**How to cite:** Corocăescu, Al., Ichim, P., Crețu, C.Ș., Dior, Al., Șerban, L., Amihăesei, V.-Al., Sfîcă, L. (2023) Assessment of Climate Characteristics of an Urban Park Using Satellite Imagery and In-Situ Measurements. Study Case of Cancicov Park From Bacău City (Romania). *2023 "Air And Water – Components of the Environment" Conference Proceedings*, Cluj-Napoca, Romania, p. 33-46, DOI: 10.24193/AWC2023_04.

# ASSESSMENT OF CLIMATE CHARACTERISTICS OF AN URBAN PARK USING SATELLITE IMAGERY AND IN-SITU MEASUREMENTS. STUDY CASE OF CANCICOV PARK FROM BACĂU CITY (ROMANIA)

**Alexandru COROCĂESCU[1], Pavel ICHIM[1], Claudiu Ștefănel CREȚU[2], Alexandra DIOR[1], Lucian ȘERBAN[3], Vlad-Alexandru AMIHĂESEI[2,4] , Lucian SFÎCĂ[1]**

**DOI: 10.24193/AWC2023_04**

**Abstract.** It is well known that urban parks, especially wooden ones, cause a cooling effect on the urban climate and have a decisive role in the formation of the so-called Park Cool Island (PCI). Urban parks can help at lowering the land surface temperature (LST), and consequently mitigate the effects of the surface urban heat island (SUHI). The thermal characteristics of the Urban Park Cancicov from Bacău city are analyzed using LANDSAT-8 imagery, but also in-situ measurements for the growing season of 2022 (March to October). For the calculation of LST based on LANDSAT images, several methods have been applied among which the mono-window method has been finally used. The results showed that Cancicov Park, through its structural characteristics and its central position in a densely-built area, determines a cooling effect in an area where the SUHI intensity reaches the highest values. During the day the LST is by 4.5$^0$C lower compared to densely built areas in the surroundings for April-September, the diurnal LST exceeding 30$^0$C from May to August, while the surrounding urban LST exceeds 35$^0$C from June to August. Regarding the results from in-situ measurements, we have used the monitoring results from 2 points, one represented by the monitoring point located in the city center ("Gheorghe Vrănceanu" College) and the second one located on the eastern side of the park ("Ștefan cel Mare" College). The diurnal thermal differences between these two points rise to over 2.5$^0$C during the summer morning hours. At the nocturnal level, thermal differences are reduced from 0.75 to 1$^0$C. This study emphasizes the capacity of green areas to alleviate the UHI, providing viable information for urban planners to correctly assess climate risks and guide development management by maximizing the intensity of PCI.

[1] Alexandru Ioan Cuza University, Faculty of Geography and Geology, Department of Geography Iași, Romania, sfical@yahoo.com
[2] Alexandru Ioan Cuza University, Doctoral School of Geosciences, Iași Romania.
[3] Gheorghe Vrănceanu College, Bacău, Romania.
[4] National Meteorological Administration, Bucharest, Romania.

## 1. INTRODUCTION

Due to densely built areas and global warming, urban heat islands (UHI) have become one of the most significant climatic phenomena in urban climatology studies. The UHI effect is characterized by higher temperatures in urban areas than that in rural peripheral regions (Manoli et al., 2019; Oke et al., 2017). Some of the major agents underlying the formation of the UHI effect are the massive replacement of natural vegetation cover with dark-coloured asphalt and concrete surfaces which increase sunlight absorption, while the morphology of high-density urban buildings affects shading and air movement (Chibuike et al., 2018; Aram et al., 2019). In the past decades, a plethora of studies around the world tried to understand the characteristics of the UHI effect in order to generate mitigation strategies and efficiently manage the urban thermal environment (Park et al., 2017; Chun and Guldmann, 2018).

The effectiveness of urban parks in reducing urban thermal islands by creating cooling buffer zones is already proven through measurements (Aram et al., 2019), thus this study aims to emphasize the capacity of green areas to mitigate the effects of the surface urban heat island (SUHI). With the advance of remote sensing technology, it is possible to study large spatial datasets of land cover and spatially comprehensive observations of the urban thermal condition (Smith et al., 2023). Some advantages of using satellite images reside in the data acquisition consistency, the low-cost data gathering, and the capability of reaching even restricted study areas.

The major flaw in using remote sensing imagery to analyze the UHI effect consists in the lack of continuous information on LST due to low temporal resolution (Arellano and Roca, 2022). The thermal satellite images have an important use in understanding the UHI spatial effects instead, especially in the analysis of daytime LST (Arellano and Roca, 2022). LST influences the comfort and the health of the urban inhabitants (Rasul et al., 2017), consequently, the LST data is of vital importance in the climate process as an indicator of air temperature and allows monitoring land cover changes and derivation of LST over time (Chibuike et al., 2018).

