THE MULTIANNUAL REGIME OF PRECIPITATION IN TÂRGU JIU DEPRESSION (GORJULUI SUBCARPATHIANS) OVER THE 1961-2010 PERIOD

Strat Daniela *, Nistor Stelian**

*Universitatea din Bucure□ti, Facultatea de Geografie,
Bd. N. Bălcescu nr. 1, cod 010041, sector 1 Bucure□ti
danielastrat@gmail.com
**Universitatea din Oradea, Facultatea de Geografie, Turism si Sport
C.P. nr. 114, O. P. 1, str. Universită□ii nr. 1
snistor@uoradea.ro

Abstract.
This paper analyzes the temporal precipitation characteristics of the Târgu Jiu Depression, Getic Subcarpathians (South - West Romania) over the 1961-2010 period. The study used monthly precipitation database for Târgu Jiu climatic station. Annual precipitation concentrations have been examined in context of their multi-annual mean values and inter-annual variability. To assess the trends have been used parametric and non-parametric tests.
The results obtained indicate an increase in precipitation amount for 1961-2010 period reported at mean of 20th century, especially for the beginning of 21th century. To compare these values, the 30-years climate normal has been computed. However, Mann-Kendal rank test application for the period under review indicates that there is no positive or negative trend.

Key words: Târgu Jiu Depression, precipitation regime, statistical analysis, Mann-Kendall Rank test

INTRODUCTION

The precipitations, together with temperature, are the main elements with the help of which one could establish the climatic profile of a region. Climatic changes are very "visible" using these two terms used for calculating several bioclimatic parameters (Alexander et al., 2006). Due to the tendency of global warming (IPCC Report, 2007), it was confirmed the increase of multi-annual average quantities of precipitations in extra tropical regions from the Northern Hemisphere (Solomon et al., 2007). On the other hand, the same Report suggests that relatively with the general trend there is a significant variability at sub regional level.

Târgu Jiu Subcarpathian Depression (TgJD) is the main subdivision of the main Depression belonging to the Gorjului Subcarpathians, defined by Motru valley to the west, Olteț valley to the east (Mihăilescu, 1966). The limits of TgJD are: Domaneşti Hill, to the west, Copăcioasa Saddle to the east and Bran Hill to the south. Northward, the Depression is elongated along Jiu, Jaletului and Bistriței valleys (Baranovski et Bugă, 1992).

From morphogenetic point of view, the depression is an alluvial plain, formed from the wide terraces of the Jiu river with an altitude under 200 m.

Together with the surrounding hills, the TgJD has a mild climate, caused by the dominant south, south-west and, west air circulation (Baranovski et Bugă, 1992).

Synthesized, the multi-annual monthly climatic features within TgJD are illustrated by Péguy and Bagnouls-Gaussen climographs (Fig 1 and 2).

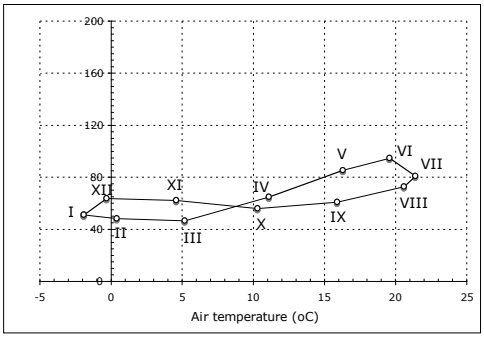

Fig. 1 Péguy Climograph at Târgu Jiu Station (1961-2007, 45° 2′ 3″ N, 23° 16′ 29″ E)

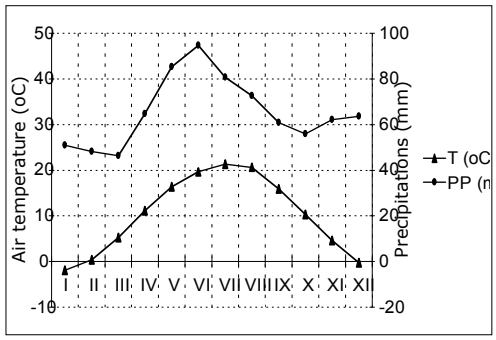

Fig. 2 Bagnouls-Gaussen Climograph at Târgu Jiu Station (1961-2010)

The mean temperature at Târgu Jiu is slightly higher as in nearby hills and depressions (Baranovski et Bugă, 1992). The average temperature of the XXth century was 10.2^0 C (Săraru, 2008). From this average, the mean temperature of the last decade of XXth century had a 0.2^{0}C positive deviation and in the first decade of the XXIst century, the mean temperature was 10.9 ^{0}C.

