



Department of
Environmental
Conservation



Can We Use Satellites to Identify Harmful Algal Blooms in the Finger Lakes?

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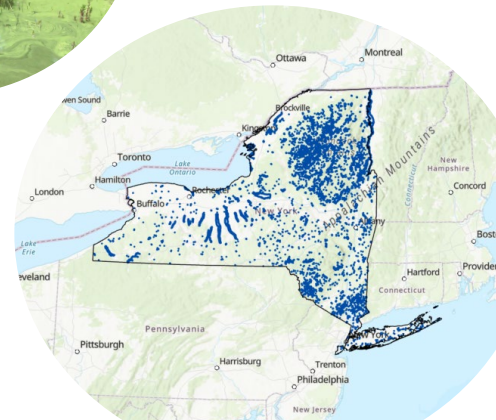
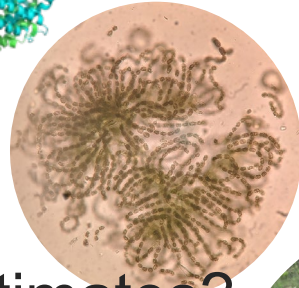
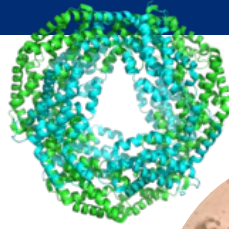
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Outline

- Current lake monitoring
- HAB monitoring
- Why Satellite-based WQ estimates?
- Building a model for NY Lakes
- Model verification & validation – ‘Sniff tests’

Phycocyanin ($\alpha\beta$)₆ hexamer. Image: Mitscho
Dolichospermum
HAB (also known as CyanoHAB) on Lake Neatahwanta
Lakes in NYS



Patterns in frequency, intensity, and duration, 2012 - 2020


LAKE AND RESERVOIR MANAGEMENT
2023, VOL. 39, NO. 1, 21–36
<https://doi.org/10.1080/10402381.2022.2161436>

 **Routledge**
Taylor & Francis Group

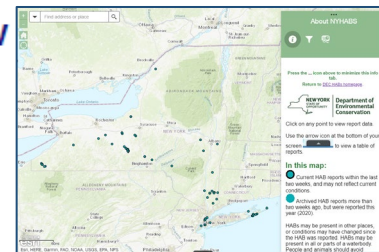
 OPEN ACCESS

 Check for updates

Detections of cyanobacteria harmful algal blooms (cyanoHABs) in New York State, United States (2012–2020)

Rebecca M. Gorney , Stephanie G. June, Karen M. Stainbrook and Alexander J. Smith

Division of Water, New York State Department of Environmental Conservation, Albany, New York, USA



Findings

- Increase in confirmed HAB *reports* through 2016, no increase in number of lakes
- No increase in open water HAB intensity (phycocyanin as measured by Flouoroprobe)
- HAB duration did not lengthen over the study period based on beach closure data
- **Highlighted the need for more unbiased and representative HAB monitoring and evaluation methods**

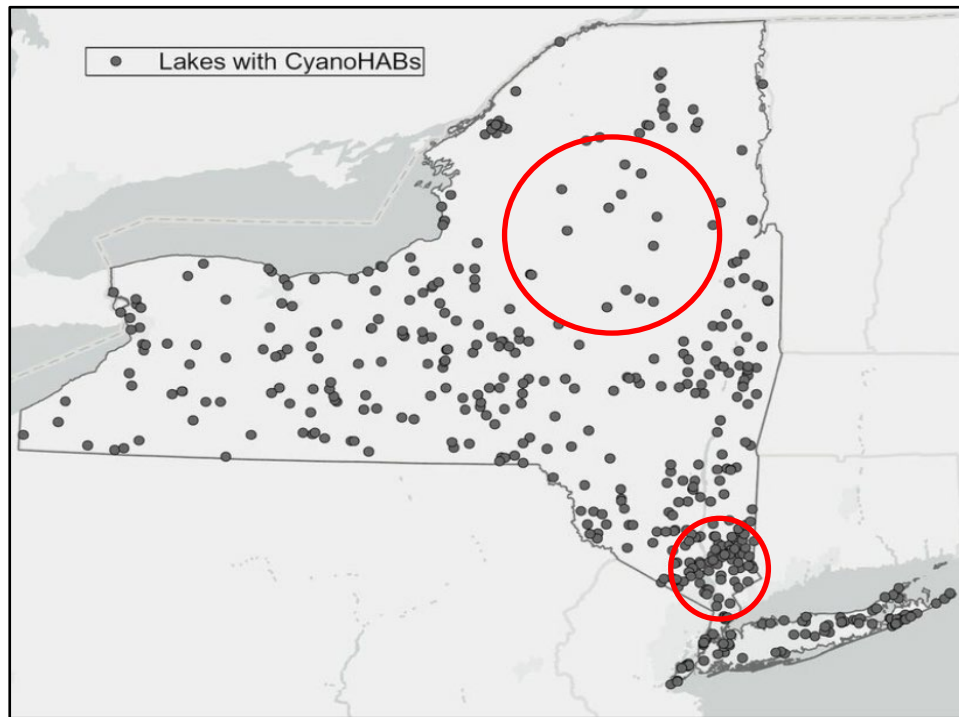
Challenges of HAB monitoring

Evaluating the impacts of HABs is complex, given:

- Spatial variability (patchy, limited perspective)
- Temporal variability (short-lived, mobile)
- Difficulty in defining representativeness
- Observation bias from:
 - + Frequently visited lakes
 - + Higher profile lakes
 - + Densely populated areas
 - + Lake Observation Networks
 - Access difficulties
 - Cellular network

Clear need for approaches favoring representative lake characterization

Satellite observations may be a solution



Modified from Gorney et al 2023.



