



# Can you predict the future?

## Introduction to the NEON Forecasting Challenge

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Workshop lead:  
Contact:



# Workshop overview

## Objectives:

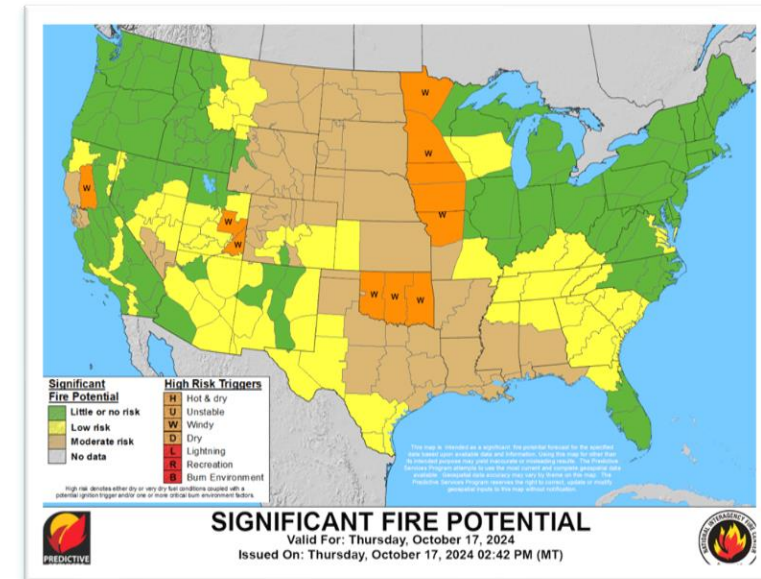
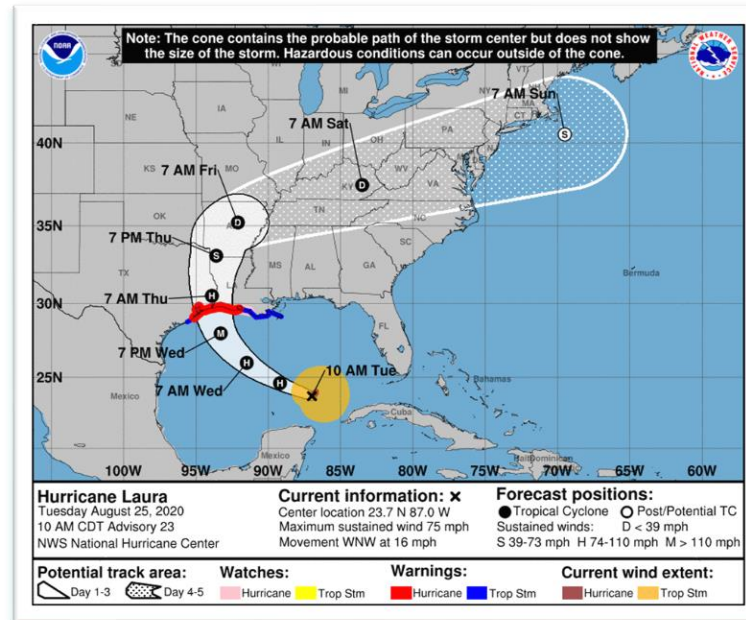
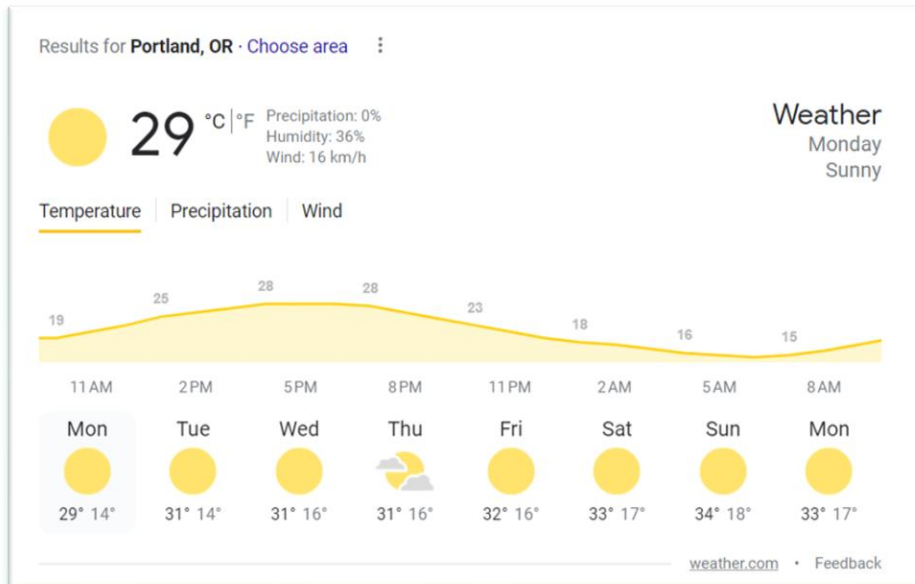
1. Highlight some key concepts of ecological forecasting
2. Introduce NEON and the Forecasting Challenge
3. Walk through a simple forecast workflow
4. Point to resources to get involved and find more information

# Workshop Overview

11:30-11.55	Introductory presentation
11.55-12.10	<b>Break and R set-up</b>
12:10-13:00	Hands-on coding/follow-along



# Why forecast?



# Near-term, iterative, ecological forecasts

- **Near-term** = sub-daily to decadal timescales
- **Iterative** = process of repeatedly validating forecasts, updating model initial conditions and parameters, and issuing new forecasts as new data become available
- **Ecological forecast** = future predictions of physical, chemical, or biological variables *with quantified uncertainty*

