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The Periods with Pluviometric Surplus from the Timiş Hydrographical Basin (1965-2009)

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Abstract

The present study is based on the statistical processing of values, referring to the average monthly and average annual precipitations, for the period 1965-2009. The data was taken from six meteorological stations, five of which are located in the hydrographical basin of the Timiş river, and one station is located in the immediate proximity of this basin. The calculation formula used for the identification of the periods with pluviometric surplus, from the entire period and for all analysed meteorological stations, was the Standardised Precipitation Anomaly – SPA. According to the SPA values and their distribution during the analysed period, within the basin, the degree of vulnerability may be determined for the Timiş hydrographical basin compared to the climatic risk, induced by the precipitation surplus, and, thus, compared to the risk induced by the extreme hydrological phenomena, like floods, which are especially of a pluvial origin.

Keywords: *pluviometric surplus*, *climatic risk*, *Standardised Precipitation Anomaly*, *probability*, *flood risk*

Rezumat. Perioadele de excedent pluviometric din bazinul hidrografic al Timişului

Acest studiu se bazează pe prelucrarea statistică a valorilor, referitoare la cantităţile medii lunare şi anuale de precipitaţii, din perioada 1965-2009, de la 6 staţii meteorologice, dintre care 5 sunt situate în cuprinsul bazinului hidrografic al râului Timiş, iar o staţie în imediata apropiere a acestuia. Formula de calcul folosită pentru identificarea perioadelor pluviometrice excedentare, din întreaga perioadă şi pentru toate staţiile meteorologice analizate, a fost cea a Anomaliei Standardizată de Precipitaţii - ASP. În funcţie de valorile ASP şi de distribuţia acestora de-a lungul perioadei analizate, dar şi în cadrul bazinului, se poate stabili gradul de vulnerabilitate pe care îl are bazinul hidrografic al râului Timiş la riscul climatic, indus de excedentul de precipitaţii, şi în consecinţă la riscul indus de fenomenele hidrologice extreme, cum sunt inundaţiile, care în cadrul bazinului, sunt în special de origine pluvială.

Cuvinte-cheie: *excedent pluviometric*, *risc climatic*, *anomalia standardizată de precipitaţii*, *probabilitate*, *risc la inundaţii*

Introduction

The Timiş river, the main hydrographical artery of the historic region of Banat, springs from the crystalline massif of Semenic, under the peak of Piatra Goznei from the altitude of approximately 1135 m and drains the waters that spring from Banat Mountains, Ţarcu Mountains, Godeanu Mountains, Poiana Rusca Mountains and finally the piedmont hills of Lugoj and Pogăniş. The hydrographical basin of the Timiş river has a total surface of 10.352 km2, of which only 5.795 km2 are located on the territory of Romania, meaning approx. 2.44% of the surface of our country (Munteanu, 1998, p. 9).

The periods with pluviometric surplus show the predominance of years with positive deviations of precipitations, compared to the regular years from a pluviometric point of view. These are the consequence of the appearance and the persistence of synoptic situations characterized by the predominance of low-pressure areas, triggering the occurrence of humidity surplus, and, thus, the extreme hydrological phenomena, such as floods (Bogdan, Niculescu, 1999, quoted by Moldovan, 2003).

Method

In order to identify the extremely rainy years and the periods with pluviometric surplus from the analysed period (1965-2009), the values of the *Standardised Precipitation Anomaly* (SPA), for the 6 meteorological station analysed, 5 of them located in the basin (Ţarcu, Cuntu, Semenic, Caransebeş and Lugoj) and 1 of them located in the field area located outside the basin (Banloc), have been calculated first through statistical methods and then interpreted (fig. 1).

