ANALELE
UNIVERSITĂȚII DIN CRAIOVA
- SERIA GEOGRAFIE -

ANNALS
OF THE UNIVERSITY OF CRAIOVA
- SERIES GEOGRAPHY -

ANUL 2016, VOL. XVII

ANNALS OF THE UNIVERSITY OF CRAIOVA
- SERIES GEOGRAPHY –

WINTER AIR TEMPERATURE CHARACTERISTICS WITHIN OLTENIA PLAIN

CARACTERISTICILE REGIMULUI TERMIC DIN ANOTIMPUL DE IARNĂ ÎN CÂMPIA OLTENIEI

Alina VLĂDUŢ [1]

Abstract: The interannual and decadal variability and trends of winter (December to February) air temperature over the Oltenia Plain area is analysed for the period 1961 to 2010. The datasets cover monthly temperatures from six meteorological stations. The variability of the temperature data was analysed by means of standard deviation, the mean of three distinct sub-periods (1961-1990, 1971-2000, 1981-2010), as well as the mean of ten-year intervals. Linear regression and the non-parametric Mann-Kendall test were used to emphasize any trends present in the datasets. From the temporal variations viewpoint, an increase in temperature is observed particularly in the third and fourth decades, as the average values for the last decade mark a slight decrease in temperature. From the spatial distribution viewpoint, the most significant positive deviations characterize the northern and western part of the plain. Mann-Kendall test illustrates a monotonic upward trend all over the analysed region, but the results are not statistically significant except for the aforementioned parts of the plain for the entire winter season and February.

Key-words: *standard deviation, winter temperature trends, Mann-Kendall test, Oltenia Plain*
Cuvinte cheie: *abatere standard, tendinţe temperatura iarna, testul Mann-Kendall, Câmpia Olteniei*

I. INTRODUCTION

Variation of surface air temperature is one of the most important and simplest indicators used when assessing climate variability and change. Besides data availability, temperature is considered to better respond to radiative forcing changes associated with increasing greenhouse gases (Braganza et al., 2003). Instrumental records indicate that global surface temperature has increased by about 0.6°C since the 19th century, a significant period from this point of view being registered after 1976 (IPCC, 2007). According to the same study, the largest recent warming is registered in winter in the Northern Hemisphere, within extra-tropical regions. In Europe, average temperature of land areas increased at a higher rate compared to the global average temperature (Karl et al., 2000; Tank et al., 2002; EEA, 2012). The analysis illustrated that the average value of the decade

---

[1] University of Craiova, Geography Department, vladut_alina2005@yahoo.com

2002-2011 is 1.3°C above the pre-industrial level and different scenarios indicate continuous warming especially over eastern and northern parts of the continent during winter and over southern Europe during summer.

Thus, assessing temperature variability and trends at local and regional scales gained in importance. In Romania, studies focussed especially on temperature trends on local scale – Sibiu Depression (Dragotă et al., 2002), northwestern Romania (Hauer et al., 2003), Suceava Plateau (Mihăilă, 2005), northeastern Romania (Piticar&Ristoiu, 2012), Oltenia Plain (Vlăduţ et al., 2011; Vlăduţ&Onţel, 2013) etc.

II. DATA AND METHODS

For the present study, there were used temperature monthly values for the interval 1961-2010 from six meteorological stations located within Oltenia Plain or in its immediate proximity (Fig. 1, Table no. 1). Four of the stations are in the plain area, one (Craiova) at the contact between the plain and piedmont areas, while Drobeta Turnu-Severin is located within the depression with the same name, near Mehedinţi Plateau. The data were provided by the National Meteorological Administration.

It was calculated the deviation from the normal (the mean temperature for the period 1961-1990) for each winter season included in the analysis, as well as the liner trend of these deviations.

