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Process studies of water percolation in a Mediterranean karst area

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In drylands karst environments comprise large areas and their groundwater resources are important for local and regional water supply. Recharge estimations are usually based on long term averages and hence uncertain, because they do not explicitly account for the accentuated variability of dryland precipitation, where a large fraction of annual rainfall is concentrated in a small number of high magnitude events. To provide process information in adequate temporal resolution the present study directly investigates percolation processes in an Eastern Mediterranean karst system, Mt. Carmel, Israel. Therefore the drip response of stalactites in a karstic cave 28m below a sprinkling experiment was measured. Besides hydrometric measurements (soil moisture, surface runoff, stalactite dripping rates) also tracers were applied. Sprinkling water was pumped from two wells of the underlying karst aquifer. The experiment took place at the end of the dry season. Simulating a series of two high intensity storms, 190 mm of artificial rainfall was sprinkled over two days on a 143 m2 plot. Two types of tracers were used: (i) the relatively high conductivity of the sprinkling water facilitated the separation between old (pre-sprinkling) and new (sprinkling) water by mixing analysis, (ii) before second day sprinkling bromide was injected as a dirac impulse on top of selected soil pockets to facilitate direct insights into percolation fluxes.
On the plot surface saturation excess runoff was observed towards the end of first day sprinkling and entire soil saturation occurred down to the deepest soil moisture sensor. During the second day the entire soil reached quickly saturation and remained at field capacity until the end of data collection. In the cave the drip response depended on stalactite type: (i) perennial stalactites were already dripping continuously before sprinkling onset. Conductivity dynamics resulted in high percentages of pre-sprinkling water suggesting continuous input from the fissured rock matrix. (ii) dripping at the other stalactites initiated only after sprinkling and was mainly made of event water following preferential flow paths. Although bromide was injected prior to second day sprinkling its breakthrough was delayed at every location compared to drip response. This suggested piston flow effects at high moisture states. Two-part recession dynamics of the bromide breakthrough curves suggested different percolation mechanisms: Until about 24h after sprinkling a quick recession indicated preferential flow paths, while thereafter a delayed recession suggested mixing in epikarst reservoirs. Over the entire experiment quick percolation as collected in the drips was in the same range as estimated evaporation losses during the 2 days sprinkling (both about 6%). Most water filled up empty soil pockets (about 32%) or epikarst storages (about 53%). Despite soil saturation very little surface runoff (about 2%) was generated. In a 36 km2 catchment the experimental findings are now being used as input for high-resolution water balance modelling.