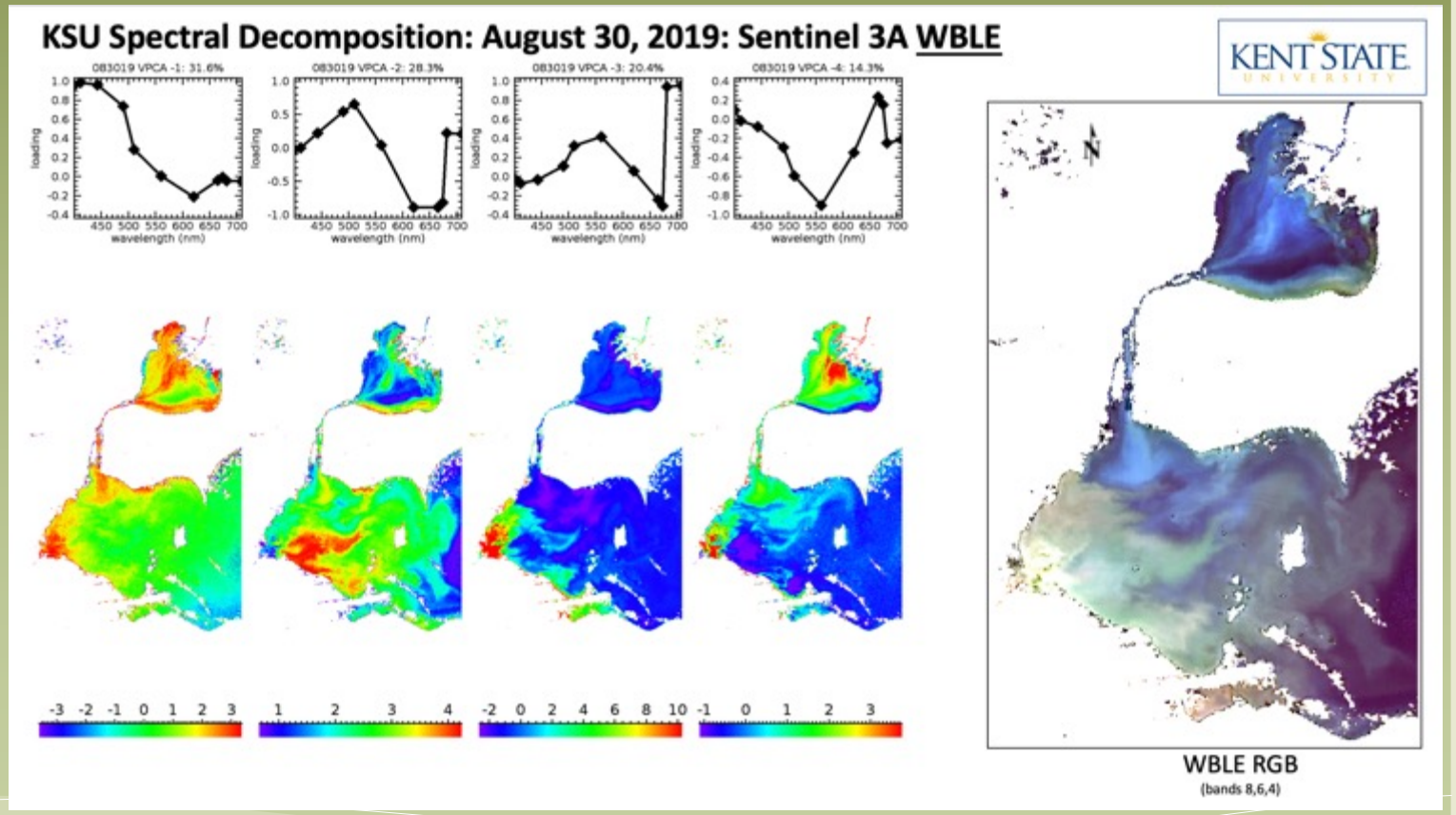
Porting VPCA to Google Earth Engine: Harmful algal blooms and Benthic cover

Dr. Joseph Ortiz (jortiz@kent.edu)
Kent State University
Department of Geology

Today's talk

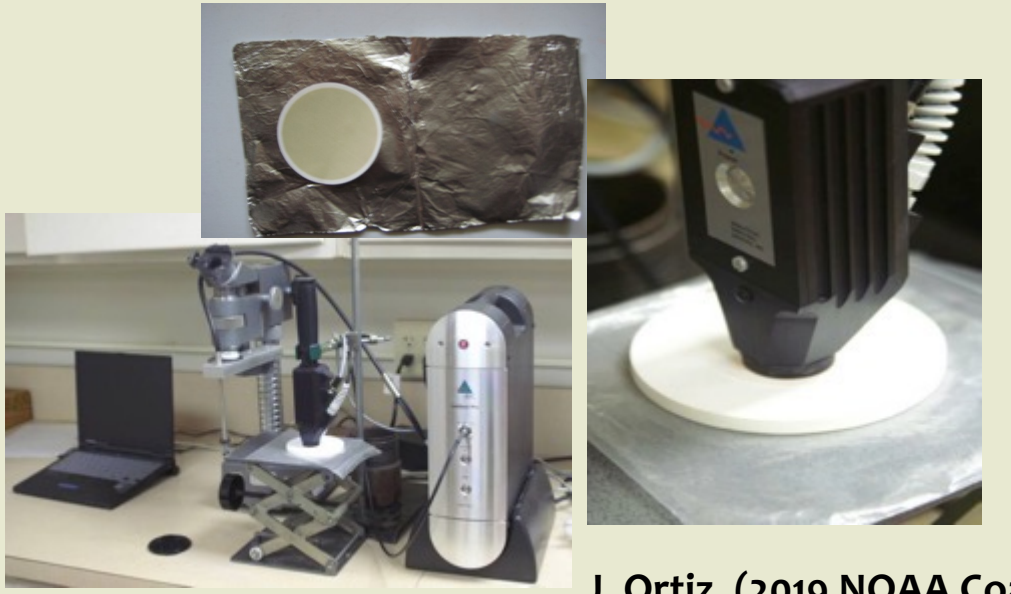
1. Lake Erie
2. Indian River Lagoon
3. Examples in GEE
    1. Landsat 8 HABS
    2. Sentinel 2 HABS
    3. Sentinel 2 Benthic cover

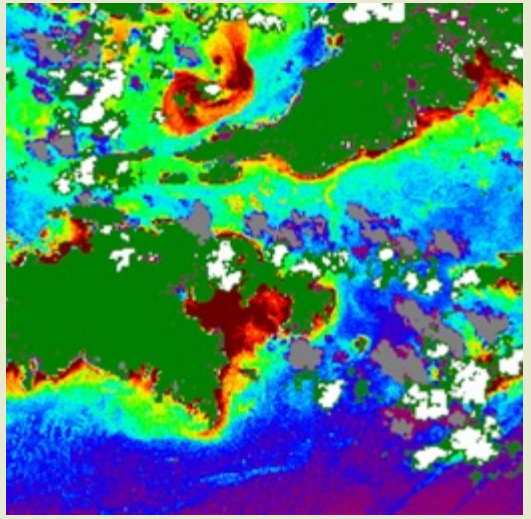


KSU VPCA spectral decomposition from Sentinel 3A OLCI Lake Erie August 30, 2019

The Kent State Approach

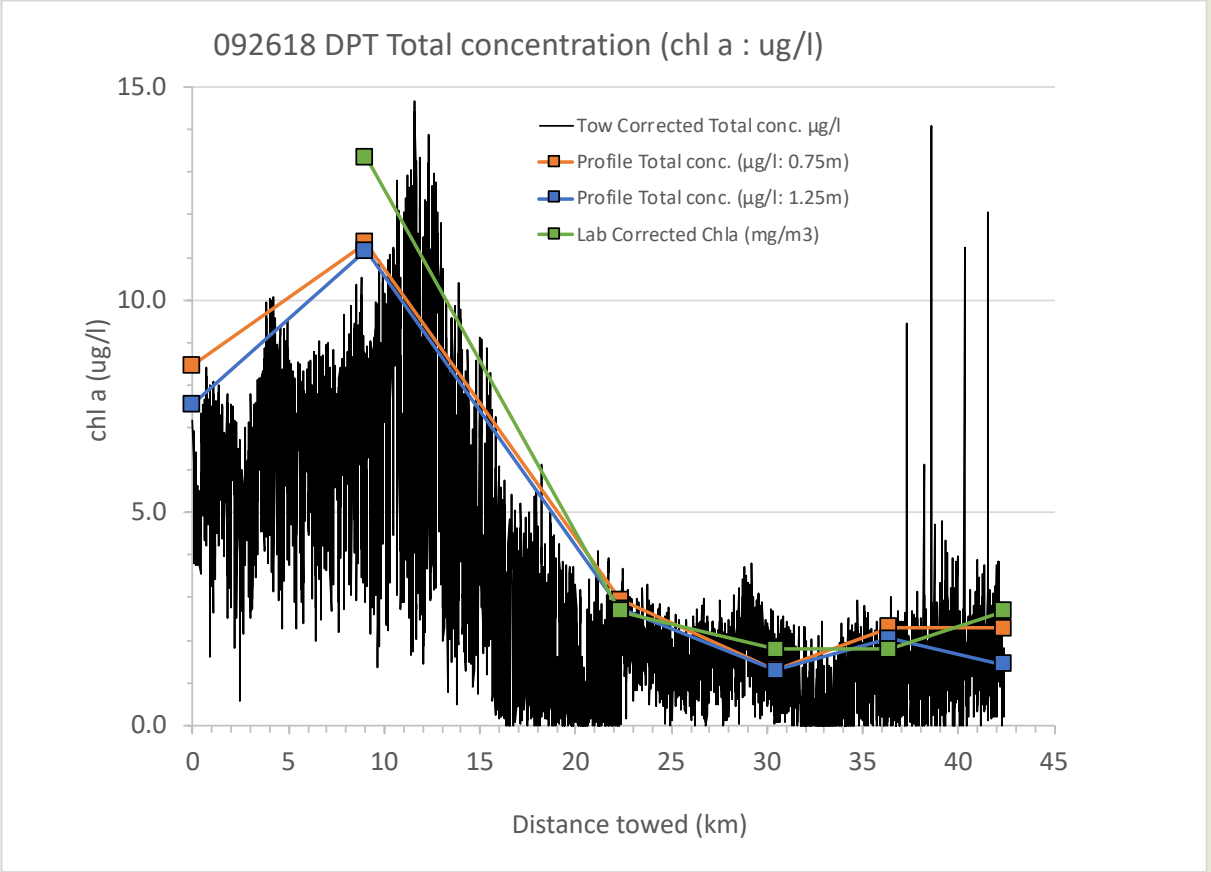
- Goal: Quantify the relationship between phytoplankton pigments and phytoplankton assemblages from Field Samples, Field Spectroradiometers, Remote Sensing data
- Objectives –
  - Measure water samples by visible derivative spectroscopy
  - Match spectral pigment assemblages to known signatures for classes of phytoplankton
  - Compare pigment assemblages to measures of concentration in the lake (Cell counts, pigments, degradation products, genomics).





