

## THE ANNUAL NUMBER OF DAYS WITH PRECIPITATION AND ITS ASSURANCE DEGREE DURING 1961-2016, IN MARAMUREȘ COUNTY

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**Keywords:** number of days with precipitation, assurance degree, frequency, trend, decade.

**Abstract.** The paper analyzed the annual number of days with precipitation from 4 weather stations located in Maramureș County, during 1961-2016. The frequency of these days, their spatial and temporal variability, the decennial distribution of the number of days with precipitation, the trend and the assurance degree of the annual number of days with precipitation were also studied. The result was that in Maramureș County, between 157 and 194 days with precipitation occur on average per year. The mean annual number of days with precipitation increases from west to east, as the altitude of landforms increases, but also from south to north, as latitude increases. The analysis of the rainy and dry yearly intervals reveals the appearance of several extreme years towards the end of the analyzed period, in the last decade and a half (2000-2016). The linear trend of the annual number of days with precipitation is slightly increasing at the lowest station Baia Mare and decreasing at the other stations. The wettest decades were the 5<sup>th</sup> (2001-2010) and the 1<sup>st</sup> (1961-1970), and the driest decades were the 6<sup>th</sup> (2011-2016) and the 3<sup>rd</sup> (1981-1990). On the territory of Maramureș County, the values corresponding to the characteristic assurances (1, 2, 5, 10, 20, 25, 50, 80 and 100%) of the annual number of days with precipitation increase from west to east and from south to north. Once every 100 years, between 225 and 273 days with precipitation can occur in Maramureș.

### Introduction

In Maramureș County, the amounts of precipitation are high, being owed to the location of the mentioned territory in the North of the country, where it is frequently crossed by the southern sectors of the atmospheric fronts of the European cyclones crossing the continent. Also, the high altitudes of the

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mountainous relief that prevails in the county, as well as the favorable exposure of the mountain ranges to the advections of the oceanic air masses, favor the fall of significant amounts of precipitation (Geography of Romania, vol.III, 1987). On this territory, the precipitation increases from west to east, as the altitude increases, the greatest heights being in Rodna Mountains (over 2000 m), where the largest amounts of precipitation are reported. In the intra-mountainous depressions, due to the lower altitudes that determine the descent of air masses, the rainfall is lower.

Studying the number of days with precipitation in a given territory has an important role not only in knowing the temporary and spatial variability of this climatological element, but also in improving the meteorological forecasts or in knowing the natural hazards generated by precipitation. The study also finds its applicability in other areas such as agriculture, hydrology, pedology, energy, ecology, economics etc. There are many studies on the number of days with precipitation, in Romania (Apostol, 2004; Larion, 2004; Gaceu, 2005; Dragotă, 2006; Mihăilă, 2006; The Climate of Romania, 2008; Şerban, 2008; Şerban, 2010; Apostol, Machidon, 2011; etc.).

#### Materials and methods

In this paper, the daily precipitation data were used for a period of 56 years (1961-2016), from 4 weather stations located in Maramureş County. The four stations selected for study have a common analysis period and are: Baia Mare, Sighetu Marmăţiei, Ocna Şugatag, Iezer. They are located at different altitudes, ranging between 216-1785 m (Baia Mare: 216 m; Sighetu Marmăţiei: 275 m; Ocna Şugatag: 503 m; Iezer: 1785 m) and are found in either depression areas or high mountains.

The monthly number of days with precipitation was extracted from the daily data of precipitation and then, the annual one was calculated. By "*a day with precipitation*" we understand *the 24-hour interval during which the measured precipitation amount was  $\geq 0.1$  mm* (Marin, 1986; Dragotă, 2006; Croitoru, 2003; Mihăilă, 2006; The Climate of Romania, 2008; Şerban, 2008; Tudose et al., 2016; etc.). The annual and decennial number of days with precipitation, the frequency of these days, their spatial and temporal variability, the decennial distribution of the number of days with precipitation and the trend of the annual number of days with precipitation were analyzed, then. The assurance degree of the annual number of days with precipitation was also calculated.

The calculation of the annual number of days with precipitation corresponding to characteristic assurances (1, 2, 5, 10, 20, 25, 50, 80 and 100%) was made using the formula:

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

where  $p$  represents the assurance (the total probability),  $m$  the order number of the data series, ordered by descending, and  $n$  the number of observation years (Marin, 1986; Bogdan, 2000). The method provides the possibility of calculating several percentage degrees of assurance, thus having greater accuracy.

The meteorological data used in the present paper come from the National Meteorological Administration of Romania and the website [www.meteomanz.com](http://www.meteomanz.com).

