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Observing the surface radiation and energy balance, carbon dioxide and methane fluxes over the city centre of Amsterdam

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Cities largely affect boundary-layer climates due to complex surface structures, pollutant emissions, and anthropogenic heat release. As urban populations are expanding worldwide, insight is required into the urban surface radiation and energy balance and urban greenhouse gas fluxes. However, little long-term flux measurement records are available for dense city centres. We present one year (June 2018 - May 2019) of flux observations taken at a 40-meters tower in the city centre of Amsterdam. We analyse the diurnal and seasonal variation of the turbulent and greenhouse gas fluxes, and we estimate the flux footprint to gain insight in flux variation with wind direction. Also, anthropogenic heat flux and storage fluxes are estimated from emission inventories and the objective hysteresis model respectively. This analysis shows that, especially during the winter, the sum of the sensible and latent heat flux exceeds the net radiation. Thus, the storage flux and anthropogenic heat flux are significant energy providers. Also, we find a surprisingly good surface energy balance closure, especially during summer. To achieve annual energy closure, the sensible heat and latent heat flux require an increase of 13%. Moreover, we find that the measured carbon dioxide flux (45 kg CO_2 m^{-2} y^{-1}) is close to bottom-up source quantification (47 kg CO_2 m^{-2} y^{-1}). For some wind directions, the agreement is better than for others. In addition, we show that the annual methane emission is slightly higher than the emission found in Florence and London. Yet the methane source partitioning in Amsterdam remains open for more research.

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