Cyanobacteria Monitoring from Space: Current and Future Applications

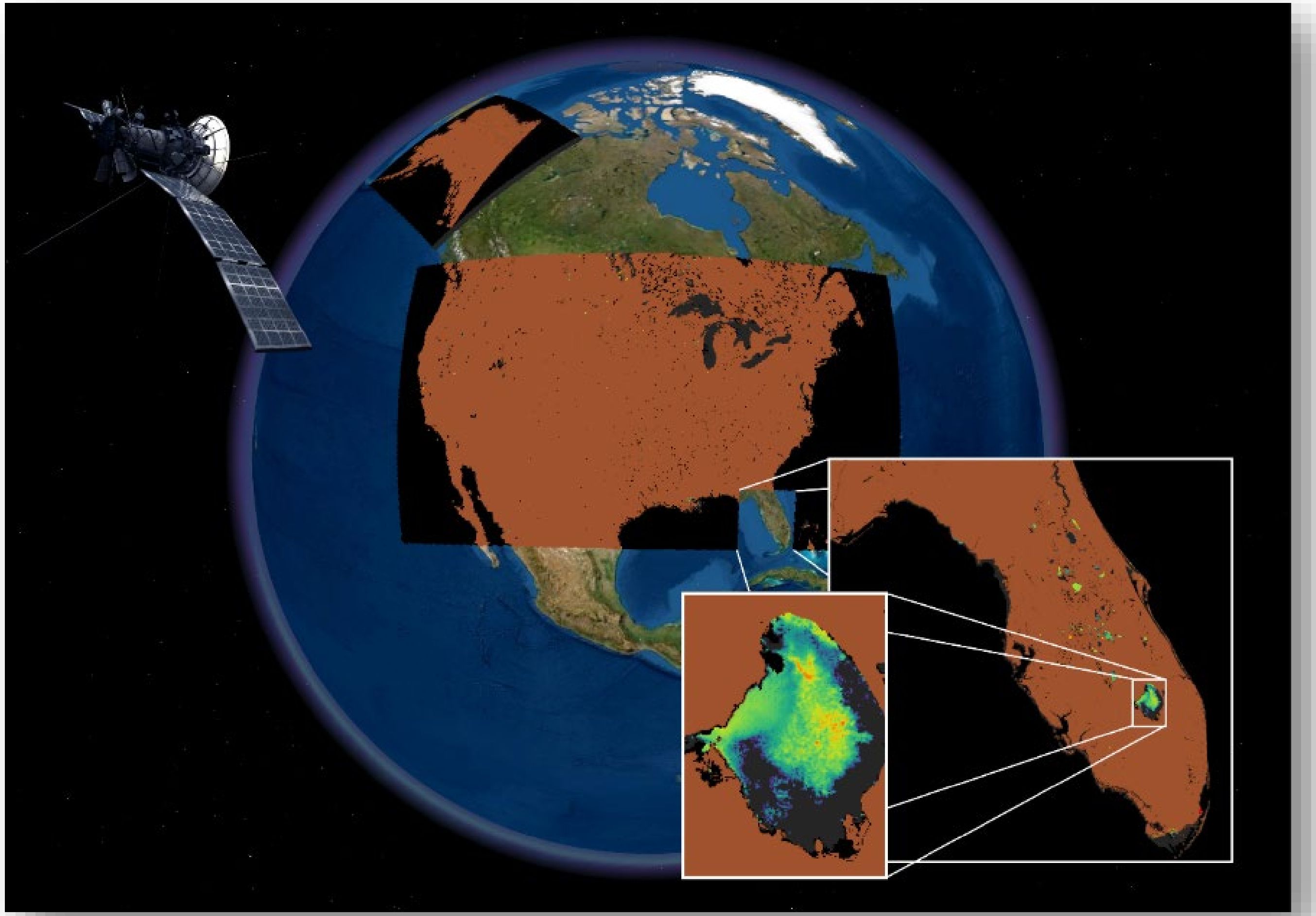
Office of Research and Development
Center for Environmental Measurement and Modeling

October 2023

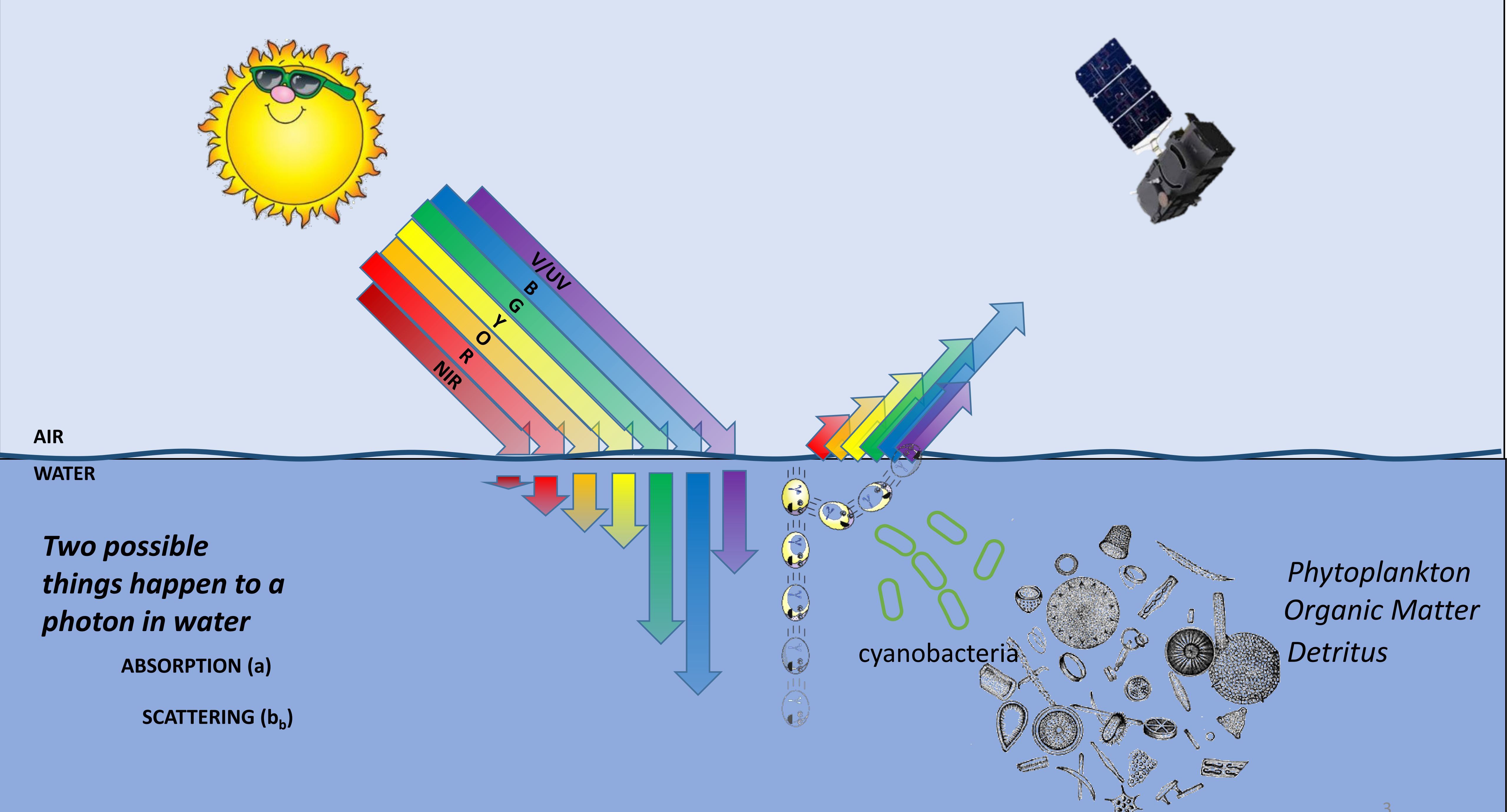
United States Environmental Protection Agency