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Why use satellites for HABs & lake evaluation?

Pros

- Thousands of lake are resolvable
- Datasets going back years / decades
- Good levels of confidence & detection limit
- No cost for imagery
- Ongoing, low lag time

Cons

- Clouds & cloud shadows!
- Somewhat complex
- Detection limit eutrophic & above
- Shoreline HABs partly resolved
- Shallow & clear lakes



Sentinel-2

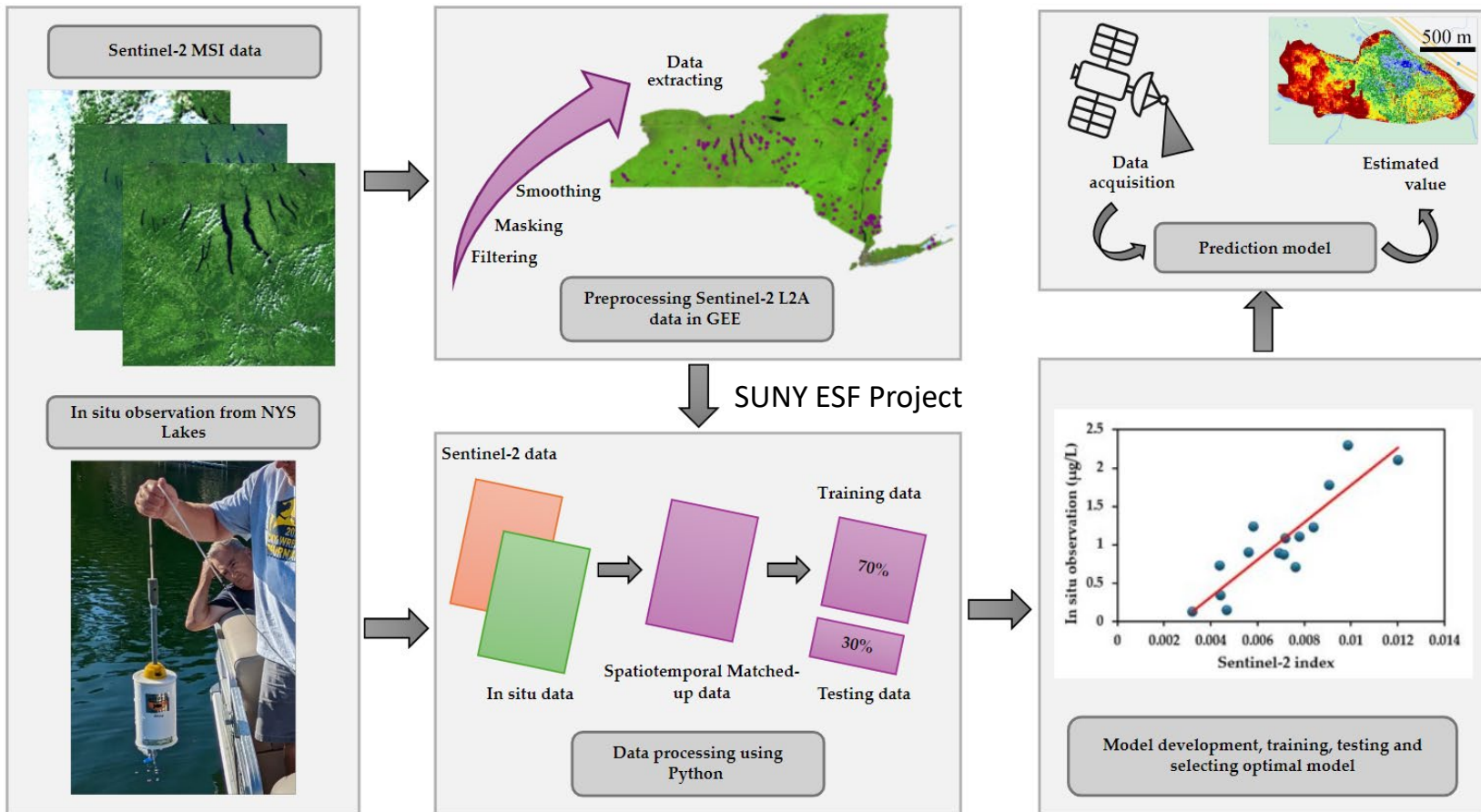
- **Two satellites (A&B)**
- **Multispectral**
- **R,G,B, VNIR**
- **10m pixels**
- **5-day revisit**
- **Free to use**

