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Dispersion upscaling in highly heterogeneous aquifers: The prediction of tracer dispersion at the Macrodispersion Experiment (MADE) site

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We derive an upscaled model for the prediction of the plume evolution in highly heterogeneous aquifers based a stochastic transport representation in terms of continuous time random walks. Transport is modeled through advective motion of idealized solute particles, which changes their speed at fixed distances. The series of particles speeds is modeled as a stationary Markov chain. The derived model is parameterized by the correlation length, mean and variance of the log-hydraulic conductivity, the mean hydraulic gradient and porosity. Furthermore, it can be conditioned on the conductivity and tracer data at the injection region. The model predicts the non-Fickian evolution of the longitudinal concentration profile observed during the MADE-1 experiment. The mass distribution is characterized by strong localization at the injection region and a strong forward tail. These features are explained by conductivity heterogeneity at the injection region, and the correlated motion of particles according to spatially persistent Eulerian flow speeds.