CyAN
CYANOBACTERIA ASSESSMENT NETWORK

EPA CyAN website



NASA CyAN website



Source: Ryan Vandermeulen & Jeremy Werdell

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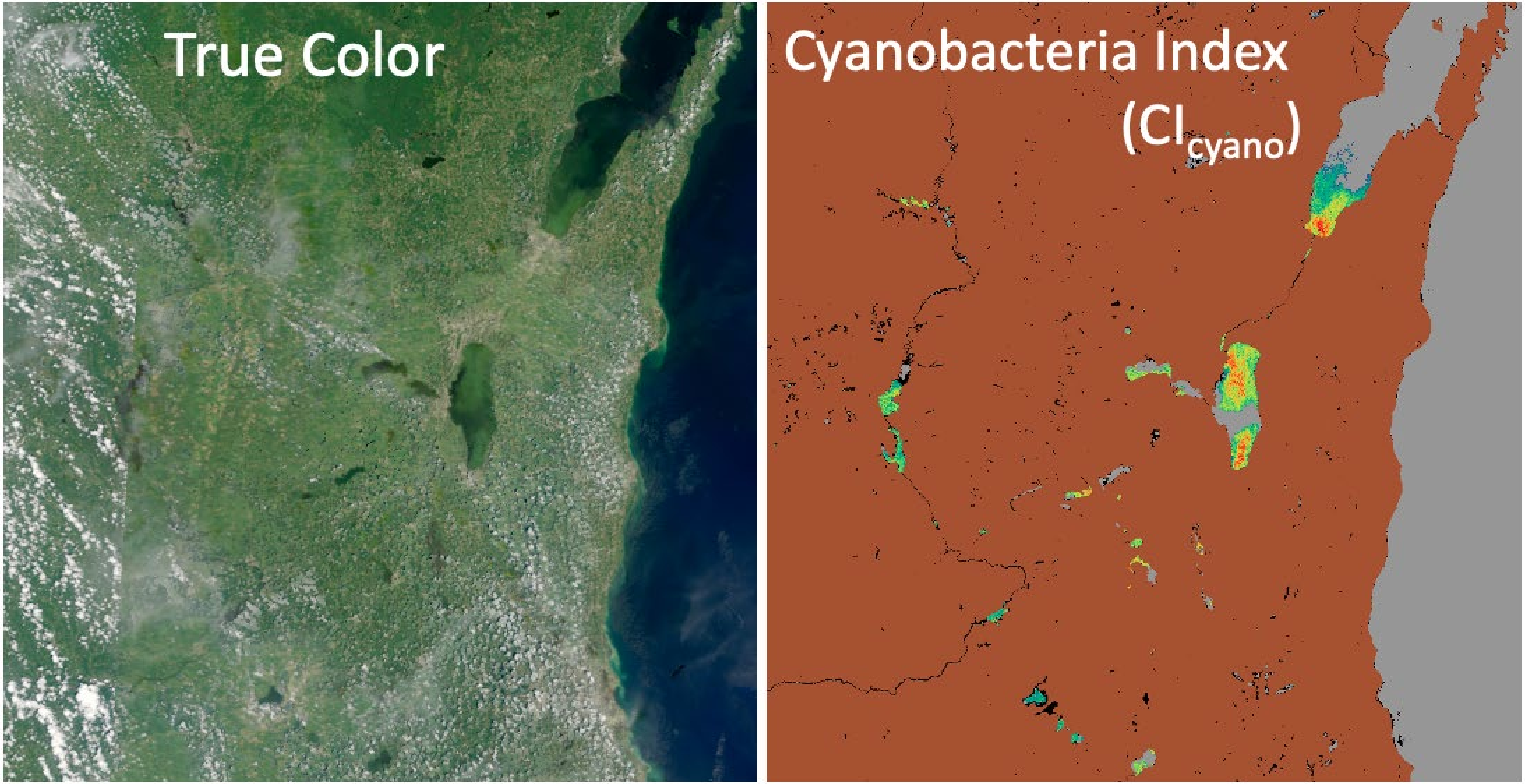

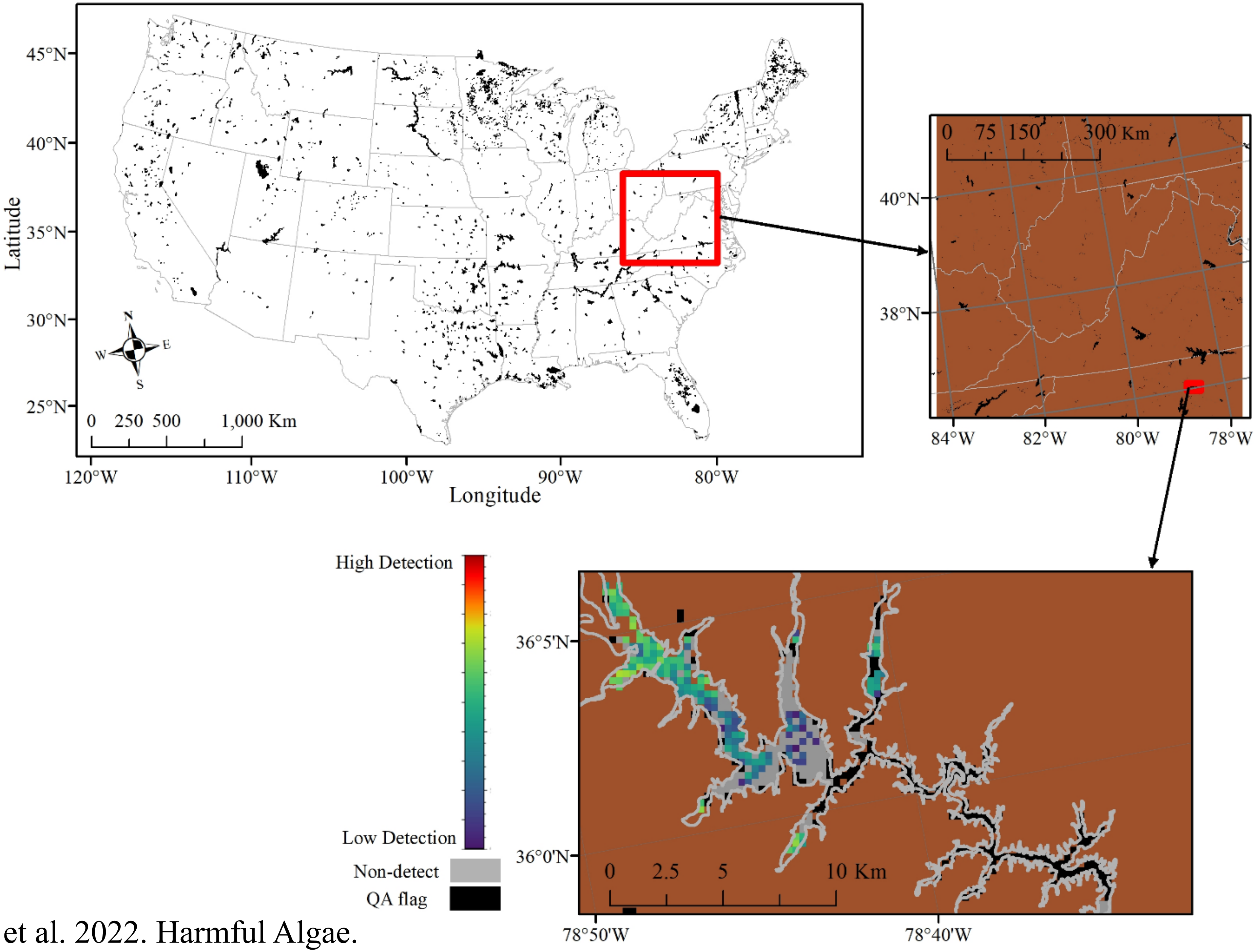

Source: Whitman et al. 2022. Harmful Algae.

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Validation

CI_{cyano}	State Recreation Advisories: Presence	State Recreation Advisories: Absence	
Presence	107 (*Presence-Presence*)	32 (*Misfit Presence*)	77% (*Positive Predictive Value*; eq. 8)
Absence	47 (*Misfit Absence*)	102 (*Absence-Absence*)	68% (*Negative Predictive Value*; eq. 9)
	69% (*True Positive Rate*; eq. 6)	76% (*True Negative Rate*; eq. 7)	73% (*Overall Agreement*; eq. 5)

Sources: Whitman et al. 2022. Harmful Algae; Seegers et al. 2021. Remote Sensing of Environment; Mishra et al. 2021. Science of the Total Environment; Coffer et al. 2021. Water Research.

