Identifying Forecasts of Opportunity for Subseasonal Precipitation Predictions using Explainable Machine Learning

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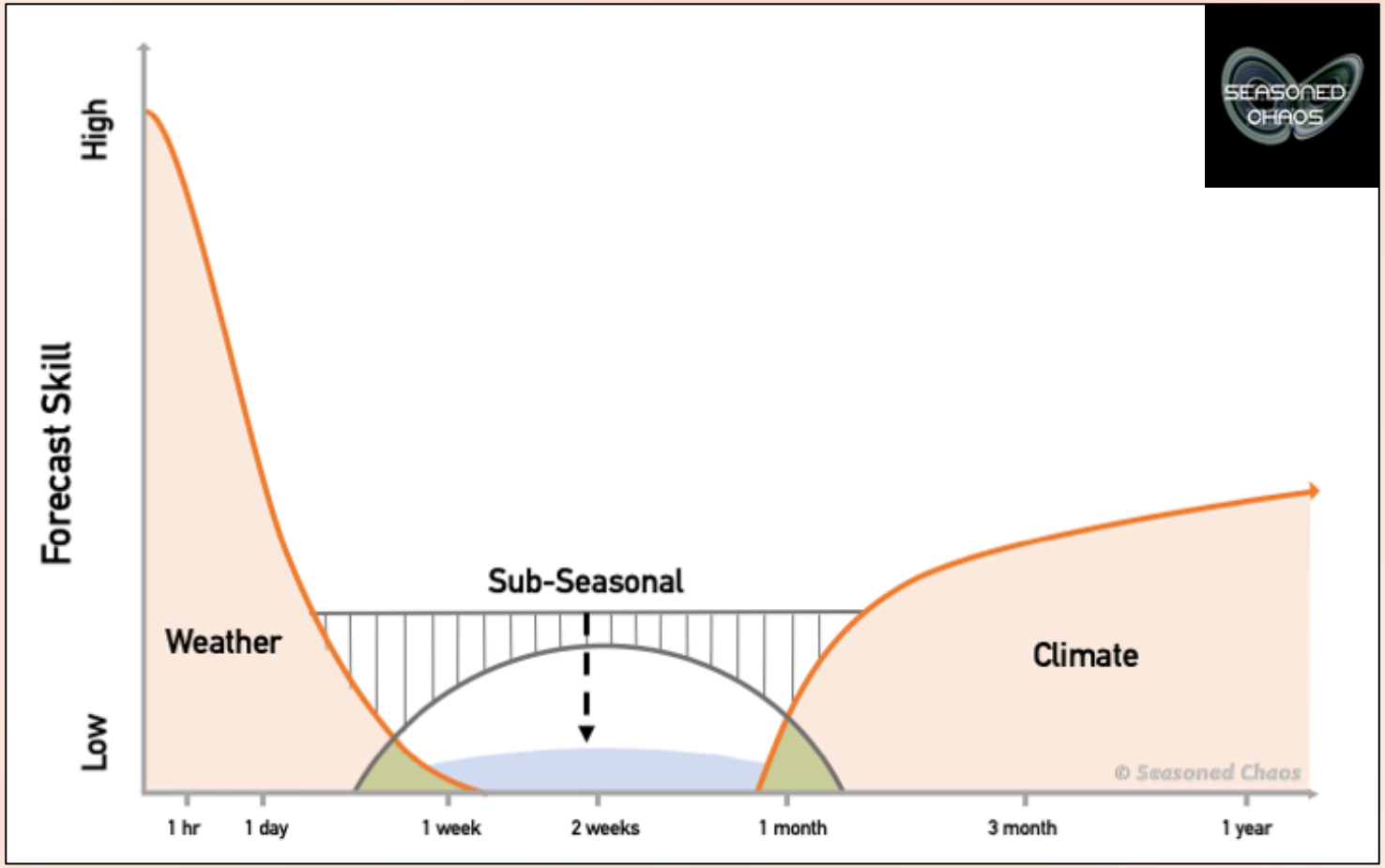
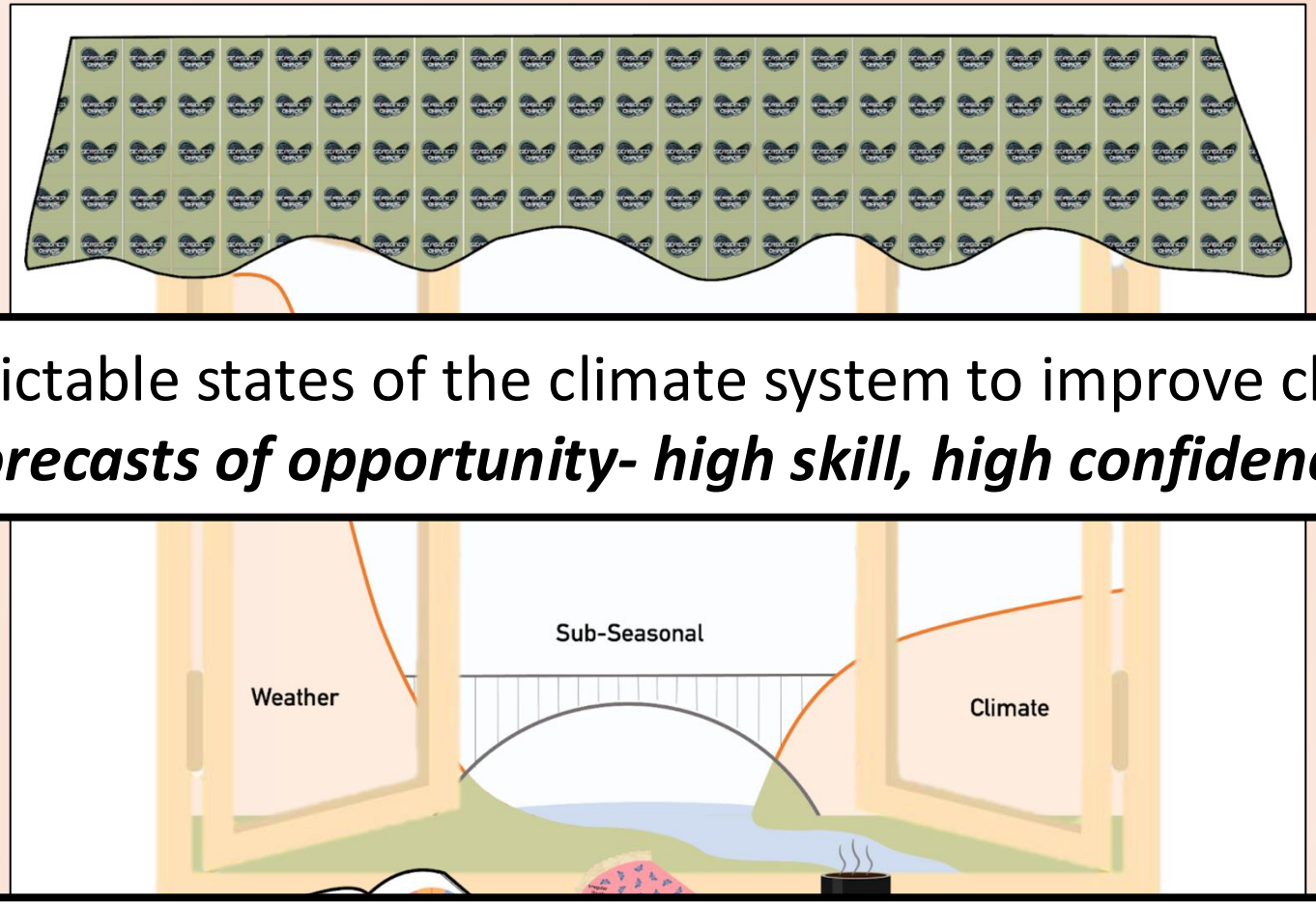
NOAA S2S Analysis, Predictions, and Services Webinar Series

