

URBAN CLIMATOLOGY

3. The climate of Brno as an example (data, methods, main outcomes)

Paper to read

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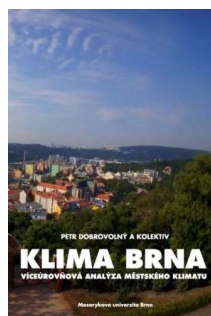
The spatial variability of air temperature and nocturnal urban heat island intensity in the city of Brno, Czech Republic

Petr DOBROVOLNÝ ^{a*}, Lukáš KRAHULA ^a

https://is.muni.cz/auth/el/sci/podzim2024/ZA311/um/67875456/03_Dobrovolny_Krahula_MGR_2015.pdf

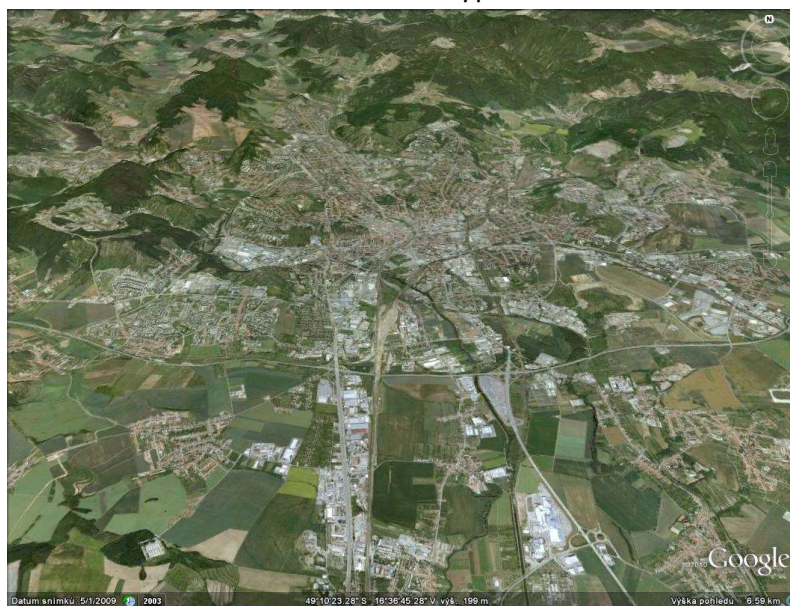
Motivation

- What are the typical features of spatial and temporal variability of the main meteorological elements?
- What is the intensity of urban heat island (UHI) during days with the radiation-driven weather?
- What is the contribution of individual factors to UHI formation?

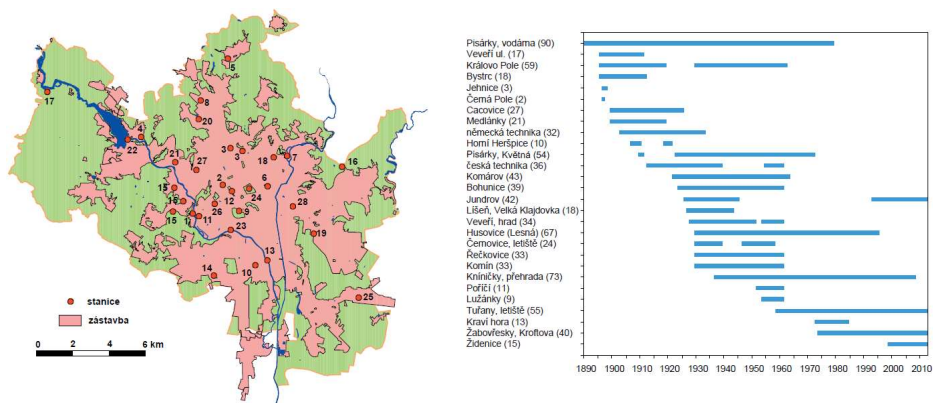


3.1 Local geography

- complex relief
- typical land use distribution



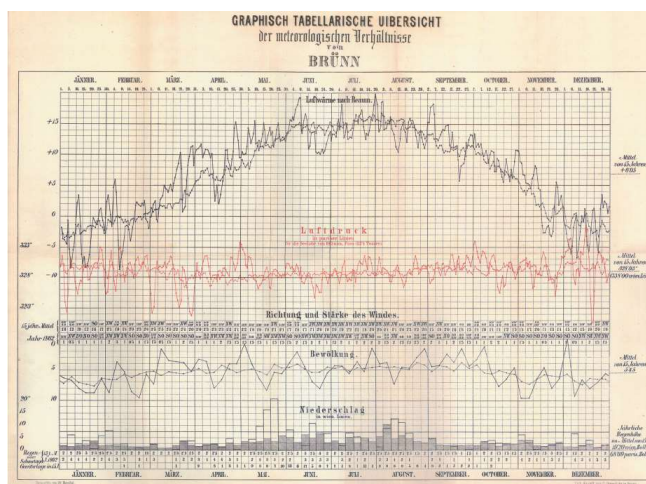
3.2 History of meteorological measurements



The network of meteorological stations (left) and its temporal evolution (right) in the Brno area in 1890–2012.

