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Experimental study of subsurface stormflow formation

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Subsurface stormflow (SSF) can play a key role for the runoff generation on hillslopes. Considerable contributions to stream flow have been observed from SSF in lateral preferential flow paths. Quantifications of SSF with regard to flow rates and timing of the flow are hampered by the high spatial variability of diameter, shape, length and network form of the invisible subsurface flow paths as well as by insufficient understanding of how SSF is formed.

The formation of SSF i.e. the initiation of the subsurface flow network was monitored on four hillslopes with different soils and geology. Highly resolved measurements of soil moisture and soil suction, surface runoff and subsurface runoff were made during sprinkling experiments and natural rainfall events. Event and pre-event water fractions were determined in the different flow components using artificially traced sprinkling water and Radon as natural tracer. Flow velocities were estimated for different flow distances with instantaneous tracer injections during steady state conditions.

SSF response, pre-event water fraction and flow velocities varied widely at the different sites. The results allowed identifying the connectivity of the subsurface flow network as well as the origin and the varying formation mechanisms of subsurface stormflow. Subsurface preferential flow paths that are long and well connected and show low interaction with the surrounding soil matrix enable quick SSF response with a high fraction of event water. In contrast, when the network of subsurface preferential flow paths shows low connectivity and high interaction with the soil matrix, SSF is fed from large saturated zones of the soil and responds delayed to rainfall events and consists mainly of pre-event water.