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THE ROLE OF THE TURBULENT/NON-TURBULENT INTERFACE IN A TURBULENT BOUNDARY LAYER WITH A LARGE-EDDY BREAK-UP DEVICE

Ramis Örlü[1], Cheng Chin[2], Nicholas Hutchins[3], Jason P. Monty[3] & Philipp Schlatter[1]
[1]*Linné FLOW Centre, KTH Mechanics, SE-100 44 Stockholm, Sweden*
[2]*The University of Adelaide, Dept. of Mechanical Engineering, Adelaide, South Australia 5005, Australia*
[3]*Dept. of Mechanical Engineering, University of Melbourne, Victoria 3010, Australia*

Coherent structures have been found to play a major role in the growth and evolution of turbulent boundary layers (TBLs), thereby opening doors for the beneficial manipulation and control [2]. These lead to the birth of large-eddy break-up devices (LEBUs), which consist of one or more thin plates or airfoils placed parallel to the wall emerged in the outer part of turbulent boundary layers, and act to 'break up' the 'large eddies'. These devices were found to be capable of reducing the local skin friction by tens of percent, and above all believed to yield substantial net drag reduction [3]. This result triggered an avalanche of follow-up studies, which, however, seemed to have faded away once direct drag measurements in towing tanks have shown that — while local and global skin friction reduction could indeed be achieved — any substantial net drag reduction by means of LEBUs turned out to be unlikely [7]. In particular, it turned out that the device drag was found to exactly balance the local skin friction reduction; a result that could recently also be confirmed in a well-resolved large-eddy simulation (LES) [1]. Despite the decline of interest in LEBUs, due to their failure in delivering the promised net drag reduction, experimental investigations continued to explore their capability in locally reducing skin friction and turbulence [6]. With the renewed interest in the very large-scale motions (VLSMs) [4] and their influence that extends to the wall [5], re-examination of LEBUs seems pertinent, especially given recent advances in our ability to simulate developing turbulent boundary layers.

Our previous LES with a LEBU placed at 80% of the boundary layer height [1] highlighted the structural changes in the flow, in particular in the neighbourhood of the turbulent/non-turbulent interface (TNTI); see figure 1. The TNTI is an important parameter in the study of boundary layers as it characterises the growth of the boundary layer and the entrainment process of high momentum flow from the free stream into the turbulent region of the boundary layer. Since the primary purpose of the LEBU is to break up large eddies, this work investigates the influence of the LEBU on the largest-scales located at the turbulent/non-turbulent interface (TNTI). Further LES with LEBUs placed closer to the wall will be performed to investigate the physics of the interface and its relation to the prevalent skin friction reduction.

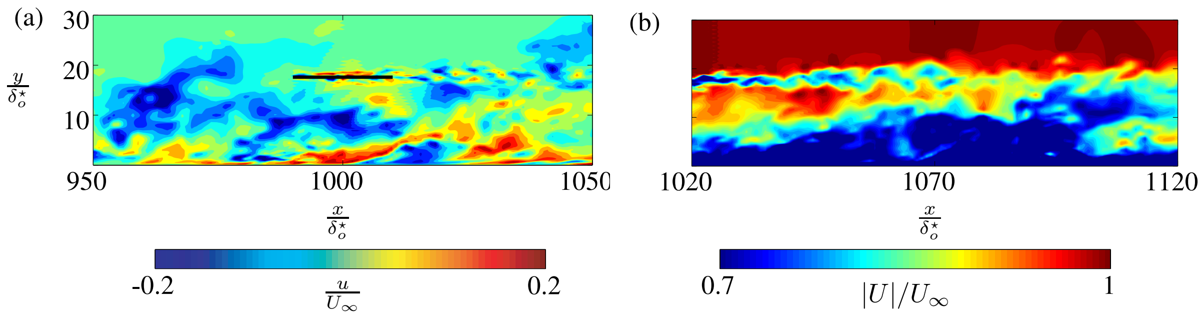

Figure 1. (a) Instantaneous streamwise velocity fluctuations of the LEBU simulation showing low momentum region in front of the LEBU. Black line indicates the LEBU. (b) Illustration of the von Kármán vortex street downstream of the LEBU.

References

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