Geophysical Research Abstracts
Vol. 21, EGU2019-18274, 2019
EGU General Assembly 2019

Rainfall-runoff dynamic association and memory in Swiss catchments: the role of physical characteristics

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The transformation of rainfall into runoff is an important process in hydrological sciences. Different spatial and temporal scales are involved, from fast runoff response to heavy rainfall in small catchments to seasonal runoff response driven by precipitation-evapotranspiration-snow dynamics in large river basins. The rainfall-runoff transformation at all scales may be examined from a statistical or physically-based point of view. The statistical perspective looks for relations between rainfall and runoff from data that reflect the transformation process. One of the features of these relations is the long- and short-term memory in the transformation of rainfall to runoff, and a key question is the impact of watershed characteristics on the memory and temporal connection of runoff to rainfall which is not constant in time.

This study investigates the dynamic relationship between rainfall and runoff in 34 selected undisturbed watersheds in Switzerland and their watershed physical properties (basin size, mean elevation, slope, drainage density, soil properties, etc.). The dynamic conditional correlation in the rainfall-runoff relationship is first estimated based on the diagonal VECH model, which is a simple bivariate Generalized Autoregressive Conditional Heteroscedasticity stochastic model, and then the parameters of the conditional covariance model are estimated using monthly rainfall and runoff time series for the period 1961-2016 for the watersheds. Results indicate that elevation plays a key role on rainfall-runoff memory among watersheds. For watersheds above 1500 m, the memory weakens with increasing elevation where the co-volatility, or the random effect of rainfall on runoff generation, increases. This implies that the rainfall-runoff memory is stronger at lower elevations. This may reflect the dominant importance of physical properties of lowland regions such as soil depth and soil water content and low gradients which allow the rainfall to infiltrate into the soil, be retained on the surface or evaporate. Interestingly, other characteristics such as watershed area and slope, river length and slope and drainage density do not show significant impact on rainfall-runoff memory in these watersheds.