

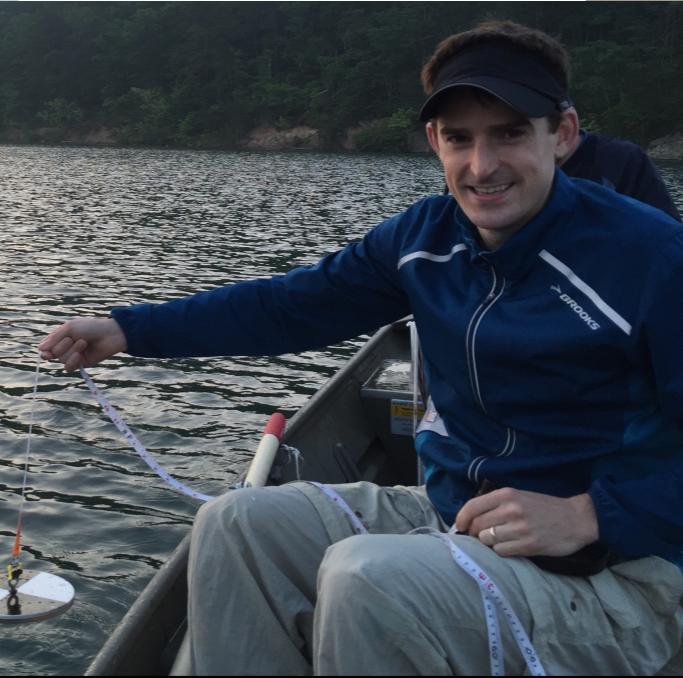
# Integrating sensor networks and real-time ecological forecasting to adaptively manage water quality

