

Developing Early Warning Forecasts of Hydrological Drought Onset, Duration, and Intensity Across the Conterminous U.S. Using Machine Learning Models



Hydrological drought impacts are widespread and recurring. Scientists on the Data-Driven Drought Prediction project are using machine learning models to develop early warning drought prediction capacity at regional and national scales. Pilot work is focused on streamflow drought onset, duration and severity prediction for gaged and ungaged areas of the Colorado River Basin region.

This project is exploring innovative visualization tools to improve understanding of how streamflow drought is defined and how it manifests at a given location. In addition to a web-based dashboard that enables visualizing the model forecasts, the project is also contributing to the creation of publicly accessible websites that communicate “what is streamflow drought” and impactful historical drought events across the U.S.

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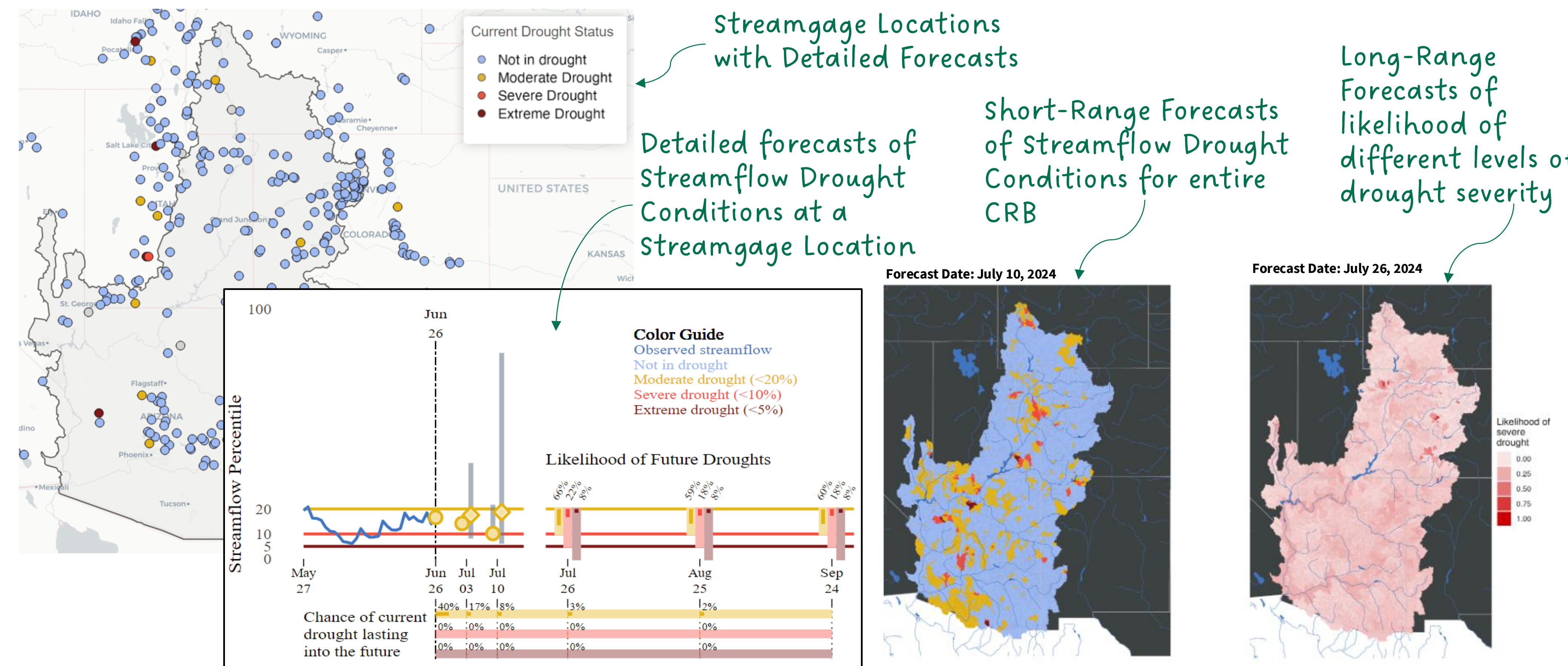
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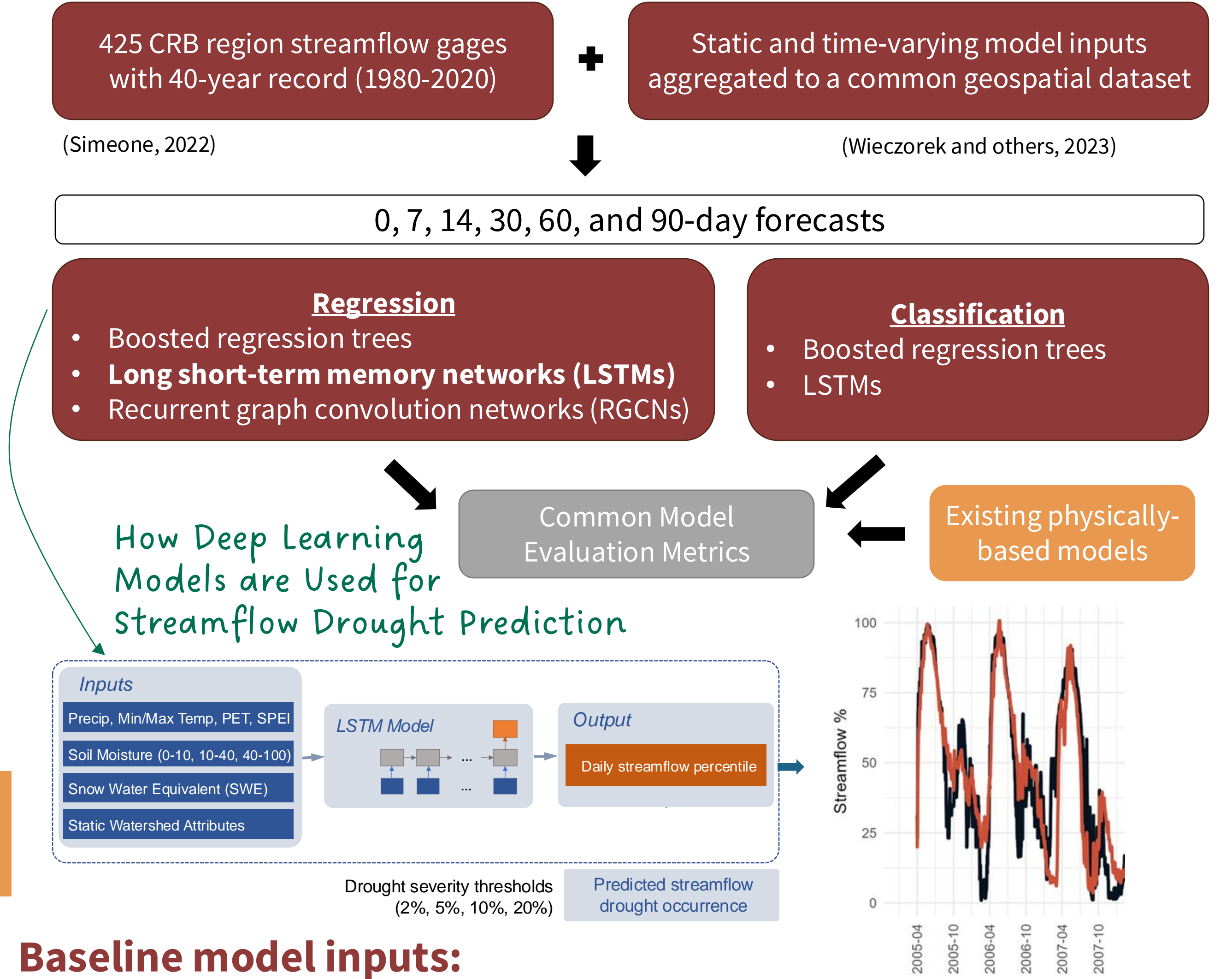
Project Objectives:

- Define drought in generalized, relevant ways for multiple stakeholder groups.
- Apply data-driven models to determine feasibility of forecasting drought onset, duration and severity days to months in advance.
- Improve methods for drought prediction in areas with heavily regulated streamflow.
- Prototype operational drought assessment and forecast tools that communicate predictions and uncertainty.
- Develop communication and data visualization tools to increase understanding of hydrologic drought.
- Collaborate with partner federal agencies to complement existing forecast tools.

Pilot Colorado River Basin Area Streamflow Drought Early Warning System



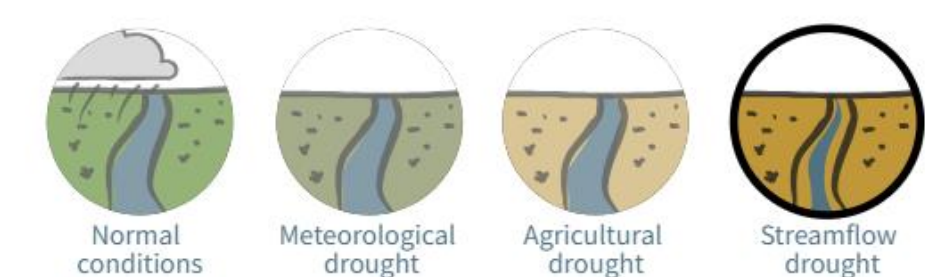
Behind the Scenes: Modeling Streamflow Percentiles using Machine Learning



Streamflow Drought Onset, Duration and Intensity Prediction

What is **streamflow** drought?

