# A reduced-order modeling procedure to isolating energy- and evolution-wise dominant features of fluid-driven pollutant dispersion in a street canyon

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**Abstract**. This paper develops a reduced-order modeling procedure, namely an adjoint Proper Orthogonal Decomposition (POD)-Dynamic Mode Decomposition (DMD) analysis, to isolate the energy and evolution-wise dominant features of fluid-driven pollutant dispersion in a street canyon. Based on large-eddy simulation (LES) results of a generic street canyon, this systematic procedure identified three types of flow field modes according to energetic and dynamic significance, providing useful guidance for pollutant dispersion phenomenon analysis.

## Introduction

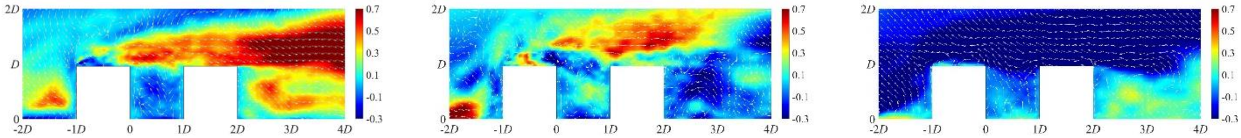
Among the present Reduced-order models (ROMs), Proper Orthogonal Decomposition (POD) is one popular scheme that has been widely employed to investigate pollutant dispersion and wake dynamics around buildings and moving vehicles [1]. The limitations of POD lie in its modes mixed in frequency components and its neglecting some low-energy modes that impose significant dynamical effects on the flow field. The former leads to difficulty identifying flow patterns corresponding to each dominant frequency. The latter leads to poor low-dimensional reconstruction models, even when the majority of energy in a dataset has been captured [2]. DMD is another purely data-driven ROM introduced by Schmid [3], in which each mode contains a unique frequency, providing great convenience in identifying specific dynamic features. However, DMD is weak in determining the highly physically relevant modes due to lacking an approach to ranking eigenvalue significance.

Due to the two schemes' limitations, this paper develops an adjoint POD-DMD analysis procedure to isolate dominant features of fluid-driven pollutant dispersion in a street canyon from the perspectives of both energetic and dynamic significance. The dominant flow field structure patterns and their contribution to pollutant dispersion are identified and summarized.

## Results and Discussion

In this paper, the adjoint POD-DMD procedure contains four steps. Firstly, conduct POD and DMD, respectively, to the raw flow field data. Secondly, based on the dominant frequencies of the high-energy POD mode, identify three types of DMD modes according to energy contribution and dynamical effects. Thirdly, conduct superposition to DMD modes within a type to identify the key features, as shown in **Fig. 1**. Finally, corresponds the dominant flow patterns to possible pollutant dispersion phenomenon.

Results show that energetically & dynamically significant modes (**Fig. 1a**) show the mainstream and the main vortex structures occurring near the stagnation point, the separating point, and the fluid reattachment area. Energetically significant & dynamically insignificant modes (**Fig. 1b**) represent where the turbulent kinetic energy is the largest, leading to periodically sudden pollutants increase near the building roofs and the wake region. Energetically insignificant & dynamically significant modes (**Fig. 1c**) show the reversed flow structures occurring near the stagnation point, inside the street canyon, and in the wake region, leading to slow but continuous pollutant increase near the upstream building roof and the windward wall.




(a) (b) (c)

**Fig. 1** Normalized velocity vectors of (a) energetically & dynamically significant modes (b) energetically significant & dynamically insignificant modes (c) energetically insignificant & dynamically significant modes

## References

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