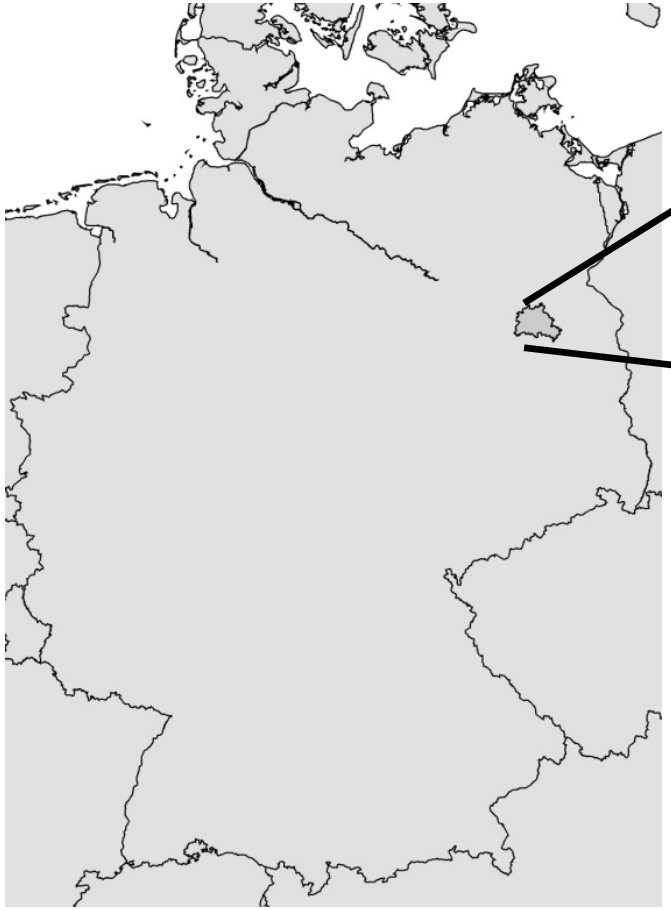
Human thermal comfort in Local climate zones of Berlin

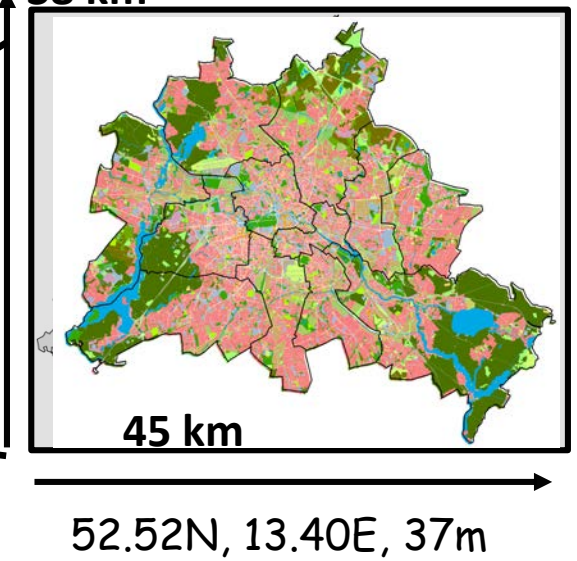
Ines Langer, Alexander Pasternack, Uwe Ulbrich
Freie Universität Berlin, Germany
Contact: ines.langer@met.fu-berlin.de

Research Area

Germany



Berlin



52.52N, 13.40E, 37m

water
buildings
forest
parks

3.5 mio. inhabitants ~ 890 km²

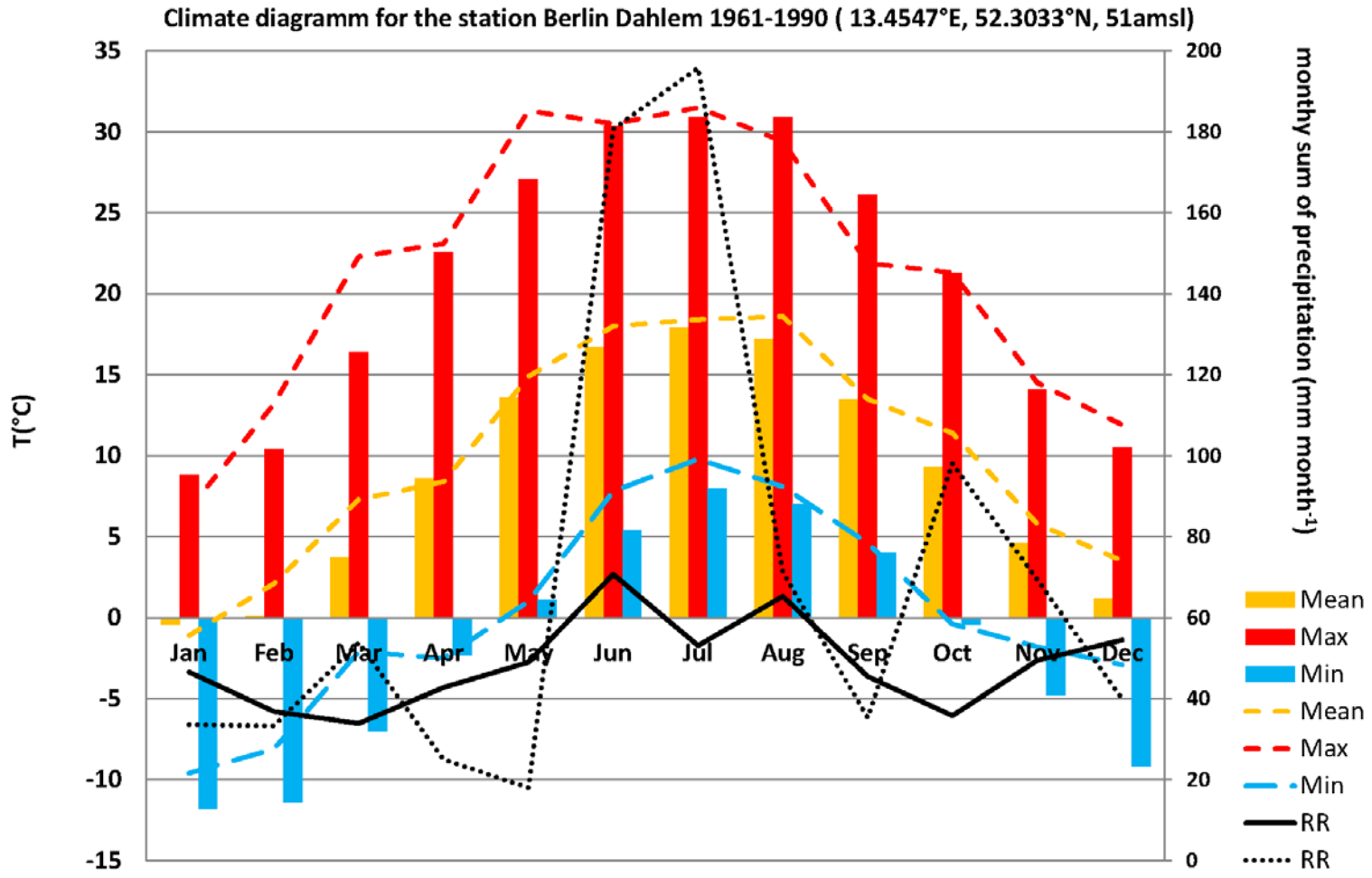
~ 17.5% forest~ 163 km²
~ 6 % water ~ 60 km²