Urban parks are a widespread component of the urban green infrastructure being an important part of studies regarding the cooling effect (Yu et al., 2020). The center-park temperatures are lower than that in the surrounding areas generating the "cool island" effect (Yang et al., 2016). The potential of the green space to manifest the PCI effect is influenced by a series of factors such as dimension, type, shape index, the composition of the species, and geographic and meteorological variables (Anjos and Lopes, 2017). The green vegetation can lower the LST through the absorption of radiation energy by photosynthesis and transpiration (Du et al., 2017). The presence of climatological monitoring points located near the urban park and the city center offers a great opportunity in understanding the UHI effect and the associated phenomena such as PCI. However, the accurate data obtained is limited due to the reduced number of meteorological observation points that cannot provide enough information for the entire study area. A dense climatological monitoring network allows a deeper study of such phenomena (Anjos and Lopes, 2017).

The objectives of this study are to determine the cooling effects of an urban park on the LST distribution using LANDSAT-8 thermal images for a period of 3 years, also in-situ measurements for the March-October period of 2022. Quantifying the cooling effect intensity of the park allows urban planners to correctly assess climate risks and guide them.

## 2. STUDY REGION

Located in north-eastern Romania, Bacău city has 11 public parks, which cover an area of approximately 60.4 ha (1.4% of the administrative territory's surface and almost 11,8% of the total urban green spaces), most of which have less than 1 ha.

The "green heart" of Bacău city, the "Cancicov" Park was laid out on land obtained by the city due to the agrarian reform of 1921-1924, as a result of a memorandum submitted to Bacău City Hall on March 22, 1935, by a group of over 100 leading citizens of the city (CMB, 1935). It is the second largest park in the city (21.9 ha), but the most important in terms of structure, functionality, accessibility, and urban image. The 1960-1980 period marked the most extensive interval of systematization. The layout style is geometric, designed by the clear subordination of the alley network to a compositional center with an aesthetic and decorative function (artesian fountain, public forum monuments, parterres, and flower circles). Two main alleys separate orthogonally from the pedestrian ring individualizing the physiognomy of the park (fig. 1), and six secondary radial alleys. The two major alleys, with the function of a promenade, generate the dominant perspectives, intensified in the case of the alley with a north-south orientation (Șerban, 2011). The functional zoning presents the greatest complexity among the parks of Bacău county, there is a sector set up for children's play, two sectors for static games, public food units with permanent operation, areas with a predominantly decorative role, an administrative-household sector (Șerban, 2011).

Trees are very well represented, occupying approx. 93% of the park area. The park is arranged in the form of alignment along the main avenues. The diversity of species is relatively modest, identifying 30 species of deciduous and resinous species, with a higher frequency of linden, horse chestnut, thuja, black walnut, Scots pine, acacia, palin, ash or maples. In terms of age, dominant are Echien specimens, which retain a significant weight, resulting from the plants carried out in the first decades after establishment.

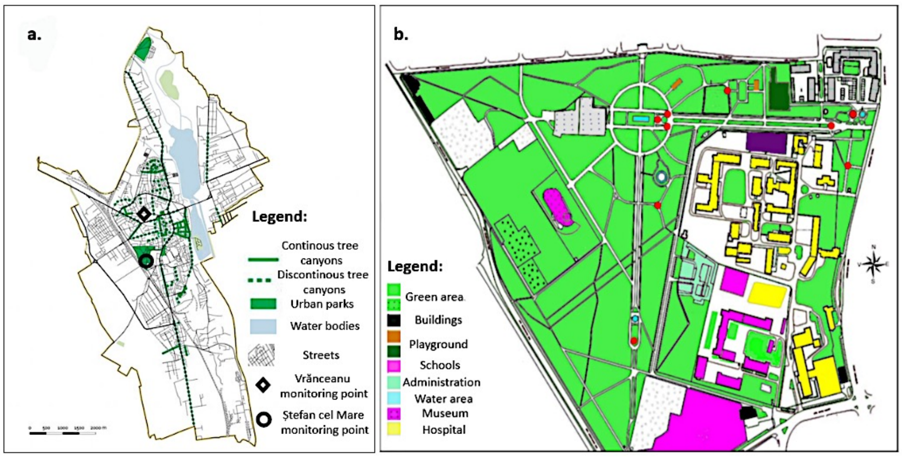



**Fig. 1.** ***Green areas inside Bacău city with the location of monitoring points (a) and Cancicov's park shape and structure (b)***

## 3. DATA AND METHODS

The thermal characteristics of the Cancicov Urban Park in the city of Bacau are analyzed using LANDSAT-8 daytime thermal images during the warm season (April-September) in the period 2019-2022, but also using in-situ hourly measurements during the growing season (March - October) of 2022. The LANDSAT-8 satellite imagery, with a spatial resolution of 30m, provided by the USGS (Earth Explorer, 2000) were used to derive Land Surface Temperature (LST) of the Cancicov Urban Park area and subsequently to quantify the Park Cool Island PCI. LANDSAT-8 satellite imagery was the subject of a sorting process, after which a collection of representative images were selected for the warm season from 2019-2022 (April to September).

