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Wall-modeled LES of 3D turbulent boundary layer in a square duct with a 30° bend[1] XIAOHAN HU, University of Pennsylvania, MINJEONG CHO, Center for Turbulence Research, Stanford University, GEORGE PARK, University of Pennsylvania — Mean three dimensionality and high Reynolds number are inherent features of turbulent boundary layers (TBL) in nature and realistic geometries of engineering applications. Wall models for large-eddy simulation (LES) have not been assessed in such nonequilibrium flows, where some of the key modeling assumptions are deemed invalid (e.g., unidirectional flow, alignment of mean shear and turbulent stresses). To this end, we are currently investigating predictive capability of two wall models in a spatially developing three-dimensional TBL. The experiment of Schwarz & Bradshow (J. Fluid Mech. (1994), vol. 212, pp. 183-209) is considered, where a skewed mean velocity profile is generated as TBL along the floor of a square duct deflects through a 30° bend. The Reynolds number is moderately high ($Re_\theta = 4000 \sim 9000$). Wall-modeled LES (WMLES) with an equilibrium ODE wall model and a non-equilibrium PDE wall model are conducted. Accuracy of the WMLES calculations will be discussed in terms of prediction quality of key mean-flow statistics at two grid resolutions, including boundary-layer integral parameters, skin-friction and wall-pressure coefficients, and y-dependent flow turning angle. Cost of wall modeling for the two wall models will be discussed.

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Xiaohan Hu
University of Pennsylvania

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