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PREDICTION OF WALL BOUNDED FLOWS BY HYBRID RANS-LES METHODS WITH WALL FUNCTIONS

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Despite a significant progress reached in development and application of hybrid RANS-LES methods (HRLM) to both separated and attached flows at high Reynolds numbers, these approaches still remain rather computationally expensive which slows down their use for industrially relevant flows. Partially, this is caused by the conventional practice of performing HRLM simulations on so-called "low-Re" grids with a dense clustering towards the wall [1]. This ensures a sufficient resolution for integration of the governing equations down to the wall, but results in a noticeable increase of required computational resources.

In order to avoid this, one can use so-called "high-Re" grids and impose the wall boundary conditions based on Wall Functions (WF). This approach is widely used in the framework of RANS and is applicable to both attached and separated flows [2]. It is also acknowledged that WF can be employed with LES approach, where they present a kind of near-wall modeling [3]. However, as of today, experience of the use of WF [3] in the framework of HRLM is very limited (the only examples the authors are aware about are simulations of wall mounted obstacles and atmospheric boundary layer carried out in [4], [5]). This is probably explained by the fact that functionality of HRLM with WF is not trivial, particularly in the case when wall adjacent cells fall into so-called "grey area" [1], where HRLM works neither in RANS nor in LES mode. Considering this and the trend of a wider and wider usage of HRLM in industrial applications, an assessment of their feasibility and efficiency, when combined with WF, is of high practical interest.

In the present work such an assessment is performed with the use of Improved Delayed Detached Eddy Simulation (IDDES) [6] coupled with Automatic Wall Treatment (AWT) [7], which is an advanced modification of WF. All the simulations are carried out in ANSYS-FLUENT [8].

Firstly, a performance of AWT with IDDES is analyzed, and then, the approach is validated on a set of test cases including both attached flows (developed channel and flat plate boundary layer) and also some more complex flows with separation and reattachment (e.g. a backward facing step [9] – see Fig.1). The simulations are performed on Cartesian grids of different resolution, which allows formulating the guidelines on grid generation for the considered type of HRLM with WF.

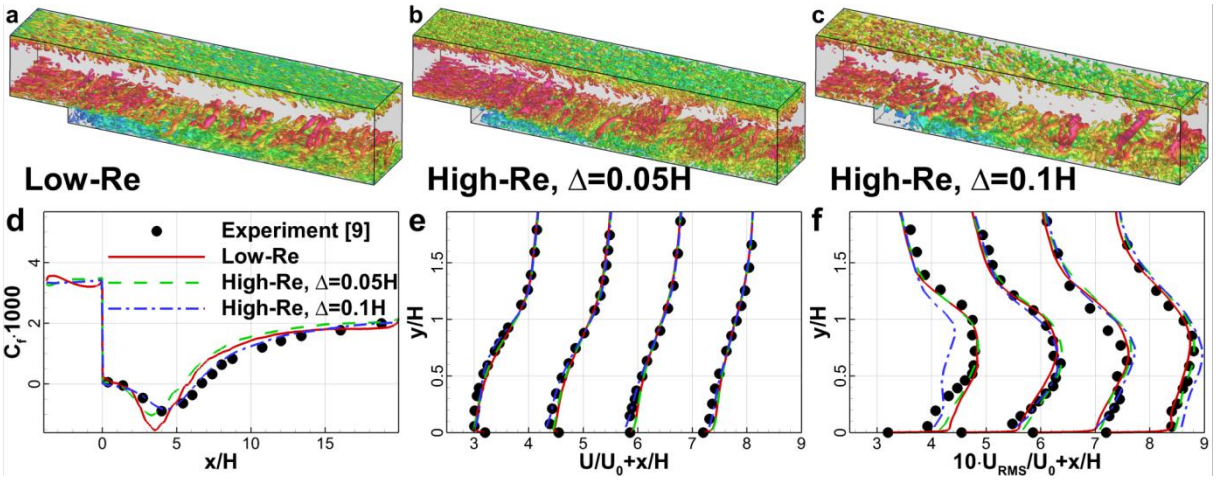

Fig.1. Results of IDDES with AWT simulation of backward facing step flow.
a, b, c: instantaneous isosurfaces of Q-criterion colored by velocity magnitude;
d: distribution of skin friction coefficient; e: profiles of mean velocity;
f: profiles of RMS of streamwise velocity fluctuations

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