Cyanobacteria Assessment Network

Rick Stumpf

National Centers for Coastal Ocean Science, NOAA

Ohio Workgroup for Water Resource Monitoring

April 6, 2016

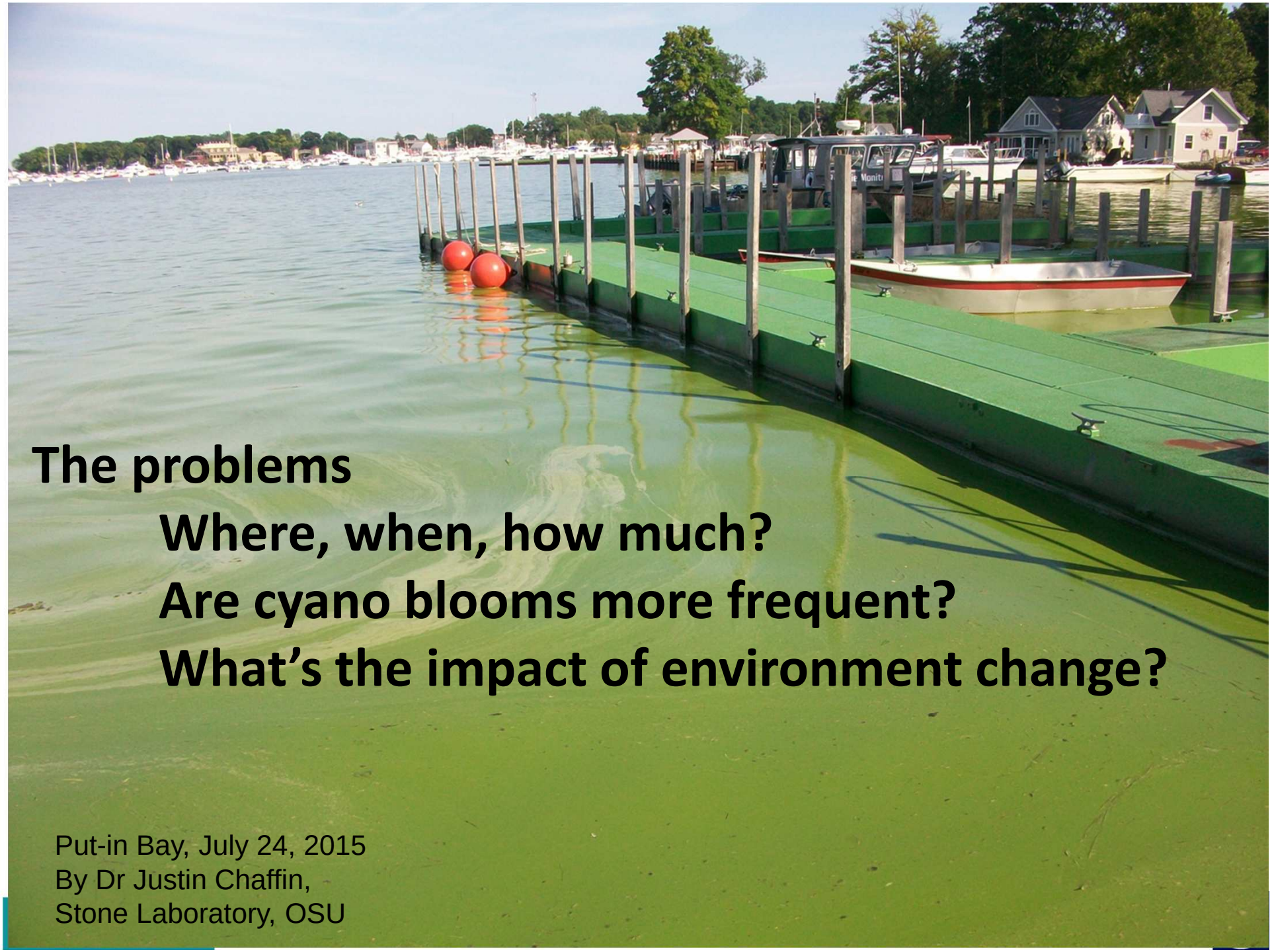
Issues with cyano blooms

URGENT NOTICE TO RESIDENTS

DO NOT DRINK THE WATER
DO NOT BOIL THE WATER

Toledo, safe water, July 2015

Tom Feran, The Plain Dealer, 29 July 2015



The problems

Where, when, how much?

Are cyano blooms more frequent?

What's the impact of environment change?

Put-in Bay, July 24, 2015

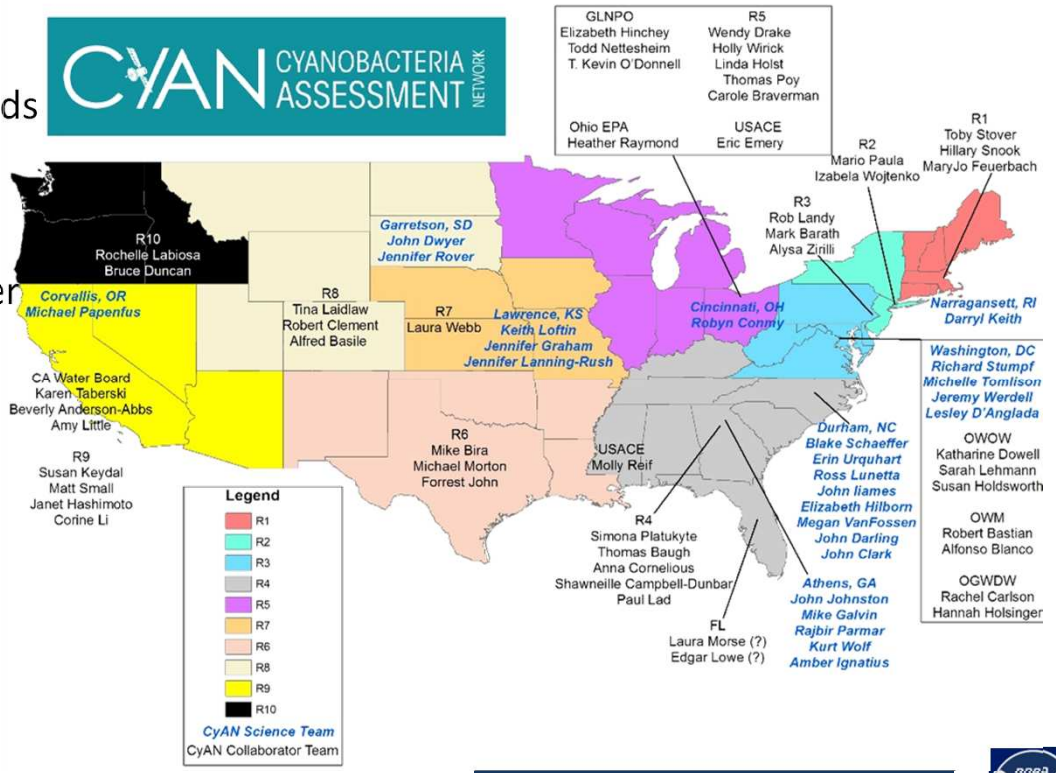
By Dr Justin Chaffin,
Stone Laboratory, OSU

Goal of CyAN:
Create a national assessment and monitoring capability for cyanobacterial blooms in lakes using satellite observations

Inter-agency effort: PIs: Blake Schaeffer, EPA; Rick Stumpf, NOAA, Keith Loftin, USGS, Jeremy Werdell, NASA

Stakeholders and participants:

- EPA Office of Water
  - Office of Wetlands, Oceans, and Watersheds
  - Office of Wastewater Management
  - Office of Science and Technology
  - Office of Ground Water and Drinking Water
- EPA Regions
- U.S. Army Corps of Engineers
- States
  - Ohio EPA
  - St. Johns River WMD
  - S. Florida WMD
  - California Water Board



Cyanobacterial bloom problems that satellite monitoring might help

- Where are blooms now?
  - How bad are they (concentration)?
- Will it be worse tomorrow
  - For swimming or for water suppliers?
- Which lakes are typically bad
- Have lakes changed over the last decade?
- Can we explain what causes blooms?
  - Predict how bad the bloom will be this summer
  - Inform management to reduce blooms by reducing nutrients

Technical Approach

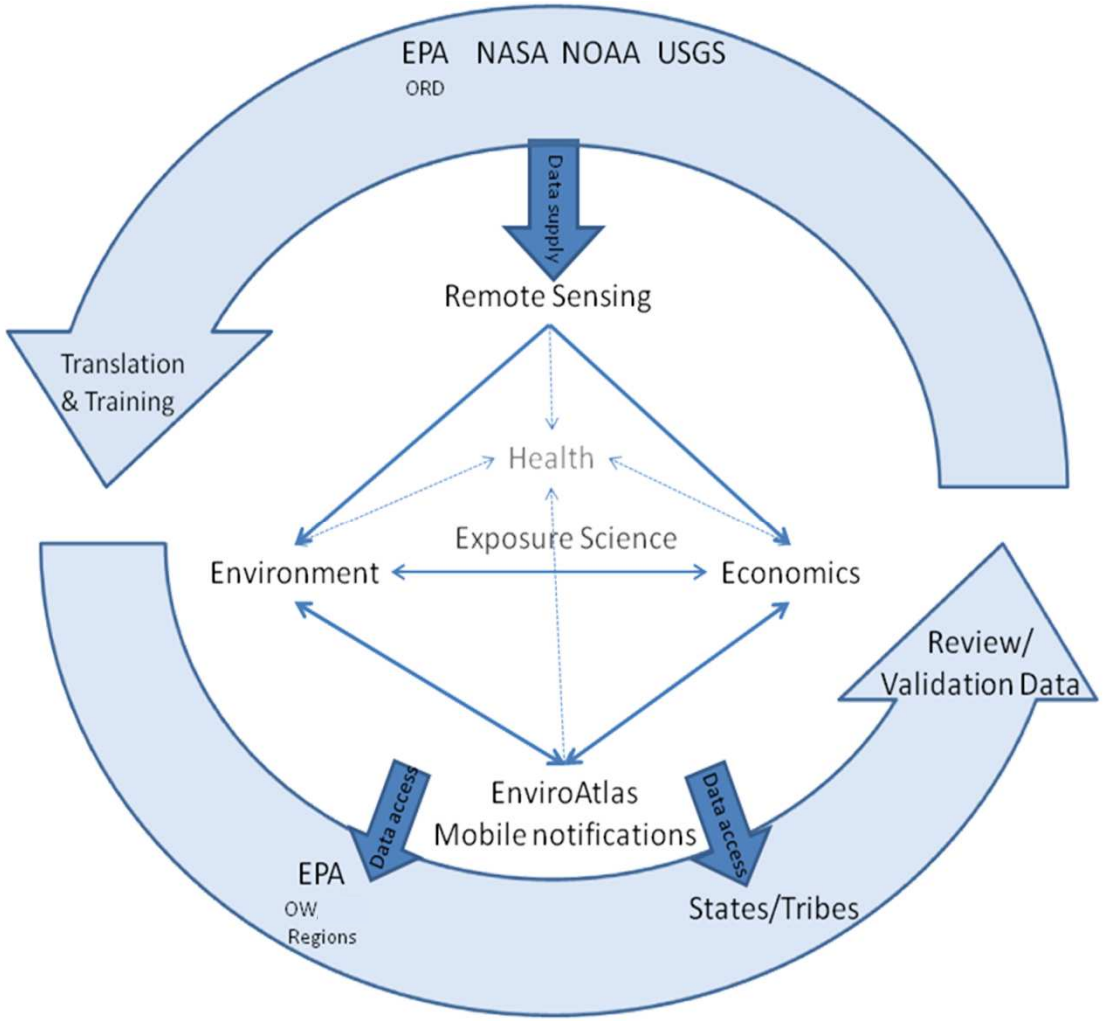
Medium to large lakes, national satellite data base.
Small lakes, establish capability.

