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Water storage dynamics within karst vadose zone assessed by joint ground-based gravity and ERT monitoring

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The vadose zone of karst systems plays an important role on the water storage dynamics. In particular, due to the high heterogeneity of karstified carbonated rocks in terms of porosity and permeability, spatially discontinuous reservoirs can appear in the subsurface following changes of weather conditions or reduced evapotranspiration. We present a multiscale geophysical and hydrological study of the vadose zone performed at the Rochefort Cave Laboratory (South Belgium), covering more than three hydrological cycles.

On the one hand, due to the very high sensitivity of today's gravimeters, recording temporal gravity variations allows tracking local hydrological changes at the mesoscale (i.e. covering the Rochefort limestone massif). We collected continuous gravity measurements during three years and eight months, comprising an experimental system using one superconducting gravimeter installed in the surface observatory, and an additional spring gravimeter installed in the cave, 35 m below the surface. With this configuration, we identified water storage changes (WSC) within the vadose zone and the epikarst layer, i.e. the uppermost layer of the karst. Such WSC could be related to seasonal drip discharges observed in the cave.

On the other hand, we developed the first long-term electrical resistivity tomography (ERT) monitoring in a karst landscape, via the installation of a permanent profile of electrodes at the surface, covering three hydrological cycles with measurements acquired on a daily basis. Such ERT systems are increasingly used to characterise hydrological processes in different environments. In our case, it allowed to identify distinct infiltration dynamics at the local scale, which are related to specific lithological layers. These different infiltration dynamics could be compared with in situ measurements of drip discharge in the cave. These results are put into perspective with the duality of flow types affecting karst systems: quickflows through open fractures and delayed infiltration associated with water storage within zones of enhanced porosity in the limestone massif.

Altogether, these observations can lead to improved karst hydrological models, which are crucial to better manage and protect karst water resources.