„Compiled“ Brno temperature and precipitation series start already in 1799 and 1803 respectively

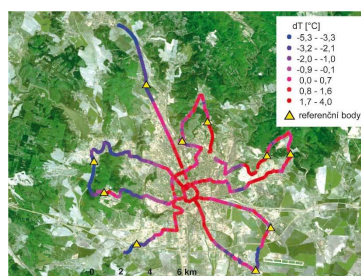
3.2 History of meteorological measurements



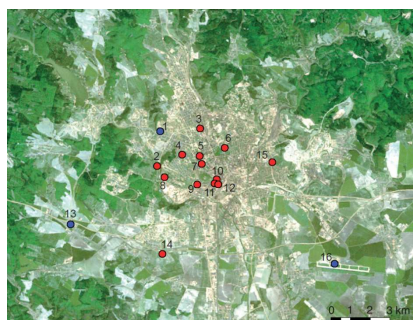
Gregor Johann Mendel, the abbot of the Augustinian monastery in Brno and the most famous person among Brno meteorological observers, and his graphic-table overview of meteorological observations in Brno for 1862 (Mendel 1863)

3.3 Database

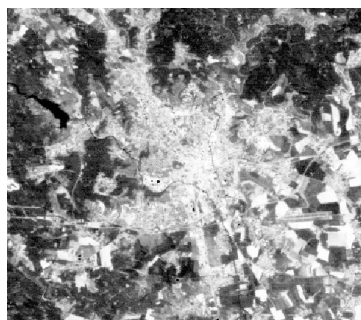
Meteorological data



Mobile measurements



Professional stations (blue) and special-purpose measurements (red)



Thermal satellite imagery

3.3 Database

Geographical database (explanatory variables)

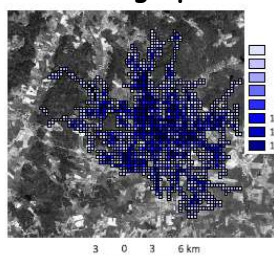


Figure 2 Total length of streets (further TLoS) calculated for a regular grid (300 x 300 m) in the study area.

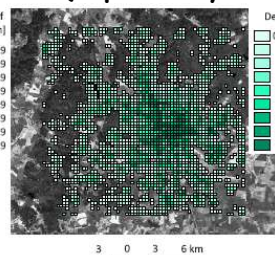


Figure 3 Density of buildings (%) (further DENS) calculated for a regular grid (300 x 300 m) in the study area.

