Remotely sensed cyanobacterial intensity predicts likelihood of lake blooms and toxins across the contiguous U.S.

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Data and analyses are preliminary and subject to change

Cyanobacterial Assessment Network

Interagency Project

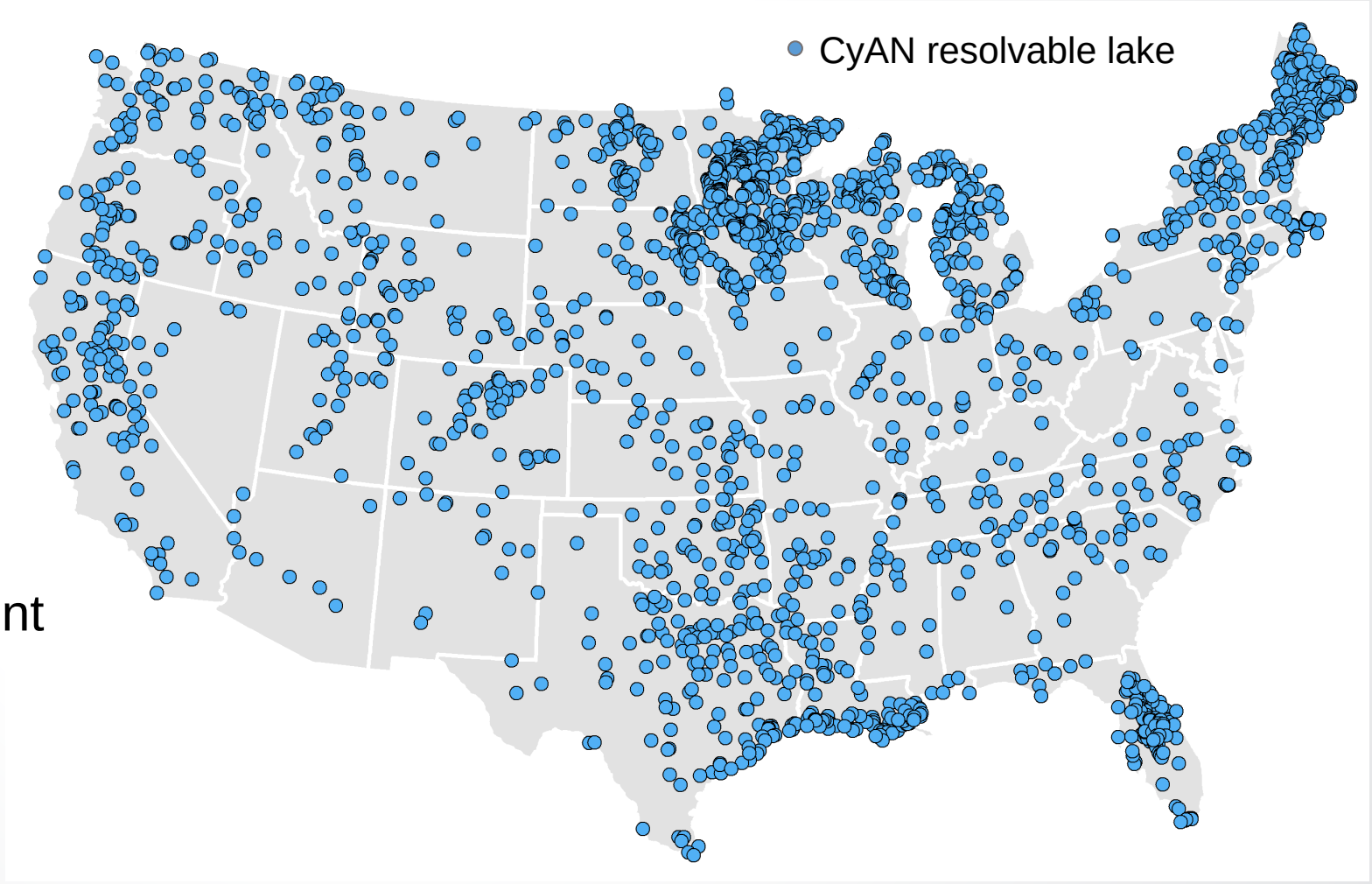
Lakes monitored: ~2,200

Pixel size: 300 x 300 m

Lake size: 1.4 – 16k km^2

Temporal coverage
