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Modeling and large-eddy simulation (LES) of a turbulent boundary layer over linearly-varying surface roughness[1] A. SRIDHAR, D. I. PULLIN, California Institute of Technology, W. CHENG, King Abdullah University of Science and Technology — An empirical model is presented, after Rotta (1962), that describes the development of a fully-developed turbulent boundary layer in the presence of surface roughness with nominal roughness length-scale k_s that varies with stream-wise distance x. For $Re_x = U_e(x)\,x/\nu$ large, use is made of the log-wake model of the local turbulent mean-velocity profile that contains the Hama roughness correction $\Delta U^+(k_s^+)$ for the asymptotic, fully rough regime. It is shown that the skin friction coefficient C_f is constant in x only for $k_s = \alpha x$, where α is a dimensionless number. For $U_e(x) = A\,x^m$, this then gives a two-parameter (α, m) family of solutions for boundary-layer flows that are self similar in the variable $z/(\alpha\,x)$ where z is the wall-normal co-ordinate. Trends observed in this model are supported by wall-modeled LES of the zero-pressure-gradient turbulent boundary layer ($m = 0$) at very large Re_x. It is argued that the present results suggest that, in the sense that C_f is spatially constant and independent of Re_x, this class of flows can be interpreted as providing the asymptotically-rough equivalent of Moody-like diagrams for boundary layers in the presence of small-scale roughness.

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