Geophysical Research Abstracts
Vol. 21, EGU2019-6787, 2019
EGU General Assembly 2019

Mean flow and momentum transport in idealised heterogeneous urban canopies

Birgit Sützl (1), Maarten van Reeuwijk (1), and Gabriel Rooney (2)

(1) Civil and Environmental Engineering, Imperial College London, London, United Kingdom (b.sutzl@imperial.ac.uk), (2) Met Office, Exeter, United Kingdom

One of the complexities of modelling urban climate comes from the heterogeneity of urban areas. Densely mixed building units of various sizes and shapes, complex road networks, paved surfaces, water and urban vegetation all interact with each other and the atmospheric boundary layer.

The present study investigates the role of urban surface heterogeneity on mean wind flow and vertical momentum transport over idealised urban areas. Large-Eddy Simulations (LES) with the DALES-Urban model are used to compare mean flow and momentum transport of several simulation setups with similar building density and frontal aspect ratio, but varying levels of complexity of buildings and street geometry. We compare simulations with different amounts of buildings, uniform and heterogeneous building heights, and varying building plan area and street geometry.

Increasing the heterogeneity of surface layout increases average building-induced drag and turbulence-related momentum fluxes, and thus increases overall momentum sinks. Heterogeneity parameters such as maximum building height, average building height weighted by frontal area, and weighted building height deviation are identified as predictors for an increased rate of momentum loss within heterogeneous canopies.

Analysis of mean wind flow and vertical momentum transport profiles further reveal distinct features of heterogeneous urban surface flows. For example, mean wind flow profiles of the simulations with homogeneous building heights show a clear separation in within canopy flow and above canopy flow. Within the canopy, air flow is obstructed by buildings. Above the canopy, a logarithmic boundary layer profile develops and the velocity profile changes from concave (within) to convex (above the canopy). Simulations with heterogeneous building heights lack a clear separation in above- and within-canopy flow, instead the velocity profiles show a gradual change from approximately linear (within) to strictly convex (above the canopy).

The study highlights the importance of accounting for surface heterogeneity in parameterisations of urban air flows, as homogeneous building blocks have significantly lower drag and momentum loss due to turbulence than heterogeneous layouts. An underestimation of drag in urban models will affect the prediction of parameters such as height of the Urban Boundary Layer or friction velocity, and can worsen prediction of urban climates. Therefore it is important to estimate realistic levels of drag and turbulence in urban models.