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Differential wall heating and flow characteristics in street canyons — a large-eddy simulation

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This study develops a large-eddy model for a street canyon flow with building/street heating based on an atmospheric numerical modelling system. The boundary condition for temperature is given as a constant at the surface of the building or street combined with a wall function. The model is applied to a canyon with the aspect ratio of unity for two idealised heating scenarios: (1) the roof and the upstream wall are heated, and (2) the roof and the downstream wall are heated.

The wall Richardson number is defined for a case with wind above the canyon blowing perpendicularly to the street axis in order to classify the flow regimes within the street canyon. Three mean flow regimes with respect to the condition of the primary vortex (PV) are proposed corresponding to different ranges of the Richardson number: 'accelerated', 'retarded', and 'retreated'. For the upstream-wall heating cases, mean wind quantities, $e.g.$ intensity of PV, provide clear evidence of the 'accelerated' feature. For the downstream-wall heating cases, results support the proposed flow regimes: the 'retarded' cases possess a PV enclosed at the roof level with a secondary vortex which occupies a significant proportion of the lower corner near the downstream wall. This enlarged secondary vortex is mainly driven by the wall heating, which is not large enough to break the enclosed PV. The 'retreated' cases occur when the wall heating is so large that the enclosed PV is 'pushed' towards the upstream direction by the growing secondary vortex so that an open, narrow updraft along the downstream wall is formed beyond the top of the canyon. Majority of heat is transferred outside of the canyon through the updraft. This flow pattern matches very well with the suggestions made by field studies (Nakamura and Oke, 1988; Idczak *et al.*, 2007; Offerle *et al.*,

2007). Due to the possible defects of the coarse resolution, the wall function, and the simple sub-grid scale model employed in the model, it is suggested that the width of the updraft may be overestimated and the critical Richardson number may be underestimated in the present study.