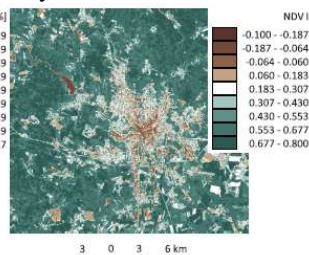
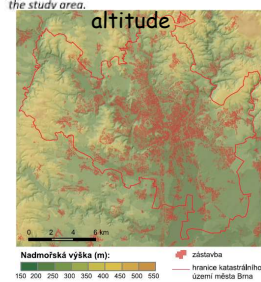
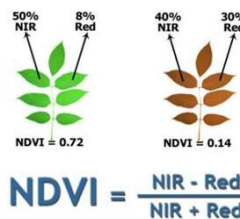
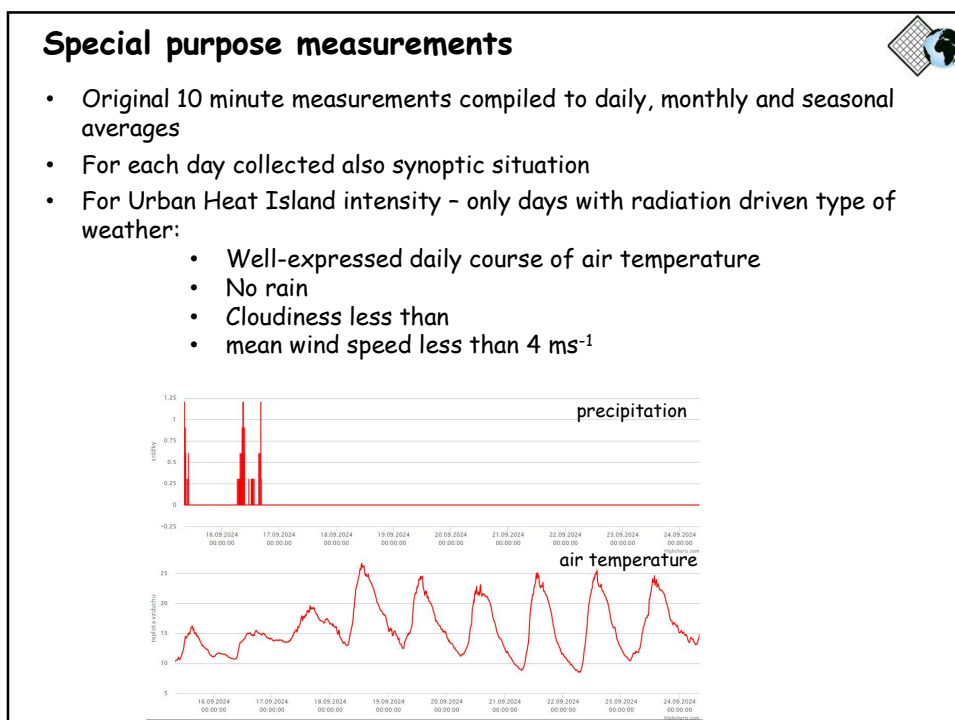
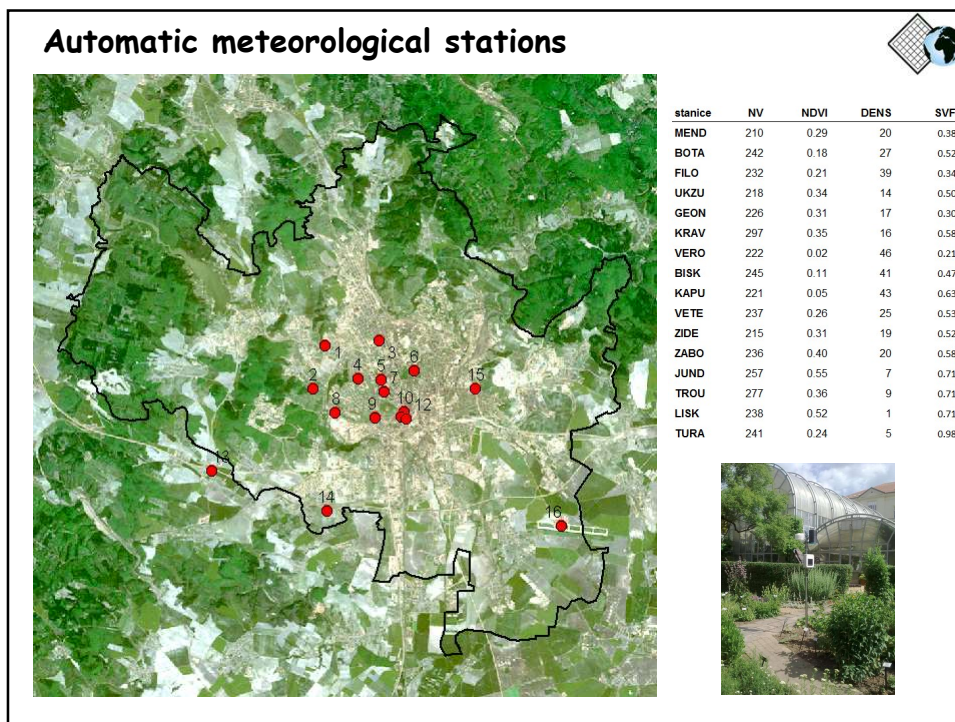


Figure 4 Normalized Difference Vegetation Index (further NDVI) as an indicator of vegetation amount and vigor in Brno area.

