UPSCALING OF TRANSPORT IN CORRELATED NON GAUSSIAN VELOCITY FIELDS: CONSEQUENCES FOR MODELING MIXING AND REACTIONS IN POROUS MEDIA

Pietro De Anna, University of Rennes 1 - CNRS, +33 2 23 23 66 24, pietrodeanna@gmail.com

1. Pietro de Anna, University of Rennes 1 - CNRS
2. Tanguy Le Borgne, University of Rennes 1 - CNRS
3. Alexander Tartakovsky, Pacific Northwest National Laboratory, Washington, USA
4. Marco Dentz, Spanish Research Council, Barcellona, Spain
5. Diogo Bolster, University of Notre Dame, Indiana, USA

Natural flow fields in porous media display a complex spatio-temporal organization due to heterogeneous geological structures at different scales. This multiscale disorder implies anomalous dispersion, mixing and reaction kinetics (Berkowitz et al. RG 2006, Tartakovsky PRE 2010). In this context, classical continuum models based on Fickian mixing may misrepresent reactive transport. Using two dimensional pore scale SPH numerical simulations of flow and transport, we demonstrate the non Gaussian nature and the long range temporal correlation of the Lagrangian velocity field. The main origin of these properties is the existence of very low velocity regions where solute particles can remain trapped for a long time. Another source of strong correlation is the channeling of flow in localized high velocity regions. Thus, this result questions the applicability of classical Langevin approaches for modeling mixing and reaction kinetics. In order to define an effective upscaled model, we adopt a upscaled model that takes into account the statistical properties of the pore scale Lagrangian velocity field. Analyzing the pore scale statistical properties of the flow, we show the spatial Markovian, and temporal non Markovian, nature of the Lagrangian velocity field. Therefore, an upscaled model can be defined as a correlated Continuous Time Random Walk (Le Borgne et al. PRL 2008) in two dimension. This account for both non Gaussian velocity distribution and long range temporal correlation property. The key feature of this model is the definition of a transition probability density for Lagrangian velocities across a characteristic correlation distance. We quantify this transition probability density from pore scale simulations and use it in the effective random walk model. In this framework, we discuss the ability of this effective model to represent correctly dispersion, mixing and reaction kinetics