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High-resolution dripwater monitoring – Relationship between modern surface climate signals and cave environments

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To apply geochemical proxy records from speleothems for paleoclimate reconstruction, the processes controlling their formation need to be understood. Detailed cave monitoring allows us to study the complex interaction between modern surface climate signals above the cave and the processes occuring in the cave environment. This relationship was investigated within the CheckExtrema project, where we combine specific trace element patterns and stable isotope ratios from stalagmite Stal-KTH-2 (Kleine Teufels Cave) and stalagmite Stal-Zoo-rez (Zoolithen Cave) in the Franconian Alb, to identify hydrological extreme events in the past. For a reliable interpretation of the recorded geochemical proxies, especially with regard to the response of the different dripsites to hydrological extreme events, a detailed monitoring program was set up in both caves with high resolution sampling since March 2016.

Dripwater collectors with integrated automatic drip counters were installed at two dripsites in Kleine Teufels Cave and in Zoolithen Cave, respectively. Furthermore, a rain water collector was installed above Zoolithen Cave. Drip- and rainwater in Zoolithen Cave were sampled weekly while dripwater in Kleine Teufels Cave was sampled at intervals of up to two weeks. Concentrations of major and trace elements together with δ^{18}O and δD values were analysed at the Institute of Applied Geosciences (AGW, KIT). Additionally, physico-chemical parameters and alkalinity were measured onsite during 12 different cave trips.

The four dripsites show three different types of discharge behaviour, including a slow seasonal pattern with moderate driprate variations, a fast seasonal pattern with distinctive driprate variations and a non-seasonal pattern. The driprate patterns of all dripsites are mostly consistent with the main precipitation events, taking into account a delay of several hours. The dominant cation in the dripwater is Ca^{2+}, which co-varies with HCO_3^- concentration and mostly with driprate. Prior Calcite Precipitation (PCP) was also identified. Distinctive peaks of trace elements, e.g. Fe, Zn and P co-vary with times of increasing driprates, representing particles, colloids and organic material from the surface, flushed into the cave due to heavy precipitation events. The δ^{18}O and δD values of the rain water show significant variations with a trend towards lower values in winter. In the dripwater, however, the δ^{18}O and δD variations are clearly damped, indicating the importance of mixing processes in the karst aquifer.

From these monitoring results we can conclude that even seasonal trends are detectable through certain trace elements at all types of dripsites, whereas short-term variations in δ^{18}O and δD values are difficult to see. Therefore, extreme events should be preserved more clearly in the stalagmite record. Our study emphasizes the importance of high-resolution monitoring programs as a basis to understand cave dynamics and to interpret paleoclimatic signals recorded in speleothems of a specific site.