It is well known that the availability of satellite imagery is controlled by a number of objective factors, cloudiness being the most important factor. Consequently, the rigorous selection of images was necessary, the selection criterion being the absence of cloud cover in the study region. Following the sorting process, we obtained a total of 18 satellite images, taken at 9AM, based on which the main thermal characteristics of the days with clear skies in the warm season (April - September) from 2019-2022 were outlined.

Subsequently, we calculated LST based on the radiative transfer method (RTE) because this is well known for its high accuracy of about 0.6°C for the derived LST (Sobrino & Jimenez-Munoz, 2014; Ghosh & Das, 2018; Sekertekin, 2019; Li et al., 2020). The radiative transfer equation (RTE) method is one of the most widely used methods for calculating LST and is generally divided into several steps (Price, 1983; Zhou et al., 2012; Ghosh & Das, 2018, Li et al., 2020).

The first step consists of the reflectance values into radiance values by spectral radiance scaling based on equation 1 (USGS: LANDSAT-8 (L8) Data Users Handbook, 2019):

$$L\lambda = ML * Qcal + AL,$$

*where Lλ is the Spectral radiance (W/(m2 * sr * µm), ML is the Radiance multiplicative scaling factor for the thermal band, AL = Radiance additive scaling factor for the band and the Qcal is the Level 1 pixel value in DN.*

The second step was the conversion of spectral radiance to atmospheric radiance according to Equation 2 (USGS: LANDSAT-8 (L8) Data Users Handbook, 2019).

$$\rho\lambda' = M\rho * Qcal + A\rho$$

*where ρλ' is TOA Planetary Spectral Reflectance with correction for solar angle, Mρ is the Reflectance multiplicative scaling factor for the thermal bands; Aρ is the Reflectance additive scaling factor for the te bands and Qcal is the Level 1 pixel value in DN.*

For LST estimation, it was necessary to convert radiance values to temperature in degrees Kelvin using Equation 3 (Ghosh & Das, 2018).

$$T = \frac{K2}{\ln\left(1 + \left(\frac{k1}{L\lambda}\right)\right)}$$

*where T is the temperature in Kelvin scale; K2 and K1 are constants for LANDSAT-8 image (Ghosh & Das, 2018) and Lλ is the Spectral radiance (W/(m2 * sr * µm).*

It should be noted that the derived temperature from the Kelvin scale for bands 10 and 11 of the LANDSAT-8 image represents the average value because the bands mentioned are both thermal bands (Ghosh & Das, 2018). The next process was to convert the estimated Kelvin scale temperature to °C.

Based on the obtained values of LST, we quantified the intensity of the Park Cool Island (PCI) using equation 4.

$$TPCI = TU - TP,$$

where TU is the average land surface temperature of densely built urban surroundings within a 500 m buffer zone from the park, and TP is the average park surface temperature (Ren et al., 2013).

For the calculation of TU it was necessary to remove the land surface temperature of other green spaces and water surfaces from the analysis as indicated in the literature (Xu & Yue, 2008; Ren et al., 2013).

The results obtained from the LST processing were then compared with those of the in-situ measurements in order to analyze the thermal differences between the LST of the park and air temperatures measured at monitoring points located in the proximity of the park (tab. 1).

***Table 1. Geographical location of meteorological monitoring points***

| Monitoring points | Latitude | Longitude | Altitude (m) |
|---|---|---|---|
| Gheorghe Vrănceanu College | 46.5570 | 26.9080 | 171 |
| Ștefan cel Mare College | 46.5707 | 26.9102 | 168 |

Another scientific goal of this study was to check if monitoring from 2 points, one represented by the monitoring point located in the city center (Gheorghe Vrănceanu College) and the one located on the east side of the park (Ștefan cel Mare College), helps us validate the results obtained on the basis of satellite images.

## 4. RESULTS AND DISCUSSIONS

### 4.1. Air temperature characteristics of the Cancicov urban park under standard weather observations

Analyzing the average daily temperature recorded between March and October 2022 at the two monitoring points used in the study area, we observe that, generally, the park is colder about 1.2°C than the core of the UHI. May reaches the maximum difference (1.4°C) corresponding with the explosive development of the park vegetation (Fig. 2c). Actually, during May-July, the daily air temperature differences between the weather shelters inside the urban park and that representing the central urban area conditions reaches even 2.5°C (Fig. 2a). The monthly differences are smaller during March-April when the vegetation canopy is not developed or completed, the daily differences are close to zero, but even so the urban park is colder with 0.6 to 0.8°C that the core of UHI.

