Trends in air temperature and atmospheric precipitation in Botoşani between 1961 and 2017

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ABSTRACT: Air temperature and precipitations are major factors affecting the climate of a certain place. They define the basic matrix of the climate, and their evolution are of interest for the whole of both human and scientific community. The purpose of the present study is to highlight the sign and the magnitude of the trend in the air temperature at Botoşani city weather station for the whole period 1961-2017, and for both its major subdivisions (1961-1990 and 1991-2017, respectively) throughout different temporal subsets (from the level of an average year to the level of a month). Besides air temperature, we determined the evolutive trend in the amount of rainfall using a similar methodology (based mainly on the Mann- Kendall and t tests). Following our approach, we showcased the thermal and pluviometric reality at Botoşani, which is in a continuous change (as for the temperature values) or in a relatively dynamic balance (with respect to the amount of precipitations). More precisely, at Botoşani, against an annual average temperature of 9.4°C and an annual average of precipitations of 569.0 mm, after the year 1961 and mostly after 1990, the tendency was positive, which indicates an increase in air temperature. From a thermal point of view, considered annualy, seasonally and by warm and cold seasons (excepting autumn, with an insignificant increase), air temperature displayed a representative increase in value over the assessed period (1961-2017). On the whole, the annual temperature values increased by 0.32°C / decade, which presents a maximum statistical significance. Annual amount of rainfall increased over the period 1961 – 2017 by 4.46--5.35 mm/ decade, but this was not statistically significant.

KEY WORDS: thermal trends, pluviometric trends, Botoşani, Mann-Kendall.

1. Introduction

The knowledge of the value and the trends in temperature and rainfall has theoretical, scientific and mostly practical importance. Thermo-pluviometric variability and trends in air temperature or atmospheric precipitation were calculated for several parameters of these elements, at several stations and locations in the Moldavian Plain (including Botoşani), by Mihăilă in 2002, 2004 and in 2006.

Piticar and Ristoiu (2012) analysed soil temperature in the north-eastern region of Romania, and they also rendered graphically the evolutionary trends of the temperature in the active surface. Among the stations that took part in the survey we can mention the one located at Botoşani.

Mihăilă and Briciu (2012) analysed, on thermic and pluviometric grounds, the evolutionary trends of the climate in the North – Eastern Romania, by using in their statistical approach the data concerning the temperature and rainfall provided by the station at Botoşani.

In 2013 Croitoru and Piticar tackled the problem of changes in the daily air temperature extremes taking place outside the Carpathian Basin and their analysis included as well the weather station in Botoşani. Croitoru et al (2012b, 2013) have studied the spatial and temporal distribution of the aridity indices by analysing the temperature and rainfall outside the Carpathians, and mentioned the evolutionary trends of the thermo – pluviometric complex in the area pertaining to the station in Botoşani.

In 2013, Piticar assessed that the annual average temperature in the North – Eastern Romania increased by 0.16 – 0.33°C/decade from 1961 to 2020. According to the Mann-Kendall test and the forementioned author, the annual average temperature increased at Botoşani by 0.23°C/decade.

When analysing the decennial evolution of the air temperature, the same author found that it increased from 8.9°C over the decade 1961-1970 to 9.9°C over the decade 2001-2010. For periods of 30 years each, he noticed that air temperature increased from 9.0°C during the decade 1961-1990 to 9.5°C during the period 1981-2010. According to the test Mann – Kendall combined with the Sen‘s slope, the annual rainfall data series indicated a rising tendency in the amount of rainfall for eight stations in the NE region (among which is Botoşani, where the rise was of 12.32 mm/decade), which was considered statistically insignificant. Mihăilă et al. (2017) researched space distribution and temporal occurrence of water balance within the territory between the Carpathians and the Dniester and showed – for a large number of stations in this territory, Botoşani included – the trend over time, after 1961, of this climatic indicator.