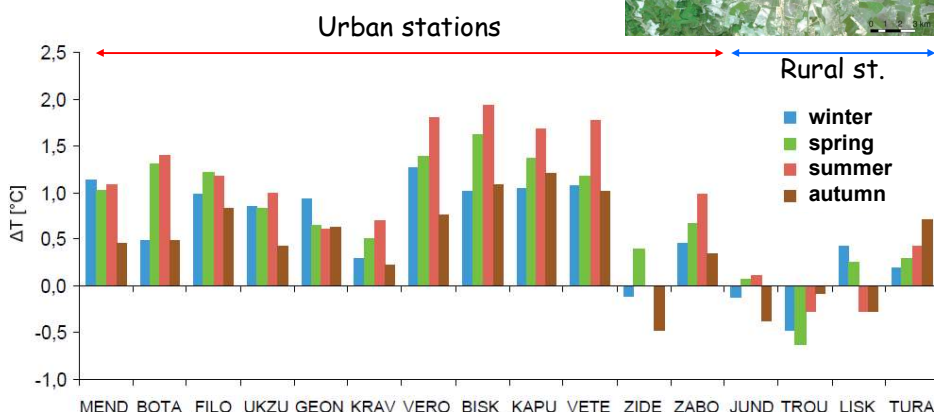
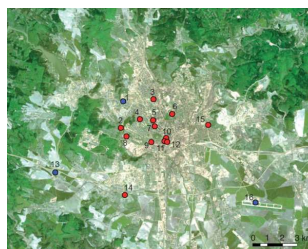


Sky View Factor





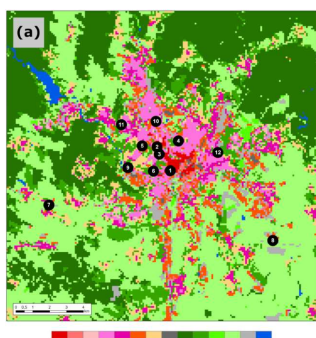
3.4 Atmospheric UHI derived from station measurements



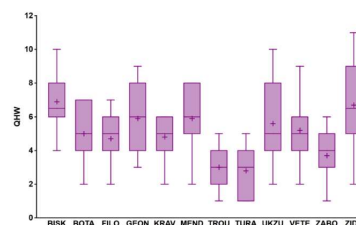
Intensity of AUHI (ΔT) defined as a difference of air temperature at a given station and mean air temperature at all rural stations

Do Heat Waves Amplify the Urban Canopy Heat Island?

- homogenized mean (T_a), maximum (T_x), and minimum (T_n) daily temperatures
- 12 stations located in Brno during the 2011-2020 period
- heat waves (HW) recognized as at least three consecutive days with $T_x \geq 30^\circ C$
- heat magnitude (HM) - difference of UHI intensities separately during and outside of HWs



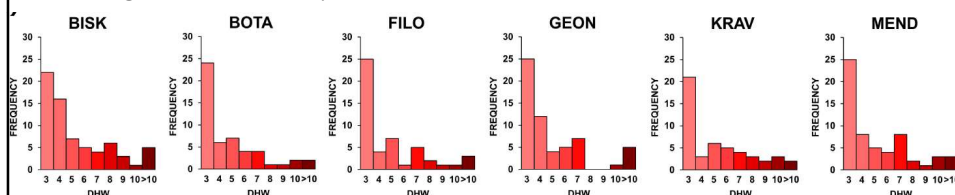
Spatial distribution of LCZs in Brno



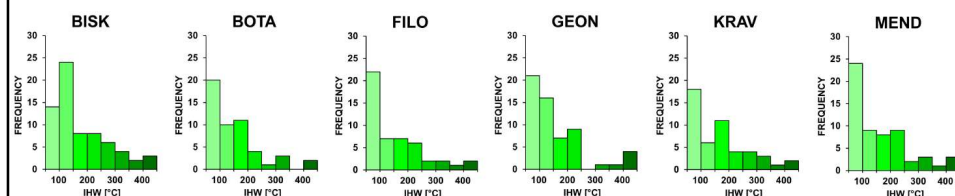
An average annual number of HW days (QHW) recorded at meteorological stations in Brno in the 2011-2020 period.

Do Heat Waves Amplify the Urban Canopy Heat Island?

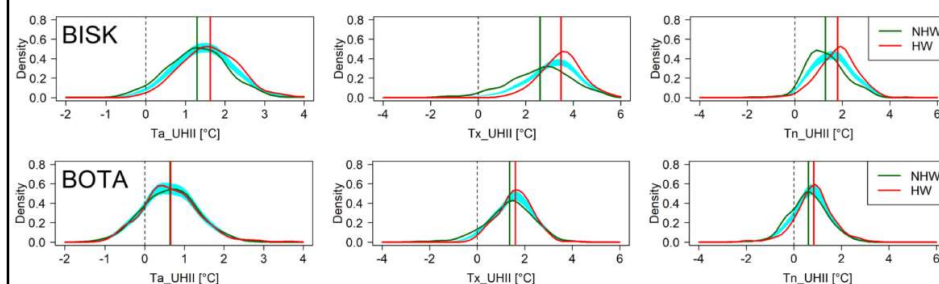
No of Heat Wave Days (DHW)
the length of HW in days



