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Time-Dependent Velocity-Field Controls on Anomalous Chemical Transport in Porous Media

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Temporal variations in the subsurface velocity field are often, if not always, present in the real world to at least some degree. However, an accounting of their effects on chemical transport has been largely neglected. Here, we demonstrate experimentally effects of a time-varying velocity field on conservative chemical tracer transport in porous media, as compared to constant velocity conditions. We find that velocity-field fluctuations increase chemical tracer spreading and residence time, which intensify the anomalous nature of the transport. This behavior is modeled by a continuous time random walk particle tracking method formulated to account for time-dependent velocity fields. The model matches the experimental results with a parsimonious and consistent set of parameters. The model is then applied to study the effects of different magnitudes in velocity-field fluctuations, as well as different degrees of porous media heterogeneity, on 1-D and 2-D spatiotemporal propagation of an injected, point source, chemical plume. Increased intensity of velocity-field fluctuations, and increased porous medium heterogeneity, each serve to increase the extent of chemical spreading and anomalous behavior.