The relative excessive climate of the TgJD (Baranovski et Bugă, 1992) is revealed by the temperature values of the two extreme seasons (the mean temperature of the summer is 20.5^{0}C and of the winter is -0.6^{0}C) and the annual amplitude is 23.3^{0}C, close to the value of Câmpia Română (Săraru, 2008). In the winter, the temperature inversions are frequent. Annually, in TgJD the average precipitation amount is 750 mm (Baranovski et Bugă, 1992; Romanian Statistical Yearbook 2007, p. 21).

Although in May-September interval, which includes the rainiest month of the year (June) the potential evaporation is higher than the precipitation amount, throughout the entire year, within TgJD, the moisture deficit is not present (Fig. 2), and the mean multi-annual potential evapotranspiration is 677.0 mm (Baciu, 2008).

Recently, an analysis of the main climatic features of TgJD for the last 25 years of the XX century was made by Bogdan et al. (2004). Also, information regarding the regime of the main climatic elements for Târgu

Jiu climatic station for the period 1961-2000 was published in Romania's climate syntheses (Sandu et al. 2008).

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 at meteorological yearbooks. The annual amounts for 2008-2010 years were taken from published papers (http://terraiii.ngo.ro/date/b2d1f2f8f1bb3ec1206dd2e29da29cba/ GASC.pdf, http://arpmdj.anpm.ro/files/ARPM%20Craiova/rsm%202008/Capitolul1.pdf). On the basis of monthly and annual values were calculated multi-annual arithmetic means, the standard deviation and the variation coefficient for 1961-2010. Also were calculated averages values for the climate normal (World Meteorological Organization normal period – WMO normal period 1961-1990, 1971-2000, and 1980-2010), and for 10 years sub-periods.

In order to analyze the trend, the moving average has been calculated for groups of five years, and the Mann-Kendall Rank test was applied:

$$\tau = \frac{\sum_{i=1}^{N} n_i}{N(N-1)} - 1,$$

where n_i is the number values larger than the i^{th} value in the series subsequent to its position in the series value. Its standard deviation (σ) is given by

$$\sigma^2 = \frac{4(N+10)}{9N(N-1)}.$$

The ratio of to the standard deviation gives an indication of trend or no trend in the data. For no trend in the data series, the value of τ/σ gives an indication of trend or no trend in the data (Rakhecha et Singh, 2009).

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

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 XX^{th} century.

The precipitation features of each year, compared with the multi-

annual mean, were evaluated using Hellmann Index (Briciu, 2010) and standardized anomalies of precipitation (SAP): $SAP = \frac{(x_i - \mu)}{\sigma}$, where x_i is precipitation of the *i* year, μ is mean precipitation of entire period time, and σ is standard deviation (Katz et Glantz, 1986; Sneyers, 1992; McKee et al., 1993).

The Lang Rain Factor $\left(L = \frac{P}{T}\right)$ and de Martonne Aridity Index $\left(I_{arDeMartone} = \frac{P}{T+10}\right)$ were calculated for each year also as multi-annual means. P represents the annual precipitation values (in mm) and T is the air temperature (in ^{0}C).

RESULTS AND DISCUTIONS

The statistical data processing revealed that the multi-annual mean (1961-2010) value in TgJD is 790.1 mm (Fig 3 and 4). This value is the cumulative result of the fallen precipitations in about 137 days per year. The mean deviation of the series is 39.3, the standard deviation is 174.35, and the coefficient of variation is 22.16%.

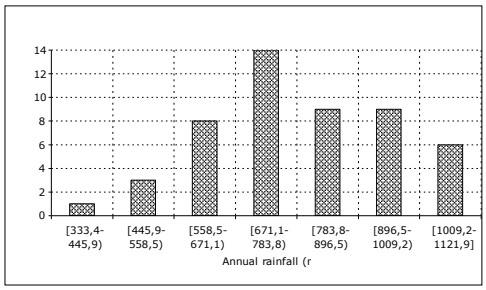

Fig. 3 The annual precipitation values at Târgu Jiu Station (1961-2010) and the frequency distribution

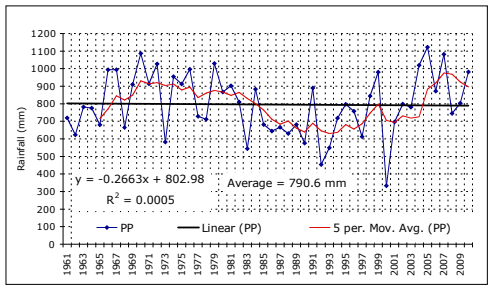

Fig. 4 The evolution of precipitation quantity in Târgu Jiu Depression over the 1961-2010 period

We note that the average value precipitations in 1961-2010 period (790.1 mm) is higher than the mean value of the XXth century (752.3 mm), very close to climate normal 1961-1990 (788.9 mm), and also higher than the climate normal 1971-2000 (748.4 mm), the climate normal 1981-2010 (761.8 mm), and higher than average of 1961-2000 period (765.1 mm).