Intensity of Heat Waves (IHW)
sum of Tx during HW



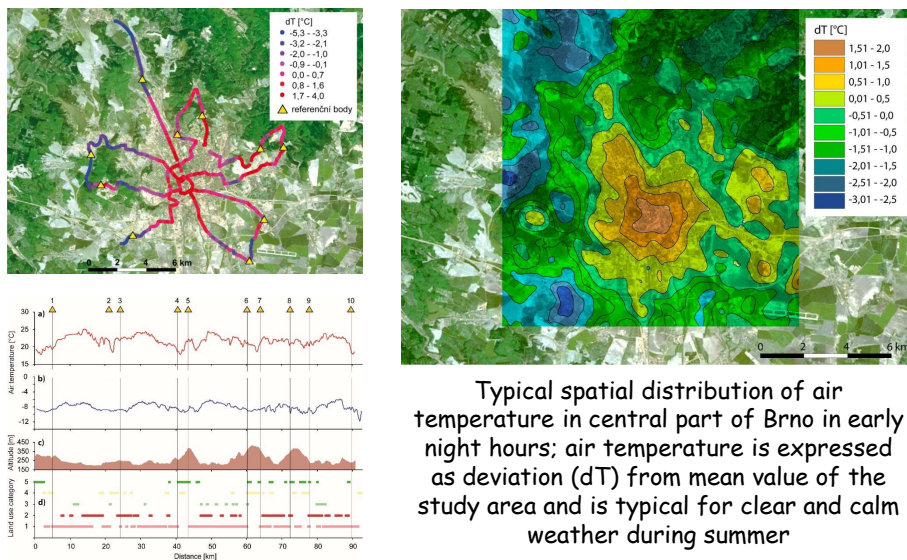
Do Heat Waves Amplify the Urban Canopy Heat Island?



Urban heat island intensity (UHII) empirical density curves calculated from HW days (HW) and non-HW days (NHW).

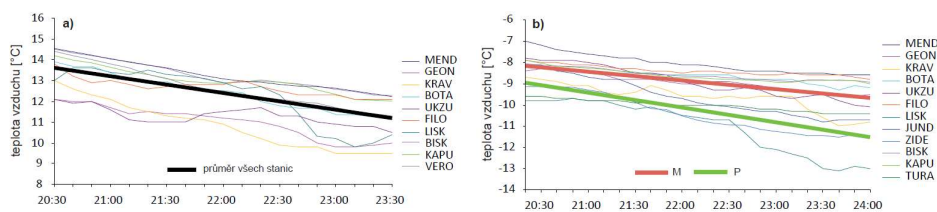
- The density curves outside the reference band (blue) indicate a significant difference in the two distributions (and vice versa).
- Vertical lines are mean UHIIs, and their differences express the heat magnitude (HM).

3.5 Nocturnal UHI intensity derived from mobile measurements

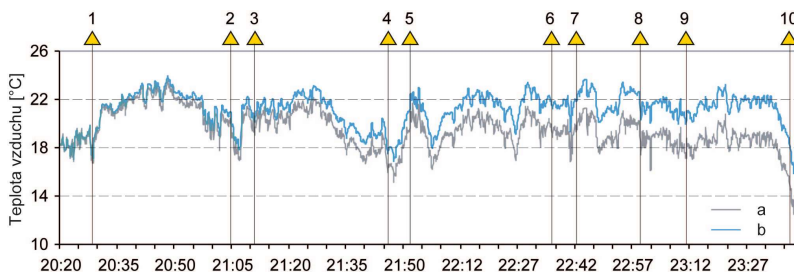


Typical spatial distribution of air temperature in central part of Brno in early night hours; air temperature is expressed as deviation (dT) from mean value of the study area and is typical for clear and calm weather during summer

