# Remote Sensing and Forecasting *Karenia brevis* and Cyanobacteria

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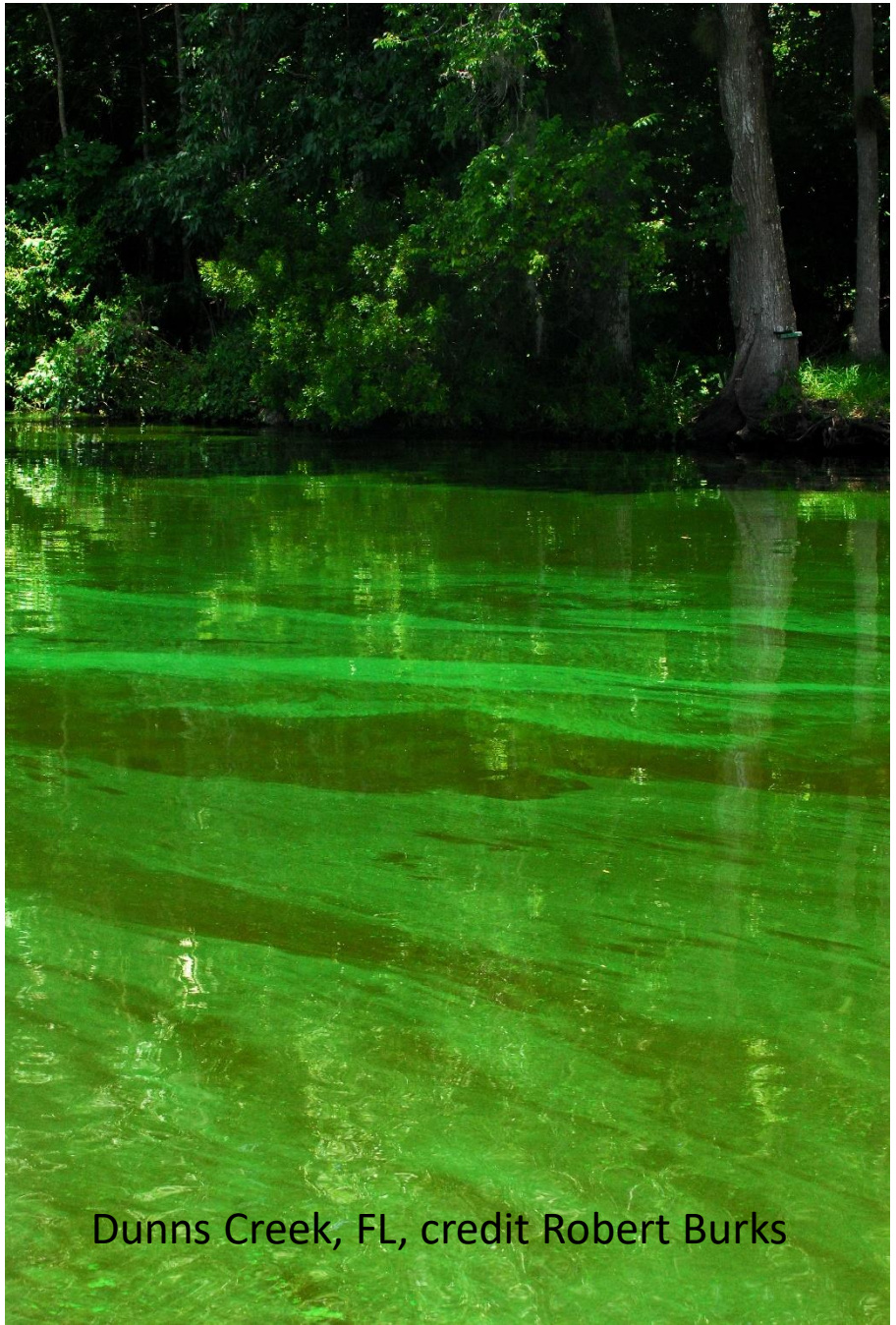
NOAA National Ocean Service

*Florida HAB State of Science Symposium, Aug 2019*

Pinellas County, Oct 3, 2018



Dunns Creek, FL, credit Robert Burks

# Florida Blooms. “Red tides” and “blue-green”

Both are amenable to satellite or other remote sensing

- *Karenia brevis typically dominates biomass on west Florida shelf in the fall (Vargo et al.).*
- *Cyanobacteria produce high biomass blooms in lakes.*

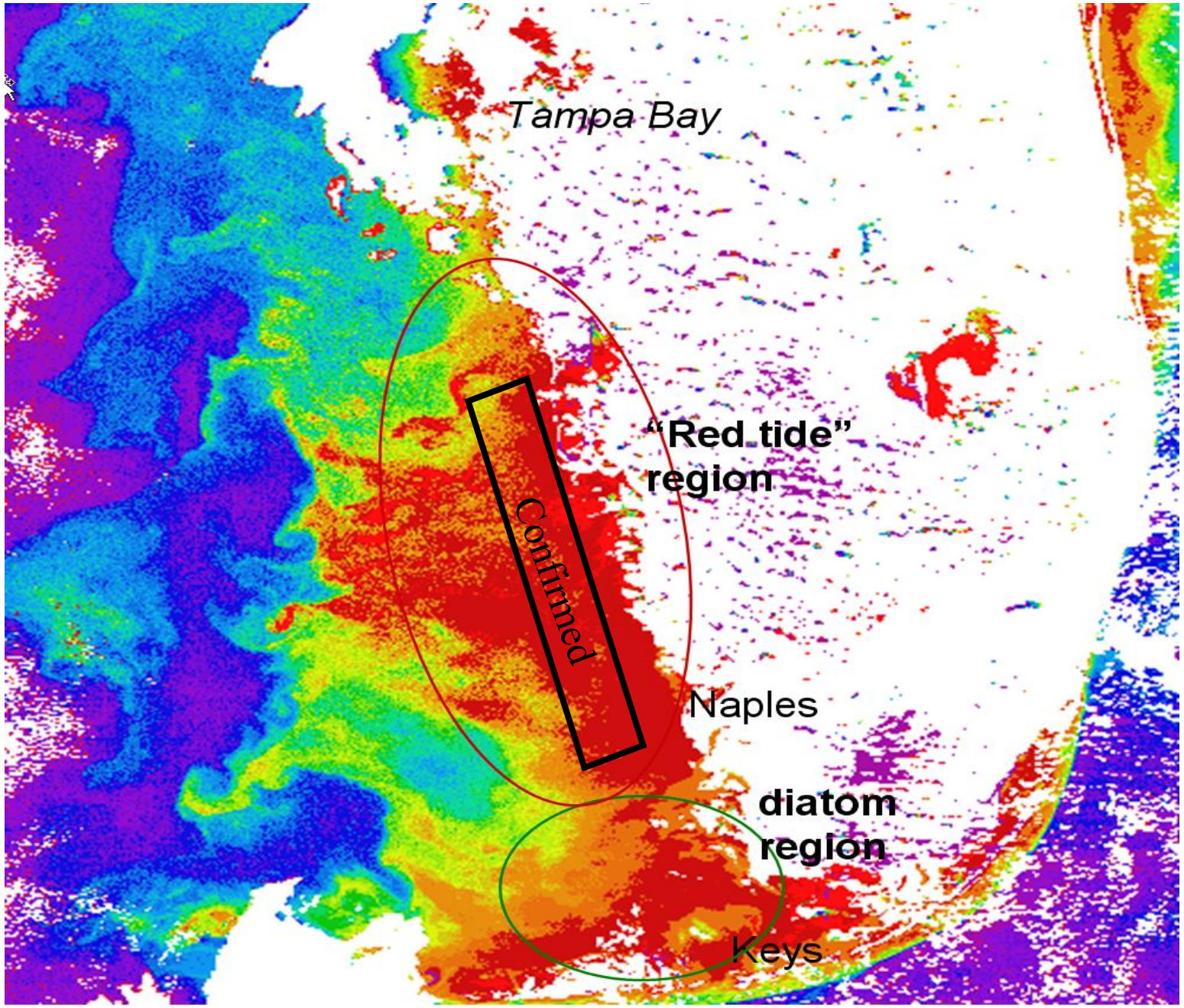
Satellite data can provide key data for various modeling efforts.

