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Karst vadose zone infiltration processes highlighted via drip discharge and long-term ERT monitoring

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A duality of flow types is commonly observed within karst systems, from quickflows through open fractures to delayed infiltration in zones of enhanced porosity in the carbonated rocks. To investigate the water flows within the vadose zone, a common approach consists in measuring cave drip discharges. We present an experiment including the monitoring of three distinct percolating water discharge stations at the Rochefort Cave Laboratory (RCL; South Belgium), covering altogether more than 3 hydrological cycles. Despite being located close one to each other, the three different monitored stations show distinct flow types, which can be classified as vadose flow (PWD1), seasonal drip (PWD2) and seepage flow (PWD3). Using a lumped karst modeling of the vadose zone infiltration processes based on the drip discharge data (using the KarstMod modeling platform) we could build a two-tank model simulating the measured data. A hysteretic function needs to be added in the transfer between the uppermost reservoir and the observation point in order to explain the pronounced seasonal behavior of PWD2.
In parallel, we developed a long-term electrical resistivity tomography (ERT) monitoring at the surface of the RCL. It is made of a permanent profile of electrodes, measuring on a daily basis during the same period of time. Because resistivity is linked to the moisture content of the subsurface, such systems stand out as powerful tools to investigate hydrological processes in different environments. In our case, combined with a detailed geological study, it brought crucial insights on various infiltration dynamics associated with specific lithological layers. Compared with the two-tank model results, we could identify subsurface areas as the sources of distinct flow types. Especially, superficial layers imaged by the ERT data could be related to PWD1 data, exhibiting the highest variability in terms of discharge. Conversely, deeper subsurface features are linked to PWD2 and PWD3 data sets. More specifically, the time-lapse ERT data image a deactivation between superficial epikarst storage and deeper layers at the beginning of dry periods, which explains well the hysteretic component required to fit observed drip discharge data with the KarstMod model.
This experiment shows the strength of combining in-cave drip discharge and ERT monitoring to better understand water infiltration within karst landscapes. It allows to image the sources of drip discharge observed in the cave, identifying specific lithologies and structures associated with each flow types.