~17.6 % parks, green spaces
~150 m² per inhabitants

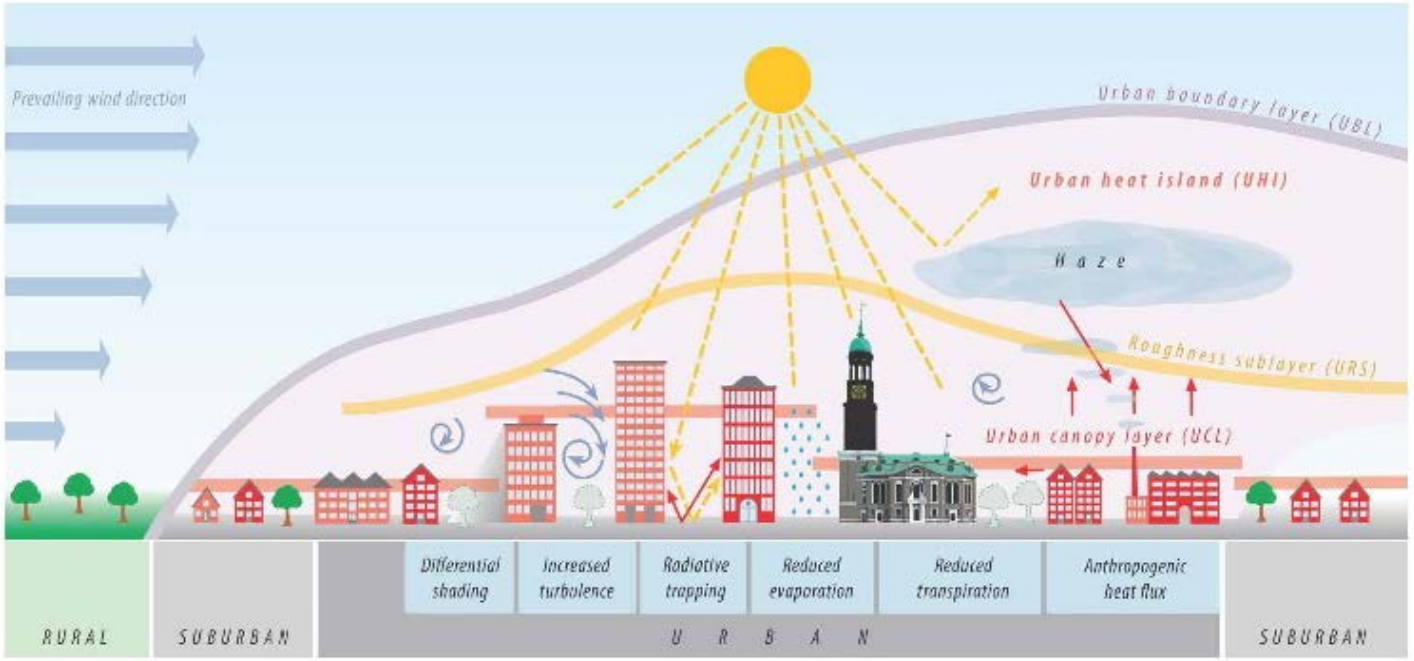
~ 59% built- up area, streets

Climate of Berlin

moderately continental, with cold winter, moderately warm summer,
average mean temperature 9.9°C:, precipitation: 576 mm/year



Urban heat island effect (UHI)



Bechtel & Schmidt, 2011

- limited applied urban climatic studies in urban planning and development
- missing link between urban development and its corresponding impact on local climatic conditions

Analyzing 'LOCAL CLIMATE ZONES' after Stewart & Oke, 2012
(L) ***local*** in scale, (C) ***climatic*** in nature, and (Z) ***zonal*** in representation)