# Coastal Zone Color Scanner, Nov 14, 1978, one month after launch

Field documented (by coincidence) “Red Tide”HAB of *Karenia brevis* (then *Gymnodinium breve*)

Demonstrated the potential value of ocean color (Used by Steidinger and Haddad, 1981)

But chlorophyll concentration is insufficient.



# Sensitivity (ID blooms, true positives)
# Specificity (ID other blooms, true negatives)

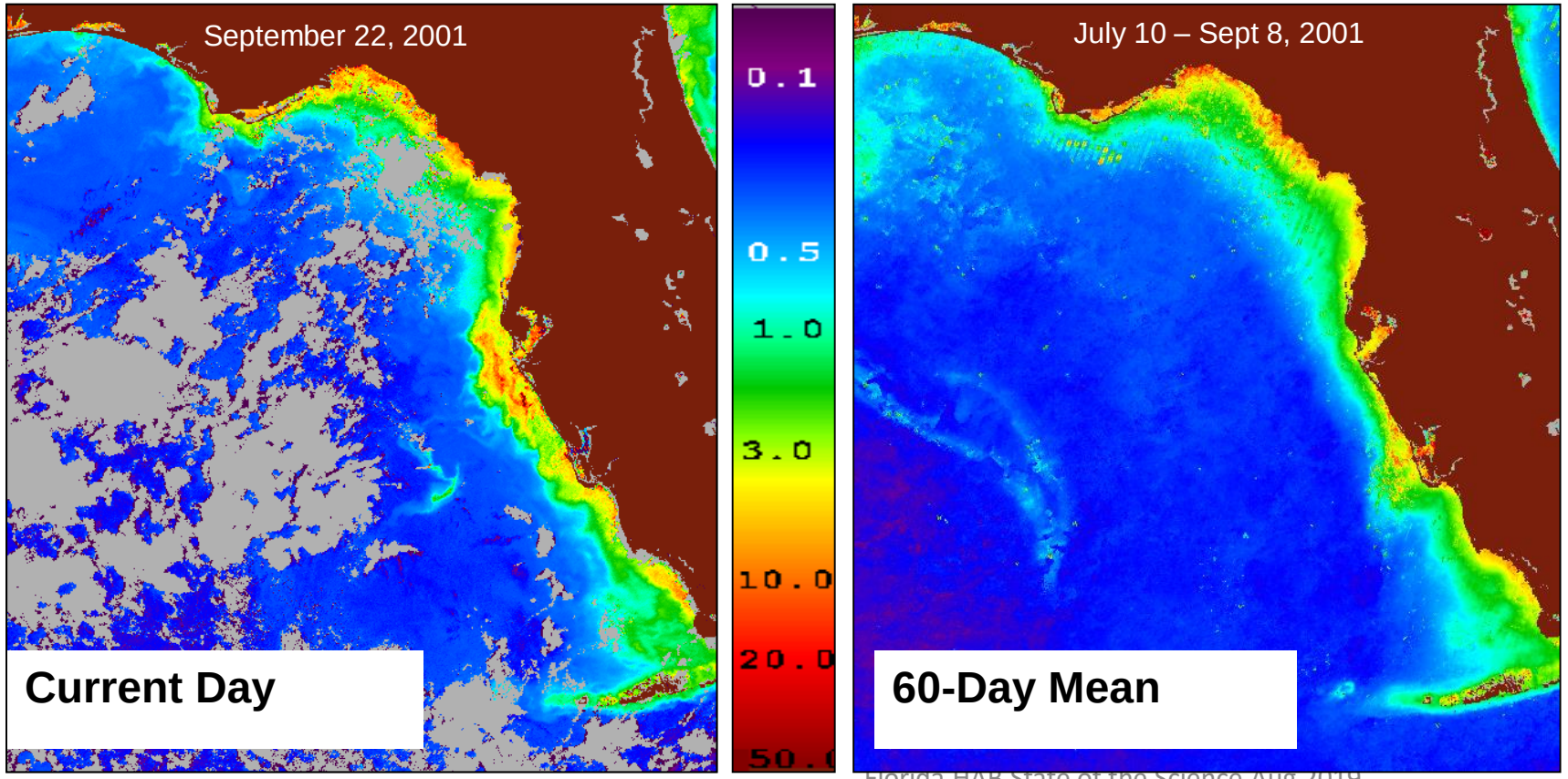
1. Chlorophyll,  not specific to either
2. Color is not particularly useful
    1. *Karenia* is not “red”, diatoms and other dinos will be brown, similar pigments
    2. cyanos are not always bright green. *Raphidopsis* (formerly Cyli) is golden brown
        1. **But color might help separation some cyanos, depends on CDOM interference**
3. Algorithm issues
    1. Some algorithms are sensitive to other phenomenon
    2. Interference from sediment, CDOM, bottom (optically shallow)
4. Method/presentation need to explicitly identify algorithm issues
5. Quality requires routine review and evaluation.

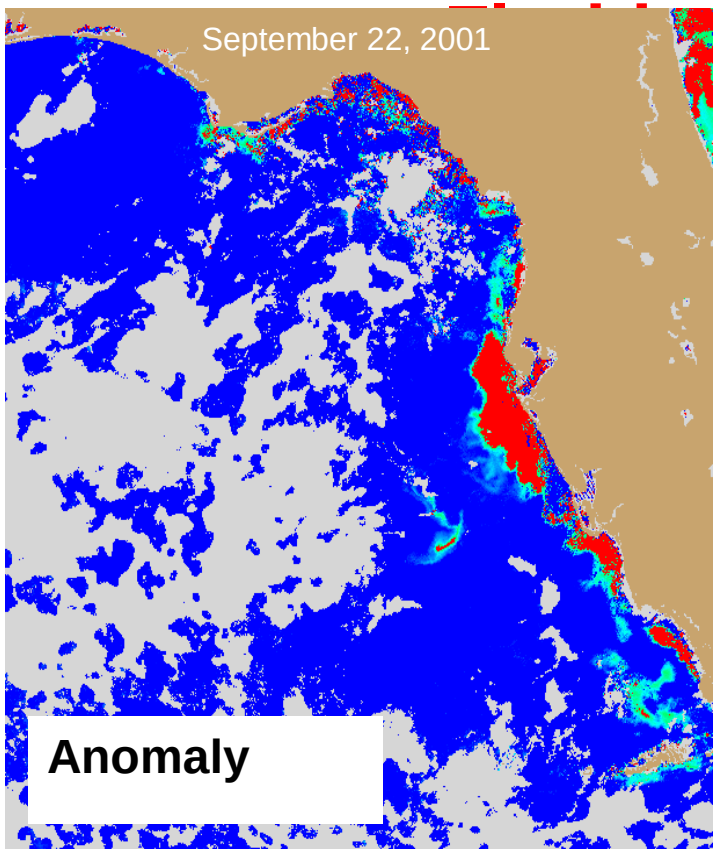
# “New Bloom” Anomaly
# “oldest” (from 2000) routine *Karenia* detection method

