

Monitoring and Forecasting Cyanobacterial Blooms for Public Health Protection and Response

NASA - Decision Support through Earth Science
NNH08ZDA001N-Decisions

Rick Stumpf, Shelly Tomlinson, Tim Wynne, NOAA
Andy Reich, Becky Lazensky, Florida Department of Health
Lorrie Backer, Centers for Disease Control, Environmental Health
Other state “partners”: Heather Raymond OEPA, Cathy Wazniak,
MD DNR.

Lake Erie 22 July 2011

Why worry about cyano HABs?

- ❖ Degrades water quality
 - ❖ Taste/odor issues
 - ❖ Loss of recreational and fishing value to affected waters
 - ❖ Hypoxia/anoxia, may lead to mortality in benthic invertebrate community and fish kills
- ❖ Alters food webs
 - ❖ Unpalatable to many zooplankton grazers
- ❖ Toxin producer
(neurotoxins, hepatotoxins, dermatotoxins)
 - Toxic to zooplankton, shellfish, fish, animals, humans

Dogs have been known to die of renal failure within hours of drinking water with microcystins.

The health perspective

Ohio, 2010, 48 human illnesses, 5 dead dogs, closure of YMCA lake near (1000 ppb microcystin 19 kids sick, Silver Lake, Ohio, 2010). Posting Grand Lake St Marys

MD Girl Scout camp lost the use of its Lake Williston in 2009-10 from *Microcystis* blooms. Lake drained & treated (2011)

WHO standard for microcystin, 20 ppb; no US standard; and no std for other toxins.

2013 Had an early season bloom in Lake Erie that closed many Canadian Beaches.

Forecasting

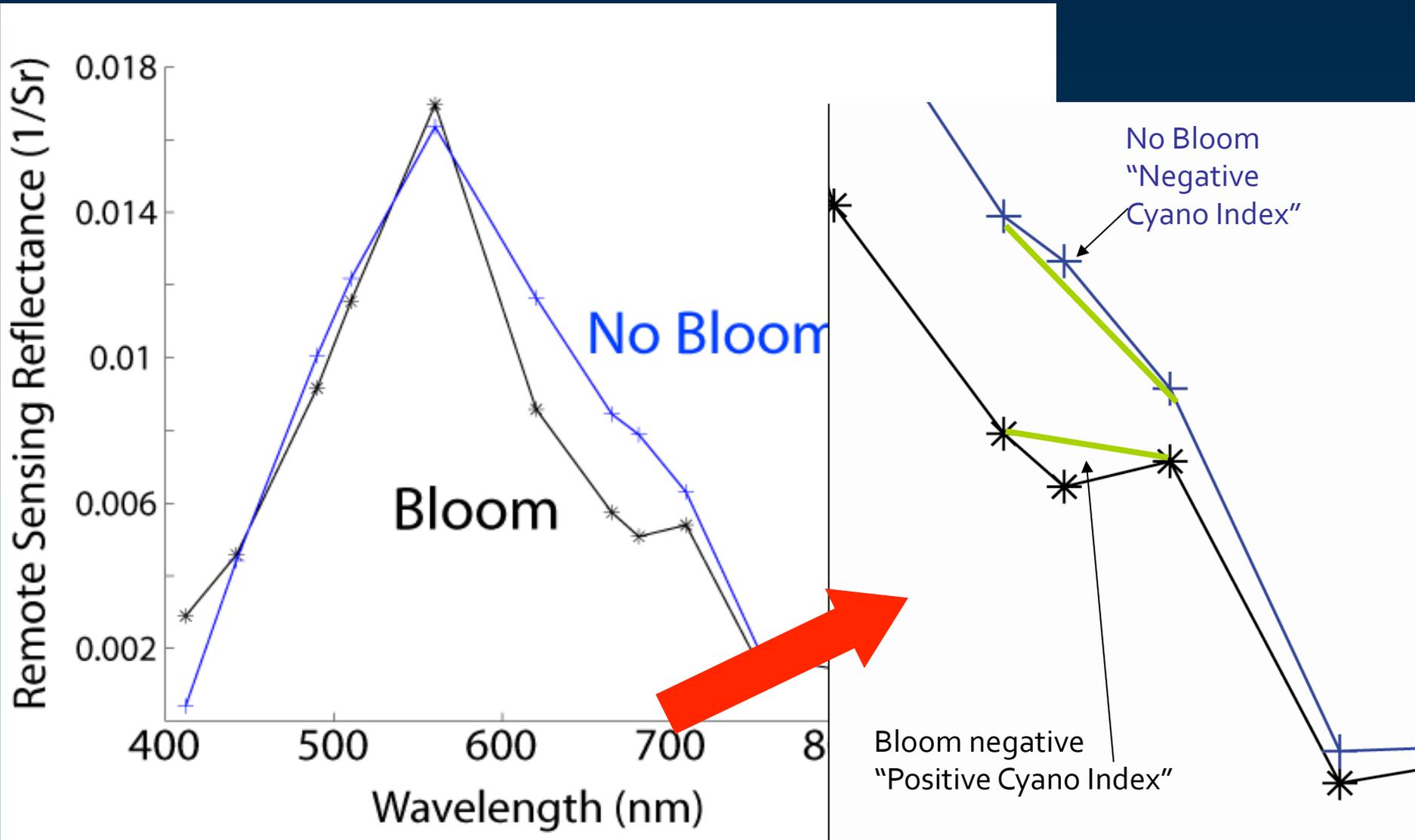
Nowcast & Short term forecasts (up to ~ 3 days)

Seasonal forecasts

Inter-annual forecasts

It all starts with satellite data; used MERIS from 2008-2011; MODIS from 2012-present.

Finding Blooms



MERIS Failed in April 2012; switch to MODIS

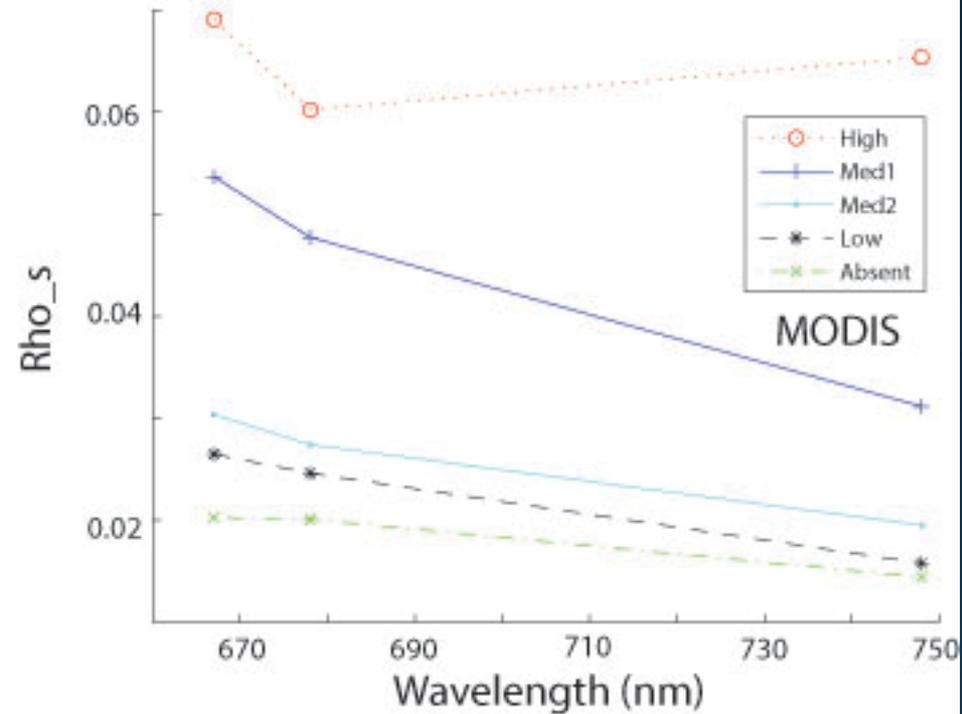
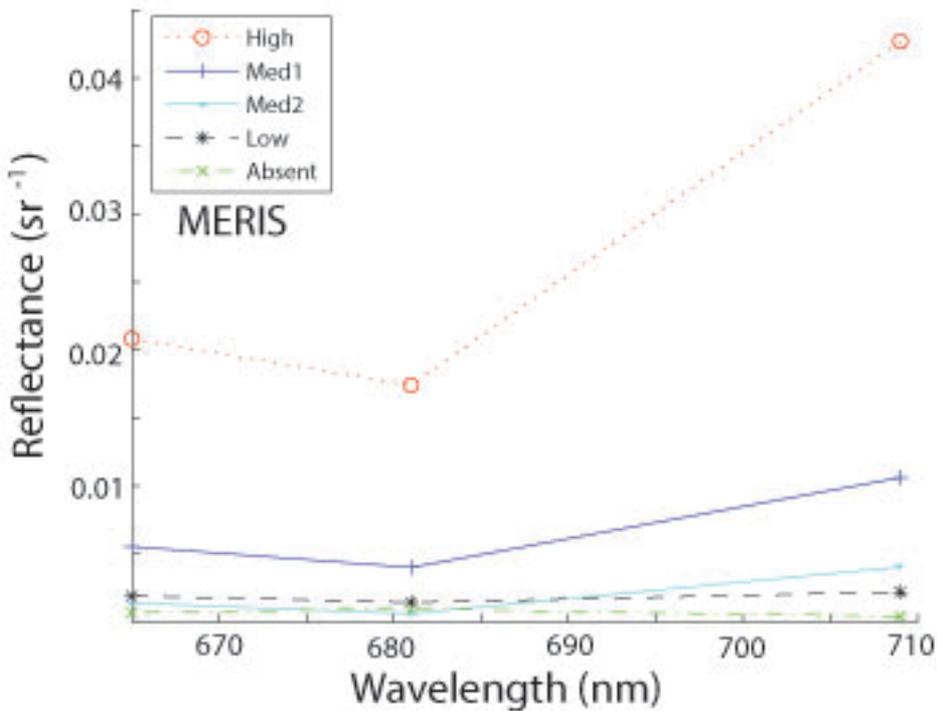
MERIS