The standard deviation is calculated by extracting the square root of the variance (σ^2). Dispersion is a synthetic indicator, respectively the square mean of the deviations of individual values from the average of the entire string (Cheval et al., 2003). Dispersion (σ^2) is calculated according to the formula:

$$\sigma^2 = \frac{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}{n}$$, where n represents the number of years

Standard deviation (σ) is calculated according to the formula:

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\sum_{i=n}^{n}\left(x_i - \overline{x}\right)2}{n}}$$

When the data string is longer than 30 years, n is replaced by $n-1$, but the results do not significantly modify. The method was applied by Dragotă et al. (2002).

In order to perform a detailed analysis of the temperatures registered during winter it was calculated and examined the mean of three distinct sub-periods (1961-1990, 1971-2000, 1981-2010), as well as the mean of ten-year intervals.

The detection of winter temperature trends was based on the Excel template MAKESENS (Mann-Kendall test for trend and Sen's slope estimates), developed by the researchers of the Finnish Meteorological Institute (Salmi et al., 2002). The purpose of this test is to statistically assess if there is a monotonic upward or downward trend of a variable, in this case, winter temperature, within a predetermined level of significance. A major advantage of this test is that it

presents a reduced sensitivity to abrupt breaks induced by the inhomogeneity of the time series.
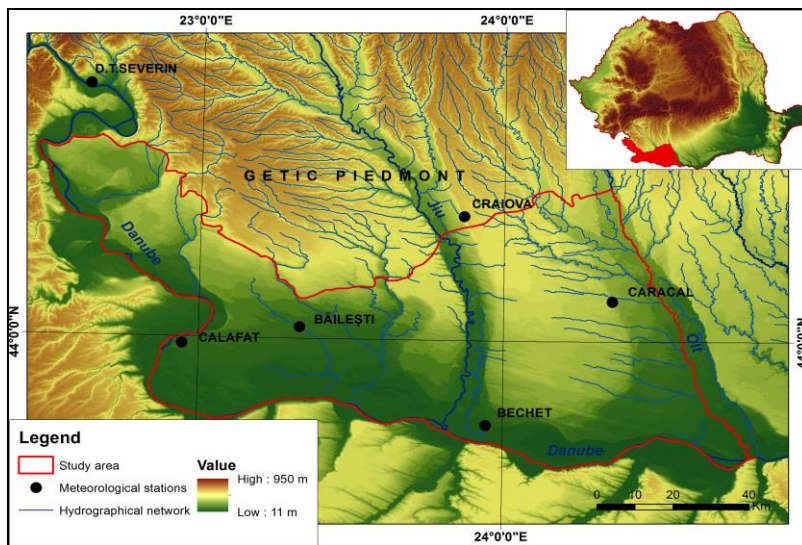
Fig. 1. Study area and considered meteorological stations
(Source: Vlăduţ&Onţel, 2013)

Table no.1. Location of the meteorological stations within Oltenia Plain

No.	Station	Altitude (m)	Latitude	Longitude
1.	Dr. T. Severin	77	44°38`	22°38`
2.	Calafat	61	43°59`	22°57`
3.	Bechet	36	43°47`	23°57`
4.	Băileşti	57	44°01`	23°20`
5.	Craiova	192	44°19`	23°52`
6.	Caracal	106	44°06`	24°22`

III. RESULTS AND DISCUSSIONS
3.1 Average winter temperatures within Oltenia Plain

The mean temperature in winter for the interval 1961-2010 varies between a minimum of -0.5°C in the eastern (Caracal) and northern parts (Craiova) of the plain and a maximum of 0.9°C in the west (Drobeta Turnu Severin). The values are negative except for the western extremity (D.T. Severin and Calafat) (Table no. 2). In terms of maximum and minimum values, there is a high territorial homogeneity, the highest and lowest temperatures being registered in the same winters, namely 2006-2007 and 1962-1963. Spatially, there are emphasized the same differences, namely higher maximum values in the west (4.9-5.4°C) and lower values in the east and north (-5.3…-5.1°C).

