6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

a-PRIORI STUDY OF WALL MODELING IN LARGE EDDY SIMULATION

Saleh Rezaeiravesh[1,*], Timofey Mukha[1] and Mattias Liefvendahl[1,2]

[1] Uppsala University, PO Box 256, SE-751 05 Uppsala, Sweden,
saleh.rezaeiravesh@it.uu.se, timofey.mukha@it.uu.se, www.uu.se.
[2] Swedish Defence Research Agency (FOI), SE-164 90 Stockholm, Sweden,
mattias.liefvendahl@foi.se, www.foi.se.

Keywords: *Large Eddy Simulation, Wall Modeling, Turbulent Channel Flow*

The high computational cost imposed by the requirement of resolving the near-wall structures of turbulent boundary layers (TBLs), is a barrier to applying wall-resolved large eddy simulation (WRLES) to many real-life applications. As an alternative, wall-modeled (WM)LES has received considerable attention in the last decades, see e.g. [1]. The core of this approach is to resolve the outer part of the TBL and, at the same time, employ an appropriate wall modeling strategy for accurate prediction of the wall shear stress, τ_w. The main focus of this paper is on the a-priori study of algebraic wall models. In a-posteriori WMLES, the input to this type of wall models is the velocity, $\bar{u}$, sampled at a distance h away from the wall. To synthesize the inputs in our a-priori study, high quality data of WRLES of turbulent channel flow at $\mathrm{Re}_\tau = 1000$ are, in the course of simulations, spatially averaged over the volume of cubic boxes centered around the WMLES sampling points. The volume of each cube, which mimics a WMLES cell, is $(\delta/n)^3$, where δ specifies the channel flow half-height, and n^3 denotes the number of cells per δ^3. Employing this procedure over enough number of time steps, signals of sampled velocity vectors are generated which are then imported to the wall model to predict signals of wall shear stress, $\bar{\tau}_w$. This process can be formulated as $\bar{\tau}_w = f(\bar{u}, q, \Theta)$, in which, q specifies the wall model parameters, and Θ contains all other factors influencing the predictions. In the developed framework, effects of several factors including wall model f, q, n, and h/δ on the statistical moments of $\bar{\tau}_w$ are studied. For comparison, signals of reference wall shear stress, τ_{w_M}, obtained by the spatial averaging of the WRLES shear stress, are considered. It is shown that if q are taken to be fixed for all $\bar{u}$ samples at all time steps, as it is the case in a-posteriori WMLES, the mean and the variance of $\bar{\tau}_w$ do not become simultaneously the same as those of τ_{w_M}. Moreover, the correlation between $\bar{\tau}_w$ and τ_{w_M} decreases with h/δ, independent of the value of the wall model parameters. Inspired by these, a dynamic procedure is proposed which allows for adjusting q for each set of velocity samples taken at the WMLES cell centres. As a result of this modification, the correlation between $\bar{\tau}_w$ and τ_{w_M} signals does not drop with h/δ.

REFERENCES

[1] J. Larsson, S. Kawai, J. Bodart and I. Bermejo-Moreno, Large eddy simulation with modeled wall-stress: recent progress and future directions, *Mechanical Engineering Reviews*, Vol. **3**, No. **1**, pp. 15-00418–15-0041, 2016.