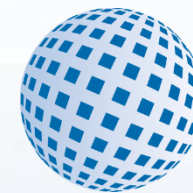




Palacký University
Olomouc



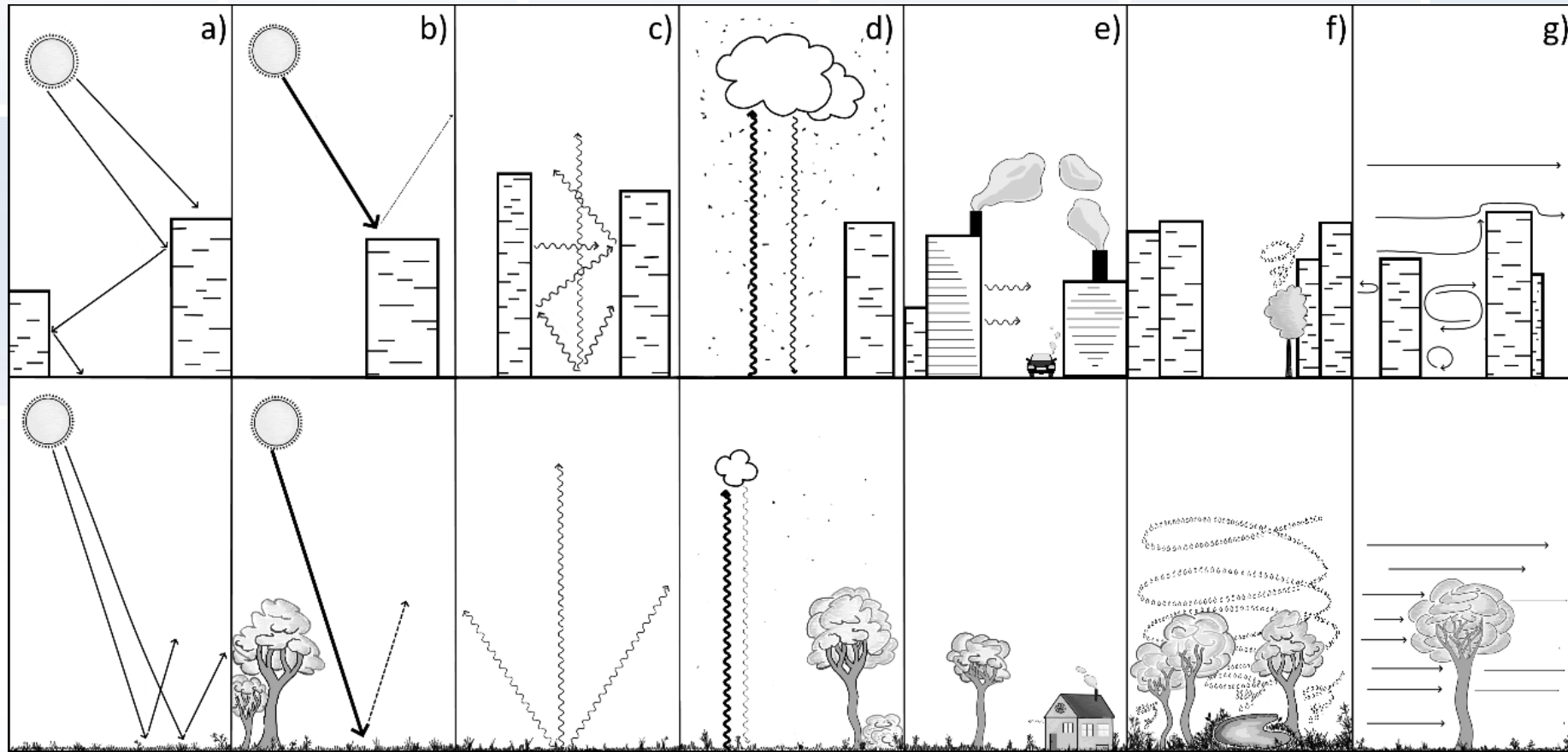
Katedra geografie
Přírodovědecká fakulta
Univerzita Palackého v Olomouci

Urban Heat (Island): A common and complex problem of cities

Michal Lehnert

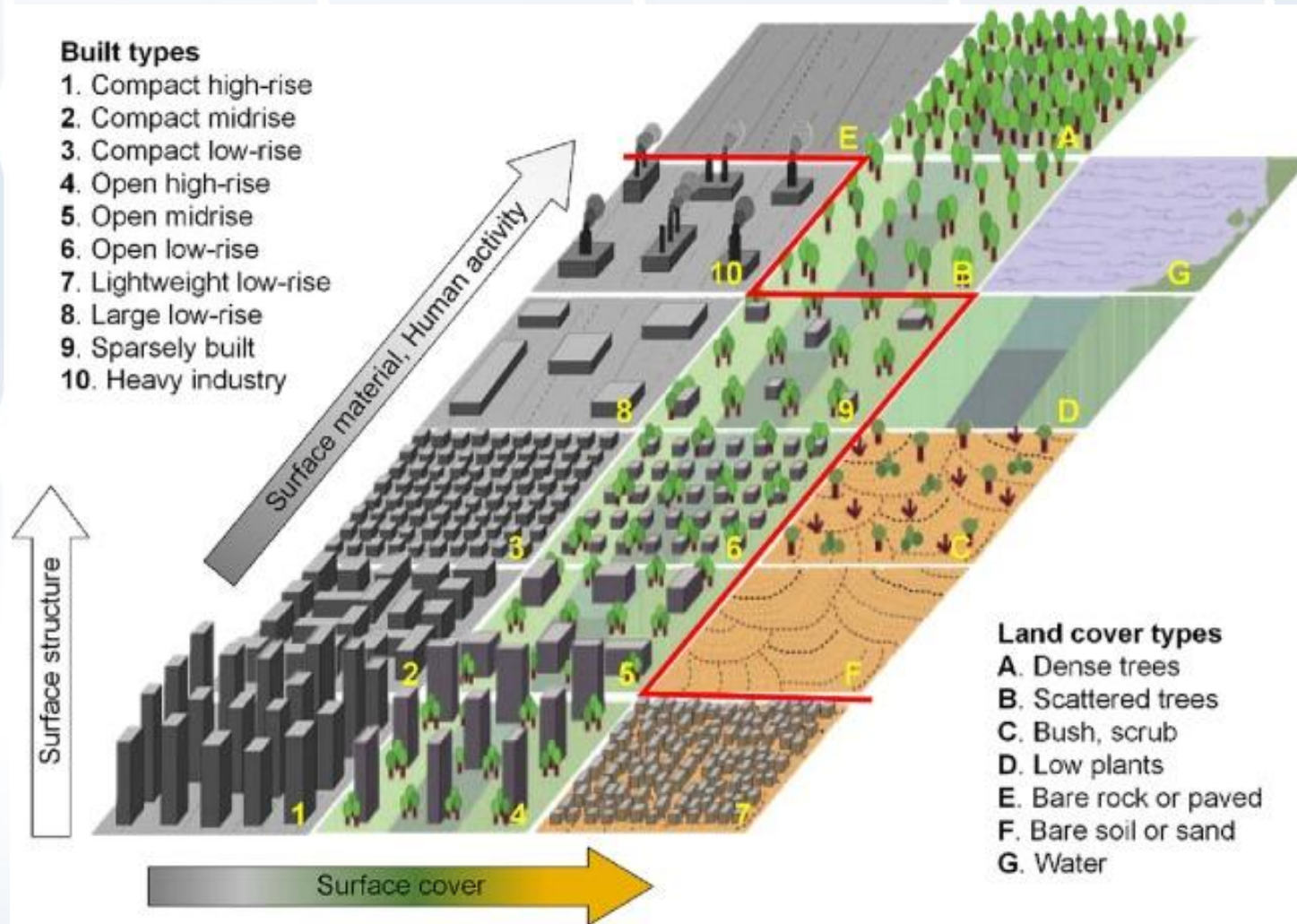
Olomouc, May 5, 2025

Urban heat load



Causes of urban heat load
(Modified from Kleerekoper et al. 2012)

