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Direct numerical simulations of the dense regime of roughness MICHAEL MACDONALD, LEON CHAN, DANIEL CHUNG, NICHOLAS HUTCHINS, ANDREW OOI, University of Melbourne — We investigate the sparse and dense regimes of roughness using Direct Numerical Simulations (DNS) of turbulent flow over three-dimensional sinusoidal surfaces in the transitionally rough regime. The sparse regime is known to lead to an increase in the Hama roughness function, ΔU^+, as the roughness density increases, while the dense regime is associated with a decrease in ΔU^+ as density increases. In this parametric study, the wavelength of the sinusoidal roughness elements is varied while the roughness height is fixed. The minimal-span channel is used, as the high cost of the grid would otherwise make the dense roughness simulations unattainable. It was found that the dense regime began at solidity values (frontal area divided by wall-parallel projected area) greater than 0.15, in agreement with the literature. An analysis of the mean momentum balance above the roughness reveals that the decrease in ΔU^+ in the dense regime is due to a reduction in the Reynolds shear stress. This reduction is located just above the roughness crest in the near-wall region, and the difference in the energy spectra of streamwise velocity between smooth and dense roughness clearly demonstrates that this is at long streamwise length scales.

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