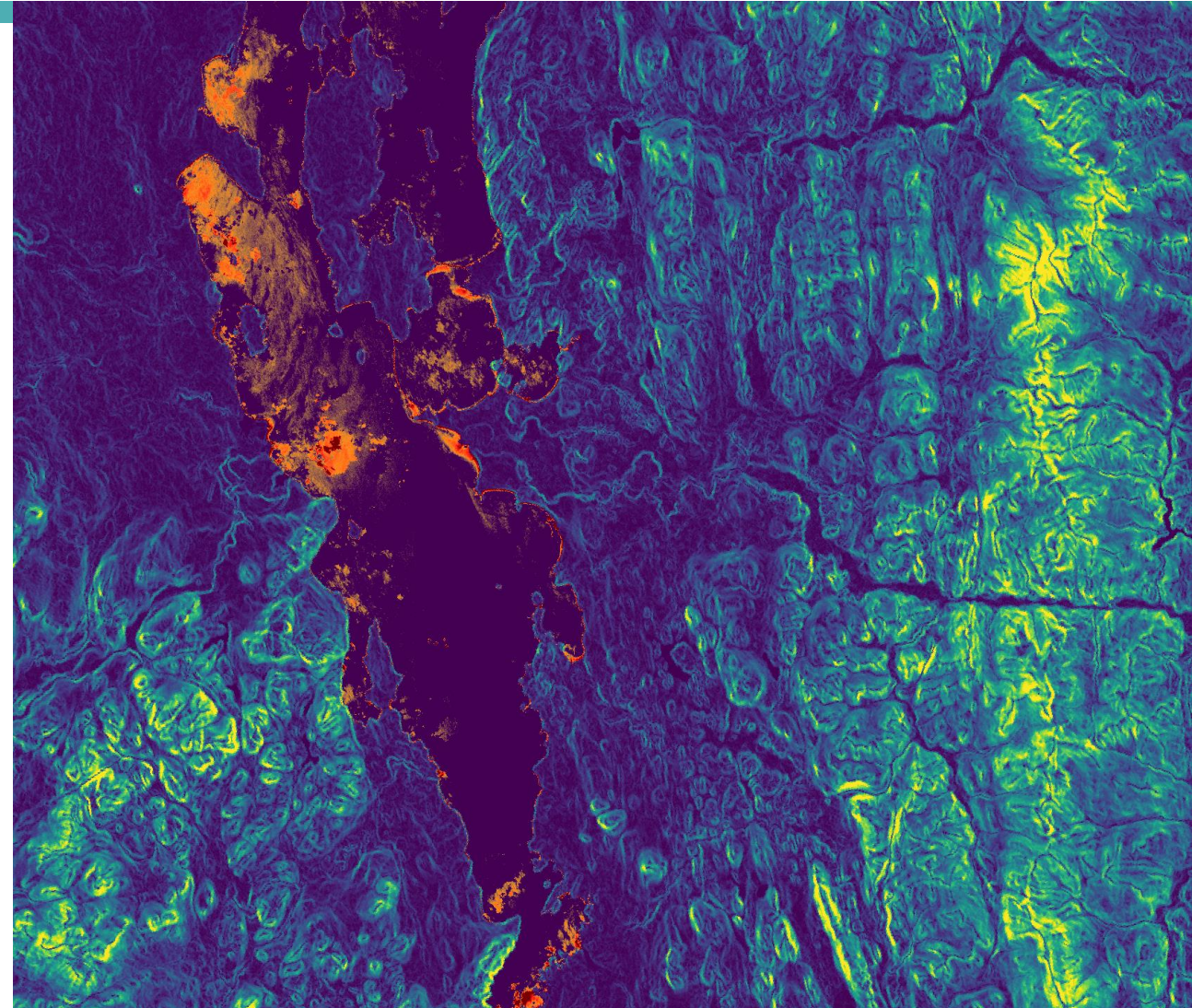
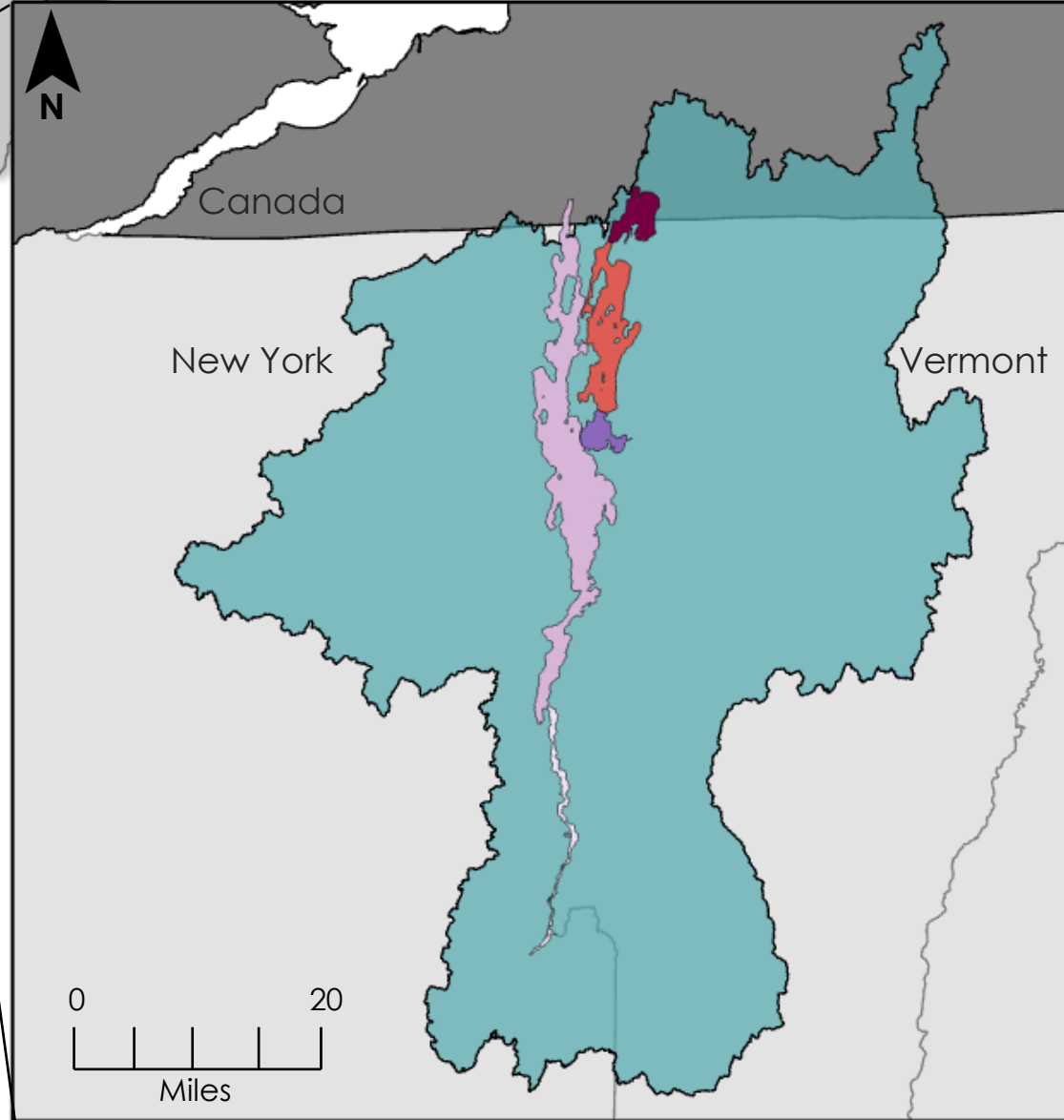
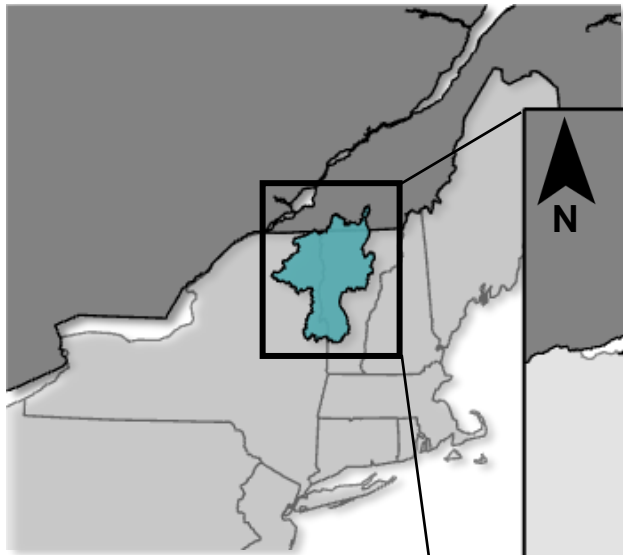










# Using NASA Earth Observations to Identify Spatial and Temporal Trends of Harmful Algal Blooms in Lake Champlain

Brianne Kendall, Laramie Plott, Aaron Carr, Ian Turner





-  Missisquoi Bay
-  Northeast Arm
-  Mallets Bay
-  Main Lake
-  South Lake
-  Lake Champlain Watershed

