Indoor and outdoor ambient air temperatures during summer 2019 in Augsburg, Germany

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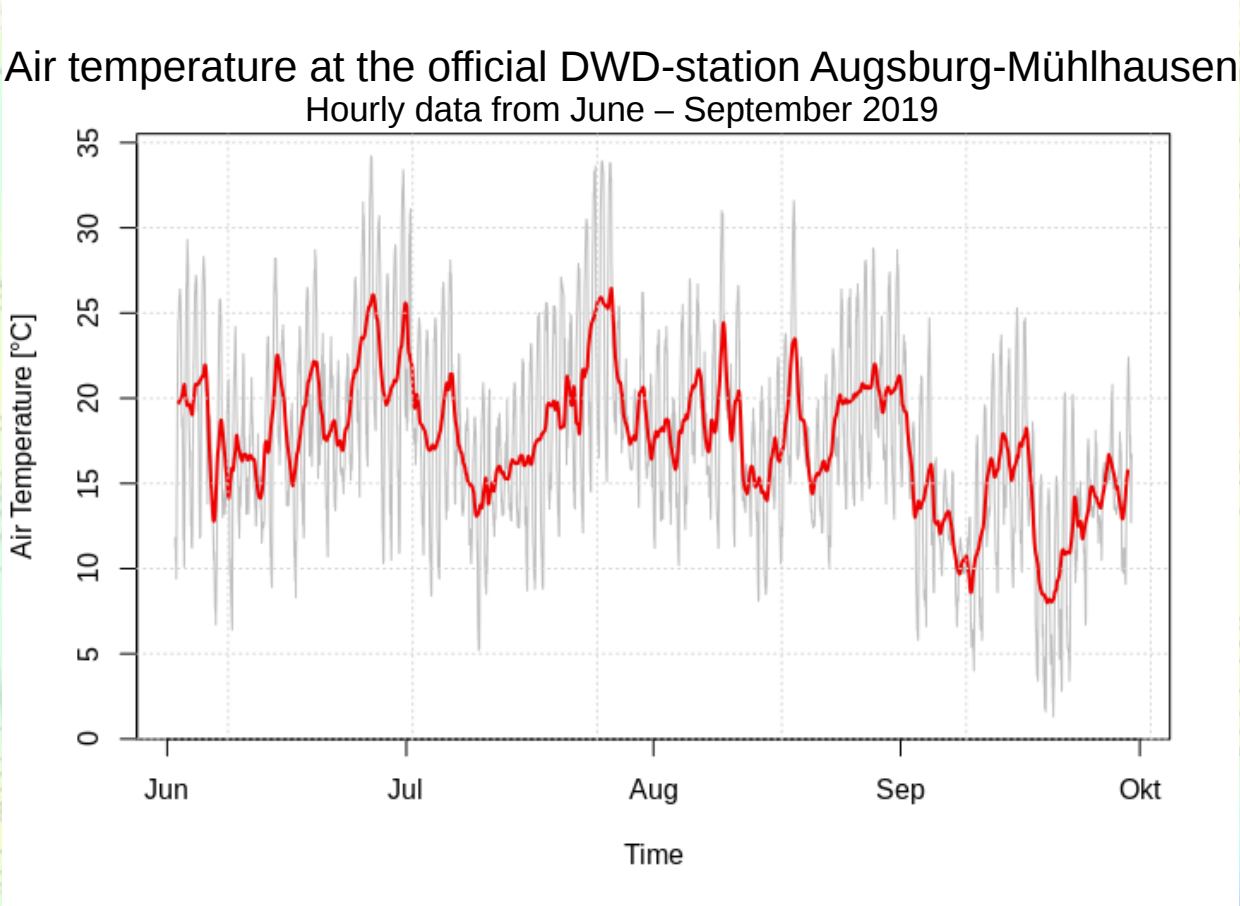
Background – the Abc Project

Related to recent and future climate change an increase in frequency and intensity of heat waves is expected for Germany (e.g. Zacharias et al. 2014). In particular for urban areas a distinct vulnerability against such events has to be stated. However, depending on the specific urban structural characteristics also intra-urban variations concerning the potential thermal load have to be taken into account (Straub et al. 2018).

Within the framework of the interdisciplinary research project Abc (Augsburg bleibt cool – Augsburg stays cool) – funded by the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety – it is intended to detect and quantify urban thermal hot-spots with respect to outdoor and as well indoor air temperatures in the city of Augsburg (Bavaria, SE Germany). The knowledge of such spatiotemporal patterns of thermal and especially heat-stress exposure are an indispensable basis for any further aspired local climate modeling and adaptation studies.

Temperature Measurements in Summer 2019

The summer of 2019 featured significantly too warm conditions in Germany during all summer months (e.g. Matzarakis et al. 2020). This included several distinct warm episodes and heat waves, the most pronounced of these appearing around end of July.



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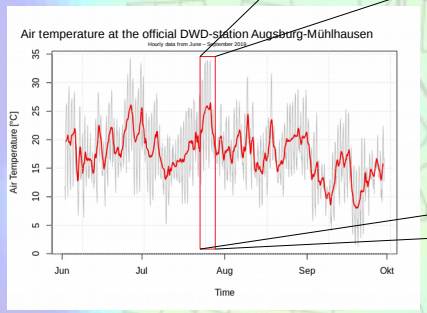

