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Statistically constrained neural networks for augmenting LES wall modeling[1] YUE HAO, CHARLES MENEVEAU, TAMER ZAKI, Johns Hopkins University — The equilibrium wall model in large-eddy simulations (LES) is designed to predict the mean behavior but, applied to instantaneous realizations, it appreciably underpredicts the variance of the stress. We introduce a formalism whereby the equilibrium model provides a prior estimation of the stress, and a statistically constrained neural network (NN) provides a correction to that estimate. The network design is motivated by universal properties of the joint probability density functions of the local LES Reynolds number at the first grid point above the wall and the instantaneous wall stress. Inputs and outputs of the network are normalized, conditioned on the estimate from the equilibrium wall model; and the loss function is designed to ensure the statistics of the corrected stress match the universal trends. Spatially filtered data from the JHTDB channel flow at Re_τ =1000 and 5200 are used for training and testing. A priori tests are performed to assess the accuracy of the model relative to filtered wall stress from the database. The NN demonstrate better accuracy than the equilibrium wall model in (i) predicting statistics of the wall stress and (ii) the correlation of instantaneous predictions with the true filtered stress.

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