An explanation of unstable wetting fronts in soils

Tammo Steenhuis (1), Jean-Yves Parlange (1), Samuel Kung (2), Cathelijne Stoof (3), and Christine Baver (1)

(1) Cornell University, Biological and Environmental Engineering, Ithaca NY, United States (tss1@cornell.edu), (2) University of Wisconsin-Madison, College of Agriculture and Life Sciences, Madison, WI 53706-1299, USA, (3) Wageningen University, Droevendaalsesteeg 4, Atlas, Building 104, Wageningen Campus, Wageningen, Gelderland 6708 PB

Despite the findings of Raats on unstable wetting front almost a half a century ago, simulating wetting fronts in soils is still an area of active research. One of the critical questions currently is whether Darcy law is valid at the wetting front. In this talk, we pose that in many cases for dry soils, Darcy's law does not apply because the pressure field across the front is not continuous. Consequently, the wetting front pressure is not dependent on the pressure ahead of the front but is determined by the radius of water meniscuses and the dynamic contact angle of the water. If we further assume since the front is discontinuous, that water flows at one pore at the time, then by using the modified Hoffman relationship - relating the dynamic contact angle to the pore water velocity - we find the elevated pressures at the wetting front typical for unstable flows that are similar to those observed experimentally in small diameter columns. The theory helps also explain the funnel flow phenomena observed in layered soils.