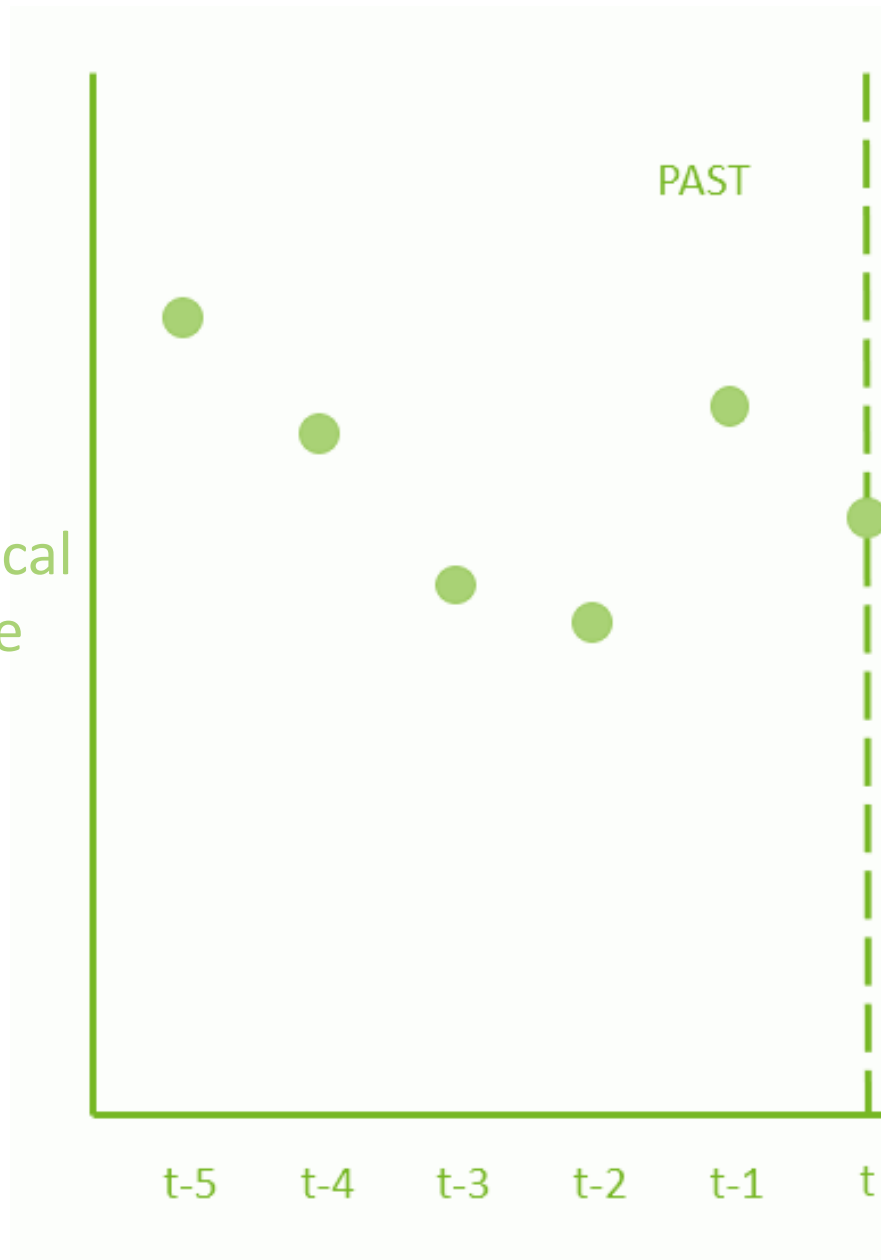


# Examples:

1. Forecast of river dissolved oxygen concentration for the next 1-48 hours for fish stocking
2. 1-3 month ahead predictions of the % chance of leaf fall to estimate peak leaf-peeping
3. Forecasts of tick abundance for the next 1-30 days in a popular hiking area