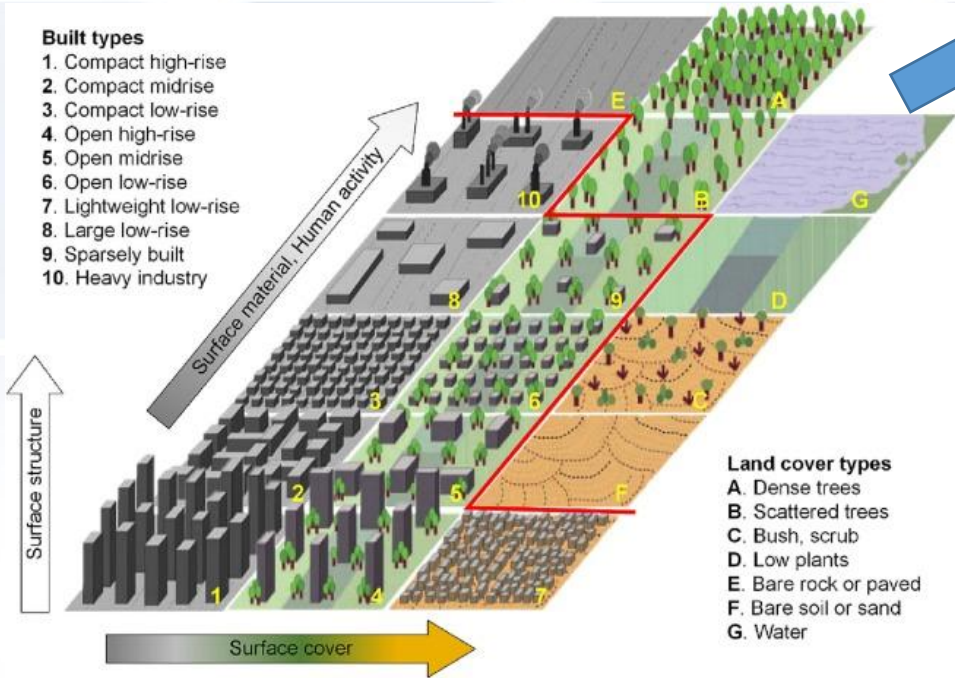
Local climate zones



Source: Huang 2023

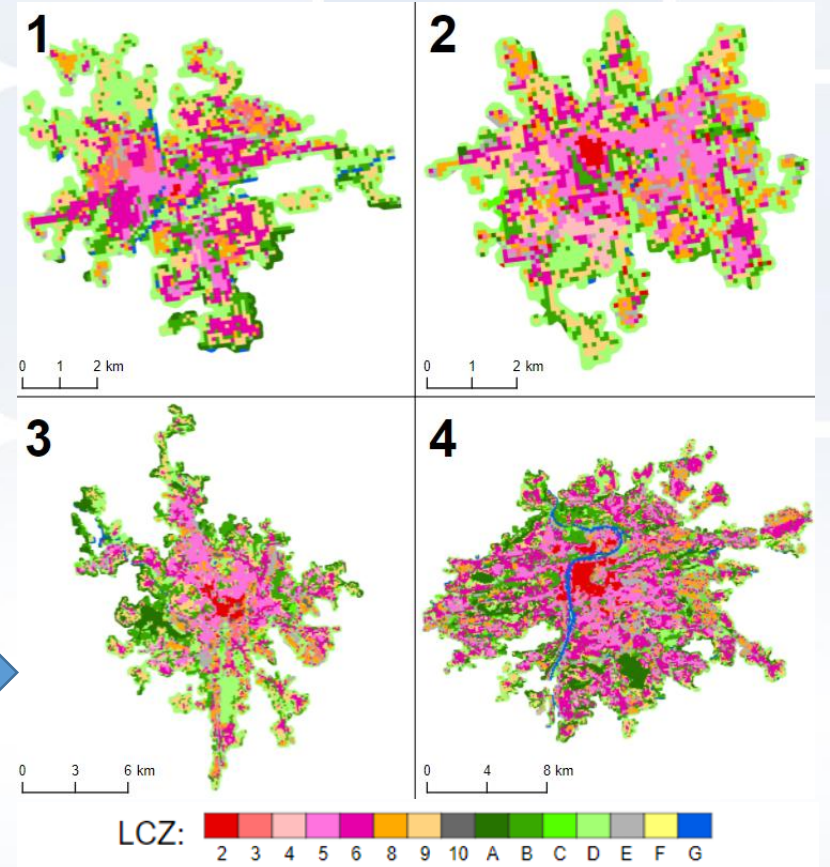
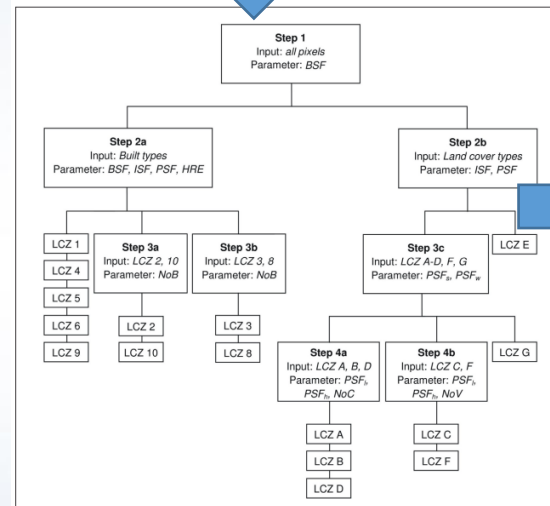
Built types

1. Compact high-rise
2. Compact midrise
3. Compact low-rise
4. Open high-rise
5. Open midrise
6. Open low-rise
7. Lightweight low-rise
8. Large low-rise
9. Sparsely built
10. Heavy industry

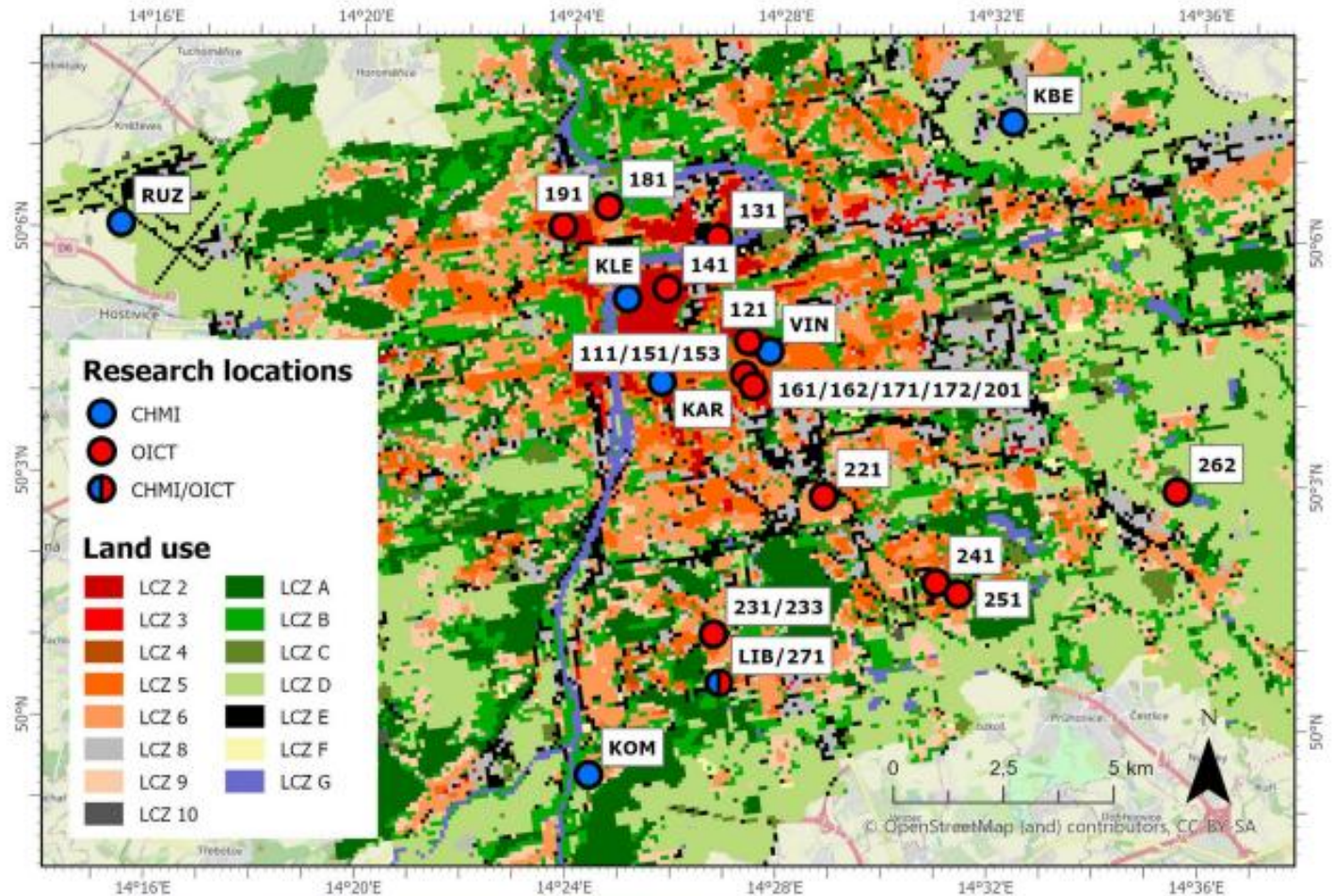


Land cover types

- A. Dense trees
- B. Scattered trees
- C. Bush, scrub
- D. Low plants
- E. Bare rock or paved
- F. Bare soil or sand
- G. Water



