

SOME THERMIC DIFFERENCES IN THE SOUTHERN METROPOLITAN AREA OF IAȘI

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Key words: air temperature, thermic differences, Iași metropolitan area.

Abstract. The regimen of air temperature in the Iași municipality and the metropolitan area is a complex one, highlighted by the particularities of the average annual temperature, soil temperature, average monthly temperature, the frequency of days with different values of temperature and inversions of temperature.

Introduction

With a surface of approximately 800 km², the metropolitan territory occupies the south-eastern part of Iași County, situated on the contact area between the Central Moldavian Plateau and the Moldavian Plain, the general features of the relief being dictated by the monoclinical structure of the rock strata and the evolution of the denudational process from the Pliocene to the present. The differentiated erosion based on the geologic structure and the paleogeography evolution of the relief gave birth to a contact area between the Moldavian Plain and the Central Moldavian Plateau, named “the Coast of Iași” (David 1921) which imposes itself in the relief through altitudes larger with up to 350 m. The altitudinal differences between the Bahlui Valley (which passes through the median area of the Iași metropolitan area, 35-40 m) and Păun Hill (407 m, situated south-east of Iași City) impress themselves on a series of differences between the climatic elements which characterize this area. The relief energy of over 250 m and the general orientation of Bahlui Valley on the east-west direction have some consequences on the dynamics of the air masses or on the origination of specific meteorological phenomena. The difference in altitude between the Coast of Iași and the Bahlui Valley can lead to the appearance of light foehn processes of the air masses when the air circulation is from the south or south-east, impressing some specific characteristics of the climate in the southern part of the Iași metropolitan area.

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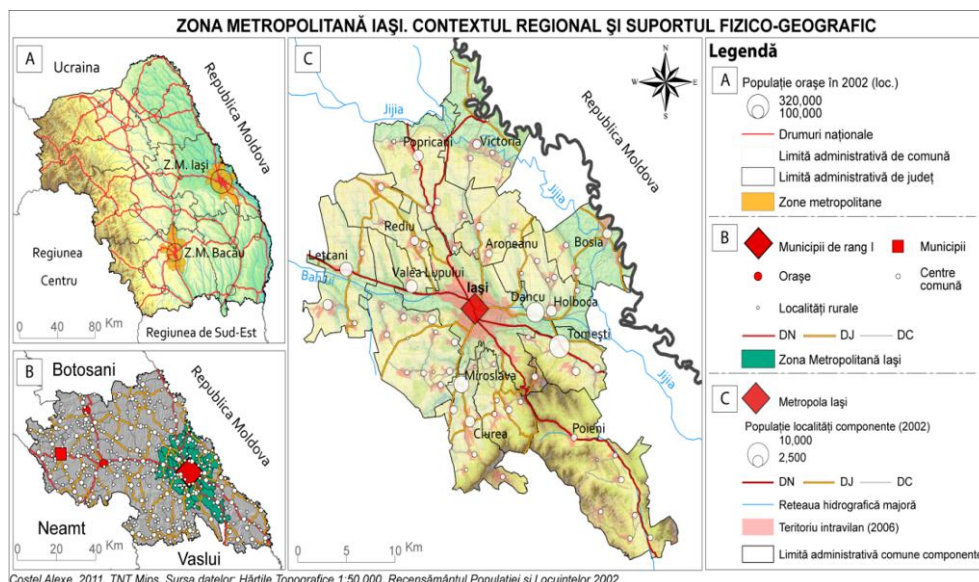


Fig. 1 - The Iași metropolitan area. Regional context and physical-geographic base

1. Database

In this study the author has utilized the data regarding the air and surface temperatures recorded at the Iași weather station, located at $47^{\circ}10'$ N lat. and $27^{\circ}36'$ E long., at an altitude of 102 m. For the analysis of the characteristics and the air and surface temperature variations in the Iași metropolitan area, I have taken into consideration a number of 49 years, in the 1961-2009 interval, for the Iași station. At the same time I have used, processed, analyzed and interpreted the data from the Podul Iloaiei station between the years 1967-1993, totaling a string of data of 27 years and from Bârnova for the 2003-2009 period, adding for these the string of data to the common period (1961-2009) with the ones recorded at the Iași weather station, which has been utilized as a reference station.

2. The surface soil temperature – spatial differentiations

The average annual soil temperature is distributed in the direction dependent on the solar radiation distribution, the dynamics of the atmosphere and the local geographic particularities and the extremely varied physical and chemical properties of the soil impress on the thermic regimen of the surface significant deviations from the averages of the diurnal and annual cycles. The values of the temperature recorded at the surface of the soil follow closely, but with a certain

inertia, the annual cycle of solar radiation, thus during the year there is a recorded maximum, generally in July, and minimum, preponderantly in January.

Among the local modifier factors which highlight the differences inside the territory the most important are the altitude, the shape of the relief, the slope orientation and latitude.