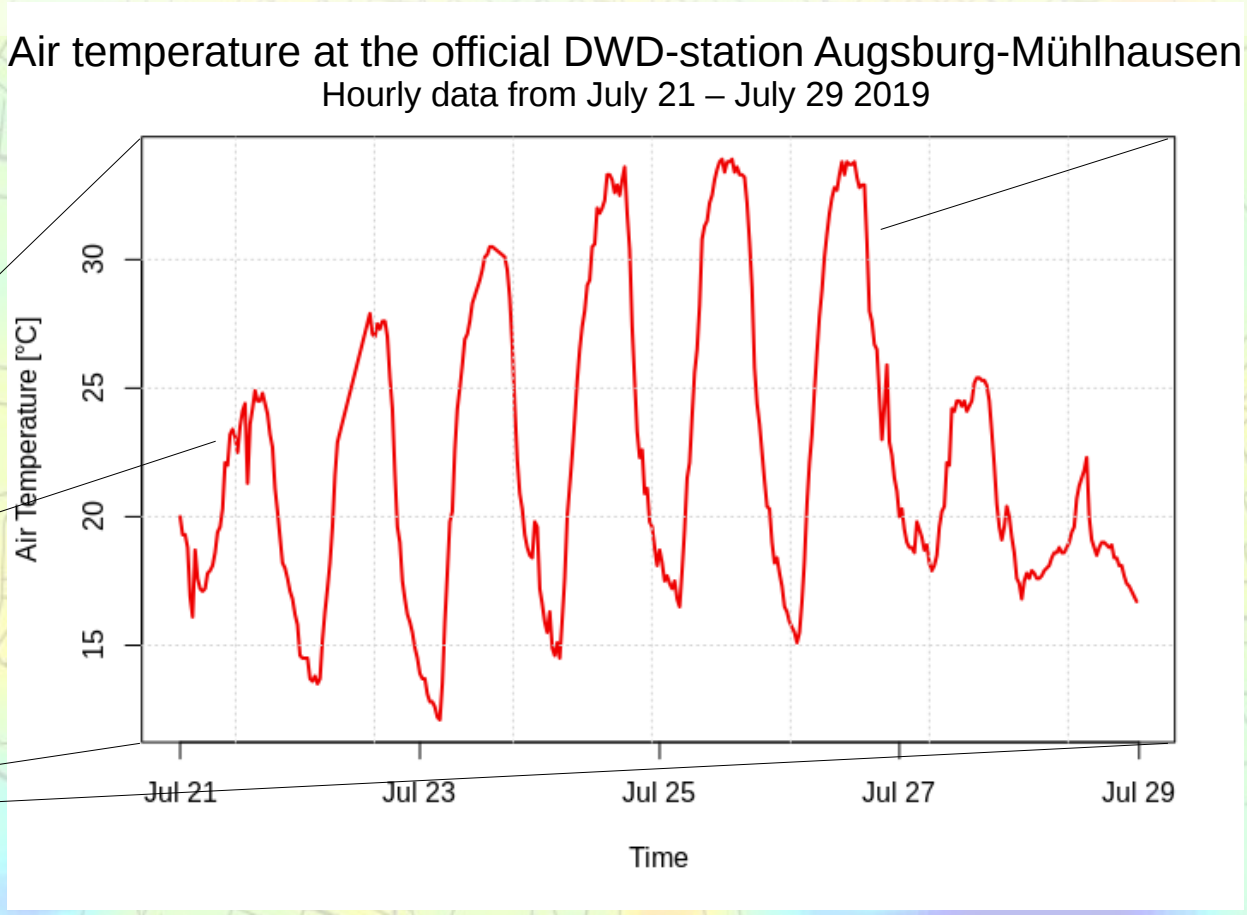

Temperature Measurements in Summer 2019

To record thermal indoor conditions, in June 2019 around 500 low-cost thermometers and around 50 thermo-hygrometers have been distributed among residents of the central city parts of Augsburg to record ambient indoor temperatures during summer. As high indoor air temperatures are suspected to be health relevant in particular during night (e.g. Anderson et al. 2013), participants placed the thermometers in their bedrooms.

Outdoor temperature and humidity have been recorded simultaneously by an already existing comprehensive urban climate measuring network (Beck et al. 2018).

Mobilisation activities for promoting the indoor temperature measurements

Temperaturmessaktion des Projektes Abc

Vielen Dank für Ihre Teilnahme an der Temperaturmessaktion. Bitte beachten Sie die folgenden Anweisungen zur Platzierung des Thermometers. Um die Forschungsergebnisse wissenschaftlich korrekt auswerten zu können, bitten wir Sie uns ein paar Fragen zu beantworten. Den Fragebogen dazu finden Sie **ab Freitag, den 28.06.2019 unter www.surveymonkey.de/r/umfrage-abc.**
Alle Teilnehmer/innen, die angekreuzt haben, dass sie persönlich oder telefonisch befragt werden möchten, werden demnächst von uns per Email oder Telefon kontaktiert.

Wo soll das Gerät angebracht werden?

Am besten auf den Schrank oder ins Regal legen, an den Schrank oder an die Wand hängen oder kleben. Dazu entweder einen Faden durch die Öse am Thermometer fädeln oder das doppelseitige (wieder ablösbare) Klebeband auf der Rückseite des Geräts nutzen.

Dabei ist Folgendes zu beachten, damit wir die bestmöglichen Messergebnisse erhalten:

- Nicht direkter Sonneneinstrahlung aussetzen (nicht direkt am Fenster anbringen)
- Nicht direkt an Wärmequellen positionieren (Heizkörper, Nachtschlampe etc.)
- Nicht in Schrank oder die Schublade legen (Belüftung sollte gewährleistet sein)
- Die Position des Gerätes während der Messperiode nach Möglichkeit nicht verändern

Was misst das Gerät?

Das Thermometer ist bereits aktiviert und zeichnet alle 15 Minuten die aktuelle Lufttemperatur auf. Über die Taste > können Sie den aktuellen Messwert auch selbst abrufen. Das Gerät ist so programmiert, dass es nicht versehentlich ausgeschaltet werden kann.

Wann und wie gebe ich das Gerät zurück?

Wir werden uns Ende September bzw. Anfang Oktober mit Ihnen per Email oder Telefon in Verbindung setzen, um die Rückgabedetails zu klären. Folgende Möglichkeiten wird es zur Rückgabe geben: Wir können das Thermometer entweder persönlich abholen, Sie können das Thermometer beim Umweltamt der Stadt Augsburg abgeben oder wir lassen Ihnen einen frankierten Rückumschlag zukommen.

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Vielen Dank für Ihre Unterstützung!

