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Water flow and seepage in unsaturated zone of karst aquifer: Observations and modeling

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Karst aquifers are complex and heterogeneous. Indeed, water transfer can occur through varied structures like potholes, drains, fractures or porous matrix. This leads to a large variability of unsaturated water flow in karst systems. In this study, we aim to understand mechanisms and processes associated to water flow in karst aquifers with observations of stalactites drip flow and seepage. Our measurements describe local water flows in the unsaturated zone and are measured at different depths of a well developed karst system.
Stalactite drip flows are monitored with tilting-bucket rain gauges that collect water seepage beneath stalactites, group of stalactites or soil, with 0.001 ml accuracy. Our study area is located on the dolomite karst system of Durzon (Larzac plateau, South of France). All infiltrated water in drained by the Durzon perennial spring. Water flow and seepage are monitored at 0.4 m, 8 m, 42 m and 65 m depth in different caves of the karst system. Recording periods range from one to three years according to sites. Stalactite and soil drip flow are analyzed on a hourly base for each site. Each site displays a specific response following important rain events.
For example, increase of a single stalactite flow at 45 m depth occurs $\sim$20 days after heavy precipitations. During relatively dry periods, no significant responses to rain impulsion are observed. Long period recession occurs immediately after increase of stalactite drip flow.
On a site located at 65m depth a recession is also observed after heavy rain. However the recorded signal is more complex. For example, stalactite drip flow is anti-correlated to atmospheric pressure variations during rainy period. Moreover, stalactite drip flow has a peculiar behavior during pronounced recession with sudden stop and rerun of the drip flow.
For each site we observe short and abrupt variations of flow which are not linked to rain flow. These flow variations are likely caused by external factors like atmospheric pressure or by internal reservoir properties such as threshold tank or fractures connectivity. The comparison with Durzon spring flow hydrograph indicates that water transfer in the vadose zone is much more complex than the spring flow hydrograph can let think.
We finally attempt to model each flow signal using simple physical models which include the porosity, the connectivity, and the saturation of water reservoirs. This way we aim to determine mechanism of local water transfer at depth on the Durzon karst system.