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Roughness-like modulation of canonical wall-bounded turbulence using effective boundary conditions.[1] SEYED MORTEZA HABIBI KHORASANI, SHERVIN BAGHERI, KTH Royal Institute of Technology — Small-scale surface inhomogeneities result in a displacement of the turbulent and mean quantities of wall-bounded flows such that they perceive smooth walls at different virtual origins of ${l_U}^+$ and ${l_T}^+$ respectively. Recent direct numerical simulations of geometry-resolved flows over drag-reducing surfaces have shown that the turbulence perceives an origin at a shallower depth than the mean flow and that after setting the origin at ${l_T}^+$ the shift of the mean velocity profile becomes $\Delta U^+ = {l_U}^+ - {l_T}^+$. Such a displacement of smooth-wall-like turbulence also extends to drag increasing surfaces such as roughness where the resulting increase in drag is due to the turbulence origin being deeper than the mean flow. We use a set of boundary conditions designated the transpiration-resistance model (TRM) to reproduce this behavior. The TRM accounts for both tangential slip and wall-normal transpiration, the latter of which is essential for emulating turbulent flow over structured surfaces, through the constitutive parameters ${l_x}^+, {l_z}^+$ and m^+. We also demonstrate that streamwise slip has a negligible effect on the turbulence displacement while transpiration is strictly coupled to the spanwise crossflow induced at the boundary.

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