- Brings “ecology” into consideration, removes signal from bottom,  reduces CDOM

**New Blooms in fall in SW**

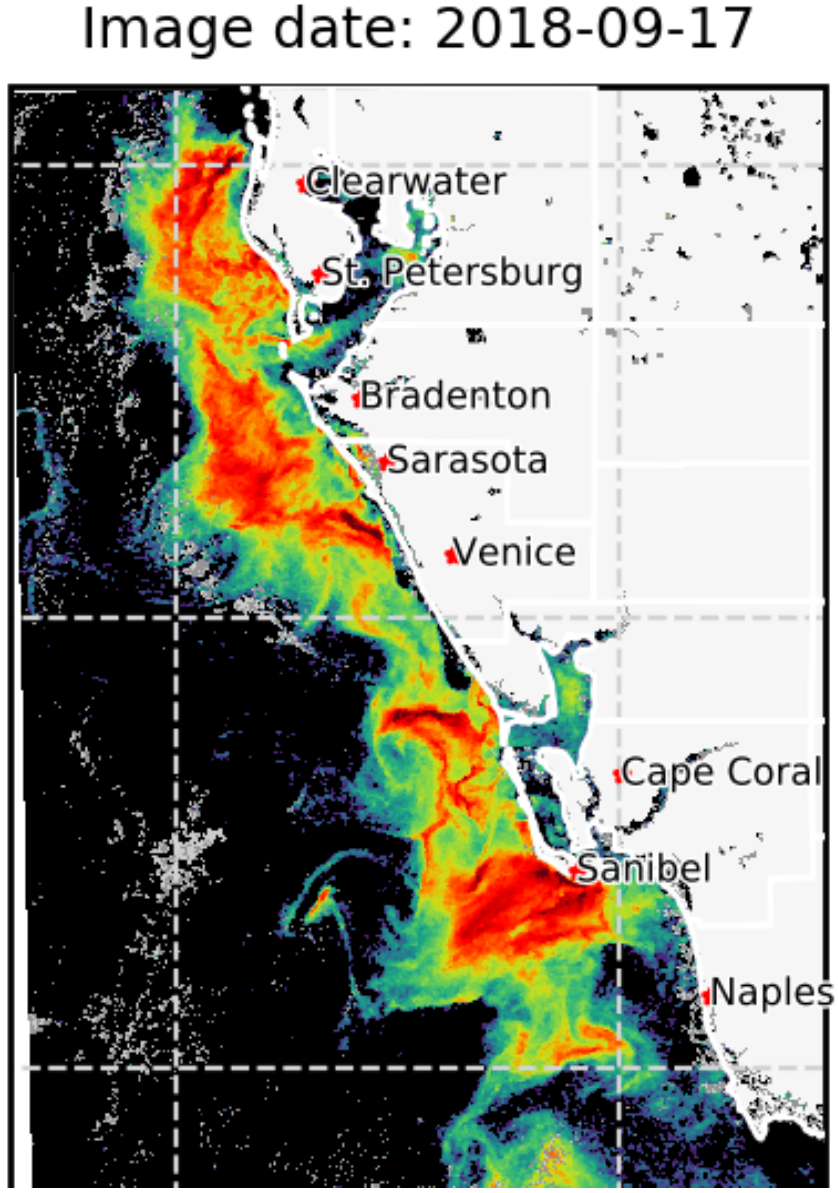
**SeaWIFS data**



# Anomaly intended for short-lived blooms. Newer method is chla fluorescence

- MODIS and Sentinel-3 products
  - Doesn’t work with VIIRS NOAA-20
    - (or SeaWIFS 1997-2010)
  - Does not detect bottom (mostly) or CDOM
  - Some Fluor algorithms respond to sediment
  - Some Fluor algorithms fail in densest bloom



# Fluorescence not specific to *Karenia*
# Other algae fluoresce, how do we apply this?

- Easy during unique mono-specific *Karenia* blooms in the fall.
- **Need "ecology"**
- However, images are treated as pixels, not as features
  - Pixels, good for concentration,  not good for ID
- Application,  classification, prior knowledge matters
  - was/wasn't *Karenia* last week, probably is/isn't this week

    **If we were right/wrong last week,  right/wrong this week**
- We need a data base to aid in bloom identification
- *Karenia* may scatter less than diatoms, but need accurate chl-a and scatter for that
- More work on bloom feature, ID, and tracking

# ~680 nm band is now critical for both blooms: chla absorption peak AND chla fluorescence peak

**Fluorescence*: Karenia* (PS-II, photosynthetic eukaryotic algae and plants)**

chl-a fluoresces about 680 nm, overwhelms chl-a absorption.

peak in reflectance around 680 nm.

Eliminates CDOM, bottom mostly, sediment (depending on algorithm)

**Absorption: Cyanobacteria** (PS-I, negligible chl-a fluorescence at 680 nm)

Chl-a absorption peak about 680 (dip in reflectance)

