EGU General Assembly 2023
Vienna, Austria & Online | 23–28 April 2023

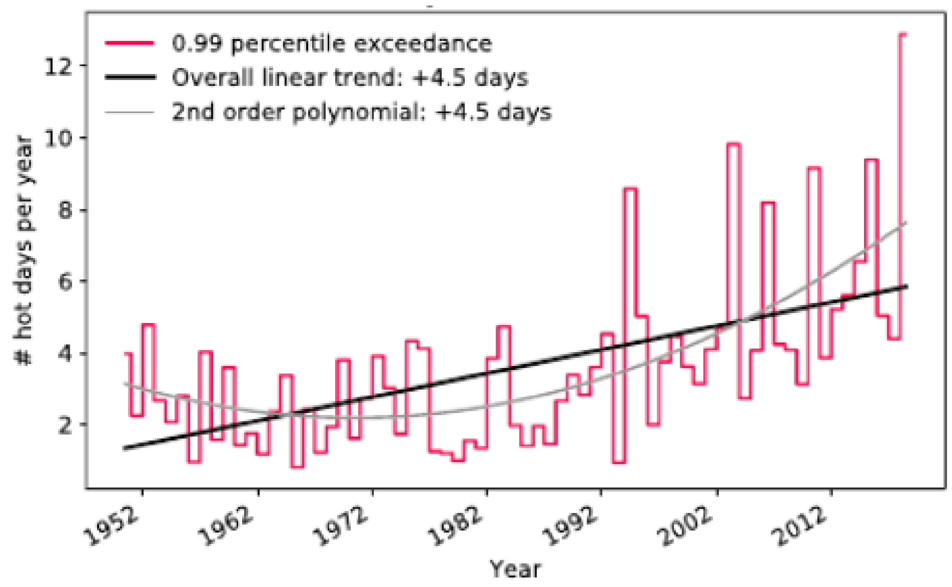
Universität zu Köln

Evaluation of microclimatic variations and adaptation effects in a central European city during the most excessive heat wave in summer 2022 by ENVI-met modelling

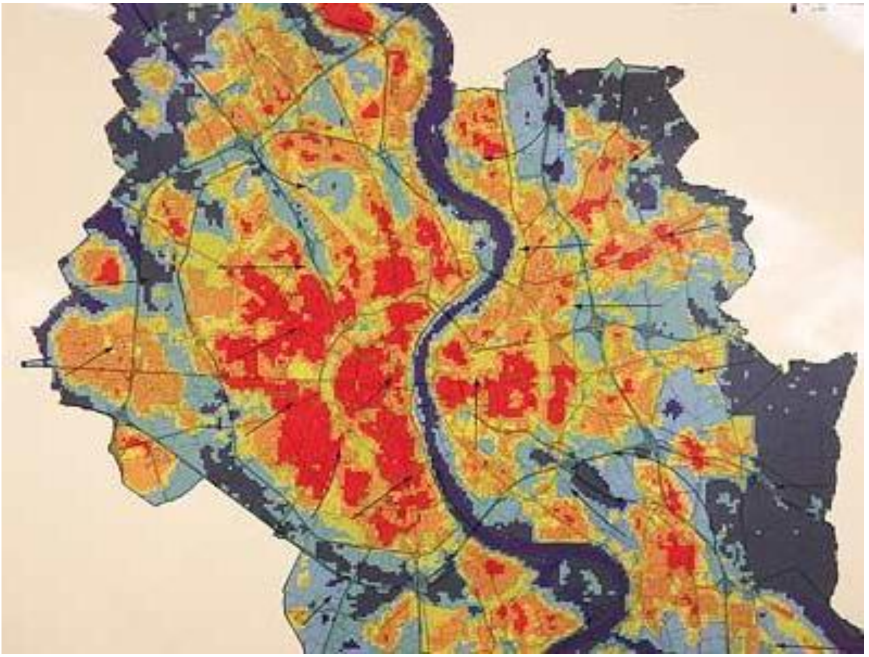
Eingrüber, Nils; Schneider, Karl; Korres, Wolfgang
University of Cologne, Institute of Geography, nils.eingrueber@uni-koeln.de

EGU23-11806
Session CL2.8: Urban climate, urban biometeorology, and science tools for cities

Extreme heat events are becoming more frequent in urban areas, and the magnitude of the urban heat island effect is increasing.



