

When and where does preferential flow matter – from observation to large scale modelling

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Preferential flow can be of relevance in a wide range of soils and the interaction of different processes and factors are still difficult to assess. As most studies (including our own studies) focusing on the effect of preferential flow are based on relatively high precipitation rates, there is always the question how relevant preferential flow is under natural conditions, considering the site specific precipitation characteristics, the effect of the drying and wetting cycle on the initial soil water condition and shrinkage cracks, the site specific soil properties, soil structure and rock fragments, and the effect of plant roots and soil fauna (e.g. earthworm channels).

In order to assess this question, we developed the distributed, process-based model RoGeR (Runoff Generation Research) to include a large number relevant features and processes of preferential flow in soils. The model was developed from a large number of process based research and experiments and includes preferential flow in roots, earthworm channels, along rock fragments and shrinkage cracks. We parameterized the uncalibrated model at a high spatial resolution of 5x5m for the whole state of Baden-Württemberg in Germany using LiDAR data, degree of sealing, landuse, soil properties and geology. As the model is an event based model, we derived typical event based precipitation characteristics based on rainfall duration, mean intensity and amount. Using the site-specific variability of initial soil moisture derived from a water balance model based on the same dataset, we simulated the infiltration and recharge amounts of all event classes derived from the event precipitation characteristics and initial soil moisture conditions. The analysis of the simulation results allowed us to extract the relevance of preferential flow for infiltration and recharge considering all factors above. We could clearly see a strong effect of the soil properties and land-use, but also, particular for clay rich soils a strong effect of the initial conditions due to the development of soil cracks. Not too surprisingly, the relevance of preferential flow was much lower when considering the whole range of precipitation events as only considering events with a high rainfall intensity. Also, the influence on infiltration and recharge were different.

Despite the model can still be improved in particular considering more realistic information about the spatial and temporal variability of preferential flow by soil fauna and plants, the model already shows under what situation we need to be very careful when predicting infiltration and recharge with models considering only longer time steps (daily) or only matrix flow.