7

Table no. 2. Mean, maximum and minimum winter temperatures within Oltenia Plain (1961-2010)

	Băileşti	Bechet	Calafat	Caracal	Craiova	D.T.S.
M	4.4	4.2	5.4	3.9	3.6	4.9
Year	2006	2006	2006	2006	2006	2006
m	-5	-5.3	-4.2	-5.2	-5.1	-3.7
Year	1962	1962	1962	1962	1962	1962
1961-2010	-0.21	-0.3	0.4	-0.5	-0.5	0.9

M – the highest maximum value, m – the lowest minimum value

3.2 Variability of winter temperature

In order to analyse the variability of the data strings there were calculated both the temperature deviations from the normal for each year and a synthetic parameter, the standard deviation (σ). If taking into considerations the deviations of each year, it results that there predominate positive deviations (Fig. 2), especially in the last two decades, when the pick value is reached (2006-2007). Linear regression also emphasizes a clear upward trend for the entire plain, the tendency being more obvious in the north and west.

According to standard deviation, for the last 50 years of recordings, it resulted a low variability (0.18-0.19°C). However, if analysing the values of standard deviation on sub-periods, it results that variability increases, as the highest values (0.19-0.21°C) corresponds to the last sub-period (1981-2010).

In order to assess the trend of winter temperature we compared the average temperature on three distinct sub-periods, namely 1961-1990 (the standard period according to WMO) and 1971-2000, respectively 1981-2010. It can be noticed an increase of 0.4 and 0.6°C for the second sub-period within the entire plain. The increase is also higher in the north and west. For the last period, it can be remarked that the increase characterizes only the northern and western parts of the plain, but the increase rate is much lower than the one registered during the previous sub-period (0.2°C compared to the 1971-2000 and 0.7-0.8°C compared to 1961-1990). In the central, southern and eastern sectors of the plain the increase is of 0.5°C, as there is no difference between the last two sub-periods.

The average winter temperature over 10-year intervals highlights a similar situation. Namely, the average temperature constantly increased during the first 4 intervals and decreases in the last interval. The most obvious increase was registered between the first two intervals, the difference oscillating between 1°C (Bechet) and 1.2°C (Craiova). If we compare the values registered in the first and last intervals, it results that the highest differences are in the western (D. T. Severin, 1.4°C) and northern (Craiova, 1.6°C) parts of the plain (Table no. 4, Fig. 3).
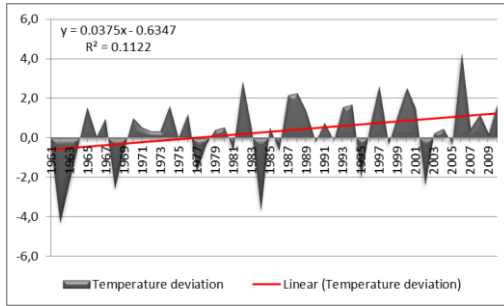
Drobeta Turnu Severin
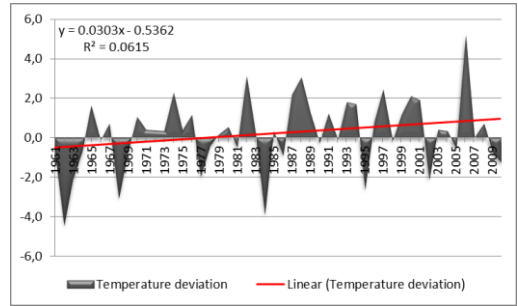
Calafat
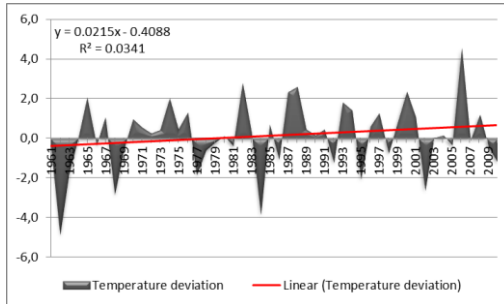
Bechet
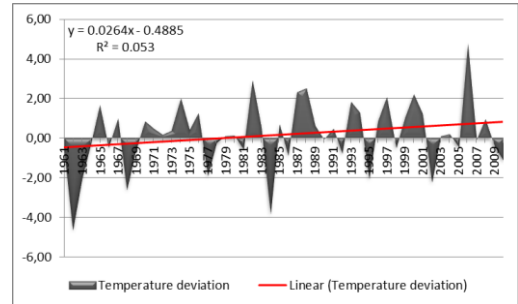
Băileşti
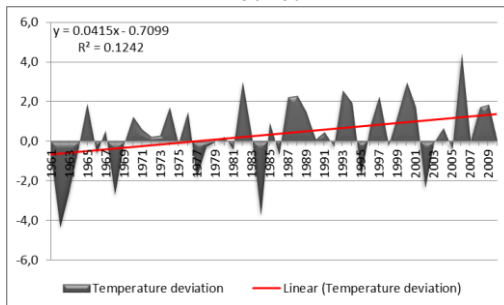
Craiova
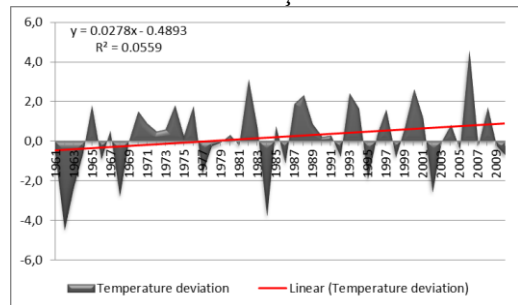
Caracal

