Hysteretic soil water retention functions from field time series for initial development phases of an artificially-constructed hydrological catchment

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1. Objective

Soil water retention functions are frequently obtained by determining the main drainage branch on standard-sized soil cores in the lab. Especially for the initial phases in constructed systems, the estimation of water retentions functions is uncertain because many assumptions of hydraulic pedotransfer functions for established soil systems (i.e., pore rigidity, homogeneity, hystereses) may not be valid. In this contribution, field-measured data of soil water contents and pressure heads are evaluated to obtain hysteretic water retention functions for characterizing initial soil pore structure development phases directly after artificially constructing a hydrological catchment and during first water table establishment.

2. Methodes

The construction of the 6 ha size catchment “Chicken Creek”, located in the Lusatian mining district in eastern Germany was finished in 2005. The catchment body consisted of a layer of 2 to 3 m quaternary overburden sediments. Tensiometers and TDR-probes were installed in 30, 50, and 80cm soil depth at for locations in July 2008. The hourly logged time series’ were analyzed separately for wetting and drying periods and for seasonal changes to characterize the dynamics of the hysteretic water retention.

- create retention curves from time series by separating time periods of directed changes of soil water content (θ) and pressure head (h)
- distinguish between drying and wetting periods
- quantifying the parameters of van Genuchtens retentions function using the RETC code for m=1-1/n (van Genuchten et al. 2009) and comparison to laboratory measurements
- comparing measured pressured head and elevation of ground water table
- identification of capillary fringe (Gillham 1994)

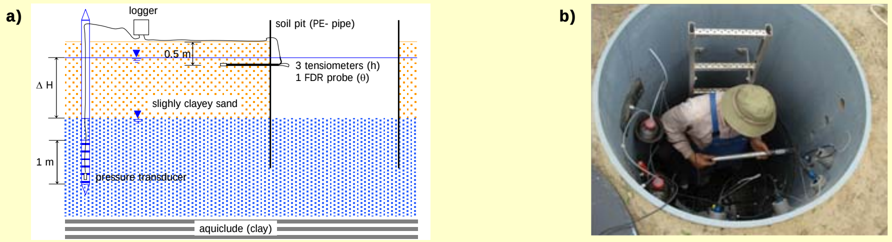

Figure 1: Instrumentation at the soil pits in the Chicken Creek catchment a) schematic 2D vertical cross-section with vertically-installed piezometer and horizontally-installed tensiometers and FDR-probes (ΔH: groundwater level fluctations) and b) photo of the soil pit with tensiometers and FDR-probe

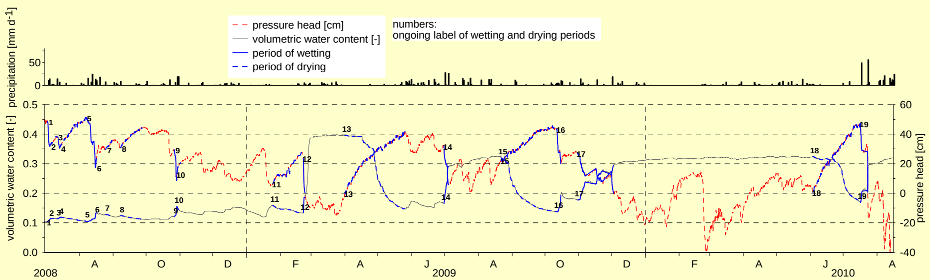

Figure 2: Measured time series` of pressure head and soil water content with marked periods of drying and wetting used for analysis

3 . Results

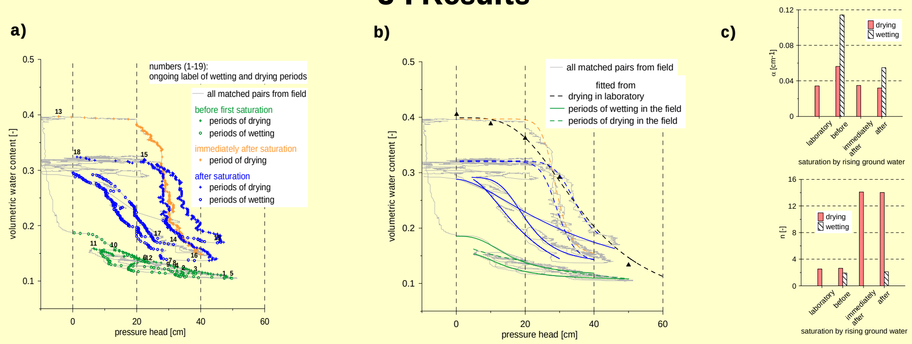

Figure 3: Hysteretic soil water retention from a) field data and b) comparison with analytic functions for wetting and drying periods fitted to laboratory and field data, and c) van Genuchten parameters values of α and n analyzed for selected periods obtained with the RETC program (assuming m=1-1/n)

- strong hysteresis between drying and wetting cycles (Fig. 3 a)
- saturated water content (total pore volume) decreases from about 0.4 to 0.3 after saturation by rising ground water (Fig. 3 a b, Fig. 4)
- retention function from laboratory match with those fitted from drying episode immediately after first saturation (Fig. 3 b)
- retention functions are similar (Fig. 3 b, c) for time spans: before first saturation, immediately after first saturation and after saturation by rising groundwater respectively
- a capillary fringe can identified from the field retention curves as the zone of tension saturation by about 25 cm (Fig. 3 a b)

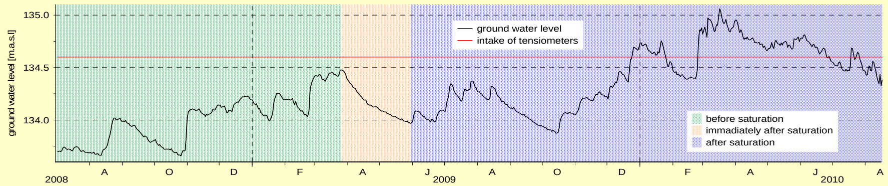

Figure 4: Ground water level fluctuations and elevation of tensiometers

4. Conclusions

Clear differences in water retention are found during wetting and drying periods and lab measured data indicating strong hysteretic behavior.
The seasonal data indicate temporal changes in the water retention, which seem to correspond with episodic water saturation during the establishment and rising of the water table.
The analysis improves understanding of dynamics of soil hydraulic properties during initial development phases and helps parameterization of soil hydraulic functions for a quantitative analysis.

References:
Gillham, R.W., 1984: The capillary fringe and its effect on water-table response. J. Hydrology, 67, 307-324.
van Genuchten, M. Th., Simunek, J., Lej, F. J., Seina, M., 2009: Code for Quantifying the Hydraulic Function of Unsaturated Soils [computer software], Retrieved January 10 , 2011 from http://www.hydrus3d.com

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