A compact and customisable street-level sensor system for real-time weather monitoring and outreach in Freiburg, Germany

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[Image 1: Weather Station in Freiburg]

[Image 2: Weather Station in Freiburg]

[Image 3: Weather Station in Freiburg]

[Image 4: Weather Station in Freiburg]

[Image 5: Weather Station in Freiburg]

[Image 6: Weather Station in Freiburg]

[Image 7: Weather Station in Freiburg]

[Image 8: Weather Station in Freiburg]

[Image 9: Weather Station in Freiburg]

[Image 10: Weather Station in Freiburg]

[Image 11: Weather Station in Freiburg]

(1) Freiburg’s Weather Sensor Network

Our two-tiered weather sensor network (WSN) aims to map, for example, localised thermal heat stress, heavy precipitation events or air quality, spatially resolved across cities at high temporal resolution. Therefore 13 Tier 1 and 29 Tier 2 stations are installed across Freiburg (Fig. 1). Installed within the canopy layer height at ~3 m on city-owned street lights, the stations are capable of mobilising intra-urban variables and microclimates at the level of people. To quantify the impact of different environments on heat stress, the stations are placed in urban and rural areas (Fig. 21, 22, 23).

(2) In-House Developed Data Logger

Modular? Scalable? Customisable? That’s what our custom data logger offers, besides real-time data transmission and remote interaction capabilities. Built with easily obtainable components such as the Raspberry Pi Zero and Arduino analog, digital and ISRA-10 based sensors can be read. Data is stored in the onboard data storage and transmitted via Wi-Fi to a server (Fig. 3).

(3) uniWeather App

The uniWeather app [2] allows for near-real-time data access and interpretation for stakeholders and public outreach. Different visualisation types and variables can be selected for the last 5 min and 24 h (Fig. 4). 41, 42, 43). The system is open to be used by other groups for their data visualisation.

(4) Network Development

The developments were based on experiences from the previous Berlin campaign, where a similar logger system was needed. Initially, hardware was developed quickly, software developments and logger production (delayed due to global supply shortages) took most of the time (Fig. 5).

(5) The PCB

The heart of the Logger is the Raspberry Pi Zero (RPi). Building the components on perfboard is not efficient and would take too long, but thanks to an Analog Discovery tool, the RPi PCBs are already in small quantities. We were able to quickly manufacture professional logger boards. The PCB lay-out and Circuit Schematic are shown in Fig. 6.

(8) Thermal Comfort

Human thermal comfort can be expressed by indices such as Physiological Equivalent Temperature (PET) or Minimal Climatic Thermal Index (MCTI). The heating in Fig. 9 shows the hourly mean PET for Freiburg since August 2002, with anemometry values ranging from +14°C to +35°C. The recorded values are also used to validate high-res deep learning models of urban thermal comfort, see the map showing the hours per year with an LCTI > -32°C in 1° resolution (Fig. 10).

(9) Measured Variables

In addition to air temperature, humidity and precipitation, measured by the Tier 1 stations, the Tier 2 stations allocated data on wind. Remote sensing of meteo parameters from these, other meteorological and biomedical variables are obtained. Measuring thermal radiation is necessary to calculate thermal indicators such as the PET from above.

(10) Take-Home Message

Our weather station (uniWeather) can be used to study the impact of urban microclimates on people. In Freiburg, the system is installed in 24 stations and provides near-real-time information on thermal comfort, thermal stress and air quality. The system is open to be used by other groups for their data visualisation.

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References
