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Transition to saturation in a gradually layered soil: effect of the hydraulic conductivity decrease with depth

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The soil hydraulic conductivity at saturation K_s typically decreases with depth across the upper soil layers, thus strongly characterising the water partitioning and playing an important role in the groundwater recharge. Peaks of water content and perched waters can in fact take place even if the porosity and the soil–water retention relationship are homogeneous, and if the soil lies on a capillary barrier.

Aiming at better understanding these processes, a one dimensional infiltration at constant rate, into a finite depth gradually layered soil, was numerically investigated by means of Hydrus1D and compared with theoretical approaches. K_s was assumed to exponentially decrease with depth and the soil to be saturated at the bottom. After a preliminar dimensional analysis on the basis of the Buckigham π–theorem, two sets of simulations were performed, in order to investigate a strongly K_s–decreasing soil and a more homogeneous one.

According to an analytical solution of the Richards equation, peaks of water content onset at the soil surface and they are enveloped as the maximum water content moves downward. Then either the saturation is reached within the soil, thus leading to a perched water table which rapidly reaches steady conditions, or the peak vanishes. In this case, depending on the infiltration rate, a perched water can anyway onset growing from the bottom of the domain, or the solution can recover its monotonicity allowing a water flow to take place in the direction of the increasing water content. The infiltration rate at which the soil is lead to waterlogging depends on the whole K_s profile and it is therefore less than the K_s of the upper soil layer.