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A-priori wind tunnel studies of subgrid-scale models for large-eddy simulations over rough-to-smooth surface transitions

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An improved understanding of subgrid-scale (SGS) physics is essential to make large-eddy simulation (LES) a reliable tool to study atmospheric boundary layer fluxes over heterogeneous surfaces. Most of the errors in LES are associated with the parameterization of the subgrid-scale fluxes required to account for the effect of the unresolved (subgrid) scales on the resolved scales. In particular, SGS stresses need to be specified within the boundary layer, using a SGS model, and at the surface, through a boundary condition. Here we present *a priori* wind tunnel experiments designed to directly evaluate SGS stresses and energy transfers in a boundary layer over a rough-to-smooth transition. In the first experiment, aimed at studying SGS models, high-resolution, 2-D velocity fields were obtained downstream of the transition using particle image velocimetry (PIV) at varying positions in the surface layer. These velocity fields are spatially filtered (in 2-D) and used to calculate SGS stresses and the local energy transfers between the resolved and subgrid scales. In a concurrent second experiment in the same flow, the surface boundary condition is studied by means of high-resolution hot-wire anemometry. Simultaneous measurements were made of the fluctuating surface shear stress, with a single-wire probe located at the wall, and two velocity components in the log-layer using a cross-wire probe. The time series of surface shear stress and velocities are filtered to evaluate exactly the filtered surface shear stress (required boundary condition) and filtered (resolved) velocity as found at the lowest grid point in LES. The results from our *a priori* analysis are used to evaluate the performance of a variety of SGS models and surface boundary conditions.