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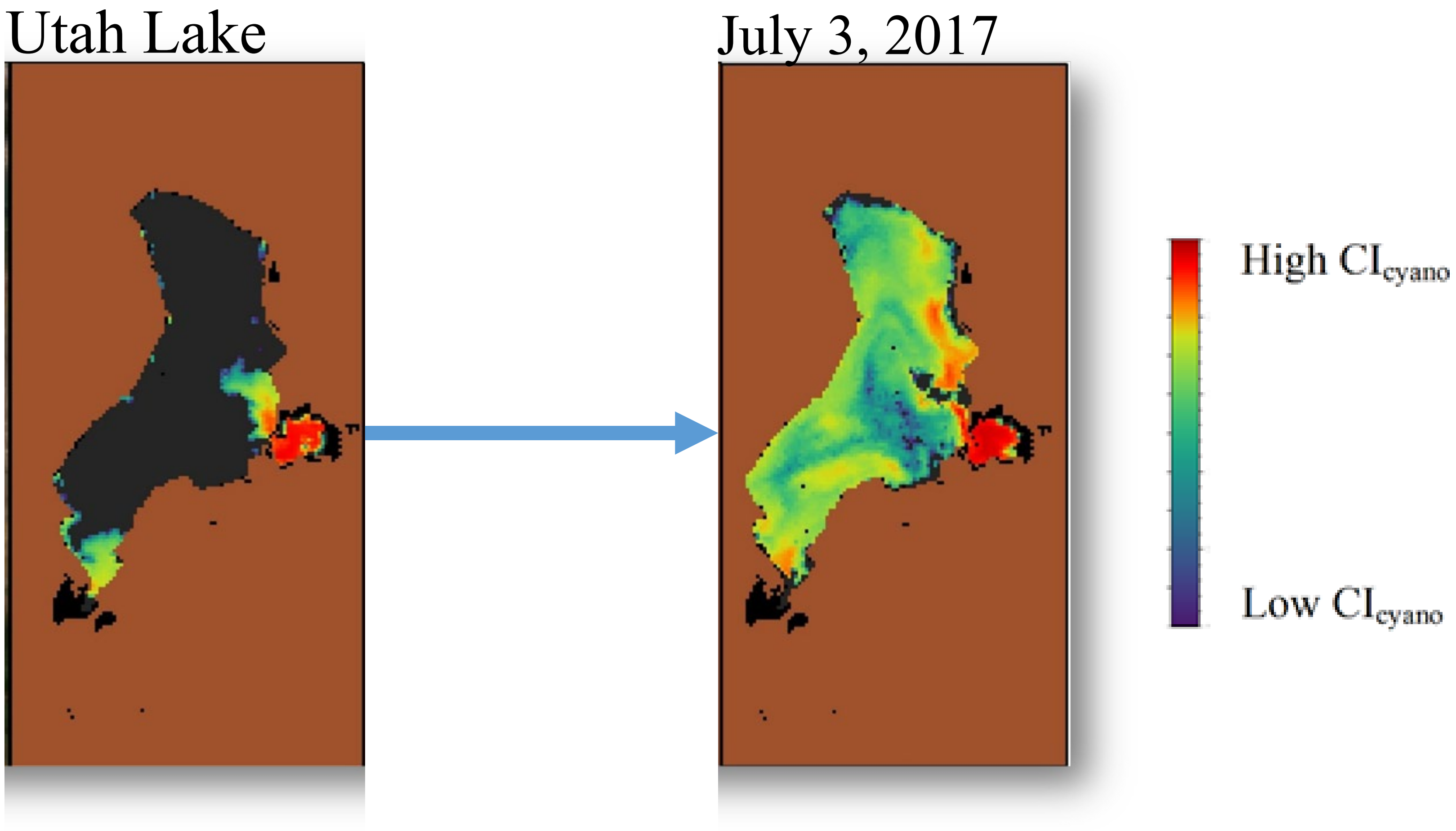
(Rick Egan/The Salt Lake Tribune)



Source: Stroming et al. 2020. GeoHealth

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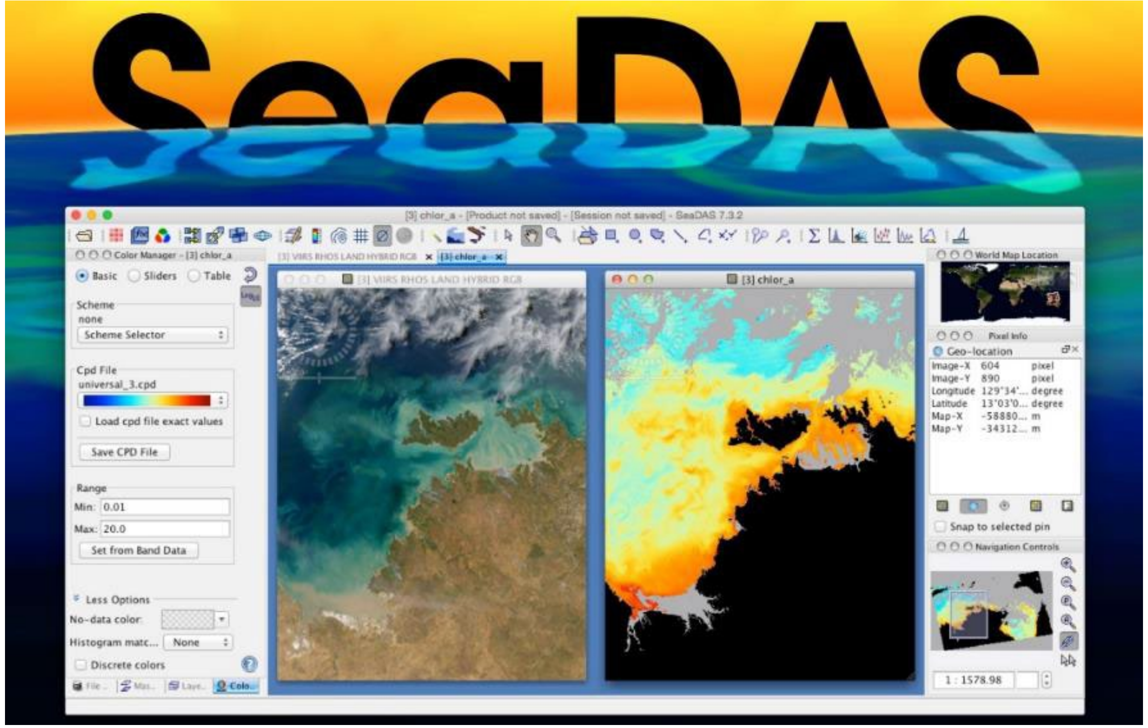
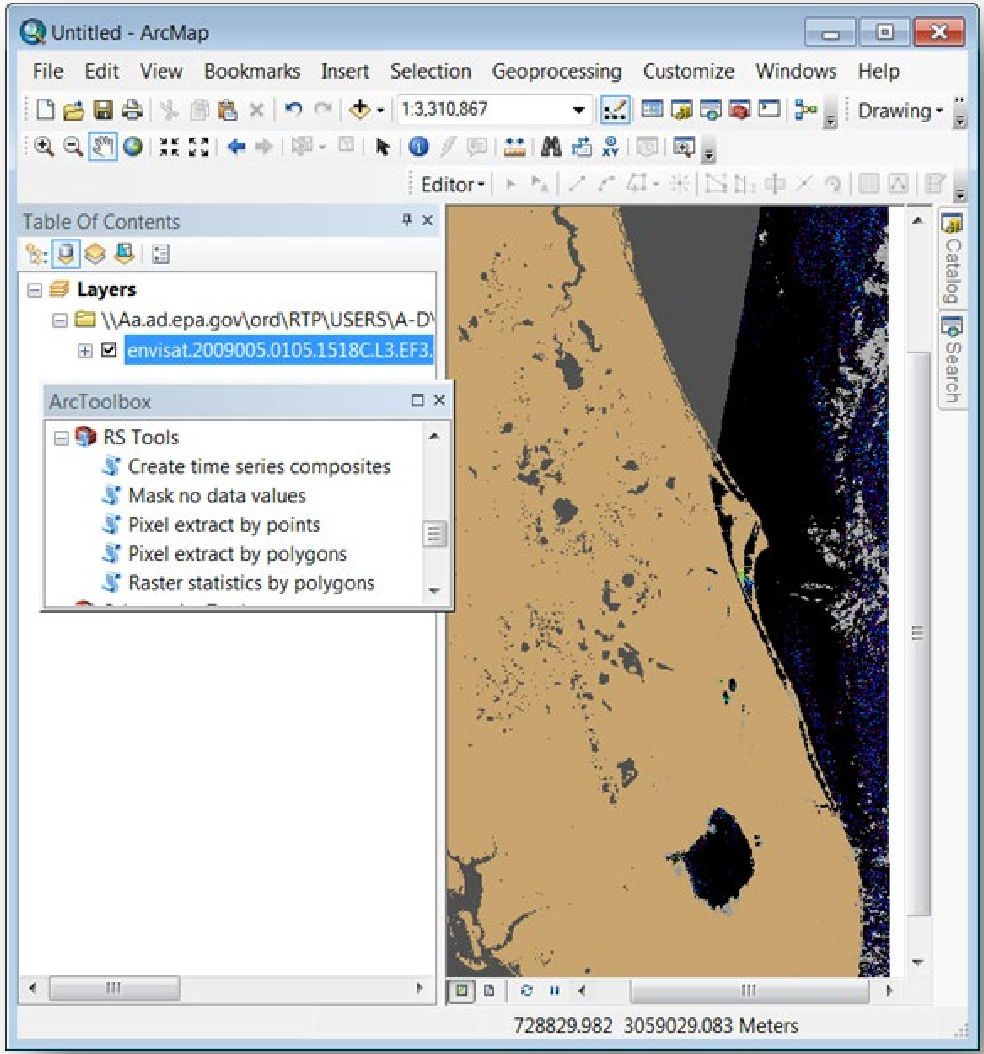
Software





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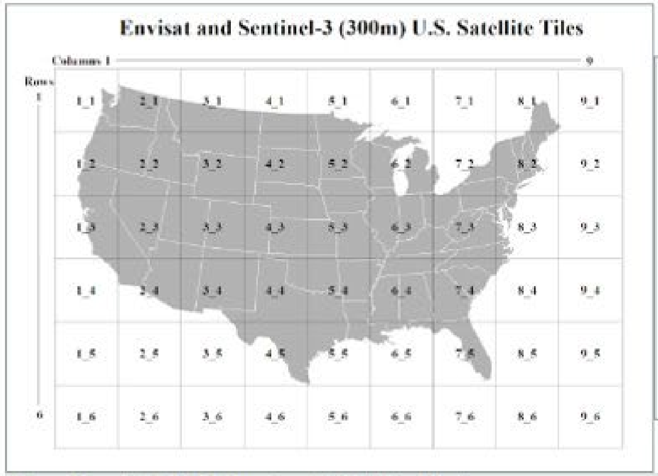
Version 5 of CyAN data were released on May 22, 2023. Click here for details.

