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Crowdsourcing urban air temperatures from smartphone battery temperatures

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Accurate air temperature observations in urban areas are important for meteorology and energy demand planning. They are indispensable to study the urban heat island effect and the adverse effects of high temperatures on human health. However, the availability of temperature observations in cities is often limited. Here we show that relatively accurate air temperature information for the urban canopy layer can be obtained from an alternative, nowadays omnipresent source: smartphones. In this study, battery temperatures were collected by an Android application for smartphones. It has been shown that a straightforward heat transfer model can be employed to estimate daily mean air temperatures from smartphone battery temperatures for eight major cities around the world. The results demonstrate the enormous potential of this crowdsourcing application for real-time temperature monitoring in densely populated areas.

Battery temperature data were collected by users of an Android application for cell phones (opensignal.com). The application automatically sends battery temperature data to a server for storage. In this study, battery temperatures are averaged in space and time to obtain daily averaged battery temperatures for each city separately. A regression model, which can be related to a physical model, is employed to retrieve daily air temperatures from battery temperatures. The model is calibrated with observed air temperatures from a meteorological station of an airport located in or near the city. Time series of air temperatures are obtained for each city for a period of several months, where 50% of the data is for independent verification. The methodology has been applied to Buenos Aires, London, Los Angeles, Paris, Mexico City, Moscow, Rome, and Sao Paulo. The evolution of the retrieved air temperatures often correspond well with the observed ones. The mean absolute error of daily air temperatures is less than 2 degrees Celsius, and the bias is within 1 degree Celsius. This shows that monitoring air temperatures employing an Android application holds great promise. This study will particularly focus on new results: The methodology has been applied to data from three cities in the Netherlands (Amsterdam, Rotterdam, and Utrecht) for the period June – August 2013. It is shown that on average 282 battery temperature readings per day are already sufficient to accurately estimate daily-averaged air temperatures. Results clearly deteriorate when on average only 80 battery temperature readings are available.

Since 75% of the world's population has a cell phone, 20% of the land surface of the earth has cellular telephone coverage, and 500 million devices use the Android operating system, there is a huge potential for measuring air temperatures employing cell phones. This could eventually lead to real-time world-wide temperature maps over the continents.