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Turbulent convection from a 2D array of heating and cooling[1]

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— Recent simulations of Rayleigh-Bénard convective turbulence showed that an asymptotic state is attained at $Ra >> 10^{10}$, where flow is dominated by long-lived, large-scale structures that, in turn, undergo shear instability leading to production of the small scales of turbulence and viscous dissipation at a rate similar to turbulent mixing. Here we show that neither a net heat input nor a global temperature gradient is required to produce turbulence. Convection is simulated above a horizontal plate having a 2D sinusoidal array of many warm and cold patches with the system allowed to evolve to the thermal equilibrium state in which there is no net heat flux through the boundary. This is "horizontal convection," but replacing the usual 1D distribution of boundary temperature and domain scale of forcing to allow full three-dimensionality for all scales of flow and a forcing scale much smaller than the domain. DNS reveals a full spectrum of scales dominated, for a deep domain, by the emergence of box-scale structures much larger than the scale of the forcing. In this flow the Reynolds number is large despite small viscous dissipation, demonstrating that zero net buoyancy flux does not constrain the amount of kinetic energy in a flow dominated by turbulent mixing and diffusion.

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