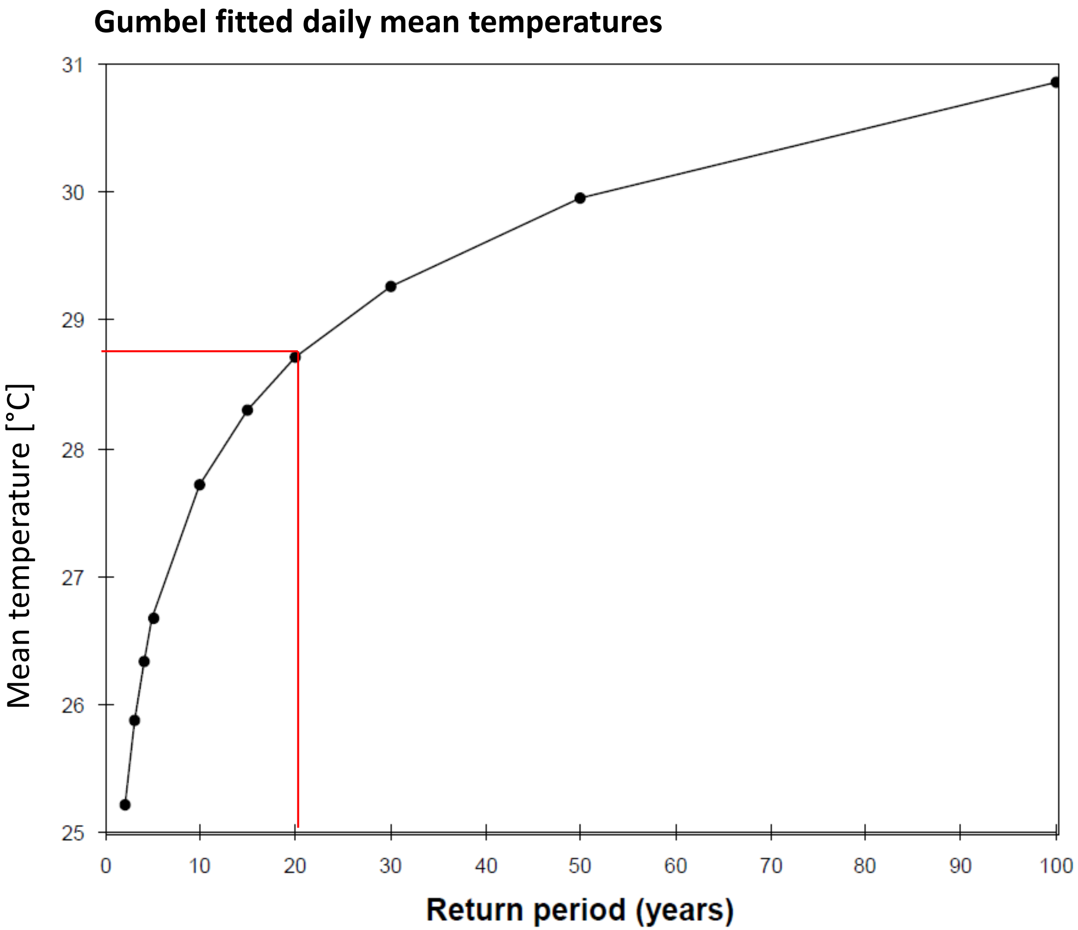
Number of hot days per year, average for European cities
(Lorenz et al. 2019, Geophysical Research Letters)



Urban heat island effect in Cologne / Germany
(Klimawandelgerechte Metropole Köln, report-k.de, 2013)

Motivation / *Research Aim* / *Methods* / *Results* / *Conclusions*

The summer of 2022 was characterized by extreme and prolonged heat and drought periods. A 20-year heat event was observed in Cologne/Germany.



