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Investigation of hydrological threshold and hysteresis processes on two heterogeneous field sites in the Eastern Ore Mountains, Germany

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Runoff formation is influenced by rainfall properties (amount, intensities, variability) and by the antecedent conditions, i.e. the antecedent water storage in the catchment: ground water, soil moisture and snow.
In case of sub-surface flood generation mechanisms, the wetness conditions prior to a rainfall event are particular interesting because it controls subsurface connectivity structures and it may trigger the formation of different types of sub-surface flow processes. A switching between different types of response can be often observed and depends on the connectivity within the watershed. The connectivity of the watershed is thus a major factor controlling how much storm runoff will be delivered into the channel network.
Using a sampling strategy of two TDR clusters, tensiometers and piezometers installed in the headwaters of the Wilde Weißeritz catchment (Eastern Ore Mountains, Germany), we investigated the effect of antecedent conditions on the runoff generation. A grassland site and a forested site both located on gentle slopes were instrumented with two Spatial TDR clusters (STDR) that consist of 39 and 32 coated TDR probes of 60 cm length. The spatial variability of soil water content is quite large at both sites, between 0.07 m^3/m^3 and 0.08 m^3/m^3. However, the ranks of the soil moisture contents observed at different probes in a cluster remain temporarily stable. Additionally, both sites were instrumented with piezometers to quantify the groundwater response.
The field-scale dynamics of these state variables were related to runoff data from three nested head water catchments: the Becherbach with a size of 2 km^2, the Rehefeld catchment (17 km^2) and the superordinate Ammelsdorf catchment (49 km^2).
We observed two types of rainfall-runoff response: Under dry conditions the system reacted with single-peak hydrographs with low runoff coefficients. A hysteresis effect between soil moisture and runoff with a faster recession in runoff can be observed. Under wet conditions a bimodal discharge peak is a typical response and runoff coefficients are high. The hysteresis effect is reversed compared to the dry case. This behaviour is deemed to be the result of complex interactions between the unsaturated zone and the saprolite zone.