High-fidelity simulations of simplified urban flows

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High-fidelity large-eddy simulations (LES) of the flow around rectangular obstacles exposed to a zero-pressure-gradient turbulent boundary layers are carried out using the spectral-element code Nek5000, following those reported in our previous studies[1,2]. In a first set of data, we examined the flow between two equal obstacles at different distances and at a Reynolds number of $10,000$ based on the free-stream velocity and the obstacle height. Fig. 1 shows an overview of the flow in the case where the obstacles are closer, and the second obstacle is completely engulfed in the wake of the first one (skimming-flow regime). In other configurations with progressivly larger distances between obstacles, we study the regimes of wake interferece and isolated roughness. We examine mean velocity, turbulent fluctuations, the turbulent-kinetic-energy (TKE) budget, and the anisotropy-invariant maps, and we find that the three flow regimes differ not only in the distribution of turbulent fluctuations but on the main mechanism responsible for the generation of turbulent kinetic energy. For instance, the TKE-production term in the region immediately in front of the second obstacle is positive and with relatively high values in the regime of the skimming flow, but becomes negative for the other two regimes, when the obstacles are farther apart. In this contribution, we will present results of simulations on more complex geometries, including cases with different heights and periodic arrays and with passive scalars, and employing methodology such as the higher-order dynamic mode decomposition (HODMD).

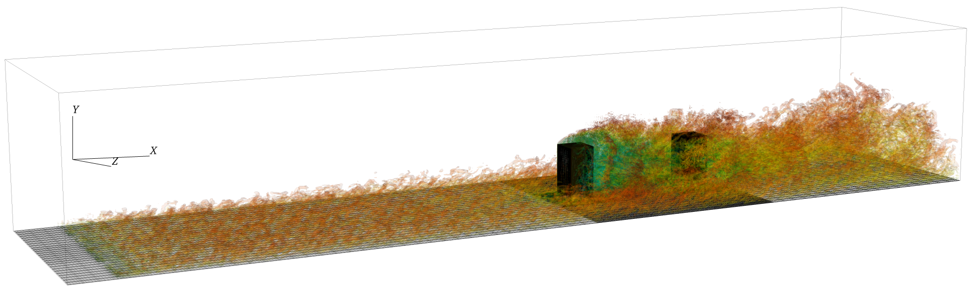

Figure 1: Overview of the flow for one of the considered cases, including vortex clusters coloured with the streamwise velocity component (values from ≈ -1 in blue to ≈ 2 in red).

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