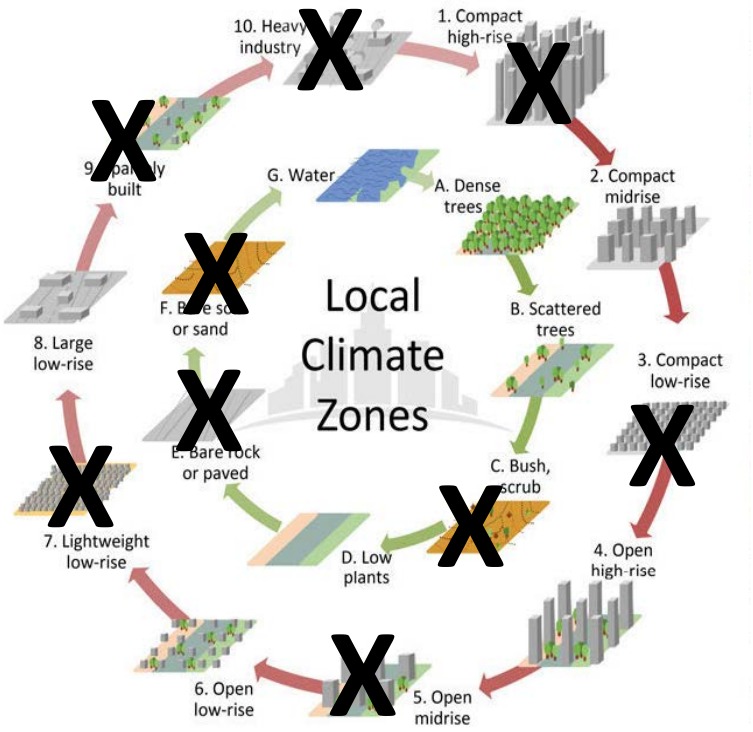
define local climate zones as regions of uniform surface cover, structure, material, and human activity that span hundreds of meters to several kilometers in horizontal scale. Each LCZ has a characteristic screen height temperature regime that is most apparent over dry surfaces, on calm, clear nights, and in areas of simple relief.

Local climate zone

research framework for
UHI studies and
standardizes the worldwide
exchange of urban
temperature observations.

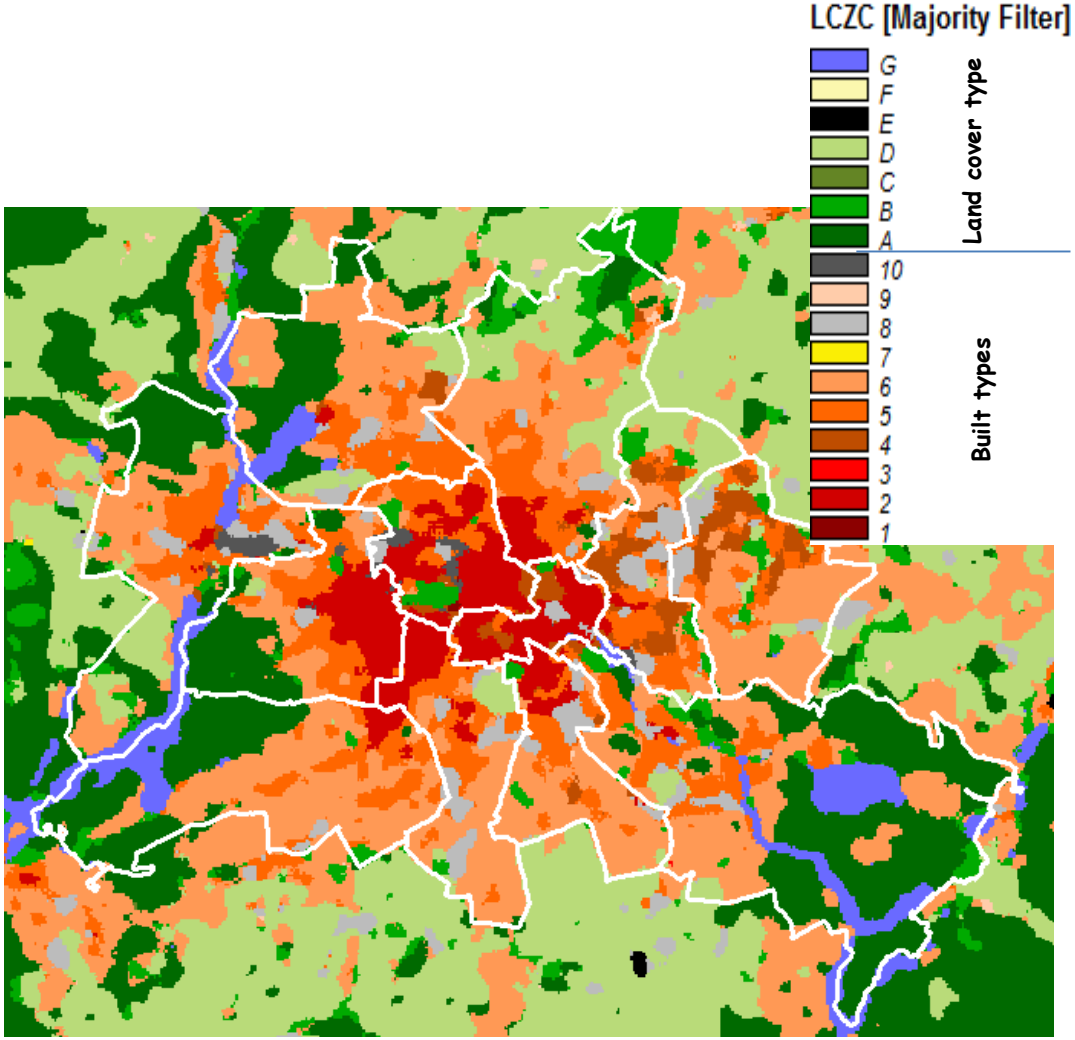
Result of the LCZ classification for Berlin

Existing Local Climate zone (LCZ) for Berlin



X: doesn't exist

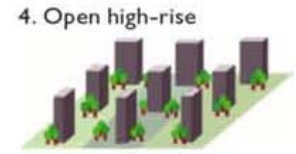
Figure taken from Bechtel et al. (2017)