Sentinel 2 C
4 Sept 2024

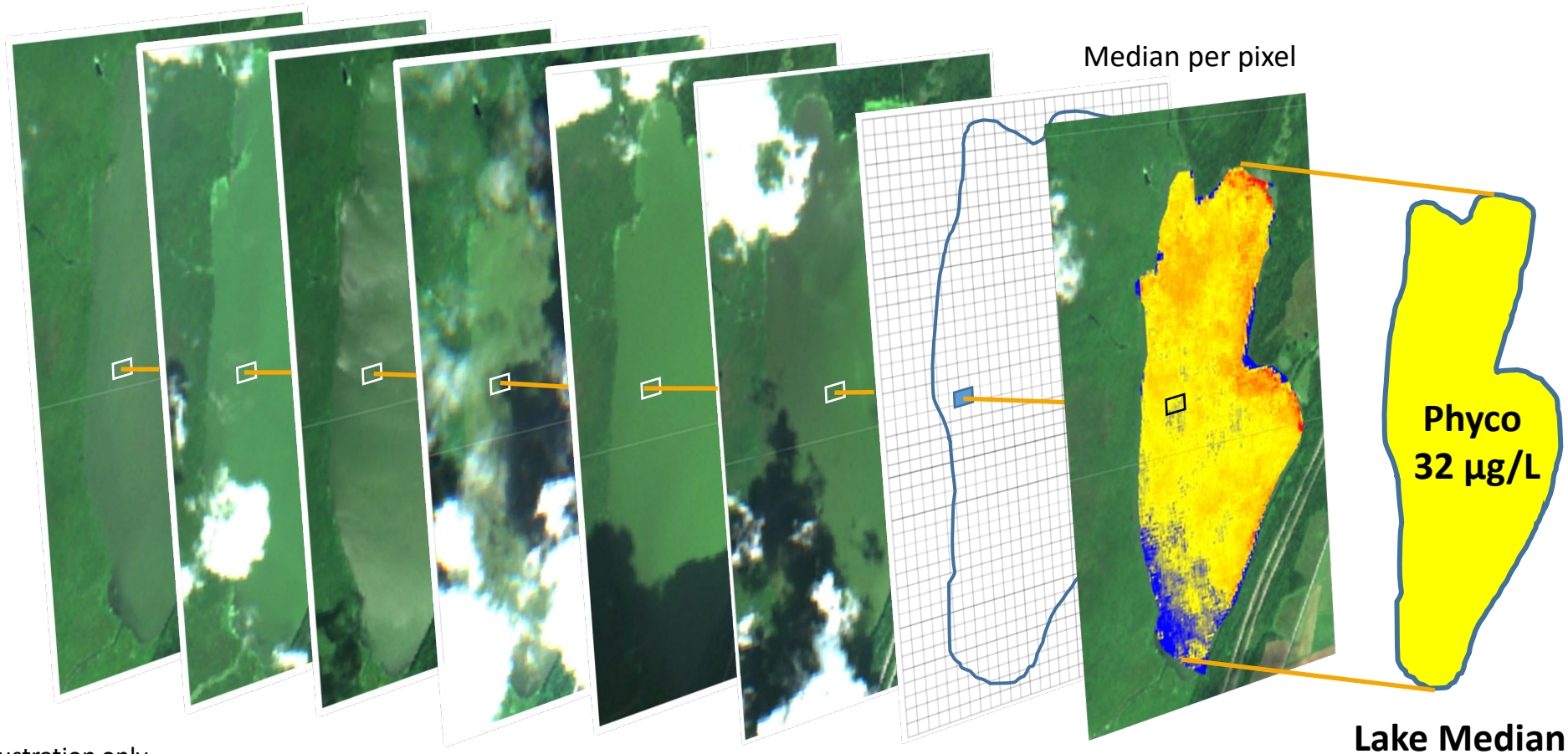


Method

Remote Sens. **2024**, 16(18), 3504; <https://doi.org/10.3390/rs16183504>



Calculate median concentration for every pixel in a lake over ~n years...



Petabyte-scale Earth system data science in the cloud

Pros

- Accessed via web-browser
- No data to download
- Fast, distributed computing
- Multiple datasets
- Easy to modify
- Easy analysis across time
- Free for researchers

Cons

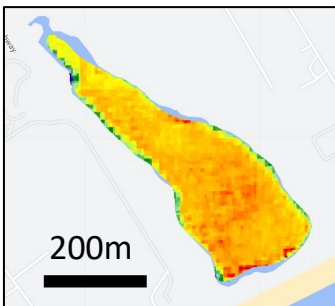
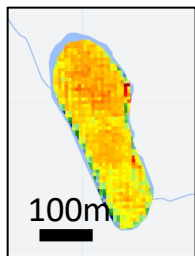
- Computer programming essential
- Complex output format



