

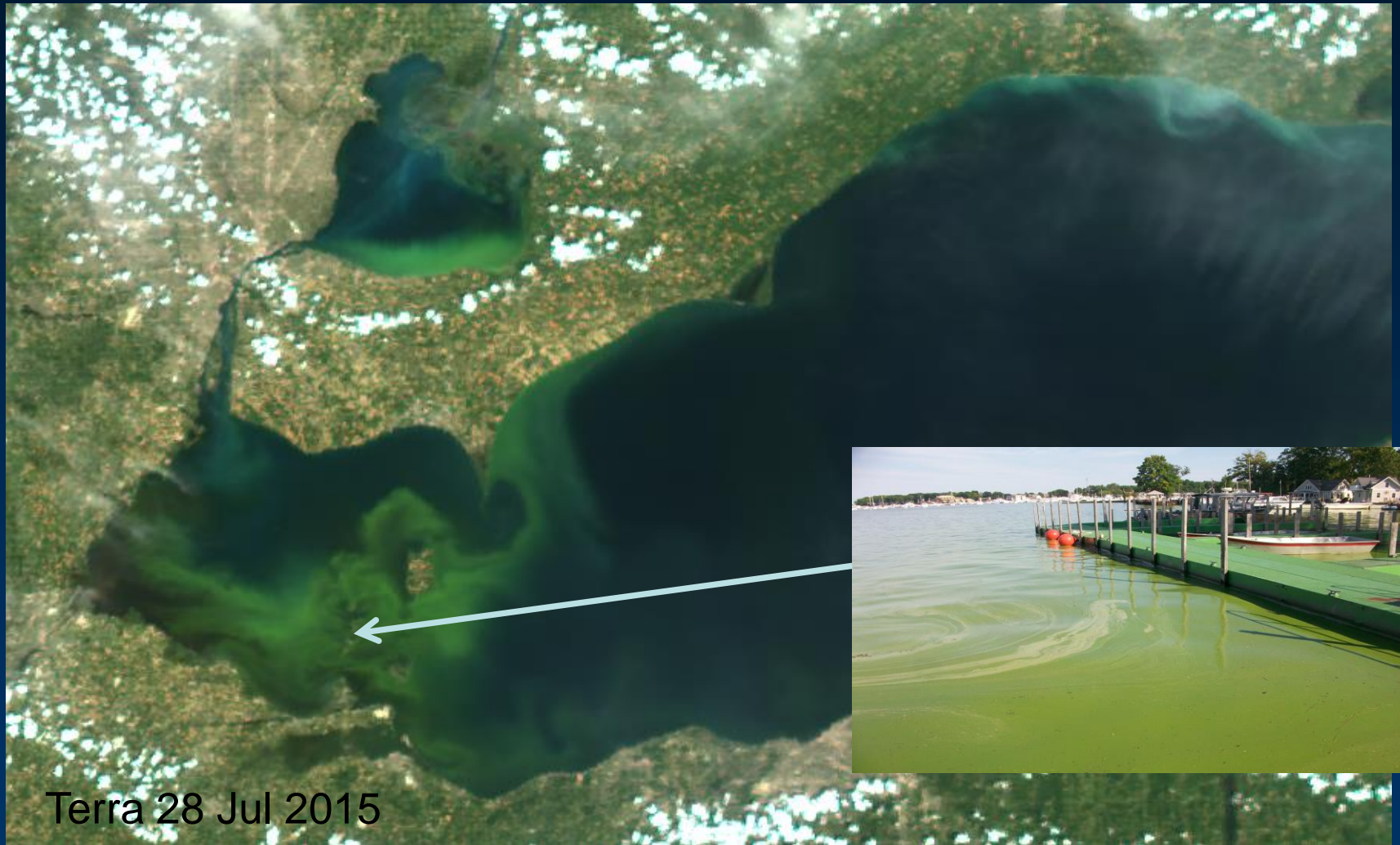
# Can Lake Erie help us monitor cyanobacterial blooms in the rest of the country?

Rick Stumpf, NOAA



Put-In Bay, 24 July 2015.  
Justin Chaffin, OSU Stone Lab

A view from 700 miles up.



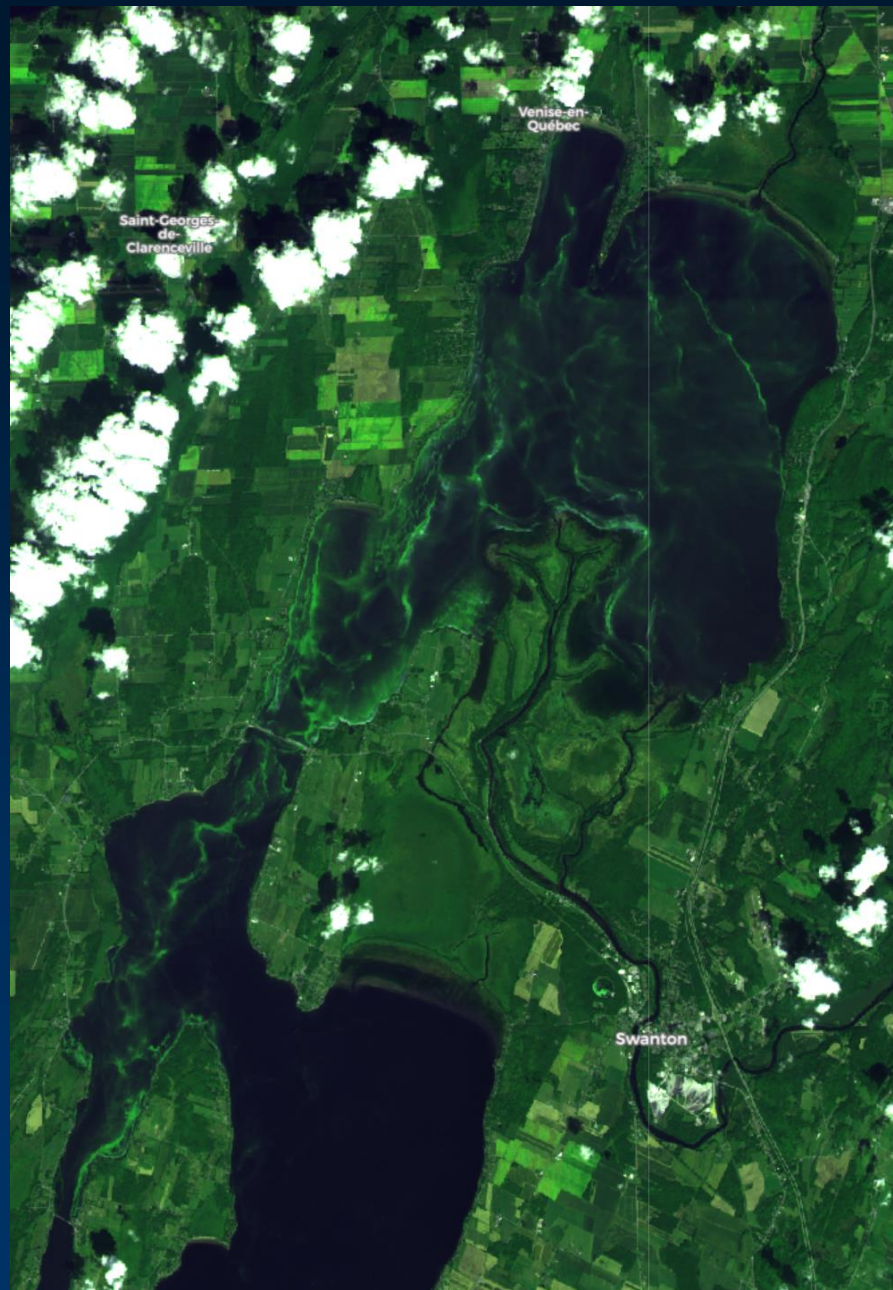
Terra 28 Jul 2015



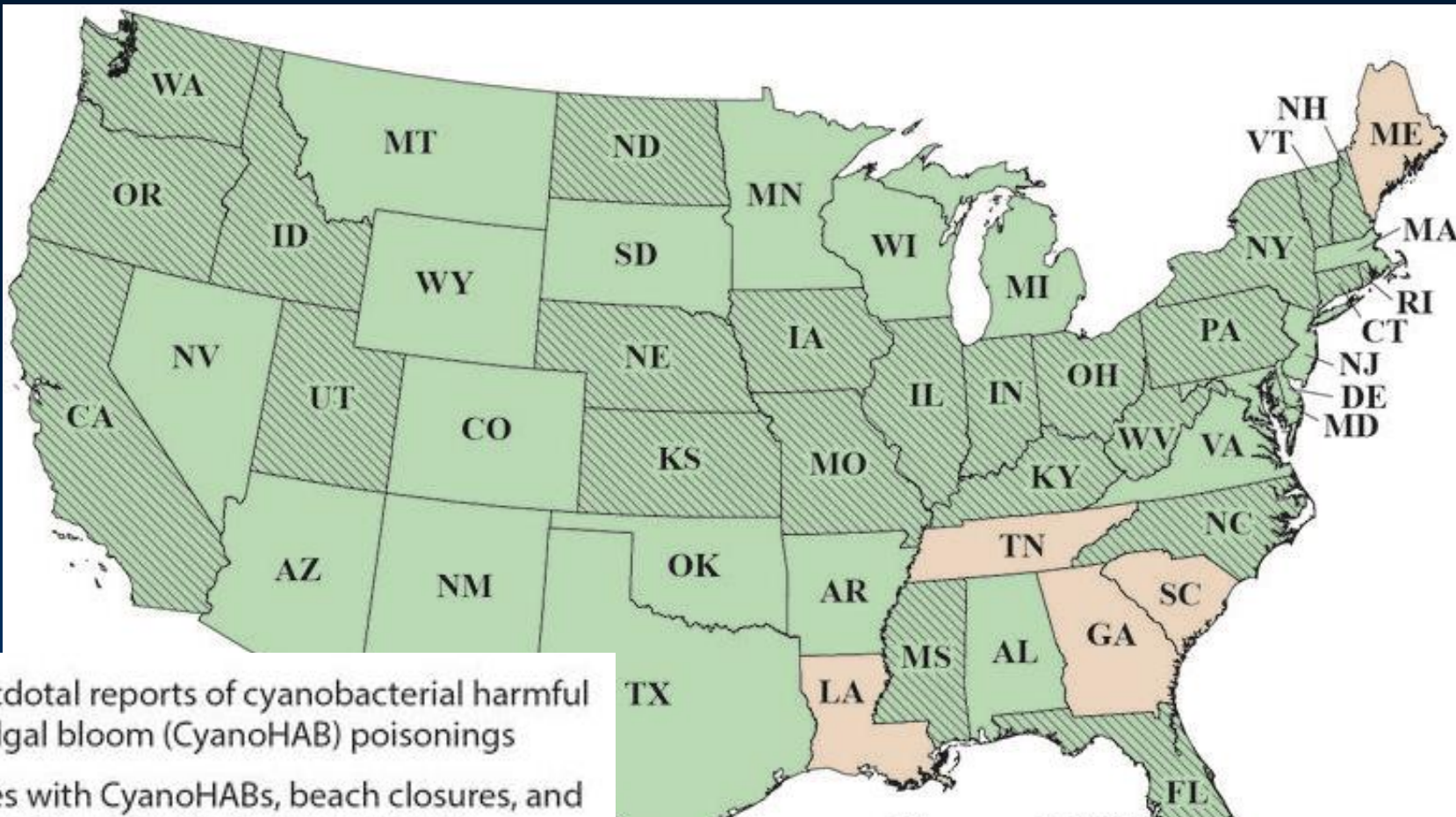
And your backyard

Mississiquoi Bay  
Sep 13, 2018

Sentinel-2  
processed to show  
scum



## National problem (USGS status 2016)



[www.usgs.gov/media/images/national-status-cyanohabs-august-2016](http://www.usgs.gov/media/images/national-status-cyanohabs-august-2016)

## Graham et al. 2009 Lifeline



# People and animals

## CDC MMWR

Harmful Algal Bloom—Associated Illnesses in Humans and Dogs Identified Through a Pilot Surveillance System — New York, 2015

Weekly / November 3, 2017 / 66(43);1182–1184

Canine cyanotoxin poisonings in the United States (1920s-2012): review of suspected and confirmed cases from three data sources. Backer et al. 2013

## Dairy Herd Management



Sea Otters; Miller et al. 2010 PLoS ONE

### Animal Safety Alert

#### BLUE-GREEN ALGAE BLOOMS

When in doubt, it's best to keep out!



### LIVESTOCK > NUTRITION

## Be watchful for toxic blue-green algae in stock ponds

Blue-green algae blooms can devastate cattle producers.

