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Onset of a perched water table during infiltration in a gradually layered soil: Reanalysis of a laboratory experiment

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Perched water tables in the upper soil layers play a key role in water partitioning during infiltration. They are typically thin and ephemeral, and onset in soils where a decrease of hydraulic conductivity and diffusivity is observed with depth. Aiming at better understanding their dynamics, we theoretically and numerically reanalysed a laboratory experiment, during which the onset of a perched water table was observed in a reconstructed soil with gradually decreasing conductivity at saturation with depth.
The laboratory prototype was a prismatic column filled with 9 different 0.1 m–deep soil layers. The grain–size distribution curve and porosity of the layers were designed in order to reproduce an exponential decay of conductivity, on the basis of the application of a modified Kozeny–Carman relationship. During the experiment the 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 by means of 9 multiplexed TDR probes.
As a result of the experiment a water content peak was observed below the soil surface. Then it emphasised and moved downward until a perched water table formed at an intermediate height in the column, about 6 h after the beginning of the experiment. The thickness of the perched water table rapidly increased upward while the wetting front slowly travelled downward.
The observed patterns supported phenomenological aspects enlightened by an analytical solution of transient infiltration in a gradually layered soil and by a numerical solution of similar cases. When the perched water table onset, the infiltration was quantitatively compatible with the presence of a perched water table within the soil column, on the basis of a steady infiltration theoretical framework. Then a reanalysis of the experiment was performed by numerically solving the Richards equation for a multilayered porous medium with a classical van Genuchten–Mualem conceptualisation of the soil–water constitutive laws. Due to the great number of involved soil parameters, we chose a deterministic approach with a minimum calibration of the dry–soil initial conditions. The reanalysis allowed to fairly describe the water content dynamics, and the obtained tensiometer–pressure potential profiles were found in good agreement with a steady solution of the saturated layer.