The spring months are characterized by small differences in air temperatures between the two monitoring points, with a higher variation difference in the first part of the day that gradually decreases towards the end of it. The summer months record the highest hourly air temperature differences between Pedagogic and Vrănceanu monitoring points, with maximum mean differences recorded in the first part of the day (8-11 AM) peaking up to 2.7°C (Figure 3).

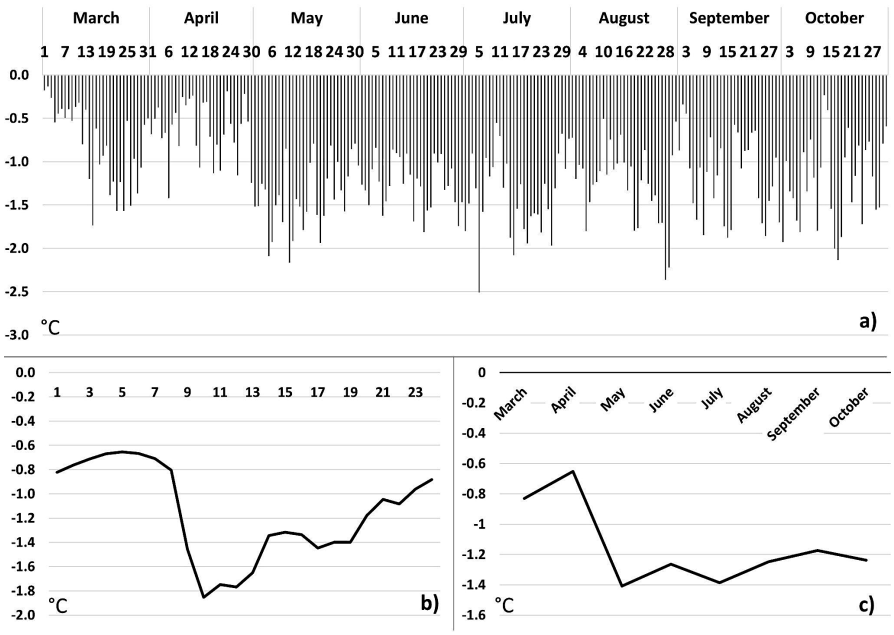



**Figure 2.** ***Daily (a), hourly (b) and monthly (c) air temperature differences from March to October 2022 between Pedagogic and Vrănceanu monitoring points in Bacău city***

This interval during the morning corresponds with the maximum sheltering effect of the vegetation canopy in the park area, while in the core of the UHI due to the radiative heating, the air rapidly warms. Also, during the morning the consumption of heat in evaporative processes is more intense in the park area and therefore the increase in air temperature is slower. In brief, for the whole interval, the urban park is colder by 0,6°C at 06:00 AM, and by 1,8°C at 10:00 AM (Fig. 2c).

Actually, the hourly air temperature differences are heterogeneous with smaller differences in May-July between 12 and 15 PM. This is due most probably to the local sheltering conditions determined by the cathedral building at Vrănceanu monitoring point during this interval of the day.

In a nutshell, we can observe that the impact of the urban park on air temperature is sufficiently intense to alleviate the thermal imprint of Urban Heat Island for Bacău city, as results from the observations made throughout the year 2022.

