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.

Model intercomparison in the

Forecasting severe streamflow

droughts 1 and 2 weeks in advance:

Colorado River Basin

Data-Driven Drought Prediction Project Team:

Althea Archer¹ Gericke Cook¹ Hayley Corson-Dosch¹ Jeremy A. Diaz¹ Phillip Goodling²

Model intercomparison across the

droughts 1 and 2 weeks in advance:

for 1-week forecasts

Conterminous United States

Forecasting severe streamflow

John C. Hammond³ Scott D. Hamshaw⁴ Aaron Heldmyer⁵ Ryan McShane⁵ Cee Nell¹

Bryce Pulver⁶ Roy Sando⁵ Caelan Simeone⁷ Erik Smith⁸ Leah Staub³

William David Watkins¹ Ellie White¹ Michael Wieczorek³ Kendall Wnuk³ Jacob A. Zwart¹

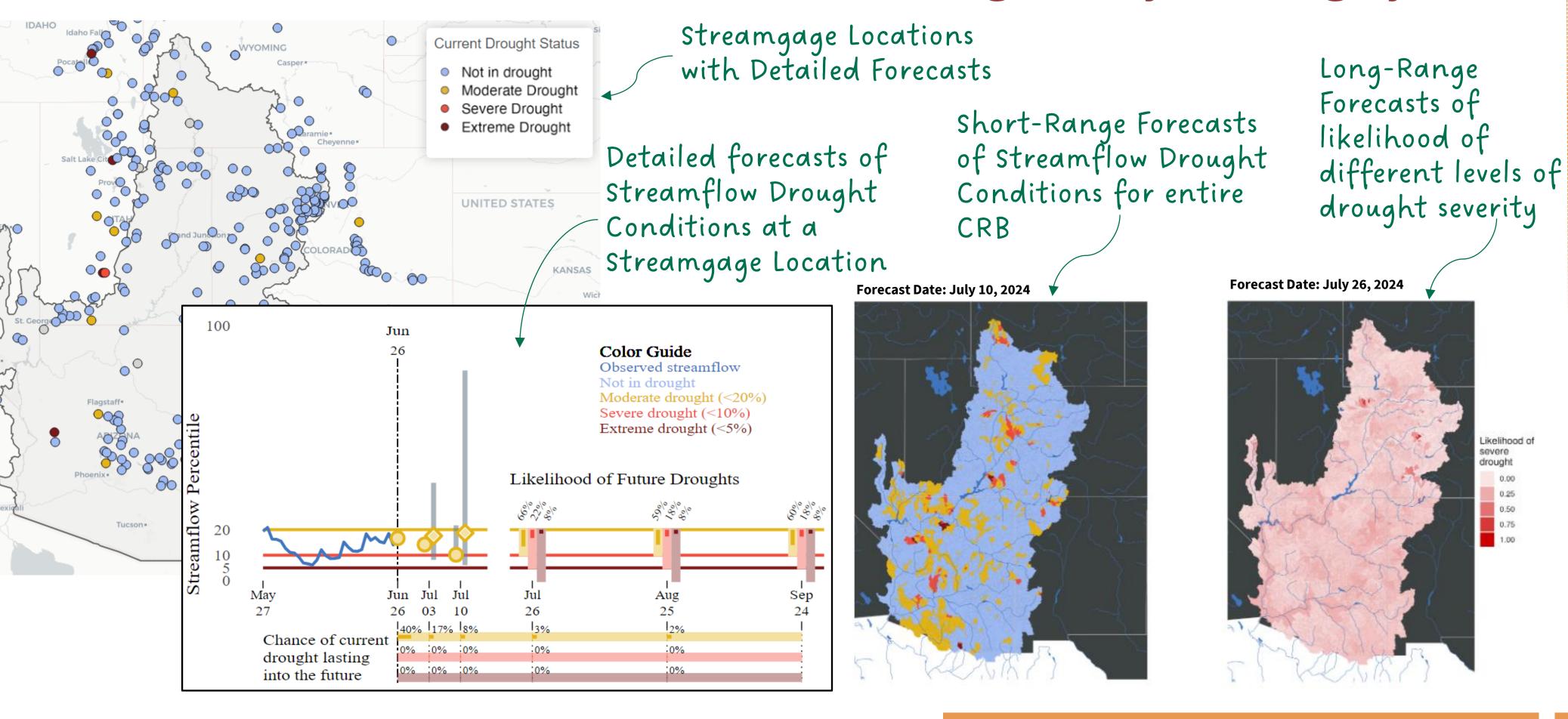
Project Objectives:

- 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.

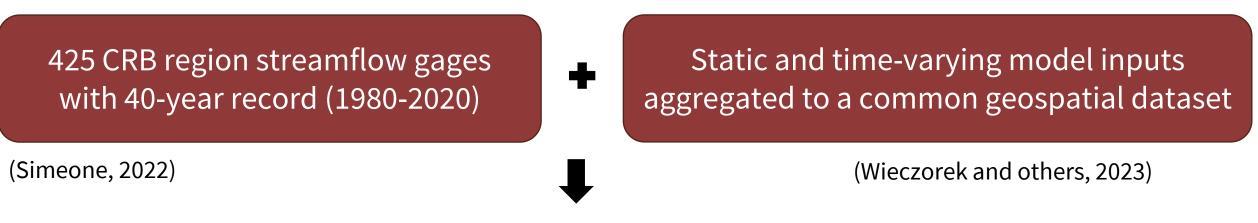
s **streamflow** drought?

what does "unusually low" really mean?

Pilot Colorado River Basin Area Streamflow Drought Early Warning System

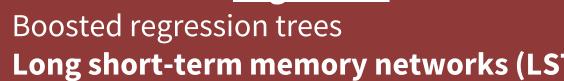


Behind the Scenes: Modeling Streamflow Percentiles using Machine Learning





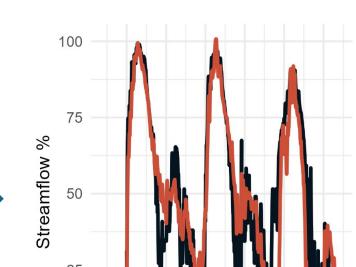
0, 7, 14, 30, 60, and 90-day forecasts



Long short-term memory networks (LSTMs) Recurrent graph convolution networks (RGCNs)

Classification Boosted regression trees LSTMs





Predicted streamflow

Baseline model inputs:

Antecedent streamflow

Precip, Min/Max Temp, PET, SPE

oil Moisture (0-10, 10-40, 40-100)

- •gridMET precipitation, maximum temperature, minimum temperature, standardized precipitation-evaporation index, potential evapotranspiration
- University of Arizona Snow Water Equivalent
- •NLDAS2 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

Interested in Using These Forecast Products or Providing User Feedback? Please reach out!

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

View the

Full Site

■(25%)

Daily

streamflow

streamflow

Here

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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

Streamflow Drought Onset, Duration and Intensity Prediction

Depending on your water use type,

more useful than others.

management constraints, and location,

different ways of defining drought may be

Components of a streamflow drought event

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/P99I1VBJ

Wieczorek, 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 Streamgage Basins, https://doi.org/10.5066/P98IG8LO.

*Presenter Contact: jhammond@usgs.gov

- ¹ Integrated Information Dissemination Division ² Earth System Processes Division
- ³ Maryland-Delaware-D.C. Water Science Center
- ⁴ Integrated Prediction & Modeling Division ⁵ Wyoming-Montana Water Science Center
- ⁶ Utah Water Science Center
- ⁷ Oregon Water Science Center
- ⁸ Oklahoma-Texas Water Science Center