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Local patches of turbulent boundary layer behaviour in classical-state vertical natural convection CHONG SHEN NG, ANDREW OOI, The University of Melbourne, DETLEF LOHSE, Physics of Fluids Group, Faculty of Science and Technology, J. M. Burgers Center for Fluid Dynamics and MESA+ Institute, University of Twente, DANIEL CHUNG, The University of Melbourne —
We present evidence of local patches in vertical natural convection that are reminiscent of Prandtl–von Kármán turbulent boundary layers, for Rayleigh numbers 10^5–10^9 and Prandtl number 0.709. These local patches exist in the classical state, where boundary layers exhibit a laminar-like Prandtl–Blasius–Polhausen scaling at the global level, and are distinguished by regions dominated by high shear and low buoyancy flux. Within these patches, the locally averaged mean temperature profiles appear to obey a log-law with the universal constants of Yaglom (1979). We find that the local Nusselt number versus Rayleigh number scaling relation agrees with the logarithmically corrected power-law scaling predicted in the ultimate state of thermal convection, with an exponent consistent with Rayleigh–Bénard convection and Taylor–Couette flows. The local patches grow in size with increasing Rayleigh number, suggesting that the transition from the classical state to the ultimate state is characterised by increasingly larger patches of the turbulent boundary layers.

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