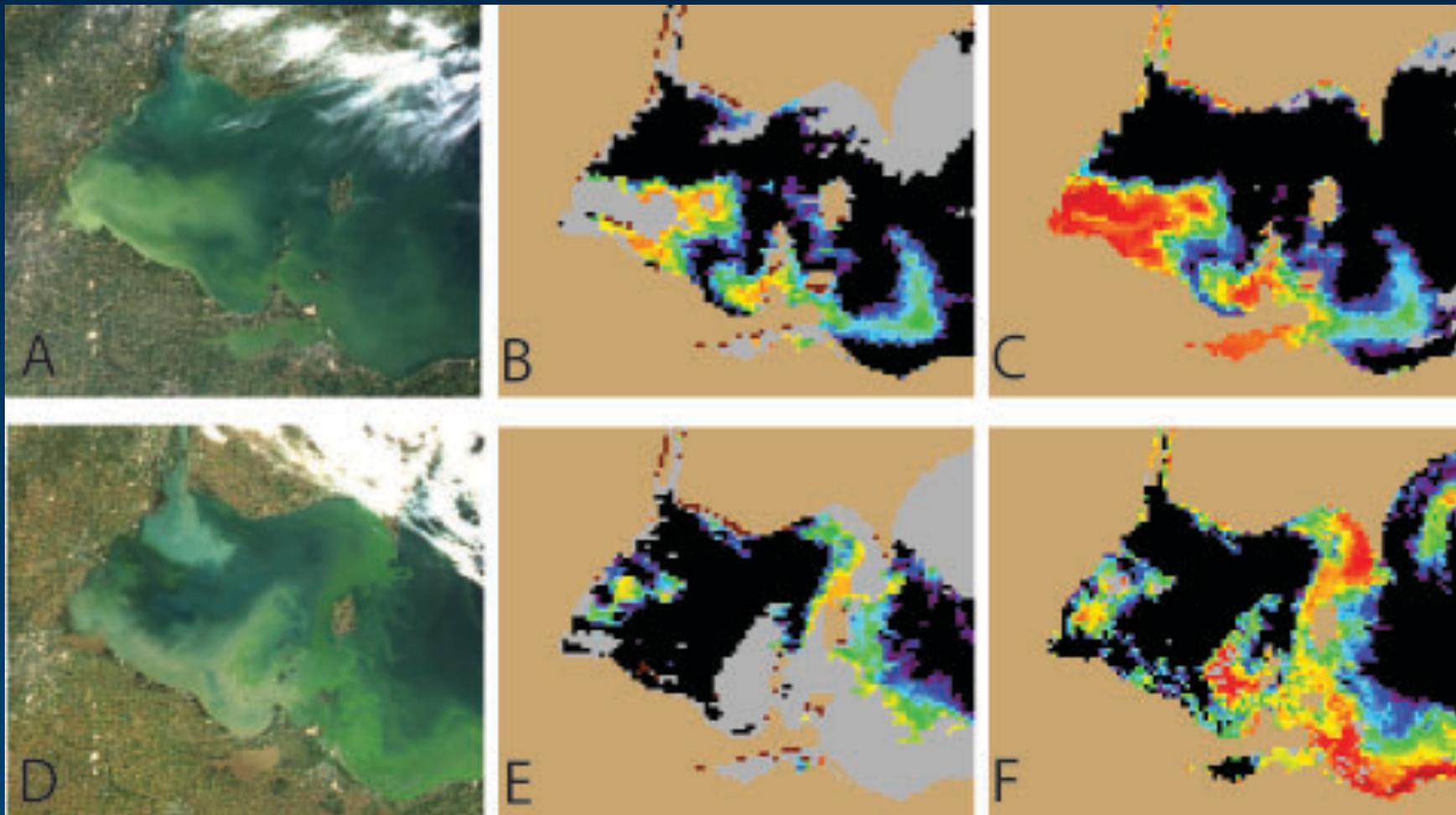
MODIS



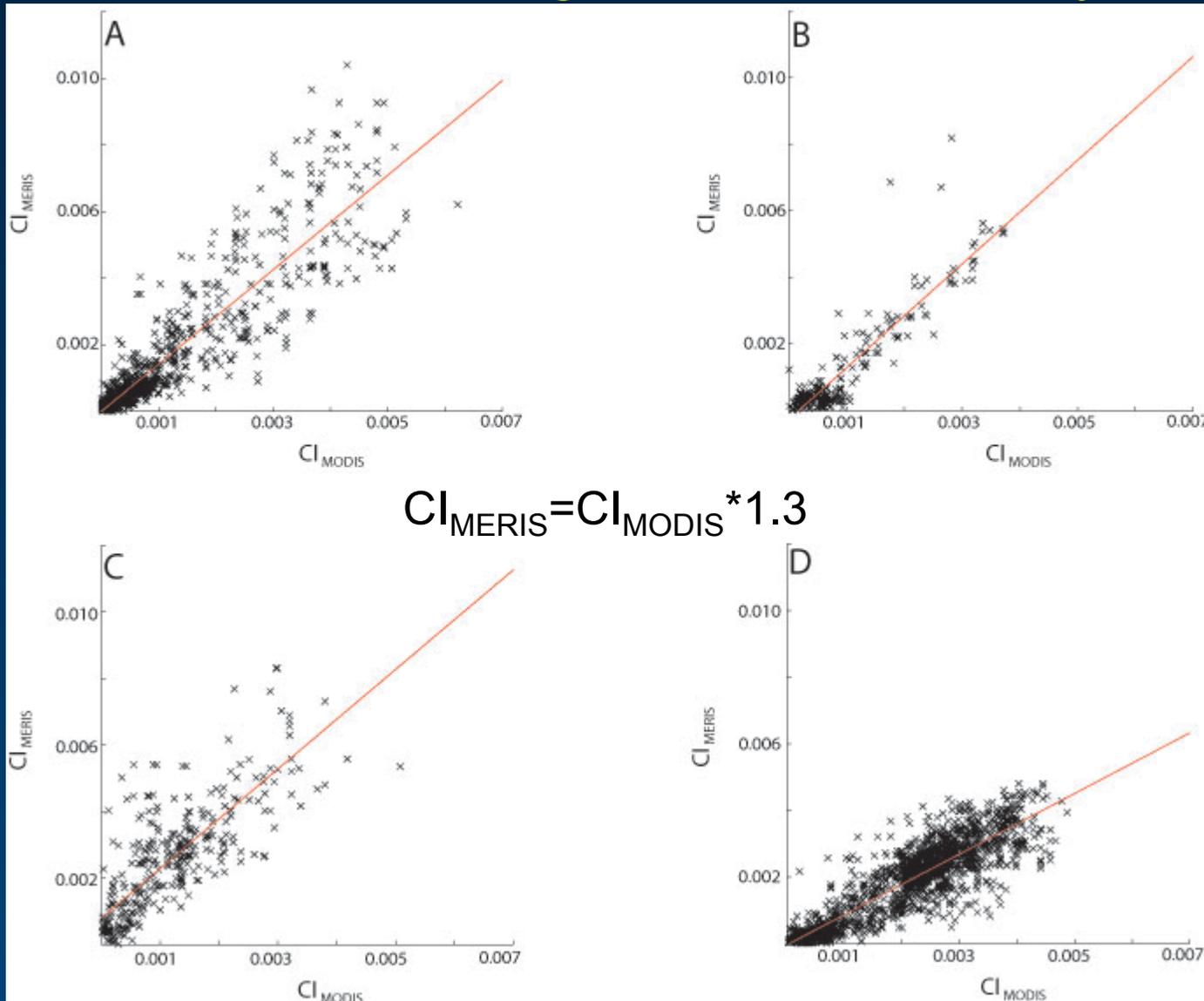
Find the Bloom



MODIS has some saturation problems



Overall MODIS is well-behaved compared to MERIS, although somewhat noisy

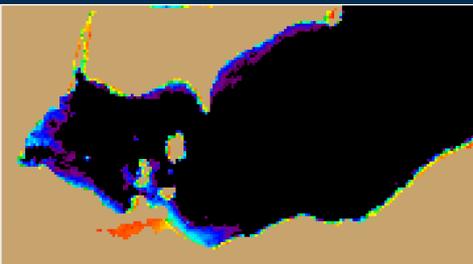


10 years of MERIS data and 1 for MODIS, we have now mapped the peak of bloom for each year

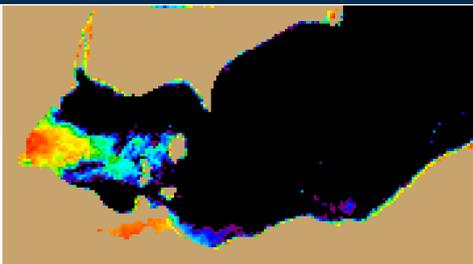
0.0002

0.001

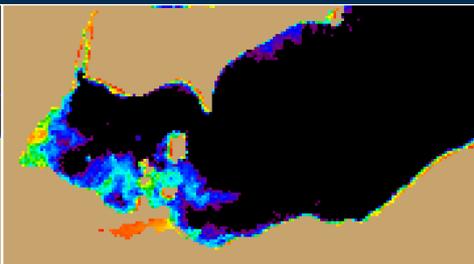
0.01



2002



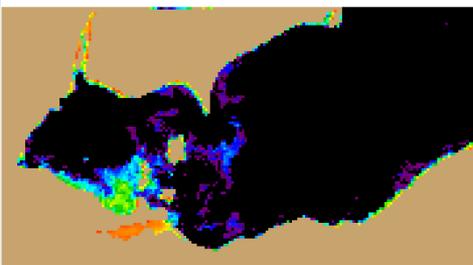
2003



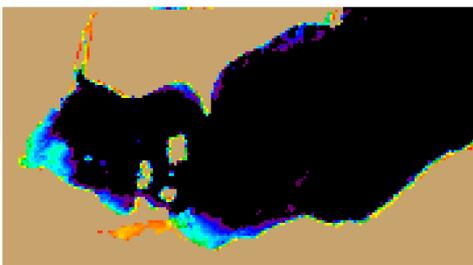
2004



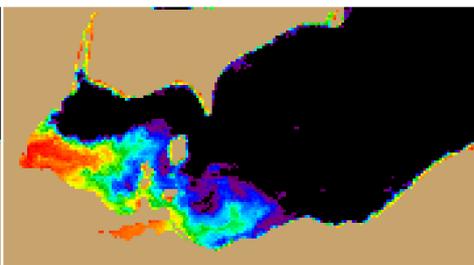
2005



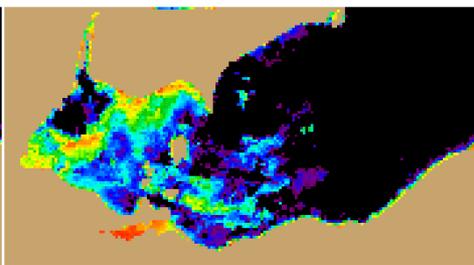
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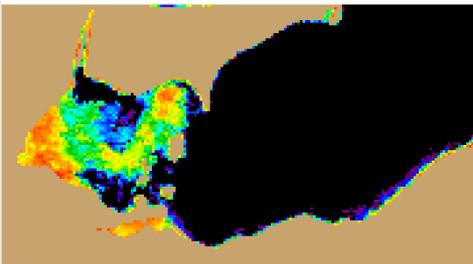
2007



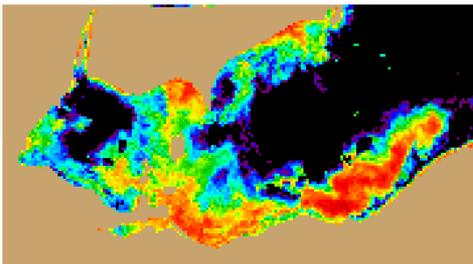
2008



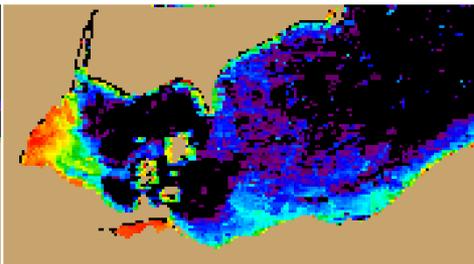
2009



2010



2011

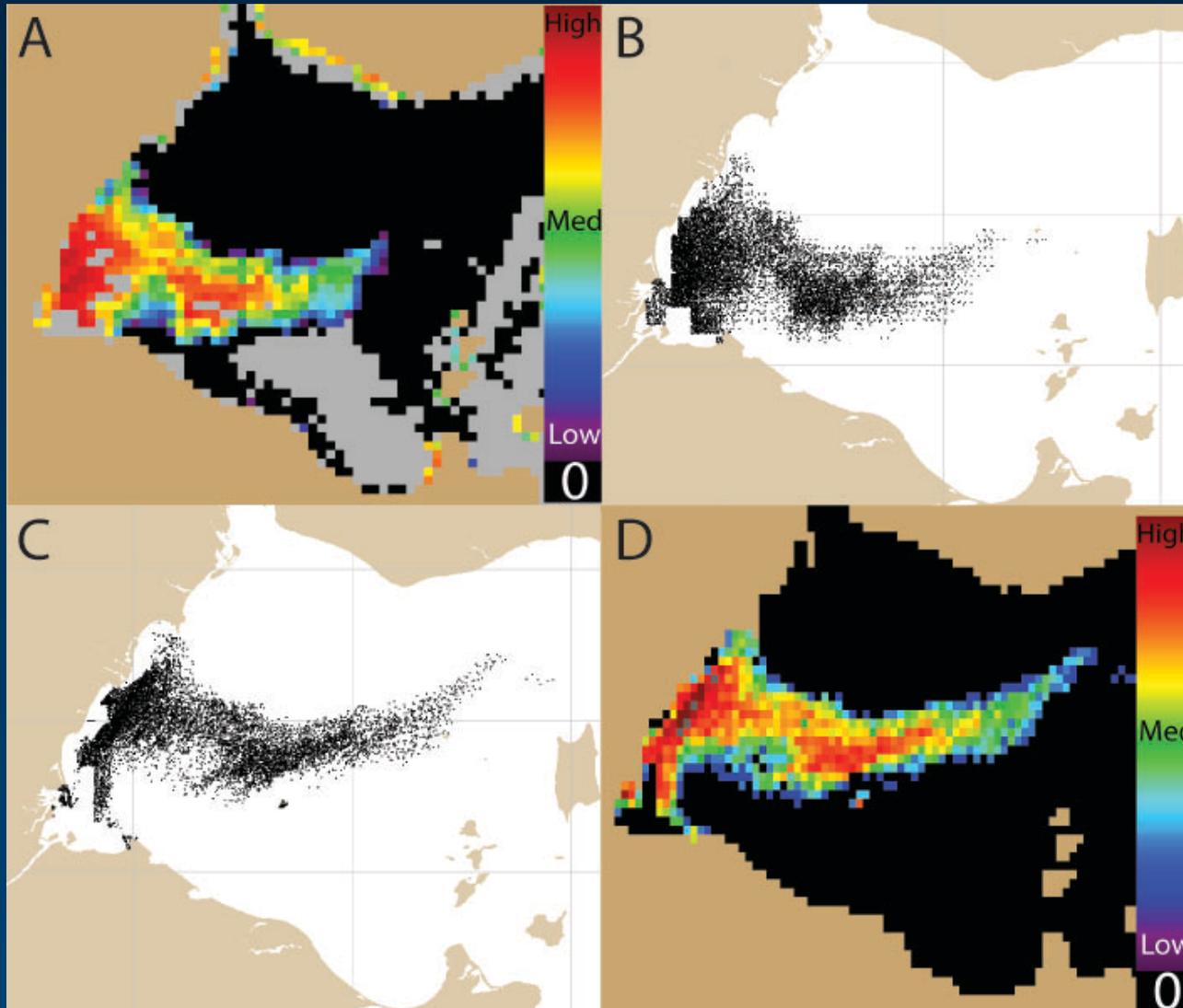


2012

Create a short term Forecast...

- 1.) find bloom
- 2.) Model Bloom trajectory
- 3.) Create Forecast
- 4.) Disseminate Forecast

Model the bloom....



From Lake Erie HAB Bulletin <lake-erie-hab-bulletin@list.woc.noaa.gov>★

Subject [Lake-erie-hab-bulletin] Lake Erie HAB Bulletin 16

8/27/2013 2:20 PM

To lake-erie-hab-bulletin@list.woc.noaa.gov★

Other Actions ▾

Make forecast

To view the pdf, [click here](#) or on the image below.



Experimental Lake Erie Harmful Algal Bloom Bulletin

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

27 August 2013; Bulletin 16

The area of most intense bloom remains in the far western part of Lake Erie and Maumee Bay, with less scum than previously observed. The moderate winds have caused some mixing of the bloom in the rest of the western basin, keeping down the surface concentration. Scum may be seen in pockets near land.

Slight eastward transport is forecasted for the next three days. Low winds (<8 knots) could allow the bloom to intensify at the surface and produce patchy areas of scum.

