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Turbulence structure in the roughness sublayer over large cubical obstacles

The structure of turbulence in the roughness sublayer over groups of cubical obstacles is investigated numerically using direct numerical simulations. Results are analysed in terms of first and second order statistics, by visualisation of instantaneous flow fields and by conditional averaging and EOF (POD) analysis. The accuracy of the simulations is established by detailed comparisons of first and second order statistics with wind tunnel measurements.

Detailed comparisons are made with recent findings over vegetated flows by Finnigan et al. in an attempt to develop a unified understanding of the structure of the roughness sublayer. Several statistics and two-point correlations are remarkably similar to the vegetation case. Quadrant analysis gives similar qualitative results but the transition from ejection to sweep dominance takes place much closer to the roughness than over vegetation.

The dominant coherent structures are deduced by a combination of conditional averaging, linear stochastic estimation and EOF (POD) analysis. Several qualitative structural similarities again emerge in comparison with vegetation canopies, but the relative importance of different elements seems to differ. In spite of these qualitative similarities, it is clear that mechanisms other than those present in vegetation canopies are important when the roughness consists of large bluff bodies. The mixing-layer mechanism invoked by Raupach et al. (1996) as a conceptual model of turbulence structure over vegetation appears to be less applicable in this case. Possible modifications will be discussed.