Geophysical Research Abstracts
Vol. 21, EGU2019-11935, 2019
EGU General Assembly 2019

Field Experimental Study on the Influence of Street Aspect Ratio and Urban Thermal Storage on Thermal Environment at Scale Model

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Street aspect ratio and urban thermal storage are significant to influence urban ventilation, urban thermal environment and subsequently building energy consumption in cities. We performed scale-model outdoor field measurement of urban turbulence and thermal environment over three days in summer of 2016-2017 in Guangzhou, China. The ground area of outdoor field measurement is 4800 m2 with concrete floor and far away from the surrounding buildings which produce little influence in most wind directions. Two types of north-south street canyons (building height H=1.2m, street width W=1.2m, 0.6m, 0.4m; Aspect ratio H/W=1, 2, 3) were investigated. The 'empty' street canyon model consists of 1000 hollow buildings with wall thickness of 1.5cm and the 'sand' model is made up of 1000 buildings filled with sand producing bigger heat capacity. The velocity and turbulence distribution, air temperature and basic characteristics of radiation in and above the idealized street canyons were measured by using ultrasonic anemometers, temperature and humidity sensors, four-component radiometers, infrared camera. Especially the impacts of different building heat storage and street aspect ratio on urban thermal environment were emphasized.

Under realistic meteorological conditions, this study found that the diurnal cycle characteristics of wall temperature are obvious. The wall heats up in the morning, and reaches the highest temperature in the afternoon (about 15:00pm), and at night it is cooled down mainly by longwave radiation and convective ventilation. During the daytime, the narrower street canyon has weaker ventilation but better solar shading effect. The wider street (H/W=1) warms up more quickly, and at night, it cools down more quickly than the narrower streets (H/W=2, 3). Thus street aspect ratios produce complicated non-linear impacts on urban thermal environment. What's more, the street mean temperature and temperature amplitude all decline as building density increases. The thermal storage capacity in the empty model is much smaller than the sand model. Therefore, during the daytime the wall temperature (Twall) of empty model reached its peak earlier in the afternoon and this peak value is much higher than those of the sand model. After sunset, results are quite contrary: Twall in the sand model are higher than those in the empty model because the sand model stores more heat in the daytime and releases much more heat at night than the empty model. The findings between infrared temperature and thermocouple temperature are consistent, it can provide benchmark data for numerical simulation and theoretical model when we combine with the turbulence, air temperature, radiation and other observations.

ACKNOWLEDGEMENT
This study was financially supported by the National Natural Science Foundation of China (No 51478486 and 41875015) and National Natural Science Foundation–Outstanding Youth Foundation (grant No. 41622502)