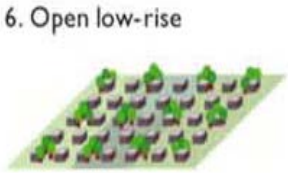


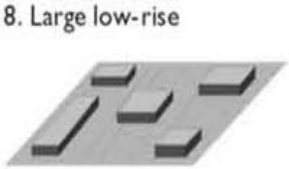
https://www.geo.fu-berlin.de/met/ag/Stadtklima/FUMiNet-OpenStreetMap/index.html

Urban climatological city network of Berlin (FUMiNet)~ 32 stations for analyzing the human thermal comfort (Physiologically Equivalent Temperature)

	SVF:	No. of stations	
Fasanenstr. Jagowstr. Schillerstr. Galvanistr.	0.25	4	Compact midrise
Marzahn	0.44		Open high-rise
Amselgrund 1 Amselgrund 2 Amselgrund 3 Prignitzstr. Petitweg Martin-Hoffmannstr.	0.35	6	Open low-rise
Montanstr. Zerpenschleuser Ring Landsberger Allee Motardstr. Buckower Chaussee	0.40	5	Large low-rise





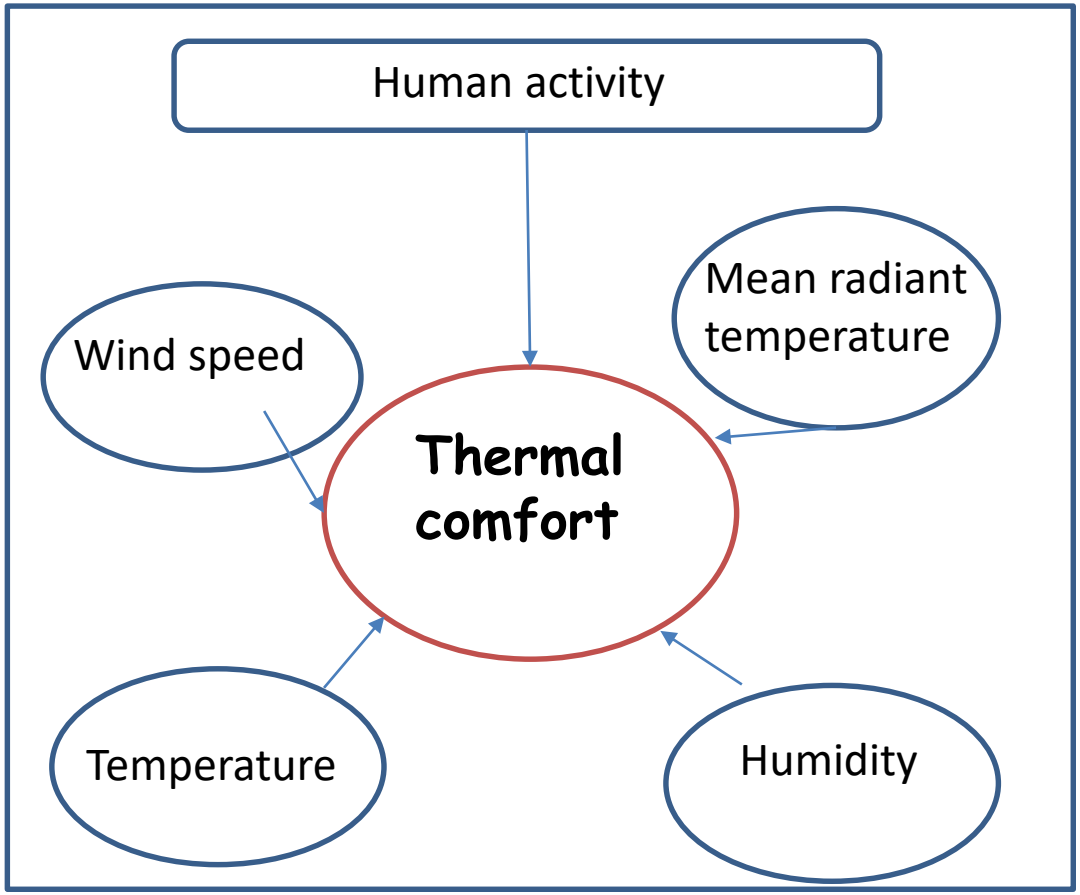


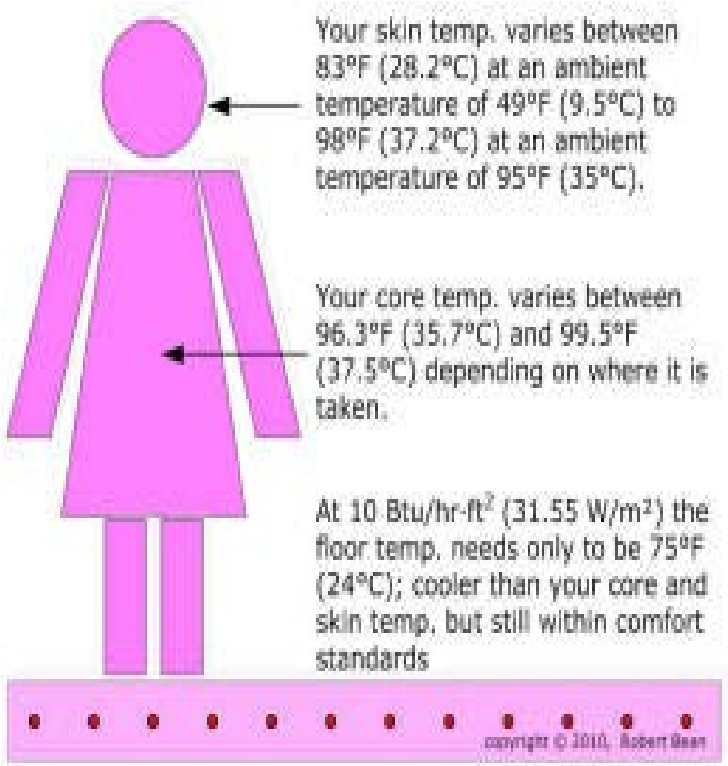
	SVF:	No. of stations		
Forstamt Tegel Preiss Wald Tegel	0.15	3	Dense Trees	A
Botanischer Garten Zoo	0.27	3	Scattered Trees	B
Gatow Buchholzer Str. Elisabeth-Aue	0.59	3	Low Plants	D
Wannsee Pichelsdorf Müggelsee Tegeler See Ruderclub Tegel	0.57	5	Water	G