1. Use pilot states to organize satellite data with water measurements.

2. Evaluate with existing satellite data (MERIS 300 m) 2002-2012

3. Establish routine monitoring with new sensor (OLCI, MERIS replacement)

4. Bring in high resolution (30 m) Landsat and Sentinel-2.

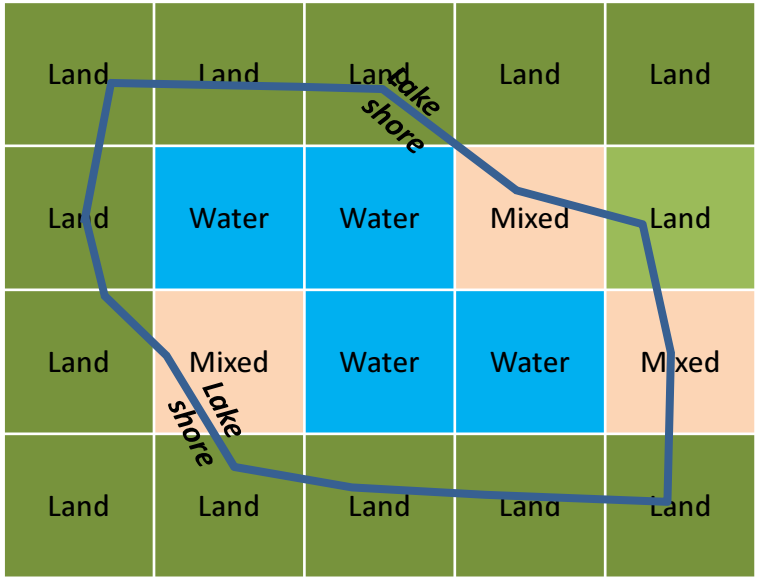


Satellite Comparison for cyano applications

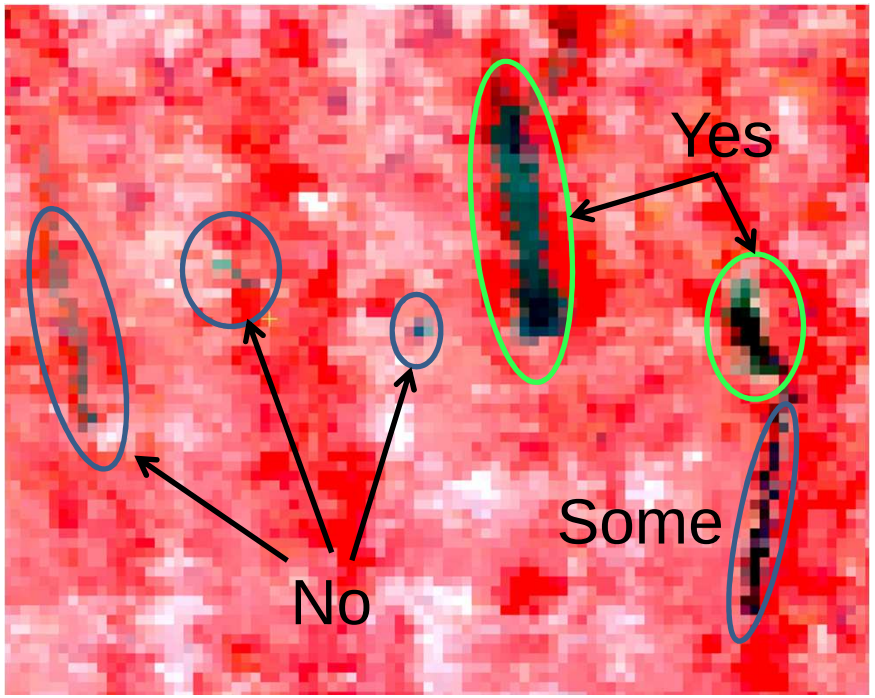
Satellite	Spatial	Temporal	Key Spectral
MERIS (2002-12) **OLCI Sentinel-3 2016**	300 m *OK*	**2 day** ***good***	**10 (5 on red edge)** ***good***
MODIS high res Terra 1999; Aqua 2002	250/500 m *OK*	**1-2 day** ***good***	4 (1 red, 1 NIR) *marginal*
MODIS low res & SeaWiFS	1 km *poor*	**1-2 day** ***good***	7-8 (2 in red edge) *OK*
Landsat	**30 m** ***good***	8 or 16 day *poor*	4 (1 red, 1 NIR) *marginal*
Sentinel-2 (2015)	**20 m** ***good***	10 day (5 day with 2nd satellite in 2017) *Potential with 2*	5 (1 red; 2 NIR, 1 in red edge) *potential*

Clouds take out 1/2 to 2/3 of imagery
Some sunglint is not a problem for our algorithms
Minimum resolution, 3 pixels across (2 mixed land/water)

Resolution and water bodies

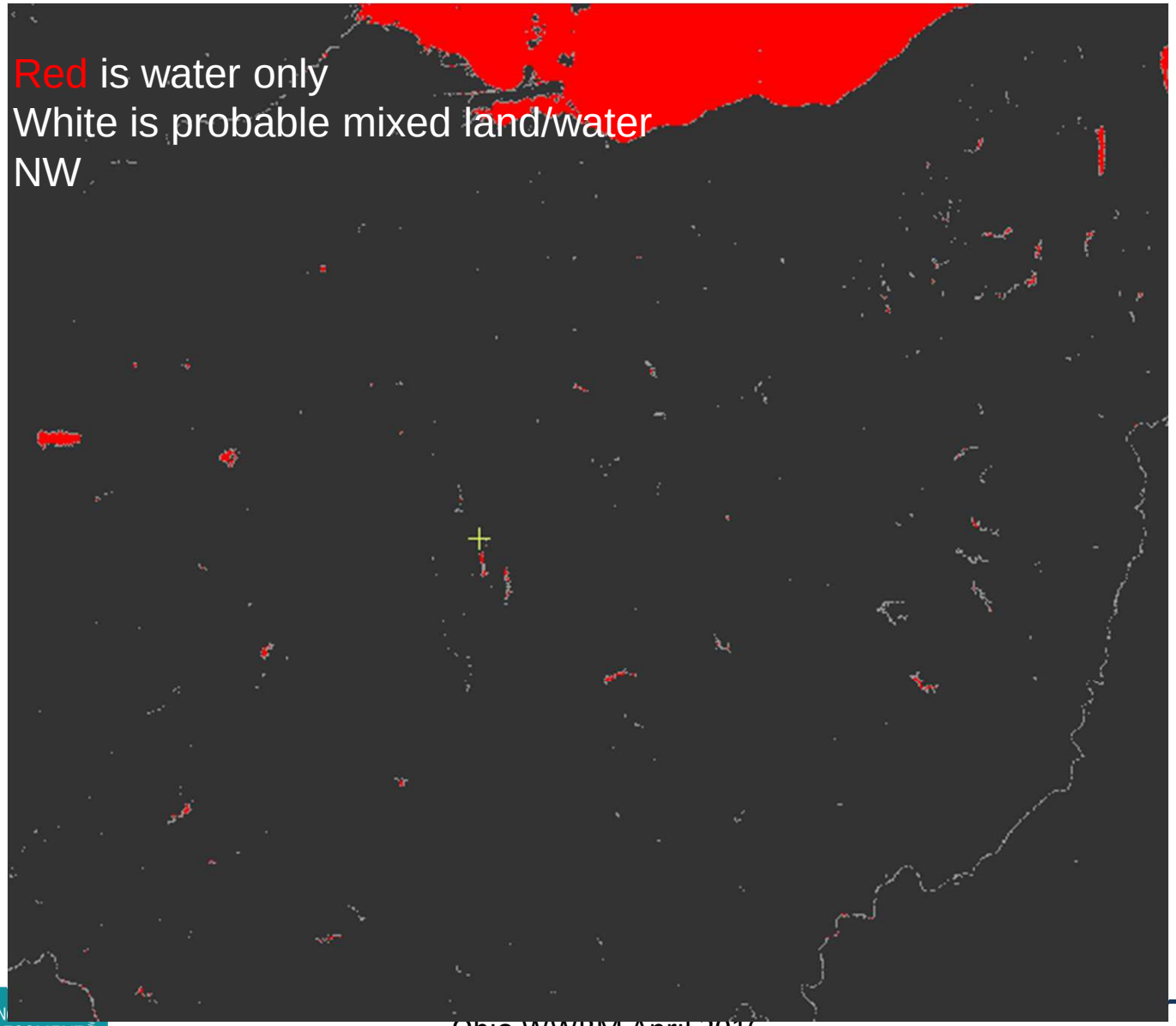


Mixed pixels limit our ability to monitor small water bodies.

