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Urban turbulence fluxes for free! Estimating the surface fluxes for heat, moisture and momentum over cities from crowdsourced observations.

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The interest in urban meteorology is growing and thus the need to understand and quantify the urban energy balance consisting of the sensible heat flux (QH), the latent heat flux (QE) and the momentum flux (u*) is essential. However, professional meteorological flux observations over cities are scarce and challenging to maintain. Nevertheless, many cities have a dense network of personal weather stations, operated by citizens. This study presents a model to estimate turbulence fluxes over cities that is driven by air temperature, wind speed, and relative humidity from urban weather stations and by information about the urban morphology. The model was tested against flux observations in Amsterdam (the Netherlands) once fed with professional observations from the automatic weather stations of the Amsterdam Atmospheric Monitoring Supersite and once from crowdsourced observations Netatmo personal weather stations. Overall, for both professional and crowdsourced input the estimated QH and u□ agreed with the observations, whereas the model performed relatively poor for QE. Using crowdsourced input resulted in nearly identical root mean squared errors (RMSE) for QH and QE as using professional input, whereas for u□ the RMSE was smaller when professional input was used. The model performed better during daytime, under conditions with few clouds and without precipitation. Also, we test the approach for Vienna (Austria) and Tokyo (Japan), and develop the approach further and show that the spatial variability of the temperature across an urban network can be used as proxi for the downwelling solar radiation. Although there is room for model improvement, our results illustrates the potential of using crowdsourced observations to estimate the urban surface fluxes for heat, moisture and momentum.