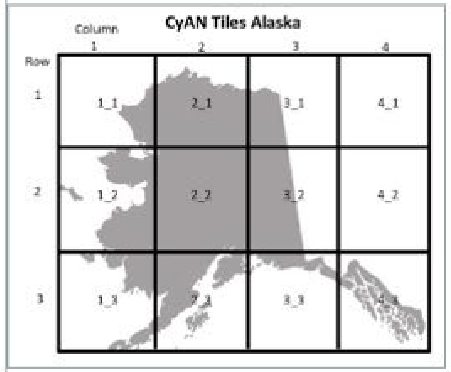
Introduction

Cyanobacteria Assessment Network (CyAN) is a multi-agency project among EPA, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the United States Geological Survey (USGS) to support the environmental management and public use of U.S. lakes and estuaries by providing a capability of detecting and quantifying cyanobacteria algal blooms. This effort has resulted in the production of satellite remote sensing products using the cyanobacteria index (CI) algorithm to estimate cyanobacteria concentrations (CI_cyano) in lakes across the contiguous United States (CONUS) and Alaska.

The CI data products available are GeoTIFF dailies and a 7-day maximum value composites from different ESA sensors: MERIS (2002-2012) and OLCI on Sentinel-3A (2016-present) and OLCI on Sentinel-3B (2018-present).

Data produced for CONUS and Alaska is delivered in tiles referred to as the column number followed by row number (see maps). The sensor spatial resolution is 300m. The CONUS images use a 50m land mask, while the Alaska product uses a less refined 500m land mask. The temporal resolution depends on the sensor and date with best coverage since 2018, as images utilize sensors on two Sentinel-3 satellites.





Data Access

- Version 5 Data Details
- File Search Tool ›
- Direct Data Download › (Level 2 & 3)

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Click Here for Bulk Data Download Instructions

Date

Start yyyy-mm-dd End yyyy-mm-dd

Period 14 Day [2002-2007]

14 Day
Daily
Weekly

Product cyanobacteria index

cyanobacteria index
true color

Additional Options

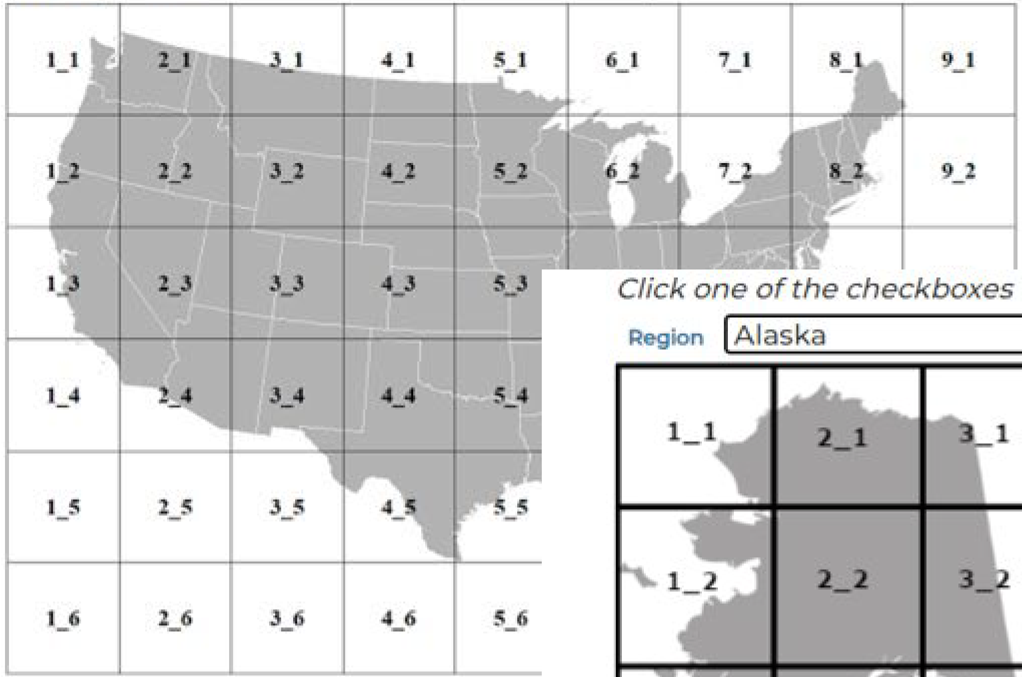
- [ ] Download results as a text file
- [ ] Add URL prefix to results text file
- [ ] Generate checksum text file

Submit

CONUS ALL - Single GEOTIFF
CONUS ALL - Individual Tiles

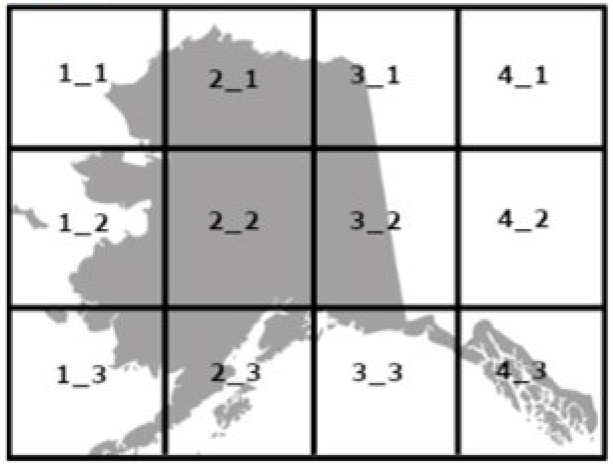
Click one of the checkboxes to select all tiles or click your area(s) of interest on the map.

Region CONUS



Click one of the checkboxes to select all tiles or click y

Region Alaska



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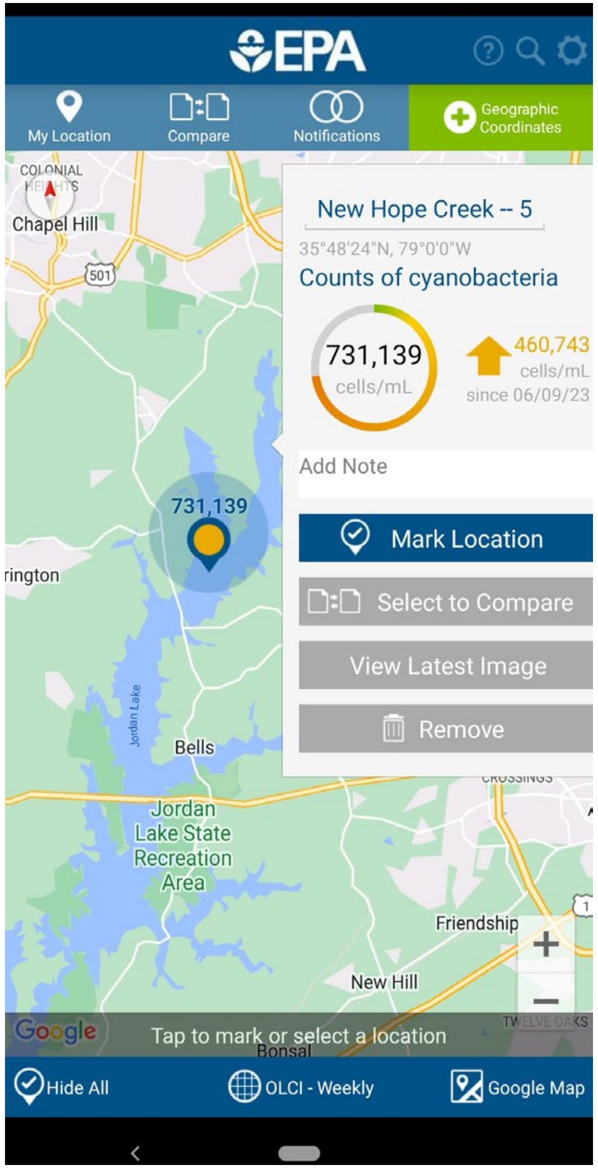
1