**Study Area:**  
Lake Champlain

**Study Period:**  
May 2016 – July 2022

**Partners:** Natural Resources Conservation Service: Northeast Region



# Harmful Algal Blooms

Dead Zone Formation



Credit: Nara Souza

Excessive Algae Growth



Credit: NRCS

Nutrient Pollution



Credit: Felix Andrews



Credit: Lake Champlain Basin Program



Credit: NOAA

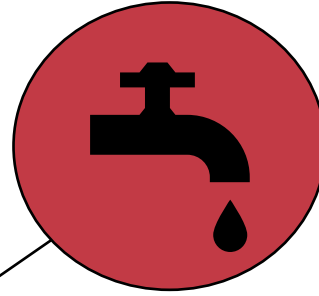
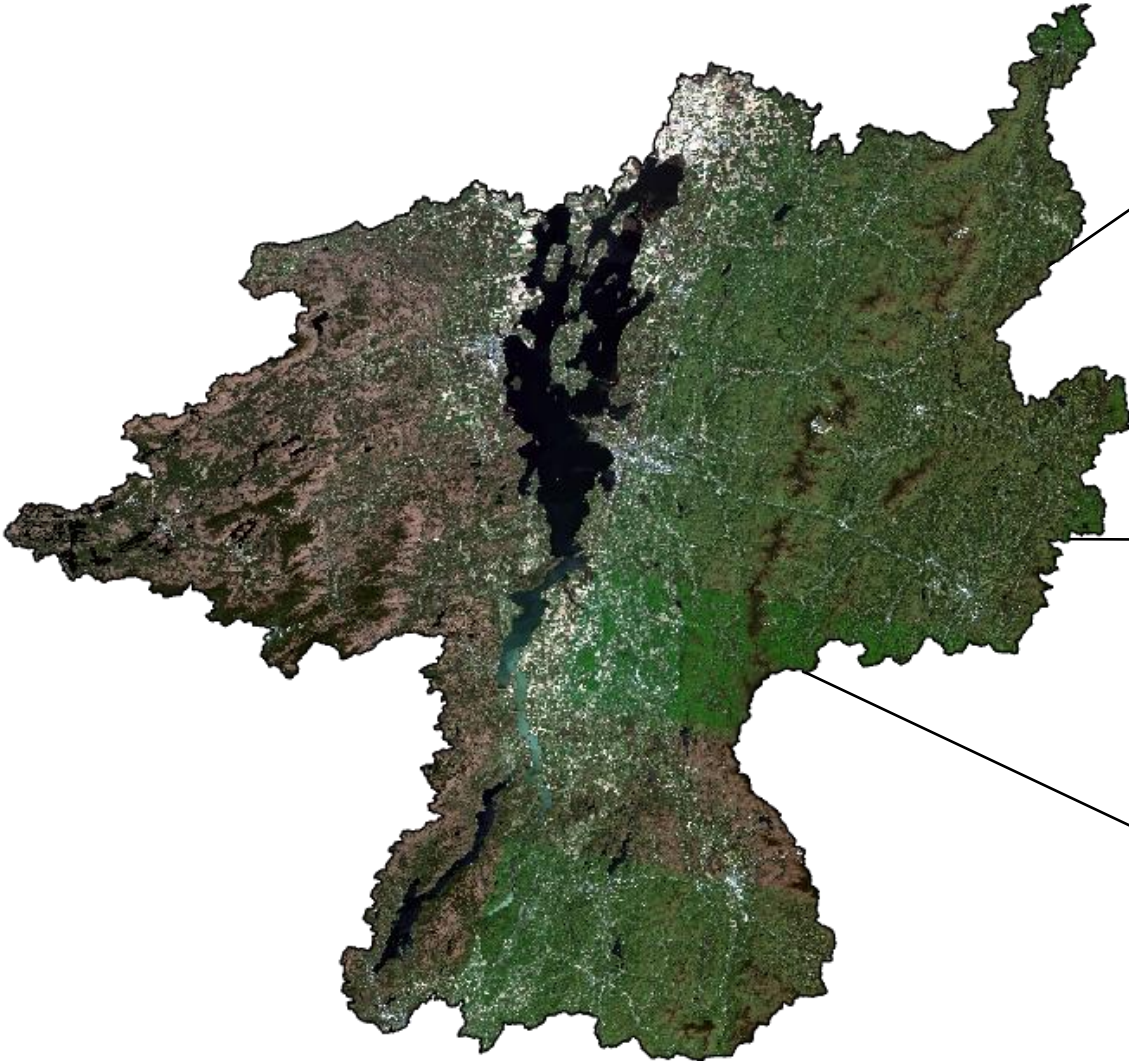


Credit: Wilfredo R. Rodriguez H.

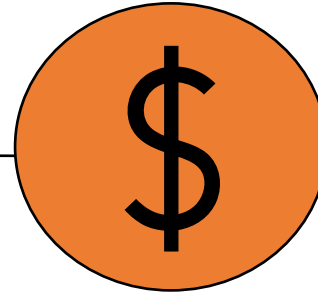


Credit: Lake Champlain Basin Program

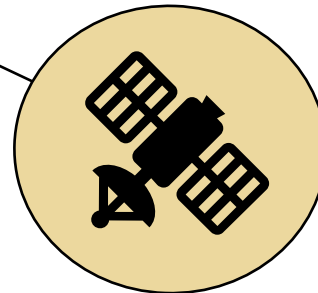
# Community Concerns



Contaminated drinking water for 200,000 individuals

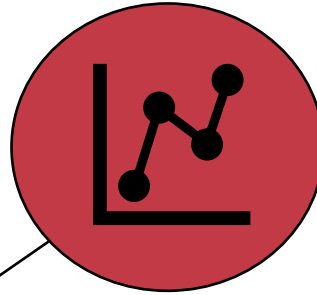
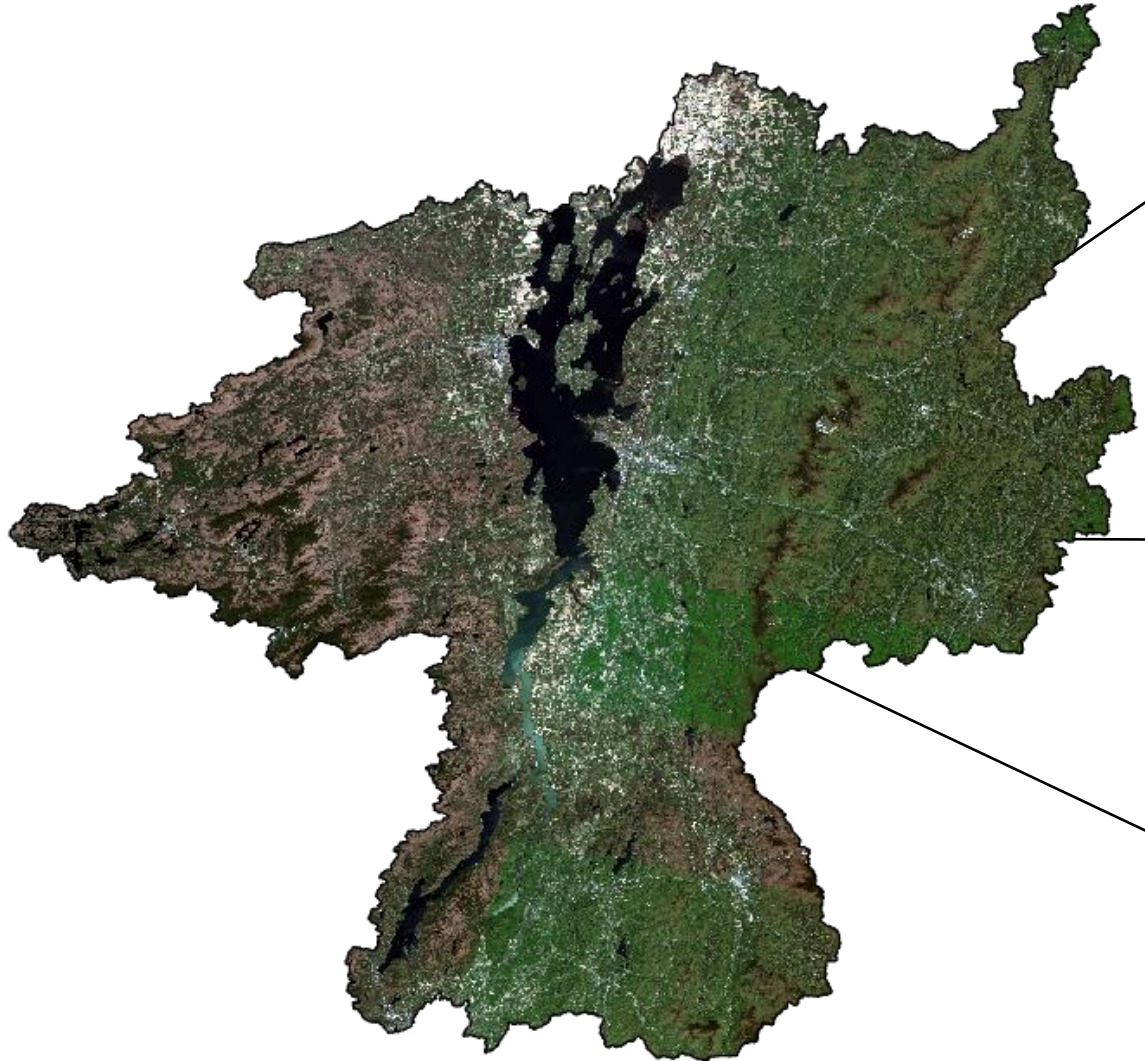