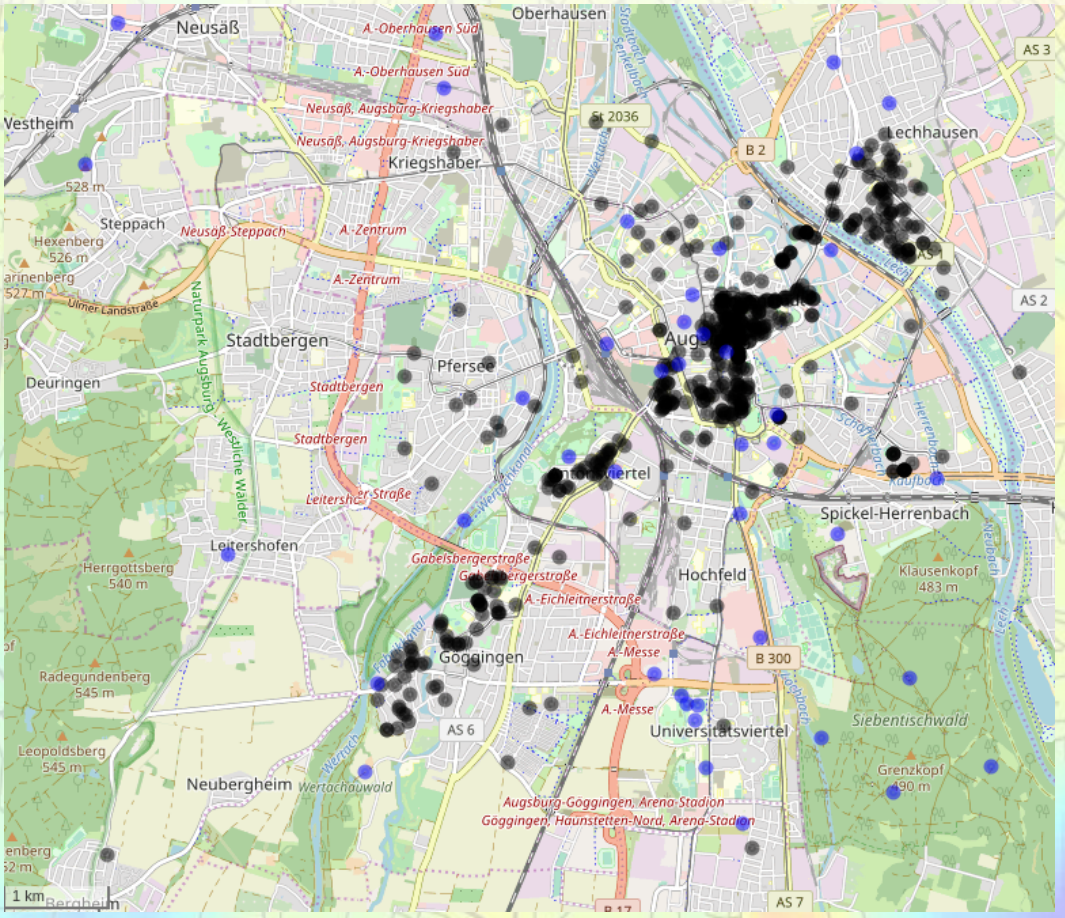
Info leaflet for participating citizens

Elitech RC-5 and GSP-6 temperature and temperature-humidity logger

Sent back loggers waiting for read-out

Temperature Measurements in Summer 2019

Indoor temperature measurements have been performed in different parts of Augsburg. Focusing on Local Climate Zone categories Compact Mid Rise, Open Mid Rise and Open Low Rise and covering urban neighbourhoods with different characteristics concerning building age etc.



