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The path from stochastic theory to applications in groundwater transport

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Quantitative understanding of solute transport is possibly the most challenging problem of groundwater hydrology and many other sciences. The Advection Dispersion Equation (ADE) is widely used to simulate transport, but is known to suffer severe limitations when compared to actual field data. These include scale dependence of dispersivity, time and directional dependence of apparent porosity and tailing. These effects are known to be caused by heterogeneity, which motivated the use of stochastic methods. Stochastic hydrology has successfully explained observations. However, as yet, it has failed to impact hydrological practice significantly.

The situation may change because of exciting new developments in recent years. On the one hand, characterization tools are becoming increasingly apt. Stochastic inversion can take advantage of data ranging from direct measurements of heads and concentrations to geophysical observations, or qualitative descriptions of geology. These tools are becoming capable of linking stochastic methods with site specific data, which should make them realistic. Unfortunately, they are hard to apply in general. On the other hand, the Continuous Time Random Walk (CTRW) method is easy to apply and it is yielding very good results, in that it is capable of reproducing field observations, including tailing and scale dependence of dispersion. Unfortunately, it requires calibration against site specific breakthrough curves, which are rarely available in practice. The situation is paradoxical. CTRW works well and is easy to apply, but requires rarely available data. Stochastic methods can incorporate widely available data, but are hard to apply. Conceptually, the two approaches should not differ in the essentials. Thus the grand question is whether they can be made compatible.