EMS Annual Meeting Abstracts
Vol. 8, EMS2011-447-2, 2011
11th EMS / 10th ECAM

Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Spatial Decomposition for Inner and Outer Layer Turbulence Over Very Rough Surfaces

C. Castillo (1), A. Inagaki (2), and M. Kanda (3)

(1) Department of International Development Engineering, Tokyo Institute of Technology, Japan (criscastillo.ac.uk@gmail.com), (2) Tokyo Institute of Technology, Japan (inagaki.a.ab@m.titech.ac.jp), (3) Tokyo Institute of Technology, Japan (kanda.m.aa@m.titech.ac.jp)

The nature of the turbulence structure over a flat wall and that over large roughness, such as buildings, were originally thought to be different. Low speed streaks, which have been vigorously investigated for decades, dominantly characterize flat wall turbulence. Before Cheng and Castro (2002) conducted wind tunnel experiments for urban-like roughness, the structures for a fully turbulent flow within and above large roughness were unknown. Oikawa and Meng 1995, Raupach et al. 1996, Roth 2000, Christen et al. 2007 have considered that the turbulence structure over large roughness to be roll-like in nature. Meteorologists have identified that the streaky structures over large obstacles to be a type of thermal roll in the atmospheric boundary layer. The numerical simulations of Kanda et al. (2004) and Castillo et al. (2011), as well as the comprehensive outdoor scale experiments for an urban model (COSMO) of Inagaki and Kanda (2010), indicated that the low speed streaks over large roughness to be similar to those over a flat surface, such as discussed by Adrian et al. 2000. Results from numerical simulations (Kanda et al. 2004, Castillo et al. 2011), outdoor scale model (Inagaki and Kanda 2010) and wind tunnel experiment (Cheng and Castro 2002) reveal this similarity between the low speed streaks over smooth and rough walls. They also indicate the difference in quality between smooth and rough walls that are largely anchored on the relative contribution of the outer layer flow on the turbulent fluctuation within the inertial sublayer. Considering that the surface layer is composed of an inner layer and an outer layer, streaky structures in the former are the low speed streaks that are shear-driven and are ‘active’, while those in the latter are buoyancy-driven thermal rolls in the convective boundary layer and are ‘inactive’. The presentation aims to discuss the spatial decomposition method utilized in the outdoor scale model experiment (Inagaki and Kanda 2010) and the numerical simulation (Castillo et al. 2011) that was the key to reveal inner-scale similarity (i.e. Monin-Obukhov similarity) of the turbulence structure over urban-like roughness. The separation of inner-layer and outer-layer scale motions was accomplished by using a moving average along the spanwise direction for the outdoor scale model, and a spatial filter for the numerical simulation. The filter size was empirically scaled between the two scales of motion, wherein the inner length scale is approximately the height of a building and the outer length scale is the atmospheric boundary layer height. The numerical experiment was conducted using the urban version of a parallelized Large-Eddy Simulation (PALM, Raasch and Schroter 1992) for an urban model with a typical daytime convective mixed layer and a near-neutral inertial sublayer, a domain size of 2560m x 2560m x 2600m, 40-m (=H) cubic buildings regularly spaced (plane index area =0.25), and a spatial resolution of H/16.