



Variable Drought Threshold Method for Low-Flow Behavior Reveals Distinct Clustering Across the Continental United States

Ryan van der Heijden¹, Ali Dadkhah¹, Amin Aghababaei², Xueyi Li², Eniola Webster-Esho³, Prabhakar Clement³, Mandar Dewoolkar¹, Ehsan Ghazanfari¹, Norm Jones², Gustavious Williams², and Donna Rizzo¹

¹University of Vermont, Civil and Environmental Engineering, Burlington, United States of America (rvanderh@uvm.edu)

²Brigham Young University, Provo, Utah, USA

³The University of Alabama, Tuscaloosa, Alabama, USA

Groundwater and surface water are interconnected in most climatic regions. Baseflow, the contribution of streamflow not directly associated with precipitation forcing, is a critical component of streamflow prediction and water resource allocation. Baseflow is often considered to be a low-frequency component of streamflow and many of the methods for estimating it are based on this premise. The climatic and physiographic attributes of a region will contribute to the low-flow behavior of its surface waterways. For example, baseflow in a snowmelt-driven basin may produce a distinct hydrologic signature compared to baseflow in a precipitation-driven basin.

In this study, we developed a unique metric based on the variable drought threshold method (VDTM) for characterizing historical streamflow timeseries and performed cluster analysis on a large set of gages in the continental United States (CONUS). Our study goal was to observe correlations between low-flow characteristics and distinct hydrologic, physiographic, and climatic regions to provide insight into the underlying mechanisms influencing baseflow.

The VDTM applies a non-exceedance percentile (NEP) computed based on the distribution of flow recorded at a stream gage over a given time frame (i.e., month, season) throughout the complete record of measurement. This study used daily streamflow records for 1,462 reference quality gages across the CONUS from the USGS GAGES-II data set; each gage contained at least 20 years of complete daily streamflow measurements. We computed the 10th NEP for each month at all 1,462 gages and normalized this value by the mean streamflow to develop the parameter r_{10} . We performed K-means clustering on the monthly r_{10} values, forming seven clusters of low-flow behavior.

We observed clusters with distinct low-flow behavior across different ecoregions related to possible mechanisms driving streamflow and baseflow in those regions. For example, a cluster located in the intermountain-west shows unique behavior largely seen nowhere else in the CONUS, possibly a result of the predominantly snowmelt-driven shallow subsurface flow that contributes to baseflow seen in that region. Conversely, clusters located in the Pacific Northwest and parts of the Appalachians show a different behavior, possibly a result of the predominantly

rainfall-driven streamflow observed in those regions. Principal components analysis suggests that the critical months associated with clustered gages are during the summer (June, July) and winter (January, February).

The spatial distribution of the clusters largely adheres to the defined physiographic and climatic regions of the CONUS despite the absence of any physiographic or climatic variables used for clustering, suggesting a possible linkage between these attributes and the low-flow behavior of surface waterways. Analysis of the trend and magnitude of r_{10} may provide insight into whether (and when) a stream is losing water to or gaining water from groundwater as well as the magnitude of the transfer. The results of this study suggest that using NEPs and the r_{10} metric may be an effective method for defining regionalization based on low-flow metrics.