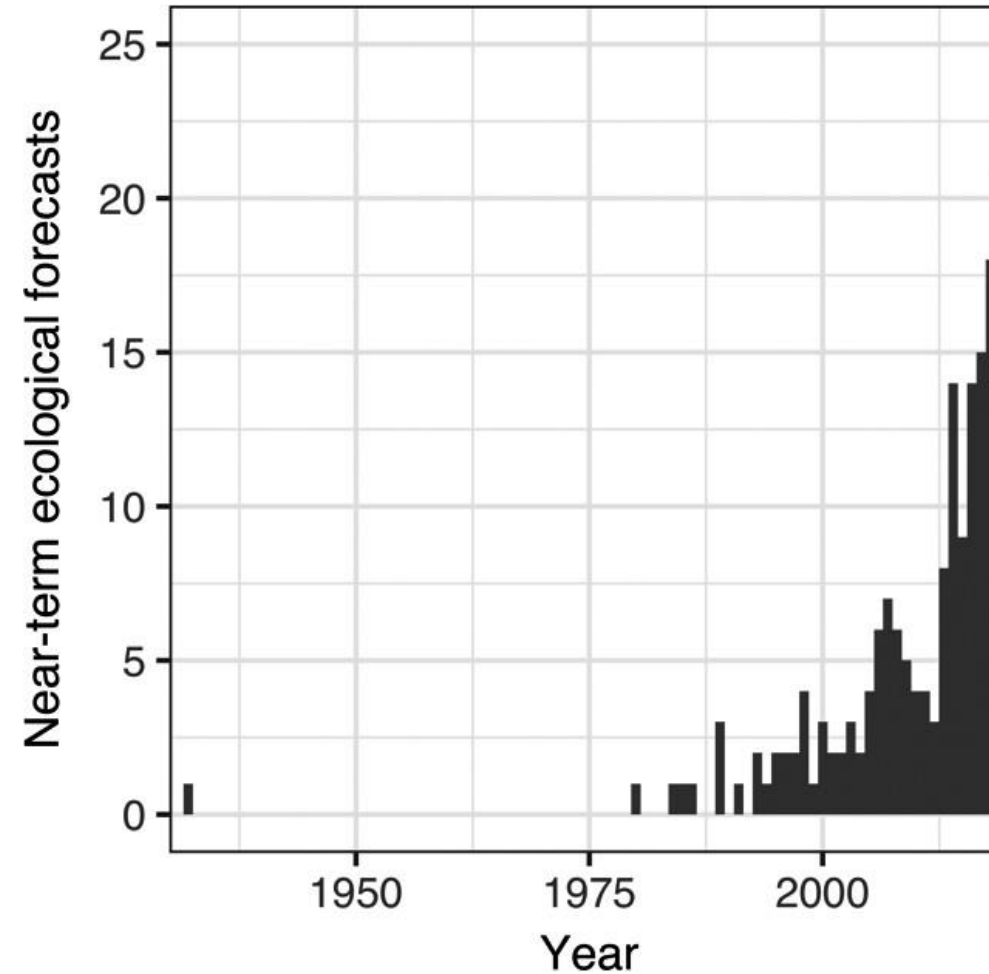


Ecological  
variable



# Ecological forecasting

## An emerging and growing field



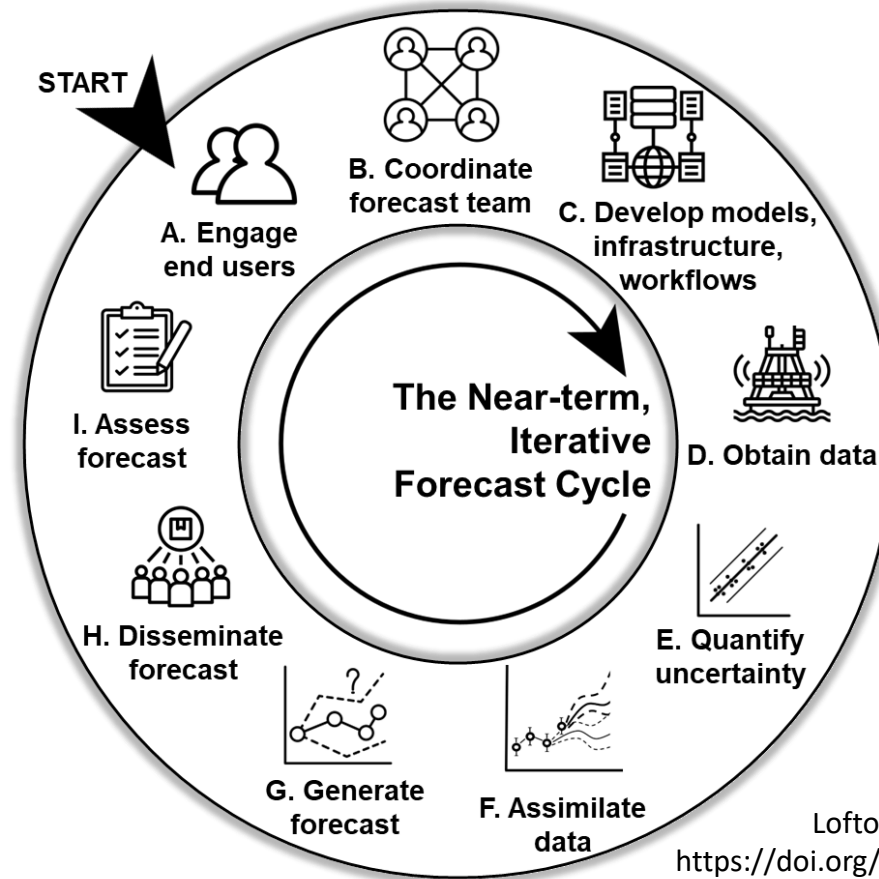
Lewis et al., 2021

(<https://doi.org/10.1002/eap.2500>)



# Forecasting Challenges

Forecasting is challenging!



