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Wall-stress Modeling for Laminar Boundary Layers[1] CARLOS GONZALEZ, MICHAEL KARP, PARVIZ MOIN, Center for Turbulence Research, Stanford University — As described in NASA's CFD Vision 2030 report (Slotnick, et al. 2014), for external aerodynamic applications such as flow over an airfoil, the number of computational volumes in the laminar and transitional region can exceed that of the turbulent region by up to two orders of magnitude (100 times) in a wall-modeled large eddy simulation (WMLES). The associated high computational cost is a key bottleneck in the application of such reduced-order models. The goal of this study is to develop a wall model capable of treating the laminar region without the need to fully resolve it. We demonstrate that for a stagnation flow, the semi-analytical wall stress, derived from the Hiemenz flow similarity solution, can be used as a wall-model for coarse laminar simulations. The wall model is then extended to flows over a flat plate with a spatially varying edge pressure gradient by considering the family of Falkner-Skan similarity solutions. The local behavior of the pressure gradient is used to select the appropriate Falkner-Skan wall stress. The similarity-solution based wall model is applied using the unstructured charLES solver. The wall stress of both cases is well predicted using the new wall model.

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