OCCURRENCE OF TROPICAL DAYS IN CITIES

***Jaroslav Rožnovský*[1,2]**
[1]*Czech Hydrometeorological department, branch Brno, Kroftova 43, 616 67 Brno, Czechia*
[2]*Department of Breeding and Propagation of Horticultural Plants, Faculty of Horticulture, Mendel University in Brno, Valtická 337, 691 44 Lednice,Czechia*

https://doi.org/10.11118/978-80-7701-087-0-0272

Abstract
The urban environment climate is is determined by the specifics of the surface of cities, the number of inhabitants, the area of greenery, etc. This means that cities have a specific climate, different from the natural landscape. The urban environment is not expressed by measurements at climatological stations of the Czech Hydrometeorological Institute (hereinafter referred to as KS). To characterize the urban climate, it is necessary to carry out separate meteorological measurements in the territory of a given city. In the warmest periods of the year, the differences in air temperature between measurements at KS and in the city center are more than 7 °C for the maximum temperature, around 5 °C for the minimum air temperature. Heat waves are more frequent in urban environments (continuous occurrence of tropical days for 3 or more days).On tropical days (maximum is equal to and higher than 30 °C), there are states of considerable discomfort for residents, especially in large unshaded paved areas, such as squares, industrial areas, but also parking lots at shopping centers.

Key words: Urban climate, tropical day, tropical day wave, discomfort

Introduction
Compared to open countryside, cities have a specific climate that develops through the combined effect of the specific active surface of cities, anthropogenic heat energy production, and industrial, transport, and other activities within urban areas. The active surface of cities is formed by rooftops and building walls, artificially surfaced roads, and limited green areas; its characteristics also depend on the type of development, street width, and similar factors, as noted in earlier works (Kopec, 1970; Oke, 1973; Rožnovský, 2019, Střeštík et al. 2014, Rožnovský and Litschmann, 2014 and others).
Evidence of this condition in cities is provided by a large number of publications, e.g. Dobrovolný et al., 2012; Hinkel et al., 2003; Petrovič, 1979; and many others. Particularly during the summer months, elevated air temperatures lead to heat stress among the population and contribute to increased morbidity in elderly people and children. Air pollution in cities also contributes to negative impacts on the health of residents. The effects of the urban environment, including impacts on public health, have received attention from many authors, e.g. Cao et al., 2016; Li et al., 2020.
Based on purpose-specific measurements carried out in the city of Brno, Dobrovolný et al. (2012) report that the deviation in air temperature between the centre of Brno (Mendlovo náměstí) and its surroundings (Tuřany Airport) for minimum air temperatures during the growing season in 2005 was 0.9 °C, for mean temperatures 1.3 °C, and for maximum temperatures 2.5 °C.

Materials and methods
To evaluate the occurrence of extreme air temperatures in urban areas, air temperature measurements were carried out at four locations with differing radiation conditions within the cadastral area of the city of Brno in 2025. The northern peripheral part of the cadastral area is represented by the Starý Lískovec station (hereafter SL), situated in an orchard. Its counterpart is the station in the central part of Brno, located within the grounds of the Augustinian Abbey at Mendlovo náměstí (hereafter MN), representing continuous built-up development. The influence of built-up surroundings is similarly represented by the site within the inner courtyard of the Faculty of Arts of Masaryk University in Brno, though with the additional effect of shading. The influence of greenery in the central part of the city is represented by measurements taken in Lužánky Park (Luz). Continuous measurements at 10-minute intervals were carried out at all of the aforementioned locations. From the individual data, the onset and end dates of summer days (daily maximum of 25 °C or above), tropical days (daily maximum of 30 °C or above), tropical day waves, defined as a sequence of at least 3 consecutive tropical days, and their total count were evaluated. The data were processed using standard statistical methods, including the calculation of mean daily air temperature.

Results

Air temperature is the most frequently used meteorological element, with mean values over various periods, beginning with the daily mean, being the most commonly reported. It should be noted in general that in 2025, temperatures were higher compared to the mean temperatures of the 4th climatological normal, i.e. the period 1991 to 2020. It follows that the number of tropical days was also higher. For the period 1926 to 1950, the publication Podnebí ČSSR–Tabulky (1961) records a mean of 10.2 tropical days for Brno. It should also be noted that during this period, temperatures of 30 °C or above were recorded even in May, albeit amounting to only 0.1 of a day.

The specific occurrences of the first and last summer and tropical days, heat waves, and the total number of tropical days in 2025 are shown in Table 1 for the four aforementioned locations in Brno.