Negative impacts on recreational tourism

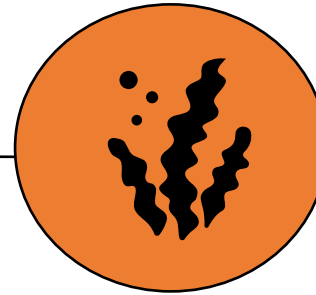


Phosphorus sources are difficult to pinpoint and manage

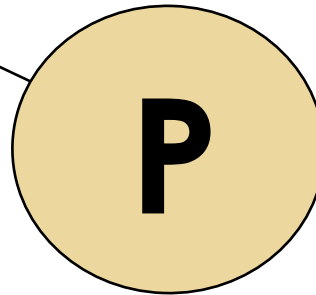
# Objectives



Generate historic algal events time series analysis

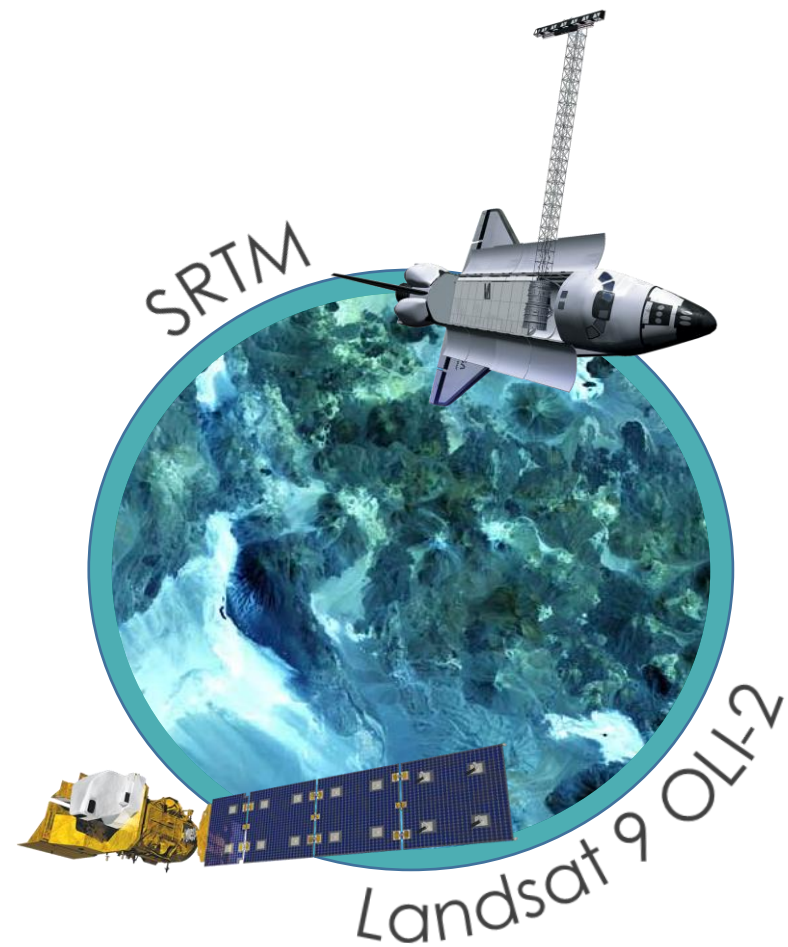
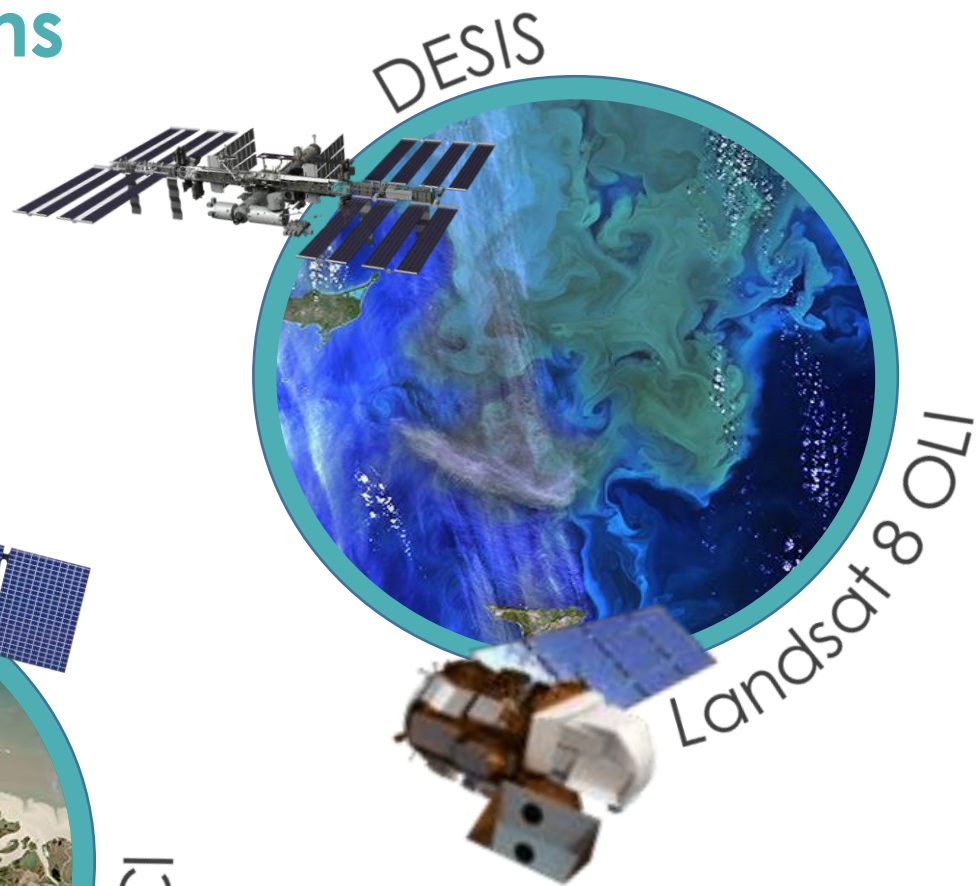
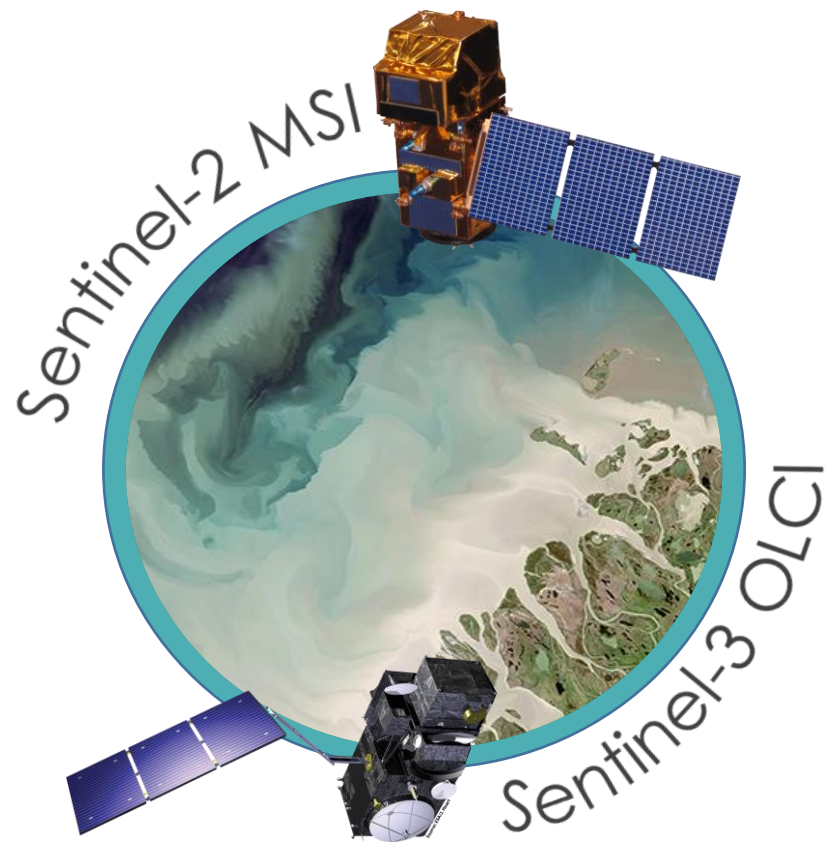