### Results and discussion

At the analyzed weather stations, the multiannual mean amount of precipitation for the period 1961-2016 is 885.1 mm at Baia Mare, 772.4 mm at Sighetu Marmăţiei, 748.9 mm at Ocna Şugatag and 1261.4 mm at Iezer. The highest values are recorded in the east of the county, at the highest station, Iezer, a station located in the glacier cirque below Pietrosu Peak (2303 m altitude), a peak belonging to Rodna Mountains. The lowest values are reported at the stations in Maramureş Depression (Ocna Şugatag and Sighetu Marmăţiei), due to the katabatic effects of air masses.

#### 1. The annual number of days with precipitation

In Maramureş County, between *157 and 194 days with precipitation* occur on average per year (Table 1), meaning that on this territory it rains about *5-6.5 months* a year, on average. The mean annual number of days with precipitation increases from west to east, as the altitude of landforms increases, but also from south to north, as latitude increases. Most days with precipitation are recorded at the highest station, Iezer. The fewest days are reported in Baia Mare, the station of the lowest altitude, located in the depression with the same name.

Table 1. The mean, maximum and minimum annual number of days with precipitation in Maramureş (1961-2016)

STATION	Baia Mare	Sighetu Marmăţiei	Ocna Şugatag	Iezer
Mean no.	157	166	162	194
Maximum no.	196	219	214	252
Year of maximum number occurrence	1970	1970	1970	1970
Minimum no.	114	123	125	146
Year of minimum number occurrence	1961	1961	1961	2000

Figures 1-2 show the annual number of days with precipitation in Maramureş, between 1961 and 2016. At all 4 stations, the same periods with increases and

decreases of the values are observed, a sign that in the analyzed area, the fallen rains are due to the same synoptic situations. If at the lowest station, Baia Mare, the annual number of days with precipitation from the 56 analyzed years did not exceed 200 days, instead, at the stations in Maramureş Depression, it was slightly above this value in a few years. Significantly superior to the values of the other stations are those of the Iezer station, which go up to over 250 days, having a large number of years with values over 200 days (19 years).

The graphs highlight the drought of 1961, the peak of the year 1970, the dry period 1972-1977, the rainy period 1978-1981, the drought interval 1982-1993 (with a few exceptions at Iezer station), the rainy interval 1994-2010 (interposed with the great droughts of the years 2000, 2003 and culminating with the peak of the rainy year 2010), the droughts of the years 2011-2012 and 2014-2015. Actually, we notice *the appearance of several extreme years towards the end of the analyzed period, in the last decade and a half (2000-2016)*.

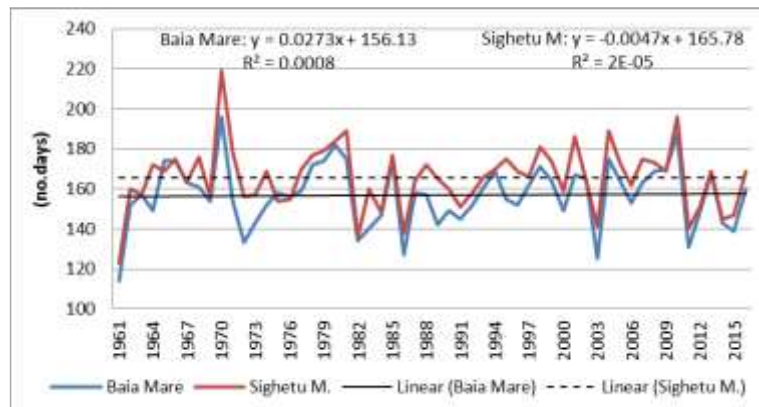


Fig. 1. The annual number of days with precipitation and its linear trend, at the weather stations Baia Mare and Sighetu Marmarței (1961-2016)

At all the analyzed stations, the highest annual number of days with precipitation was  $\geq 180$  days. Thus, 3 years were recorded in Baia Mare, 4 years in Ocna Şugatag, 7 years in Sighetu Marmarței and 46 years in Iezer, far exceeding the other stations. In this case, we also notice the increase in the number of years with high values of the days with precipitation from south to north and from west to east.

*The maximum annual number of days with precipitation varied between 196 and 252 days and occurred, at all the analyzed stations, in 1970 (Table 1). That means in this year, it rained between 6.5 and 8.5 months in Maramureş. The year 1970 recorded large amounts of precipitation and floods in many regions of*

Romania. In Transylvania, the catastrophic floods caused great damage (Topor, 1970). At most stations in Maramureş, the annual precipitation amount exceeded 1000 mm, reaching 1935.1 mm at Iezer.