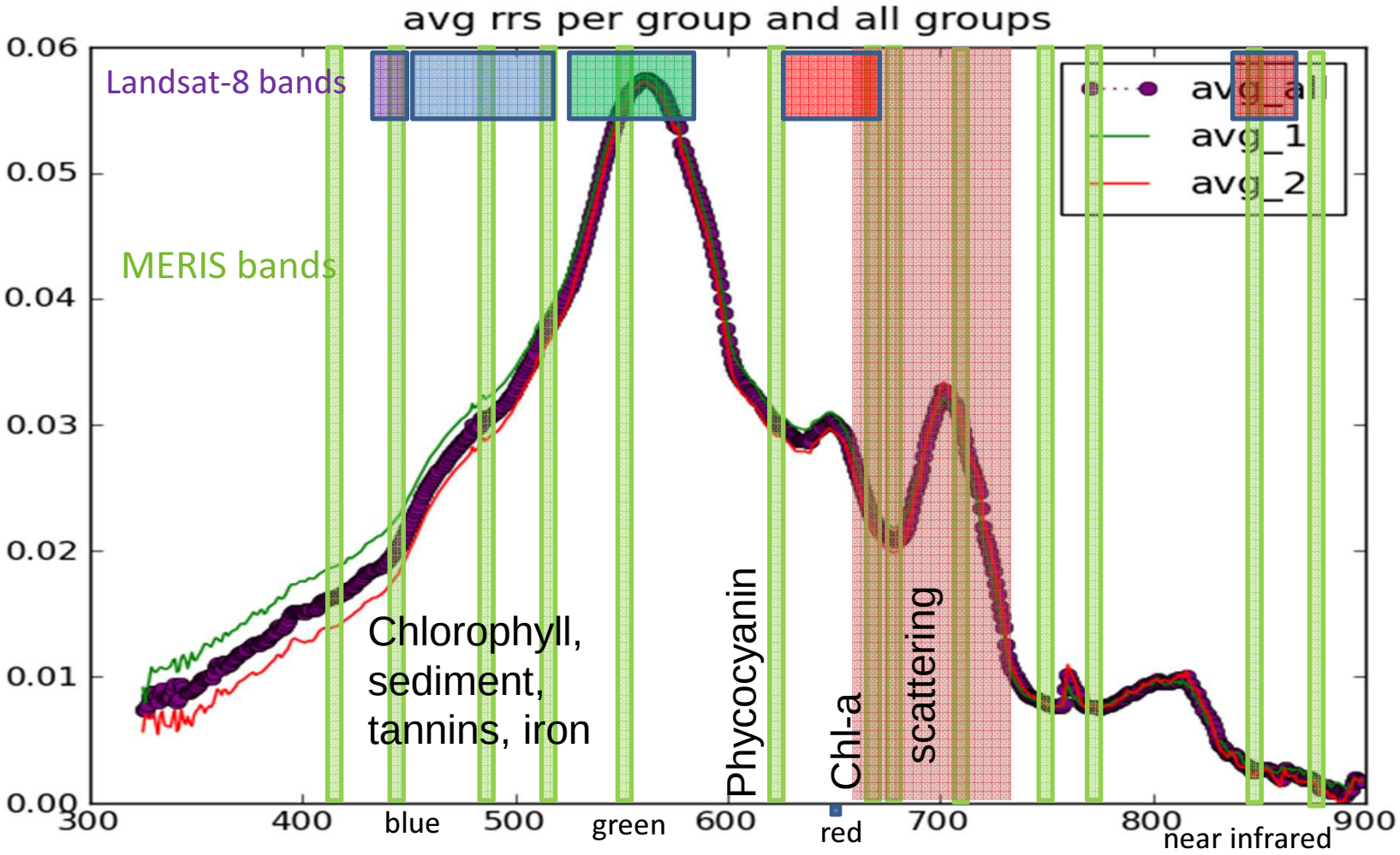


Note: false color sharpens distinction between land and water.
Reddish pixels at right include land.

Areas potentially monitored by MERIS and MODIS

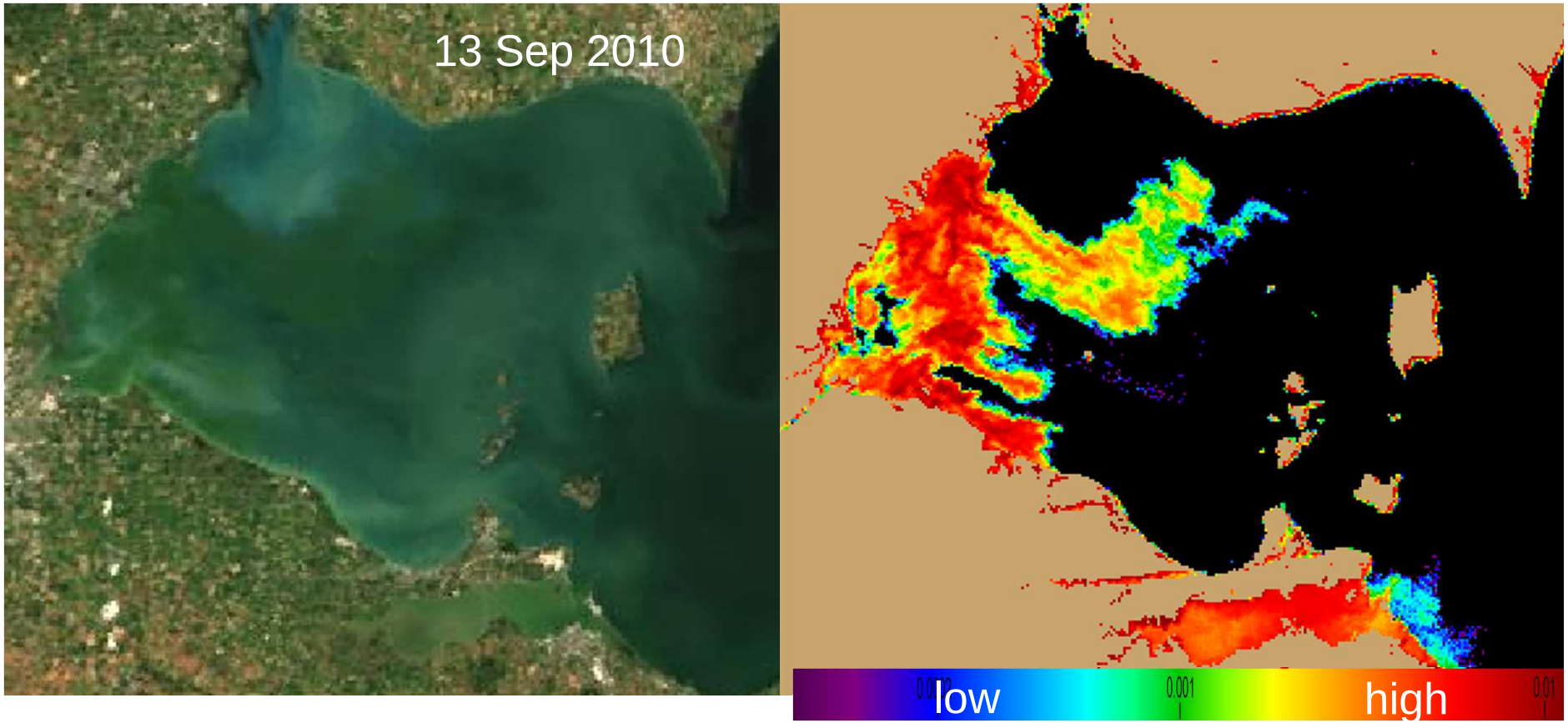


MERIS (and Landsat) Bands on water spectra from *Microcystis*



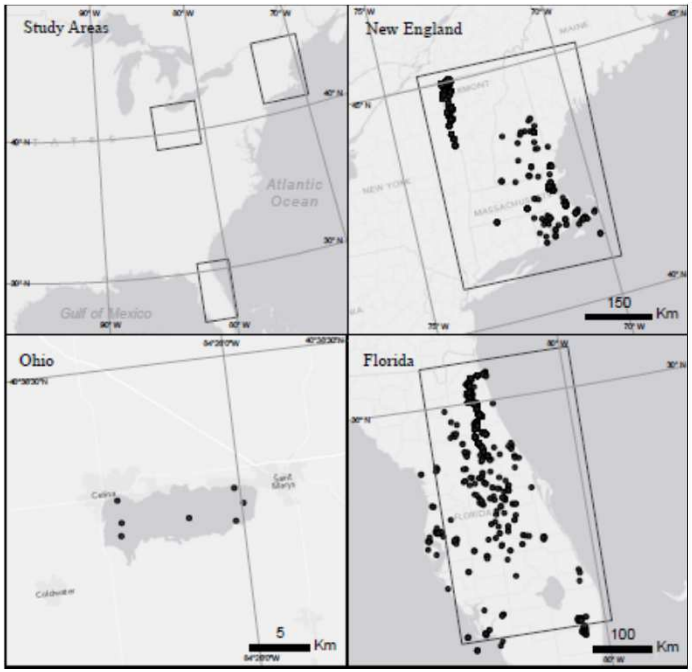
Also have to correct for atmosphere;
Landsat runs out of information content to discriminate everything