2. Study area

The municipality of Botoşani lies at 47°44′55″N 26°40′10″E, in the northeastern part of Romania, the North-West of Jijia Plain, in a hilly, forest-steppe landscape with a temperate continental climate, marked by Eastern influences of aridity (Mihăilă, 2006). The municipality is bounded by the valleys of rivers Sitna and Dresleuca.

The Meteorogical Station Botoşani is located on the south- east periphery (enjoying a peri-urban establishment), at 47°44′ 8.274″ N, 26° 38′ 43.907″ E and an altitude of 161 m (Fig. 1).

From 1955 to 1974, the Meteorogical Station Botoşani functioned at 32, Dragoş Vodă St. and since 1974 it has been functioning on the current site. That year, an adequate building, endowed with a proper weather station was built at 62, Mihai Eminescu (near Pacea Cemetery). Since then, there have been taken observations every hour day and night, to be sent to S.R.P.V. Bacău. In Botoşani, an automated weather station type Vaissale has been functioning since July 2000 (information taken from the history of the Botoşani Meteorological Station).

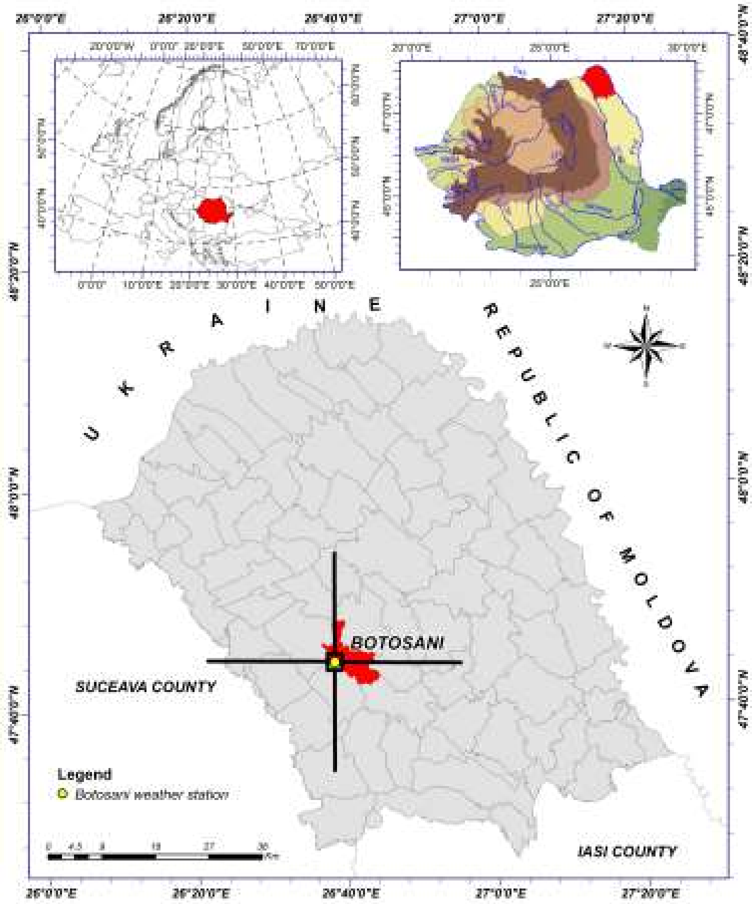

Figure 1 Location of the Botoşani meteorological station within the municipality and of Botoşani county - below; the location of Botoşani county in Romania and of Romania in Europe – top.

3. Data and methods

In order to conduct this study, we used the monthly, warm and cold seasons, seasonal, and annual averages of air temperature registered at the station in Botoşani and the before mentioned values for the rainfall at the same station for the period 1961 – 2017.

The data were analysed by means of the Mann – Kendall test and the t test.

