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Low-frequency runoff dynamics: catchment vs climate controls

Lukas Gudmundsson (1), Lena M. Tallaksen (1), Kerstin Stahl (1,2), and Anne K. Fleig (1)

(1) University of Oslo, Department of Geo Sciences, Oslo, Norway (lukas.gudmundsson@geo.uio.no), (2) Institute of Hydrology, University of Freiburg, Germany

Catchment runoff depends on atmospheric water input (precipitation) and loss (evapotranspiration) as well as on catchment processes, which determine how atmospheric fluctuations are translated into runoff. On short time scales (days, months) a multitude of processes is known to influence runoff generation. On longer time scales (years, decades) climate fluctuations gain increasing importance. To assess the different roles of catchment-processes and climatic forcing on time scales longer than 12 months and thus elucidate catchments' sensitivity to climate change, this study considered the variance and the temporal evolution of the low-frequency components of runoff. The analysis was based on 375 monthly series of observed pan-European runoff (small near-natural catchments) and corresponding time series of precipitation and temperature from a bias-corrected re-analysis product (the WATCH forcing data). The dominant space-time patterns of the low-frequency components of runoff, identified using isometric feature mapping (isomap), were found to be closely related to the space-time patterns of low-frequency precipitation and temperature components. The fraction of low-frequency variance of runoff is on average larger than (and not correlated to) the fraction of low-frequency variance of precipitation and temperature. However, it is correlated with water balance characteristics such as mean annual runoff, precipitation, and temperature, indicating that they control the amplification of climatic fluctuations. More precisely, the fraction of low-frequency variance of runoff increases (decreases) under dryer (wetter) conditions. These findings may be of particular interest for climate sensitivity studies. The influence of a given climate signal on runoff may vary largely between streams, depending on the long-term water budget. Climatic change, however, may influence the mean water budget, eventually changing the fraction of low-frequency variance of runoff. In the case of increasingly wetter conditions, low-frequency runoff variability is likely to decline, simplifying water management on a year to year basis. On the other hand, increasingly drier conditions may lead to an increase in the low-frequency runoff variability, eventually decreasing predictability and challenging water management.