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Whitney  
Woelmer



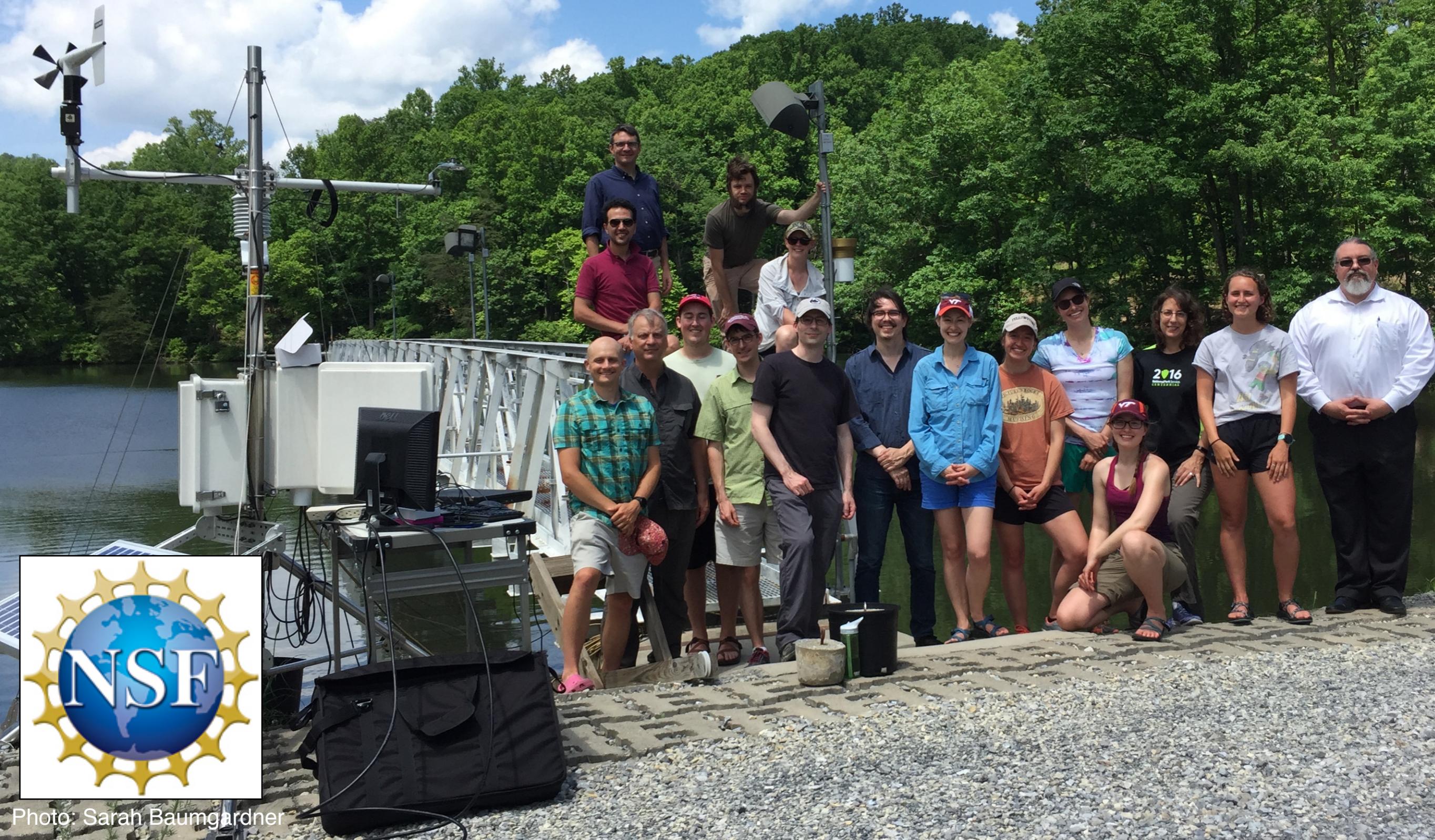
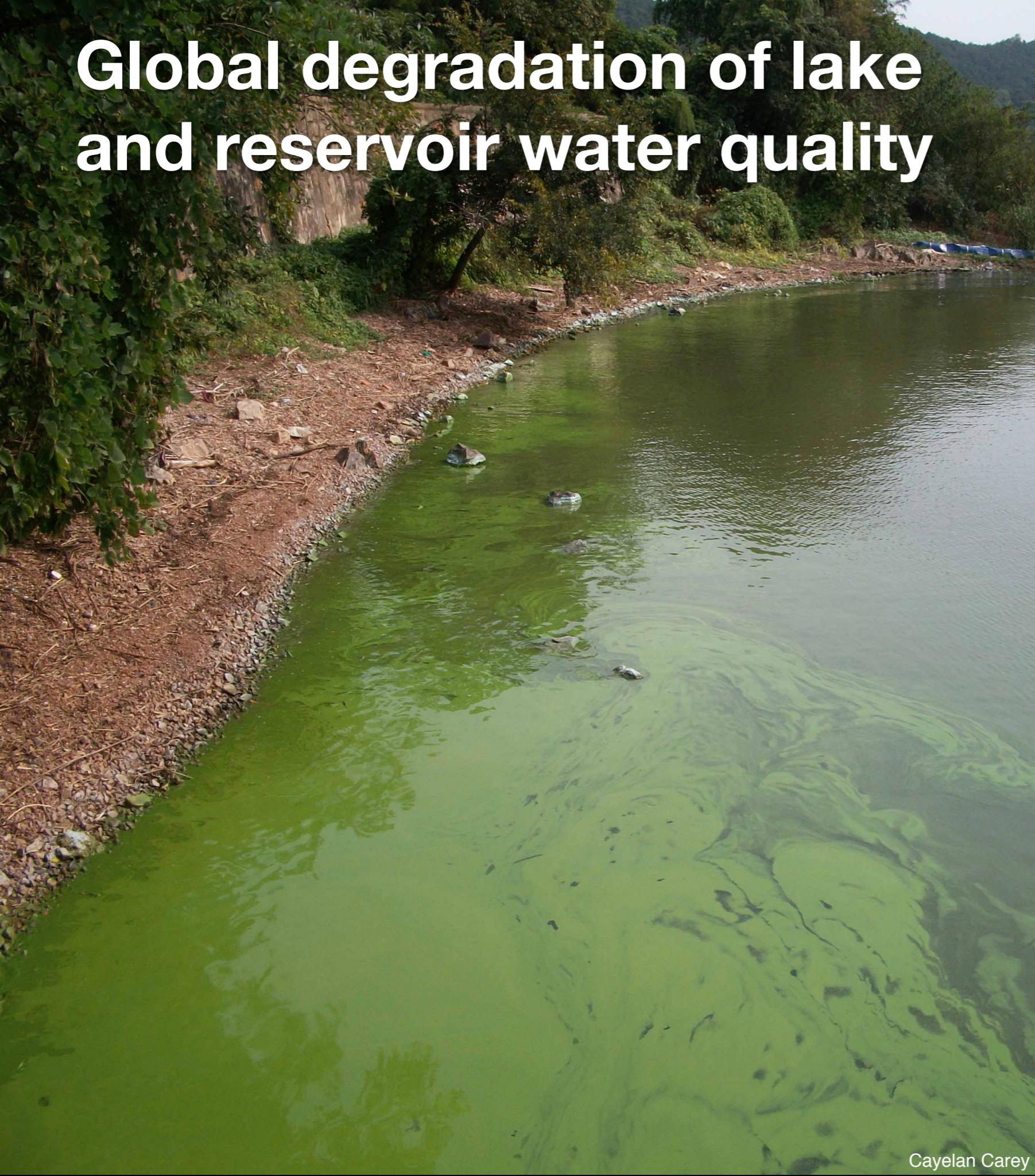
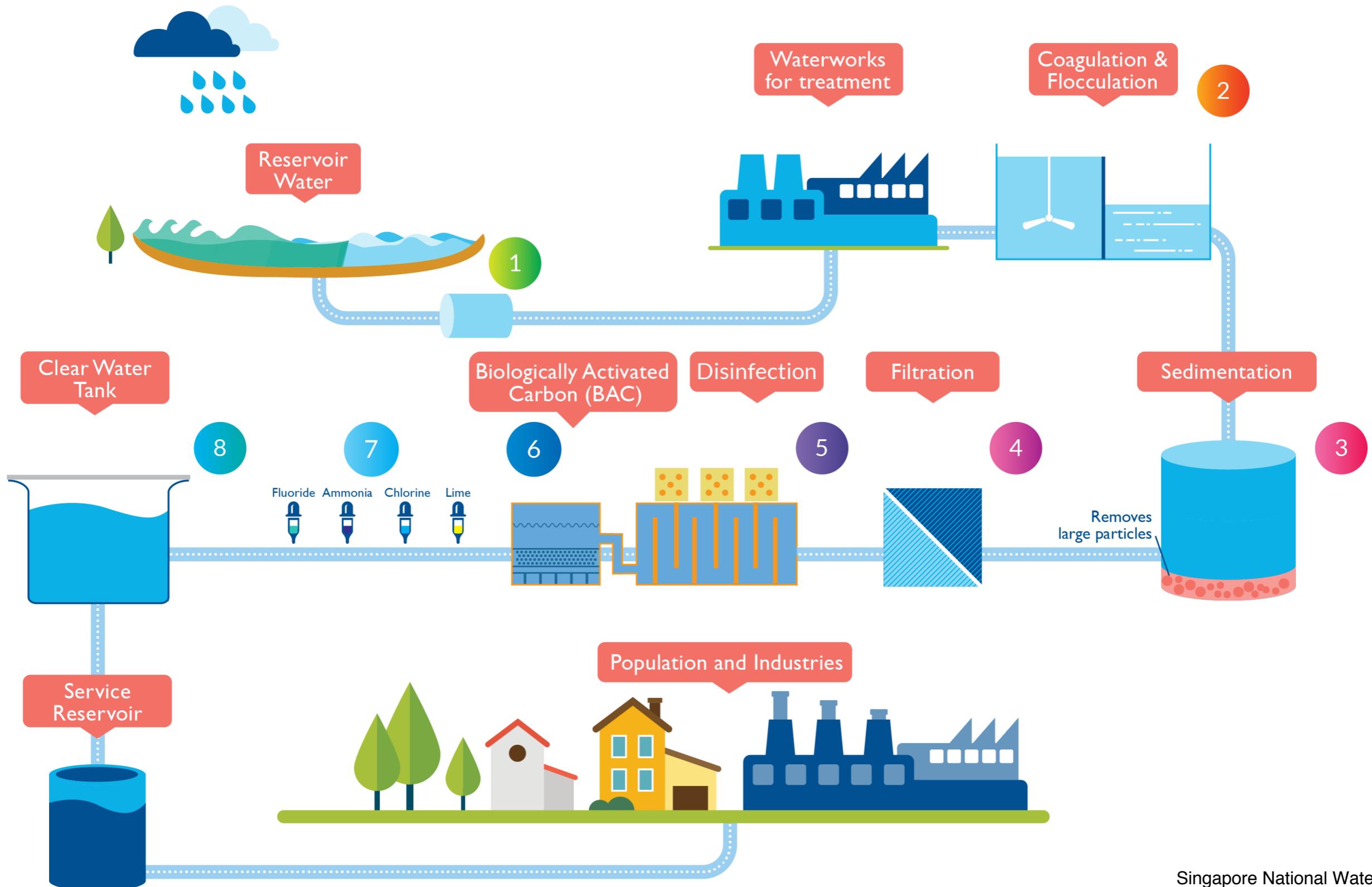


