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Generating synthetic images of unsaturated porous media with a multiscale multipoint statistics approach to study transport in two-fluid-phase systems

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Human activity influences largely the unsaturated vadose zone. Located above water tables, the vadose is impacted by pollution, typically from agriculture and industrial activities. Therefore, understanding contaminant transport in the vadose zone is crucial for water resources management. However, there is still a lack of comprehension on dispersion in unsaturated porous media, and the subject remains an active research topic. Classical models such as advection-diffusion equation often fails to predict the dispersion, notably because of the increased heterogeneity in the multiphase system. Particularly, the link between the nature of the multiphase flow, the phase configuration in the porous medium and the dispersion stays unclear. Notably, experimental techniques often struggle to gather significant number of data and to consider long time dispersion. Therefore, we propose a multiscale multipoint statistic algorithm (MPS) to generate porous media images at different saturation of immiscible fluids. Generated images are based on experimental observations of immiscible multiphase flow air/water in a complex porous structure. To evaluate the representativeness of MPS generated images, we first analyze structural properties like the grains and air clusters size and geometry. These properties, compared to the experimental image's ones, show a good match. Then, flow and transport are computed using Lattice-Boltzmann simulation in both experimental and generated images for different saturation. The resulting velocity distribution and concentration profile are very comparable. Particularly, the variances of the concentration profiles are very well reproduced. These results shows that MPS algorithm are willing to capture and reproduce the main pore scale features that govern flow and transport in a complex porous media. Therefore, the MPS algorithm could be used to generate a large number of images based on experimental images to study transport in unsaturated porous media. Notably, it allows more statistical coherence that leads to a better understanding of the link between two-fluid phase configuration and transport. Furthermore, we generate larger images (in comparison to experimental data) which allow us to get more insight on long time dispersion.

Participation

In-Person

References

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