



Is there such a thing as a local scale?

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A common assumption (or hope) among hydrogeologists is that a local transport model is correct at some small scale. Then the problems associated with prediction are not due to the underlying physics, but poor measurement resolution. In fact, many of the “upscaled” nonlocal (convolutional) transport models from the 1990’s are stochastic averages of a local (Fickian) advection-dispersion equation (ADE). A few studies have shown non-Fickian behavior in column studies, but this does not rule out Fickian fluxes at the sub-grid (or sub-column) scale. An experiment by Klise et al. (AWR, 2008) allows us to test the hypothesis of Fickian sub-grid fluxes. A 35 x 35 cm slab of relatively homogeneous sandstone was entirely covered by over 16,000 permeability measurements. Potassium iodide was used as a tracer while the slab was x-rayed, giving complete coverage of the parameters, ICs, BCs, and concentration evolution for flow and transport models. The ADE fails to reproduce the tailing of solute breakthrough. Adding sub-grid heterogeneity—even extreme amounts, does not improve the fit, implying that the ADE is not the correct model at any scale. A simple temporally-nonlocal model fits the data with parameters that remain essentially scale invariant.