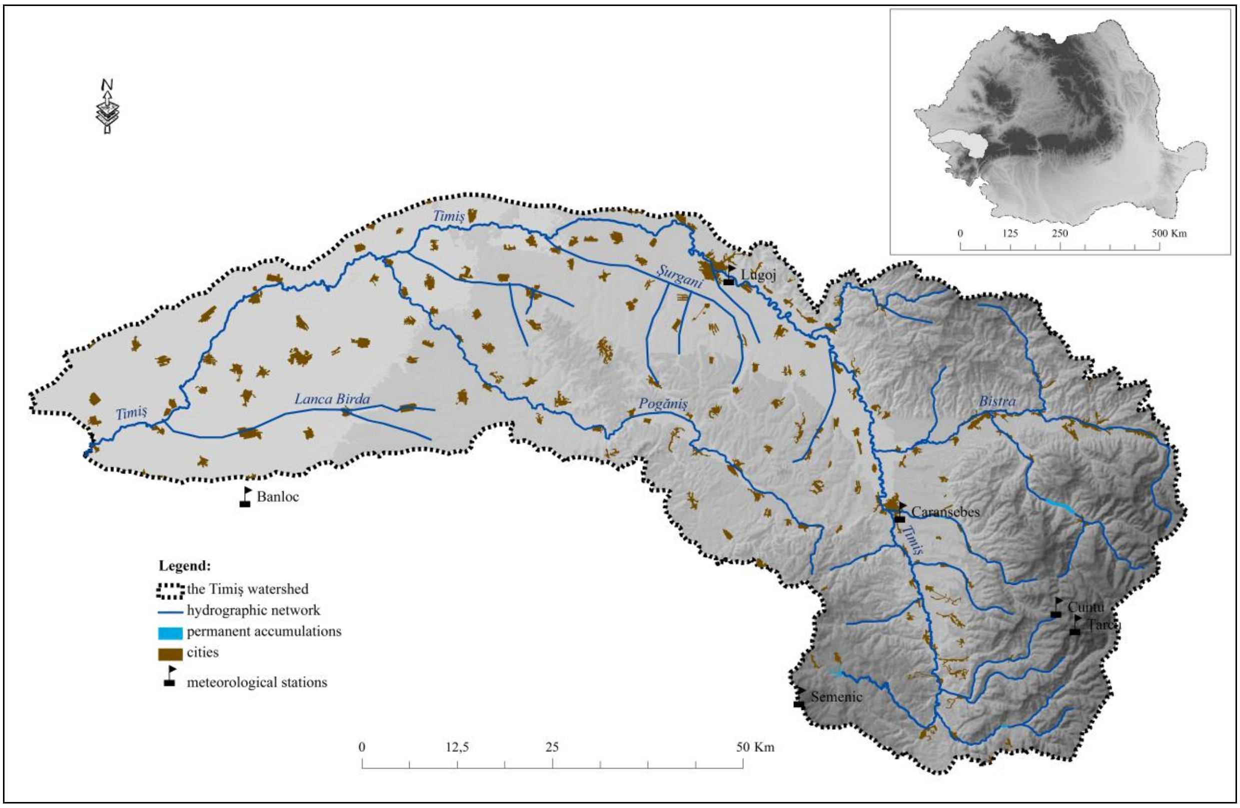

Fig. 1: The location of the meteorological stations analyzed

Even if initially this index was designed to define, to identify and to monitor the dry periods, it may be used successfully to identify the pluviometric surplus situations from a series of data.

The Standardised Precipitation Anomaly (SPA) is based on the cumulative probability of rain that occurs at an observation point from a mathematical point of view, and according to the World Meteorological Organisation, this may be calculated using the following formula:

$$SPA = \frac{x_i - \bar{x}}{\sigma}$$

where:

xi – term of the series, $\bar{x}$ - the average of the series, σ – the deviation from the square average (Moldovan et al., 2002).

The deviation from the square average has been calculated using the following formula:

$$\sigma = \sqrt{\frac{\sum \left(x_i - \bar{x}\right)^2}{n}}$$

where:

xi – the value of the term i of the series, n – the number of values.

