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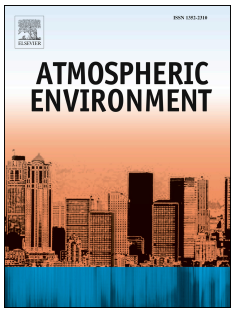

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Integrated analysis of numerical weather prediction and computational fluid dynamics for estimating cross-ventilation effects on inhaled air quality inside a factory

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Abstract

Mechanical and passive ventilation strategies directly impact indoor air quality. Passive ventilation has recently become widespread owing to its ability to reduce energy demand in buildings, such as the case of natural or cross ventilation. To understand the effect of natural ventilation on indoor environmental quality, outdoor–indoor flow paths need to be analyzed as functions of urban atmospheric conditions, topology of the built environment, and indoor conditions. Wind-driven natural ventilation (e.g., cross ventilation) can be calculated through the wind pressure coefficient distributions of outdoor wall surfaces and openings of a building, allowing the study of indoor air parameters and airborne contaminant concentrations. Variations in outside parameters will directly impact indoor air quality and residents' health. Numerical modeling can contribute to comprehend these various parameters because it allows full control of boundary conditions and sampling points. In this study, numerical weather prediction modeling was used to calculate wind profiles/distributions at the atmospheric scale, and computational fluid dynamics was used to model detailed urban and indoor flows, which were then integrated into a dynamic downscaling analysis to predict specific urban wind parameters from the atmospheric to built-environment scale. Wind velocity and contaminant concentration distributions inside a factory building were analyzed to assess the quality of the human working environment by using a computer simulated person. The impact of cross ventilation flows and its variations on local average contaminant concentration around a factory worker, and inhaled contaminant dose, were then discussed.

Keywords

Computational fluid dynamics; Numerical weather prediction; Dynamic downscaling; Cross-ventilation; Factory environment; Computer simulated person