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Testing the fractional advective-dispersive equation for solute transport in soil with data from miscible displacements experiments

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Understanding and modeling transport of solutes in porous media is a critical issue in the environmental protection. Contaminants from various industrial and agricultural sources can travel in soil and ground water and eventually affect human and animal health. The parabolic advective-dispersive equation (ADE) is the commonly used model of solute transport in porous media. This model assumes that the diffusion-like spread occurs simultaneously with the purely advective transport. Although the solute dispersivity in this equation is regarded as a constant, it has been found to increase with the distance from the solute source. This can be explained assuming the movement of solute particles belongs to the family of Lévy motions. A one-dimensional solute transport equation was derived for Lévy motions using fractional derivatives to describe the dispersion. Published data from miscible displacement experiments were used to show the applicability of this fractional equation – the fractional advective-dispersive equation (FADE) – to the conservative transport in soils. Dirichlet, or constant concentration, boundary condition at the surface of the column were used. Earlier research on the ADE applications to the miscible displacement experiments has shown that this boundary condition introduces mass balance errors in the solute transport simulations. Recently, we observed a similar effect for the FADE. We developed a mass conserving procedure to solve FADE numerically and used it to fit FADE solutions to experimental breakthrough curves for conservatives tracers. We demonstrate and discuss improvements in solute transport simulations that FADE provides for some but not all data from miscible displacement experiments with soils and sediments.