- Dupuy, Stumpf

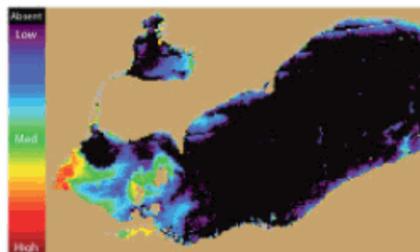


Figure 1. MODIS Cyanobacterial Index from 25 August 2013. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 35,000 cells/ml.

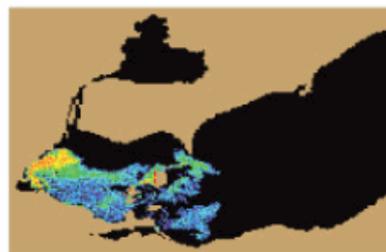


Figure 2. Nowcast position of bloom for 27 August 2013 using GLCFS modeled currents to move the bloom from the 25 August 2013 image.

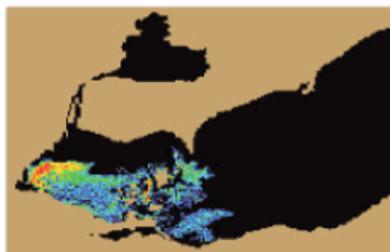
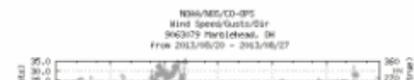
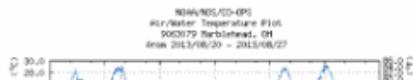


Figure 3. Forecast position of bloom for 30 August 2013 using GLCFS modeled currents to move the bloom from the 25 August 2013 image.

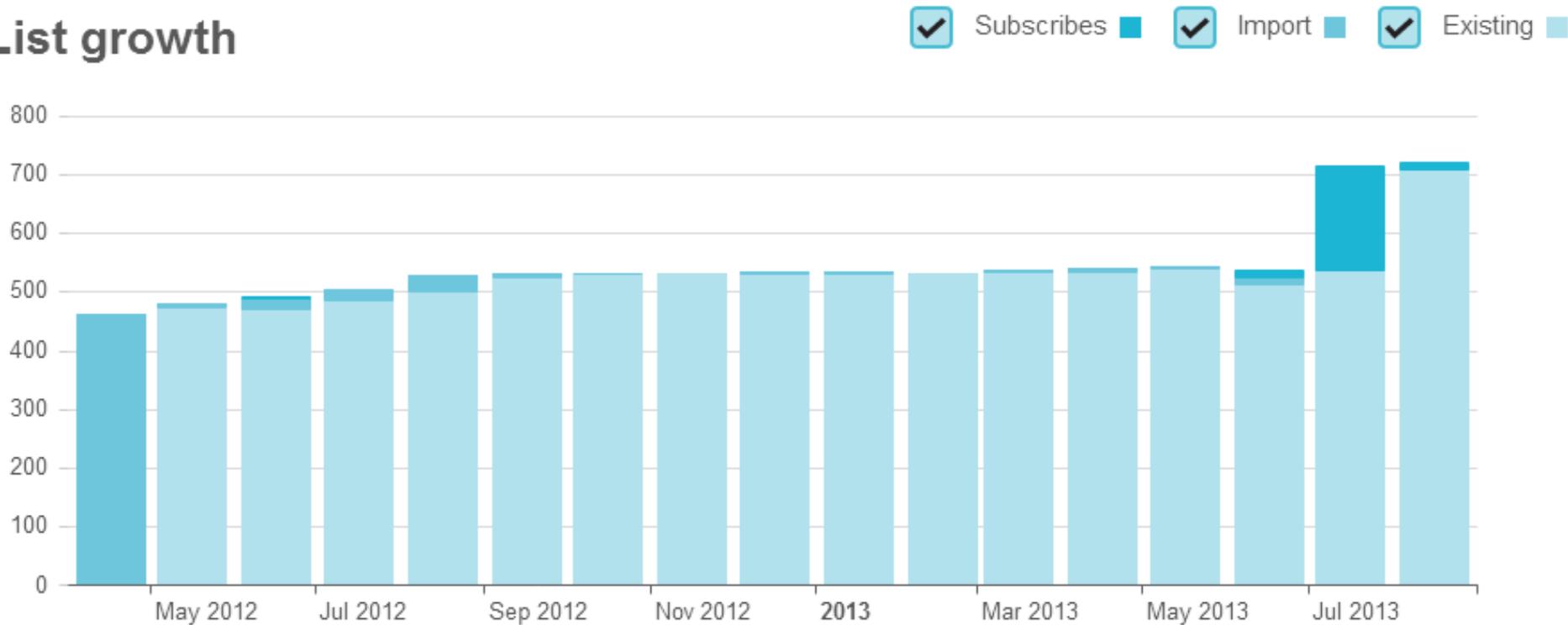


Averaged forecasted currents from Great Lakes Coastal Forecasting System over the next 72 hours.

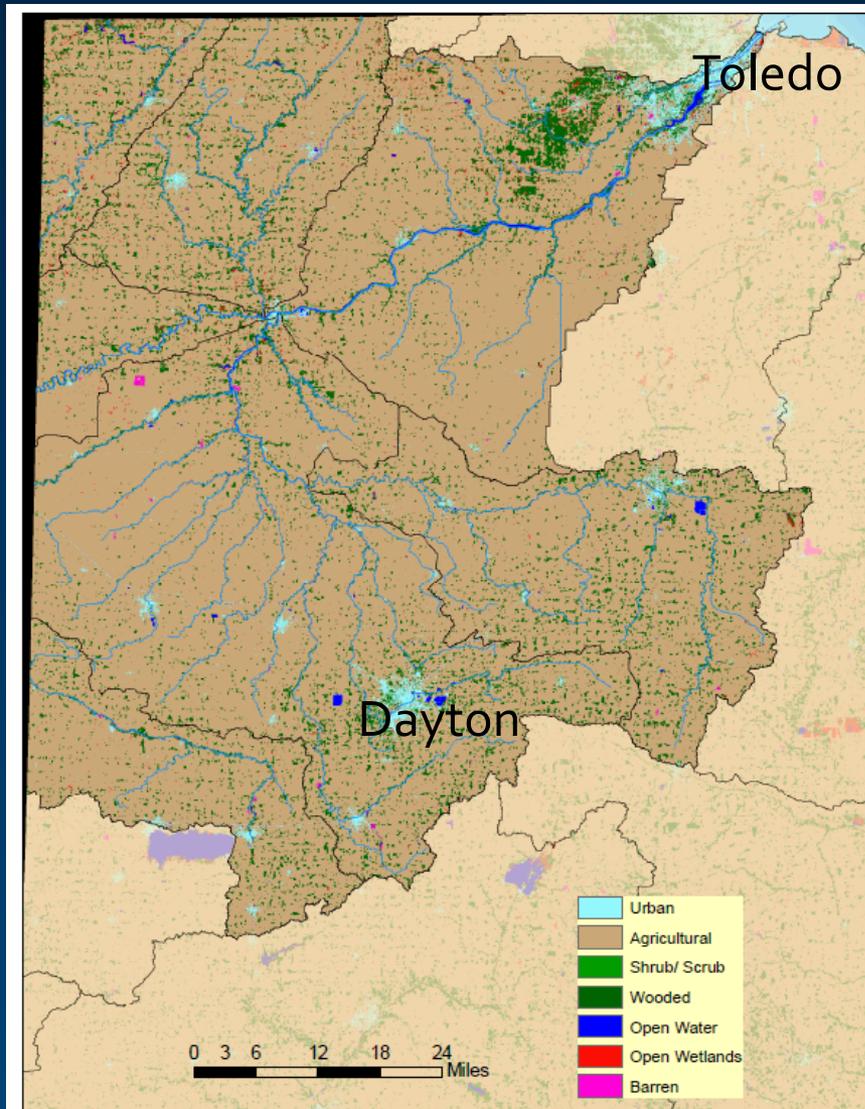


Disseminate Forecast

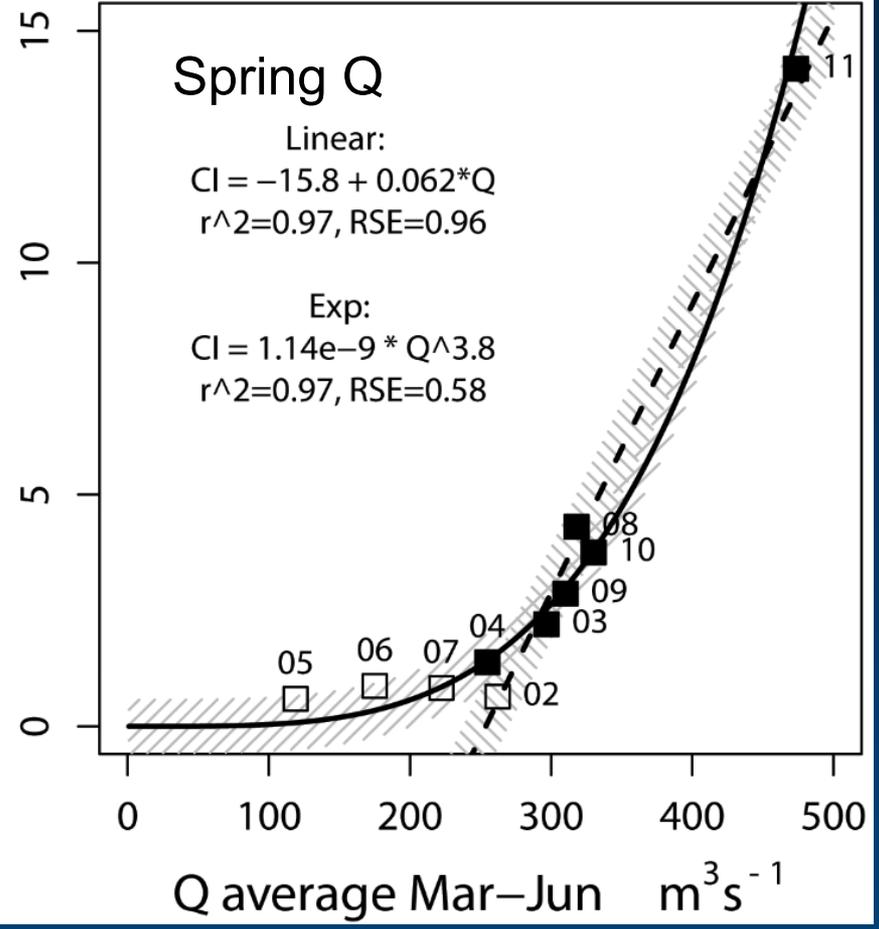
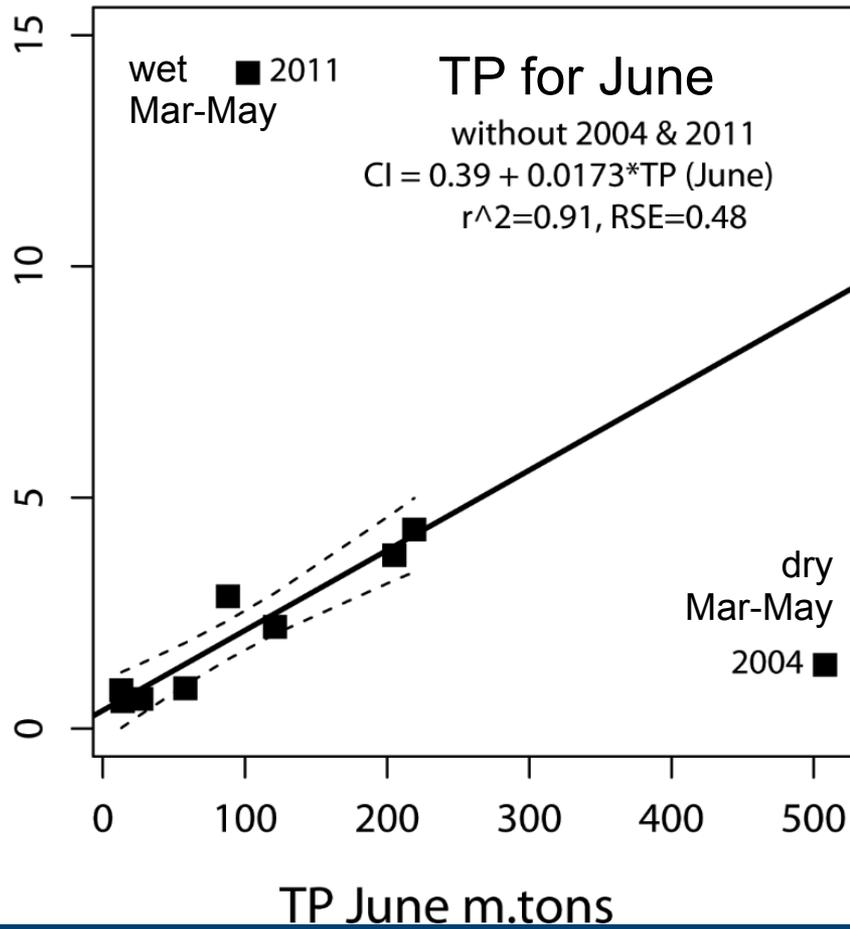
List growth