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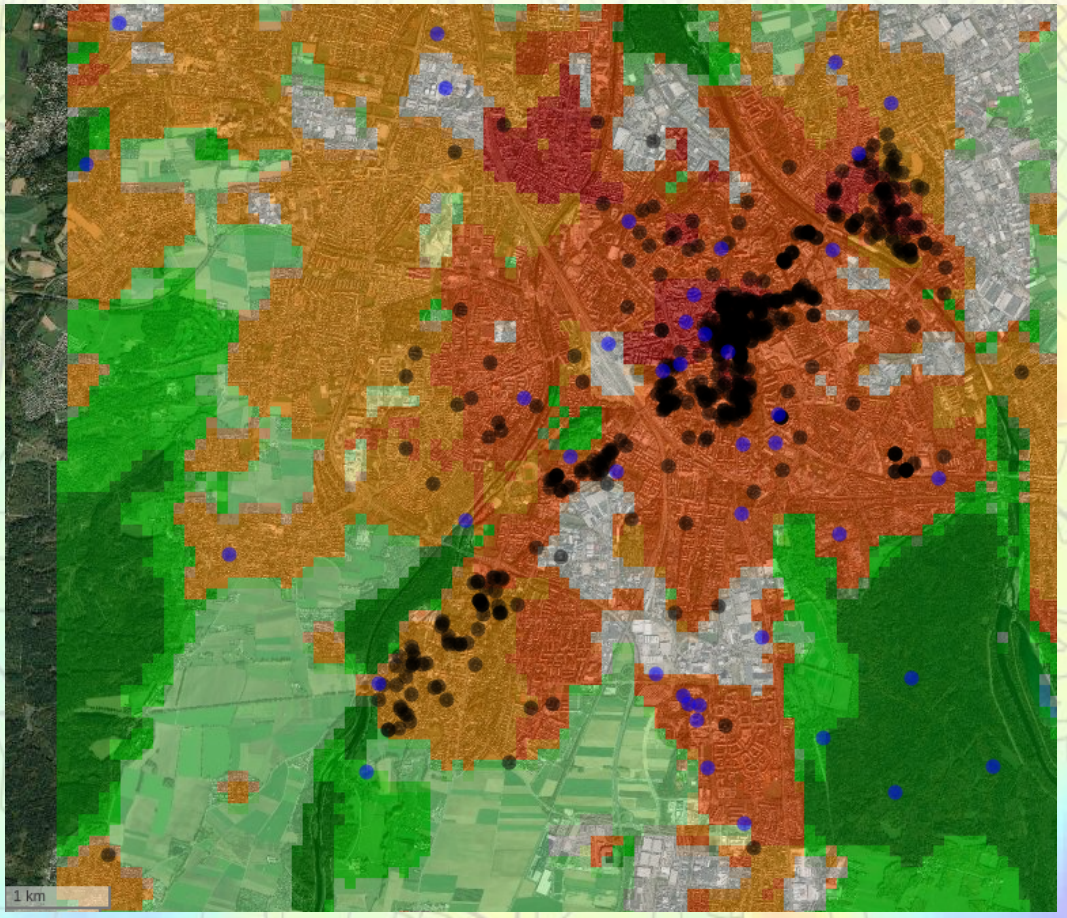
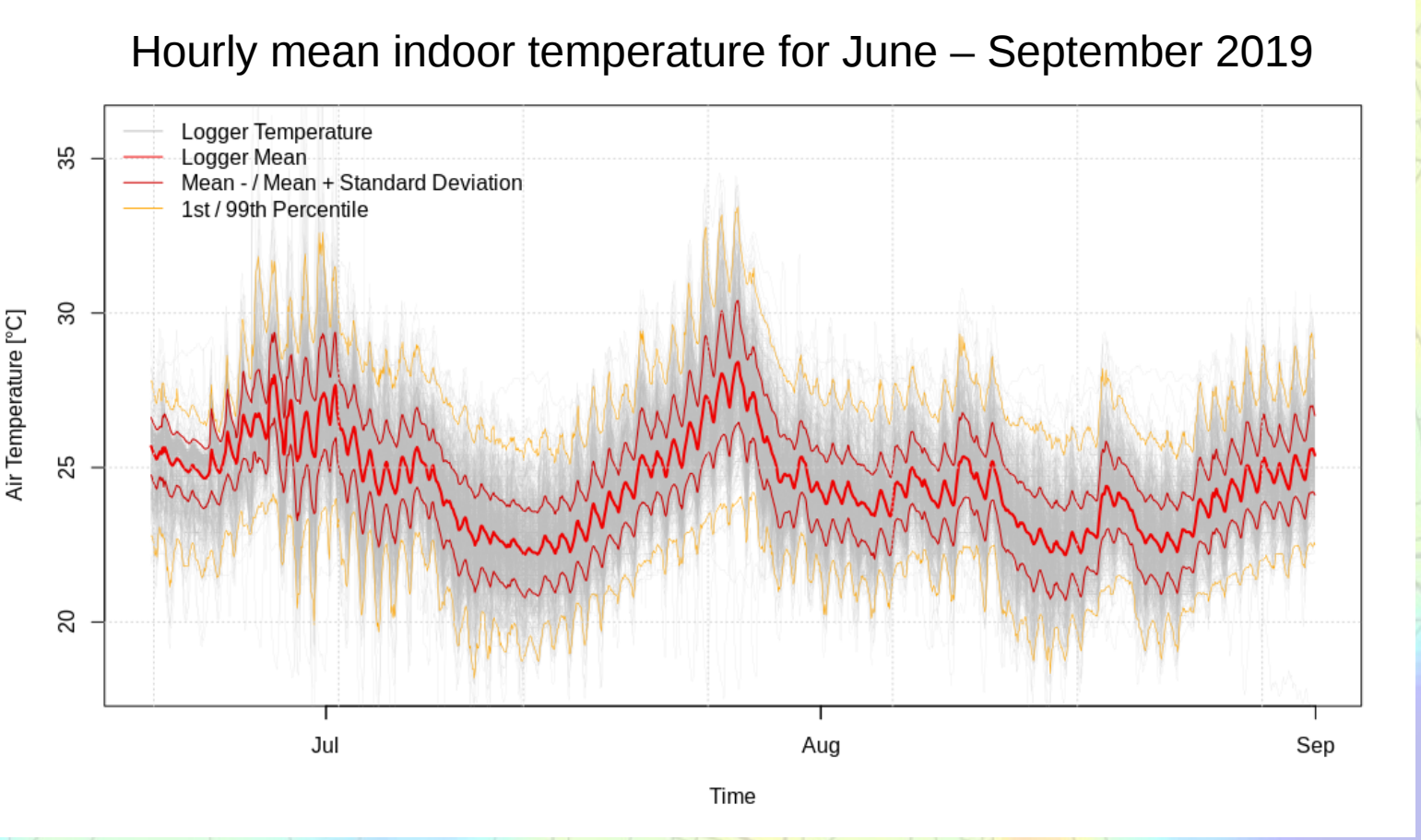


Results

Indoor temperature measurements are available for 554 temperature loggers.



