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Transport upscaling from pore- to Darcy-scale: Incorporating pore-scale Berea sandstone Lagrangian velocity statistics into a Darcy-scale transport CTRW model

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For the past several years a lot of attention has been given to pore-scale flow in order to understand and model transport, mixing and reaction in porous media. Nevertheless we believe that an accurate study of spatial and temporal evolution of velocities could bring important additional information for the upscaling from pore to higher scales. To gather these pieces of information, we perform Stokes flow simulations on pore-scale digitized images of a Berea sandstone core. First, micro-tomography (XRMT) imaging and segmentation processes allow us to obtain 3D black and white images of the sample [1]. Then we used an OpenFoam solver to perform the Stokes flow simulations mentioned above, which gives us the velocities at the interfaces of a cubic mesh. Subsequently, we use a particle streamline reconstruction technique which uses the Eulerian velocity field previously obtained. This technique, based on a modified Pollock algorithm [2], enables us to make particle tracking simulations on the digitized sample. In order to build a stochastic pore-scale transport model, we analyze the Lagrangian velocity series in two different ways. First we investigate the velocity evolution by sampling isochronically (t-Lagrangian), and by studying its statistical properties in terms of one- and two-points statistics. Intermittent patterns can be observed. These are due to the persistance of low velocities over a characteristic space length. Other results are investigated, such as correlation functions and velocity PDFs, which permit us to study more deeply this persistence in the velocities and to compute the correlation times. However, with the second approach, doing these same analysis in space by computing the velocities equidistantly, enables us to remove the intermittency shown in the temporal evolution and to model these velocity series as a Markov process. This renders the stochastic particle dynamics into a CTRW [3].

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