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UPSCALING OF FLOW, TRANSPORT AND DEFORMATION IN HETEROGENEOUS POROUS AND FRACTURED MEDIA

Marco Dentz

Spanish National Research Council (IDAEA-CSIC), Barcelona, Spain

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Abstract. The understanding and prediction of flow, transport and deformation phenomena in natural and engineered media are key items in different fields of science and engineering, with applications ranging from groundwater management to geological energy storage. Spatial heterogeneity in the physical medium properties leads to scale effects in the flow, dispersion and deformation processes. Classical upscaling approaches aim at the prediction of average flow and transport attributes such as the mean flow rate (effective hydraulic conductivity), and the dispersion rate (hydrodynamic dispersion). However, large-scale flow and transport behaviors are characterized, for example, by long tails in fluid production rates and contaminant breakthrough curves, and anomalous solute dispersion that cannot be described based on a constant flow and transport rates. Such behaviors are manifestations of memory processes that occur due to the fact that flow velocities and mass transfer rates in heterogenous media are broadly distributed. This talk presents two approaches for the upscaling of flow, transport and deformation in porous and fractured media that account for these memory effects. Both approaches are based on stochastic representations of the medium heterogeneity and its statistical characterization. The first approach analyzes the detailed Lagrangian flow and transport properties to derive stochastic evolution equations for contaminant transport in the framework of continuous time random walks. The second approach uses a multi-continuum representation to predict large scale flow and deformation behaviors in fractured media.