Assessment of Environmental Impact for AWS Observation Data Using a Computational Fluid Dynamics Model

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The effects of buildings and topography on wind speed and direction of automatic weather stations (AWSs) located on the central region of urban areas are investigated using a computational fluid dynamics (CFD) model. For more realistic representation of buildings and topography in the urban areas, the geographic information system (GIS) data are used as an input data. For each AWS station, 16 cases with different inflow directions are considered to evaluate the effects of buildings and topography on wind speed and direction of the AWSs. The results show that the flow patterns are very complicated due to the buildings and topography. The simulated wind speed and direction at the locations of the AWSs are compared with those of inflow. As a whole, the wind speed at the AWSs decreases due to the drag effect of buildings. The decrease rate of wind speed is strongly related with total volume of buildings which are located in the upwind direction. It is concluded that the CFD model is a very useful tool to evaluate suitability of AWS's location in urban areas.

1. Introduction

Over the past several decades, increasing urbanization have induced population growth and increase of industrial facilities in urban areas. In urban areas, buildings are a very important forcing acting on flow and dispersion (Kim and Baik, 2005). Automatic weather stations (AWSs) data is affected by surrounding buildings and topography in urban areas (Lee and Kim, 2011). Recently, observational environment in urban areas becomes worse due to urban renewal planning and residential redevelopment. Therefore, scientific and objective evaluation on AWSs is necessary. In this study, the effects of buildings and topography on wind speed, wind direction, temperature observation data of AWSs located on the central region of urban areas are investigated using a computational fluid dynamics (CFD) model.

2. Model description and experimental setup

The numerical model used in the study is the same as Kim and Baik (2010)'s computational fluid dynamics (CFD) model. Kim and Baik (2010) showed that the model can reproduce the wind and temperature profiles very well in the second street canyon of the Uehara et al. (2000)'s configuration. The model employs the k-ε turbulence closure scheme based on the Renormalization Group (RNG) theory and assumes a three-dimensional, nonhydrostatic, nonrotating, and boussinesq airflow system. The governing equation set is numerically solved on a staggered grid system using a finite volume method and the semi-implicit method for a pressure-linked equation (SIMPLE) algorithm.

For more realistic representation of buildings and topography in the urban areas, the geographic information system (GIS) data are used as an input data (Fig. 1). For each AWS station, 16 cases with different inflow directions are considered to evaluate the effects of buildings and topography on wind speed and direction of the AWSs.

3. Results and discussion

The results show that the flow patterns are very complicated due to the buildings and topography (Fig. 2). The simulated wind speed and direction at the locations of the AWSs are compared with those of inflow (Fig. 3). As a whole, the wind speed at the AWSs decreases due to the drag effect of buildings. The decrease rate of wind speed is strongly related with total volume of buildings which are located in the upwind direction. It is concluded that the CFD model is a very useful tool to evaluate suitability of AWS's location in urban areas.

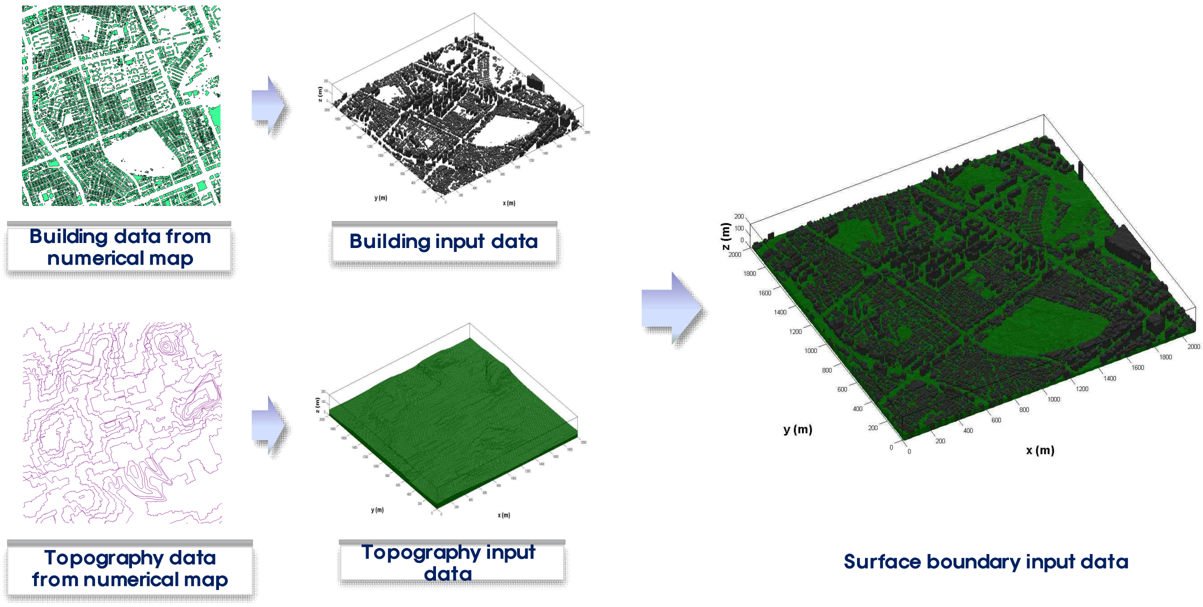

Fig. 1. Construction of surface boundary input data using GIS data.