Beef Magazine, 2015

By Miranda Meehan and Gerald Stokka. North Dakota State University

# Lake Okeechobee algae bloom threatens to worsen water woes



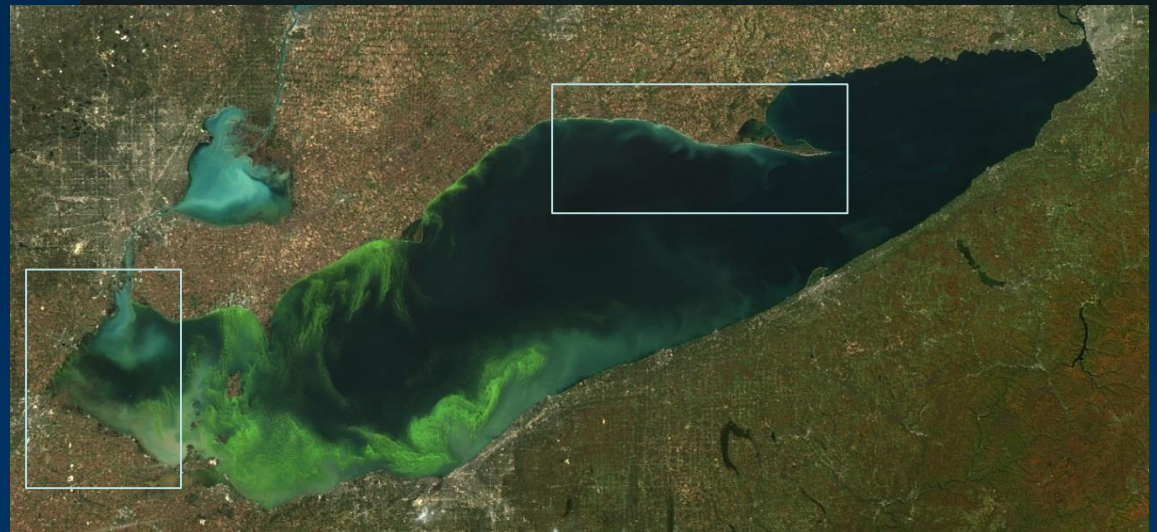
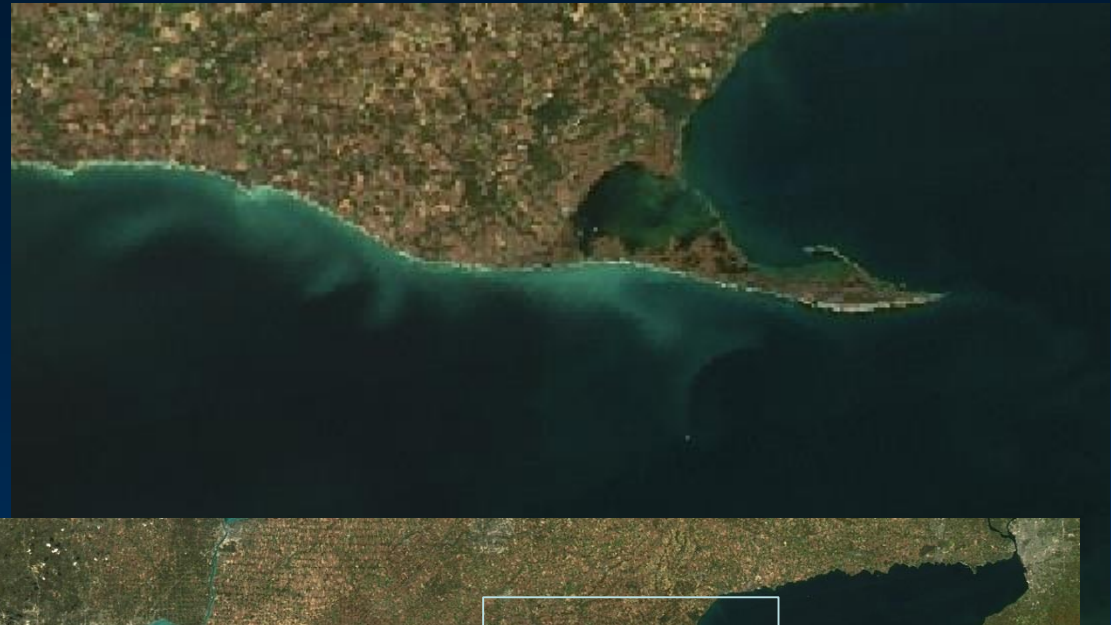
## Algae bloom, bacterial spike close several South Florida beaches

**BUSINESS** By Jennifer Sorentue - Palm Beach Post Staff Writer



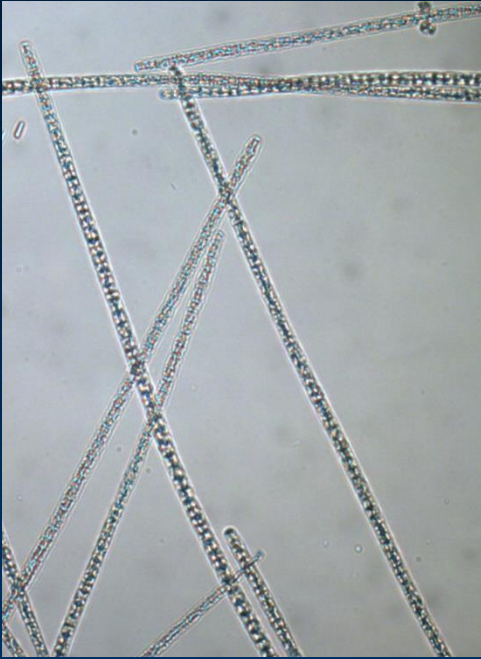
Updated: 5:39 p.m. Tuesday, June 28, 2016 | Posted: 5:27 p.m. Tuesday, June 28, 2016

To monitor cyanobacteria you have to detect it,  
and not detect other stuff.



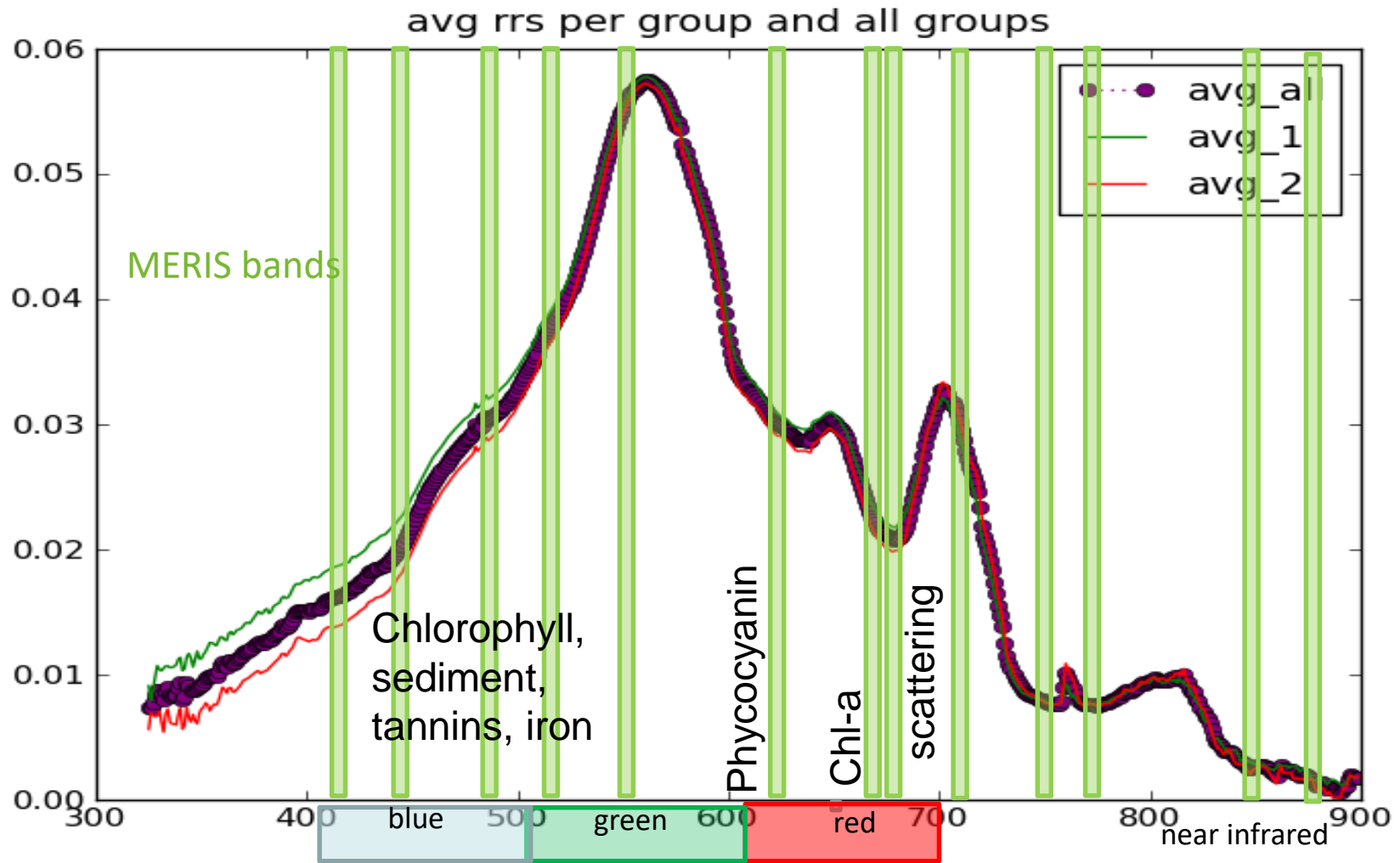


# Scum isn't the answer. Planktothrix in Sandusky Bay, which doesn't make scum

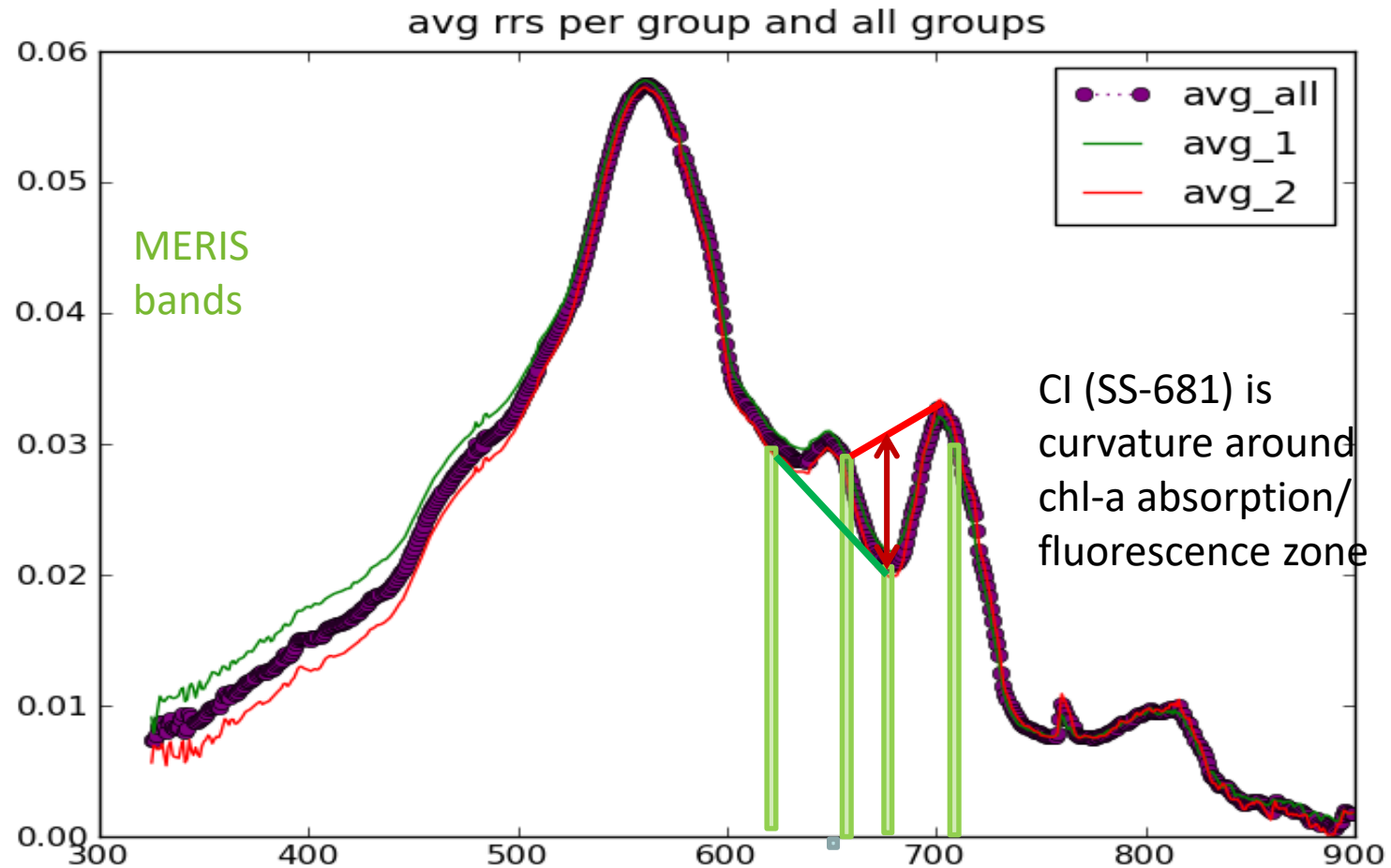




# MERIS bands and reflectance of cyanobacteria

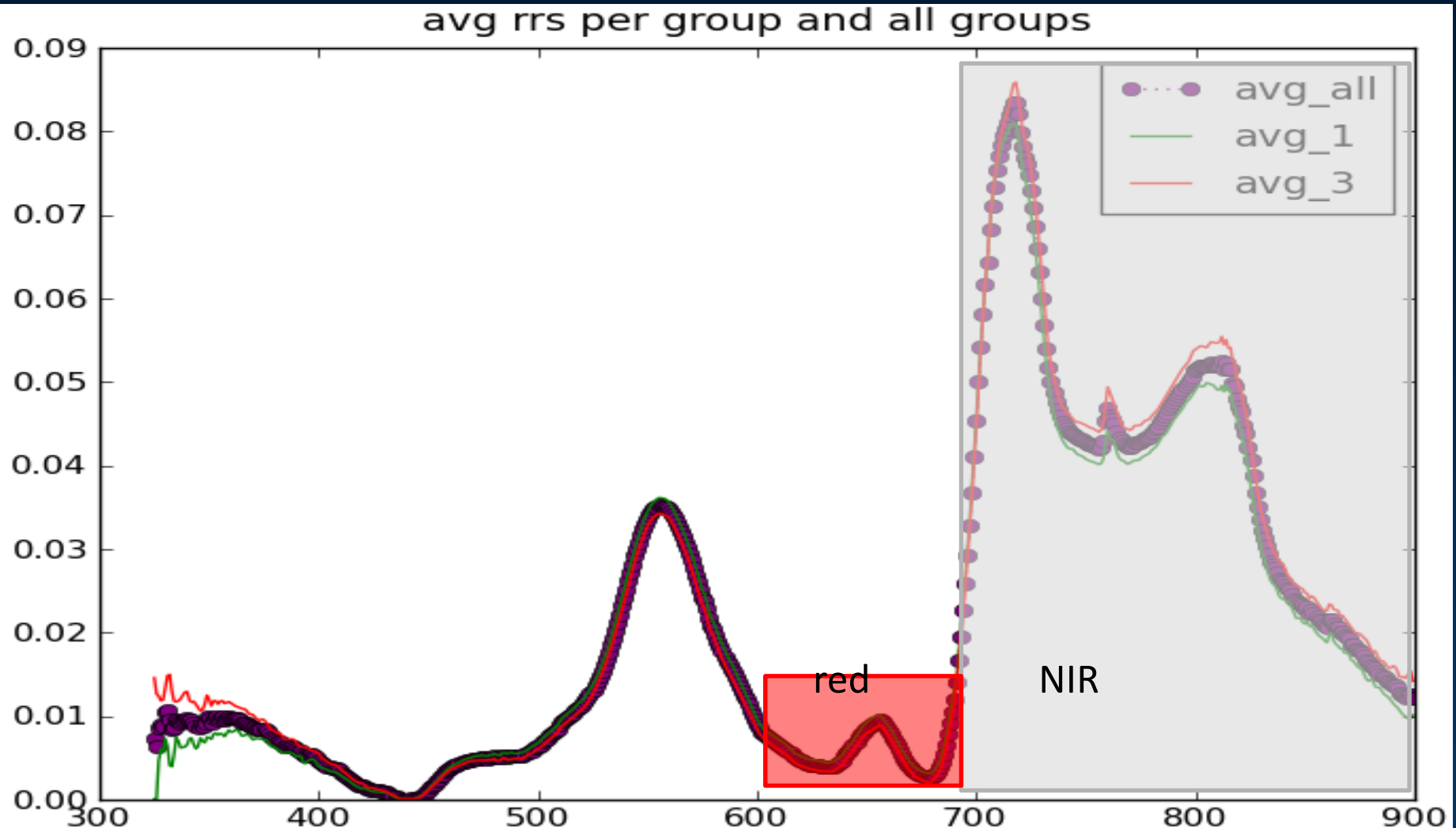


# So we capture the dips, chl-a and PC





Even more interesting when it forms scum.  
Need satellite to see near-infrared (NIR)



