The influence of spanwise heterogeneous surfaces on forced, mixed and natural convection

K. Schäfer*, J.P. Mellado†, B. Frohnapfel*

Spanwise heterogeneous surfaces are known to induce turbulent secondary motions that can significantly modifify the mean flow through the introduction of local up- and downdrafts. These secondary motions, which manifest as large-scale vortical motion oriented in streamwise direction, are most clearly visible in the time-averaged turbulent flow field. They have been intensively studied in forced convection over the last decade. In mixed convection over smooth surfaces, convection rolls are known to emerge which are also a type of large-scale streamwise vortical motion. In contrast to turbulent secondary flow, convection roles are clearly visible in the instantaneous flow fields. They are known to impact the heat transfer between surface and fluid.

In the present work, we consider direct numerical simulations (DNS) of turbulent channel flows to study the interactions between turbulent secondary motions and convective rolls. Secondary motions are induced by streamwise aligned ridges, and convective rolls are induced by warming the bottom surface. In this DNS we vary the bulk Richardson number in order to cover the flow regimes of forced, mixed and natural convection. The impact of ridges on the emergence of convection rolls and the related impact on heat transfer and friction drag is discussed. It will also be shown that convective cells in natural convection over ridge type surfaces have a preferred direction in contrast to smooth wall cases. A visualization of convective cells over a smooth and anisotropic structured surface is shown in the figure below. The conference contribution will include recently published results[1] which have not been presented at a conference before.

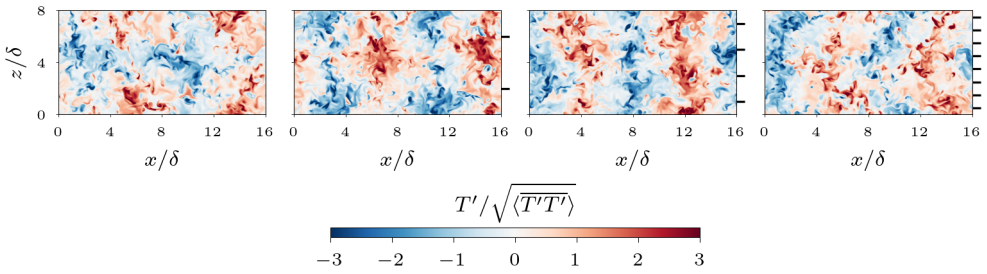

Figure 1: Instantaneous temperature fluctuation fields at horizontal midplane ($y = \delta$) for natural convection cases $Ri_b = \infty$ ($Ra = 10^7$, $Re_b = 0$) with different wall conditions. The smooth wall case is shown in the first column, while the other cases display ridge cases. For the latter the spanwise position of the streamwise-aligned ridges is indicated by the black lines on the right outer frame of the figures.

*Institute of Fluid Mechanics (ISTM), Karlsruhe Institute of Technology (KIT), Germany
†Meteorological Institute, University of Hamburg, Germany
[1]Schäfer et al., *J. Fluid Mech.* **950**, A22 (2022).