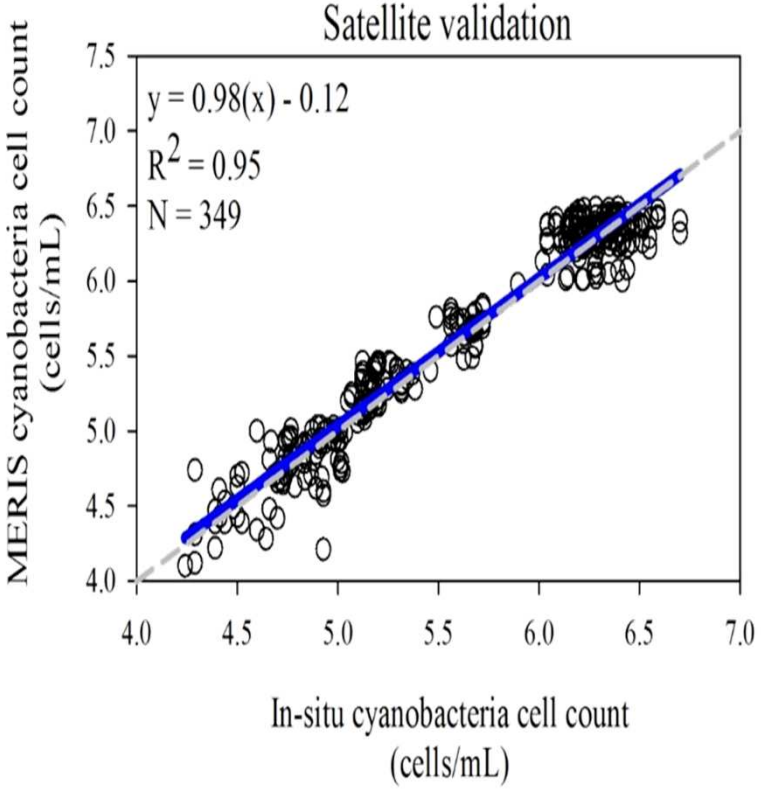
The extra wavelengths give a cyanobacteria chlorophyll index, "CI", which equates to concentration

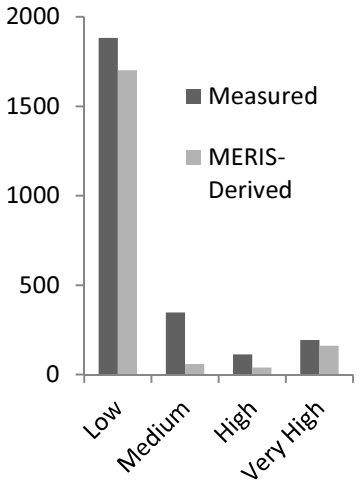


Validation of Lake Erie concentration algorithm for other areas

- **Remote Sensing**
  - *Uniform and systematic approach for identifying & quantifying cyanobacteria blooms.*
    - Second derivative spectral shape algorithms (SS; Wynne et al. 2008)



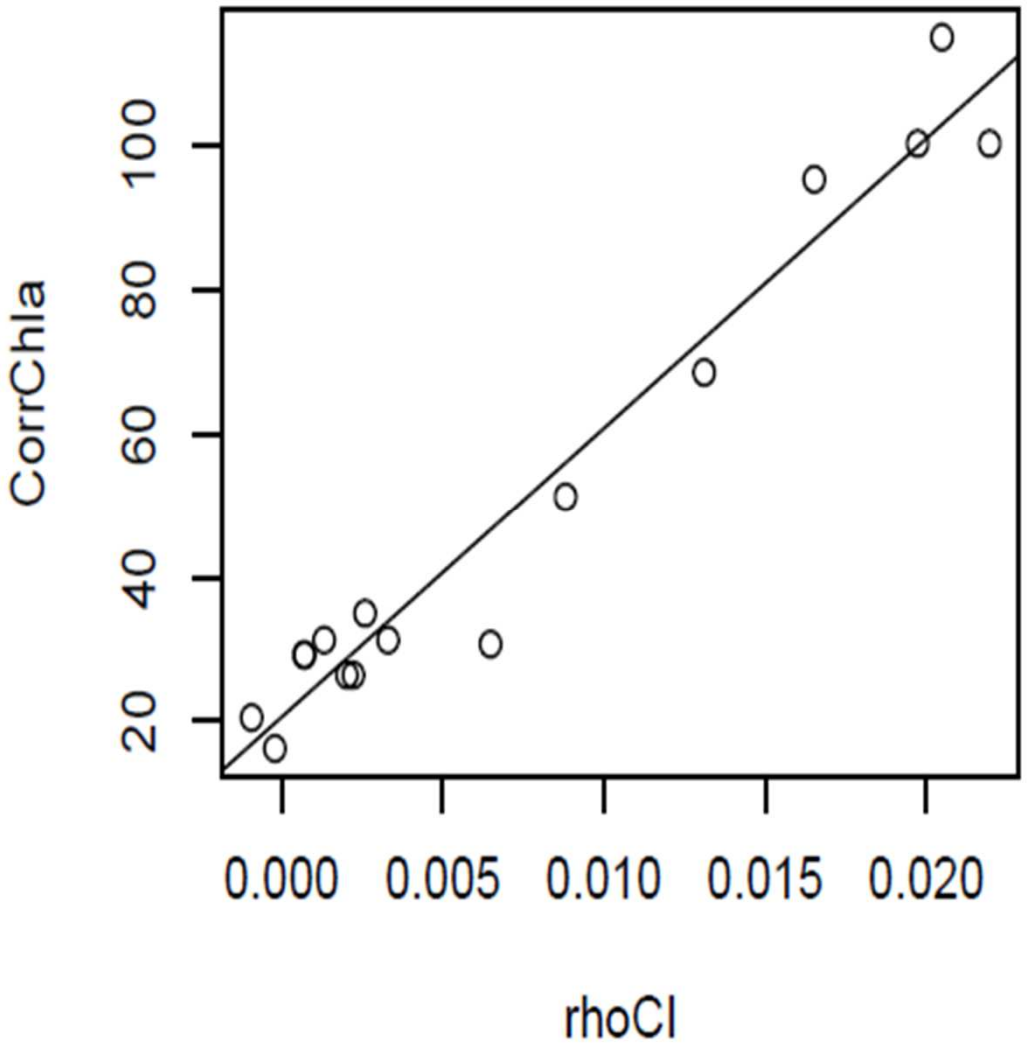




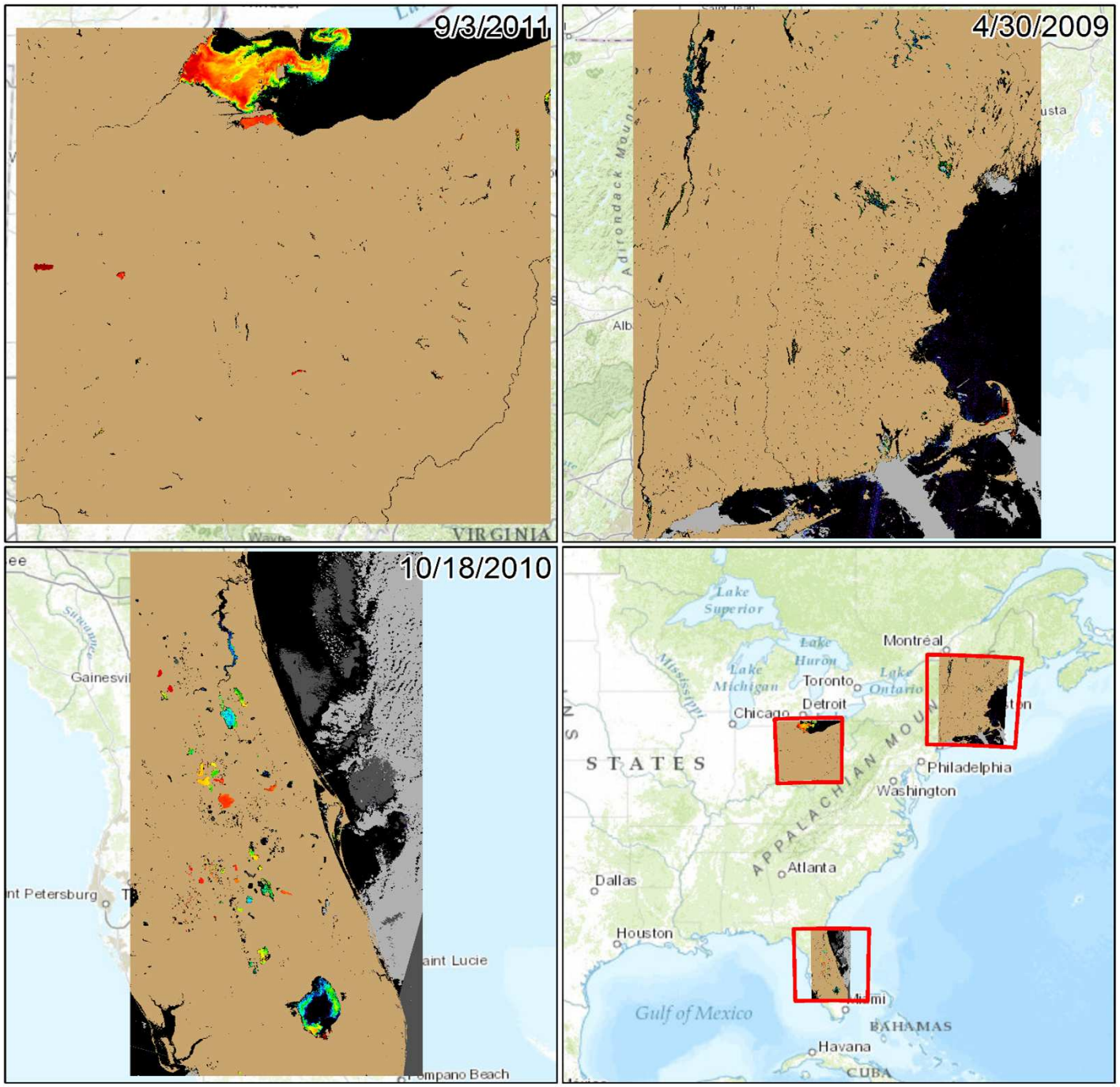
Lunetta, Schaeffer, Stumpf et al. Remote Sensing of Environment

And Between CI and chl-a from Florida (St Johns River WMD)

- 10% mean uncertainty
- *Est chl* a =
- 4020*(*CI*) + 20
- Detection of chlorophyll > 20 µg/L
  - (working on > 10 µg/L)



