

## **THERMIC DIFFERENTIATIONS IN THE IAȘI MUNICIPALITY DURING A HEAT WAVE. CASE STUDY JULY 10-20 2011**

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**Key-words:** thermic differentiations, heat wave, Iași municipality, case study

**Abstract:** With a surface of approximately 800 km<sup>2</sup>, the metropolitan territory of Iași city is extremely differentiated in terms of the way in which the physical-geographic base is occupied, with important implications for the spatial differentiations of the climatic elements. For the identification of the thermic differentiations at the level of urban area of the city of Iași a series of thermo-hydrometric sensors was utilized (DT171) for determining temperature and air humidity, placed in different spots of the city, through which we tried to identify the influence that this exerts over the thermic regimen in different synoptic conditions. In this respect we chose as case study the heat wave produced in the period July 10-20th 2011 that highlights some differentiations in the manner of heat propagation at the level of the entire urban area.

### **Introduction**

In the interior of the metropolitan area, the municipality of Iași, the second city in terms of population and occupied surface, due to an additional quantity of heat emitted with the burning of industrial fuels and gases, and also due to the surfaces of asphalt and cement, to which is added the large concentration of population, is outlined as an island of urban heat in the Iași metropolitan area, with variable intensities.

Besides, since a long time ago I. Gugiuman characterized Iași as a thermic island in the regional landscape, because the air temperature in the city is much differentiated than the one in its surroundings, noticing that the average temperature of the urban atmosphere is 1.1°C higher than the atmosphere temperature in the outskirt area of the city (Gugiuman, 1968).

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In the metropolitan area of Iași the influence of the urban environment on the air temperature is very noticeable in the cold season, when the difference between the city and surroundings can reach and even exceed  $1^{\circ}\text{C}$ , these differences in the rest of the year are greatly reduced, so much that in the summer they do not appear at all or are only  $0.1^{\circ}\text{C} - 0.3^{\circ}\text{C}$ , and the multiannual average values render them null. There is the fact to underline that the size of the thermic differences between the city and surrounding area is in direct proportion to the dimensions of the city.

These differences of temperature between cities and neighboring towns, with values that oscillate on average annually between  $0.5^{\circ}\text{C}$  and  $1.5^{\circ}\text{C}$ , that apparently doesn't mean much, reach real dimensions if we take into consideration the fact that the annual difference of  $1^{\circ}\text{C}$  corresponds in latitude to the distance of 200km, and in altitude of 150-200m. Thus, the difference between Bucuresti ( $10.9^{\circ}\text{C}$ ) and Iași ( $9.7^{\circ}\text{C}$ ) of  $1.2^{\circ}\text{C}$  can be compared to that of  $1.1^{\circ}\text{C}$  (between Bucuresti and Filaret and Bucuresti-Baneasa) (Ciulache, 1980).

### 1. Database

For the identification of thermic differentiations at the level of the entire urban area of the city of Iași there was utilized a series thermo-hydrometric sensors (DT171) for determining the air temperature and humidity, placed in different spots of the city (fig. 1) through which we tried to highlight the influence that this exerts over the thermic regimen in different synoptic conditions.

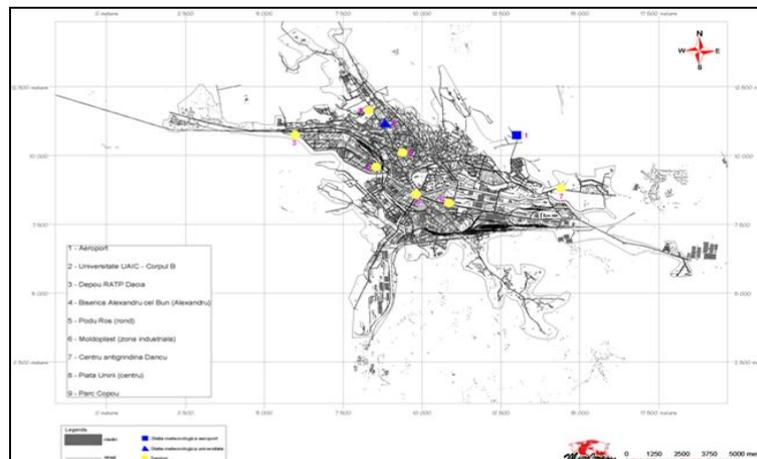


Fig. 1 – The sensor placement at the level of the Iași municipality

Also, Modis satellite images were utilized, in infrared domain, for satellite determining of temperature differences in the Iași municipality in the July 8-20th 2011 interval.

