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Non-modal growth of perturbations in miscible displacements with non-monotonic viscosity profiles

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We study the effect of a non-monotonic viscosity profile on miscible viscous fingering in porous media. This hydrodynamic instability is studied by coupling the continuity and Darcy equations with a convection-diffusion equation for solute concentration that determines the viscosity. A toy viscosity model composed of a sequence of transformation in a sine function is considered. Parametric studies are performed in terms of the end-point viscosity contrast, maximum viscosity, and the corresponding value of the concentration. We employ a non-modal analysis (NMA) based on the singular value decomposition of the propagator matrix approach to perform the stability analysis of the non-autonomous linear system. NMA facilitates to identify the optimal amplification of the perturbations and its spatial structure. We demonstrate that there is a disagreement of previous linear stability analyses and NMA. This disagreement is inherited from the perturbation structure and the parameters involved in defining the non-monotonic viscosity profiles. Our study shows that miscible displacements with non-monotonic viscosity profiles can successfully be analyzed using NMA and paves the way for future work to understand the displacements with a non-monotonic viscosity in miscible reactive flows.

References

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