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Chaotic mixing due to oscillatory flow in porous media

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Solute mixing in time-periodic porous media flows is relevant to a wide range of natural, industrial and biological processes spanning from seismicity through hydropeaking to pulsatile flows in biological tissue. Nevertheless, it remains poorly understood how the (spatial) frequencies of the porous medium and the (temporal) frequencies of the time-varying flow field interplay and affect the mixing dynamics. Here we investigate the dynamics of solute mixing by a single-frequency oscillatory flow through an archetypal porous medium consisting of periodically arranged cylindrical obstacles. By extensive high-resolution pore-scale simulations, we find that successive stretching and folding events across stagnation points generate chaotic mixing, meaning that fluid elements are elongated exponentially in time. We propose a theoretical model allowing us to analytically predict the Lyapunov exponent based on the frequency and amplitude of the flow. The model opens new avenues for predicting mixing and reaction rates across a host of time-dependent porous media flows.

Participation

In-Person

References

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