Most excessive heat wave in summer 2022:
three hottest consecutive days which show the maximum 72-hour mean temperature in 2022

Mean:
18 July: 25.4 °C
19 July: 28.7 °C
20 July: 26.2 °C

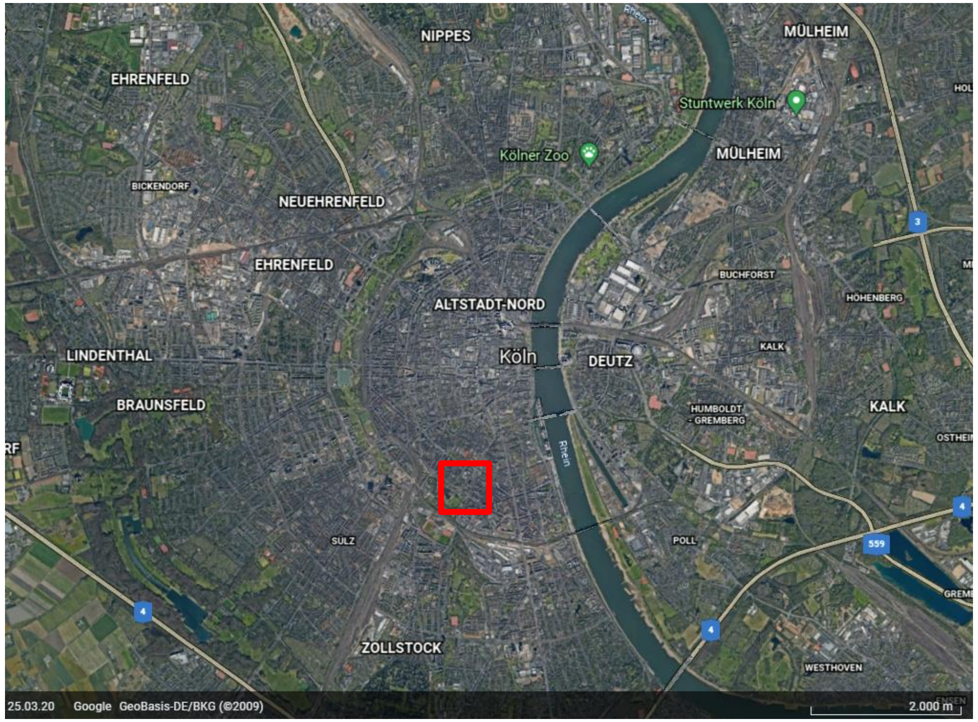
Maximum:
18 July: 37.1 °C
19 July: 40.2 °C
20 July: 33.4 °C

Calculations based on daily mean measurements from the DWD station at Cologne/Bonn Airport