Example data



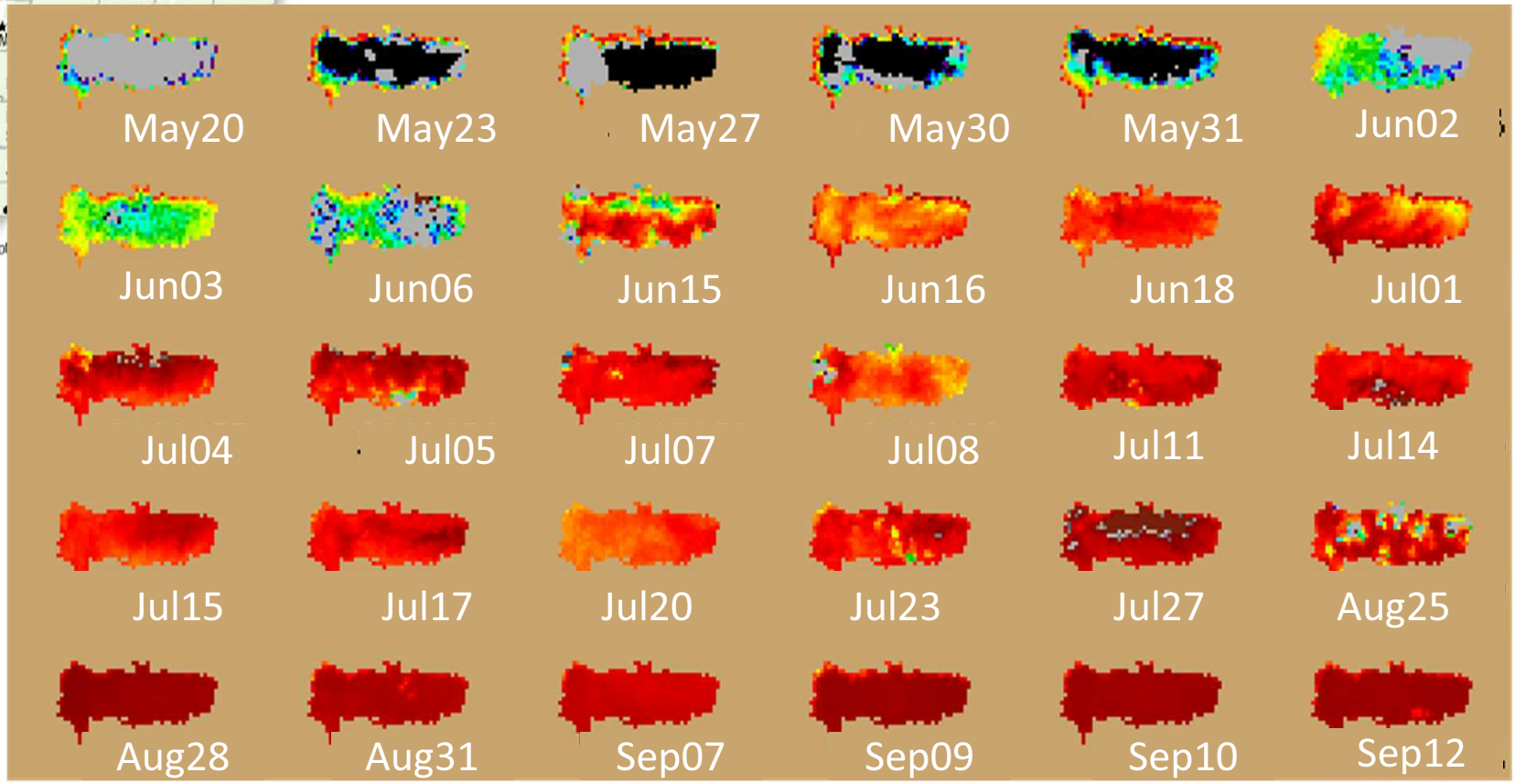
Lakes with health warnings

Lakes at Dillon, Lake Hope and Lake Loramie state parks were removed yesterday from the list of lakes that have tested positive for toxic algae. The lake at Mount Gilead State Park was added to the list. There are now 15 lakes and ponds where officials fear that liver and nerve toxins produced by blue-green algae could be a health threat.

* Bodies of water affected are not the main lakes or reservoirs.

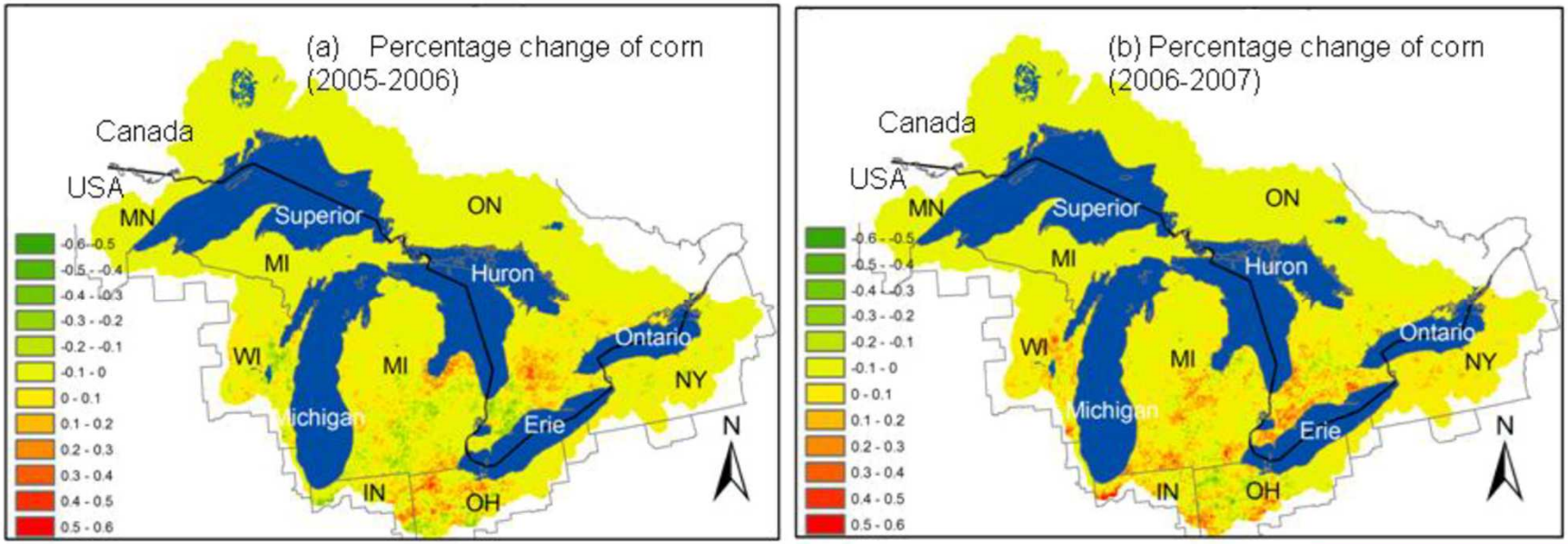
Temporal Patterns, when does bloom start?
Grand Lake St Marys, Ohio

- Cyano index for 2010



Technical Approach, Environment

- **Examine Environment**
  - *Identify landscape linkages causes of chlorophyll-a and cyanobacteria.*
  - Evaluate chlorophyll-a concentrations and cyanobacteria cell count trends.
  - Identify changes related to land-cover modifications (2001–2016).
  - 13+ years of data observations across Great Lakes Basin, including all inland lakes (≥100 ha), focus on sources of potable water.



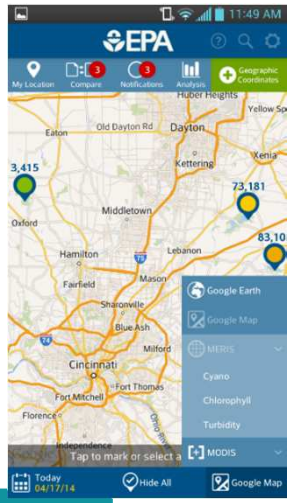
Technical Approach, Socio-economic questions

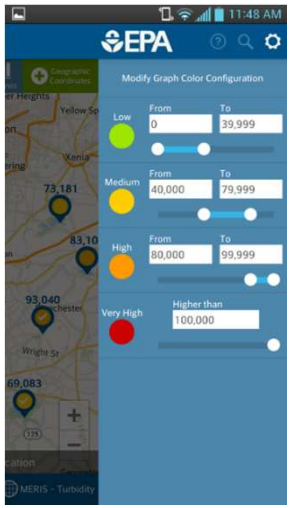
- **Health**
  - *Exposure and human health effects in drinking and recreational waters.*
  - Remote sensing provides opportunity to estimate human exposure to cyanotoxins over specific geographic areas
  - Retrospective evaluation of existing health records among communities with a past history of cyanobacteria blooms detected via satellite.

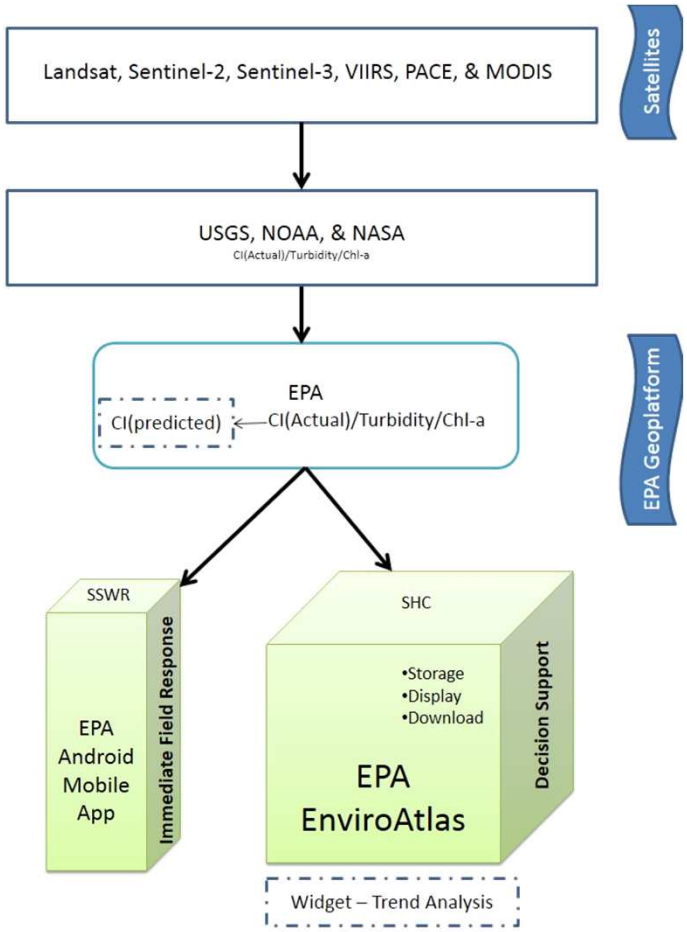
- **Economics**
  - *Behavioral responses and economic value of the early warning system.*
  - Database of public resources spent on monitoring or responding to HABs. Assessment of the potential value of more comprehensive monitoring by satellite.
  - Economic impact of avoiding toxic and nuisance bloom events in freshwater lakes.