According to the classification system achieved by McKee et al. in 1993 (table 1) and according to the SPA values, the intensity of the rainy years from the analyzed period could be defined.

Table 1 Identification criteria of the intensity of the periods with an excess or deficit of precipitations

SPA value	Qualification	Type of risk
≥ 2	extremely wet	high risk
1.5 …1.99	very wet	average risk
1 … 1.49	moderately wet	low risk
-0.99 … 0.99	almost normal	no risk
-1 … -1.49	moderately droughty	low risk
-1.40 …-1.99	very droughty	average risk
≤ -2	extremely droughty	high risk

Source: adapted from McKee et al., 1993, completed by Croitoru, 2006

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Another very useful method for processing the series of meteorological data, but also of the hydrological data, is the occurrence probability calculation of certain maximum values (Teodorescu, 2003). The empirical probabilities of the 3 risk categories regarding the precipitation surplus, for all the stations, have been calculated using the formula:

$$p = \frac{m - 0,3}{n + 0,4} * 100\%$$

where:

m – order number of the maximum flow from the series of the descending terms;

n – the number of the terms from the series

Discussion

For the analyzed period 1965-2009, in order to achieve the study herein, the years with pluviometric deficit, the years with pluviometric surplus and the almost regular years, without pluviometric risk, have been identified (table 2). From the 45 years analyzed, 8 extremely rainy years have been identified at all the analyzed meteorological stations, representing 17.80% of the total number of years analyzed. These years are: 1966, 1969, 1970, 1974, 2001, 2005, 2007 and 2009.

The extremely rich atmospheric precipitations, occurred within the basin over time, have generated the overflow of the Timiş river and its main tributaries, during several years, famous for the significant floods that have affected this area. However, from these 8 years, only 2 (1966 and 2005) have recorded significant floods. Other extremely rainy years, from the beginning period of monitoring the rivers and up to the present, which have led to the occurrence of extreme hydrological phenomena within this hydrographical space, such as floods, have been: 1973, 1912, 1940, 1955, 1975, 1978, 1980, 1990, 1991, 1993, 1995, 1996 and 1997.

Table 2 The frequency of the years with risk of deficit/excess, recorded at the stations

Type of risk	Deficit		Without risk		Excess	
SPA	> -1,0		-1,0 ... 1,0		> 1,0	
Frequencies	No. cases	%	No. cases	%	No. cases	%
Ţarcu	9	20	28	62.22	8	17.78
Cuntu	9	20	28	62.22	8	17.78
Semenic	9	20	28	62.22	8	17.78
Caransebeş	8	17.78	30	66.67	7	15.56
Lugoj	10	22.22	25	55.56	10	22.22
Banloc	6	13.33	29	64.44	10	22.22

Source: the Archives of the Regional Meteorological Centre (C.M.R.) Banat-Crişana, Timişoara

By analyzing figure 2 and 3, we may notice the different distribution of the years with pluviometric surplus, according to the frequency values, at the Ţarcu meteorological station, located at high altitude, as well as at Banloc station, located at the lowest altitude, from the 6 stations analyzed. Thus, we find, in the case of Ţarcu meteorological station, a group of years with pluviometric surplus, with 5 periods (1965-1972, 1974-1977, 1998-1999, 2001-2002 and 2005-2007), as well as a dispersion of the years with risk of precipitation surplus, in the case of Banloc meteorological station. Regarding the frequency values and the mark of the years with different degree of precipitation surplus risk, we may notice from the analysis of table 3 that these differ from one meteorological station to another, separating mainly 3 categories of meteorological stations.