# First Remote sensing of an algal bloom, 1974

## letters to nature

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*Nature* **250**, 213 - 214 (19 July 1974); doi:10.1038/250213a0

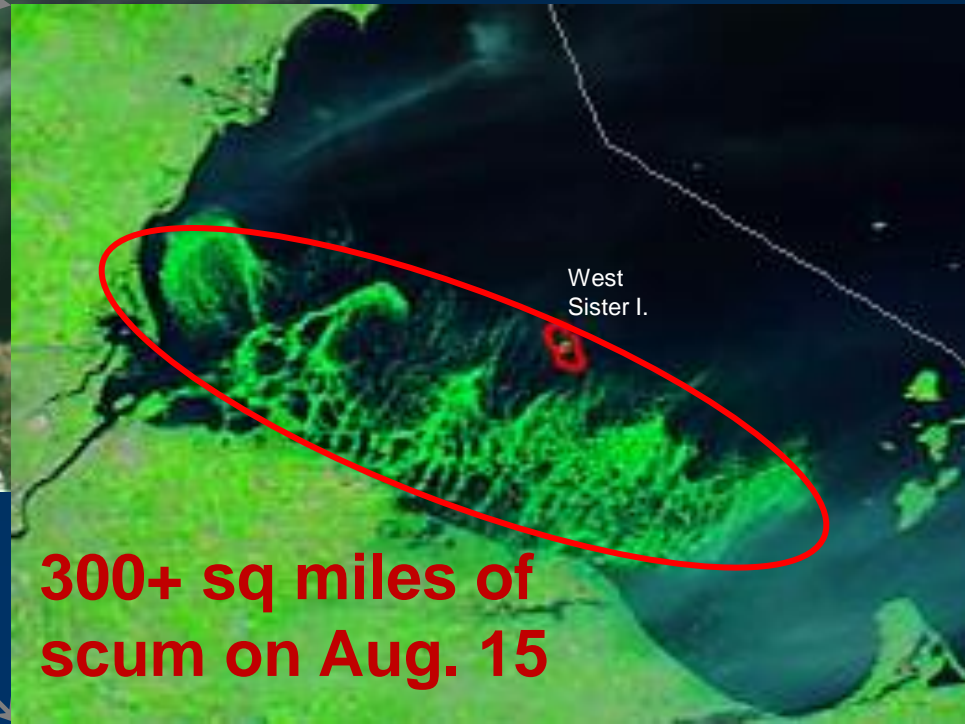
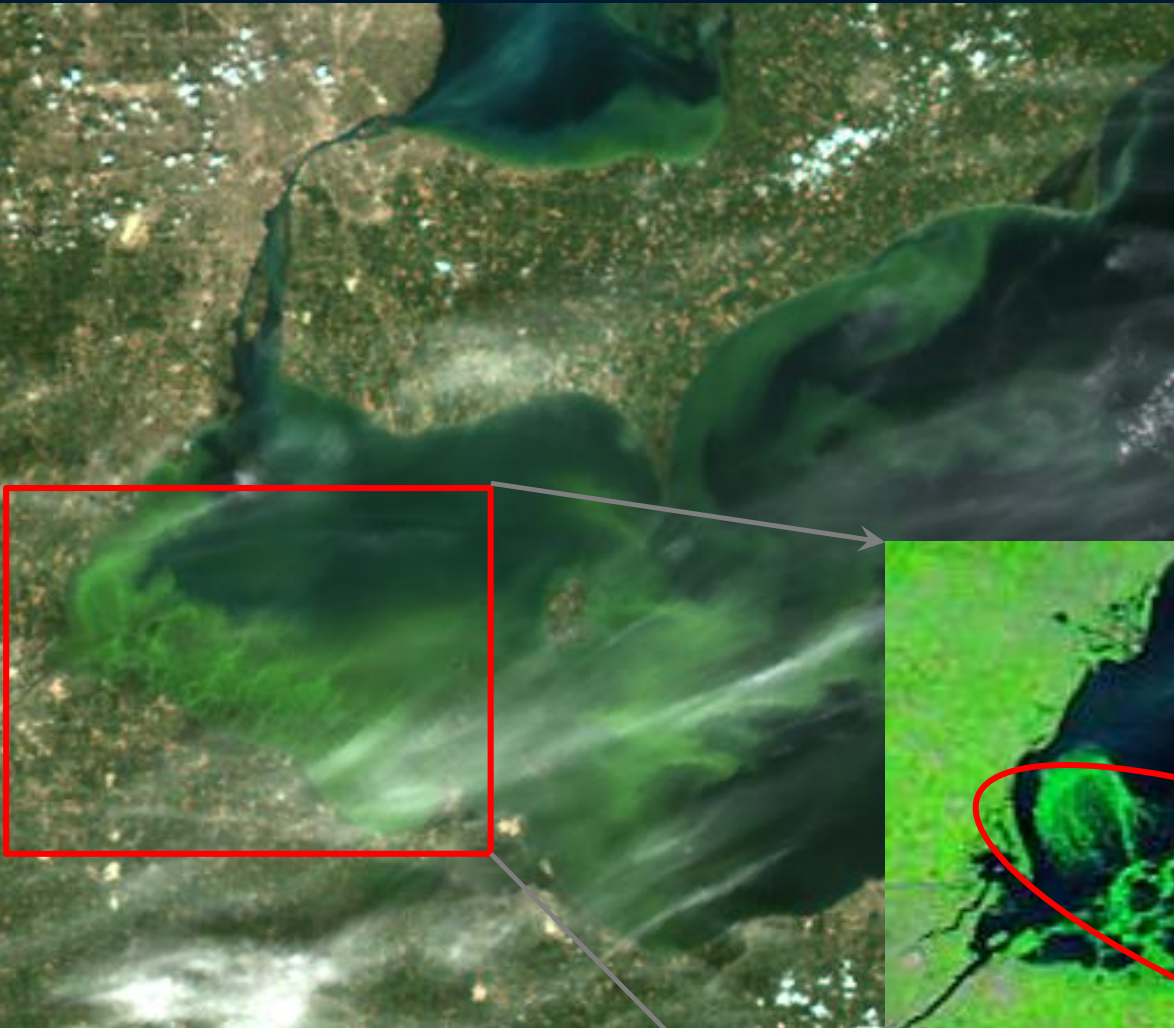
## Remote sensing and lake eutrophication

ROBERT C. WRIGLEY<sup>\*</sup> & ALEXANDER J. HORNE<sup>†</sup>

An infrared photograph of part of Clear Lake, California (Fig. 1) shows beautiful, complex patterns of blue-green algal blooms which were not observed by conventional limnological techniques. Repeated observations of patterns such as these can be used to chart the surface movement of these buoyant algae and can also be used to help control algal scums in eutrophic lakes.