Analyzing groups of ten years of precipitations, one could notice that the first two decades of the series had an ascendant trend, followed by also an ascendant trend for the following two decades. The mean of the last decade of the last century was lower then both the mean century-old

tendency and mean climate normal. Instead, the mean of the first decade of the XXIth century (890.0 mm) was higher with about 100.0 mm then the mean value of the analyzed period (Fig 5).

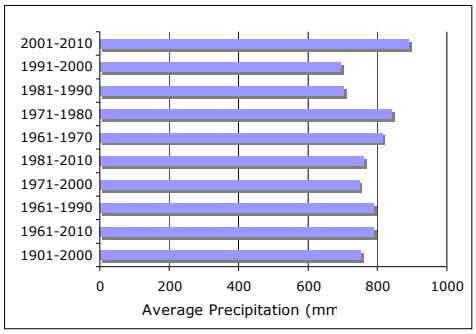

Fig. 5 The multi annual and decadal evolution of mean multi-annual precipitation values

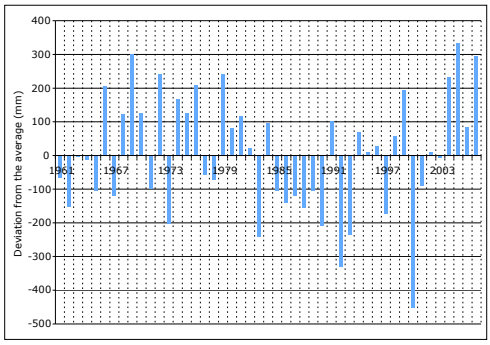

Fig. 6 The deviation of the multi-annual mean of the precipitations (790.1 mm)

In 2005 year had been recorded the maximum absolute value of the all data series (1121.9 mm). Also, in 2005, precipitation amount from TgJD, was a national record (Ru□itoru et Doba, 2010) and the third value from the entire data series (1961-2010). This case is especially notable because, for whole Romania, 2005 was a dry year, the mean precipitation quantity being 540.0 mm (http: // terraiii.ngo.ro/ date/b2d1f2f8f1bb3ec1206dd2e29da29cba / GASC.pdf).

Overall one can see that for the 1961-2000 period was a clear negative trend (R2 = 0.11), but the increase of the precipitation quantities for the 2001-2010 period has caused mitigation of this trend (R2 = 0.0005) for entire analyzed period.

The Mann-Kendall test application revealed the lack of a trend within the entire data series (1961-2010). The value of the t/σ ration is (-1.13) thus being inside the ± 1.96 at 5% level significance, which means that there is no evidence for a positive or negative trend within the data series.

Compared with the mean multi-annual value, in 52% of the cases, the annual precipitation value had a negative deviation. The highest frequency characterized the years in which the annual precipitations had negative deviation compared to the mean (Fig. 6).

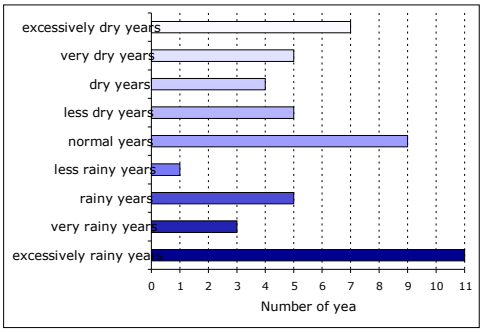

Fig. 7 The precipitation features of the 1961-2007 period according to Hellmann criterion

