AIR TEMPERATURE DYNAMICS AND RECREATION IN THE CITY OF HRADCE KRÁLOVÉ

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Abstract
The climatological station in the city of Hradec Králové allows one to evaluate the dynamics of air temperature as an indicator of conditions for recreation in the city. A suitable indicator is the air temperature during various seasons, especially in the summer and possibly in the winter. Increase in the average air temperature in the summer during the period of 1961 to 2020 in the city of Hradec Králové is 2° C. The air temperature has risen more significantly in the last 30 years. Each consecutive decade in the period from 1961 has been the warmest on record. Change in the average temperature in winter changes the conditions for winter sports, both the duration and period of continuous snow cover and restrictions for skating.

Key words: Summer, winter, climate change, snow cover

Introduction
It is quite difficult to define the concept of the term recreation. It represents a very wide field of activities with various aims. In any case, a suitable environment is necessary for recreation, and this does not include just nature, but also cities. These provide both historical buildings, other various monuments, pleasant facilities, but also completely new attractions. In this respect, it is therefore necessary to take into account the urban environment for recreation, the most dynamic part of which is the urban climate. This has been evaluated in detail in the recent decades.
One common subject of study is the occurrence and effects of the urban heat island are studied, which can lead to extreme values, unfavorable to human health. A change in the urban surface is directly associated with a change in the radiation balance and an increase in the extremity of meteorological parameters. Atmospheric Urban Heat Island can be identified by measuring the temperature or humidity of air at standard meteorological stations, performing special purpose measurements within a dedicated network of stations or, for example, using the so-called measuring rides, which allow spatial expression of temperature and humidity field in the area of analysis.
Particularly hot spots with characteristic features (car parks, industrial facilities, flat roofs, asphalt roads, etc.) are defined as "micro urban heat islands - MUHI". An extensive study of the urban environment that used the city of Brno as an example and which was based on a network of special-purpose meteorological stations, can be found in the Klima Brna publication (Dobrovolný et al., 2012).

Material and methods
To evaluate the urban climate of the city of Hradec Králové, a climatological station located in the inner city was used (Střeštík et al 2014). This provides one with data measured in accordance with standards of the Czech Hydrometeorological Institute. The measured air temperature data were processed by basic statistical methods and their graphical representation is given.

Results
Thirty-year evaluations, the so-called normal periods, have been introduced for the climatological evaluations. Fig. 1 shows the course of average monthly air temperatures for the normal periods 1961 - 1990 (blue curve) and 1991 - 2020 (red curve). It is clear from their course that in case of all the months in the period 1991 to 2020, the average air temperatures were higher. The course of air temperature expressed by average annual temperatures is shown in Fig. 2. Annual values further prove the increase in air temperature by 2.3 °C over the 60-year period.

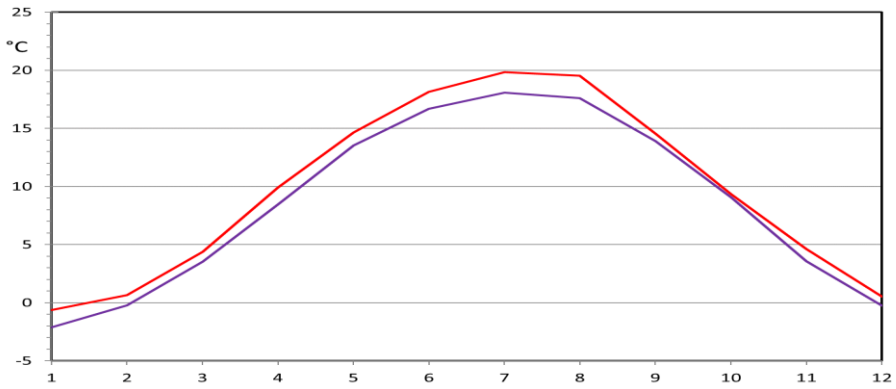

Fig. 1: Course of average monthly air temperatures (°C) for the normal periods 1961 - 1990 (blue) and 1991 – 2020 (red) in Nový Hradec

