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Basic Features of Urban Energy Balance in High-rise High-density Urban Models Obtained from the Outdoor Scale Model Experiment

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The experimental studies of the daily urban surface energy balance (UEB) in high-rise high-density urban districts are still few so far. This paper, experimentally investigated the daily UEB in such urban model by the open-path eddy covariance system in the scale-model outdoor field experiment in the suburb of Guangzhou which locating the East Campus of Sun Yat-sen University from August to December, 2017,including 3 days in summer,11 days in autumn and 9 days in winter. The idealized urban model consist of 2900 concrete square building models (58 rows, 50 columns) with the height of H=1.2m and building width of B=0.5m. The street width is W=0.5m producing street aspect ratio of H/W=2.4 and building area density of λp=0.25 and frontal area density of λf=0.6. The ground area of outdoor field measurement is 2900 m2 with concrete floor and far away from the surrounding buildings in most wind directions. The influence of the surrounding buildings under nine wind directions are evaluated by wind tunnel experiments. Most of the time the models are empty with building wall thickness of 1.5cm, to raise the urban thermal storage, we also measured the UEB with all buildings models filled with water in November 2017. And we make a comparison between clear sky day and occasionally cloudy day to analyze the different features of the UEB in various weather conditions. We also calculated the building surface heat flux (i.e. urban heat storage items in by energy balance) by using the measured history of temperature variations at building surfaces and within building models by thermal couples.
For empty building models, the results indicate that the features of the UEB as follows:(1) In clear sky conditions, the diurnal variations of net radiation(Q*), solar shortwave radiation and surface longwave radiation in urban areas show a single peak, and the values of Q* are positive in the daytime and negative at night. But in occasionally cloudy day, more complicated characteristics may occur in cloudy conditions. (2) Due to the impermeability of concrete underlying surface, the normalized sensible heat flux QH/ Q* is much bigger than the normalized latent heat flux QE/Q*. Moreover the QH/ Q*rises when the friction velocity (u*) increases. (3)The heat storage (ΔQS) acts as the main source and sink item in the surface energy balance. The values of ΔQS / Q*in summer (0.48) tend to be much larger than that in winter (0.25). Finally, with building models filled with water, ΔQS / Q*is found to be greater than that with empty building model.

KEY WORD: Urban surface energy balance (UEB), Scale-model outdoor field experiment, Diurnal variations, Thermal storage.

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