Analysing Urban Heat Islands in Stuttgart using Satellite and Citizen Science Data

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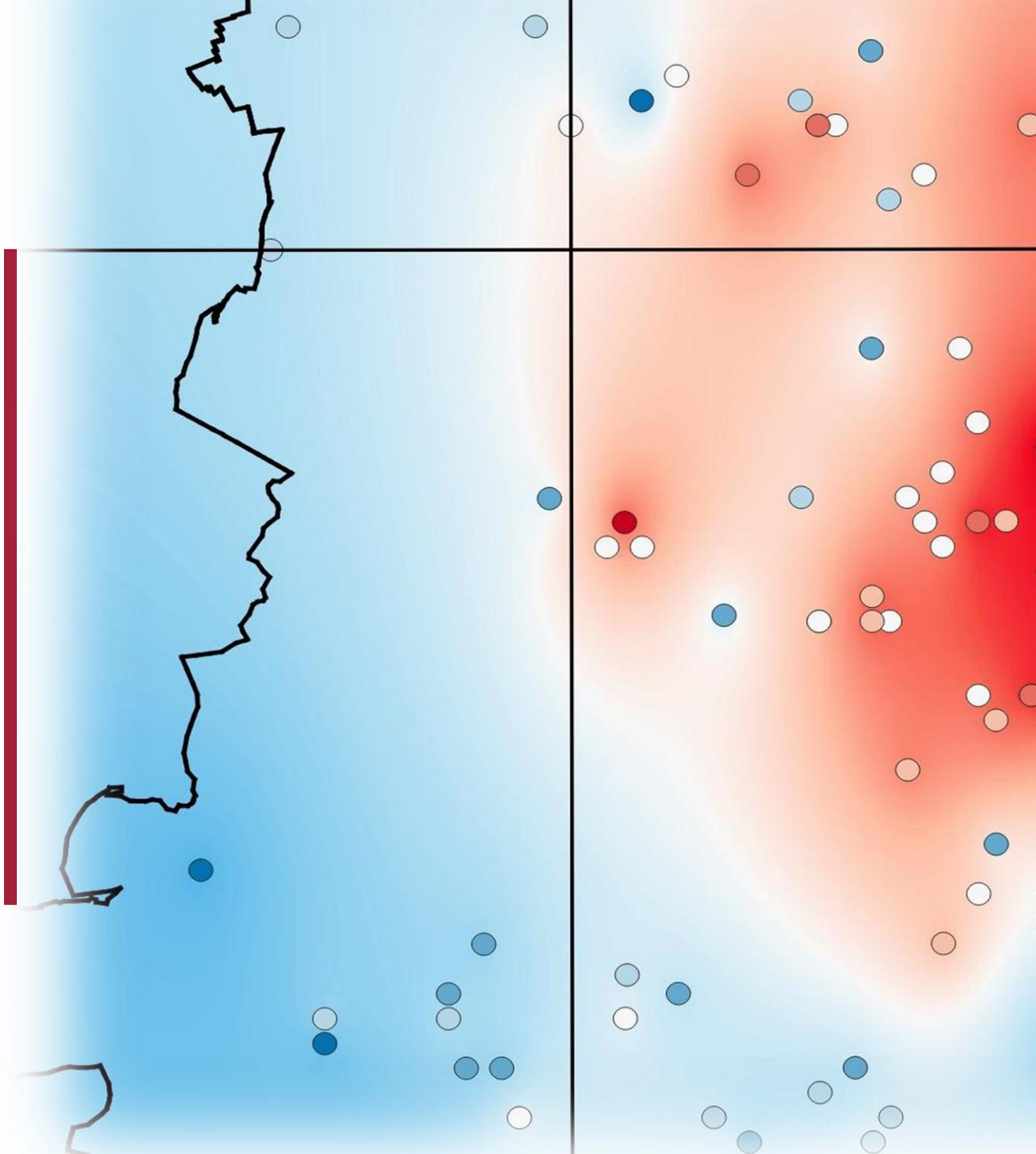
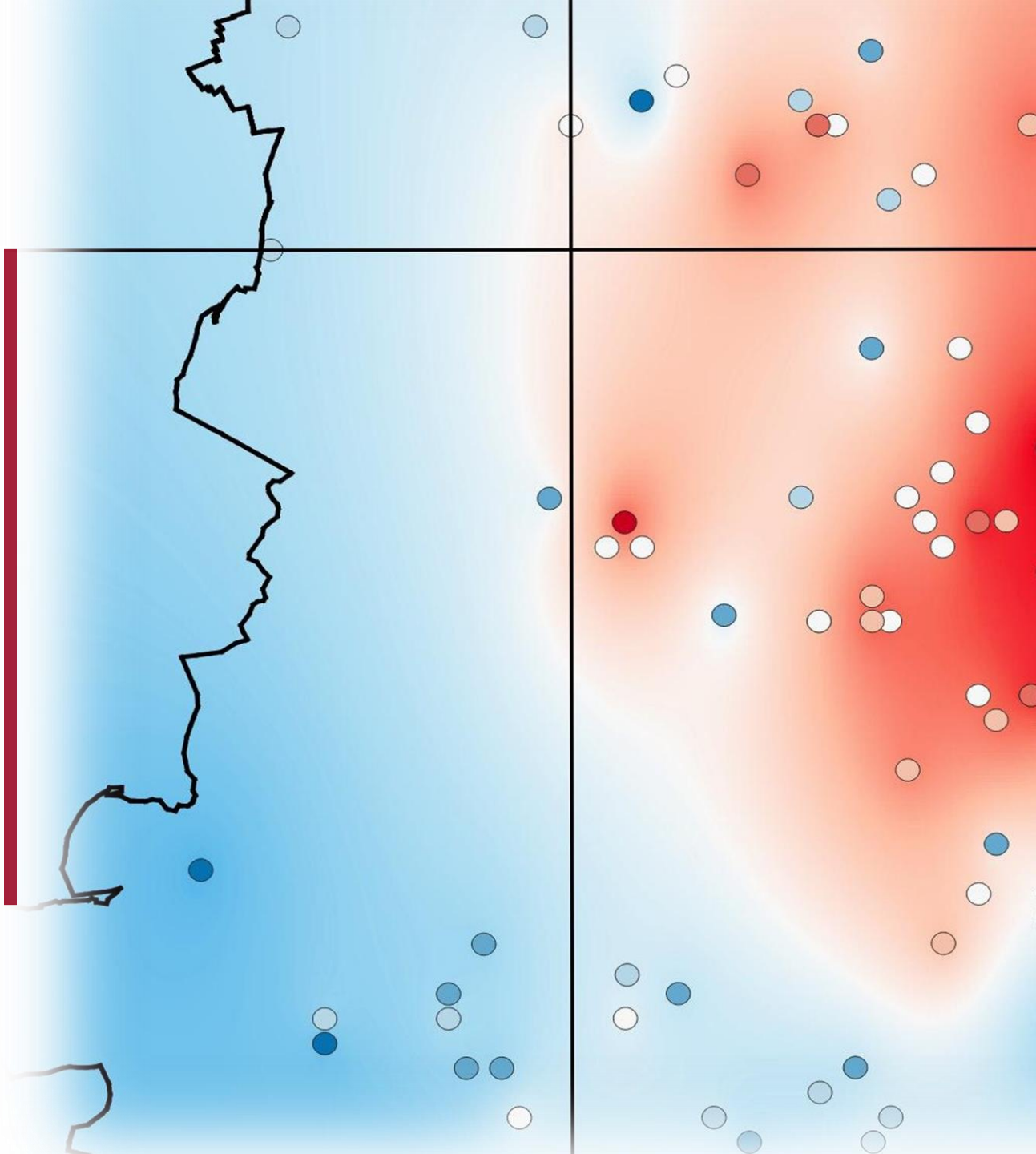


Research Questions

1) What is the spatial and temporal structure of Stuttgart's urban heat island?