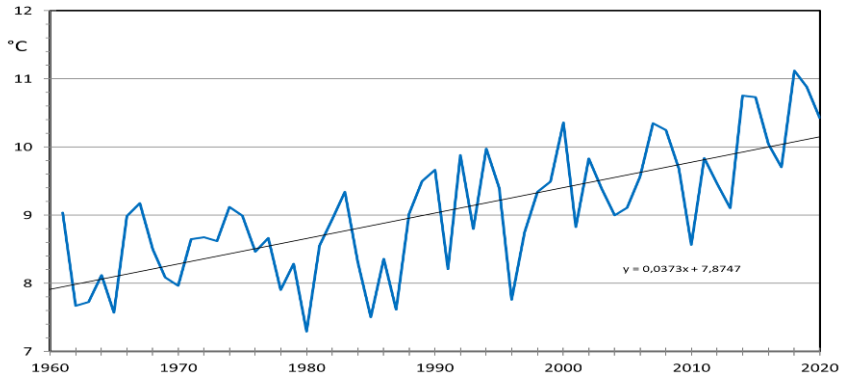

Fig. 2: Average annual air temperatures (°C) in the period 1961 - 2020 and the associated linear trend at the station in Nový Hradec.

The annual averages range from 7.2 °C to 11.1 °C, with natural fluctuations. One can see an evidence of the constant rise in air temperature during the evaluated period in Fig. 3, where one can see that temperatures have been rising steadily since the 1960s. From the perspective of recreation, however, it is more important, to evaluate the air temperature during shorter periods, it was therefore decided to further analyse the various seasons of the year.

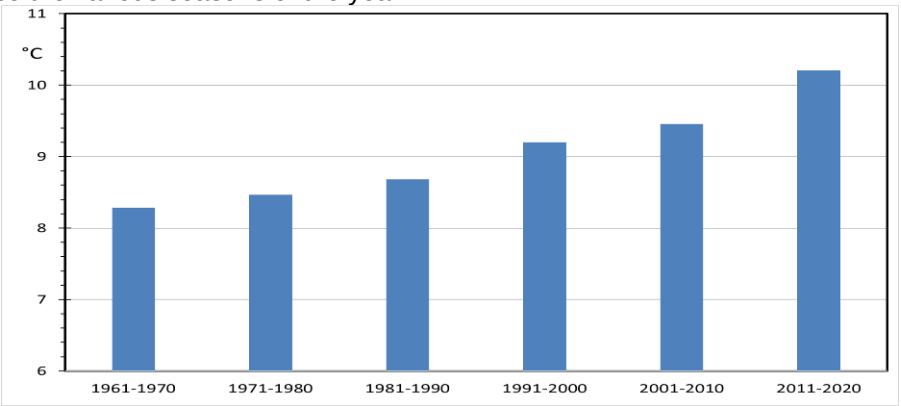

Fig. 3: Average annual air temperatures (°C) for the individual decades in the period 1961 - 2020 at the station in Nový Hradec

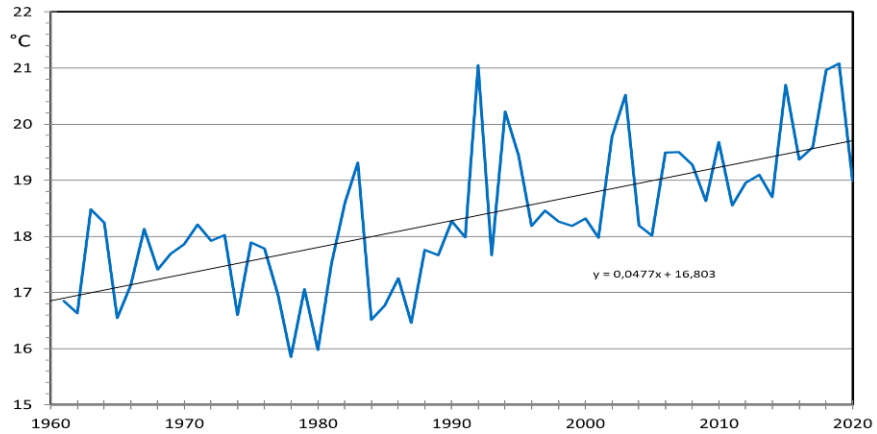

Fig. 4: Average summer air temperatures (°C) in the period 1961 - 2020 and the associated linear trend at the station in Nový Hradec