The Mann – Kendall (Mann, 1945; Kendall, 1975) test in combination with Sen's slope (Gilbert, 1987) was used in order to determine the trend in monthly, seasonal, warm and cold seasons and annual series. The test allowing for missing series, the data do not have to be in accordance with any particular distribution, and Sen's slope isn't particularly affected by singular errors in the data series (Moberg et al., 2006). The assessment using these two methods were made by using MAKESENS software / package (Mann- 17 Kendall test for trend and Sen´s slope estimates), created by the researchers at the Finnish Meteorological Institute (Salmi et al., 2002). The MAKESENSE performs two types of statistical analyses: the former consists of testing the presence of a monotonous trend, be it positive or negative, by means of the nonparametric test Mann – Kendall (Mann, 1945; Kendall, 1975), and the latter involves calculating the slope of the linear trend as estimated by means of the nonparametric method of Sen (Sen, 1968). Sen's slope (Sen, 1968) uses a linear model in order to estimate the slope of a tendency; to that end, the residual variance has to be constant over time. In the MAKESENS the levels of statistic significance α are: 0.001/***, 0.01/**, 0.05/* şi 0.1/+. The parametric t-test was calculated supplementary in order to have the elements of rapport with the Mann –Kendall test. The data available to us were analysed both for the whole period 1961 – 2017 and for two distinct subperiods: 1961-1990 and 1991-2017, respectively. The reference period was divided into two subperiods: the former lasting 30 years (1961 – 1990), and the latter lasting 27 years (1991 – 2017), in accordance with W.M.O. and I.P.C.C. recommendations, with the purpose to determine how the trends in the two basic meteorological elements evolved within the two subperiods.

4. Results and discussion

4.1. Trends in air temperature

From Tables 1 and 2 we can notice that the multiannual average temperature for 1961-2017 is 9.4°C. The annual thermal average over the mentioned period ranges between 7.7°C (1969, 1980, 1985) to 11.8°C (2015). Moreover, during the coldest month of the year, January, the mean air temperature is negative (-3.0°C) but there were extremely cold January months in 1963 (when the thermal average decreased to -12.2°C) or the chilly January of 2007, when the average rose to 4.5°C. In the hottest month of the year, July, the average rises to 20.7°C (however, there were colder months – in 1974 (with an average of 17.9°C) or very hot – in 2012, with an average temperature of 24.7°C). Basic thermal particularities at the Meteorological Station Botoşani are rendered in Tables 1 and 2.

Table 1 Basic thermal particularities (annual, seasonal and by season thermal indices) at the Meteorological Station Botoşani for the period 1961-2017.

	Annual	Winter	Spring	Summer	Autumn	Warm season	Cold season
The lowest average temperature	7.7	-7.0	6.3	17.5	7.0	14.8	-1.7
Thermal average	9.4	-1.7	9.7	19.9	9.7	16.8	2.1
The highest average temperature	11.8	2.9	12.0	22.9	11.8	19.3	5.3
Thermal amplitude - calculated based on averages	4.1	9.9	5.7	5.4	4.9	4.5	7.0
The mean square deviation	1.0	2.2	1.4	1.1	1.1	1.0	1.6

Table 2 Basic thermal particularities (monthly thermal indices) at the Meteorological Station Botoşani for the period 1961-2017.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
The lowest average temperature	-12.2	-9.4	-3.0	6.1	12.2	16.9	17.9	16.3	11.7	6.7	-3.8	-6.6
Thermal average	-3.0	-1.3	3.4	10.0	15.7	19.1	20.7	19.9	15.3	9.6	4.1	-0.7
The highest average temperature	4.5	5.6	8.5	13.4	19.7	22.6	24.7	23.6	19.2	13.4	9.3	3.9
Thermal amplitude - calculated based on averages	16.7	15.0	11.5	7.3	7.5	5.7	6.8	7.3	7.5	6.7	13.1	10.5
The mean square deviation	3.3	3.4	2.8	1.7	1.5	1.4	1.5	1.5	1.6	1.4	2.5	2.5

Given this thermal context, by analysing inter-annual variability of the air temperature (of the average annual temperature, in January and July, respectively) over the period 1961 – 2017 and the evolutive trends of those thermal parameters, as shown in Fig. 2, we could notice the following: i) all three thermal parameters registered an increase over the analysed period ii) the highest increase took place in January – of approximately 4°C, followed by the increase in July – of approximately 3°C, while the annual temperature averages rose with 1.5°C and iii) it is obvious an unequivocal tendency of warming over the period 1961 – 2017, at the level of all three temporal subsets and thermal indicators we selected. The values of R2 have no real statistical significance. Instead, they show a pronounced thermal variability for January and, to a lesser extent, for the annual thermal averages, respectively those of July.