| Month / Hour | March | April | May | June | July | August | September | October |
|---|---|---|---|---|---|---|---|---|
| 0 | -0.9 | -0.8 | -1.3 | -0.7 | -0.7 | -0.5 | -0.8 | -0.9 |
| 1 | -0.8 | -0.8 | -1.1 | -0.8 | -0.7 | -0.5 | -0.7 | -0.9 |
| 2 | -0.9 | -0.7 | -1.0 | -0.6 | -0.6 | -0.4 | -0.7 | -0.9 |
| 3 | -0.8 | -0.6 | -0.9 | -0.6 | -0.6 | -0.3 | -0.6 | -0.8 |
| 4 | -0.8 | -0.7 | -0.9 | -0.6 | -0.6 | -0.3 | -0.6 | -0.7 |
| 5 | -0.8 | -0.6 | -1.0 | -0.6 | -0.7 | -0.3 | -0.6 | -0.7 |
| 6 | -1.0 | -0.6 | -1.1 | -0.6 | -0.6 | -0.4 | -0.6 | -0.7 |
| 7 | -0.9 | -0.6 | -1.1 | -1.0 | -0.8 | -0.5 | -0.8 | -0.8 |
| 8 | -1.2 | -1.0 | -2.1 | -2.0 | -1.7 | -1.0 | -1.2 | -1.5 |
| 9 | -1.2 | -1.0 | -2.6 | -2.6 | -2.6 | -1.9 | -2.0 | -1.0 |
| 10 | -0.3 | -0.7 | -2.7 | -2.6 | -2.6 | -2.3 | -1.5 | -1.2 |
| 11 | -0.8 | -0.7 | -2.1 | -2.2 | -2.4 | -2.5 | -2.0 | -1.4 |
| 12 | -0.8 | -0.5 | -1.6 | -1.3 | -1.7 | -2.5 | -2.3 | -2.4 |
| 13 | -0.7 | -0.3 | -1.0 | -1.1 | -1.6 | -2.1 | -1.8 | -2.0 |
| 14 | -0.8 | -0.2 | -1.1 | -1.2 | -1.5 | -2.1 | -1.4 | -2.1 |
| 15 | -0.8 | -0.1 | -1.2 | -1.3 | -1.7 | -2.2 | -1.7 | -1.6 |
| 16 | -0.9 | -0.3 | -1.6 | -1.6 | -2.2 | -2.2 | -1.5 | -1.3 |
| 17 | -0.6 | -0.5 | -1.4 | -1.7 | -2.1 | -2.2 | -1.4 | -1.3 |
| 18 | -0.4 | -0.6 | -1.7 | -1.8 | -2.2 | -1.8 | -1.3 | -1.4 |
| 19 | -0.7 | -0.6 | -1.3 | -1.5 | -1.7 | -1.2 | -1.1 | -1.3 |
| 20 | -0.8 | -0.9 | -1.2 | -1.1 | -1.2 | -0.8 | -0.9 | -1.3 |
| 21 | -1.1 | -1.1 | -1.3 | -1.1 | -1.1 | -0.8 | -0.9 | -1.3 |
| 22 | -1.0 | -0.9 | -1.2 | -0.9 | -1.0 | -0.7 | -0.9 | -1.1 |
| 23 | -1.1 | -0.7 | -1.2 | -0.8 | -0.8 | -0.6 | -0.8 | -1.0 |

**Figure 3.** ***Mean hourly air temperature differences for each month for March and October 2022 between Pedagogic and Vrănceanu monitoring points in Bacău city***

#### *4.1.1. LST distribution in the Cancicov urban park and its surroundings*

The influence of the urban park on its surroundings is to some extent within the specific characteristics outlined in the literature for small parks. In general, small parks can generate an LST decrease of about 2.5°C over a distance between 25 to 152 m (Algretawee, 2022). Besides, it was observed that the LST values in Cancicov park are generally cooler than its surroundings, which confirms the Park Cool Island. During the summer, the cooling effect of urban park is different from the spring or autumn months. For example, in summer, the Cancicov park area is 5.3°C colder than its surroundings. However, the park is 2.7 °C cooler in April because the leaves surfaces of the trees are in the first stages of development. This increases to 4.5 °C in May and 3.9 °C in September (Fig. 6). Thus, Cancicov park has a remarkable cooling effect in summer when trees shading reaches its highest values.

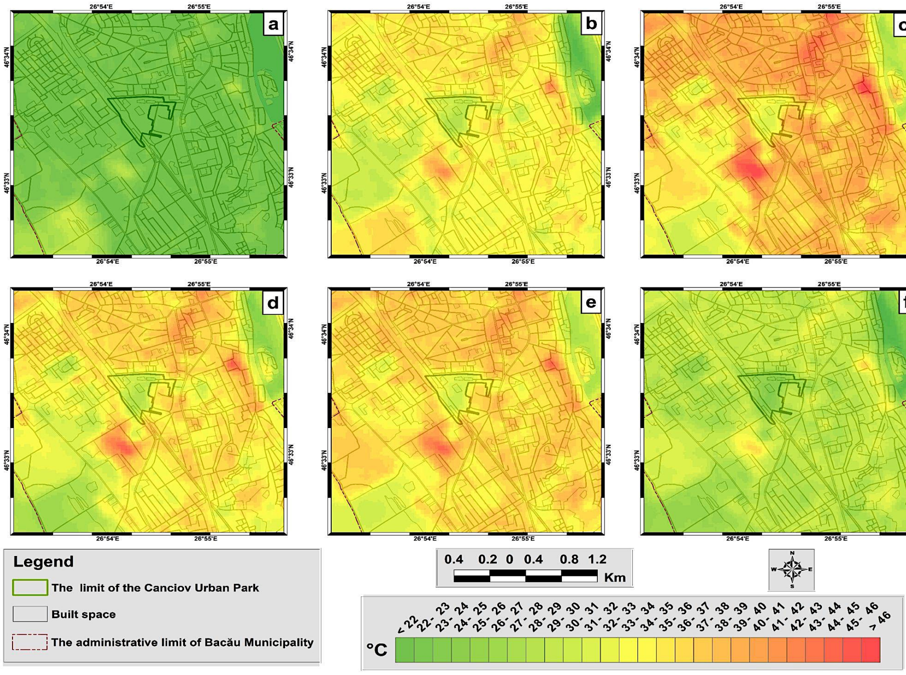



**Figure 4.** ***Distribution of monthly LST mean values in the central area of Bacău city in the surrounding of Cancicov urban park in 2022 (a-April, b-May, c-June, d-July, e-August, f-September)***