Also, Phycocyanin (PC) found in cyanos, not in most freshwater algae

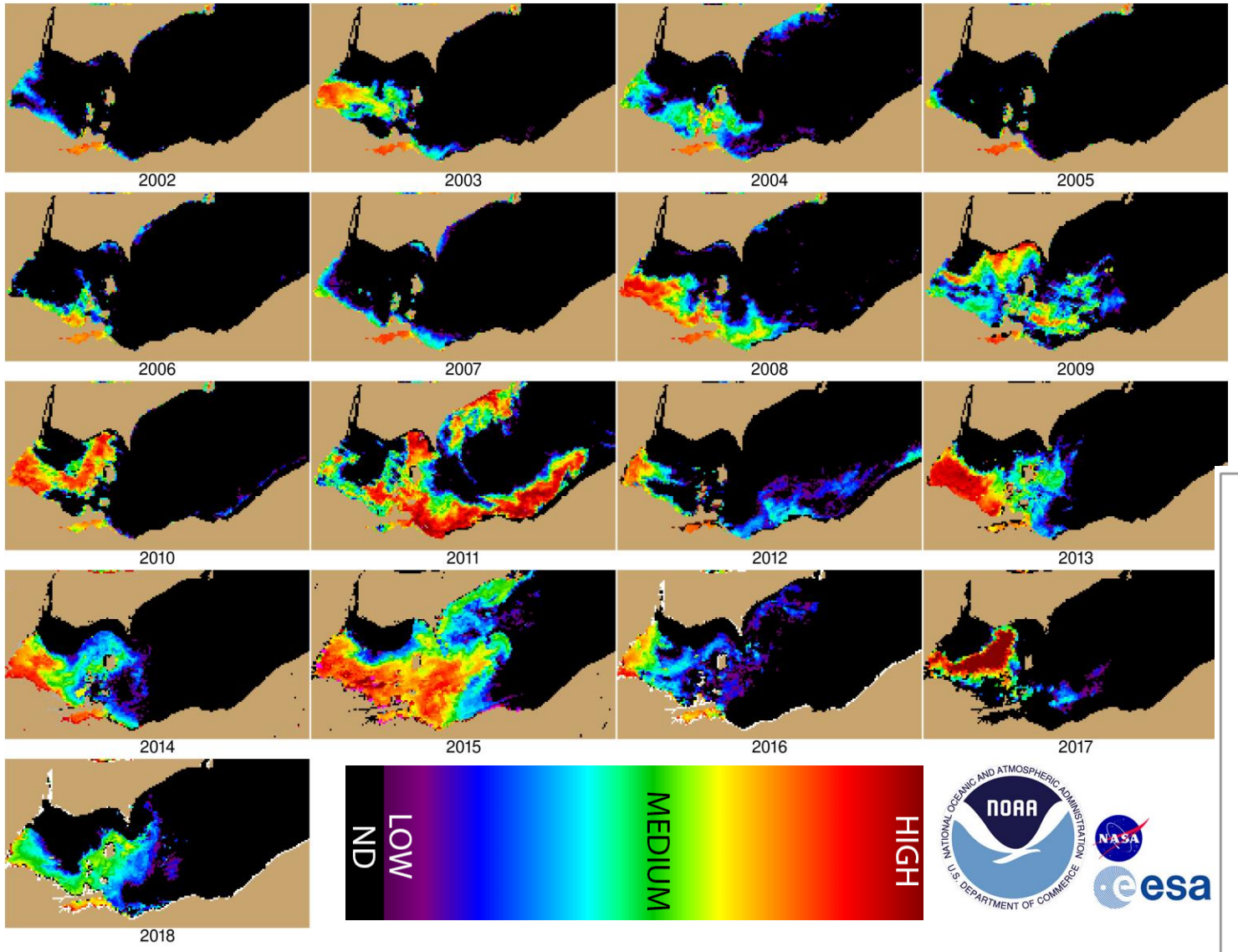
PC absorbs about 620 nm

# Cyanos, easier, chla absorption at 680 nm Phycocyanin presence

- Cyanos have PS-I so their chl-a doesn’t fluoresce.
- True algae,  PS-II, chl-a typically fluoresces.
- Look for chl-a absorption peak at 680 nm
- PC presence, absorbs more around 620 nm.
- Sentinel-3 has bands useful for this.

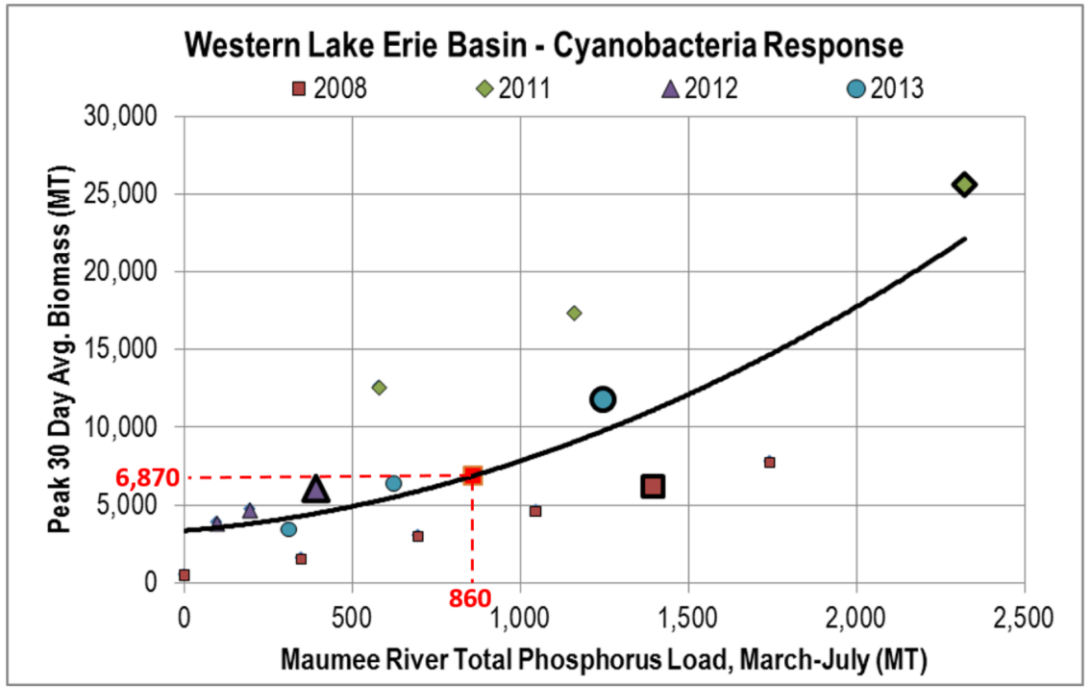
- Monitoring Lake Erie for a decade.
- U.S. monitoring with CyAN project.  Evaluations continuing

