Title: Developing seasonal streamflow forecasts to inform surface water management in Oklahoma

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Students: (Include number of students supported by the project during the project period in the table below.)

Student's Current Status	#	Department	Was the student working for experience or towards a degree?
Undergraduate			
M.S.			
Ph.D.	1	Plant and Soil Sciences	Pursuing Ph.D.
Total			

Problem and Research Objectives: Around the world the security and sustainability of surface water use are threatened by growing water demands and by changing and increasingly variable climate. These threats are difficult to address with current hydrologic forecasting systems, which can be unreliable, leaving water managers in a precarious situation. Nowhere in the US are these specific needs felt more urgently than in the surface water irrigation districts of the Great Plains. As one Great Plains water manager noted, "…*forecast[s] targeting seasonal periods are unreliable in our geographical area…It is very difficult to provide water supply estimates to irrigators…*" One reason for this lack of reliability is that current forecasting systems do not incorporate soil moisture observations, although their potential to improve streamflow forecasts has been known since the 1930's (Rosenberg et al., 2013). The overall objective of this multi-year project is to provide Oklahoma surface water managers with

improved seasonal streamflow prediction systems that are useful in making water management decisions.

Importance of Project and Findings: The successful completion of this project will lead to an improved streamflow forecasting method for Oklahoma. These improved forecasts will assist irrigators and irrigation districts in making a wide array of management decisions such as water allocations, crop type and variety, and level of investment in crop inputs and insurance. The forecasts will also inform conservation and management decisions for diverse municipal and industrial water users who rely on surface water sources.

Changes to the Project since Implementation: Initially the project was focused on the Lugert-Altus Irrigation District in southwest Oklahoma, but we have chosen instead to focus on the Fort Cobb watershed. This change was made in part because of the availability of long-term streamflow data (1995-present) and the high spatial resolution soil moisture data (17 USDA-ARS Micronet stations and 1 Oklahoma Mesonet station) available in the Fort Cobb watershed. The data from the large number of soil moisture monitoring stations in this watershed will be used instead of the soil moisture data product that was described in the Year 1 objective of the original proposal.

Methodology: A modified version of the standard Natural Resources Conservation Service (NRCS) Principle Component Regression (PCR) forecasting method is being developed to predict streamflow volumes for the April-July months for the Fort Cobb watershed. This method involves finding the linear combination of predictor variables (i.e., precipitation and soil moisture) which explains the largest amount of variance of the response variable (i.e., streamflow). Regression analyses are being carried out and used to predict streamflow values for the forecast period. Forecasts will be calculated for each water year for which data are available.

Principal Findings and Significance: PCR has been applied to fit available data from the Fort Cobb watershed for water years 2006-2014 using two sets of input variables-precipitation only (baseline scenario) and precipitation plus soil moisture (improved scenario). Using only precipitation data, PCR analysis is able to describe 74% of annual April-July streamflow variability. Preliminary results indicate that the inclusion of soil moisture data has the potential to increase forecast accuracy by >10% for the Fort Cobb watershed, capturing 86% of the observed variability in April- July streamflow volume. These results are promising, and are comparable with the 8% forecast accuracy gains observed in a similar study conducted in the mountainous U.S. (Harpold et al., 2017). Now that we know our approach can effectively describe observed streamflow data in a retrospective manner, the next step is to use the approach in a predictive manner to make forward looking forecasts. Work is ongoing to develop operational forecasts for 0-, 1-, 2-, and 3-month lead times.

Next Steps (if applicable): The funds from the Berry Fellows program enabled us to develop and prove the feasibility of this streamflow forecasting framework. We have now leveraged the Berry Fellow funds and obtained an additional $25,000 grant from

the US Geological Survey, enabling us to continue advancing this line of research. We anticipate another 1 year of effort to bring the streamflow forecasts to completion. A model for PCR forecasts using 0-, 1-, 2-, and 3-month lead times is being developed for the Fort Cobb watershed and estimates from PCR analysis will be compared to streamflow measurements in the watershed. Additional sensitivity analysis will be done to estimate the minimum number of soil moisture stations needed to provide improved streamflow forecasts for the study watershed. Once the work is completed, results of this work will be demonstrated and made available to water resource managers in the region. If successful, this work may be also applied in any watershed in the Great Plains region where the required data are available.

References

Harpold, A. A., et al. 2017. Does Including Soil Moisture Observations Improve Operational Streamflow Forecasts in Snow-Dominated Watersheds? JAWRA Journal of the American Water Resources Association 53(1): 179-196.

Rosenberg, E. A., et al. 2013. Informing Hydrometric Network Design for Statistical Seasonal Streamflow Forecasts. Journal of Hydrometeorology 14(5): 1587-1604.