THE INTRA-ANNUAL AND SEASONAL REGIME OF PRECIPITATION IN TÂRGU JIU DEPRESSION (GORJULUI SUBCARPATHIANS) OVER THE 1961-2007 PERIOD

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Abstract

This paper analyzes the intra-annual and seasonal precipitation characteristics of the Târgu Jiu Depression, Getic Subcarpathians (South - West Romania) over the 1961-2007 period. The study used monthly precipitation database for Tg. Jiu climatic station. The results obtained indicate an increase in rainfall average annual amount for 1961-2007 period reported at mean of 20^{th} century, especially for the beginning of 21^{th} century. For the summer, the rainiest season, there is a positive trend. Seasonal and supra-seasonal Precipitation Concentration Index reveals a slight concentration of the rainfalls.

Key words: Târgu Jiu Depression, precipitation regime, Angot Index, Precipitation Concentartion Index

INTRODUCTION

Within Targu Jiu Depression the longest climatological data series was recorded at Targu Jiu station. From climatic point of view Targu Jiu Depression belongs to the hills and high tableland climate with a mean annual value of precipitation between 600-800 mm, evenly distributed during the year (Mihăilescu, 1966; Baranovski et al., 1992; Bogdan et al., 2004).

At the global and regional level, observations show that changes are occurring in the amount, intensity, frequency and type of precipitation, and local and regional changes in the character of precipitation also depend a great deal on atmospheric circulation patterns determined by El Niño, the North Atlantic Oscillation and other patterns of variability (IPCC Report, 2007).

In the XX^{th} century, within Targu Jiu Depression, rainfall, snowfall and other forms of frozen or liquid water falling from clouds had a mean value of 752.3 mm. Compared with this value the 1961-1990 climate normal was higher (788.9 mm), the 1971-2000 climate normal was lower (748.6 mm) and the mean value of the last 50 years (1961-2000) was 790.1 mm (Strat et Nistor, 2012). The first decade of the XXI^{st} century was a rainy one

(890.1 mm) compared to previous decades, with mean values per year of 30 mm, and to tyhe mean of the last century (Strat et Nistor, 2012). For the 2000-2010 decade, 2005 was an excessively rainy one, the 1121.9 mm recorded value being the highest absolute value of the last 50 years (Strat et Nistor, 2012).

The objective of this study was to showing the intra-annual and seasonal precipitation characteristics of Tg.J.D over the 1961-2007 period related to the multi-annual mean references: average precipitation of 20th century and average rainfal for normal period (1961-1990). An other objective was to identify possible changes in the distribution of monthly precipitation totals with the fluctuation of annual precipitation.

DATA AND METHODS

For the present study were used daily and monthly precipitation values (P) recorded at Târgu Jiu meteorological station among 1961-2007 and the average monthly temperature values (T) for the same period, available at http://www7.ncdc.noaa.gov/IPS/mcdw/mcdw.html,http://www.tutiempo.net/clima/Rumania/RO.html,http://eca.knmi.nl/dailydata/predefinedseries.php internet link, and also meteorological yearbooks. On the basis of monthly values were calculated multi-annual arithmetic monthly and seasonal means. Also were calculated averages values for the climate normal (World Meteorological Organization normal period – WMO normal period 1961-1990, 1971-2000) and for 10 years sub-periods.

For assessing the regime of the precipitation within the year it was calculated, for each individual month, the Angot relative precipitation index $\left(K = \frac{p}{P} = \frac{q/n}{Q/\ 365} \right)$ (Dragotă et Baciu, 2008; Sorocovschi, 2010).

This index represents the ratio between the mean daily values (n - number of days from a month) and the mean daily annual value (P=Q/365, Q – mean annual precipitation value). The calculated values were compared with published values for the period 1901-1955 (Dragotă et Baciu, 2008), and the characteristic data for the XXth century.

To assess variation of seasonal and supra-seasonal variation in precipitation amount, Precipitation Concentration Index (PCI) was calculated, which was proposed by Oliver in 1982 (Michiels et al., 1992; Apaydin et al., 2006; de Luís et al. 2000, 2001, 2010; de Luís 2011). This index gives the advantage of getting information on the long-term variability of the precipitations within a region and the yearly, monthly and seasonal regime (Michiels et al., 1992 quoted by de Luís et al. 2000, 2001, 2010; de Luís 2011).