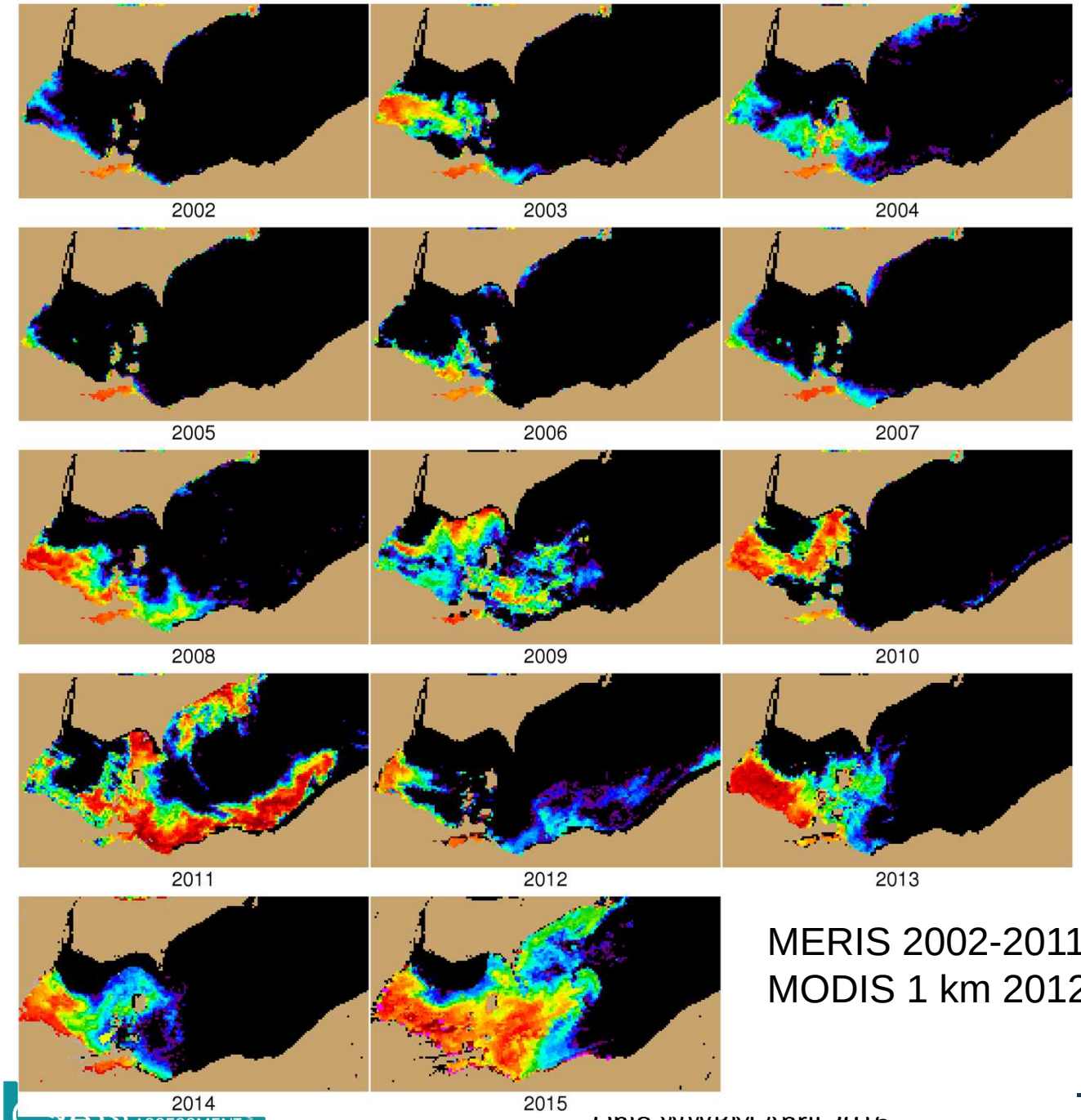
Technical Approach, multiple data distribution

- **Notifications**
  - *Bring the technology to EPA, states and tribal partners.*
  - Process and deliver satellite data in ways that are useful and practical to stakeholders and daily life.
  - Data pushed from NOAA, NASA and USGS
    - GIS formats
    - EPA Mobile Android Platform on weekly time-steps.





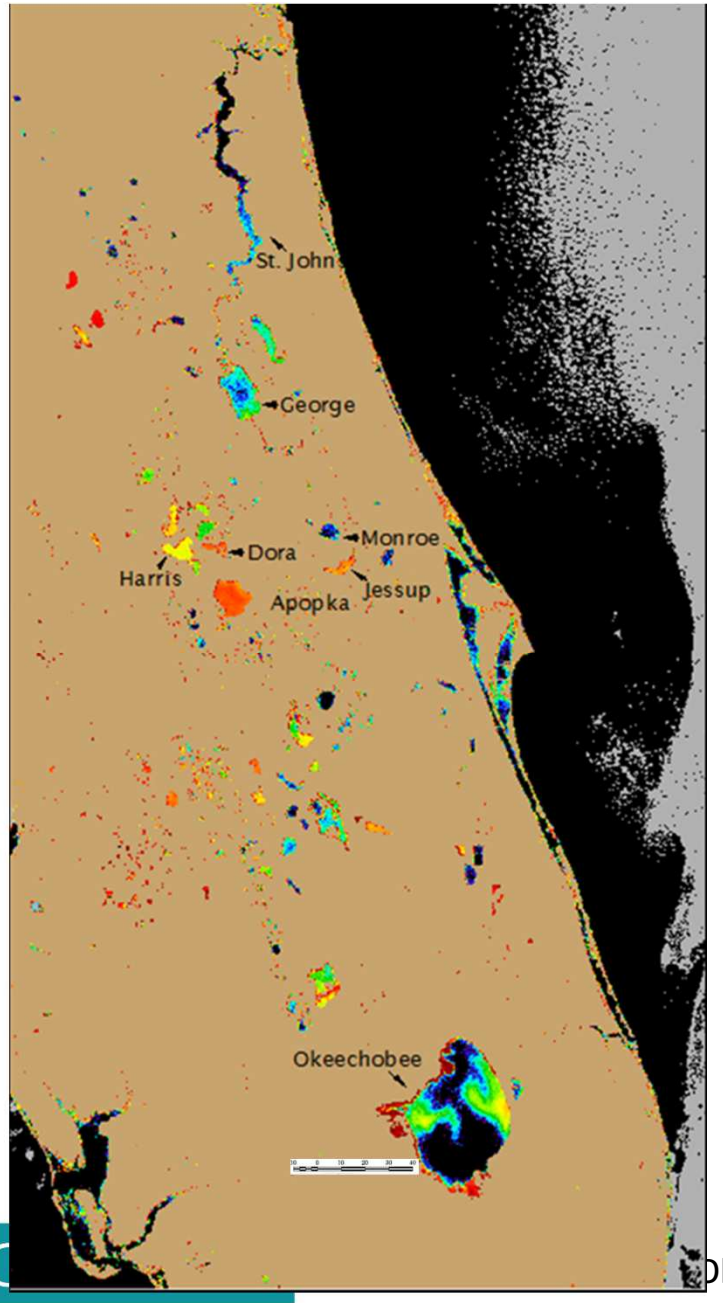




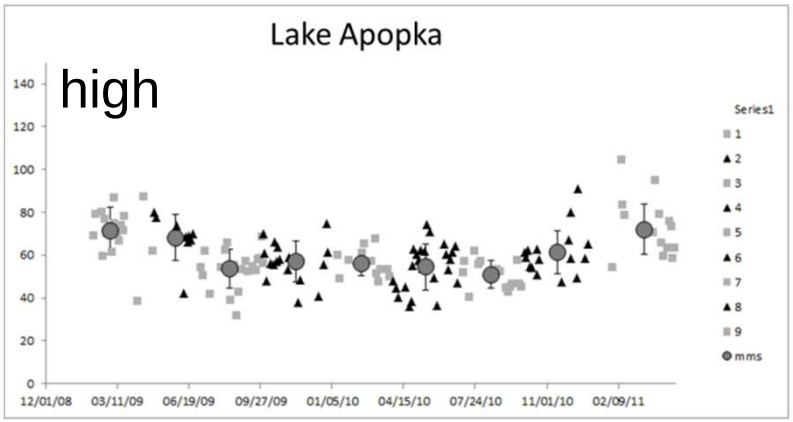
Lake Erie
13 years of satellite data provide intensity, extent, and timing