In literature, the shape of an urban park is considered to be essential to support a constant cooling effect on the surrounding areas. In this regard, the so-called “ideal shape" would be the round one in order to confer the most effective cooling effects (Ren et al., 2013). In this regard, the shape of the "Cancicov" park is somewhat irregular, similar to a triangle (Fig. 2). In these conditions, it can be easily seen that the cooling effect of the surrounding areas develops over small distances (Fig. 4 and 5).

Our results demonstrated that Cancicov park can significantly affect the magnitude of PCI intensity, and that this relationship changed across seasons. The highest PCI values can be observed in the summer months, when the maximum values recorded inside the park are below the mean LST values or even below the 1st quartile value of the surrounding areas (Fig. 6a). In these conditions, (Fig. 6b) the maximum PCI values exceed 8.0°C in summer and the highest PCI value is recorded in July (9.0 °C).

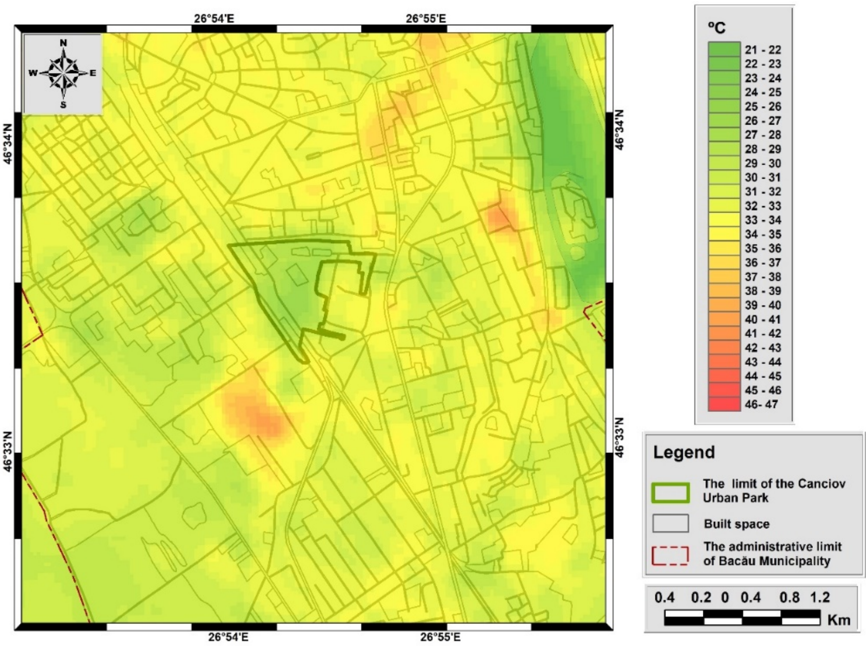
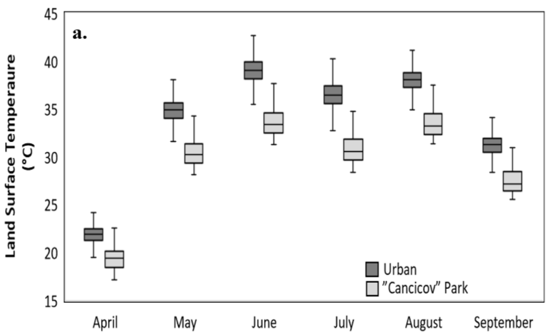



**Figure 5.** ***Distribution of LST mean values between April and September 2022 in the central area of Bacău city in the surrounding of Cancicov urban park***




| b. | Differences | | |
|---|---|---|---|
| | **Minimum** | **Mean** | **Maximum** |
| April | 1.5 | 2.7 | 5.4 |
| May | 1.8 | 4.5 | 6.4 |
| June | 2.0 | 5.5 | 8.8 |
| July | 2.0 | 5.7 | 9.0 |
| August | 1.9 | 4.6 | 7.3 |
| September | 1.4 | 3.9 | 6.1 |
| **Warm season** | 1.8 | 4.5 | 7.3 |

**Figure 6.** ***Box plot of monthly LST values for "Cancicov" Park and surrounding urban area (a) and mean PCI (°C) values minimum, maximum and mean for "Cancicov" park for April-September***

### *4.1.2. LST and 2m-temperature differences between Cancicov park and surrounding urban area*

A characteristic stage of this study consists in the attempt to observe if there are noticeable differences between the LST values and the temperature values recorded in situ at 2 m standard height. Synchronous data between Landsat thermal imagery and in situ observations from March to October 2022 count about 14 measurements, at around 09:00 AM, ± 04 minutes.