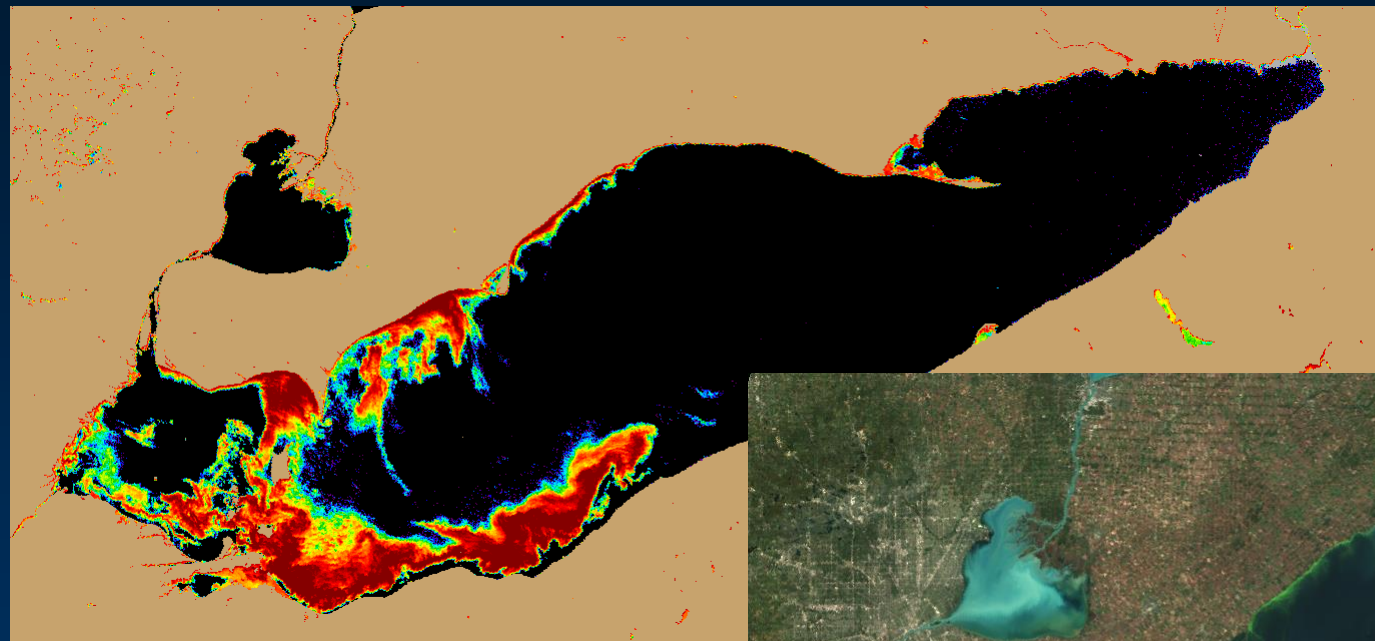


# Using NIR instead of green shows scum



**300+ sq miles of  
scum on Aug. 15**

# Finding the cyano blooms and not the other stuff



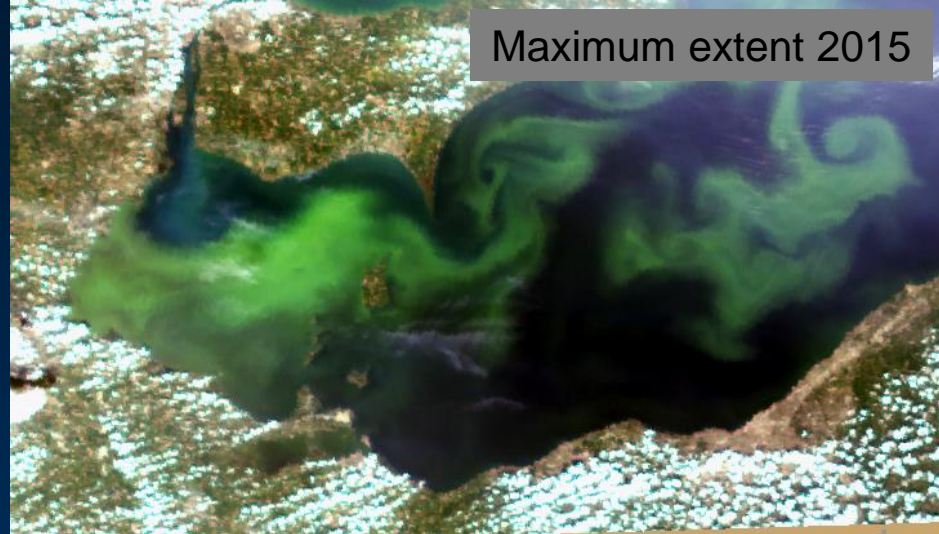


# If it works in Lake Erie, what about other places?

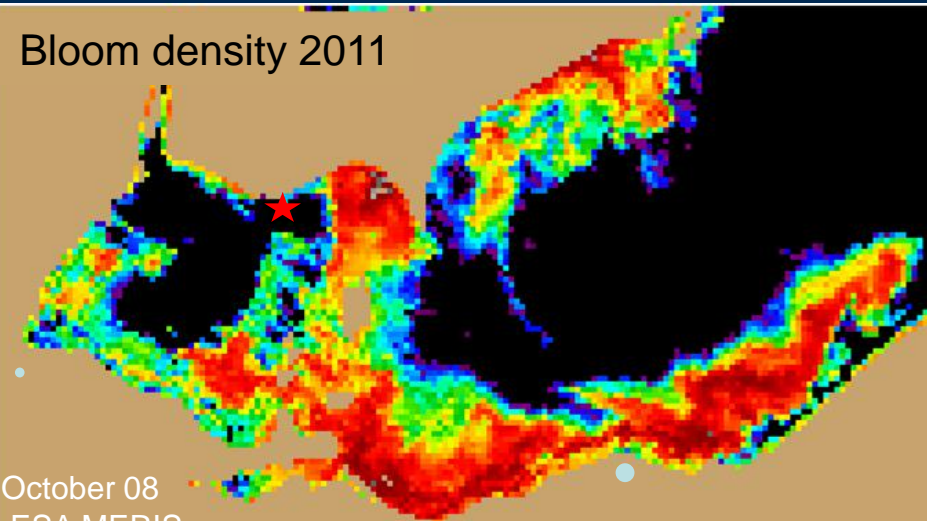
Maximum extent 2011



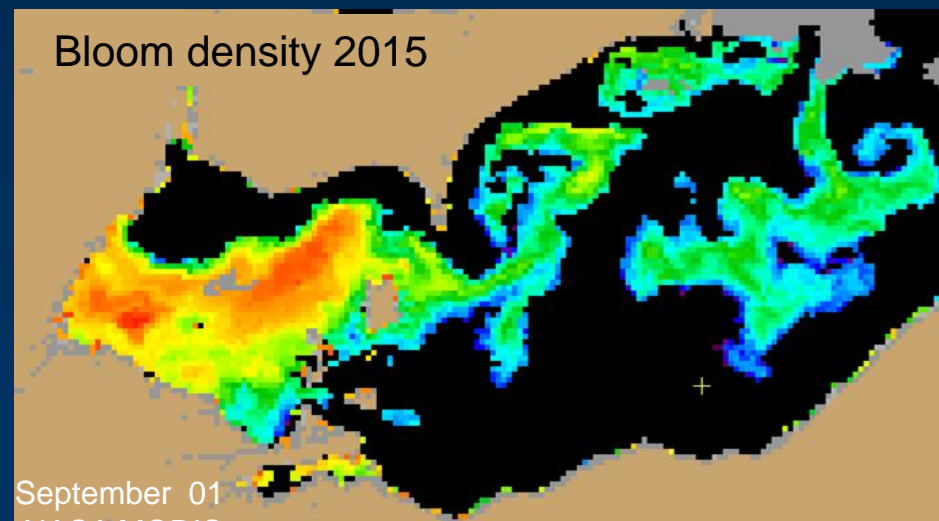
Maximum extent 2015



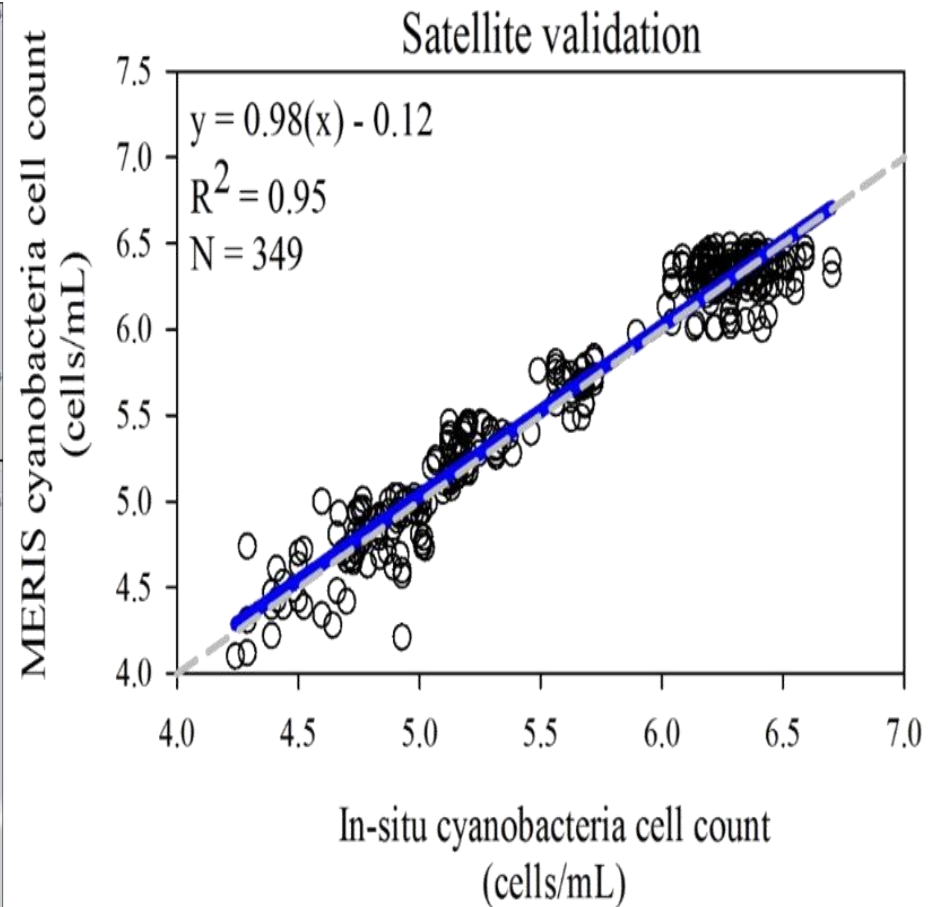
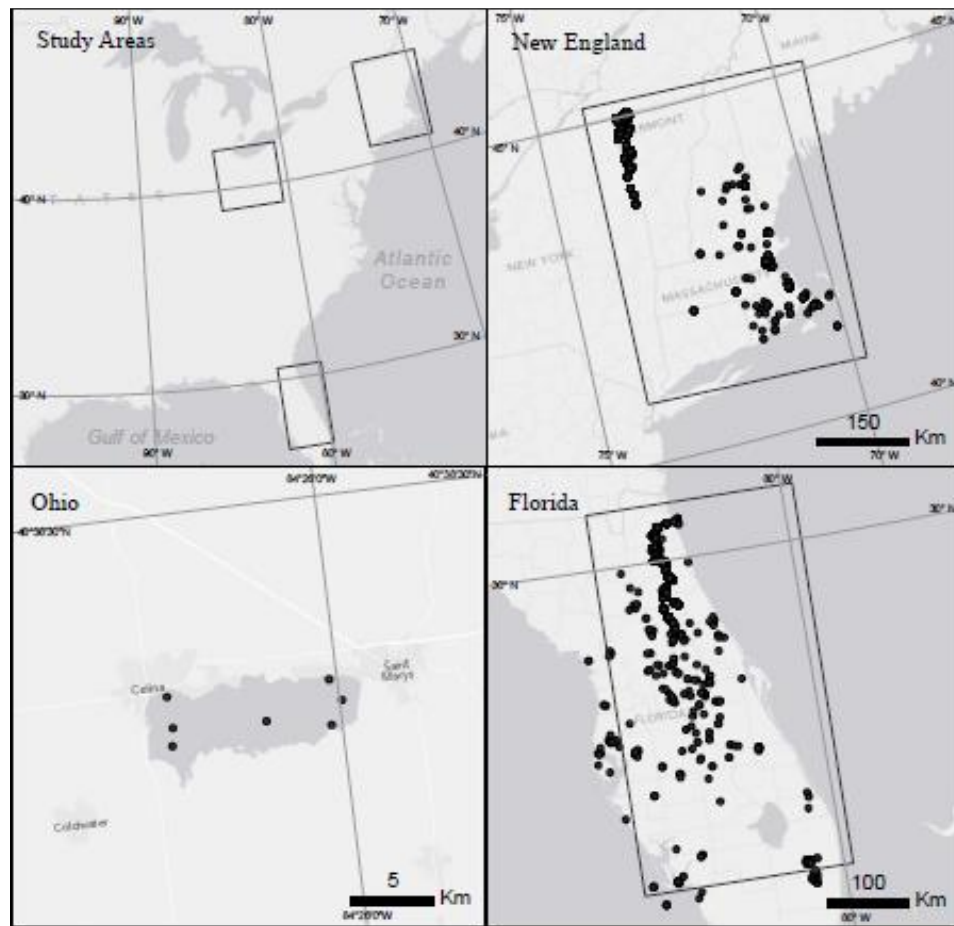
Bloom density 2011



Bloom density 2015



# Lake Erie relationship of satellite to *Microcystis* cell concentration. Does it work elsewhere?





## What about chl-a, if that's what we're detecting?

Florida lakes

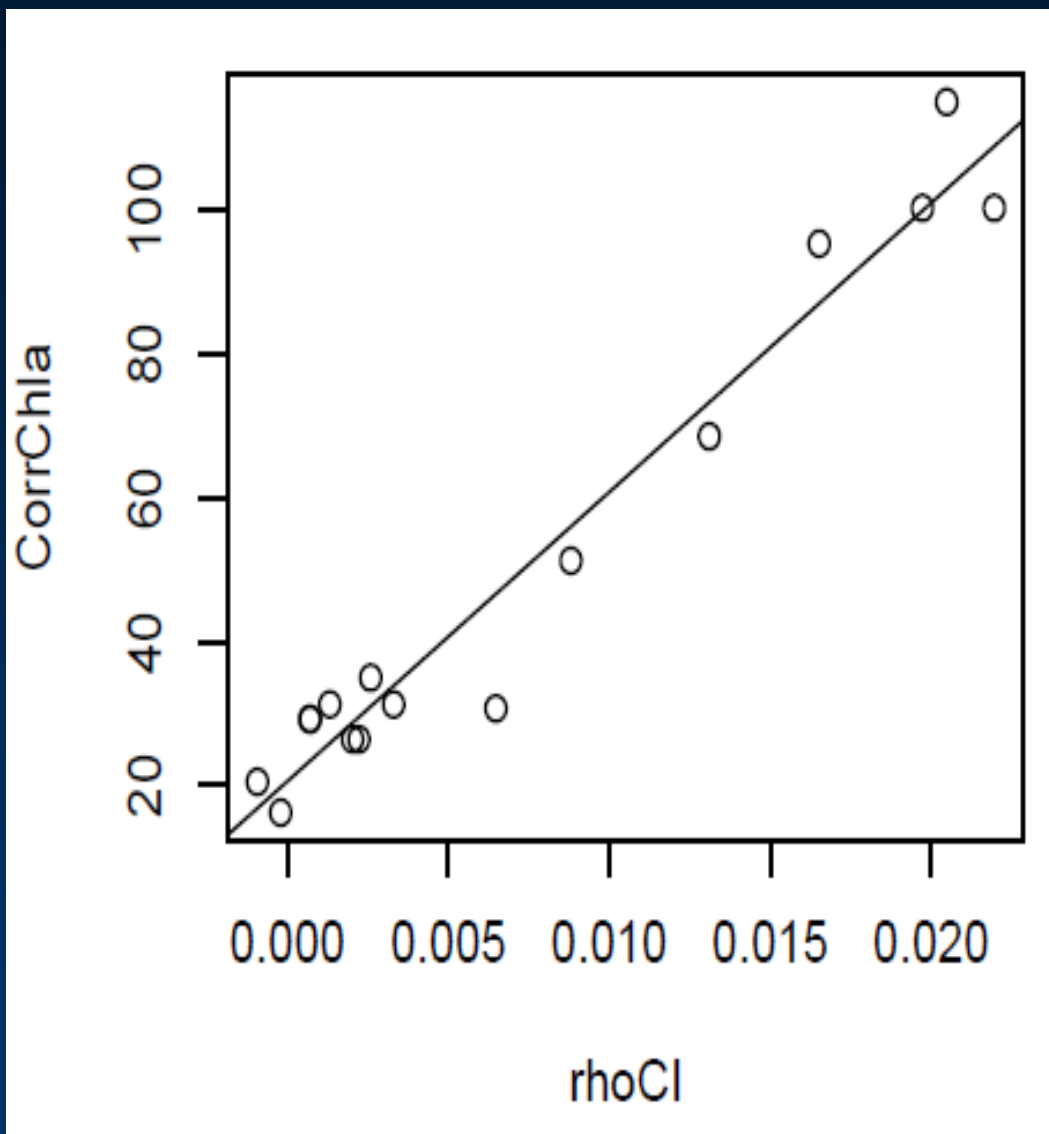
Mean error 5  $\mu\text{g/L}$

*Est chl a =*

$$4020 \cdot (CI) + 20$$

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

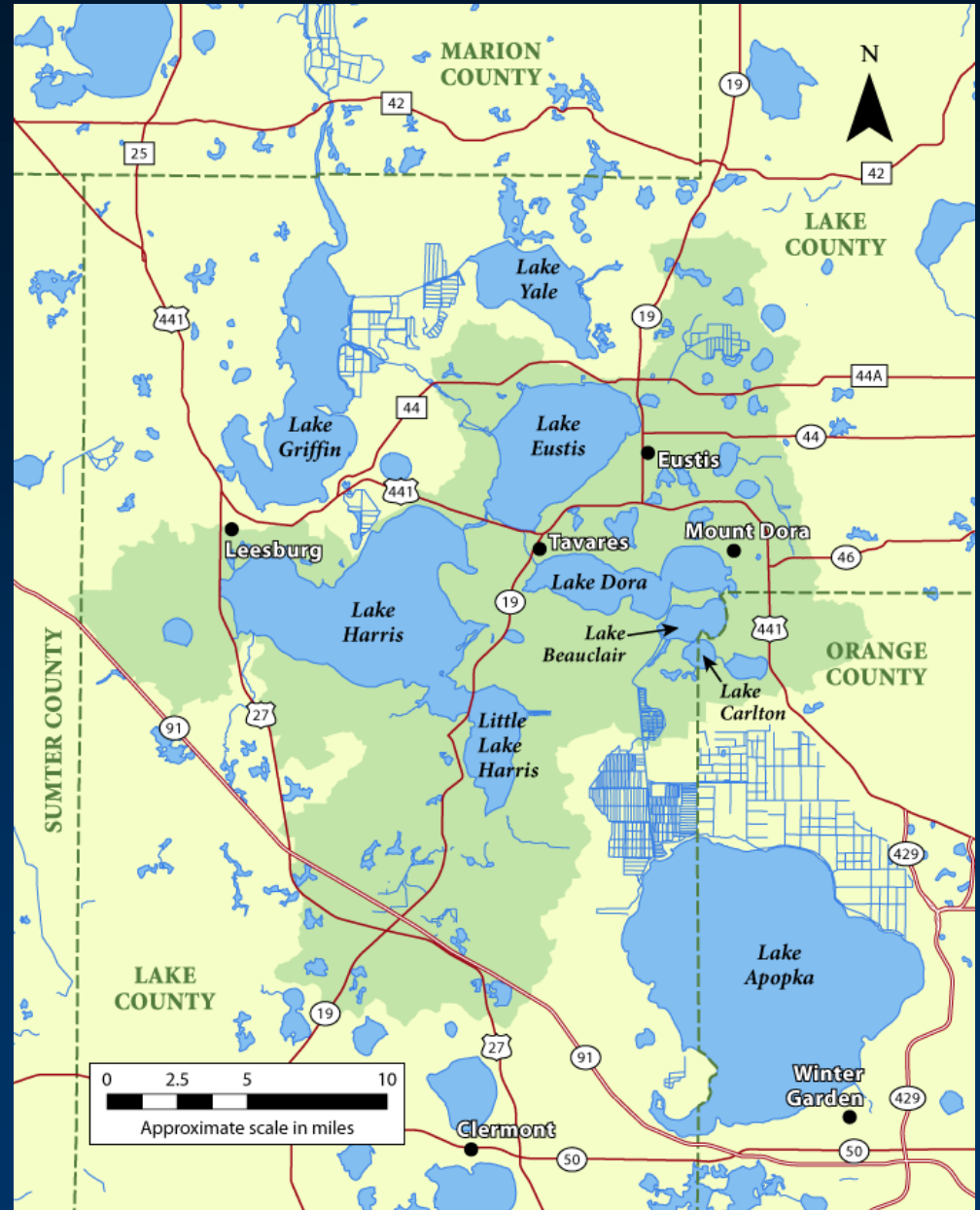
– (working on > 10  
 $\mu\text{g/L}$ )



