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Spreading due to heterogeneity in two-phase flow

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We consider idealised immiscible two phase displacement flow (Buckley-Leverett) in a heterogeneous porous medium. In particular, we consider two cases – (a) horizontal flow subjected to temporal fluctuations and (b) vertical flow with buoyancy. Using perturbation and stochastic methods we analytically derive a large scale 'mixing' (spreading) parameter for these Buckley Leverett flows. In analogy with previous work in passive scalar spreading, this 'mixing' effect can be quantified by an effective large scale dispersion term. While temporal fluctuations enhance mixing for a passive conservative tracer, we illustrate in case (a) that for multiphase flow they do not always do so. For the vertical case (b) buoyancy can act as a stabilizing or destabilizing influence competing with viscous instabilities and heterogeneity. This makes the quantification of spreading more difficult. However, our solution still works well for many cases and provides useful insight into others. In order to validate the analytical models, a series of numerical solutions was conducted. This project is motivated by a desire to understand the influence of heterogeneities on multiphase flow with a specific ultimate application to CO2 sequestration.