Stationary measurements



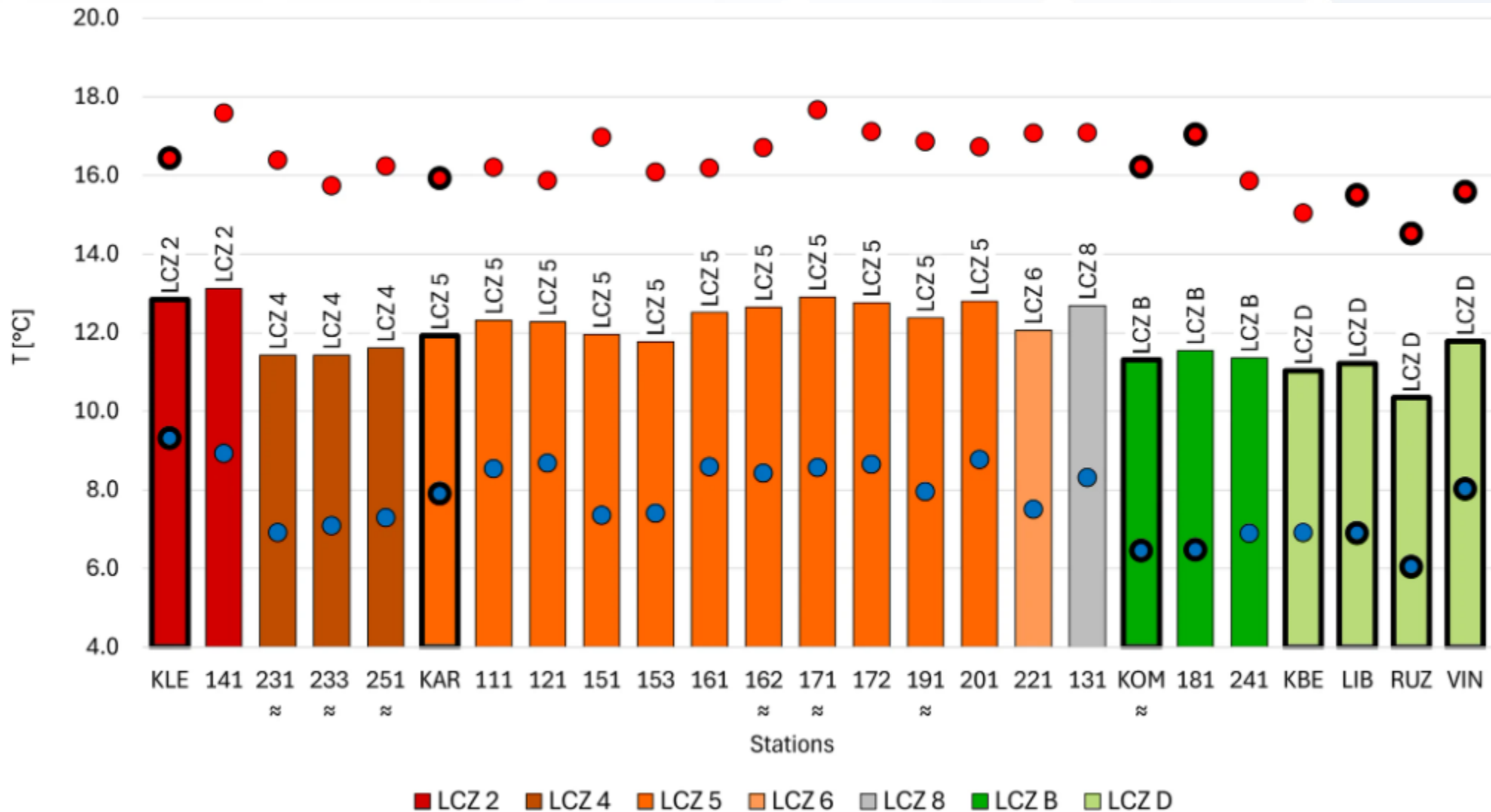
Selected stations of the IPC and CHMI station networks in Prague in 2024

(Source: Lehnert et al. 2025)

Stationary measurements

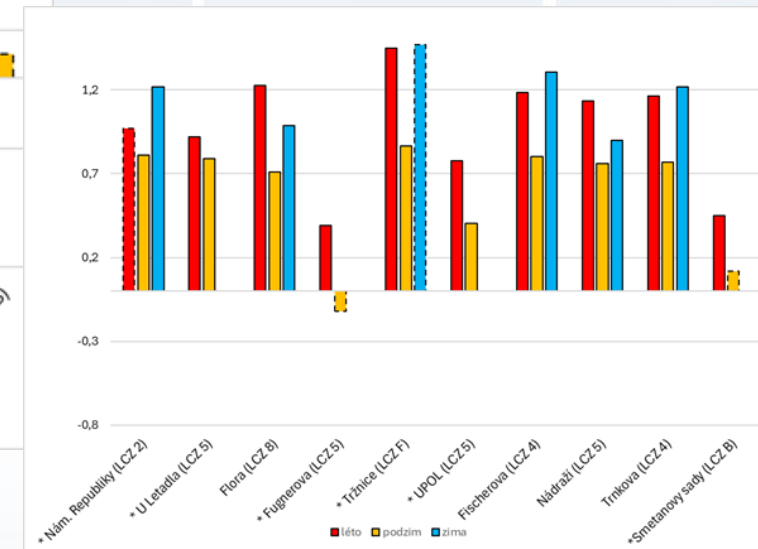
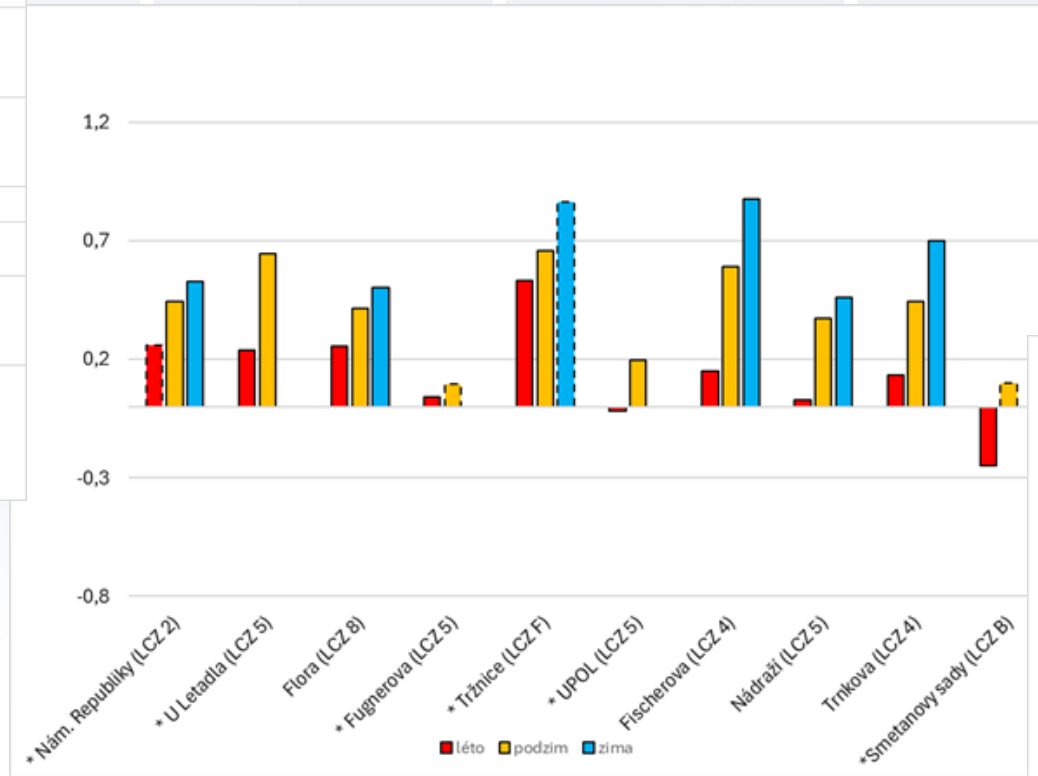
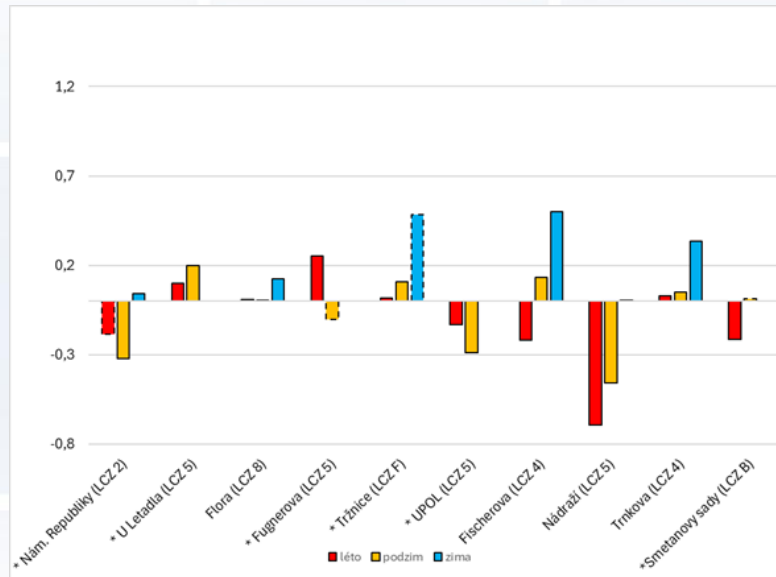


Selected stations of the IPC and CHMI station network in Prague in 2024 (Source: Lehnert et al. 2025)



Mean daily air temperature (bars), minimum daily air temperatures (blue dots), and maximum daily air temperature (red dots) in Prague in 2023 (Source: Lehnert et al. 2025)