Lofton, M. E *et al.* (2023)  
<https://doi.org/10.1111/gcb.16590>

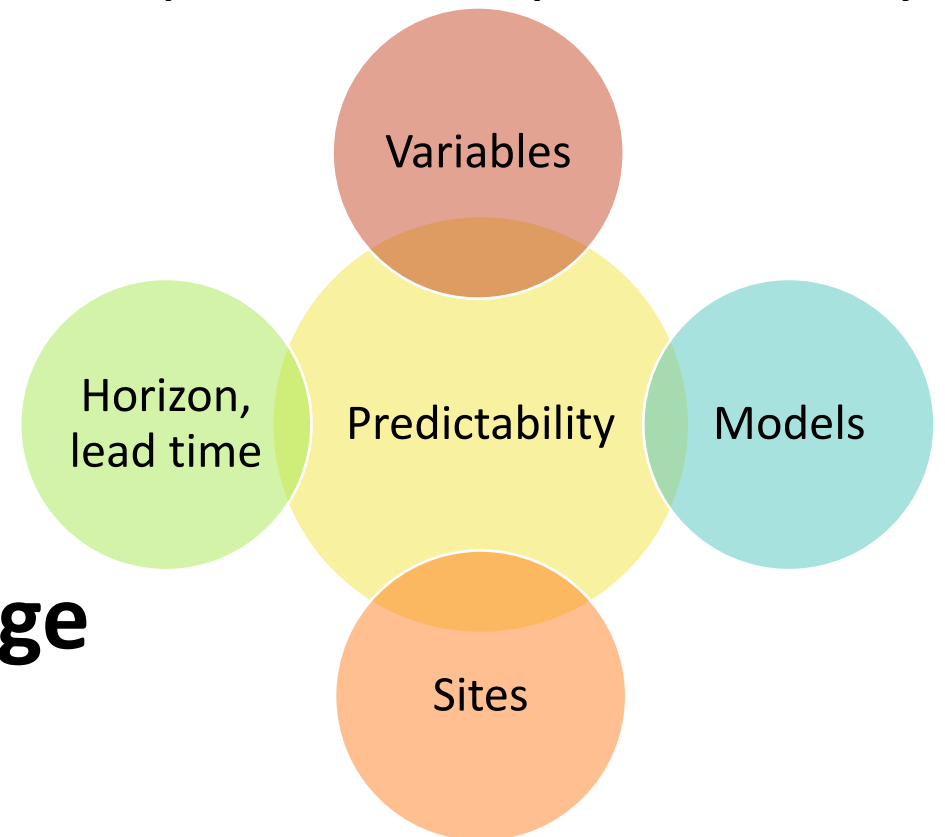
A Challenge to catalyze progress

# Why a forecasting challenge? – the power of many forecasts!

## 1. A community of forecasting

- Standards
- Development of tools and infrastructure
- A forecasting **platform**

## 2. Answer questions of predictability



The **EFI-NEON Forecasting Challenge** was born (2021)!

# Ecological Forecasting Initiative Research Co-ordination Network

- EFI RCN Goals
  - lower barriers
  - community building
  - infrastructure
  - platform development



NSF-sponsored



**Ecological Forecasting Initiative  
Research Coordination Network**  
5-year project

Create a community of practice that builds capacity for ecological forecasting by leveraging NEON data products.

<https://ecoforecast.org/rcn/>

Funded by the National Science Foundation (DEB-1926388)

# What is **neon**?

- The National Ecological Observatory Network (NEON) is a **continental-scale observation facility**
- To collect **long-term open access ecological data**
- **47 terrestrial** and **34 aquatic** sites

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## 2.1. NEON Mission

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NEON is a National Science Foundation-sponsored facility for research and education on long-term, large-scale ecological change. NEON's goals are derived from the Integrated Science and Education Plan.

The goals of NEON are to:

- Enable understanding and forecasting of the impacts of climate change, land use change, and invasive species on aspects of continental-scale ecology such as biodiversity, biogeochemistry, infectious diseases, and ecohydrology
- Enable society and the scientific community to use ecological information and forecasts to understand and effectively address critical ecological questions and issues
- Provide physical and information infrastructure to support research, education, and land management.

From: [https://www.neonscience.org/sites/default/files/NEON\\_Strategy\\_2011u2\\_0.pdf](https://www.neonscience.org/sites/default/files/NEON_Strategy_2011u2_0.pdf)

# What is the EFI-NEON Challenge?

*“A platform for the community to make predictions of conditions at NEON sites before the data are collected”*


- All 81 sites
- 6 themes



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*“A platform for the community to make predictions of conditions at NEON sites before the data are collected”*

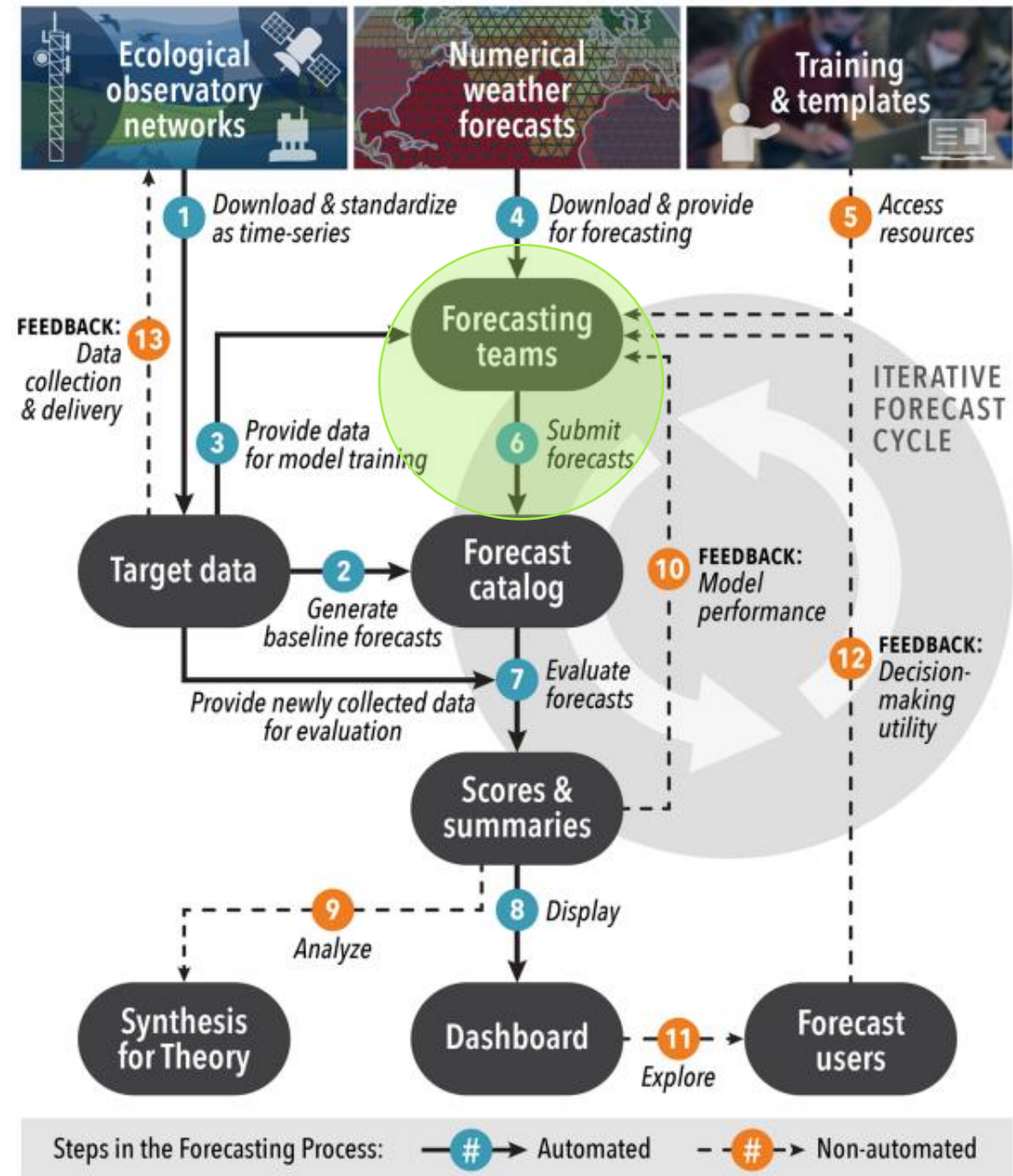
- All 81 sites
- 6 themes
- > 15,000 forecast submitted!