Bridging weather-to-climate prediction



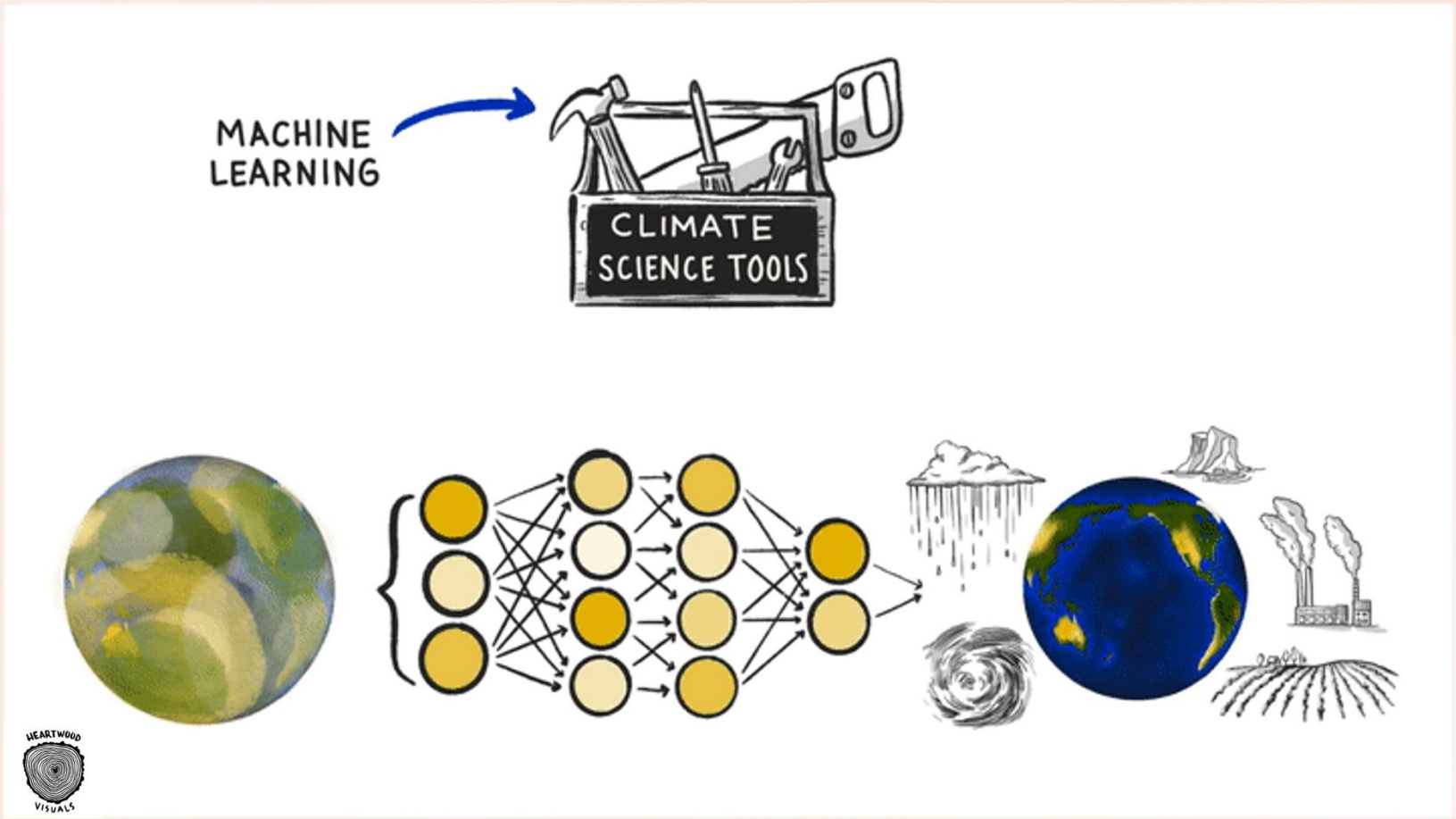
Mariotti et al. (2020); Vitart et al., (2012, 2017); Stan et al. (2017); Cassou (2008); Garfinkel et al. (2014); Schreck III et al. (2013); Pegion et al. (2019); Lee et al., (2021)

