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Correlation and quantification of flow field and pollutant dispersion mechanisms in a single street canyon

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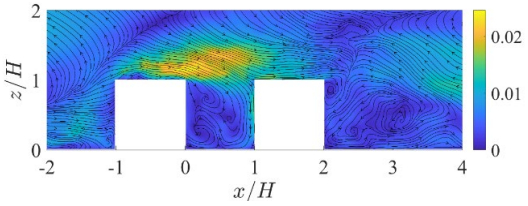
ABSTRACT

This study uses spectral proper orthogonal decomposition (SPOD) to dissect the flow field within a single street canyon (Fig. 1). SPOD captures the large-scale structures and small-scale vortices, and quantifies their respective impacts on pollutant removal above the canyon. The results indicate that pollutant dispersion in a single street canyon is affected by both advective and turbulent flows, while the latter is more influential in fully developed canyons. The study categorizes three SPOD mode types: 1) Mode A1, capturing flow separation and reattachment, has minimal effect on turbulent dispersion. 2) Modes B1-B3 (Fig. 2), linked to large-scale motions, influence sweep and ejection events and are thus pivotal to turbulent diffusion. These modes illuminate the stark contrasts between single and fully developed street canyon flows; in the latter, certain modes representing large coherent structures demonstrate a weak correlation between vertical and streamwise fluctuating components, thereby minimally impacting turbulent pollutant diffusion. 3) Modes C1-C2, associated with irregular small-scale vortices, vary in influence along the streamwise direction, significantly affecting the leeward side of the canyon. These insights facilitate understanding flow dynamics in urban environments and addressing city-scale pollutant dispersion challenges.



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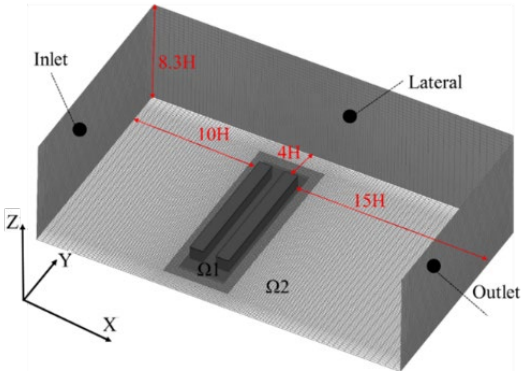

Fig. 1 CFD model of the street canyon

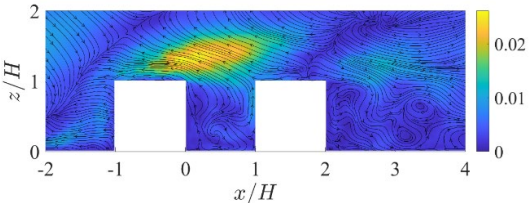

Fig. 2 SPOD mode of flow fields