

ANOMALIES OF PRECIPITATION IN MARAMUREȘ DURING THE PERIOD 1961-2013, ANALYZED BY THE SPA METHOD

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Abstract

The paper analyzed the wet, normal and dry years during the period 1961-2013, from 4 weather stations located in Maramureș County. The positive and negative annual precipitation anomalies were established by the method of Standardized Precipitation Anomaly (SPA). The climatic hazards generated by the excess and deficit of precipitation were established based on the extreme annual SPA values, using the percentile method. The result was that in Maramureș, the pluviometric surplus of the wettest years was more intense than the pluviometric deficit of the driest years. The hazards generated by the pluviometric surplus may occur starting from annual amounts of precipitation over 950-1550 mm and positive SPA values over 1.36-1.68. The hazards generated by pluviometric deficit may occur starting from annual precipitation amounts of less than 575-1025 mm and negative SPA values lower than 1.23-1.53. At most stations, a linear trend of increase in annual SPA values was revealed. The longest droughty period in Maramureș was 1982-1996 and the most intense rainy period was 1998-2010.

Key words: standardized precipitation anomaly, climatic hazard, wet year, dry year, trend

INTRODUCTION

Territories in northern Romania are characterized by a sharp increase in frequency and intensity of the severe weather phenomena, especially in recent years. These territories are exposed to the moist air masses, both of Atlantic and Mediterranean origin, which in contact with the high region of the Eastern Carpathians generates large amounts of rainfall. Large temperature differences between the air masses crossing the area cause the stormy phenomena, so that the showers, lightning, hail and even floods are common. In contrast, the long-term droughts also affect the region, but are less intense than in other regions of the country (Geography of Romania, vol.III, 1987; Ion-Bordei, 2009; Bogdan, Marinică, 2007).

Maramureș County has a mountainous and depression landform, with altitudes that generally grow from the west to the east. The highest altitudes are found in Rodnei Mountains (over 2000 m), located in the eastern county.

MATERIAL AND METHOD

The paper analyzed the wet, normal and dry years during the period 1961-2013, from the weather stations located in the county of Maramureș. In this regard, the annual amounts of precipitation from 4 weather stations were used, those with the common observation period: Baia Mare, Sighetu

Marmației, Ocna Șugatag, Iezer. The annual precipitation anomalies were established by *the method of Standardized Precipitation Anomaly (SPA)*. The data come from the database of the National Meteorological Administration of Romania.

Those 4 weather stations are located at altitudes between 216-1785 m (Baia Mare: 216 m; Sighetu Marmației: 275 m; Ocna Șugatag: 503 m; Iezer: 1785 m).

In this paper, the positive and negative annual anomalies of precipitation were highlighted, so the climatic hazards generated by the excess and deficit of precipitation. The annual standardized precipitation anomalies were calculated using the formula (Busuioc, 1992):

$$SPA = (x - \bar{x}) / \sigma \quad \sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

where:

\bar{x} - the multi-annual average amount of precipitation;

x - the precipitation amount of a particular year;

σ - the standard deviation (average quadratic deviation) of the annual amount of precipitation;

n - the length of the data row.

The thresholds between the pluviometric ratings were established on the basis of *the percentile method*, a method considered more efficient (Busuioc, personal communication; Șerban et al., 2008; Șerban, 2010; Șerban, Dragotă, 2014; Șerban, 2015 etc.). The method is based on the increasing ordering of the n values in a row of data and dividing them into a number of k equal parts (n/k) (Țarcă, 1998, quoted by Dragotă et al., 2003). Thus, 10 classes of values were established for annual SPA. The pluviometric ratings were considered from "extremely wet" to "extremely dry". The pluviometric hazards were established based on the annual extreme SPA values.

RESULTS AND DISCUSSION

In Maramureș county, during 1961-2013, the multi-annual average amount of precipitation stood at 748.3-774.8 mm at the weather stations in Maramureș Depression (Ocna Șugatag and Sighetu Marmației), at 891.1 mm in Baia Mare and 1269.6 mm at the highest station, Iezer.