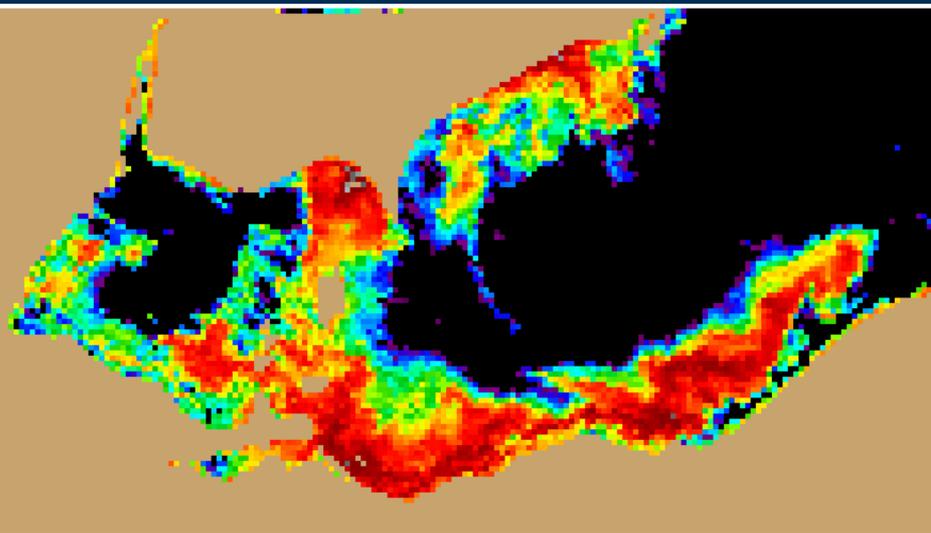
Use Maumee River Discharge to make seasonal predictions



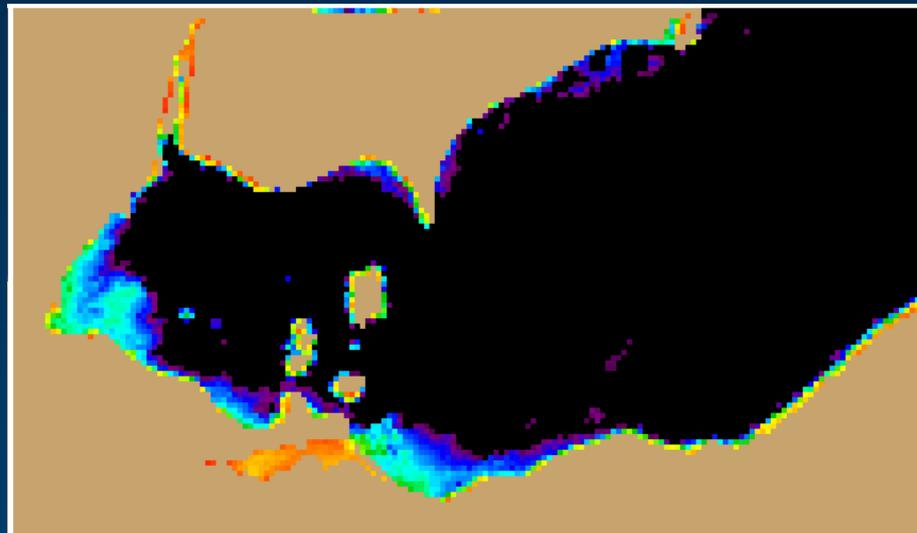
We have established the long-suspected link of blooms to Maumee River. Spring discharge and June TP drive cyano-bloom intensity



**On July 5, we made the 2012 prediction for western Lake Erie
western Lake Erie
*a mild bloom, < 1/10 of 2011, close to 2007***



2011



2007

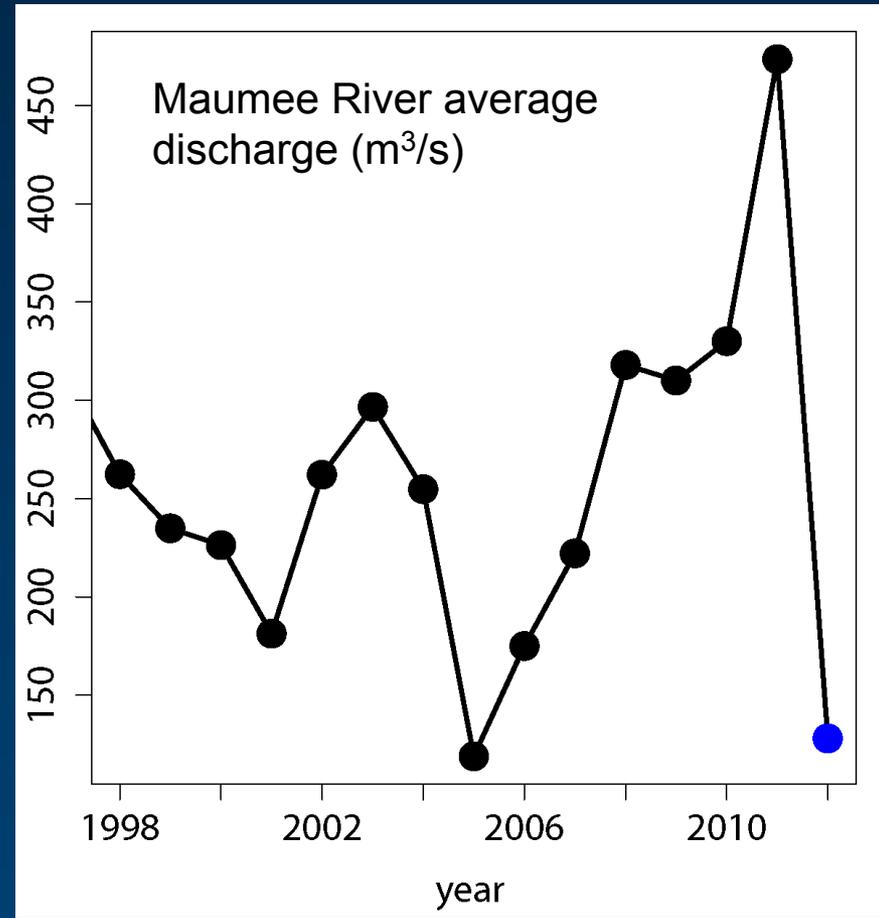
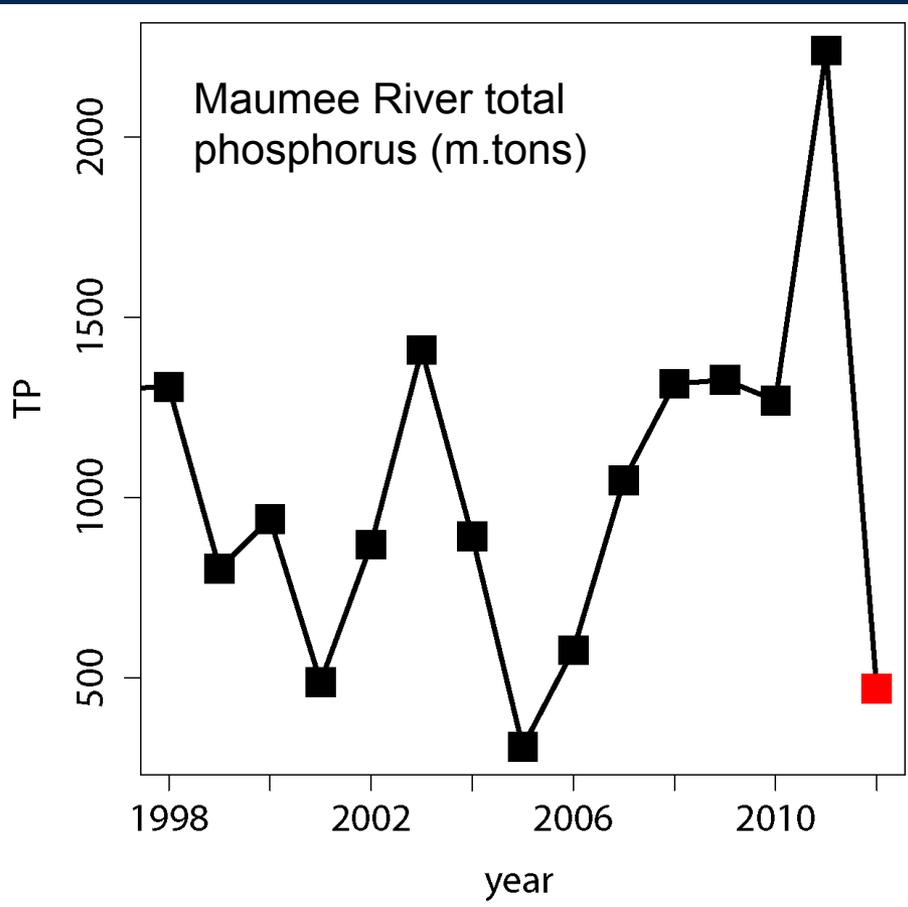
low

medium

high

concentration

2012: dry spring and low loads Equivalent to 2005 to 2007



2012: First prediction for Lake Erie announced at Stone Lab, Ohio, July 05. Press attended



Friday, July 6 2012 3:23pm

Forecast predicts mild Harmful Algal Bloom

The National Oceanic & Atmospheric Administration's National Centers for Coastal Ocean Science issued the first-ever seasonal harmful algal bloom forecast for Lake Erie at an all-day press event Thursday at Ohio State University's Stone Laboratory. The forecast predicts a mild bloom, similar to conditions last seen in 2007 and about one-tenth the size of last year's bloom.

"A mild bloom is great news for this year," said Dr. Jeffrey Reutter, Director of Ohio Sea Grant and Stone Laboratory. "But this is happening because we're in a drought, not because phosphorus loading to Lake Erie has improved. If we have a real wet spring in 2013, we could be right back to where we were."

Researchers
predict smaller
Lake Erie algae
bloom

[ASSOCIATED PRESS](#)



fact-checking THE FORECAST



July's harmful algal blooms forecast turns out to have been highly accurate

by Christina Dierkes, Ohio Sea Grant Communications

Back in July, scientists from the National Oceanic & Atmospheric Administration's National Centers for Coastal Ocean Science (NCCOS) issued the first-ever seasonal harmful algal bloom (HAB) forecast for western Lake Erie at a press event at Ohio State University's Stone Laboratory. Now, with the 2012 HABs season over, Dr. Jeff Reutter reflects on the successful prediction and looks ahead to next year.

"I would say that we were right on with what we tried to do," Reutter, Ohio Sea Grant & Stone Lab's Director, says. "The rationale behind the press conference was to let people know that, based on phosphorus loading and concentrations in the lake, things were looking really good for the summer."

The forecast predicted a mild bloom for the western basin, similar to conditions last seen in 2007 and about one-tenth the size of the 2011 bloom. While it was somewhat larger than predicted, the bloom was still 70% smaller than last year. "It was a welcome bit of relief, and the key point is the model was accurate," Reutter says.

Harmful algal blooms in Lake Erie most often consist of *Microcystis*, a cyanobacterium—more commonly called blue-green algae—that can produce the liver toxin microcystin. The toxin can be removed from drinking water, but increases the cost of water treatment by about \$3,000 per day. Phosphorus, which is contained in many agricultural fertilizers and manure, and enters the lake as runoff during rainstorms, tends to be the nutrient that determines how much *Microcystis* can grow in Lake Erie.

Microcystis can also severely reduce tourism income, limiting recreational water use with high toxin levels and unpleasant floating blue-green algae. Being able to forecast the HAB's severity allows community officials and tourism managers to prepare for impacts in advance instead of reacting as the bloom happens.

"The idea of the forecast was that, if people knew what to expect, we wouldn't

have a negative impact on tourism based on what had happened the previous year," Reutter explains. "People that came up in August and September of 2011 were pretty disenchanting. That was why we wanted to have that press conference, to let people know that it looked like 2012 was going to be nowhere near as bad."

The forecast's accuracy came from the combination of NOAA computer modeling, put together by NCCOS oceanographer Dr. Richard Stumpf, and targeted sampling efforts from Stone Lab, Heidelberg University, and the University of Toledo. Based on satellite images, NOAA could request samples taken at specific points in Lake Erie's western basin, to help them better calibrate their satellite for future passes.