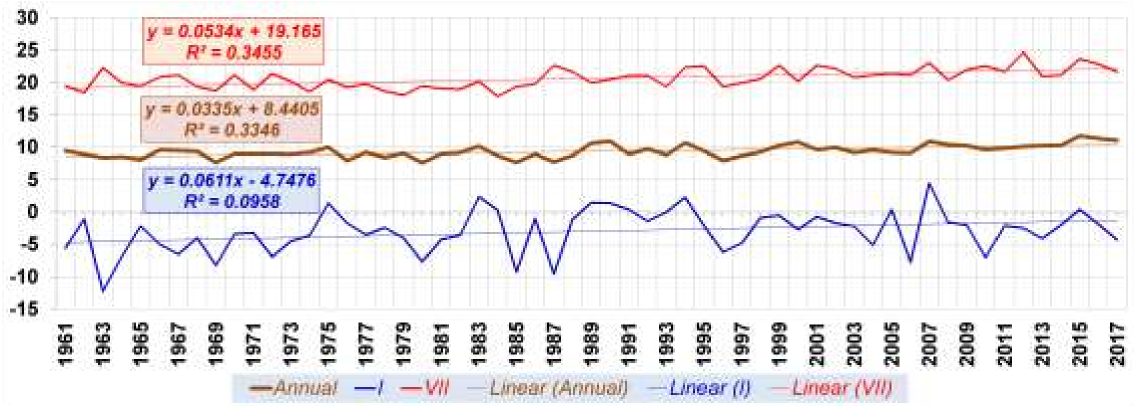

Figure 2 The inter- annual regime of annual and monthly (January and July) averages of air temperature at the Botoşani Meteorological Station during 1961 – 2017 period and the evolutive trends of those.

A more comprehensive image of the trend in the data series of air temperature, for different temporal subsets (from year to month), at Botoşani, is given in Tables 3a and 3b.

Table 3a Trends in the evolution in the annual, seasonal, warm and cold seasons values of air temperature (°C/decade) at Botoşani for the whole period 1961 – 2017 and for the two subperiods – 1961 – 1990 and 1991 – 2017, respectively.

		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
T 1961-2017 MK	Q/Signific	**0.31*****	**0.44***	**0.39*****	**0.42*****	0.12	**0.29****	**0.34*****
T 1961-2017/t	Slope/P	**0.34*****	**0.43***	**0.38*****	**0.43*****	0.08	**0.31****	**0.33*****

MK_test		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
1961-1990	Q/Signific.	0.01	**0.89⁺**	0.20	-0.08	-0.31	0.25	-0.10
1991-2017	Q/Signific.	**0.70****	-0.13	**0.93*****	**0.71****	**0.91****	0.42	**0.75*****
T_test		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
1961-1990	Slope/Signific.	0.14	**0.95***	0.22	-0.17	-0.45	0.34	-0.12
1991-2017	Slope/Signific.	**0.67****	0.04	**0.87*****	**0.70****	**0.90****	0.59	**0.80*****

Table 3b Trends in the evolution in the monthly values of air temperature (°C/decade) at Botoşani for the whole period 1961 – 2017 and for the two subperiods – 1961 – 1990 and 1991 – 2017, respectively.

