DFD15-2015-000848

Abstract for an Invited Paper
for the DFD15 Meeting of
the American Physical Society

Reduced order modeling of wall turbulence

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Modeling turbulent flow near a wall is a pacing item in computational fluid dynamics for aerospace applications and geophysical flows. Gradual progress has been made in statistical modeling of near wall turbulence using the Reynolds averaged equations of motion, an area of research where John Lumley has made numerous seminal contributions. More recently, Lumley and co-workers[1] pioneered dynamical systems modeling of near wall turbulence, and demonstrated that the experimentally observed turbulence dynamics can be predicted using low dimensional dynamical systems. The discovery of minimal flow unit[2] provides further evidence that the near wall turbulence is amenable to reduced order modeling. The underlying rationale for potential success in using low dimensional dynamical systems theory is based on the fact that the Reynolds number is low in close proximity to the wall. Presumably for the same reason, low dimensional models are expected to be successful in modeling of the laminar/turbulence transition region. This has been shown recently using dynamic mode decomposition.[3] Furthermore, it is shown that the near wall flow structure and statistics in the late and non-linear transition region is strikingly similar to that in higher Reynolds number fully developed turbulence.[4] In this presentation, I will argue that the accumulated evidence suggests that wall modeling for LES using low dimensional dynamical systems is a profitable avenue to pursue. The main challenge would be the numerical integration of such wall models in LES methodology.

[1]Aubry *et al.*, JFM, **192**, 1988.
[2]Jimenez and Moin, JFM, **225**, 1991.
[3]Sayadi *et al.*, JFM, **748**, 2014.
[4]Sayadi *et al.*, JFM, **724**, 2013.