Geophysical Research Abstracts
Vol. 18, EGU2016-14996, 2016
EGU General Assembly 2016

Spatial impacts of urban structures on micrometeorological variables

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The heterogeneity of urban surfaces including buildings and the urban vegetation causes high variability of micrometeorological variables on small spatial scales which makes it hard to observe or even predict climate conditions and in particular evapotranspiration with high resolution on the scale of entire cities. Regarding future climate changes and their impacts on urban climate and hydrology the predictability of these small scale variations becomes more and more relevant i.e. for city planners to improve the development of appropriate mitigation strategies. Therefore, new transfer functions for meteorological variables are needed, which consider the structural variability in urban areas and its impacts on the energy balance (shading effects, ventilation, lateral longwave energy fluxes).
We approach this goal by testing a mobile meteorological station (the station is mounted on a bicycle trailer and transported by an E-Bike) as a means to derive empirical spatial transfer functions for specific urban structures. We observe air temperature and relative air humidity at 2 different heights, wind direction and speed, incoming and outgoing shortwave radiation as well as infrared temperature from above and below and the four directions. First measurements have been performed in December 2015 at 22 locations in four clusters, which represent manifold different characteristics of urban areas within the city of Freiburg. Every location has been monitored two to six times. Overall, nearly 200 measurements of each variable have been taken. Each measurement takes five minutes. Values are logged every 15 seconds. These measurements were analyzed with regard to a climate station mounted on a rooftop in the proximity of all clusters.
Results show a systematic pattern in the differences between the values taken with the fixed and those taken with the mobile climate station, depending on the measurement locations. For example, lower air temperature and higher relative air humidity can clearly be observed for a larger green space. In areas that are shaded by buildings, air temperature is lower than at the fixed station. We can also observe a higher amount of reflected shortwave radiation on locations with brighter ground cover. We are able to detect thermal radiation by buildings. The detected pattern is most distinctive at days with high incoming solar radiation for all observed parameters except wind. For wind, wind tunnel effects can clearly be shown for locations which are confined by high buildings on two sides.
As the results show, the selected method is a suitable approach to assess the variability of micrometeorological variables on small spatial scales in an urban surrounding. Further testing is still needed especially with regard to the influence of the source area of the observed air mass on the measurement results and how the measured variables change i.e. with increasing/decreasing distance to a building, solitary tree or green space.