		I	F	M	A	M	J	J	A	S	O	N	D
MK	Q/Signific	**0.53***	**0.47⁺**	**0.62****	**0.30⁺**	**0.29***	**0.41*****	**0.54*****	**0.48*****	0.01	0.02	0.07	0.37
t	Slope/P	**0.61***	0.43	**0.62****	0.25	**0.27***	**0.32****	**0.53*****	**0.45*****	0.16	-0.02	0.09	0.31

MK_test		I	F	M	A	M	J	J	A	S	O	N	D
1961-1990	Q/Signific.	**1.77***	0.14	1.04	-0.33	0.13	-0.20	0.00	-0.07	-0.18	-0.25	**-1.07***	**0.94⁺**
1991-2017	Q./Signific.	-0.88	0.00	**1.18⁺**	**0.78****	0.71	**0.78***	**0.67***	**1.00****	**1.38****	0.10	**1.08⁺**	**1.35⁺**
T_test		I	F	M	A	M	J	J	A	S	O	N	D
1961-1990	Slope/Signific.	**1.53***	0.27	0.78	-0.25	0.12	-0.33	0.02	-0.18	-0.10	-0.23	**-1.00***	**1.04***
1991-2017	Slope/Signific.	-0.66	-0.08	**1.16+**	**0.86***	0.60	**0.64***	**0.69***	**0.78***	**1.22****	0.05	**1.43***	**1.31⁺**

The values in bold are statistically significant at the levels α equal to 0.001/***, 0.01/**, 0.05/* şi 0.1/⁺ for the Mann –Kendall test and at the levels P equals to 0.001/***, 0.01/**, 0.05/* for the t test

From Tables 3a and 3b (and on the base of the Mann Kendall test) we can infer some of the features of the thermal evolution during the period 1961 – 2017 at Botoşani, namely: i) for the whole period, the rise in the air temperature is obvious and has statistical significance with respect to the annual means (that rose by 1.8°C), seasonal and warm and cold seasons – except for autumn; ii) in winter and in summer the increase in air temperature was the most significant value (by 2.5°C in winter and 2.4°C in summer), but the summer increase was statistically more significant; iii) on the whole, the warm season suffered a higher warming than the cold season of the year, this gap being caused/induced by the fast increasing thermal trend for the summer months (the increase for July was of 3.1°C); iv) out of the winter months, January had the highest increase (3.0°C); v) in the autumn months, the increase was hardly noticeable and statistically insignificant.

By analysing the thermal evolution for the two subperiods, we can notice the following: i) the thermal tendency within the 1991 – 2017 as compared with that for the 1961 – 1990 is marked by warming, which is obvious when taking into account the considerable leap in the values and an increase in the statistical significance for the annual, warm season, spring, summer and autumn averages; ii) during the cold season the thermal leap from one period to the other was positive, but statistically insignificant; in winter, the warming affected the subperiod 1961 – 1990 by its amplitude and statistical significance, after which the subperiod 1991 – 2017 was affected by a slight decrease in temperature, even though lacking statistical significance. Against the background of the increase in atmospheric stability given by the higher frequency of anticyclonic weather, the accentuation of the dryness of winters, the episodes with thermal inversions and frost seem to have increased in duration and frequency in the low area of the JIjia Plain. At the monthly level, the positive leap in temperature from the subperiod 1961 – 1990 to the subperiod 1991 – 2017 is noticeable for 10 months of the year (for seven of them the increase also having statistical relevance). The highest rise in temperature, with a reversal of the trend between the two subperiods and keeping the statistical significance, was particular to the month of November (where the evolution passed from a decrease in temperature of 1.1°C/decade during the subperiod 1961-1990 to an increase of 1.1°C/decade in the subperiod 1991 – 2017), while the most important decrease, accompanied by a trend reversal, but without keeping its statistical significance, was specific for January (from an increase of 1.8°C/decade in the subperiod 1961-1990, to a decrease of 0.9°C in the subperiod 1991-2017). Overall, at the level of the most temporal entities analysed (from year to month), the thermal parameter average registered an increase in value during the subperiod 1991 – 2017 in comparison with the 1961 – 1990, highlighting a warming of the climate of the researched location.

Our results are convergent with those obtained for the Siret Corridor by Sfîcă (2011), for the North –Eastern region of Romania by Mihăilă and Briciu (2012), by Piticar (2013), or for the whole of Romania by Busuioc et al. (2010) or by Croitoru et al. (2012b).