J. Ortiz, (2019 NOAA Coast Watch meeting ; jortiz@kent.edu)

Lake Erie 9/26/18, Detroit Plume Transect Sampling



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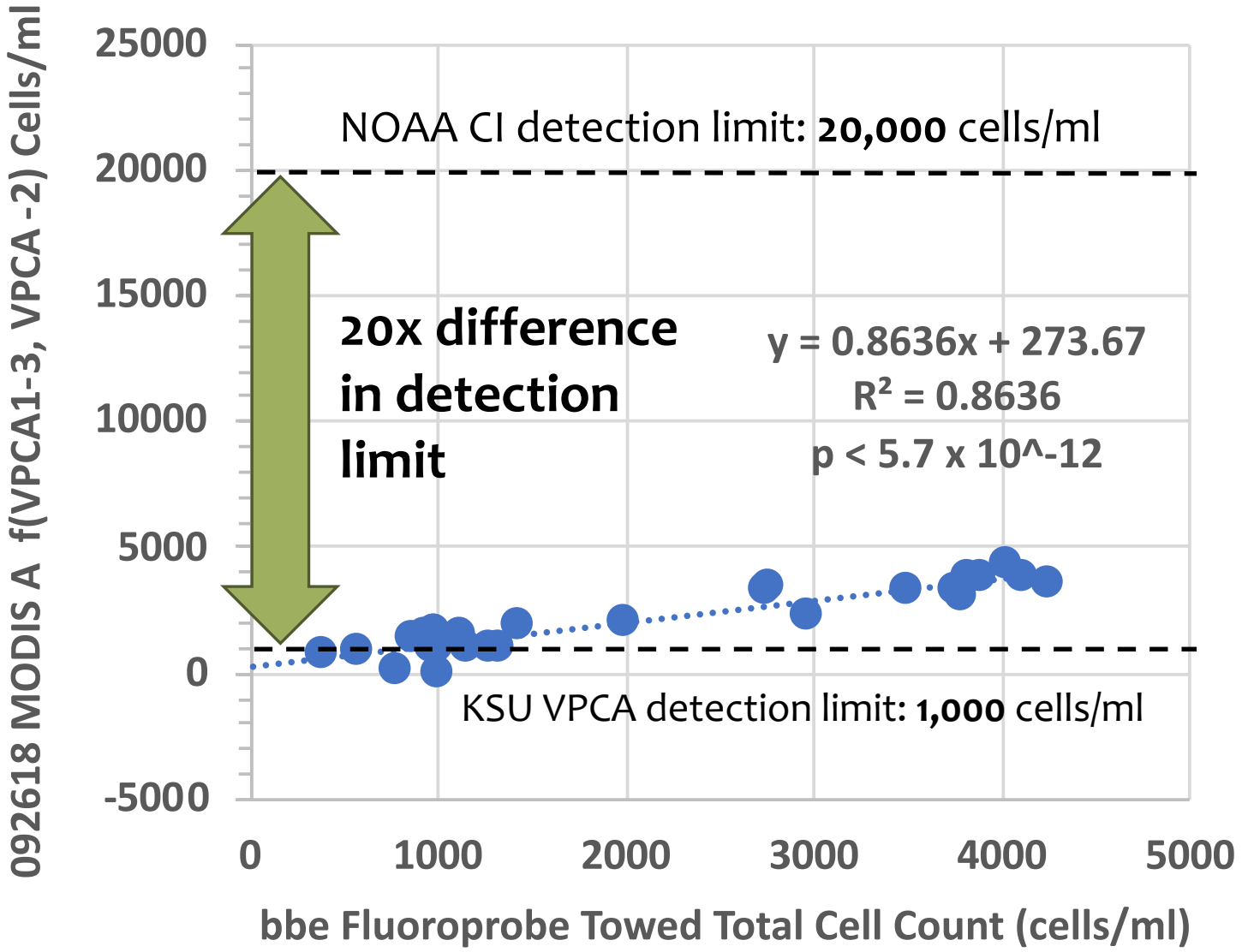
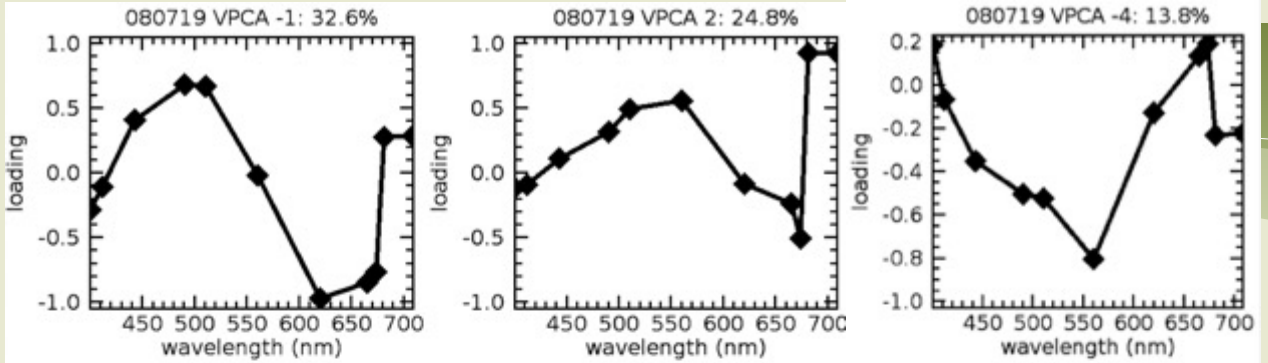
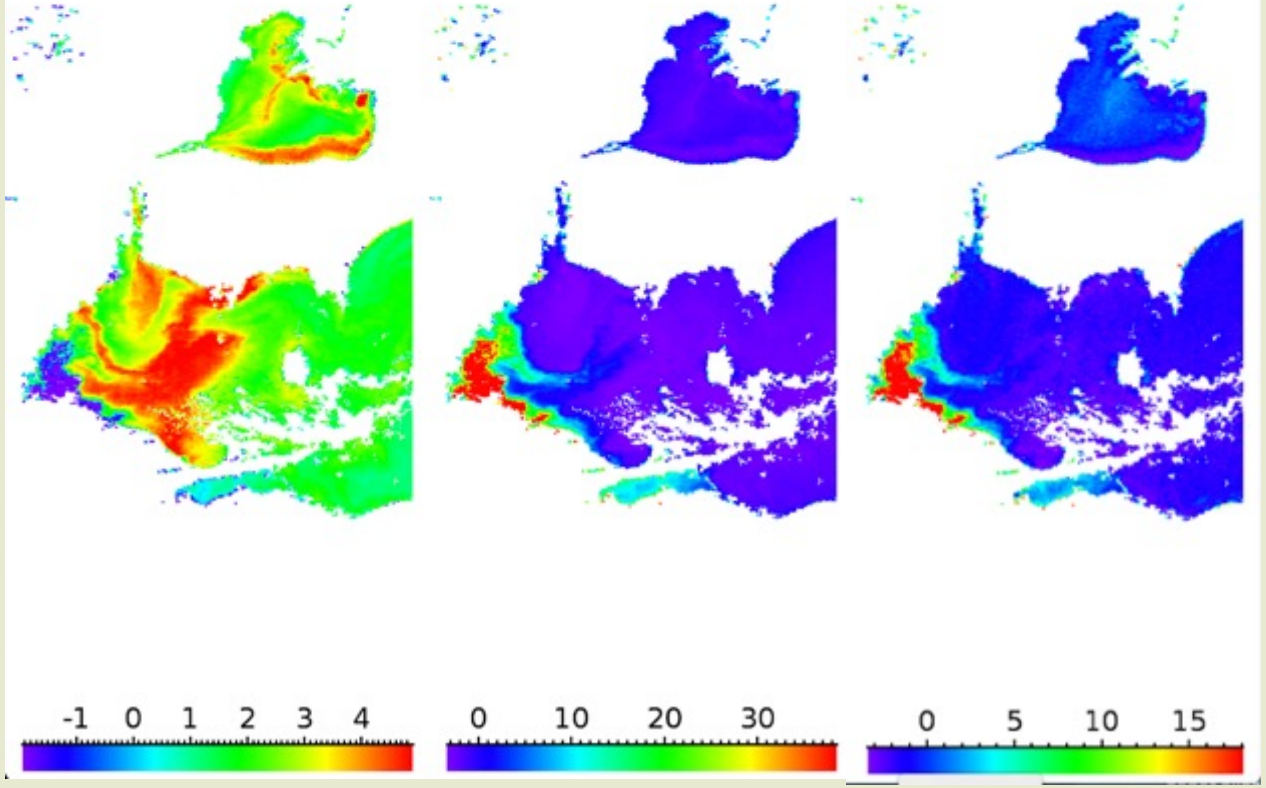
092618 bbe Fluoroprobe Tow Corrected Total cell count (1k running avg) Actual vs. Estimates





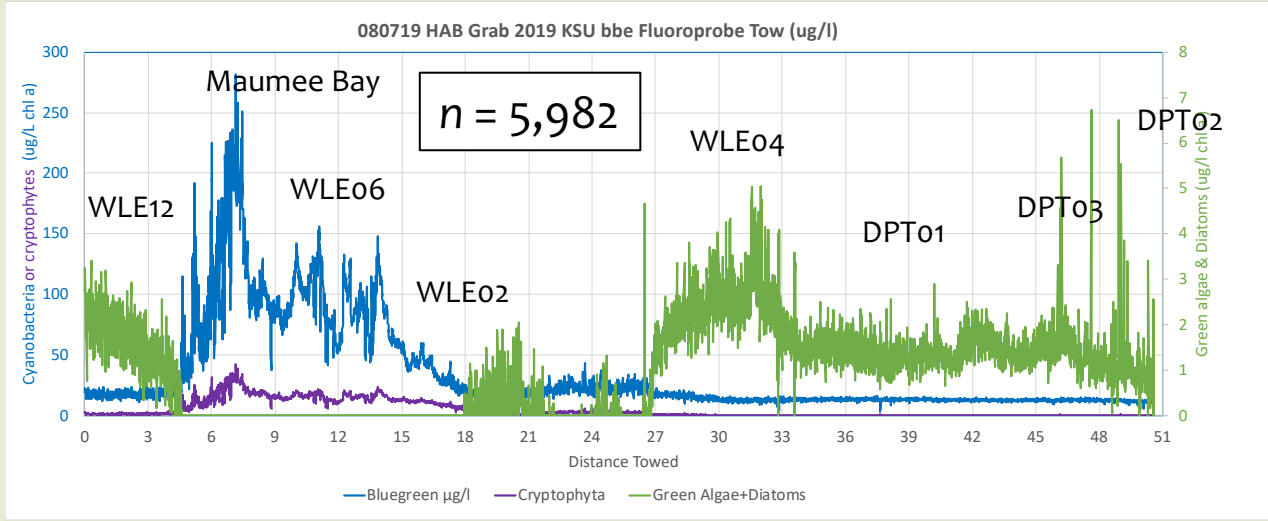
Non-HAB Algae HAB cyanobacteria Cryptophytes

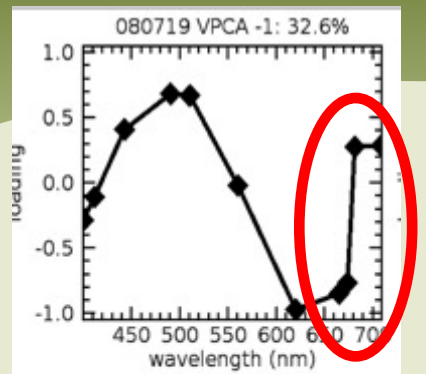


Standardized units

2019 HAB Grab
Kent State University
Dr. Joseph D. Ortiz
jortiz@kent.edu

* Approx. sample locations





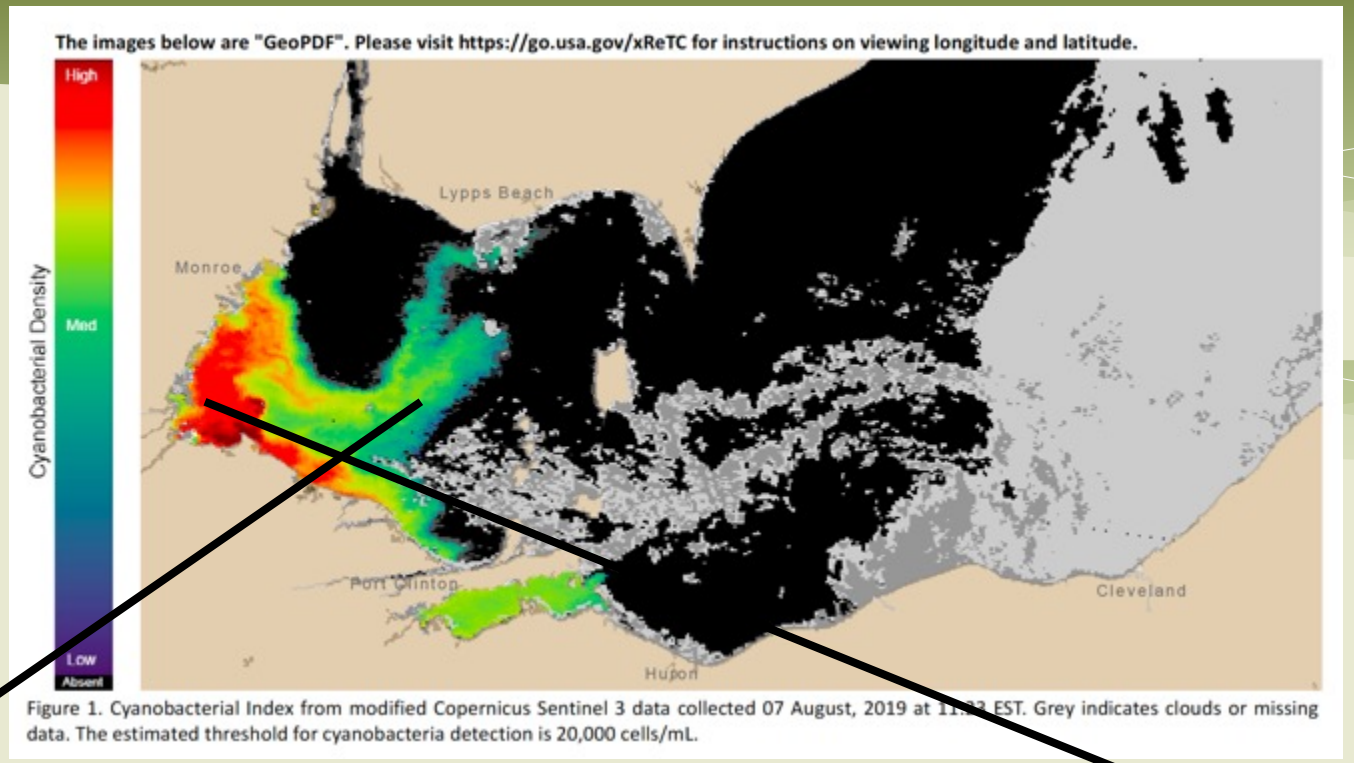
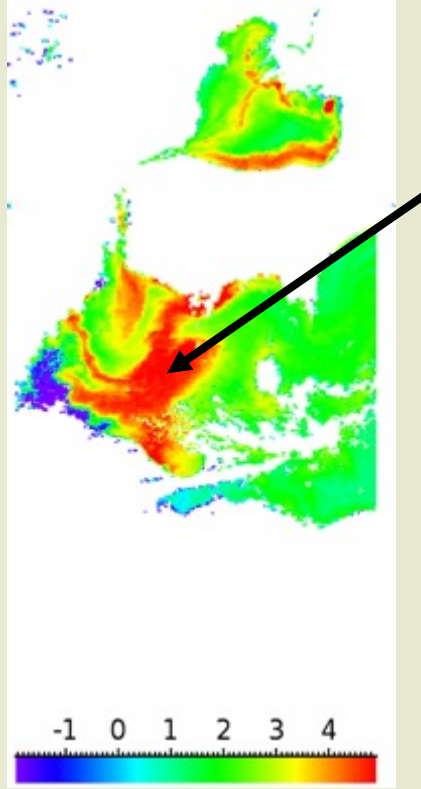
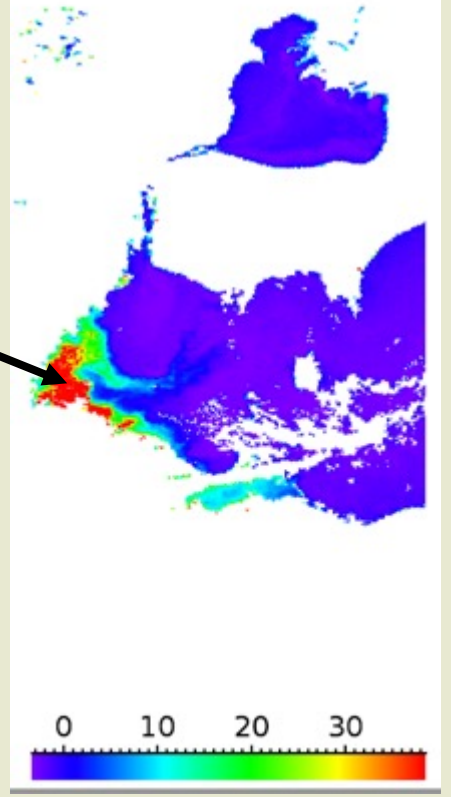