Based on the percentile method, the classes of values were established and the pluviometric ratings were given for the years of the period 1961-2013. This resulted in wet, normal and dry years (Tab. 1-2). The rainiest years were (Tab. 3):

- **2010** – with positive anomalies between +1.76 and +2.29, the highest deviation being in Baia Mare (1241.8 mm precipitation);

- **1970** – which recorded the highest SPA value of the analyzed period (+3.36), at Iezer station (1935.1 mm);
- **2001** – with the highest SPA value at Sighetu Marmației (+1.98 and 1043.5 mm precipitation).

Table 1

The wet and normal years in Maramureș (1961-2013)

STATION/ YEARS	Extremely wet	Very wet	Wet	Moderately wet	Normal	
Baia Mare	2010	2005	2002	1992	1965	2013
	1970	2008	1985	1995	1981	2000
	2001	2004	1977	1997	1979	1962
	1998	1974	2009	1984	1988	1994
	1966	2006	1980	1978	1964	2007
				1999	1993	
Sighetu Marmației	2001	1970	1974	2009	1977	1976
	1980	2007	2005	2006	1964	1993
	1998	2004	2013	1968	1985	1995
	2010	1978	1989	1979	2012	1965
	2008	1981	1966	1988	1997	1984
				1999	1972	
Ocna Șugatag	2010	1980	2013	1988	1995	1965
	2004	2005	1974	1962	1982	1966
	2001	1999	1964	2002	2009	1996
	2008	2007	1978	1981	1985	1967
	1998	1970	2006	1997	1979	1986
				1968	1977	
Iezer	1970	2006	1978	1998	1968	2012
	2010	1981	1971	2002	1969	1984
	2008	1974	1980	1995	1973	1963
	2004	1962	1972	1965	1976	1979
	2007	1977	1966	1985	2009	2003
				2005	1964	

The driest years were (Tab. 3):

- **1961** – with negative anomalies between -1.51 and -2.46, the most intense drought being in Sighetu Marmației (440.8 mm rainfall);
- **2011** – with the lowest SPA value in Baia Mare (-1.90 and 600.9 mm precipitation).

The extremely wet/dry years – representing the hazards generated by the pluviometric surplus/deficit – have the positive SPA values between +1.36 and +3.36, and the negative ones between -1.23 and -2.46. It is noted that the positive anomalies have higher values than the negative ones. This means that, in Maramureș, *the pluviometric surplus of the wettest years was more intense than the pluviometric deficit of the driest years* of the period 1961-2013. This is due to the Baltic and oceanic influences of the climate of the region, which give it a cool and wet character. It also notes that the

droughts of the lowest intensity have occurred at the highest altitude station, Iezer, a station located in the high mountain area, in the glacial cirque below Pietrosu Peak (2303m).

Table 2

The dry years in Maramureş (1961-2013)

STATION/ YEARS	Extremely dry	Very dry	Dry	Moderately dry
Baia Mare	2011	1973	1990	1996
	1961	2012	1982	1968
	2003	1971	1975	1986
	1972	1976	1969	1967
	1983	1963	1989	1991
Sighetu Marmaţiei	1961	1963	2011	1987
	1973	1971	1992	1967
	2003	1986	1983	1982
	1991	1969	1975	1994
	2000	1990	1996	1962
Ocna Şugatag	2011	1983	1992	1990
	2012	1975	1984	1987
	1961	2003	1976	1963
	1991	2000	1973	1994
	1969	1971	1972	1993
Iezer	1961	2013	1983	1982
	1996	1992	1994	1991
	1986	2011	1993	1999
	2000	1997	1990	1967
	1989	1987	1975	2001
			1988	

Table 3 shows the SPA values and the annual precipitation amounts starting from the pluviometric hazards are manifested in the studied region. Thus, in Maramureş, *the hazards generated by the pluviometric surplus may occur starting from annual amounts of precipitation over 950-1550 mm (and positive SPA values over 1.36–1.68). The hazards generated by pluviometric deficit may occur starting from annual precipitation amounts of less than 575-1025 mm (and negative SPA values lower than 1.23–1.53).*

It is observed, at the highest altitude stations (Iezer and Ocna Şugatag), that the rainiest years occurred mainly in the decade 2001-2010. Also, the wettest year (2010) was followed by the driest year (2011) of the analyzed period, at two stations (Baia Mare and Ocna Şugatag). The results coincide with those found by the author in the previous studies (Şerban, 2015).

