IMAGe Seminar

Institute for Mathematics Applied to Geosciences at NCAR

Characterization and Quantification of Effective Transport in Heterogeneous Media

Dr. Marco Dentz
Department of Geotechnical Engineering and Geosciences
Technical University of Catalonia

Abstract:

For the qualitative and quantitative understanding of transport in heterogeneous media it is essential to quantify the impact of spatial heterogeneity and temporal fluctuations of the system parameters on the effective transport behavior (upscaling). For the imaging of flow and transport processes in heterogeneous media one disposes of local measurements, which are very precise but usually scarce, and, more frequently of volume-integrated measurements, which are less precise and represent an effective behavior that results from the interaction of local scale transport processes (advection, dispersion/diffusion), spatial heterogeneity and temporal fluctuations. In order to quantify this effective behavior, we distinguish two upscaling approaches: The ‘transport coefficient approach’ studies effective transport coefficients (effective dispersion coefficients, effective retardation coefficient, etc.), which contributes to our understanding of the heterogeneity induced transport dynamics and large scale spreading and mixing mechanisms, which is of paramount importance for the characterization of saltwater intrusion into coastal aquifers, steady-state contaminant plumes, and reactive transport for example. The ‘transport process approach’ characterizes the heterogeneity induced effective transport dynamics and processes in terms of upscaled transport equations. Observed anomalous spatial and temporal tailing of solute distributions in inhomogeneous media cannot be understood nor quantified within the Fickian transport paradigm. We present methods to identify and quantify effective upscaled transport (i) by averaging, within a stochastic modeling approach, for example, which allows for the systematic upscaling from micro- to meso- to the macroscale, and (ii) by effective, temporally non-local transport models such as continuous time random walks and multirate mass transfer.

Keywords: Mixing and Spreading in Inhomogeneous Media, Continuous Time Random Walks, Multirate Mass Transfer, Levy Walks, Correlated Random Walks, Fractal Dynamics, Stratified (Random) Media

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sgentile@ucar.edu