For the studied time interval, at the Iași weather station, the thermic multiannual average of the surface air temperature has been 11.3°C, 1.6°C higher than the air temperature at 2 m from the ground for the same interval (9.7°C), the 11°C isotherm permeating deeply on the Bahlui Valley corridor up to upstream of PoduIloaiei. At the Bârnova weather station the thermic multiannual average of the soil is with the same 1.2°C higher than the air (8.3°C), while at PoduIloaiei the air temperature is 1.9°C lower than the soil (11.5°C) (Tab.1).

Tab. 1 – The average °C temperatures of the surface of the soil in the Iași metropolitan area

MonthYear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Avg.
Iași	-3.8	-2.0	3.3	12.1	20.1	24.5	26.0	24.6	17.8	10.5	3.6	-1.4	11.3
PoduIloaiei	-4.1	-2.2	3.3	12.4	20.7	25.1	26.5	25.0	18.1	10.6	3.6	-1.4	11.5
Bârnova	-4.7	-3.0	1.1	10.1	17.1	21.5	23.8	22.7	16.2	8.7	2.6	-2.7	9.5

Tab. 2 - The extremes of the annual temperatures at the surface and at 2 m above ground

Station	Period	Place	Min.	Year	Max.	Year
Iași	1961-2009	soil	9.3	1980	13.9	2007
		air	8.0	1985	11.8	2007
PoduIloaie	1967-1993	soil	9.5	1980	13.3	1990
		air	7.9	1980, 1985	11.2	1990
PoduIloaie*	1961-2009	soil	9.5	1980	14.0	2007
		air	7.9	1980, 1985	11.6	2007
Bârnova	2004-2009	soil	9.7	2006	12.4	2007
		air	8.5	2006	10.2	2007
Bârnova*	1961-2009	soil	7.3	1980	12.4	2007
		air	6.6	1985	10.2	2007

*: prolonged string of data (1961-2009)

The great annual variance of the climatic element is highlighted also by the annual averages, the lowest and the highest. Thus, the soil temperature has varied between 9.3°C, the annual average recorded in 1980 and 13.9°C in 2007. From the analysis of these thermic values of the soil, correlated with those of the air, it is highlighted the role that the soil temperature has in influencing the temperature

averages of the air above, the years 1980 and 2007 representing years with extreme values for the air temperature at 2 m above ground. The year 2007 represented the year with maximum annual average of the soil, this being 13.9°C. In the year 1980 there was recorded the extreme annual minimum both for the air surface temperature and for the air temperature at 2 m above ground, both for Iași weather station and the PoduIloaiei and Bârnova stations (tab 2).

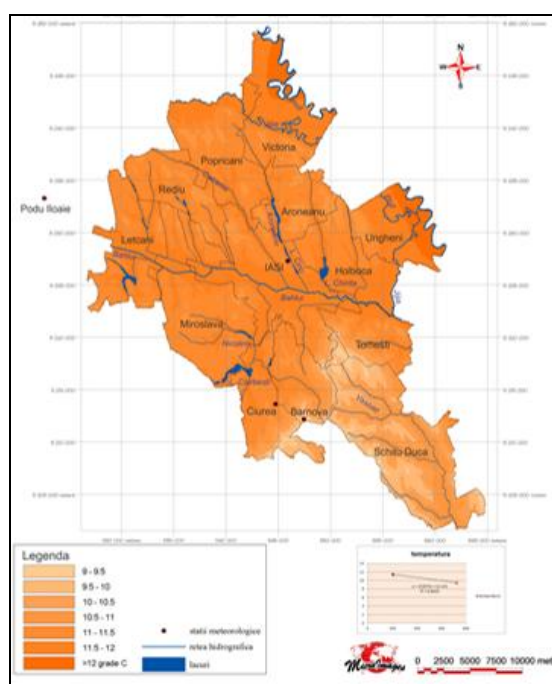


Fig. 3 – The spatial distribution of the annual average temperature at the ground in the Iași metropolitan area

A similar situation can be also observed at Bârnova, where the year 2007 represents the year with the highest annual average, both for the air temperature at the surface of the ground (12.4°C) and at air temperature at 2 m above ground (10.2°C). The high temperatures of 2007 are highlighted and supported by the fact that that year has the highest temperatures (on the surface and above ground) both for Iași and PoduIloaiei weather stations, for the entire observation period (1961-2009), thus the average annual temperature at ground level, at Iași, was 13.9°C, which generated the highest annual average at 2 m above ground, namely 11.8°C.

It can be observed thus that through its particularities, the soil impresses its own characteristics on the air above, assuming the role of active, subjacent surface.

3. Air temperature

The temperature of the air represents the most important climatic element. Although it presents a large degree of variability in time and space, the laws of its distribution are more stable than those of atmospheric precipitation. The air temperature is an essential element in determining climatic individuality, having an active role in the dynamics of the atmosphere, thanks to the uneven distribution, both horizontally and vertically, which generates differences in atmospheric pressure, the engine of atmospheric circulation. At the level of the Iași metropolitan area the determining factor for the air temperature variability is represented by the relief which acts on the parameters of air temperature through altitude, slope orientation and pitch. The thermic modifications generated by the city surface, although substantial, overlap with the general climatic variations, specific to the region in which the Iași metropolitan area is located.