Figure 1. Cyanobacterial Index from modified Copernicus Sentinel 3 data collected 07 August, 2019 at 11:33 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

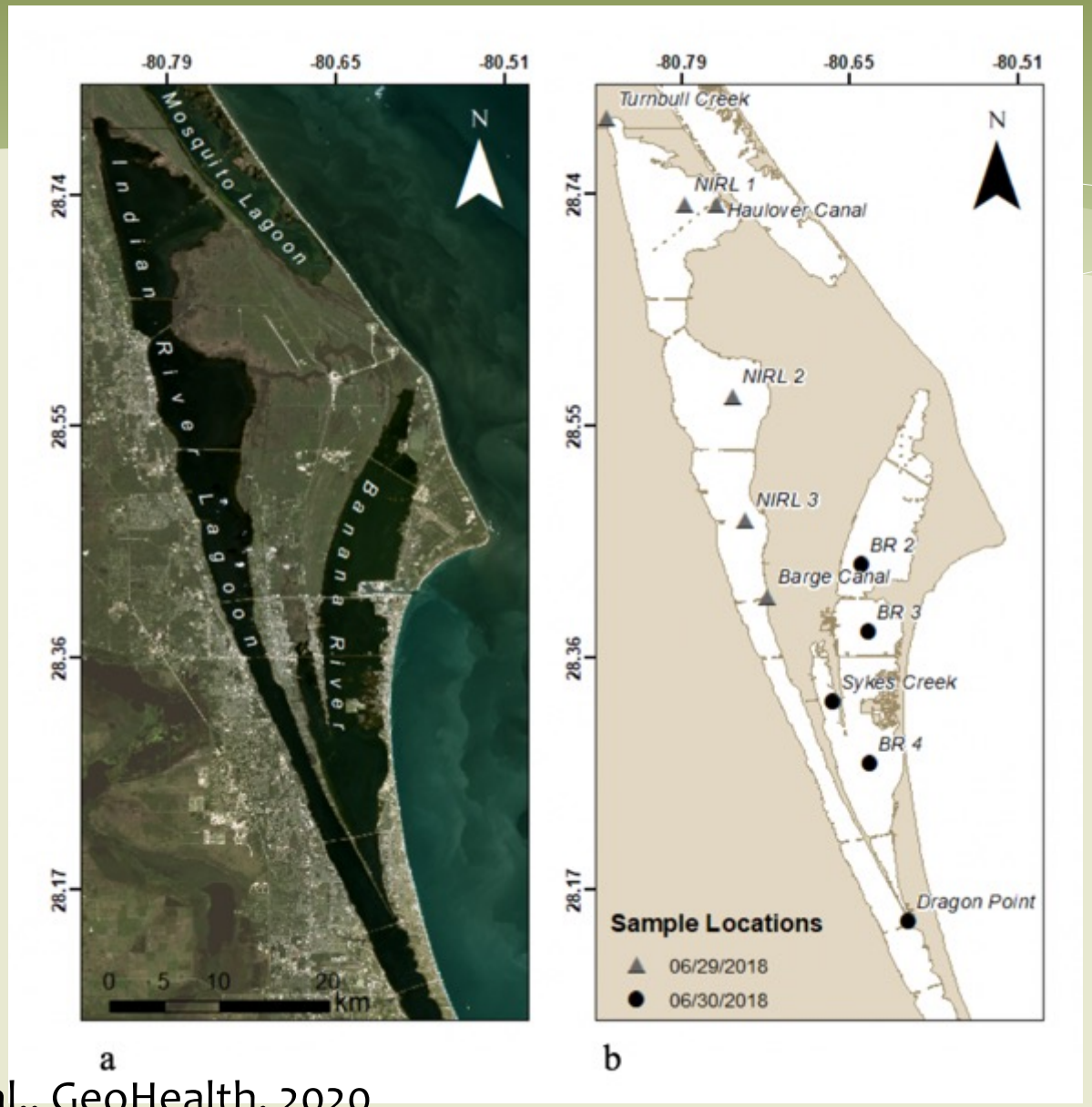


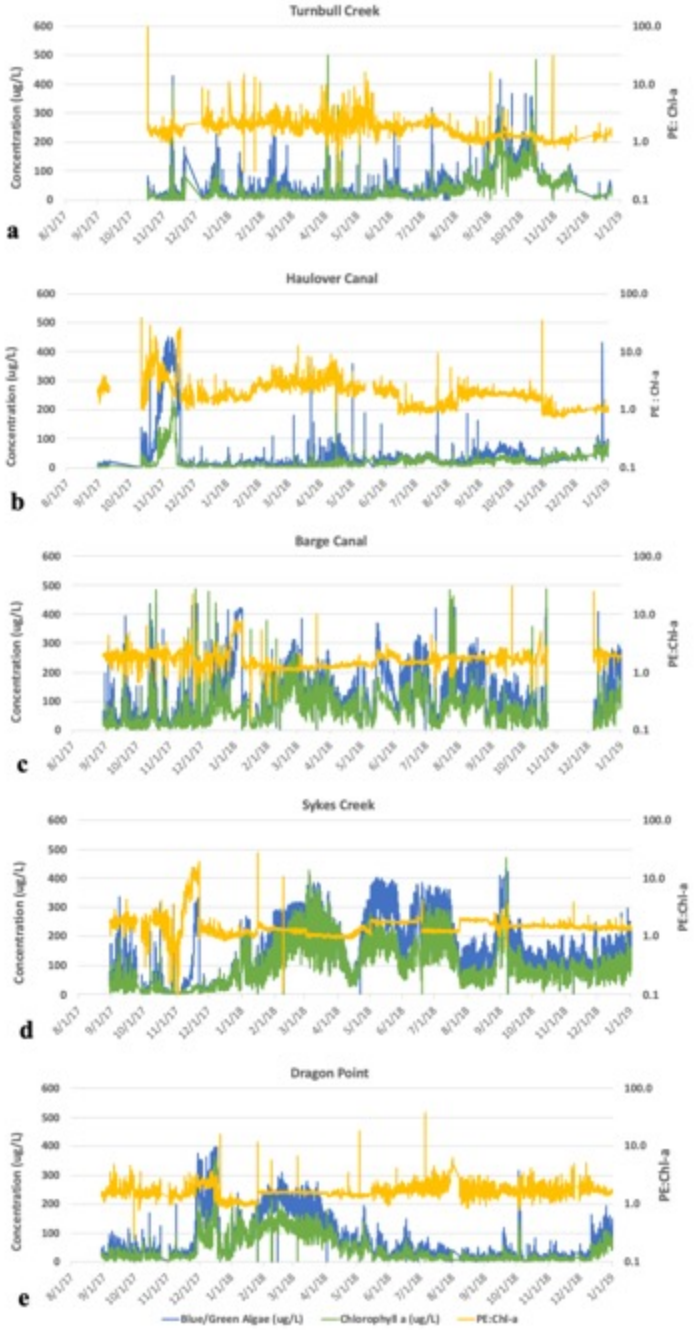


2019 HABGrab19 Sentinel 3 OCLI-derived NOAA CI (above) compared to leading two KSU VPCA components (left and right) The NOAA CI represents a mixture of these two components - and potentially two additional components (not shown) for NOAA Threshold of 20K cells/ml.

J. Ortiz, (2019 NASA Glenn HAB Algorithm meeting ; jortiz@kent.edu)

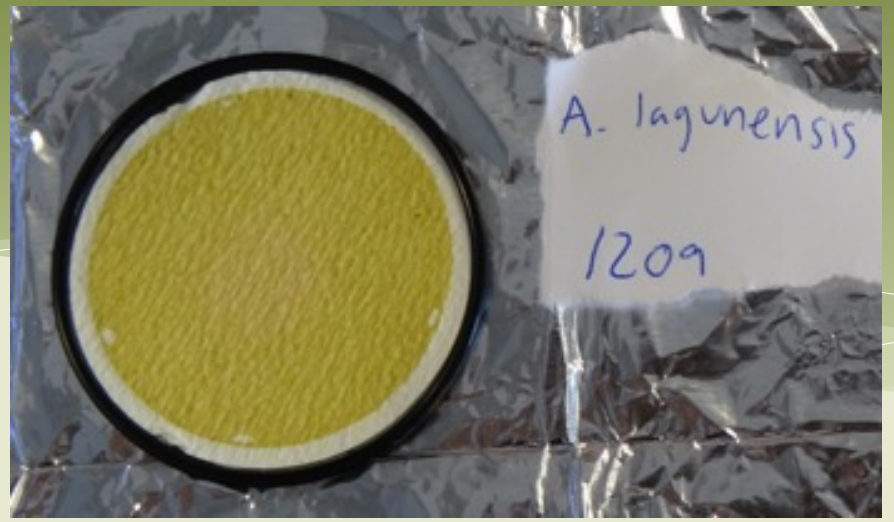
Application to IRL with ORCA





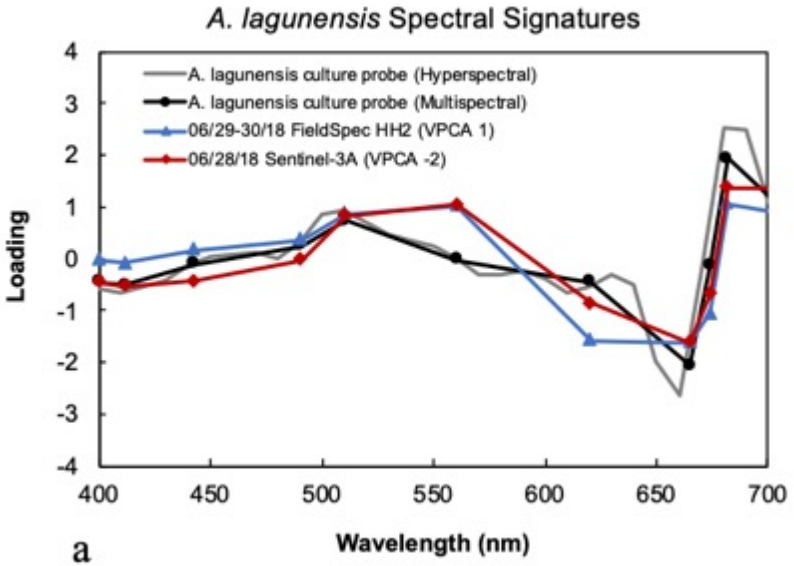
After Judice et al., GeoHealth, 2020

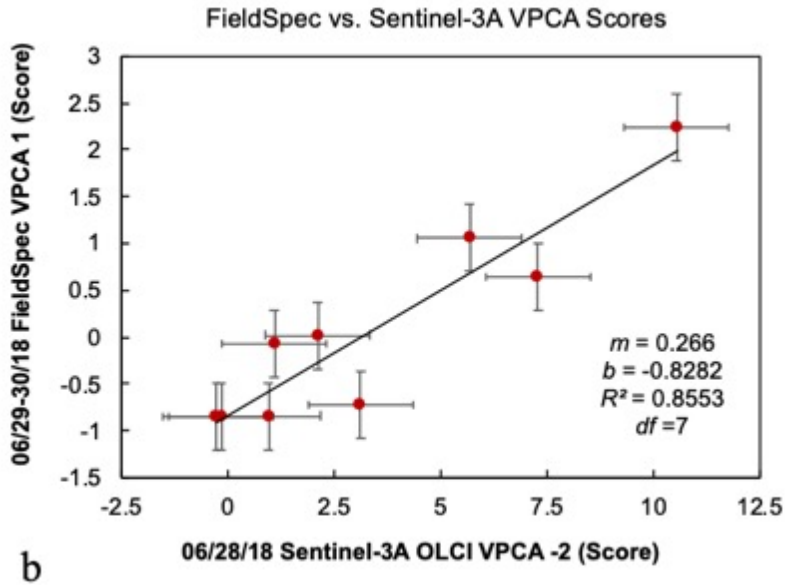
A. Lagunensis culture ID



- Spectral fingerprint from an *A. lagunensis* culture matches field and satellite spectra