Verification - Phycocyanin Results – Notable examples

McMullen Pond

66 $\mu\text{g/L}$
23 ac



Wainscott Pond
97 $\mu\text{g/L}$
35 ac



Lake Agawam
Phyco: 105 $\mu\text{g/L}$
64 ac

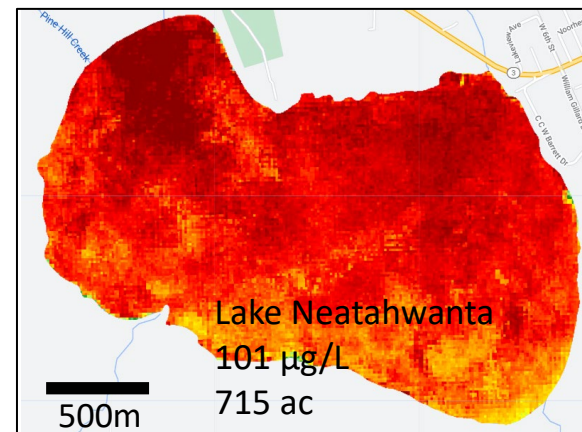
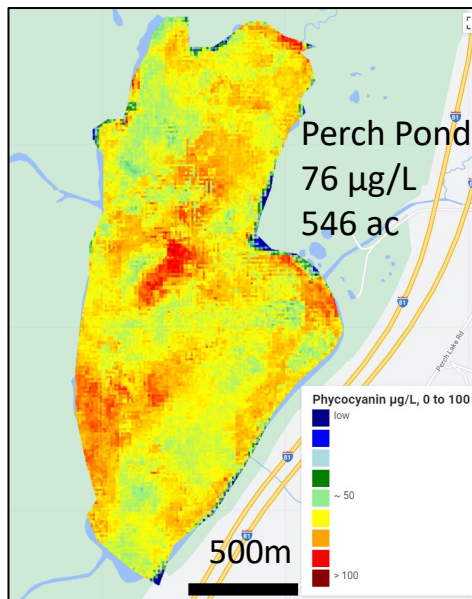
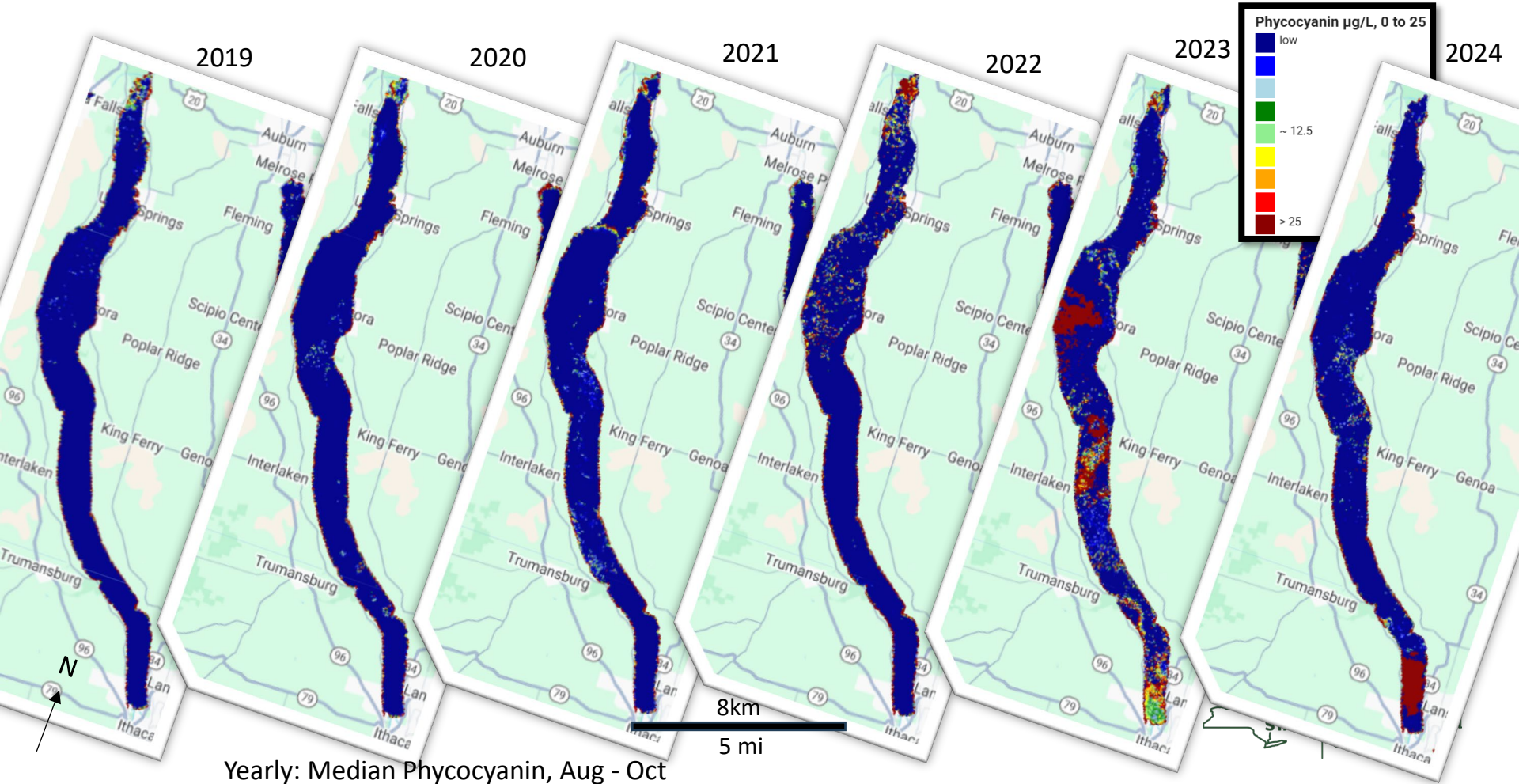
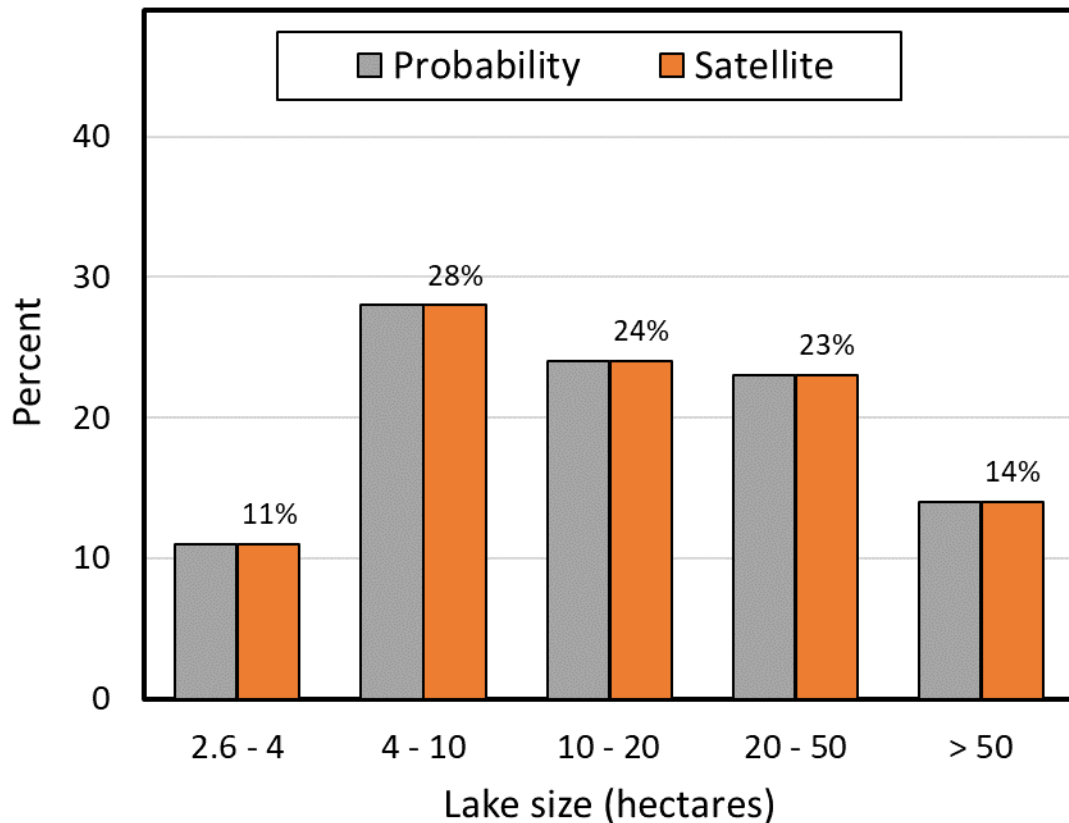