The following equations of PCI (de Luís, 2011) were used to calculate the seasonal (winter, spring, summer and autumn) and half-year variation (warm semester, from April to September, and cold semester, from October to March)

$$PCI_{seasonal} = \frac{\sum_{i=1}^{3} p_i^2}{\left(\sum_{i=1}^{3} p_i\right)^2} \times 25, \text{ and } PCI_{supraseasonal} = \frac{\sum_{i=1}^{6} p_i^2}{\left(\sum_{i=1}^{6} p_i\right)^2} \times 50,$$

where p_i is the precipitation of the i^{th} month.

The values index ranges from 8.3 to 100. For PCI values below 10, there is uniform monthly precipitation distribution over the year variability in precipitation amounts. Values from 11 to 15 denote a moderate seasonality in precipitation distribution, and PCI values from 16 to 20 denote a seasonal distribution. Values above 20 correspond to climates with substantial monthly variability in precipitation amounts (de Luís et al., 2010).

RESULTS AND DISCUTIONS

In terms of precipitation distribution during in the year, according to latitudinal climatic features, the highest precipitation quantity falls in the warm season (May-July). The monthly means for the entire analyzed period reveals that the rainiest month of the year is June: 94.7 mm (Fig. 1). Although as mean value on very long term (1901-2000) and long term (1961-1990, 1971-2000, 1961-2007), June is the rainiest month, for the analyzed period, June was the rainiest month of the year only 15 cases. Calculated on decades, the highest mean of June was on the 1971-1980 decade (102 mm), although in that decade the rainiest month was May (125.5 mm) and not June.

Starting with the last decade of the XXth century, one could notice a reduction of share of June and a shift of the precipitation maximum values towards July and August. In 2001-2007 period, the mean precipitation value of June was 94.9 mm that is same with the climate normal 1961-1990 and climate normal 1971-2000, while the mean values of July and August were 121.9 mm respectively 116.4 mm, with significant positive deviations compared with climate normal 1960-1990 and the multi-annual mean of these months.

Basically, at the beginning of the 21st century, July and August had double the amount of precipitation, compared to the average of the last century.

At century scale, the driest month of the year was February. Instead, in 1961-2007 period, as well as for climate normal, the driest month was March (46.5 mm). The mean monthly values for the 1991-2000 decade, and

2001-2007 period, revealed that the lowest precipitation quantity falls in February.

However, the distribution of the multi-annual monthly quantities reveals a positive linear trend for July, August, September, and October months and negative trends for February, March, and December.

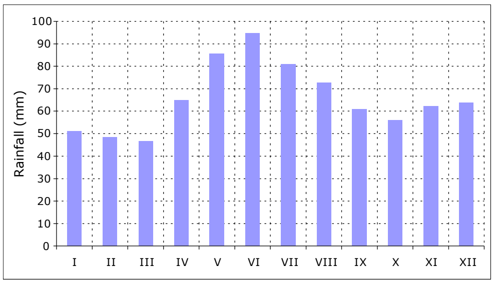

Fig. 1 The distribution of mean multi-annual precipitation over the 1961-2007 period in Târgu Jiu Depression

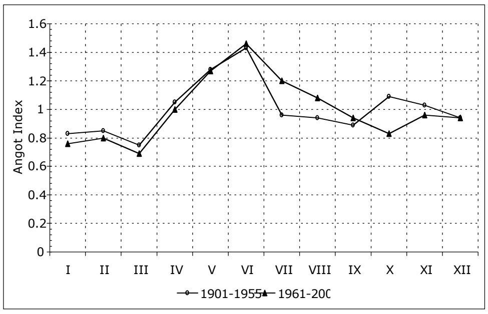

Fig. 2 The monthly multi-annual distribution of Angot Index in Târgu Jiu Depression. (The values of Angot index for 1901-1955 is after Dragotă et Baciu, 2008.)

Angot Precipitation Index highlighting the climate significance of every month in term to detect dry or rainy intervals by listing them under precipitation susceptibility classes corresponding to the precipitation attributes assigned. Thus, the values of Angot index are higher than one, the month is rainy and subunit values indicate a dry month (Dragotă et al., 2008).

