Effect of the wind depletion on the turbulent Rayleigh-Bénard convection

Nathan Carbonneau,* Julien Salort,† Yann Fraigneau ‡ and Anne Sergent §

Turbulent convection is ubiquitous in both industrial and natural fluid flows. A canonical model is the Rayleigh-Bénard convection (RBC): a fluid layer heated from below and cooled from above. With regards to the geometrical configuration, one or several convection cells can appear, which is called Large-Scale Circulation (LSC). The LSC generates a horizontal wind along the horizontal plates and shears the plumes emerging from the thermal boundary layer. Previous studies have shown that the addition of a synthetic shear to the spontaneous LSC wind shear can have a significant effect on the heat transfer[1]. However, the effect of wind shear depletion has never been studied. The aim of this work is to reveal how wind shear alters the flow in cavities by considering either flow in a cavity or in a fluid periodic layer with a horizontal aspect ratio too small for an LSC to be established.

We consider cavities and periodic fluid layers filled with water at a varying Rayleigh number between 2.10^9 and 10^{11}. The fluid flow within those configurations is modelled by means of direct numerical simulations[2]. We explore the effect of the LSC by comparing confined and periodic configurations. For example, it appears that the heat transfer scaling ($Nu \sim Ra^{\beta}$) is almost unchanged by the wind depletion in periodic domains (see figure 1). In this work we aim to describe small thermal structures with and without wind, so as to better understand how the wind depletion can lead to a nearly unchanged heat transfer.

This work benefits from the French National Research Agency funding (ANR-22-CE30-0018-02). The DNS database has been built using granted access to the HPC resources of IDRIS under allocation 2a0326 made by GENCI.

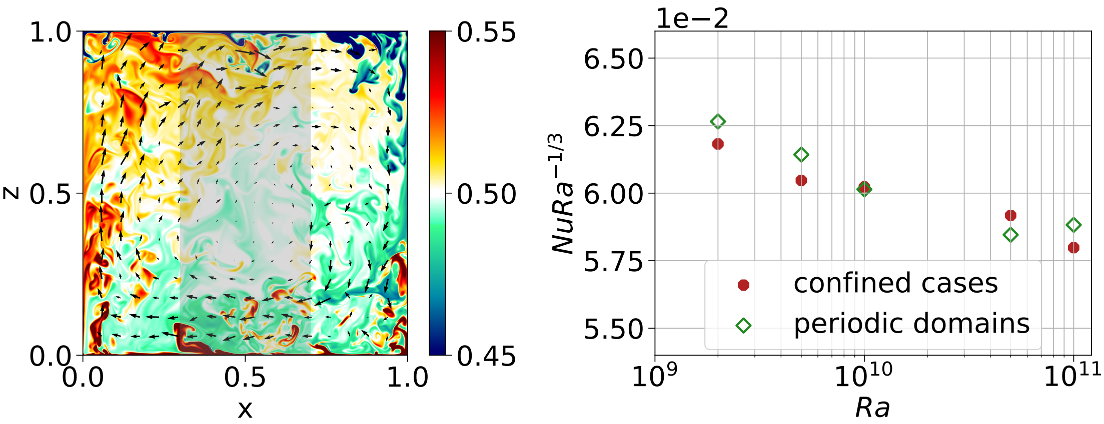

Figure 1: Left: mid-depth temperature snapshot in confined cavity ($Ra = 10^{10}$; $Pr = 4.4$). Arrows show the 2D velocity field on the same plane. The shaded area corresponds to a typical periodic domain size. Right: Compensated Nusselt number (Nu) as a function of the Rayleigh number (Ra).

*Sorbonne Université, Collège Doctoral, Paris, France; Lab. Interdisciplinaire des Sciences du Numérique, Université Paris-Saclay, CNRS, Orsay, France
†Lab. Physique, Ecole Normale Supérieure de Lyon, CNRS, Lyon, France
‡CNRS, Lab. Interdisciplinaire des Sciences du Numérique, Université Paris-Saclay, CNRS, Orsay, France
§Sorbonne Université, Faculté des Sciences et Ingénierie, Paris, France; Lab. Interdisciplinaire des Sciences du Numérique, Université Paris-Saclay, CNRS, Orsay, France

[1] Yerragolam et al., *J. Fluid Mech.* **944**, A1 (2022)
[2] Belkadi et al., *J. Fluid Mech.* **923**, A6 (2021)