Photo: Sarah Baumgardner

# Global degradation of lake and reservoir water quality



# Increasingly variable reservoir water quality puts stress on water utilities and managers



# Can we use water temperature forecasts to improve water quality management?

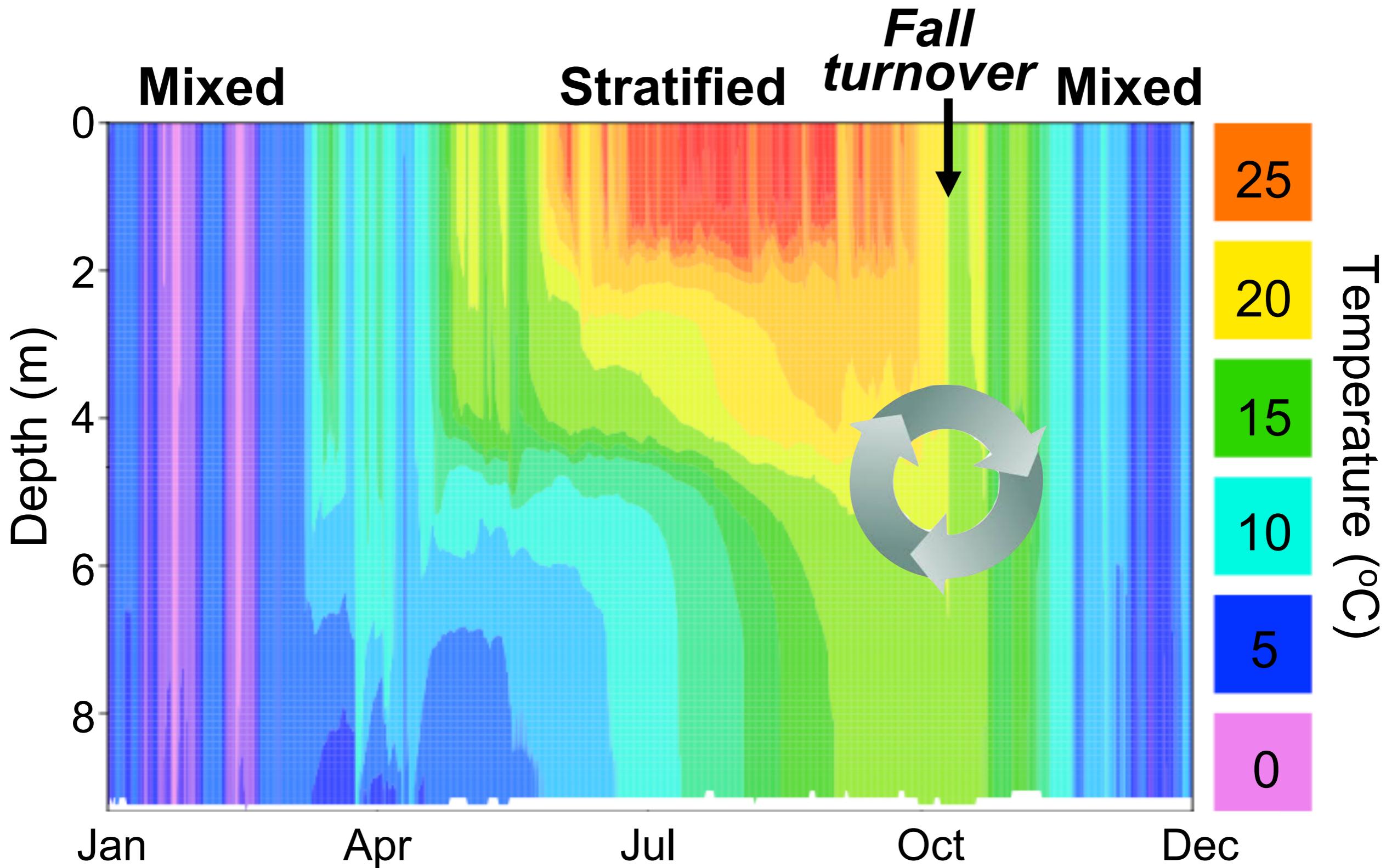
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- Concentrations of algae, metals, and oxygen are controlled by water temperature
- Water temperature forecasts can guide pre-emptive management action in treatment process



Falling Creek Reservoir, Vinton, VA

Accuracy of temperature forecasts may vary over depth and time in mixed vs. stratified conditions



Fall turnover = high iron, manganese, and phosphorus from sediments mixed to surface

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Fall turnover = high iron, manganese, and phosphorus from sediments mixed to surface



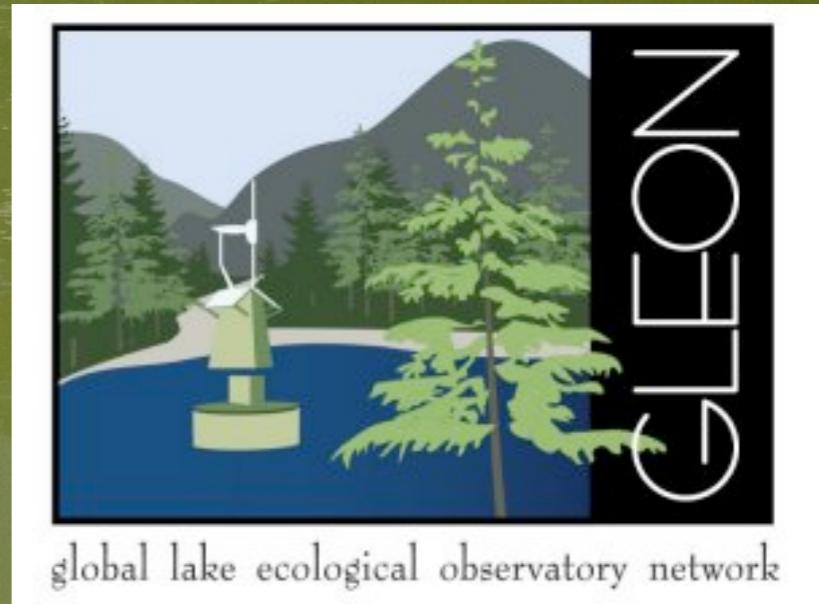
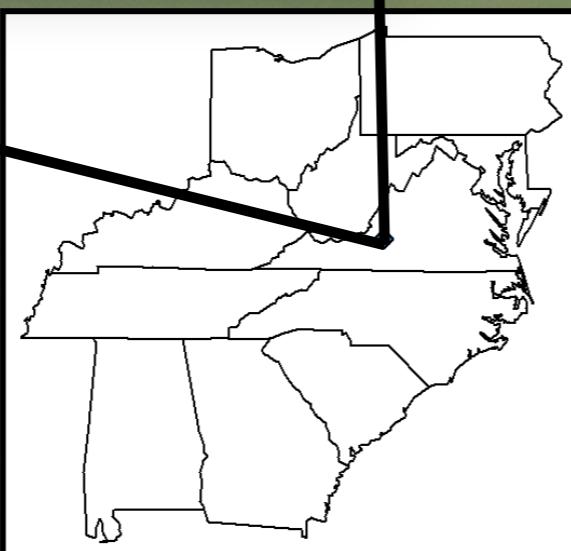
## Questions:

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- 1) How well can we forecast water temperature at different depths and times of year?
- 2) Can we successfully forecast the day of fall turnover?

