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# ***Investigation of Turbulent Natural Convection in Porous Media by using pore-scale-resolving Direct Numerical Simulations***

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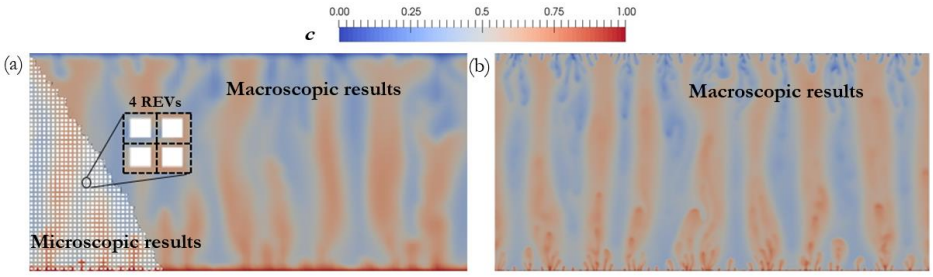


Figure 1: Instantaneous dimensionless mass concentration field. (a) DNS (microscopic and the derived macroscopic results) with a magnification of the porous medium consisting out of four REVs. (b) DOB simulation.

Turbulent natural convection in porous media receives more attention in recent years, especially due to its significance in new emerging engineering applications like the long-term storage of $CO_2$ in deep saline aquifers or the usage of thermal-energy storage systems. For calculating natural convection in porous media, typically macroscopic equations are solved. The numerical solution of volume-averaged Darcy-Oberbeck-Boussinesq (DOB) equations are well known and mainly used, due to its relatively low computational costs. However, the DOB equations only account for the microscopic properties of the porous medium via the permeability and effective diffusivity. In addition, the physical mechanisms of dispersion and viscous diffusion are not accounted for in the DOB equations. These simplifications may be the reason of the discrepancies between the Sherwood/Nusselt number scaling from DOB simulations and laboratory experiments.

Hence, by performing pore-scale-resolving direct numerical simulations (DNS) of convection in porous media and comparing those to traditional DOB simulations (figure 1), we investigated whether natural convection in porous media is influenced by parameters other than the parameters used by the DOB through additional physical mechanisms. The macroscopic fields were obtained from DNS by volume-averaging over each representative elementary volume (REV) of the porous medium. The main conclusion of our pore-scale-resolving DNS is that the pore-scale has significant effects on convection in porous media, whereby state-of-the-art DOB simulations can capture none of the observed effects.