2) Can citizen science data, in combination with remote sensing and validated against official stations, improve high-resolution UHI analysis?

Study Area



Study Area

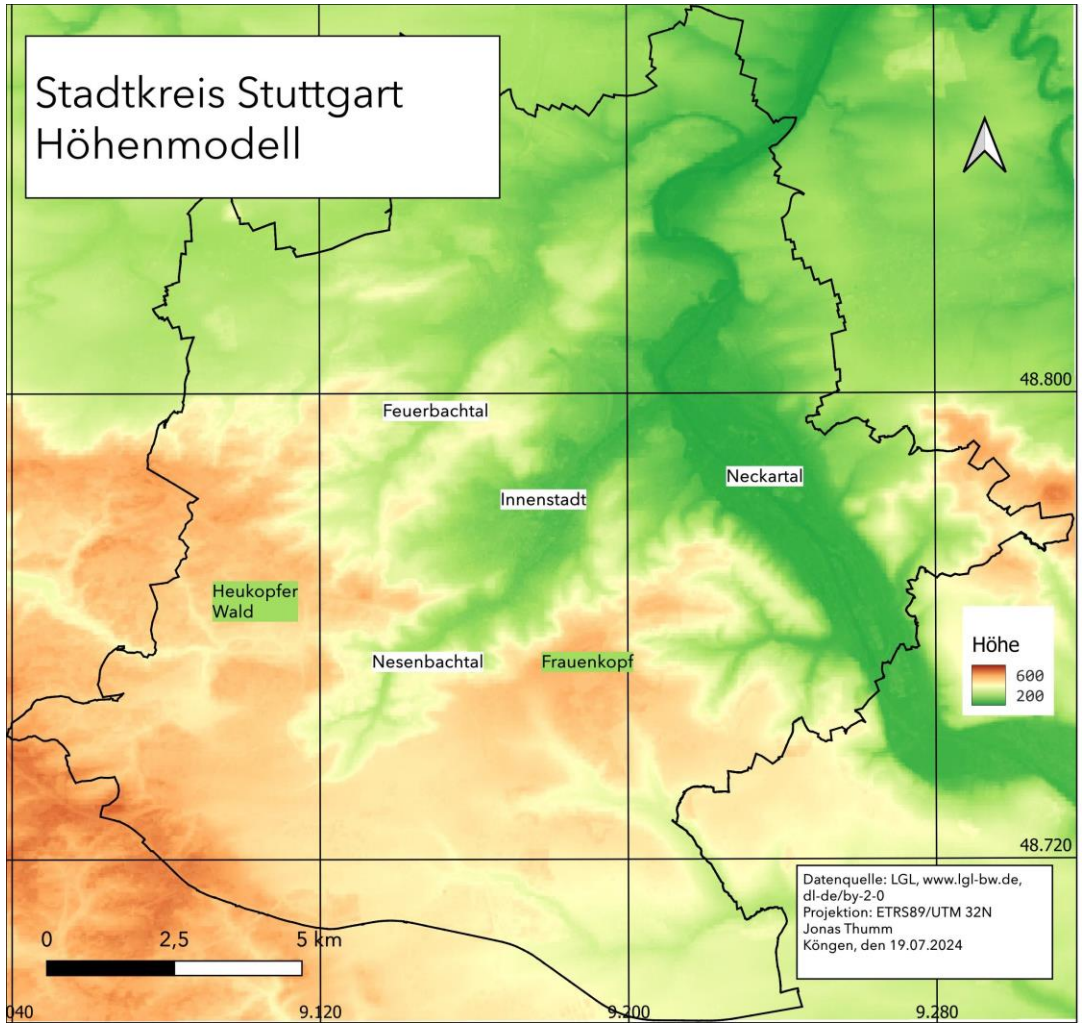


Figure 1: DEM Stuttgart; own figure

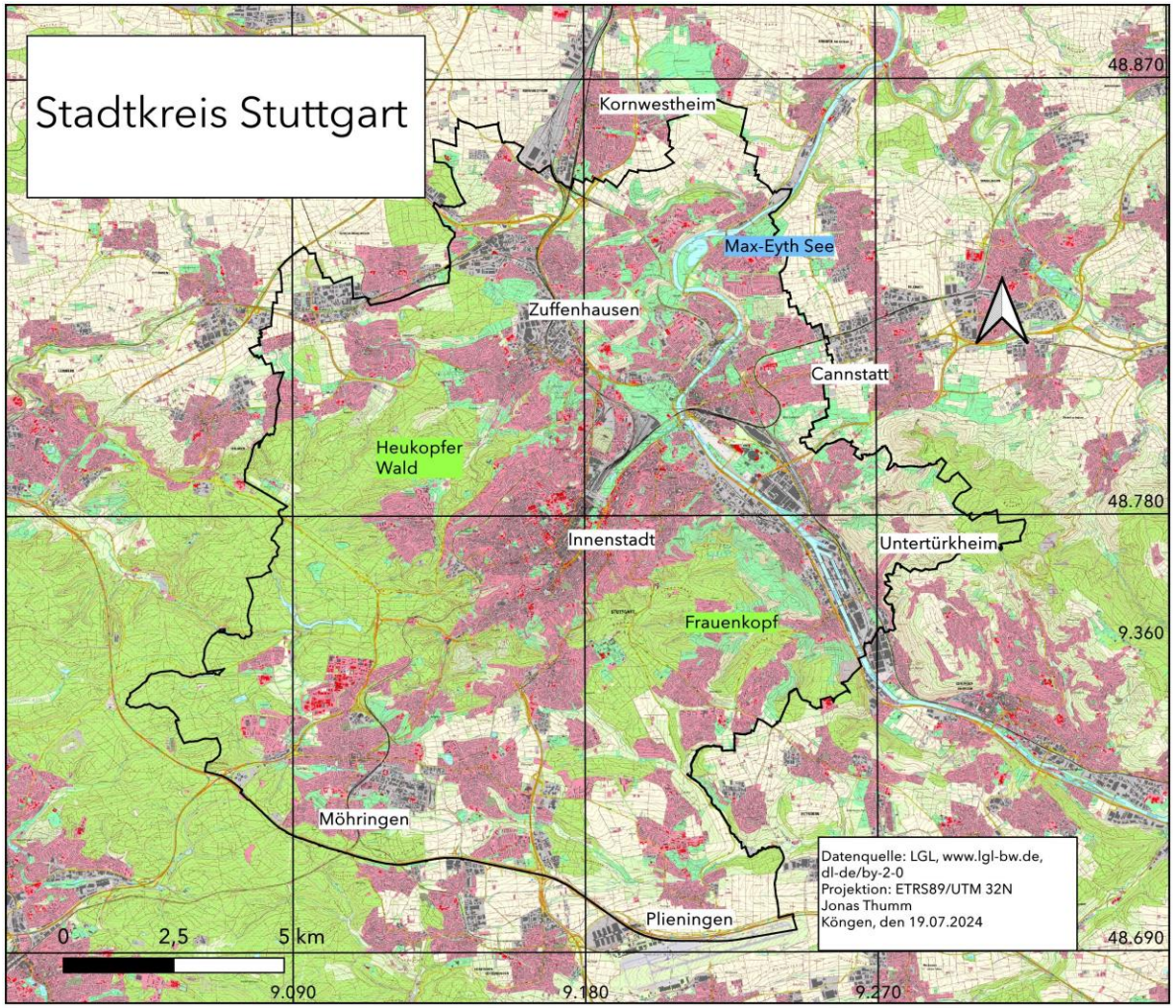
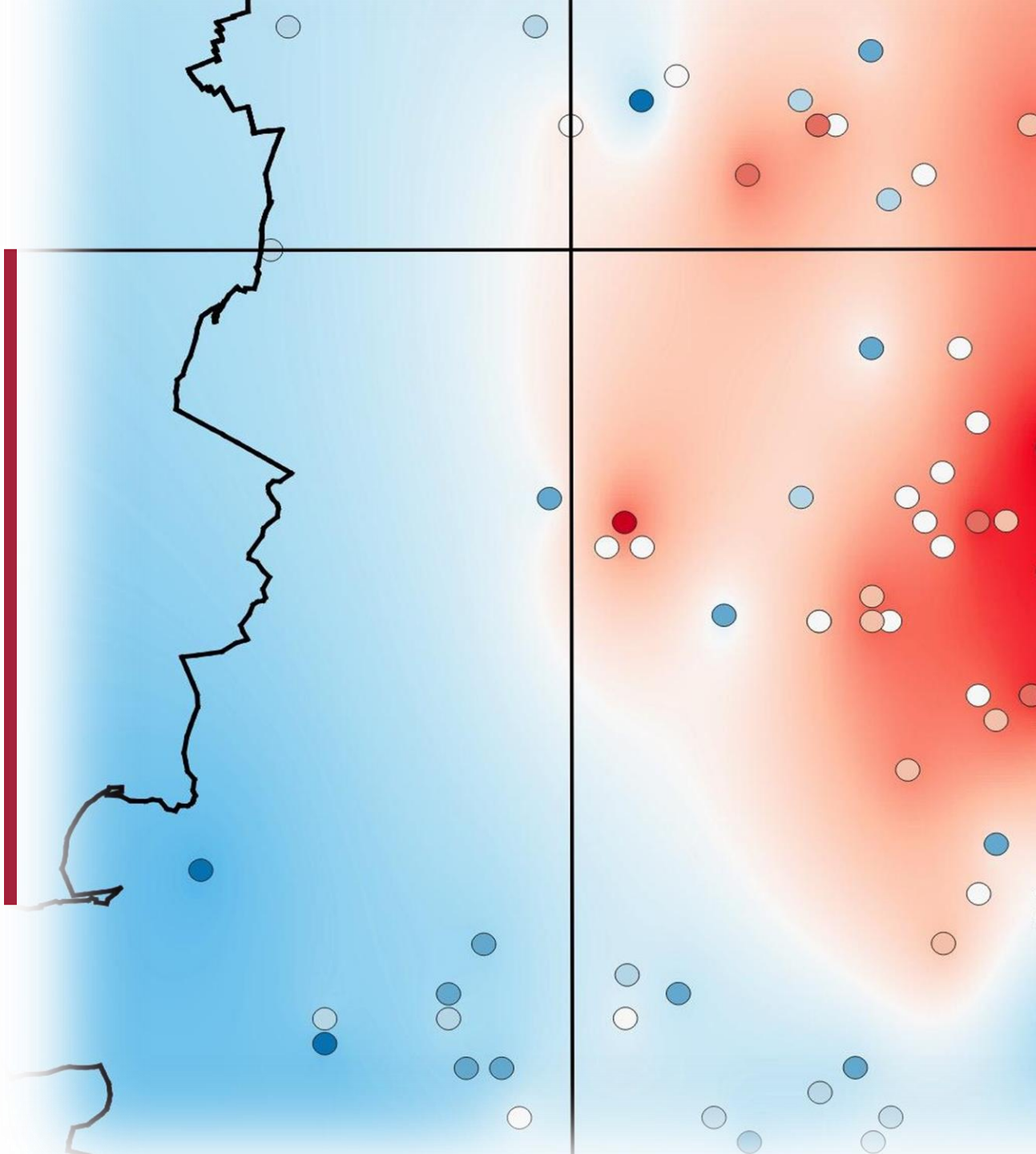


Figure 2: Built up spaces Stuttgart; own figure

Methodology



Methodology

