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# Modelling gravity-driven fingering in soils having an intrinsic non-zero contact angle (water repellent soils) using the innovative moving-boundary approach

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Quantitative and Qualitative description of infiltration into soils in general and initially dry soils in particular those in which the hydraulic properties vary spatial and temporal have been challenging soil physicists and hydrologists. Water repellent soils, whose contact angle is higher than 40° and can even reach values that are greater than 90° (noted as hydrophobic soils) are an example of such challenge cases. Infiltration in these soils takes usually place along preferential flow pathways (noted as gravity-induced fingering), rather than in a laterally uniform moving wetting front. The water content and capillary pressure distributions along these fingers are non-monotonic with water accumulation behind the moving wetting front (noted as saturation overshoot) and a decreasing water content toward the soil surface. Being a parabolic-type partial differential equation, the Richards equation that is commonly used to model flow in soils can't handle such water content/pressure distributions. Many attempts have been made to modify the Richards equation to enable it to model the non-monotonic water content profiles. These attempts that are not based on the measurable soil properties that can highlight the physics that induces the formation of such non-monotonic distribution.

A new conceptual modelling approach, noted as the moving-boundary approach, will be presented. This approach overcomes the existing theoretical gaps in the quantitative descriptions that have been suggested for the non-monotonic water content distribution in the gravity-induced fingers. The moving-boundary approach is based on the presumption that non-monotonicity in water content is formed by an intrinsic higher-than-zero contact angle. Note that non-zero contact angle have been rarely incorporated in models used for quantifying infiltration into field soils, in spite of the findings that most soils feature some degree of repellency. The verified moving-boundary solution will be used to demonstrate the synergistic effect of contact angle and incoming flux on the stability of 2D flow and its associated plume shapes. The physically-based moving-boundary approach fulfils several criteria raised by researchers to adequately describe gravity-driven unstable flow.