Bridging weather-to-climate prediction



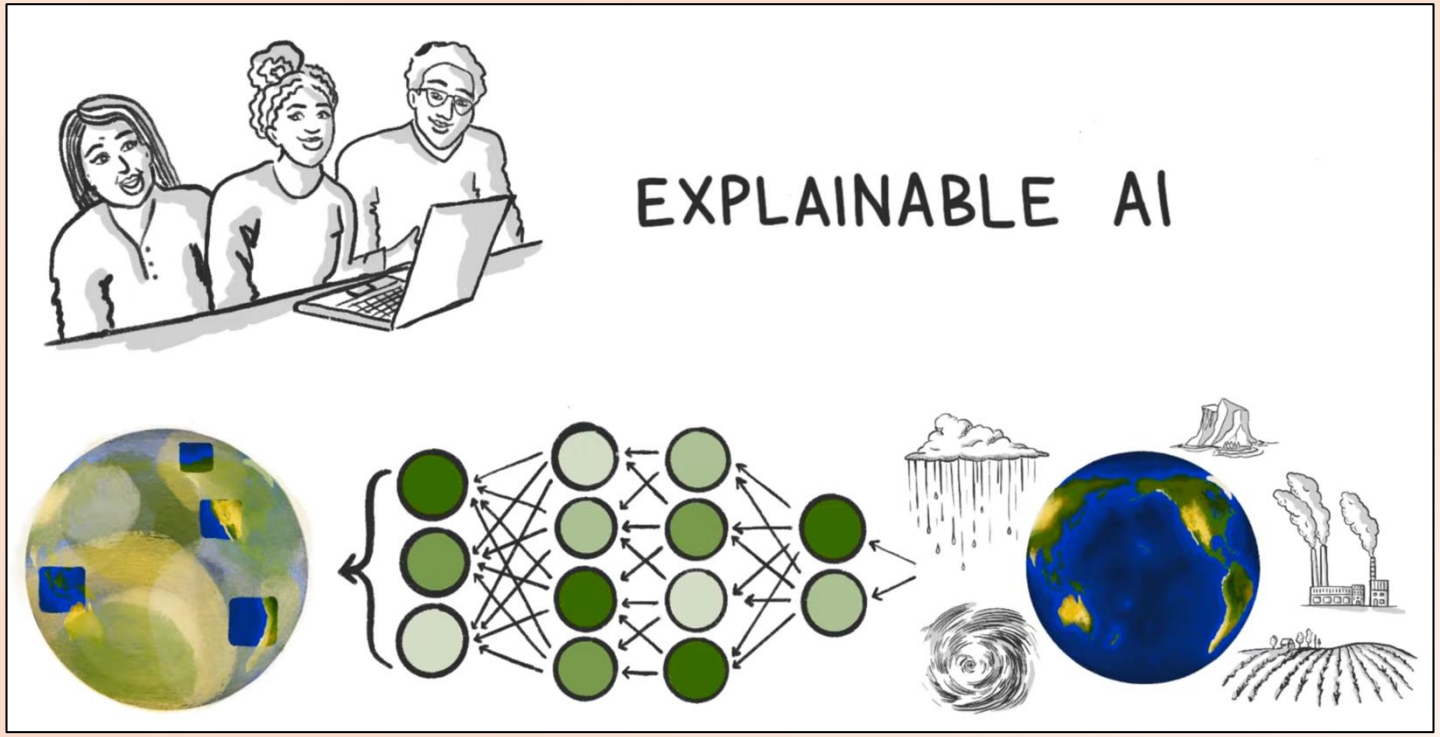
We rely on predictable states of the climate system to improve climate forecasts:
forecasts of opportunity- high skill, high confidence

Driving research question:
What are sources of predictability that provide forecasts of opportunity?



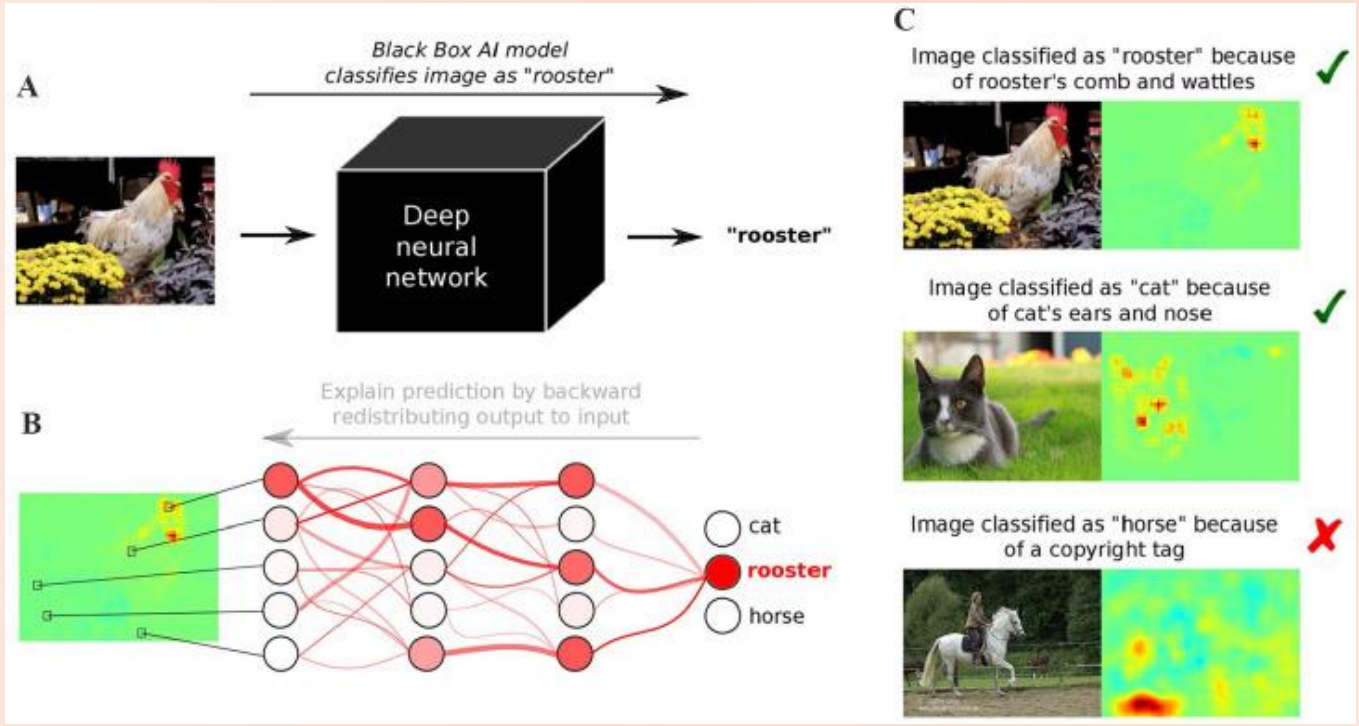
Leverage data science tools to extract signals from the noisy climate system

How can we trust black box AI models?



eXplainable Artificial Intelligence (XAI)

- Explain how a neural network makes predictions by determining the network's *decision-making strategy*