Correction of the mobile temperature measurements

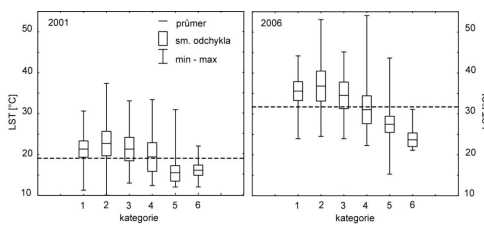
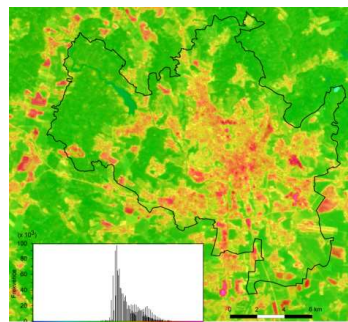
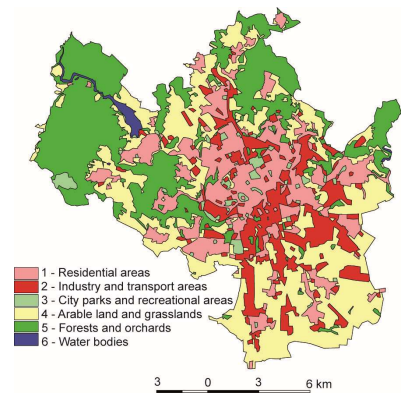


Examples of air temperature drop at stations during mobile measurements: (a) 19. 4. 2011 - the same intensity of temperature decline; (b) 31. 1. 2012 - different temperature decline on urban (M) and rural (P) stations

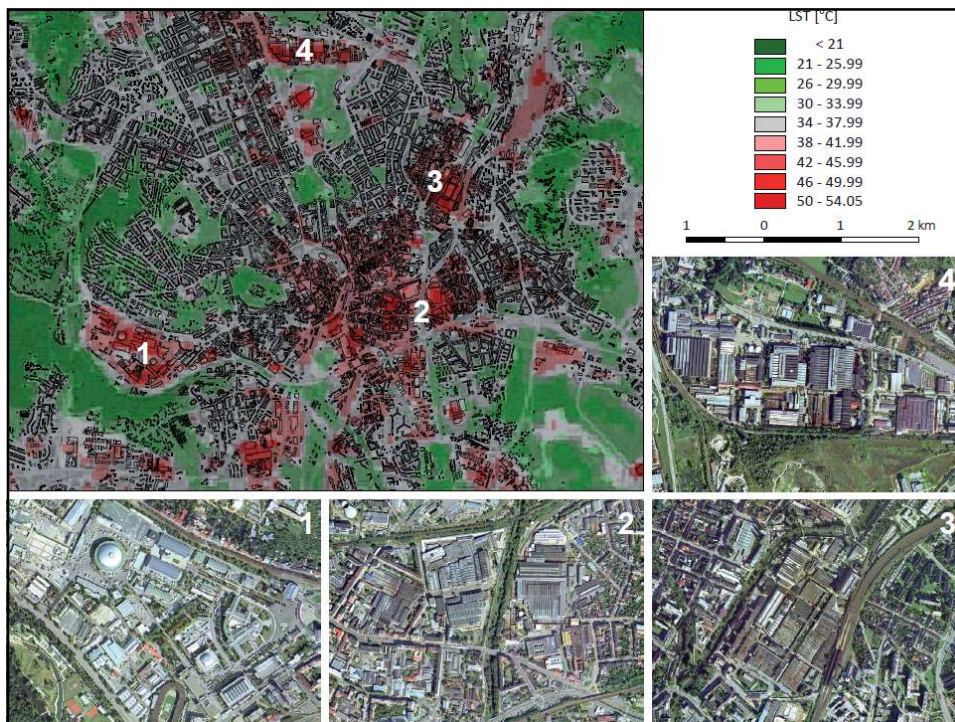


Mobile air temperature measurements on 3 August 2011 in Brno area; a - original temperature measurements, b - values corrected for temperature decay with time

3.6 Intensity of surface UHI in Brno area

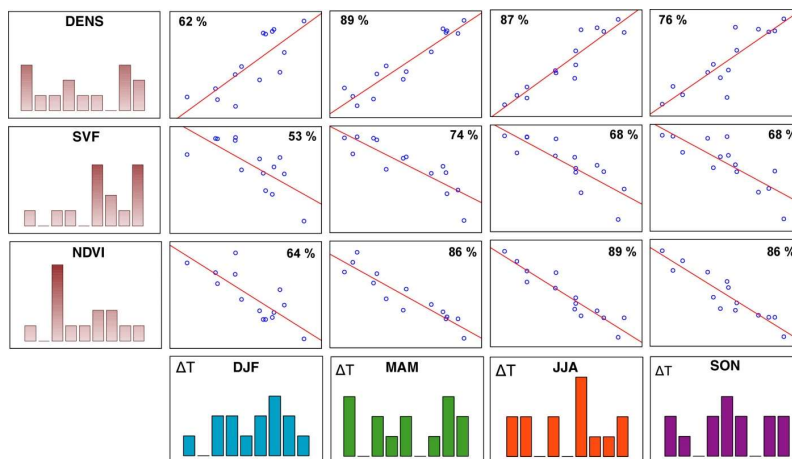


Industrial areas most contribute to SUHI intensity SUHI intensity 4,2 °C ~ 6,7 °C



