DFD19-2019-003164

Abstract for an Invited Paper
for the DFD19 Meeting of
the American Physical Society

Thoughts on Very Large Turbulence Simulations

PHILIPPE SPALART, Boeing Commercial Airplanes

The Reynolds number in channel DNS rose by a factor of 29 since the KMM paper of 1987. The imminent step from about 10petaFLOPS to 1exaFLOPS allows a factor of about 3, if we elect to simulate the same flow. Turbulence created three challenges: its results conflict with our semi-theory of wall-bounded flows. First, even with this factor of 29, a true logarithmic layer is not found. Second, the Reynolds stresses do not have a plateau in the (near) log layer. Third, they are not independent of the flow Reynolds number at a fixed y^+. All these properties are implied by classical theory and satisfied by turbulence models of conventional type. This has greatly limited the contribution of DNS to RANS models. The complaint in engineering is over smooth-body separation and reattachment. DNS of such flows at two Reynolds numbers are most desirable, but defining the same flow, at different Reynolds numbers is non-trivial because of the incoming boundary-layer thickness. A strategic community decision is whether simulations can be free-standing, or experimental confirmation is needed. The use of simulation data, be it physical understanding, engineering tools built with classical thinking, or tools built with Machine Learning, is challenging. For this third option, a sound definition of the mission is sorely needed. Also in high demand are non-DNS turbulence-resolving simulations, including Wall-Modeled LES and DES, as are simulations over complex geometries, say a Formula-1 car. Such simulations have had poor grids, and automatic adaptation is needed. Grid generation, even non-adaptive, could create a bottle-neck on massively-parallel machines. Grid convergence is not achieved over full geometries, even for RANS. Research can be improving SGS and Wall Models using DNS flow fields or exercising the non-DNS tools at high Reynolds numbers. It is difficult to define challenges that are clear, are attractive in an academic sense, and will illustrate the value of having 1 exaFLOPS.