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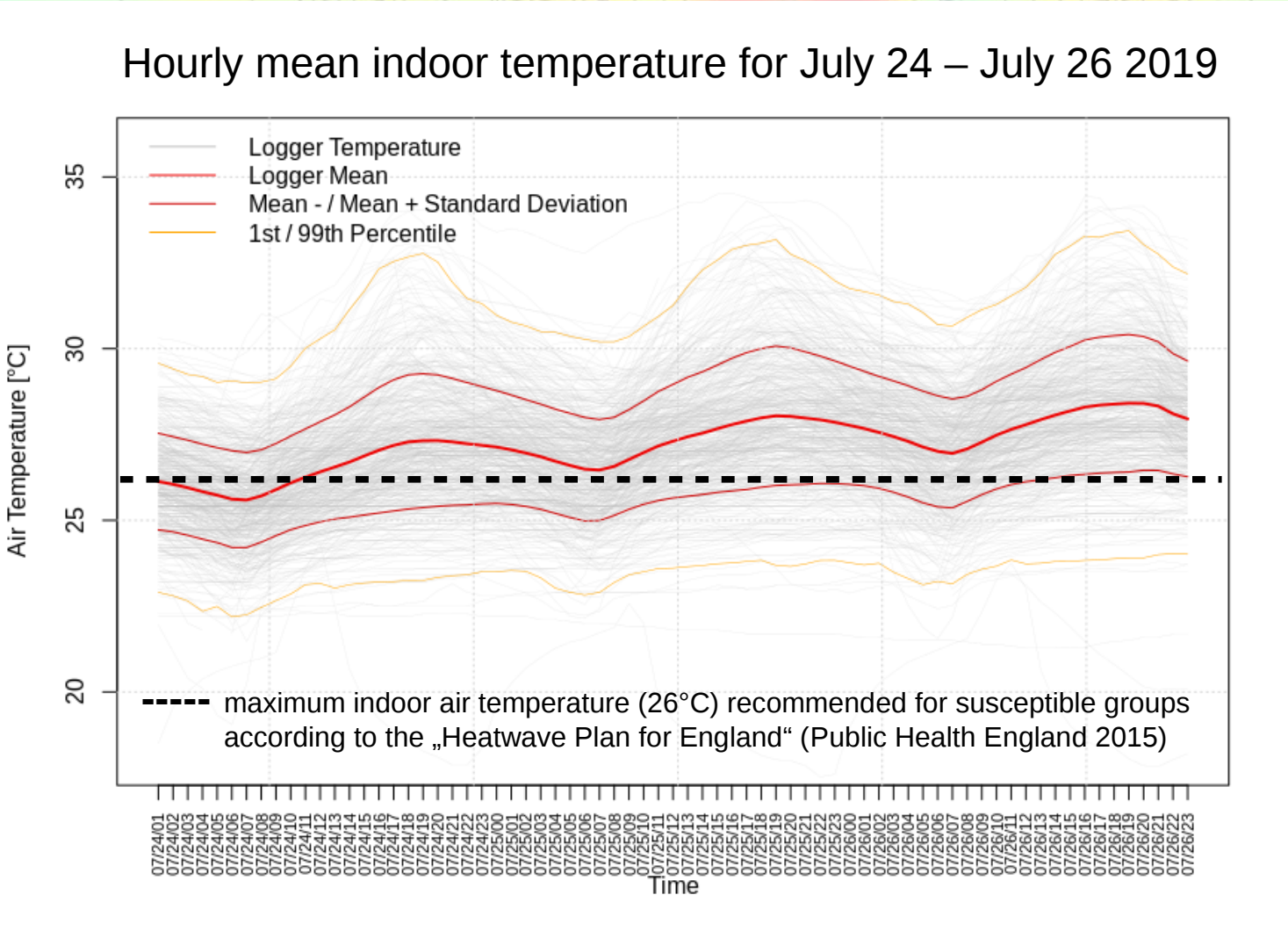
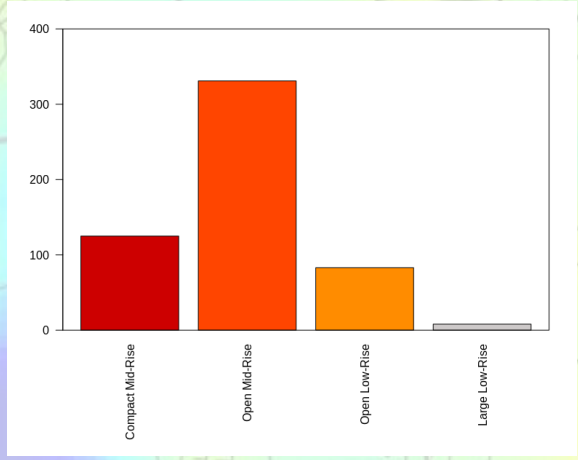


Results

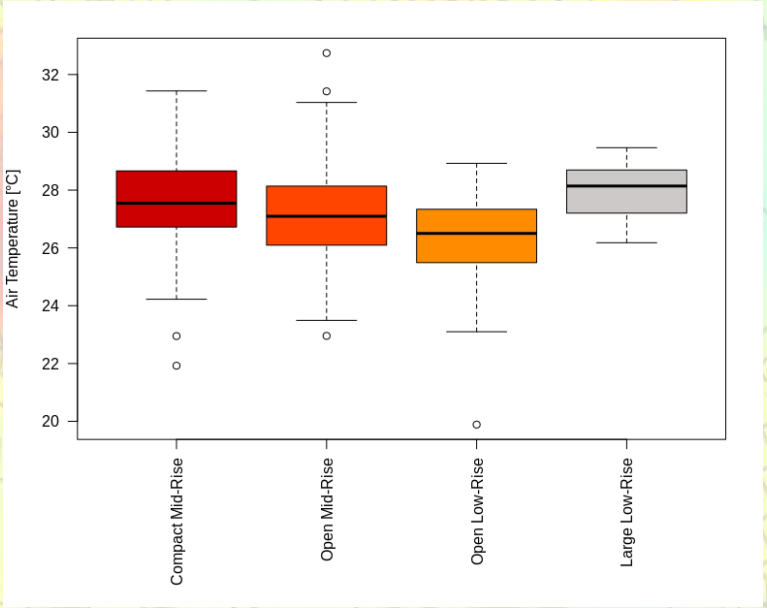
Differences of indoor temperatures between Local Climate Zones.

Distribution of Loggers between LCZ categories



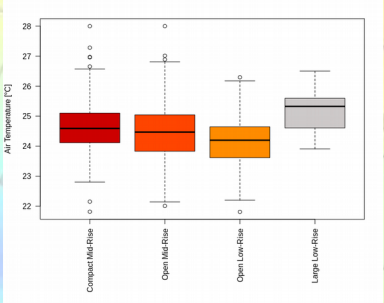
Frequencies of indoor temperature measurements for LCZ categories

July Heatwave



Daily mean indoor temperatures (July 24 – July 26 2019) grouped according to LCZ categories

June - September



Daily mean indoor temperatures (June – September 2019) grouped according to LCZ categories

