Scaling behavior of stochastic, multiphase flow in porous media

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Subsurface formations are heterogeneous at all length scales, and fine scale heterogeneities, particularly in the permeability field, can have a significant impact on large scale flow. Due to the difficulty in complete and certain characterization of these heterogeneities, stochastic representations of subsurface geologic properties have become commonplace. As a result, the flow equations have stochastic coefficients, and must also have stochastic solutions. Thus predictions of flow outcomes are inherently stochastic.

We examine multiphase flow in stochastically described heterogeneous porous media. The study centers on the interplay between nonlinearity and heterogeneity in determining fluid mixing dynamics. Monte Carlo simulations are used for a quantitative analysis of this mixing. Different flow regimes, identified by the large time scaling behavior of the mixing dynamics, are characterized. This characterization provides significant guidance for uncovering effective methods (and their limits) for the scaling-up of multiphase flow systems to scales suitable for computationally inexpensive yet accurate fluid flow simulations.