## 2. Synoptic conditions

A dorsal of warm air of north-African origin associated to an anticyclone regimen at ground level favored the formation of the heat wave that manifested itself in the south-east of Europe in the July 8-20<sup>th</sup> interval (fig. 2). We can mention that from a synoptic standpoint these are typical conditions for the formation of heat waves in our country during the summer.

The maximum temperatures at national level reached 38°C at weather stations in the western part of the country, and in Moldova the maximums were close to 36°C (Source: ANM). Judging by these values we cannot talk of an exceptional heat wave, as long as we were 4-6°C below the absolute maximum values of the month of July at national and regional level. The distinct mark of this heat wave was its duration. Based on the data from the UAIC, Iași weather station – we can extrapolate the analysis to the whole of extra Carpathian Moldova – we are talking about 13 consecutive days with maximum diurnal temperatures of over 30°C, the average climatic duration of these heat waves for the territory of Romania being between 7 and 10 days.

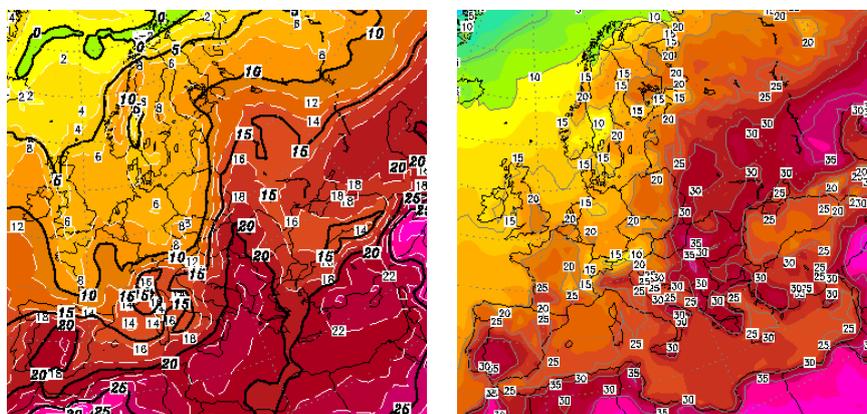


Fig. 2 - Temperatura aerului la nivelul suprafeței de 850 hPa (stânga) și la nivelul de 2m (dreapta) în data de 15.VII.2011 în Europa (wetter3.de)

To better understand the meteorological conditions that we have crossed we can say that the average maximum temperature of this heat wave at Iași was of 32.1°C, value which corresponds to the normal climatic values of the same parameter for the entire month of July in Athens. Thus, a heat wave that enables us

to extrapolate the results of this study for all the heat waves that can manifest in the region of the Moldavian Plain in the summer months.

### 3. Thermic differentiations induces by the heat wave

The thermic complexity of the city in its entirety compared to the peripheral urban area is generated by the multiple characteristics of the active surface and highlights some thermic differentiations existent between the different zones of the city at topo and microclimatic levels.

The analysis of data from the July 10-20th 2011 period taken from the measurements made with the thermo-hydrometric sensors DT171 comparative with the data provided by the Moldova regional meteorological Center in Iași highlights some extremely important aspects (fig.3):

- all of the observation spots in the city recorded higher values than the weather station at the airport (25.6°C) with at least 1 degree Celsius, less than the sensor in Copou which registered values of 24.9°C; this situation reflects the particular microclimatic conditions of parks and public gardens in the Iași municipality, these being 3-4°C cooler than the surrounding regions in terms of average temperatures and with up to 6-7°C in terms of maximum diurnal temperatures.