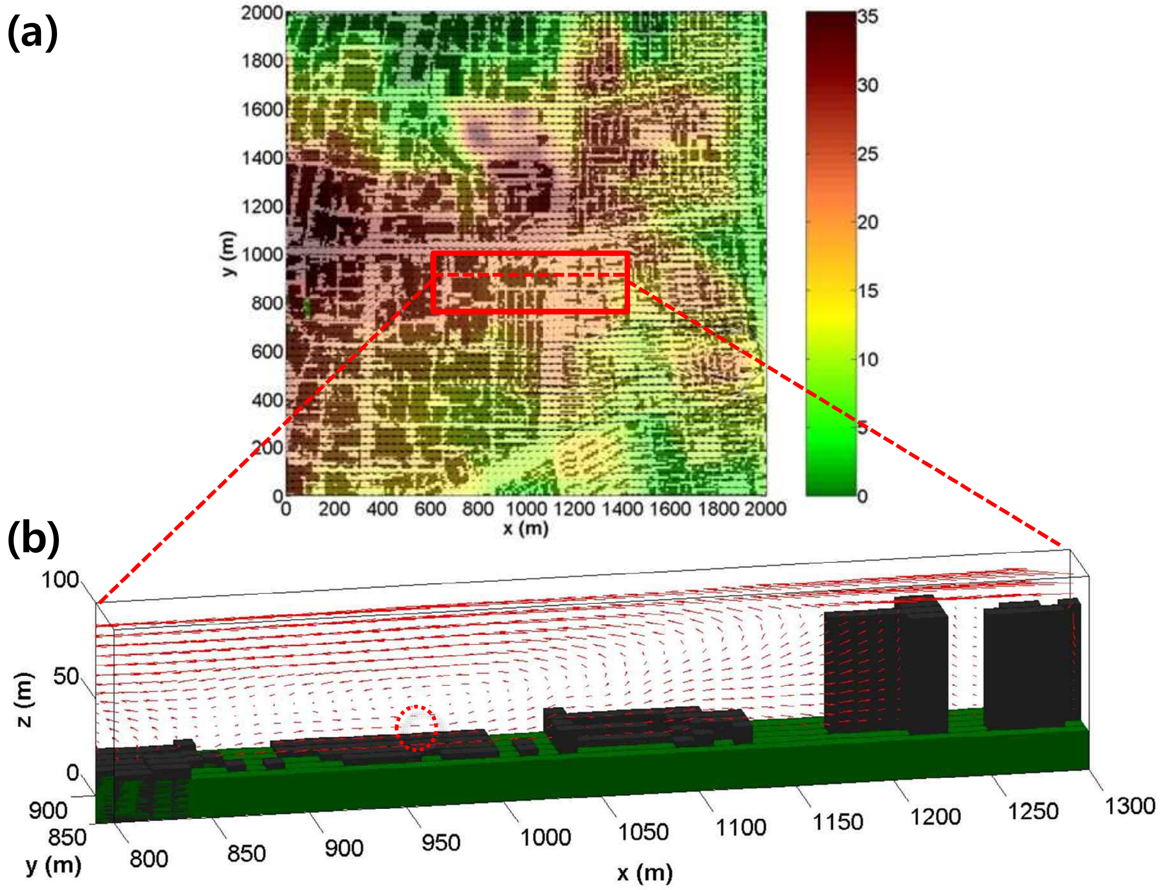

Fig. 2. The (a) Horizontal wind flow field around Seo-gu AWS (the color means an elevation height) and (b) vertical wind flow field near Seo-gu AWS.

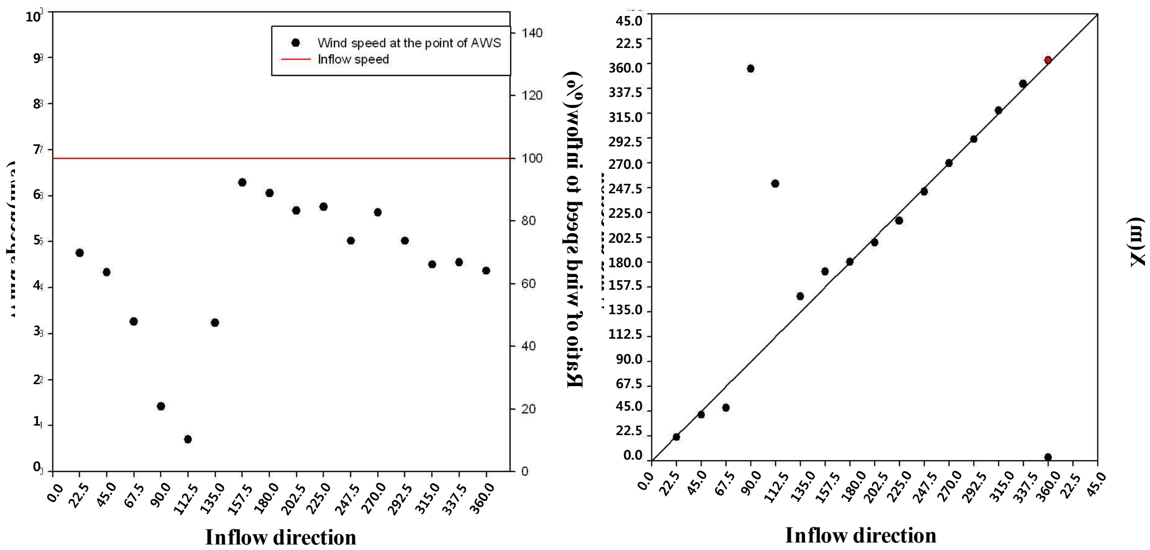

Fig. 3. The simulated wind speed (left), wind direction (right) at the Seo-gu AWS location compared with those of the inflow boundary.

Reference

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