- Relative abundance from field and satellite station data match





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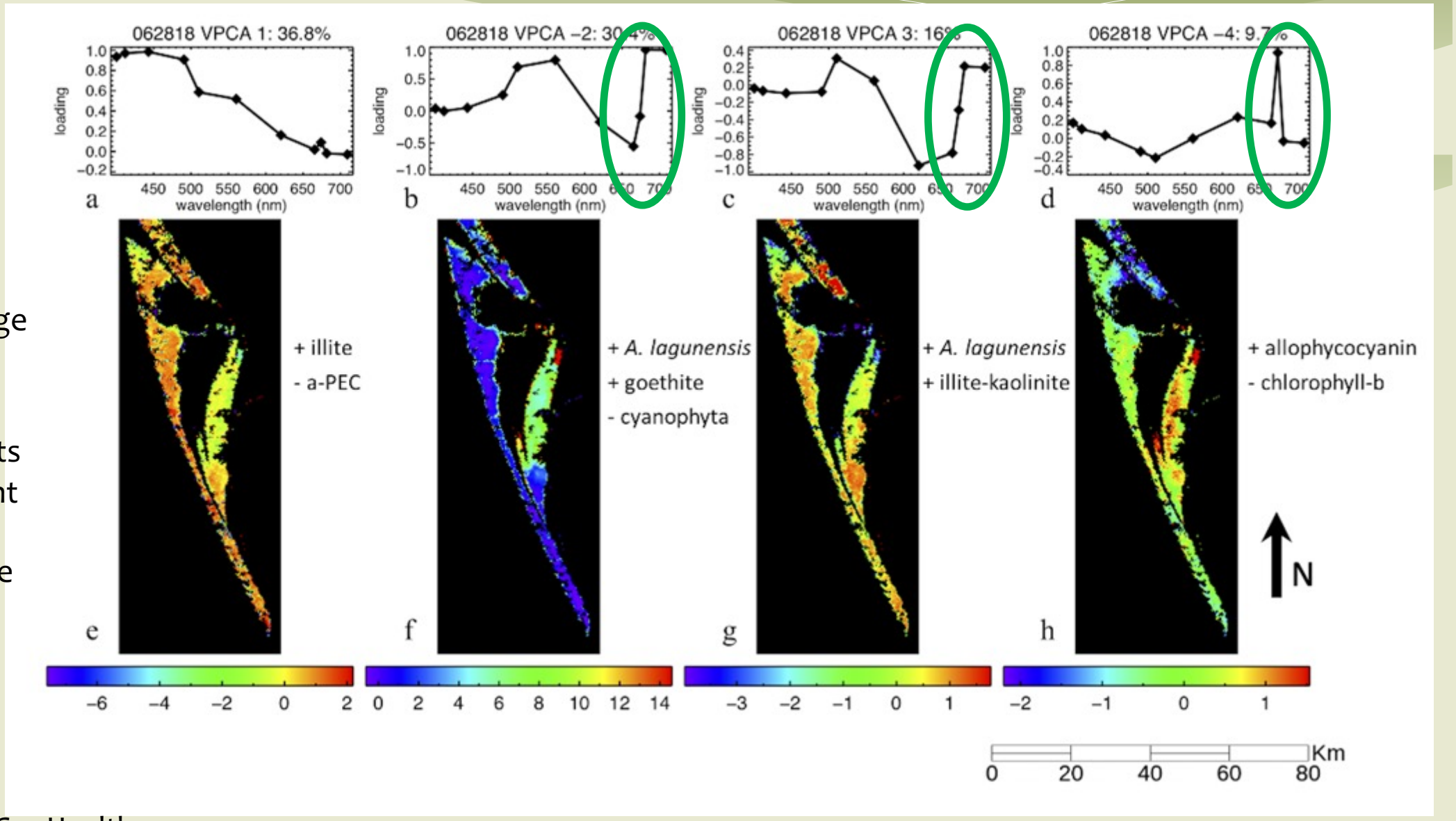
After Judice et al., GeoHealth, 2020

Chlorophyll a prediction in the Indian River Lagoon

- KSU method splits the image variance
- Select subset of components with a pigment related Red-edge response



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Comparison with other Remote Sensing methods

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VPCA explains twice as much variance with one third the noise

Published NCDI Calibration

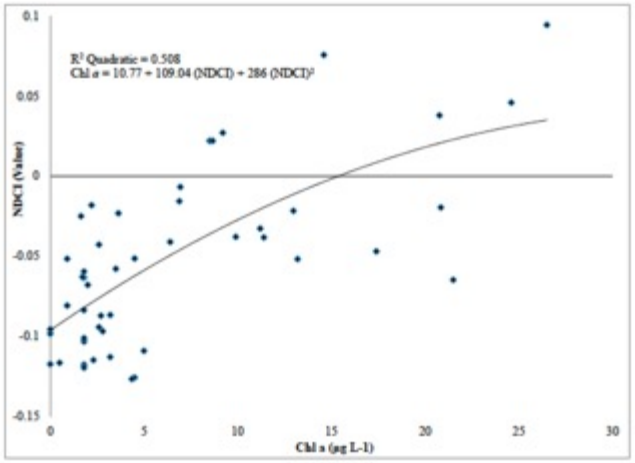
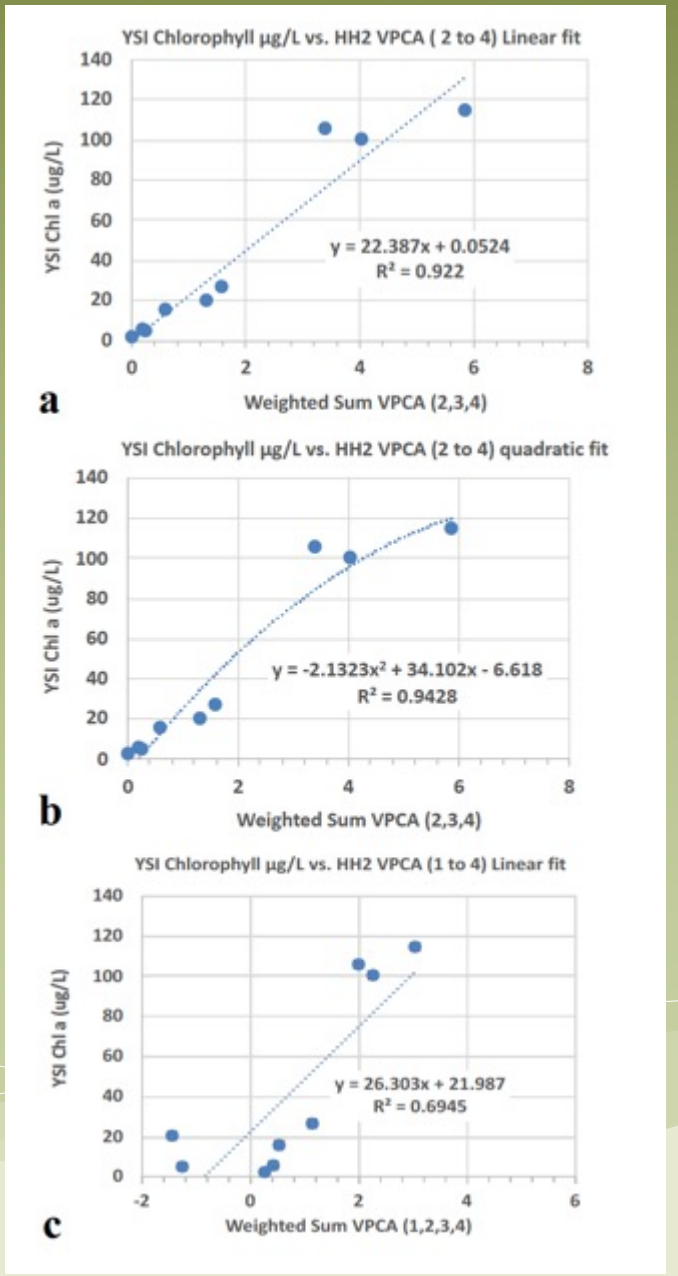


Figure 4. Regression analysis of *in-situ* Chl *a* measurements and their corresponding MERIS pixel data that has been converted by the NDCI algorithm. The resulting line of best fit is used to convert the NDCI values into estimated Chl *a*.

Table 5. Comparison to Kamerosky et al., Remote Sensing, vol. 7, 1441-1460, 2015 Calibration results

Statistic	Moses et al., (2009)	NDCI Quadratic Mishra & Mishra (2011)	This Study (Weighted S3A OLCI VPCA 2 to 4, Linear fit) Model 1	This Study (Weighted S3A OLCI VPCA 2 to 4,Quadratic fit) Model 2	This Study (Weighted S3A OLCI VPCA 1 to 4, Linear fit) Model 3
R	0.66	0.71	**0.96**	0.97	0.83
R^2	0.43	0.51	**0.92**	0.94	0.69
RMSE (ug/L)	37.42	34.93	**13.38**	11.47	39.9
Std. Err (ug/L)	5.29	4.94	**4.46**	3.82	13.31
n	50	50	**9**	9	9

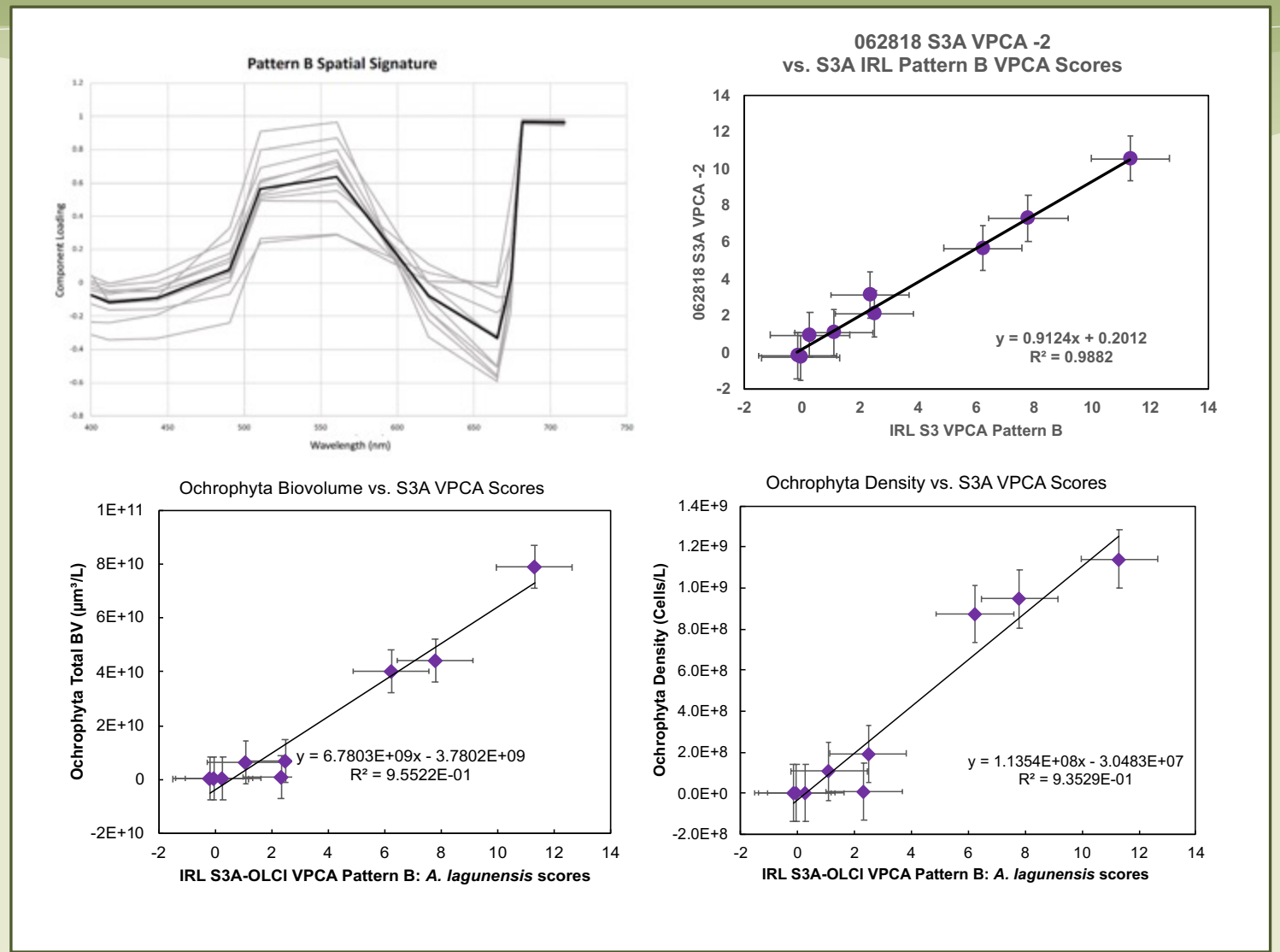
VPCA Calibration



After Judice et al., GeoHealth, 2020

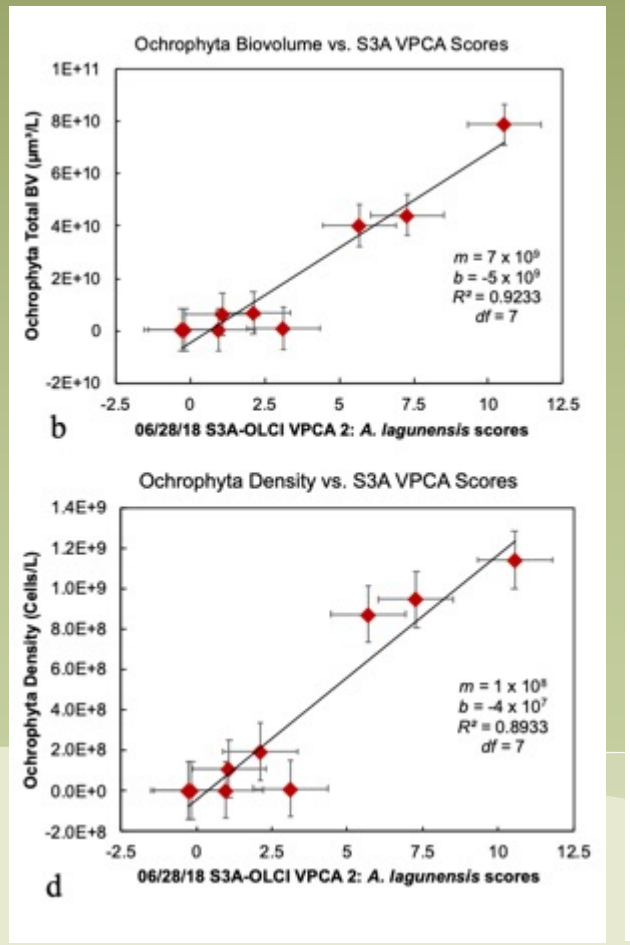
Comparison of individual daily VPCA Results with average VPCA results.