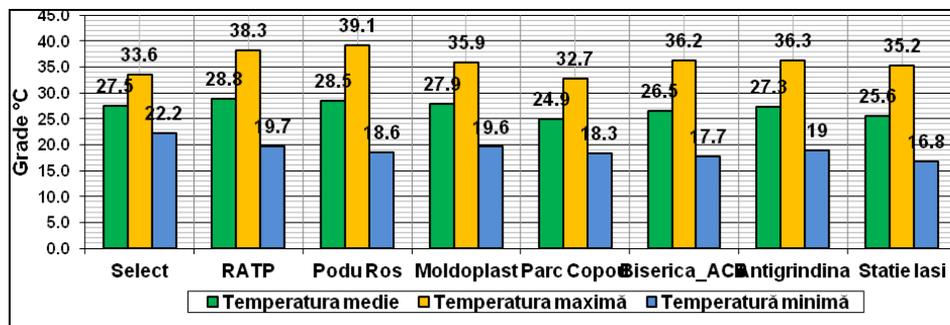


Fig. 3 – The average, maximum and minimum temperature in the Iași municipality in the observation spots in the July 10-20th 2011 period

- the strong heating of asphalt and concrete surfaces, to which it is added the presence of pollutants, lead to a rise of air temperature in contrast with the neighboring areas. Thus, in the RATP area and Podu Roș area is recorded a thermic average in the analyzed period of 28.8°C, and 28.5°C respectively, these values being able to be considered representative for the intensely circulated neighboring arteries or for those with industrial or commercial use.

- in such synoptic conditions the city, on the whole, is warmer with 1.5-2°C than its neighboring regions in terms of average temperatures, with 3-4°C warmer in terms of maximum temperatures and with up to 2.5°C warmer with respect to minimum temperatures.

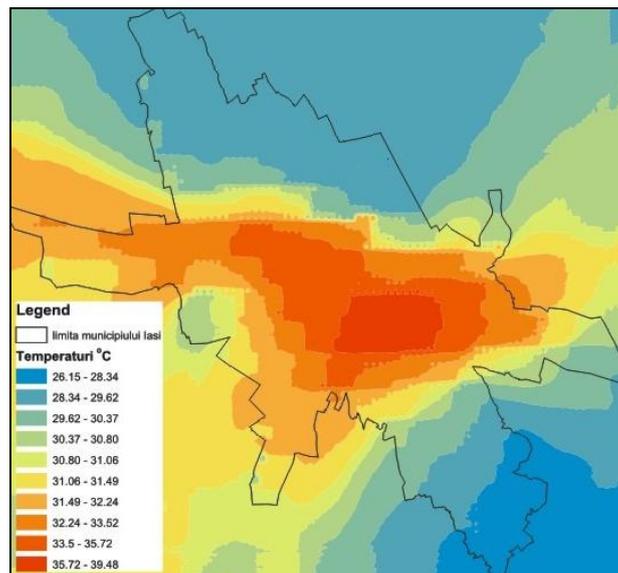


Fig. 4 – The distribution of average air temperatures in the Iași municipality in the July 8-20th interval obtained based on the Modis images

The same differences are highlighted also through the processing of Modis images – infrared domain – for the July 8-20th 2011 interval. The images based on which the map of the distribution of temperature in the Iași municipality was processed (fig. 4) were taken for our country at 15:15 hours, which confers them a special climatic value through the proximity to the moment of generation of the maximum diurnal temperature. Based on this result can be outlined the island of urban heat of the Iași municipality which is very well delineated in the central area of the municipality having as central point Podu Roș. We can mention that the temperatures were higher than those at the official weather station in an area between Piața Unirii, the Alexandru cel Bun neighborhood, Nicolina, Moldoplast, Tudor Vladimirescu and Independenței blvd.

To underline the microclimatic diversity of the area that overlaps on the Iași municipality there have been calculated coefficients of determination between all the observation spots (tab. 1). It thus stands out the homogenous thermic behaviour

of the central region of the city that circumscribes Piața Unirii, the industrial zone (Moldoplast) and the Alexandru cel Bun neighborhood, the determined coefficients of determination between these spots being over 0.90. Instead, the coefficients of determination between the observation spot at the Anti-hail Center, located in the eastern part of the municipality, underline the contrast between the thermic regimen from inside the island of urban heat and its outskirts.

Besides, a series of linear correlations made between the data coming from the Iași weather station and some observation spots in the municipality highlight some significant differentiations. If between the Iași weather station and the Podu Roș and Hotel Select observation spots, there aren't significant correlations in terms of temperature values produced in the analyzed interval, between the station and the observation spot in the area of the Anti-hail Center the correlation is significant, due to the spatial proximity of the two spots and the location of both observation spots outside the island of urban heat.