- MERIS 2008-2011
- Sentinel 3a/3b 2017-Present

Weekly composite images



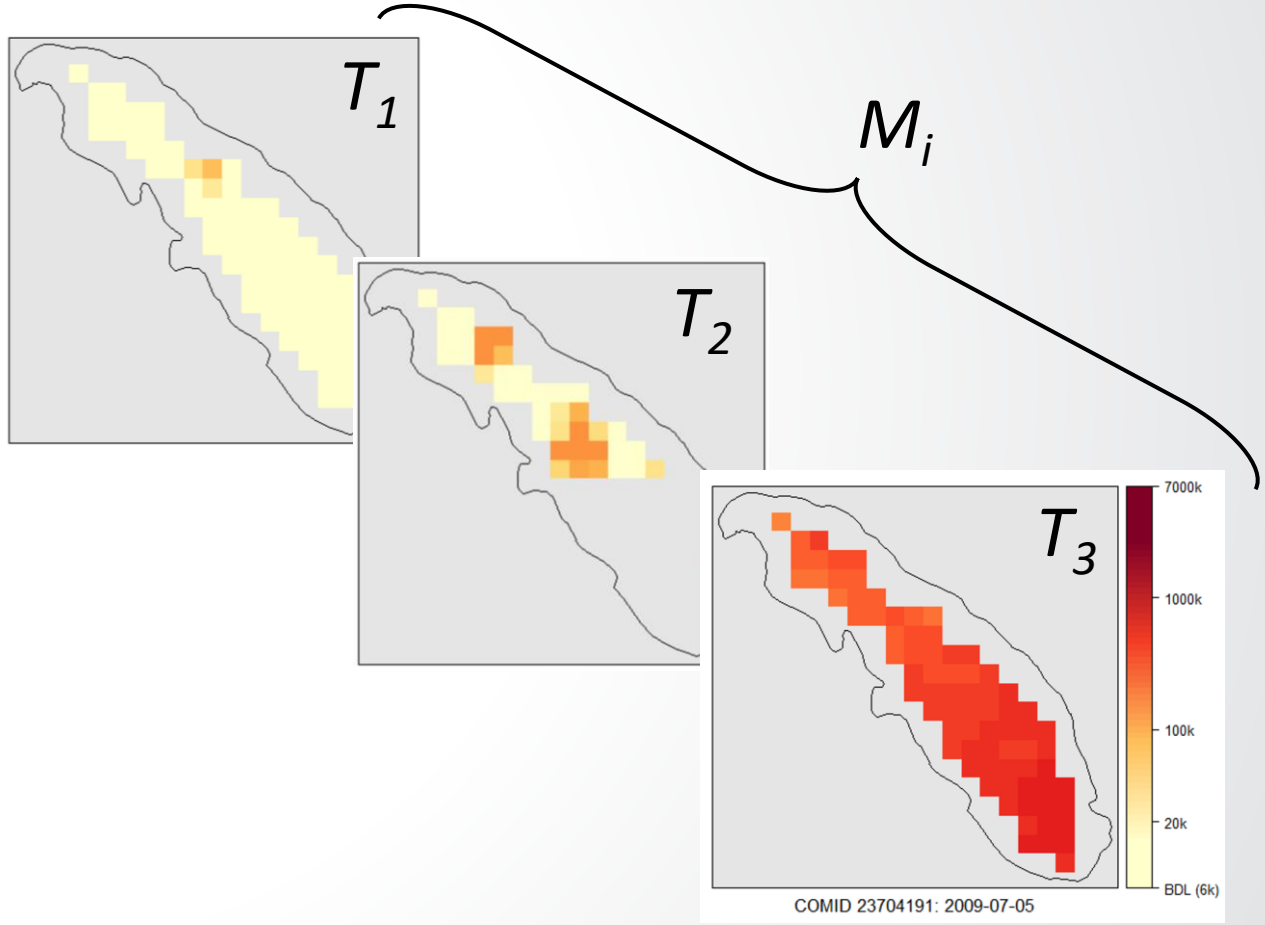
Spatiotemporal mean bloom magnitude

Mishra, Stumpf, Schaeffer, Werdell, Loftin, Meredith (2019) *Scientific Reports*

$$Lake\ bloom\ magnitude\ (CI/km^2)$$

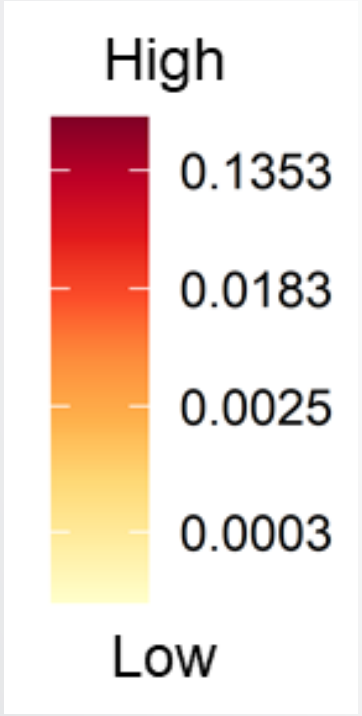
$$\frac{\frac{1}{M}\sum_{m=1}^{M}\frac{1}{T}\sum_{t=1}^{T}\sum_{p=1}^{P} CI_{p,t,m}}{Lake\ area}$$

