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Development of Urban Meteorological LES Model for thermal environment at city scale

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In this research, a large eddy stimulation (LES) model capable of simulating urban areas was developed, and the degree of impact of buildings, parks, and trees on the local temperature distribution was evaluated.

The main features of the LES model include (i)Building resolving, (ii)Roadside trees are resolved in 3-dimensional, (iii) resolving shadows from buildings and trees, (iv)Multiple reflections of short- and long-wave radiation between buildings and trees by radiosity method, and (v) incorporation of cloud physics and atmospheric radiation models (e.g., RRTM). The radiative environment within an urban canopy layer is an important factor in determining local- or micro-scale temperature distribution. In order to investigate how a 3-D structure (i.e., buildings and trees) can affect the urban thermal environment, we have developed an urban radiation model. Our urban radiation model is able to consider multiple reflections between buildings or trees. Short- and long-wave radiations are calculated by radiosity method. In our tree model, each individual tree is idealized as a porous board constituted by many layers of leaves, and each board is characterized by its Leaf Area Index. The Leaf Area Index is determined by the leaf density of each layer. Optical parameters are leaf transmittance and reflectance. The intensity of direct solar radiation is decreased by passing through the porous boards. Reflected solar radiation is calculated by the radiosity method.

Several model verification tests are performed to evaluate the robustness of model dynamics and physics, and radiation. Based on these numerical test results, our model is correctly developed at least with regarding dynamics, physics, and radiation.

Numerical simulations of thermal environment in Tajimi city, Japan were conducted to perform sensitivity analyses of roadside trees effects, impact evaluations, and future projections of urban thermal environment at city-scale.

Furthermore, we plan to examine how to plan adaptation to urban thermal environmental problems using our LES model.

Keywords: Large Eddy Simulation, Urban Thermal Environment