Influence of urban greening on air quality: A computational study of the effect of trees on turbulent dispersion of air pollutants in a street canyon

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Project description: Global climate change and worldwide urbanization challenge quality of life with regard to comfortable climate and good air quality. Risks associated with extreme weather in cities, such as heat waves, are projected to increase with global climate change; world population of urban residents (currently above 50%) is also projected to increase sharply in this century. One of the emerging ideas to mitigate the effects of climate change is urban greening, e.g. by planting more trees along streets. However this may reduce the ventilation of air pollutants below the tree canopy (MacKenzie et al. 2010; Pugh et al. 2012) and may worsen air quality at the street level. The effects of street trees on urban climate and air quality have been little studied, because direct simulation of flow through and around trees is difficult. *This project aims to quantify the effects of trees on the street canyon flow and dispersion of air pollutants using the powerful large-eddy simulation (LES) methodology which reveals the detailed turbulent processes involved*. The project will address the following issues: (i) how the ventilation is affected by a combination of building geometry, tree characteristics, and wind condition; (ii) how the altered ventilation influences the street level air quality for local traffic emissions inside the street canyon; (iii) how the altered ventilation influences the penetration of background pollution source into the street canyon; and (iv) whether it is feasible to derive a parameterization scheme for the users of the research outcome. A comprehensive dataset obtained from wind-tunnel experiments will be used to evaluate the model performance. The results of the project can be used as guidance for assessing the mitigation strategy of urban greening and the parameterization scheme can be implemented in box models as well as meso-scale models.

Approach: The research team at University of Birmingham has developed a large-eddy simulation code for both city-scale and building-scale simulations (Cui et al, 2004; Cai et al. 2008). Fig. 1 shows a few examples of simulated concentration field of a scalar in street canyons with various street widths. In this proposal, the code will be modified to consider trees. The wind-tunnel data (Gromke & Ruck 2007) will be used to evaluate the new code. After the evaluation, simulations will be conducted for a list of combination of following variables: building geometry (different canyon aspect ratio), tree characteristics (location of leaves; leaf density varying with season and tree type), wind condition (different wind speed & direction), and emissions source (either the emissions inside the canyon or the background pollution above the building roofs). The quantities to be assessed are: mean wind and pollutant concentration pattern, turbulence quantities, and exchange velocity at the roof level.

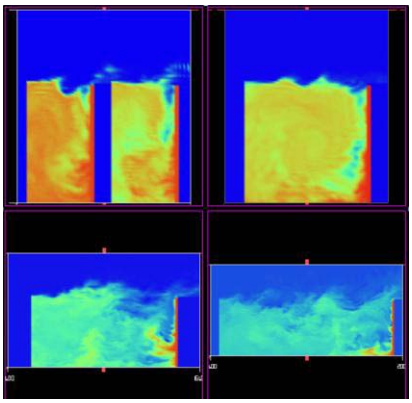

Fig. 1 Simulated flow & dispersion in street canyons with various street widths from the large-eddy simulation model at Birmingham.

Training: The goal of this project is to train the student to become a mature researcher with the expertise and skills in the areas of large-eddy simulation, turbulence & dispersion modelling, and urban air quality. The University's IT Services provide subject specific training, e.g. UNIX, parallel computation, computing languages (Matlab, R, and FORTRAN). Apart from receiving generic training from the University's programme, the student will receive training on LES.

References

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