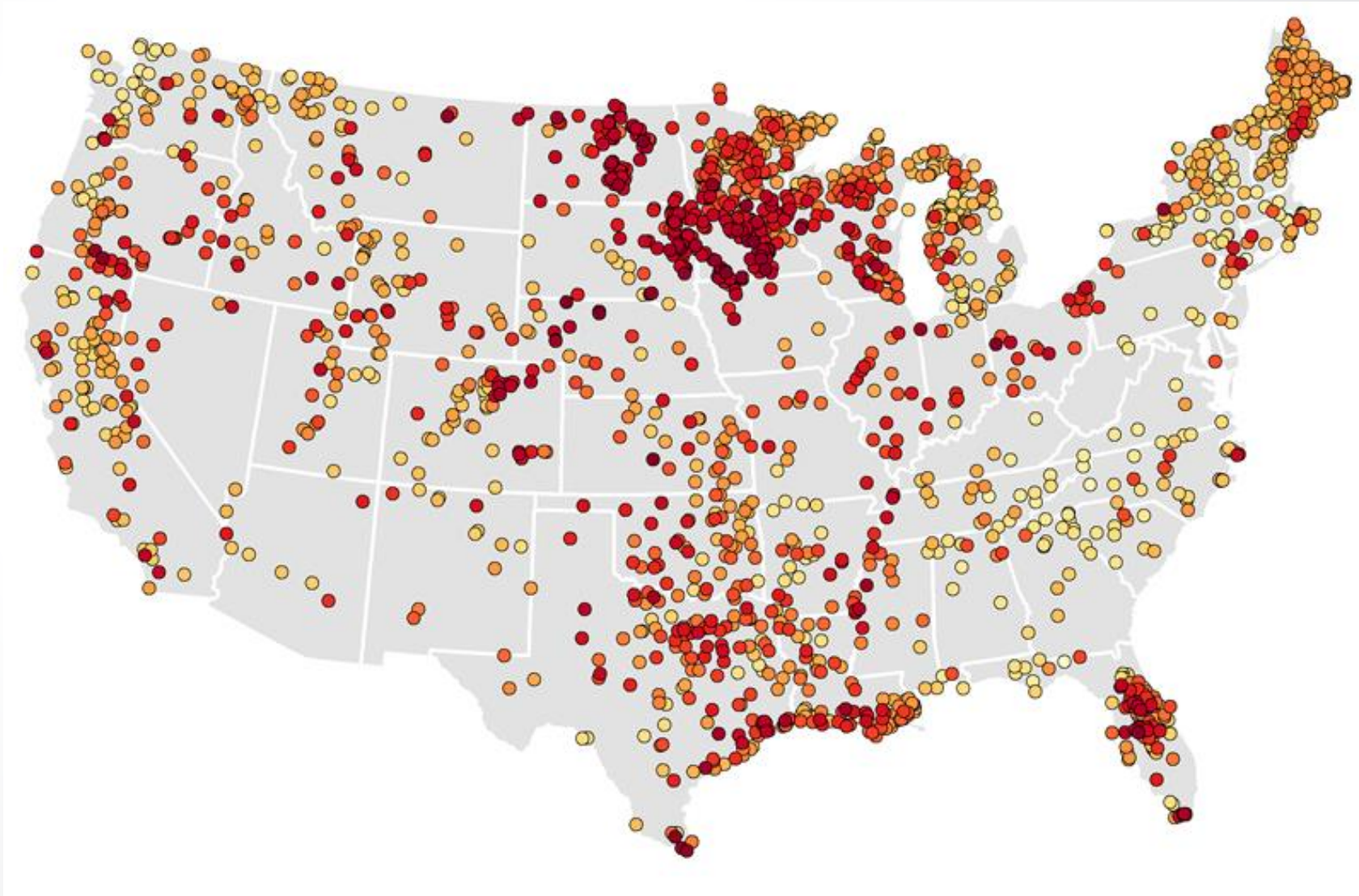
M	months included in mean
T	composite images in each month
P	pixels in each composite image
CI	cyanobacteria index



Summer Lake Bloom Magnitude

Area normalized summer bloom magnitude (CI/km^2)





National Lakes Assessment (NLA)

