**Zhu et al. Reply:** In their Comment [1] Doering et al. question our numerically found [2] onset of a transition to the ultimate regime of 2D Rayleigh-Bénard (RB) convection. We disagree with their reasoning.

To irrefutably settle the issue, we have extended our numerical simulations of Ref. [2] to even larger Ra, namely, now up to Ra = 4.64 × 10^{14}, sticking to the same strict numerical resolution criteria of both boundary layer (BL) and bulk. The simulation at the highest Ra was performed with a grid resolution of 31 200 × 25 600 with 28 points in the boundary layer. The evidence for the transition to the ultimate regime remains overwhelming:

1. On the global heat transfer: Nu (Ra), compensated with Ra^{0.357}, is shown in Fig. 1(a). An objective least squares fit of an effective power law Nu ∼ Ra^γ to the last 6 data points gives a scaling exponent γ = 0.345; the last 5 data points give γ = 0.354, the last 4 data points give γ = 0.352, the last 3 data points give γ = 0.357, and the last 2 points give γ = 0.358; i.e., no matter how the data are interpreted, the scaling exponent is always larger than 1/3 and monotonically increasing with Ra.

2. The key part of Ref. [2] deals with local properties of the flow; see Figs. 2–4 of that Letter. For the local heat flux in the plume ejecting regime, beyond 10^{13} the effective scaling exponents are close to γ = 0.38, see Fig. 1. In contrast, it remains ≤ 1/3 in the plume impacting regime, which therefore with increasing Ra loses more and more relevance for the overall heat transfer.

3. Beyond 10^{13}, the horizontal velocity profiles u^+ (y^+) in the BLs become logarithmic (see Fig. 2 of Ref. [2]), signaling a turbulent BL, which is characteristic for the ultimate regime (as a presumption to derive the ultimate regime scaling in Refs. [3,4]), rather than one of laminar type as in the classical regime.

4. Finally, the transition to ultimate RB turbulence in the numerical data of Ref. [2] has also been confirmed through an extended self-similarity (ESS) analysis of the temperature structure functions; see Ref. [5]. In that paper we find no ESS scaling before the transition. However, beyond the transition and for large enough wall distance y^+ > 100, we find clear ESS behavior, as expected for a scalar in a turbulent boundary layer. Therefore, also that analysis provides strong evidence that the observed transition in the global Nusselt number around Ra = 10^{13} indeed is the transition from a laminar type BL to a turbulent type BL.

Since beyond the transition, for sufficiently large Ra, the local scaling exponents are always close to 0.38, we fit the data with a power law. The inset shows the effective scaling exponent γ, obtained from a power law, fits Nu ∼ Ra^{0.38} to the last k data points in the main figure. It is always larger than 1/3, no matter how one interprets the data. (b) The local heat transfer in the plume emitting region (with effective slope 0.38) and in the plume impacting region.

**FIG. 1.** (a) Nusselt number compensated by γ = 0.357, i.e., a scaling exponent larger than the γ = 1/3 necessary to prove the transition. We took γ = 0.357 for the compensated plot as with that value the last three data points show a plateau. The error bars for the data are smaller than the symbols. The inset shows the effective scaling exponent γ, obtained from a power law, fits Nu ∼ Ra^{0.38} to the last k data points in the main figure. It is always larger than 1/3, no matter how one interprets the data. (b) The local heat transfer in the plume emitting region (with effective slope 0.38) and in the plume impacting region.


