Wall Modeling in Large Eddy Simulation

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Modeling turbulent flow near a wall is a pacing item in computational fluid dynamics for naval and aerospace applications and geophysical flows. In high fidelity numerical simulations, wall modeling leads to dramatic reduction in the required computational resources. Gradual progress has been made in statistical modeling of near wall turbulence using the Reynolds-averaged equations of motion. Recent advances in this area will be reviewed with applications to complex turbulent flows. Recently, a new approach for wall modeling has been proposed using slip velocity and transpiration at the wall. This approach is free from RANS legacy models and does not have any adjustable parameters. The slip model has led to accurate predictions of one point turbulence statistics in various canonical flow configurations and grid resolutions. Modeling of laminar/turbulence transition is particularly challenging in wall modeled LES simulations, requiring 10-100 times more grid points in the thin laminar region than in turbulent regime to properly capture the amplification of disturbances prior to the breakdown to turbulence. We have examined the potential of the use of the non-linear parabolized stability equations (PSE) in this region. When the PSE are used in conjunction with wall-resolved and wall-modeled LES, the computational cost in both the laminar and turbulent regions is reduced by several orders of magnitude compared to DNS.