Results

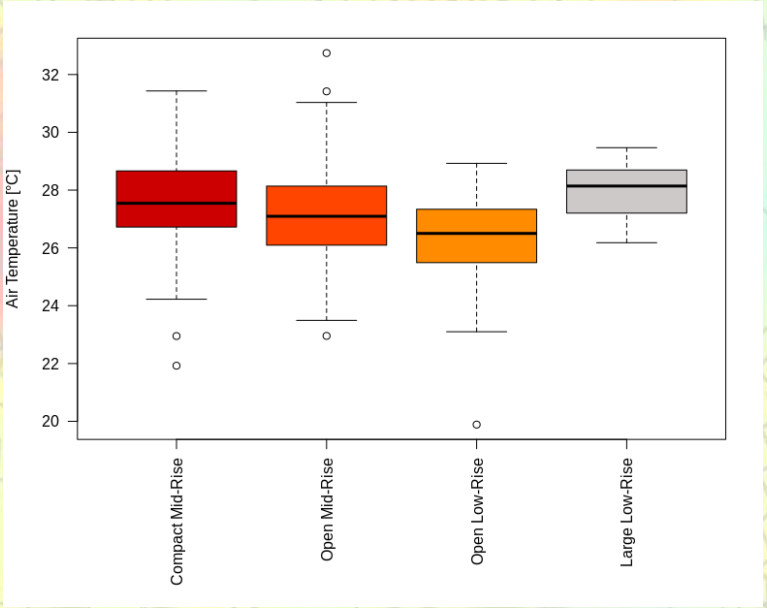
Differences of indoor temperatures between Local Climate Zones.

Significance of differences between LCZs

(p-values from a pairwise Wilcoxon test)

	Compact Mid-Rise	Open Mid-Rise	Open Low-Rise
Open Mid-Rise	0.0577		
Open Low-Rise	0	0.0078	
Large Low-Rise	0.437	0.2311	0.0329

July Heatwave



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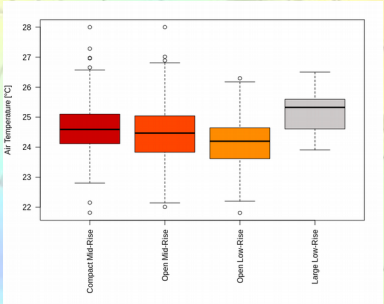

Daily mean indoor temperatures
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grouped according to LCZ categories

Significance of differences between LCZs

(p-values from a pairwise wilcoxon test)

	Compact Mid-Rise	Open Mid-Rise	Open Low-Rise
Open Mid-Rise	0.1105		
Open Low-Rise	5e-04	0.0164	
Large Low-Rise	0.1105	0.0587	0.0071

Results

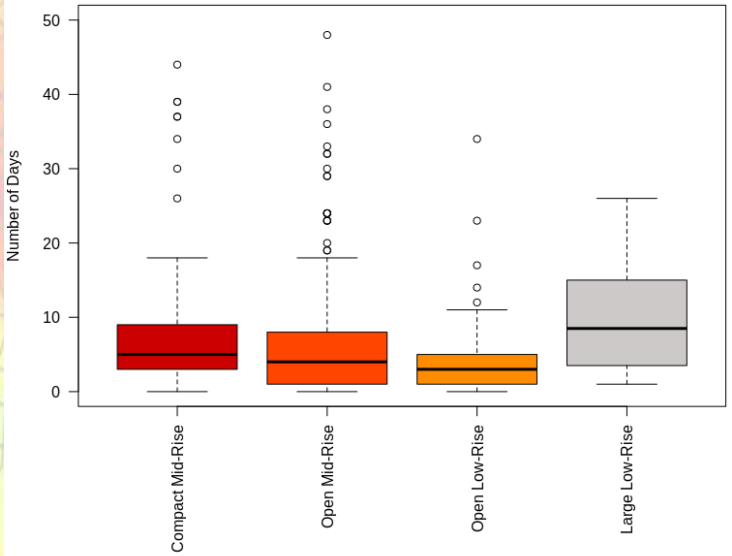
Differences of indoor temperatures between Local Climate Zones.

Significance of differences between LCZs

(p-values from a pairwise Wilcoxon test)

	Compact Mid-Rise	Open Mid-Rise	Open Low-Rise
Open Mid-Rise	0.0334		
Open Low-Rise	0	0.0153	
Large Low-Rise	0.3031	0.1753	0.0334

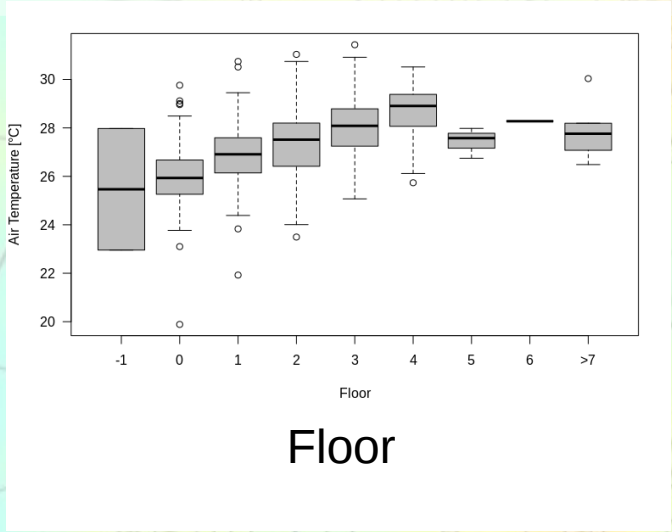
June - September



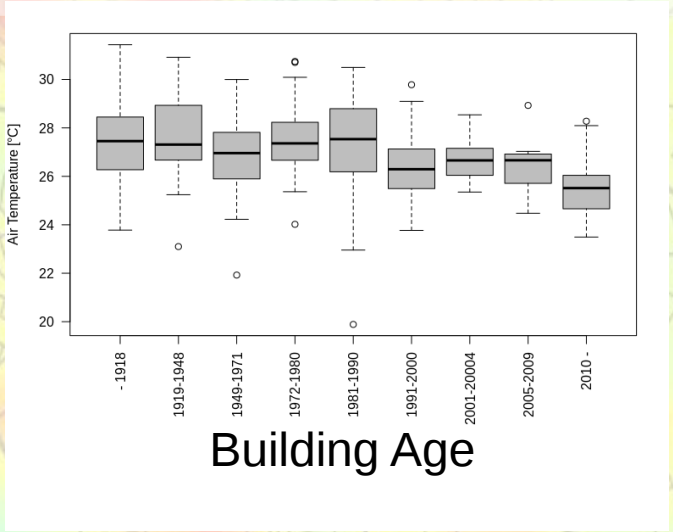
Number of days with a minimum indoor air temperature exceeding
26°C (June – September 2019; n = 73 days) grouped according to LCZ categories

