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Numerical investigation of instantaneous flow structure within a cubical canopy

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Instantaneous flow structure within a cubical canopy was investigated using large eddy simulation (LES). The main interests are (1) large scale coherency of instantaneous flow field within a cubical canopy, (2) how the large scale coherent structures coupled with the turbulent organized structures (TOS) above.

A large numerical domain (i.e., 2560 x 2560 x 1710 m) was used to simulate a whole atmospheric boundary layer for daytime settings with a regular array of cube of 40m height (= H), and a fine spatial resolution (2.5m) to explicitly resolve each cube. The convective mixed layer was sustained by the constant heat supply from all roof and floor surfaces, but the strong mechanical mixing attributed to cubical roughness kept the around the roof level near-neutral.

The numerical result revealed that there are very large coherent structures of both in velocity and temperature fields within the canopy layer. The size of the structures is much larger than that of the cubes. It was also found that the shapes and locations of these structures are closely related with the TOS above.

The upward momentum and heat transport events were clearly related with the TOS developed in the inertial sublayer, which frequently occur below low momentum streaks. Meanwhile, the downward transports are not so correlated with the TOS above but more regulated by the structure of canopy since it frequently occurred within the street axis parallel to the mean wind direction.

Keywords: urban canopy, surface layer, convective mixed layer, turbulent organized structure