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Measuring (non)stationarity in porous media images and what it means for pore-scale simulations

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The structures we obtain with, for example, X-ray tomography imaging and then use for pore-scale imaging actually says a lot about the applicability of obtained simulated results. For example, to utilize classical homogenization scheme and obtain continuum scale properties such as permeability, relative permeabilities and numerous others, one needs to establish representativity, which is equal to structural homogeneity of the sample [1]. While no natural sample is strictly stationary [2], we shall show that weak stationarity can be effectively established for the purpose of representativity through the analysis of images produced by stationary random processes. But where is that threshold between homogeneous and inhomogeneous structures and why is it important for pore-scale simulations?

The first question highlights the central problem of the blurred interface between heterogeneous and homogeneous, which also depends on the metrics used for its identification. Our results uncover the physics of structural stationarity quantification, based on correlation functions and clustering based on these functions different between image subregions [3]. By applying the methodology to a wide variety of synthetic and real images of binary porous media, we confirmed computationally that only periodically unit-celled structures and images produced by stationary processes with resolutions close to infinity are strictly stationary. Natural structures without recurring unit cells are only weakly stationary. We established a physically meaningful definition for these stationarity types and their distinction from nonstationarity. In addition, the importance of information content of the chosen metrics is highlighted and discussed [4].

In this presentation we shall focus on:

- Methodology to analyze the porous media images to establish their homogeneity;
- The importance of stationarity to establish REV;
- The crucial role of image analysis with structural metrics prior to any pore-scale simulations.

As we argue, the image analysis based on structural metrics is necessary prior pore-scale simulations. We discuss all the details to establish such an analysis protocol and lay down major methodological procedures.

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References

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Primary authors: GERKE, Kirill (RAS); LAVRUKHIN, Efim; ZUBOV, Andrey; KARSANINA, Marina

Presenter: GERKE, Kirill (RAS)

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