SVF: Sky View Factor

Human thermal comfort

- Outdoor thermal conditions might affect occupants thermal percepetions





Using the Physiologically Equivalent Temperature (PET) we can analyse how changes in the thermal environment can affect human well-being.

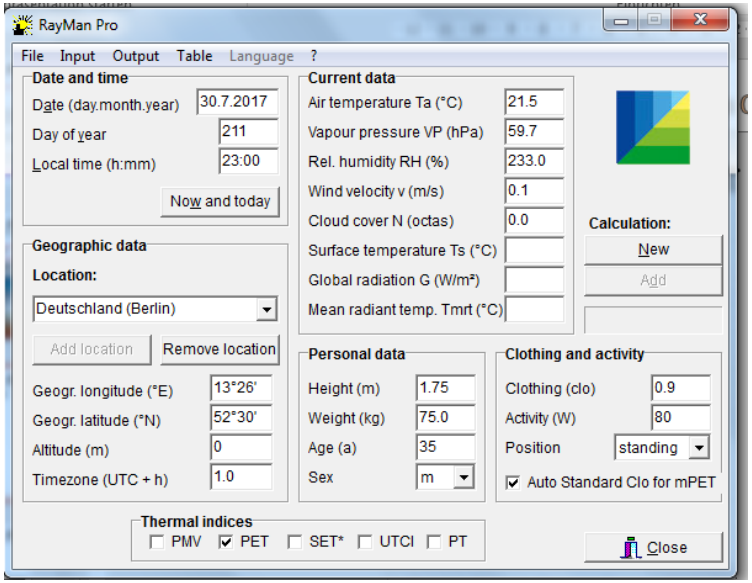
Analysis PET using RAYMAN software (Matzarakis,and Mayer, 1996)

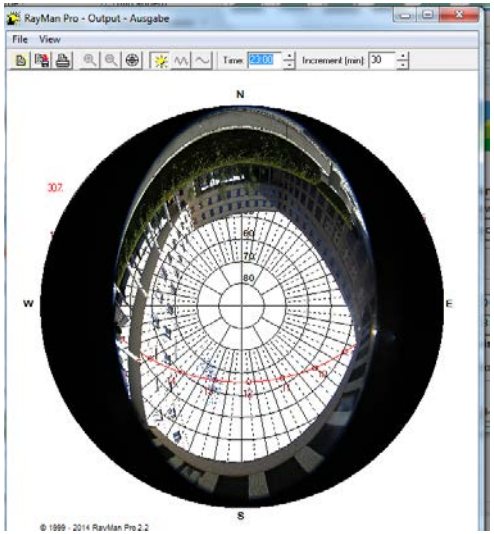
PET is an universal index and is irrespective of clothing and metabolic activity, its measured in degree Celsius, it has thermophysiological background and it gives the real effect of the sensation of climate on human beings

Date and time, Geographic data

Geo factors import of fisheye-photo

Required data
Air temperature °C
Relative humidity %
Wind velocity m/s





Thermal index PET

MATZARAKIS A., H. MAYER, 1996: Modelling radiation fluxes in simple and complex environments: basics of the RayMan model - International Journal of Biometeorology 54, 131-139. DOI: 10.1007/s00484-009-0261-0.

(PET) could give an information how changes in the thermal environment can affect human well-being.

PET/°C	Thermal perception	Grade of physiological stress
≤4.0	Very cold	Extreme cold stress
4.1-8.0	Cold	Strong cold stress
8.1-13.0	Cool	Moderate cold stress
13.1-18.0	Slightly cool	Slight cold stress
18.1-23.0	**Comfortable/Neutral**	**No thermal stress**
23.1-29.0	Slightly warm	Slight heat stress
29.1-35.0	Warm	Moderate heat stress
35.1-41.0	Hot	Strong heat stress
41.1≤	Very hot	Extreme heat stress

Result of PET for Berlin 2018 at 11pm

yearly mean value: 8°C

Fasanenstr. Jagowstr. Schillerstr. Galvanistr.	Compact midrise	2
Marzahn	Open high-rise	4
Amselgrund 1 Amselgrund 2 Amselgrund 3 Prignitzstr. Petitweg Martin-Hoffmannstr.	Open low-rise	6
Montanstr. Zerpenschleuser Ring Landsberger Allee Motardstr. Buckower Chaussee	Large low-rise	8

