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Turbulent plumes in asymmetric rough Rayleigh-Bénard cell

G. de Romemont^a, S. Rosenkranz^a, Y. Fraigneau^a and A. Sergent^{a,b}

In a real thermal system, the underlying surfaces involve specific topographies or small-scale roughness which have a significant impact on the heat transfer. Particularly, in the case of turbulent convection, the addition of wall roughness results in a global heat transfer enhancement and even in an increase of the exponent of the heat transfer scaling law [1, 2]. It is commonly admitted that the heat transfer enhancement originates from an intensification of the thermal plume emission. In the present study, we consider convection over a regularly roughened plate in a Rayleigh-Bénard cell. The objective of this work is to identify how roughness changes the plume features and their dynamics, depending on the regime. Three-dimensional direct numerical simulations have been performed for Rayleigh numbers covering five decades up to $Ra=10^{10}$ and for two roughness sizes. As expected, the three heat transfer regimes have been obtained [3]. Taking advantage of the cavity asymmetry, we conduct a comparative study of the plume dynamics near the rough and smooth horizontal plates within the same set-up. Based on thermal and velocity fluctuations, thermal plumes are extracted from the turbulent background. Temporal and spatial statistical properties of the plumes are analysed in the mixing layer of both cavity sides in terms of fluctuations or energy content. Interactions between roughness, plumes, large scale circulation and turbulent background are also investigated.

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¹ Xie and Xia. *J. Fluid Mech.* **825**, 573 (2017).

² Rusaouën et al., *J. Fluid Mech.* **837**, 443 (2018).

³ Belkadi et al. *J. Fluid Mech.* **923**, A6 (2021).

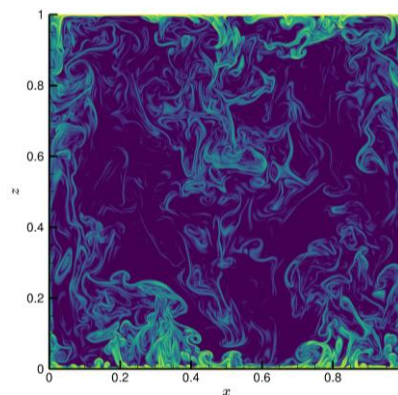


Figure 1: Thermal plumes in a water-filled cell at $Ra=10^{10}$ with several hundred blocks roughened on the bottom plate.