In the Iași metropolitan area, the urban crowd of the city, although not presenting a large development on the vertical axis of built surface, can influence air temperature values. Thus, for the period 1894-1943; 1945-1975, analyzing the multiannual average temperature of the air for the two stations that functioned simultaneously in Iași, Iași-boarding-school and Iași-Airport, can be observed a plus 0.3°C at the Iași-boarding-school station, compared to the Iași-Airport station (9.4°C) (tab. 3).

Tab.3 – The average monthly and annual temperature in Iași municipality, at Boarding-School and Airport weather stations

Weather Station	Period	Months												Y. avg.	Amp.
		J	F	M	A	M	J	J	A	S	O	N	D		
Board School	1894 – 1943	-3,5	-1,5	3,2	10,4	16,1	19,4	21,4	20,6	16,2	10,3	4,5	-0,7	9,7	24,9
Airport	1945 - 1975	-4,0	-2,2	2,7	9,9	15,7	19,2	21,1	20,4	16,1	10,1	4,2	-1,0	9,4	25,1

To highlight the thermic particularities in the south of the Iași metropolitan area I have considered necessary the comparative analysis of the air temperature at the Iași weather station with the Bârnova one (47°.00" lat. N; 27°.34" long. E) for the 2004-2009 period and Ciurea (1985-2009).

The temperature data recorded at the weather stations Iași, Podu Iloaiei, Ciurea and the meteorological radar Bârnova are insufficient to be able to determine with precision the spatial distribution of the air temperature characteristics. Still, starting from knowing the monthly and annual values of the thermic vertical and horizontal gradients, using a hypsometric map and applying laws regarding the temperature distribution on slopes based on their orientation I

have made through successive interpolations and extrapolations, different maps in which the spatial distribution of temperature cannot be much different than the real one.

In the Iași metropolitan area, the average annual temperatures influenced by local factors (altitude, positioning of relief forms inside the depression, exposure to the sun, slope inclination, level of vegetation covering etc.) have an uneven distribution. On the plain of Bahlui, where frequent accumulations of cold air occur, the average annual temperatures are 0.4°C lower in January and 1°C higher in July and 0.4°C higher than the annual average.

In the Iași metropolitan area, where the differences in altitude between the bottom of valleys and the prominent parts of the relief do not exceed a few hundred meters, the influence of altitude is visible in the rise of average annual temperatures from the higher regions, Bârnova (8.3°C) to the lower, Iași (9.7°C), which shows the important role of relief that acts constantly on the genesis and development of atmospheric processes and phenomena (Stoenescu, Tastea, 1962).

The annual distribution of air temperature in the studied area is the resultant of all the factors that contribute to the formation of the thermic regimen of our country's territory, in time and space. Thus, the Iași metropolitan area with average multiannual values lower than 10°C is part of the area of influence of the masses of cold air which enter Romania's territory from the north and east, at similar latitude and altitude, Oradea having an average annual temperature higher with 0.4°C (Bâzâc, 1983).

For the Iași metropolitan area, the average multiannual temperature for the 1961-2009 interval had a value at Iași of 9.7°C, at Podu Iloaiei of 9.6°C, at Ciurea of 9.4°C, while at Bârnova the average temperature was 8.3°C. (tab. 4)

Tab.4 – Average monthly and annual temperatures in °C in the Iași metropolitan area

Nr. crt	W. S.	Alt. (m)	Months												Year avg.	Period
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	Iași	102	-3.0	-1.2	3.4	10.4	16.3	19.6	21.2	20.4	15.8	10.2	4.3	-0.8	9.7	1961-2009
2	Podu Iloaiei*	100	-3.2	-1.7	3.2	10.0	16.0	19.0	20.4	19.7	15.4	9.6	3.8	-0.3	9.3	1967-1993
			-3.1	-1.2	3.4	10.3	16.2	19.5	21.0	20.1	15.4	9.9	4.2	-0.8	9.6	1961-2009
3	Ciurea*	110	-2.0	-0.4	3.9	10.2	15.8	19.3	21.3	20.4	15.2	9.8	3.7	-0.7	9.7	1985-2009
			-2.8	-0.9	3.5	10.0	15.5	19.0	20.5	19.9	15.3	9.8	3.1	-0.6	9.4	1961-2009
4	Bârnova*	396	-2.4	-1.5	3.4	9.6	14.5	18.3	20.5	19.5	14.4	9.9	4.1	0.0	9.2	2004-2009
			-3.7	-2.2	2.0	8.8	14.2	17.6	19.2	18.9	14.0	9.0	3.2	-1.6	8.3	1961-2009

*: prolonged string of data (1961-2009)