UHI intensity based EnCLOD network in Olomouc

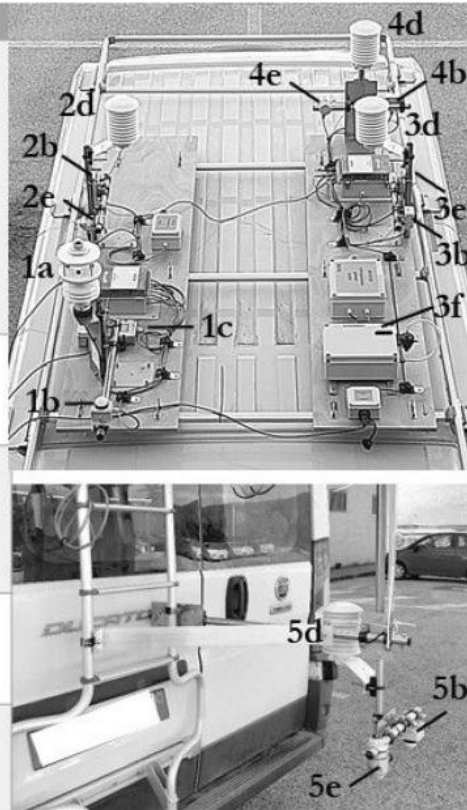


UHI intenzity based on a) maximum daily temperatures, b) mean daily temperatures and c) minimum daily temperatures in different seasons 2025/2026

(Source: Hyblová 2026)

Mobile measurements

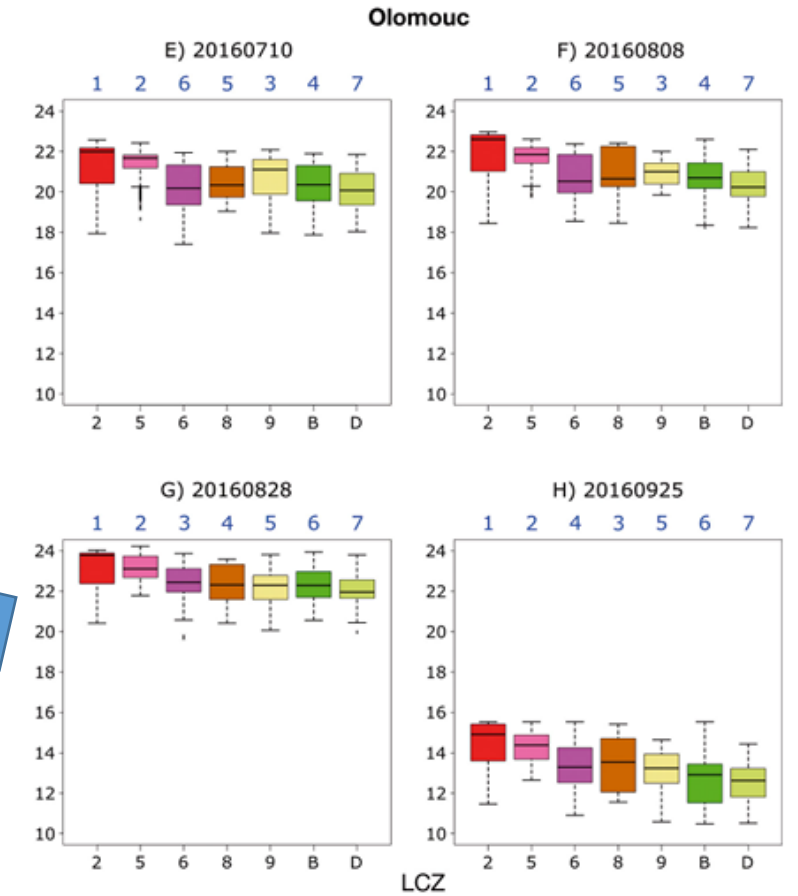
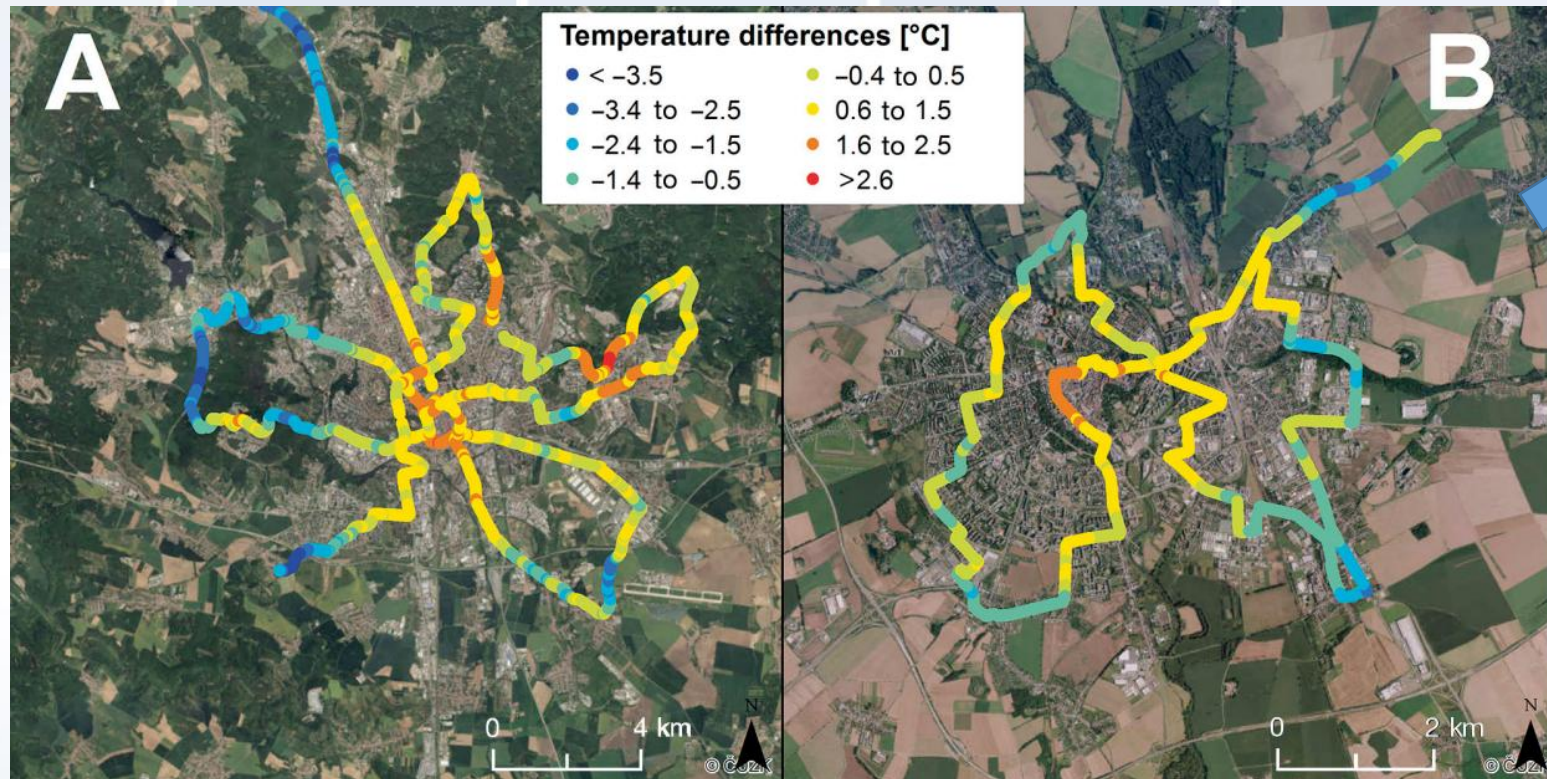
Sensors Unit	Monitored parameter
1 – Front unit	a. Air temperature a. Relative humidity a. Wind speed a. Wind direction a. Barometric pressure a. Short radiation downward b. Illuminance downward c. CO ₂ concentration
2 – Right side unit	d. Air temperature e. Short radiation leftward b. Illuminance leftward
3 – Left unit	d. Air temperature e. Short radiation rightward b. Illuminance rightward f. PM10
4 – Back unit	d. Air temperature e. Short radiation forward b. Illuminance forward
5 – Bottom unit	d. Air temperature e. Short radiation upward b. Illuminance upward



