THE EFFECT OF LARGE-SCALE VORTICES ON FRICTIONAL DRAG IN CHANNEL FLOW

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We reconsider the control scheme proposed by Schoppa & Hussain [3], using new direct numerical simulations (DNS). In this method, large-scale streamwise vortices are imposed onto the turbulent channel flow, modulating the mean flow and reducing the total pressure drop by up to 20%. The purpose of the present contribution is to re-assess this control method in the light of more modern developments in the field, in particular also related to the discovery of (very) large-scale motions. Our DNS are performed in a turbulent channel at various friction Reynolds numbers (Re_τ) between 104 (employed value in original study) and 550. As a first step we found it necessary to re-design the method: moving from imposing the mean flow to the application of a volume force. In this way, sustained drag reduction (DR) can be obtained, as opposed to the transient DR in the original publication [1]. A drag reduction of 18% is obtained at the lowest Re_τ for a viscous-scaled spanwise wavelength of the vortices of 230; the optimal wavelength increases with Re_τ, but the efficiency is reduced, leading to a zero DR for $Re_\tau = 550$, confining the method to low Re for internal flows [2]. Although ultimately the findings by Schoppa & Hussain are invalidated by considering the higher Reynolds numbers, the forcing method and its ability to alter the large-scale structures that naturally occur in the flow are still interesting: In addition to discussing the mentioned drag-reduction effects, the present paper will also address the potential effect of the natural large-scale motions on frictional drag, and give indications on the physical processes for potential drag reduction possible at all Reynolds numbers.

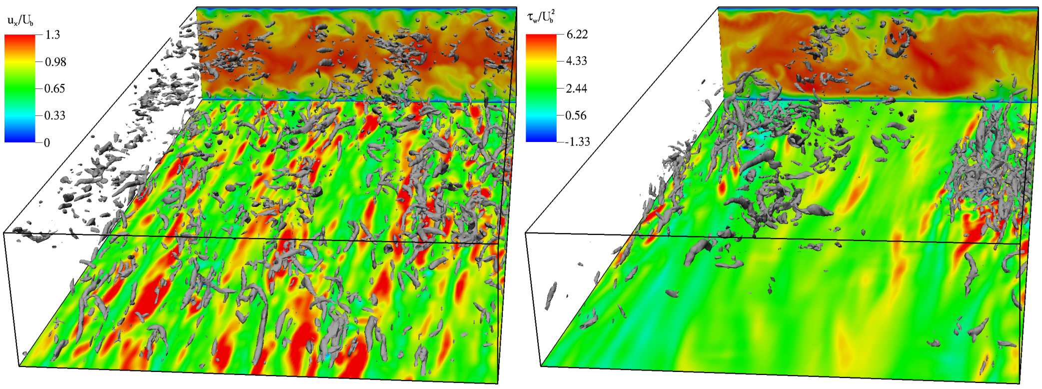

Figure 1: Uncontrolled (left) and controlled (right) flow visualized using isocontours of negative λ_2, and colours of streamwise velocity and wall-shear stress.

References

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[3] W. Schoppa and F. Hussain, *Phys. Fluids*, **10**, 1049, 1998.

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