2



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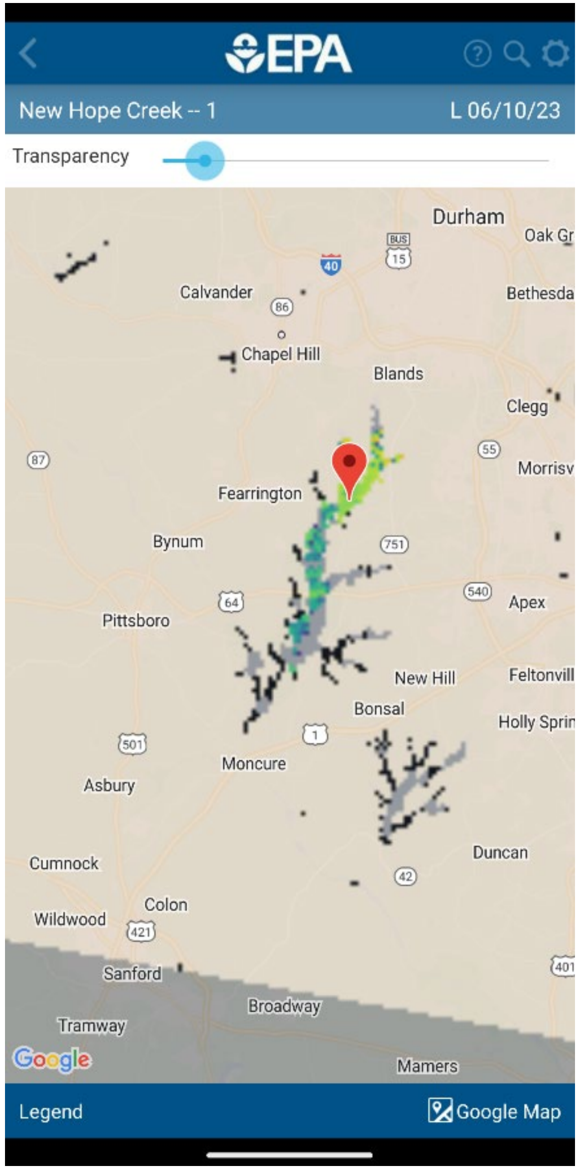

Source: Schaeffer et al. 2018. Environmental Modelling and Software

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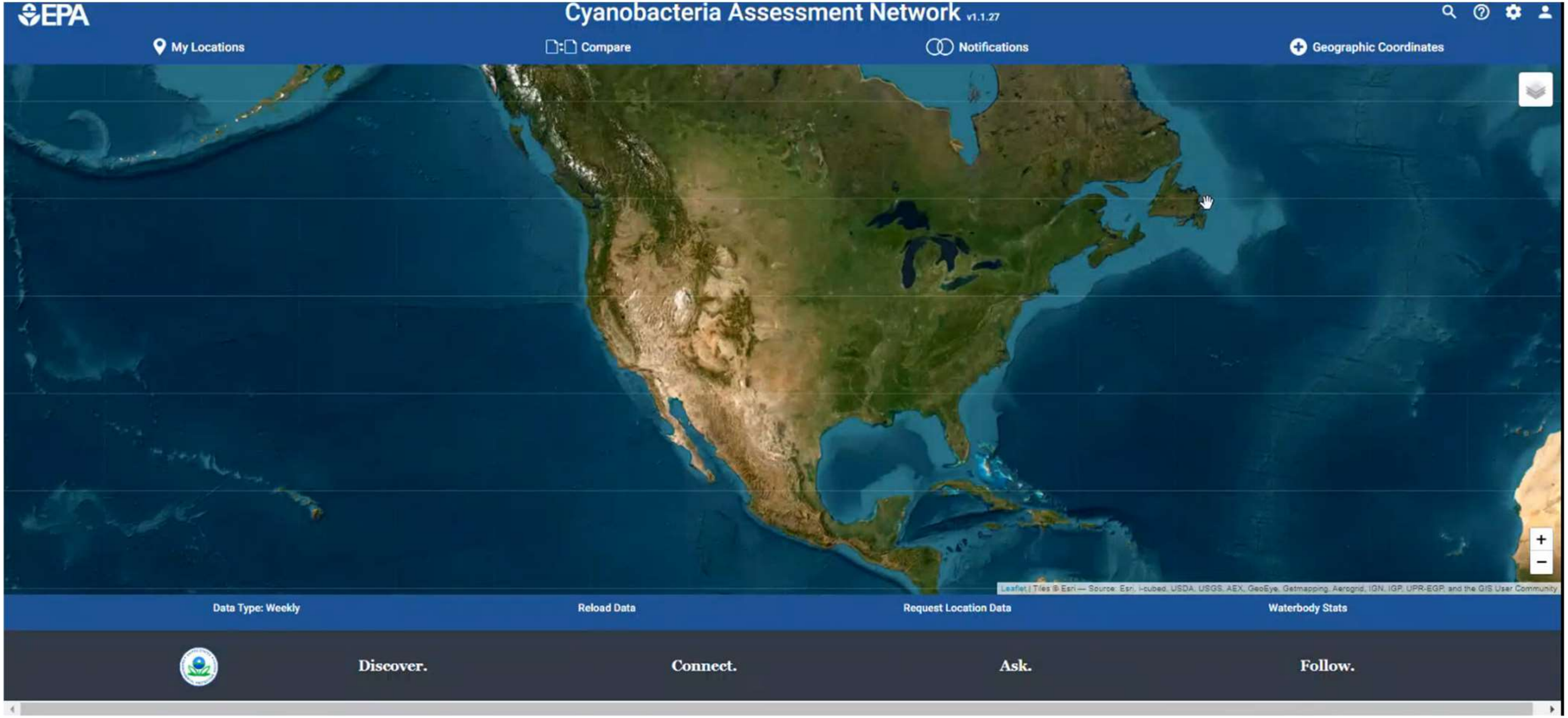

Source: Schaeffer et al. 2018. Environmental Modelling and Software

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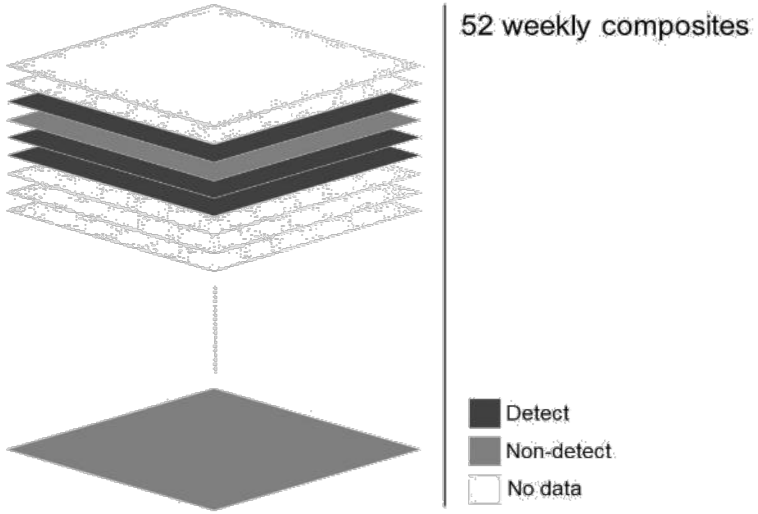
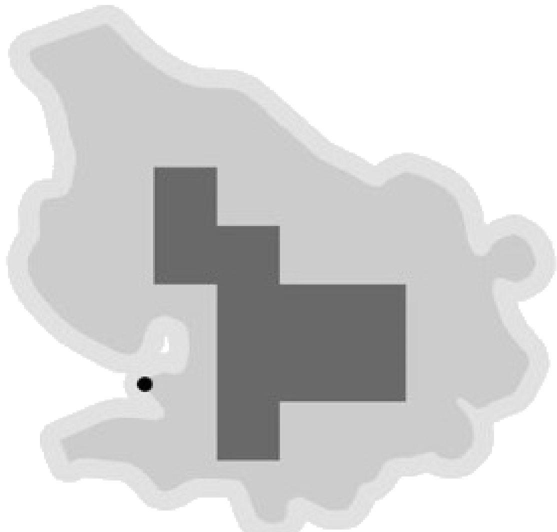
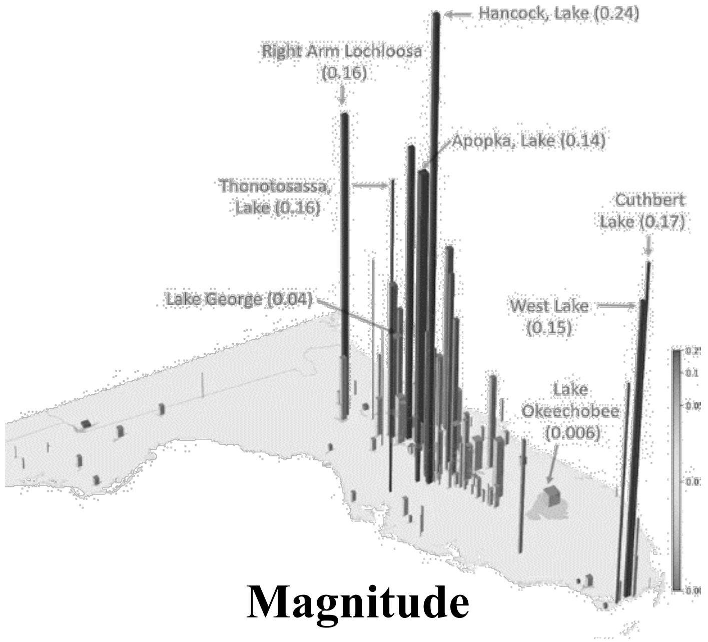
EPA's Report on the Environment (ROE)