Source: Kousis et al. 2021

Source: Writzl et al. 2023

Mobile measurements



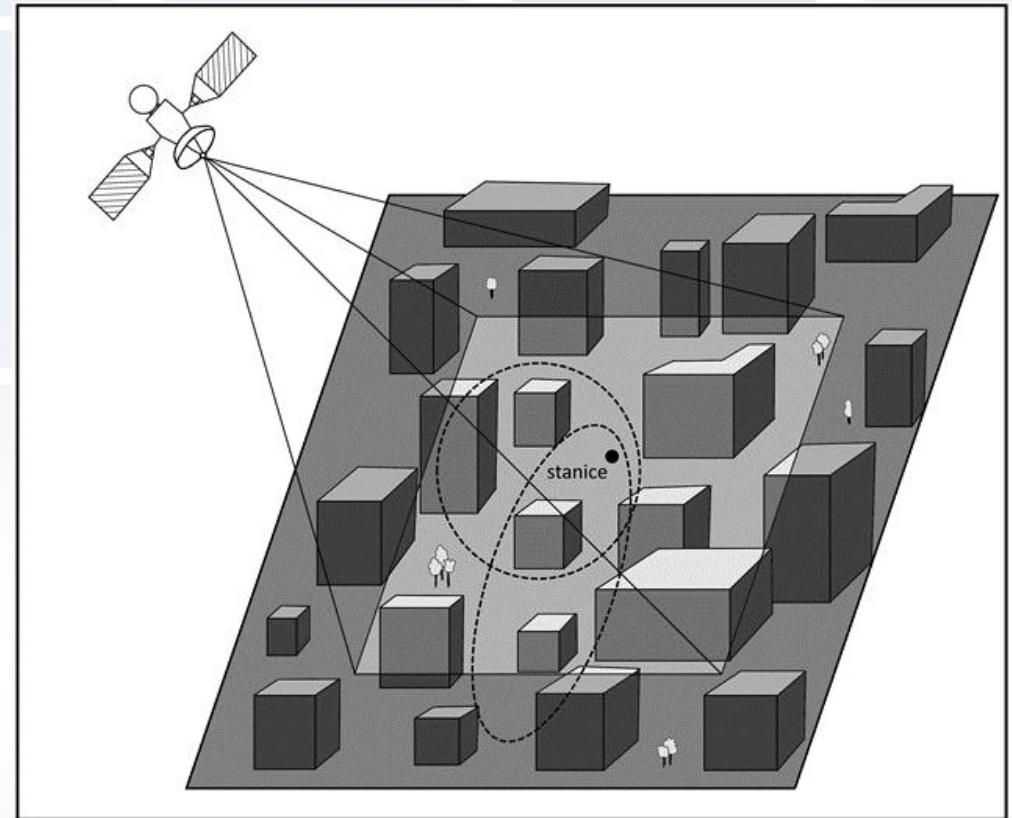
Source: Lehnert et al. 2018

Fig. 3. Temperature differences based on mobile measurements: (A) Brno, 3 August 2011 and (B) Olomouc, 8 August 2016

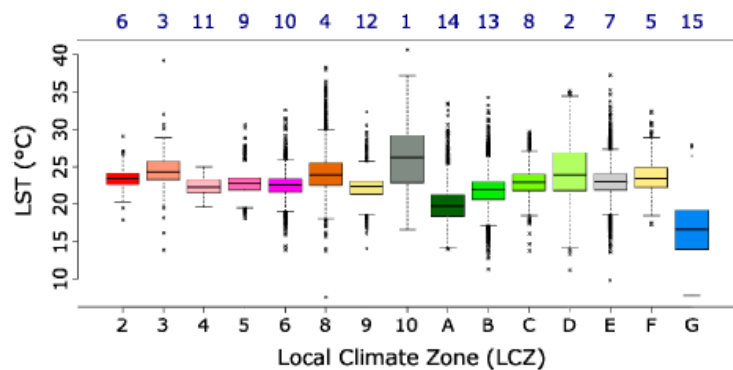
Remote sensing

Satellite imagery

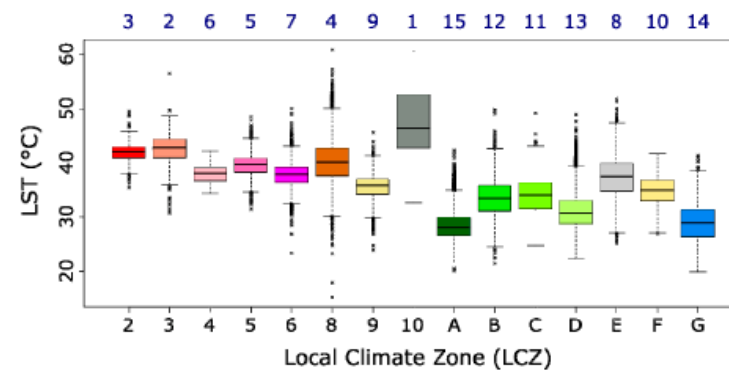
- Satellite sensors capture thermal images in atmospheric windows within the 3–5 μm and 8–14 μm wavelength ranges
- Commonly used imagery is acquired by satellites from the ECOSTRESS and LANDSAT missions, Terra with the ASTER sensor, SENTINEL-3 or MODIS...