View the Full Site Here

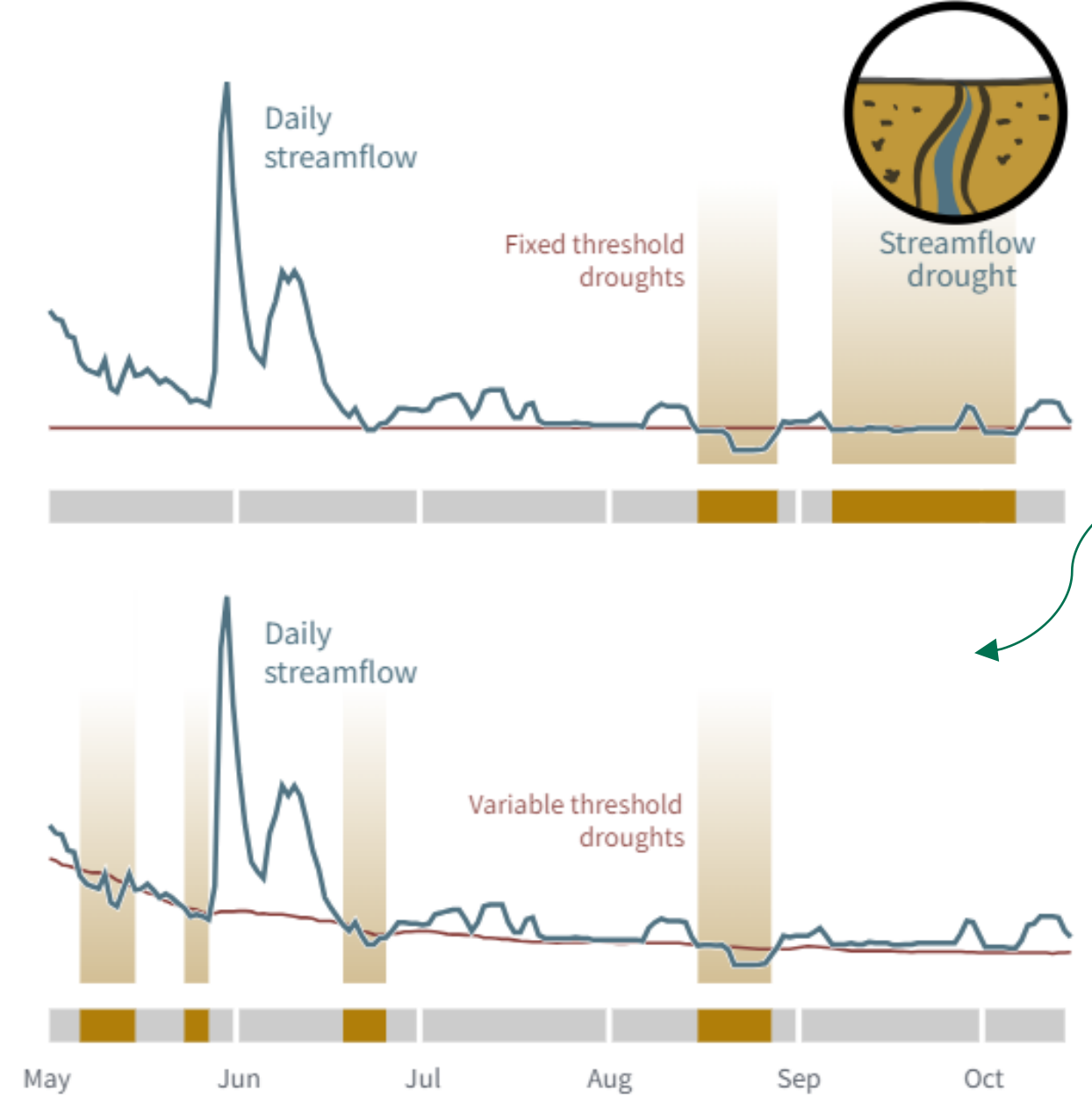
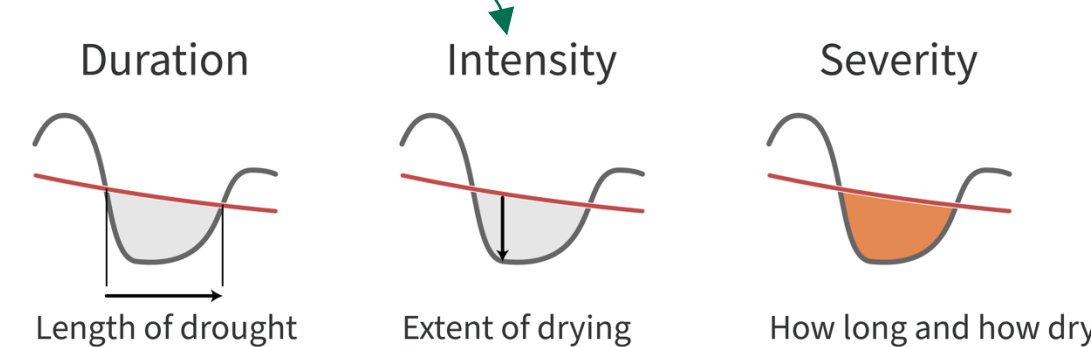


As drought conditions persist, less water moves into and through streams. Reduced streamflow has significant impact on plants, animals, and humans. When streamflow levels are unusually low, this is defined as streamflow drought. But what does “unusually low” really mean?