Results

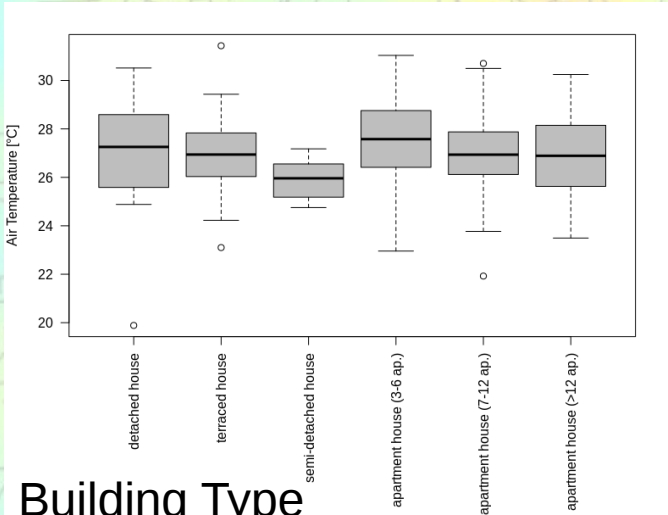
Differences of indoor temperatures (July heatwave) related to building/apartment characteristics.



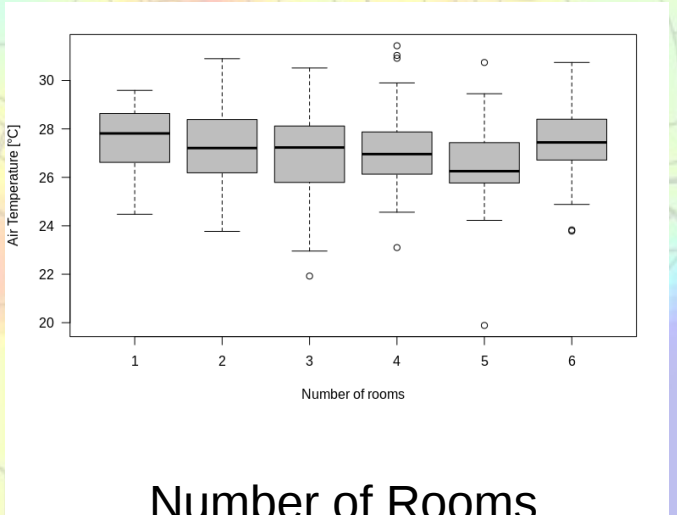
Floor



Building Age



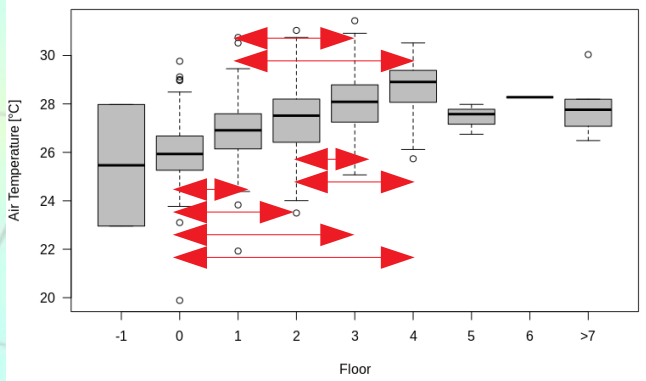
Building Type



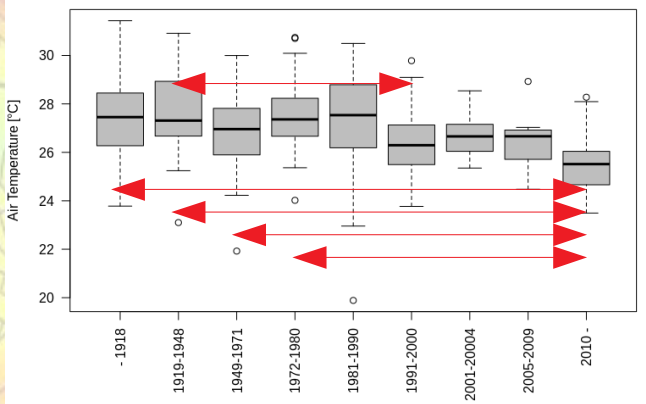
Number of Rooms

Results

Differences of indoor temperatures (July heatwave) related to building/apartment characteristics.

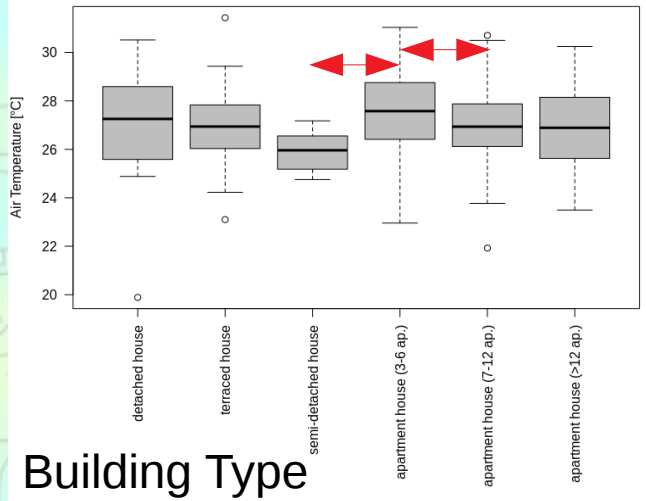


Floor



Building Age

↔ indicate significant (α = 0.05) pairwise differences (according to pairwise Wilcoxon tests)