# understand inter-annual variability and build seasonal forecasts




Satellite data either used for model building, or for evaluation

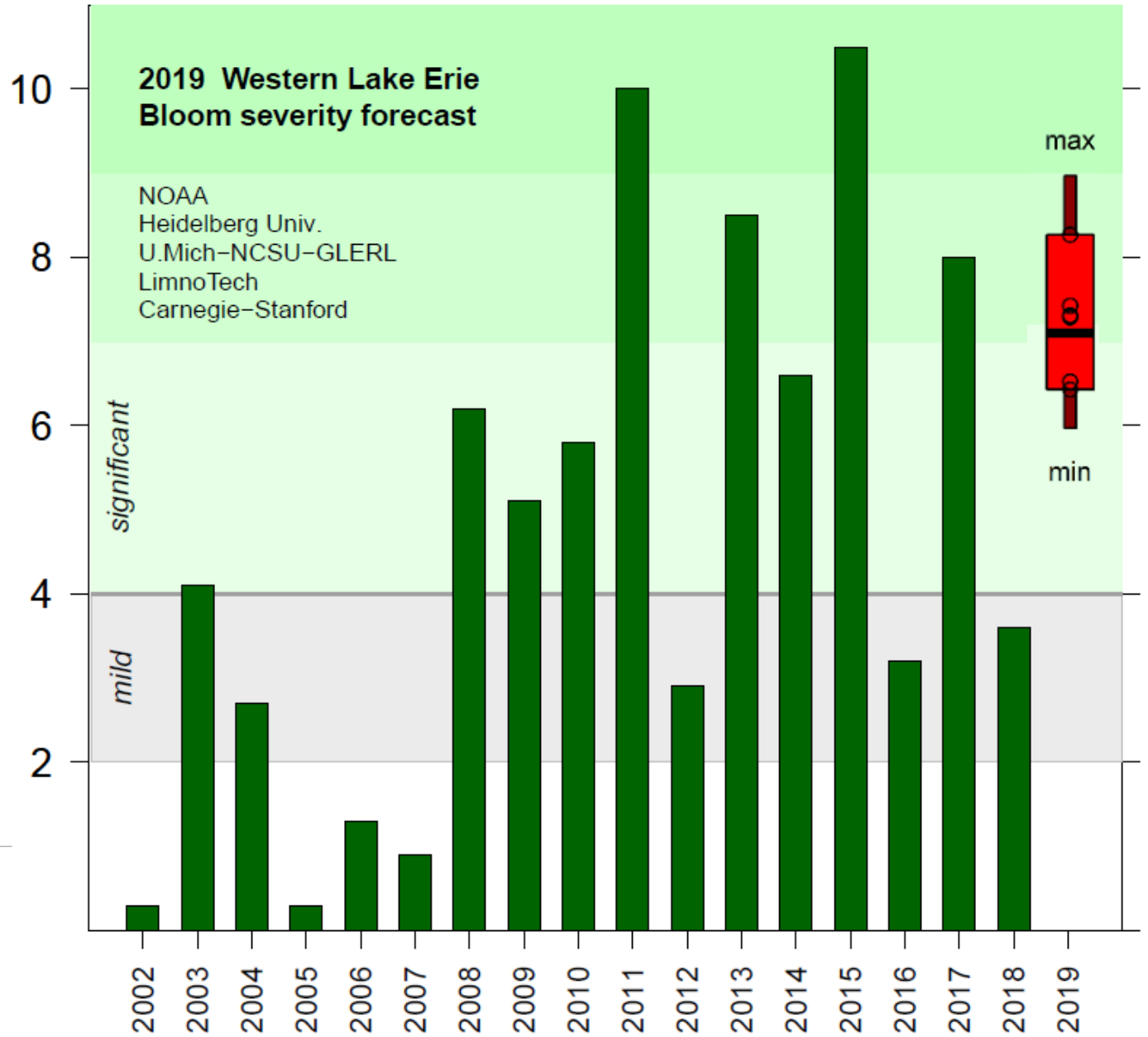
Multiple models to determine phosphorus target



Models used for forecasts
Satellite data validates.

Correct forecasts in 2012-2017.
overestimate in 2018. Forecast approach modified in 2019.

**Requires good environmental data**
**decade+ daily nutrient loads were available**




HOME NEWS & FEATURES

# NOAA, partners predict large summer harmful algal bloom for western Lake Erie

**Wet spring enhanced the flow of nutrients into lake, providing fuel for algal growth**

Oceans & Coasts | harmful algal blooms (HABs)

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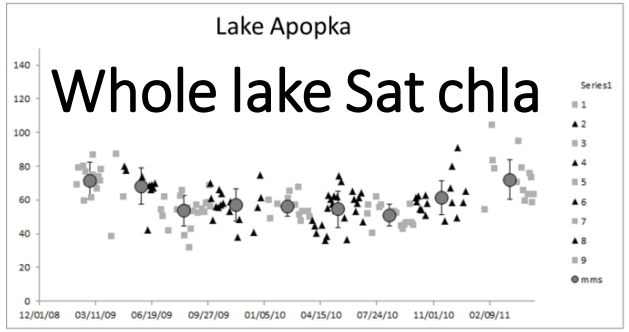
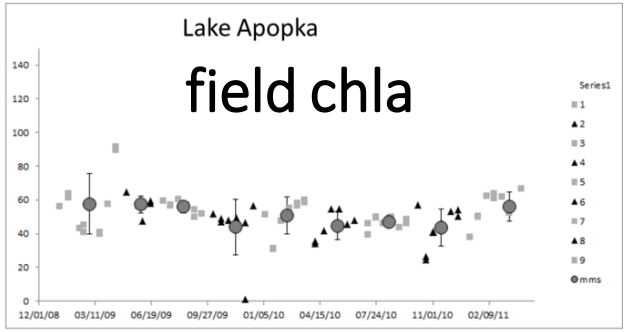
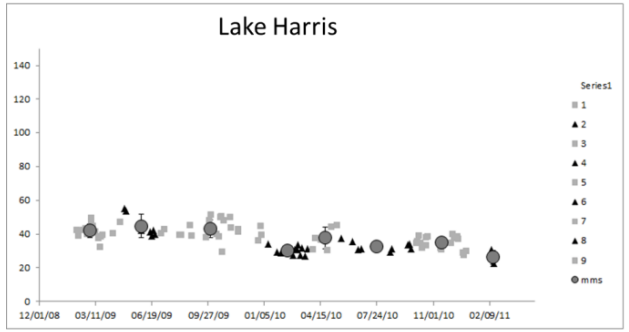
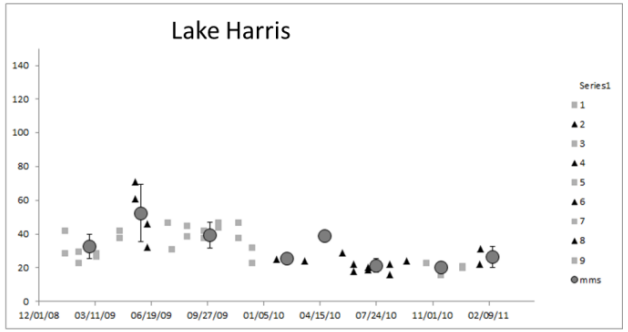
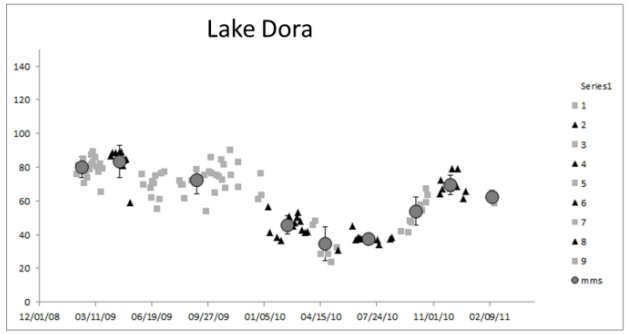
July 11, 2019 —