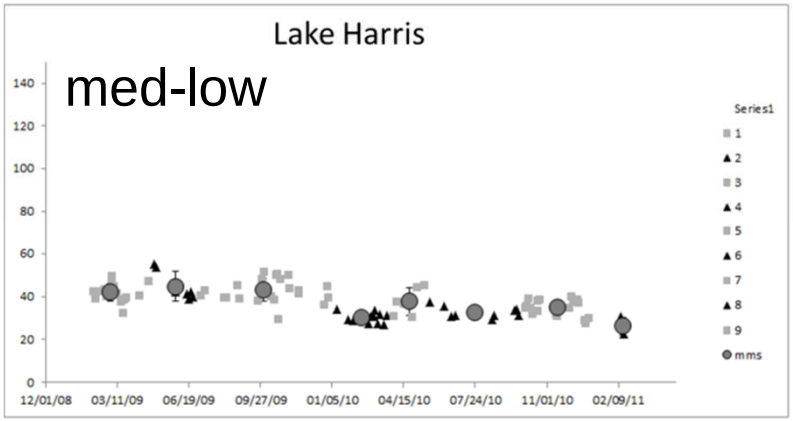
MERIS 2002-2011
MODIS 1 km 2012-2015

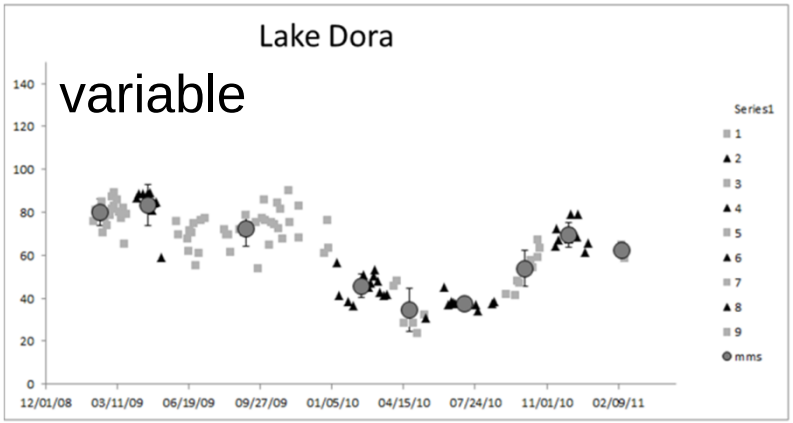
Tracking biomass in Florida

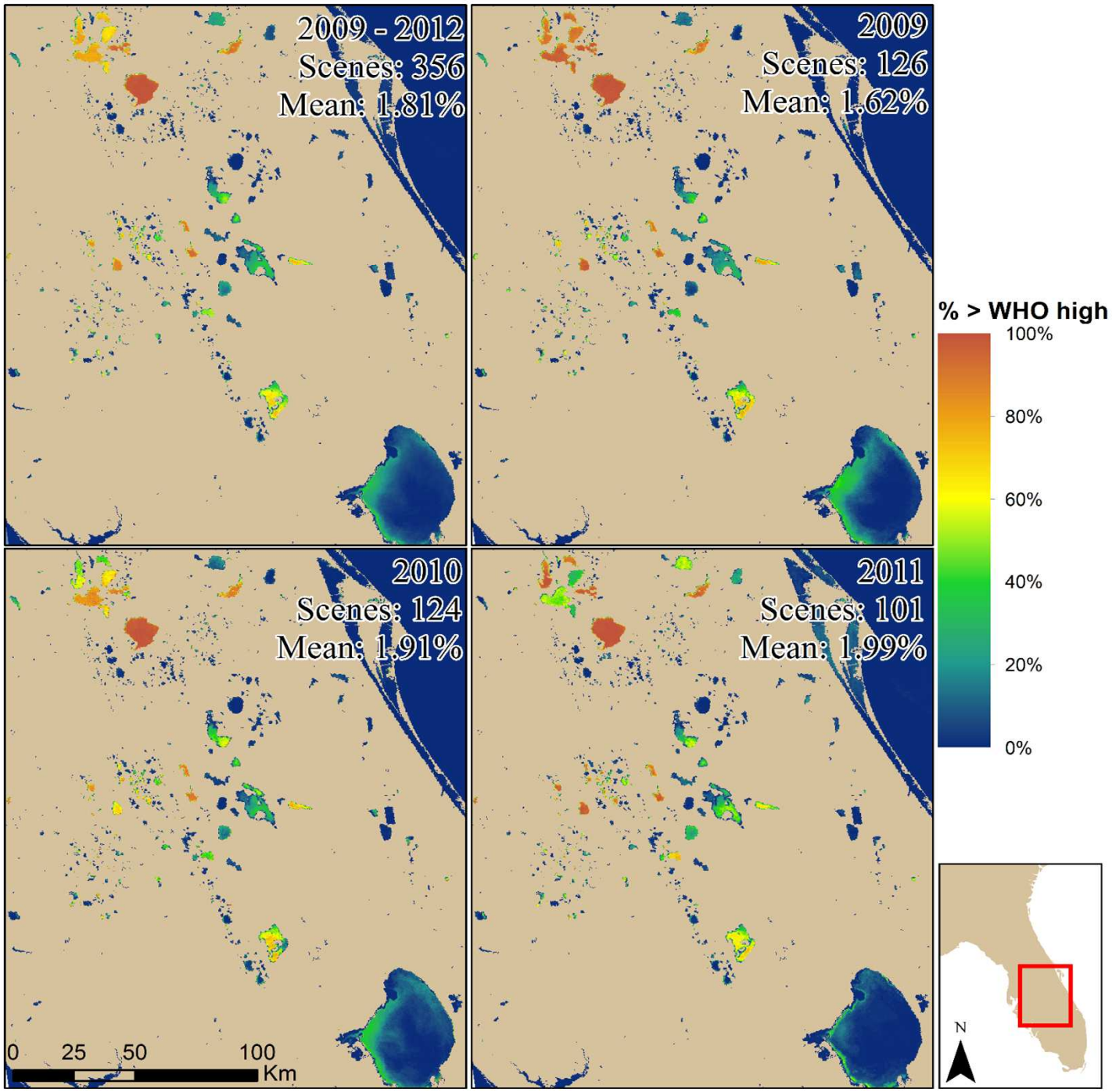


Biomass over 3 years









Frequency map

(warm is more frequent)

CYAN CYANOBACTERIA ASSESSMENT NETWORK

Example preceding CyAN: 1500 subscribers + media

Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

17 August, 2015, Bulletin 11

The *Microcystis* cyanobacteria bloom continues across a large part of the western basin south of West Sister Island from Michigan to the islands. Dense scums have formed in highest concentration areas, with extensive scums occuring in the red to dark red areas in the western basin. The bloom is found east of the islands, including scum patches away from shore. Moderate concentrations extend as far as Rondeau on the Ontario coast. Microcystin is present in this bloom, and the toxin levels are extremely high in scums.

Light southerly to southwesterly winds will continue today and Tuesday, gradually increasing to Thursday. Least mixing and greatest scum formation earlier in the week, and greatest mixing with passage of a cold front late Wed and Thursday. These winds will cause continued movement of the eastern edge into the central basin and also eastward on the Ontario coast.

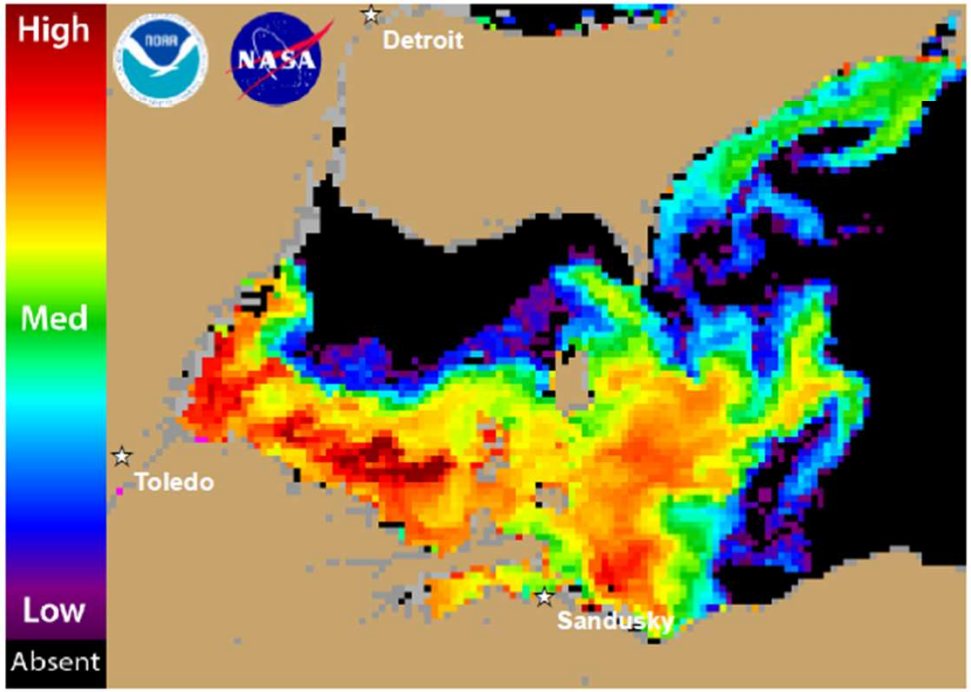


Figure 1. Cyanobacterial Index from NASA's MODIS-Terra data collected 16 August, 2015. Grey indicates clouds or missing data. Black represents

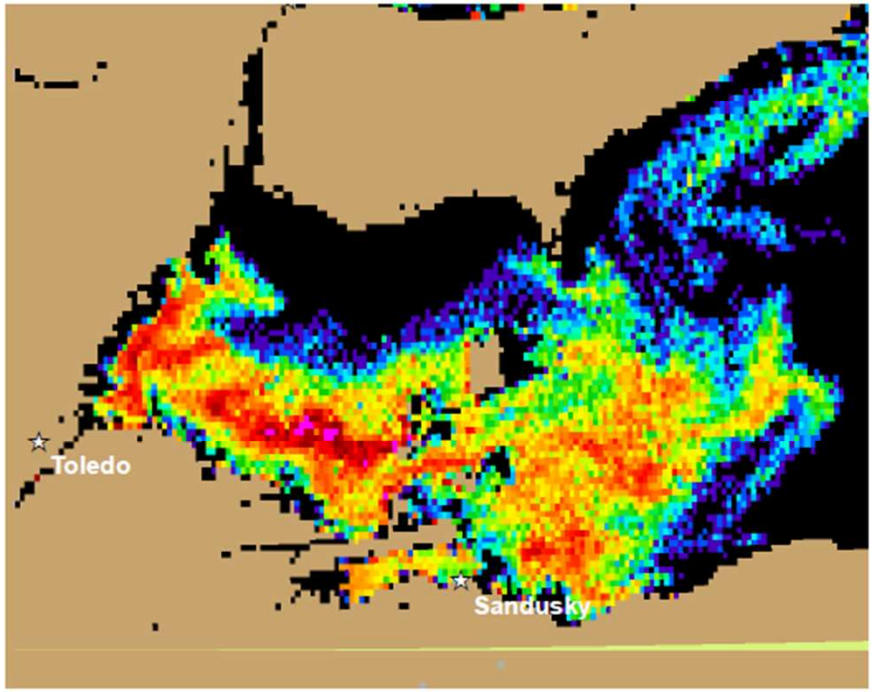
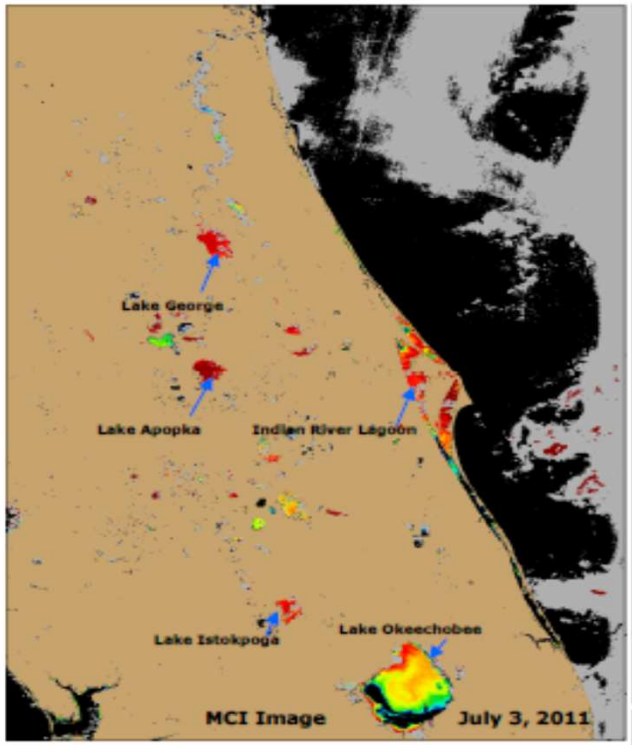