Tab. 1 – The coefficient of determination (R-squared) between the temperature observation spots in the Iași municipality in the July 8-20th 2011 interval

	Select	RATP	Podu Ros	Moldoplast	Copou	ACB	Antigrindina
Select	1						
RATP	0.88	1					
Podu Ros	0.8	<b>0.93</b>	1				
Moldoplast	<b>0.9</b>	<b>0.97</b>	<b>0.92</b>	1			
Copou	<b>0.9</b>	<b>0.92</b>	0.83	<b>0.92</b>	1		
ACB	0.89	<b>0.95</b>	<b>0.93</b>	<b>0.96</b>	<b>0.92</b>	1	
Antigrindina	0.69	0.76	0.82	0.78	0.72	0.84	1

A decisive role in the spatial-temporary variations of the values of the climatic elements is attributed to the strictly local physical-geographic factors and especially to the way in which the terrain is covered with various constructions that imprint on the air temperature in the urban area specific particularities compared to the area surrounding the city.

Instead, the values of the coefficients of determination between the official weather station and the Podu Roș and Hotel Select observation spots drop below 0.50 (fig. 5, fig. 6, fig.7), not as much because of the thermic differences between these spots, but due to the disparities that are produced in the diurnal regimen of temperature between the center and the outskirts.

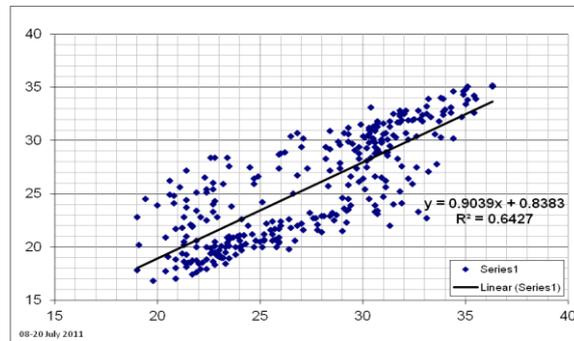


Fig. 5 – Linear correlation between the air temperature at the Iași weather station and the observation spot at the Anti-hail Center

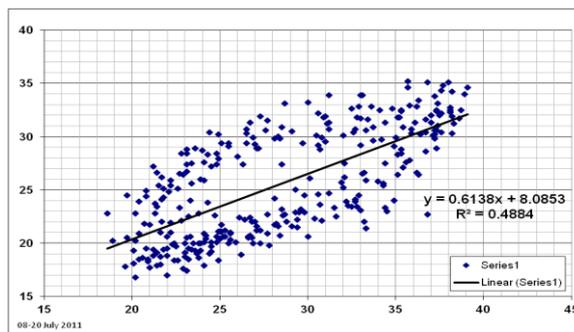


Fig. 6 – Linear correlation between the air temperature at the Iași weather station and the Podu Roș observation spot

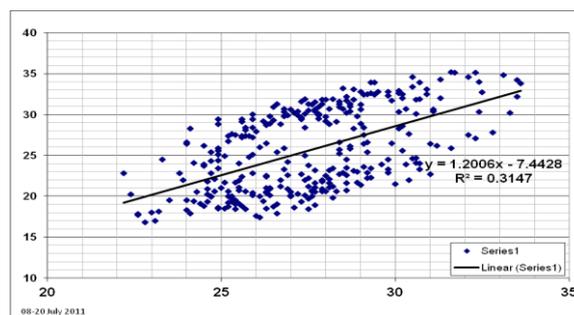


Fig. 7 – Linear correlation between the air temperature at the Iași weather station and the Hotel Select observation spot

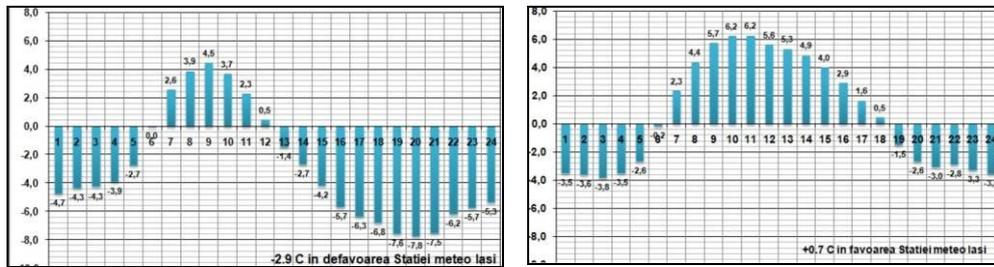


Fig. 8 – Hourly thermic differences between the Iași weather station and Podu Roș (left) and the Iași weather station and Copou Park (right) în the July 8-20th 2011 interval