4.2. Trends in atmospheric precipitation

From Tables 4 and 5 we notice that at Botoşani the annual rainfall amount is of 569 mm. The annual rainfall ranges from 311.4 mm (2015) to 859.3 mm (2006). It is also to be highlighted that the January precipitation amount average is the lowest in the year – 22.6 mm (there were months of January richer in rainfall, e.g. January 1966 with 74.8 mm, or months of January with smaller rainfall, e.g. January 1978 with 2.5 mm, while in July the rainfall is the largest – 91.2 mm (with wetter months, such as July 2002 with 225.8 mm, and drier ones, such as July 2016, with 8.0 mm). The defining rainfall particularities for the Botoşani Meteorologocal Station are rendered in Tables 4 and 5.

Table 4 The basic rainfall particularities (average and extreme monthly rainfall, seasonal and for the warm and cold seasons) at Botoşani Meteorological Station for the period 1961 – 2017.

	Annual	Winter	Spring	Summer	Autumn	Warm season	Cold season
The smallest amount	311.4	32.3	36.3	88.8	20.6	152.9	64.9
The average amount	569.0	72.6	148.1	238.1	110.0	398.6	169.4
The largest amount	859.3	151.3	268.0	528.8	290.7	710.1	343.9
Rainfall amplitude - calculated based on the amounts of precipitation in the considered range	547.9	119.0	231.7	440.0	270.1	557.2	279.0
The mean square deviation	124.5	25.4	57.4	79.8	61.2	110.4	51.3

Table 5 The basic rainfall particularities (average and extreme monthly rainfall) at Botoşani Meteorological Station for the period 1961 – 2017.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
The smallest amount	2.5	1.4	2.2	5.8	3.6	10.7	8.0	8.9	0.0	1.5	0.4	3.6
The average amount	22.6	23.5	30.4	52.8	65.0	84.9	91.2	62.0	42.8	36.9	30.3	26.7
The largest amount	74.8	65.4	83.5	175.7	150.7	165.4	225.8	232.4	166.9	193.5	76.6	80.5
Rainfall amplitude - calculated based on the amounts of precipitation in the considered range	72.3	64.0	81.3	169.9	147.1	154.7	217.8	223.5	166.9	192.0	76.2	76.9
The mean square deviation	14.8	15.3	20.9	32.3	40.3	41.2	52.0	43.8	35.1	32.8	18.3	18.3

In this thermal context, by analysing the interannual fluctuation in rainfall (i.e. annual, January and July) for the period 1961 – 2017 and their evolutionary trends, (Fig. 3), we could notice several aspects. The annual rainfall registered, from a statistical point of view, a slight increase (25 – 30 mm), due to the very large rainfall in some years during the later part of the period (1998, 2006, 2010) quantities fallen mostly torrentially and that cover an extremely uneven distribution of interannual rainfall, which leads to the occurrence of short periods of pluvio – hydric surplus followed by periods with enhanced pluvio – hydric deficit (Fig. 3). In June, rainfall decreased by approx 20 – 25 mm (In July it was less – by 0.5 – 1 mm), and in January it was by approx. 5 mm. These declines are not quantitatively relevant and are identified statistically and graphically against the background of a large interannual rainfall fluctuation in the months we analysed.