Iași city, with an average multiannual amplitude of 25.1°C for the period 1894-1943; 1945-1975, has been included in the category of regions with high average annual amplitudes (Erhan, 1979) with values higher than the area beyond the Oriental Carpathians where the higher frequency of maritime air masses

temperate transitional climate, of summers with average annual temperatures which rise at over 18°C for the entire metropolitan area, with a multiannual average of 20.4°C at Iași and 18.6°C at Bârnova. The winters, for the entire analyzed area, are very cold with temperatures dropping below -1.0°C. (tab.5)

Tab. 16 – Average seasonal and semestrial temperatures in the Iași metropolitan area

Nr. crt	Weather station	Alt. (m)	Studied period	Seasons				Semesters	
				Winter	Spring	Summer	Autumn	Cold sem.	Warm sem.
1	Iași	102	1961-2009	-1.7	10.0	20.4	10.1	2.1	17.3
2	Podulloazei	100	1961-2009	-1.7	10.0	20.2	9.8	2.1	17.1
3	Ciurea	110	1961-2009	-1.4	9.7	19.8	9.4	2.0	16.7
4	Bârnova	396	1961-2009	-2.5	8.3	18.6	8.8	1.1	15.5

From the analysis of the thermic differences between the months of the year it can be observed that the modification of the average air temperature values from one month to another is done slowly in the summer and winter months, more evident thermic contrasts being recorded in the transitional season months.

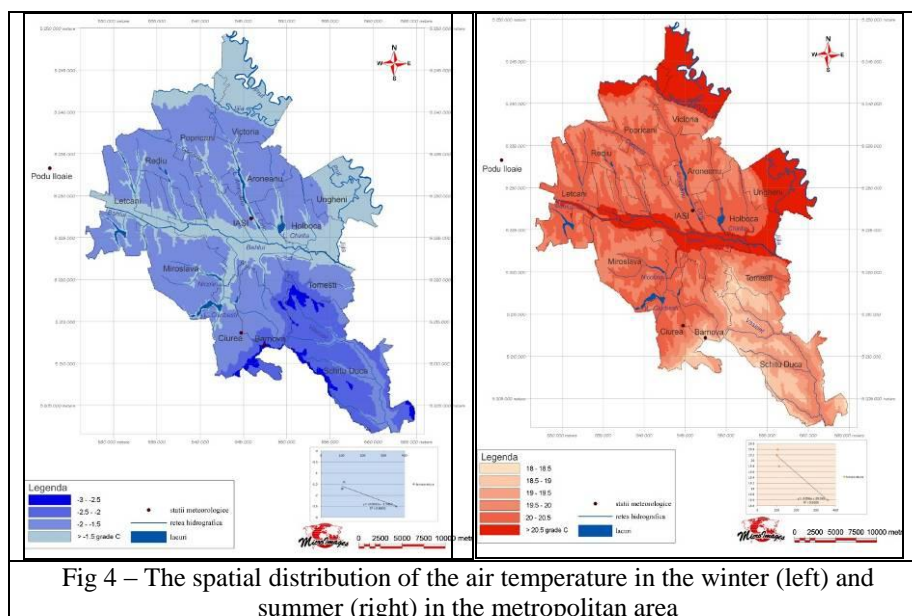
In the *spring*, the maximum difference between May and March has been 21.9°C in the year 1996, registering values of 20.0°C in other two cases, in the years 1969 and 2003, in the analyzed period for the Iași weather station.

In the *winter*, the thermic characteristic is given first and foremost by a high atmospheric stability, the masses of polar and arctic continental air, strongly cooled over the snow covered surfaces in European Russia stagnating for a longer period over this region. Likewise, once installed, these masses of air continue the cooling process through radiative phenomena, reaching an even higher stability.

In this season, for Iași and the entire metropolitan area the average temperatures are negative, with the mention that the lowest values are recorded in the Bahlui Valley (fig. 21), while in the higher neighboring areas the temperatures are higher, this type of distribution characterizing the inversions of temperature. These meteorological phenomena have the highest frequency and constancy in the winter months and low areas in Moldova. For the Bahlui Valley, in the winter, the inversion phenomenon is very frequent, the air temperature being sometimes with up to 10-15°C lower than the temperature of the low altitude hills in the region. (Gugiuman, 1968).

The *summer* is characterized, evidently, by the highest average seasonal temperatures for the entire metropolitan area, registering a multiannual average of 20.4°C at Iași, 10.4°C higher than the preceding season.

In the summer the average temperatures correlate best with altitude, the vertical thermic gradient being the largest. The values exceed 20°C at Iași and Podu Iloaiei (at 90-100m) and drop at about 19.8°C at Ciurea and 18.6°C at Bârnova at 396 m altitude (fig. 4).



In the *autumn*, the average temperatures return to values close to those in the spring season, however the springs are colder than the autumns due to thermic inertia which manifests coming out of the winter, and the autumns have higher values due to the fact that air cooling is produced slower than for the soil, the waters and the whole active surface have accumulated in the summer season a thermic reserve which they release gradually to the air above.

