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Quantitative assessment of an urban canyon resistance network through large-eddy simulations of wall-heated scenarios

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It is a challenging task to find an appropriate temperature boundary condition for a meso-scale meteorological model over a heated urban surface because of extremely complicated turbulent and thermo-dynamical processes inside the urban canopy layer. Often the urban canyon resistance network (UCRN) approach is adopted to provide a simplified solution to it. Such a UCRN model normally consists of multiple boxes (representing layers / volumes of air and urban facets) that are inter-connected by resistances. However, knowledge of the resistances is poor due to lack of observational data and the complexity in the processes of heat transfer in/above urban canopy layer. In order to address the fundamental issue, a modelling methodology is adopted based on large-eddy simulation (LES) of the urban surface layer over a heated street canyon. A new wall-function for temperature is constructed using existing knowledge of heat transfer over a rough facet and implemented in a LES model. A set of wall heating scenarios (either the upstream or downstream wall is heated) has been simulated. The LES output has been analysed in order to assess the heat transfer characteristics near the urban facets and the magnitudes of resistances in a UCRN. This study reveals that the near-facet resistance is the highest one in the UCRN, and thus has the greatest influence on the heat flux. In other words, the heat transfer process in the near facet region plays a far more important role than that at the top of the urban canopy. In addition, the value of the near-facet resistance depends on the local turbulent convection regimes (force convection, natural convection, or mixed convection). Therefore, the future research on the flux-temperature relationship over a heated urban surface should be focused primarily on the quantification of the near-facet resistance for various rough urban facets in different convection regimes.