# Falling Creek Reservoir (Roanoke, VA, USA)

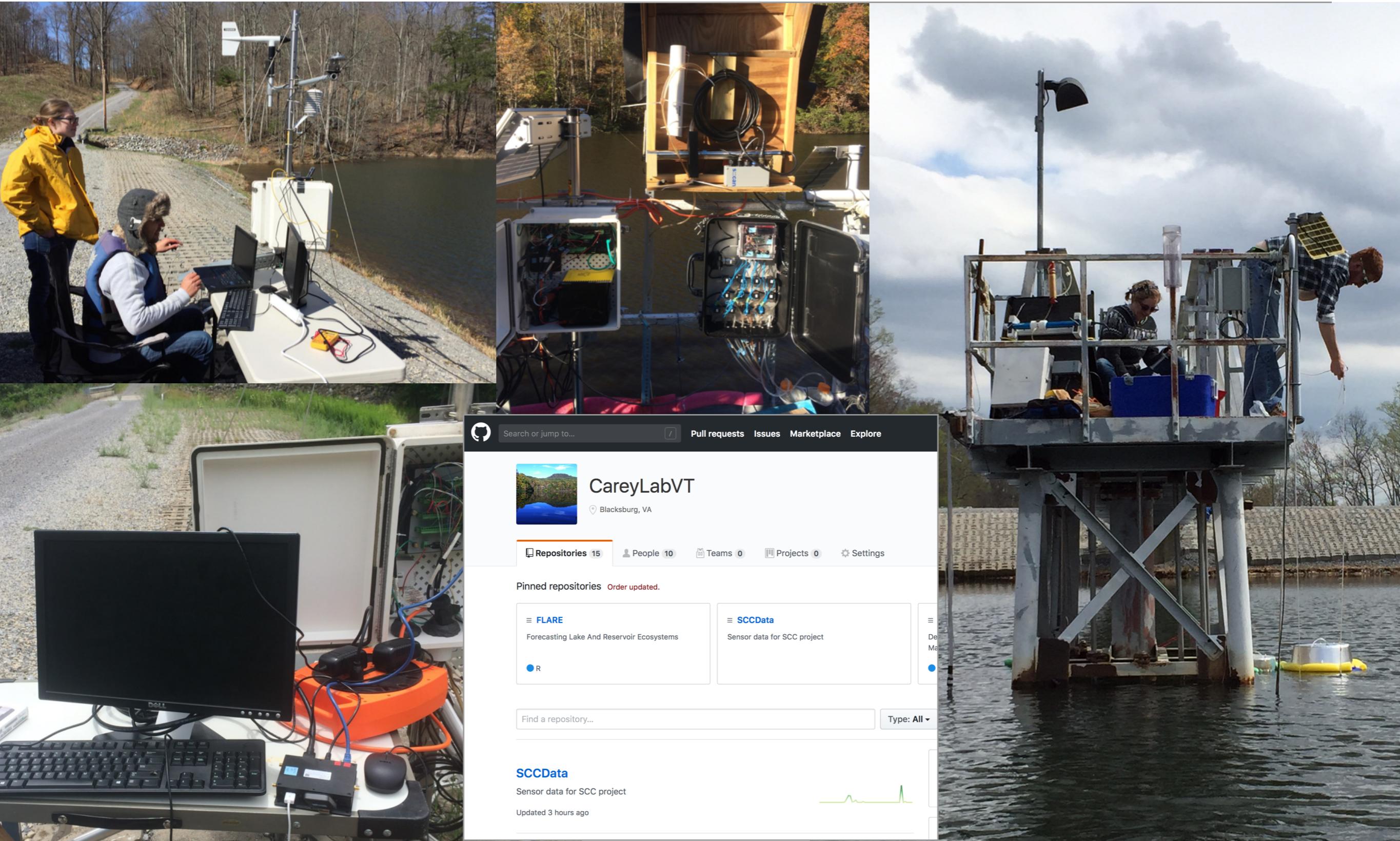
- Shallow (Max. depth = 30 ft)
- Small surface area (21 acres)
- Drinking water source
- Algal blooms, high metals
- GLEON site



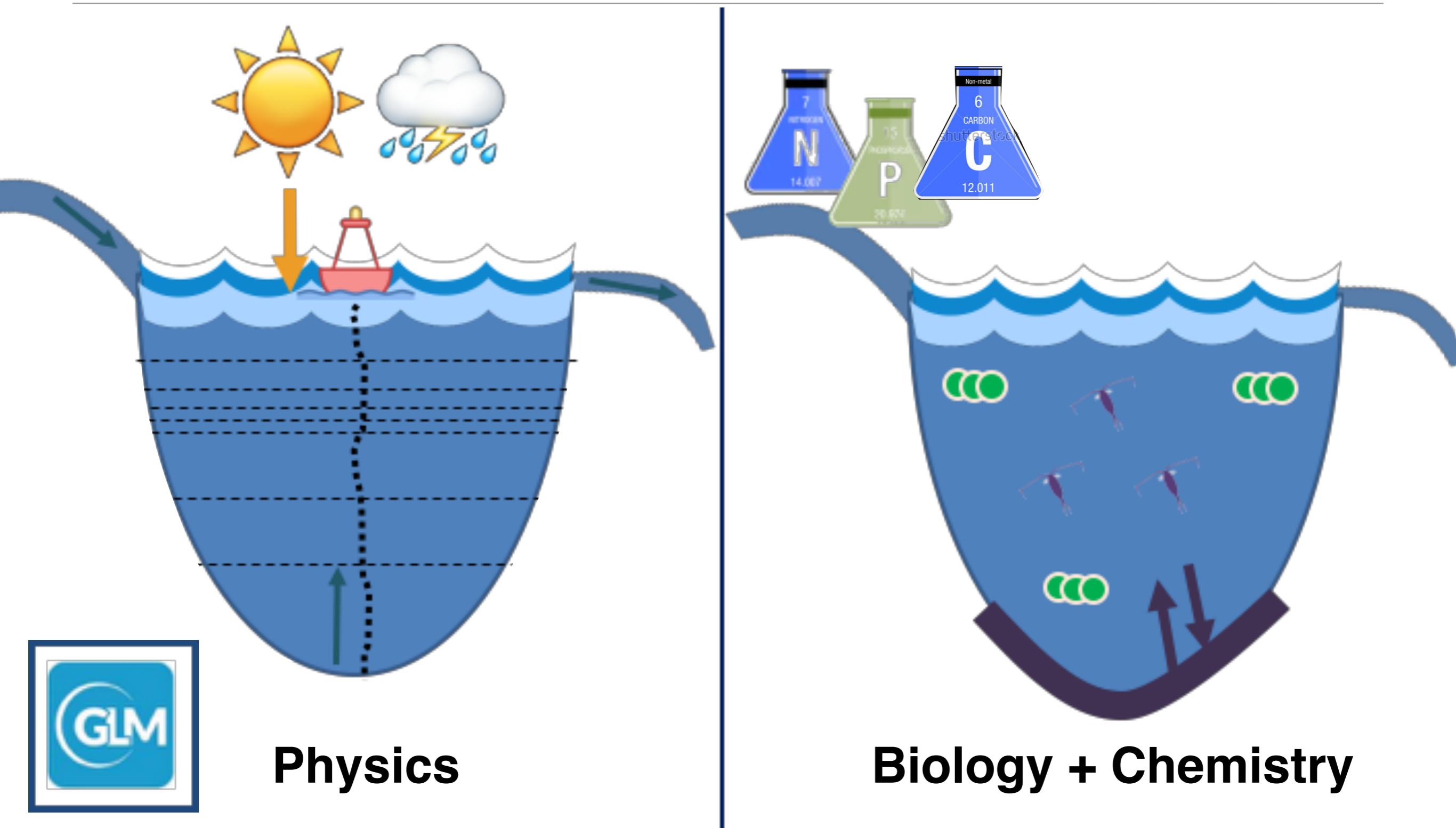
global lake ecological observatory network



