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Flow of Turbulent Boundary Layers Over Low-Order Representations of Irregular Surface Roughness R. MEJIA-ALVAREZ, K.T. CHRISTENSEN, Univ. of Illinois — The relative impact of various topographical scales present within irregular surface roughness on a turbulent boundary layer is explored. Low-order representations of roughness replicated from a turbine blade damaged by deposition of foreign materials are generated using singular value decomposition (SVD) to decompose the surface into a set of topographical basis functions (383 total) of decreasing importance to the original ("full") surface character. The low-order surface models are then formed by truncating the full set of basis functions at the first 5 and 16 modes (containing approximately 65% and 95% of the full surface content, respectively), so that only the most dominant, and large-scale, topographical features are included in the models. Physical replications of the full surface and the two models are created by rapid prototyping and PIV is used to acquire ensembles of velocity fields for all cases. Comparison of single-point statistics indicates that a 16-mode model of the full surface generally reproduces the statistical character of flow over the full surface. In the outer region, both the 5- and 16-mode models reproduce the characteristics for flow over the full surface in accordance with Townsend's wall similarity hypothesis. However, both surface representations fail to reproduce important details of the Reynolds-shear-stress-producing events within the roughness sublayer.

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