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Evaluation of pollutant exposure using virtual walkers and large-eddy simulation: Application to an idealised urban neighbourhood

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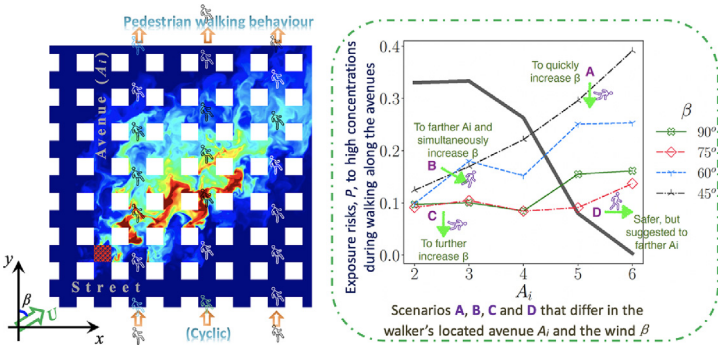
HIGHLIGHTS

- Exposure to an impulse release is quantified for virtual walkers using LES.
- Spatial variability of the exposure risk is well captured by moving receptors.
- Actual exposure of pedestrians can differ from simple Eulerian estimates.
- Evacuation routes are discussed for different walker locations and winds.

GRAPHICAL ABSTRACT



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ABSTRACT

Urban air quality studies have primarily focused on pollutant dispersion; however, spatial or temporal concentrations collected at discretely distributed grid points (or fixed receptors) do not reflect the actual pollutant exposure of pedestrians. Using large-eddy simulation (LES) with virtual walkers implemented, this study investigates pollutant exposure of walking agents (or moving receptors) in an urban turbulent boundary-layer flow developed over an aligned building array under the influence of different wind directions. The spatial variability of the exposure risks are found to be better captured by the moving receptors than the fixed receptors along the same agent walking tracks. We demonstrate that the actual exposure can differ significantly from results interpreted from data recorded by the fixed receptors (corresponding to Eulerian estimates) and show that large discrepancies occur in avenues near the source, wherein dispersion of the point release has not occurred on larger spatiotemporal scales. In most scenarios, optimal evacuation routes are shown to be ones that deviate as much as possible from the dominant wind direction; however, one needs to decide the priority of moving to further avenues first or immediately adjusting the walking direction. The results should serve as a useful baseline reference for environmental health impact assessment and evacuation route planning against hazardous releases of air pollutants in more complex urban environments.

1. Introduction

Rapid urbanization has significantly accelerated anthropogenic and industrial activities in and around urban areas. Emissions of gaseous pollutants are imposing increasingly growing risks to urban air quality (Wong et al., 2019; Zheng and Yang, 2022; Wang et al., 2022). In the case of

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