

# A Comparison of Numerical Simulation and Wind Tunnel Experiment on Unstable Stratified Flow within and above a Modeled Urban Canopy

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## 1. Introduction

When thinking of the microclimate or the air quality in an urban city, the airflow structure and turbulent exchange in the urban boundary layer should be pre-determined since they control the wind, temperature and pollution concentrations. The urban canopy is considered as a typical morphological unit in the urban boundary layer, and therefore much research has been focused on it in terms of understanding its dynamics and energy balance. In the present work, we implement and apply LES (Large Eddy Simulation) numerical model and wind tunnel to investigate the stratified flow within and above a modeled urban canopy. The focus of this work is to compare the LES results against the wind-tunnel measurements of the modeled urban canopy flow, and to examine the temporally average structures of the thermal canopy flow.

## 2. Outline of Wind Tunnel Experiment

The thermal stratification wind tunnel at Building Research Institute (BRI), Japan, was used. In the BRI wind tunnel the urban atmospheric boundary layer was simulated by using roughness elements set on the approaching area floor. In this study, the experiment was carried out under an unstable atmospheric condition. The Reynolds number  $Re$  and Richardson number  $Ri$  are 2667 and -0.2, respectively. To simulate a typical urban canopy for case of the low-rise building residential area, a model that consists of 70 wooden blocks of the dimension 60 mm×60 mm×40 mm was used. An auto-traverse system was built up for sampling 3D field data of the wind velocity and temperature within and above the modeled urban canopy layer.

## 3. Outline of Numerical Simulation

The urban-canopy-resolving meteorological LES numerical model, which has been developed recently in Tohoku University, was utilized. The model coded in the Cartesian coordinate has been verified well to treat any complex object (buildings in urban boundary layer, etc.) explicitly with a finer resolution. In this modeling, values of the  $Re$  and  $Ri$  were set to those of the wind tunnel experiment.

## 4. Results and Conclusions

The comparison between the simulated and measured wind speed and temperature fields at the sampling locations within and above the urban canopy has been done. The prediction from the LES model modeling was compared with available data obtained from the wind tunnel experiment. The agreement between the predicted mean velocity and temperature within and above the urban canopy layer and the experimental data is generally good. Quantitative features in mean vertical profiles of the velocity and temperature were also reproduced well. The comparison of the predicted and observed flow quantities in the modeled canopy layer indicates that the LES modeling is accurate enough to warrant its application to the prediction of flows within and over other more complicated urban canopy layer.