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Event based recharge assessment from soil moisture monitoring sites under a steep Mediterranean - semi-arid climatic gradient

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The unsaturated soil zone is of fundamental importance for the understanding of temporal and spatial variability of groundwater recharge. This is especially true for the Mediterranean region where a large fraction of long-term groundwater recharge occurs during above-average wet winters. To improve process knowledge, a dense monitoring network consisting of rainfall gauges, meteorological stations and soil moisture plots was installed along a steep climatic gradient in the Jordan Valley region. Ten-minute soil moisture dynamics of two entire years were modelled by Hydrus-1D whose parameters were calibrated with the help of the Shuffled Complex Evolution algorithm. The scrutinized model was applied to four locations with entirely different soil depth and annual rainfall.

During high intensity rainfall events, saturation of deep soil layers was observed for several hours. The continuously modelled water balance yielded percolation pulses that depended on rainfall amounts and occurred simultaneously to a cooling of karst groundwater in a nearby groundwater well. Overall, a strong correlation between the magnitude of deep percolation and soil depth was observed. When the model was applied to a 40-year time series of rainfall data, a mean annual percolation fraction of 40% resulted. This value varied by up to 30% between years with similar (average) rainfall but different rainfall distribution. Here the length of dry spells between single recharge events was one important factor. Percolation fraction of exceptional wet years reached up to 69% of rainfall while for very dry years no percolation was modelled at all.

A focused view on the unsaturated soil zone in areas with highly variable annual rainfall can provide valuable insights into recharge heterogeneity under Mediterranean and semi-arid climates.