3.7 The role of explanatory variables

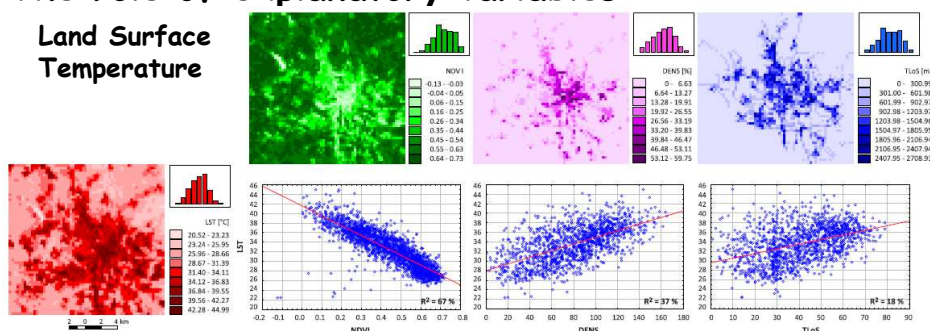
Air temperature

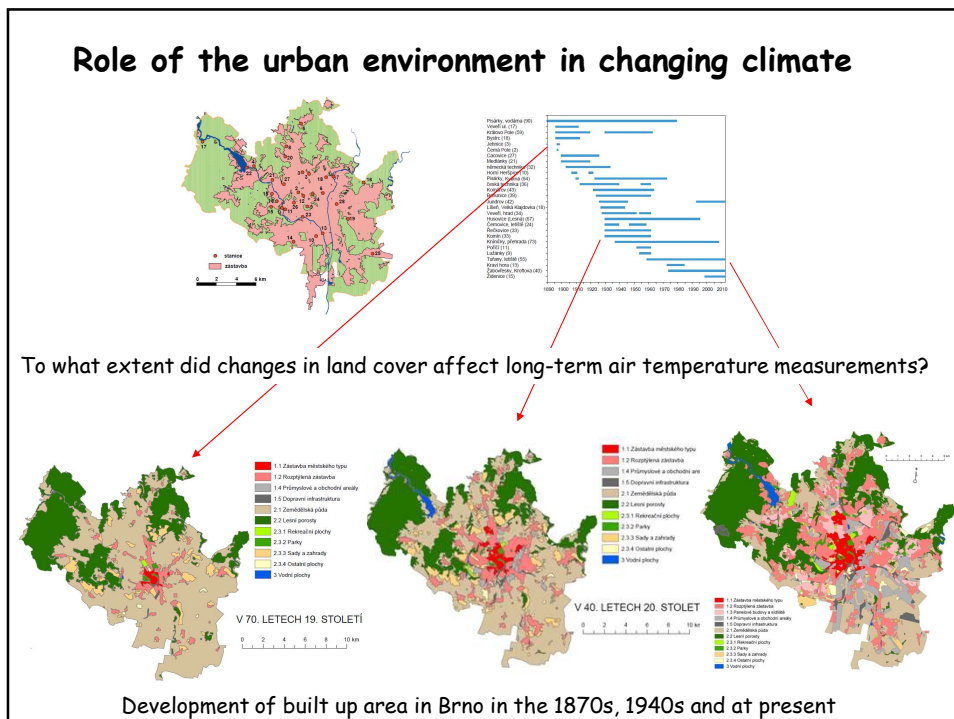
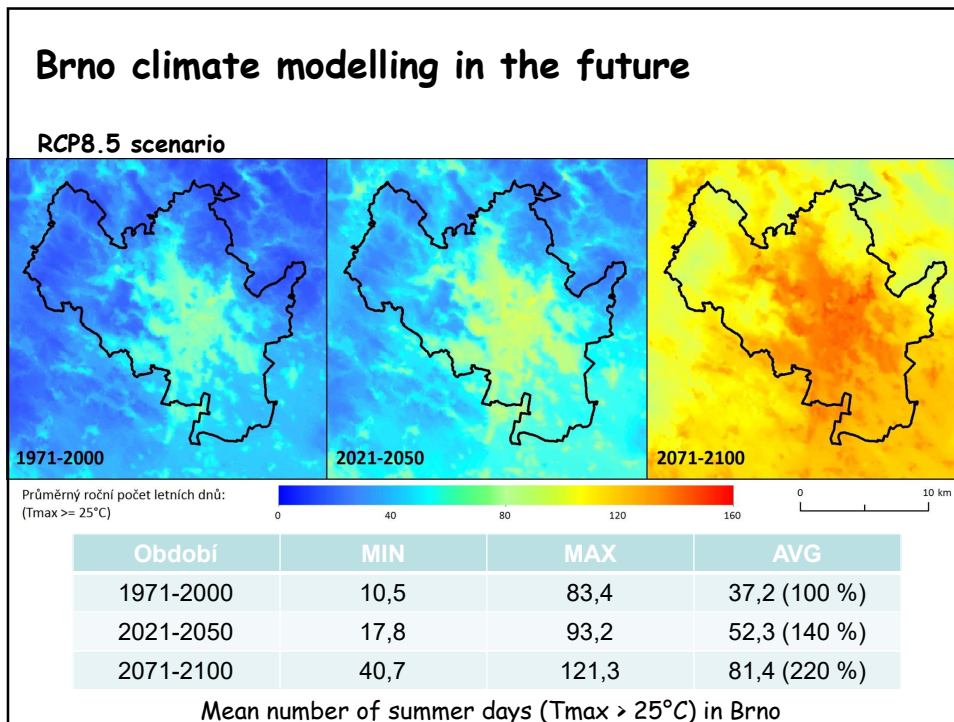


