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Roughness topographical effects on mean momentum and stress budgets in developed turbulent channel flows MOSTAFA AGHAEI JOUYBARI, JUNLIN YUAN, Michigan State University — Direct numerical simulations of turbulent channel flows are carried out over two surfaces: a synthesized sand-grain surface and a realistic turbine roughness that is characterized by more prominent large-scale surface features. To separate the effects of wall-normal variation of the roughness area fraction from the (true) variation of flow statistics, the governing equations are area-averaged using intrinsic averaging, contrary to the usually practice based on the total area (i.e., superficial averaging). Additional terms appear in the mean-momentum equation resulted from the wall-normal variation of the solid fraction and play a role in the near-wall balance. Results from surfaces with a step solidity function (e.g., cubes) will also be discussed. Compared to the sand grains, the turbine surface generates stronger form-induced fluctuations, despite weaker dispersive shear stress. This is associated with more significant form-induced productions (comparable to shear production) in Reynolds stress budgets, weaker pressure work, and, consequently, more anisotropic redistribution of turbulent kinetic energy in the roughness sublayer, which potentially leads to different turbulent responses between the two surfaces in non-equilibrium flows.

Mostafa Aghaei Jouybari
Michigan State University

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