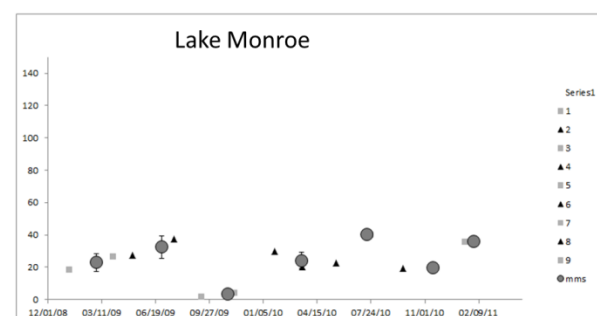
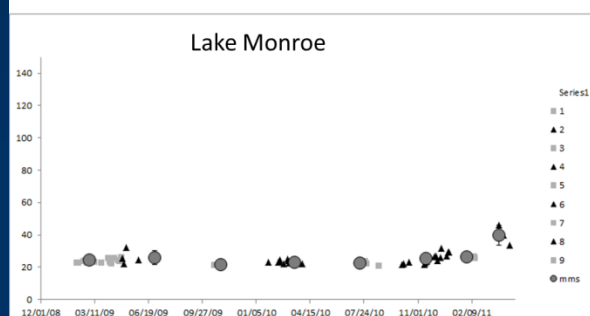
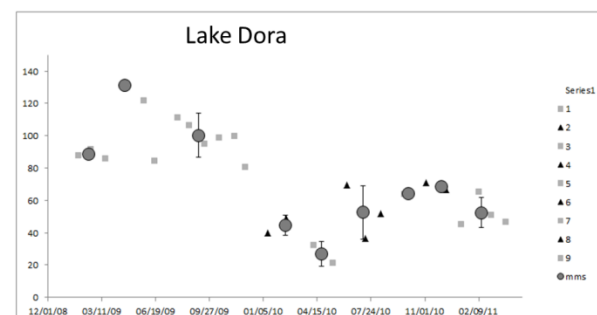
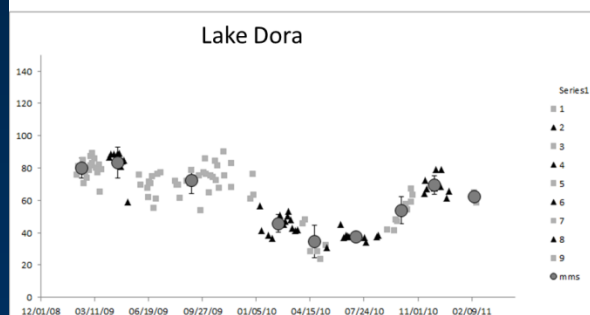
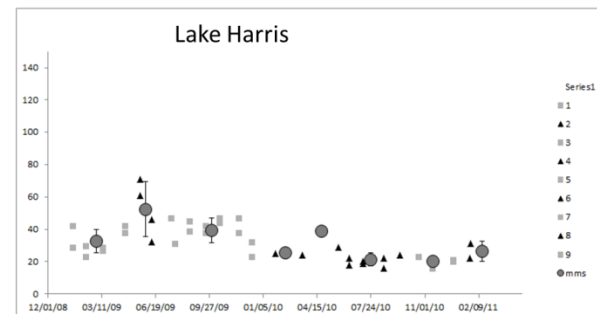
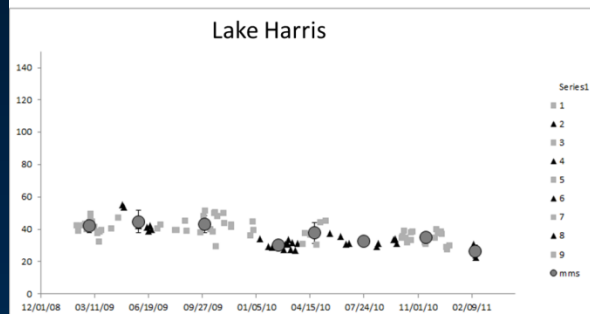
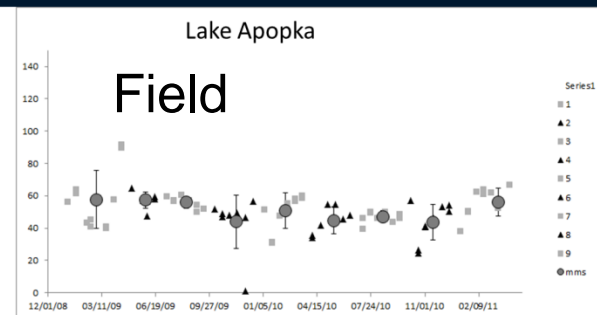
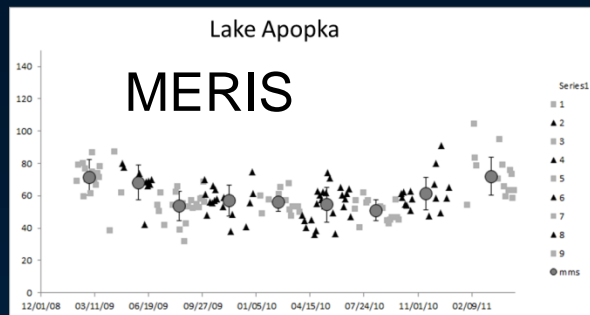
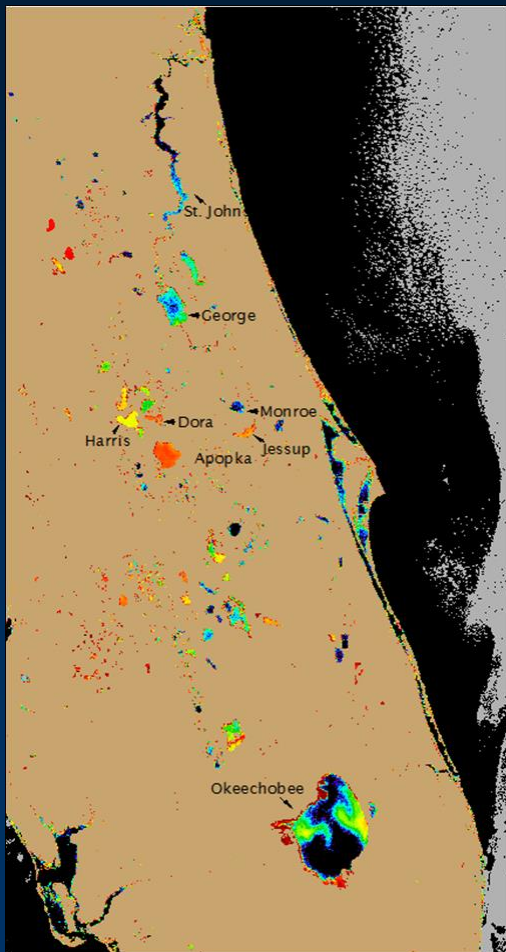
# Harris Chain of Lakes central Florida

Starts in Apopka,  
and flows  
through the  
rest.

Restoration to  
reduce P, saw  
lower P loads in  
Griffin and  
Dora.



# MERIS vs field





# Some lakes in California

## Clear Lake



**HEALTH ADVISORY**

High levels of blue-green algae have been observed in this area and can produce harmful toxins

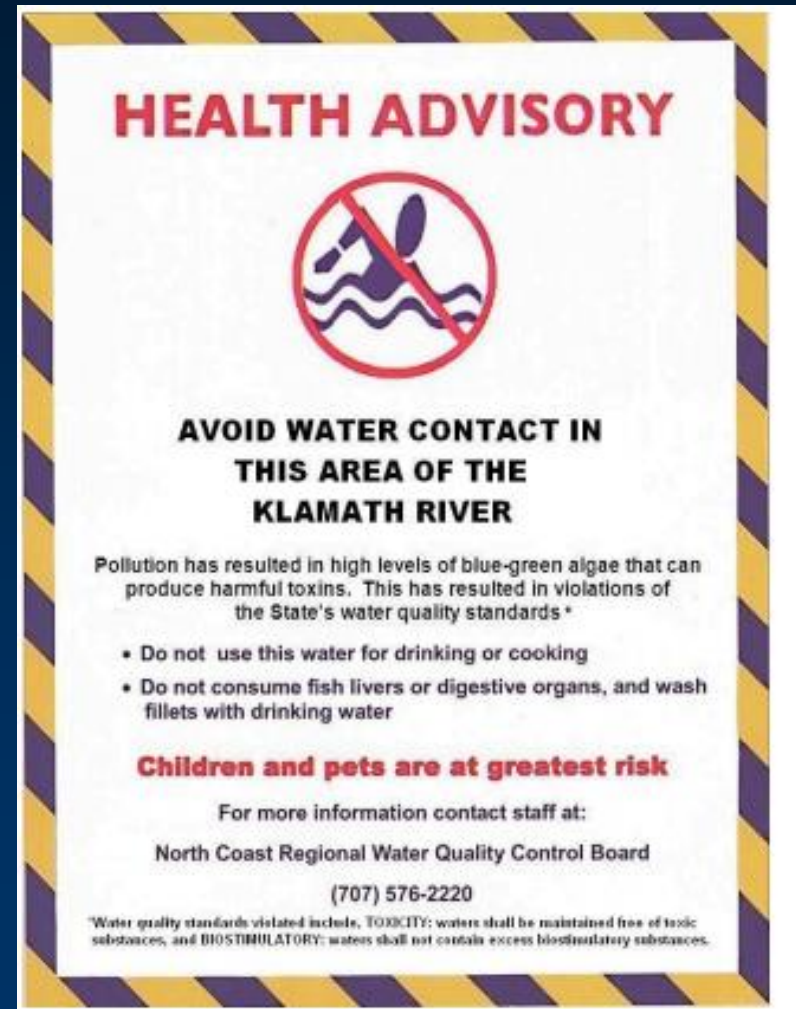
**AVOID WATER CONTACT IF THERE ARE VISIBLE SIGNS OF BLUE-GREEN ALGAE MATS**

Do not use this water in this area for swimming, drinking, or cooking. Keep pets away from water in this area. Other parts of Clear Lake, that are not posted and show no signs of algae mats are open to swimming and boating.


 Lake County Environmental Health  
(707) 263-1164

The sign features a central title 'HEALTH ADVISORY' in white text on a dark blue background. Below the title are three icons: a lake with a red 'X' over it, a swimmer with a red 'X' over it, and a glass of water with a red 'X' over it. To the left and right of the central text are two small photographs of a lake with green algae mats. At the bottom left is the Lake County Environmental Health logo, which is a circular seal with a tree and the words 'LAKE COUNTY CALIFORNIA'.

## Klamath Lake



**HEALTH ADVISORY**



**AVOID WATER CONTACT IN  
THIS AREA OF THE  
KLAMATH RIVER**

Pollution has resulted in high levels of blue-green algae that can produce harmful toxins. This has resulted in violations of the State's water quality standards\*

- Do not use this water for drinking or cooking
- Do not consume fish livers or digestive organs, and wash fillets with drinking water

**Children and pets are at greatest risk**

For more information contact staff at:  
North Coast Regional Water Quality Control Board  
(707) 576-2220

\*Water quality standards violated include, TOXICITY: waters shall be maintained free of toxic substances, and BIOSTIMULATORY: waters shall not contain excess biostimulatory substances.

The sign has a yellow and black diagonal striped border. It features a large red circle with a diagonal line through it, over a black silhouette of a swimmer. The text is in bold black and red fonts. At the bottom, there is a small asterisked note about water quality standards.

