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The use of high-temporal resolution, in-situ sampling of stable isotopes of water to capture fine-scale hydrological responses

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Hydrological responses to precipitation events in headwater catchments often vary in space and time. Understanding of such patterns leads to constrain runoff generation mechanisms and flow pathways. The use of stable isotopes of water combined with classical hydrometrics have increased in recent years to elucidate the response behavior of runoff components and their drivers in runoff generation. However, most of the previous studies dealing with investigation of catchment responses were limited to daily to monthly data, at which potential fine-scale variations could not be captured. Recently, few studies applied high-temporal resolution sampling of stable isotopes of water to investigate isotopic response variation within precipitation events. Sampling sources were mostly limited to streamflow and precipitation. An important, yet poorly known mechanism is the response of shallow groundwater to precipitation.

In this study, we used an automated in-situ mobile laboratory to continuously sample stable istopes of multiple sources, including stream water, groundwater and precipitation every 20 mintutes. The study was realized in the Schwingbach Environmetal Observatory (SEO) in Hesse, Germany. Hydrograph seperation technique was applied to quantify the share of event and pre-event water contribution to the stream and to estimate response times of maximum event water fractions in the stream water and the groundwater for 20 events in the dry year 2018. We investigated the control of precipitation and antecedent wetness hydrometrics on response characteristics using Spearman rank correlation analysis.

High-temporal resolution sampling of multiple sources captured the fine-scale variation of isotope concentrations in stream water and groundwater sources during the precipitation events indicating that the Schwingbach is a highly responsive, pre-event water dominated creek. More than 79% of the runoff consisted of pre-event water. Short response times combined with soil moisture variations of different depths revealed the linkage between shallow groundwater in near-stream zones and the stream itself. As a response of the dry conditions in 2018, an extended crack network developed that acted like adrainage system causing rapid delivering of water to the stream network. Event water contribution increased with increasing precipitation amount. Pre-event water contribution was moderately affected by precipitation amount, while antecedent wetness did not influence the runoff generation. The response time of stream water and groundwater was controlled by mean precipitation intensity. A two-phase system was identified, at

which the response times of stream water and groundwater started to decrease after reaching a threshold of mean precipitation intensity (0.5 mm h^{1}).