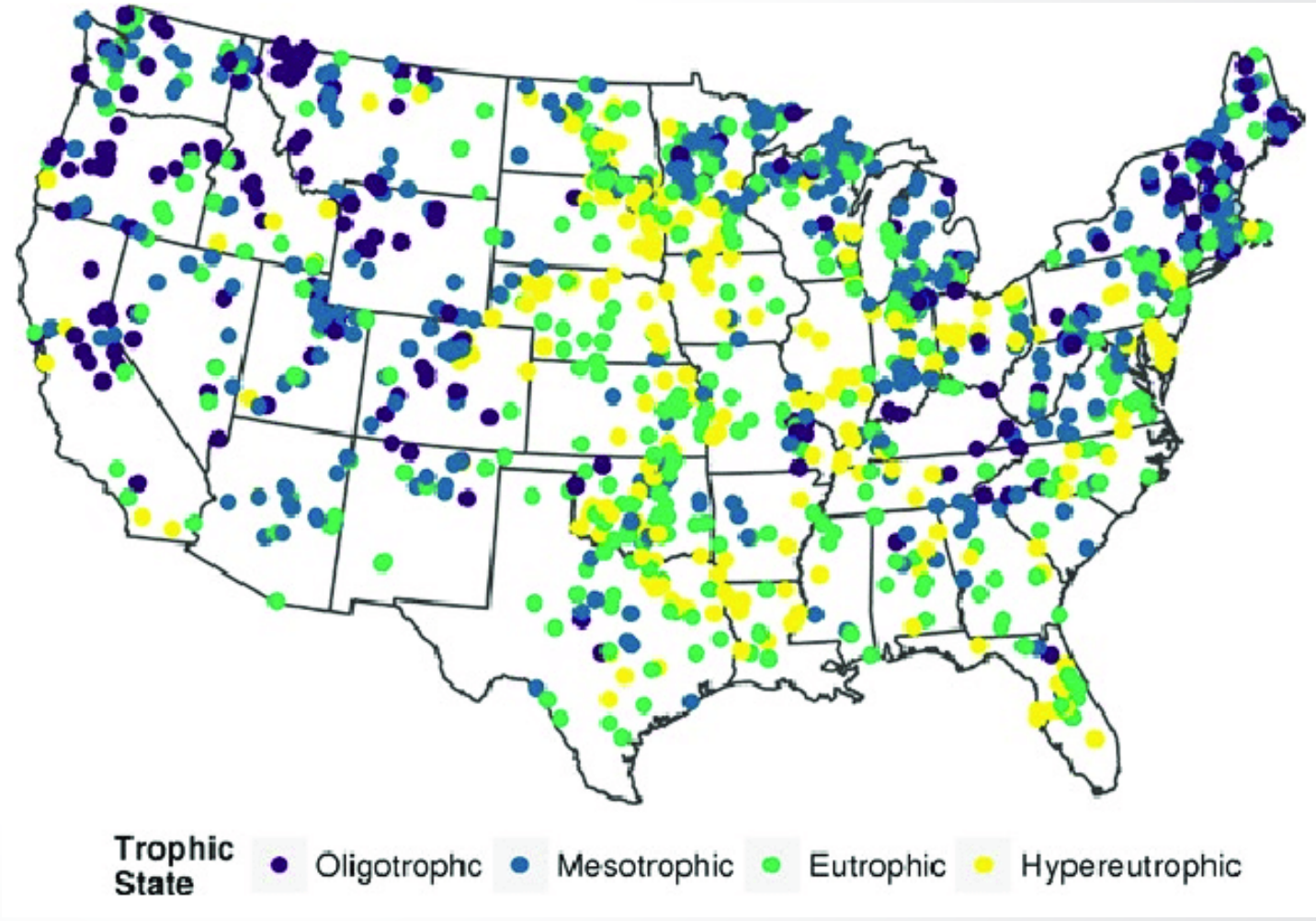
Survey of lakes in 2007 & 2012

Single sample during summer

Lake size: 0.4 – 16k km^2

Algal bloom metrics

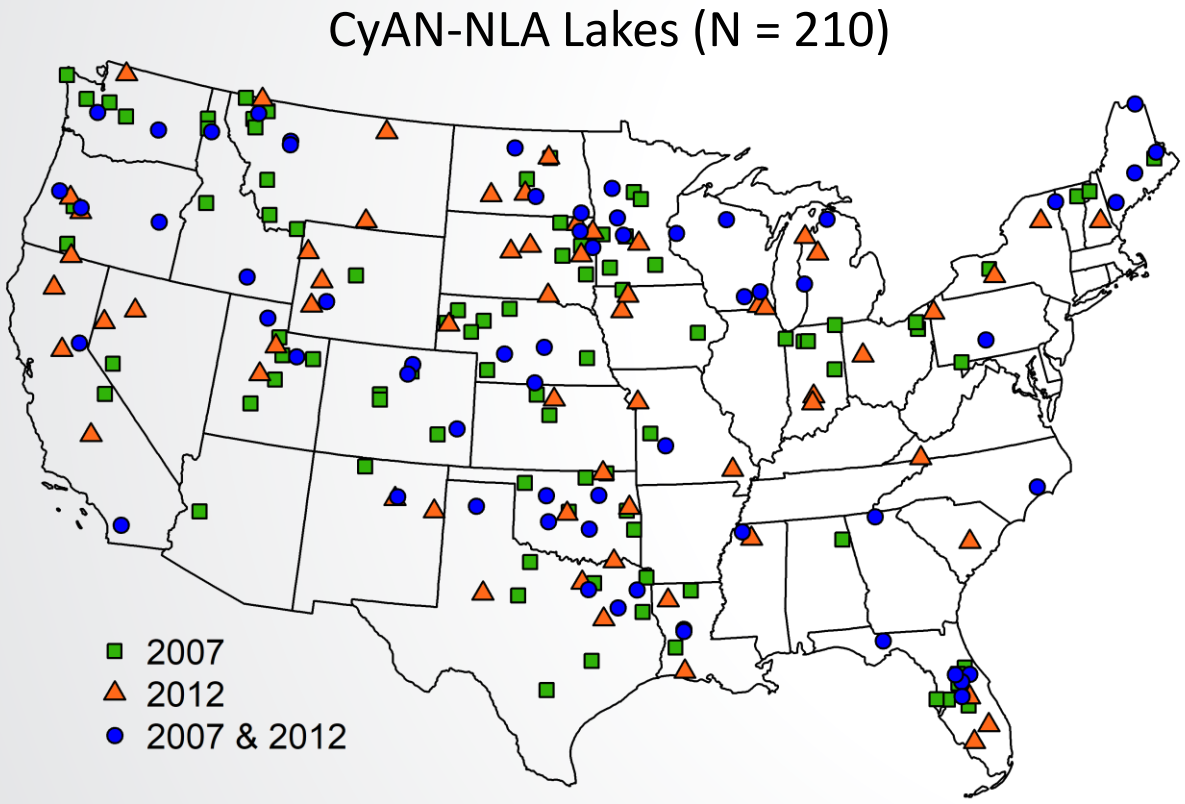
- Microcystin
- Cyanobacteria cell density
- Chlorophyll a