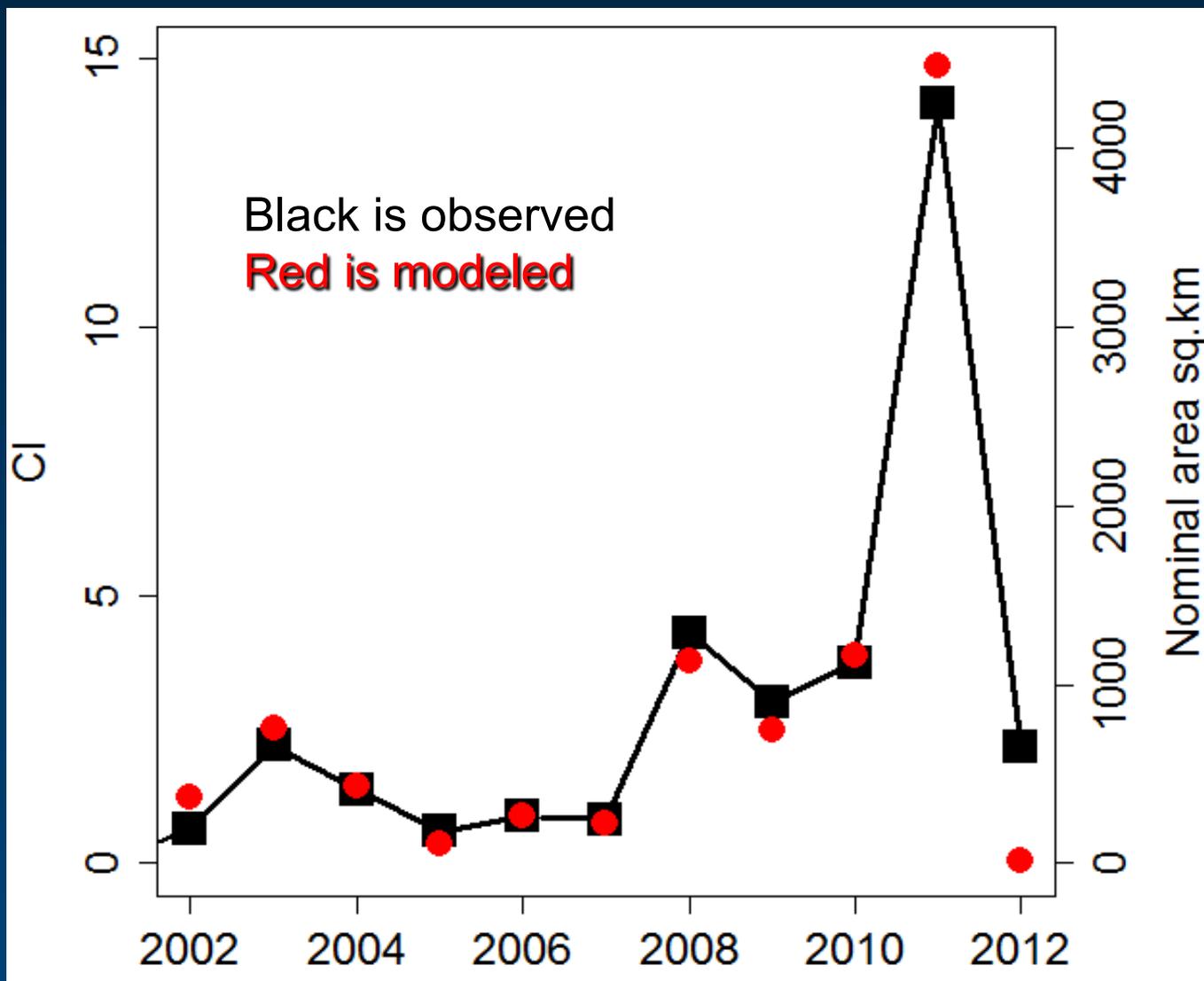
The collaboration will be expanded in 2013 to include Stone Lab's new water quality lab along with continued partnerships with Heidelberg University's National Center for Water Quality Research and the University of Toledo.

"We'll be able to provide phosphorus concentrations in and around the Lake Erie islands, the western portion of the central basin, and Sandusky Bay, which we've been unable to provide in the past," Reutter says. "If we get another bloom in the central basin, we'll also be prepared to take a trailerable research boat down to Lake or Ashtabula County and gather data there to come up with a better understanding of what's causing those blooms."

"And the fact is that the HABs problem is not gone. 2012's mild bloom was in large part due to the drought that affected most of the Midwest, which significantly reduced runoff into the western basin, and efforts to reduce that phosphorus loading are as important as ever," Reutter cautions. "If the spring of 2013 is a wet spring, we'll have another bad bloom." TL

→ Above: NOAA satellite images from 2004 (top) and 2011 (bottom) show the extent of each year's HAB in green. The 2012 bloom was similar in size to 2004.

Spring (Mar-Jun) explains annual bloom intensity; a lag between P supply and the bloom

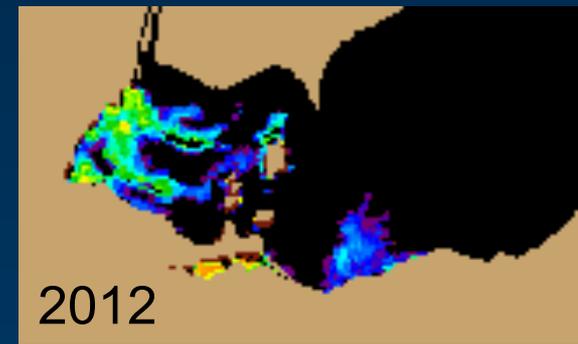
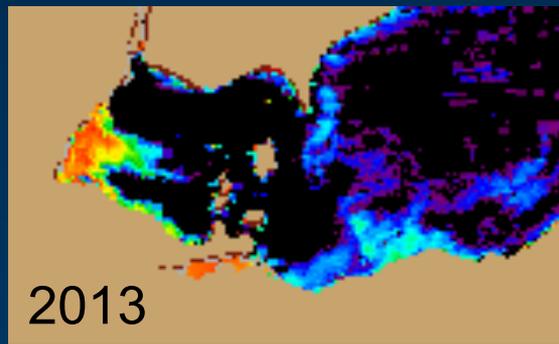
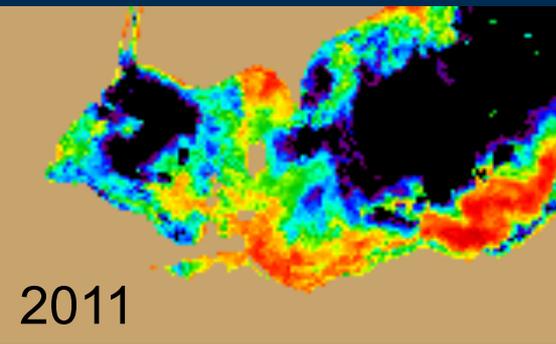


2013: Second prediction for Lake Erie announced at Stone Lab, Ohio, July 02.

NOAA and its research partners predict that the 2013 western Lake Erie harmful algal bloom (HAB) season will have a significant bloom of cyanobacteria, a toxic blue-green algae, this summer. **The predicted bloom is expected to be larger than last year, but considerably less than the record-setting 2011 bloom.** Bloom impacts will vary across the lake's Western basin. This marks the second time NOAA has issued an annual outlook for western Lake Erie.

Director of Ohio EPA and the press attended

Preliminary validation of 2013 seasonal forecast



Single image from
September 10 2013
More or less max
concentration



Blue-Green Algae: Iridescent but Deadly

By Jessica Marshall
Sep 18 2012

Media hits



PortClinton
NewsHerald.com

Algae makes its way to Kelleys Island

Aug 27, 2011

KELLEYS ISLAND --The Kelleys Island State Park's public beach includes a posted warning about the algae bloom that has made its way to the island's north side.

"They are a blue-green algae, and we call them harmful algae blooms because they produce a toxin called microcystin," said Sonia Joseph-Joshi, outreach coordinator for the National Oceanic and Atmospheric Administration's Center of Excellence for Great Lakes and Human Health.

In Asia and South America, she said, the toxins in blue-green algae have caused deaths after being ingested.

At an Ohio Lake Erie Commission meeting in June, researchers predicted a thicker, longer-lasting algal bloom than seen in past years, because of heavier than normal rains. Those rains are blamed for transporting high levels of fertilizer and phosphorous from agricultural fields into small streams and, eventually, into Lake Erie.

"There are three major rivers," Joseph-Joshi said, "the Maumee, Detroit and Sandusky, and they all converge in western Lake Erie."

According to researchers, those rivers and others are pouring tens of thousands of tons of nutrients into the lake each year, feeding the algae blooms.

Mike Libben, a technician with the Ottawa Soil and Water Conservation District, said his organization works hard to educate and help change the habits of people who work in agriculture.

GREAT LAKES ECHO

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Satellite system warns swimmers, treatment plants of harmful algae

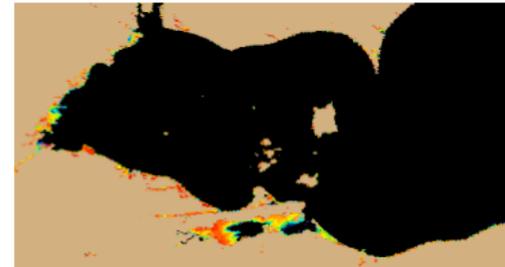
JUL 12 2011 SHAHEEN KANTHAWALA 3 COMMENTS

Satellite images of Lake Erie sent right to your inbox can warn you about harmful algae in the lake before you decide to visit.

People can [sign up](#) for the emailed bulletin that was developed at the Center of Excellence for Great Lakes in Human Health at the National Oceanic and Atmospheric Administration.

They'll learn where waves, winds and currents are expected to move algal

blooms, said Sonia Joseph Joshi, Sea Grant extension outreach coordinator at the Center of Excellence for Great Lakes in Human Health at the National Oceanic and Atmospheric



Satellite images of Lake Erie on June 07, 2011, from MERIS - the European Space Agency. The different colors show the likelihood of the last known position of the Microcystis bloom (where red- highest, white squares -very high, circles -high, diamonds -medium, triangles -low, + -very low and X -not present). Image: National Oceanic and Atmospheric Administration.

Carroll Township Ohio, “do not drink”

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Warning posted for Lake Erie toxin-tainted drinking water

LOCAL

Pedestrian killed on I-71 on South Side

Proposal may resolve fight between food trucks and restaurants

Soccer brings together immigrant students from many countries

Civic groups prepare candidate nights

Man killed by

By [Spencer Hunt](#)

The Columbus Dispatch · Friday September 6, 2013 3:05 PM

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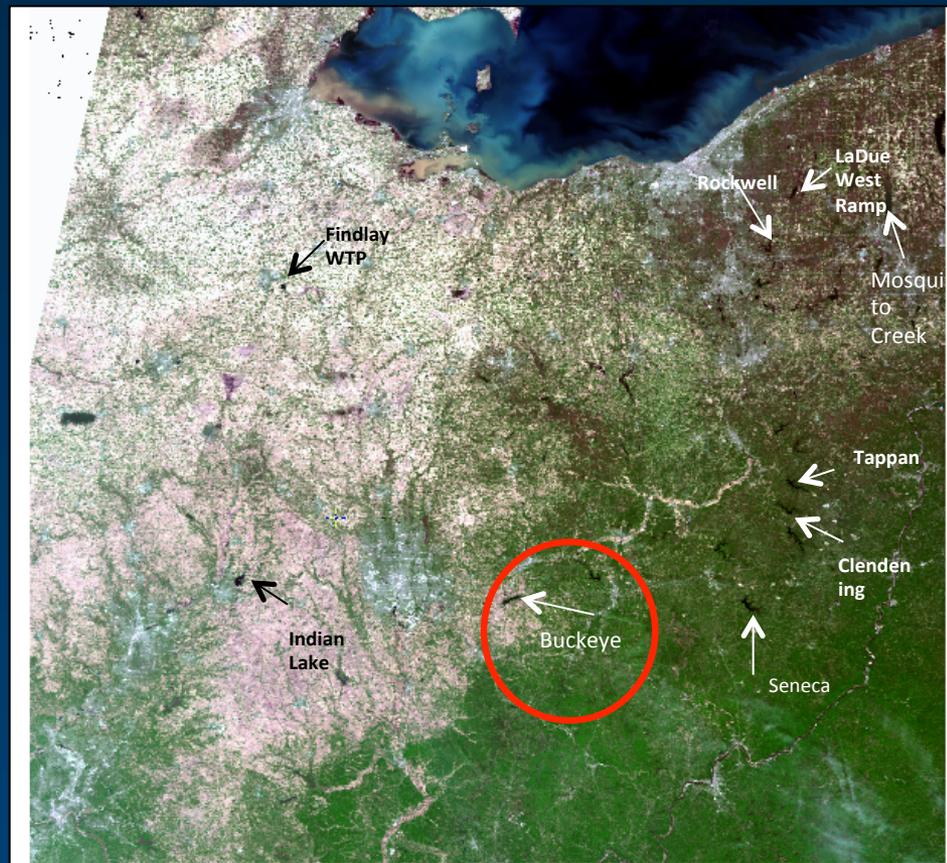
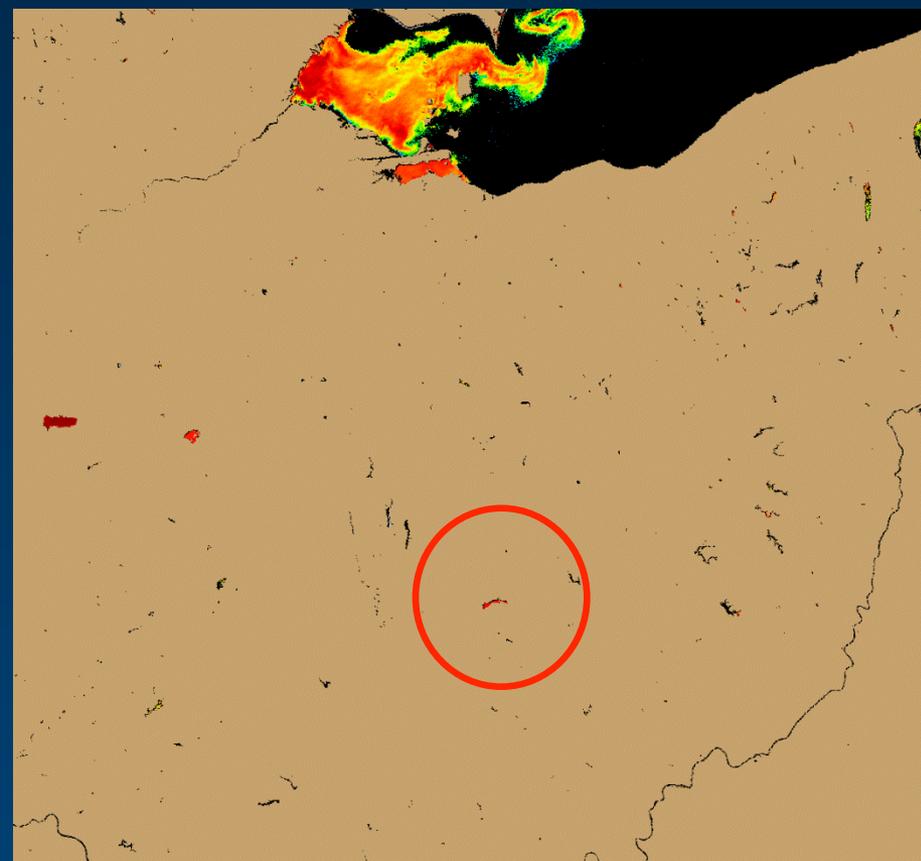
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About 2,000 residents in Ottawa County have been told not to drink or cook with their tap water because it might be contaminated with a blue-green algae liver toxin.