Illustration Only

Verification - Phycocyanin - Year to year variation



Validation – Representativeness of lakes - Phycocyanin & Chl-a



Distribution

Compared to NY lakes dataset, satellite technique:

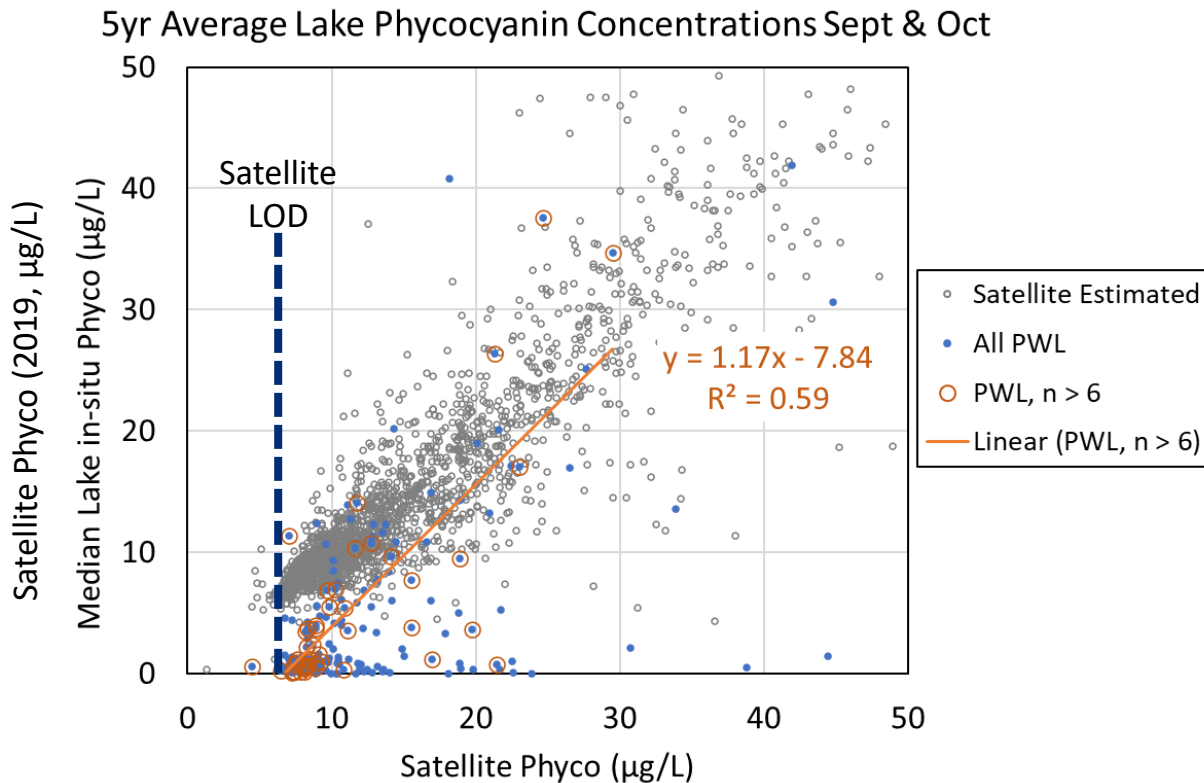
- Matches fully
- Satellite dataset is not a sample – it is the whole population of 2096 'regulated' lakes



Validation – Phycocyanin - Comparing measured to estimated concentrations

- Use only Sept & Oct ('peak bloom season')
- Exclude poorly sampled lakes
- Moderate agreement ($R^2=0.59$)
- Satellite to satellite comparison has many more datapoints ($n = 2094$)

“Quantity has a quality
all of its own”

