**Title:** Developing Early Warning Forecasts of Hydrological Drought Onset, Duration, and Intensity Across the Conterminous United States Using Machine Learning Models

**Authors:** John Hammond, Althea Archer, Gericke Cook, Jeremy Diaz, Phillip Goodling, Scott Hamshaw, Aaron Heldmyer, Ryan McShane, Bryce Pulver, Roy Sando, Caelan Simeone, Erik Smith, Leah Staub, David Watkins, Michael Wieczorek, Kendall Wnuk, Jacob Zwart.

**Abstract:**

Drought events will likely be more impactful and difficult to predict in coming years given continued climate change. The U.S. Geological Survey Water Mission Area Drought Program is working to characterize and predict hydrological drought, defined as abnormally low streamflows and groundwater levels. Work at regional and national scales is focused on developing data-driven methods to advance early warning capacity for hydrological drought onset, duration, and severity. In this presentation we focus on tree-based and long short-term memory neural network modeling approaches to forecast 0-90 day streamflow drought conditions across the conterminous United States (CONUS). We use gridded meteorology and meteorological forecasts including GEFS and NMME, modeled snow and soil moisture storage, and watershed properties to train our models. Our modeling approaches predict hydrological drought for moderate (20%), severe (10%), and extreme (5%) intensity levels using both fixed (one threshold applied to all days and years) and seasonally varying drought thresholds (different drought thresholds for each day of the year). Quantile regression models are used to estimate streamflow percentiles and uncertainty ranges, while drought likelihood is additionally modeled using classification approaches. Overall, models show a strong ability to identify severe droughts via variable streamflow percentiles in the near term, with median Cohen's kappa values of 0.72 for 7-day forecasts and 0.60 for 14-day forecasts. Models had weaker predictive capacity for regulated basins, drier areas of the CONUS, increasingly intense droughts, longer lead times, and variable thresholds, and for these reasons modified approaches are being explored to improve model performance. We also present initial results of models predicting groundwater drought at sites across CONUS. As we continue to develop prototype forecast tools for assessing and predicting hydrologic drought conditions, we are incorporating stakeholder input to design tools that complement existing drought and water supply prediction tools.