The turbulence modeling group

The papers in this section encompass Reynolds averaged modeling (RANS) and large eddy simulation (LES). They are addressed to effects of rotation and stratification on turbulence, to bypass transition to turbulence, and to numerics.

From a practical standpoint, RANS is the only method of turbulent flow prediction that has found widespread use in engineering flows. One of the many roadblocks to use of LES is the need for special purpose codes and intensive user involvement in preparing and performing calculations. The report by Choi addresses the potential for industrial CFD codes to be used for LES applications. In the long run, the objective is to make LES a viable tool for engineering fluid dynamics. The aspect addressed here is the possibility of using codes that have been developed for RANS purposes.

The RANS modeling papers (Ooi, *et al.* and Pettersson-Reif, *et al.*) are outgrowths of earlier work here at Stanford. The mathematical approach grew out of papers of Speziale and co-workers. The observation is that turbulence models respond to sufficiently strong stabilizing forces through a bifurcation between solution branches. A model of rotation effects that evolved out of such analysis is applied to several test cases in the article by Ooi, *et al.* The article by Pettersson-Reif, *et al.* explores the potential to apply the same ideas to stratified turbulence. In that case the bifurcation occurs as a function of the gradient Richardson number.

The report by Ham, *et al.* is on the topic of bypass transition. Direct numerical simulations done here at Stanford revealed a complex process by which this type of transition occurs. The initial stages of transition involve large structures — 'backward jets' — that are well within the large eddy domain. But the key instability process that ultimately cause transition is a highly localized breakdown of these jets, which occurs in the upper part of the boundary layer. It subsequently spawns a turbulent spot that penetrates to the wall. There is some question of whether these later stages of transition can be captured by LES. The spots are quite intermittent; subgrid models that average over span will include laminar and turbulent zones. That could reduce the fidelity of the simulation. This project applied a new time-integration scheme, developed at Waterloo by Ham and Lien, to the problem of transition simulation.

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