An LES study on the structure of coherent eddies in the roughness sublayer over a homogeneous plant canopy

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The roughness sublayer is distinguished from the surface layer above it by the existence of coherent eddies developed near the top of roughness canopy layer. The enhanced vertical transport due to the coherent eddies is the main reason for the breakdown of Monin-Obukhov (M-O) similarity theory within the roughness sublayer (*i.e.*, non-dimensional shear functions are generally smaller than predicted by M-O similarity). It is, therefore, important to investigate the structure and mechanism of coherent eddies to better understand transport and diffusion processes across the roughness sublayer.

Several Large-Eddy Simulation (LES) runs were performed to model neutrally stratified flow in and above a completely homogeneous plant canopy. Each run differed by the size of computational domain and the driving force of flow. A conditional sampling technique was used to detect streamwise sharp variations of velocities in the simulated three-dimensional turbulence field. Ensemble averaged images of the coherent eddies that caused the velocity variations were constructed.

The ensemble image of the eddies that caused sharp variations in the vertical velocity near the canopy-top was a cross-streamwise vortex which consists of the pair of downstream sweep and upstream ejection accompanied by the low-pressure core in between. This vortex has a compact spatial scale comparable to the canopy height, and can be explained by the mixing-layer analogy proposed by Raupach *et al*. (1996; *Boundary-Layer Meteor*., **78**, 351–382). On the other hand, dominant perturbations in the streamwise velocity near the canopy-top were, on average, induced by pairs of much larger eddies of the upstream sweep and downstream ejection, both of which were streamwise elongated for more than four times the canopy height. A high-pressure zone appeared corresponding to the convergence between the sweep and ejection eddies. Because of their large spatial scale and the absence of low-pressure core, these eddies are not directly explained by vortical motions arisen from the inflection instability near the canopy-top. Instead, the above-mentioned vortices that caused perturbations in the vertical velocity were embedded in a streamwise elongated high-speed eddies. These results support the previous findings that the canopy-scale eddies are most often produced when a large-scale coherent downdraft (sweep) impinges on the canopy and the inflection instability near the canopy-top is enhanced (Watanabe, 2004; *Boundary-Layer Meteor*., **112**, 307–341). Since extracted structures were essentially similar for all runs, these coherent eddies are inherent phenomena in a neutrally stratified turbulent flow near the canopy-atmosphere interface.