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How deep do signals of surface conditions extend into the subsurface Critical Zone?

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Fluids (water and gases) connect surface and subsurface compartments of the Critical Zone by transporting matter, including chemical energy and organisms. In the AquaDiva Collaborative Research Center, one of our research goals is to use a variety of tracers to determine how the subsurface and the organisms inhabiting it reflect and depend on surface conditions. This research is performed at the Hainich Critical Zone Exploratory (CZE), a hillslope transect in limestone and marlstone sedimentary rocks where a network of surface observations is linked to routinely monitored groundwater wells. This CZE is especially interesting because its different rock units and hydrogeologic conditions create environments with different microbiomes and conditions.

This talk will synthesize information collected by AquaDiva researchers on how different kinds of 'signals' identify important mechanisms connecting surface and subsurface. Biologically dominated signals, such as cell counts, metagenomics, metabolomics, the molecular composition and properties of dissolved organic matter, change with distance from the surface. While some individual compounds and organisms can be found across the different critical zone compartments, it is clear that that ground water and its inhabitants are not just diluted from the surface but reflect and co-evolve with microbial communities and subsurface environmental conditions. Isotopic tools trace elements rather than chemical compounds and provide independent information on the timescales for surface-subsurface transport or the sources of energy or metabolites. For example, we used bomb-radiocarbon as a tracer for surface carbon recently fixed by plants. The 14C in dissolved or particulate organic matter and inorganic C demonstrate how newly fixed, recycled or even fossil (rock derived) C is incorporated into microbial food webs. Finally, surface conditions, including structure, influence the subsurface metabolism by regulating the transfer of electron acceptors like O2, excess nutrients from fertilizers, or reactive nanocrystalline Fe, through soils and unsaturated zones into groundwaters.