Geophysical Research Abstracts
Vol. 18, EGU2016-2386, 2016
EGU General Assembly 2016

Seasonal forecasting of discharge for the Raccoon River, Iowa

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The state of Iowa (central United States) is regularly afflicted by severe natural hazards such as the 2008/2013 floods and the 2012 drought. To improve preparedness for these catastrophic events and allow Iowans to make more informed decisions about the most suitable water management strategies, we have developed a framework for medium to long range probabilistic seasonal streamflow forecasting for the Raccoon River at Van Meter, a 8900-km2 catchment located in central-western Iowa.

Our flow forecasts use statistical models to predict seasonal discharge for low to high flows, with lead forecasting times ranging from one to ten months. Historical measurements of daily discharge are obtained from the U.S. Geological Survey (USGS) at the Van Meter stream gage, and used to compute quantile time series from minimum to maximum seasonal flow. The model is forced with basin-averaged total seasonal precipitation records from the PRISM Climate Group and annual row crop production acreage from the U.S. Department of Agriculture's National Agricultural Statistics Services database. For the forecasts, we use corn and soybean production from the previous year (persistence forecast) as a proxy for the impacts of agricultural practices on streamflow. The monthly precipitation forecasts are provided by eight Global Climate Models (GCMs) from the North American Multi-Model Ensemble (NMME), with lead times ranging from 0.5 to 11.5 months, and a resolution of 1 decimal degree. Additionally, precipitation from the month preceding each season is used to characterize antecedent soil moisture conditions.

The accuracy of our modelled (1927-2015) and forecasted (2001-2015) discharge values is assessed by comparison with the observed USGS data. We explore the sensitivity of forecast skill over the full range of lead times, flow quantiles, forecast seasons, and with each GCM. Forecast skill is also examined using different formulations of the statistical models, as well as NMME forecast weighting procedures based on the computed potential skill (historical forecast accuracy) of the different GCMs.

We find that the models describe the year-to-year variability in streamflow accurately, as well as the overall tendency towards increasing (and more variable) discharge over time. Surprisingly, forecast skill does not decrease markedly with lead time, and high flows tend to be well predicted, suggesting that these forecasts may have considerable practical applications. Further, the seasonal flow forecast accuracy is substantially improved by weighting the contribution of individual GCMs to the forecasts, and also by the inclusion of antecedent precipitation.

Our results can provide critical information for adaptation strategies aiming to mitigate the costs and disruptions arising from flood and drought conditions, and allow us to determine how far in advance skillful forecasts can be issued. The availability of these discharge forecasts would have major societal and economic benefits for hydrology and water resources management, agriculture, disaster forecasts and prevention, energy, finance and insurance, food security, policy-making and public authorities, and transportation.