Tab. 1: Occurrence of summer and tropical days at the evaluated locations within the cadastral area of the city of Brno in 2025

Lokalita	Starý Lískovec	Mendelovo náměstí	Filozofická fakulta	Lužánky
First summer day	23. 4.	16. 4.	17. 4.	23. 4.
Last summer day	28. 9.	22. 9.	21. 9.	22. 9.
First tropical day	3. 5.	3. 5.	3. 5.	18. 6.
Last tropical day	4. 9.	21. 9.	29. 8.	4. 9.
Tropical day wave	29. 6. – 3. 7. 13. 7. – 15. 7. 8. 8. – 10. 8. 12. 8. – 16. 8..	22. 6. -6. 7. 13. 7. -15. 7. 8. 8. – 16. 8. 19. 9. – 21. 9.	29. 6. – 3. 7. 8. 8. – 10. 8. 13. 8. – 16. 8.	29. 6. – 3. 7. 3. 8. – 16. 8.
Number of tropical days	29	47	27	26

The occurrence of summer days in 2025 across all locations begins in the centre on 16th or 17th April, and at the periphery of the Brno cadastral area and in Lužánky Park both on 23rd April. The last summer day of the year occurs, surprisingly, at the peripheral location SL on 28th September, whilst at the remaining locations it falls on 21st or 22nd September. Regarding tropical days, the first occurrence is consistently on 3rd May, with the exception of the park, where it does not occur until 18th June. The last tropical day falls on 4th September at both the SL and Luz locations. In the city centre, the pattern differs: at FF it occurs earlier, on 29th August, whilst at MN it is as late as 21st September.

Only two tropical day waves occurred at Luz, totalling 9 days, with 26 tropical days recorded there overall. Three such waves occurred at the FF site, totalling 12 days, with 27 tropical days recorded there in total. Surprisingly, four tropical day waves occurred at the peripheral location SL, totalling 15 days, with an overall count of 29. A markedly higher number of tropical days was recorded at MN, namely 47, with four waves occurring there. The longest was a continuous run of 15 days, with the remaining three again totalling 15.

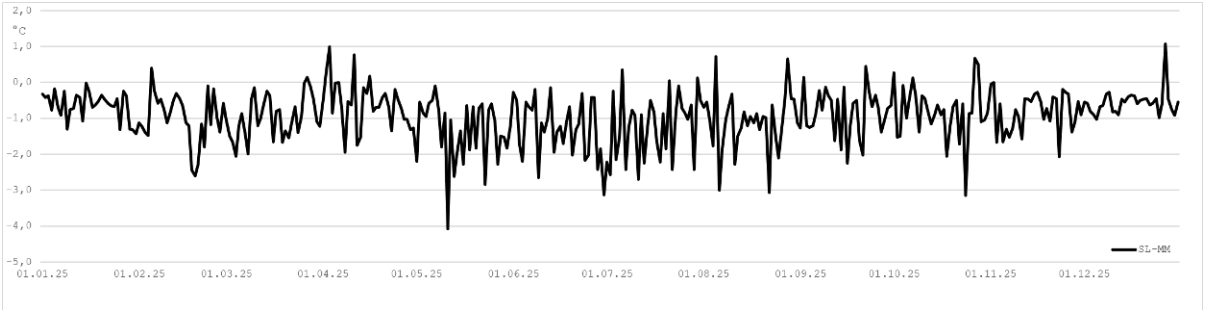

Fig. 1: Difference between daily mean air temperatures at the Starý Lískovec and Mendel square stations in 2025

