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DNS of a Backward-Facing Step at high Reynolds number. Towards a better understanding of RANS-LES transition in DES models.

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1 Introduction

Backward-Facing Step (BFS) represents a canonical configuration to study wall-bounded flows subjected to sudden expansions. The flow separation leads to a shear layer downstream of the step, rising the well-known Kelvin-Helmholtz instabilities. These are fed along the shear layer, until they impinge at the lower wall, contributing to the recirculation bubble detachment (see Figure 1). This kind of flows have been extensively studied through experimental and numerical experiments due to its importance in many engineering applications. In a numerical context, the Detached Eddy Simulation (DES) family models, presented by Spalart et al. [1] in the late 90's, were specifically designed to simulate these flow configurations (such as BFS, airfoils at stall and jets). Since then, several authors have focused their efforts on addressing the main DES shortcomings, but there are still unsettled issues. In particular, the delays in the transition zone from RANS to LES severely effects the shear layer development, triggering completely different flow behavior. In this regard, the length-scale chosen in the DES model defines the RANS-LES transition zone (Grey Area), so several research has been carried out so far in this topic [2, 3]. Recently, Schur et al.[4] obtained interesting results developing complex length-scales, which depend on kinematic flow properties, instead of mesh parameters. Apart from the DES current, we have also been working on new length-scales, but in LES modelling [5] in order to improve the existing LES models. Besides reporting good performance in regions where fluid presented an anisotropic behaviour, our research could also be applied in DES models.

2 Problem Statement

DNSs of massive separation flows at high Re number would be a valuable tool providing new insights in the RANS-LES transition. However, the existing BFS DNSs in the literature were fed using turbulent channel flows not higher than $Re_\tau \sim 180$ (where low Reynolds effects are still present). In this context, a DNS of an incompressible fluid over a BFS with expansion ratio 2 at $Re_\tau = 395$ will be presented in the conference (see Figure 1), providing data to be compared with DES simulations and shedding light in the Grey Area issue. Moreover, the studied case is also interesting for understanding how a classical turbulent channel flow is expanded under certain conditions.

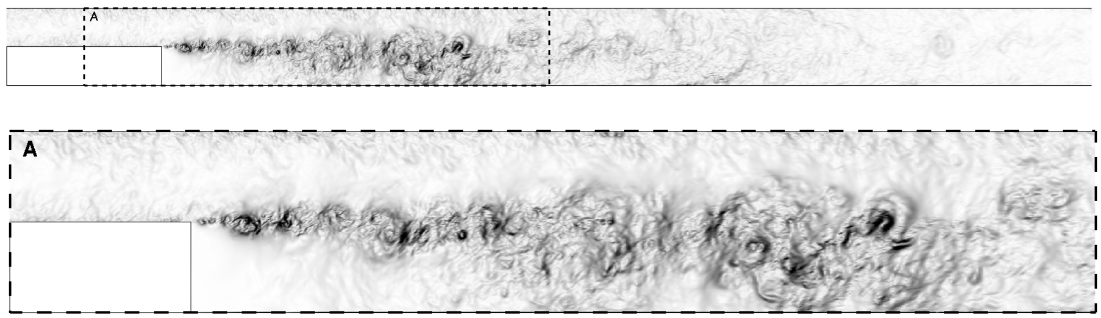

Figure 1: Instantaneous magnitude of the pressure gradient in a large part of the BFS domain (top) and a detailed view of the sudden expansion (bottom) marked as *A*. Higher values are denoted in black. See the movie attached in the paper data base [6].

References

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