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Field observations of subsurface flow path evolution over 10 Millennia

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Where water goes when it rains, is to a large part controlled by subsurface storage and subsurface flow paths. While these aspects are essential for basic hydrological process understanding, their large spatial and temporal variability makes both systematic studies and extraction of generalizable results challenging.
We investigate systematically how subsurface storage and flow paths change during the temporal evolution of hillslopes. In order to do so we selected 4 moraines of different ages (30, 160, 3000 and 10.000 years) in a glacial foreland in the Swiss Alps. We then studied both soil physical characteristics as well as flow path evolution across this chronosequence by extensive sampling and soil physical laboratory analyses on the one hand and 36 in-situ dye tracer experiments (Brilliant Blue) on the other hand.
We find that soil physical characteristics change significantly over the millennia. However, vegetational development seems to have a similarly strong effect on flow path evolution. Flow paths evolve from mainly matrix flow at the youngest moraine to increasingly more dominant preferential flow. At the oldest moraine we furthermore find increased subsurface storage, especially in the now strongly developed organic horizon. At intermediate ages preferential flow is less dominated by flow in macropores but is initiated at the soil surface through spatially variable vegetation and microtopography. With this study we provide a first systematic and detailed study of flow path evolution across the first ten millennia of hillslope evolution.