# Meteorological and water quality data stream wirelessly to Github via sensor gateways



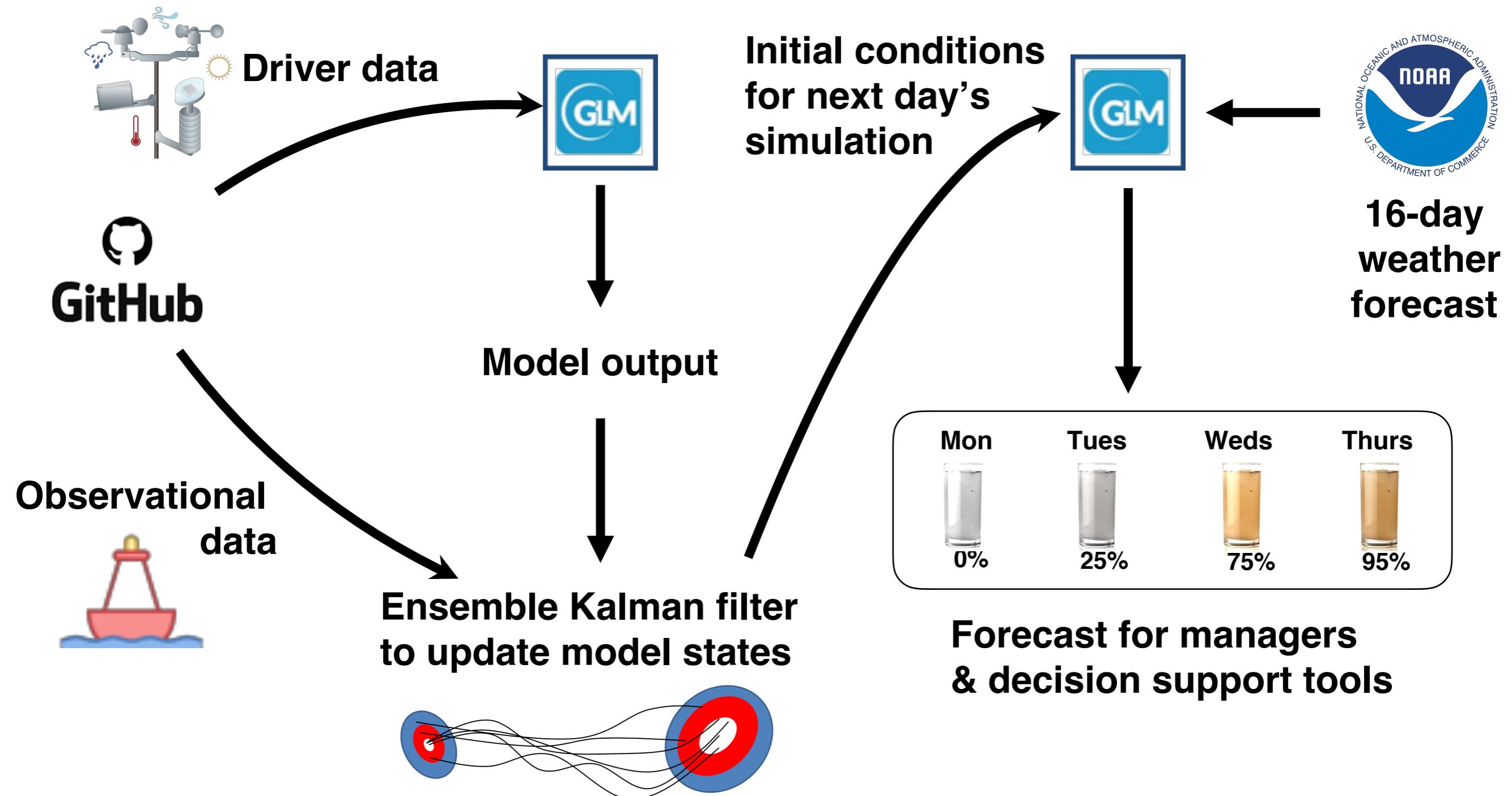
# Numerical simulation ecosystem model: General Lake Model - Aquatic EcoDynamics (GLM)