Analyze recent cyanobacteria concentration maps



Produce phosphorus runoff potential map

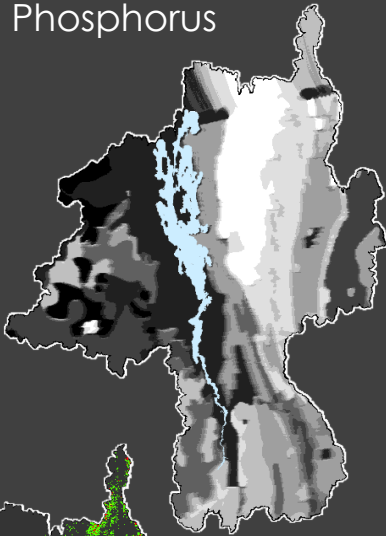
# Earth Observations



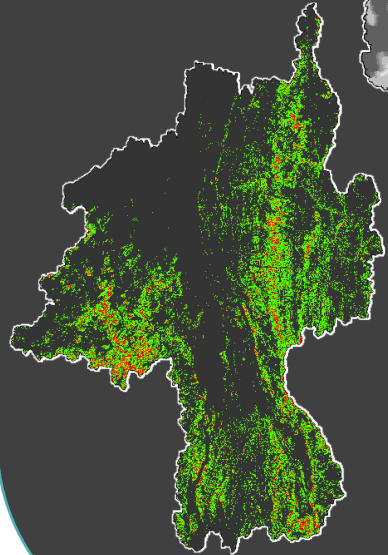
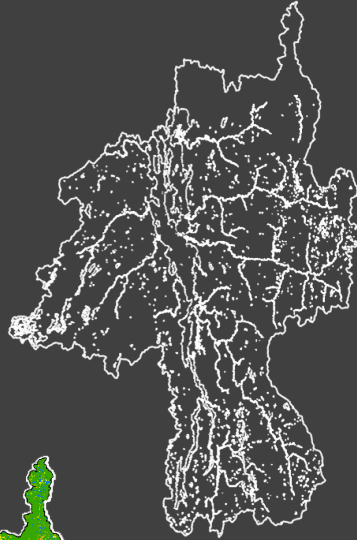
# Methodology – Phosphorus Runoff