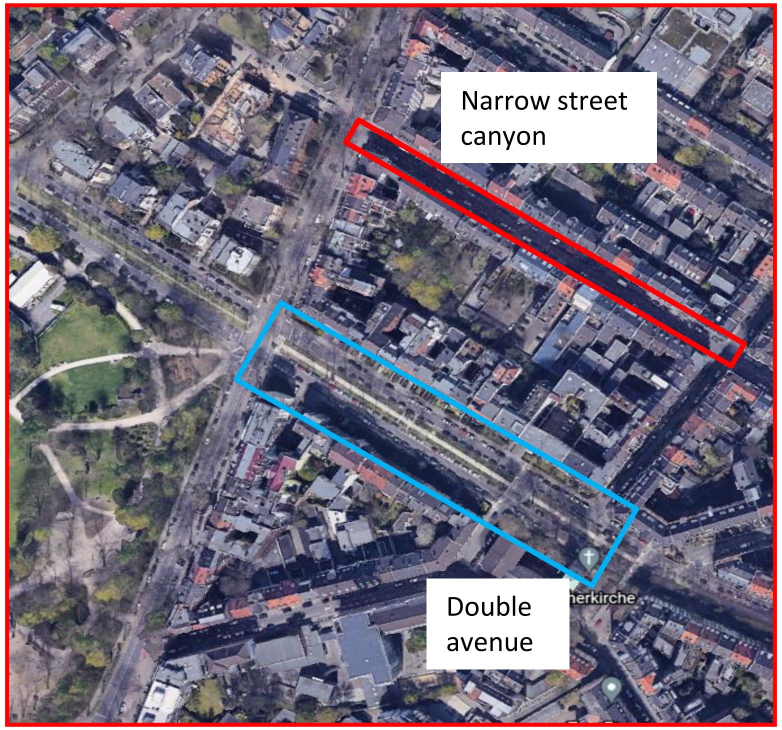
Universität zu Köln

This research aims to identify small-scale microclimatic differences between two parallel streets in an urban study area in Cologne during this heat wave.

Location of the 16 ha study area in Cologne:

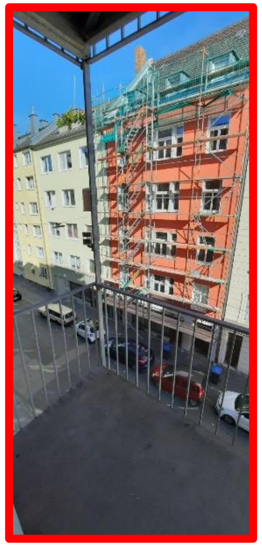


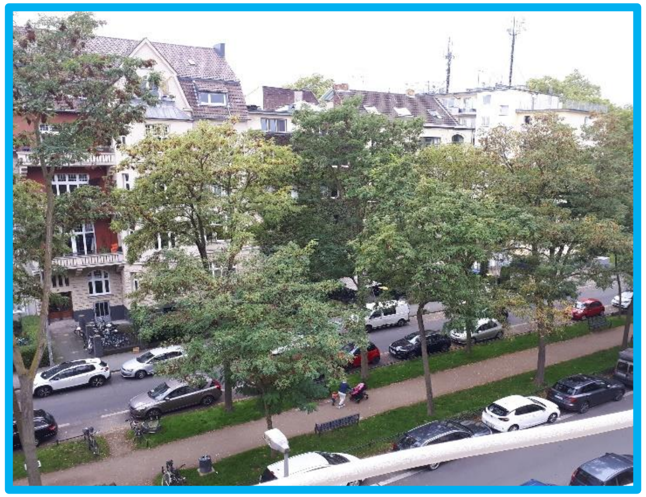
Satellite image (2020-03-25): Location of the study area in Cologne
(Google Earth Pro 2020, GeoBasis-DE/BKG 2009)



Satellite image (2020-03-25): Study area
(Google Earth Pro 2020, GeoBasis-DE/BKG 2009)