Forstamt Tegel Preiss Wald Tegel	Dense Trees	A
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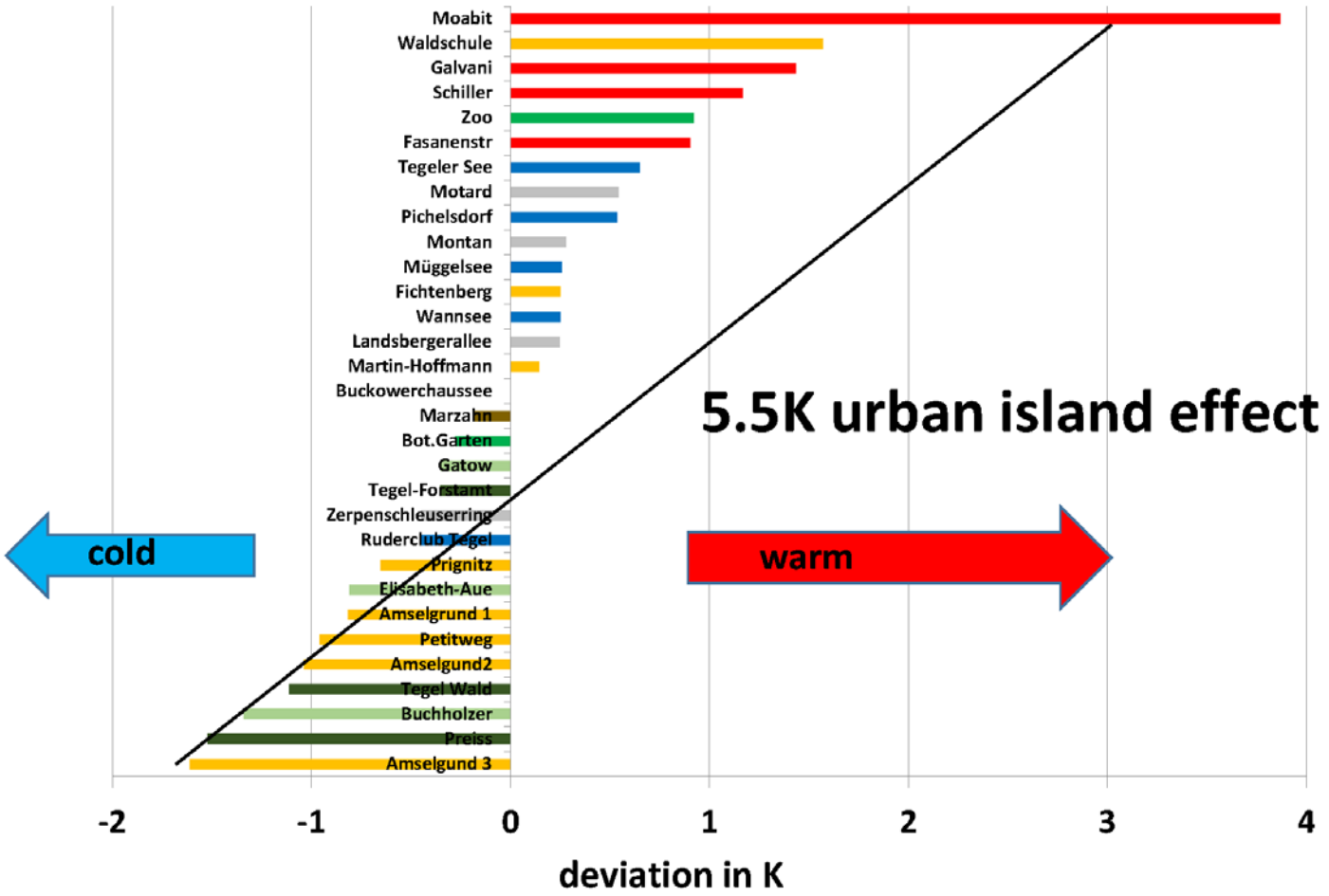

City stations are warmer than green areas

Temperature deviation in comparison with PET for July 2018

Fasanenstr. Jagowstr. Schillerstr. Galvanistr.	Compact midrise	2
Marzahn	Open high-rise	4
Amselgrund 1 Amselgrund 2 Amselgrund 3 Prignitzstr. Petitweg Martin-Hoffmannstr.	Open low-rise	6
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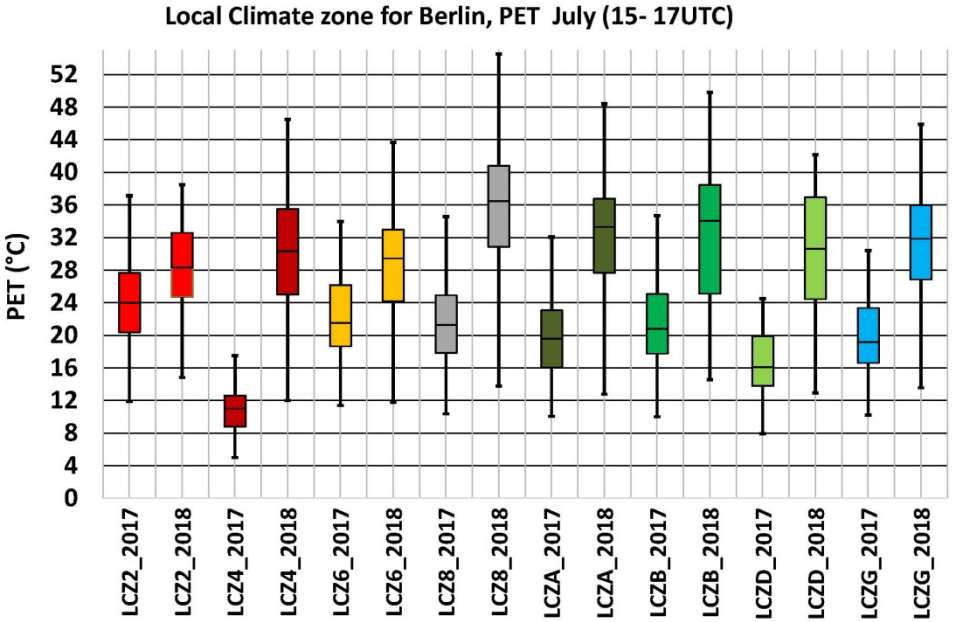
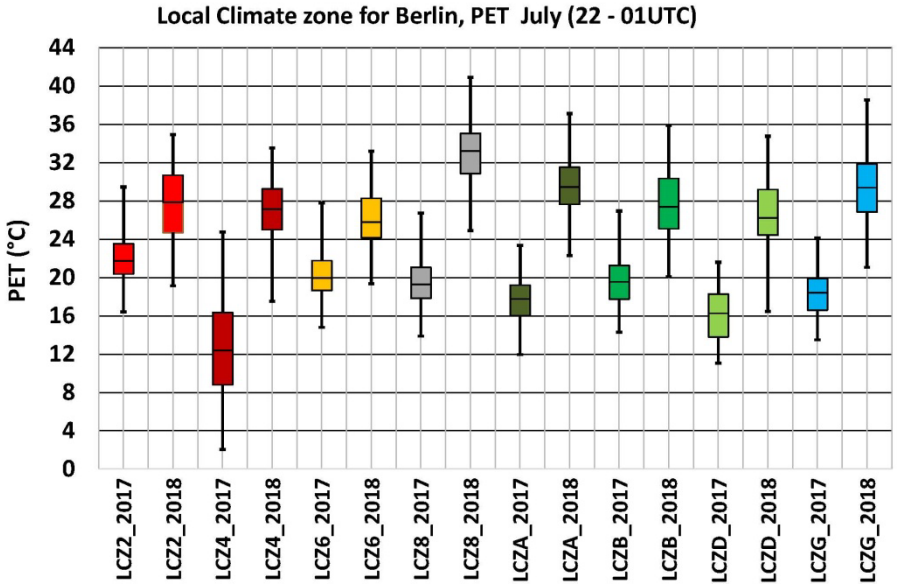
afternoon