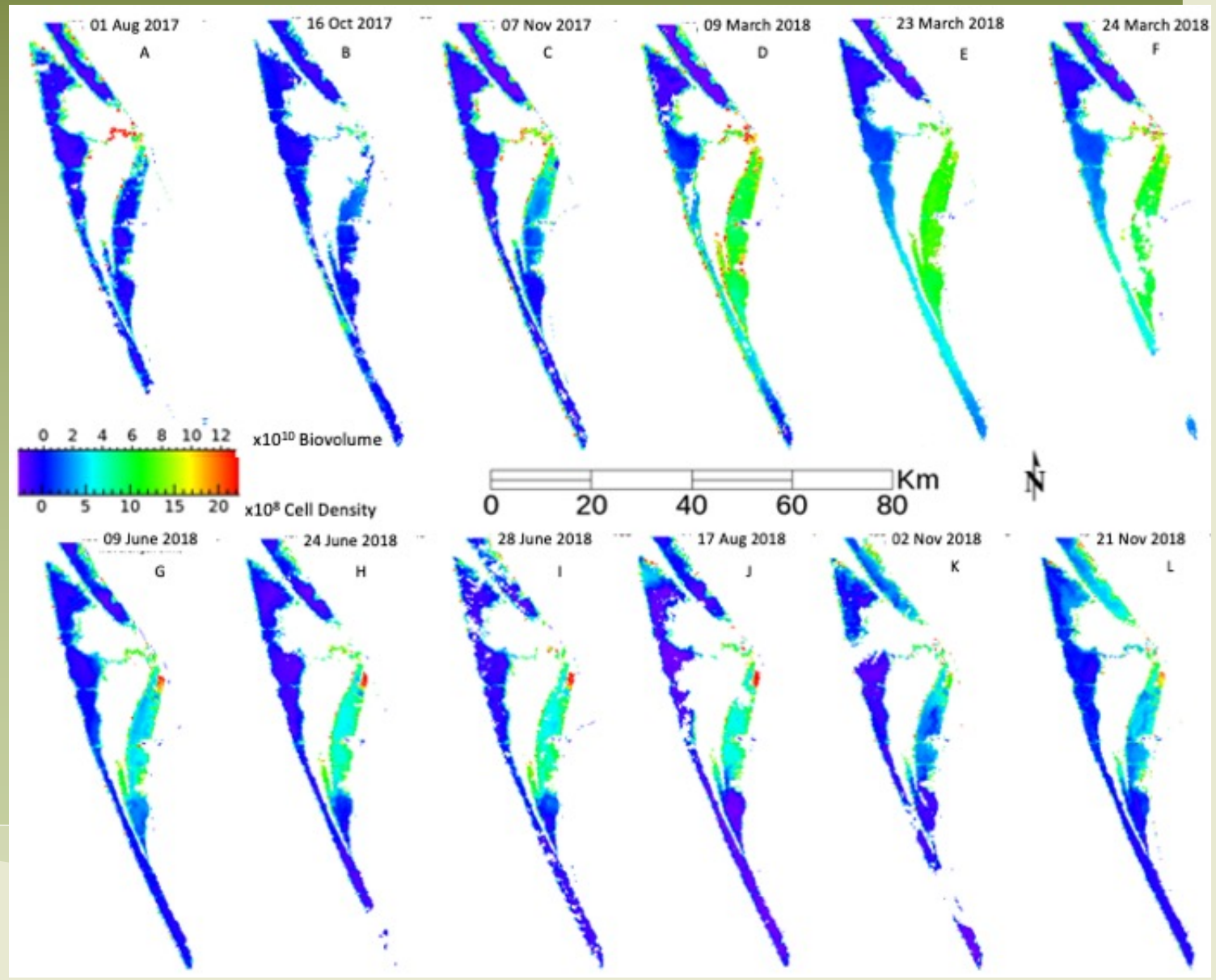
- The extracted daily component loadings are stable, so the component scores and the regression coefficients of the average component loadings are stable.
- Averaging the component loadings gives even cleaner transfer functions to cell density and biovolume than the daily estimates: R^2 increases to 0.96 and 0.94