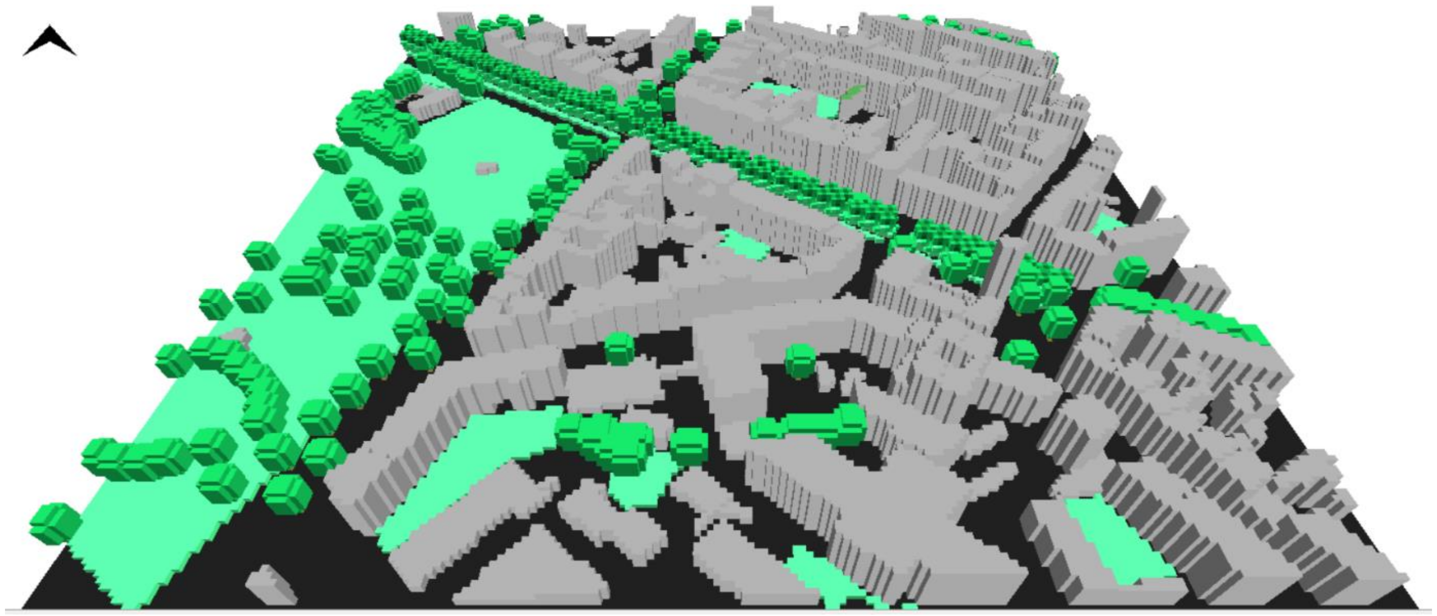
The two streets show significant differences in street width and greenery.





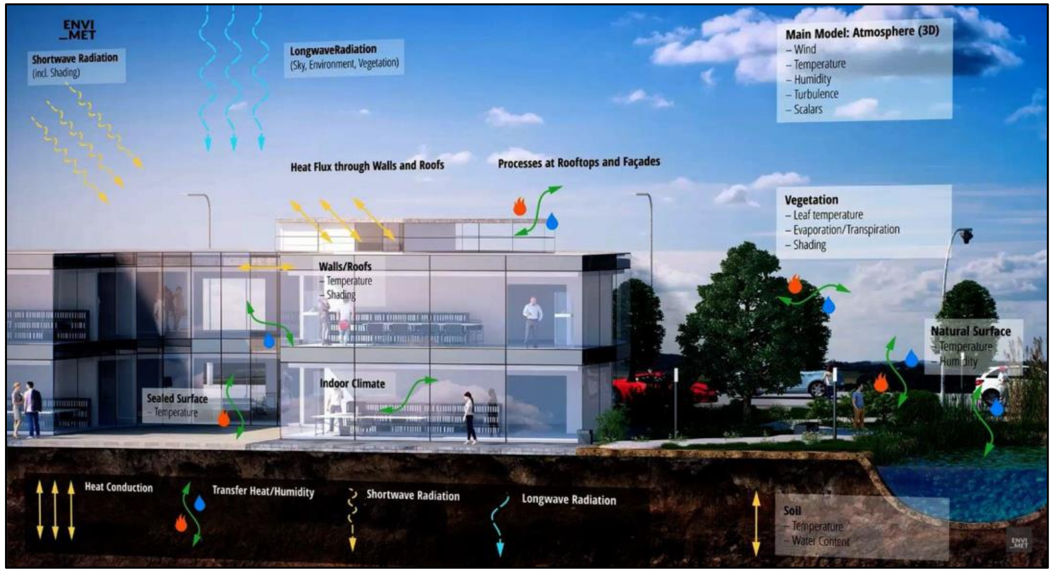
Motivation / **Research Aim** / *Methods* / *Results* / *Conclusions*

The physically-based high resolution 3D ENVI-met model is used to simulate the microclimatic conditions like temperature from 18th – 20th July.



