Wake Characteristics of Tall Buildings in a Realistic Urban Canopy

Explainer | An explainer on research from the Climate Science for Service Partnership (CSSP) China for decision-makers in China // No. 13

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Summary

Tall buildings (>50m height) are becoming increasingly common in urban areas and can affect the urban climate locally and across neighbourhoods. Tall buildings also interact with low-rise buildings. Compared to tall buildings in isolation, the presence of a low-rise canopy of smaller buildings displaces the building wake (the flow of air immediately behind the building) vertically, so that flow speeds are reduced over longer distances downwind well-above street-level. Current pollution dispersion and urban air quality models do not capture this so may predict pollutant spread incorrectly.

Why?

Based on current UN estimates, by 2050 over 6.6billion people (68% of the world's population) will be living in cities. Across the world, tall (>50m height) and super-tall (>300m) buildings define the skylines of many large cities and will continue to become more common.

Tall buildings, in isolation or as clusters, affect the urban micro-climate of local surroundings and the neighbouring region. The impact on aerodynamics (e.g. local flow distortions, long-range wake effects), radiation budget (e.g. the shadows buildings cast) and components of the surface energy balance (e.g. storage of heat in building materials, anthropogenic heat emissions) can be large compared to low-rise buildings. Tall buildings strongly change pedestrian-level winds in the surrounding streets and the flow field above the roofs of low-lying buildings. This affects pollutant pathways, which may affect disease transmission, and the overall ventilation potential of cities. Flow interactions between tall and low-rise buildings also change the structure of the wind fields behind tall buildings.

How?

A 1:200 scale 3D-printed model is used within a wind-tunnel to represent a (simplified) region of central London which contains three buildings taller than 32m (tallest is 134m). Buildings are represented by blocks, without small-scale façade details (*figure 1*). The model is positioned on a turntable to allow different wind directions to be explored and different configurations of the model are used: tall buildings only, low-rise only and tall and low rise combined to represent the real-world case. These measurements remove some of the complexity of the real-world atmosphere, whilst capturing the mean flow behaviour.

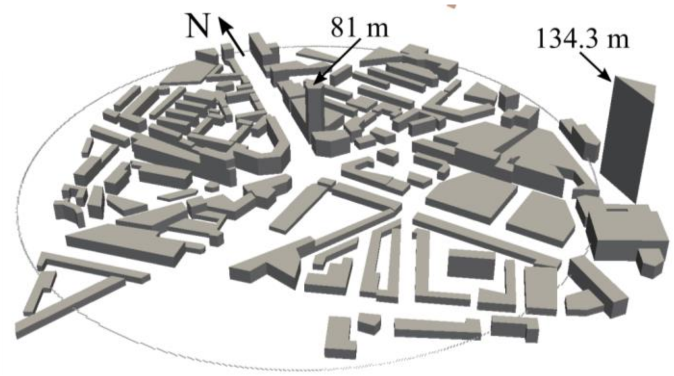

Figure 1: The 3D simplified model.

What now?

Understanding and quantifying tall-building impacts on the near-surface atmosphere over cities is essential. Computerised forecasting models (e.g. weather prediction, air quality) need to take into account the urban roughness and often large range of wind-field effects caused by tall buildings.

References

Hertwig, D., Gough, H.L., Grimmond, S. *et al.* Wake Characteristics of Tall Buildings in a Realistic Urban Canopy. *Boundary-Layer Meteorology* **172**, 239–270 (2019). https://doi.org/10.1007/s10546-019-00450-7