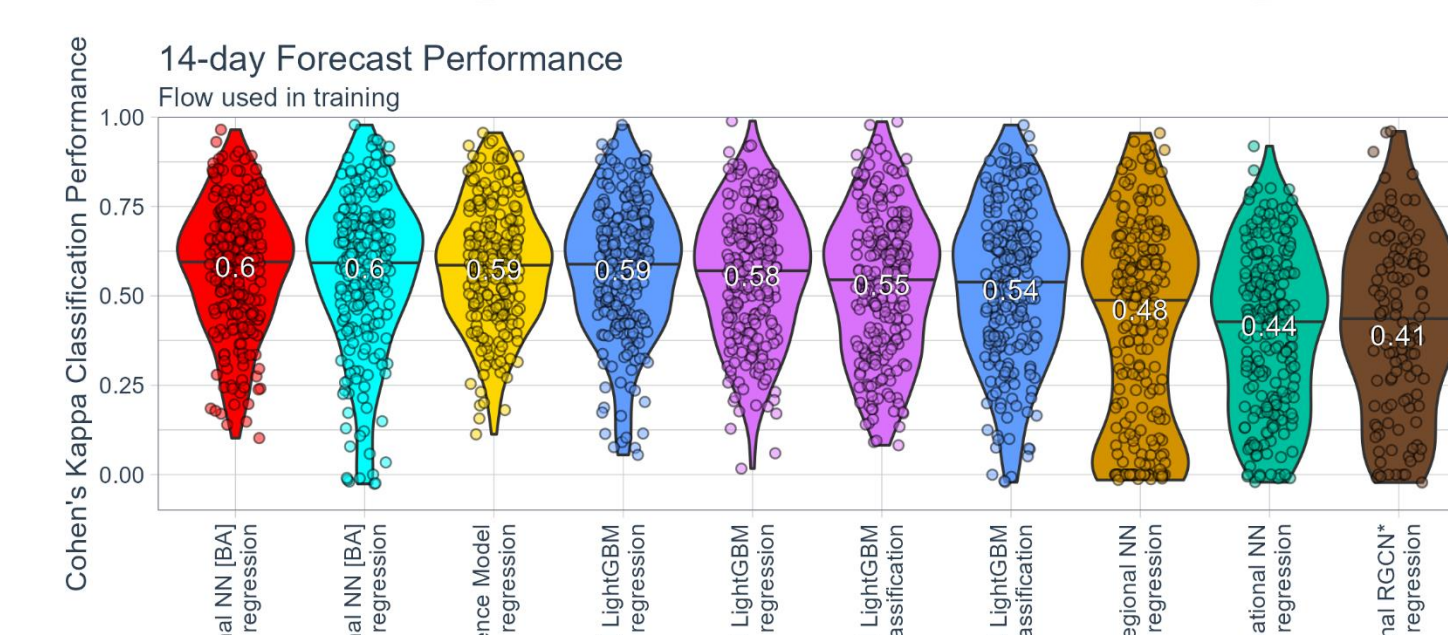
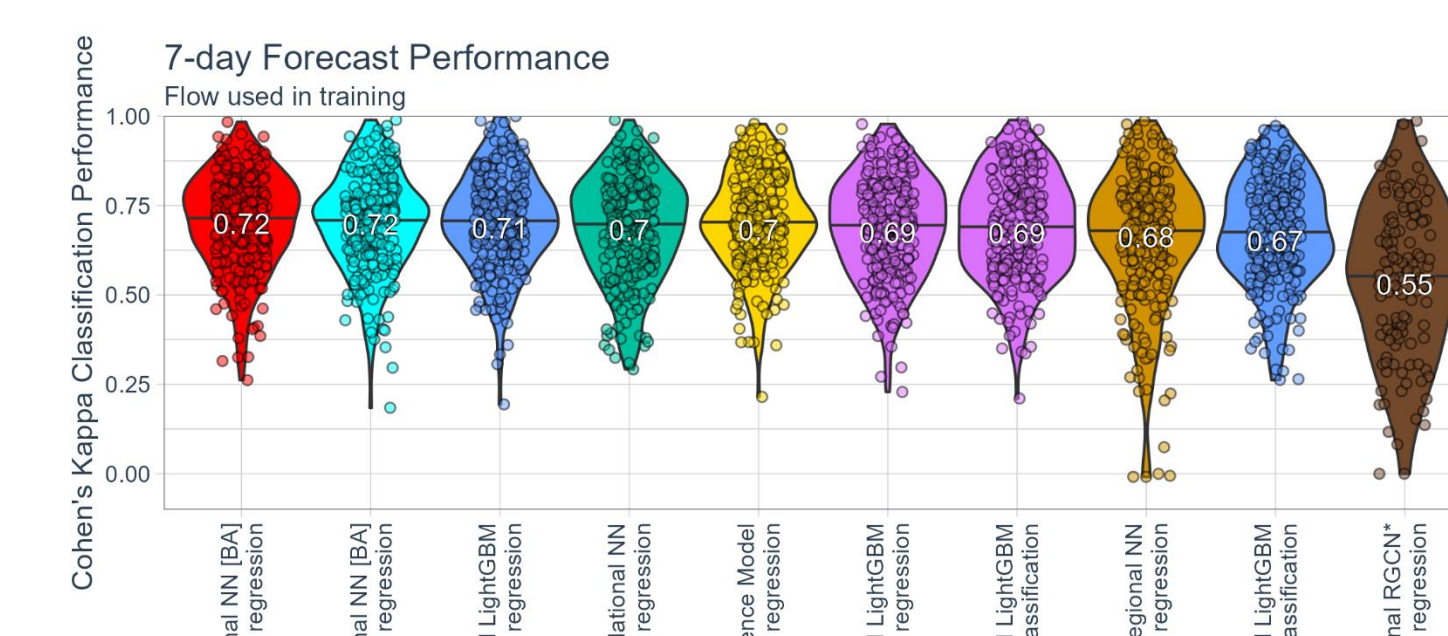
Depending on your water use type, management constraints, and location, different ways of defining drought may be more useful than others.