Representation of the 3D model domain, parameterized based on soil, surface, building wall, vegetation properties, etc.
(1m spatial & 2 seconds temporal resolution)

ENVI _MET

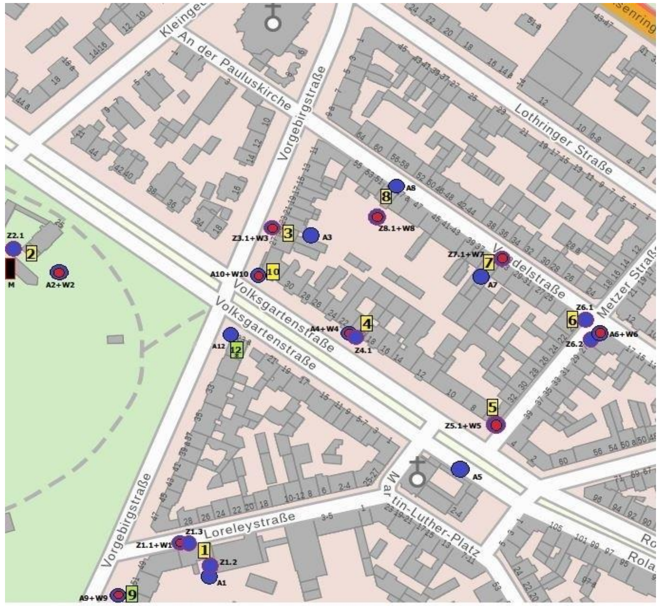


(ENVI-met GmbH, 2023)

Model driven by a research-grade (Campbell) meteorological station within the study area (urban park) using full forcing and open LBCs.

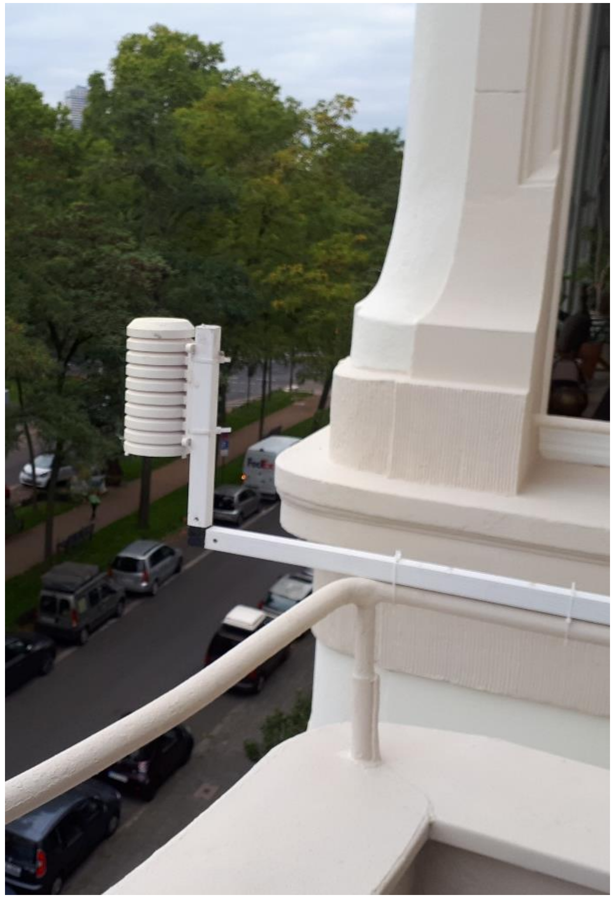
Universität zu Köln

Model outputs are validated using a densely-distributed microclimatic citizen science sensor network (36 sensors) which is recalibrated continuously.



