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Measurements and simulations of energy fluxes over a highly-dense and compact urban area in Hong Kong

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Energy fluxes measurements in the highly-dense and compact urban area are rare and challengeable due to the complex urban surface. This study assessed the surface energy flux observations over a highly-dense urban area in Hong Kong and compared the estimations of anthropogenic heat fluxes (Qf) derived from two inventory methods (i.e. LQF model and Kanda Global Anthropogenic Heat Datasets) and the energy balance residual method. Eddy covariance measurements were carried out from Sep 2018 to Dec 2018 at a building roof. Net radiation (Qn), turbulent sensible (Qh) and latent (Qe) heat fluxes were measured from the eddy covariance system, Qf was derived from the above methods, and the net storage heat flux (Qs) was estimated by the objective hysteresis model. The energy fluxes exhibited obvious diurnal variations but no significant difference among each month. Qn displayed a daily fluctuation of about 600 Wm-2. Qh dominated in the daytime with a largest value of 620 Wm-2, and the average fluctuation of Qe was around 100 Wm-2. The simulated Qs had the largest value of 280 W m-2. The results of Qf simulations based on the two inventory methods were consistent, with the daily magnitude of 700 Wm-2 in September and 500 Wm-2 in December. However, Qf calculated from the energy balance residual method (regarding Qf as the residual of Qn, Qh, Qe and Qs) presented significant fluctuations during the simulation period and a large underestimation (200-400 Wm-2) comparing with the inventory methods. On the other hand, based on the measured Qn, Qh, Qe and the simulated Qf from LQF, Qs, the energy balance closure ratio [EBCR=(Qh+Qe+Qs)/(Qn+Qf)] displayed significant difference between the day and nocturnal times of the four months. The best EBCR was observed in the day time of Sep with a value of 0.6 and EBCR values less than 0.1 always appeared in the nocturnal time during the observation period. The serious energy imbalance could be associated with the complex source areas. A 3D footprint analysis combining with computational fluid dynamics model should be applied to estimate the potential contribution from the spacing between buildings in the future. This study was carried out in the compact area of a megacity with large population density and extended our understanding of energy fluxes in such environment.