Large-Eddy Simulations of Wall Bounded Turbulent Flows
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We report recent progress on wall-resolved and wall-modeled large-eddy simulation (LES) of wall-bounded turbulent flows, including model development and applications. The sub-grid-scale (SGS) model employed is the stretched spiral vortex SGS model, originally proposed by Misra & Pullin (Phys. Fluids 1997). The present wall-model is an extension of the original one proposed by Pullin & co-workers in a series of papers on LES of high Reynolds number flows in a channel, turbulent boundary layer, and a pipe. Our extension to the wall model includes three modifications: relaxation of the log-law assumption, extension into two-dimensional wall model and reformulation in generalized curvilinear coordinates.

Five flow configurations are examined in detail. The first case is that of a zero pressure gradient turbulent boundary layer in which our objective is to address whether the mean velocity profile obeys a log-law or a power-law. The second case is that of a separated and re-attached turbulent boundary layer, where the two-dimensional wall model is shown to reasonably predict the wall stress in the separated flow. The third case is flow over period hill, a benchmark case for LES modeling, and our LES show good results compared with experiments.

The fourth and perhaps more challenging case is that of a flow over a circular cylinder with emphasis on reproduction of the drag crisis at $Re \sim O(10^5)$ and quantification of skin friction on the surface. The final case is that of flows over airfoils, which is a prerequisite step for applying the present curvilinear wall model on cases with even more complex geometry. In all these, our emphasis is on validation and quantitative comparisons with experimental data when available.

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