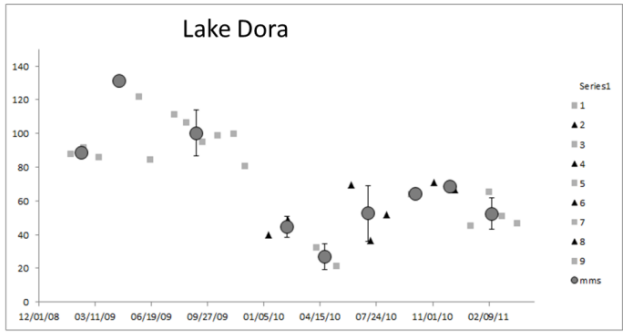


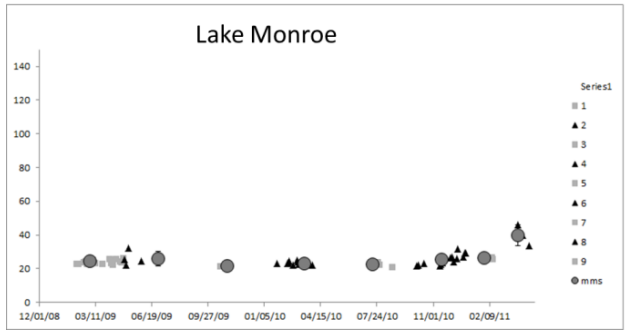



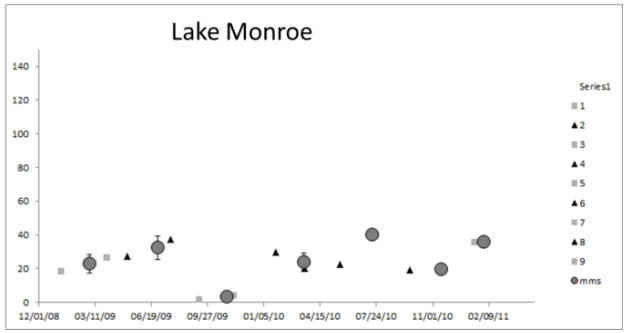



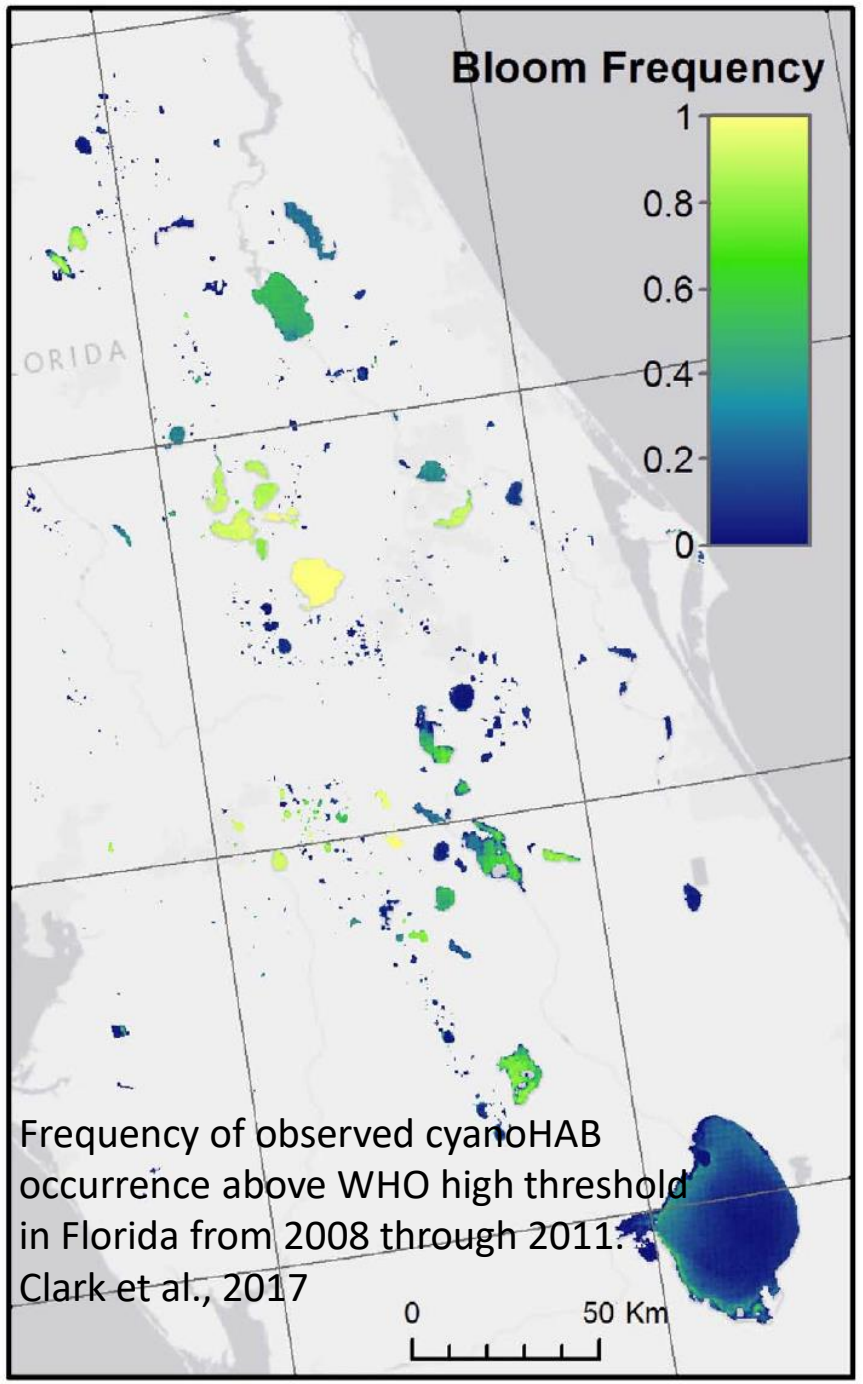




Frequency of observed cyanoHAB occurrence above WHO high threshold in Florida from 2008 through 2011. Clark et al., 2017

# Cyano problems

- Toxicity cannot be measured from satellite.
  - Work on model approach in Lake Erie.
- Picocyanoplankton.  Can have PC, does it matter?
- Satellite sensitivity is greater than eyeball sensitivity
  - Cyanos can be detected at concentrations that pose a risk and are not visible.

- Spatial resolution.
  - Sentinel-3 is 300 pixels,  so water body width > 600-900 m
  - Cyanos have strong spatial gradients nearshore.
  - Sentinel-2 can find scum at 10 m, but only every 5 days (at best in summer).

# Sentinel-2 MSI 20 m every five days, potential cyano product (“MCI”)

- Glint for the several months around solstice
- 07/28 image, Caloosahatchee
- MCI or similar only identifies high biomass. Not specific.

# Questions in satellite + modeling

- We can find *Karenia*, but it will be confused with other eukaroytes.
  - Big intense *Karenia* blooms are easy.
  - **We need a data site for bloom species information for ID and validation.**
  - This information may need to be incorporated into monitoring.
  - If *Karenia* doesn't fluoresce, we won't see it. How often does this occur?
- Freshwater Cyanos, much better discrimination
  - If it isn't toxic does it matter?
  - If it is picoplankton, does it matter?
  - How do we collect valid field data during potential errors?
- **Cyanos can be used for evaluation of different lakes, model building etc.**
  - **Is there enough environmental data for a water body to develop seasonal forecasts?**
- *Karenia* imagery may best support monitoring and input into other models.
- Resolution. Unmanned vehicles. We are now developing a system that may allow routine monitoring near the beach.
- Respiratory forecasts are another topic

