EGU25-10457, updated on 12 Apr 2026
https://doi.org/10.5194/egusphere-egu25-10457
EGU General Assembly 2025

Tracing Subsurface Stormflow: Insights into Preferential Flow and Pre-Event Water Contributions from Controlled Sprinkling Experiments

Jonas Pyschik[1], Emanuel Thoenes[2], Stefan Achleitner[2], Bernhard Kohl[3], and Markus Weiler[1]
[1]Albert Ludwigs University Freiburg, Hydrology, Freiburg, Germany (jonas.pyschik@hydrology.uni-freiburg.de)
[2]Unit of Hydraulic Engineering, University of Innsbruck, Austria
[3]Austrian Research Centre for Forests (BFW), Innsbruck, Austria

Subsurface stormflow (SSF) is an essential process in runoff generation, particularly in headwater catchments where it can contribute for more than 90% of streamflow (Beasley, 1976). However, the fundamental mechanisms of SSF are still inadequately comprehended. Studies based on observing natural rainfall events provide valuable insights, but they introduce uncertainties stemming from uncertain input, particularly in forested sites where throughfall alters both the volume and isotopic composition of precipitation. To address these uncertainties and to allow detailed measurements under controlled conditions, we performed 7 sprinkling experiments with specified amount and intensities and elevated isotopic signatures.

We performed the large-scale (200 m²) artificial rainfall experiments in four low mountain and alpine catchments, each with two trenched slopes. The trenches exceeding 10 m in width were stratified to differentiate between shallow (< 1 m) and deep SSF (1 to max 3 m). We monitored groundwater levels using five wells above each trench and measured soil moisture dynamics in one profile per trench. Irrigation was applied at a rate of ~16 mm h^{-1} for 3 hours. The initial half served as a wetting phase without tracer, while for the latter half we added deuterated water as an artificial tracer.

Runoff was continuously measured and water samples were analysed for their isotopic composition. Deep soil cores were extracted from one trench to identify deuterated water in the soil matrix after the event. The results showed that deuterated water rapidly reached the trench outlet (within 20-40 minutes), indicating substantial preferential flow. Nevertheless, tracer water was exclusively detected in the topsoil of the soil matrix, indicating limited matrix flow. We applied mixing models that indicated that only 5-20% of the irrigation water was recovered at the outlet, with the remainder being pre-event water. We further analysed groundwater level data and soil moisture profiles to identify activated flow paths and better understand SSF dynamics.

These findings underscore the dominance of preferential flow pathways in SSF and indicate that pre-event water contributions play a major role in SSF.

Beasley, R.S. (1976) 'Contribution of subsurface flow from the upper slopes of forested watersheds to channel flow', *Soil Science Society of America Journal*, 40(6), pp. 955–957. doi:10.2136/sssaj1976.03615995004000060039x.