Geophysical Research Abstracts, Vol. 8, 09236, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09236

A-priori wind tunnel study of subgrid-scale models for LES over heterogeneous terrain

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Our understanding of subgrid-scale (SGS) physics in large-eddy simulations (LESs) of the atmospheric boundary layer must be improved to allow for more reliable simulations, especially over realistic surface conditions such as heterogeneous, rough terrain. The largest errors associated with LES occur due to its limited ability to parameterize the subgrid-scale fluxes that account for the effect of the unresolved (subgrid) scales on the resolved scales. The goal of this study is to validate and test current subgrid-scale models in a boundary layer over heterogeneous surface conditions using a unique, high-resolution data set that was acquired in a wind tunnel using stereoscopic particle image velocimetry. This data set captures the complex, subgrid-scale dynamics in a boundary layer at various positions relative to a roughness transition and is ideally suited for *a priori* evaluation of subgrid-scale variables. Two-dimensional spatial filtering is applied (without using Taylor's hypothesis) to evaluate the filtered velocity field, filtered strain rate tensor and SGS stress tensor. These subgrid-scale quantities are used to study the SGS transfer rate of energy that exhibits a highly-intermittent behavior and a dependency on the position in the flow relative to the location of the roughness transition. The results of this study recognize the short-comings of current SGS models and provide guidance toward the development of improved paramterizations.