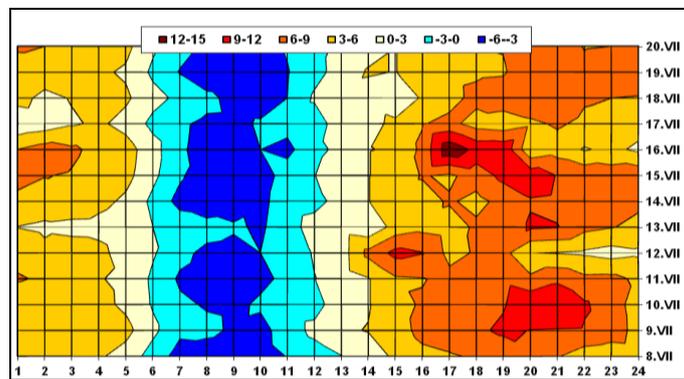


Fig. 9 – Isopleths of hourly thermic differences between the Iași weather station and the Podu Roș observation spot (July 8th and 20th 2011)

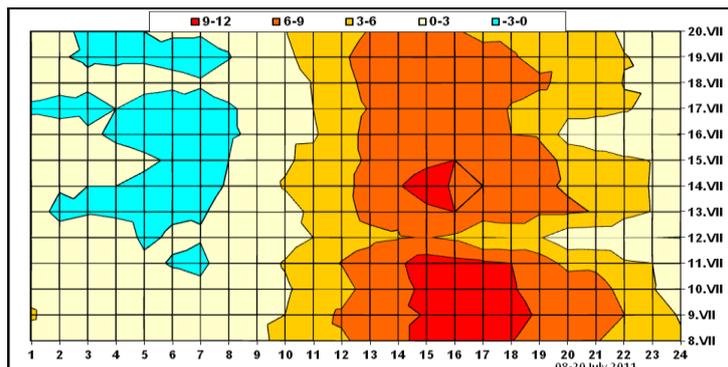


Fig. 10 – Isopleths of hourly thermic differences between between the Podu Roș and Copou Park observation spots (July 8th and 20th 2011)

The detailed analysis of horary differences between the Iași weather station and the observation spots placed in the interior of the urban area highlights a multitude of situations. In synthesis, at the level of the horary analysis, in general the observation spots in the city are cooler than the outskirts of the city in the first part of the day (with up to 3-4°C around 9:00 hours) but much warmer in the second part of the day and during the night, the largest horary differences being recorded in the 18:00-22:00 interval (up to 6-8°C in Podu Roș or Moldoplast). The appearance of the largest thermic differences at 20:00-21:00 hours is explained through the strong heating of the subjacent surface in the city during the day and the crossed emission of infrared radiation in the evening, when the clear field has already cooled (fig. 8, fig. 9, fig.10).

If the lower morning temperatures are the direct result of the lower degree of sunshine in the interior of the city, the differences during the evening and night represent the true expression of the island of urban heat that the Iași municipality generates.

### Conclusions

The analysis of data from the July 10-20th 2011 period taken from the measurements made with the thermo-hydrometric sensors DT171 comparative with the data provided by the Moldova regional meteorological Center in Iași highlights some extremely important aspects:

- all of the observation spots in the city registered higher values than the weather station at the Airport (25.6°C) with at least one degree Celsius, lower than the sensor in Copou that recorded values of 24.9°C;
- the strong heating of asphalt and concrete surfaces, to which it is added the presence of pollutants, lead to a rise of air temperature in contrast with the neighboring areas. Thus, in the RATP area and Podu Roș area is recorded a thermic average in the analyzed period of 28.8°C, and 28.5°C respectively;
- the arboreal vegetation is the one that imprints the most important climatic characteristics in the case of parks, thus the air temperature measures values lower with 2-3°C, compared to the residential areas;
- the maximum differences of temperature between the city and the surroundings are produced in the evening, around 20:00-21:00 hours, reaching 7.8°C in Podu Roș and Moldoplast, and the minimum, at noon around 14:00 hours, when the heating of the city is lower than the clear field.

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