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Deriving Macropore and Preferential Flow Parameters from Tracer and Time-lapse 3D GPR Experiments at the Plot-Scale

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"Hydrology - a science in which all processes are preferential" (Uhlenbrook, 2006) - as such preferential flow is known and discussed in hydrology since almost three decades. At the same time, preferential flow remains problematic as explicit descriptions are hard to define and upscale and implicit descriptions remain rather case sensitive. Moreover, our techniques to monitor preferential flow and especially flow structures are very limited.

We conducted three multi-tracer plot-scale (1m x 1m) sprinkler experiments at a forested hillslope in the Attert Basin in Luxembourg with prevailing geogenic and biogenic preferential flow structures. It was accompanied by a 3D time-lapse GPR (Ground Penetrating Radar) survey covering an area of 3m x 3m.

We present the results with special emphasis on the derivation of macropore parameters for further modelling. To do so, we developed an automated analysis of images from excavated Brilliant Blue stained profiles. Additionally, we analyse our time-lapse GPR data with respect to temporal changes and derive 3D strutural information of the preferential flow patterns. Superior to tracers, this high resolution subsurface imaging technique is non-invasive, repeatable and therefore helps to disentangle the dye stained patterns towards process observation.

The results of the image analyses and the GPR surveys are compared and referenced to soil moisture monitoring, sampled Bromide profiles and stable isotope signatures. We further discuss implications for joint development of model concepts and observation methods.