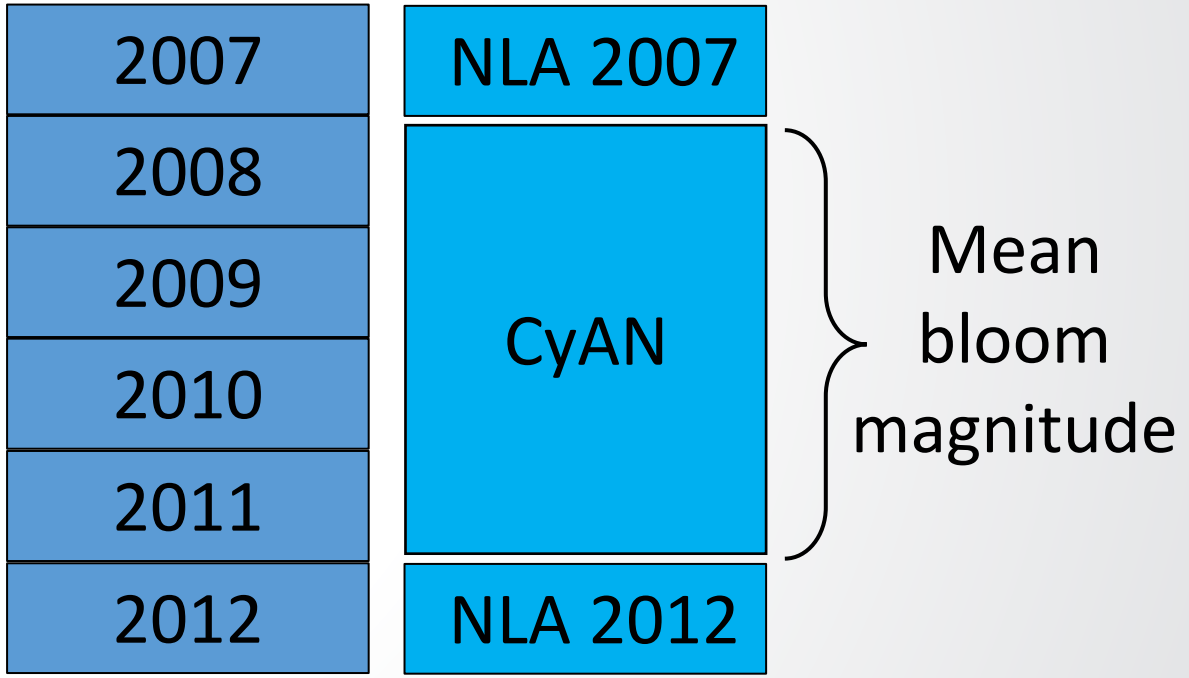
Hollister et al. (2016) *Ecosphere*

Combining CyAN and NLA HAB data

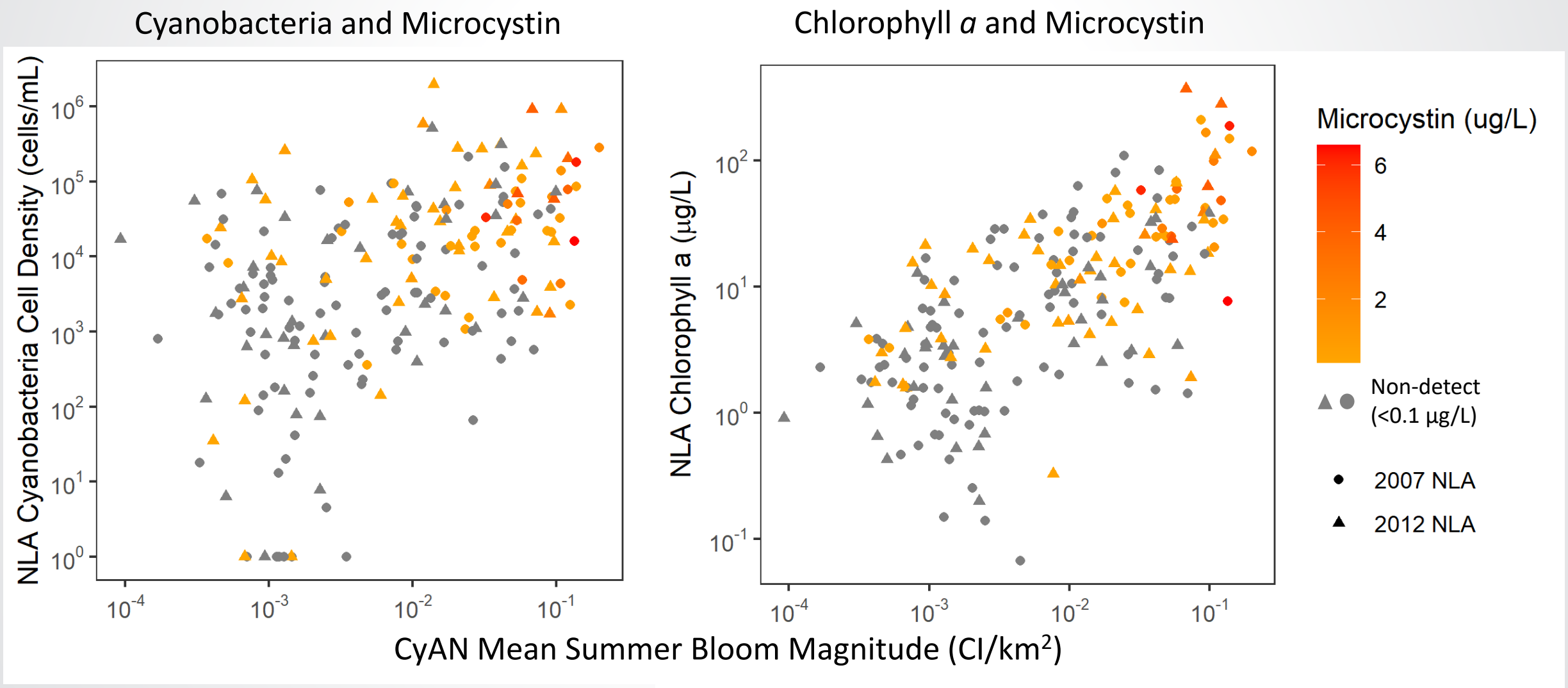
Spatial overlap



Temporal overlap



CyAN and NLA HAB data relationship



Modeling thresholds

Can we use mean summer bloom magnitude to predict likelihood of exceeding thresholds in NLA data?

Risk Level	Microcystin (µg/L)	Cyanobacteria[b] (cells/mL)	Chlorophyll *a*[b] (µg/L)
Low	0.2[a]	20,000	10
High	1.0	100,000	50

