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Onset of perched water in a gradually layered soil: a laboratory experiment

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The genetic layering of the soil hydrological properties can significanly affect a number of processes as the onset of soil–slips, the runoff production and those related to the interaction between soil, water, plants and atmosphere. Therefore, with the aim of better understanding some aspects of these processes, we focused on the effect, during an imbibition process, of the decrease of the soil hydraulic conductivity at saturation K_s. A laboratory experiment was setup in order to observe the conditions and dynamics of the onset of a perched water in a gradually layered soil. A prismatic column was realised and filled with 9 different soil strata, each 0.1 m deep, whose grain–size distribution curve and porosity were such as to reproduce an exponential decay of K_s, on the basis of the application of a modified Kozeny–Carman relatioship. The so–rebuilt soil was artificially wetted by means of a rainfall simulator at a rate previously determined in order to maintain a constant water content on the surface for 9 hours. Istantaneous volumetric water content profiles were measured along the soil profile by means of 9 TDR probes and a multiplexer device.

As a result of the experiment we observed and documented the formation of a water content peak at about 0.15 m depth, about 1.5 h after the beginning of the imbibition process. Then the peak emphasised and moved downward and a perched water formed at an intermediate height in the column, about 6 h after the beginning of the experiment. By this experiment we could then verify the formation of a water content peak, as predicted by a previously developed theoretical model and by a finite volume numerical simulation. The peak is then enveloped reaching the saturation as the wetting front moves downward. The perched water depth then rapidly increased upward while the wetting front slowly travelled downward. Before the transition toward saturation, the experiment supported the phoenomenological aspects enlightened by the analytical solution, although the adopted Gardner's constitutive laws tend to overestimate the unsaturated conductivity for most of the soils. A quantitative good agreement was observed between the experimental data and the numerical simulations.