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The soil water retention curve: a rare beauty that's hard to observe in the field

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It is soil physics most used function. It is the base for all water budget modeling, and it is determined in well defined lab experiments: the soil water retention curve. Yet it is well known that there are many cases where the water retention cannot be described by a unique relationship between water content and water potential but that its trajectories often deviate in a hysteretic manner and in dynamic situations with fast infiltration fronts. Yet it is implicitly considered that the deviations are of a mere academic interest and that the simple unique retention curve can mimic the retention characteristics of soils under natural conditions.

In this overview we will demonstrate from several years of monitoring of different field and lysimeter studies that the non-unique relationship between water content and water potential is the rule rather than the exception, and that the water flow regime is dominated by these 'anomalies' of the water retention characteristic. Under slowly changing water contents the dynamics can be described by hysteretic models. Of the tested hysteretic models any performed reasonably well, with the best model performance depending on the soil type and flow situation. However at fast infiltration events none of the models was able to describe the water potential signal, which was progressing much faster than the water content signal. This phenomenon has been derived from theoretical considerations for heterogeneous soils. The consequences are that water is released from the soil much faster than could be expected based on the local soil hydraulic properties.

Under the impression of the presented field data it can be concluded that an elaborated determination of water retention curves at the lab scale seems to be of limited use, as the water characteristics that dominate the field scale behaviour are not captured by retention curves. A field adapted soil pysical model must cope with both hysteretic and dynamic processes, and so far the modeling of hysteretic and dynamic behaviour based on field data is rare. It might be achieved either by heterogeneous models or by concepts that explicitly include dynamic behaviour.