USGS Northeast Region Drought Forecasting Pilot Effort

Northeast Monthly Climate Update
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July 31, 2018
Droughts in the NE

* Tend to be short-term and recover quickly
* Local to regional extent
* Drought of 1960s generally drought of record, local and short-term droughts exceed this
* 2016 was the most severe drought since the early 1980s
Who Cares?

- Water shortage and droughts impact public water supplies, industries, agriculture and the quality of both aquatic and terrestrial environments.
- State drought committee involving emergency management and water resource agencies depend on streamflow and groundwater data and climate forecasts for decision making.
- 2016 showed that many states are not prepared and up-to-date on drought preparedness/plans.

Who Cares?
2 regional approaches for assessing potential future drought conditions

- Streamflow: Probability of stream flow levels in the summer
- Groundwater: probability of water levels exceeding a threshold

Both approaches are based on existing published methods
Virginia Drought Streamflow Studies

This statewide cooperative study with the US Geological Survey led to a nationwide study…

Methods for Estimating Drought Streamflow Probabilities for Virginia Streams

Led to a nationwide study…

Modeling Summer Month Hydrological Drought Probabilities in the United States Using Antecedent Flow Conditions
We investigated the likelihood of a relation between winter streamflow and summer streamflow based on local water availability.


Funding from 2 USGS programs (the *Groundwater and Streamflow Information Program*, and the *Water Availability and Use Science Program*) was used to determine whether similar relations could be identified nationwide.
We developed and tested a method for estimating hydrological drought probabilities for rivers and streams in the United States using maximum likelihood logistic regression (MLLR).

Hydrological drought streamflow probabilities for summer months are estimated 5 to 11 months in advance of their occurrence using streamflow data from previous winter months.

Scope is limited to characterizing hydrological drought probability in 9,152 basins across the United States using USGS streamflow data spanning each basin’s period of record.

A test of predictions of September 2013 hydrological droughts for these sites using data from October 2012 resulted in an overall correct classification rate of 91%.
MLLR is used to fit Y responses (P[No] and P[Yes]) to linear models of X terms.

The chance (likelihood) that a streamflow daily value (DV) in a particular month will not exceed (P[No]), or exceed (P[Yes]), a hydrological drought flow threshold as a function of mean monthly flow from an earlier month, is described.

Each logistic curve is fitted using the difference in the logs of each binary response (Y’s of P[No] and P[Yes]), as a linear function of a factor variable (X’s of mean streamflow from a previous month).

Each logistic function has the form:

\[ p = \frac{1}{1 + e^{-(\beta_0 + \beta_1 \cdot X)}} \]

where:
- \( e \) is the base of the natural logarithm
- \( \beta_0 \) is an intercept parameter
- \( \beta_1 \) is a slope parameter
- \( x \) is a factor variable

15 equations for each of 9,152 basins describe July, August, and September hydrological drought probabilities as functions of mean streamflow from the previous October, November, December, January, and February.

All (y) responses use a 20th-percentile drought flow threshold.
Study Gages In 21 USGS National Water Information System (NWIS) Hydrologic Units (HUC). County boundaries are shown. Alaska and Hawaii are drawn at a reduced scale.
Hydrological Drought
Future Streamflow Probabilities

Sam Austin, Chintamani Kandel, Jennifer Rapp

https://va.water.usgs.gov/webmap/drought/
Probability of Future Groundwater Levels Below Specified Thresholds


Statistical models to identify probability of water levels going below a set threshold based on numerous input variables

Predictions best for wells with low month-to-month variability/longer duration low levels
Probability of Future Groundwater Levels Below Specified Thresholds

- Logistic regression approach
- 102 wells used
  - not impacted by pumping
  - 20 years of record
- Predicted 1, 2, 3, 6, 12 months out
  - predictor variables included nearby streamflow sites, Palmer drought index, precip, atmospheric-ocean indices
FIGURE 2. Plot Showing an Example Application of a Three-Month Forecast Model for a Well in Georgia. Blue dots and lines represent the monthly groundwater-level time series. Points colored red are groundwater levels at or below the 10th percentile low threshold. The vertical green lines are the monthly estimated probability that the groundwater level will be at or below the 10th percentile three months later. The explanatory variables for this forecast model comprise current groundwater level, a Fourier seasonality term, and the current monthly Atlantic Multidecadal Oscillation index value.

FIGURE 3. Plot Showing an Example Application of the Three-Month Forecast Model for a Well in Georgia from December 2006 to December 2007. The vertical green lines are the monthly estimated probability that the groundwater level will be at or below the 10th percentile three months later.
Plan Moving Forward in NE Region

- Prepare factsheets and web sites describing methods, results, strengths/weaknesses of methods
- Complete this calendar year; funded by WSCs with discretionary funds
- Provide briefings to partners, agencies, NIDIS and others
- Improving our forecasting skills
Other USGS Opportunities relating to Droughts

* Update low flow statistics
* Incorporate low flow statistics, Sustainable Yield Estimators, water use into Streamstats
* Evaluate collection networks for efficiency in providing drought conditions for streams or groundwater
* Add new monitoring to help with forecasting (soil moisture probes, ET, snow pack)
* Develop other forecasting tools for surface and ground waters – based on long-term climate forecasts or selected thresholds
* Basin-wide/watershed studies to store excess water for use during dry periods (optimal storage and release)
* Enhanced web pages/data delivery
Thank you!