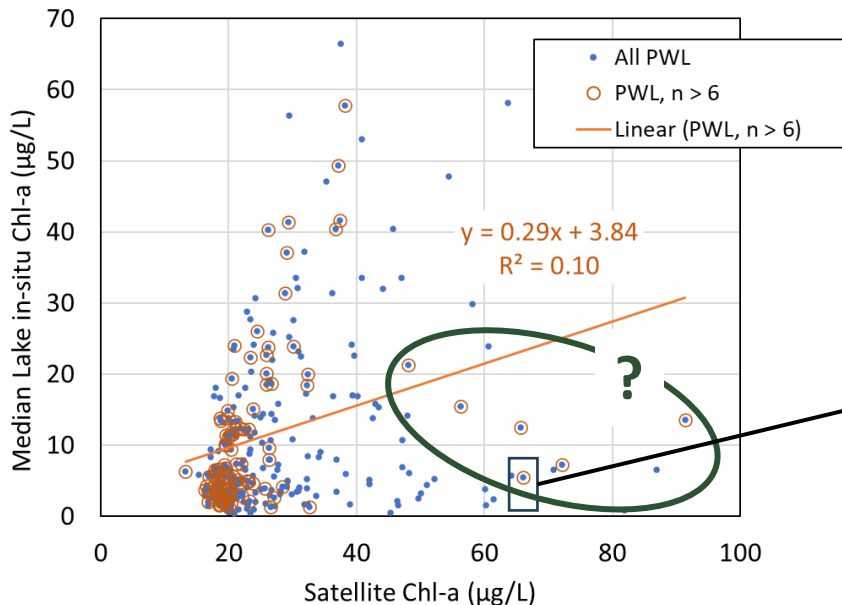


Validation – Chl-a - Comparing measured to estimated concentrations

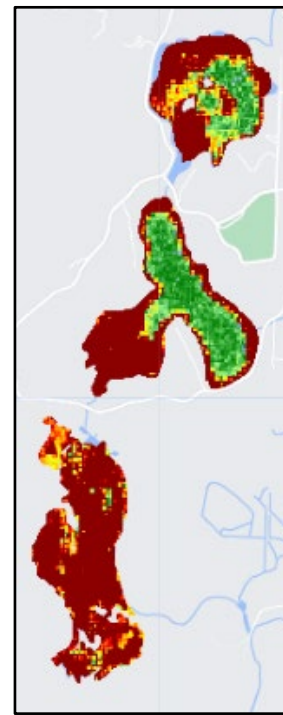
Chl-a subject to interference

Anomalous high satellite Chl-a investigated
Likely due to macrophytes/duck weed, e.g.:

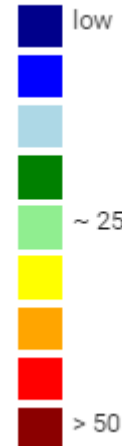
5yr Average Lake Chlorophyll-a Concentrations Sept & Oct



Example: 09-16-2024
Thompson, Stissing, Mud/Twin Isl Ponds



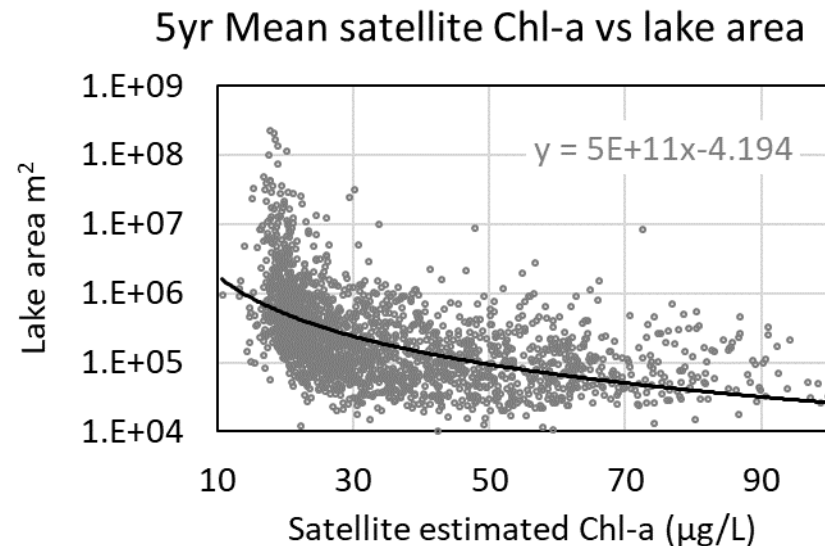
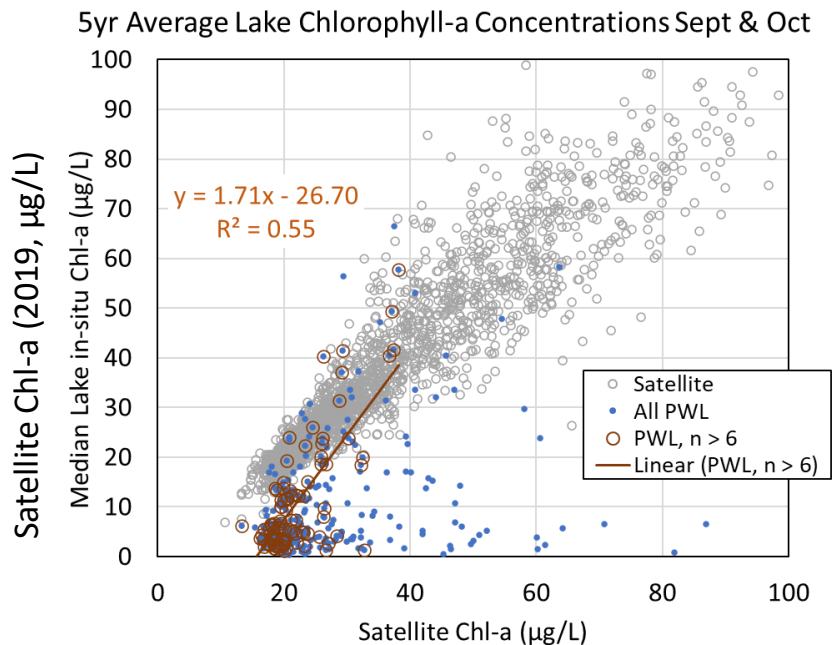
Chlorophyll