Table 3

The extremely wet/dry years, the SPA values and annual precipitation amounts corresponding to those years, in Maramureş (1961-2013)

YEARS		Baia Mare	Sighetu Marmaţiei	Ocna Şugatag	Iezer
Extremely wet	Year	2010	2001	2010	1970
		1970	1980	2004	2010
		2001	1998	2001	2008
		1998	2010	2008	2004
		1966	2008	1998	2007
	SPA value	+2.29	+1.98	+2.12	+3.36
		+1.81	+1.84	+1.80	+1.93
		+1.76	+1.82	+1.79	+1.82
		+1.67	+1.76	+1.76	+1.48
		+1.36	+1.68	+1.54	+1.43
	Precip. amount (mm)	1241.8	1043.5	1022.4	1935.1
		1168.4	1023.8	982.0	1652.2
1160.0		1021.3	980.1	1630.2	
1146.9		1013.0	976.1	1561.7	
1099.7		1003.1	948.0	1552.4	
Extremely dry	Year	2011	1961	2011	1961
		1961	1973	2012	1996
		2003	2003	1961	1986
		1972	1991	1991	2000
		1983	2000	1969	1989
	SPA value	-1.90	-2.46	-1.54	-1.61
		-1.86	-1.46	-1.52	-1.50
		-1.78	-1.36	-1.51	-1.41
		-1.58	-1.33	-1.46	-1.35
		-1.53	-1.24	-1.33	-1.23
	Precip. amount (mm)	600.9	440.8	549.3	951.3
		606.3	576.8	552.0	973.2
618.7		590.5	552.2	991.0	
648.7		595.2	559.2	1001.4	
656.8		606.6	575.4	1025.2	

Figures 1-4 highlight a linear trend of *increase* in annual SPA values at most stations (except the station Iezer, where the trend is slightly decreasing). The increase is due to higher amounts of precipitation recorded since 1998. The biggest growth is recorded at the northernmost station, Sighetu Marmaţiei.

The polynomial trend highlights periods of pluviometric deficit, succeeded by periods of surplus. Thus, the longest period of deficit in Maramureş is, generally, 1982-1996, and the most pronounced period of excess is 1998-2010.

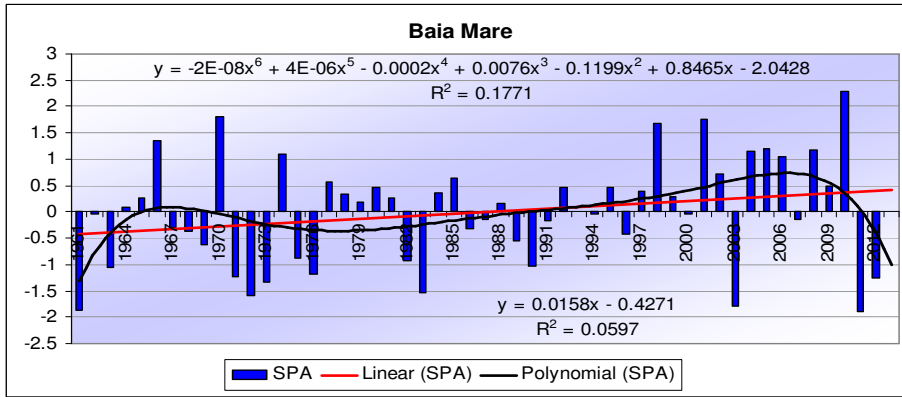


Fig. 1. The linear and polynomial trend of the annual SPA values, at Baia Mare weather station (1961-2013)

