EMS Annual Meeting Abstracts
Vol. 10, EMS2013-259-1, 2013
13th EMS / 11th ECAM

Computation of complex terrain turbulent flows using hybrid algebraic structure-based models (ASBM) and LES.

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The development of turbulent boundary layers under zero or weak pressure gradients is effectively captured by a number of turbulence models. On the other hand, a more common occurrence in nature are flows over curved surfaces[3,7,9]. Such flows exhibit strong spatially varying pressure gradients, often including flow separation and recirculation, and are difficult to predict. The failure of conventional models in such flows can be in part traced to the fact that these closures carry information about the turbulence velocity components (componentality), but not about the shape and orientation of the turbulence eddies (dimensionality)[1]. On the other hand, the Algebraic Structure-Based Model (ASBM)[5,8] takes into account information about the turbulence structure. Thus, the objective of this work is to investigate the ability of standard RANS models, when coupled with the ASBM, to successfully predict turbulence statistics in these complex terrain flows. Here, we consider the coupling of the ASBM procedure with the Baseline Model (BSL) and Spalart-Almaras (SA) models and the application of the resulting hybrid closures to the case of a two-dimensional smooth, steep hill in the form of a modified "Witch of Agnesi" geometry. To validate the models, a Large Eddy Simulation of the same case was also carried out[2], allowing for a detailed comparison. Special attention was paid to generating consistent inlet profiles for the RANS and LES simulations. Mean and fluctuating statistics were extracted at specific locations and compared with an experimental data set[6]. Overall, we show that the hybrid ASBM-BSL and ASBM-SA closures produce very satisfactory predictions not only for the turbulence shear stress but also for all turbulence intensities, something that is not possible with the standard BSL and SA closures. Finally, we discuss the effect of the ASBM coupling on the predicted extent of the recirculation bubble.

References

[1] S. C. Kassinos, W. C. Reynolds and M. M. Rogers, 2001, "One-point turbulence structure tensors", *J. Fluid Mech.*, **428**, 213–248.

[2] D. G. E. Grigoriadis, N. Kanaris and S. C. Kassinos, 2012, "Large Eddy Simulations of equilibrium and separating turbulent boundary layers using inlet conditions", *Internal Report*, Mechanical Engineering Department, University of Cyprus.

[3] P.S. Jackson and J.C.R. Hunt, 1975, "Turbulent wind flow over a low hill", *Q. J. R. Meteorol. Soc.*, **101**, pp. 929-955.

[4] C. A. Langer and W.C. Reynolds, 2003, "An algebraic structure-based turbulence model for rotating wall-bounded flows", *Technical Report TF-85*, Mechanical Engineering Department, Stanford University.

[5] B. Aupoix, S. C. Kassinos and C. Langer, 2009, "An easy access to the structure-based model technology", *Proceedings of the 6th Int. Symp. on Turbulence and Shear Flow Phenomena*, pp. 22–24., Seoul, Korea.

[6] J. Loureiro, F. Pinho, and A. Silva Freire, 2007, "Near wall characterization of the flow over a two-dimensional steep smooth hill", *Experiments in Fluids*, **42** (3), 441457.

[7] P.J. Mason and R.I. Sykes, 1979, "Flow over an isolated hill of moderate slope", *Q. J. R. Meteorol. Soc.*, **105**, pp.383-395

[8] W. C. Reynold, C.A. Langer and S.C. Kassinos, 2002, "Structure and scales in turbulence modeling", *Phys. of Fluids*, **14(7)**, 2485–2492.

[9] Stratford BS (1959) The prediction of separation of the turbulent boundary layer", *J. Fluid Mech.*, **5**, pp. 1-16.