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Inclined porous medium convection at large Rayleigh number

BAOLE WEN, The University of Texas at Austin, University of New Hampshire, GREG CHINI, University of New Hampshire — DNS are performed to study pattern formation in and transport properties of high-Rayleigh-number (Ra) convection in a 2D porous layer inclined at an angle ϕ to the horizontal. The results indicate that for $0 < \phi < 25^{\circ}$, the flow exhibits a similar 3-region structure as is manifest in the horizontal case, except that as ϕ is increased the time-mean spacing between neighboring interior 'mega-plumes' is also substantially increased. Nevertheless, for $0 < \phi < 20^{\circ}$, the Nusselt number Nu is almost unchanged. However, when $\phi > \phi_t$, where $30^{\circ} < \phi_t < 32^{\circ}$, the columnar flow structure is completely broken down: the flow transitions to a large-scale traveling-wave convective roll state, and the heat transport is significantly reduced. To better understand the physics of high-Ra porous medium convection at small ϕ, a spatial Floquet analysis is performed, yielding predictions of the linear stability of numerically-computed, fully nonlinear steady convective states. Our results show that the background flow induced by the inclination of the layer intensifies the bulk instability during its subsequent nonlinear evolution, thereby favoring increased spacing between the interior plumes relative to the horizontal scenario.

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