The first bar is the air tempertaure of each LCZ, the second bar the PET result.



night



In comparison with the air temperature the result show that PET is much warmer. The industriel zone is the warmest one, and the coldest the low plant zone, due of less humidity and wind

Temperature deviation in comparison with PET for August 2018

Fasanenstr. Jagowstr. Schillerstr. Galvanistr.	Compact midrise	2
Marzahn	Open high-rise	4
Amselgrund 1 Amselgrund 2 Amselgrund 3 Prignitzstr. Petitweg Martin-Hoffmannstr.	Open low-rise	6
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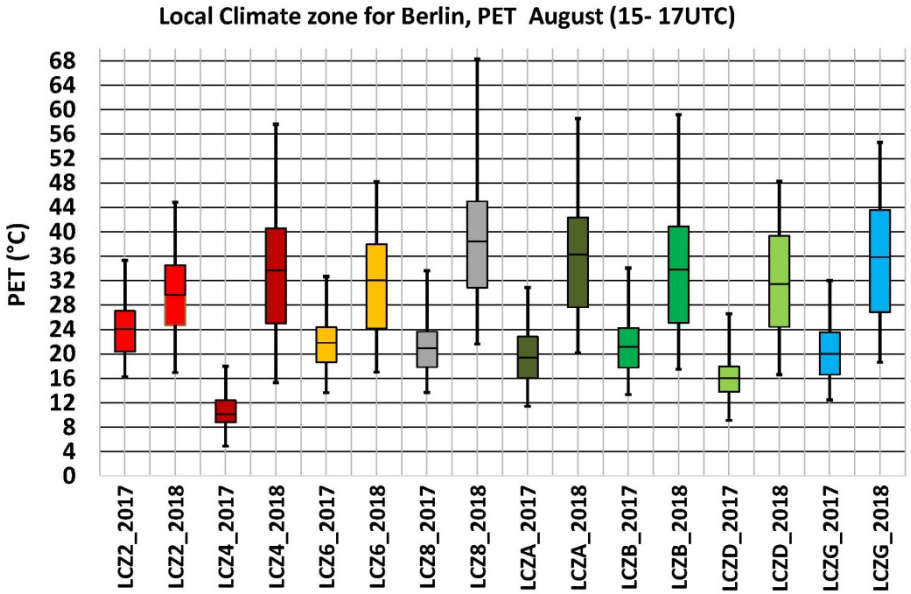
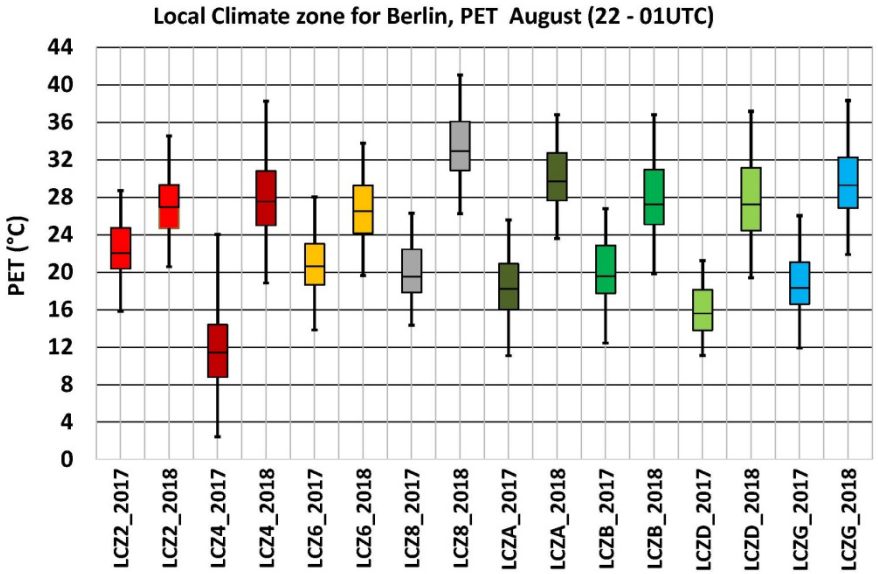
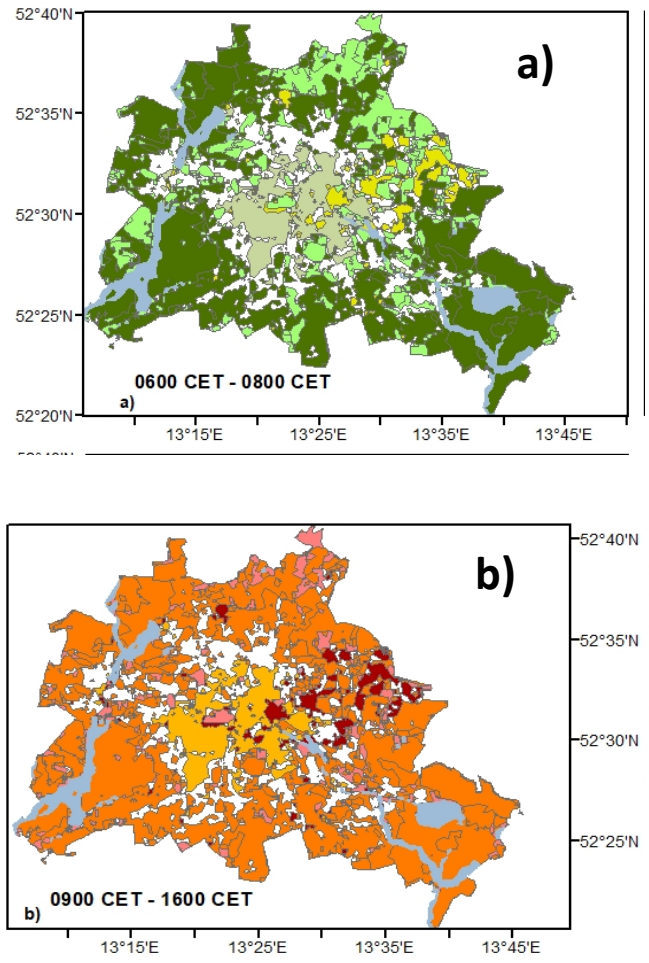


