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Subsurface flow observations at a steep forested hillslope using fiber-optic fluorometry

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As preferential flow and transport phenomena are frequently encountered in hillslope studies, their quantitative assessment is important to understand the runoff generation processes in the respective catchment.

We present a set of tracer experiments at a forested hillslope in a small Alpine catchment near Dornbirn, Austria. The objectives of this experimental study were (a) to examine the subsurface flow characteristics with the use of fluorescence tracers and in situ fiber-optic fluorometry, and (b) to quantify the contribution of preferential processes to subsurface flow. The hillslope features steep slope angles (30° to 50°) and a shallow soil cover (0.4 to 1.2 m) of silt loam to silty clay loam. Shrinkage cracks and root channels were observed as hydrological active structures that favoured preferential flow during in situ measurements of hydrological conductivity and dye tracer infiltration experiments.

The tracer experiments were conducted under high-intensity artificial rainfall simulation, with which steady-state discharge conditions could be achieved, as well as during high-intensity natural rainfall events. In each case, fluorescein and sodium chloride, applied as a pulse input on the forest floor at two different plots, were used to trace water flows over distances of 8 m to 41 m to two natural outlets of the slope segment, where flux concentrations were monitored using fiber-optic fluorometry and specific conductivity measurements with high temporal resolution. Under steady-state conditions, fast preferential transport of parts of the marked event water was observed. Subsequent tracer peaks were caused as natural rainfall activated additional flow do-

mains, illustrating the importance of connectivity of the structural features. During a second experiment natural rainfall conditions were dominating. Here, tracer responses were again fast and positively correlated to rainfall and discharge dynamics.

The findings show that preferential infiltration and subsurface flow can play a major role in transporting event water over distances of several tens of meters where interconnected hydraulic active structures are present.