1) Define study period
2) Find and analyze suitable remote sense data
3) Find and analyze air temperature measurements
    1) Official stations
    2) Citizen science stations

Methodology

1) **Study Period**
2) Remote Sensing
3) Air Temperature
    1) Official stations
    2) Citizen science

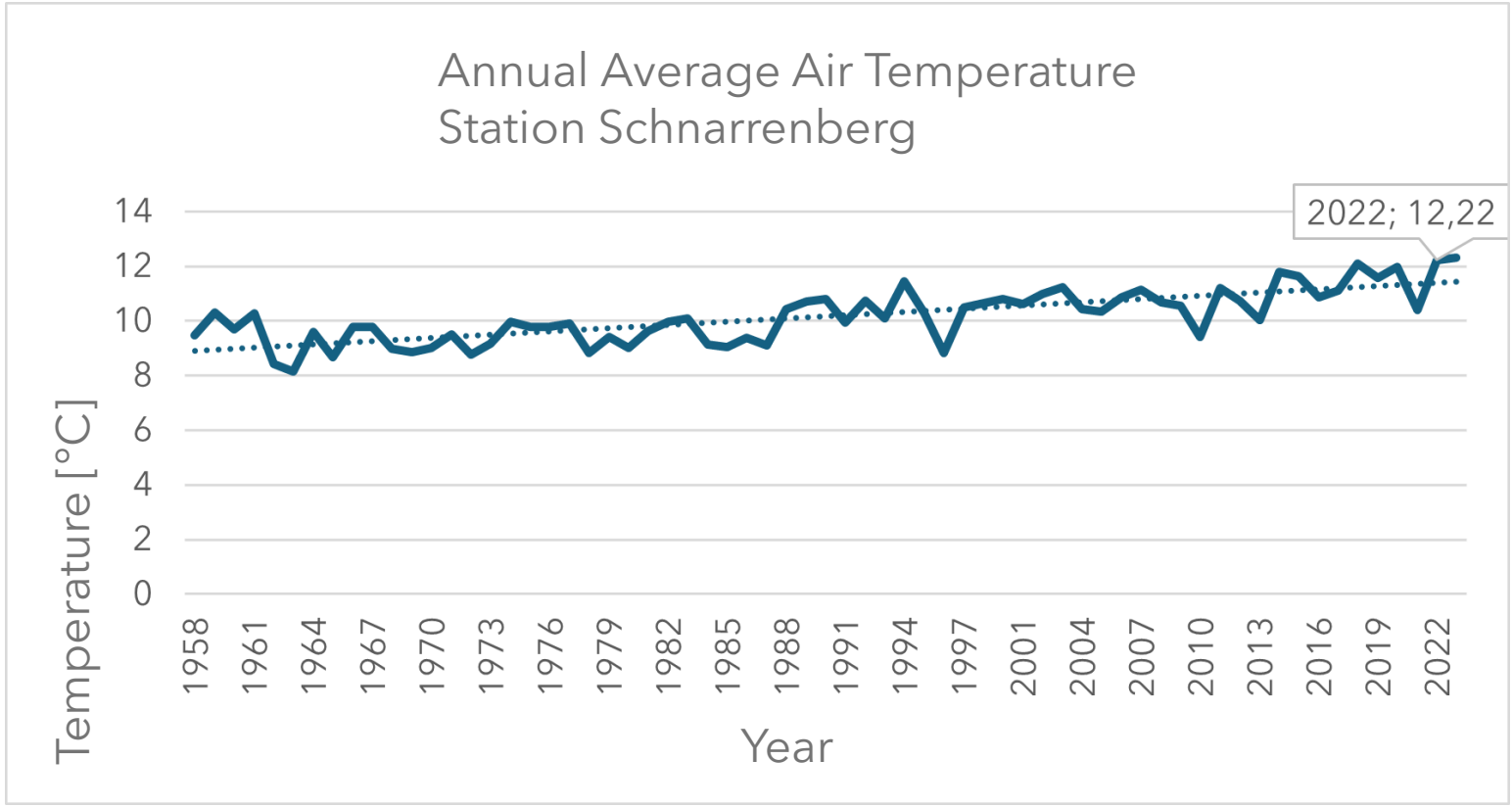


Figure 3: annual average air temperature Station Schnarrenberg; Datasource: DWD 2024/b

