Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

A Flow-structure-based wall-modeled large eddy simulation paradigm[1] AHMED ELNAHHAS, ADRIAN LOZANO-DURAN, PARVIZ MOIN, Center for Turbulence Research, Stanford University — A promising and cost-effective method for numerical simulation of high Re wall-bounded flows is wall-modeled large-eddy simulation (WMLES). Most wall models are formulated from the Reynolds-averaged Navier-Stokes equations (RANS). These RANS-based wall models are calibrated using mean turbulence data and make no use of the current vast knowledge on turbulent flow structure. Moreover, RANS-based models are limited to predicting the mean velocity profile and the mean wall shear stress, while higher-order statistics such as turbulent intensities and velocity spectra are not predicted near the wall. Here, we propose a near-wall model for LES which predicts subgrid-scale quantities such as the wall stress, velocity fluctuations, kinetic energy spectra, and flow structure across the entire near-wall layer. The model combines 1) a rescaling mapping which predicts the flow structure at different wall-normal distances and 2) a channel flow unit (CFU) with a domain-size fixed in inner units. The information from the mapping on how different flow structures scale with the distance to the wall is used to synthesize the top boundary condition for the CFU. This physics-based approach contrasts with other multiscale models where either the CFU size is linked to the LES grid size (Sandham, 2017), or the link between the two domains involves renormalization of velocity fields between time steps (Tang, 2016).

[1]Research funding through NASA

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Date submitted: 02 Aug 2020 Electronic form version 1.4