Carroll Township has become the first Ohio community where such a warning has been posted. State and local officials said routine tests of drinking water, taken last night, showed that some of the liver toxin in water taken from Lake Erie made it through the township's treatment process.

Henry Biggert, the Carroll Water and Sewer District superintendent, said

The rest of Ohio: Ohio EPA wants more info on other lakes. Sampled for validation in Sep 2011. Also discussions with USACE.



Field sampling

- ❖ 2012 sampling
 - ❖ Monthly and event response
 - ❖ Stations throughout western Lake Erie, including drinking water intakes
- ❖ Samples collected
 - ❖ Cell counts – major HAB species
 - ❖ Microcystin
 - ❖ Phycocyanin (pigment indicator of cyanobacterial HABs)
 - PC fluorescence sensor
 - ❖ Chlorophyll a, Secchi depth

Florida Department of Health (FDOH) Aquatic Toxins Disease Prevention Program

Satellite Health Bulletin

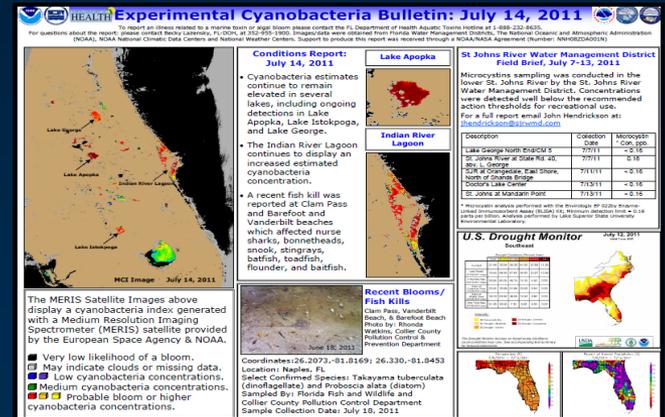
Andrew Reich, MS, MSPH

Becky Lazensky, MPH

- FDOH developed a satellite health bulletin to disseminate satellite imagery data and interpretation to users on a routine basis
- Bulletins contain MERIS satellite images with interpretation, a section on recent algae blooms, a HABs and health section, and field observations
- Reports are produced on a bi-weekly basis when MERIS satellite images are available



Florida Satellite Health Bulletins



The bulletin's distribution list includes these state and local agencies:

- FDOH -FL-DEP
- CHDs -SJRWMD

Fall 2011, 57 people in Florida subscribed
Spring 2013, 117 people from 15 agencies subscribe

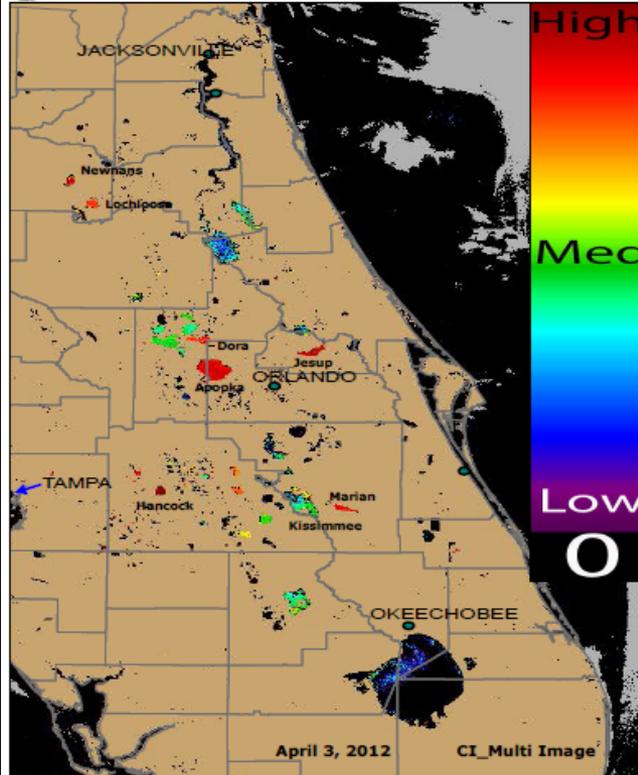
Satellite Health Bulletins: Example



Experimental Cyanobacteria Health Bulletin: April 3, 2012

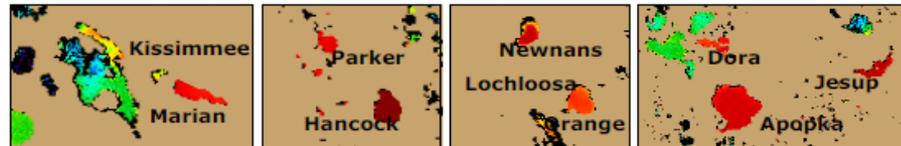


To report an illness related to a marine toxin or algal bloom please contact the Florida Poison Information Center-Miami Aquatic Toxins Hotline at 1-888-232-8635.
For questions about the report: contact Becky Lazensky, FL-DOH, at 352-955-1900. Images/data were obtained from Florida Water Management Districts, 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)



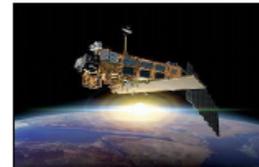
Cyanobacteria HABs Conditions Report: April 3

- Lakes Kissimmee and Marian (Osceola County) displayed medium and high estimated cyanobacteria concentrations
- Lakes Parker and Hancock (Polk County) displayed high estimated cyanobacteria concentrations
- Newnans, Lochloosa, & Orange Lakes (Alachua & Marion Counties) and Jesup, Dora, and Apopka Lakes (Seminole, Lake, and Orange Counties) displayed high estimated cyanobacteria concentrations



ENVISAT SATELLITE IS DOWN-Impacts on MERIS Images

On April 8th, communications between the European Space Agency (ESA) and the Envisat satellite were lost. The Envisat satellite platform carries the MERIS sensor which captures the images featured in this bulletin. This will impede the production of MERIS satellite imagery until repairs are made or a new satellite is launched. The last MERIS image we have is the April 3rd image. NOAA may provide alternative MODIS imagery until communications are re-established. We will keep everyone updated on the progress. For more information visit: <http://www.nature.com/news/workhorse-climate-satellite-goes-silent->



Envisat (Photo courtesy of European Space Agency)

Algal Bloom on the Caloosahatchee River-Update: April 13th

Olga, FL: An ongoing cyanobacteria bloom was reported in the Caloosahatchee River. Samples collected on April 2nd were positive for Planktothrix and Anabaena/Aphanizomenon dominant species. (Green Water Laboratories). These species of algae are potential toxin producers. Toxin testing is being conducted by Green Water Laboratories. The South Florida Water Management District plans to send down pulses of freshwater from Lake Okeechobee to 'flush' out the river and increase flows to the Caloosahatchee. The Lee County Health Department has issued a health advisory for the river.



If your agency has field sampling data, which can be used to help validate the MERIS Imagery, Contact Becky Lazensky at: 352-955-1900

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

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

Page 2: Satellite Health Bulletins

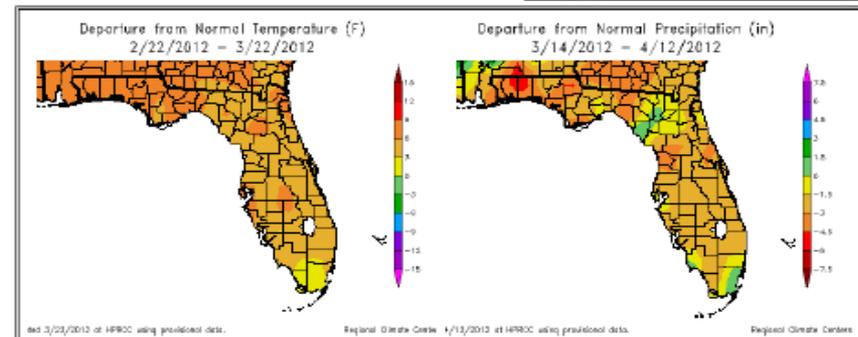
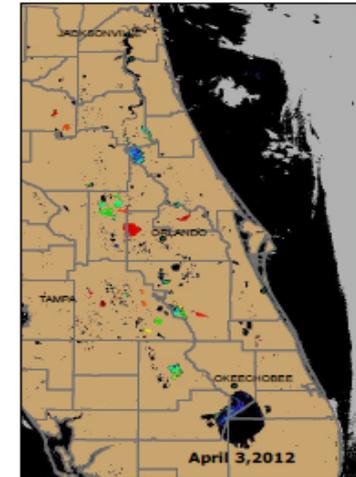
Interpreting Medium Resolution Imaging Spectrometer Satellite Imagery

- The medium resolution imaging spectrometer (MERIS) is located on the Envisat satellite deployed by the European Space Agency.
- The cyanobacterial index algorithm is designed to identify high biomass algal blooms caused by cyanobacteria. However, the current algorithm tends to have false positives, so other blooms may be "flagged". NOAA is currently testing new algorithms that are more specific to cyanobacteria.
- Data can be used to estimate near surface cyanobacteria concentrations which are an indication that algal blooms may be present.
- The algorithms used to generate the satellite images can vary, resulting in some models having a higher likelihood of detecting surface blooms. The satellite identifies the biomass near the surface (in the upper few feet of water). As a result, it may underestimate the total biomass for blooms that are mixed or dispersed through the water column. Turbidity does not otherwise influence the algorithms.
- The satellite imagery does not display the species of algae present.
- While patches of red or warm colors may indicate a bloom, these data have not been verified in most cases using ground-truth methods. Data collected by the satellite is considered experimental.
- Only part of FL is in the satellite's coverage area.
- Several environmental factors may affect how results can be interpreted. For example, areas with abundant aquatic vegetation may present with a high cyanobacteria index on the color spectrum, resulting in a false positive bloom reading.

Weather Conditions: March 14- April 12 Temperature and Precipitation



- Weather conditions can impact the duration and location of blooms and the satellite imagery shown in this report may no longer be relevant. Images represent the last image taken with a realization that blooms may have moved, dissipated or intensified.
- Cloud coverage can obscure imagery and create patches or gray areas on map and obscure bloom detection.



To review HABs satellite reports in the Gulf of Mexico and marine waters visit the NOAA Harmful Algal Bloom Operational Forecast System bulletin archive at: <http://tidesandcurrents.noaa.gov/hab/bulletins.html>



For Individual Weather Station Data Visit:
http://www.serpc.com/climateinfo/historical/historical_fl.html

Questions about the report or suggestions: You can contact Becky Lazensky, MPH 352-955-1900 Becky_Lazensky@doh.state.fl.us



New HABs Tracking Website

In 2012, the FDOH Aquatic Toxins Program developed a new online tracking module for documenting cyanobacteria blooms statewide.

Link to the Caspio Web Hosting Site:

– <http://www.caspio.com/>

HABs Tracking Website

Harmful Algal Bloom Tracking Module

Welcome to the Florida Harmful Algal Bloom (HAB) Online Tracking Module. This site is designed to be a secure electronic database.

PRIVACY DISCLAIMER: This site should not be used to collect HIPAA protected health information, the name and address of a private citizen or details about a person's health status. This includes site health complaints related to a bloom, contact the Florida Department of Health's Aquatic Toxins Division, Reich, at: 850-245-4187.

- Format for all dates and times is MM/DD/YYYY and HH:MM AM/PM EST
- Size limit for attachments is 15MB per submission and up to 60MB cumulatively (initial submission)
- (*) Indicates the field is required

Descriptive Bloom ID*

Format: AgencyName_Date_WaterBody

-Note: Use the name of the agency you represent- Examples: FDOH, CHD, FDEP, FDACS, FWC/F

Name of Water Body

To protect privacy, do not report blooms that occurred in a water body with a single residence located next to

Collects information on the location of bloom events, environmental conditions, site visit observations, & laboratory results.

Searchable Database of Bloom Records

Bloom Contact ID

Descriptive Bloom ID

Name of Water Body

Bloom Recorder's First Name

Bloom Recorder's Last Name

Date Record Was Added

Date Record Was Last Modified

Date Bloom Was

Contains a Searchable Database for Retrieving Data

New HABs Tracking Website

This website allows public health professionals and environmental scientists to collaborate on bloom reporting by populating a shared web-based data page.

The online data page will be used as a repository for HAB-related data and is available to assist with ongoing NOAA/ NASA satellite data validating efforts.

Satellite Imagery Guide for County Health Departments

A user guide on how data can be applied to public health practice was developed

Examples of possible uses:

- Epidemiologists can include water sites with high a cyanobacteria index when interviewing ill persons about their recent recreational water exposures
- Environmental Health programs may rely upon satellite imagery data when deciding where to conduct field assessments of public swimming areas
- State and local agencies can use imagery to target sampling and educational health interventions

Applications of Satellite Imagery Data

- Informing Public Health Investigations
- Increasing Surveillance
- Identifying Toxin Producing Blooms
- Targeting Sampling Efforts
- Protecting Public Drinking Water

Cyanobacteria Satellite Imagery Uses for County Health Departments

1. **Provides Increased Situational Awareness:** Satellite imagery can provide County Health Departments (CHDs) with a picture of environmental conditions in their county and a view of what is happening statewide. This information can serve as part of an early-warning system to notify counties when conditions are favorable for bloom formation and provides valuable time to prepare education and risk communications materials and inform key stakeholders. Satellite information may be useful during large-scale event planning such as before holidays or events that include recreational water activities to allow for early precautionary measures to be taken like testing the water body before the event.