Methodology

1) **Study Period**
2) Remote Sensing
3) Air Temperature
    1) Official stations
    2) Citizen science

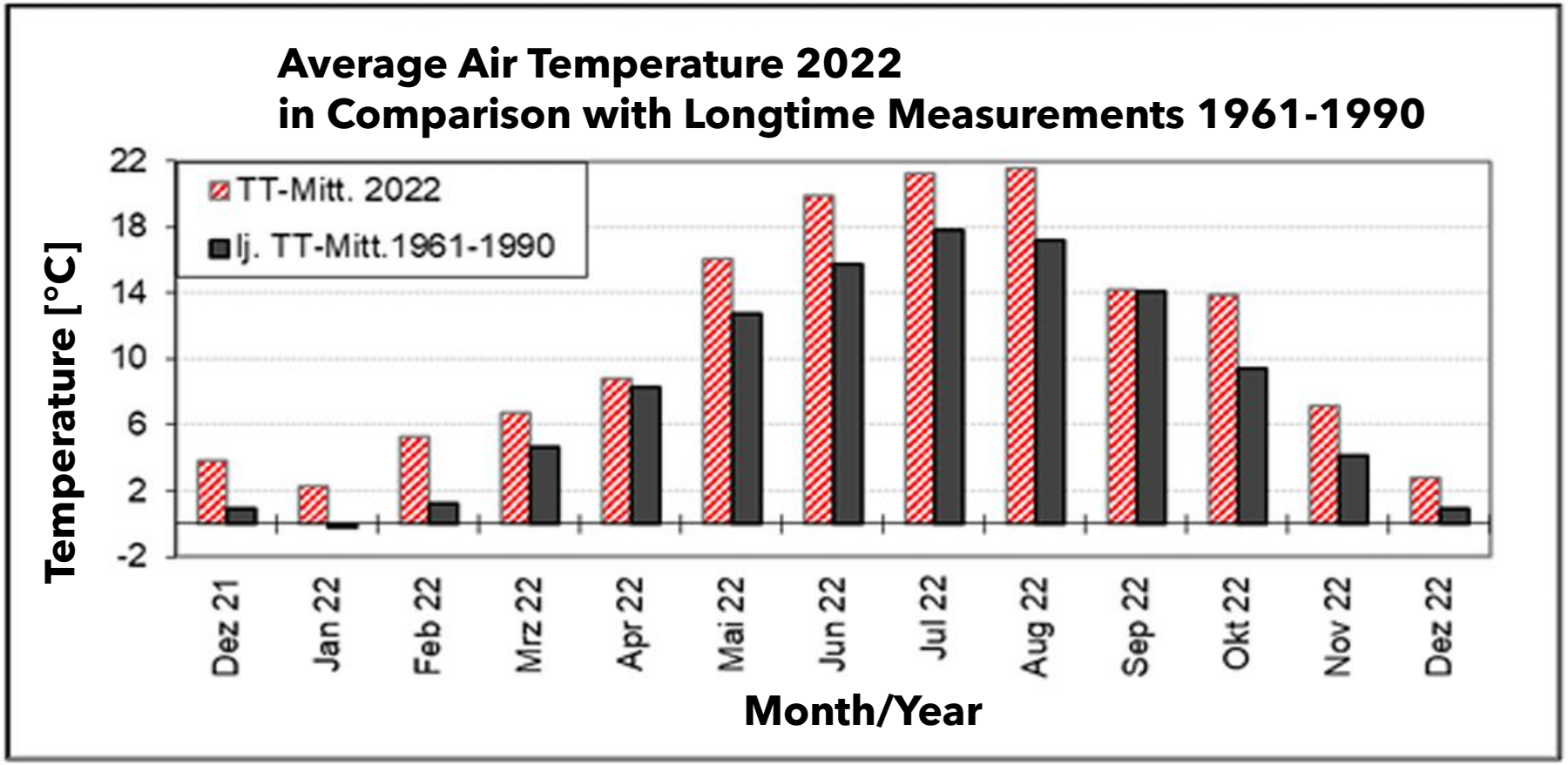


Figure 4: Jahresgang der Lufttemperatur (°C) 2022 im Vergleich zu den langjährigen Monatsmittelwerten 1961-1990 für die Station Hohenheim; Institut für Physik und Meteorologie Universität Hohenheim 2022 p.8

Methodology

1) Study Period
2) **Remote Sensing**
3) Air Temperature
    1) Official stations
    2) Citizen science

Datum	Großwetterlage	Witterung
14.05.2022	Übergangstag, von Westlage antizyklonal zu Südlage antizyklonal	Dichte Bewölkung löst sich zum Nachmittag hin auf
21.05.2022	Westalge antizyklonal, Frontalzone weit nach N verschoben	Zwischenhocheinfluss, rasch abklingende Niederschläge, kühle Luft vom Hoch
15.06.2022	Hoch über Mitteleuropa, Frontalzone verläuft in antizyklonal gekrümmten Bogen nördlich des 60. Breitengrads	Hoch "David" bringt warmes, sonniges und trockenes Wetter
16.07.2022	Hoch über Mitteleuropa, Frontalzone verläuft in antizyklonal gekrümmten Bogen nördlich des 60. Breitengrads	10-13 Sonnenstunden durch Hoch "Jürgen"
17.07.2022	Hoch über Mitteleuropa, Frontalzone verläuft in antizyklonal gekrümmten Bogen nördlich des 60. Breitengrads	Hoch "Jürgen" verlagert sich von Britischen Inseln über NDT nach Polen, sehr trockene Subtropikluft aus SW, in Nacht zum 17. sinkende Temperaturen, tagsüber wolkenfreie, östliche Strömung
25.07.2022	Südwestlage antizyklonal, trockene Witterung aufgrund Einfluss Hochdruckzone Südeuropas	Aufgrund Tiefdruckwanderung kommt Warmluft nach DT, sehr heißer Tag mit möglichen Gewittern am Abend
09.08.2022	Nordostlage antizyklonal, Hochdruckbrücke von Azoren über GB bis Mitteleuropa, Festlandsluft strömt an südostflanke nach Mitteleuropa	sonnig
10.08.2022	Nordostlage antizyklonal, Hochdruckbrücke von Azoren über GB bis Mitteleuropa, Festlandsluft strömt an südostflanke nach Mitteleuropa	sonnig, heiße Tage im Südwesten

Figure 5: selected Landsat images with respective weather situation; own figure

Methodology

1) Study Period
2) Remote Sensing
3) **Air Temperature**
    1) Official stations
    2) Citizen science