**Physics**

**Biology + Chemistry**

# Forecasting workflow

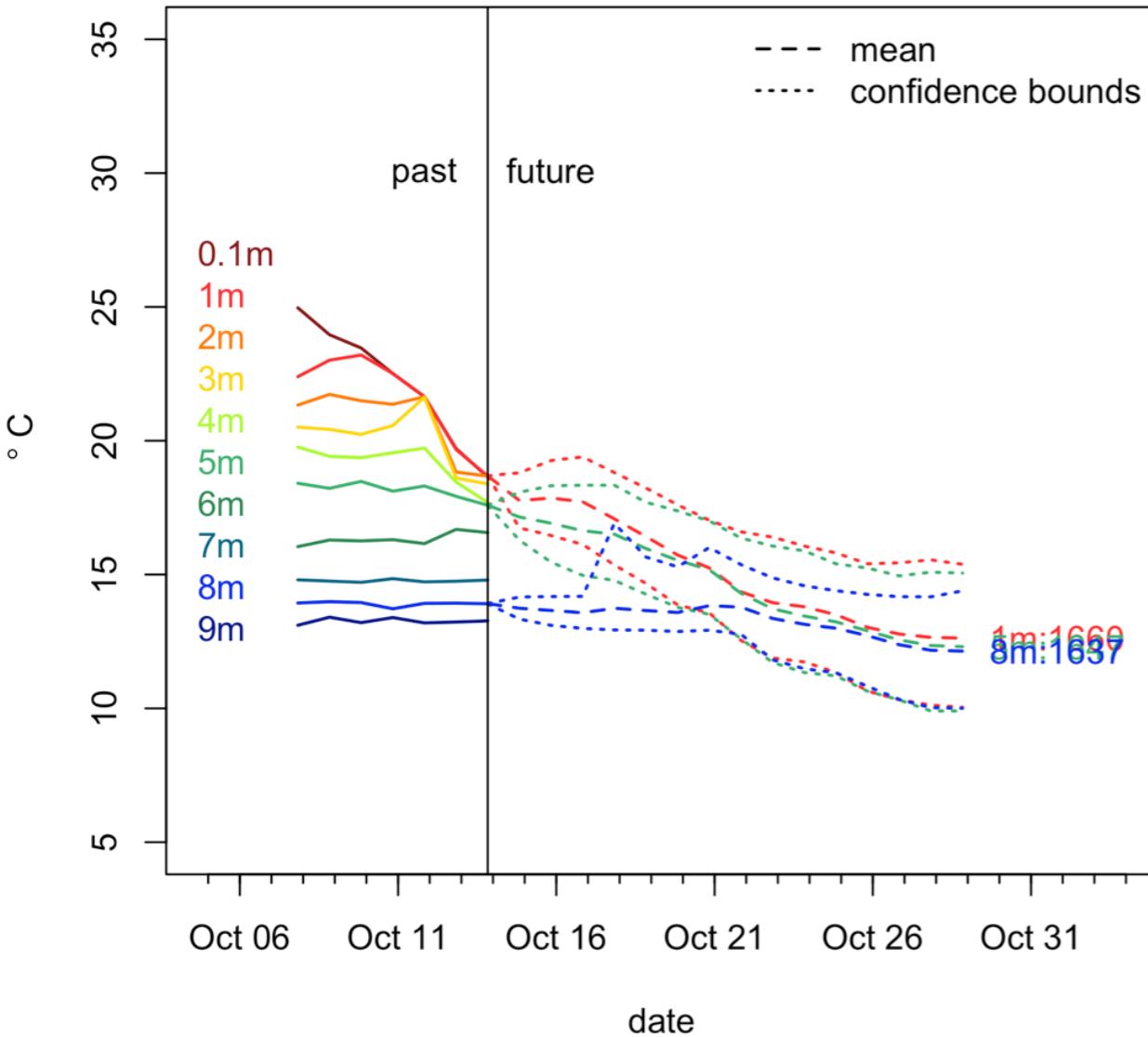


# Forecasts automatically emailed every day to team members and managers

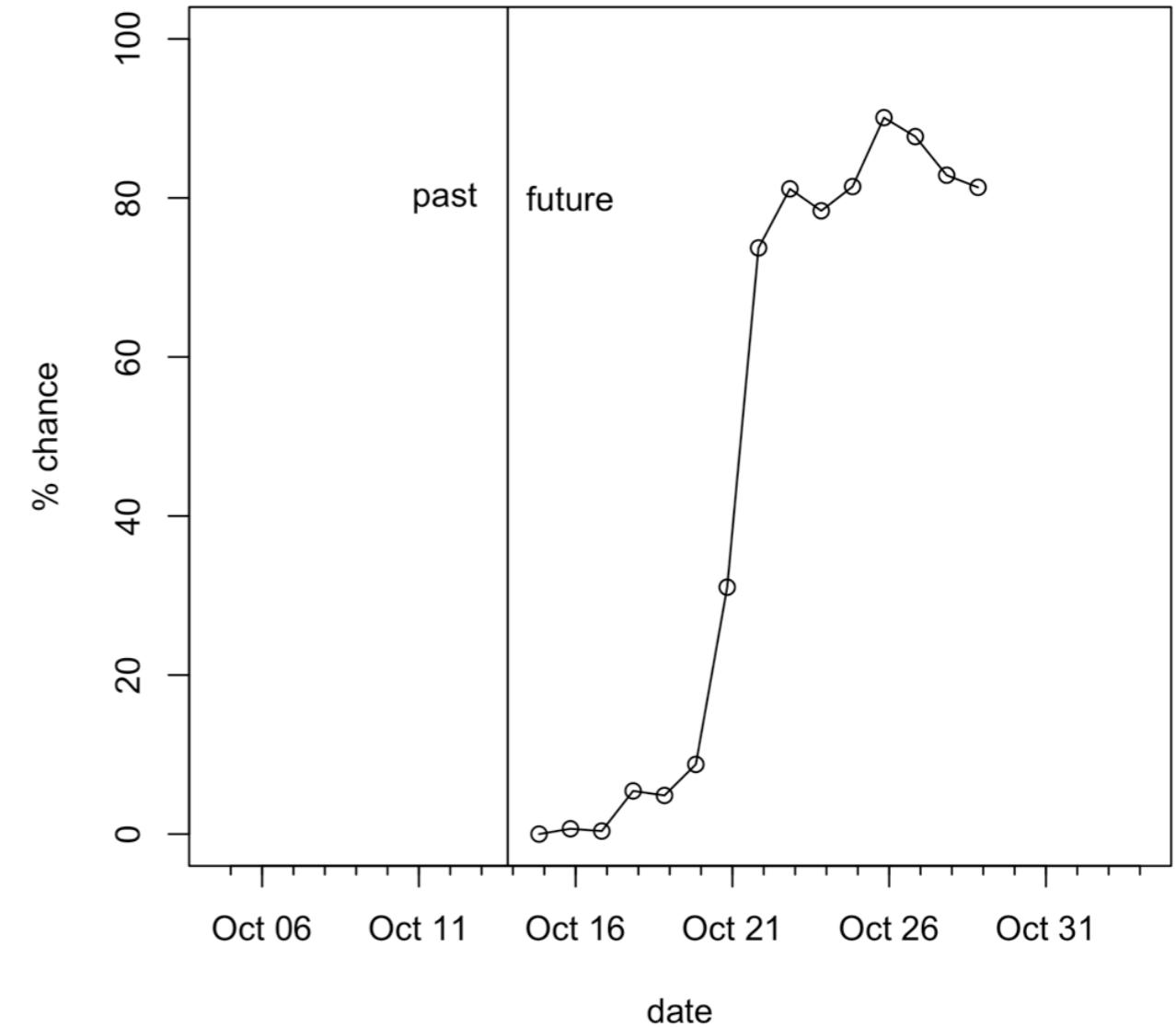
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## Falling Creek Reservoir Forecast 10/13/2018

