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Analysis of fine-scale airflows over complex topography by super-high-resolution numerical model

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With the increase in computational resources, mesoscale meteorological simulations with the grid spacing on the order of 100 m have been conducted not only in idealized studies but also in studies that deal with real cases. In real cases, the benefits from such high-resolution simulations are considered to be better representations of surface topography such as complex terrains and complex distribution of man-made structures. In this presentation, we will demonstrate how fine-scale airflows over complex topography such as terrains and urban districts are represented in numerical simulations of local-scale wind fields under real meteorological settings. Some of the case studies of high wind events are described. For the numerical simulations of specific weather events, we use the Weather Research and Forecasting (WRF) model by downscaling from kilometer-scales to 100-meter-scales with the use of nesting capability. Further downscaling from 100-meter-scales down to 10-meters or higher requires the explicit representation of not only complex terrains but also buildings and structures. For this purpose, we developed an approach to couple a mesoscale meteorological model (i.e., the WRF model) and a computational fluid dynamics (CFD) model (Nakayama et al. 2012). A large-eddy simulation model for airflows over urban geometries (Nakayama et al. 2011) is employed as a CFD model. A unique feature of the present coupling approach, an improved version of the perturbation recycling method of Mayor et al. (2002), is to generate turbulence due to urban-like roughness obstacles with the meteorological effects produced by the mesoscale model being retained. The basic idea of this coupling approach and a case study for a high wind event in the downtown district of Tokyo are demonstrated. Furthermore, some other applications of the present approach for airflow simulations over complex topography including airflows over complex terrain of Fukushima during March 2011 will be briefly introduced.

Keywords: High-resolution numerical model, airflows over complex topography, mesoscale meteorological model, large-eddy simulation