After Judice et al., GeoHealth, 2020

Brown Tide Monitoring in the Indian River Lagoon





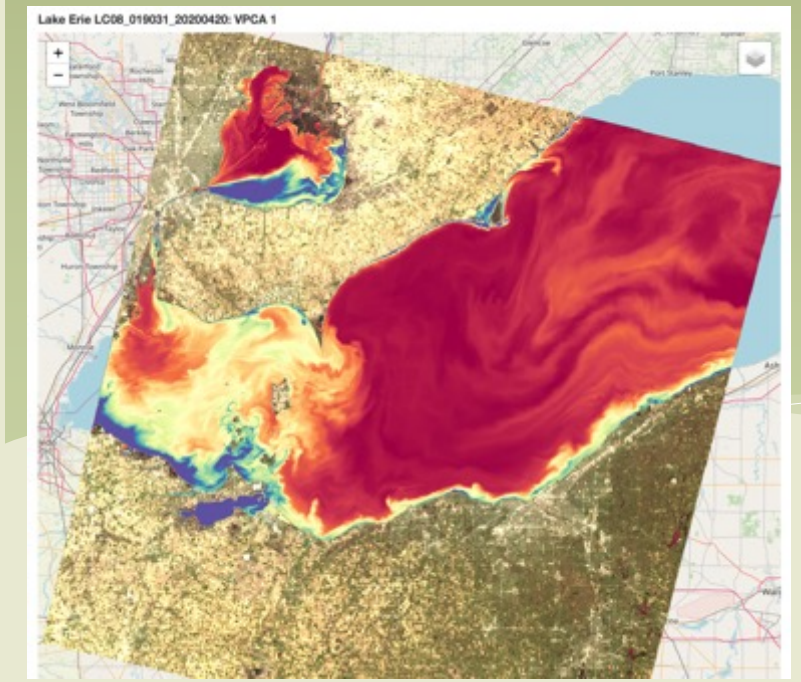
After Judice et al., GeoHealth, 2020

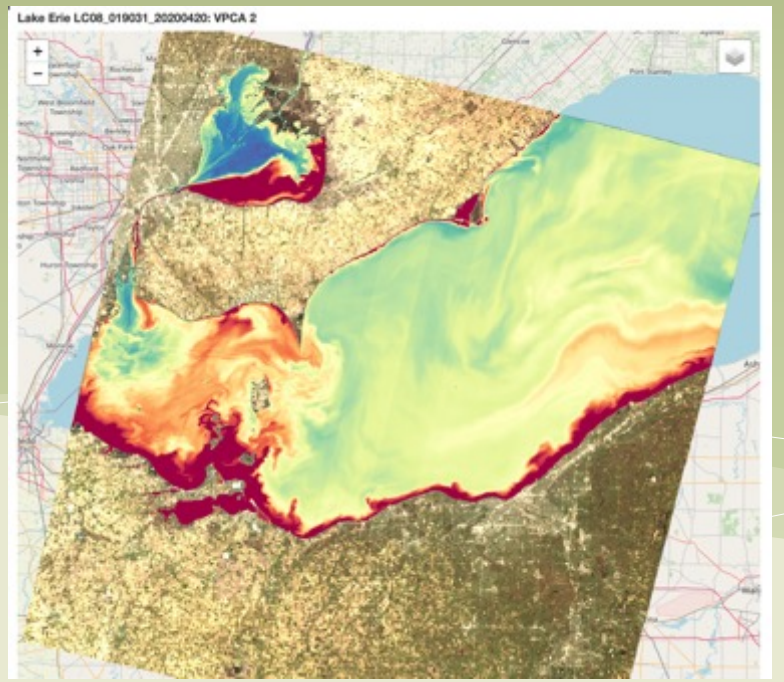
VPCA in Google Earth Engine

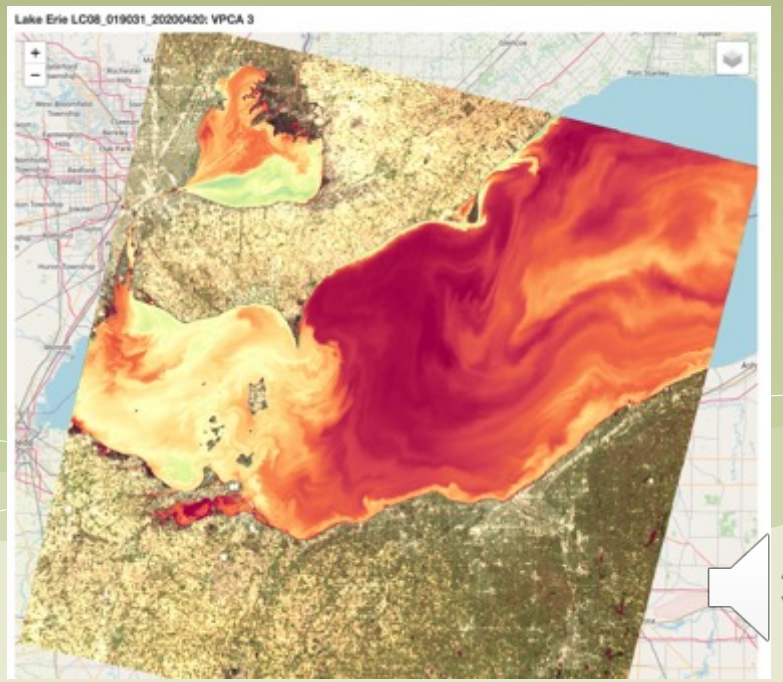
Lake Erie

Landsat 8 WRS-2 Scene 019 031

on 20200420





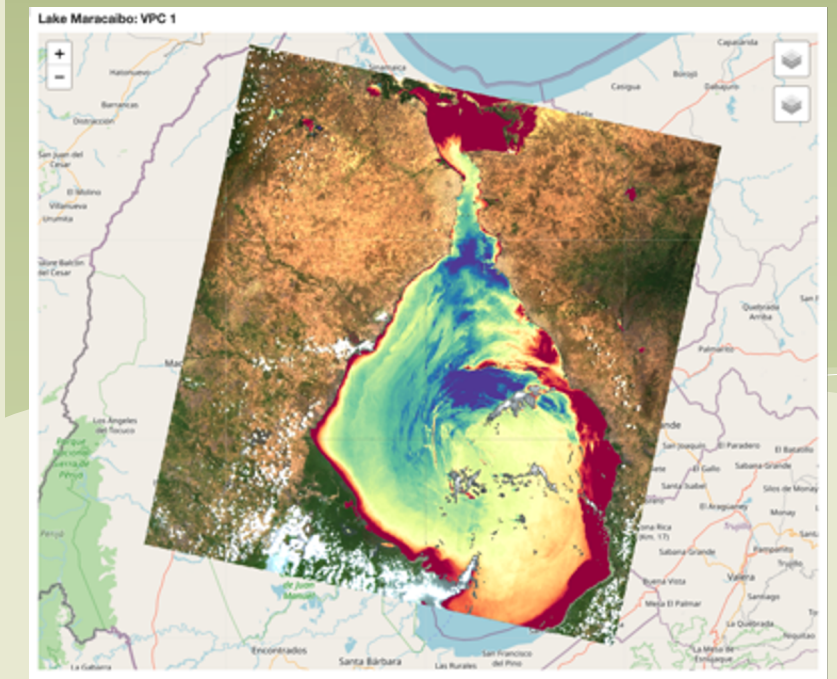


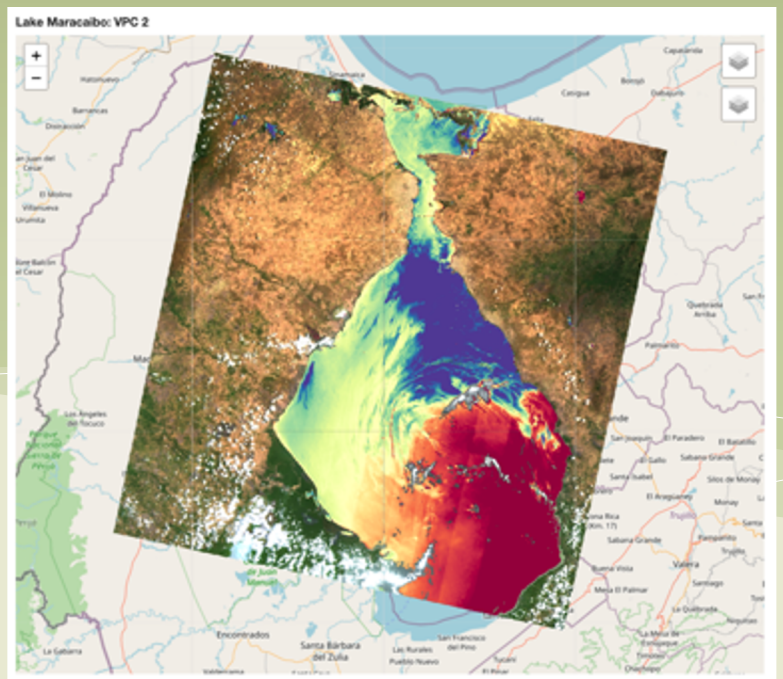
VPCA in Google Earth Engine

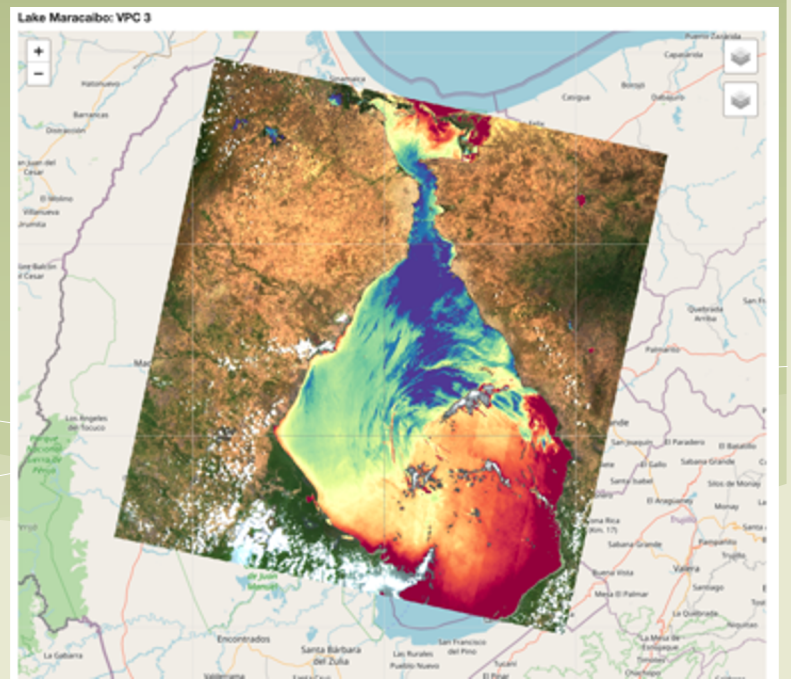
Lake Maracaibo

Landsat 8 WRS-2 Scene 007 053

on 20200416







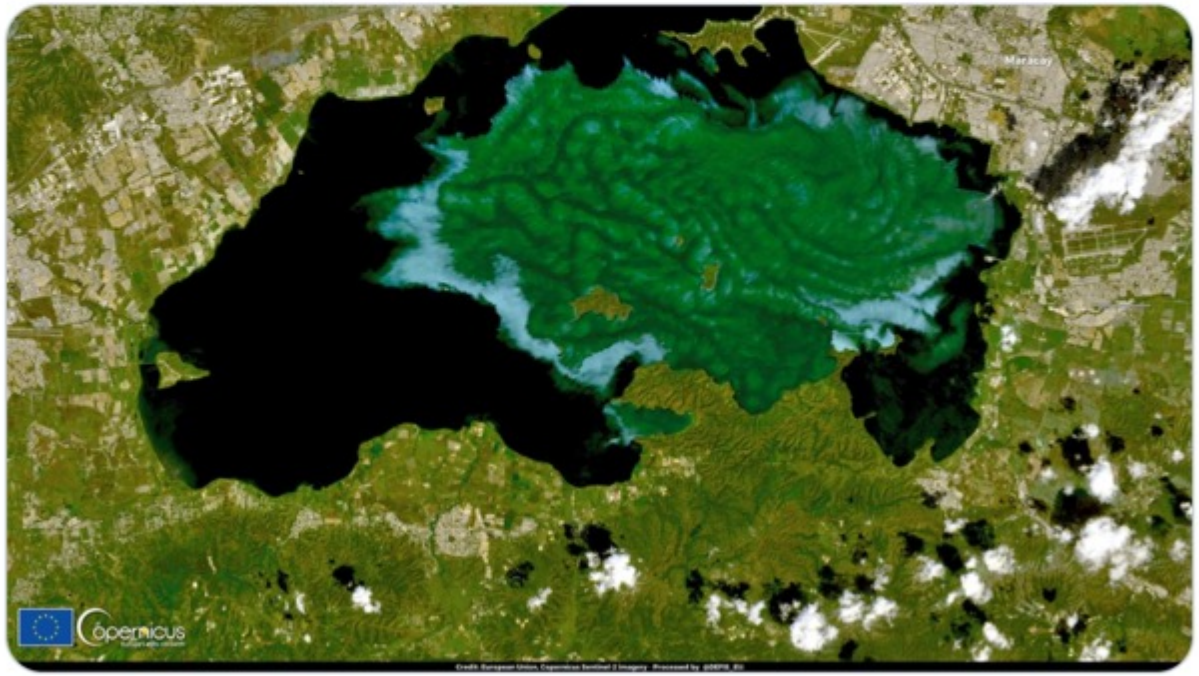
DG DEFIS #StrongerTogether @defis_eu · Jan 16

#ImageOfTheDay

Lake Valencia is the largest freshwater lake in #Venezuela

Its #WaterQuality is affected by the influx of untreated wastewater from the surrounding urban, agricultural & industrial land uses

⬇️Massive algal bloom seen by @Copernicus #Sentinel2 on12 January



UEenVenezuela and 9 others

5 29 50

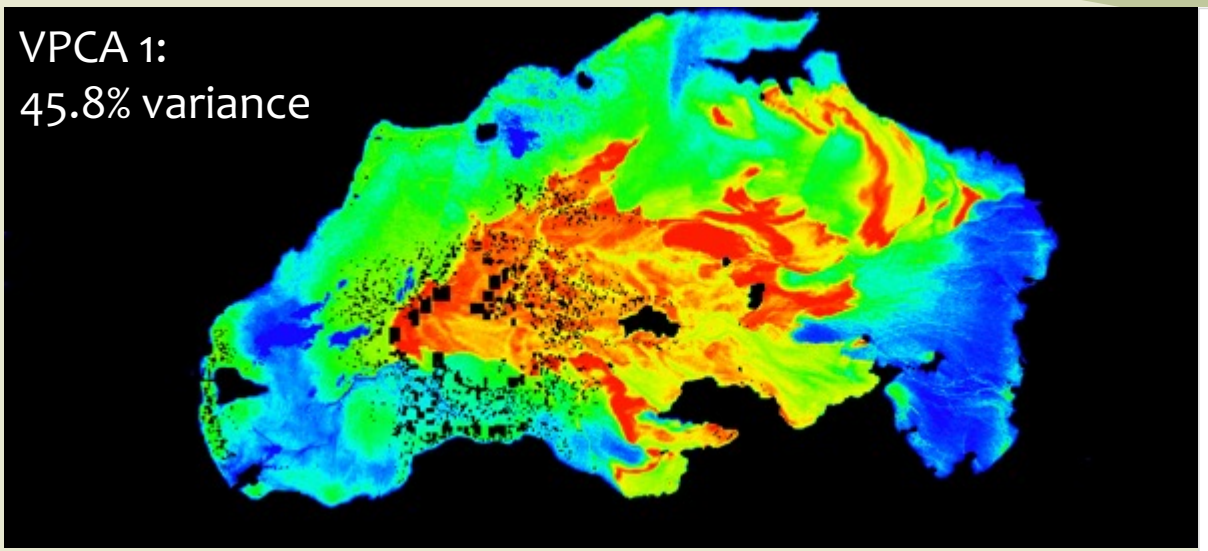
Lake Valencia RGB 2021-01-12

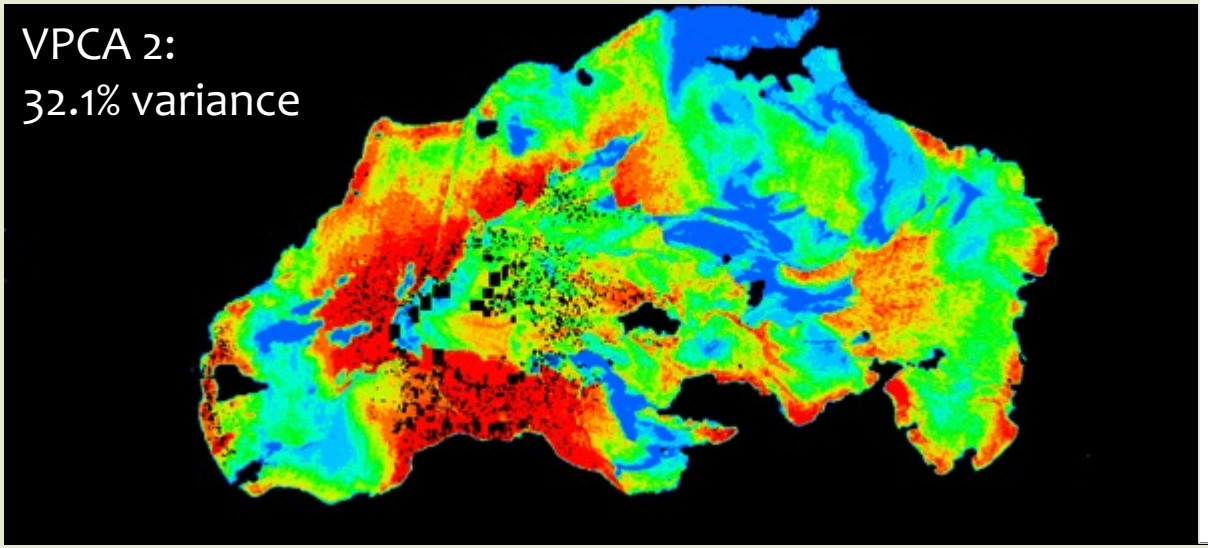
Recurrent cyanobacterial blooms on Lake Valencia

