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Dispersion upscaling from a pore scale characterization of Lagrangian velocities

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Mixing and reactive transport are primarily controlled by the interplay between diffusion, advection and reaction at pore scale. Yet, how the distribution and spatial correlation of the velocity field at pore scale impact these processes is still an open question. Here we present an experimental investigation of the distribution and correlation of pore scale velocities and its relation with upscaled dispersion.
We use a quasi two-dimensional (2D) horizontal set up, consisting of two glass plates filled with cylinders representing the grains of the porous medium : the cell is built by soft lithography technique, wich allows for full control of the system geometry. The local velocity field is quantified from particle tracking velocimetry using microspheres that are advected with the pore scale flow. Their displacement is purely advective, as the particle size is chosen large enough to avoid diffusion. We thus obtain particle trajectories as well as lagrangian velocities in the entire system.

The measured velocity field shows the existence of a network of preferential flow paths in channels with high velocities, as well as very low velocity in stagnation zones, with a non Gaussian distribution. Lagrangian velocities are long range correlated in time, which implies a non-fickian scaling of the longitudinal variance of particle positions. To upscale this process we develop an effective transport model, based on correlated continous time random walk, which is entirely parametrized by the pore scale velocity distribution and correlation. The model predictions are compared with conservative tracer test data for different Peclet numbers.
Furthermore, we investigate the impact of different pore geometries on the distribution and correlation of Lagrangian velocities and we discuss the link between these properties and the effective dispersion behavior.