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Modeling the variability of karstic recharge - a multi-objective approach

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Many parts in the Mediterranean are karst regions, where groundwater balances the annual variability of water availability. In these regions recharge is controlled by the epikarst. Located at the upper parts of the carbonate rock, it acts as temporary storage and distribution system for infiltrating water into the karst system. Depending on precipitation, system state and location, diffuse as well as concentrated percolation, enhanced by lateral flow towards enlarged fissures, can occur. This results in a high spatial and temporal variability of karstic recharge. To adequately represent the dominating recharge processes in hydrological models is still a challenge, especially in data scare regions.
In this study we have developed a conceptual, process-based model implementing the variability of karstic recharge. We hypothesize that the shape of the lower epikarst boundary to the rock matrix controls the abundance and quantity of lateral flow and hence concentrated infiltration. Introducing a power law function describing the boundary's shape we define model compartments with varying depth. Reaching the semi-permeable lower boundary infiltrating water can create a perched water table and flow laterally towards neighboring compartments following the hydraulic gradient. This procedure results in a spatial pattern of percolation rates (one for each compartment), which sum up to a net percolation for a considered area. Hence, not only an average percolation rate but also information about its variability is simulated. The model was benchmarked with measured responses of a set of drips (stalactites) in a karstic cave at Mount Carmel, Northern Israel, which is located 28 m below surface. These data comprise both dripping rates and the concentration of selected tracers (EC, chloride, bromide). For model calibration we did not fit single hydrographs but statistical parameters of the average response function for all measured drips (mean, standard deviation, skewness). The model was applied to two different time scales. First, we simulated a two-day sprinkling experiment yielding high resolution data for dry and wet preconditions. Second, we applied the model to an entire season under natural conditions. Model performance and parameter values were analyzed and general recommendations for its use to simulate karst recharge were derived.