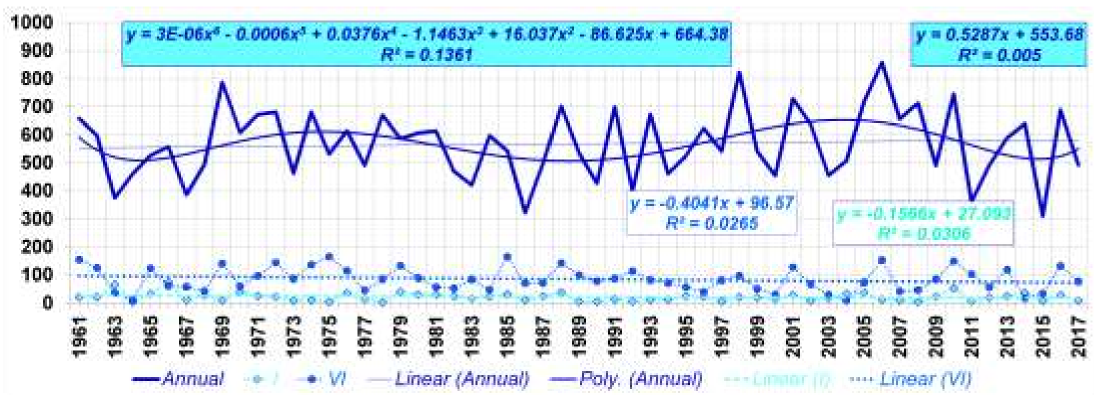

Figure 3 The inter- annual regime of annual and monthly (January and July) averages of rainfall at the Botoşani Meteorological Station during 1961 – 2017 period and the evolutive trends of these parameters.

The rainfall evolutionary trends (be it positive or negative +/-, larger or smaller in value terms) in time at Botoşani (1961 – 2017), analysed for different time subperiods/subsets (from year to month), on the basis of the Mann – Kendall test (Tables 6a and 6b) are marked firstly by a lack in statistical significance. Even though we can highlight a quantitative increase in rainfall at the level of the annual sums of the cold season and of the autumn, or a decrease (in winter, spring and summer), these do not have a relevant statistical coverage we can rely on. At the monthly level, beyond an increase or decrease in value (with no statistical significance) in rainfall, the month of October is the one that distinguishes by a trend both ascending and statistically significant (during this month at every 10 years rainfall rose by 5.1 mm, according the Mann – Kendall test).

Table 6a Trends in the evolution of annual, warm and cold seasons, and seasonal rainfall (mm/ decade) at Botoşani for the whole period 1961 – 2017 and for the two subperiods – 1961 – 1990 and 1991 – 2017, respectively.

		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
T 1961-2017 MK	Q/Signific	6.5	-2.5	-0.95	-0.9	6.84	4.4	-0.13
T 1961-2017/t	Slope/P	5.3	-2.2	0.4	-2.4	9.6	5.5	0.4

MK_test		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
1961-1990	Q/Signific.	-19.8	**-10.6+**	-1.4	3.8	-0.3	-17.8	9.0
1991-2017	Q/Signific.	-11.1	2.8	-0.5	-19.9	-7.1	**25.1***	-35.2
T_test		Annual	Winter	Spring	Summer	Autumn	Cold season	Warm season
1961-1990	Slope/Signific.	-13.7	**-10.4+**	-2.7	-1.4	-1.2	-16	3.5
1991-2017	Slope/Signific.	-14.4	4.0	3.8	-19.3	-5.9	**31***	-37.1

Table 6b Trends in evolution of the monthly sums of rainfall (mm/decade) at Botoşani for the whole period 1961 – 1990, 1991 – 2017, respectively.

	I	F	M	A	M	J	J	A	S	O	N	D
MK Q./Signific.	-0.93	0.03	0,00	0.24	-1.8	-4.5	-0.1	-1.9	2.3	**5.4****	0.2	-0.6
T Slope/Signific..	-1.6	-0.1	0.4	1.1	-1.1	-4.0	1.6	0.0	2.8	**7.1****	-0.3	-0.6

MK_test		I	F	M	A	M	J	J	A	S	O	N	D
1961-1990	Q./Signific.	-2.8	-2.9	-7.7	4.9	2.2	2.4	-5.9	-2.8	0.9	3.3	-3.0	-1.3
1991-2017	Q./Signific.	3.0	**5.6***	2.5	2.1	-5.3	-1.8	-2.0	-8.2	-14.2	6.5	-1.3	-2.9
T_test		I	F	M	A	M	J	J	A	S	O	N	D
1961-1990	Slope/Signific.	-4.8	-2.8	-7.3	2.4	2.0	1.8	-3.2	-0.03	0.5	1.8	-3.5	-0.9
1991-2017	Slope/Signific.	3.2	**6.3+**	5.1	3.8	-5.1	2.2	-15.3	-6.2	-16.6	12.9	-2.2	-2.5

The bolded values are statistically significant at the levels α equal to 0.001/***, 0.01/**, 0.05/* şi 0.1/$^{+}$ for the Mann-Kendal test and at the levels P equal to 0.001/***, 0.01/**, 0.05/* for the test T.

