Seminario de Análisis Numérico y Modelación Matemática

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A momentum-based approach to saturation overshoot

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Resumen

Liquid infiltration into a porous medium stands as a basic phenomenon encountered in diverse engineering, geophysical, and biological applications, including processes in enhanced oil recovery, immiscible gas injection, air filling of the lungs, chemical flooding, thermal recovery, to name a few. Classical models of unsaturated flow in porous media are typically based on Richards equation (a combination of mass balance and Darcy's law including gravity and capillarity). Recently, there has been a relatively high interest in the development of refined models and suitable numerical techniques capable to accurately reproduce saturation overshoots, which are non-monotone travelling saturation profiles. This particular phenomenon is characterized by a constant flux infiltration of water into initially dry porous media causing an overshoot of the water saturation and pressure profiles at the initial wetting front before reaching an asymptotic drainage value behind the front. Emphasis has been placed in the apparent shortcomings of traditional formalisms (Richards-like equations based on single-valued monotone constitutive functions) to provide sound theoretical explanations to the most salient features of saturation overshoot observations. Even if a number of remedies are now available (mostly involving adding ad hoc non-equilibrium terms), we believe that a simpler and more natural context can be offered by recasting the main effects of the phenomenon into a general formalism based on a momentum approach. In this talk we will derive a simple model to recover saturation overshoots, we will discuss the relevance of travelling wave solutions, and perform a linear stability analysis of the flow patterns. Next we will briefly outline the main properties of a mixed-primal finite volume element method tailored for flow-transport couplings, and provide some numerical experiments. This is a joint work with Prof. Ivan Lunati (ISTE, Lausanne).