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Effect of Roughness on Vertical Dispersion Coefficient over Idealized Urban Street Canyons under Neutral Stratification

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Ground-level pollutants (e.g. vehicular emission) are the primary pollutant sources affecting the public health and living quality in many modern compact cities. Thus, it is necessary to estimate the pollutant concentration and distribution in urban areas in a fast and reliable manner for better urban planning. Gaussian plume dispersion model is commonly used in practice. However, one of its major parameters, dispersion coefficient, often overlooks the effect of surface roughness so its accuracy in urban application is in doubt. In the existence of large-scale roughness element, the calculation of pollutant distribution in the urban boundary layer (UBL) would be prone to error. Our previous studies, using identical street canyons, have shown that urban (rough) surfaces modify pollutant dispersion significantly. To further look into the correlation between surface roughness and turbulent dispersion, non-uniform rough surfaces constructed by buildings of different heights are used in this study instead. A series of large-eddy simulations (LESs) with street canyons of non-uniform heights and ground-level passive pollutant sources in neutral stratification are performed. Buildings with two different heights are placed alternatively in the computational domain to construct street canyons in cross flows.
LES results show that non-uniform building height greatly increases the aerodynamic resistance of narrow street canyons. In-line with our previous findings, the variables used in parameterization of vertical dispersion coefficient depend on the friction factor in a way similar to that of uniform street canyons. Besides, the air exchange rate (ACH) of street canyons increases with increasing friction factor, thus street-level ventilation could be improved by introducing building height variability (BHV). It is also demonstrated that aerodynamic resistance is one of the key factors affecting urban air quality. Moreover, friction factor is a useful parameter to parameterize the dispersion coefficients over urban roughness.