Explanation/ relevance heatmaps

Schwendicke et al. 2020, *J Dentistry Research*

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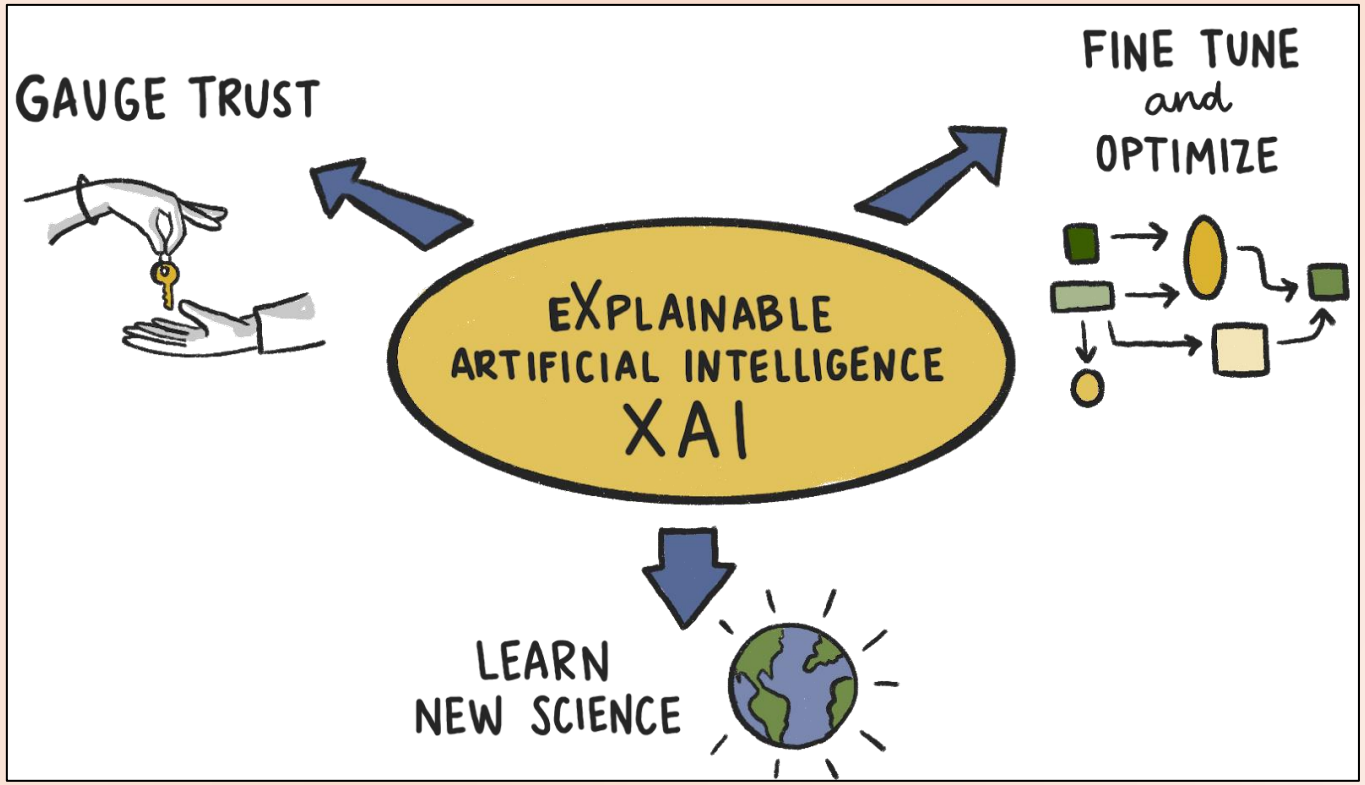

Real-time Subseasonal Forecasting Tool

Project team: Chi-Jui Chen, Nimay Mahajan, Emily Becker, Dan Collins, Emerson LaJoie

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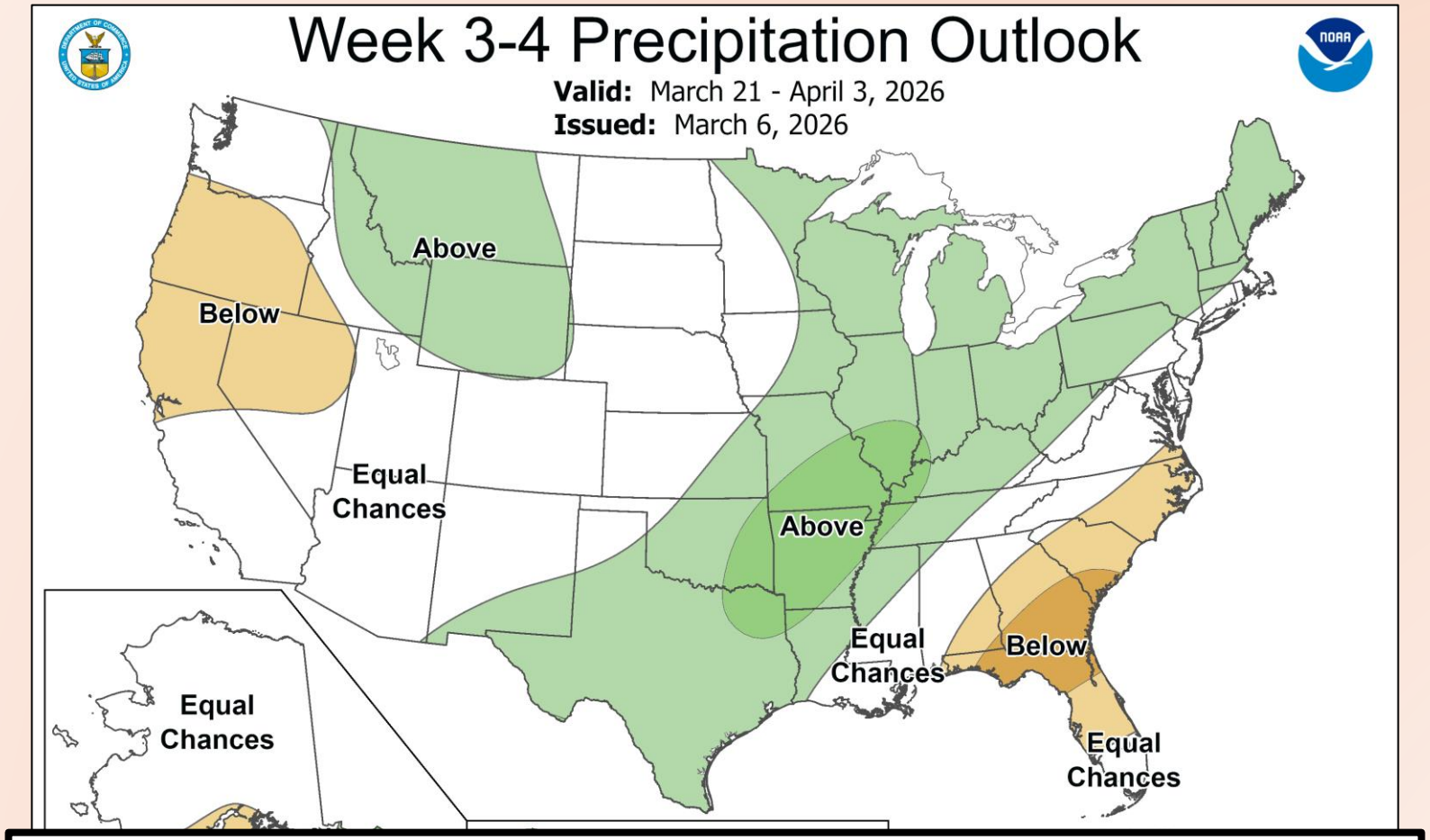
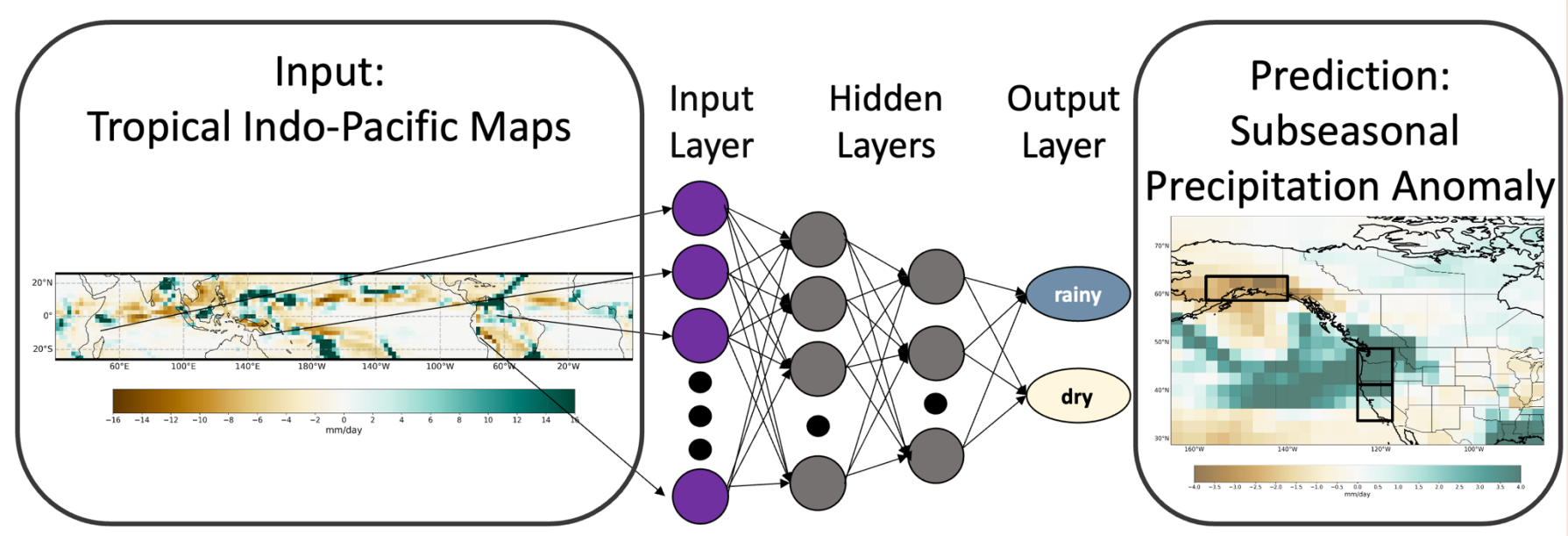
Climate Prediction Center



