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Combining water stable isotopes and Sr-Nd-Pb-U radiogenic isotopes to study the hydrological functioning of the critical zone: a case study in the Weierbach experimental catchment in Luxembourg.

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Catchment hydrological functions of water collection, storage and release have geochemical signatures in stream water largely mirroring those found in critical zone compartments. These signatures are largely controlled by the different bio-geo-physico-chemical processes that occur within the regolith-plant interface. Although water-rock interactions within the regolith are well understood, the significance of the regolith's mineral and geochemical compositions for hydrological processes conceptualisation remains unclear. Recent work has shown that there is an urgent need for interdisciplinary research on this topic. Until now, investigations into the critical zone's regolith and hydrological processes research have largely remained uncoupled – eventually leading to a widespread use of non-conservative tracers with multiple origins and thereby violating some of the most fundamental assumptions of classical approaches in tracer hydrology. Consequently, this has stymied our capability for identifying water pools and flow paths.

Here we study the mixing of water in the subsurface through a unique portfolio of complementary groups of tracers (O-H stable isotopes and Sr-Nd-Pb-U radiogenic isotopes) which enables investigating regolith evolution processes and solutes transport within the critical zone. We especially report the interest to combine O-H stable isotope and trace element radiogenic isotopes to strengthen water end-members characterization and identify flowpaths within the regolith of a forested experimental catchment in Luxembourg over one winter flood event.