**Water temperature forecast**

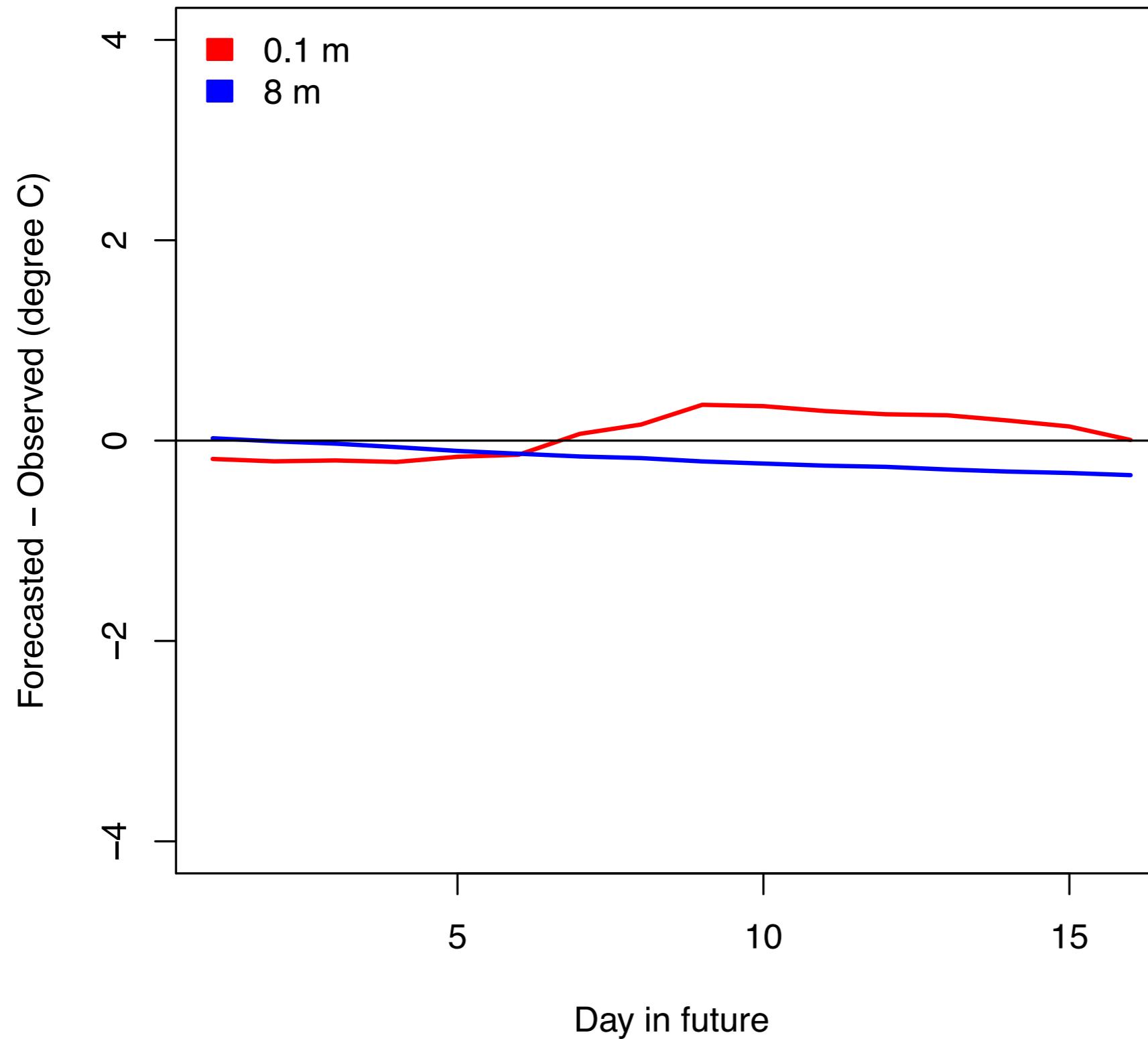


**Turnover forecast**



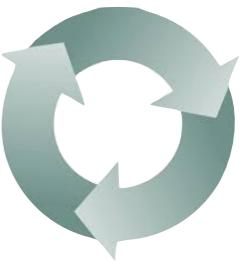
# 16-day forecasts predicted water temperature within 1°C in both mixed and stratified conditions

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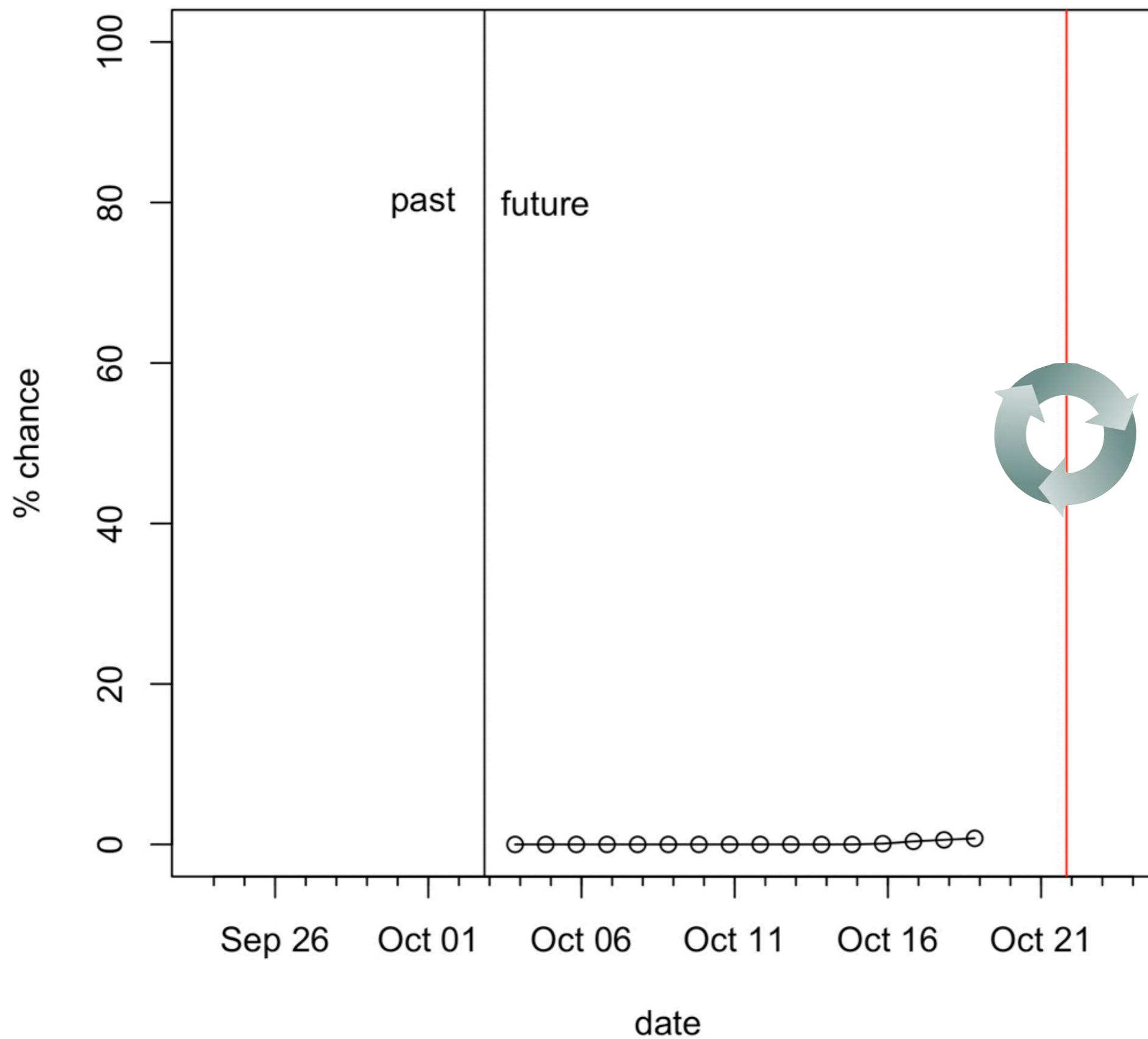


Can we successfully forecast the day of fall turnover?