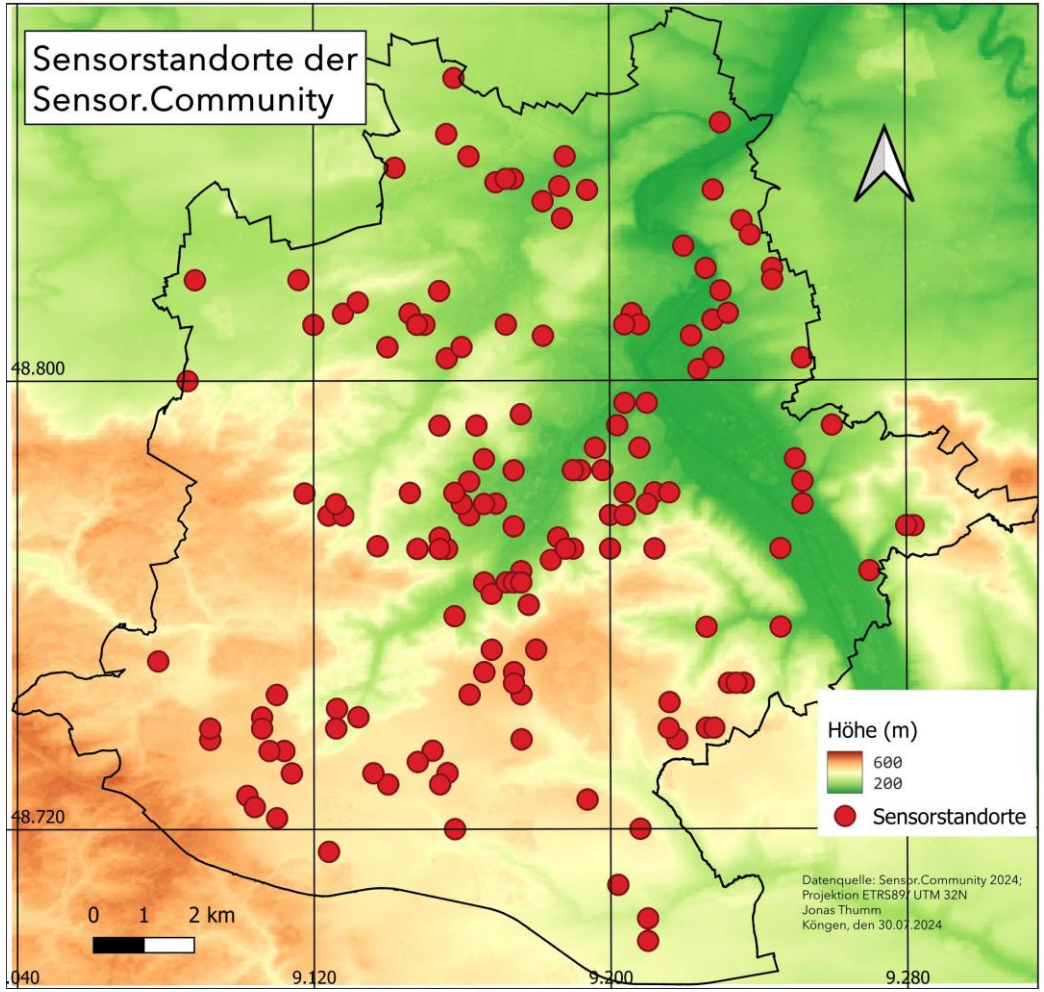


Figure 6: Sensor locations Sensor.Community; own figure

Methodology

1) Study Period
2) Remote Sensing
3) **Air Temperature**
    1) **Official stations**
    2) Citizen science

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Datei Bearbeiten Format Ansicht Hilfe

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       4928;202001010010;    3;  995.5;   1.6;   0.3;  84.2;  -0.8;eor
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Figure 7: DWD data

Methodology

1) Study Period
2) Remote Sensing
3) **Air Temperature**
    1) Official stations
    2) **Citizen science**

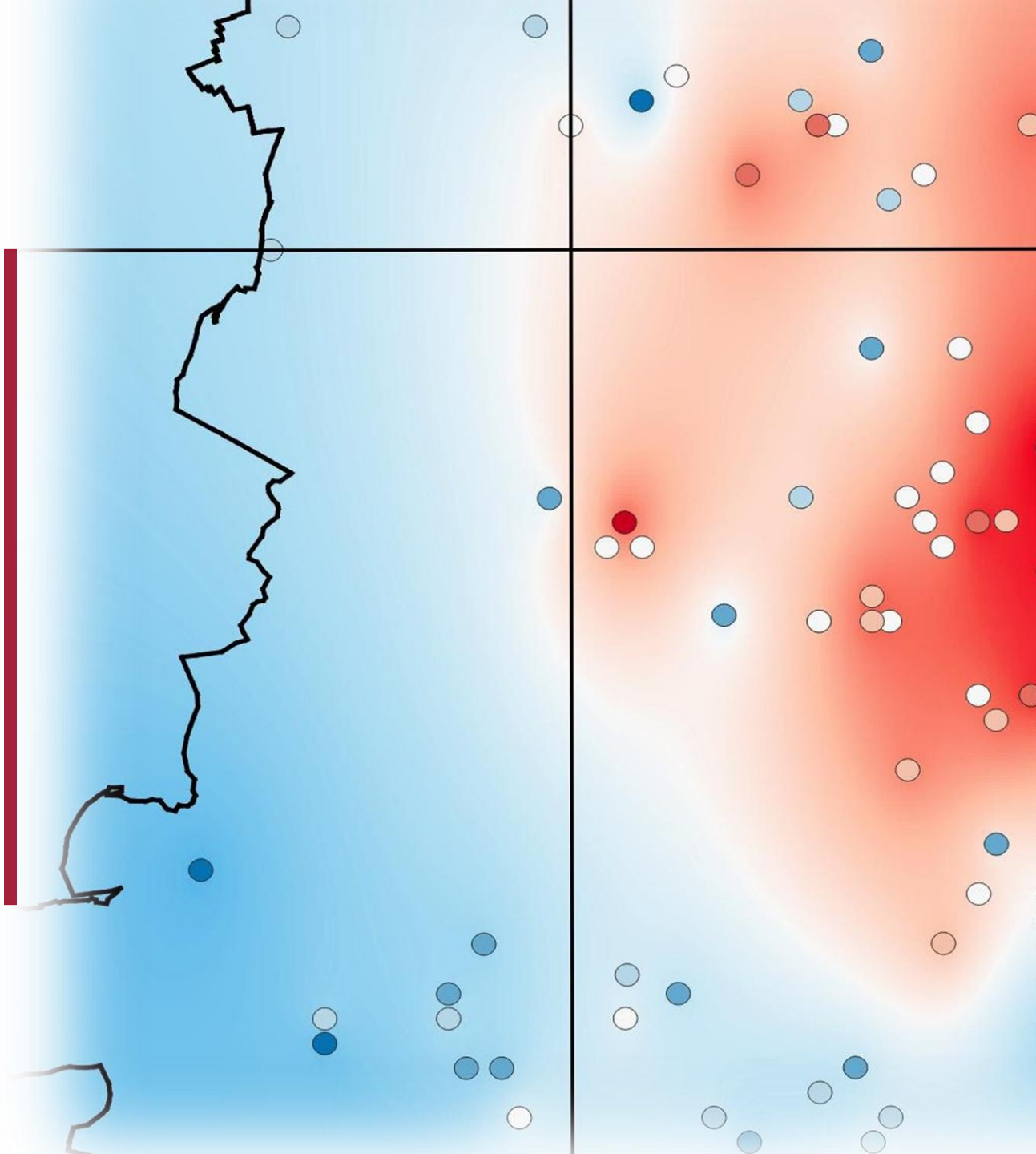
Quality Control

(based on Napoly et al. 2018; Meier et al. 2017)

1. Remove negative values
2. Remove sensors with correlation < 0,9 with official stations
3. Extract timepoints
4. Additional outlier removal via 1,5 IQA
5. Interpolation Ordinary Kriging

