How do turbulent superstructures interact with skin friction drag?

In turbulent wall-bounded flows at increasing values of the Reynolds number, the size of the near-wall region, in which an important autonomous mechanism of turbulence self-sustainment occurs, shrinks, while a hierarchy of turbulent structures with increasing size appears. These structures are termed turbulent superstructures and, even though they have been frequently observed as extremely large-scaled velocity fluctuations or vortex clusters, their impact on turbulent mixing processes and, in particular, on momentum transfer is still unknown. In the present project we aim at understanding the role of turbulent superstructures in momentum transport towards the wall, with particular focus on their impact onto turbulent skin friction drag. Our investigation relies on high-fidelity direct numerical simulation of turbulent incompressible channels and boundary layer flows at high values of the Reynolds number. In order to study the mutual interaction of turbulent superstructures with skin-friction drag and near-wall turbulence, we will observe how superstructures react to modification of the flow natural state by applying directly at the wall or in its vicinity turbulent flow control strategies, which are capable of reducing turbulent drag. The contribution of turbulent superstructures to skin friction drag is quantified by estimating their scale contribution to the Reynolds shear stress. Several strategies to identify turbulent coherent structures will aid us in providing a kinematic description, which is compatible with their footprint on turbulent statistics. Finally, we analyse whether flow manipulation explicitly targeting superstructures is an attractive means for skin friction drag reduction at large values of the Reynolds numbers.