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Hysteresis laws in porous media provide an explanation of gravity fingering

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Abstract.

Unsaturated flow in porous media is usually described with the Richards' equations. This model uses pressure and saturation as unknown variables, they satisfy one parabolic equation and one algebraic relation. The Richards' equations provide a useful model in many situations, but they fail dramatically in the explanation of one specific experiment: if one highly saturated medium is above a very dry medium, then, driven by gravity, the fluid from the top layer enters the (initially) dry medium. In well designed experiments, it does so in the form of fingers: the fluid travels downward in thin channels. The Richards' equations cannot explain this effect: these equations predict uniform fronts. We show that a physically motivated hysteresis model (which replaces the algebraic relation by an ordinary differential equation) can describe the effect of gravity fingering. We show some analysis for the hysteresis equations, a qualitative explanation of the fingering effect, and numerical results.