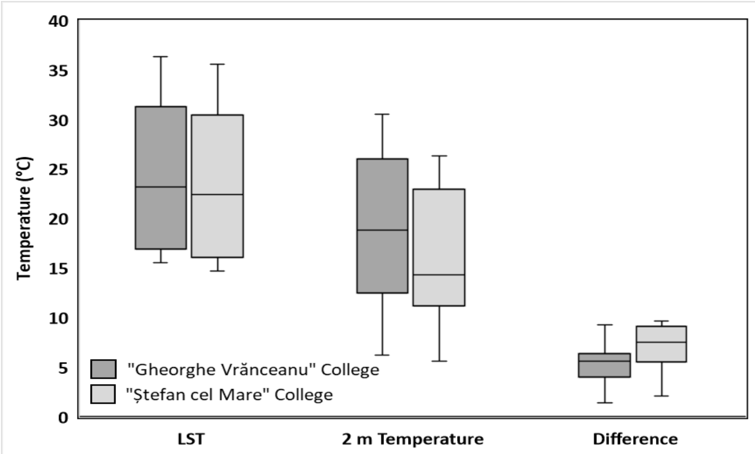



**Figure. 7.** ***LST vs. 2 m Temperature values and the temperature differences recorded for the Landsat satellite crossings over Bacău city in clear sky conditions***

In almost all situations (fig. 7) the LST values are higher compared to the data recorded at the standard height of 2 m in urban areas but also in the park area.

The differences between the LST and air temperature recorded at 2 m are about 5.1 C for the Vrănceanu observation point, meanwhile, in the Stefan cel Mare observation point the difference increases to 7.1C, as an effect of urban park conditions.

The highest temperature difference between LST and the temperature at 2 m for the urban park monitoring point can be attributed to the shading effect of the trees canopy, especially during morning hours when the cooling effect of the park (the observation point is located at the outer boundary of the park) reaches the highest intensity (Fig. 3).

## 5. CONCLUSIONS

In this study, we outline the impact of urban parks on reducing the warming effect induced by the urban heat island of Bacău. The Cancicov park enhanced the mitigation of UHI in central area of the Bacău city by decreasing temperature in the surrounding built-up areas.

By using satellite image and in situ meteorological observations it could be showed that the Cancicov urban park can create PCI effect, getting its maximum intensity during the morning hours from May to July when the maximum development of the urban vegetation is reached. Otherwise, in

April and September, the PCI effect intensity is minimal. However, the PCI intensity varied across the warm season and the highest cooling effect of the park is specific in the summer months.

## ACKNOWLEDGEMENT

This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P1-1.1-TE-2021-0882, within PNCDI III (UCLAR).

## REFERENCES

1. Algretawee, H., 2022. The effect of graduated urban park size on park cooling island and distance relative to land surface temperature (LST). *Urban Climate*, ***45,*** 101255, doi: 10.1016/j.uclim.2022.101255.
2. Anjos, M., Lopes, A., 2017. Urban Heat Island and Park Cool Island Intensities in the Coastal City of Aracaju, North-Eastern Brazil. *Sustainability,* ***9(8)***, 1379. doi:10.3390/su9081379.
3. Aram, F., Higueras García, E., Solgi, E., Mansournia, S., 2019. Urban green space cooling effect in cities. *Heliyon,* ***5(4)***, 01339, doi:10.1016/j.heliyon.2019.e01339.
4. Arellano, B., Roca, J., 2022. Effects of urban greenery on health. a study from remote sensing. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, ***XLIII-B3-2022***, 7–24. doi:10.5194/isprs-archives-xliii-b3-2022-17-2022.
5. Chibuike, E.M., Ibukun, A.O., Abbas, A., Kunda, J.J., 2018. Assessment of green parks cooling effect on Abuja urban microclimate using geospatial techniques. *Remote Sensing Applications: Society and Environment*, ***11***, 11–21, doi:10.1016/j.rsase.2018.04.006.
6. Chun, B., Guldmann, J.M., 2018. Impact of greening on the urban heat island: Seasonal variations and mitigation strategies. *Computers, Environment and Urban Systems*, ***71***, 165–176, doi: 10.1016/j.compenvurbsys.2018.05.006.
7. Council of the Municipality of Bacău (CMP), 1935. Minutes no. 6 of July 10, 1935, Bacău City Hall, file no. 65.
8. Du, H., Cai, W., Xu, Y., Wang, Z., Wang, Y., Cai, Y., 2017. Quantifying the cool island effects of urban green spaces using remote sensing Data. *Urban Forestry & Urban Greening,* ***27***, 24–31, doi:10.1016/j.ufug.2017.06.008.
9. Environmental Protection Agency, Bacău, 2021. Annual report on the state of the environment in Bacău county for the year 2021, APM Bacău, 2022, available at: http://apmbc.anpm.ro/rapoarte-anuale1
10. Earth Explorer; 2000. FS; 083-00; Geological Survey (U.S.), available at earthexplorer.usgs.gov
11. Ghosh, S., Das, A., 2018. Modelling urban cooling island impact of green space and water bodies on surface urban heat island in a continuously