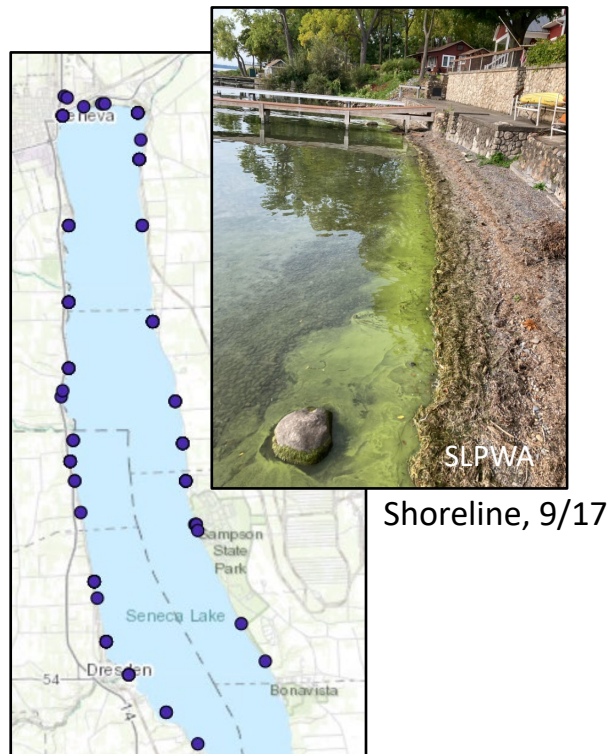
Validation – Chl-a - Comparing measured to estimated concentrations

Remove obvious anomalies:

But there remains a bias to high Chl-a in smaller waterbodies:

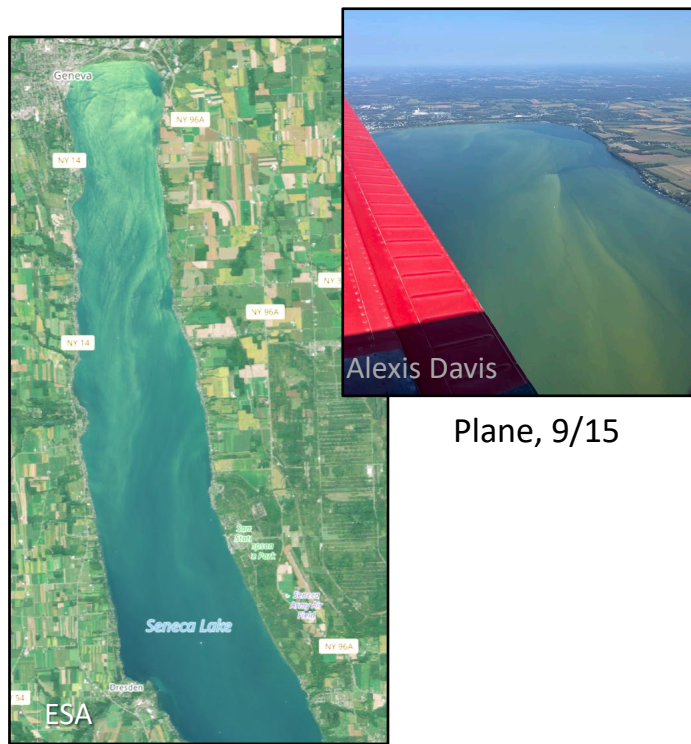


Validation - Comparison with NYHABS reports – Seneca Lake 2024



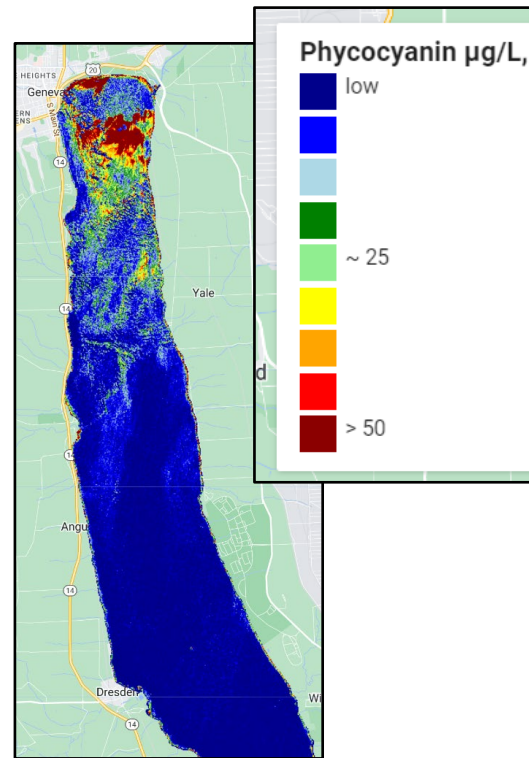
NYHABS reports, 9/1 – 9/19

Shoreline, 9/17



Sentinel 2, 9/14

Plane, 9/15

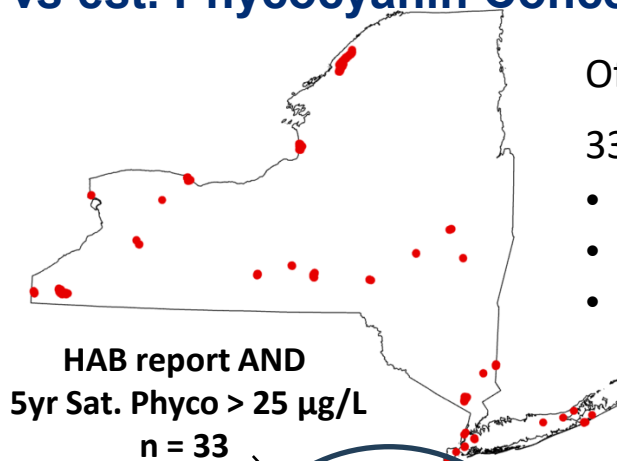


This Study, 9/1 – 9/19

Validation – HAB Reports vs est. Phycocyanin Concentration

NYS had 2517 reports of HABs in 2023, on 200 lakes

- This includes ‘small’ and ‘large’ localized blooms, which may not be picked up by satellite