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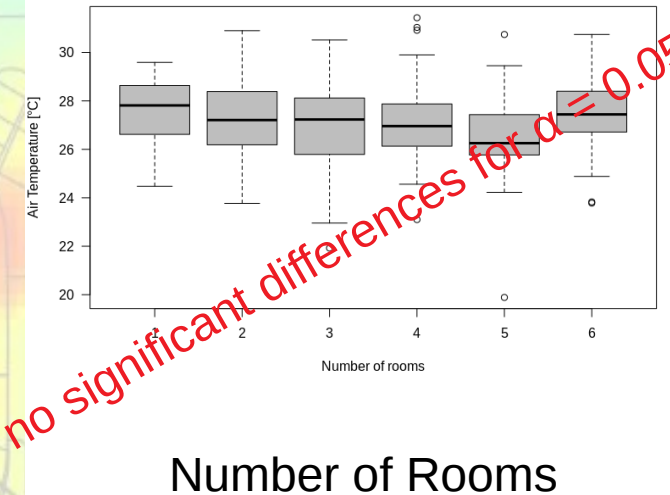

Number of Rooms

Results

Indoor temperatures in different apartments of one single building

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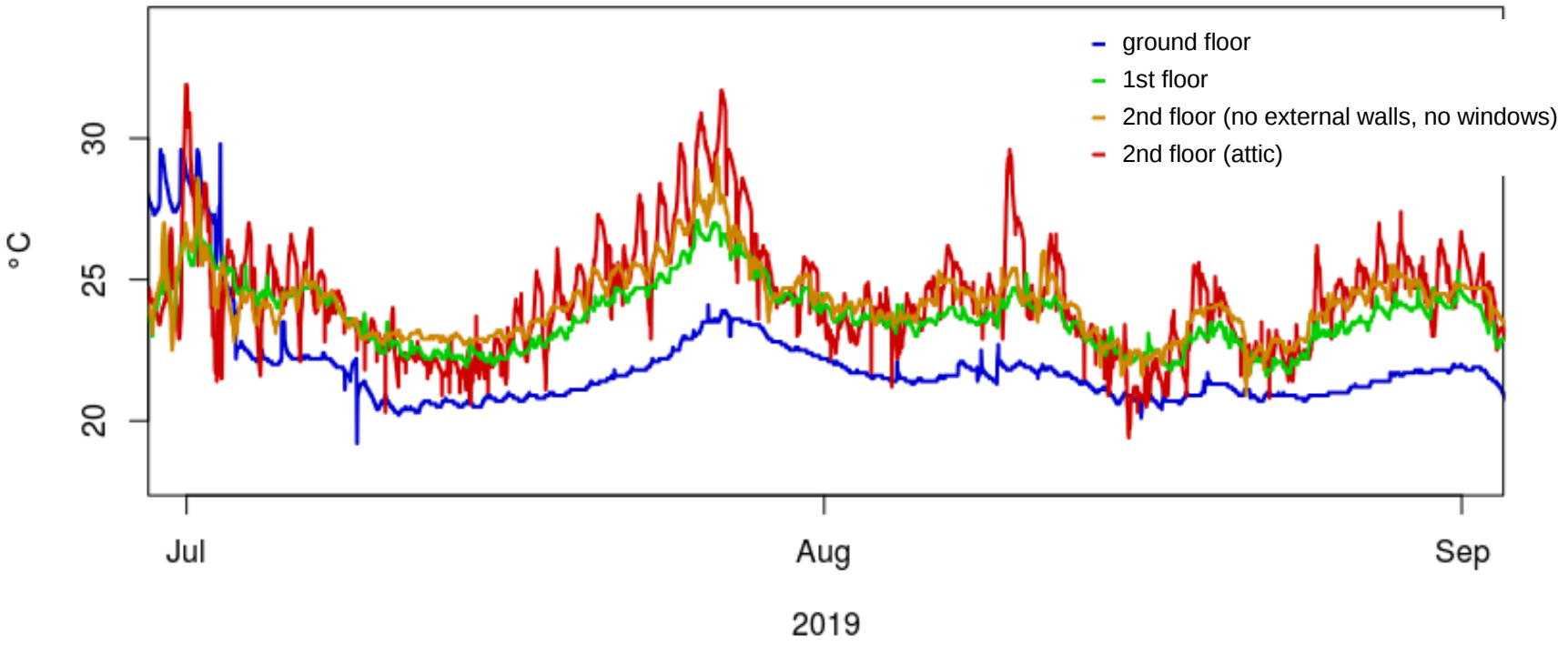
Indoor temperatures in different apartments of one single building

Bedroom temperatures (15min data) in different apartments in the same building



Summary

- During summer 2019 around 550 low cost temperature loggers have been distributed among residents in the city of Augsburg
- Resulting indoor temperature measurements reach values exceeding 35°C
- and document several days featuring a potentially health relevant thermal load (daily minimum temperature above 26°C)
- Indoor air temperatures – and the number of threshold exceedances – show a clear-cut connection to urban structure (Local Climate Zones)
- and as well to some building characteristics (e.g. floor, building age),
- which is partly in line with previous studies (e.g. Franck et al. 2013) which were mostly based on less comprehensive data
- Indoor air temperatures reached their maximum during a short heat wave end of July
- During this period also the effects of urban structure and building characteristics appear to be most pronounced
- Our preliminary results emphasize the relevance of the urban environment for indoor temperatures and thus the need for taking into account these effects in any strategies for urban climate change adaptation

Outlook

In the framework of the Abc-project the here presented work will be complemented in several ways.

- Extended analysis of indoor temperature measurements concerning:
  - diurnal variations of environment/building effects on indoor temperatures
  - Consideration of effects not taken into account so far (e.g. exposition of windows, approx. duration of insolation, ...)
  - Comparison of indoor temperatures with nearby outdoor temperatures

- Statistical and numerical model studies including:
  - Numerical ENVImet based simulations of different adaptation measures
  - Statistical modeling of the 3-dimensional temperature distribution based on remote sensing data

- Studies focusing on aspects like heat risk perception among urban citizens (Beckmann & Hiete 2019)

References

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