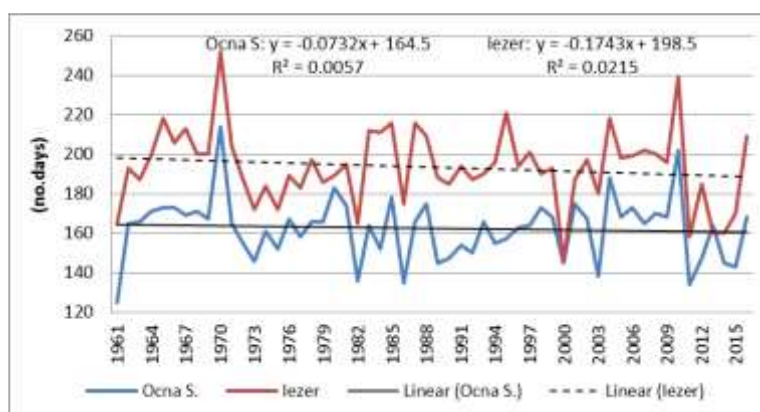


Fig. 2. The annual number of days with precipitation and its linear trend, at the weather stations Ocna Şugatag and Iezer (1961-2016)

At all 4 stations, the second year with high values was 2010, an extremely rainy year (Şerban, 2016). That year recorded between 187-239 days. Other years with high values of the days with precipitation were: 2004, 1980, 1981, 1995, etc.

The minimum annual number of days with precipitation ranged between 114 and 146 days. At most stations, this number was registered in 1961 and only at Iezer station in the year 2000 (Table 1). These years were extremely dry in Maramureş (Şerban, 2016). Thus, in 1961, the annual precipitation amounts dropped to about 440-600 mm at all weather stations, except Iezer station (950 mm). The drought of these two years was, in fact, intense throughout Romania.

Other years with a small number of days with precipitation were: 2011, 1986, 1982, 2003, 2014, 2015, etc.

The linear trend of the annual number of days with precipitation (Fig. 1-2) is *slightly increasing* at the lowest station Baia Mare and *decreasing* at the other stations. In Sighetu Marmăţiei, the downward trend is very weak. The most pronounced decrease is reported at the Iezer station and is due to the low values of the last years. However, the annual precipitation amounts had an upward trend between 1961 and 2016 at most stations (except for Iezer, where the trend was decreasing). These predominantly opposite trends (downward of the number of days with precipitation and upward of the amounts of precipitation) are due to the increase in the frequency of convective cloudy formations in recent years, because

of the increase in air temperature, which generates large amounts of precipitation in short intervals.

Figure 3 shows *the frequency* of the mean annual number of days with precipitation from the total number of days of the year. On the territory of Maramureş County, the days with precipitation have a frequency of 43-53% of the total number of days of the year. The lowest station, Baia Mare has the lowest frequency (43%). In Maramureş Depression, the frequency of these days is 45%. Instead, at the highest station, Iezer, the days with precipitation exceed a half of the days of the year, on average (53%).

## 2. The decennial number of days with precipitation

The annual number of days with precipitation was averaged over the 6 decades of the analyzed period 1961-2016, resulting in the mean decennial number (Fig. 4). The last decade (2011-2016) is not complete, including just 6 years. The figure shows that most days with precipitation occurred, at most weather stations, during the 5<sup>th</sup> decade (2001-2010), then in the first decade (1961-1970). Only at the Iezer station the most days were reported in the first decade, followed by the 5<sup>th</sup> decade. These two decades were the rainiest, in the entire county. Sighetu Marmatiei station is an exception, here the rainiest decades being the 5<sup>th</sup>, followed by the 2<sup>nd</sup> and the 1<sup>st</sup>.

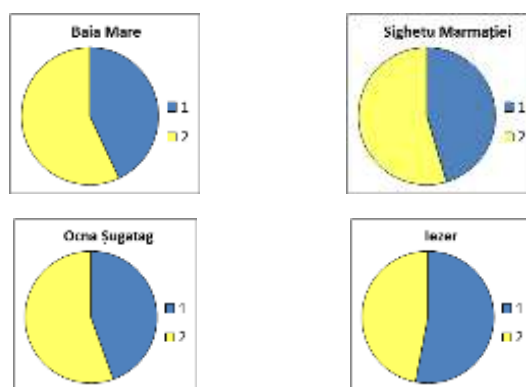


Fig. 3. The frequency (%) of the mean annual number of days with precipitation from the total number of days of the year, in Maramureş (1961-2016): 1, days with precipitation; 2, days without precipitation.

At all stations, the decade with the fewest days with precipitation was the last (2011-2016), which included several dry years. The second decade poor in

precipitation was the 3<sup>rd</sup> (1981-1990), at most stations. Only in Iezer, the second decade with a small number of days was the 2<sup>nd</sup> (1971-1980).