# Satellite issues

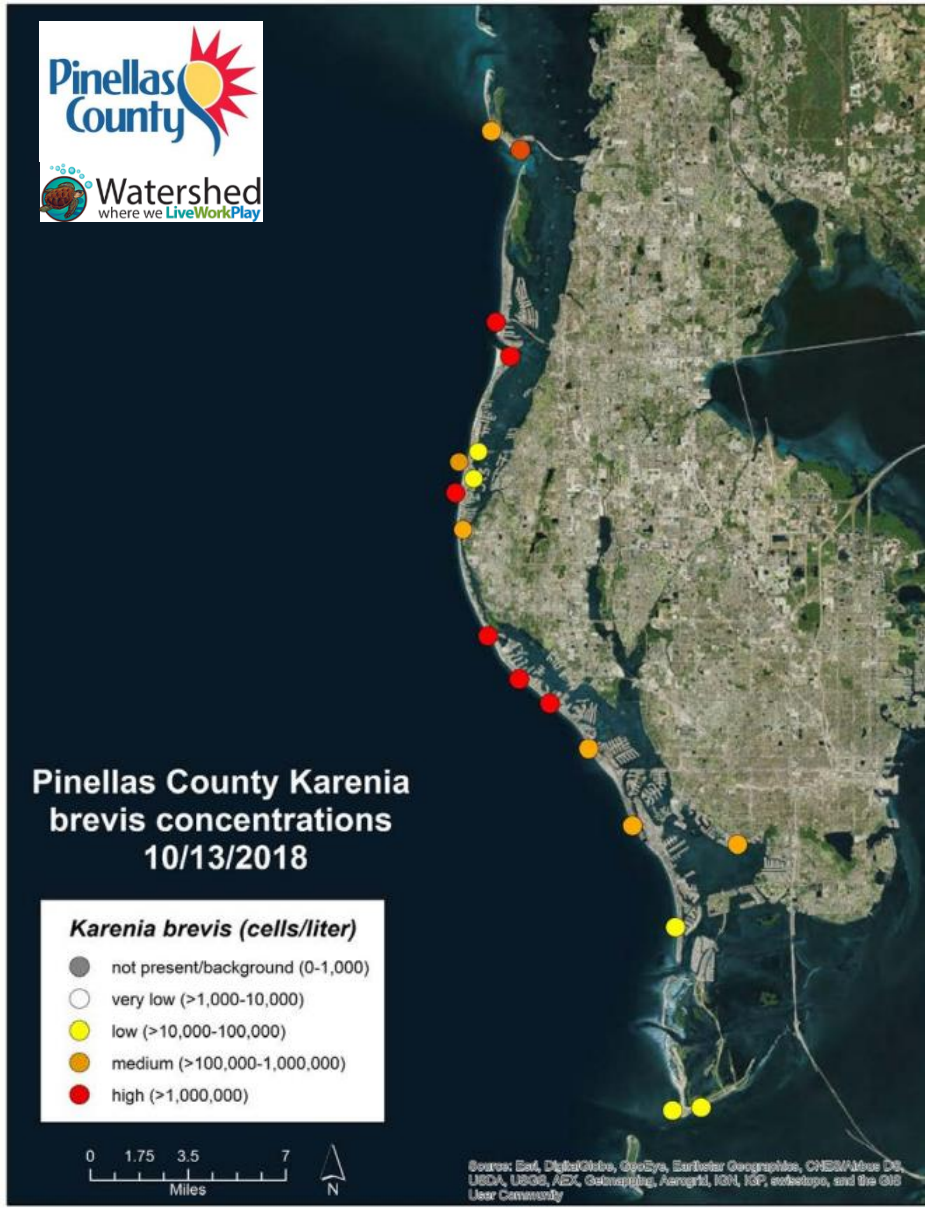
- Can't see *Karenia* when not at the surface. We don't know how much of  a problem this is.  Do blooms form at bottom or at the surface?

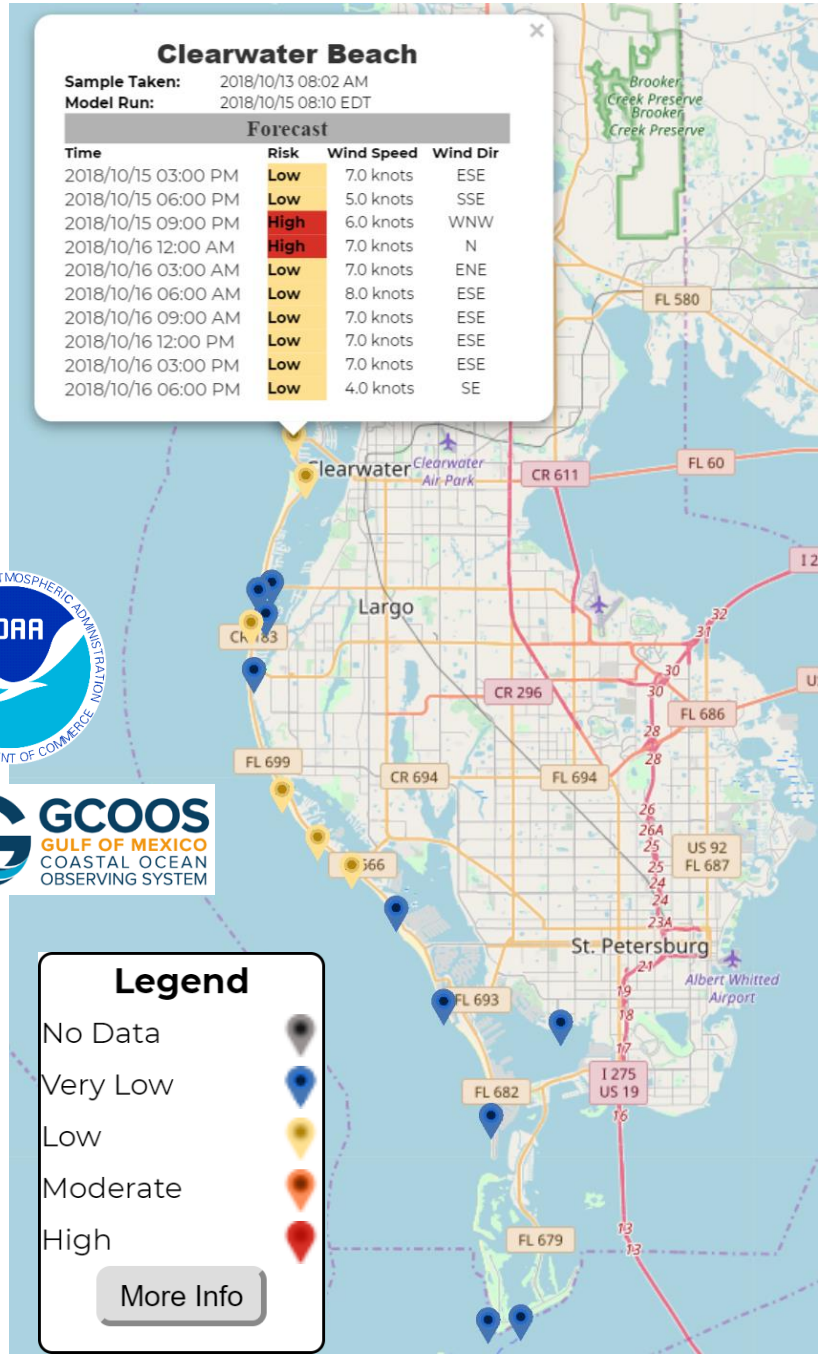
- Scum forming Cyanos strongly affected by wind.  We have a model for this for Lake Erie.  Will it work in other lakes?

