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Model-assisted investigation of stormflow generation processes in a low mountain range headwater basin

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In a 31 ha headwater basin in the Northpalatine Mountains, Western Germany, subsurface flow processes during intense precipitation have been studied. On the one hand, sprinkling experiments and soil physical investigations have been carried out at the plot scale. On the other hand, discharge has been captured continuously at one pipe spring and at the outlet of the headwater basin. The aim was to identify and potentially quantify the dominant stormflow processes at different scales and to relate the observations at smaller scale to those at larger scale.
To allow for interdisciplinary discussions a very comprehensible and rather simplistic model was set up to assess the vadose zone flow processes during different moisture conditions. Here, the matrix and preferential flow has been assessed in a lumped manner along a deeply incised channel of 300 m length. Measurable parameters (e.g. mean hydraulic conductivity, number of macropores, mean flow rate of macropores) and simple algorithms were used to calculate the flow rates at the channel edge. Only the parameter cf that represents converging flow processes and control the actual height of the saturated zone along the channel incision has been calibrated. This model has been applied to two storms with high antecedent soil moisture and to one summer storm with a lower antecedent soil moisture.
The results showed that during wet conditions the subsurface flow rates are about 90 % during peak flow. In contrast, for the short but intense summer storm the hydrograph consists solely of surface runoff components. Obviously, the parameter cf has been found as very sensitive. Consequently, the extension of the contributing subsurface space mainly governs stormflow processes as shown by several previous studies in other regions. Further investigations shall focus on the relationship between subsurface flow processes and the lateral and vertical extension of the nearly saturated soil moisture conditions.