Mesoscale and LES Modeling of Turbulent Heat Transfer and Thunderstorm Generation in Urban Districts

Tetsuya Takemi

Professor, Disaster Prevention Research Institute, Kyoto University

President of the Meteorological Society of Japan

Abstract:

In urban areas with high-rise and densely distributed buildings, highly turbulent flows are generated, which affects heat transfer from urban surfaces to the atmosphere. Such heat transport will influence the development of isolated thunderstorms in urban areas. Sensible heat fluxes from urban surfaces are considered to play a role in causing such thunderstorms. This study numerically investigates the impacts of the geometrical features of urban surfaces and the heat transfer from urban areas on the generation of isolated thunderstorms and the resulting local-scale precipitation by combining a mesoscale meteorological model and a building-resolving large-eddy simulation (LES) model. In the LES, we examine the impacts of changing surface sensible heat fluxes on the turbulent flows and heat transfer in urban areas having various geometrical features in Osaka City and quantitatively assess the changes in turbulent momentum and heat transfers with the changes in urban surface fluxes in the urban areas. The district with high-rise buildings with a higher packing density effectively transfers heat, compared with the district with a lower packing density of buildings. The impact of the changes in surface sensible heat fluxes on precipitation intensity over a mesoscale area is examined with the WRF model through changing the surface fluxes. The change in the precipitation intensity and amount through changes in heat fluxes from the urban surfaces is quantitatively assessed from the hybrid analysis using the WRF and LES models.