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Characterizing subsurface hillslope-stream connectivity at multiple sites with salt water injection and time-lapse ERT

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Lateral subsurface hillslope-stream connectivity and its dynamics and spatial variability are an important factor to better understand and simulate runoff generation. In this investigation infiltration experiments from a trench with salt water were conducted and changes in electric conductivity (EC) were visualized via three continuous ERT transect measurements – two across and one along the hillslope – and EC measurements in piezometers and in the stream.

In total six experiments were conducted at the hillslope-stream interface in the Attert Catchment, Luxembourg – two in each of the three main geologies: marls, schist/slate and sandstone. Hand-dug trenches (7 m long and 40 cm deep) were used for infiltrating salt water for several hours into the subsurface, which allowed to focus on subsurface flow processes. The spatio-temporal changes in EC in the soil were monitored by time-lapse ERT to identify the establishment of flow paths or flow regions. For one of the experiments additional time-lapse GPR measurements were used to obtain complementary information. In addition, EC in the streamwater above and below the tested hillslope was measured, as well as the shallow ground water level at seven piezometers deployed on a regular grid between the infiltration trench and the stream. The former allowed us to observe the establishment of connectivity between hillslope and stream whereas the latter detected state changes and possible steady state conditions.

The combined information of the various data sources provides a comprehensive image of how hillslopes and streams connect in three different geologies. For marls, fast EC responses in several piezometers were detected, despite the low hydraulic conductivity, implying lateral preferential flow. Schist/slate shows fast and deep vertical infiltration patterns and water level responses only at the piezometers closest to the stream, indicating subsurface connectivity at the weathered soil-bedrock interface. Sandstone developed surface puddles close to the infiltration trench suggesting reduced lateral flow towards the stream.