Contribution ID: **39** Type: **Oral Presentation**

Dynamic Mode Decomposition (DMD) for Analyzing Dynamics in Multiphase Flow in Porous Media

Monday, 30 May 2022 10:50 (15 minutes)

The advances in imaging technology over the past decade provide us with a much richer set of capability both in terms of quality and resolution to visualize the structure and processes in porous media. In particular the improvement in time resolution brings us into the position of gaining insight into dynamic process both at pore and Darcy scale at an unprecedented level. While we are finally able to resolve the dynamic processes at their natural time and length scale at flowing conditions, it also poses a challenge to analyze large data in time-resolved data sets. While we traditionally analyze time series of 1D or even 3D imaging data sets by visual inspection, there are relatively few tools that help us to quantitatively characterize the dynamics. We do have methods such as Fourier analysis to extract characteristic signatures of the dynamics e.g. periodic aspects of the dynamics, that then occurs largely de-coupled from spatial structure –and the other way around. Also, in Fourier analysis, we often struggle to identify the dominant modes because long time series would be required, and the signal is not separated from the noise very well.
Dynamic Mode Decomposition (DMD) provides an approach to analyze spatio-temporal experimental data in a quick and largely automated manner and allows for simultaneous analysis of both spatial modes and their dynamics, in a consistent manner. Here we provide an application case where DMD is used to analyze spatio-temporal behavior of an instability in 2-phase "steady-state"flow in a Darcy scale fractional flow experiment. The (1D) space-time data which exhibits periodic "traveling wave"features is analyzed by DMD by decomposing it into the underlying modes and respective Eigenvalues. We observe that the system is well approximated by 4-5 modes and their respective dynamics.
For the analysis of dynamics in porous media flows this is a paradigm shift compared to the traditional approach which starts either with a traditional scaling-up approach or directly commencing with fitting models to the data. The dynamic mode decomposition is an entirely data-driven approach that allows to extract the relevant dynamics within a few characteristic modes, which can then serve –at much better signal-to-noise ratio, for instance as surrogate models for further analysis.

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References

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[2] P. J. Schmid. Dynamic mode decomposition of numerical and experimental data. Journal of Fluid Mechanics, 656:5–28, 2010.

[3] M. Rücker, A. Georgiadis, R. T. Armstrong, H. Ott, N. Brussee, H. van der Linde, L. Simon, F. Enzmann, M. Kersten, and S. Berg. The origin of non-thermal fluctuations in multiphase flow in porous media. Frontiers in Water, 3:671399, 2021.

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Online

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