Analyzing the thermic gap (the difference between the highest and lowest temperature value) in the territory of the metropolitan area of the two semesters, it results that it is about 14°C, registering values of 15.2°C at Iași, 15.0°C in Podu Iloaiei, 14.7°C at Ciurea and 14.4°C at Bârnova. The average temperature of the cold semester, calculated from the monthly averages in the October-March interval has positive values for the entire studied area (2.1°C at Iași and Podu Iloaiei, 2.0°C at Ciurea or 1.1°C at Bârnova).

In the warm semester the vertical distribution conforms to the usual thermic stratification of the troposphere, which marks a drop in temperature on the vertical (Fig. 37). Thus, in the metropolitan area, for the 2004-2009 period, it can be observed that at Ciurea the temperatures are 0.9°C lower than at Iași (18.0°C) and at Bârnova they are 1.9°C lower than at Iași, the altitudinal difference of 260 m putting its mark on things.

The average multiannual amplitude of the warm semester has varied in the studied period between 3.4°C at Ciurea and 3.8°C at Iași and PoduIloaiei, with a multiannual average of 3.5°C at Bârnova.

During the year, the average monthly temperature varies in direct proportion to the amount of solar energy received by the terrestrial surface and the inertia imposed by nature to the active surface, the lowest values being in the month of January and the highest in the month of July, as for which the air temperature registers two important moments, namely that the annual minimum in the coldest month of the year corresponds to January and the annual maximum of the hottest month of the year to July.

From the analysis of the monthly average values of air temperature, it results that at Iași they have a normal gait, painting an upward curve in the first part of the year, as a result of the rise in intensity of solar radiation, with a maximum in the month of July, after which the variation curb turns downward, dropping to a minimum in the month of January.

Therefore, the minimum monthly value of the air temperature at Iași is registered in the month of January, with a value of -3.0°C , and the maximum in July, when it reaches 21.2°C , resulting in a monthly multiannual amplitude of 24.2°C . The lowest multi-monthly value of the month of January was recorded at Bârnova (-3.7°C), and the lowest at Ciurea, with 0.2°C higher than at Iași and with only 0.9°C higher than at Bârnova, although the altitude difference between the two stations is about 286 m (tab. 5)

In the month of January, the calculation of the multiannual average shows the fact that the average monthly temperature is the lowest, being on average of -3.0°C at Iași and -3.1°C at PoduIloaiei, lower on the average with 0.7°C compared to Bârnova (-3.7°C), which is located at an altitude of 396 m, due to the accumulation of cold air in the valleys of the metropolitan area.

In the month of January the oscillations of the thermic average, based on the dynamics of the atmosphere, have been very high, being on average of 5°C . For the analyzed period, the month of January has been in some cases a warm month, as has been for example the January of 2007 with an average of 3.8°C at Iași, with a deviation of 6.8°C compared to the multiannual average of the month of January. January 2007 was an especially warm month for the entire metropolitan area, values of over 3°C being recorded at Bârnova (3.4°C) and Ciurea (3.6°C).

Tab. 17 – Average monthly and annual temperatures (°C) in the Iași metropolitan area

Nr.	Weather st.	Alt. (m)	Months												Year avg.	Period
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	Iași	102	-3.0	-1.2	3.4	10.4	16.3	19.6	21.2	20.4	15.8	10.2	4.3	-0.8	9.7	1961-2009
2	Podu Iloaiei*	100	-3.2	-1.7	3.2	10.0	16.0	19.0	20.4	19.7	15.4	9.6	3.8	-0.3	9.3	1967-1993
			-3.1	-1.2	3.4	10.3	16.2	19.5	21.0	20.1	15.4	9.9	4.2	-0.8	9.6	1961-2009
3	Ciurea*	110	-2.0	-0.4	3.9	10.2	15.8	19.3	21.3	20.4	15.2	9.8	3.7	-0.7	9.7	1985-2009
			-2.8	-0.9	3.5	10.0	15.5	19.0	20.5	19.9	15.3	9.8	3.1	-0.6	9.4	1961-2009
4	Bâmoava*	396	-2.4	-1.5	3.4	9.6	14.5	18.3	20.5	19.5	14.4	9.9	4.1	0.0	9.2	2004-2009
			-3.7	-2.2	2.0	8.8	14.2	17.6	19.2	18.9	14.0	9.0	3.2	-1.6	8.3	1961-2009