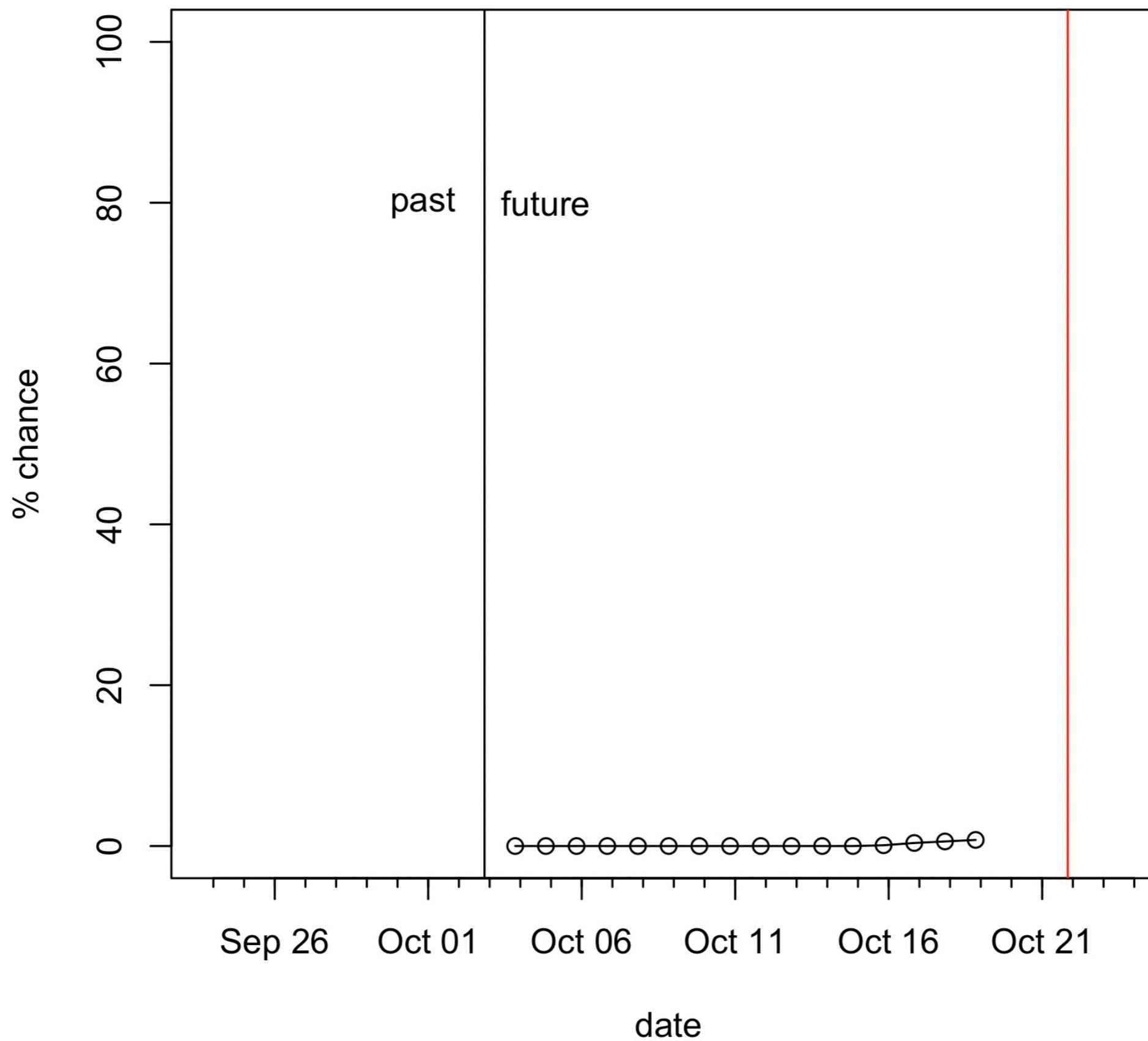
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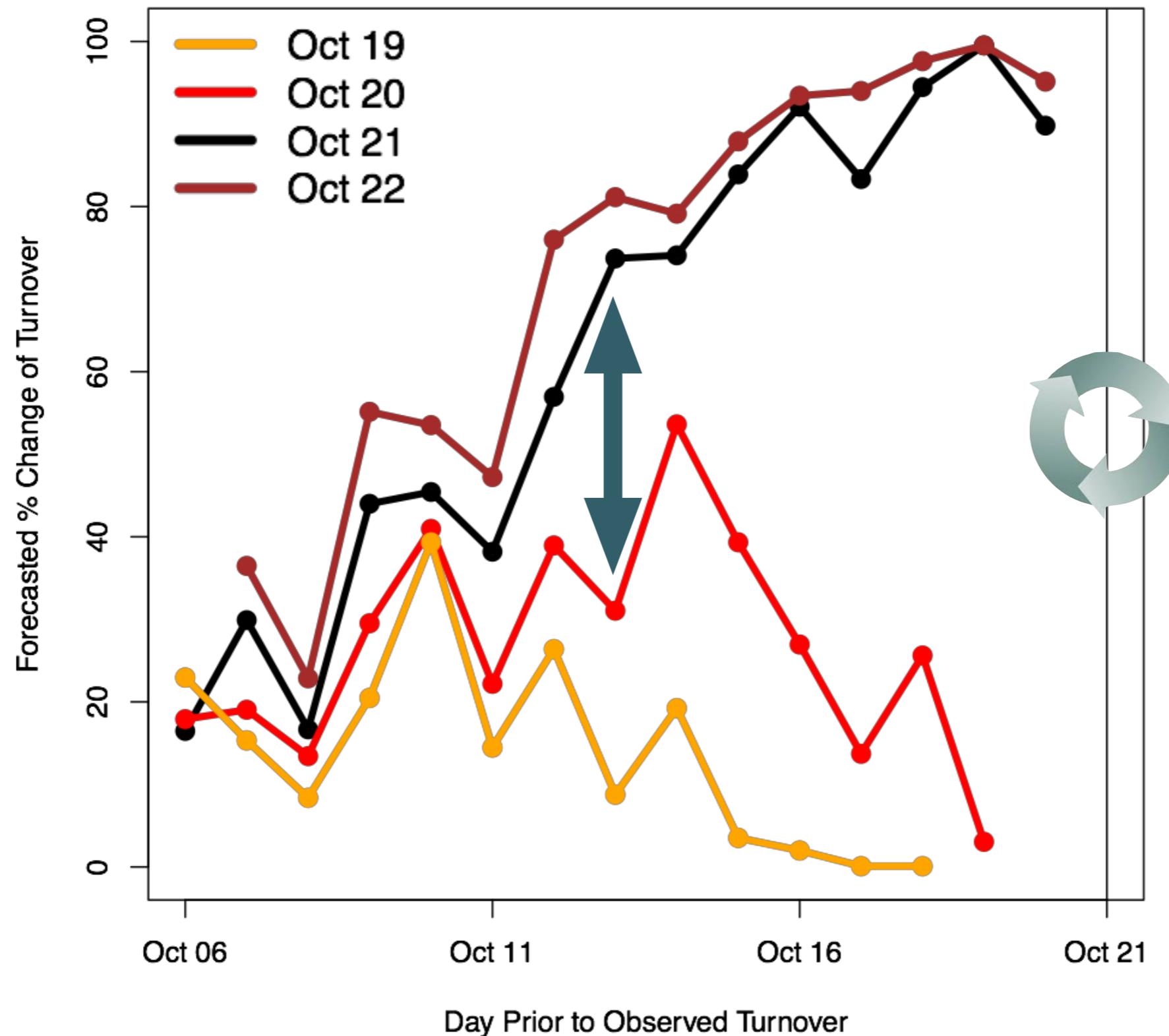
## Turnover forecast



## Turnover forecast



# Forecasts were able to anticipate fall turnover >1 week in advance



Fall turnover = high iron, manganese, and phosphorus from sediments mixed to surface

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# Take-home messages

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- We are able to successfully forecast water temperature at all depths in both stratified and mixed conditions and identify the day of fall turnover ~1 week in advance
- Our near-term, iterative forecasting system (*FLARE*) uses open-source software, sensors, code, and tools that can be scaled to other lakes
- FLARE is already being used by managers to improve drinking water treatment and quality in Roanoke, Virginia

# Thank you!



- PRAGMA lake expedition team
- Smart Reservoir team & Carey Lab members
- Western Virginia Water Authority
- National Science Foundation



WESTERN VIRGINIA  
WATER AUTHORITY



# Questions?