Figure 8: Citizen Science Sensor; luftdaten.info

Results



Results

1) **Surface Temperature**
2) Air Temperature

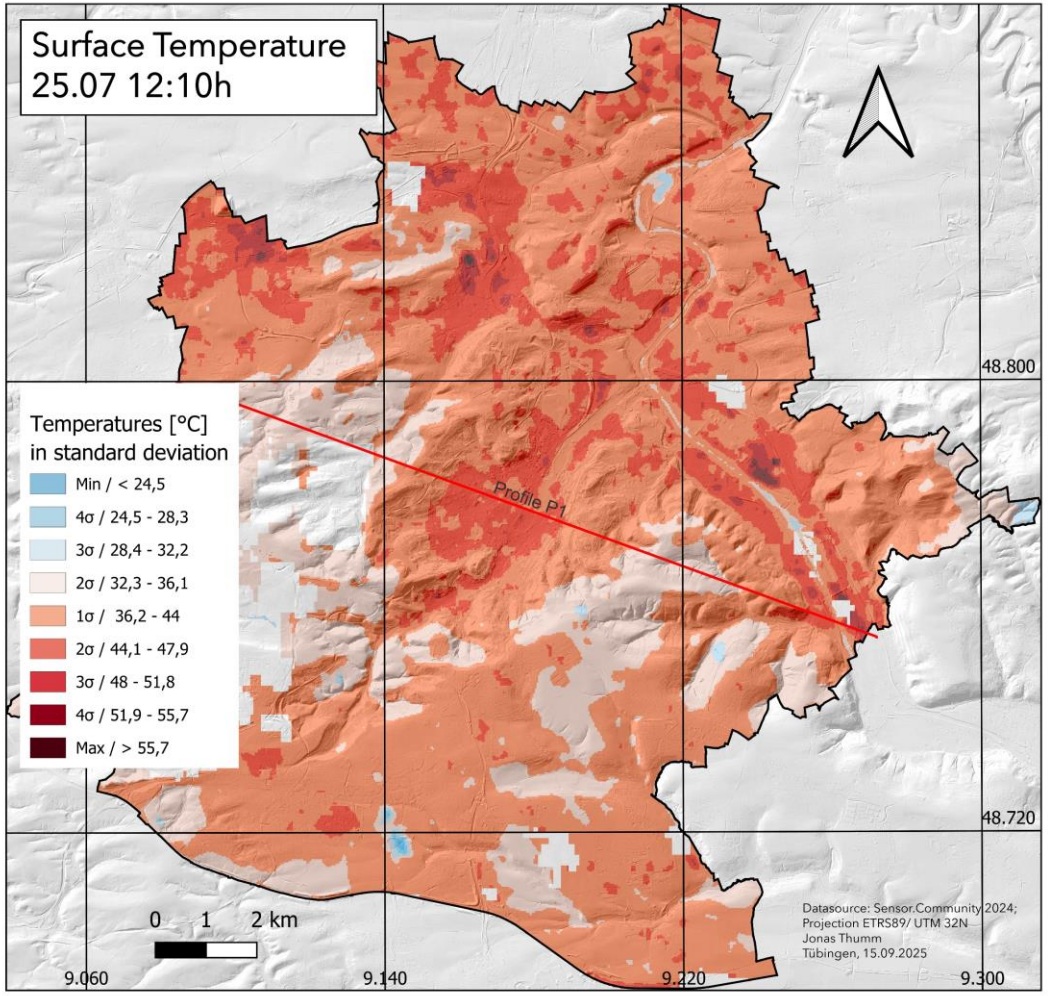


Figure 9: Surface temperature 25.07 12:10h; own figure

Results

1) **Surface Temperature**
2) Air Temperature

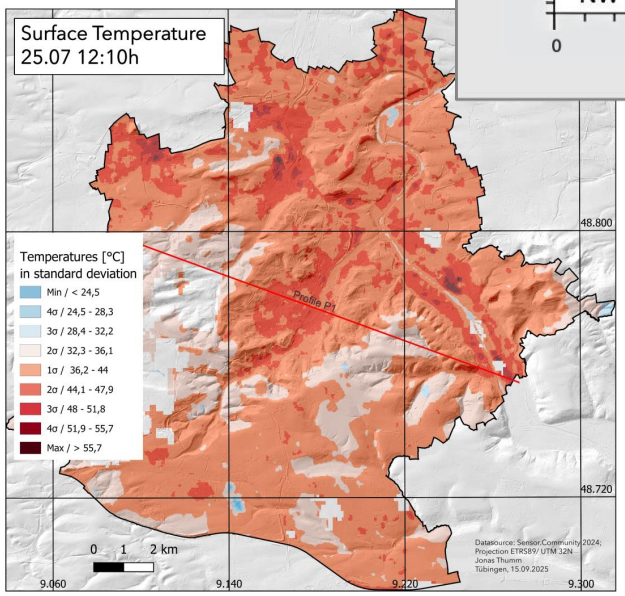


Figure 9: Surface temperature 25.07 12:10h; own figure