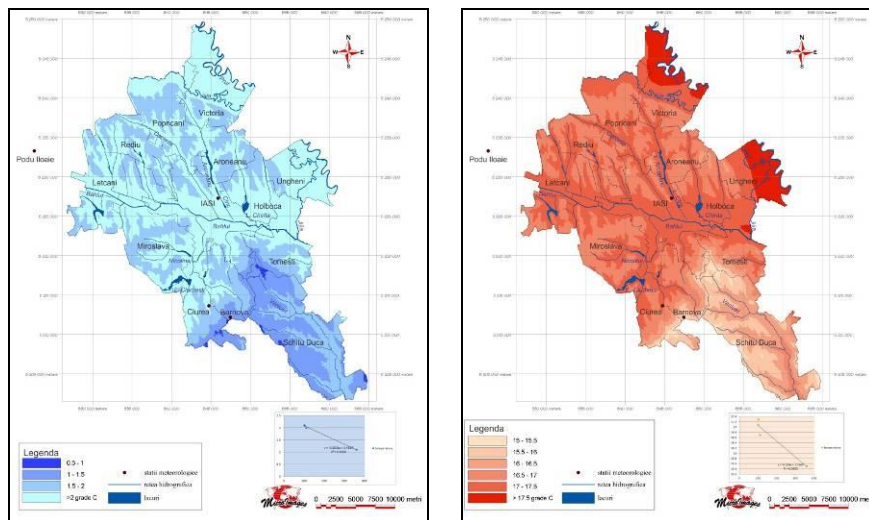


Fig.5 – The spatial distribution of air temperature at semestrial level in the Iași metropolitan area

The month of July is not always the hottest due to fluctuations in the general circulation of the atmosphere. In 61% of the cases the month of July is that of thermic maximum, being followed by August with 27% of cases, then June with 12% of cases. The lowest monthly average has been of 18.6°C at Iași in 1979, with a deviation from the average of 2.6°C, and the highest monthly average has been recorded in July 2007, having a value of 25.4°C, 4.2°C higher than the multi-monthly average of the month of July (21.2°C). For the analyzed period, at Iași, in 49% of cases the month of July has a temperature higher than the multi-monthly average.

The diurnal regimen of the differences in temperature between the city and its surroundings has been highlighted by numerous researches, undertaken in cities from different regions of the world. These have shown that during the whole year

the maximum differences in temperature between the city and the neighboring rural settlements are produced in the evening, at around 21:00 o'clock, and the minimum, at noon at around 14:00. The appearance of the largest thermic differences at 21:00 o'clock can be explained by the strong heating of urban constructions during the day and the crossed emission of infrared radiations in the evening, when the surrounding field has already cooled.

The slower warming of the city and the faster one of the clear field renders the noon thermic differences minimum.

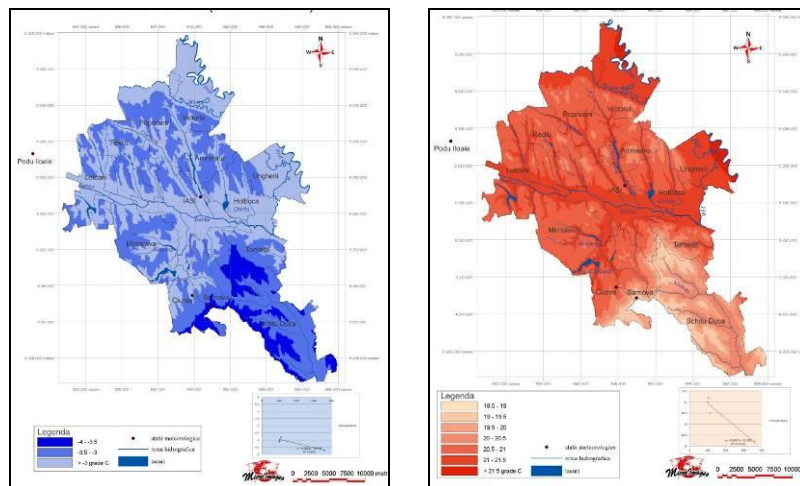


Fig. 6 - The spatial distribution of the average air temperature in the months of January and July in the Iași metropolitan area

In the winter the city stays warmer than its surroundings even at noon, but in the spring, autumn and sometimes summer it is colder than its surroundings. The values of the negative differences are extremely small however. (Ciulache, 1980)

In the metropolitan area, during the year, the diurnal average amplitudes present differentiations based on the season, the lowest diurnal thermic amplitudes being recorded in January, with values of 4.7°C at Iași and the highest values of thermic amplitudes are in July (9.5°C).

Spatial differentiations appear also in the case of the absolute maximum and minimum temperatures. The absolute maximum temperature in the metropolitan area was recorded at Iași(40.1°C) in July 2007, when the synoptic conditions were given by the presence of anticyclones of thermic nature in the north of Africa and above the Arabian and Anatolian peninsulas, the extensions of which, towards eastern Europe, favored conditions of clear sky and atmospheric calm and a pronounced warming of the weather. (Mihăilă, 2006).

Close values have also been recorded at Iași, thus, 40.0°C at the Iași-Boarding-school weather station (July 27, 1909) and +39.6°C at Iași Airport station (August 18, 1946). Then, in both cases, over northern Africa, south-west Asia and East Europe, anticyclone areas persisted for a prolonged time, which favored over the Romanian territory a clear sky and a pronounced warming of the atmosphere.

In order to have a term of comparison, it is useful to know that the absolute maximum for the whole country has been 44.5°C, recorded on August 10, 1951, in the town of Ion Sion, today called Râmnicelu, from Bărăganul Brailei.

In the Iași metropolitan area the maximum annual temperature is recorded mainly in the month of July but also in the month of August the absolute maximum annual temperature has a high frequency, registering together with July more than 80% of the cases.