2. **Informing Public Health Investigations:** Satellite bloom detection will allow CHDs to make important linkages between health complaints in their community and specific health threats. When they know locations of ongoing blooms, CHDs are better equipped to associate illnesses with cyanobacteria exposures. Identifying areas with active algae blooms encourages epidemiologists to inquire whether symptomatic persons swam in the affected water source. While some blooms are considered nuisance blooms, others can cause respiratory, gastrointestinal, and neurological symptoms within a short time following an exposure.

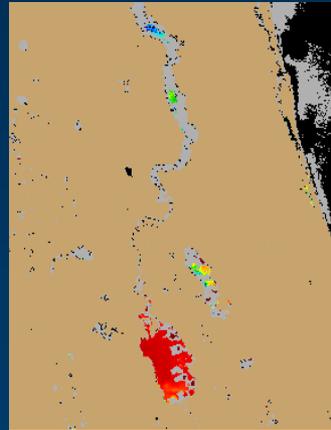
3. **Increasing Surveillance Efforts:** CHDs may share details of recent cyanobacteria blooms with local healthcare providers to improve case finding. When blooms are associated with health effects, CHDs often increase surveillance efforts to identify additional illnesses and implement response activities aimed at reducing health impacts.

4. **Identifying Toxic Blooms by Targeting Sampling Activities:** Satellite imagery can assist in identifying areas which are at an increased risk of cyanobacteria blooms and guide field sampling efforts more effectively. Blooms can then be assessed for toxins which pose a threat to human and animal health. Environmental Health programs can rely upon imagery to provide timely oversight of public swimming areas. Field assessments of permitted freshwater bathing sites can be done when satellite imagery indicates there may be high cyanobacteria concentrations. Collaboration between CHDs and partner agencies such as the Florida Fish and Wildlife Conservation Commission, Florida's five Water Management Districts, and the Department of Environmental Protection) encourages using the appropriate agency's resources to test whether blooms are composed of toxin-producing algal species.

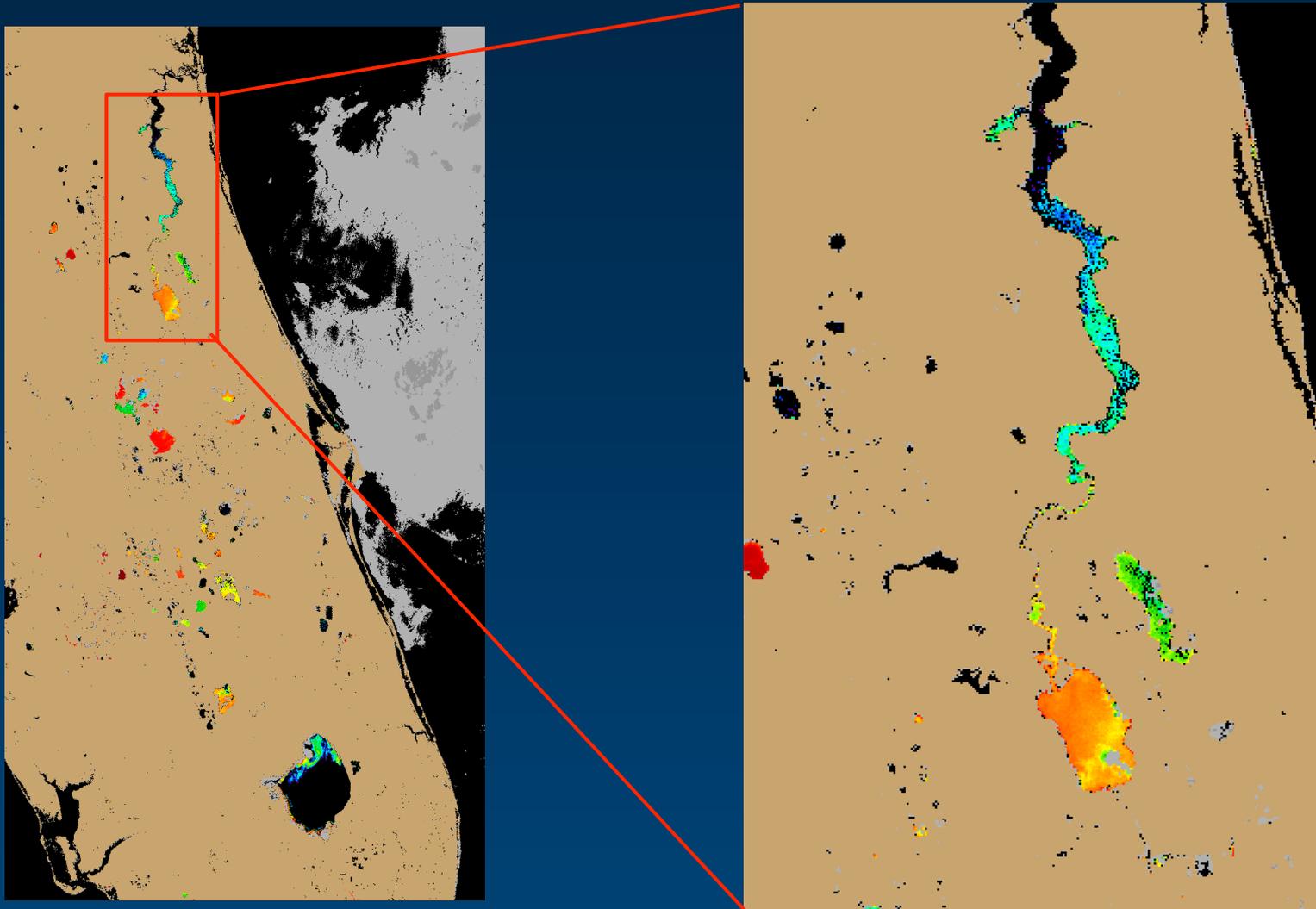
5. **Protecting Public Drinking Water:** Surface water treatment facilities can use satellite imagery as a mechanism to identify blooms that have the potential to affect their source water. The imagery, together with NOAA predictive modeling, provides water facilities time to develop contingency plans for alternate sources of potable water. This would reduce the likelihood that cyanotoxins will enter the public drinking water supply.

Partnering with the St Johns River Water Management District

- ◆ In 2011-NOAA conducted 2 radiometer trainings w/ 6 SJRWMD and 1 FDOH scientist in March and June
- ◆ Radiometer data were collected from the St Johns River, Lake Apopka, Newnans Lake, Bivens Lake, Lake George, & Crescent Lake
- ◆ *Microcystis* blooms indicated in NOAA satellite imagery were confirmed by local sampling efforts in Crescent & George Lakes

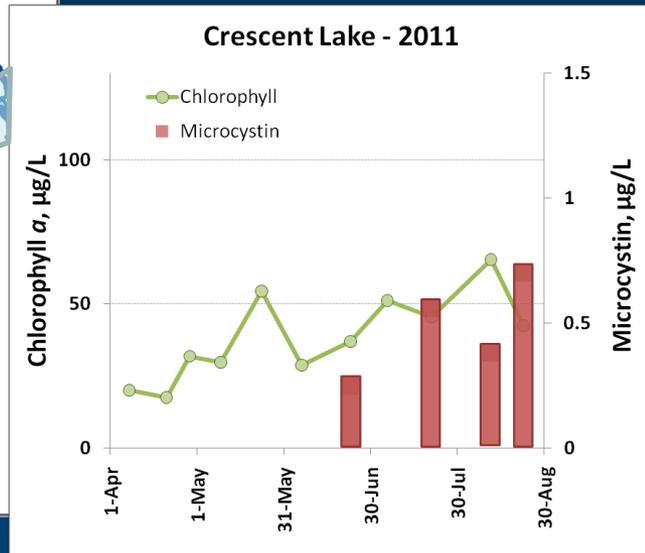
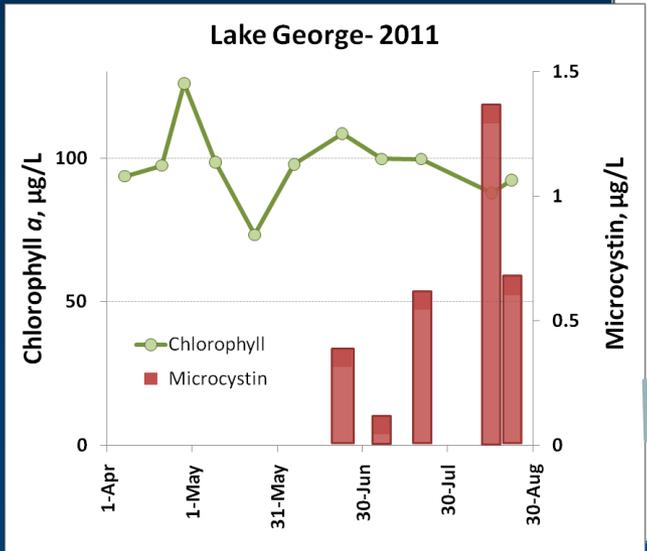
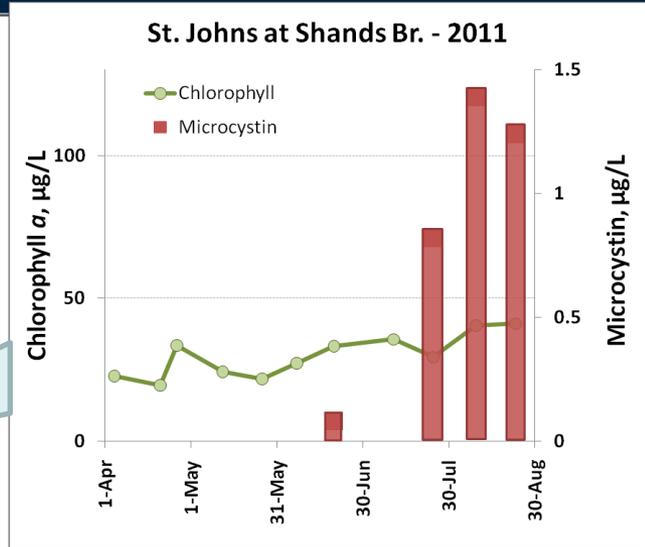
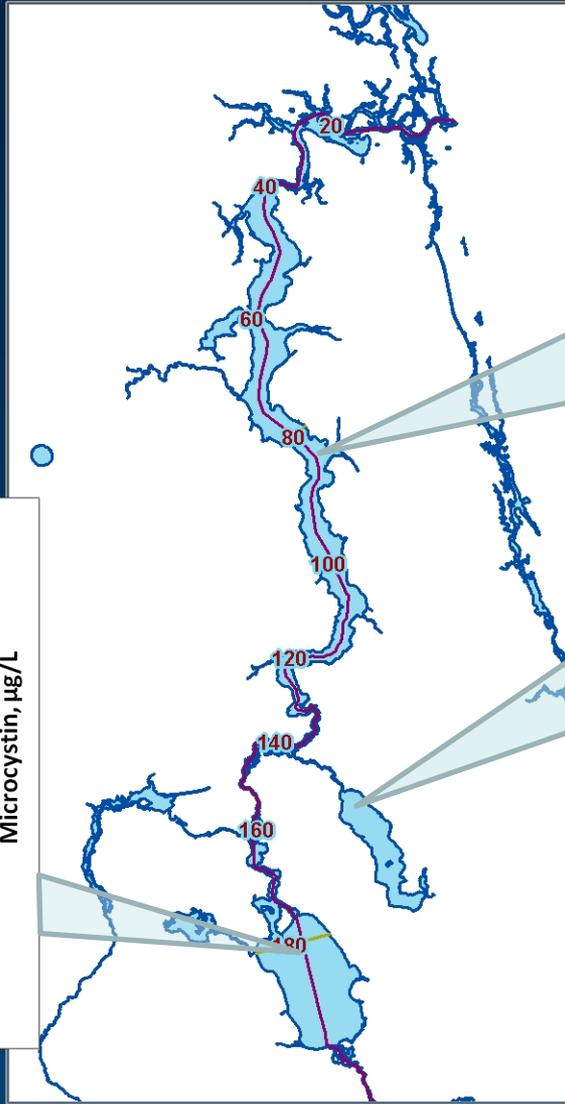


Cyano bloom in St Johns River, July 19, 2011



St. Johns River Estuary Cyanobacteria Blooms 2011

Microcystin concentration
more a function of
composition than density.