## Identify Risk Factors

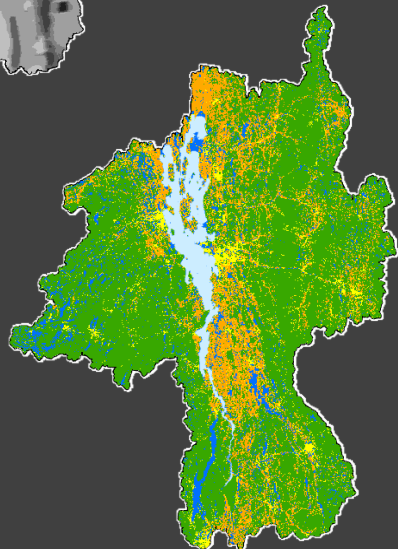
Soil Phosphorus



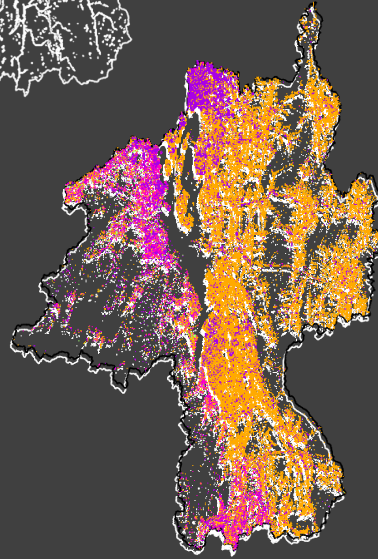
Distance to Water



Slope

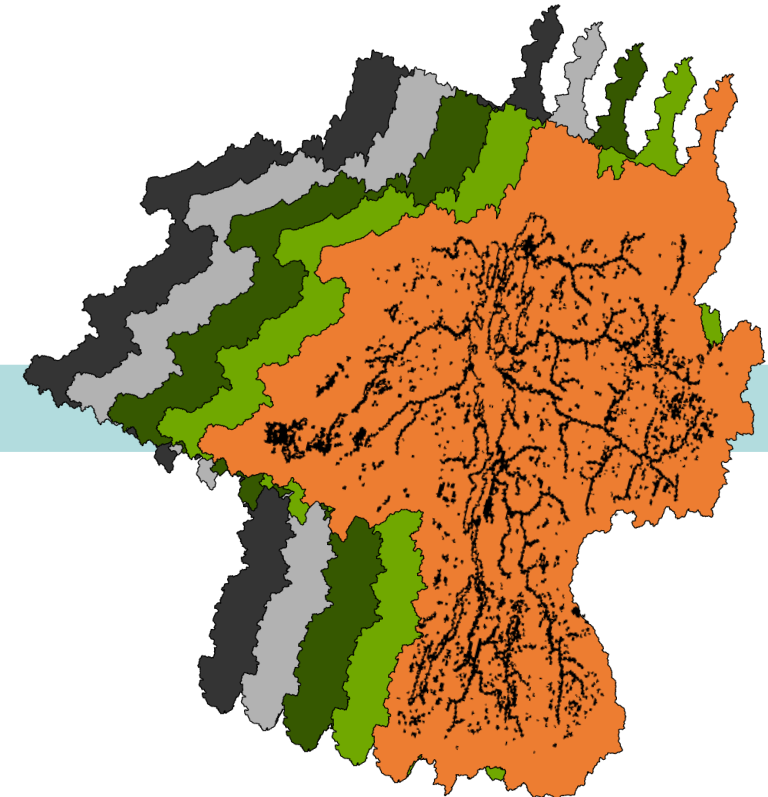


Landcover



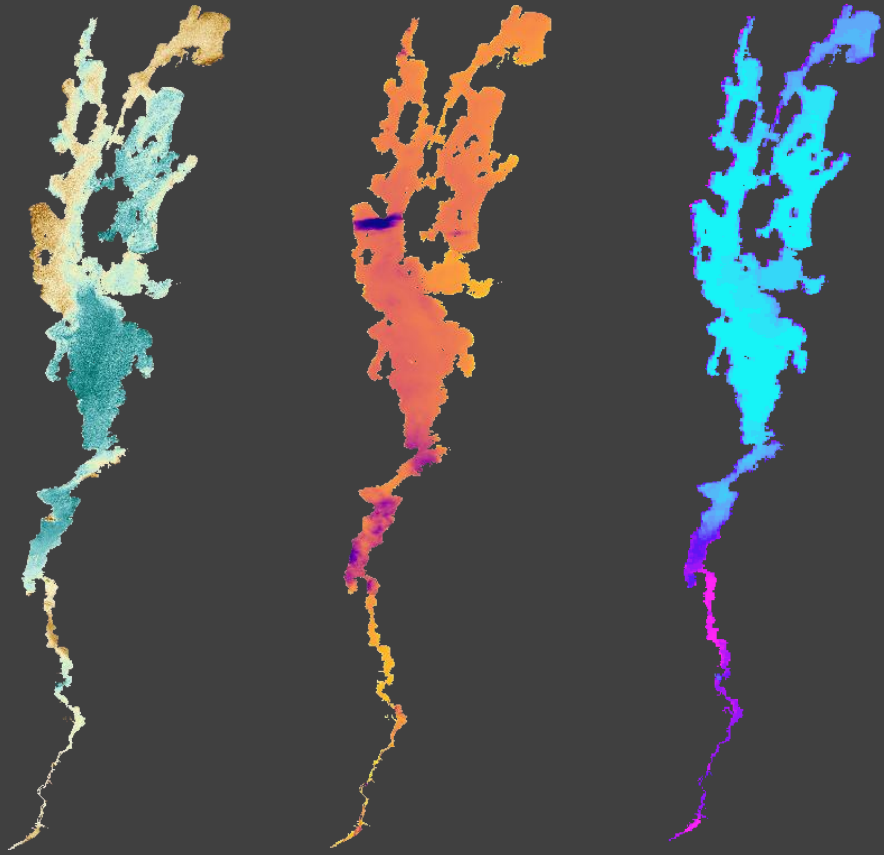
Crop Type

## Overlay Risk Factors



# Methodology – Algal Blooms

**Identify** Historic Algal Trends



Turbidity

Temperature

Cyanobacteria

**Create** Time Series



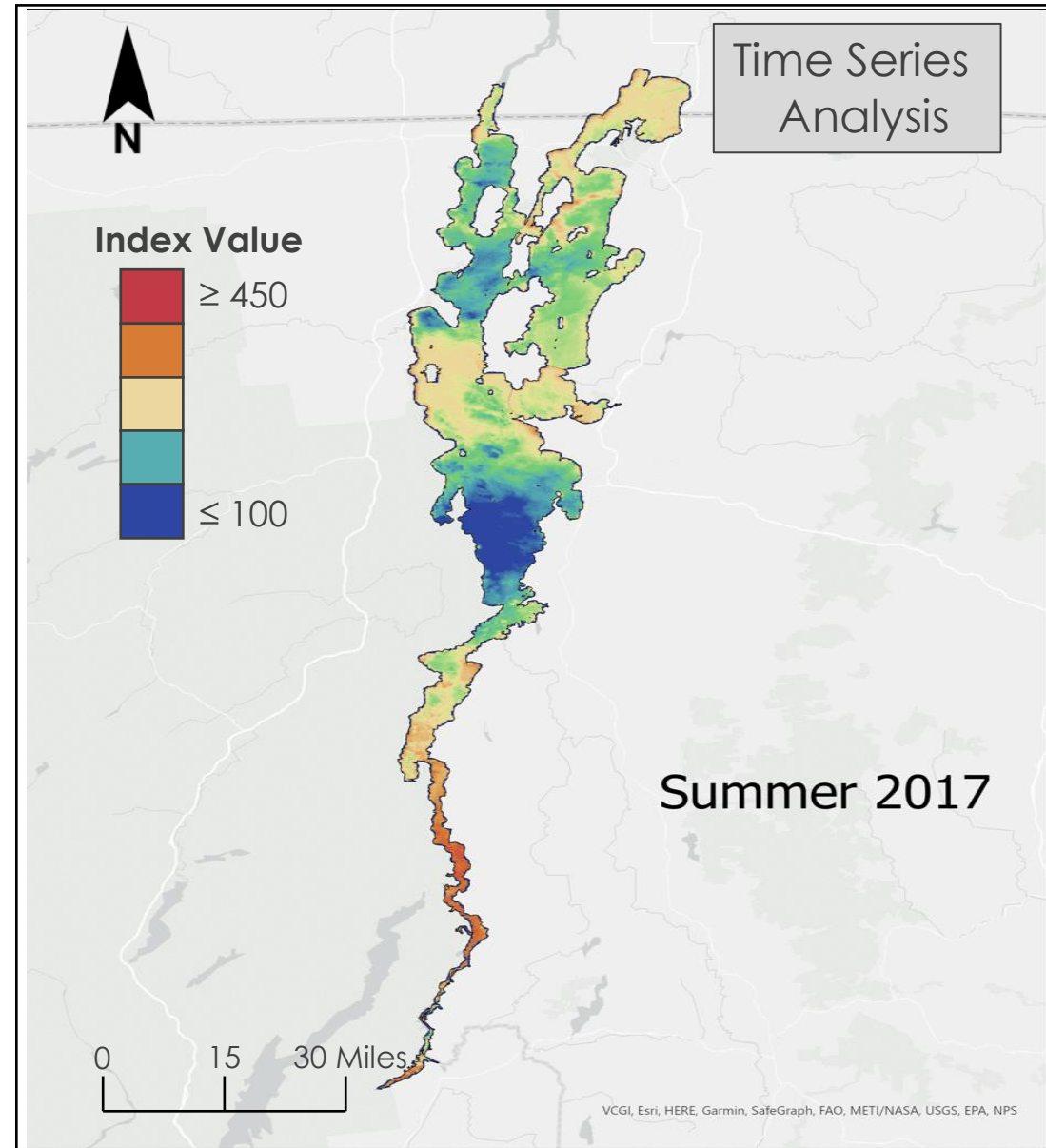
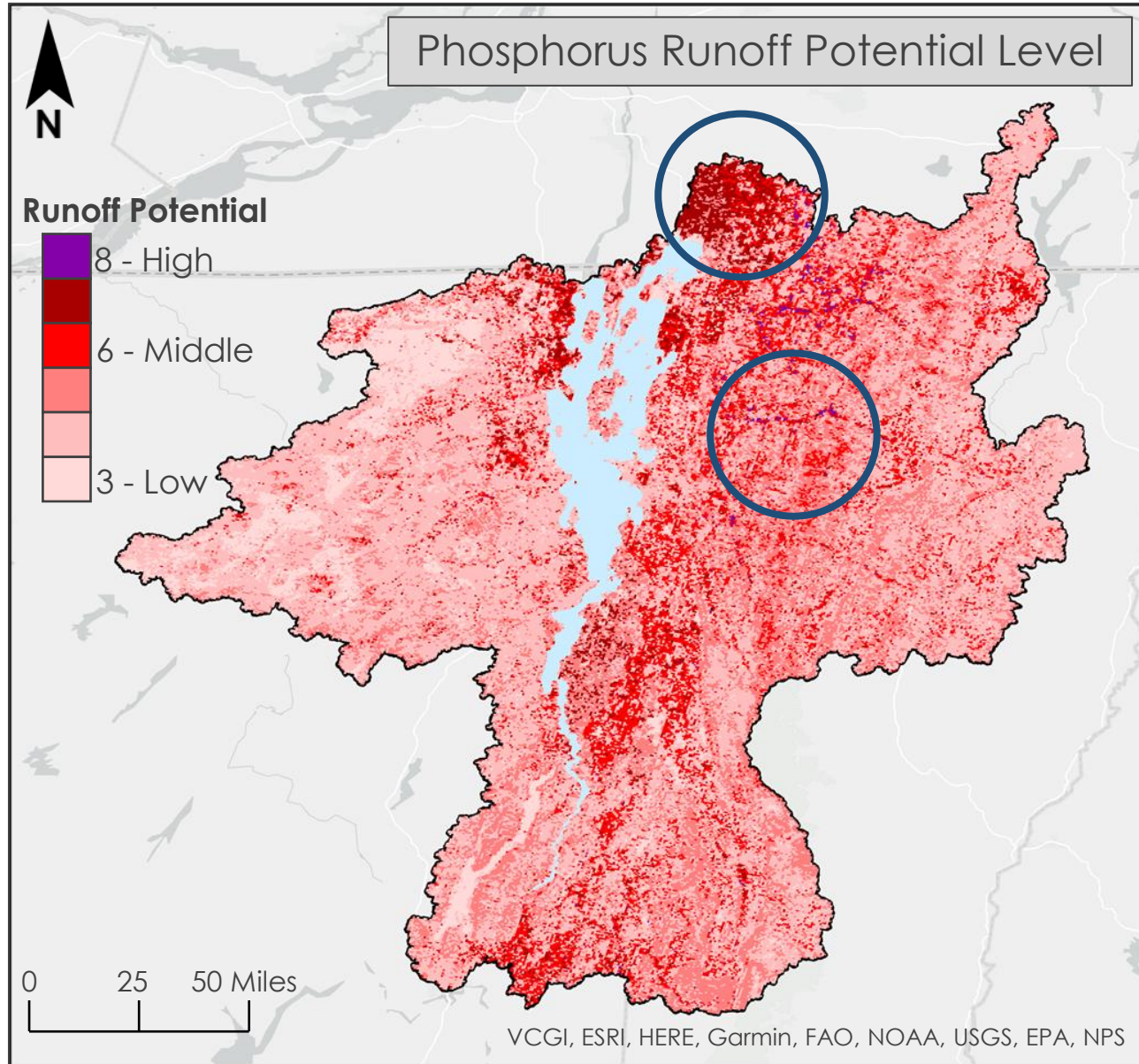
**Localize** Bloom Patterns



