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# Upscaling transport in heterogeneous porous media featuring local-scale dispersion: Flow channeling, macro-retardation and prediction

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Many theoretical treatments of transport in heterogeneous Darcy flows consider advection only. When local-scale dispersion is neglected, flux weighting persists over time; mean Lagrangian and Eulerian flow velocity distributions relate simply to each other and to the variance of the underlying hydraulic conductivity field. Local-scale dispersion complicates this relationship, potentially causing initially flux-weighted solute to experience lower-velocity regions as well as Taylor-type macrodispersion due to transverse solute movement between adjacent streamlines. To investigate the interplay of local-scale dispersion with conductivity log-variance, correlation length, and anisotropy, we performed a large-scale Monte Carlo study of flow and advective-dispersive transport in spatially-periodic 2D Darcy flows in high-resolution multivariate Gaussian random conductivity fields. We observed flow channeling at all heterogeneity levels and quantified its extent. We found evidence for substantial effective retardation in the upscaled system associated with increased flow channeling, not attributable to numerical considerations, and for limited Taylor-type macrodispersion, which we may physically explain. A quasi-constant Lagrangian velocity was consistently observed within a short distance of release, allowing usage of a simplified continuous-time random walk (CTRW) model we previously proposed in which the transition time distribution is understood as a temporal mapping of unit time in an equivalent system with no flow heterogeneity. The numerical data set was modeled with such a CTRW and we determined how dimensionless parameters defining the CTRW transition time distributions are predicted by dimensionless heterogeneity statistics. Implications will be discussed.

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## References

Upscaling transport in heterogeneous media featuring local-scale dispersion: Flow channeling, macro-retardation and parameter prediction L Zhou, SK Hansen Advances in Water Resources 193, 104830 https://doi.org/10.1016/j.advwatres.2024.104830

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