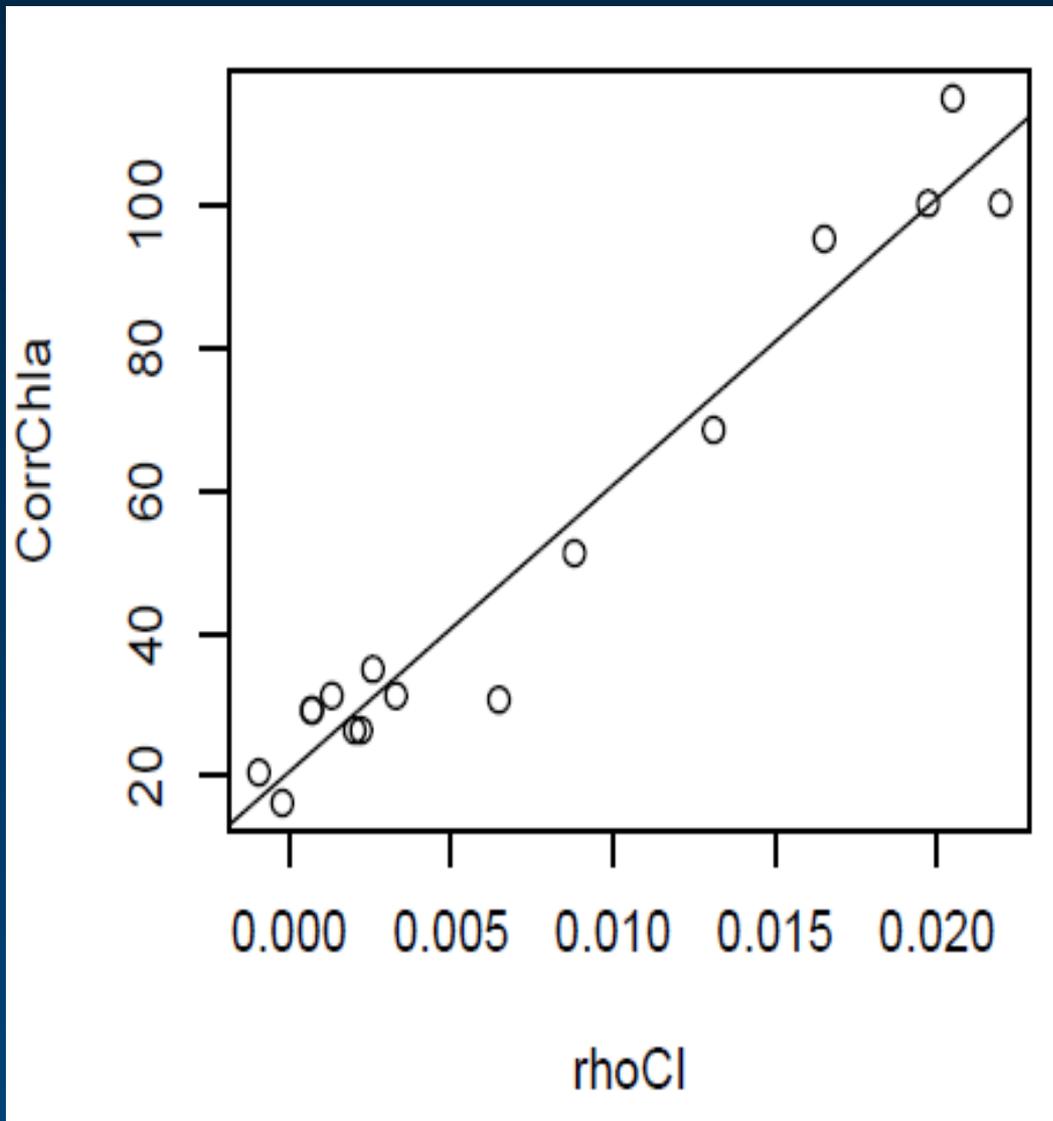
Slide courtesy of John Hendrickson, SJWMD

Relationship between CI and chl-a from field measurements (SJRWMD)

$$r^2=0.96$$

$$\text{Est chl a} = 4020*(CI) + 20$$

Detection of chlorophyll
> 20 $\mu\text{g/L}$

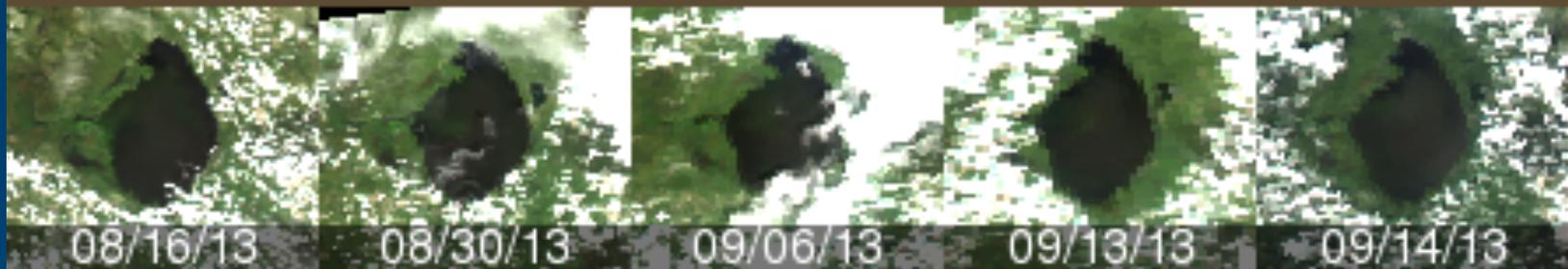


Lake Okeechobee MODIS time-series

CI
MODIS



True
Color



Enthusiastic Partner responses

“Looking at the MODIS imagery from today it was a pretty good forecast for the movement of the bloom.

Sure wish you guys could do this several times each week instead of just once, especially this time of year”

Brenda Snyder
Chief Chemist
Toledo Water Treatment

NOAA’s product “ will minimize resources necessary for large scale surveillance. It will help us focus our resources.”

Linda Merchant-Masonbrink
Ohio EPA, Div of Surface Waters. Aug 2011

“The satellite data should provide us with a new way to track the Potomac bloom (spatially and temporally) as it progresses this year.”

Cathy Wazniak, Maryland DNR

Successes

- Lake Erie Five years of bulletins. Now with 700 + subscribers
 - Transition to MODIS in 2012, and MODIS Aqua and Terra 2013.
- Florida Health Bulletin (year 2).
- Seasonal Forecasts 2012 and 2013 for Lake Erie.
- Trained SJWMD and FDOH on collecting radiometry. Calibration of CI index to chlorophyll now possible.
- Training of Ohio EPA, training of Ohio PWS (three years at OSU).
- Florida draft user manual by FDOH.
- Preliminary online satellite imagery viewer (HABViewer)
- Input to Lake Erie phosphorus load task forces.

Publications

- Wynne, T.T., R.P. Stumpf, and T.O. Briggs. 2013. Comparing MODIS and MERIS spectral shapes for cyanobacterial bloom detection. *International Journal of Remote Sensing*. Vol 34 pp 6668-6678.
- Wynne, T.T., R.P. Stumpf, M.C. Tomlinson, G.L. Fahnensteil, D.J. Schwab, J. Dyble, S. Joshi. 2013. Evolution of a cyanobacterial bloom forecast system in western Lake Erie: Development and initial evaluation. *Journal of Great Lakes Research*. <http://dx.doi.org/10.1016/j.jglr.2012.10.003>
- Stumpf, R.P., T.T. Wynne, D.B. Baker, G.L. Fahnenstiel, 2012. Interannual variability of cyanobacterial blooms in Lake Erie. PLoSONE. 7(8): e42444. doi:10.1371/journal.pone.0042444
- Wynne, T.T., R.P. Stumpf, M.C. Tomlinson, D.J. Schwab, G.Y. Watabayashi, and J.D. Christensen. 2011. Estimating cyanobacterial bloom transport by coupling remotely sensed imagery and a hydrodynamic model. *Ecological Applications*. Vol. 21, No. 7 pp. 2709-2721, [doi:10.1890/10-1454.1
- Lanerolle, L.W.J., R.P. Stumpf, T.T. Wynne and R.C. Patchen. 2011. A One-Dimensional Numerical Vertical Mixing Model with Application to Western Lake Erie. NOAA Technical Memorandum NOS NCCOS 131. National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science. Silver Spring, MD.
- Faris, J., Lazensky, B., Reich, A., Stanek, D., Blackmore, C., 2011. Cyanotoxins and the Health Impacts on Pets, Livestock, and Wildlife. The Florida Cattleman, Nov. Ed, pp. 57-65.
- Lazensky, B., Reich, A., Stanek, D., Blackmore, C., 2011. Cyanotoxins and the Health Impacts on Pets, Livestock, and Wildlife. The Advocate Magazine, 4th Ed. pp. 8-11.
- Wynne, T.T., R.P. Stumpf, M.C. Tomlinson, J. Dyble, 2010. Characterizing a cyanobacterial bloom in western Lake Erie using satellite imagery and meteorological data. *Limnology and Oceanography*, v. 55, No. 5, pp. 2025-2036.



Presentations

- Wynne, T.T. 2013. NOAA Algae Forecast Model: Model Overview-What, How and When. WLEB Leadership Team Meeting. 20 June 2013. Sylvania, OH.
- Stumpf, R.P., T.T. Wynne, D. Baker, P. Richards, and M.C. Tomlinson. 2013. Inter-annual patterns in cyanobacterial blooms in Lake Erie. 56th Annual Conference on Great Lakes Research. 2-6 June 2013. West Lafayette, IN
- Stumpf, R.P., T.T. Wynne, P.R. Richards, D. Baker. 2013 Forecast Western Lake Erie Harmful Algal Bloom. Press Event. 2 July 2010. Stone Laboratory, South Bass Island, OH.
- Stumpf, R.P., The 2012 Seasonal Forecast of Cyanobacterial bloom in Lake Erie. July 05, 2012. Ohio State University Stone Lab. (with University of Toledo, Heidelberg University).
- Stumpf, R.P. 2012, Interannual Variations in Cyanobacterial Blooms in Lake. EPA Great Lakes NPO, Nearshore/Nonpoint Work Group Webinar.
- Stumpf, R.P., T.W. Wynne, M.C. Tomlinson, G. Fahnenstiel, D.B. Baker, 2012. 10 years of variation in cyanobacteria blooms in Lake Erie. Intl Association of Great Lakes Research 2012 Conference, May 13-17, Cornwall, Ontario, Canada.
- Stumpf, R.P., Monitoring Status, Mid-Atlantic HAB Working Group. Annapolis, MD, December 06, 2011.
- Tomlinson, M.C., R.P. Stumpf, and T.T. Wynne. 2011. Finding and Forecasting Harmful Algal Blooms. The National Shellfisheries Association 103rd Annual Meeting. March 27-31, 2011. Baltimore, MD.
- Neff, C., M.C. Tomlinson, R.P. Stumpf, T.T. Wynne, R. Burks, G. Fahnenstiel. 2011. Bloom characterization of cyanobacteria using radiometry. Poster, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Fisher, K.M., R. Stumpf, M.C. Tomlinson, Operational HAB Forecasting: progress, challenges, and prospects. Talk, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Stumpf, R.P., K. Fisher, Q. Dortch, T. Tomlinson, 2011 Forecasting harmful algal blooms: differences in ecology, commonalities in execution. Talk, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Tomlinson, M.C., T. Briggs, C. Neff, R. Burks, R. Lazensky, C. Hart, A. Reich, H. Raymond, C. Wazniak, R.P. Stumpf, T.T. Wynne, 2011. Monitoring cyanobacterial blooms with full-resolution MERIS imagery to support state management activities. poster, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Stumpf, R.P., 2011. Remote sensing and Modeling of Harmful Algal Blooms, CDC HABISS Annual Users Meeting, Jan 24-25.
- Stumpf, R.P., M.C. Tomlinson, T.T. Wynne, S. Joseph-Joshi, J. Dyble. 2010. Using models to forecast Harmful Algal Blooms, an example from Lake Erie. The Modeling for Public Health Action: From epidemiology to operations, conference. Atlanta, GA Dec 9-10 2010.



Milestones and Results year 4

Data:

MODIS has been successfully used as a surrogate for MERIS.

Predictions & Climate:

Made second seasonal prediction of bloom severity and extent for Lake Erie.

Nutrient linkage narrowed to spring, impact on Lake nutrient mgmt discussions

Forecasts:

Monitoring of Lake Erie, starting June with MODIS

Discussions across NOAA on formal creation of robust forecast system.

Milestones and Results year 4

Product distribution:

Maryland and Florida products, have been successfully transitioned to MODIS

Web site built for improved image product distribution

EPA funded a 1-year project to design smartphone distribution option of satellite bloom data to mgrs

Product Type:

Validation continuing

Collaboration with EPA on national MERIS validation

Budget

IAG and contracts are slow. Year 4 expenditures recently started.

Year 5 IAG is still ongoing in NOAA.

Will need one-year extension for our associated contracts.

Change of personnel and changes in CDC will alter the mix somewhat from proposal (previously noted in year 4).

Risks

Loss of MERIS:

Loss of bloom discrimination and resolution has concerned partners. We got MODIS to deliver quantity at 1-km, it cannot give discrimination in scum conditions, but delivers satisfactory data in other areas.

Working on assumption of OLCI/Sentinel-3 in 2014.

Assuring partners of this. **(one year extension will make this possible.)**

CDC engagement unclear after 2013 (EH tracking is possible)

US EPA now investing in distribution. US Army Corps of Engrs is interested. NOAA is writing a formal ecological forecast system plan.

These may lead to alternative paths to operations.

2013 ARL status

Start of project: ARL = 2 (Application components and decision making identified).

Current: ARL 7-8: Prototype demonstrated and being used by end-users (Forecasts Ohio, Florida HAB bulletin, MD image distribution).
User training and documentation.

Goal: ARL 8-9: Approved by end-user for decision making. Expect sustained use.

Goals for 2013-2014

- Lake Erie bulletin for 2014, and seasonal forecast
- Florida Satellite Health Bulletin with FDOH, expand to south Florida.
- Algorithm cal/val for Sentinel-3 launch 2014
- Outreach: Host user workshops in Ohio, Florida, and Maryland on training and review of products
- Workshop with CDC for states on environmental monitoring requirements.
- Spatial climatology for Lake Erie
- Examine Florida lake climatology
- Coordinating with EPA and USGS on cyano program
- ARL goal 8 (Florida) 9 (Ohio).