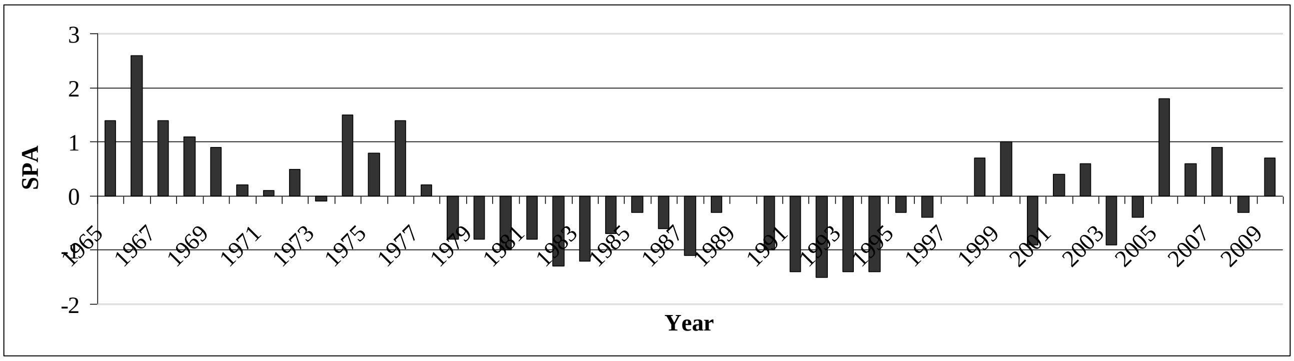

Fig. 2 The chronological variation of SPA values, at the Ţarcu meteorological stations (1965-2009)

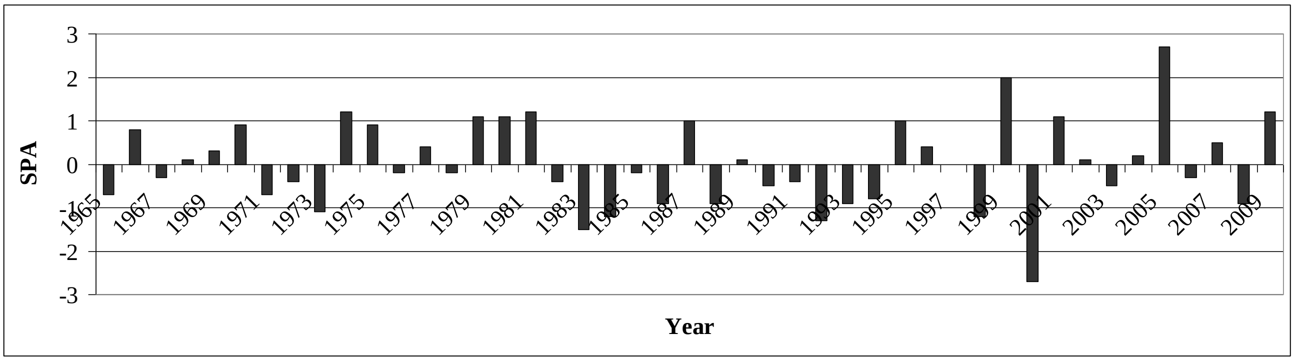

Fig. 3 The chronological variation of SPA values, at the Banloc meteorological stations (1965-2009)

Table 3 The frequency of the years with risk of deficit/excess, recorded at the stations

Qualification	Moderately wet		Very wet		Extremely wet	
SPA	1 ... 1,49		1,5 ... 1,99		≥ 2	
Frequencies	No. cases	%	No. cases	%	No. cases	%
Ţarcu	5	11.11	2	4.44	1	2.22
Cuntu	4	8.89	4	8.89	-	-
Semenic	4	8.89	2	4.44	2	4.44
Caransebeş	2	4.44	4	8.89	1	2.22
Lugoj	6	13.33	2	4.44	2	4.44
Banloc	8	17.77	-	-	2	4.44

Source: the Archives of the Regional Meteorological Centre (C.M.R.) Banat-Crişana, Timişoara

The first category consists of Caransebeş meteorological station, located at an average altitude, with the lowest values of the frequency of years with pluviometric surplus (15.56%). The second category consists of the mountainous meteorological stations (Ţarcu, Cuntu and Semenic), with an average frequency of 17.78%, that is 8 years with pluviometric surplus. And the last category consists of the meteorological stations located at low altitudes Banloc an Lugoj, which have recorded the highest values of frequency, that is 22.22%, 10 years with pluviometric surplus, from the total of 45 years analysed.

