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Improved engineering models for turbulent wall flows ZHEN-SU SHE, Peking University, XI CHEN, Texas Tech University, HONG-YUE ZOU, Peking University, FAZLE HUSSAIN, Texas Tech University — We propose a new approach, called *structural ensemble dynamics* (SED), involving new concepts to describe the mean quantities in wall-bounded flows, and its application to improving the existing engineering turbulence models, as well as its physical interpretation. First, a revised $k-\omega$ model for pipe flows is obtained, which accurately predicts, for the first time, both mean velocity and (streamwise) kinetic energy $\langle u'u' \rangle$ for a wide range of the Reynolds number (Re), validated by Princeton experimental data. In particular, a multiplicative factor is introduced in the dissipation term to model an anomaly in the energy cascade in a meso-layer, predicting the outer peak of $\langle u'u' \rangle$ agreeing with data. Secondly, a new one-equation model is obtained for compressible turbulent boundary layers (CTBL), building on a multi-layer formula of the stress length function and a generalized temperature-velocity relation. The former refines the multi-layer description - viscous sublayer, buffer layer, logarithmic layer and a newly defined bulk zone - while the latter characterizes a parabolic relation between the mean velocity and temperature. DNS data show our predictions to have a 99% accuracy for several Mach numbers Ma=2.25, 4.5, improving, up to 10%, a previous similar one-equation model (Baldwin & Lomax, 1978). Our results promise notable improvements in engineering models.

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