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Mixing in Porous Media: Observations and Modeling of the Local Concentration PDF

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In most types of natural and artificial porous media, even before taking larger-scale (e.g., permeability) heterogeneities into consideration, fluid flow usually exhibits complex random local velocity patterns. This has traditionally made scalar transport difficult to accurately predict whenever pore-scale concentration variability is of concern, which is usually the case when dealing with nonlinear processes such as chemical reactions, especially at high Péclet numbers.
This problem can be approached by representing the microscale concentration variability as a probability density function (PDF). Concentration probability density is then transported (i) spatially through macroscopic advection-dispersion and (ii) over the "concentration space" due to local mixing.
For instance, a classical model for the local mixing term, Interaction by Exchange with the Mean (IEM), has the form of a probability density drift (advection) towards the local mean concentration. This model is based on strong assumptions and generally fails to reproduce observations. A recently proposed multirate IEM model (MRIEM) attempts to overcome the simplicity of the former by allowing multiple simultaneous rates of drift towards the mean, but still lacks a direct link to the structure of the porous medium or the actual physics of the local mixing process.
In this work we further investigate the mathematical nature of the local mixing term and develop an improved model based on microscale physics and heterogeneity statistics, producing results that agree with recent observations from direct numerical simulations.

Participation

In-Person

References

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