Of 315 lakes with 25 µg/L or over,

33 had confirmed blooms in 2023 → ■

- Wide distribution
- But none in the Adirondacks
- Low overlap with HAB lakes

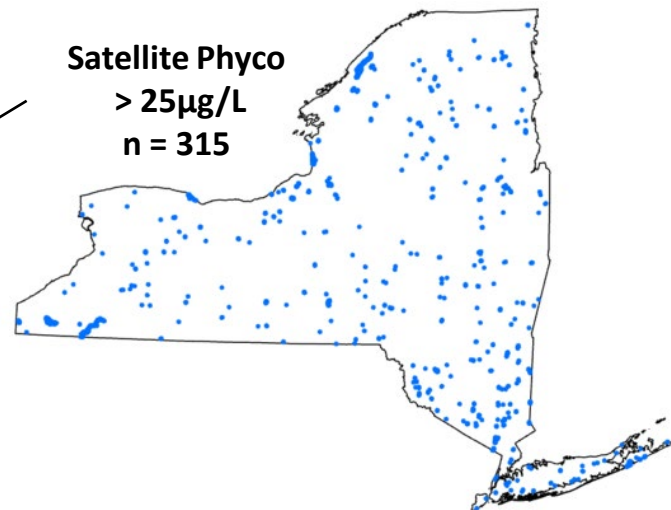
**Lakes with
Reported HABs
n = 200**

**‘Lakewide’ HABs
n = 79**

**305(b) lakes
n = 2096**

**Satellite Phycy
> 25µg/L
n = 315**

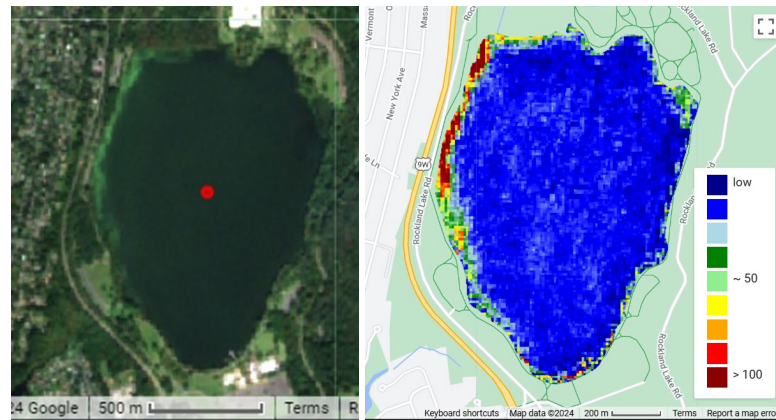
- Small/large localized
- Widespread/lakewide



Validation – HAB Reports vs Satellite HAB image / concentration

For 200 lakes with reported blooms in 2023

- 79 lakes had “widespread / lakewide” blooms
 - 26 of those lakes had at least one cloud-free image on a day a bloom was reported
 - 9 lakes had cloudy images
 - 45 lakes had no imagery on a day a bloom was reported ☹️



Most images confirm extent, but e.g. Rockland Lake 04 Oct '23

Lakes with cloud-free Sentinel-2 imagery on a HAB report day
n = 26

Lakes with Reported HABs
n = 200

'Lakewide' HABs
n = 79

305(b) lakes
n = 2096

- Small/large localized
- Widespread/lakewide

Possible Future Work

Model Improvements

Chlorophyll-a & Phycocyanin estimates

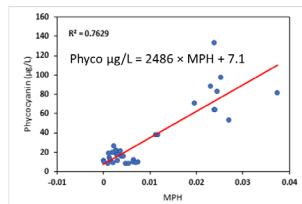
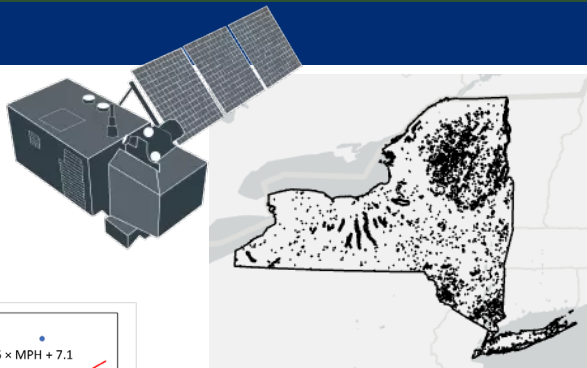
- Machine Learning
- Extend training dataset to CSLAP 2021-2023
- Adirondak-specific WQ dataset
- Temporal resolution: use of Landsat/Sentinel 2 Harmonized dataset
- Bathymetry – mask out shallow/weedy areas

Screening

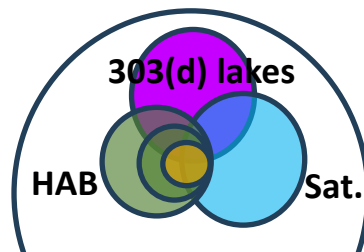
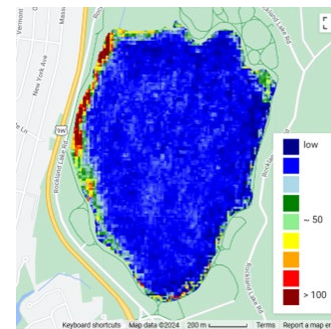
Use this technique to screen for HAB affected lakes and aid lake Assessment

Conclusions

- Sentinel-2 satellite imagery is suitable for many lakes in New York State
- Use of QA-controlled local data for best local fit
- Cloud computing solution provides significant benefits, & complications
- ‘Lakewide’ HABs can be confirmed, at times
- YES! Satellite-estimated pigment concentrations can identify HABs *under the right conditions*



Google Earth Engine



Thank You!

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