Assessing the Impacts of Extreme Weather on Local-Scale Hazards in Urban Districts

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Abstract

Airflows over complex geometrical surfaces such as complex terrain and densely built urban districts are highly turbulent and sometimes become a threat under disturbed weather conditions. Among the meteorological disturbances, the landfalls of tropical cyclones cause strong winds and may lead to severe damages in populated urban areas and in mountainous areas. Because gusty winds are primarily a cause for damages, diagnosing and predicting quantitatively wind and turbulent characteristics are critically important. In order to assess strong wind hazards in complex urban areas, this study uses a large-eddy-simulation (LES) model with buildings and structures explicitly resolved at an O(1 m) grid spacing. With such a building-resolving LES model, we have analyzed turbulent airflows in urban districts of Japanese major cities and have found that the LES model is capable of estimating the magnitude of gusty winds and turbulent fluctuations. In order to improve the accuracy in representing the properties of airflows, we have developed a data assimilation method which incorporates observed turbulence. The proposed data assimilation method used a vibration equation which can incorporate turbulence winds toward target mean winds while maintaining small-scale turbulent fluctuations and was applied for airflows in actual urban districts of Kyoto City by incorporating data obtained from meteorological observations located in Kyoto. We have concluded that the data assimilation method using the vibration equation successfully nudges toward the target mean winds while maintaining small-scale turbulent fluctuations well. Our recent LES analyses of airflows in urban districts have been extended to studies related to the impact assessment of and the adaptation to climate change in urban areas. A building-resolving LES model has become a practical tool to more applied side of turbulent airflow analysis.

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