# Klamath Lake Area, Oregon/California



Susan Gorum

Karuk Tribe Dept. Natural  
Resources

2009 9 20



Lost Creek  
Lake

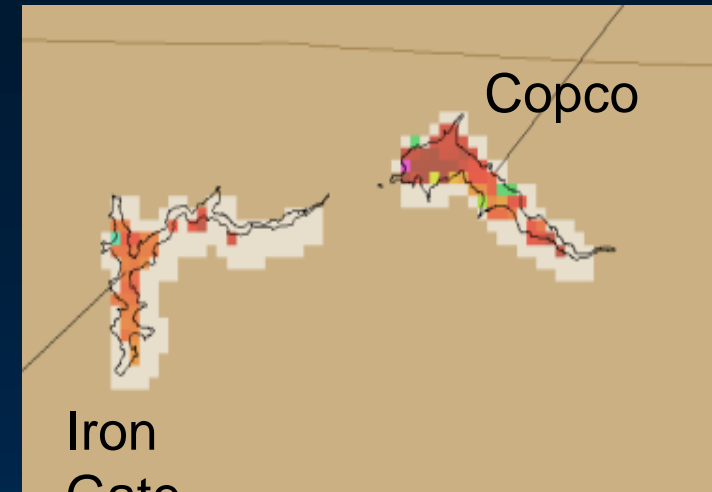
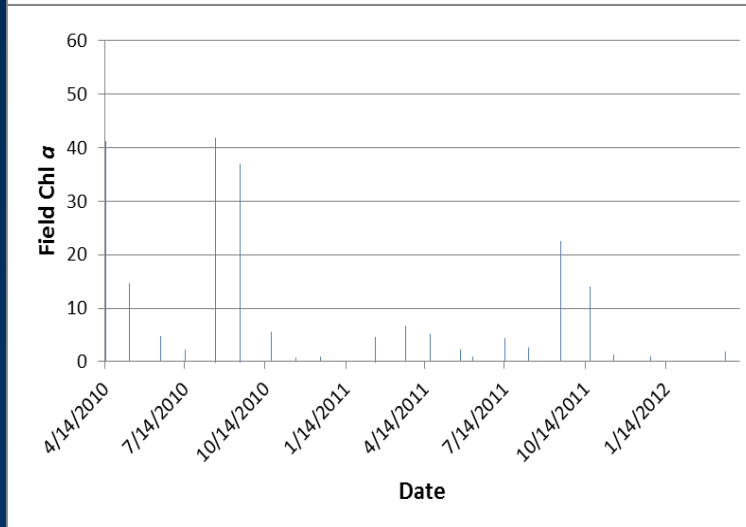
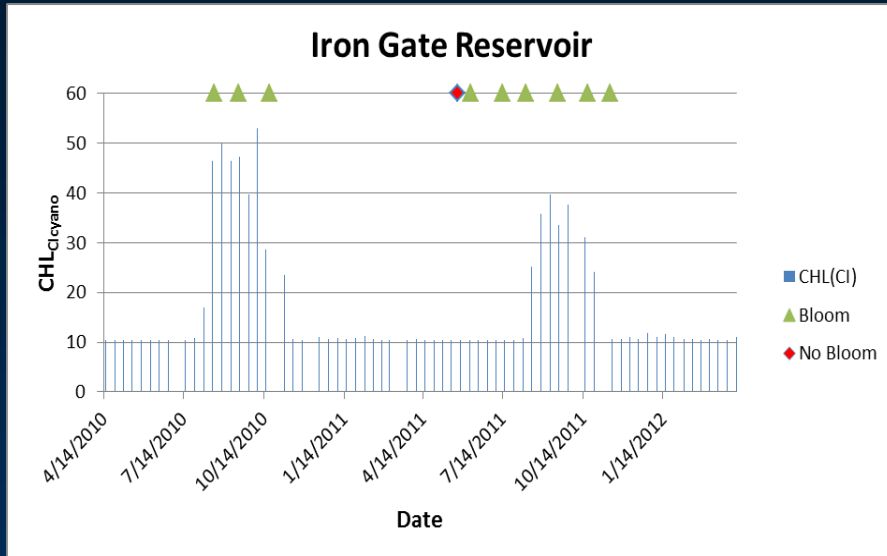


Upper Klamath  
Lake

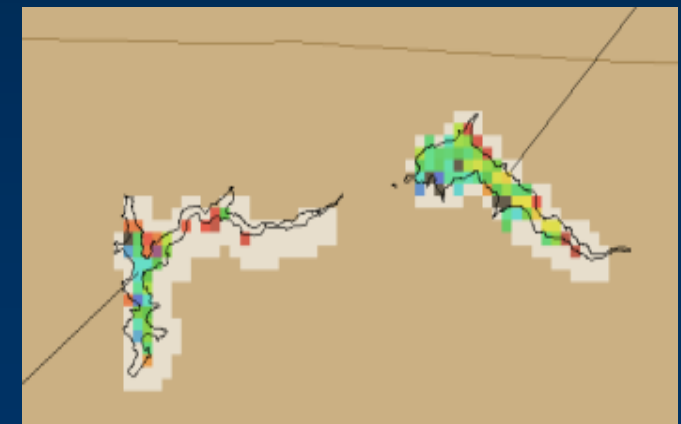
Iron Gate  
Copco



# Klamath River (California) reservoirs.



MERIS composites  
Aug 11-20, 2010 top  
Feb 1-10, 2011 bottom





# First Remote sensing of an algal bloom, 1974

## letters to nature

---

*Nature* **250**, 213 - 214 (19 July 1974); doi:10.1038/250213a0

## Remote sensing and lake eutrophication

ROBERT C. WRIGLEY<sup>\*</sup> & ALEXANDER J. HORNE<sup>†</sup>

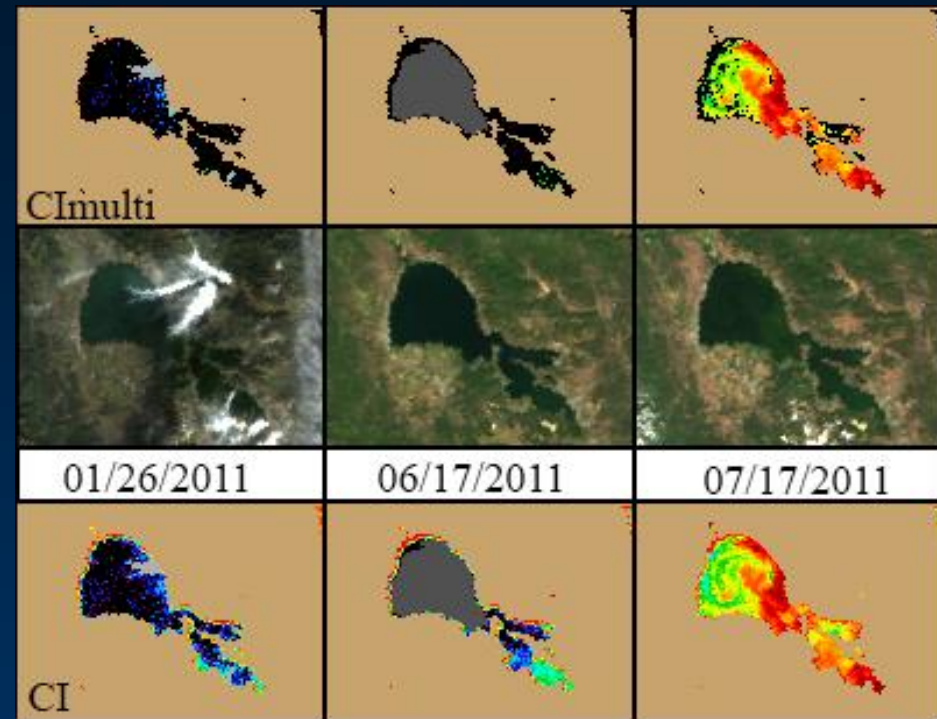
An infrared photograph of part of Clear Lake, California (Fig. 1) shows beautiful, complex patterns of blue-green algal blooms which were not observed by conventional limnological techniques. Repeated observations of patterns such as these can be used to chart the surface movement of these buoyant algae and can also be used to help control algal scums in eutrophic lakes.

# Proof-of-of Concept example Clear Lake, CA

(Imagery shows intensification of chlorophyll-a in June)

In mid June chlorophyll increased dramatically Clear Lake Lower Arms on June 16th, 2011. Clear Lake subsequently suffered a devastating cyanobacteria bloom that continue through the summer. Early June chlorophyll ~3 ug/L in NW, 15 ug/L in Lower Arms.

60 and 130 ug/L in mid July.



# Utah Lake, Utah, 2016



WATER

## Toxic algae bloom closes Utah lake, sickens more than 100 people

Published July 23, 2016 · Associated Press



At 150 sq miles,  
one of the largest  
freshwater lakes in  
western US;  
36<sup>th</sup> in entire US

**SALT LAKE CITY (DEQ)** – Public health officials have decided to close Utah Lake, effective immediately, due to a large, harmful algal bloom that may pose a serious health risk to the public and animals.



# Utah Lake, Utah, 2017

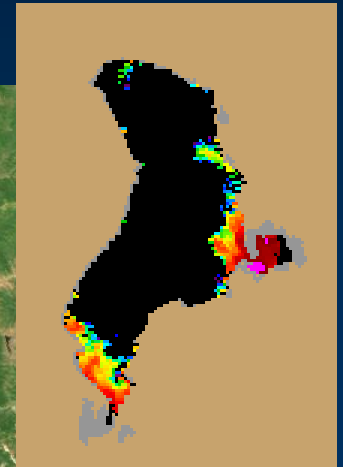
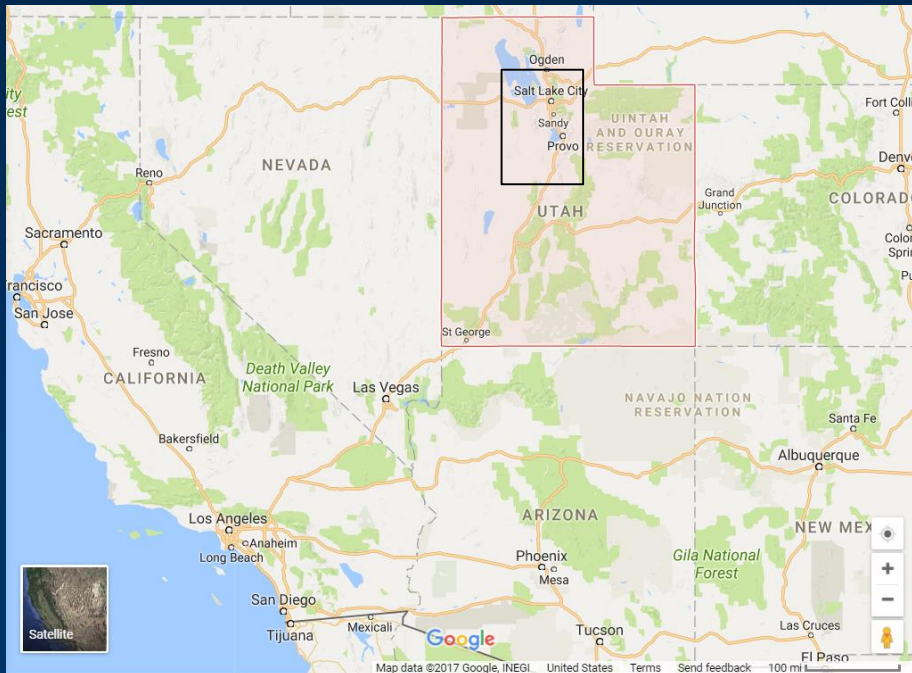
## Public warned to avoid Provo Bay in Utah Lake due to algal bloom

POSTED 3:50 PM, JUNE 29, 2017, BY MARK GREEN, UPDATED AT 05:29PM, JUNE 29, 2017



samples collected at the lake showed indications of harmful levels of cyanobacteria in the waters of Provo Bay after the bloom was spotted on satellite imagery.

*Dolichospermum crissum* 2.6M cells/mL in Provo Bay, June 22



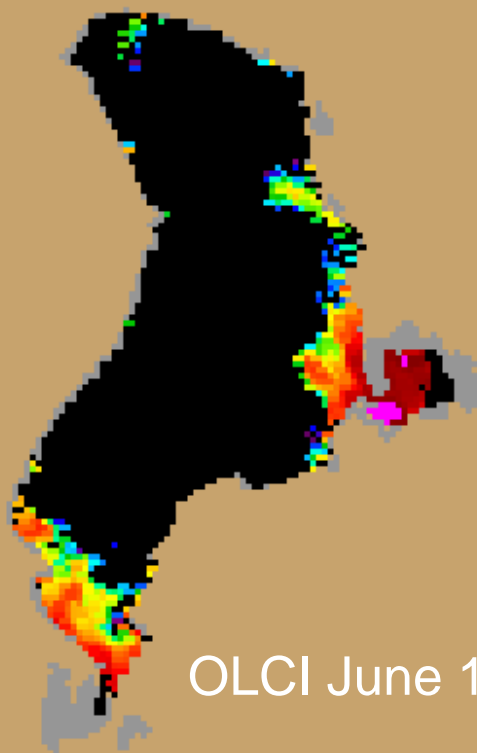
OLCI June 18

# Utah Lake, Utah, 2017, rapid growth

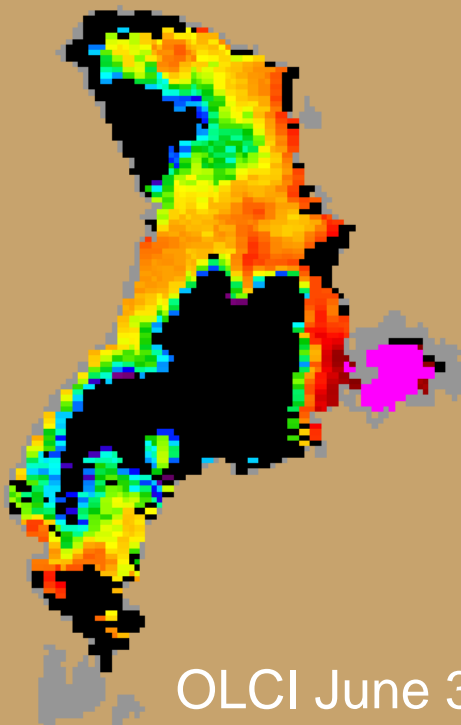
## Algal bloom in Utah Lake's Provo Bay begins spreading north



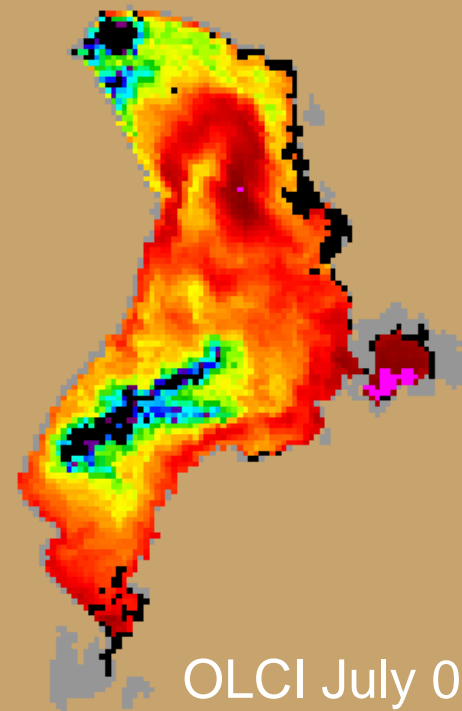
POSTED 4:45 PM, JUNE 30, 2017, BY [MARK GREEN](#), UPDATED AT 04:48PM, JUNE 30, 2017