Components of a streamflow drought event



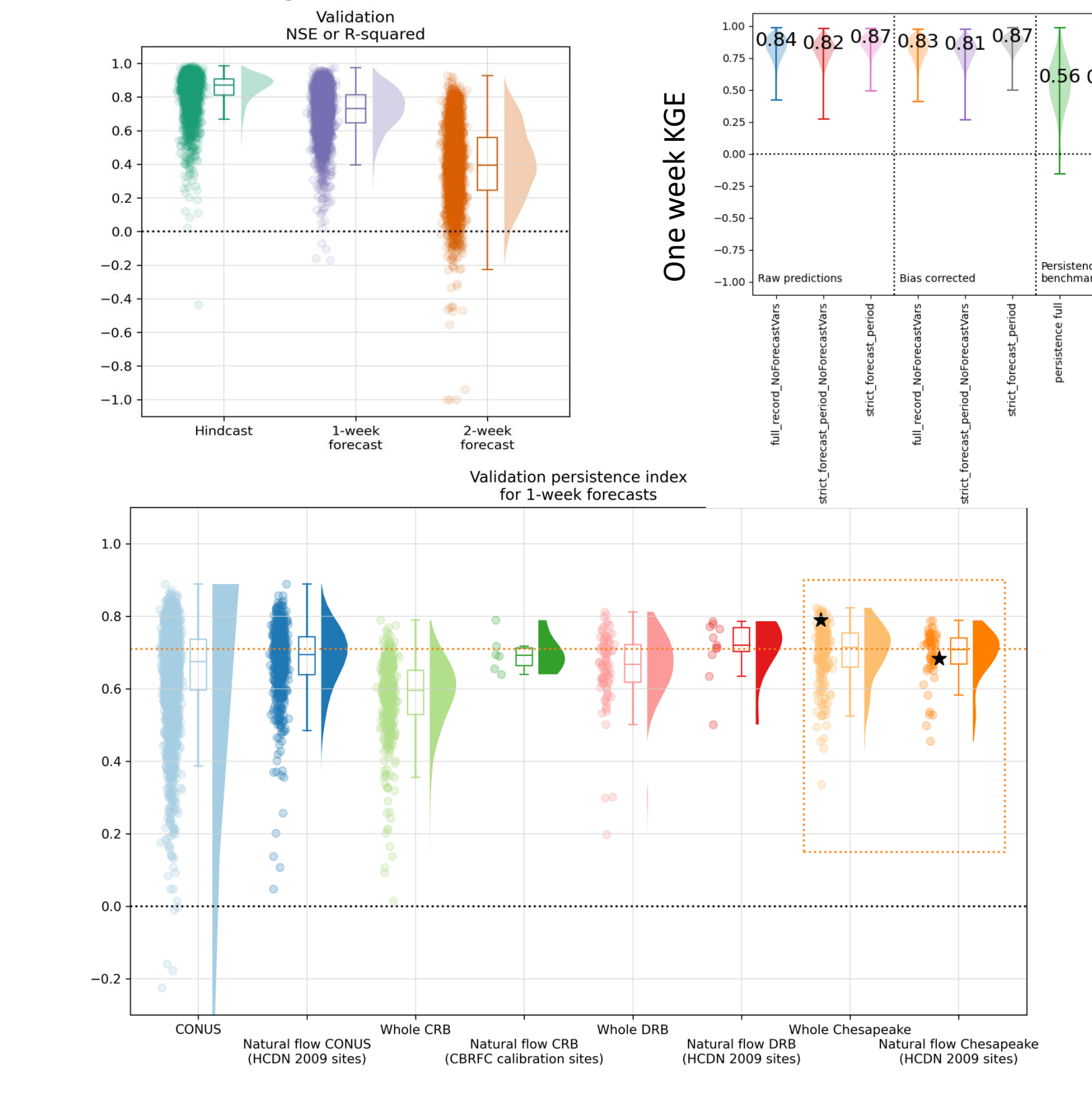
Model intercomparison in the Colorado River Basin