**Forecast =**  
A prediction of  
future environmental  
conditions that  
includes quantified  
uncertainty



# Challenge overview







# Workshop overview



## Objectives:

1. Highlight some key concepts of forecasting
2. Introduce NEON and the Forecasting Challenge
3. Walk through a simple forecast workflow
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# Hands-on workshop:

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- **Aquatics theme – Can we predict how water temperature will change over the next month?**
  - Water temperature in lakes
  - NEONs water temperature data product (DP1.20264.001)
  - 30 day forecast horizon
  - Data latency of 2-3 days
- **Simple baseline** model to build on

**Water temperature** = key variable in driving many biogeochemical cycles and habitat available for thermal-sensitive species



NEON Buoy at Crampton Lake  
(Land O'Lakes, WI)



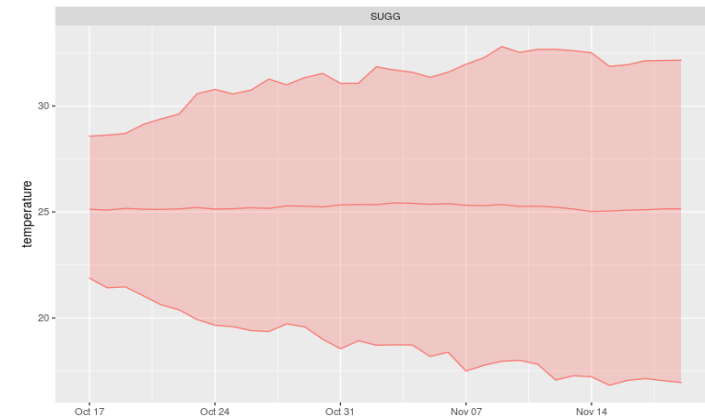
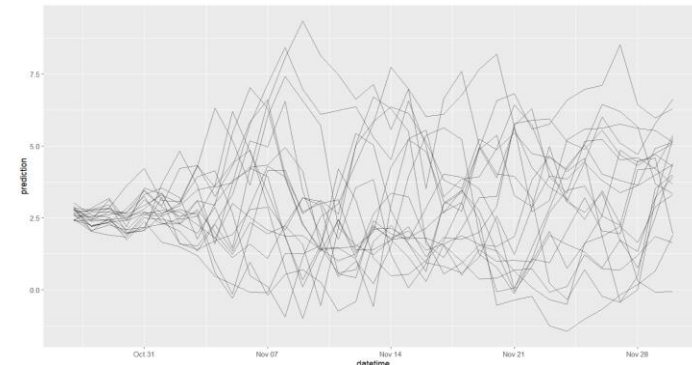
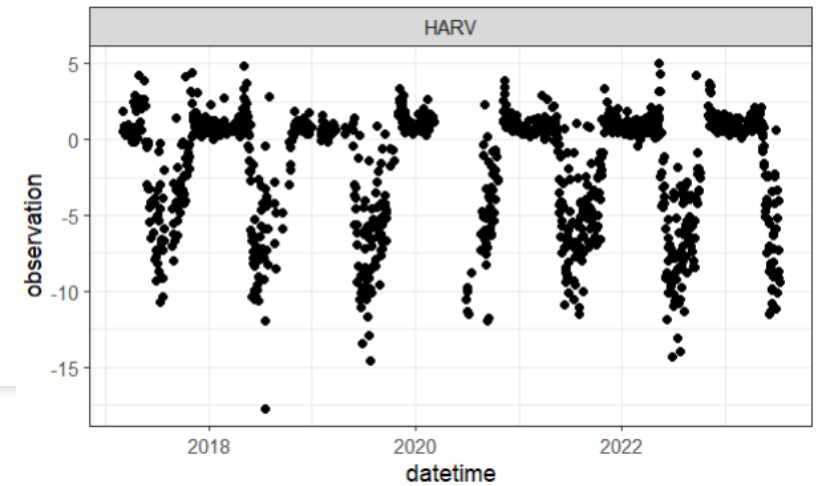


# Diversity of NEON aquatic sites



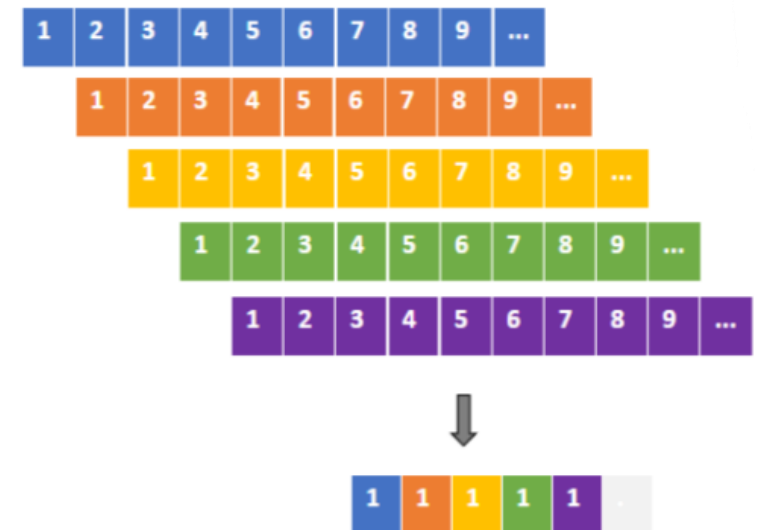
# Some forecast terminology:

- Targets – water temperature
- Uncertainty – forecasts must include an estimate of uncertainty.  
The uncertainty can be represented using different model runs (**ensemble members**) or the statistics of the forecast (**mean and standard deviation**).