night



For August 2018 we analyzed the same result like in July 2018, but the whisker of max. and min. values is larger than in July.

Example: PET from 17 July 2018 to 09 August 2018 for Berlin



Time slice of thermal stress in the City of Berlin:

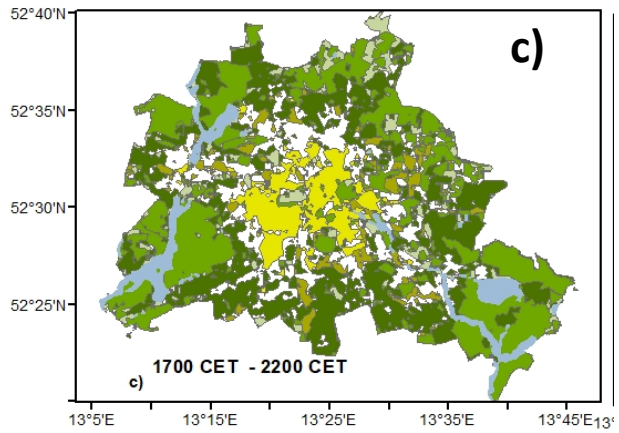
a) rush hour time,
b) daytime.

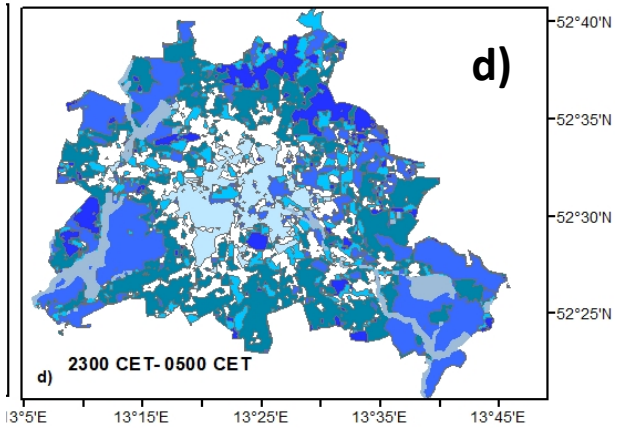
for a)
inner-city (LCZ 2): thermal sensation "slighthy warm", while the forest area (green) show "comfortable".

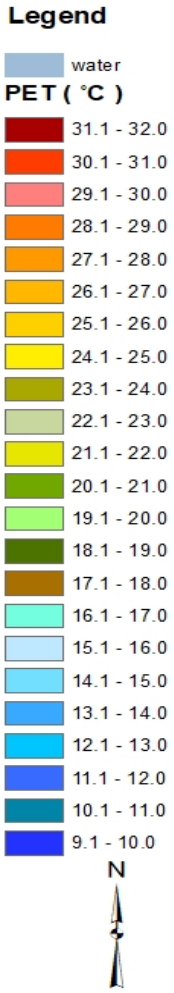
for b)
inner-city (LCZ 2) and the forest area LCZ G show a thermal sensation of "slightly warm" only LCZ 4 is warm, due to dense high buildings (called satellite city).

Published in Meteorologische Zeitschrift upcoming in 2020: 'Spatial variation of physiologically equivalent temperature in different Local Climate Zones of a large city during a hot spell', Langer et al.

Example: PET from 17 July 2018 to 09 August 2018 for Berlin







Time slice of thermal stress in the City of Berlin:
c) afternoon/evening,
d) night time.

for c)
the inner-city show a human sensation of "comfortable", while some spots of the forest area show "slightly cool" and LCZ 4 "slightly warm".

for d)
in inner-city is "slightly cool", the forest area "cool" and the single family area (LCZ 6) "slightly cool".

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Summary

- 32 weather station partly confirm the LCZ in order to find the UHI in the city.
- RayMan software is used together with fisheye photos to calculate PET for each LCZ.
- Two reasons affect this human sensation calculation; the relative humidity and the SVF. However, the results show that a lower SVF where the station is much more shadowed and lower relative humidity during daytime causes a lower PET, during night it is inverted.


Thanks for your attention !
Save the urban climate!