Enhance Urban Climate Understanding from a Comprehensive Meteorological Measurement Network

[1]Nico Bader, [1]Alexandra Reiss, [1]Nicolas Zurfluh, [1]Oliver Indra, [1]Sebastian Schlögl,[1]Karl G. Gutbrod
[1]meteoblue AG, Greifengasse 38, Basel, Switzerland

Introduction

- With the impacts of climate change, cities are increasingly exposed to extreme air temperatures, making effective heatwave management a critical priority.
- Localized measurements provide valuable insights into the variability of weather patterns and their effects on infrastructure and public health.
- Adaptation strategies, such as de-sealing surfaces, implementing rooftop greening, and adopting blue infrastructure solutions, are essential to mitigate the urban heat island effect.
- Monitoring and tracking these mitigation measures can establish a robust data foundation to support informed decision-making by city planners and policymakers.
- The "Basel Living Lab" exemplifies the wide-ranging applicability of a dense measurement network, offering key insights and actionable results from its analyses.

Methods

The measurement network in Basel, Switzerland

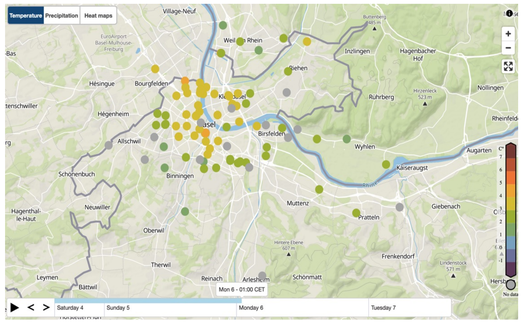

Figure 1: Map of the temperature network of the "Living lab" in Basel, established in 2019.

- The network comprises 200 meteorological IoT sensors from various providers, including Barani, Pessl, Sensirion, and Decentlab
- Measure key parameters such as air temperature, relative humidity, and precipitation with data quality ensured through rigorous error detection and correction processes
- In June 2023, 10 Campbell Blackglobe sensors were added measuring mean radiant temperature
- Further infrared measurements like camera images assess surface temperatures

Figure 2: Image of the black globe sensor (left). Example locations of the black globe sensors for the use case "sun vs. shade" (center). Image of the InfraTec VarioCAM HD research 900 used by meteoblue (right).

Project "Triangel"

- De-sealing of approximately 1 ha area and planting of 16 young trees in the beginning of 2021
- Installation of 3 air temperature sensors in the Triangel area, 12 sensors used as reference in near proximity
- Calculation of the differences in measurements ($T_{Triangel} - T_{Reference}$) and time periods ($\Delta T_{After} - \Delta T_{Before}$) by averaging over the number of stations.

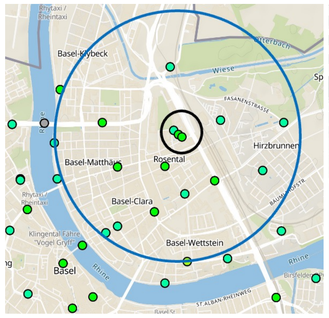

Figure 3: Sensors within the Triangel area (black circle) and reference stations within near proximity (blue circle). Study sight before the transformation (center) and after (right).

Project "White Street"

- Location: Swiss Rhine ports
- Intervention: Asphalt surfaces were painted white to reduce heat absorption.
- Instrumentation: Installed 3 Pessl LoRain sensors and 2 Campbell Blackglobe sensors.
- Measurements and infrared imaging were conducted before and after the transformation
- Status: The project is ongoing.

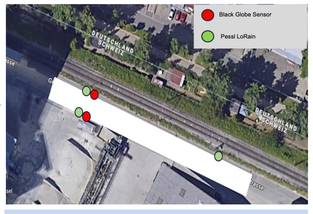

Figure 4: Illustration of the study site and location of the different sensors

Results

Variability of radiant temperatures

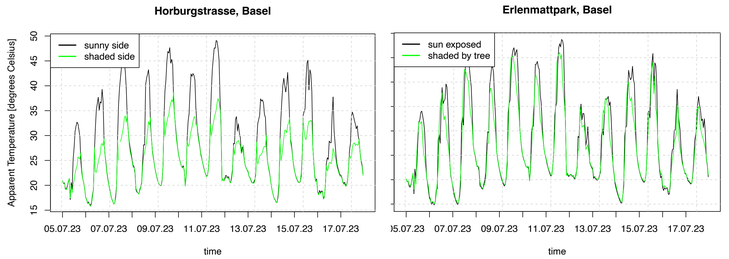

Figure 5: Measured radiant temperature [°C] of the sensors located in the sun and in the shade for two example sites: Horburgstrasse (left) and Erlenmattpark (right).

- Horburgstrasse: Radiant temperature is up to 13°C lower in shaded areas (Figure 5, left).
- Smaller differences are observed in Erlenmatt (Figure 5, right), where the shade provided by trees is limited due to their relatively young age (Figure 2, center).

Analyses of climate change mitigation strategies

1) Triangel

- The mitigation strategy has resulted in a temperature reduction of 0.3 ºC.
- Further decrease is anticipated as the trees continue to grow and mature

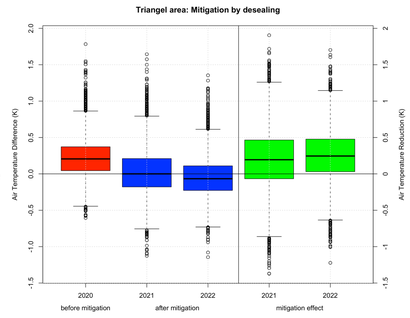

Figure 6: Air temperature difference in the Triangel area to surrounding before and after the mitigation.

2) White Street

Figure 7: Photograph and infrared image of studied site before (upper) and after (lower) the transformation.

- First infrared images show the necessity of the adaptation strategy.
- Following the transformation, a surface temperature reduction of up to 8.5°C was observed.
- Further analysis of local air temperature and radiant temperature in progress.

Summary & Outlook

	Air Temperature	Surface Temperature	Mean Radiant Temperature
De-Sealing and Greening (Triangel)	- 0.3 K	-	-
White Street	tbd	- 8.5 K	tbd
Shading Effect - Horburgstrasse	-	-	- 13 K

Figure 8: Summary of different effects on different temperature variables

- **Black globe measurements** play a crucial role in evaluating the thermal stress levels at specific urban locations by accounting for additional cooling and heating effects of various weather variables.
- **Extensive urban measurement networks** help identify temperature hotspots and their impact on public health. These networks provide invaluable data for future adaptation measures and actionable insights for city planners.
- **Future and ongoing projects** aim to further investigate the effects of heat on urban infrastructure, enhancing resilience in cities.

info@meteoblue.com
www.meteoblue.com