Linear regression between intensity of UHI (ΔT) and explanatory variables for individual seasons in Brno region; numbers represent percentage of explained variance

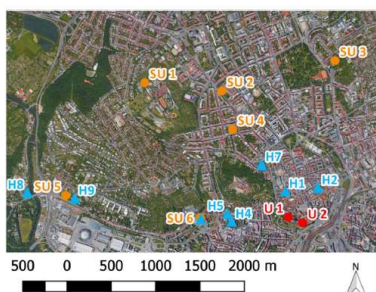
The role of explanatory variables

Land Surface Temperature

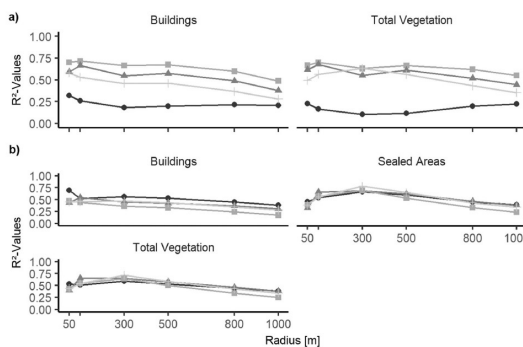




Addressing the relocation bias in a long temperature record by means of land cover assessment

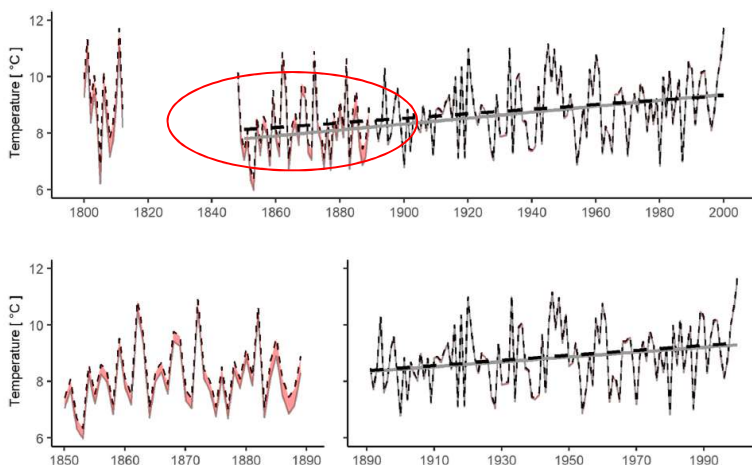


- ▲ Historical Measurement Location
- Rural Station
- Suburban Station
- Urban Station



Coefficients of determination for a) seasonal average and b) minimum temperatures correlated with selected types of land cover relative to different distances to the stations

Addressing the relocation bias in a long temperature record by means of land cover assessment



Measured and corrected Brno MAM record from 1800 to 1812 and 1848 to 2000. Data from the nineteenth century (left) and twentieth century (right) are displayed separately to illustrate the strong corrections in the beginning and the minor changes in the later part.

3.8 Final remarks and questions

1. Why is it useful to have a long term meteorological measurements?
2. What are the main data types we need for an analysis of urban climate?
3. What parts of the city are most susceptible to higher temperatures?
4. Compare positive/negative features of satellite thermal mapping and mobile measurements used for air temperature measurements in urban environment