If we focus on these two subperiods, we notice that from 1991 to 2017, the most important mutations took place during the cold seson. The pluviometric trend changed from negative in the period 1961 -1990 to positive during the subperiod 1991 – 2017. During the subperiod 1991 – 2017 the decennial quantity of rainfall rose by 25.1 mm. Winter passed from a significant decrease in value (-10.6 mm/ decade) and statistic significance (α = 0.1) to a slight increase in the rainfall quantity that was insignificant from a statistical point of view. The change in trend and values of the rainfall during winter seems to be due to the mutations in point of snow and rainfall in the month of February (during the subperiod 1961 – 1990) the precipitation amount decreased, but the decrease was not statistically important, while in the subperiod 1991 – 2017 rainfall increased by 5.6 mm/ decade, and the level of statistical significance of this increase, α, is of 0.05.

Even though the results regarding pluviometric trends are not very conclusive so far, they are in agreement with those obtained by Piticar (2013) for the meteorological stations in the NE region of Romania and for the station in Botoşani.

Piticar et al., (2015) showed for Moldova from east of the Prut, that between 1961 and 2012 the time series of air temperature showed increasing trends at most stations, including Botoşani station. The differences in terms of increasing the annual average temperatures, obtained by us (0.31°C / decade) and those obtained by Piticar in 2013 (0.23°C / decade) for the stations in the NE-Romania Region are not large, given that the period analyzed by us was longer and its last years were very hot. Compared to the surrounding stations (Fălticeni, Suceava, Darabani, Cotnari, etc.), the thermal increase in Botoşani did not differ much, keeping within ± 0.1°C.

Compared to the results obtained by Piticar in 2013, regarding the increase of the decennial quantities of precipitation from Botoșani (average annual precipitation amounts increased according to the cited author by 12.32 mm / decade between 1961-2010), our results show a more attenuated growth (about 5 mm / decade). This is due to the fact that the years after 2010 showed significantly lower rainfall than in previous years (2006, 2008, 2010 which were years with high rainfall and major floods). The differences between the increases in Botoşani and those in the surrounding stations remain within low value limits (of 1-5 mm / decade) and can be attributed to the entire matrix of pluvio-genetic factors.

5. Conclusion

Air temperature at Botoşani registered a remarkable increase in value with statistical significance over the period 1961 – 2017. This increase was neither uniform nor statistically meaningful for all the temporal entities that were analysed. The annual average temperature increased by 0.31°C/decade or 1.8°C over the whole period, having the maximum statistical significance (α = 0.001). The warm and cold seasons, summers, springs, winters and the months January – August distinguished by a statistically significant increase in the air temperature. The other temporal entities (autumns, the months September – December) were marked by warming, but the process lacks in statistical significance. During the subperiod 1991-2017 it took place an acceleration in warming over the most time unities and subunities considered. Therefore, warming at Botoşani increased over the second subperiod analysed.

As for rainfall amount, the high fluctuation per day, per month, per year, per season and per warm or cold seasons did not lead to clearly outlining statistically significant rainfall trends for each of the time subdivision analysed. What became clear to a certain extent (beyond the sligltly increase trend of the annual and October rainfall), was the rise in time of the rainfall in February, in winter and in the cold season. However, we cannot assert for sure that we have discerned a certain trend in rainfall, as this trend is seemingly on the way towards its own shaping. The rainfall increase in October, even though not consistent in its statistic significance nor at its subperiods level, may be, together with the high and statistically significant increase in temperature in November, a signal of climate mutation affecting autumn in this part of Romania.

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