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Ecohydrological Interfaces as Dynamic Hotspots of Biogeochemical Cycling

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Ecohydrological interfaces, represent the boundaries between water-dependent ecosystems that can alter substantially the fluxes of energy and matter. There is still a critical gap of understanding the organisational principles of the drivers and controls of spatially and temporally variable ecohydrological interface functions. This knowledge gap limits our capacity to efficiently quantify, predict and manage the services provided by complex ecosystems. Many ecohydrological interfaces are characterized by step changes in microbial metabolic activity, steep redox gradients and often even thermodynamic phase shifts, for instance at the interfaces between atmosphere and water or soil matrix and macro–pores interfaces.

This paper integrates investigations from point scale laboratory microcosm experiments with reach and sub-catchment scale tracer experiments and numerical modeling studies to elaborate similarities in the drivers and controls that constitute the enhanced biogeochemical activity of different types of ecohydrologica interfaces across a range of spatial and temporal scales. We therefore combine smart metabolic activity tracers to quantify the impact of bioturbating benthic fauna onto ecosystem respiration and oxygen consumption and investigate at larger scale, how microbial metabolic activity and carbon turnover at the water-sediment interface are controlled by sediment physical and chemical properties as well as water temperatures. Numerical modeling confirmed that experimentally identified hotspots of streambed biogeochemical cycling were controlled by patterns of physical properties such as hydraulic conductivities or bioavailability of organic matter, impacting on residence time distributions and hence reaction times. In contrast to previous research, our investigations thus confirmed that small-scale variability of physical and chemical interface properties had a major impact on biogeochemical processing at the investigated ecohydrological interfaces. Our results furthermore indicate that to fully understand spatial patterns and temporal dynamics of ecohydrological interface functioning, including hotspots and hot moments, detailed knowledge of the impacts of biological behavior on the physic-chemical ecosystem conditions, and vice-versa, is required.