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Assessing soil hydrological variability at the cm- to dm-scale using air permeameter measurements

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Soils and surficial sediments are crucial elements in the hydrological cycle since they are the medium through which infiltrating precipitation percolates to the aquifer. At the same time, soil horizons and shallow stratigraphy may act as hydraulic barriers that can promote runoff or interflow and hamper deep infiltration. For most catchments little is known about the small-scale horizontal and vertical variability of soil hydrological properties. Such information is however required to calculate detailed soil water flow paths and estimate small scale spatial variability in recharge and run-off.

We present the results from field air permeameter measurements to assess the small-scale variability of saturated hydraulic conductivity in heterogeneous 2-D soil profiles. To this end, several outcrops in the unsaturated zone (sandy soils with podzolisation) of an interfluve in the Kleine Nete river catchment (Campine area, Northern Belgium) were investigated using a hand-held permeameter. Measurements were done each 10 cm on $\sim$ 2 x 1 m or $\sim$ 2 x 0.5 m grids. The initial results of the measurements (air permeability K_{air}; millidarcy) are recalculated to saturated hydraulic conductivity (K_s; m/s) using specific transfer functions (Loll et al., 1999; Iversen et al., 2003). Validation of the results is done with independent lab-based constant head K_s measurements.

The results show that field based K_s values generally range between 10^{-3} m/s and 10^{-7} m/s within one profile, but extremely high values (up to 10^{-1} m/s) have been measured as well. The lowest values are found in the organic- and silt-rich Bh horizon of podzol soils observed within the profiles ($\sim$ 10^{-6}-10^{-7}m/s), while the highest values are observed in overlying dune sands less than 40 cm deep (up to 10^{-3} m/s with outliers to 10^{-1} m/s).

Comparison of field and laboratory based K_s data reveals there is fair agreement between both methods, apart from several outliers. Scatter plots indicate that almost all points, regardless the transfer function used, are within 10% (logK_s) from perfect correlation. However, it is not clear yet which transfer function would best fit to the data: both show a slight systematic offset of ca. 5% (logK_s) from the line of perfect agreement. Reasons for the observed discrepancies can be differences in measurement scale (5-10 times smaller for the air permeameter compared to constant head core samples) and possibly effects of the soil's saturation degree.

Despite the small but systematic offset, we conclude that field based air permeametry is a relatively cheap, quick and reliable method to map the spatial variability of saturated hydraulic conductivity in heterogeneous soil profiles.

References

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