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Radon as natural tracer to separate event and pre-event water

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To identify runoff formation mechanisms and the origin and age of the stream flow, environmental tracers, notably stable isotopes of oxygen and hydrogen, have been applied for hydrograph separations. However, large temporal and spatial variations of these isotopes lead to unclear end-member concentrations.

For hydrograph separation into event and pre - event water, Radon-222 provides clearly defined event water concentration, as there is no Radon in precipitation. Water infiltrating into the soil accumulates Radon emanating from the solid phase of the soil. Accumulation of Radon in soil water is limited by radioactive decay, and therefore, the increase of Radon with time follows an exponential growth to a site-specific steady state concentration after about two weeks. This concentration can be used as pre-event water concentration. New methods allow monitoring Radon in-situ and with high temporal resolution.

Fast subsurface stormflow (SSF) can be an important factor in the formation of extreme floods. We studied SSF formation in the vadose soil zone on four hillslopes covering a range of different soils and geology. Radon concentrations in SSF were continuously monitored over several months during natural rainfall events with a temporal resolution of about 30 minutes. Pre-event water fractions determined with Radon as well as with artificially traced sprinkling water agreed well during sprinkling experiments.

Pre-event water fractions in SSF varied substantially at the different sites. SSF responded quickly and contained low pre-event water fractions, when precipitation fed directly into well-connected subsurface preferential flow paths with low interaction

with the surrounding soil matrix. In contrast, SSF response was delayed and consisted mainly of pre-event water when it was fed indirectly via saturated zones of the soil and when the network of subsurface preferential flow paths was poorly connected and had high interaction with the soil matrix.