OLCI June 18



OLCI June 30



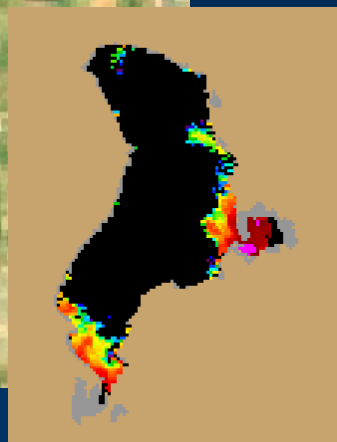
OLCI July 07

## Advisories posted for 'majority' of Utah Lake as harmful algal bloom grows

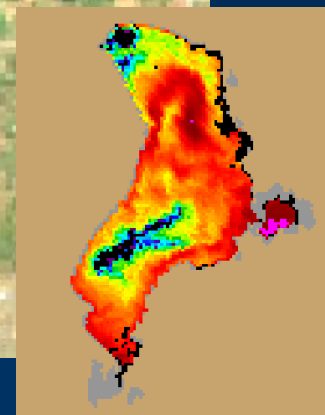
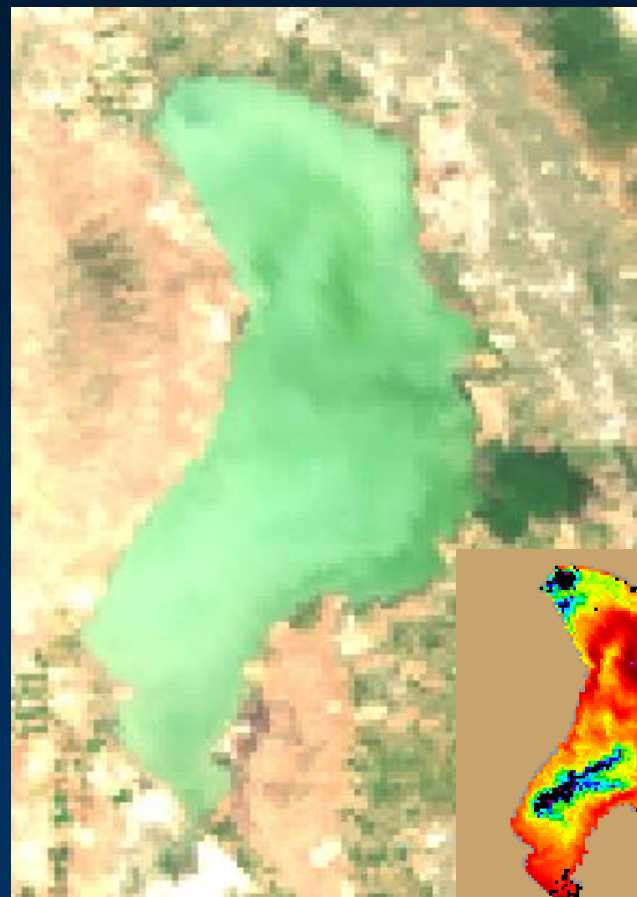
POSTED 4:45 PM, JULY 12, 2017, BY [MARK GREEN](#), UPDATED AT 05:03PM, JULY 12, 2017

# Value of algorithm over true color

June 18 2017



July 07





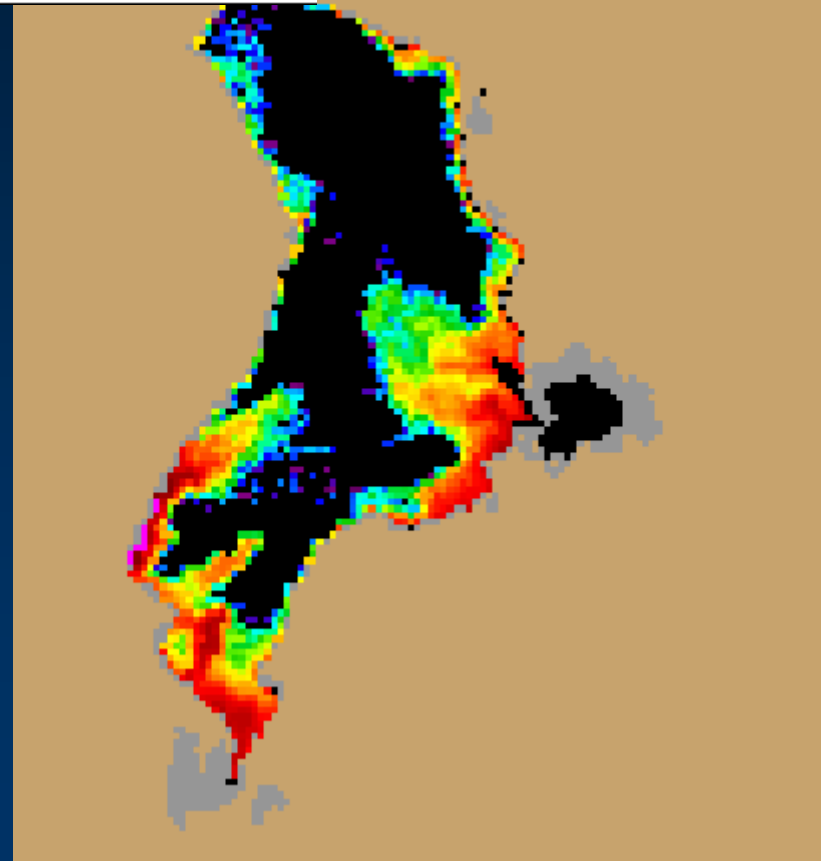
June 2018

# Here we go again: Algal bloom found in Utah Lake prompts health warning



June 25,  
2018

Warning: Provo Bay,  
Sandy Beach, and Utah  
Lake State Park  
Danger (Closed): Lincoln  
Marina



# Lake Okeechobee algae bloom threatens to worsen water woes

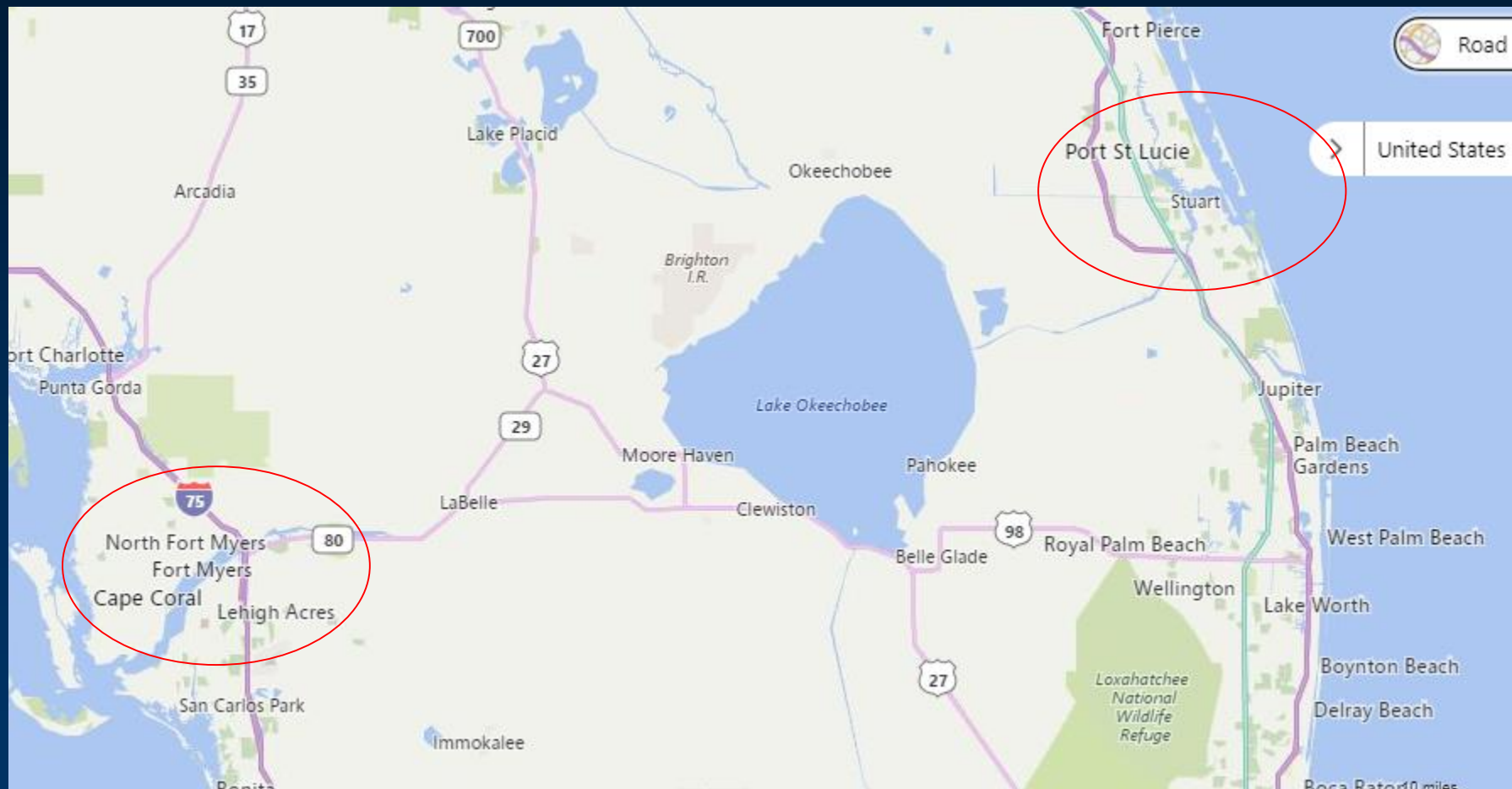


## Algae bloom, bacterial spike close several South Florida beaches

**BUSINESS** By Jennifer Sorentue - Palm Beach Post Staff Writer



Updated: 5:39 p.m. Tuesday, June 28, 2016 | Posted: 5:27 p.m. Tuesday, June 28, 2016





# St Lucie Estuary 2016



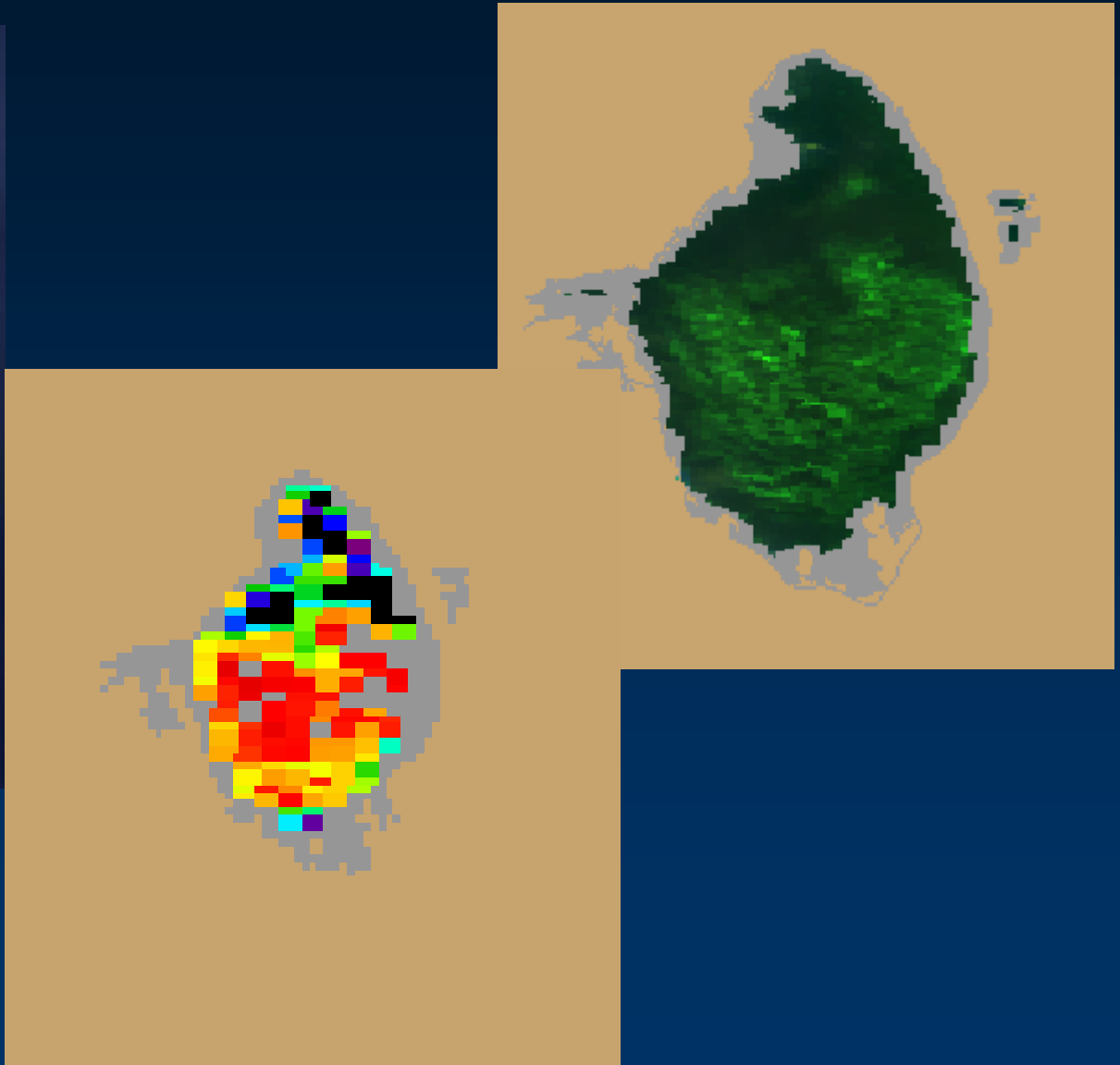
The New York Times

SUBSCRIBE NOW



Greg Lovett/The Palm Beach Post, via Associated Press

# Okeechobee on June 14, 2016





# Caloosahatchee River Estuary, July 9, 2018

The New York Times

## *Algae Bloom in Florida Prompts Fears About Harm to Health and Economy*





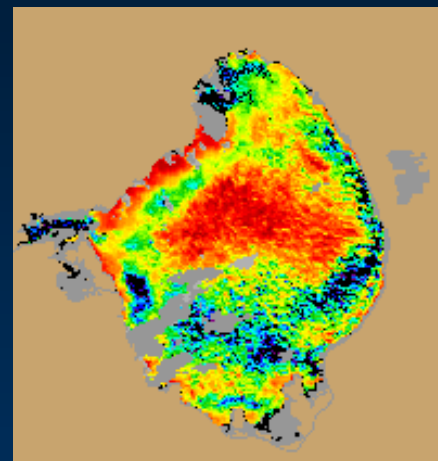
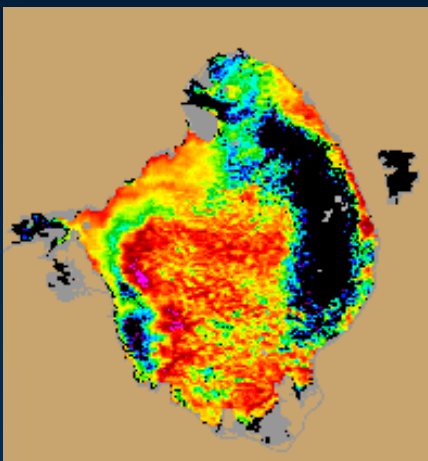
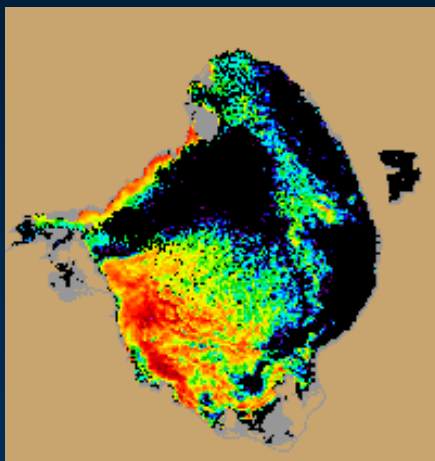
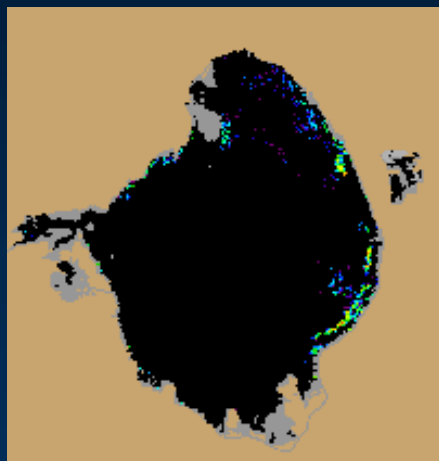
# Lake Okeechobee, 2018

