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Identifying the relationships among low-flow characteristics and their climate-landscape controls: a case study in upstream region of Huai River Basin, China

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Low-flow is of great importance to evaluate the availability of water resources. Low-flow possesses multi-faceted dependent characteristics, which are considered co-evolved with climate-landscape factors in basins. However, how these low-flow characteristics interact and to what extent they can be determined by climate-landscape factors are still unclear. In this study, seven low-flow signatures are extracted from 24 sub-basins in upstream region of Huai River Basin, China, including mean annual baseflow depth and coefficient (RB, RBc), baseflow index (the ratio of baseflow volume to total streamflow, BFI), fast and slow baseflow recession coefficient (Kf, Ks), 90th flow quantile (Q90), and slope of flow duration curve for low-flow (SFDC). Relationships among these signatures are explored by hierarchical cluster analysis and their connections to climate-landscape factors are investigated by correlation analysis and multivariate regression. Results demonstrate that these low-flow signatures can be classified into three groups: low-flow magnitude (RB, RBc and Q90), low-flow decay (BFI, Kf, and Ks), and low-flow slope (SFDC). Mean annual precipitation and topography factors are the first- and second-order controls for all signatures in low-flow magnitude group. In contrast, climate factors show little impact on low-flow decay group while basin scale is identified as the dominant control. Larger basin area corresponds to a slower baseflow recession and higher BFI value. As to the low-flow slope group, vegetation also shows significant effect besides basin area and topography factors. In comparison with the determination coefficients for each signature from the multivariate regression, low-flow magnitude signatures are much more predictable than those in the other two groups. The study suggests that the target low-flow signatures can be estimated more accurately in ungauged basins combining climate-landscape factors with other similar low-flow signatures obtained a priori.