EGU21-8710
https://doi.org/10.5194/egusphere-egu21-8710
EGU General Assembly 2021

Suitability of 2D modelling to evaluate flow properties in 3D porous media

Ester Marafini[1], Michele La Rocca[1], Aldo Fiori[1], Ilenia Battiato[2], and Pietro Prestininzi[1]
[1]Department of Engineering, Roma Tre University, Rome, Italy
[2]Department of Energy Resources Engineering, Stanford University, 367 Panama St, Stanford, CA 94305, USA

Limitations stemming from the employment of 2D models to investigate the properties of 3D flows in porous media are generally overlooked. In this study, the extent to which 2D modelling can be employed for the representation of genuinely 3D flows in porous media is quantified. To this scope, Representative Elementary Volume (REV) sizes of 2D and 3D media sharing the same porosity are compared. The spatial stationarity of several Quantities of Interest (QoIs) namely, porosity, permeability, mean and variance of velocity, is numerically evaluated. In order to extend conclusions to transport phenomena, the analysis of the velocity variance, which is closely associated to the hydrodynamic dispersion process, is included. Porous media adopted in this study are composed by spheres and disks in 3D and 2D domains respectively, where both 2D and 3D geometries are characterized by random locations. Specifically, for 3D random packings creation, a sphere packing generator program is used. Pore scale flow is simulated by means of the Lattice Boltzmann Model (LBM): the LBM is employed as a numerical flow solver to reproduce the Darcy's experiment through the aforementioned domains. The LBM represents a powerful tool to model flow in porous media and it is able to accurately predict flow paths, permeability and hydraulic conductivity. Hydraulic QoIs are analysed at steady state conditions. To this purpose, the flow velocity field is used to inspect stationarity. The quantitative approaches adopted in the REV assessment procedure allow one to determine the residual variability of the quantity associated to the REV and consequently the level of accuracy that the modeller wants to achieve with respect to the QoIs. Such criteria show that REV estimations through 2D models are much larger than their 3D counterparts. In conclusion, pore scale LBM simulations highlight that the 2D approach leads to inconsistent results, due to the profound difference between 2D and 3D porous flows.