Spatial distribution of the installed NETATMO weather sensors

(NETATMO shop, 2023)

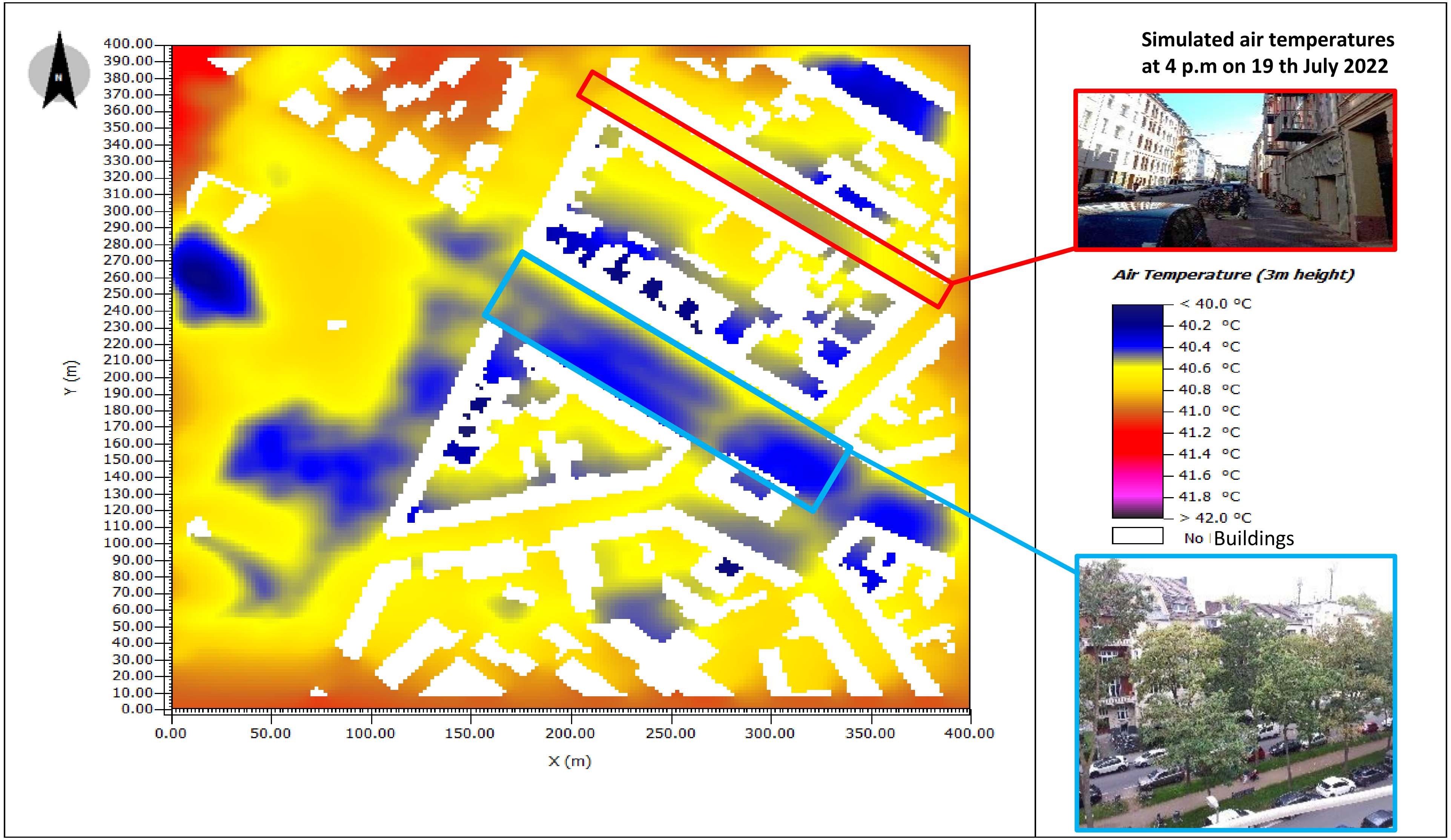


Installed sensor under uniform controlled conditions with radiation protection

- Accuracy of sensors is checked by four recalibration runs under laboratory conditions and direct comparisons with research-grade meteorological sensors in the study area.
- High long-term stability and consistency: average **RMSE = 0.059 °C**
- ENVI-met model outputs and measurements are in very good agreement and show a high correlation: average **NSE = 0.94**