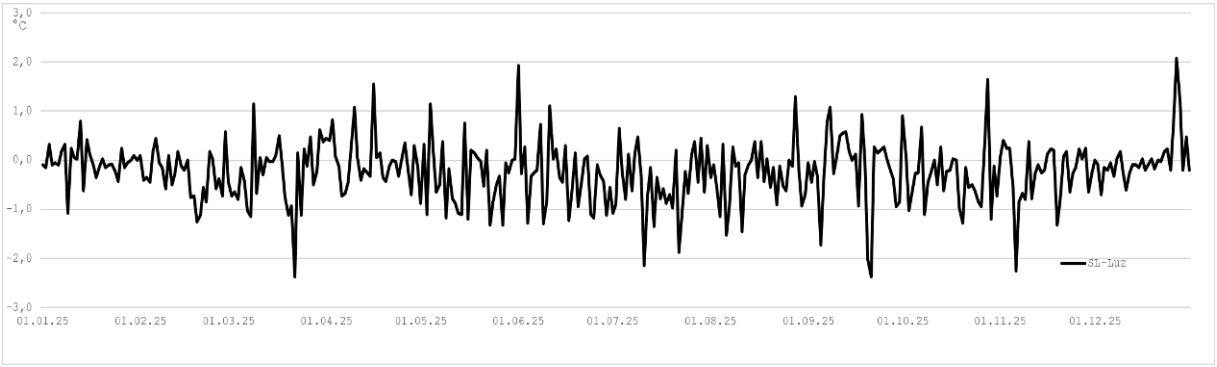

Fig. 2: Difference between daily mean air temperatures at the Starý Lískovec and Lužánky stations in 2025

The course of air temperature expressed as the difference between SL and MN, and between SL and Luz, for daily mean air temperatures, daily minima, and daily maxima is shown in Figs. 1 to 6. The individual courses demonstrate that there are partial differences in the behaviour of daily maxima and minima. In this respect, it should be noted that daily means partly obscure these differences.

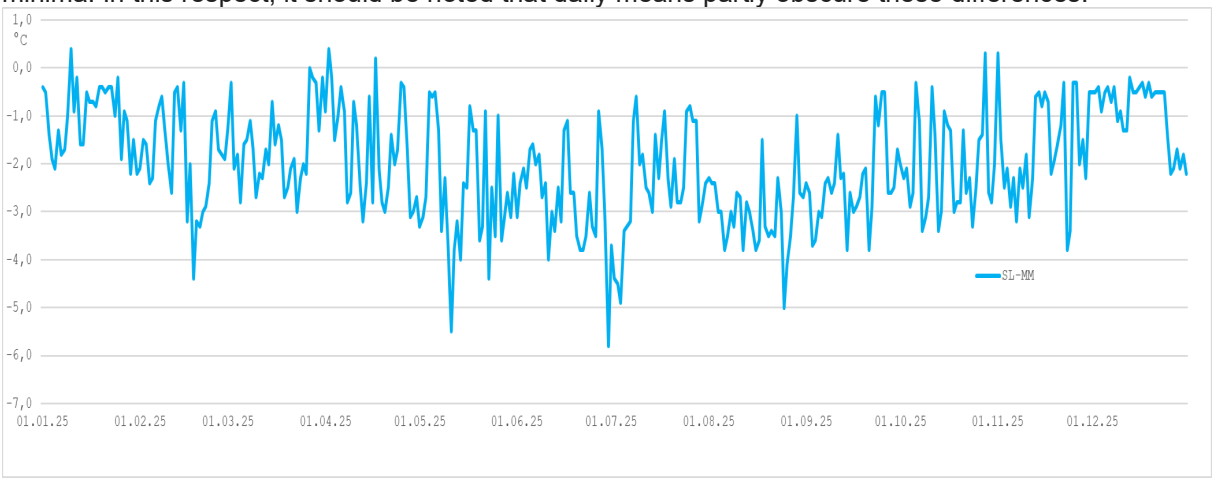

Fig. 3: Difference between daily minimum air temperatures at the Starý Lískovec and Mendel square stations in 2025

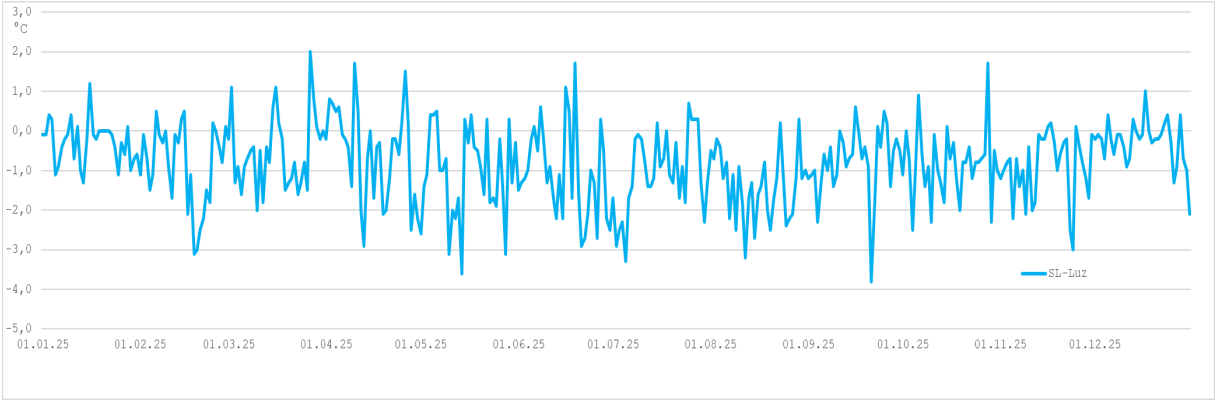

Fig. 4: Difference between daily minimum air temperatures at the Starý Lískovec and Lužánky stations in 2025

