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The role of preferential flow in soils along a hillslope dominated by periglacial slope deposits, Bavarian Forest (Germany)

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Periglacial slope deposits are an important hydrological landscape feature of mid mountain areas in Germany. The stratification of these deposits (Upper Head, Middle Head and Lower Head) determines the infiltration and flow process along the hillslope. Preferential flow processes are closely related to the characteristics of these periglacial slope deposits and have a significant influence on the soil water regime, but identification and quantification of preferential flow is still a challenging task.

In this study we investigate macropore flow and its influence on the soil water regime along a hillslope in the Bavarian Forest, Germany. The aim is to identify and quantify macropore flow along the hillslope by conducting dye tracer tests. Three different grassland sites were chosen along a single hillslope, formed by periglacial processes. Soil profiles were classified according to the lithostratigraphy of periglacial deposits. Soil moisture monitoring systems of TDR and tensiometer profiles were installed in 2007.

The sites were subdivided into two subplots and sprinkled with different total rainfall amounts (12 and 24 mm) at a constant rainfall intensity of 12 mm/h. During the sprinkling experiment soil water contents were recorded with ten horizontally installed TDR-probes in different depths. Vertical and horizontal macropore patterns were exposed by excavating and photographing the soil in layers. Flow types and macropore properties were evaluated by digital image and dye pattern analysis. The influence of macropores on soil water dynamics was determined by different hydrological models calibrated against the data of the tracer tests. Modeled soil moisture was evaluated by TDR measurements recorded during the tracer test at each plot.

Results show that the sedimentary and soil characteristics as well as the soil water regime differ significantly along the hillslope. The upslope site is complex and heterogeneous with Upper Head and Middle Head over an assumed paleo-soil, whereas the downslope site is dominated by relatively homogenous loess material. Five different flow types were identified at the three different sites. Calculated flow types lead to the conclusion that macropore flow is dominating at both sites, whereas matrix flow plays a more prominent role at the downslope site than at the upslope site. TDR measurements during the tracer tests confirm these results by showing a stronger response of the deeper probes for the upslope site than for the downslope site.