By analysing table 4, we may notice that the probability values for all the 3 risk categories are different from one meteorological station to another, values according to which 3 categories of meteorological stations may be separated, as in the case of frequency.

The first category, with a probability <15%, is represented by the Caransebeş station, with the lowest risk regarding the precipitation surplus, thus a reduced risk of occurrence of extreme phenomena triggered by the excessive precipitations, such as floods. The second category of stations is the one with a probability ranging between 15 and 20% consisting of the mountainous stations, such as: Ţarcu, Cuntu and Semenic. The last category is formed of the stations located at the lowest altitude, such as: Lugoj and Banloc, which have a probability >20%.

The highest value of the probability of years with precipitation surplus recorded at the Banloc meteorological station (20.70%), value that may be explained by the station location, in the western extremity of the country, more exposed to the oceanic masses of air, coming from the west part of the continent, than the other meteorological stations within the basin.

Table 4 The probability of the years with risk regarding the pluviometric surplus, according to SPA

Qualification	Moderately wet	Very wet	Extremely wet	Total
Probability	Low risk (%)	Medium risk (%)	High risk (%)	(%)
Ţarcu	10.35	3.74	1.54	15.64
Cuntu	8.15	8.15	0	16.30
Semenic	8.15	3.74	3.74	15.64
Caransebeş	3.74	8.15	1.54	13.44
Lugoj	12.56	3.74	3.74	20.04
Banloc	16.96	0	3.74	20.70

The differences that occur between the 3 mountainous stations are due to the different location related to the masses of air coming from the west and south-west. Semenic meteorological station is located on the western slope of Semenic Mountains, reason for which the climbing of the masses of air from the west and south-west favour the intensification and the increase of the precipitation quantities (Stanciu, 2002). Therefore, the frequency of years with precipitations surplus from this station is similar with the value of the frequency specific for the Ţarcu station, located at the highest altitude, 748 m higher than the first.

The frontal activity developed by the cyclones moving from the Mediterranean Sea over the Balkan Peninsula, over the western part of our country, is one of the main causes for the occurrence of extreme hydrological phenomena, such as floods, and it is responsible for the increase of the flood risk of this hydrographical space, especially during spring, in April, when the precipitation quantities fallen on the surface of the basin are added to the quantity of water resulted from the sudden melting of the snow.

The pluviometric differences, which occur between the analysed meteorological station and the stations from other parts of the country, but also from one station to another, are due to the complexity of the physical and geographical factors, existing in the Timiş hydrographical basin, among which the fact that the relief is disposed in stages from east to west, from the mountainous area to the field area, in the way of the oceanic and Mediterranean masses of air (Ghibedea et. al., 1973).

Conclusion

The present study emphasises that, for the period 1965-2009 and for most of the meteorological stations from the basin, the periods with pluviometric surplus have a more reduced frequency than the pluviometric defective periods, and the frequency of the years with these two categories of pluviometric risk, is much lower than the frequency of the normal years from a pluviometric point of view.

Unlike other regions of the country, the western region, where the Timiş hydrographical basin is located, dominated by moderate oceanic influences, records a relatively high frequency, duration and intensity of extreme hydrological phenomena, caused by the large quantities of precipitations, especially that, most of the times, the water resulting from the sudden melting of snow during spring is added to the precipitations fallen, a phenomenon caused by the invasion of the masses of Mediterranean warm air.

Taking into account the negative consequences of the precipitations surplus and the frequency of the years with this kind of risk, responsible for the occurrence of the extreme hydrological phenomena, such as floods, the need to draw up this type of studies regarding the risk induced by the precipitation surplus, is obvious. The first step in the analysis of the vulnerability is that certain regions have to this type of risk, and indirectly to the risk that the same regions may have to flooding.

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