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A dynamic roughness model for LES of flow over multiscale, fractal-like surfaces: application to synthetic and real topography[1]

WILLIAM ANDERSON, CHARLES MENEVEAU, Johns Hopkins University, Baltimore, MD — The topography of many natural surfaces encountered in geophysical flows is known to be multiscale and fractal-like. We present the so-called dynamic surface roughness (DSR) model, a framework for representation of drag effects imposed on a high- Reynolds number boundary layer by a multiscale rough surface. In developing and testing the DSR model, we consider synthetic fine-grained multiscale surfaces with spectral exponent β_s ranging between -3.0 (smoothest) to -1.2 (roughest). The fine-grained surface is spatially filtered at the large-eddy simulation (LES) resolution, resulting in a resolvable and subgrid-scale (SGS) component. The SGS component is represented with an effective roughness length. The effective roughness length is written as the product of local SGS roughness root-mean-square and an unknown roughness index, α. We dynamically evaluate α with a self- consistency condition applied to the plane-average of total wall stress resolved at the grid- and a test-filter width. Results for flow over synthetic surfaces indicate strong dependence of α on surface spectral exponent. We also apply the DSR model to LES of flow over a real landscape using digital elevation map data from the USGS.

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