**Fig. 2. Winter temperature deviations and the
linear trend within Oltenia Plain (1961-2010)**

**Table no. 3. Mean air temperature over the 1961-1990, 1971-2000 and
1981-2010 periods**

	Băileşti	Bechet	Calafat	Caracal	Craiova	D.T. Severin
1961-1990	-0.41	-0.4	0.2	-0.7	-0.8	0.6
1971-2000	0.1	0	0.7	-0.2	-0.2	1.1
1981-2010	0.1	0	0.8	-0.2	0	1.3

Table no. 4. Average air temperature evolution over 10-year intervals

	Băileşti	**Bechet**	**Calafat**	**Caracal**	**Craiova**	**D.T.Severin**
1961-1970	-1.2	-1.1	-0.6	-1.5	-1.6	-0.1
1971-1980	-0,1	-0.1	0.5	-0.3	-0.6	0.9
1981-1990	0.0	0.0	0.7	-0.2	-0.2	1.0
1991-2000	0.3	0.1	1.0	-0.1	0.2	1.5
2001-2010	-0.1	-0.2	0.6	-0.3	0.0	1.3
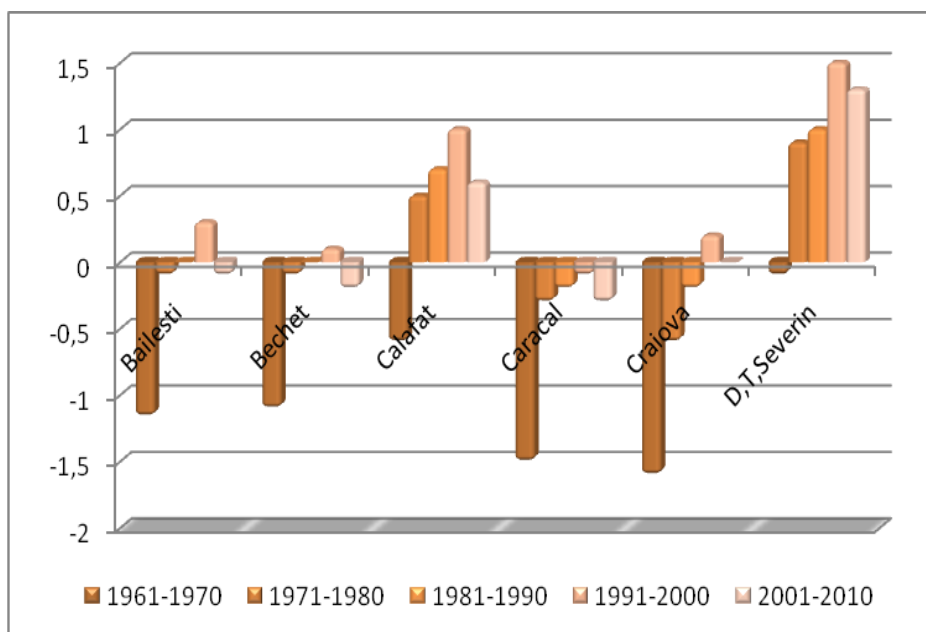
Fig. 3. Average temperature over 10-year intervals