developing urban area. *Modeling Earth Systems and Environment, **4(2)***, 501-515.
12. Li, H., Wang, G., Tian, G., Jombach, S., 2020. Mapping and analyzing the park cooling effect on urban heat island in an expanding city: A case study in Zhengzhou city, China. *Land, **9(2)***, 57.
13. Manoli, G., Fatichi, S., Schläpfer, M., Yu, K., Crowther, T.W., Meili, N., Burlando, P., Katul, G.G., Bou-Zeid, E., 2019. Magnitude of urban heat islands largely explained by climate and population. *Nature, **573***, 55–60.
14. Oke, T.R., Mills, G., Christen, A., Voogt, J.A., 2017. Urban Climates. Cambridge University Press.
15. Park, J., Kim, J.-H., Lee, D.K., Park, C.Y., Jeong, S.G., 2017. The influence of small green space type and structure at the street level on urban heat island mitigation. *Urban Forestry & Urban Greening, **21***, 203–212. doi:10.1016/j.ufug.2016.12.005.
16. Price, J. C., 1983. Estimating surface temperatures from satellite thermal infrared data—A simple formulation for the atmospheric effect. *Remote sensing of environment, **13(4)***, 353-361.
17. Rasul, A., Balzter, H., Smith, C.S., Remedios, J., Adamu, B., A. Sobrino, J., Srivanit, M. and Weng, Q., 2017. A Review on Remote Sensing of Urban Heat and Cool Islands. *Land,* pp.6, 38. doi:10.3390/land6020038.
18. Ren, Z., He, X., Zheng, H., Zhang, D., Yu, X., Shen, G., Guo, R., 2013. Estimation of the relationship between urban park characteristics and park cool island intensity by remote sensing data and field measurement. *Forests, **4(4)***, 868-886.
19. Sekertekin, A., 2019. Validation of physical radiative transfer equation-based land surface temperature using Landsat 8 satellite imagery and SURFRAD in-situ measurements. *Journal of Atmospheric and Solar-Terrestrial Physics*, ***196***, 105161.
20. Şerban, L., 2021. Urban green spaces of towns from Bacău County: planning, management and susteinable development, Alexandru Ioan Cuza University of Iași, PhD thesis.
21. Smith, I.A., Fabian, M.P., Hutyra, L.R., 2023. Urban green space and albedo impacts on surface temperature across seven United States cities. *Science of The Total Environment*, 857, p.159663. doi:10.1016/j.scitotenv.2022.159663.
22. Sobrino, J. A., Jiménez-Muñoz, J. C., 2014. Minimum configuration of thermal infrared bands for land surface temperature and emissivity estimation in the context of potential future missions. Remote sensing of environment, 148, 158-167.
23. US Geological Survey, 2019. Landsat 8 (L8) data users handbook.
24. Xu, L., Yue, W., 2008. A study on thermal environment effect of urban park landscape. *Acta Ecol. Sinica, **28(4)***, 1702-1710.
25. Yang, X., Li, Y., Luo, Z., Chan, P.W., 2016. The urban cool island phenomenon in a high-rise high-density city and its mechanisms. *International Journal of Climatology, **37(2)***, pp.890–904. doi:10.1002/joc.4747.

26. Yu, Z., Yang, G., Zuo, S., Jørgensen, G., Koga, M., Vejre, H., 2020. Critical review on the cooling effect of urban blue-green space: A threshold-size perspective. *Urban Forestry & Urban Greening*, 49, p.126630. doi:10.1016/j.ufug.2020.126630.
27. Zhou, J., Li, J., Zhang, L., Hu, D., Zhan, W., 2012. Intercomparison of methods for estimating land surface temperature from a Landsat-5 TM image in an arid region with low water vapour in the atmosphere. *International Journal of Remote Sensing, **33(8)***, 2582-2602.