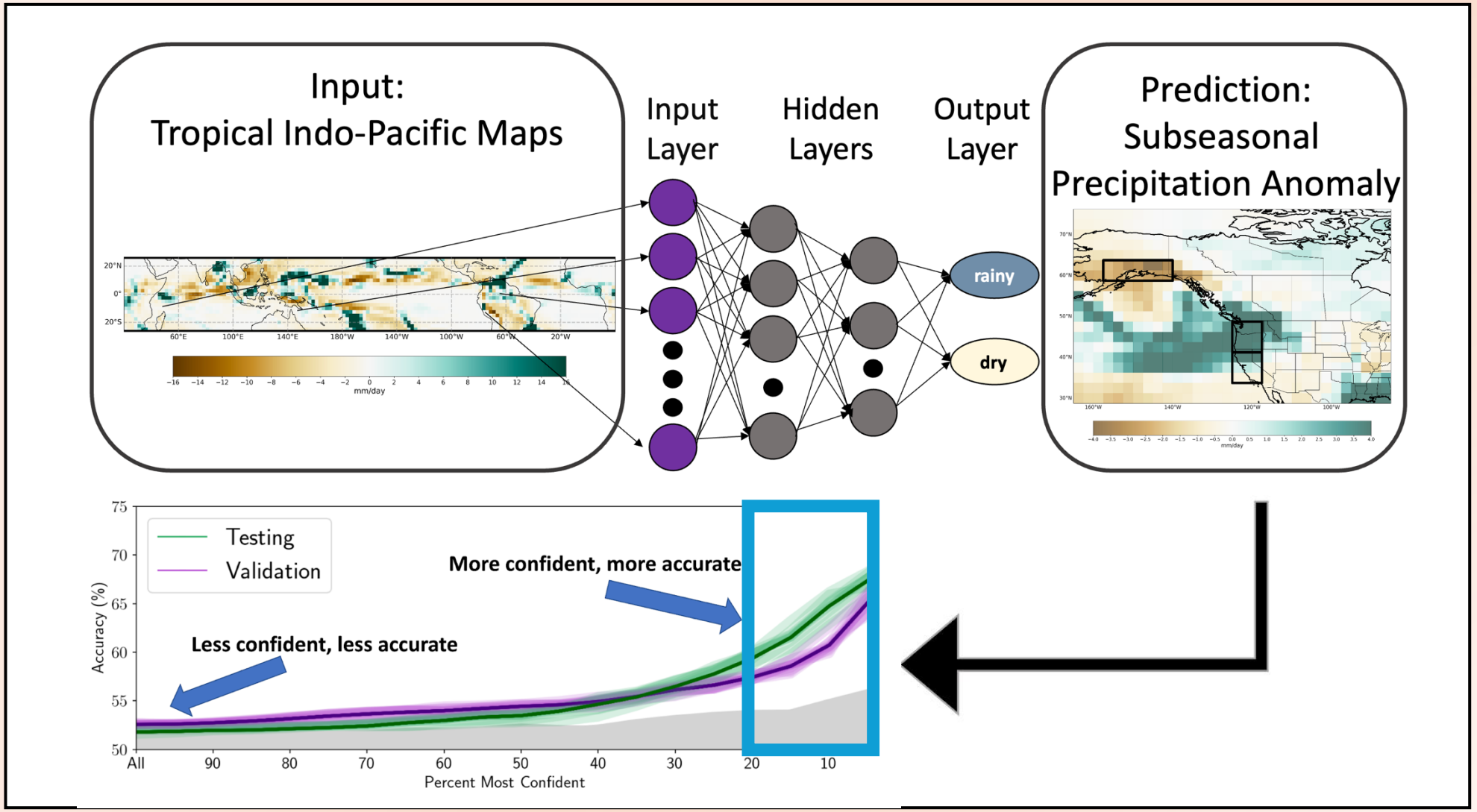
Produce a **real-time forecasting tool** to identify ***when, where, and why*** a Week 3-4 precipitation forecast can be considered a forecast of opportunity