3.3 Temperature trend analysis

The Mann-Kendall test was applied to 4 data sets for each station for the period 1961-2010. Even if all the analysed stations display positive trends for both monthly and seasonal temperatures (Z value), the test illustrated that these trends are not statistically significant in most of the cases. Thus, the only statistically significant upward trends are registered at D. T. Severin and Craiova. At monthly level, in both cases, January presents a 0.1 level of significance and February 0.05. Regarding the winter season, the level of significance is also 0.05 at the two stations (Table no. 5). Thus, considering the obtained values, it results that winter temperature over Oltenia Plain is not significantly increasing, in spite of certain peak values registered during the last two decades.

Table no. 5. Test Z, Sen's slope estimate (Q) and their statistical significances (SS) for air temperature trends

Station / Month	D.T. Severin			Calafat			Bechet		
	Z	SS	Q	Z	SS	Q	Z	SS	Q
December	0.47		0.011	0.03		0.000	-0.06		0.000
January	1.74	+	0.040	1.36		0.036	0.94		0.029
February	2.05	*	0.063	1.16		0.039	0.87		0.035
Winter	2.17	*	0.029	1.20		0.020	0.67		0.011
Station / Month	Băileşti			Craiova			Caracal		
	Z	SS	Q	Z	SS	Q	Z	SS	Q
December	0.47		0.011	0.03		0.000	-0.06		0.000
January	1.74	+	0.040	1.36		0.036	0.94		0.029
February	2.05	*	0.063	1.16		0.039	0.87		0.035
Winter	2.17	*	0.029	1.20		0.020	0.67		0.011

*** if trend at α= 0.001 level of significance; ** if trend at α= 0.01 level of significance; * if trend at α= 0.05 level of significance, + if trend at α= 0.1 level of significance

IV. CONCLUSIONS

Identifying temperature variability and trends acquired a great significance in the general context of global warming and climate change during the last decades. The analysis of winter temperature in the last 50 years, within Oltenia Plain, emphasized certain territorial patterns. Deviations and standard deviation indicated a reduced variability; however, spatially, the values of standard deviation are higher in the north and west, while temporally, the second sub-period (1971-2000), respectively the second 10-year interval display the highest deviation compared to the previous sub-period or 10-year interval. The results indicate a high correlation between stations.

The analysis does not clearly confirm the general warming trend registered at annual level or during summer. The Mann-Kendall test highlighted positive slopes but they are not statistically significant except for the northern and western parts of the plain (0.05 level of significance). Consequently, we can assume that winter temperature do not increase at the rate summer temperature increase.