Cyanobacteria  
Concentrations



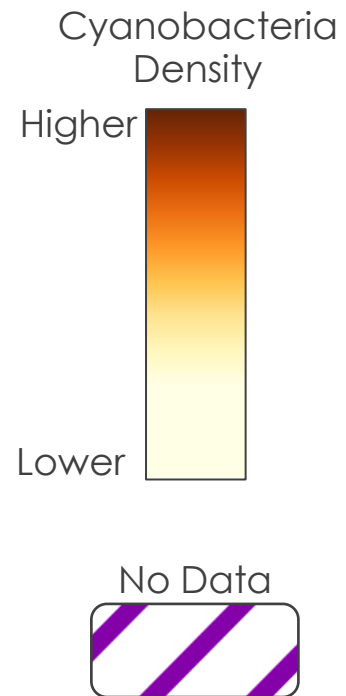
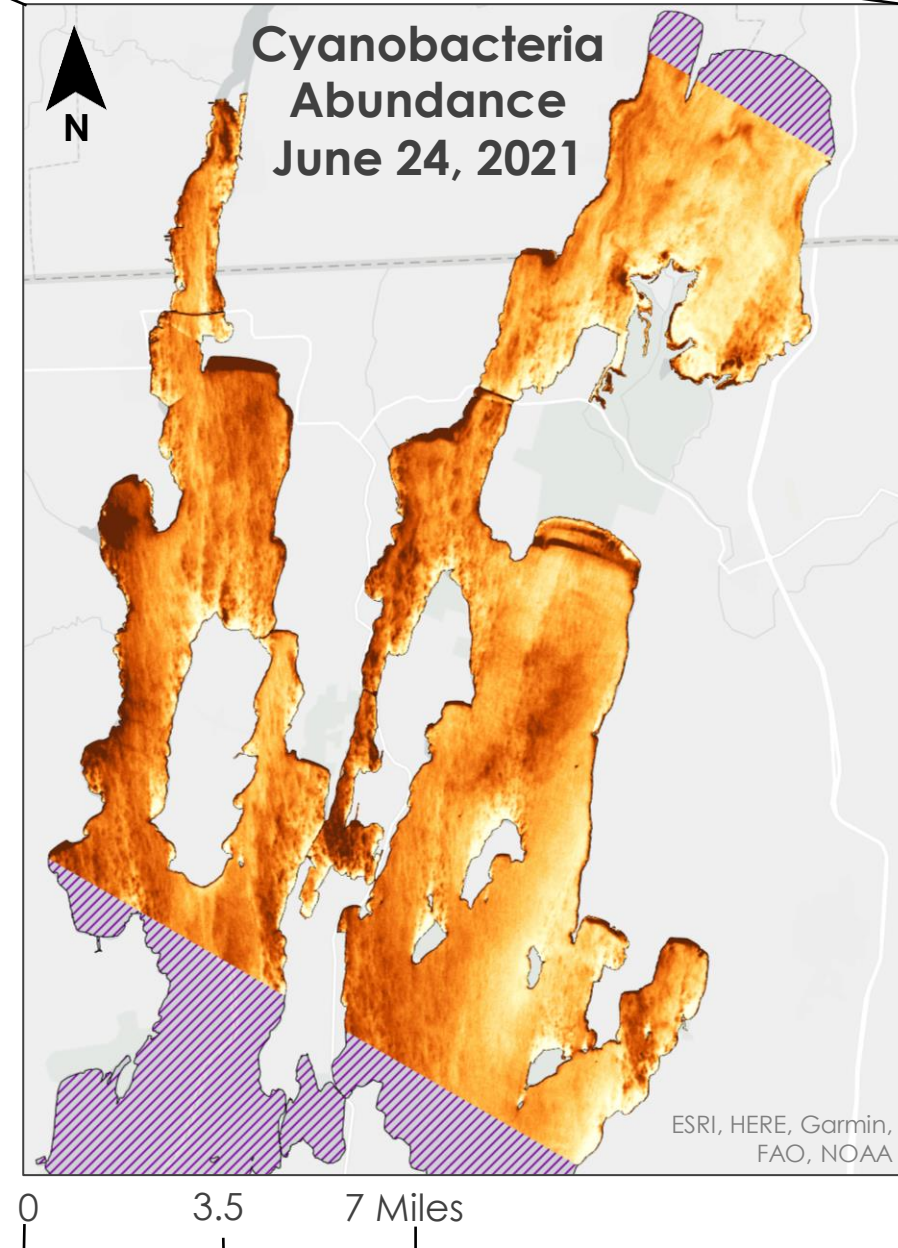
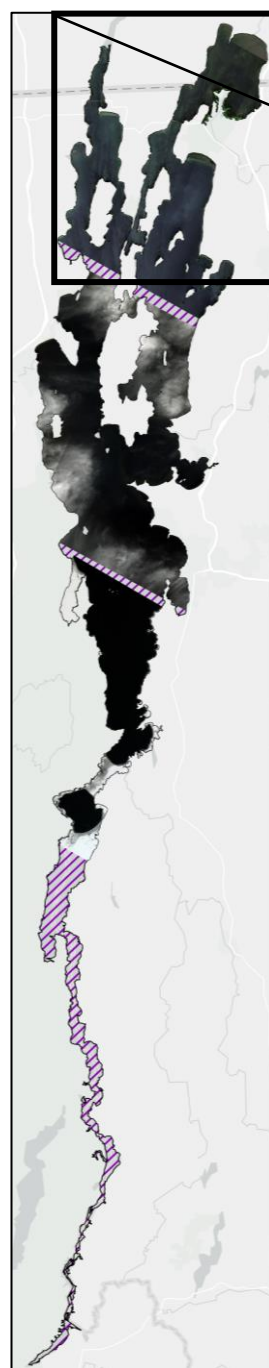
# Results – Phosphorus Runoff



# Results – Algal Blooms

## DESI limitations

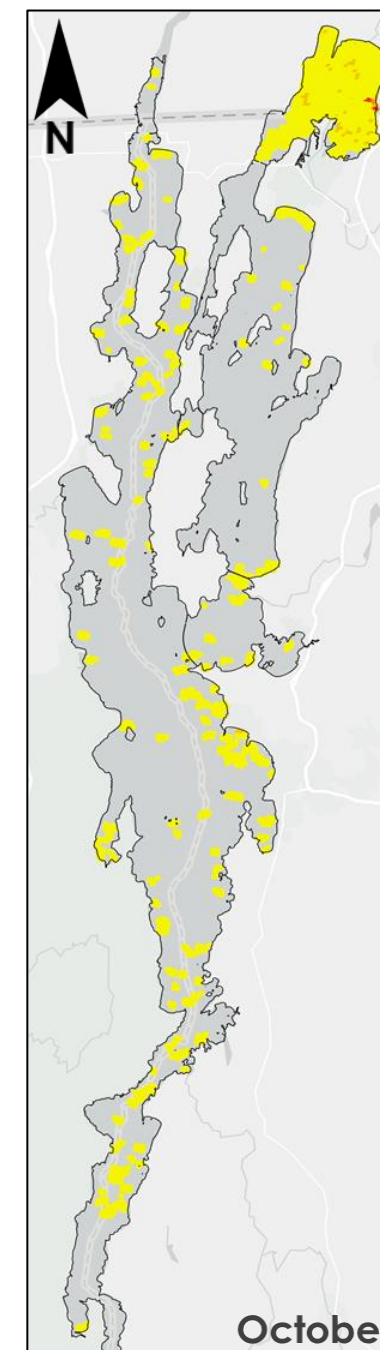
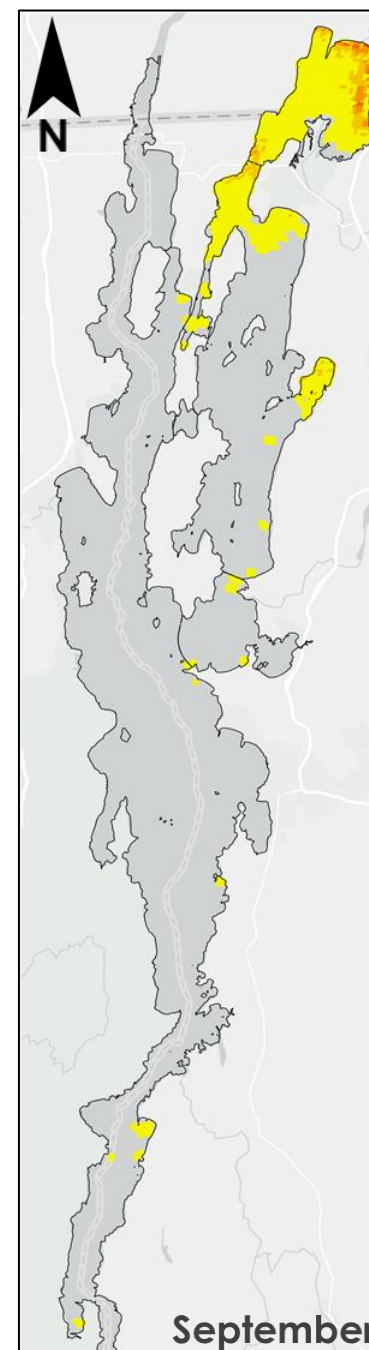
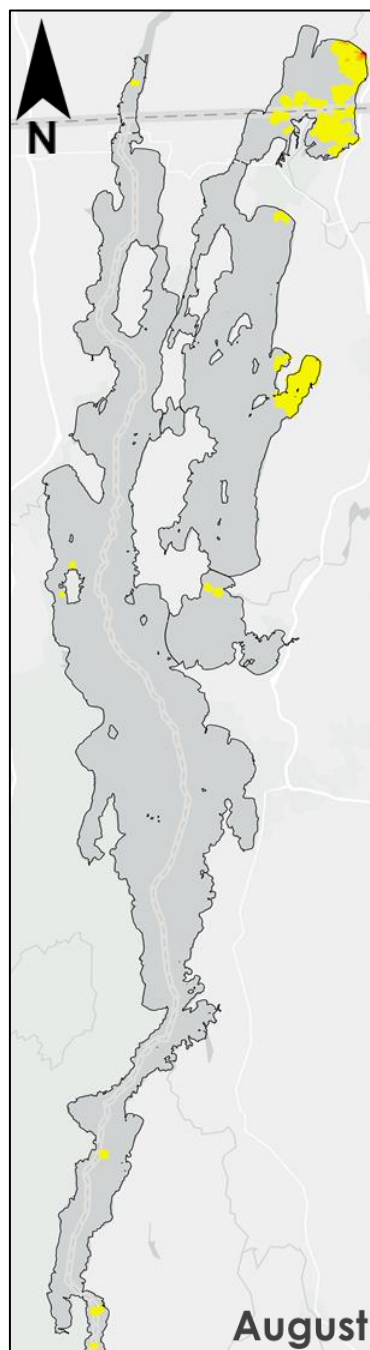
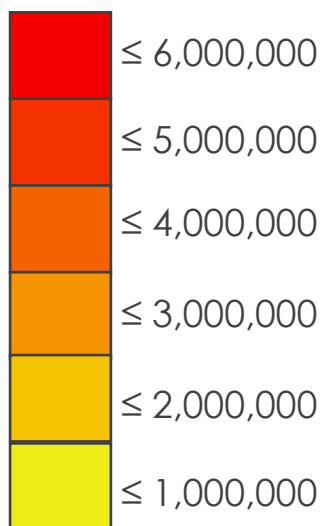
- ▶ Image availability
  - ▶ Ice
  - ▶ Clouds
  - ▶ Frequency
- ▶ Transitioning image processing
  - ▶ Quality flags
  - ▶ Criterion exclusion



