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Guidelines for interpreting convergent-flow tracer tests to estimate dispersivity coefficients: Small source size and short distance test scales effects

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In typical field settings, forced-gradient tracer tests (FGTTs) are preferred over natural-gradient tracer tests (NGTTs). In FGTTs, a few deep-penetrating injection and pumping wells are used to conveniently modify the natural flow configuration. Thus, they provide faster test durations and a better control of the flow system. Common tracer tests of this type such as the convergent-flow tracer test (CFTTs) and divergent-flow tracer tests (DFTTs) involve radially dispersive solute transport and the use of small tracer sources with respect to the scale of heterogeneity. Dispersivities estimated from such FGTTs involving a small source are often used to make predictions on the movement of a large contaminant plume under natural-gradients. Recently, two-dimensional numerical simulations [Chao et al., 2000; Chao, 2000; Tiedeman and Hsieh, 2004] revealed that dispersivity estimates obtained from FGTTs (involving a small source) may not be adequate to simulate the movement of a large contaminant plume migrating under natural-gradients. Discrepancies were primarily attributed to two causes: (1) the influence of the plume size on dispersivities, and (2) non-uniform flow effects. These conclusions could not be directly extended to field aquifer settings because these studies focused on two-dimensional heterogeneous porous media. Here, Monte Carlo numerical simulations of linearly sorbing solute transport in three-dimensional physically heterogeneous porous media were conducted to further investigate the differences between dispersivities estimated from FGTTs and corresponding quantities estimated from NGTTs. We specifically investigate the effect of small source sizes and short distances test scales -typically used in CFTTs in the field- on dispersivities estimated from measured concentration breakthrough curves. Simulation results provide useful guidelines on the relationship between dispersivities estimated from short-distance small-source CFTTs and the corresponding effective asymptotic values in UFTTs.