[a]ELISA concentration detection limit

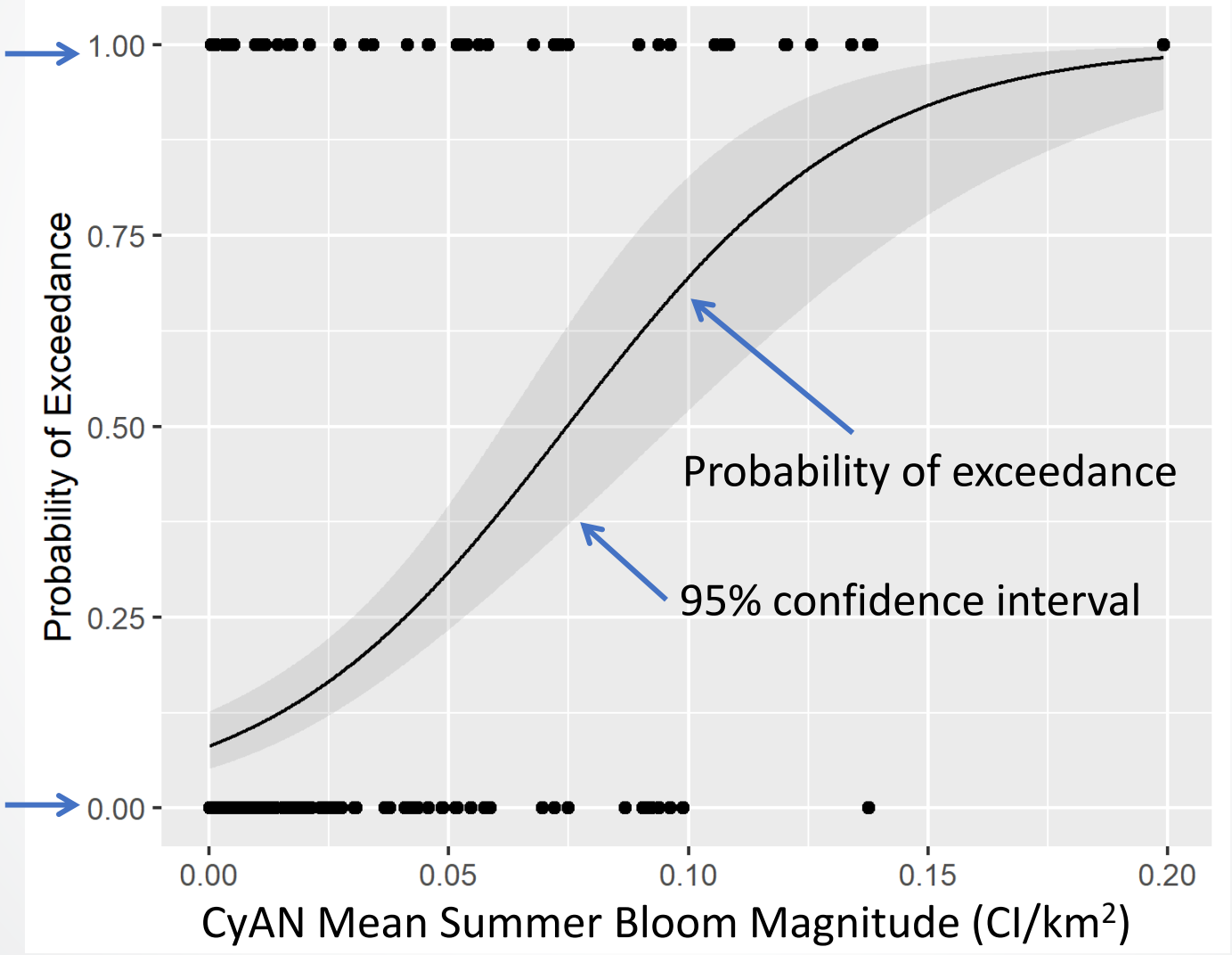
[b]World Health Organization guidelines for recreation low likelihood of generating health problems (low) and high likelihood (high)

