EGU25-12612, updated on 18 Apr 2026
https://doi.org/10.5194/egusphere-egu25-12612
EGU General Assembly 2025

Subsurface stormflow transport of water-soluble organic matter in hillslopes

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The transport of water-soluble organic matter (WSOM) during stormflow events is an important link between hillslope hydrology and biogeochemical cycling, as it determines the movement of organic carbon from soils to streams. Hydrological dynamics in hillslopes, particularly subsurface stormflow (SSF), exhibit substantial spatial and temporal variability, making quantification and generalization challenging. SSF can account for up to 90% of rainfall input to stream discharge during storm events, highlighting its importance in catchment hydrology. Despite its significance, current research frequently overlooks WSOM dynamics during SSF, which are not only key components of carbon cycling but may also serve as tracers for identifying potential critical source areas.

This emphasizes the importance of studying hillslope hydrological dynamics and determining the factors that contribute to SSF spatial and temporal variability. Furthermore, the specific flow paths within hillslopes remain poorly understood, which complicates the identification of spatial sources and transport mechanisms for organic carbon. To fill these knowledge gaps, we conducted a field study in the Black Forest, Germany, using a trench system to collect lateral subsurface flows at two depths (0-100 cm and 100-200 cm) over several rain events. We analysed WSOM concentration and quality using absorbance and fluorescence properties to assess the variability in critical source areas. We also conducted isotopic analyses of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) of the same water samples to infer flow pathways with a conservative tracer.

This approach provides valuable insights into the temporal dynamics and spatial heterogeneity of SSF. Our findings will contribute to our understanding of flow paths, transit times, and the characteristics of WSOM export, offering a deeper understanding of subsurface flow processes in catchments. Finally, the findings of this study can help to improve biogeochemical models and improve scaling of hillslope processes models, particularly in understanding their contribution to organic carbon transport via SSF.