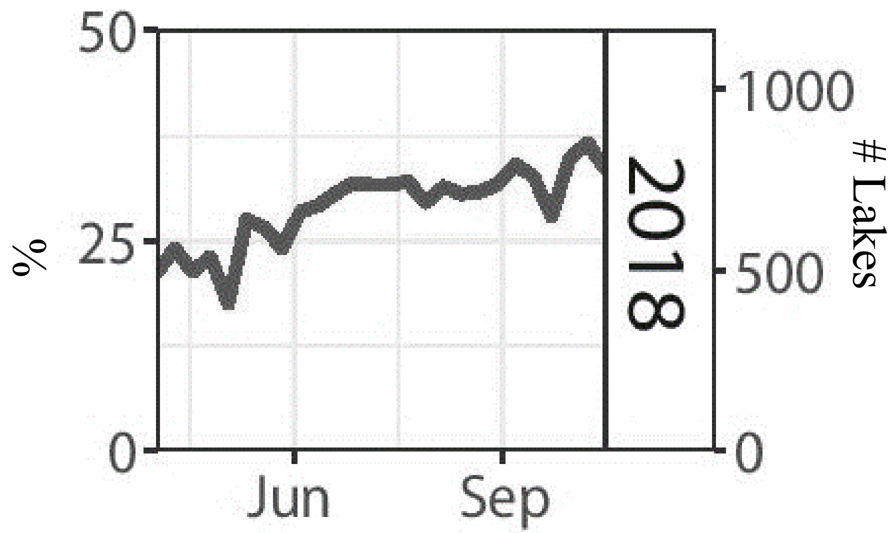
Temporal Frequency



Spatial Extent

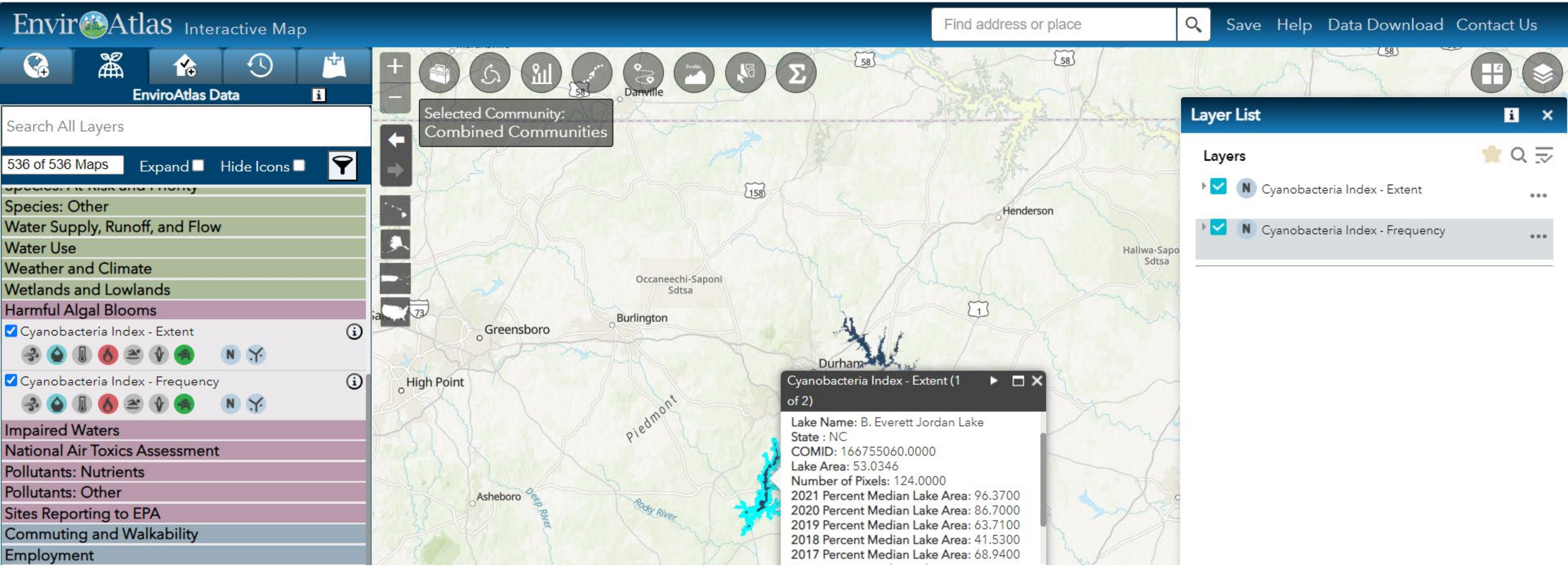


Magnitude



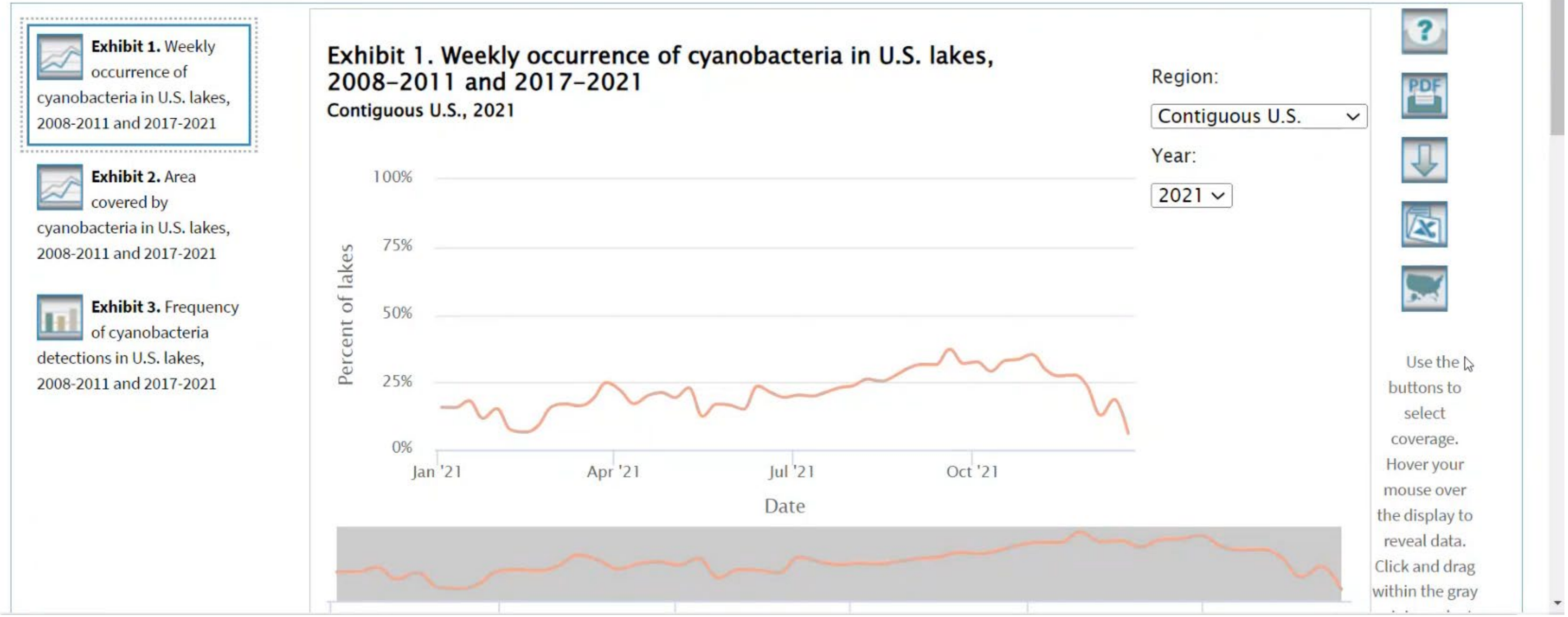
Occurrence

Source: Mishra et al. 2023. Science of the Total Environment; Schaeffer et al. 2022. Ecological Indicators; Coffer et al. 2021. Ecological Indicators and others…



