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An application of the unifying theory of thermal convection in vertical natural convection CHONG SHEN NG, ANDREW OOI, The University of Melbourne, DETLEF LOHSE, University of Twente, DANIEL CHUNG, The University of Melbourne — Using direct numerical simulations of vertical natural convection (VNC) at Rayleigh numbers 1.0×10^5–1.0×10^9 and Prandtl number 0.709, we provide support for a generalised applicability of the Grossmann–Lohse (GL) theory, originally developed for horizontal natural (Rayleigh–Bénard) convection. In accordance with the theory, the boundary-layer thicknesses of the velocity and temperature fields in VNC obey laminar-like scaling, whereas away from the walls, the dissipation of the turbulent fluctuations obey the scaling for fully developed turbulence. In contrast to Rayleigh–Bénard convection, the direction of gravity in VNC is parallel to the mean flow. Thus, there no longer exists an exact relation linking the normalised global dissipations to the Nusselt, Rayleigh and Prandtl numbers. Nevertheless, we show that the unclosed term, namely the global-averaged buoyancy flux, also exhibits laminar and turbulent scaling, consistent with the GL theory. The findings suggest that, similar to Rayleigh–Bénard convection, a pure power-law relationship between the Nusselt, Rayleigh and Prandtl numbers is not the best description for VNC and existing empirical power-law relationships should be recalibrated to better reflect the underlying physics.

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