The modifications in the monthly and seasonal pluvial regime in the last 50 years can be observed if we compare the Angot Index for two distinct periods: 1901-1955, 1961-2007 (Fig 2). Thus, compared with the first half of the XXth century, the value of Angot Index increased for the whole summer months and for September, the values for July and August being higher than one, but decreased for the other months of the year. All the months with values of the Angot Index higher than one (April-August) belong to the warm season and they are rainy months. The most significant variation is linked to the moment of appearance of the secondary maximum and minimum precipitation period. Thus, if before 1955, the second precipitation maximum took place in October, in the second half of the XXth century in October took place the second minimum precipitation period, the second maximum period being in November. Because the Angot values are less than one, all autumn months are dry. The summer pluvial peak is caused by the convectional precipitation; while the autumn peak is determined by the frontal rains (Dragotă et Baciu, 2008).

The annual values of PCI range between 9.9 and 17.9. In 55% of the cases, the value of PCI ranges between 11 and 15. According to Oliver (1980) these values reveal a slight concentration of the precipitation during in the year. Just in two years, with PCI>16, the distribution of the precipitations had an irregular pattern. For the rest of the years, due to the fact that the value of PCI was under 11, the distribution of the precipitations was relatively uniform.

As can be seen from figures 1 and 2 summer is the rainy season and the winter is the driest season in TgJD. In the XXth century, the summer precipitations accounted 28.44% of the annual but in the second half of the last century (1961-2000) the percentage was higher (30.47%). In the beginning of the XXIst century, to the increased quantity of the precipitations, also increased the share of the summer period up to 37% (2001-2007). To note that in the driest year of the analyzed period (the year 2000), the summer precipitations were with 78.5% fewer than multi-annual mean value of this season and they represented just 16% from the total percentage of the year.

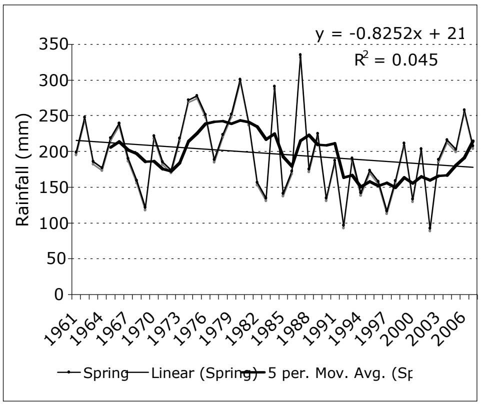

Fig. 3 The multi-annual evolution of the rainfalls in spring for 1961-2007 period

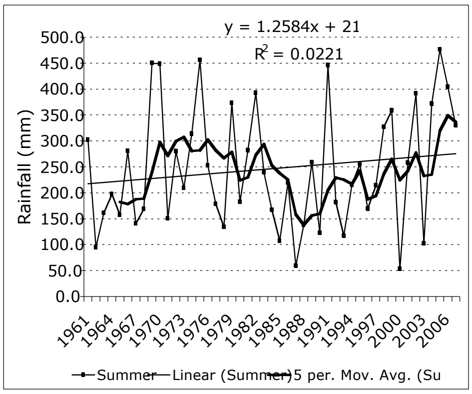

Fig. 4 The multi-annual evolution of the rainfalls in summer for 1961-2007 period

Thus, on the basis of seasonal distribution, the regime of the precipitations according to Musset-Gaussen Index is summer-spring-autumn-winter type within TgJ D. The amplitude between summer and winter increased from the end of the XXth century and the beginning of the XXIst century, the summer precipitations being the double of the winter precipitations. In terms of absolute frequencies, in 1961-2007 period, were just ten years in which a dry winter was followed by a rainy summer. The trends of precipitation for each season in 1961-2007 period show a positive tendency for summer and autumn and negative tendency for winter and spring (Fig 3, 4, 5, 6).

Also, there were changes in the transition seasons in terms of reduction both of quantities and of percentages from the spring months and an increase for the autumn months (Marinică et Marinică, 2010). In these conditions the regime of the rainfalls at the end of XXth century and the beginning of XXIst century turns from summer-spring-autumn-winter type to summer-autumn-spring-winter type.

