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Non-equilibrium model for gravity-driven fingering in water repellent soils: Formulation and 2D simulations

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Abstract

The instability of infiltrating flow is studied using the mass balance equation coupled with a first-order relaxation equation relating the rate of change of saturation to the difference between the dynamic water pressure and the saturation-dependent equilibrium water pressure. A numerical solution of the mass balance equation, based on a mass conservative scheme, is applied to the simulation of infiltrating flows in a vertical, two-dimensional plane region. Both water wettable and water repellent soils are considered in the analysis. The effect of water repellency is introduced by modification of the equilibrium saturationpressure relationship, in which water repellency causes the relation to become flatter. Conditions of even slight water repellency are found to be sufficient to cause infiltrating flows to become unstable. A sensitivity analysis related to the width of the surface source shows that the number of fingers generated increases with increasing source width. The sensitivity analysis also indicates that the non-equilibrium model approach can provide a physically plausible reason for flows becoming stable when the surface flux becomes vanishingly small.

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