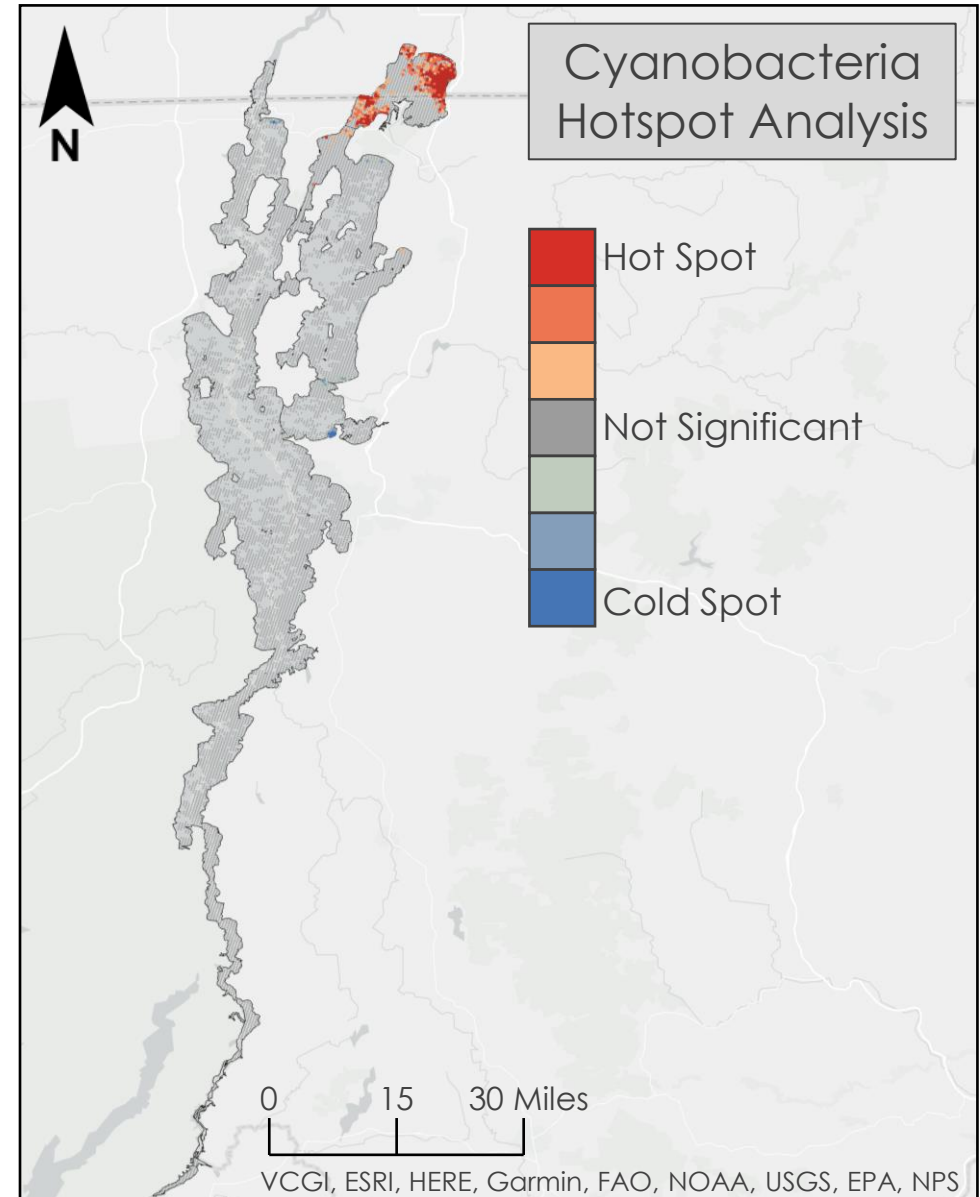
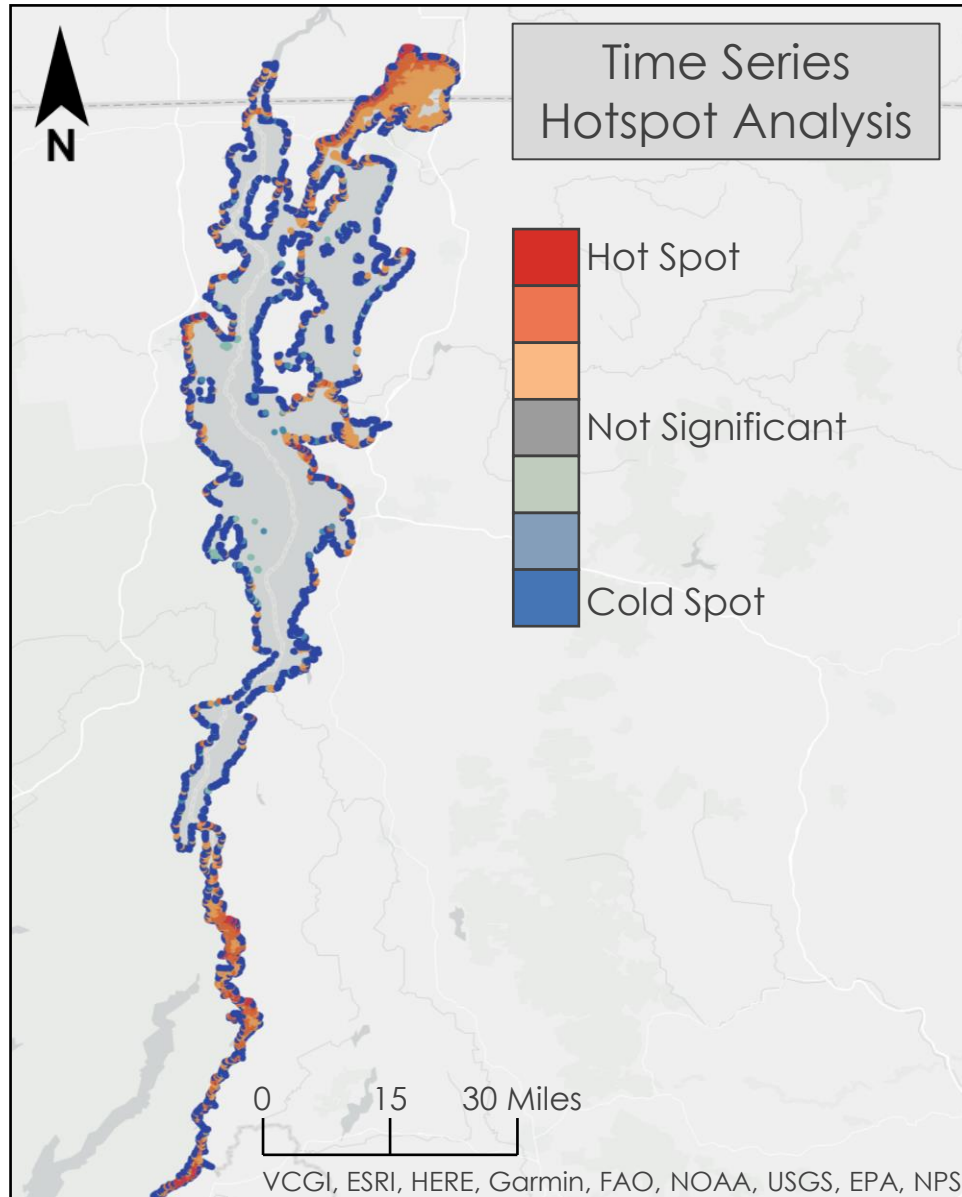
# Results – Algal Blooms

## Cyanobacteria Events - 2017

Cyanobacteria Density (cells/mL)