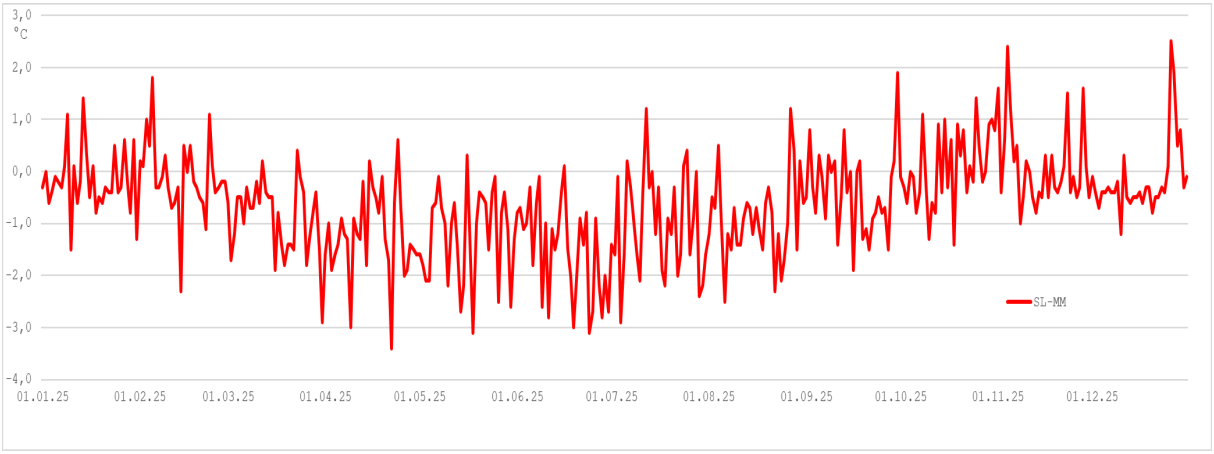

Fig. 5: Difference between daily maximum air temperatures at the Starý Lískovec and Mendel square stations in 2025

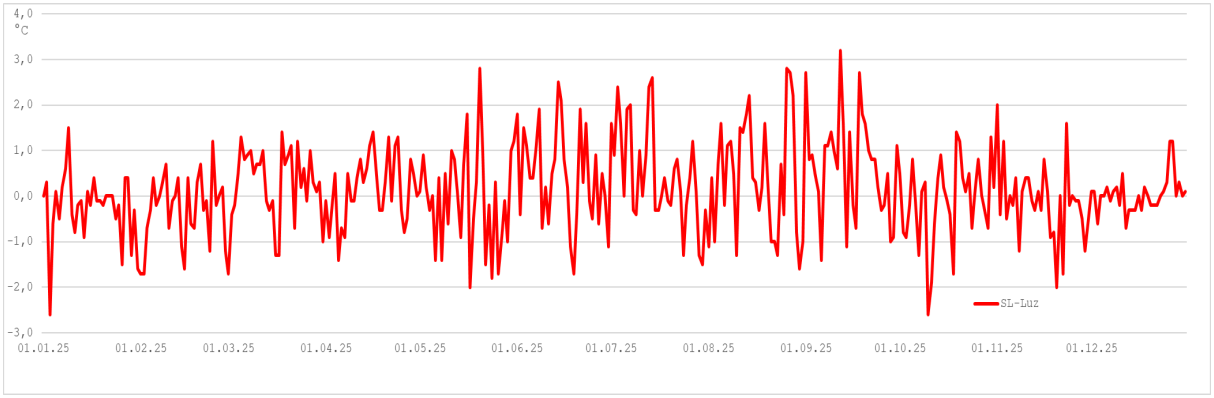

Fig. 6: Difference between daily maximum air temperatures at the Starý Lískovec and Lužánky stations in 2025

Discussion

As is well known from various statistical analyses, air temperature across our territory is rising, both in annual means and across individual seasons and months. In accordance with many authors, our results indicate that whilst the centre of Brno has significantly higher temperatures, thus constituting an urban heat island. This island is not homogeneous, as evidenced by the differences between MN and FF. The significance of continuous green space is demonstrable, with the lowest occurrence of tropical days recorded in the park.