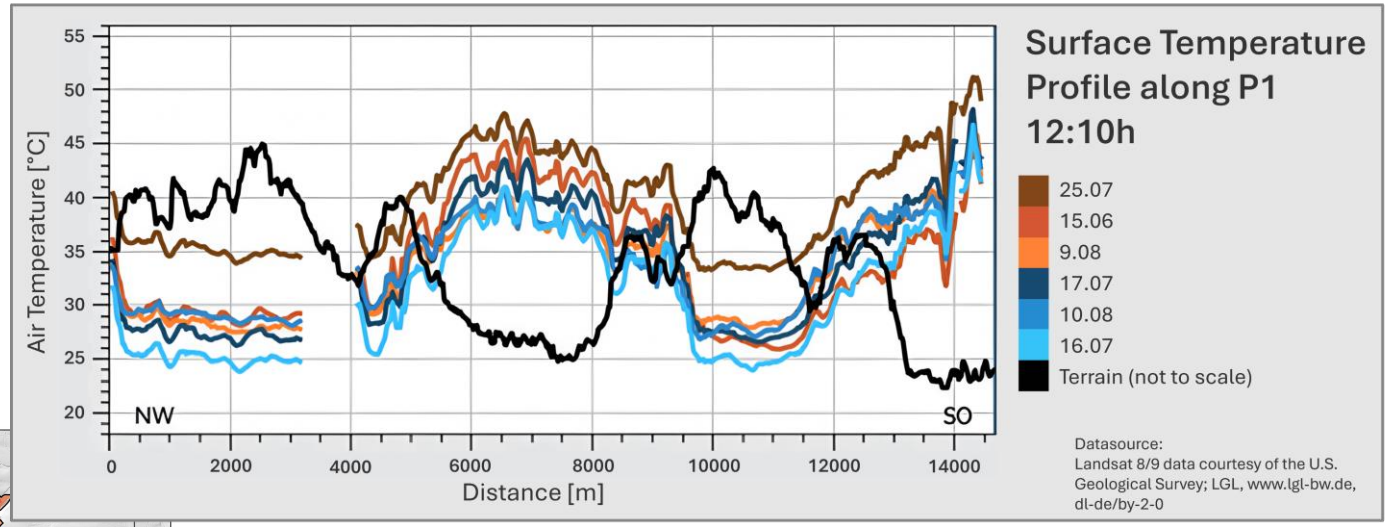


Figure 10: Surface temperature 25.07 12:10h Profile; own figure

Results

1) Surface Temperature
2) **Air Temperature**

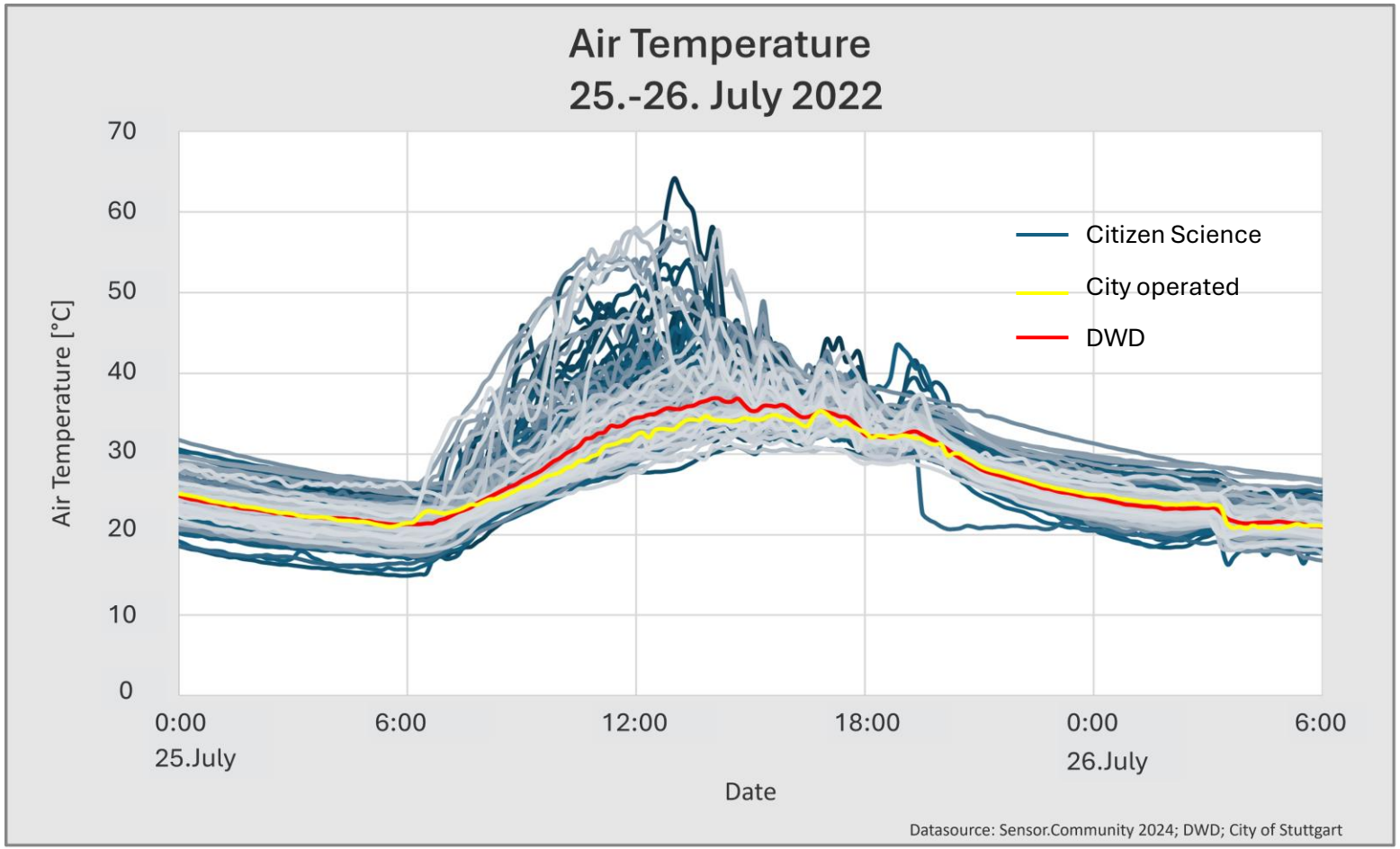


Figure 11: Air temperature 25-26.7; own figure

Results

1) Surface Temperature

2) Air Temperature

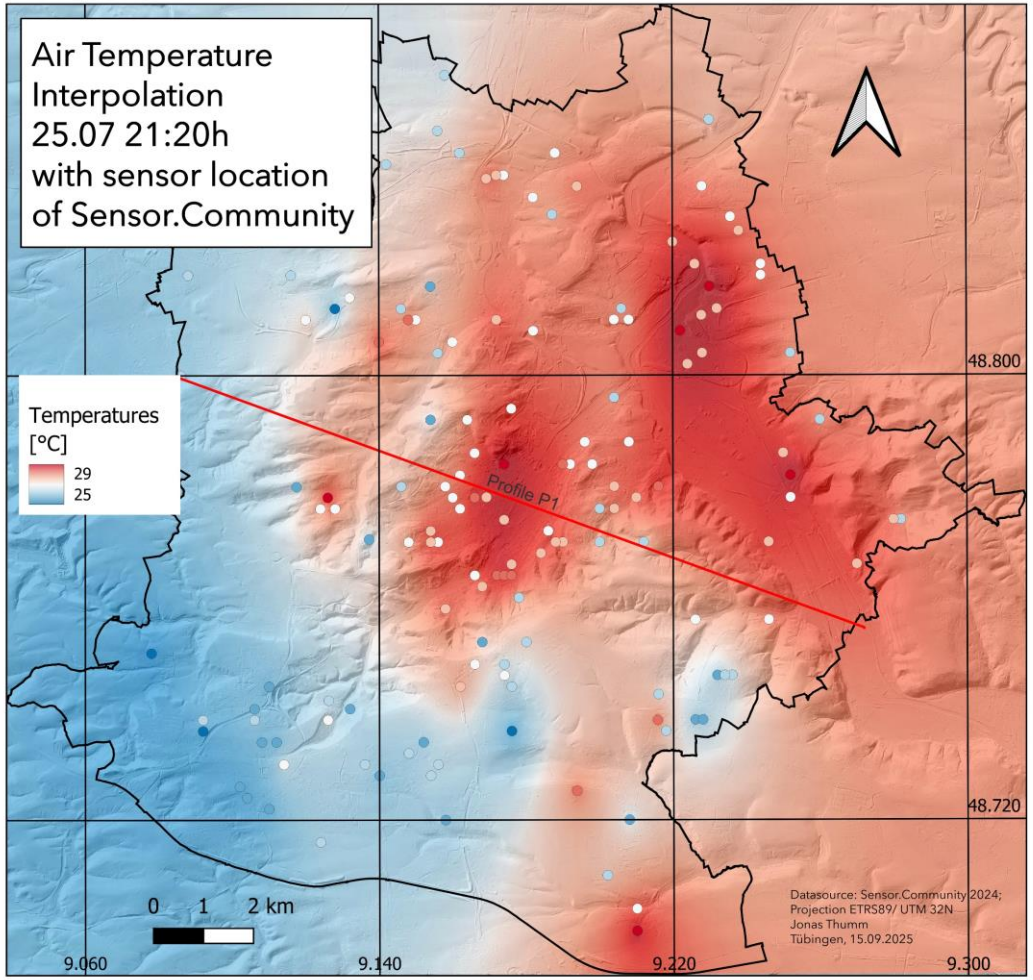
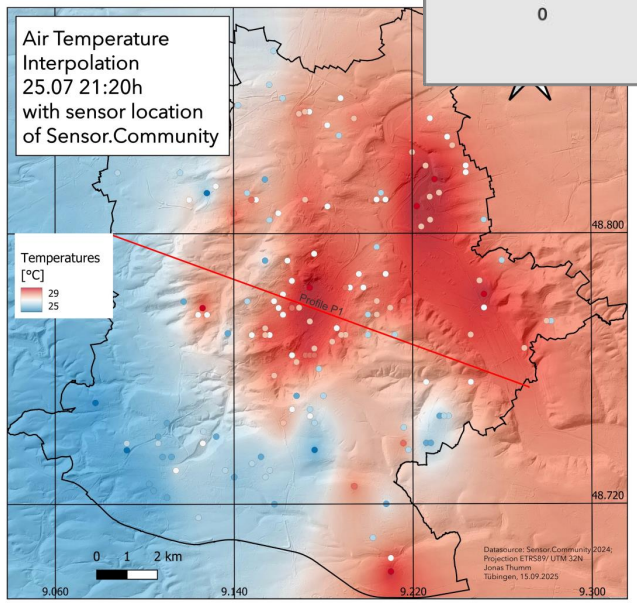