- Wind could be used to distinguish scum-formers and non-scum (*Microcystis* in Lake Erie,  from and *Planktothrix*  in Sandusky Bay).

# Experimental respiratory forecast

https://habscope.gcoos.org/

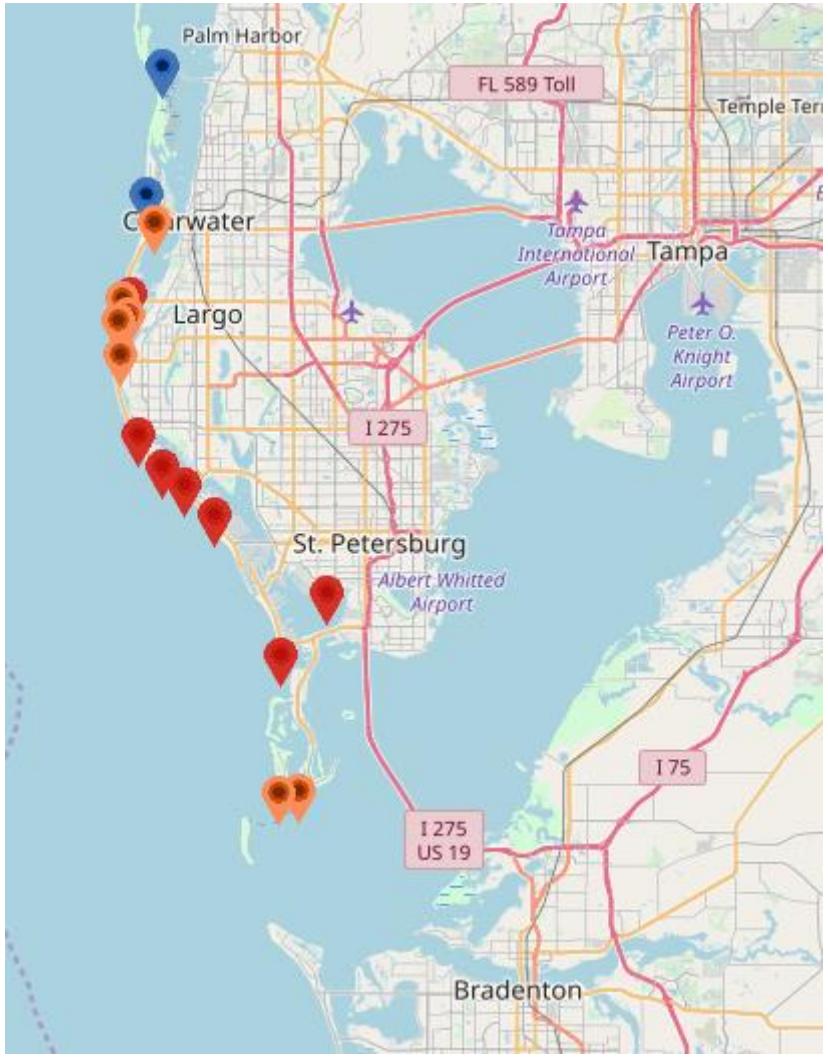


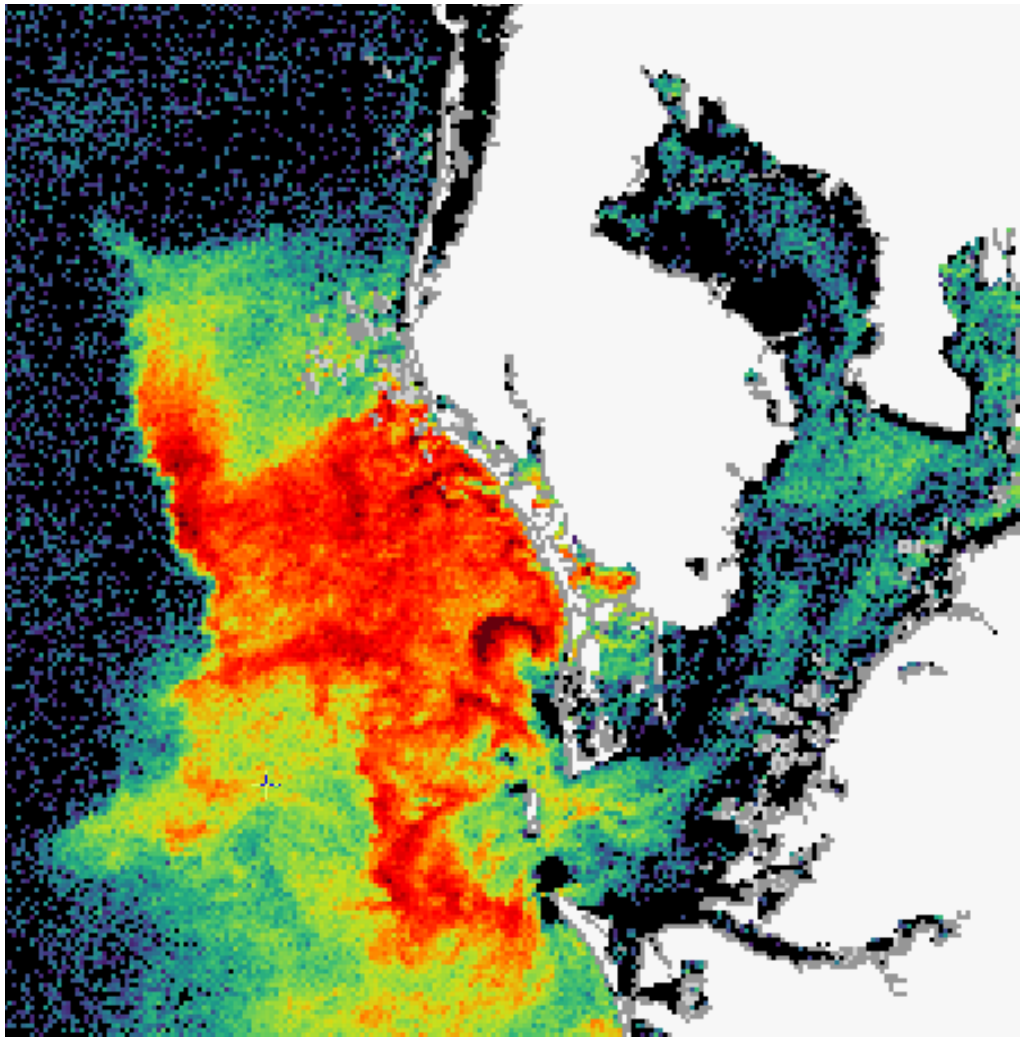




NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

GCOOS GULF OF MEXICO COASTAL OCEAN OBSERVING SYSTEM

# Oct 26 11 am nowcast, Oct 25 image, satellite may help, but only on clear days.



# Finally, a reality check

1. Hindcast validation ≠Forecast validation.
2. “All models are wrong, … how wrong do they have to be to not be useful?”  (George E.P. Box, 1987)