Conclusion

The results presented demonstrate that in order to evaluate urban climate and its various classifications, measurements must be carried out across different parts of the urban environment. It is certainly not appropriate to rely solely on data from the climatological stations of the Czech Hydrometeorological Institute.

It must be emphasised that the high number of tropical days has an impact on the deterioration of the thermal comfort of residents not only in the city of Brno, but across the greater part of our territory. The rise in air temperature has also influenced the values of other meteorological elements, as evidenced by the occurrence of drought, since increasing air temperature induces greater evapotranspiration and thereby a negative moisture balance.

Given the demonstrable rise in air temperature, we must also account for this trend in the future; it is therefore highly probable that the number of tropical days and heat waves will increase. This will in turn bring about changes in our landscape as well as in the urban climate.

References

Cao, C., Lee, X., Liu, S., Schultz, N., Xiao, W., Zhang, M. and Zhao, L., (2016). Urban heat islands in China enhanced by haze pollution. *Nature communications*, 7(1), pp. 1-7.

Dobrovolný, P., L. Řezníčková, R. Brázdil, L. Krahula, P. Zahradníček, M. Hradil, M. Doležalová, M. Šálek, P. Štěpánek, J. Rožnovský, H. Valášek, K. Kirchner A J. Kolejka. 2012, *Klima Brna.*

Víceúrovňová analýza městského klimatu. Brno: Masarykova univerzita, 200 s. ISBN 978-80-210-6029-6.
Kopec, R. J. (1970). Further observations of the urban heat island in a small city. Bulletin American meteorological Society, Vol. 51, No. 7, s. 602-606
Li, H., Sodoudi, S., Liu, J., Tao, W., (2020). Temporal variation of urban aerosol pollution island and its relationship with urban heat island. *Atmospheric Research,* 241.
Oke, T.R. (1973). City size and the urban heat island. Atmospheric Environment 7, 769-779.
Petrovič, Š., (1979). Klíma a bioklíma Bratislavy. VEDA, Bratislava, 272 s.
Rožnosvký, Jaroslav. Water Balance and Phase of Hydrocycle Dynamics. In: ZELENAKOVA, Martina, Jitka FIALOVÁ a Abdelazim M. NEGM, ed. *Assessment and Protection of Water Resources in the Czech Republic*. Springer Water, 2019, s. 403-414. ISBN 978-3-030-18362-2.
Střeštík, J., J. Rožnovský, P. Štěpánek a P. Zahradníček, (2014). Increase of annual and seasonal air temperatures in the Czech Republic during 1961-2010. In: ROŽNOVSKÝ, J. a T. LITSCHMANN eds. Mendel and Bioclimatology. Conference proceedings, Brno, 3rd-5rd Sep. 2014 [CD]. Brno: 2014. ISBN 978-80-210-6983-1.

Acknowledgement
The article is part of the project SS07020449 under the "Environment for Life" program by the Technology Agency of the Czech Republic (TA ČR). The project is titled *"Mitigating the Negative Impacts of Meteorological Extremes (Temperature, Wind, and Precipitation) on Public Health and the Environment in Large Agglomerations".*

Souhrn
Městské prostředí klima je dáno specifiky povrchu měst, počtem obyvatel, plochou zeleně apod. Tím je dáno, že ve městech je specifické klima, odlišné od přírodní krajiny. Městské prostředí není vyjádřeno měřením na klimatologických stanicích Českého hydrometeorologického ústavu (dále jen KS). Pro charakteristiku městského klimatu je potřebné provádět samostatná meteorologická měření na území daného města. V nejteplejších obdobích roku jsou rozdíly teploty vzduchu mezi měřeními na KS a v centru měst i o více jak 7 °C u maximální teploty, kolem 5 °C u minimální teploty vzduchu. V městském prostředí jsou častější výskyty vlny veder (souvislý výskyt tropických dnů po 3 a více dnů). V tropických dnech (maximum je rovno a vyšší jak 30 °C) dochází ke stavům značného diskomfortu pro obyvatele zvláště v rozsáhlých nezastíněných zpevněných plochách, jako jsou náměstí, průmyslové části, ale také parkoviště u nákupních center.

Contact:
RNDr. Ing. Jaroslav Rožnovský, CSc.
E-mail: jaroslav.roznovsky@chmi.cz