Figure 12: Air temperature interpolation 25.07 21:20h; own figure

Results

1) Surface Temperature
2) **Air Temperature**



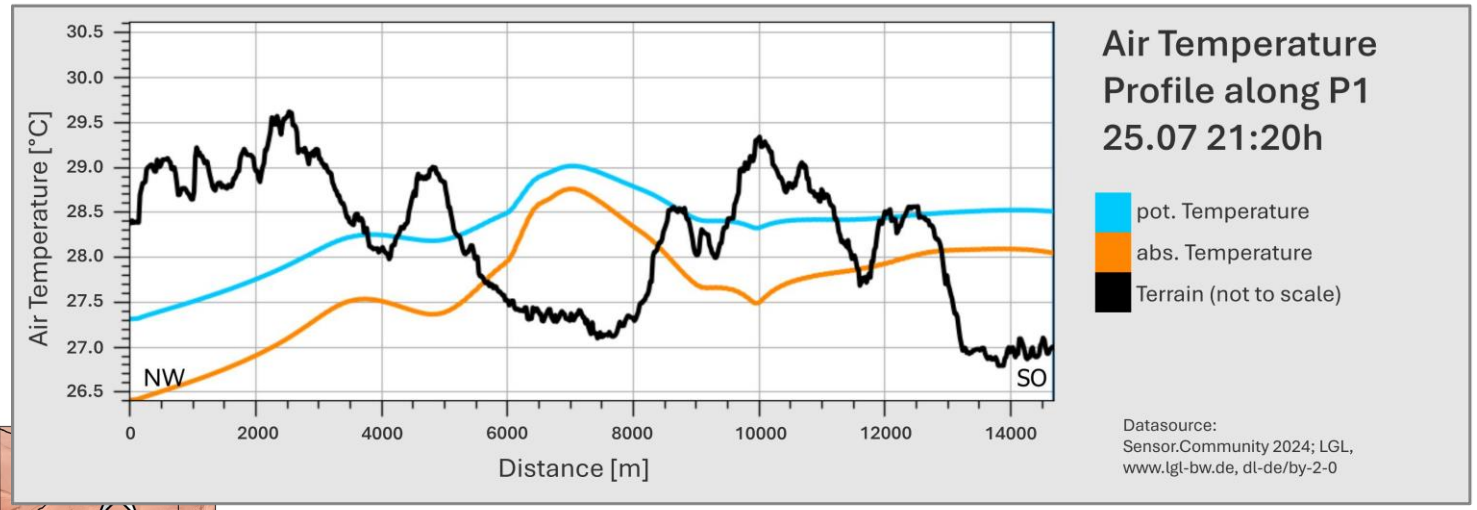
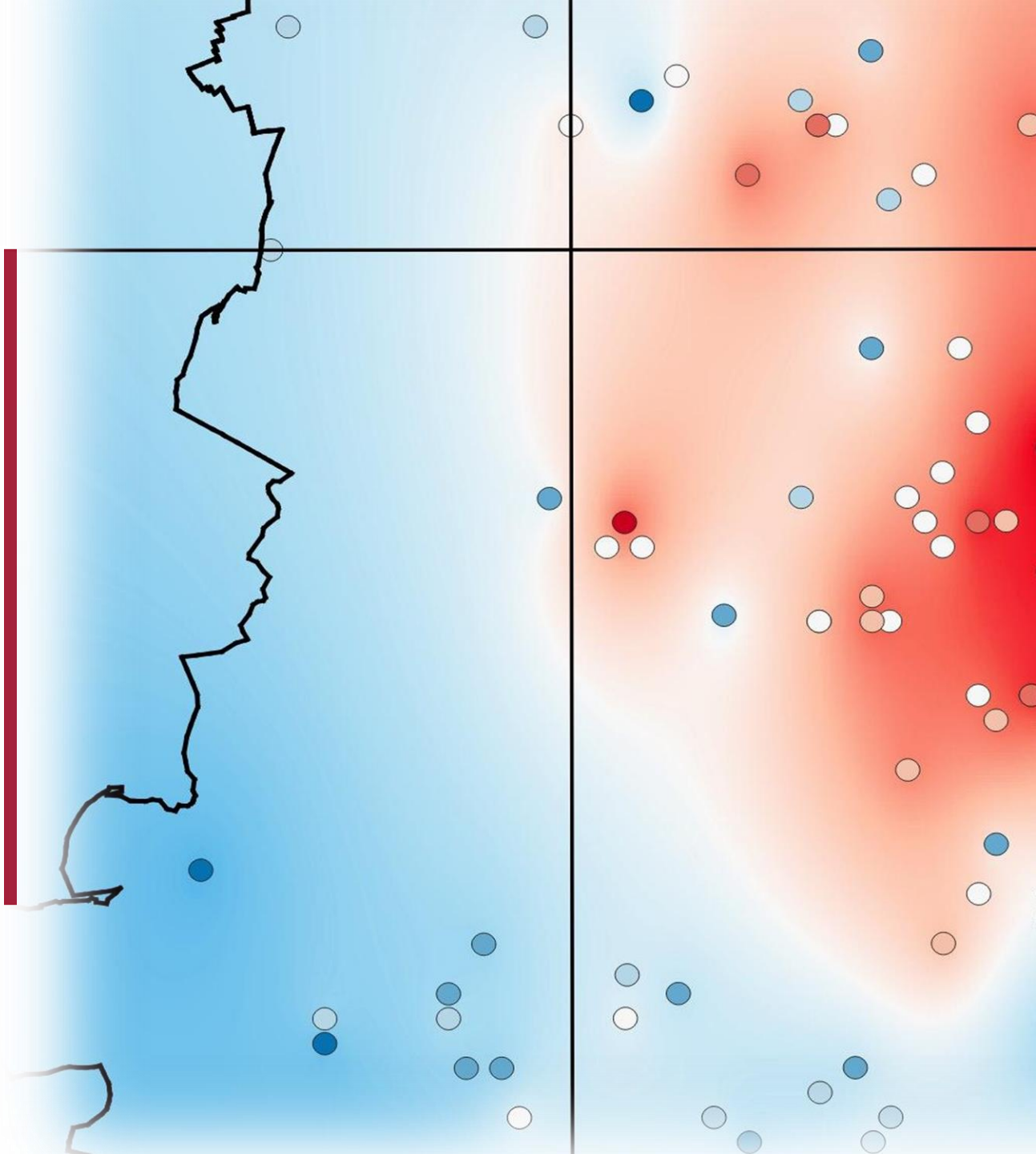


Figure 12: Air temperature interpolation 25.07 21:20h; own figure

Figure 13: Air temperature interpolation 25.07 21:20h Profile; own figure

Conclusion



Conclusion

- Persistent high surface and air temperatures in inner city and riverside industrial areas.
- Daytime citizen science data limited by missing metadata and poor radiation shielding, but useful for nighttime analysis.
- Enhanced sensor design would create synergy effects with remote sensing, improving UHI analysis.

Bibliography

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Meier, F. et al. (2017): Crowdsourcing air temperature from citizen science weather stations for urban climate research. In: Urban Climate, Vol. 19, Nr. 10, S.170-191.