Source: www.enviroatlas.epa.gov

Cyanobacteria in Lakes



Source: https://www.epa.gov/report-environment

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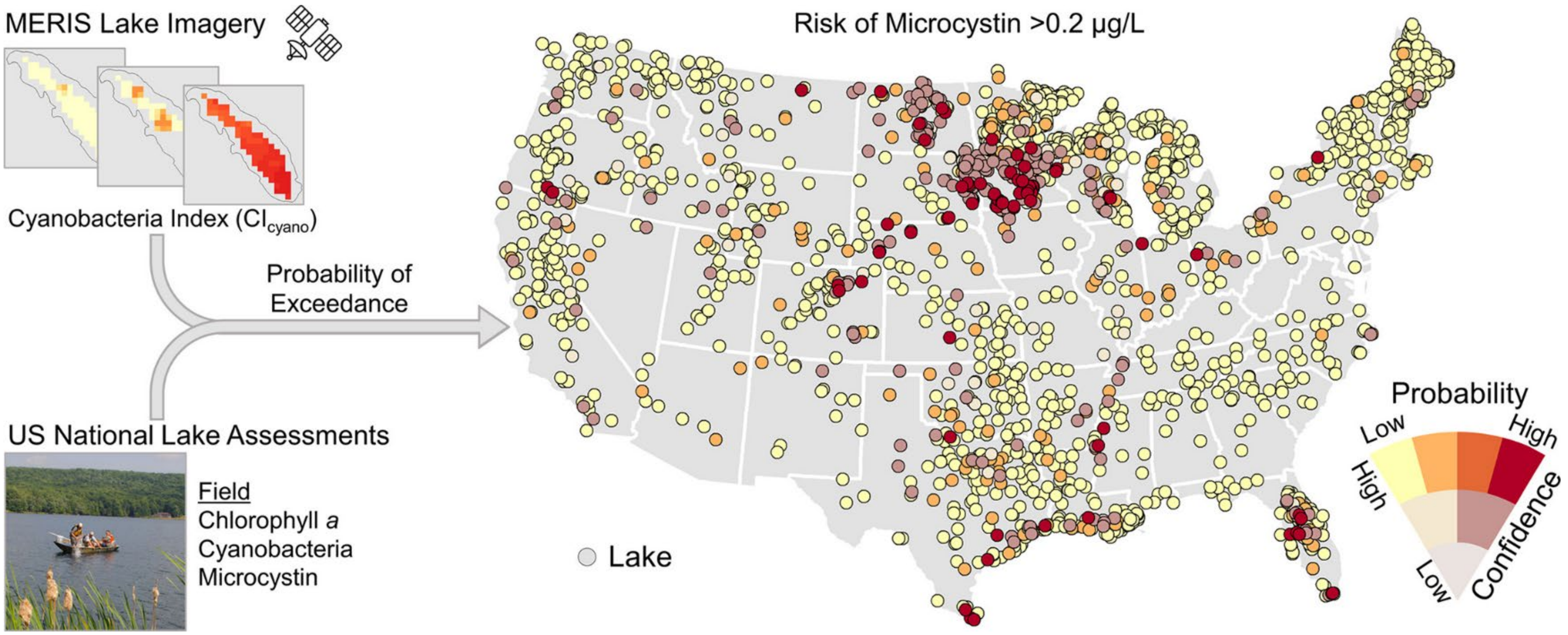
Scenario	Northeast Regional annual benefit
1 week/year reduction in cyanobacteria	$14,606,248

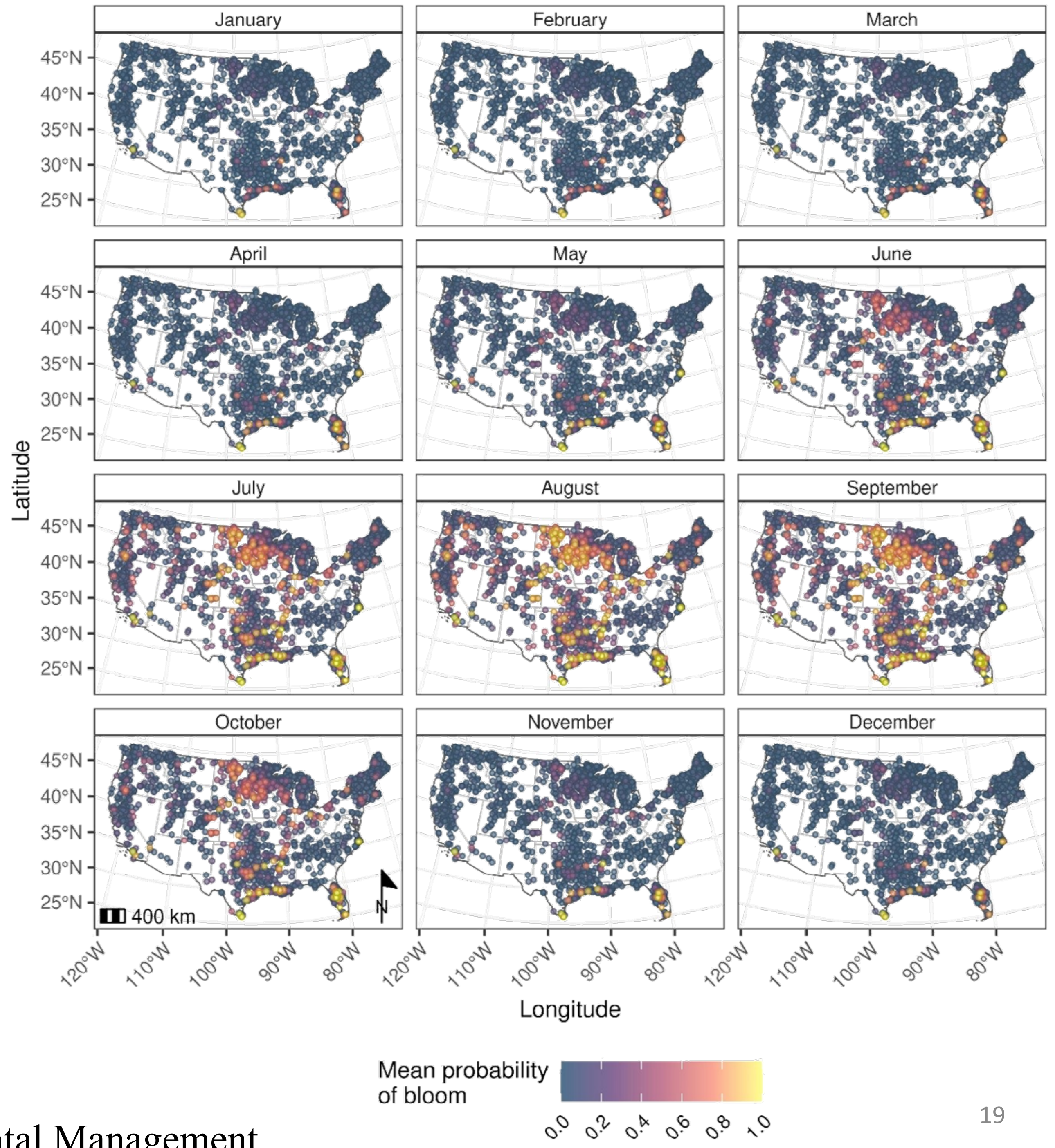
Source: Zhang et al. 2022. Ecological Economics



Source: Handler et al. 2023. Science of the Total Environment

What is next?

Metric	Prediction dataset (2021)
Sensitivity	0.88
Specificity	0.91
Accuracy	**0.90**



Source: Schaeffer et al. In Review. Journal of Environmental Management

What is next?

US Army Corps of Engineers®

NOAA

NASA

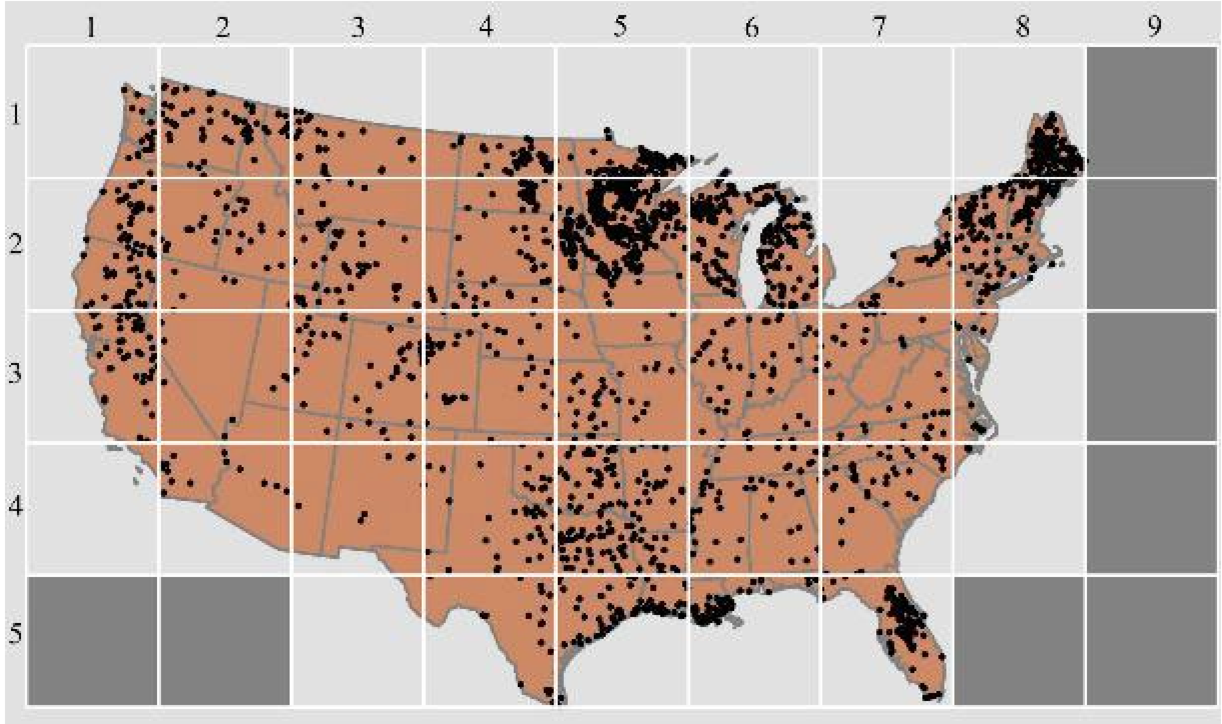
USGS
science for a changing world

NOAA
National Environmental Satellite Data and Information Service
DEPARTMENT OF COMMERCE

