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Quantifying the Effect of Urban Heat Advection using Crowd Weather Stations

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Detailed measurements are indispensable in order to understand small-scale urban climate effects. With professional weather stations (PWS) mostly being available outside of cities with few sites per city, alternative data sources such as crowd-sourced weather data have proven to be valuable. Often the Urban Heat Island (UHI) is studied under ideal calm conditions when its development is strongest. At the same time, it has been shown that wind leads to advection of urban air, impacting regions downwind of urban areas and within the city.

We aim to provide insights into the effects of Urban Heat Advection (UHA) in the Urban Canopy Layer (UCL). The metropolitan regions of Paris and Berlin were studied, using four years (2019 - 2022) of quality-controlled crowdsourced air-temperature data from thousands of privately-owned Crowd Weather Stations (CWS). Those data were combined with global ERA5-Land data to overcome gaps in rural CWS coverage and globally-available Local Climate Zone (LCZ) information.

It is shown that wind causes increased exposure to urban heat for areas located downwind of the city core, which was derived using a LCZ-weighted centroid detection.

For all observed wind directions, classified by dynamically moving wind sectors, differences in spatial patterns were visible with the effect being strongest with regional wind speeds of 3 $m \cdot s^{-1}$. The results highlight the importance of considering the effects of UHA when studying the UHI to avoid underestimating the exposure to urban heat in downwind areas of the city. The results could be used as a starting point for coupling the conditions in the Atmospheric Boundary Layer with the resulting conditions in the UCL, utilizing a large database with crowdsourced CWS data.