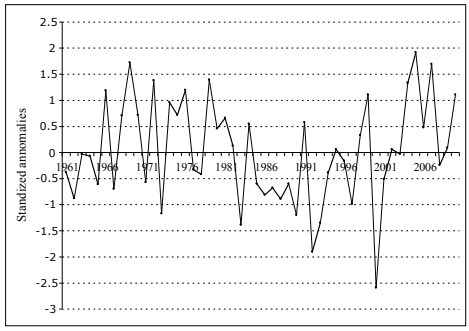

Fig. 8 The standard anomaly of the precipitations

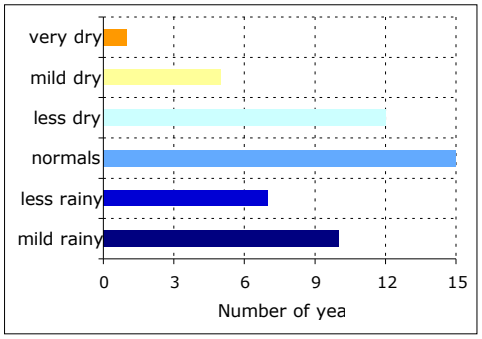

Fig. 9 The frequency of the years grouped according to Standard Anomaly of Precipitations

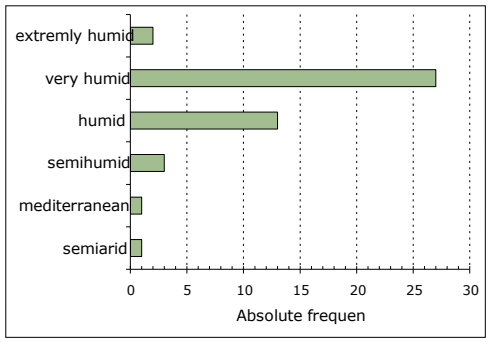

Fig. 10 The frequency of climate classes according to de Martonne Aridity Index

Hellmann test application reveals that, besides the normal years, which clusters around a mean value, a high frequency characterized the years which are in extreme classes – excessively rainy years or excessively dry years (Fig. 7).

The precipitation feature of each year was evaluated also on the basis of SAP for the entire series of data (Fig. 8). Using this criterion, the highest share (30%) was for the normal years (Fig. 9). To note that, in case of using both evaluating methods, the frequency of the dry years is higher than the rainy years, the year 2000 being an exceptionally dry year.

The mean multi-annual value of Lang Rain Factor is 77 mm/°C and the value of de Martonne Aridity Index is 38.8 mm/°C which means that TgJD has a humid climate. De Martonne Aridity Index reveals that the highest frequency have had the years with a very humid climate (Fig. 10).
The multi-annual evolution of the Lang Rain Factor and de Martonne Aridity Index reveals a slightly negative trend (Fig. 11), which is in direct correlation with the positive trend of the mean annual temperatures (Fig. 12).

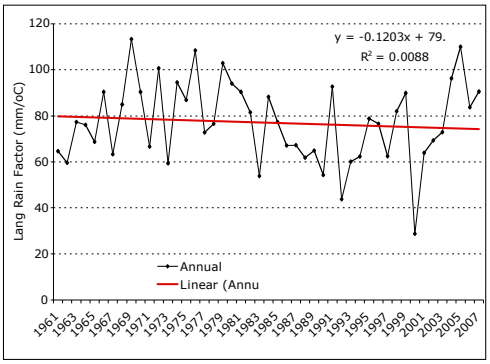

Fig. 11 The evolution of Lang Rain Factor over the 1961-2010 period

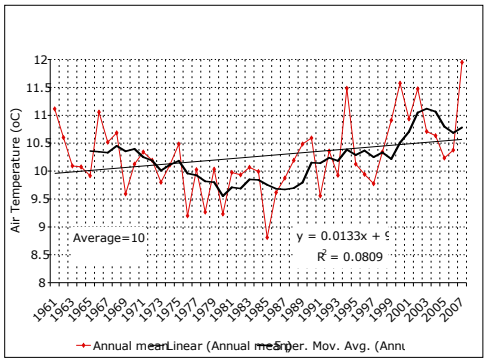

Fig. 12 The evolution of the mean annual temperatures over the1961-2010 period

CONCLUSIONS

Within Targu Jiu Depression the mean multi-annual amount of precipitations between 1961-2010 (790.1 mm) was higher than the mean value of the XXth century (752.3 mm) very close to the 1961-2000 mean climate normal (788.9 mm) but higher than 1971-2000 mean climate normal (748.4 mm) and 1981-2000 climate normal (761.8 mm). Mann-Kendall Rank test application reveals that between 1961-2010 there is no tendency of increase or decrease of precipitations even there are some oscillations from one decade to other.

Within the study period (1961-2010), the 1991-2000 decade was the driest (693.9 mm) and the 2001-2010 decade was the rainiest (889.9 mm). According to Lang Rain Factor and de Martonne Aridity Index, Targu Jiu depression has a humid climate.

Based on the Standard Anomaly of Precipitations Index values, one third of the series of years were normal in terms of precipitation annual amount.

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