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Modelling reactive pollutants in a deep urban street canyon

Challenges:

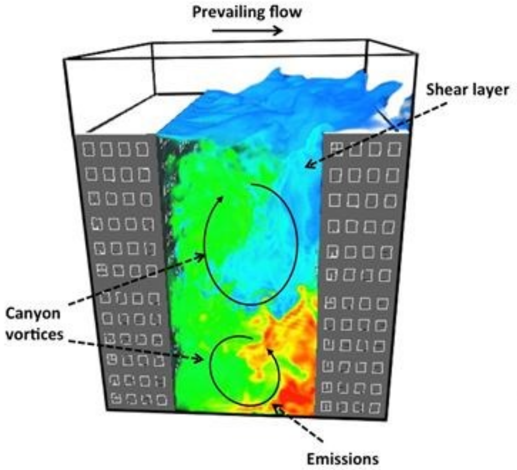
The street canyon is the basic geometric unit in the built environment and typically describes a place with surrounding buildings on both sides of the street. Buildings are the artificial obstacles to urban atmospheric flow and give rise to limited ventilation, especially for deep street canyons. The deterioration of urban air quality occurs due to the combined effects of traffic emissions, dynamics and chemistry within such an atmospheric compartment. Understanding both dynamical and chemical processes of reactive pollutants in street canyons is of vital importance to effectively quantify air quality and to help the urban planners develop policies (e.g. for street canyon design and traffic management) to mitigate the adverse impacts of air pollution.

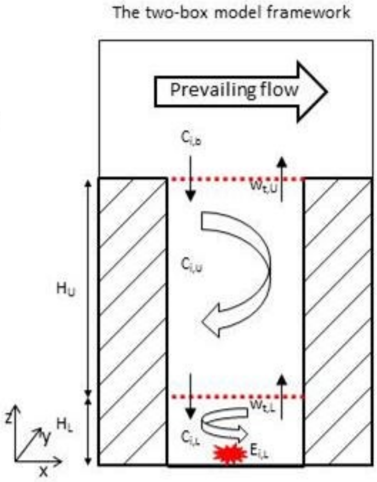
Solution:

A large eddy simulation (LES) model coupled with O_3-NO_x-VOC chemistry has been adopted to simulate the coupling effect of emissions, mixing and chemical pre-processing within an idealised deep (aspect ratio = 2) urban street canyon under a weak wind condition. A simplified two-box model coupled with chemistry has been developed to capture the concentration contrast between the lower canyon (box) and the upper canyon (box), which reflected the potential segregation effect caused by the two counter-rotating vortices.

Results:

There were significant spatial variations of reactive pollutants in the presence of two vertically aligned unsteady vortices formed in the canyon. The within-canyon pre-processing would lead to chemical conversion of NO to NO_2 and an increase in the oxidant fluxes released from the canyon to the overlying canopy layer, and this effect was more significant for the deeper street canyon than the regular canyon (with an aspect ratio of 1). In general, the simplified two-box model performs pretty well compared with the "more realistic" LES-chemistry model.





Case study

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Product Used
OpenFOAM : parallel computation of LES-chemistry model
VAPOR for 3-D data visualisation
Fortran code for data post-processing
R for graphics

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