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Three-dimensional instabilities of miscible fingers in a Hele-Shaw cell RAFAEL OLIVEIRA, UCSB, FELIX HEUSSLER, MICHAEL JOHN, ECKART MEIBURG, UCSB — We perform three-dimensional DNS simulations of the transient, variable viscosity Boussinesq Navier-Stokes equations, coupled to a convection-diffusion equation for a concentration field, to simulate miscible viscous fingers in Hele-Shaw cells. The three-dimensional problem allows for new instabilities and patterns that cannot be captured by traditional gap-averaged modeling. For constant density displacements, we find that a streamwise vorticity quadrupole forms that induces fluid transport from the walls of the cell to its center, thereby leading to a new hydrodynamic instability, termed "inner splitting." If gravity is included, the nature of the two-dimensional base flow and its subsequent instability changes dramatically. The interaction between Saffman-Taylor and Rayleigh-Taylor instabilities can lead to additional splitting events, and it can significantly enhance the mixing rates of the two fluids, thereby altering the overall displacement efficiency.
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