Tab. 6 - The absolute maximum monthly and annual temperatures, absolute minimum monthly and annual temperatures and the difference between them in the Iași metropolitan area

Weather St.	Parameter.	Month												Annual
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
Iași	Max.	15.4	22.5	26.6	30.3	36.0	37.4	40.1	39.0	34.6	32.1	24.3	19.5	40,1°C 22.07.2007
	Min.	-30.6	-24.7	-19.2	-9.4	-0.6	4.5	7.6	4.9	-3.4	-7.2	-21.1	-27.2	-30,6 °C 20.01.1963
	Diff.	46.0	47.2	45.8	39.7	36.6	32.9	32.5	34.1	38.0	39.3	45.4	46.7	70,7°C
Podul loaie	Max.	15.1	20.4	26.2	29.5	34.5	34.7	37.6	36.8	35.0	31.0	23.8	20.2	37,6 °C 06.07.1988
	Min.	-31.2	-27.5	-22.2	-5.0	-0.8	3.4	7.5	4.5	-5.3	-8.9	-25.3	-21.9	-31,2 °C/ 16.01.1985
	Diff.	46.3	47.9	48.4	34.5	35.3	31.3	30.1	32.3	40.3	39.9	49.1	42.1	68,8°C
Bărnova	Max.	13.5	15.2	18.8	21.7	31.7	34.5	38.3	34.7	23.8	21.5	10.5	7.0	38,3°C / 20.07.2007
	Min.	-26.2	-20.3	-14.1	-4.6	-1.9	6.3	9.4	7.5	2.4	-4.6	-8.6	-18.3	-26,2°C / 23.01.2006
	Diff.	39.7	35.5	32.9	26.3	33.6	28.2	28.9	27.2	21.4	26.1	19.1	25.3	64,5°C

For the Iași metropolitan area, the absolute maximum recorded temperature was of 40.1°C, recorded at the 22nd of July 2007, and the absolute minimum of -30.6°C, recorded on January 20th 1963, thus resulting in the absolute thermic amplitude of 70.7°C (tab. 28).

The absolute minimum temperatures were recorded in conditions favorable for the occurrence of strong frosts through the advections of cold, arctic, continental air and radiative cooling in an anticyclone environment.

Calculating the annual average of absolute minimums it is found that the lowest value was of -5.8°C, recorded in the year 1963, and the highest value of the annual average of the absolute minimum was of -0.1°C, recorded in the year 1975.

The multiannual average of the annual absolute minimums was of -2°C , compared to -1.9°C which was recorded at Oradea.

For the time interval taken into consideration the absolute minimum value of air temperature was recorded in the year 1963, being a value of -30.6°C , higher with 4.4°C than the absolute minimum recorded for the entire time interval in which there have been made meteorological observations at Iași (Erhan, 1979). For the analyzed periods the absolute minimums have been of -31.2°C at Podulloaiei (January 16, 1985) and -26.2°C at Bârnova (January 23, 2006).

4. Thermic inversions

Thermic inversions represent those atmospheric situations in which the air temperature rises with altitude, which means that in the lower areas the air has a lower temperature and a higher density. In the case of the metropolitan area the frequency of the appearance of this phenomenon, coupled with the periods of the year favorable for its occurrence presents a special, practical importance because their occurrence favors the appearance and lasting for a longer period of time of phenomena specific to the pollution of urban atmosphere. It is known the fact that air temperature drops as altitude rises, with $0.5\text{-}0.6^{\circ}\text{C}/100\text{m}$, but the local conditions and the dynamic of the atmosphere can introduce important variations in the vertical distribution of air temperature.

In order to determine the thermic inversions in the metropolitan area there have been calculated the average diurnal thermic differences between the average daily temperatures recorded at the weather stations in Iași (102m), Ciurea (110m) and Bârnova (396m), in the 2004-2009 interval.

Tab. 7 – The frequency of thermic inversions (%) in the metropolitan area (2004-2009)

Month/ Year	Dif. Alt (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual avg.
Iași - Bârnova	294	23	17	6	7	0	0	1	1	6	10	17	19	9
Ciurea - Bârnova	286	23	20	19	26	11	12	17	21	22	24	21	19	20
Iași - Ciurea	8	46	33	26	26	20	12	10	17	13	35	37	46	27

The average annual number of cases with thermic inversions at Iași, in terms of daily average temperatures is 9%, with a larger frequency in the winter and autumn months. Thus, at Iași the large number of thermic inversions is recorded in January (23%), while at Ciurea it is recorded in October (24%) (tab. 34)

For the analyzed period it can be observed that both at Iași and at Ciurea, the minimum number of cases with thermic inversions was recorded in 2008, when the

phenomenon was observed in 17 cases at Iași and, respectively, 43 cases at Ciurea, with a recorded maximum in 2009 for Iași (90 cases) and in the years 2005 and 2006 for Ciurea (39 cases).

The tracking of daily average thermic differences between Iași and Bârnova highlights negative presences in the winter, spring and autumn months, with values between -0.1°C and -7.1°C , the maximum value of inversion being recorded on February 1st 2004.