Identify forecasts of opportunity



Arcodia et al., 2023; Environmental Research: Climate

Identify forecasts of opportunity



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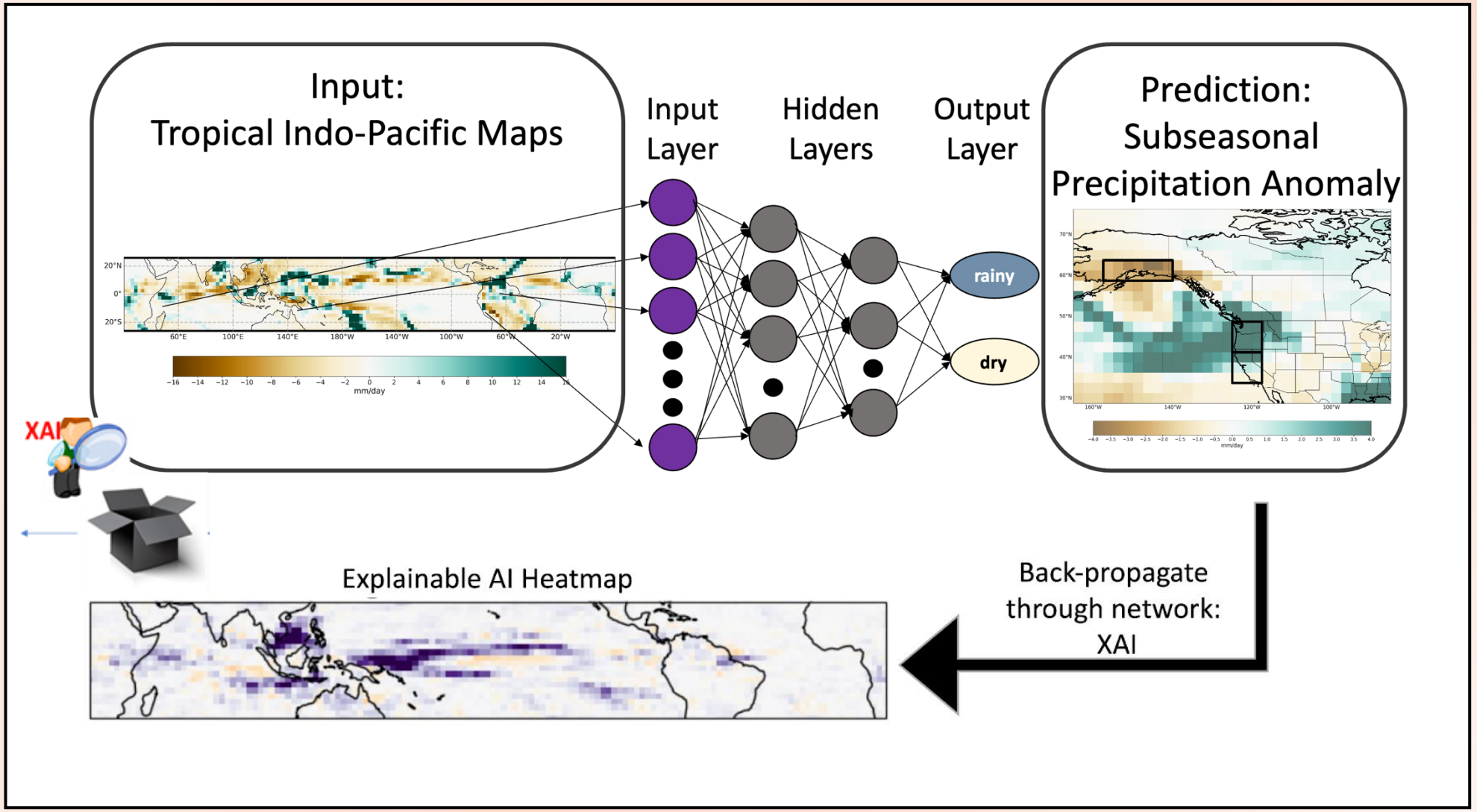
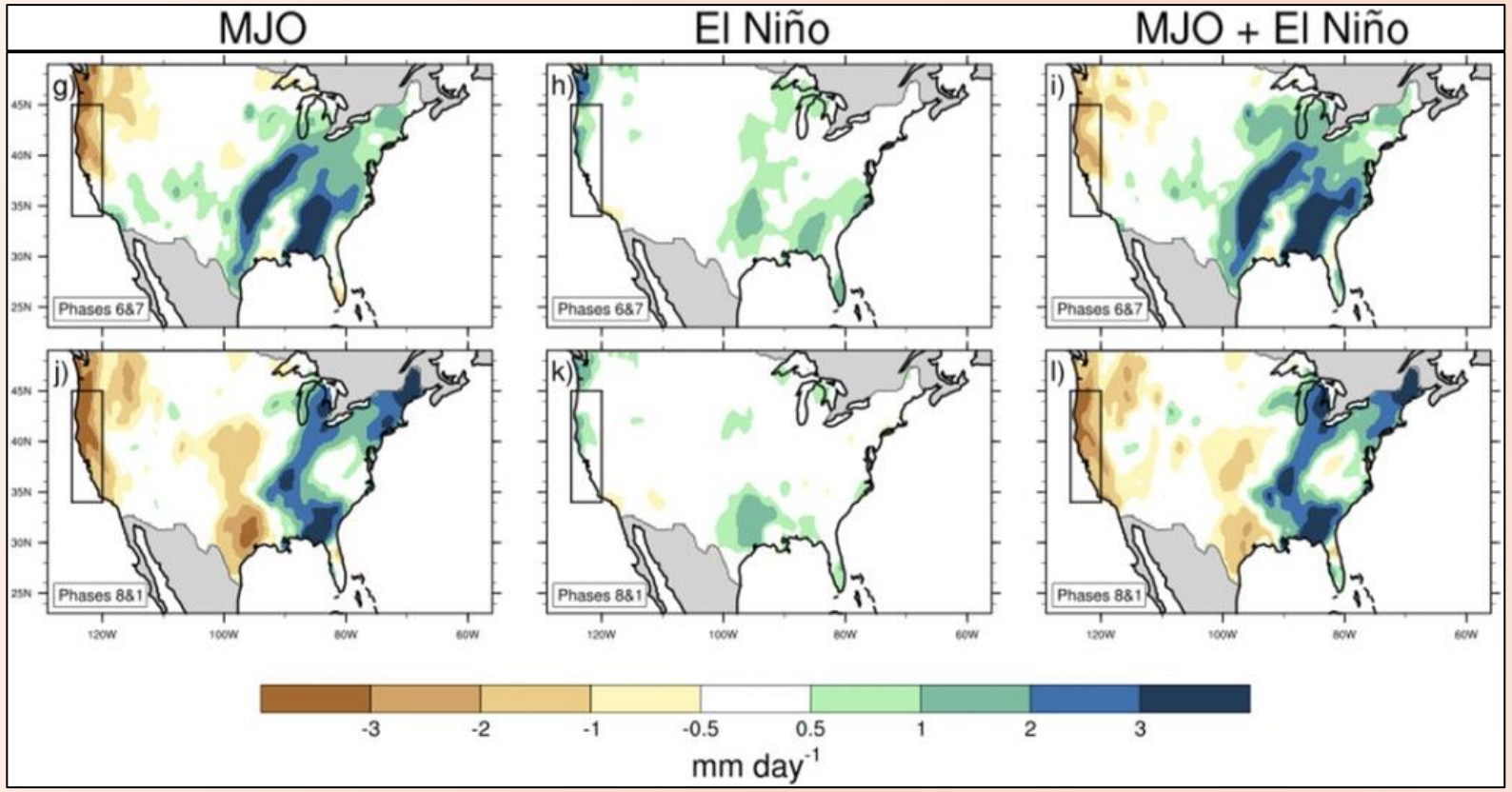
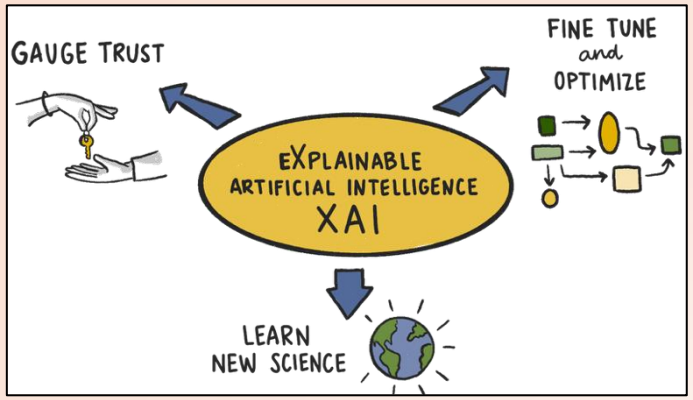
Identify forecasts of opportunity



