Lagrangian dynamic models for LES, and applications to the study of turbulent boundary layer flow over rough terrain

Charles Meneveau, Elie Bou-Zeid & M.B. Parlange
Department of Mechanical Engineering and
Center for Environmental and Applied Fluid Mechanics
Johns Hopkins University

Abstract

We review the dynamic model for LES and comment on the required modifications when high Reynolds number boundary layer flows are considered. Specifically, the scale-dependent dynamic model is described. For applications to flows in complex geometries, the usual method of averaging over regions of statistical homogeneity is not applicable. We discuss possible generalizations of the scale-dependent model in the context of the Lagrangian model, where averages are accumulated over pathlines of the flow rather than directions of statistical homogeneity. With a particularly simple, although as yet incomplete, version of this model, we study turbulent boundary layer flow over surfaces with patches of diferent roughness scales. The goal is to use LES results to formulate effective boundary conditions in terms of an effective roughness height and blending height, to be used for RANS classic treatments of environmental flows. A systematic set of simulations of flow over patches of differing roughness is performed, covering a range of patch lengths and surface roughness values. The simulated mean velocity profiles are analyzed to identify the height of the blending layer and to measure effective roughness lengths. We propose a simple model to express the effective surface roughness and blending height as function of the various surface patch roughness values and the patch length. Predictions of the model agree well with the LES results.