- Forecasting severe streamflow droughts 1 and 2 weeks in advance:



Model intercomparison across the Conterminous United States

- Forecasting severe streamflow droughts 1 and 2 weeks in advance:



Baseline model inputs:

- Antecedent streamflow
- gridMET precipitation, maximum temperature, minimum temperature, standardized precipitation-evaporation index, potential evapotranspiration
- University of Arizona Snow Water Equivalent
- NLDA2 Soil moisture from 0-10cm, 10-40cm, and 40-100cm depths
- Static Variables including degree of regulation, forest cover, water use

Forecast meteorology variables being used:

- GEFS – temperature and precipitation forecasted 1-10 days in advance.
- NMME CFSv2 - temperature and precipitation forecasts 15, 45, 75, and 105 days out.
- SUBX ensemble mean - temperature and precipitation forecasts for 1-5 weeks out.
- ECMWF ensemble mean - temperature and precipitation forecasts for 1-5 weeks out.
- CPC - temperature and precipitation above, below, normal likelihood for 1-2 months.

Other model experimentation:

- Reservoir storage and outflow inclusion
- Monthly public supply and irrigation water use
- Analog forecasting – using historical traces from observed hydroclimatology

Use Cases:

- **Retrospective predictions:** Linking to ecological and socioeconomic datasets to examine the effects of drought on different sectors
- **Operational forecasts:** Displayed on internal USGS forecasting web map for testing and user feedback

Acknowledgements

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This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

More Information and Available Data Releases:

Scott D. Hamshaw, Ellie White, and William Watkins, 20230508, Data-Driven Drought Prediction Project Model Outputs: Daily Streamflow and Streamflow Percentile Predictions for the Colorado River Basin Region, <https://doi.org/10.5066/P97NIH7Y>

Hammond, J.C., Pulver, B.A., and Hamshaw, S.D., 2023, Preliminary streamflow percentile predictions for ungaged areas of the Colorado River Basin, 1981-2020, <https://doi.org/10.5066/P9911VBJ>

Wiczorek, M.E., Hafen, K.C., and Staub, L.E., 2023, Data-Driven Drought Prediction Project Model Inputs for Upper and Lower Colorado Portions of the National Hydrologic Geo-Spatial Fabric version 1.1 and Select U.S. Geological Survey Streamgauge Basins, <https://doi.org/10.5066/P981G8L0>.

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