REFERENCES

BRAGANZA K., KAROLY D.J., HIRST A.C., MANN M.E., STOTT P., STOUFFER R.J., TETT S.F.B. (2003), *Simple indices of global climate variability and change: Part I – variability and correlation structure*, Climate Dynamics, 20, 491-502

CHEVAL S., CROITORU ADINA ELIZA, DRAGNE DANA, DRAGOTĂ CARMEN, GACEU O., PATRICHE C.V., POPA I., TEODOREAU ELENA, VOICULESCU M. (2003), *Indici şi metode cantitative utilizate în Climatologie,* Edit. Universităţii din Oradea

DRAGOTĂ CARMEN, MĂHĂRA GH., DRĂGĂNESCU ADRIANA (2002), *Tendinţa de evolutive a temperaturii aerului în Depresiunea Sibiului în contextual teoriei*

privind încălzirea atmosferică globală, Lucrările Seminarului Geografic „D. Cantemir", Iaşi, p. 209-217

KARL T. R., KNIGHT R. W., BAKER, B. (2000), *The record breaking global temperature of 1997 and 1998: Evidence for an increase in the rate of global warming? Geophysics Research Letters,* 27, p. 719–722

KLEIN TANK A.M.G., WIJNGAARD J.B., KÖNNEN G.P.K, BÖHM R.B., DEMARÉE G., GOCHEVA A., MILETA M., PASHIARDIS S., HEJKRLIK L., KERN-HANSEN C., HEINO R., BESSEMOULIN P., MÜLLER-WESTERMEIER G.M., TZANAKOU M., SZALAI S., PÁLSDÓTTIR T.P., FITZGERALD D., RUBIN S., CAPALDO M., MAUGERI M., LEITASS A., BUKANTIS A., ABERFELD R., VAN ENGELEN A.F.V., FORLAND E., MIETUS M., COELHO F., MARES C., RAZUVAEV V., NIEPLOVA E., CEGNAR T., ANTONIO LÓPEZ J.L., DAHLSTRÖM B., MOBERG A., KIRCHHOFER W., CEYLAN A., PACHALIUK O., ALEXANDER L.V., PETROVIC P. (2002), *Daily dataset of 20th century surface air temperature and precipitation series for the European Climate Assessment*, International Journal Climatology, 22, p. 1441–1453

MIHĂILĂ D. (2005), *Tendinţele evoluţiei temperaturii aerului în Podişul Sucevei*, Analele Universităţii „Ştefan cel Mare" Suceava, secţiunea Geografie, anul XIV, Suceava, p. 57-68

PITICAR A., RISTOIU D. (2012), *Analysis of air temperature evolution in northeastern Romania and evidence of warming trend*, Carpathian Journal of Earth and Environmental Sciences, Vol. 7, No. 4, p. 97-106

SALMI T., MÄÄTTÄ A., ANTTILA P., RUOHO-AIROLA T., AMMELL, T. (2002), *Detecting trends of annual values of atmospheric pollutants by the Mann-Kendall test and Sen's slope estimates – the Excel template application MAKESENS*, Publications of Air Quality, No. 31, Report code FMI-AQ-31, http://www.fmi.fi/kuvat/MAKESENS_MANUAL.pdf

HAUER ELZA, CROITORU ADINA ELIZA, PAVAI C. (2003), *Tendinţele şi anomaliile extremelor termice şi pluviometrice în regiunea de nord-vest a României*, Riscuri şi catastofe, II, Edit. Casa Cărţii de Ştiinţă, Cluj-Napoca, p. 85-95

VLĂDUŢ ALINA, AVRAM S., CURCAN GH. (2011), *Trends in seasonal and annual air temperature within Oltenia Plain, Romania*, Proceedings of the Fourth International Scientific Conference-FMNS 2011, Faculty of Mathematics and Natural Sciences, Blagoevgrad, Bulgaria, p. 539-548

VLĂDUŢ ALINA, ONŢEL IRINA (2013), *Summer air temperature variability and trends within Oltenia Plain,* Journal of the Geographical Institute "Jovan Cvijic" SASA, Vol. 63, No. 3, p. 371-381

*** EEA REPORT (2012), *Climate change, impacts and vulnerability in Europe in 2012. An indicator-based report,* ISSN 1725-9177

*** IPCC (2007), *Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, USA