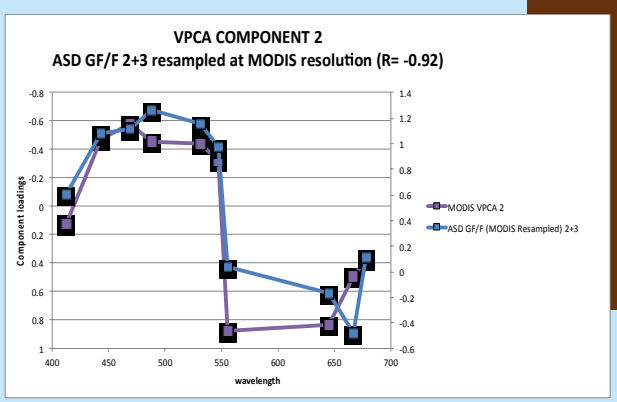
28 July MODIS decomposition

MODIS Component 1-2: Cyanobacteria – Algae & sediment







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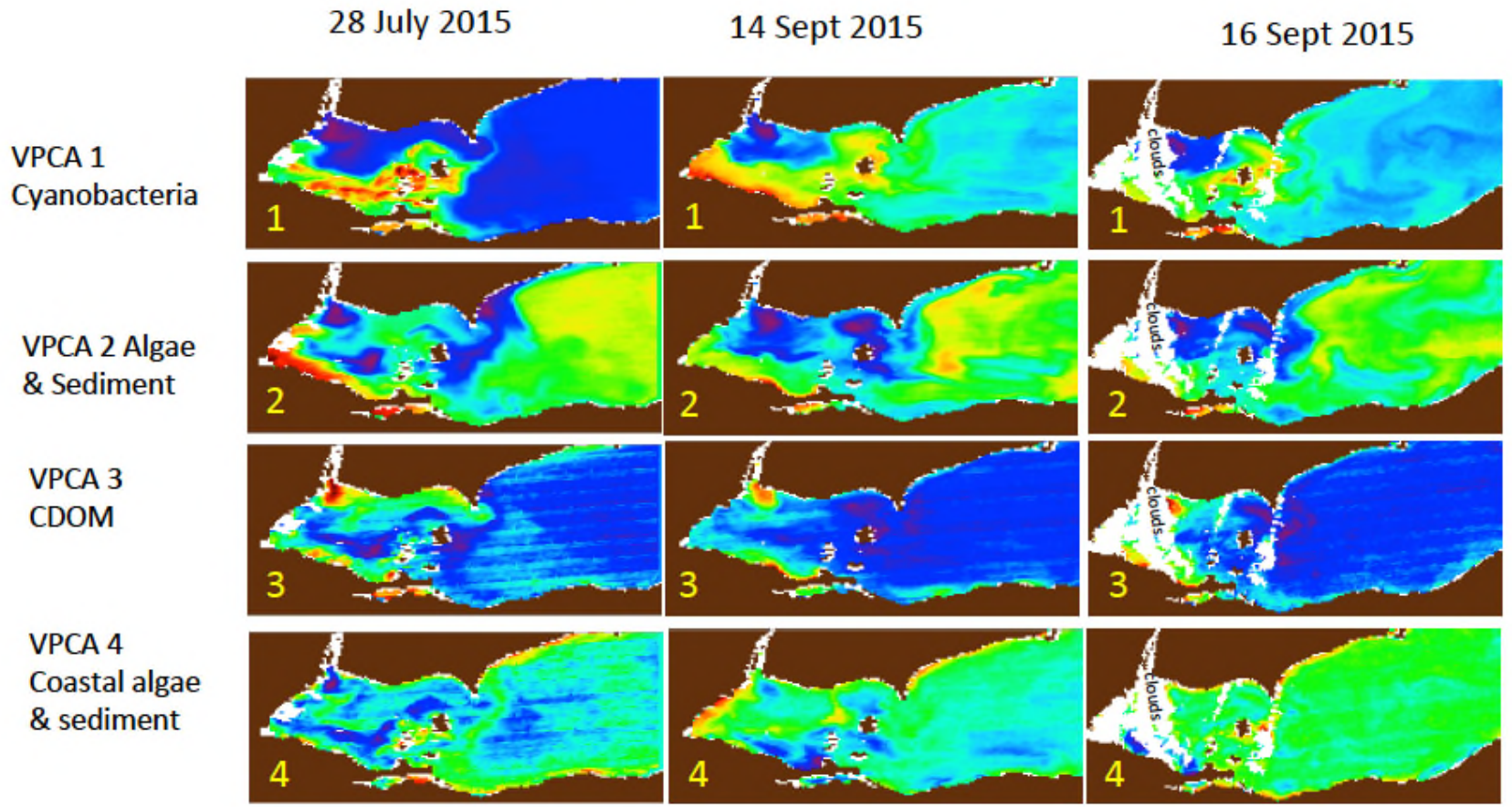
Kent State University
MODIS 4-Component Decomposition
Three day Comparison



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Summary

- ✧VPCA ties optical assemblages to cyanophytes, algae, CDOM and sediment
- ✧2015 Sandusky and Central Basin Coastal Transect field data documents export to toxic plankton from Sandusky to Central Basin
- ✧Relationship between microcystin and chl a is complex and geographically specific
- ✧But, relationship between microcystin and VPCA components is direct and linear
- ✧KSU VPCA method can be applied successfully to MODIS, Landsat
- ✧VPCA is well suited for application to Sentinel-3, HyspIRI, PACE: Makes use of all information present in hyperspectral spectra

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Recent Publications

- See Water quality webpage at: http://www.personal.kent.edu/~jortiz/home/wqr.html
- Ali, K.A., and **J.D. Ortiz**, Multivariate approach for chlorophyll-a and suspended matter retrievals in Case II waters using hyperspectral data, Hydrological Sciences Journal, 2014. DOI 10.1080/02626667.2014.964242.
- **Ortiz, J.D.,** Witter, D.L., Ali, K.A., Fela, N., Duff, M., and Mills, L., Evaluating multiple color producing agents in Case II waters from Lake Erie, International Journal of Remote Sensing, 34 (24), 8854-8880, 2013.
- Mou, X, Jacob, J., Lu, X., Robbins, S., Sun S.**, J.D. Ortiz.** Diversity and distribution of free-living and particle associated bacterioplankton in Sandusky Bay and adjacent waters of Lake Erie Western Basin, Journal of Great Lakes Research 2013.
- Ali, K.A., Witter, D.L., and **J.D. Ortiz**, Application of empirical and semi-analytical algorithms to MERIS data for estimating chlorophyll a in Case waters of Lake Erie, Environmental Earth Sciences; DOI 10.1007/s12665-013-2814-0, published Oct 1, 2013.
- Ali, K.A., Witter, D.L., and **J.D. Ortiz**, 2012, Multivariate approach to estimate color producing agents in Case 2 waters using first-derivative spectrophotometer data, Geocarto International, Early online release: 10/30/2012 DOI:10.1080/10106049.2012.743601.
- Witter, D., **Ortiz, J.D.**, Palm, S. Heath, R., Budd, J., Assessing the Application of SeaWiFS Ocean Color Algorithms to Lake Erie, Journal of Great Lakes Research, 35, 361-370, 2009.