Measuring likelihood with binomial regression

Observations above guideline

Example Threshold: 0.2 µg/L Microcystin

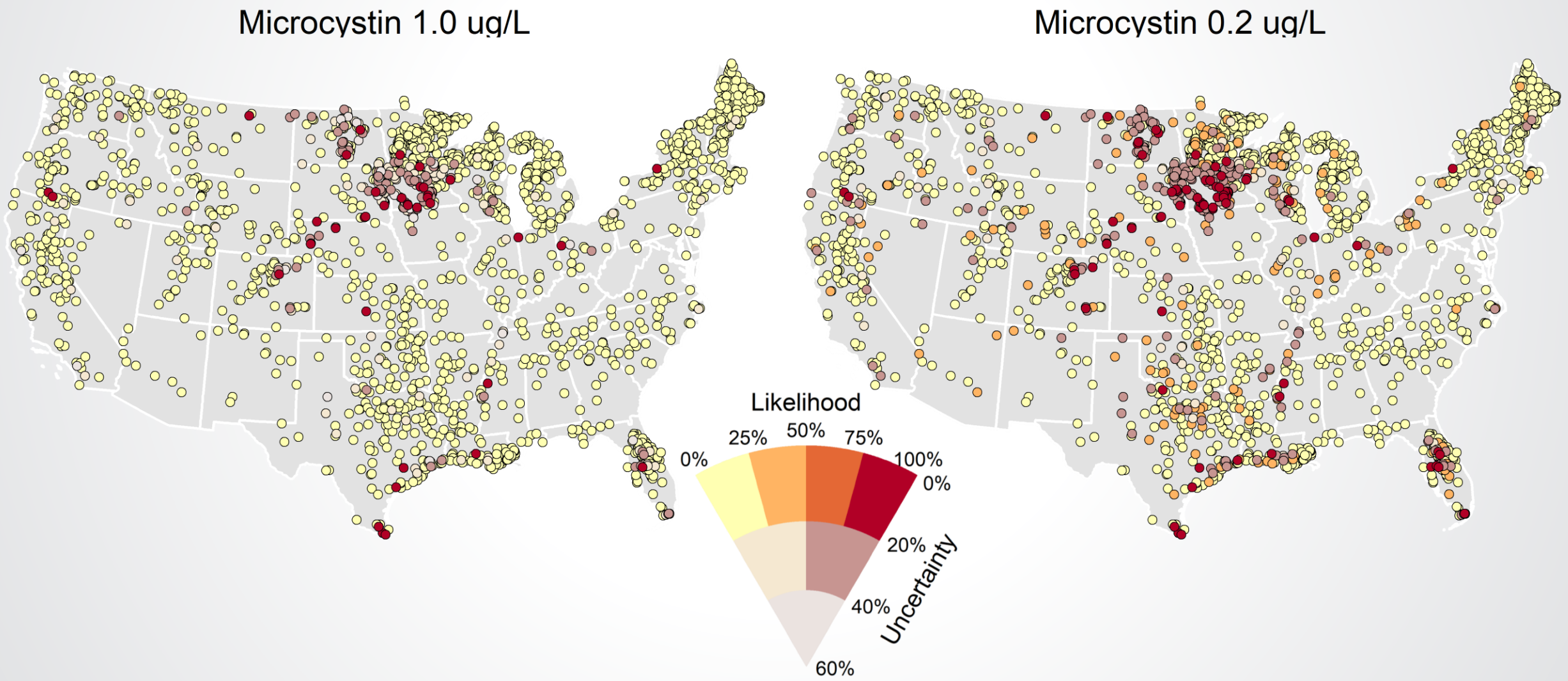
Observations below guideline



Models developed for

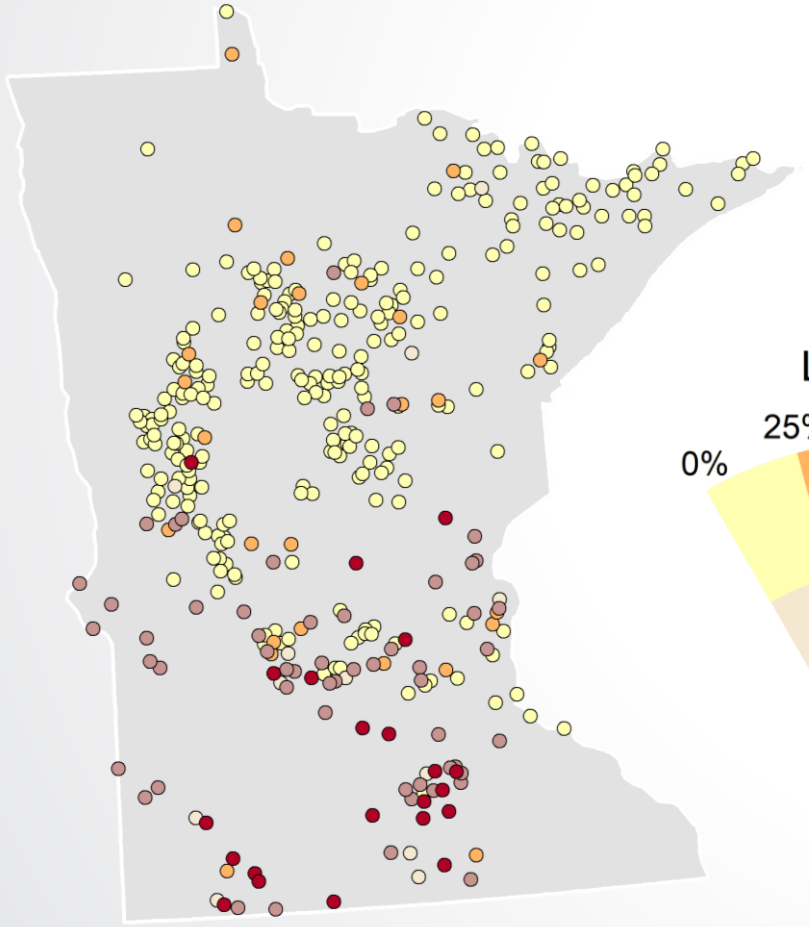
- HABs metrics
  - Microcystin
  - Cyanobacteria
  - Chlorophyll a
- Low & high thresholds
- 2007, 2012, and both