June 12 3%

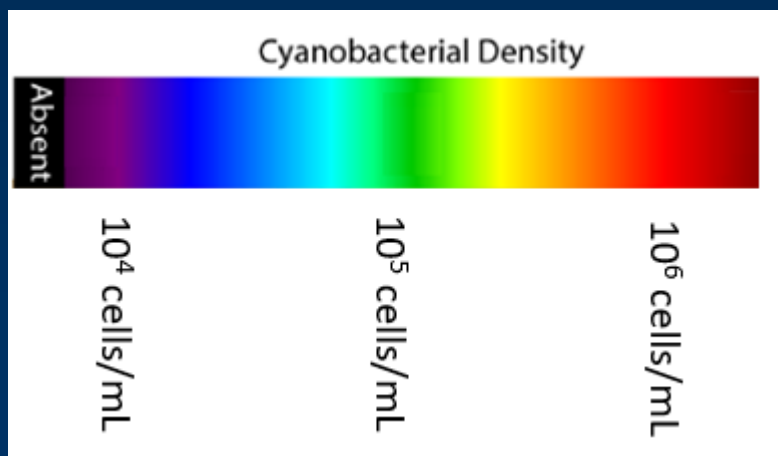
June 20 42%

June 24 78%

June 28 90%



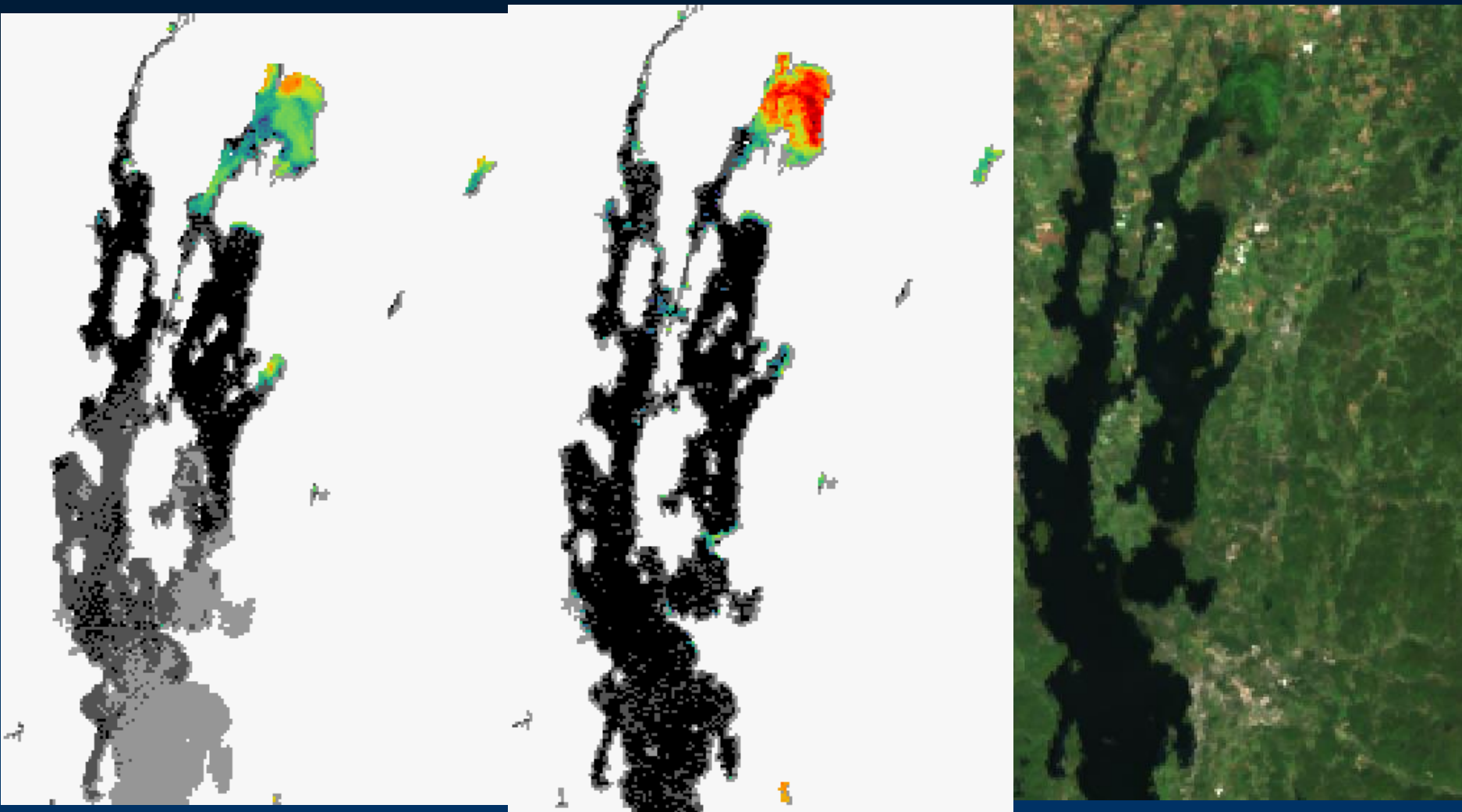
35 km



# Lake Champlain 2017

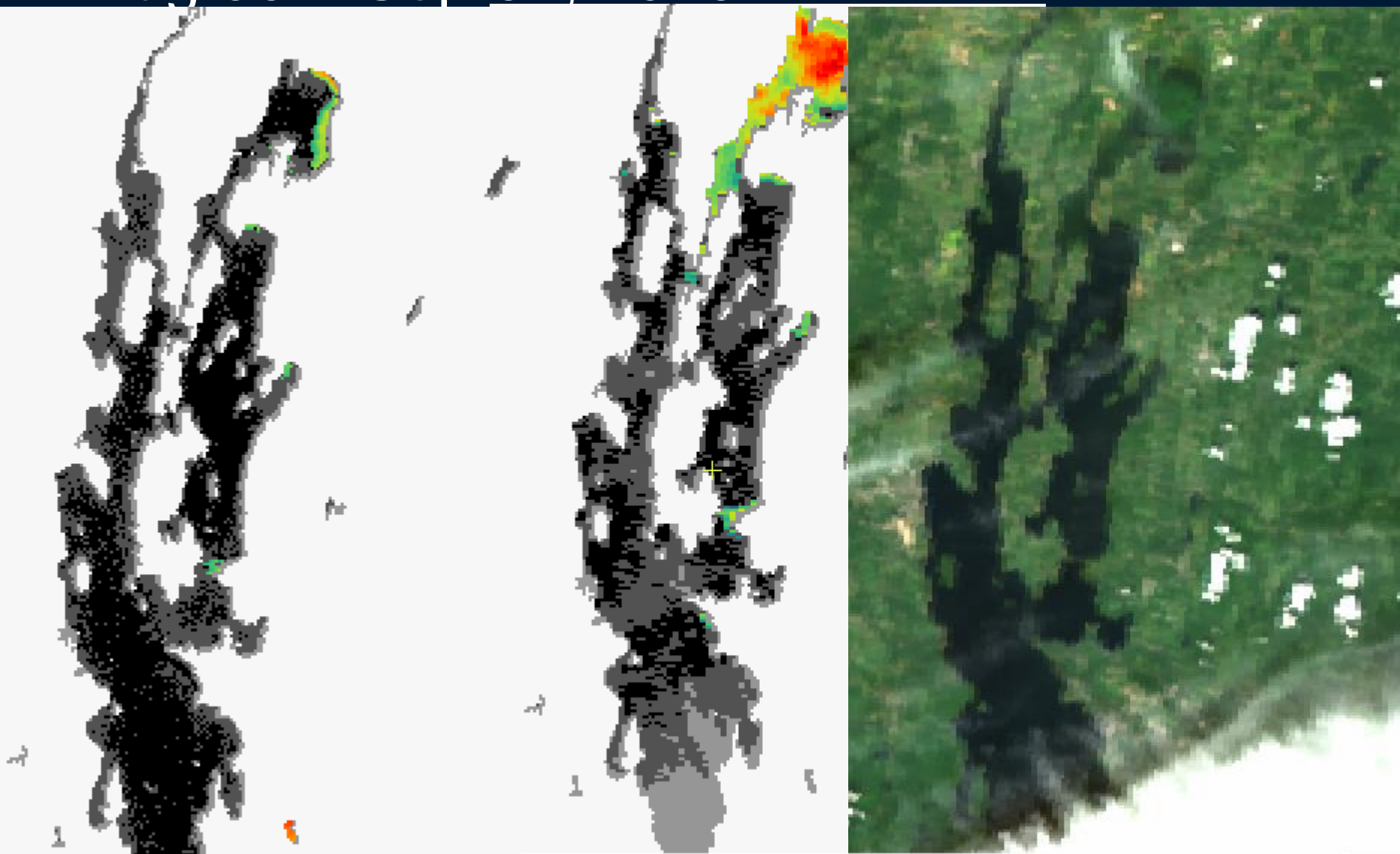
Sep 20

Oct 02



# And Lake Champlain?

Aug 06 Sep 07, 2018





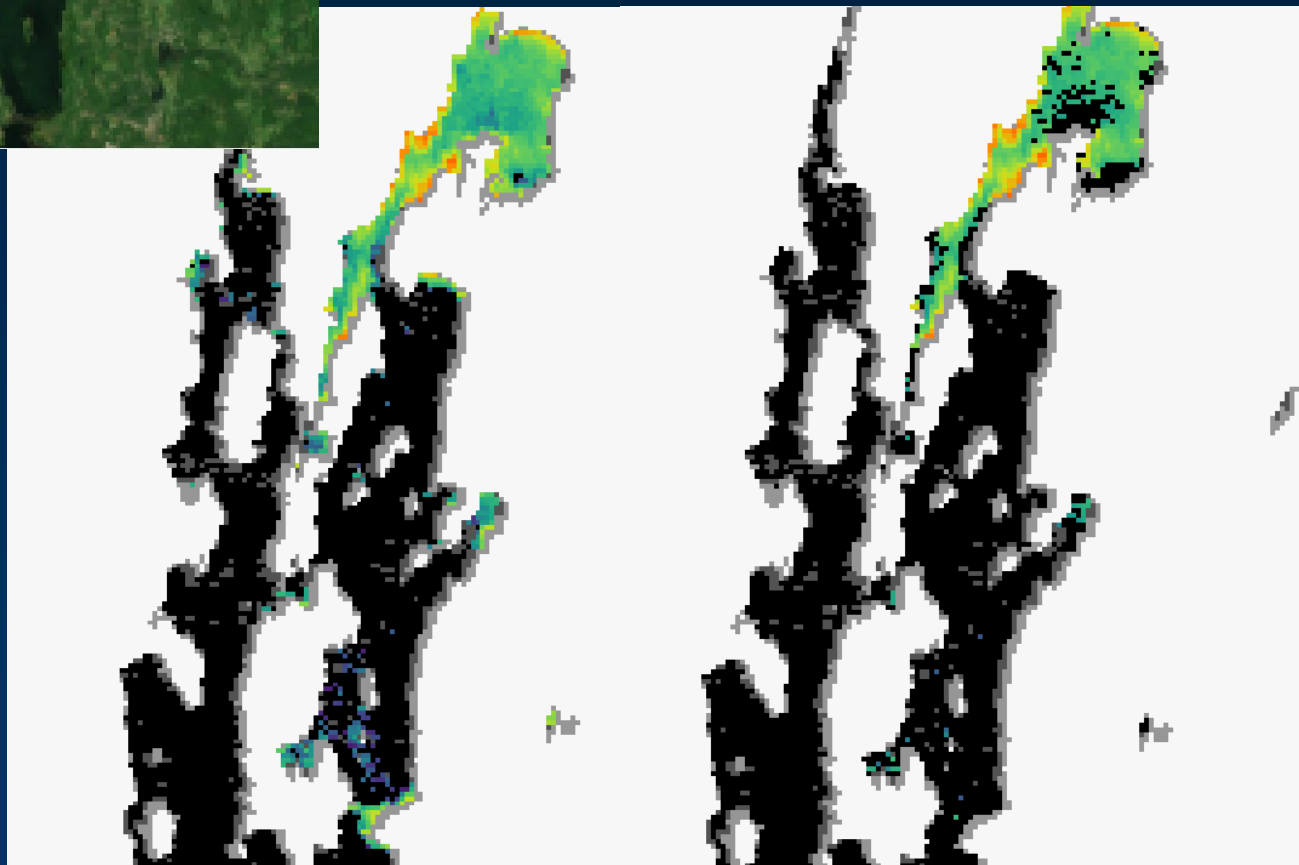
# Lake Champlain, Sep 14, 2018 Sentinel-3

S3 Sep 14  
"true color"

CI

Clcyano

S2 Sep 13  
Scum enhanced



# Lake Erie can help with other places in the country



Terra 23 June 2013