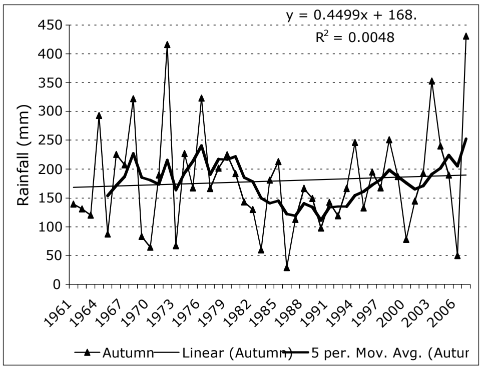

Fig. 5 The multi-annual evolution of the rainfalls in fall for 1961-2007 period

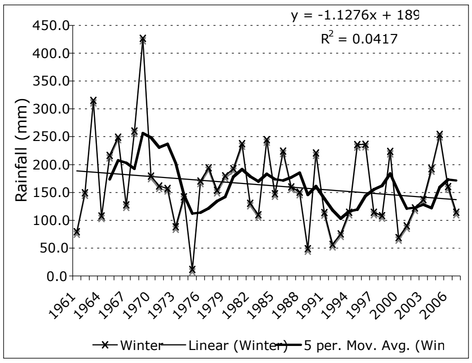

Fig. 6 The multi-annual evolution of the rainfalls in winter for 1961-2007 period

Table 1

The rainy season over the1961-2007 period compared to average and annual amount of precipitation

Year	Spring Average=196	Summer Average=248	Autumn Average=179	Winter Average=163	Annual Average=786.6
1987	**335.6**	59.0	112.9	159.6	666.5
2005	202.8	**475.8**	189.4	253.9	1121.9
2007	207.4	329.8	**431**	114.1	1082.3
1969	121.7	450	83.2	**426.6**	1081.5

Table 2

The driest season over the 1961-2007 period compared to average and annual amount precipitation (mm)

Year	Spring Average=196	Summer Average=248	Autumn Average=179	Winter Average=163	Annual Average=786.6
2002	**92.2**	391.1	192.4	122.3	798
2000	133.2	**53.2**	78.2	68.8	333.4
1986	172	219.3	**29.2**	224.2	644.7
1975	278	455.6	167.6	**11.9**	913.1

There were changes also for transition seasons, in terms of reduction both of quantities and of percentages from the spring months and an increase for the fall months (Marinică et Marinică, 2010). In these conditions the regime of the precipitations at the end of XXth century and the beginning of XXIst century turns to summer-autumn-spring-winter type.

Almost 60% of the annual precipitations fall in the warm semester. Due to the ratio between the amount of the precipitations from the warm season and the cold season is more than one (1.4), highlighting the continental feature of the climate within TgJD. Compared to the multi-annual values, the extreme values for each season have a very great range of variation (table 1 and 2, Fig 3-6).

The seasonal and supra-seasonal values of the PCI are less than 10 and reveal a uniform distribution of the precipitations for each season. Beside, the autumn value of PCI is 8.35, which indicates a perfect uniformity of precipitation distribution in this season.

CONCLUSIONS

The monthly values of Angot index shows that there are no great variations of rainfall values. The values of Angot index, calculated for 1961-2007 period, are greater than one for the warm season (April, May, June July And August). The mean values for long and very long terms shows that June is the rainiest month without significant variations from one year to other. Starting with 1991 one could notice an increase of the rainfall values for July and August. Compared to the 1961-1990 climate normal (69 mm), between 1991-2007, the mean of July was higher with 47.15%. For the same period, the maximum monthly value was recorded also in June.

As opposed to, the month with least rainfalls was February but reported to Angot Index the driest month was March. From seasonal point of view, the summer continues to be the driest season but one could notice a quantitative and percentage increase reported to yearly value. The quantitative increase of the values in fall months led to the change of rainfall regime, from summer-spring-fall-winter regime, characteristic to the XXth century, to the summer-fall-spring-winter regime, characteristic to the beginning of the XXIst century.

The values of PCI < 10 shows a relatively even distribution of the rainfalls within each season, without significant variations from one month to other.

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