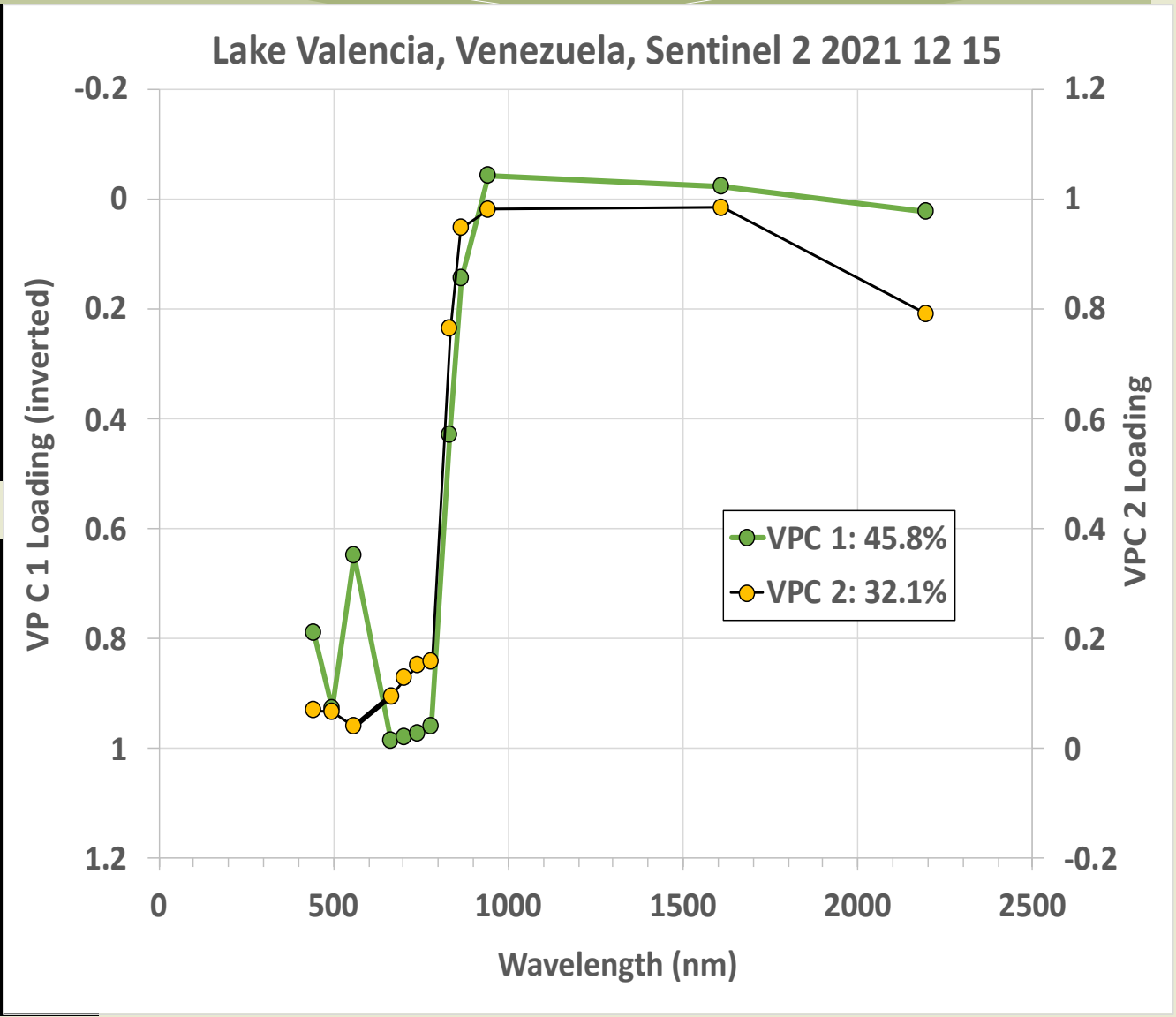
Lake Valencia RGB 2021-12-15

Lake Valencia also has a Complex algal community including green algae, diatoms

KSU Spectral Decomposition: Leading two components: 78% image variance







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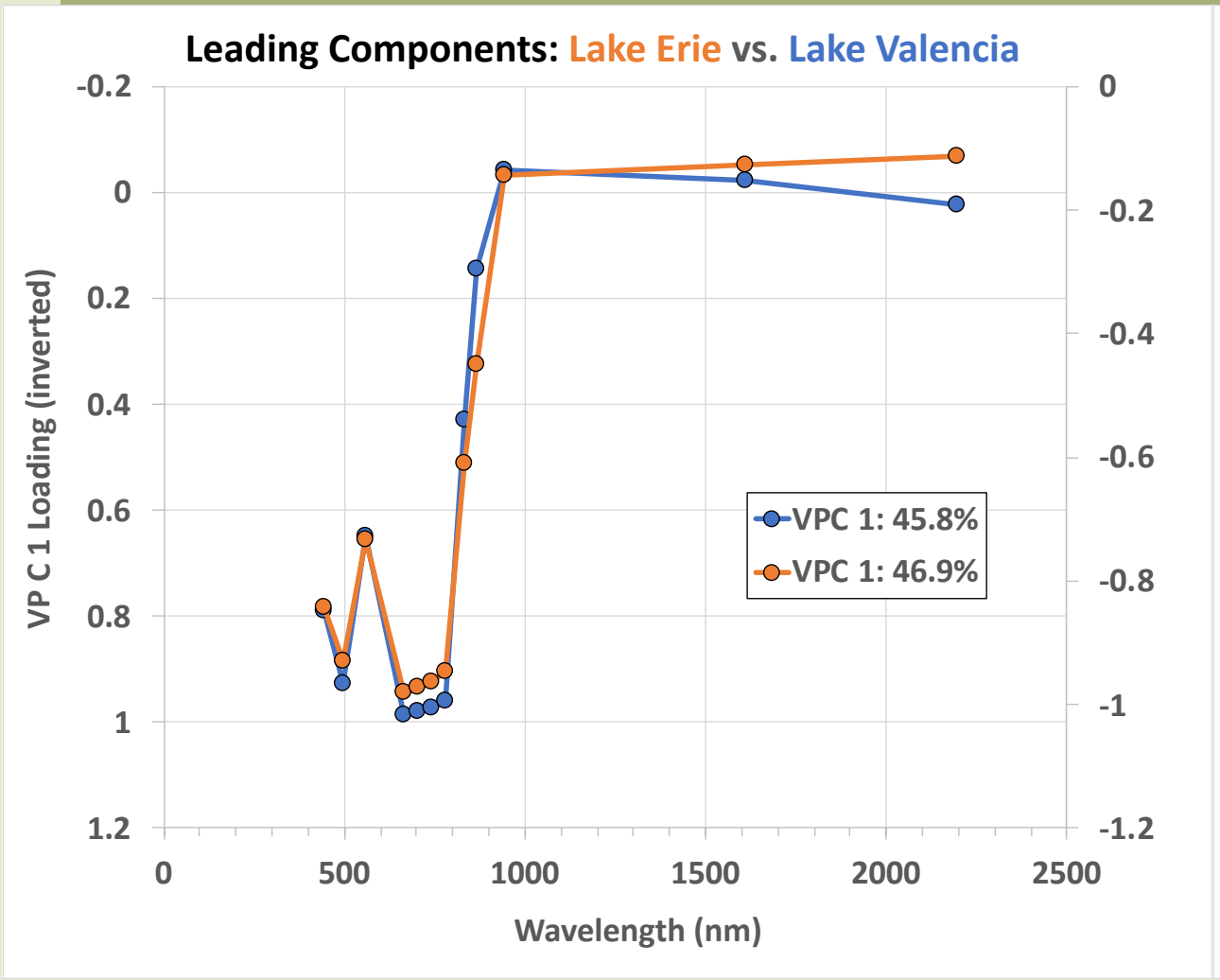
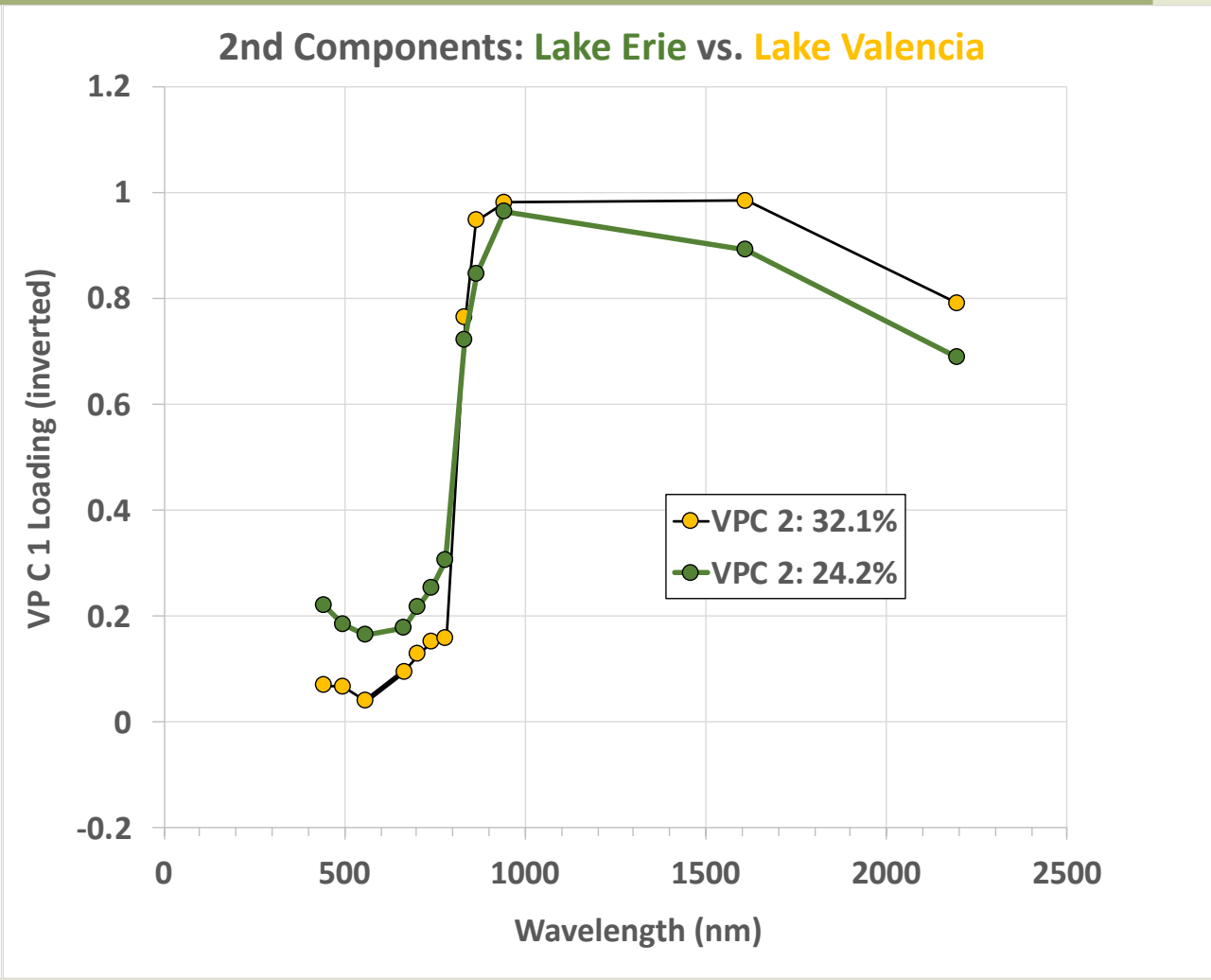
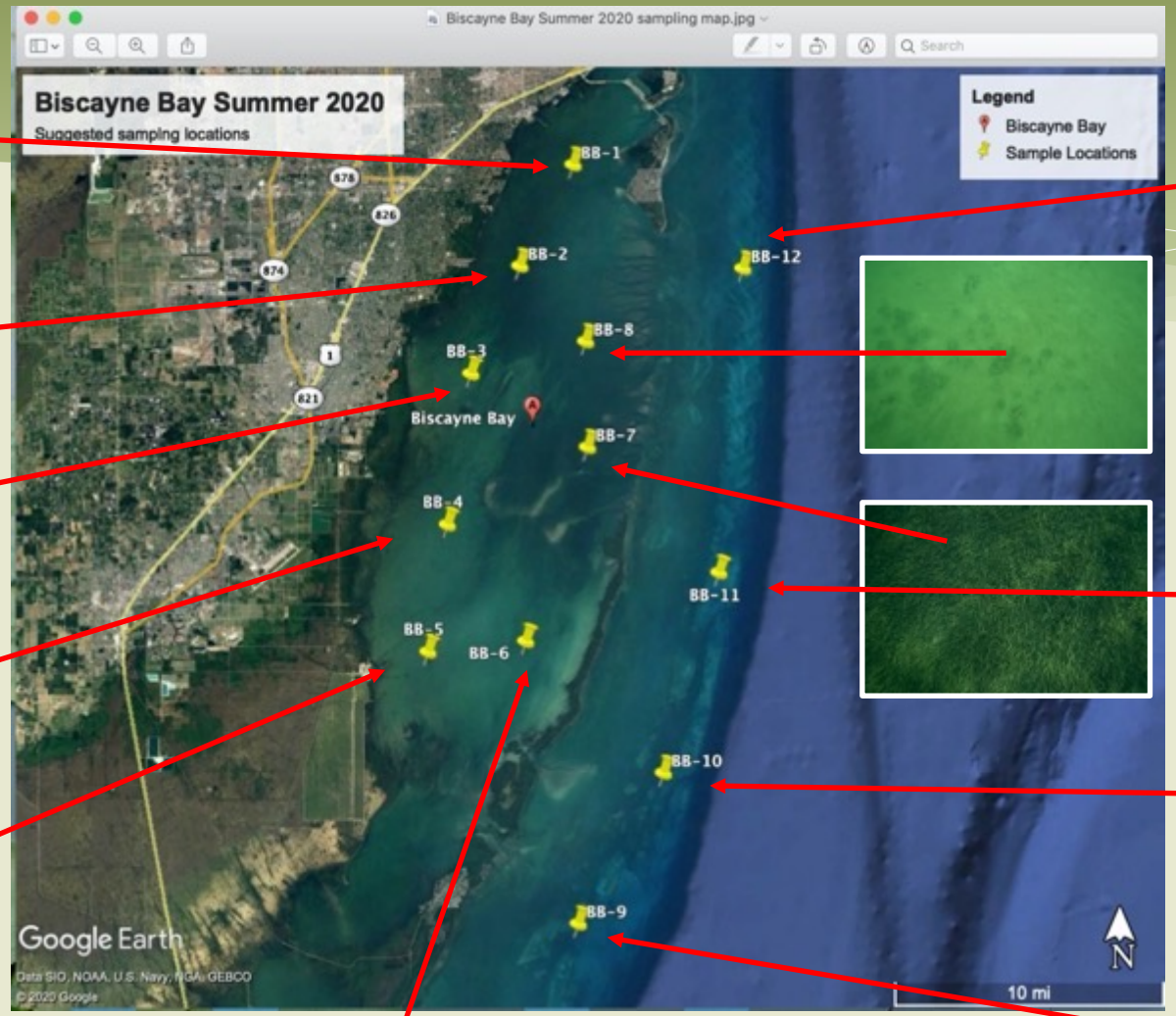
Matching components





Fall 2020 Biscayne Bay Benthic Cover Nadir views



Sea Grass spectra

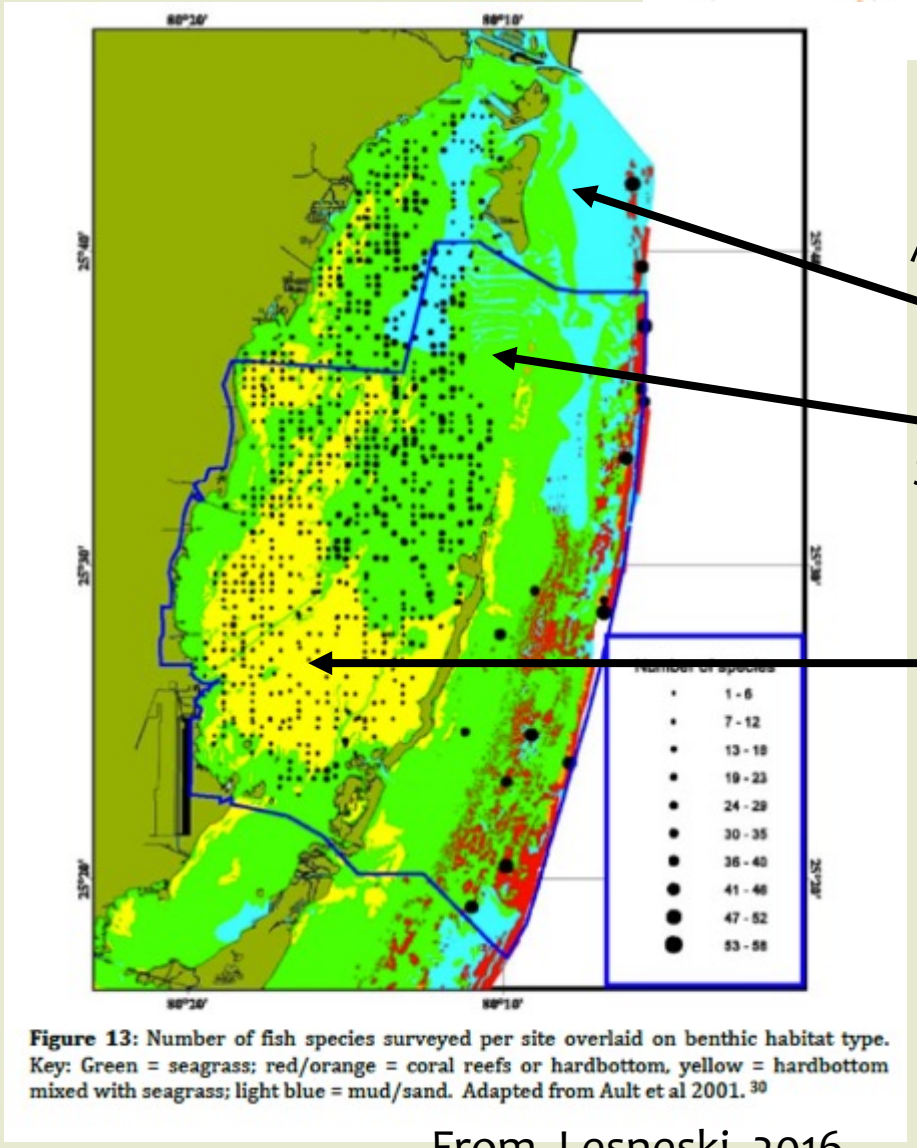
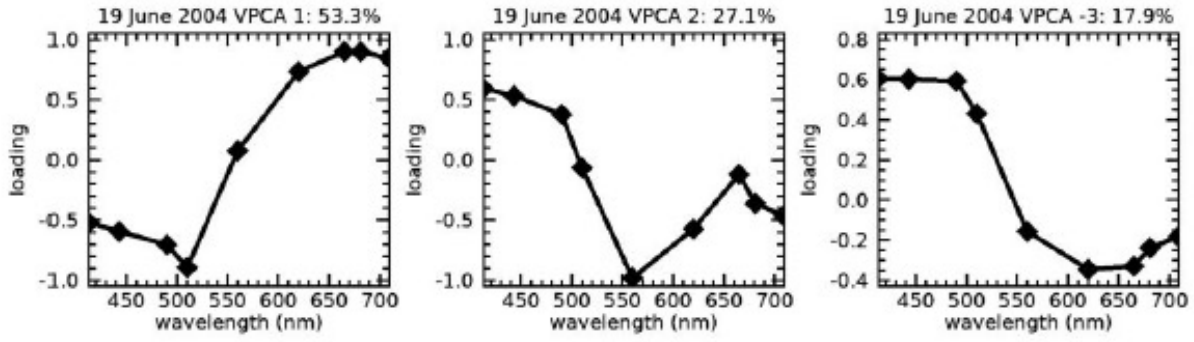