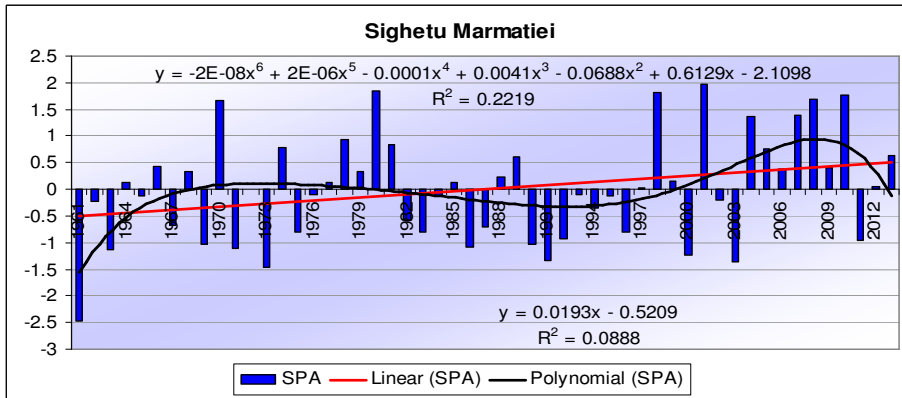


Fig. 2. The linear and polynomial trend of the annual SPA values, at Sighetu Marmatiei weather station (1961-2013)

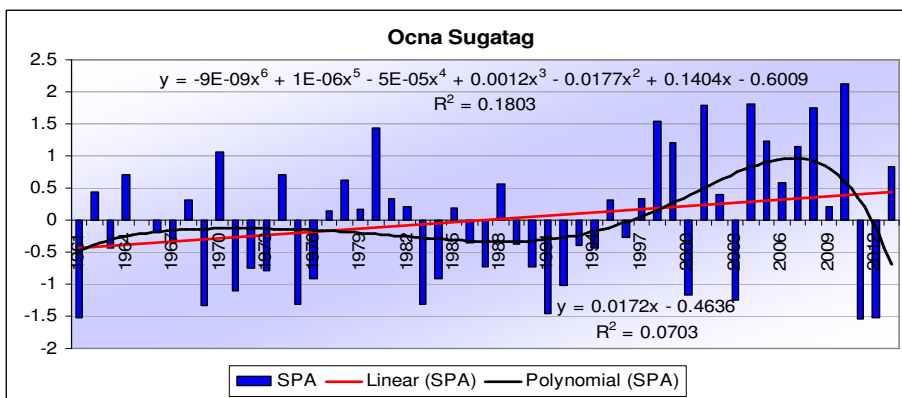


Fig. 3. The linear and polynomial trend of the annual SPA values, at Ocna Șugatag weather station (1961-2013)

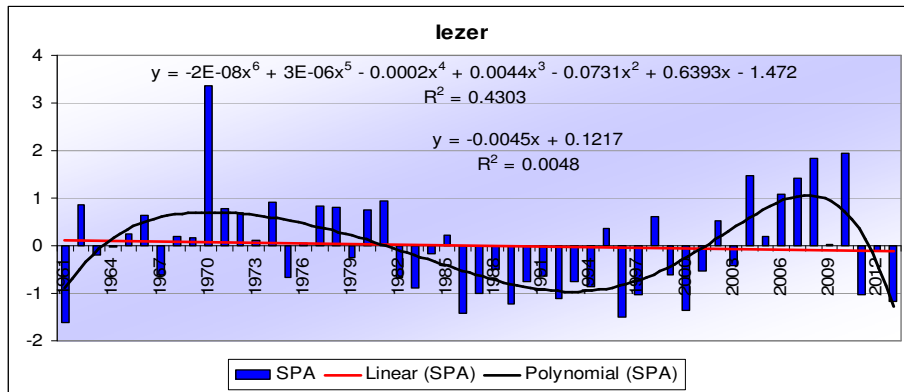


Fig. 4. The linear and polynomial trend of the annual SPA values, at Iezer weather station (1961-2013)

CONCLUSIONS

The paper debated the wet, normal and dry years that occurred in the period 1961-2013, in Maramureş County, focusing on the hazards generated by the excess and deficit of rainfall (the annual extreme SPA values). In Maramureş, the pluviometric surplus of the wettest years was more intense than the pluviometric deficit of the driest years. The droughts of the lowest intensity have occurred at the highest altitude station, Iezer. The wettest years were 2010, 1970, 2001, and the driest 1961 and 2011.

The hazards generated by the pluviometric surplus may occur starting from annual amounts of precipitation over 950-1550 mm and positive SPA values over 1.36–1.68. The hazards generated by pluviometric deficit may occur starting from annual precipitation amounts of less than 575-1025 mm and negative SPA values lower than 1.23–1.53.

At most stations, a linear trend of increase in annual SPA values was revealed. The longest droughty period in Maramureş was 1982-1996 and the most intense rainy period was 1998-2010.

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