In the case of the diurnal average thermic differences between Iași and Bârnova, in the winter months, the fact can be observed that the highest frequency of thermic inversions is produced in January (23%), December (19%) and February (17%). Thermic inversions are recorded during all seasons in the year, including in July (1%), but there are also months in which this phenomenon is not observed, namely the months of May and June.

The large number of cases with thermic inversions in the months of October, November, December and January is due to the higher frequency of the anticyclone circulations, and the intensification of thermic convection at the end of the spring and beginning of the summer determines a fall in their number.

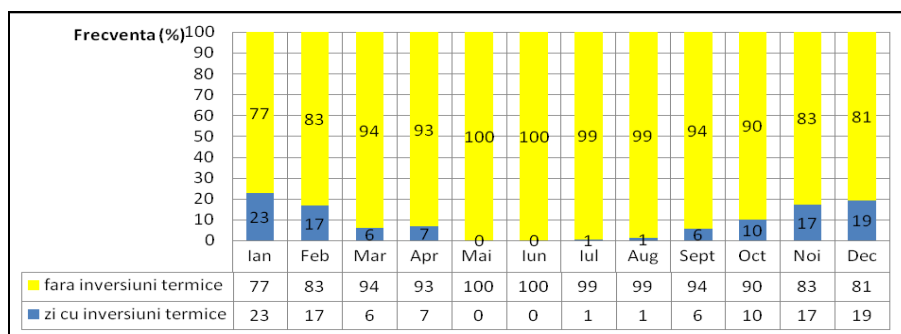


Fig.7 – The frequency of temperature inversions (%) between the weather stations Iași–Bârnova (2004-2009)

In terms of maximum temperatures I have determined a monthly frequency of thermic inversions at Iași of 17% in the months of December and January, and similar values in February and November, 8% and 9% respectively, these representing maximum monthly values, and for the summer months, when inversions have a lower frequency they are 2% in August and 1% in June and July, resulting in a multiannual frequency of 5% thermic inversions at Iași.

Taking into consideration minimum temperatures the frequency of thermic inversions at Iași is much higher, registering a maximum value in the autumn and

spring months (49% in September and 44% in April). Among the winter months the highest frequency of thermic inversions belongs to the month of January (32%), followed by December (24%) and February (23%). For the analyzed period the annual average of thermic inversions by minimum temperatures is 31%, with a maximum number of inversions recorded in 2009, 129 cases.

Conclusions

For the studied time interval, at the Iași weather station, the multiannual thermic average of soil temperature was 11.3°C, 1.6°C higher than the air temperature 2m above ground for the same interval (9.7°C), highlighting in this way the role that soil temperature has in influencing the temperature values of the air above it. The extreme annual averages of temperature, at the surface of the soil and at 2 m above ground, were recorded almost in the same years. (Iași – annual maximum: soil:13.9°C, 2007; air:11.8°C, 2007); (PoduIloaiei – the annual minimum, soil:9.5°C, 1980; air: 7.9°C, 1980, annual maximum, soil: 14.0°C, 2007; air: 11.6°C, 2007); (Bârnova – annual maximum, soil: 12.4°C, 2007; air: 10.2°C, 2007).

The average annual temperature decreases as altitude increases from 9.7°C recorded at the Iași weather station, the station with the lowest altitude in the metropolitan area (102m), to 9.4°C at Ciurea, only to measure an 8.3°C multiannual average at Bârnova, at 396 m altitude, registering a tendency to increase in the latest years.

The analysis of data regarding the average monthly values of air temperature for the metropolitan area have highlighted the month of January as the coldest of the year, with a multiannual average for Iași of -3.0°C, -2.8°C at Ciurea and -3.7°C at Bârnova and the warmest month of the year being July, with a multiannual average of 21.2°C at Iași, 21.0°C at Ciurea and 19.2°C at Bârnova.

Regarding the multiannual average amplitude of air temperature the fact emerges that it has a value of 25.9°C at Iași, 29.4°C at Ciurea, 25.8 at PoduIloaiei, being calculated through the average of all annual amplitude averages for the analyzed interval and not 24.2°C, as it would result from the difference between the months of July and January, because these in the studied interval have represented only 61% and 59% respectively, months with thermic maximum and minimum at the Iași weather station.

The absolute minimum temperature recorded at Iași was -30.6°C and it was recorded on the 20th of January 1963, and the absolute maximum was 40.1°C, recorded on the 22nd of July 2007, the absolute thermic amplitude having a value of 70.7°C.

From the analysis of data from the three weather stations in the metropolitan area the fact results that thermic inversions occur in 9% of cases in a year between

Iași and Bârnova and 20% of cases in a year between Ciurea and Bârnova, starting with September until March, with a maximum of 23% in January, according to the daily averages. If we take into consideration also the minimum and maximum daily averages, it can be observed that the frequency of inversions in the minimum averages is 31% compared to the 5% recorded in the case of the daily maximums.

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