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How can we make Fickian dispersion models useful in practice?

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H34D-04: How can we make Fickian dispersion models useful in practice?

Wednesday, 14 December 2016
16:45 - 17:00
Moscone West - 3018

Dispersion in porous media originates from the variability of fluid velocity jointly with concentration at scales smaller than the ones resolved in the continuum description of solute transport. The unresolved scales are thus associated with the pore-grain geometry and the larger-scale heterogeneity that are ignored when the composite pore-grain medium is replaced by a homogenous continuum. This applies whether the formation is modelled as homogeneous or discretized into homogeneous blocks. The process of dispersion is typically described through the Fickian model, *i.e.*, dispersive flux is proportional to the gradient of the resolved concentration, commonly with the Scheidegger parameterization, *i.e.*, a particular way to compute the dispersion coefficients utilizing dispersivity coefficients. Although the Fick-Scheidegger parameterization is by far the most commonly used in solute transport applications, its validity has been questioned.

In this presentation, we will list conditions under which the Fickian dispersion model is justified, then present how the practical Fickian model can approximate what is often thought as “non-Fickian” behavior. Specifically, we will show with several examples that the Fickian dispersion model performs adequately using appropriate dispersion coefficients in a domain that is discretized finely enough for the local equilibrium conditions that the Fickian model requires to be satisfied. Over the last thirty years, advances in numerical linear algebra, adaptive mesh refinement, and high performance computing environments, in combination with a dramatic drop in computational cost, have made it possible to perform fine-resolution simulation. We will also present how upscaled hydraulic conductivity and macrodispersion coefficients change with respect to different grid size and heterogeneity scale and discuss the role of diffusion and mean velocity. From these illustrations, we argue that the predictive ability of transport modeling can be greatly improved by finer-scale simulation because fine-scale modeling captures the physics of dispersion more accurately. New possibilities of high-resolution measurements through advanced sensor technology and data processing techniques have the potential to achieve more accurate modeling of transport.

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