# Some more forecast terminology:

- NOAA data – National Oceanic and Atmospheric Administration weather forecasts
- 3 NOAA forecast data products available in neon4cast:
  - Stage\_1: **raw forecasts** from NOAA.  
30 member ensemble forecast
  - Stage\_2: processed from stage\_1 Recommended for **future forecasts. Hourly inputs**
  - Stage\_3: the **historic data product**. A 'stacked' data set taking every 1 day ahead forecast. Useful for model training/calibration.



# A little more forecast terminology:

Scores – a means to assess forecast skill. The Challenge uses the Continuous Rank Probability Score (crps). Uses both the **accuracy** (mean) and the **precision** (sd) of the forecast.

Scores → Dashboard → Users!

Read more: <https://projects.ecoforecast.org/neon4cast-docs/Evaluation.html>



This page visualizes the forecasts and forecast performance for the focal target variables. Only forecasts from a subset of NEON sites are shown. If you want to see your forecasts or scores, the links can be found in our [forecast catalog](#) and [scores catalog](#)

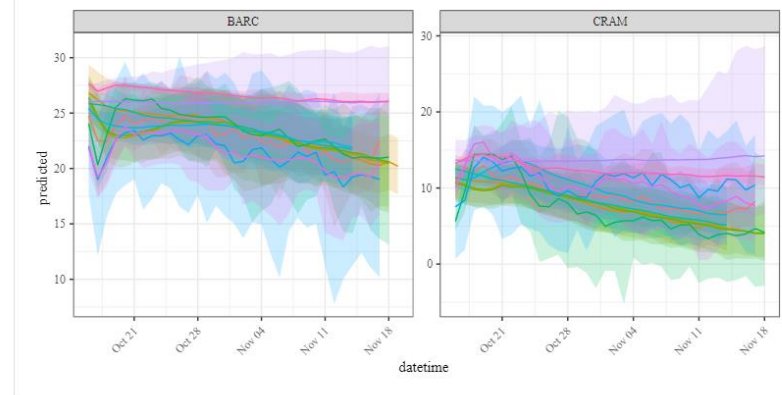
## Most recent forecasts

Only the top-performing models from the last 30 days are shown.

Forecasts submitted on 2024-10-15

TERRESTRIAL: NET ECOSYSTEM EXCHANGE	TERRESTRIAL: LATENT HEAT FLUX	PHENOLOGY: GREENNESS	PHENOLOGY: REDNESS
AQUATICS: WATER TEMPERATURE	AQUATICS: DISSOLVED OXYGEN	AQUATICS: CHLOROPHYLL-A	BEETLE COMMUNITY RICHNESS
BEETLE COMMUNITY ABUNDANCE	TICKS: AMBLYOMMA AMERICANUM		

Forecast summaries are available [here](#)



On this page

- Most recent forecasts
- Forecast analysis
- Aggregated scores

- View source
- Report an issue



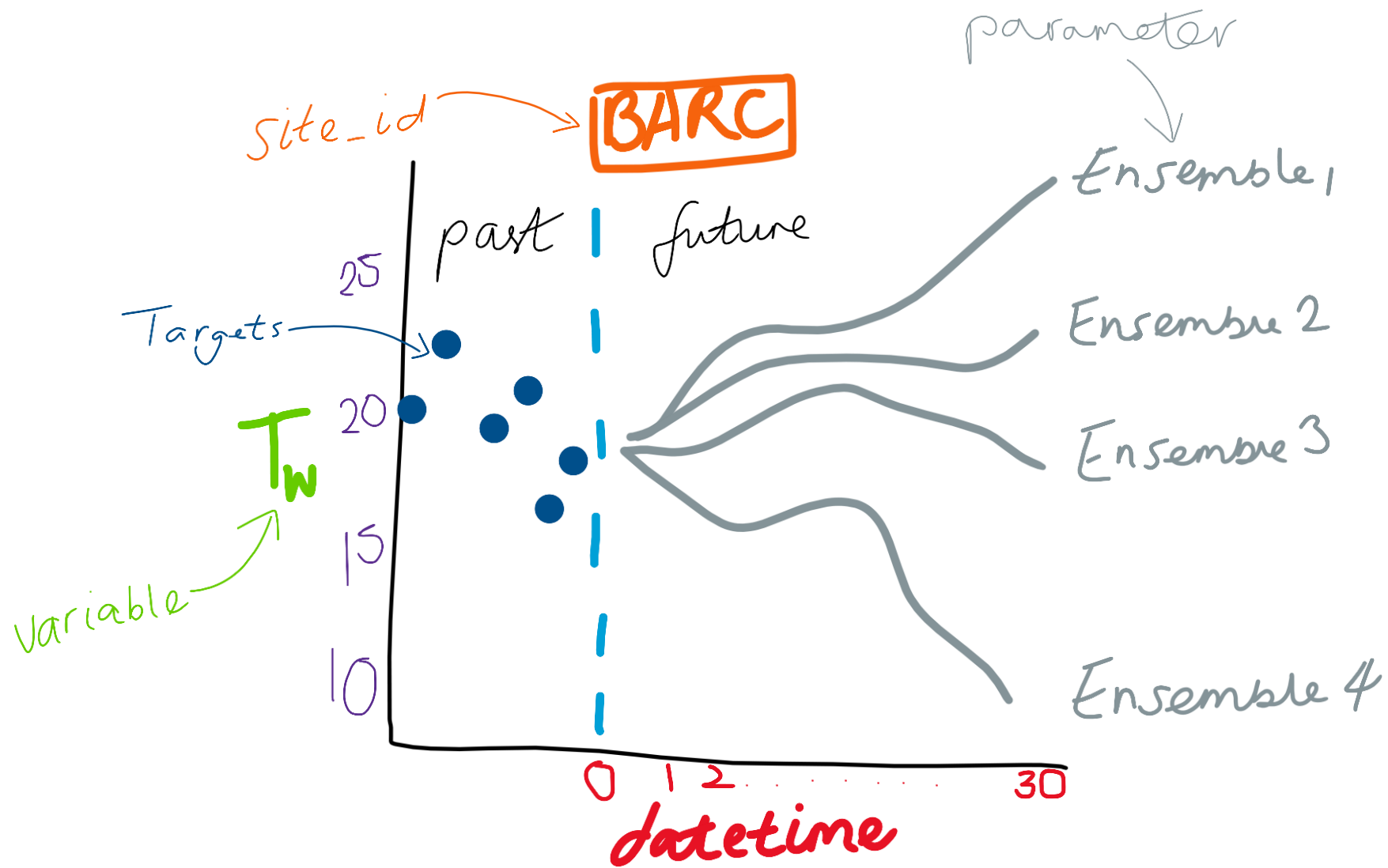
# A little more forecast terminology:

Standards - Help maintain consistency in forecast generation, submissions and scoring

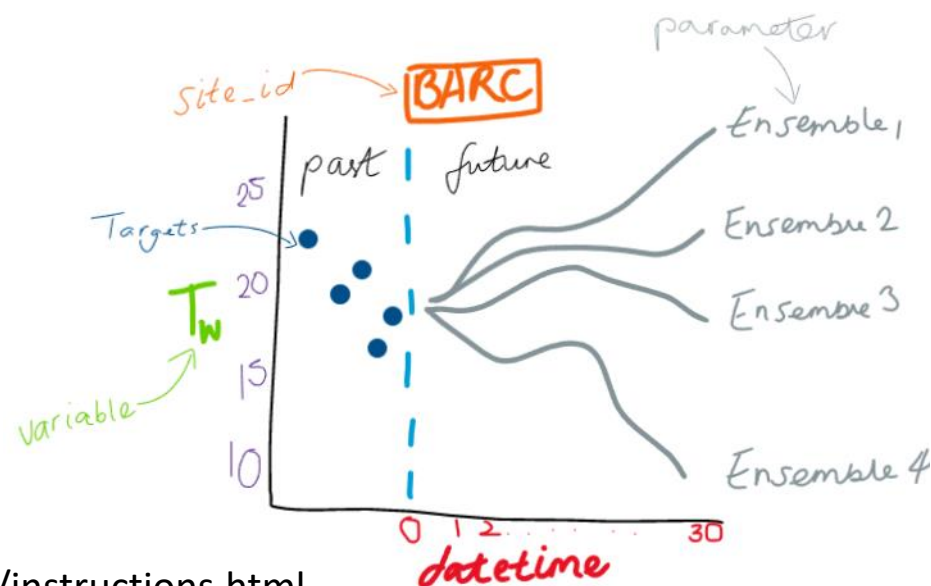
Need to submit a forecast in a standardized format

- file format (csv or NetCDF)
- file name format ([theme]-[reference\_datetime]-[team\_name].csv)
- specific column names
- column format (datetime/character/integer/etc.)





datetime	reference_datetime	site_id	family	parameter	variable	prediction	model_id
2023-01-12	2023-01-11	BARC	ensemble	1	temperature	22.63563	test_mod
2023-01-12	2023-01-11	BARC	ensemble	2	temperature	26.75148	test_mod
2023-01-12	2023-01-11	BARC	ensemble	3	temperature	24.65157	test_mod
2023-01-12	2023-01-11	BARC	ensemble	4	temperature	25.1389	test_mod
...	...	...	...	...	...	...	test_mod
2023-02-10	2023-01-11	BARC	ensemble	1	temperature	19.40379	test_mod
2023-02-10	2023-01-11	BARC	ensemble	2	temperature	24.89667	test_mod
2023-02-10	2023-01-11	BARC	ensemble	3	temperature	25.98961	test_mod
2023-02-10	2023-01-11	BARC	ensemble	4	temperature	26.40593	test_mod