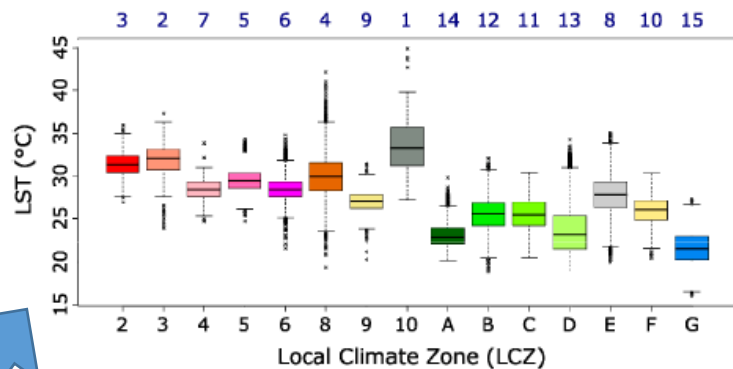
(c) AST_20080331



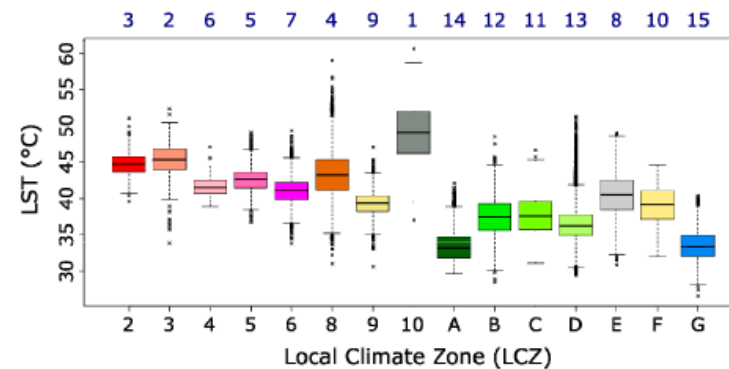
(d) AST_20110628



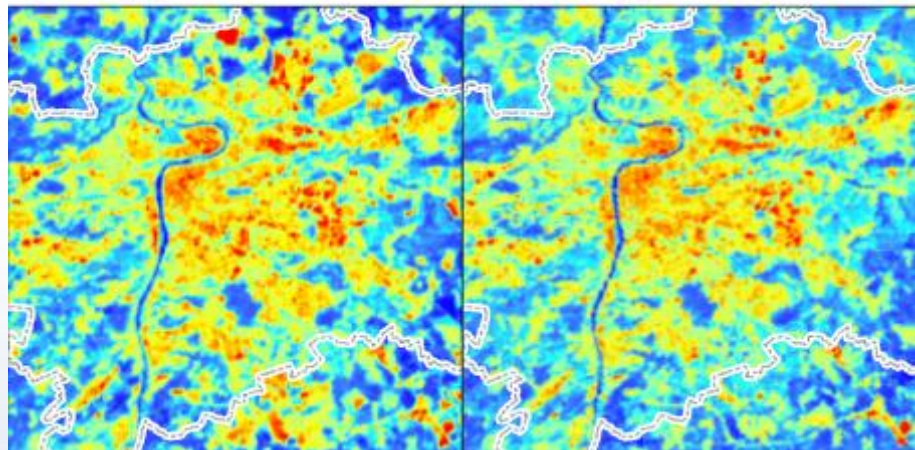
(e) LT8_20130515



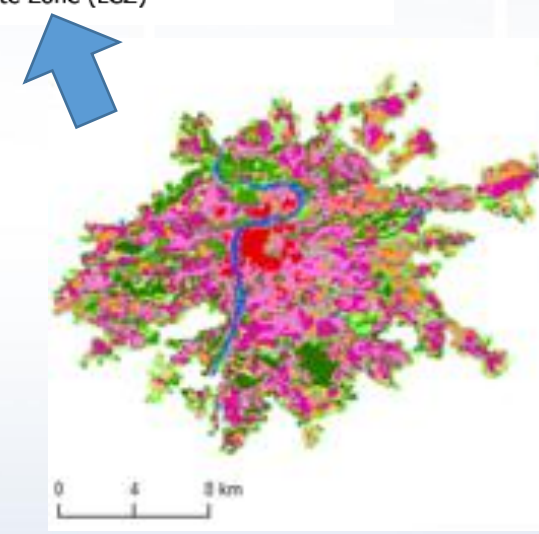
(f) LT8_20130727



(b) LANDSAT-8



(c) ASTER



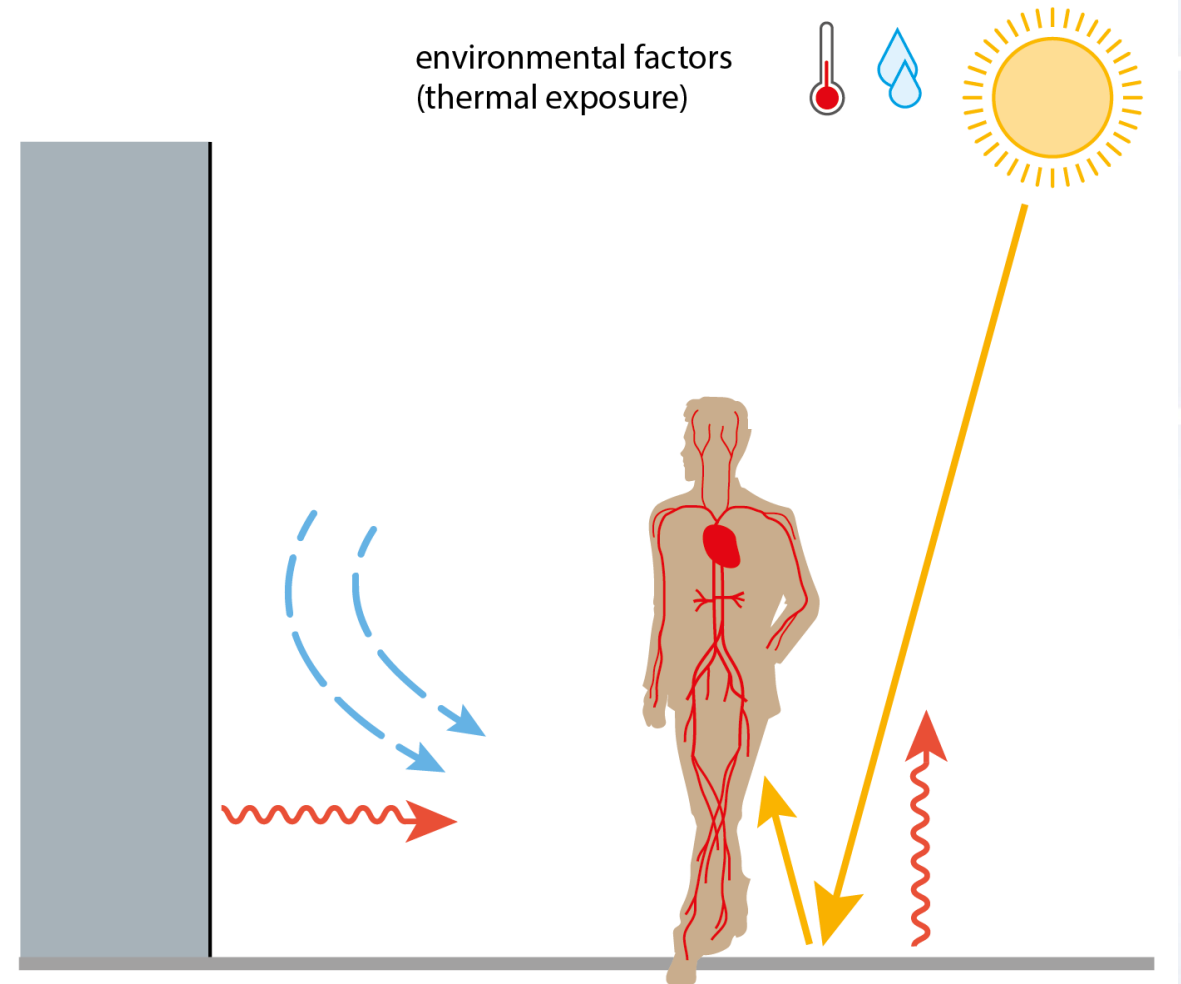
Beyond the urban heat island: Thermal exposure

- **UTCI – Universal Thermal Climate Index**

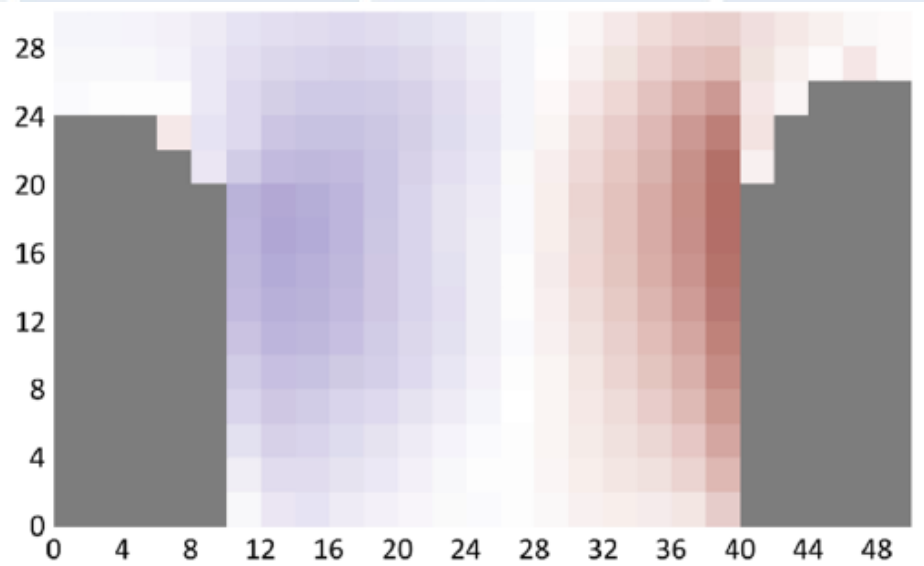
UTCI (°C)	Stress category
UTCI > 46	extreme heat stress
38 < UTCI < 46	very strong heat stress
32 < UTCI < 38	strong heat stress
26 < UTCI < 32	moderate heat stress
9 < UTCI < 26	no thermal stress
0 < UTCI < 9	slight cold stress
-13 < UTCI < 0	moderate cold stress
-27 < UTCI < -13	strong cold stress
-40 < UTCI < -27	very strong cold stress
UTCI < -40	extreme cold stress

Source: Blazejczyk et. al 2014

Heat stress categories and corresponding UTCI index ranges



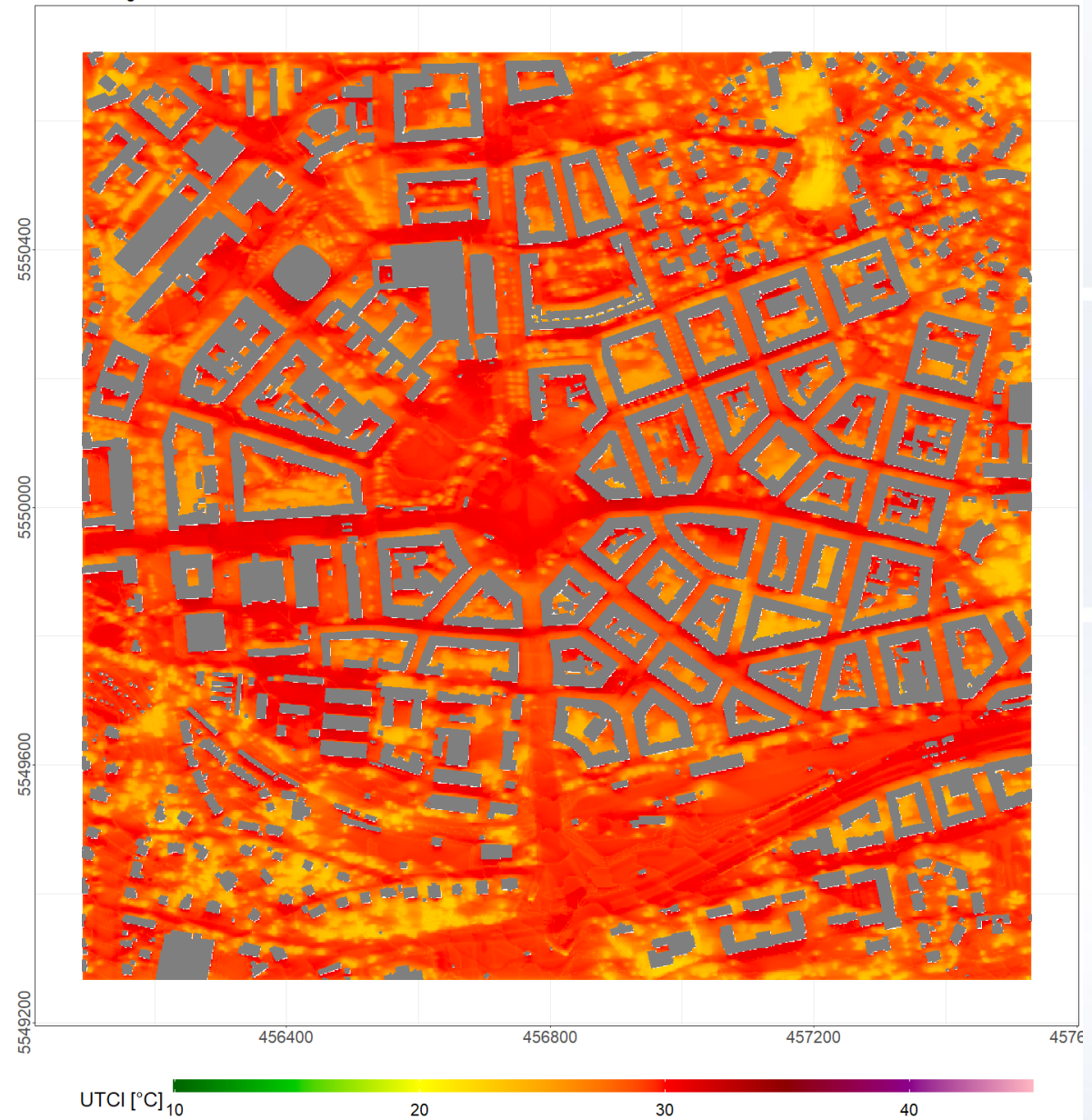
Numerical modeling

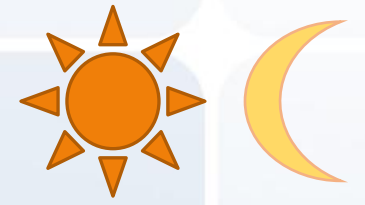


Mean values of the UTCI biometeorological index in Prague-Dejvice on July 25, 2019