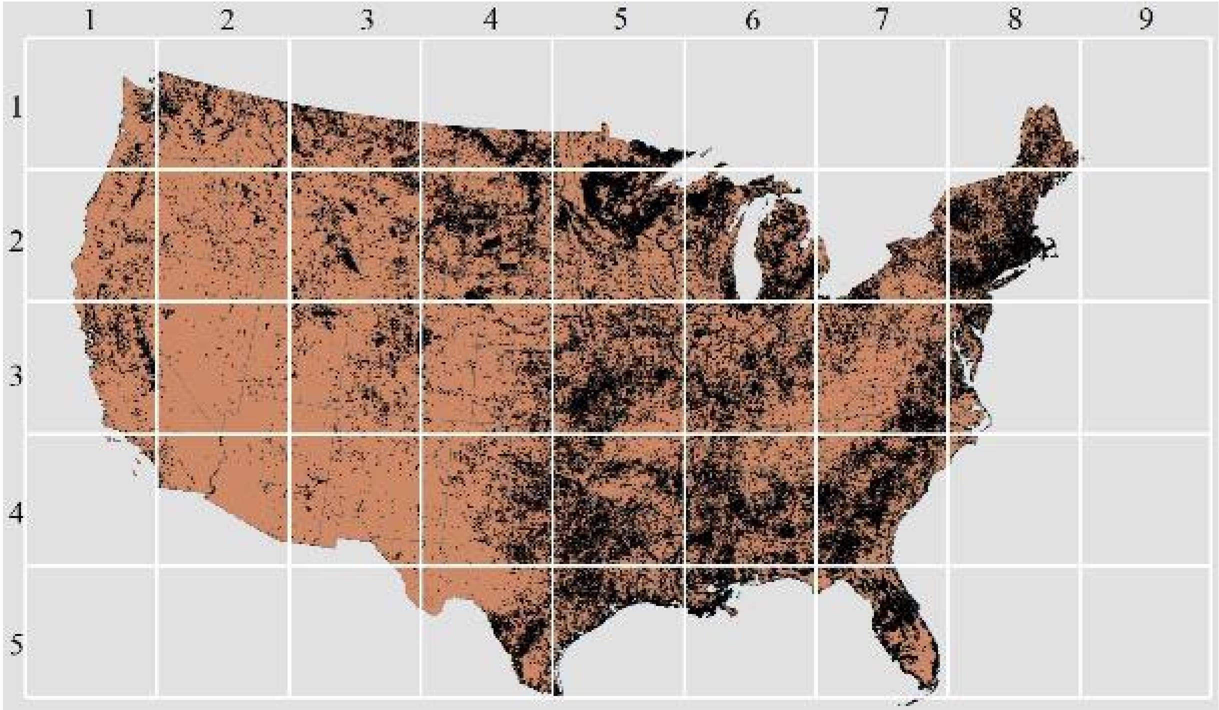
UNITED STATES • ENVIRONMENTAL PROTECTION AGENCY •

What is next?

Sentinel-3



Sentinel-2

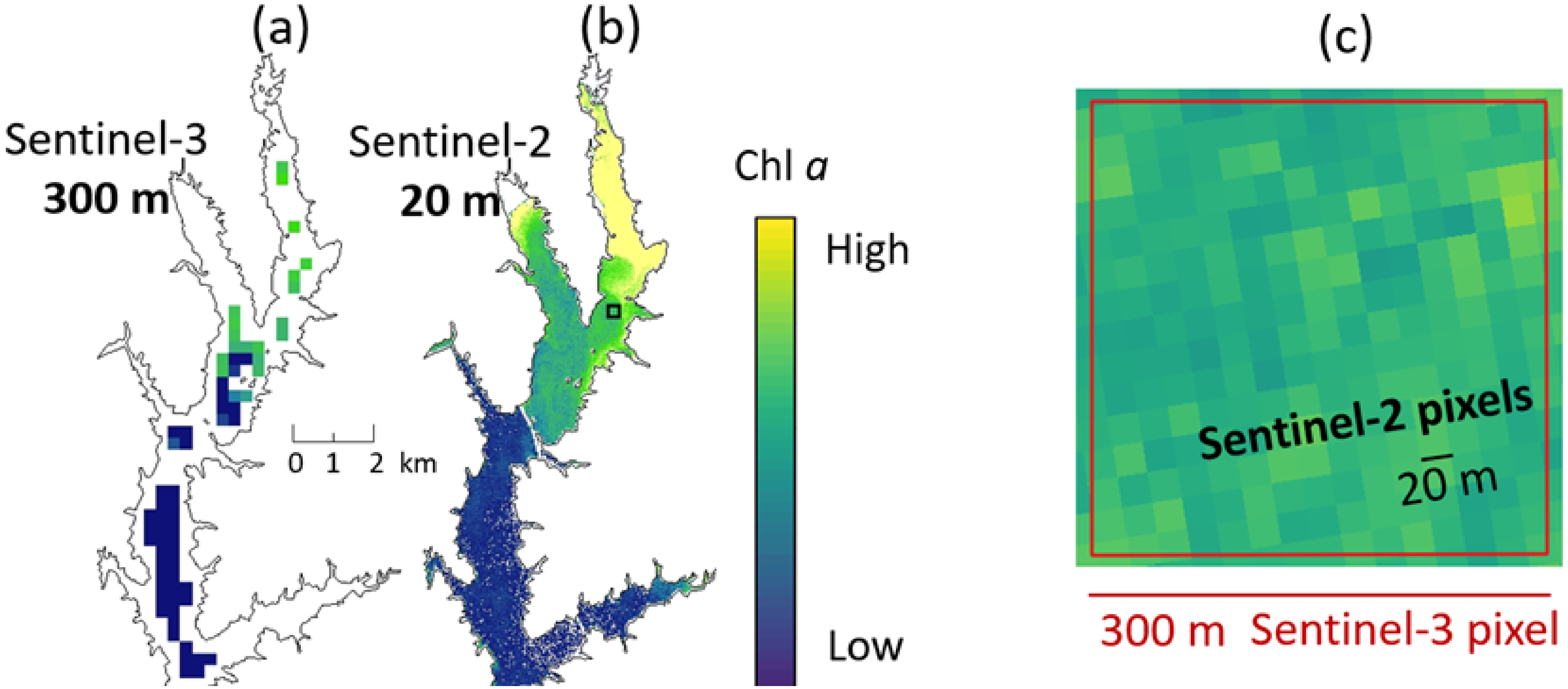


>270,000 (98%) lakes

Annual potential avoided costs ~$42 million/year

Sources: Clark et al. 2017. Ecological Indicators; Papenfus et al. 2020. Environmental Monitoring and Assessment

What is next?



Source: Salls et al. In Review. Environmental Monitoring and Assessment

Sample data

- **Date/Time** -
- **Latitude/Longitude** – Continental United States
- **Sampling Depth** – Prefer surface samples <2m
- **Sample Type** (Grab, Composite, Depth Integrated, Width Integrated, Depth-Width Integrated)
- **Variables**
  - Lab extracted chlorophyll-a (not sonde fluorescence data, ie. RFU) with method information and QC data preferred
  - Location typically toward center of the lake
  - Time typically mid-day between 10am-2pm local

Acknowledgements

Team:
Kurt Wolfe, Peter Whitman, Jeremy Werdell, Ryan Vandermeulen, Erin Urquhart, Michelle Tomlinson, Richard Stumpf, Deron Smith, Blake Schaeffer, Bridget Seegers, Wilson Salls, Joseph Salisbury, Natalie Reynolds, Rajbir Parmar, Michael Papenfus, Mark Myer, Sachidananda Mishra, Andrew Meredith, Antonio Mannino, Keith Loftin, Cindy Lebrasse, Darryl Keith, John Johnston, John Iiames, Chuanmin Hu, Elizabeth Hilborn, David Graybill, Hannah Ferriby, Boryana Efremova, John Darling, Robyn Conmy, Megan Coffer, Sean Bailey

Funding:
EPA Safe and Sustainable Water Resources Program
NASA Commercial Smallsat Data Acquisition Program
NASA Ocean Biology and Biogeochemistry Program
NASA Applied Sciences Program
NASA Commercial Smallsat Data Acquisition Program
USACE HAB Research and Development Initiative