Geophysical Research Abstracts
Vol. 14, EGU2012-3888, 2012
EGU General Assembly 2012

On the Aerodynamic Characteristics over Idealized Two-Dimensional Urban Street Canyon Models

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There are numerous anthropogenic pollutant sources in the atmospheric boundary layer (ABL) nowadays, which mainly attributed to human activities in urban areas. Hence, how urban morphology affects the heat and mass transfer in built environment is a popular research problem in the urban climate community. However, our understanding of street-level transport processes is rather limited. Laboratory experiments often serve as complementary solutions to modeling results. Although there are laboratory results available for the mass transfer over idealized urban roughness, the transport processes are not examined in details. In this paper, we attempt to demystify the pollutant removal mechanism from urban areas to the urban ABL. Laboratory measurements, which were conducted in the wind tunnel in Mechanical Engineering, The University of Hong Kong, and computational fluid dynamics (CFD) is used concurrently. The spatial air pollutant transport from the street region to the urban ABL was represented by means of water evaporation method from the soaked filter paper applied on the surfaces of the building facades and ground surface. Street canyon models of building-height–to-street-width (aspect) ratios in the range of 0.125 to 2 are carried out. The local mass transfer velocity along the street canyons was measured and archived a good comparison with the outside literature. Besides, both the laboratory and CFD results show that the pollutant removal from 2D street canyons increases with decreasing ARs. It arrives a local maximum then decreases thereafter. In the comparison between laboratory and CFD results, the difference in the size of the street canyon models, also known as scaling effects, is needed to be considered. Therefore, despite of representing the transfer behavior by the local pollutant exchange rate, scaled local/overall pollutant removal coefficient is proposed for a comparison of pollutant removal performance in a more reasonable manner. Such effect is found to be governed by street geometries. Additional sensitivity tests are undertaken to elucidate the behaviors as a function of aspect ratios.