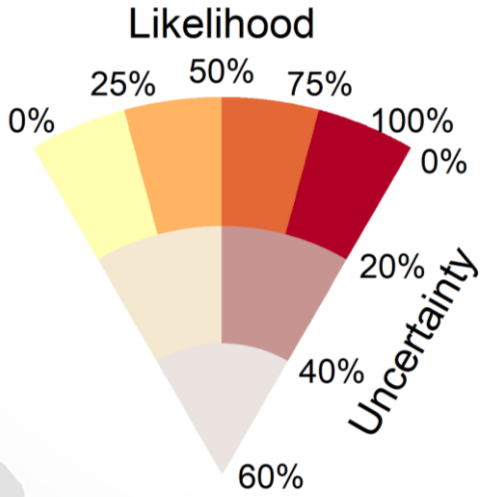
Likelihood of HABs Thresholds



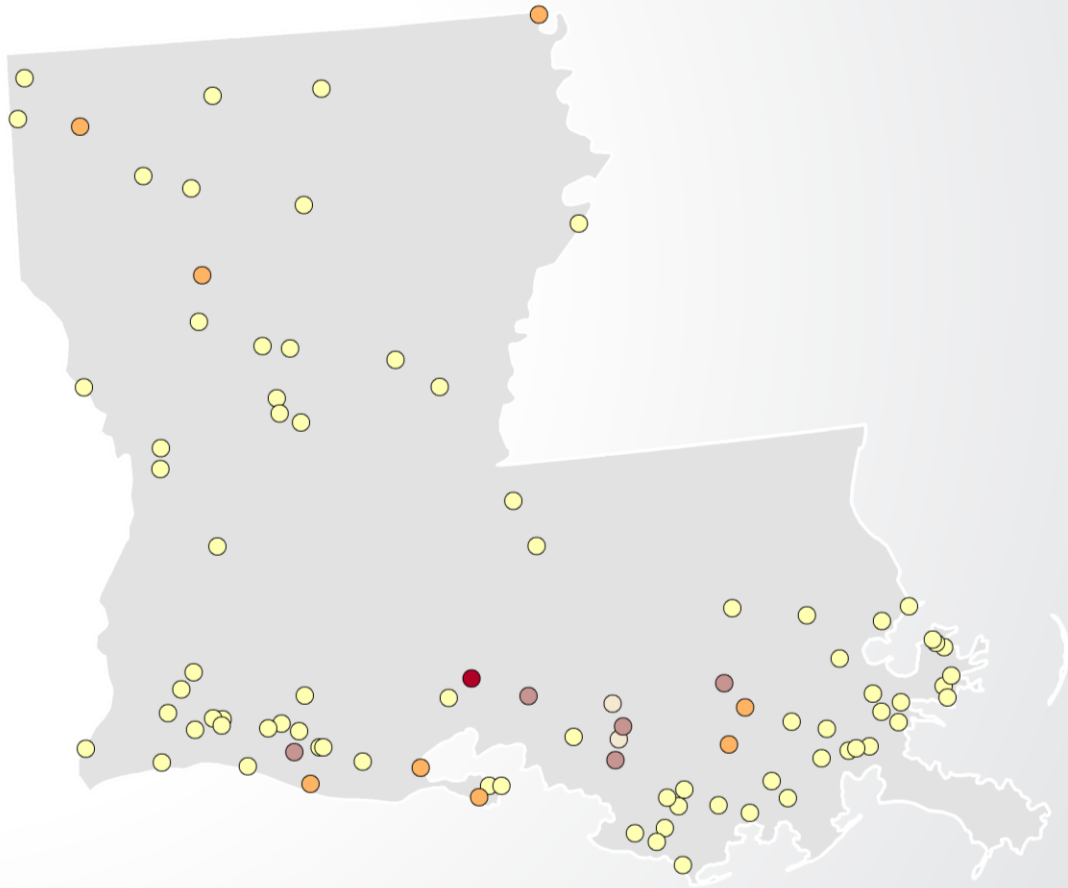
State Examples: Microcystin 0.2 µg/L

Minnesota





Louisiana



Conclusion

Implications

- A tool to help identify lakes at elevated risk for HABs
- Satellite data can help assess water quality risk
- Thresholds can be adjusted as guidelines are updated

Future Work

- Relate satellite to field data over time for 2017 NLA and CyAN data
- Examine regional versus local HABs risk drivers

Thank you!

Questions?

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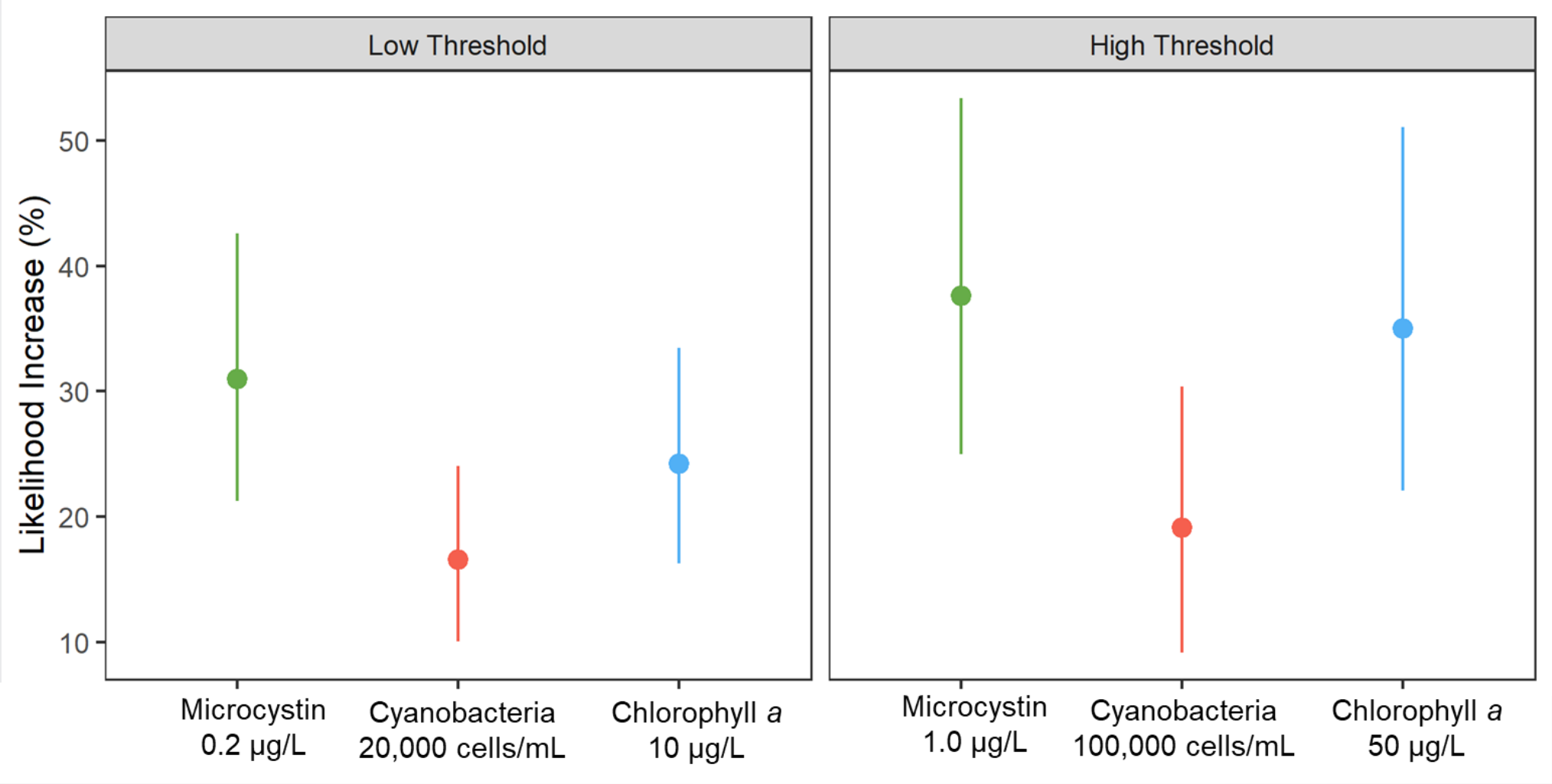
Extra slides

Relative Risk



Inter- & Extra-polate to all CyAN lakes