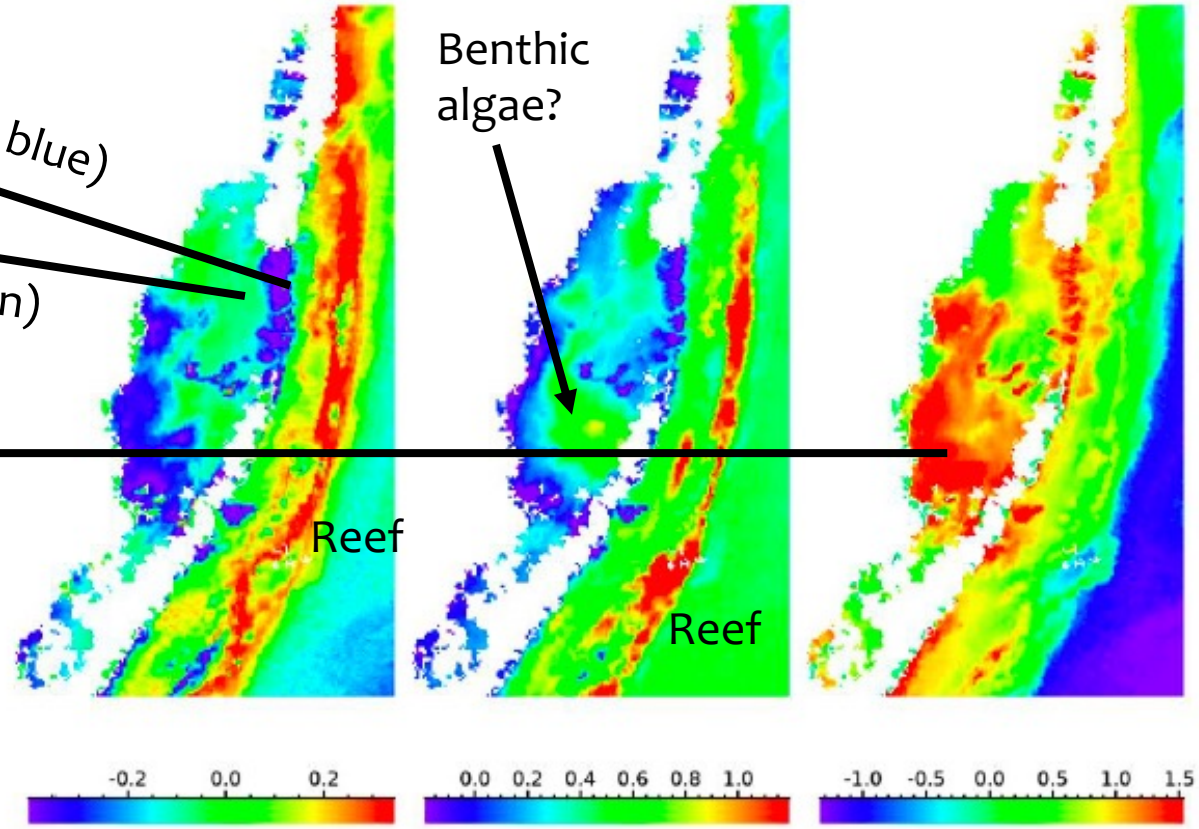
Figure 13: Number of fish species surveyed per site overlaid on benthic habitat type. Key: Green = seagrass; red/orange = coral reefs or hardbottom, yellow = hardbottom mixed with seagrass; light blue = mud/sand. Adapted from Ault et al 2001. [30]

Mud/sand (dark blue)

Seagrass? (green)

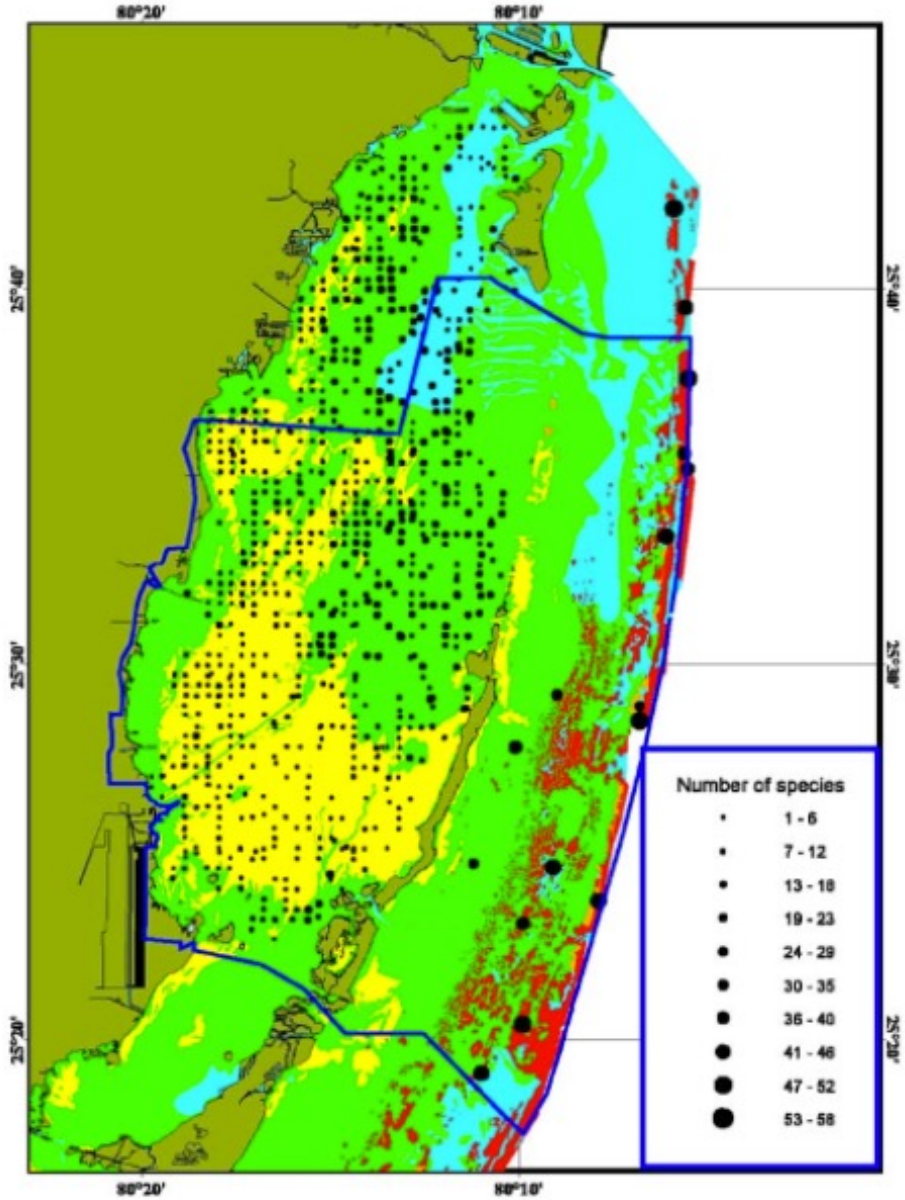
Hardbottom (red yellow)





From Lesneski, 2016

19 June 2004: Pre-CyanoHAB Stations



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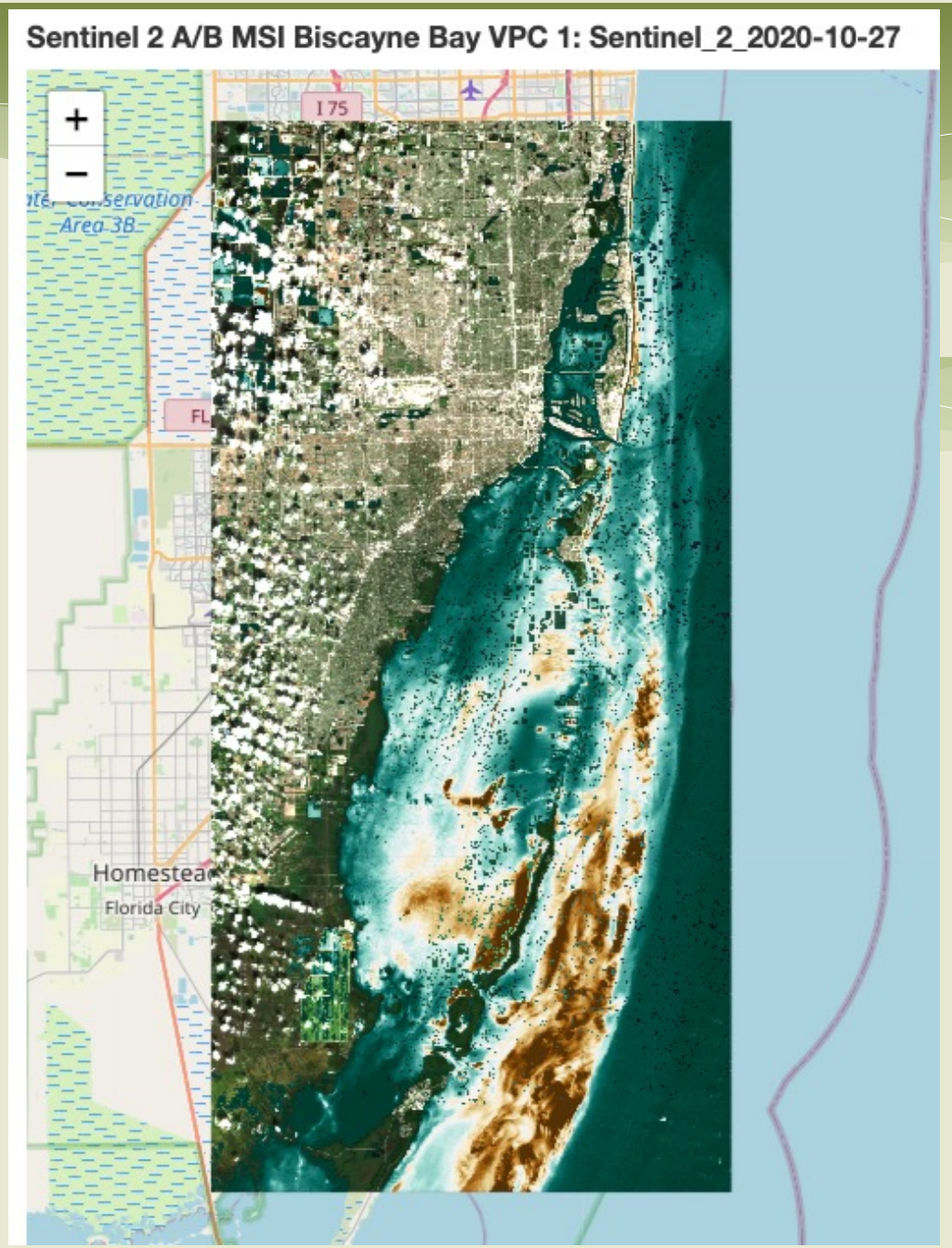

Summary and implications

- Method can provide a variety of products using NASA and ESA sensors: Phytoplankon classes, pigment degradation products, suspended minerals
- VNIR derivative spectroscopy unmixes and quantifies plant pigment assemblages in Optically complex aquatic systems (e.g. Lake Erie, Indian River Lagoon)
- Tracks phytoplankton contribution to eutrophication, with implications for harmful algal blooms, anoxia, and fisheries
- KSU VPCA decomposition method has be applied successfully to hyperspectral and multispectral lab samples, field-based spectroradiometers, HICO, NASA Glenn HSI2, MODIS A/T, Landsat 4-8, Sentinel-3A/B
- VPCA is in the process of being ported to GEE: Preliminary results are very promising
- VPCA is well suited for application to current and the upcoming hyperspectral SBG and PACE missions: Makes use of ***all*** information present in hyperspectral data

Ortiz et al., (2015 HAB Data meeting; jortiz@kent.edu)

Recent Publications

- See Water quality webpage at: http://www.personal.kent.edu/~jortiz/home/wqr.html

- Judice, T., Widder, E.A., Falls, W.H., Avouris, D.M., Cristiano, D.J., & **Ortiz, J.D.** Field-validated detection of Aureoumbra lagunensis brown tide blooms in the Indian River Lagoon, Florida using Sentinel-3A OLCI and ground-based hyperspectral spectroradiometers, GeoHealth, 2020. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GH000238
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