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# Functional hydrologic signatures to detect first order runoff formation mechanisms on the headwater scale

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The question of 'how a catchment is functioning with respect to the partitioning of precipitation (P) into discharge (Q) and evaporation (ET)' is the key issue of most quantitative hydrological assessments. Answering it can be very difficult since the response of a system is a complex and non-linear interaction of its state, structure and forcing. Moreover, the answer has a temporal dimension. On the annual or long term time scale the Budyko curve provides a simple and meaningful concept to quantify the relative contributions of Q and ET. However, on shorter time scales we are facing severe difficulties since we need to close the balances of mass- and energy. This requires assumptions, since the gradients and resistances which ultimately drive and sustain Q and ET are often unknown and/or not observable with present measurement technologies. This applies in particular for the temporal scale of individual rainfall-runoff events. A necessary first step in this context is to provide methods which help to make meaningful assumptions regarding the driving gradients and resistances which in turn, determine the partitioning of P into Q and ET. This applies in particular for quantitative hydrological assessments, comparative studies or the evaluation of large data sets where on-site knowledge and field properties are not available.

To move a step forward we propose the usage of 'functional signatures'. In our contribution we introduce a set of diagnostic signatures to discriminate runoff formation mechanisms on the headwater scale. Our signatures evaluate and compare the impact of both, different measures for the state of a catchment and properties of the forcing, to the response of a system. To describe the latter we make use of event-runoff coefficients which have been extracted from time series analysis using an automated procedure. Together our signatures provide a simple framework to test for and to distinguish between storage and intensity limited runoff formation mechanisms using event-scale information. Thereby, our signatures provide information on catchment functioning with respect to the partitioning of P into Q and ET, the resistances within the control volume and the controls of catchment storage and the intensity of the forcing on runoff generation.

We applied our signatures to a set of catchments located in southern Germany and show results for storage, intensity and threshold controlled rainfall-runoff conditions. Moreover, we empirically evaluate the potential of different surrogates for the state of a system.