Source: Geletič et al. 2022

Averaged thermal comfort (UTCI) on 25 July 2019 for a period 00:00-00:00 UTC
Min: 21.1 Avg: 28.3 Max: 32.6





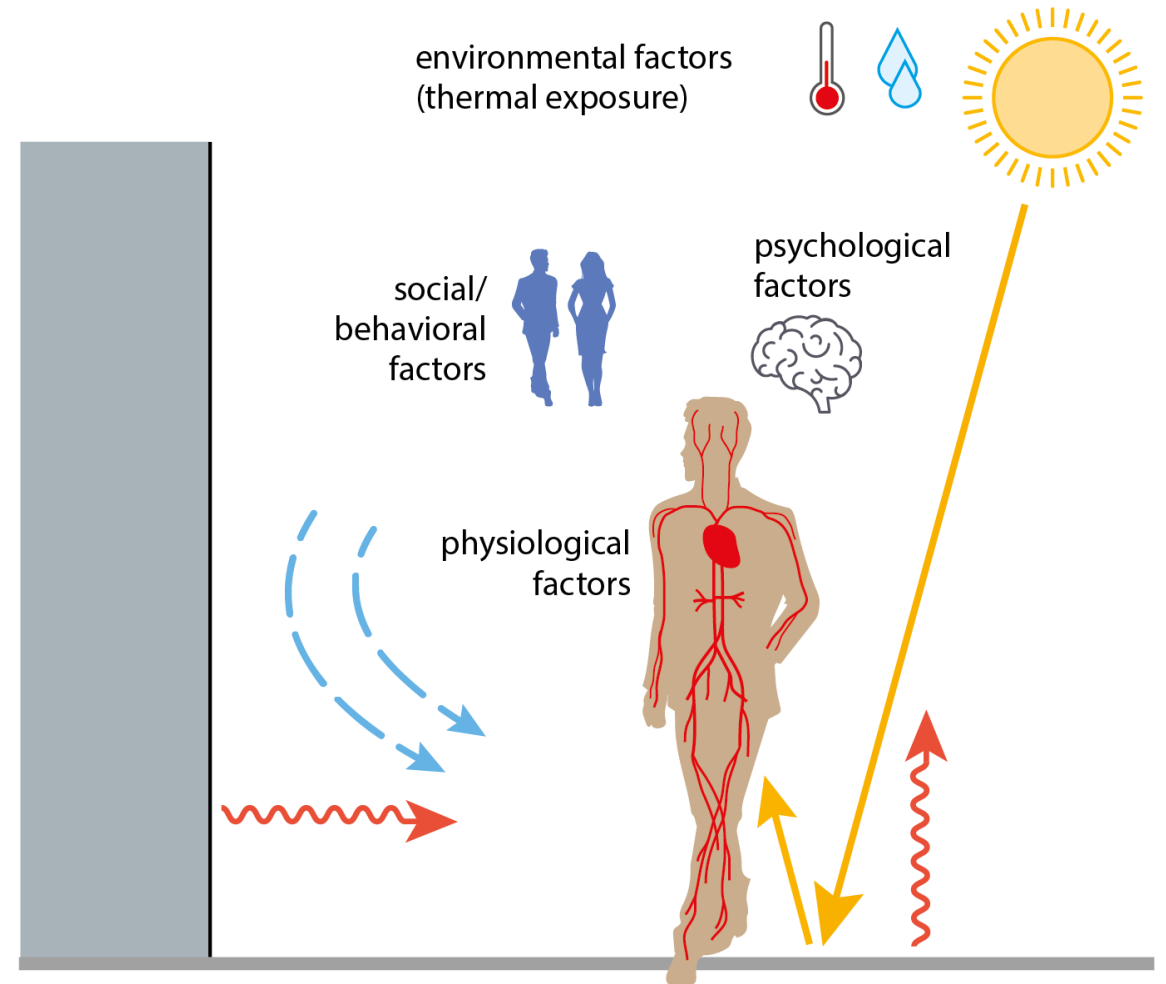
Summary of the results for Czech cities

- Trees reduce UTCI by **5–10 K** during daytime; **while they increase UTCI by \approx 0–3 K during night-time** compared to open pavement/gravel
- Shade sails reduce UTCI by **3–6 K** during daytime; **while they increase UTCI by \approx 0–2 K during night-time**
- Maintained lawn in an open space in the city leads to a **0–2 K reduction** in UTCI during daytime **as well as during night-time**
- Fountains and spray fountains cause a change in UTCI between **-2 and +1 K** during the day **and night**, depending on the character of the water element
- Sprinkling of open spaces (squares) during daytime reduces UTCI by **1–3 K**, **the cooling effect can persist during the night**

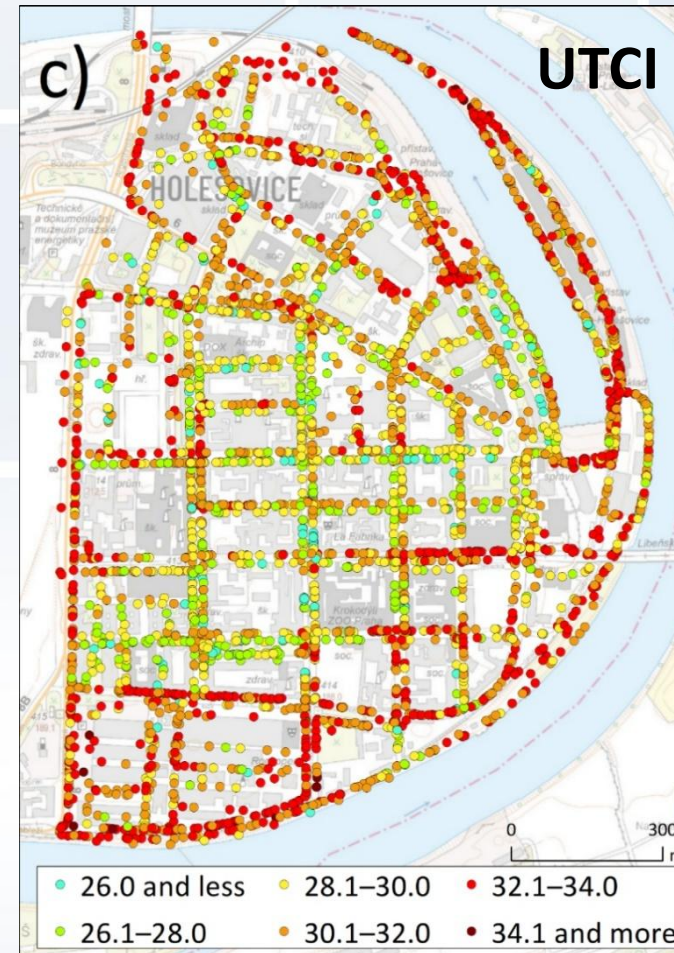
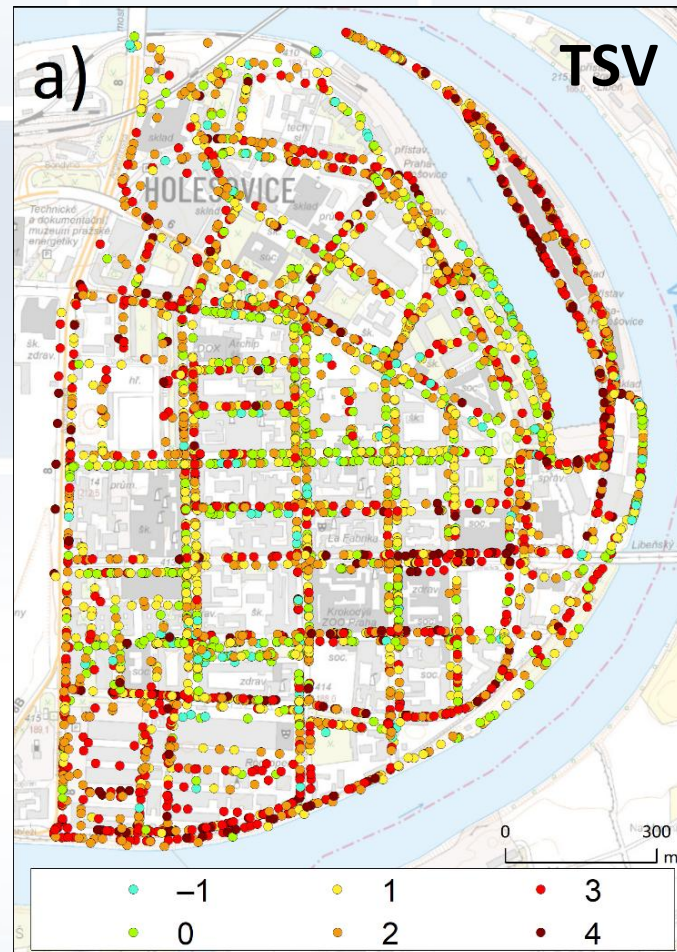
Thermal comfort and thermal sensation

- Thermal comfort: A state of mind expressing a person's satisfaction with the thermal environment (ASHRAE, 1966)
- Thermal sensation: A conscious feeling divided into categories, i.e. sensation of warmth, coolness, or neutral (ASHRAE, 2010)