In the summer one can see the highest air temperature increase, in particular by 4.2 °C, with a relatively high amplitude from 15.9 °C in 1978 to 21.1 °C in 2019 (Fig. 4). At the same time, the average summer air temperatures have not fallen below 18 °C since 1993. However, the constantly higher air temperatures mean that the number of extremely high daily maximums is increasing. It is the air temperatures above 30 °C that are already unfavorable for the human health. Especially during longer-lasting anticyclone conditions, staying in the city at noon is unsuitable and even dangerous. From the perspective of recreation, it is important to remember this fact and, especially in the central part of cities, to always establish shade areas. This role, including cooling the environment, is well fulfilled by greenery, especially mature trees with their shade.

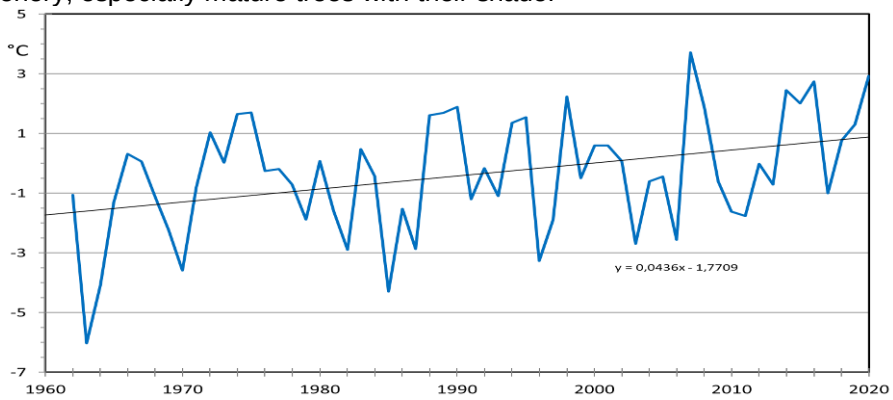

Fig. 5: Average winter air temperatures (°C) in the period 1961 - 2020 and the associated linear trend at the station in Nový Hradec

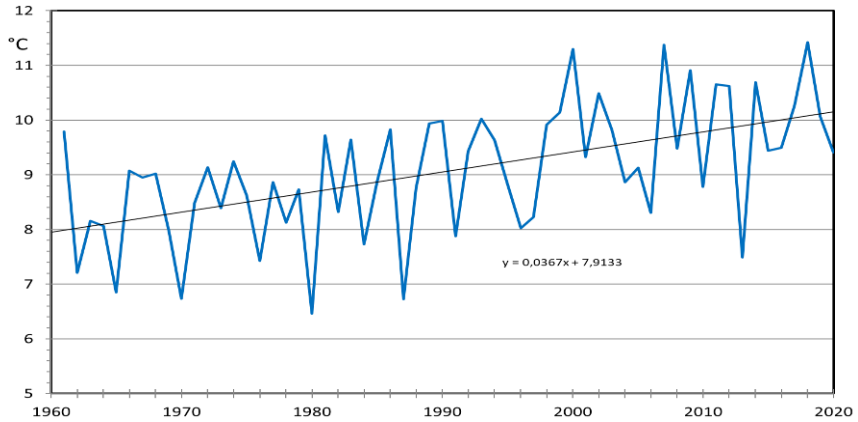

Fig. 6: Average spring air temperatures (°C) in the period 1961 - 2020 and the associated linear trend at the station in Nový Hradec

The second highest increase in air temperature of all the seasons in the year is observed in winter, on average an increase by 2.6 °C over the 60-year period (Fig. 5). With regard to winter recreation, increased air temperature has a negative impact especially on skiing and skating potential as more and more winters have an average temperature above zero, so skating in the open is almost impossible. The number of days with snow cover required for skiing is also decreasing. If one evaluates the annual season based on the extend of the air temperature increase, the third in the order is spring, with an average increase in temperature of 2.2 °C (Fig. 6). The impact of this spring increase is expressed by earlier flowering of plants, but also by an increase in the number of days suitable for an outdoor stay in the city, i.e. for walks in parks, etc.