Figure 2. Nowcast position of bloom for 17 August, 2015 using GLCFS modeled currents to move the bloom from the 16 August,

Example: State application (Florida, DOH)

Experimental Cyanobacteria Bulletin: July 3, 2011

To report an illness related to a marine toxin or algal bloom please contact the FL Department of Health Aquatic Toxins Hotline at 1-888-232-8635.
For questions about the report: please contact Becky Lazensky, FL-DOH, at 352-955-1900. Images/data were obtained from Florida Water Management Districts, The National Oceanic and Atmospheric Administration (NOAA), NOAA National Climatic Data Centers and National Weather Centers. Support to produce this report was received through a NOAA/NASA Agreement (Number: NNH08ZDA001N)



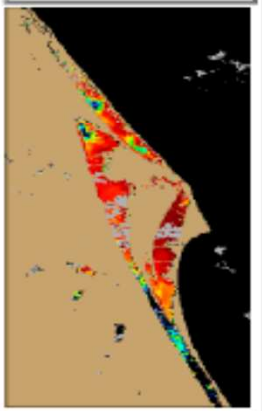
The MERIS Satellite Images above display a cyanobacteria index generated with a Medium Resolution Imaging Spectrometer (MERIS) satellite provided by the European Space Agency & NOAA.

- Very low likelihood of a bloom.
- May indicate clouds or missing data.
- Low cyanobacteria concentrations.
- Medium cyanobacteria concentrations.
- Probable bloom or higher cyanobacteria concentrations.

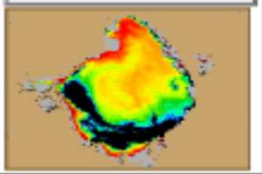
Conditions Report: July 3, 2011

- Cyanobacteria estimates were remarkably elevated in several lakes, including an ongoing detection in Lake George, Lake Apopka, Lake Istokpoga, and Lake Okeechobee.
- The Indian River Lagoon has recently begun showing an increase in estimated cyanobacteria concentrations.
- An ongoing bloom has been reported in the Caloosahatchee River (Lee County). Lake Okeechobee (photo on right) supplies water to the Caloosahatchee.

Indian River Lagoon



Lake Okeechobee



Recent Blooms

Caloosahatchee River
June 22
Photo by FL DEP

Coordinates: 26.7123, -81.6098
City: LaBelle
Confirmed Species: Anabaena flosaquae
Limnothrix, Pseudanabaena cf minima
Sample Collection Date: June 2, 2011
Bloom continuing as of June 22, 2011

St Johns River Field Brief
By: Robert Burks, St Johns River Water Management District, June 20-23

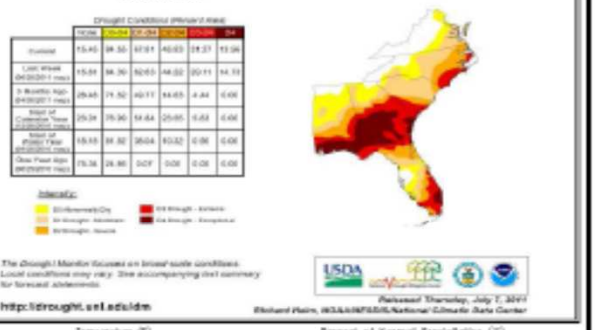
Surface Water quality: Lower Basin river continues to show high salinities through Hibernia Point (near Black Creek)

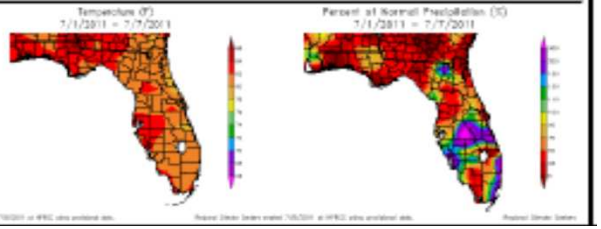
Weather/Rainfall: Hot and humid. Well above average day temps (+47F for week) and night (+ 16F for week). Rainfall at 1.21 inches on 6/17, and 1.78 inches for 6/23

Algal/HAB: No bloom or scum formations observed from Astor to Mayport, with the exception of some filamentous formations near shore at Black Creek on 6/22. HAB species were identified in samples from Doctors Lake, Mandarin Pt, & Plummers Cove

For a full report:
Email Robert Burks
rburks@sjrwmd.com

U.S. Drought Monitor
Southeast
July 5, 2011

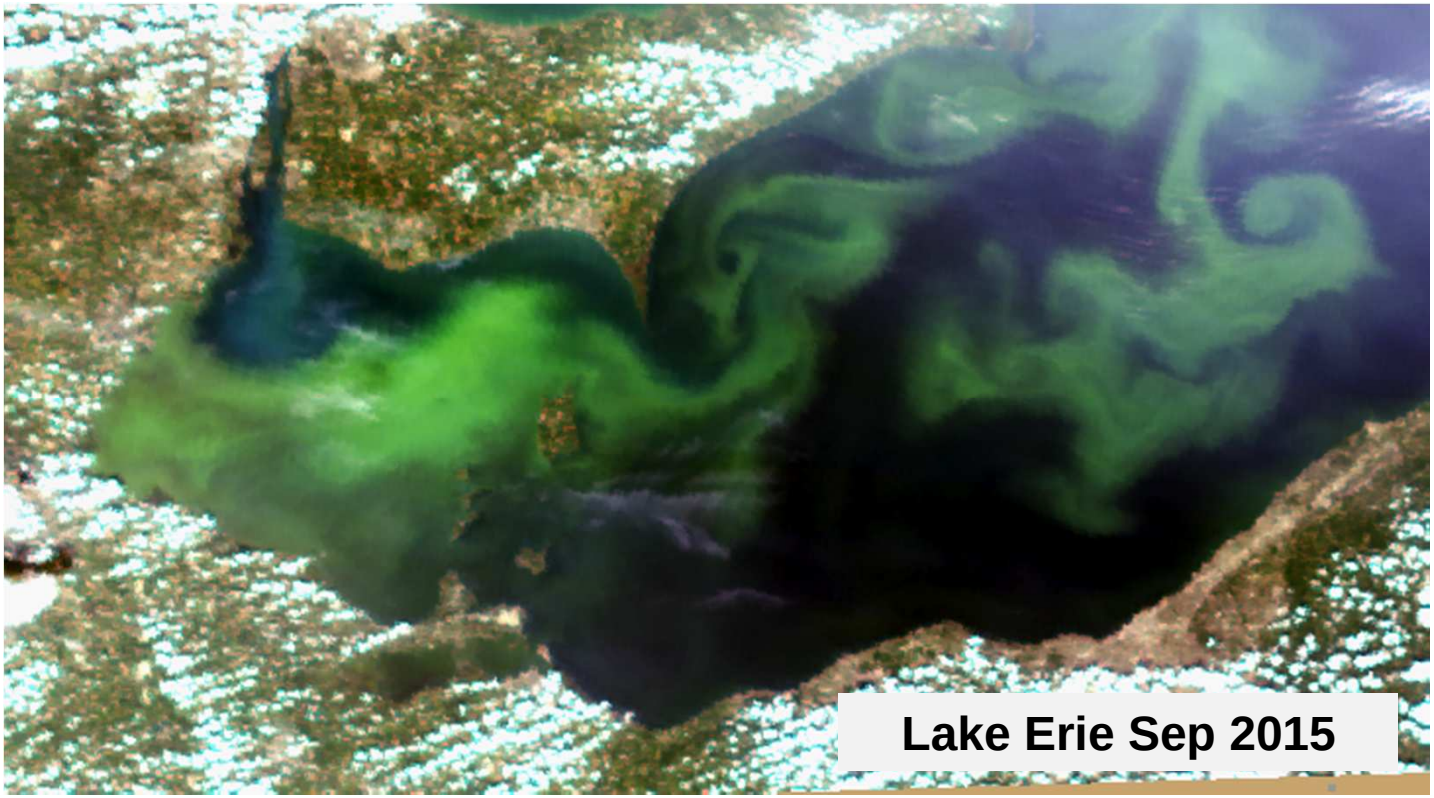




Technical Approach

- FY16
  - Florida, Ohio, California, New England (retrospective)
- FY17
  - Continental US
  - Lakes, reservoirs, and estuaries
- Satellite derived products
  - Cyanobacteria concentration/ chl-a concentration
  - Turbidity
  - Temperature
- Satellite updates
  - Sentinel – 2A/3A

Web links



CyAN web site:
www.epa.gov/water-research/cyanobacteria-assessment-network-cyan-project

NOAA Lake Erie Bulletin:
coastalscience.noaa.gov/research/habs/forecasting

Additional support by NASA Ocean Biology and Biochemistry Program.
Previous support by NASA Applied Science, Public Health