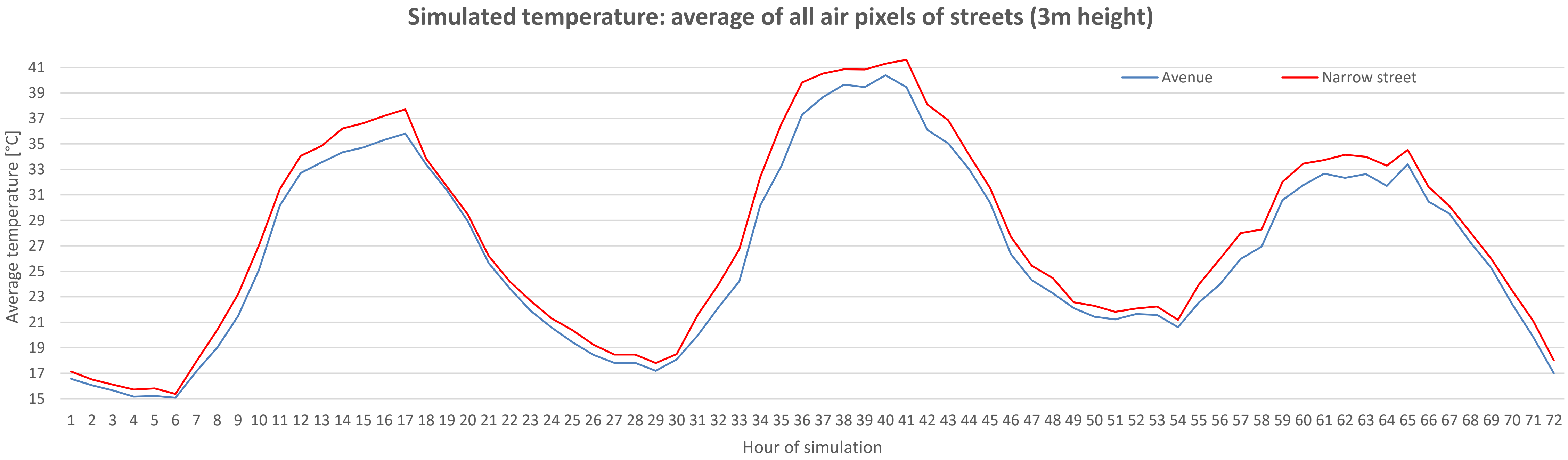
Motivation / Research Aim / **Methods** / Results / Conclusions

Significant temperature differences were identified when comparing the narrow, vegetation-free street canyon with the parallel broader street.



Motivation / Research Aim / Methods / **Results** / Conclusions

Significant temperature differences were identified when comparing the narrow, vegetation-free street canyon with the parallel broader street.



72-hour average:

Avenue: 26.38°C

Narrow street: 27.67°C

significant difference in means according to t-test for alpha = 0.05

Motivation / *Research Aim* / *Methods* / **Results** / *Conclusions*

EGU

Universität zu Köln

Results show that local climate change adaptation measures can be highly effective in mitigating urban heat stress during such extreme heat waves.

- Significant small-scale temperature differences were found for this extreme heat event showing local effects and potentials for local adaptation and participation in climate change mitigation.

- Microscale temperature differences can be traced back to …
  (1) differences in radiation absorption due to the albedo of urban surfaces
  (2) shading effects by vegetation or buildings, determined by street character/geometry
  (3) cooling effects though evapotranspiration of green infrastructures, green facades/roofs

- In further research, potentials of various heat mitigation strategies will be compared to improve thermal outdoor comfort with an increasing frequency of heat waves with over 40°C.

Nils Eingrüber
University of Cologne, Institute of Geography
Hydrogeography and climatology research group
nils.eingrueber@uni-koeln.de