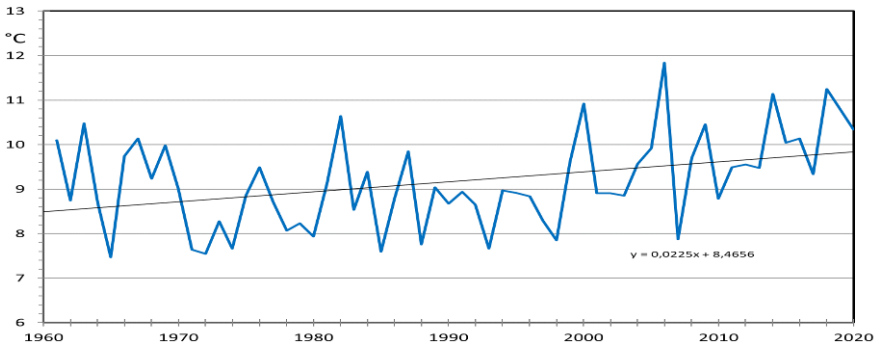

Fig. 7: Average autumn air temperatures (°C) in the period 1961 - 2020 and the associated linear trend at the station in Nový Hradec.

The smallest increase in average air temperatures is observed in the autumn, in particular an increase by 1.3 °C (Fig. 7). This increase allows extending the period for staying in the outdoor environment and the period for recreation.

It is also important to note that with the exception of the winter season, the last two decades have been the warmest. This finding is a proof that one can expect an increase in air temperature in cities in the future. It should also be noted that this increase is higher in these urban environments compared to the open countryside.

Discussion

The presented results are in accordance with findings published on the issue of urban climate in both older (Petrovič 1979, Oke 1973) and contemporary literature (Hinkel 2003, Técher 2021). Even though calculations of apparent categories, such as the temperature-humidity characteristic Humidex index (Toy et al., 2007), are not included, it can be assumed that increasing temperature leads to an increase in the number of days unsuitable for recreation in cities, especially in their central parts (Litschmann, Rožnovský). However, with regard to the possibilities of recreation development in cities, one must also take into account the outputs from climatological models, according to which the air temperature will continue to rise, albeit not

Conclusion

From the above results, it can be stated that, similarly to other cities, as documented in the literature, air temperatures in the city of Hradec Králové increase in all seasons of the year. Highest rate of increase is observed in the summer, particularly in the central built-up areas of cities, where there is no or a minimum ratio of greenery, the air temperatures exceed the values favorable for outdoor stay, i.e. cause discomfort or even extreme discomfort.

Rising air temperature negatively affects winter recreation, because shorter period of snow cover makes it more difficult to maintain ice for skating etc. Increase of air temperature in the spring and autumn, on the other hand, prolongs the suitable period for recreation. However, with regard to the outputs from climatological models, it is necessary to look for ways of preventing further rise in air temperature in general, especially in the cities. Despite the fact that Hradec Králové is known for its large parks and green areas, these should be further expanded in order to take advantage of the cooling effect of greenery as much as possible.

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Souhrn
Údaje z klimatologických měření na stanici Hradec Králové Nové dvory byla analyzována dynamika teploty vzduchu, jako ukazatel podmínek pro rekreaci na území města. Vhodným ukazatelem je teplota vzduchu v ročních obdobích, hlavně v létě a případně v zimě. Vzestup průměrné teploty vzduchu v létě za období 1961 až 2020 na území města Hradce Králové činí 2 °C. Výraznější vzestup teploty vzduchu je v posledních 30 letech. Pokud jde o desetileté průměry, potom každé desetiletí od roku 1961 bylo vždy v celé řadě nejteplejší. Změna průměrné teploty za zimu mění podmínky pro zimní sporty, a to jak dobu pro setrvání souvislé sněhové pokrývky, omezení pro bruslení.

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