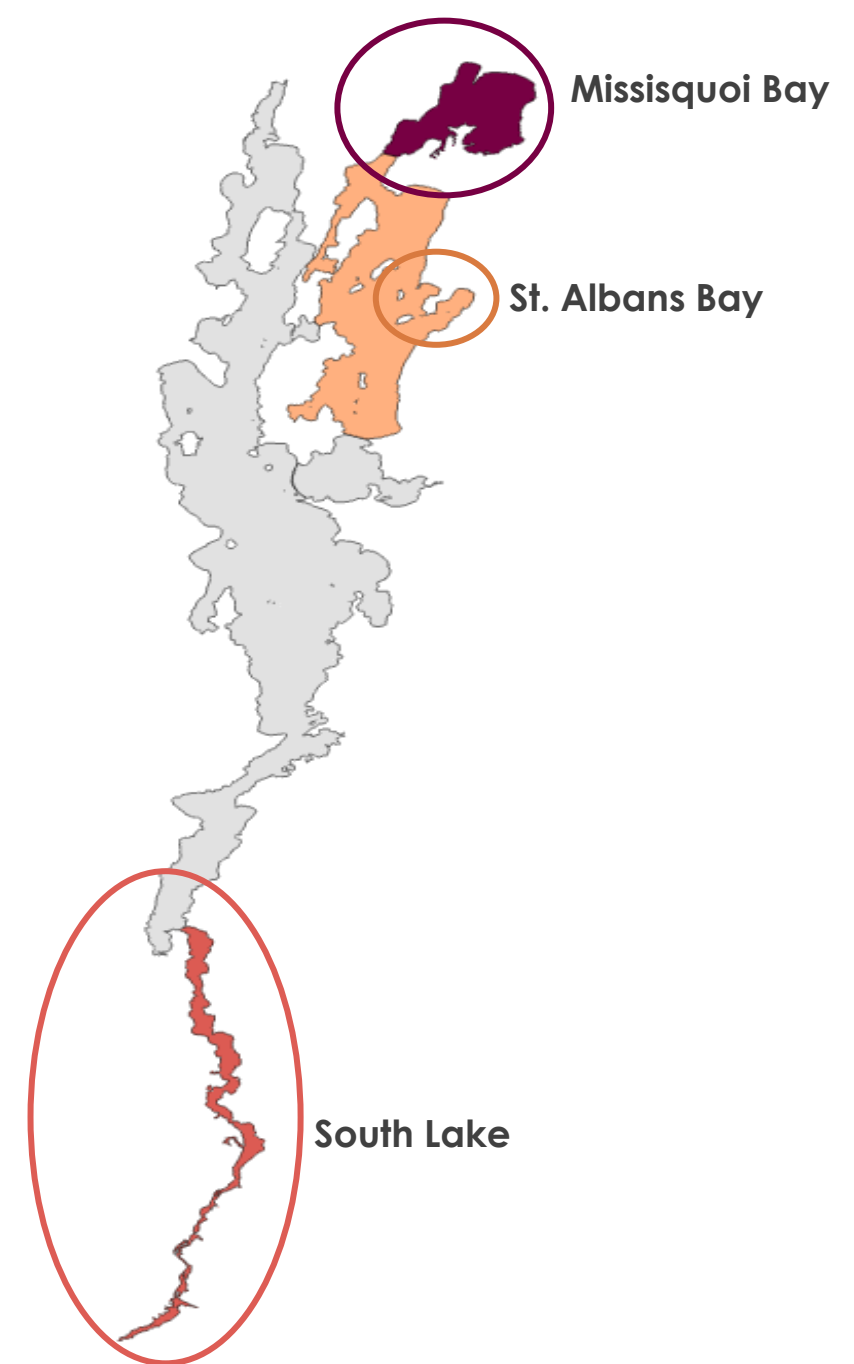


# Results – Hot Spot Analysis

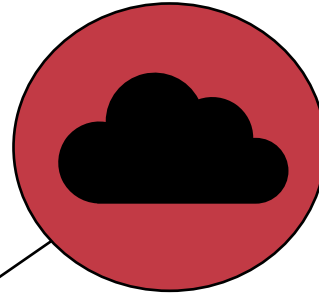
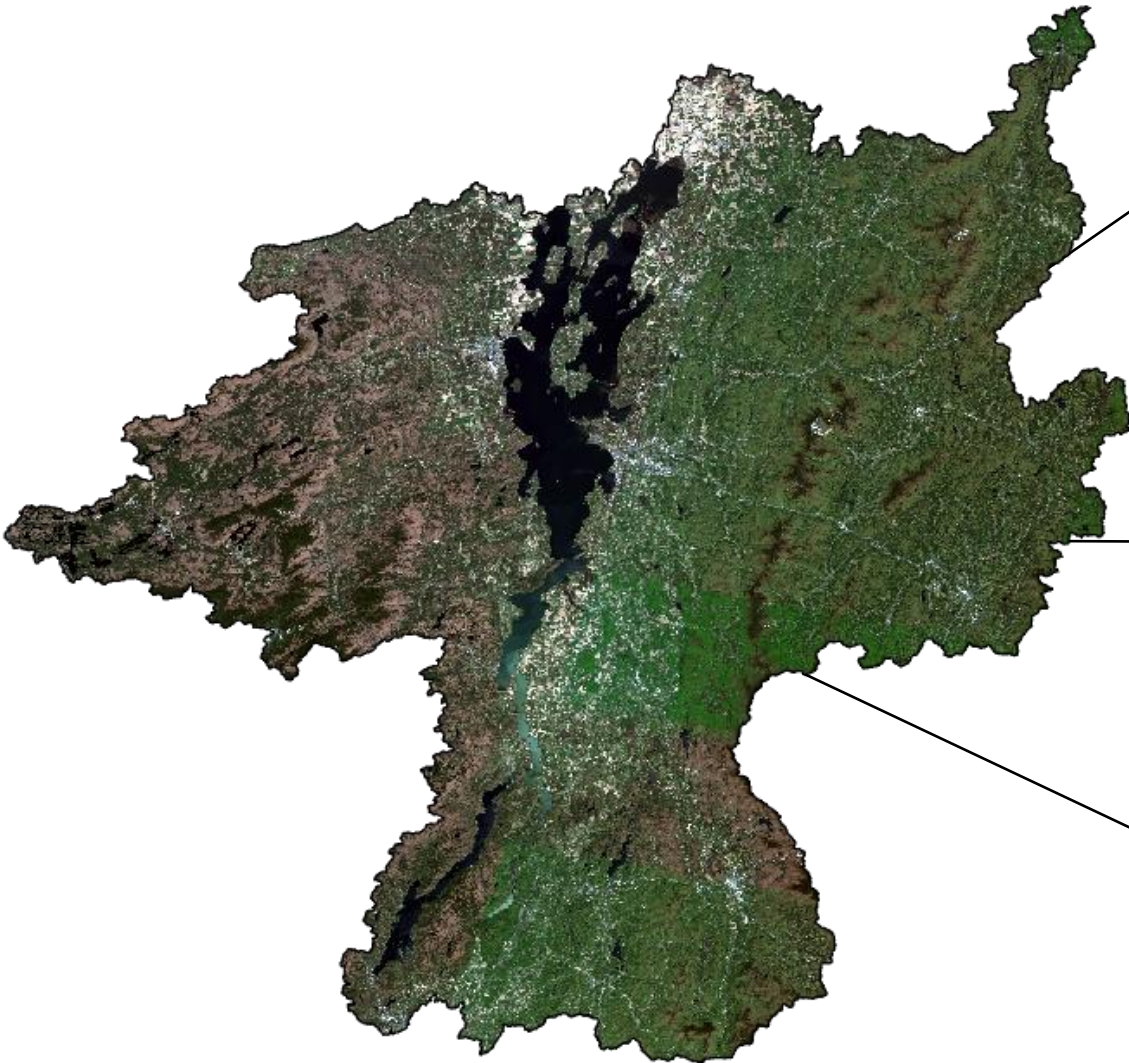


# Conclusions

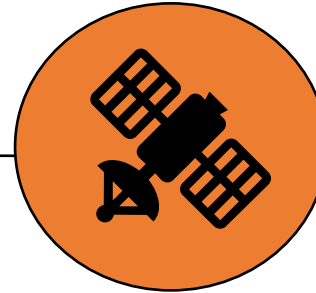
- ▶ Cyanobacteria blooms proliferate through June and July and **peak in August**.
- ▶ **Summer 2016 and 2021** exhibited the most severe bloom events.
- ▶ The greatest concentrations of cyanobacteria from 2016–2022 occurred within **Missisquoi Bay and St. Albans Bay** ( $\leq 7$  million cells/mL). **South Lake** also presented the right conditions for cyanobacteria blooms.
- ▶ **16%** of the entire watershed is classified as **areas of greatest concern**.
- ▶ The **Missisquoi Bay sub-watershed** presents the greatest threat to the lake, with 229,044 acres (~30%) being classified  $\geq 6$  phosphorus runoff potential



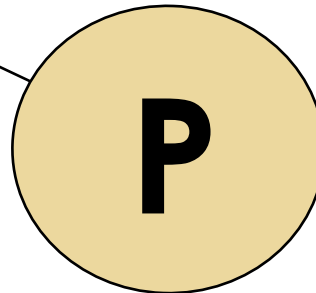
# Errors and Uncertainties



Sentinel-3 cloud masking uncertainty



Lack of spectral and in-situ data



Phosphorus extrapolation into Quebec

# Future Work

Wetlands as phosphorus sinks

DESIIS vs. Sentinel-3 OLCI

Lake Champlain drainage basin



# ACKNOWLEDGEMENTS

## Fellow

- ▶ Paxton LaJoie

## Partners

USDA Natural Resources Conservation Service:  
Northeast Region

- ▶ Luis Hernandez
- ▶ Matthew Havens
- ▶ Zachary Warning
- ▶ Rebecca Fox
- ▶ Lisa Duriancik
- ▶ Travis Thomason
- ▶ Joe Buford
- ▶ Maggie Payne
- ▶ Jessica Philippe
- ▶ John Vanhoesen

## Science Advisors

- ▶ Dr. Robert Griffin, The University of Alabama in Huntsville
- ▶ Dr. Jeffrey Luvall, NASA Marshall Space Flight Center

## Other

- ▶ Dr. Kenton Ross, NASA Langley Research Center
- ▶ Dr. Joshua Faulkner, The University of Vermont
- ▶ Ryan Mitchell, Lake Champlain Basin Program
- ▶ Dr. Blake Schaeffer, Environmental Protection Agency

This material contains modified Copernicus Sentinel data (2016-2022), processed by ESA.

*This material is based upon work supported by NASA through contract NNL16AA05C. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.*



# Questions