# Basic workflow to submit a forecast

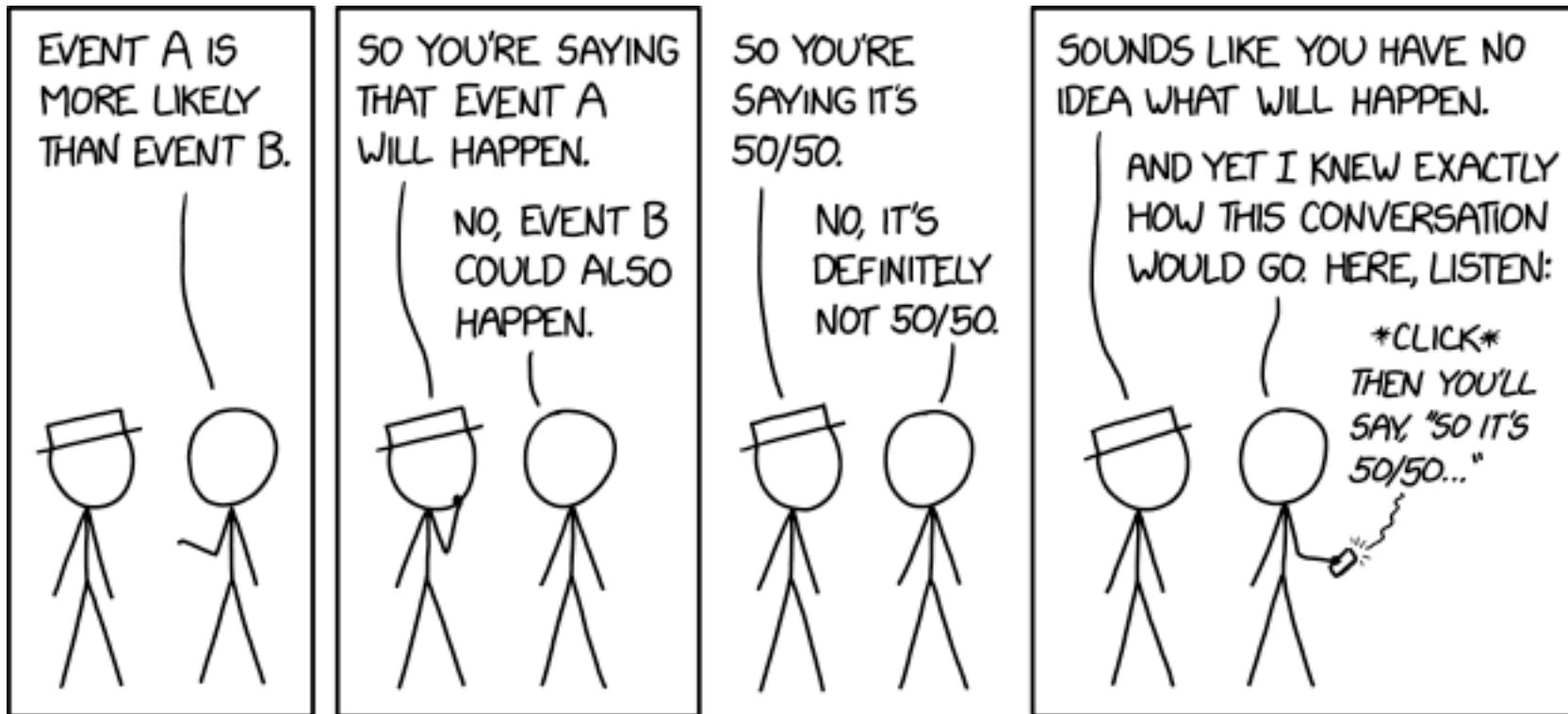
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1. Read EFI-NEON Challenge documentation (neon4cast.org)
2. Investigate the forecast target variables
- ➡ 3. Build/apply your model!
- ➡ 4. Produce forecast of future conditions – SUBMIT TO THE CHALLENGE!
5. Register, complete model description, and submit your forecasts
6. Wait for the scores to come in and revel in the glory of predicting the future (~5-day before first evaluation)
7. Use new data to update the model
8. Submit another forecast! And another...!



See detailed instructions here <https://projects.ecoforecast.org/neon4cast-ci/instructions.html>

# Questions?



<https://xkcd.com/2370>

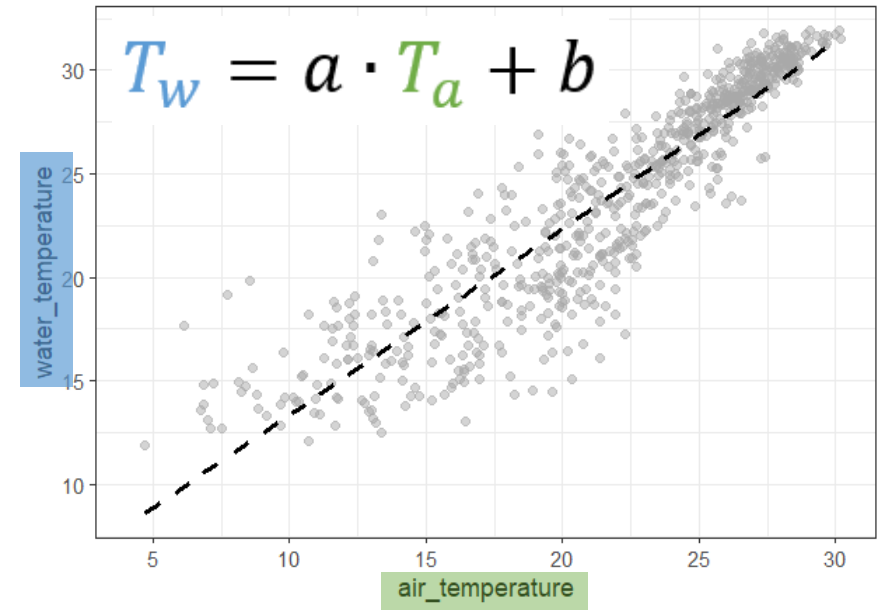
# Let's forecast!

## 1. Follow-along R markdown

- Forecasting water temperature using a Linear model with air temperature


## 2. Modify the model and submit your forecast!

- More/other covariates
- Different model structures
- Other variables





Thank you  
for  
attending!



Big thanks to the EFI-NEON team - especially **Quinn Thomas** (Virginia Tech) and **Carl Boettiger** (UC-Berkley) developers of the cyberinfrastructure underpinning the Challenge.

For questions contact  
**[eco4cast.initiative@gmail.com](mailto:eco4cast.initiative@gmail.com)**

**Visit [ecoforecast.org](http://ecoforecast.org) & [neon4cast.org](http://neon4cast.org)**