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Turbulent boundary layer flow over distributions of cubes and evaluation of transient dynamics WILLIAM ANDERSON, University of Texas at Dallas, QI LI, ELIE BOU-ZEID, Princeton University — We have used large-eddy simulation with an immersed boundary method to study turbulent flows over a distribution of uniform height, staggered cubes. The computational domain was designed such that both the roughness sublayer and a region of the aloft inertial layer was resolved. With this, we record vertical profiles of time series of fluctuations of streamwise velocity and vertical velocity (where fluctuation is computed as a quantity's deviation from its time-averaged value during a time period over which the simulation exhibits statistical stationarity). Contour images of fluctuating velocity component shown relative to vertical position and time reveals an advective-lag between the passage of a high- or low-momentum region in the aloft inertial layer and excitation or relaxation of cube-scale coherent vortices in the sublayer. We quantify this advective lag and demonstrate how these events precede elevated Reynolds stresses associated with turbulent sweeps at the cube height. We propose that coherent, low and high momentum regions in the inertial layer are responsible for the reported advective lag. Vortex identification techniques are used to illustrate the presence of hairpin packets encapsulating low momentum regions, thereby supporting our hypothesis. Based on this, a simple, semi-empirical model for prediction of advective lag with height is developed. In spite of its simplicity, the model manages to capture the advective lag profiles reasonably well.

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