Scale	Thermal sensation
4	Very hot
3	Hot
2	Warm
1	Slightly warm
0	Neutral
-1	Slightly cool
-2	Cool
-3	Cold
-4	Very cold

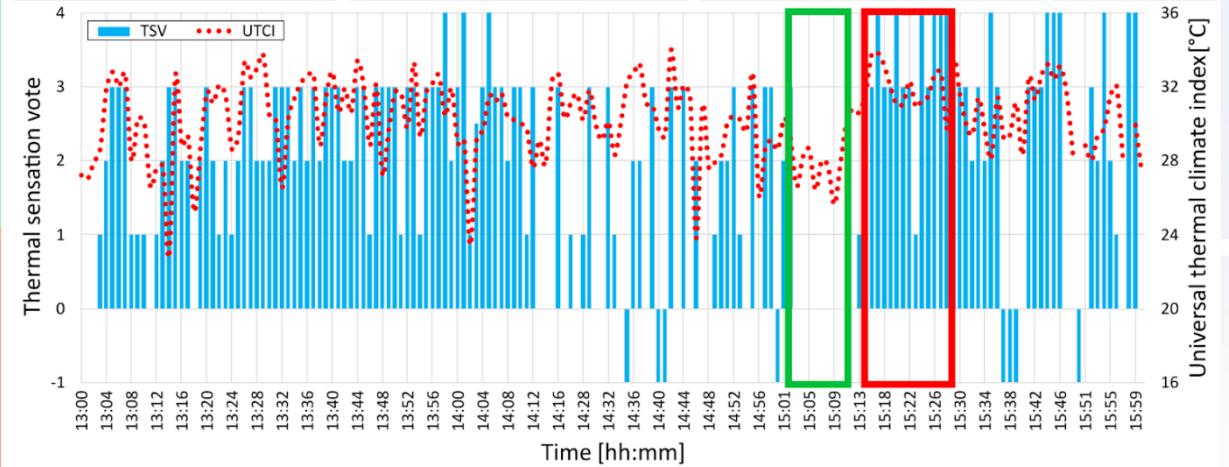
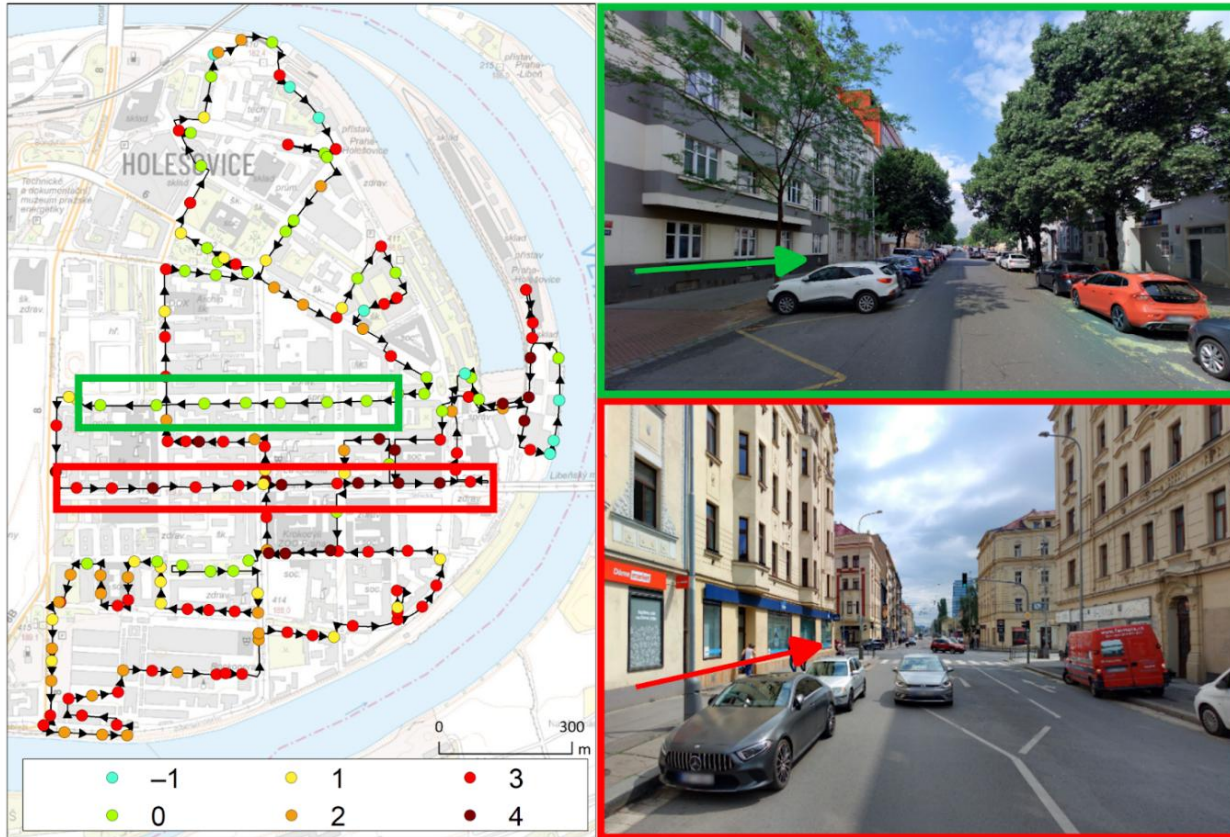


Heat walk



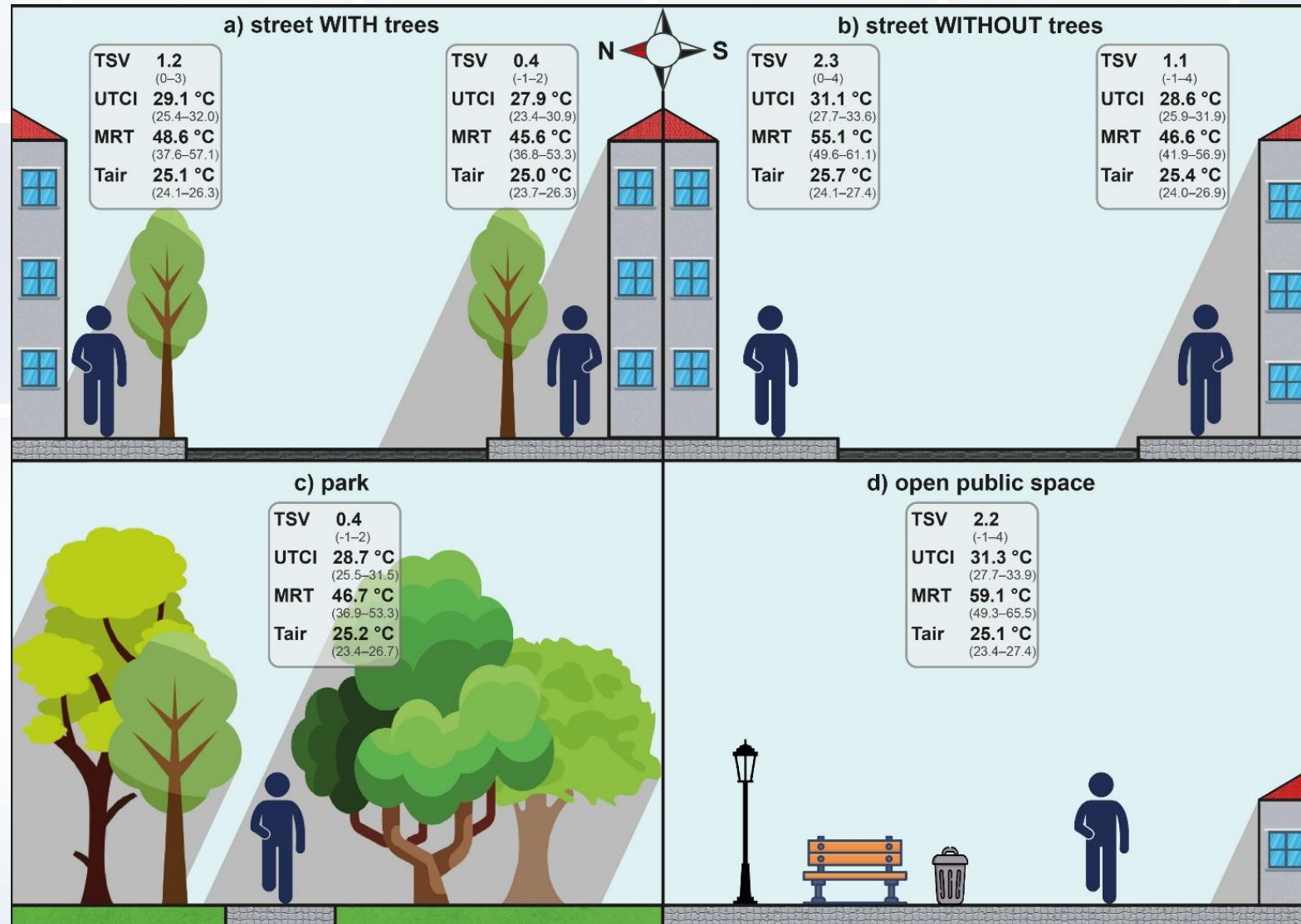
Source: Geletič et al. 2026 (unpublished)

Heat walk



Source: Geletič et al. 2026 (unpublished)

Complex human oriented research on urban heat



Thank you for your attention!

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