We also notice the appearance of precipitation extremes in the last two decades (2001-2010 and 2011-2016).

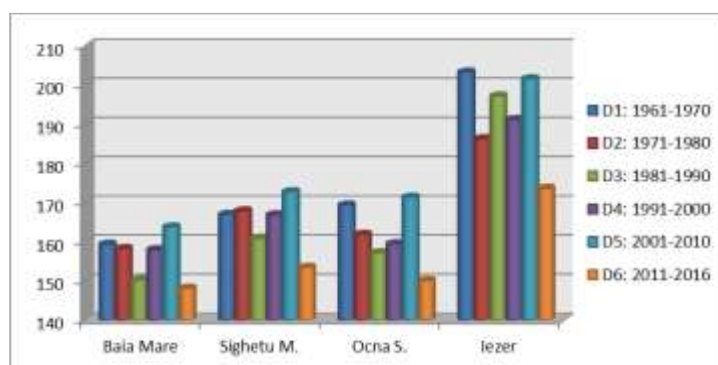


Fig. 4. The mean decennial number of days with precipitation in Maramureş (1961-2016)

### 3. The assurance degree of the annual number of days with precipitation

The calculation of the annual number of days with precipitation corresponding to characteristic assurances (Table 2) highlighted some aspects. Thus, the lowest values of the annual number of days with precipitation are found in the 100% assurance, which means that they can occur every year. These values are between 114 days at Baia Mare station and 146 days at Iezer station. For the 50% assurance (once every 2 years), there can be values between 157 days at Baia Mare and 194 days at Iezer.

Table 2. The annual number of days with precipitation with various assurances, in Maramureş (1961-2016)

STATION	DEGREE OF ASSURANCE								
	100%	80%	50%	25%	20%	10%	5%	2%	1%
<b>Baia Mare</b>	114	144	157	169	170	174	181	192	225
<b>Sighetu M.</b>	123	155	166	175	176	184	189	210	235
<b>Ocna Ş.</b>	125	147	165	171	173	175	187	209	229
<b>Iezer</b>	146	182	194	203	209	216	221	247	273

Once with the fall in assurance degree, the values of the annual number of days with precipitation increase, but these values are rarely encountered. Thus, once every 5 years (assurance of 20%) between 170 and 209 days with precipitation can be recorded in Maramureş County, once every 10 years (10%

assurance) between 174 and 216 days, once every 20 years (5% assurance) between 181 and 221 days. With a return period of 50 years (2% assurance), higher values can occur, between 192 and 247 days, and with a return period of 100 years (1% assurance) the highest and less frequent values occur, between 225 and 273 days.

It can be noticed that at all assurance degrees, the smallest values are given by the lowest station Baia Mare, and the highest values, by the highest station Iezer. Except for the assurance of 100%, the northern station Sighetu Marmăţiei has higher values than Ocna Şugatag station. We can say again that, on the territory of Maramureş County, the values corresponding to the characteristic assurances (1, 2, 5, 10, 20, 25, 50, 80 and 100%) of the annual number of days with precipitation increase from west to east and from south to north.

### **Conclusions**

In Maramureş County, between 157 and 194 days with precipitation occur on average per year, meaning that on this territory it rains about 5-6.5 months a year, on average. The mean annual number of days with precipitation increases from west to east, as the altitude of landforms increases, but also from south to north, as latitude increases. The analysis of the rainy and dry yearly intervals reveals the appearance of several extreme years towards the end of the analyzed period, in the last decade and a half (2000-2016).

The linear trend of the annual number of days with precipitation is slightly increasing at the lowest station Baia Mare and decreasing at the other stations. The opposite trends (downward of the number of days with precipitation and upward of the amounts of precipitation) found in this territory are due to the increase in the frequency of convective cloudy formations in recent years, because of the increase in air temperature, which generates large amounts of precipitation in short intervals.

The analysis of the mean decennial number of days with precipitation highlights the fact that, in Maramureş County, the wettest decades were the 5<sup>th</sup> (2001-2010) and the 1<sup>st</sup> (1961-1970), and the driest decades were the 6<sup>th</sup> (2011-2016) and the 3<sup>rd</sup> (1981-1990). We also notice the appearance of precipitation extremes in the last two decades (2001-2010 and 2011-2016).

On the territory of Maramureş County, the values corresponding to the characteristic assurances (1, 2, 5, 10, 20, 25, 50, 80 and 100%) of the annual number of days with precipitation increase from west to east and from south to north. Once every 100 years, between 225 and 273 days with precipitation can occur in Maramureş.



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