Arcodia et al., 2023; Environmental Research: Climate

Neural network has identified physically-meaningful sources of predictability for subseasonal forecasts of opportunity

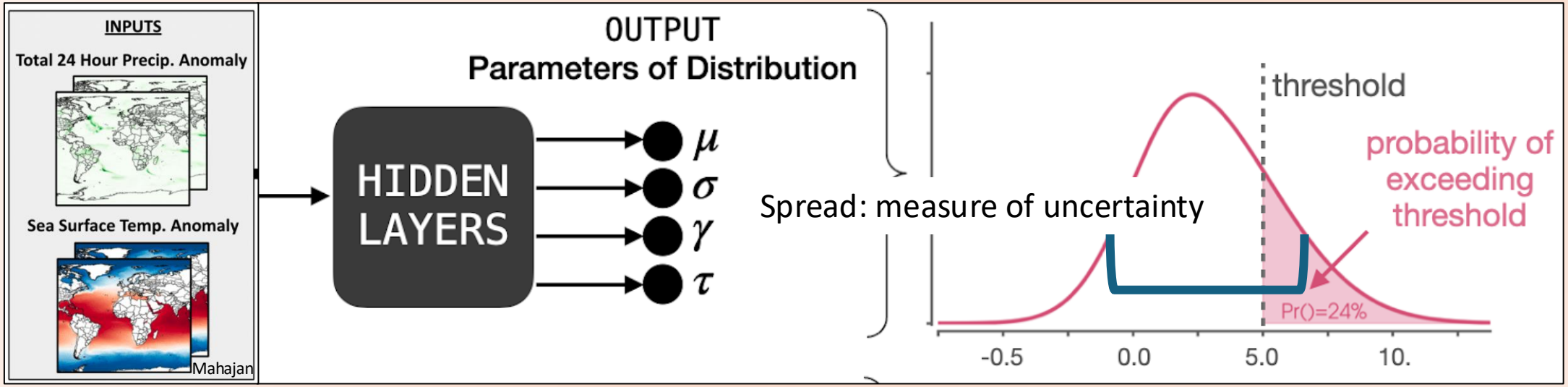




Arcodia, Kirtman, and Siqueira 2020; Journal of Climate

Wang et al. 2023, Tseng et al. 2019, 2020; Moon et al. 2011; Garcia-Franco et al. 2025; Lee et al. 2023

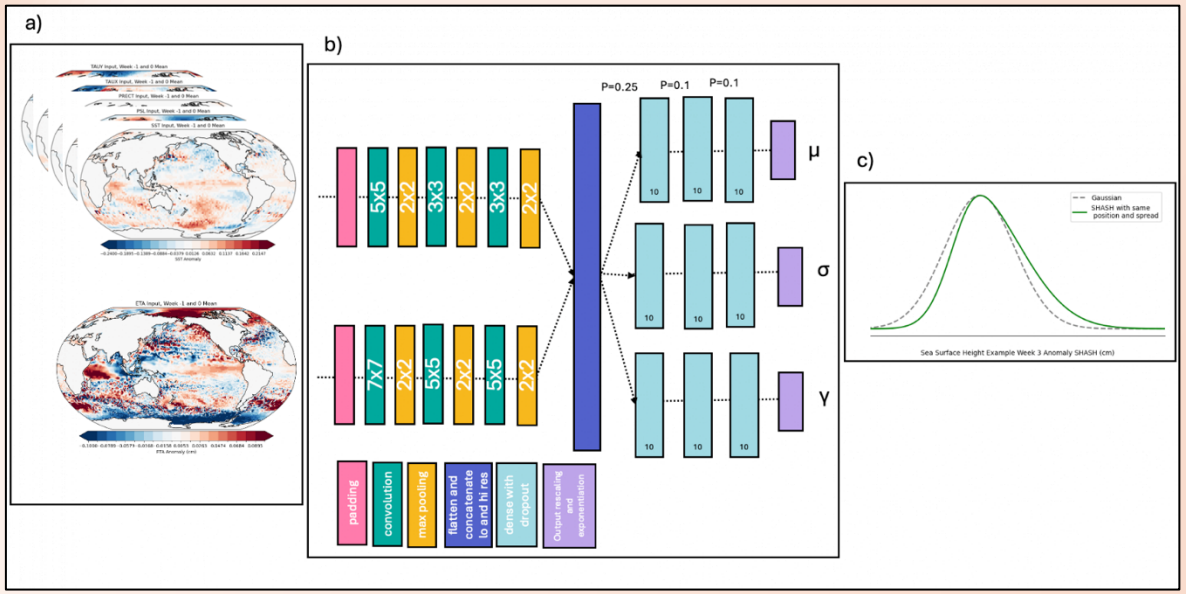
Better capture uncertainty in forecasts



Produce skillful subseasonal precipitation forecasts with uncertainty quantification in real-time

