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Aerodynamic heating effects on wall-modeled large-eddy simulations of high-speed flows XIANG YANG, JAVIER URZAY, PARVIZ MOIN, Stanford University — Aerospace vehicles flying at high speeds are subject to increased wall-heating rates because of strong aerodynamic heating in the near-wall region. In wall-modeled large-eddy simulations (WMLES), this near-wall region is typically not resolved by the computational grid. As a result, the effects of aerodynamic heating need to be modeled using an LES wall model. In this investigation, WMLES of transitional and fully turbulent high-speed flows are conducted to address this issue. In particular, an equilibrium wall model is employed in high-speed turbulent Couette flows subject to different combinations of thermal boundary conditions and grid sizes, and in transitional hypersonic boundary layers interacting with incident shock waves. Specifically, the WMLES of the Couette-flow configuration demonstrate that the shear-stress and heat-flux predictions made by the wall model show only a small sensitivity to the grid resolution even in the most adverse case where aerodynamic heating prevails near the wall and generates a sharp temperature peak there. In the WMLES of shock-induced transition in boundary layers, the wall model is tested against DNS and experiments, and it is shown to capture the post-transition aerodynamic heating and the overall heat transfer rate around the shock-impingement zone. This work is supported by AFOSR.

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