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Low-cost multi-vehicle air temperature measurements for heat load assessment in local-scale climate applications

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In the recent years there has been a strong interest in exploring the potential of low-cost measurement devices as alternative source of meteorological monitoring data, especially in the urban areas where high-density observations become crucial for appropriate heat load assessment. One of the simple, but efficient approaches for gathering large amount of spatial data is through mobile measurement campaigns in which the sensors are attached to driving vehicles. However, non-standardized data collecting procedure, instrument quality, their response-time and design, variable device ventilation and radiation protection influence the reliability of the gathered data. We investigate what accuracy can be expected from the data collected through low-cost mobile measurements and whether the achieved quality of the data is sufficient for validation of the state-of-the-art local-scale climate models.

We tested 5 types of temperature sensors and data loggers: Maxim iButton, Lascar EL-USB-2-LCD+ and Onset HOBO UX100-003 as market available devices and self-designed solar powered Arduino-based data loggers combined with the AOSONG AM2315 and Sensirion SHT21 temperature and humidity sensors. The devices were calibrated and tested in stationary mode at the Austrian Weather Service showing accuracy between 0.1°C and 0.8°C, which was mostly within the device specification range. In mobile mode, the best response-time was found for self-designed device with Arduino-based data logger and Sensirion SHT21 sensor. However, the device lacks the mechanical robustness and should be further improved for broad-range applications.

We organized 4 measurement tours: two taking place in urban environment (Vienna, Austria in July 2011 and July 2013) and two in countryside with complex terrain of Mid-Adriatic islands (Hvar and Korcula, Croatia in August 2013). Measurements were taken on clear-sky, dry and hot days. We combined multiple devices attached to bicycle and cars with different radiation protection. Duration of each measurement tour lasted approximately 2 hours covering the distances in radius of about 10-30 km, logging the air temperature and geographical positioning in intervals of 1-5 seconds.

The collected data were aggregated on a 100 m horizontal resolution grid and compared with the local-scale climate modelling simulations with the urban climate model MUKLIMO_3 initialized with the atmospheric conditions for a given day. Both measurement and modelling results show similar features for distinct local climate zones (built-up area, near water environment, forest, parks, agricultural area, etc). The spatial gradients in temperature can be assigned to different orographical and land use characteristics.

Even if many ambiguities remain in both modelling and the measurement approach, the collected data provide useful information for local-scale heat assessment and can serve as a base to increase the model reliability, especially in areas with low data coverage.