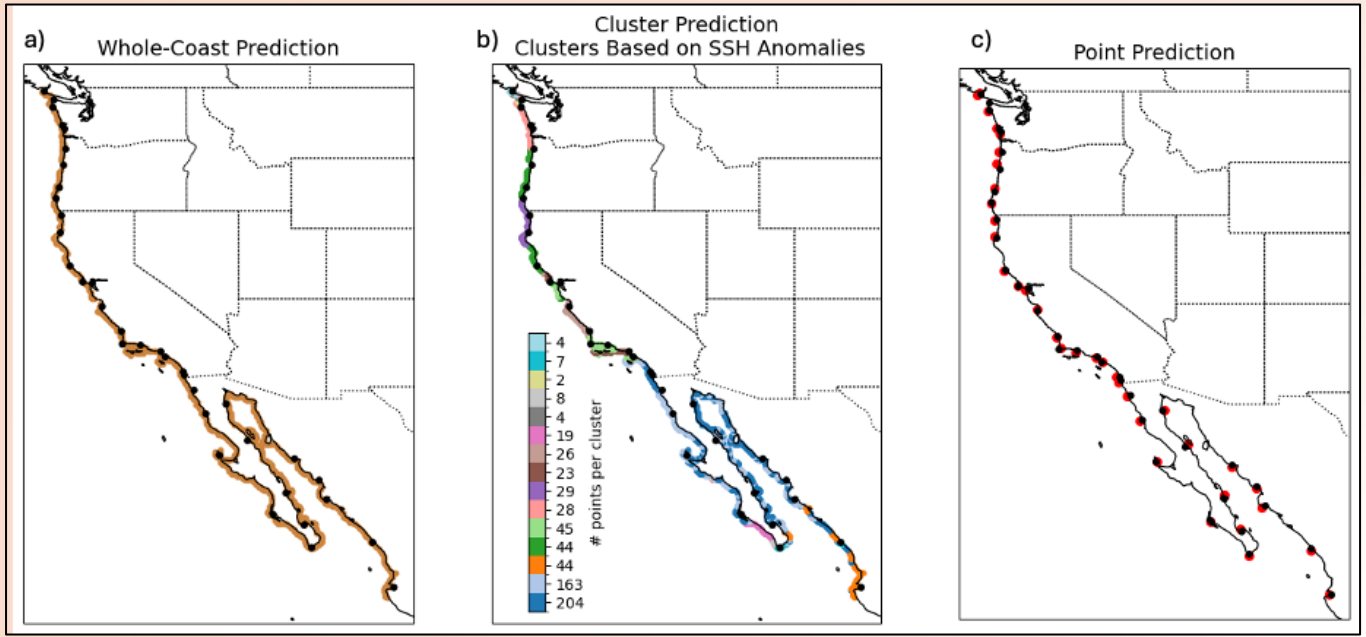
Predictability  **Prediction**

Capturing uncertainty in S2S coastal sea predictions



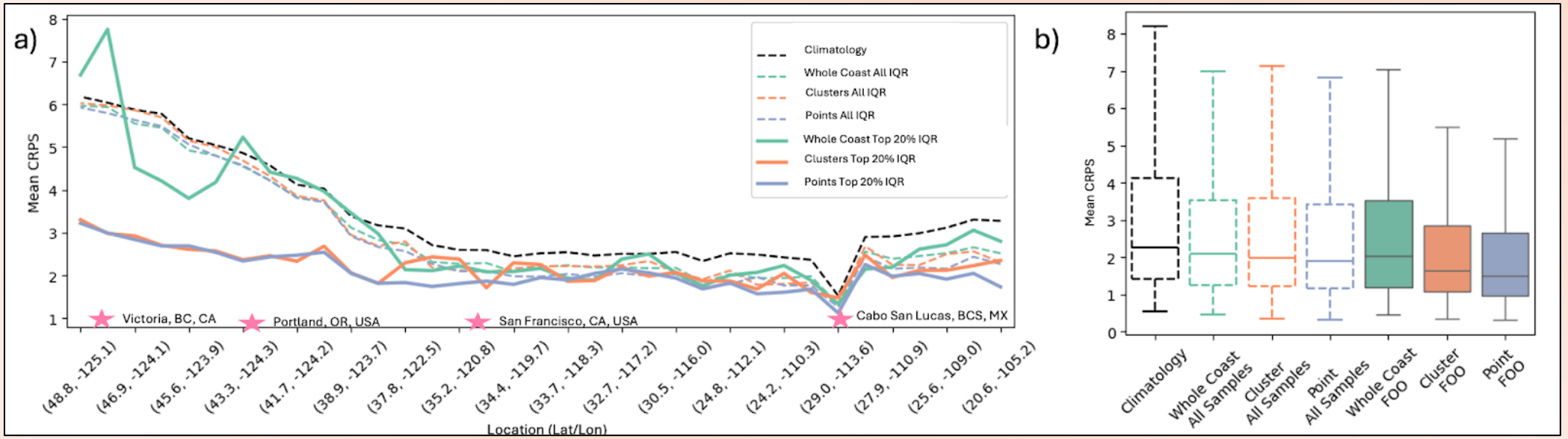
Compare CNNs trained to predict sea level probability distributions in 3 ways: 1) whole Northeast Pacific Coast simultaneously, 2) over pre-determined clusters within this coastline, 3) individual gridpoints near tide gauges.

Data: CESM-HR iHESP daily
Train (36 years); Val (8 years); Test (8 years)



Thapa, Arcodia, and Barnes;
submitted to *Lessons Learned (AIES)*

Identifying S2S Forecasts of Opportunity



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- When comparing the skill of each tasks' 20% most confident predictions, the skill of the Cluster and Point tasks to be on par with each other and substantially more skillful than the Whole Coast task
- Cluster task represents all gridpoints in the Northeast Pacific Coast with minimal tunable parameters *and* reliably identifies S2S forecasts of opportunity for coastal sea level

Research Team

UNIVERSITY OF MIAMI
FROST INSTITUTE for DATA SCIENCE & COMPUTING

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

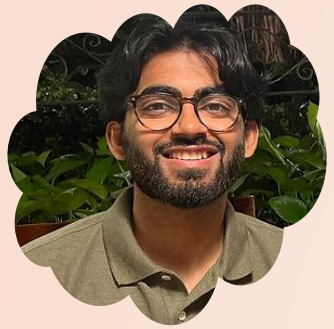
Our research group explores climate predictability and change through data science applications, collaborative interdisciplinary approaches, and localized analyses for actionable climate solutions.

Research topics:
- explainable and interpretable machine learning applications to climate problems
- climate variability and predictability on subseasonal to decadal timescales
- tropical-extratropical teleconnections
- climate modeling
- climate risks to communities and ecosystems

Marybeth Arcodia

Chi-Jui Chen

Juliette Rocha



Nimay Mahajan

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What's next?

- Using XAI prediction setups to predict onset of heat stress of Florida's Coral Reef with up to 6-week warnings using NOAA Coral Reef Watch data
- Leveraging recently developed ML-ESMs (machine learning based earth system models) and AI climate emulators to identify and analyze S2S forecasts of opportunity in purely AI-based models
- In conclusion,
  - Build ML prediction schemes using climate model and observational data to predict Week 3-4 precipitation anomalies and S2S coastal sea level with uncertainty quantification
  - Identify high-skill, high-confidence periods, aka *forecasts of opportunity*
  - Use XAI to investigate the sources of this predictability

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