Seventh HRLM Symposium, 19-21 September 2018, Berlin, Germany

Session:

A study on the behavior of PANS and wall-modeled LES for turbulent boundary layer flows

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Abstract

The approach of Partially Averaged Navier-Stokes, PANS, is a non-zonal hybrid RANS/LES model that has been successfully applied to bluff body and separated flows [1,2]. Recently, near wall models, based on the k-ω family of RANS models, has also been applied to channel flows up to moderate Reynolds numbers [3]. However, the number of applications of PANS to flows with developing boundary layers is very limited.

Wall-modelled LES, WMLES, [4,5], has been studied with the fundamental aim to be able to use a consistent LES formation but alleviating the excessive mesh resolution requirements of wall-resolved LES for high Reynolds number flows. The applications have here, similarly to for PANS, primarily been limited to canonical flows or bluff body problems. Recently, however, efforts have been made to expand the studies to developing turbulent boundary layers [6] and a first attempt on a ship hull in model scale [7].

Both of these approaches, PANS and WMLES, rely on partly resolving the structures in the boundary layer, and while the resolution requirements for WMLES are investigated in [8], there are, to our knowledge, no corresponding studies for PANS.

In this study, we will compare the performance of PANS with that of WMLES to the developing boundary layer over a flat plate, as studied by WMLES in [6], illustrated in Fig. 1. The objective is to gain in understanding of the interaction between the grid resolution and the specified ratio of unresolved to total turbulent kinetic energy and dissipation in a fixed parameter PANS k-ω model. Simulations will be performed both with a sequence of parameter variation on a fixed grid, and with a sequence of grids using a specified parameter. Performance will be assessed regarding predicted wall-shear stresses, boundary layer growth, as well as velocity profiles and distribution of turbulent quantities across the boundary layer. Comparisons will be made with existing WMLES results, as well as power-law estimates [8] and DNS data [9].

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Fig. 1. Resolved turbulent structures visualised by an iso-surface of the second invariant of the velocity gradient, coloured by streamwise velocity, from [6].

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