

## THE MONTHLY NUMBER OF DAYS WITH PRECIPITATION IN MARAMUREȘ COUNTY AND ITS INFLUENCE ON HUMAN HEALTH

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### Abstract

*The paper presents the analysis of the mean, maximum and minimum monthly number of days with precipitation, from 4 weather stations in Maramureș County, during 1961-2016. The frequency of these days, their temporal and spatial variability, as well as the influence of the days with precipitation on human health have also been studied. The result was that in Maramureș County, the most days with precipitation are recorded in May-July (13-19 days/month, on average) and November-February (13-17 days/month). The fewest days are reported in the August-October interval (10-14 days/month, on average).*

*The highest monthly number of days with precipitation occurred in the cold period December-March (25-26 days), at most stations and in May (30 days) at Iezer station. The maximum monthly values have been produced especially in the first half of the analyzed period (1961-1988). The lowest monthly number of days with precipitation generally occurred in the September-December and February-March intervals (0-4 days). The wettest month was May 2010 (22-30 days), and the driest month, November 2011 (0-2 days). On the territory of Maramureș County, both the wettest and the driest months occurred in the last years of the analyzed period (2000-2011).*

*Weather influences our mood. The rainy days decrease concentration and increase sleepiness, cause circadian rhythm disturbances or even depressive disorder, affect human health through the pathogens, which become more aggressive etc. Rains can also affect human health indirectly, through the atmospheric pollutants, such as sulfur oxides and nitrogen oxides, which produce acid rains in the atmosphere. As the air quality has improved since 2012 in Maramureș County, especially for the SO<sub>2</sub> indicator, an improvement in the health of the population is also estimated in the future.*

**Key words:** day with precipitation, monthly number, frequency, human health

### INTRODUCTION

Atmospheric precipitation is a climatological element often studied at national and world level, the importance of this element being particularly great in the climatic characterization of a region. But precipitation is used in a multitude of types of studies, among which we mention a few: the frequency and trend of the meteo-climatic hazards generated or associated to precipitation, the establishment of areas affected by drought or humidity excess, the determination of the vulnerability degree of a territory to the risks generated by precipitation, the calculation of climatic indices, etc. Studies on the monthly number of days with precipitation are useful not only in climatological knowledge, but also in other areas, such as:

agriculture, horticulture, hydrology, energy potential, water resources and human health, etc.

The northern territories of Romania, where Maramureş County is also including, are characterized by rich rains, due to the general circulation of the atmosphere over Europe, which influences the climate of these regions, but also to the presence of the mountain landforms, the both favoring the occurrence of precipitation. As the altitudes are increasing from west to east, the rainfall also shows the same increase, in Maramureş County. The highest rainfall is recorded in the east of the county, in Rodna Mountains (over 1200 mm), where the altitudes exceed 2000 m. The smallest amounts of precipitation are reported in the intra-mountainous depressions (750-770 mm), with low altitudes (Geography of Romania, vol.III, 1987; The climate of Romania, 2008; Şerban, 2010).

#### **MATERIAL AND METHOD**

The daily data of rainfall were used in the paper, from 4 weather stations located in Maramureş County, during 1961-2016 (56 years). The stations have a joint analysis period, these stations being: Iezer, Ocna Şugatag, Sighetu Marmaţiei and Baia Mare. Their altitudes vary between 216-1785 m, the highest station being Iezer (1785 m), which is located in the eastern part of the county, at the base of the glacier cirque below Pietrosu Peak (2303 m altitude – the maximum altitude of Rodna Mountains). The lowest station is Baia Mare (216 m), which is located in the western part of the county, in Baia Mare Depression. In Maramureş Depression there are two stations, Sighetu Marmaţiei (275 m) and Ocna Şugatag (503 m), located at the northern border of the county, respectively in its central-northern area.

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

From the daily data of precipitation, the monthly number of days with precipitation was extracted, by "*day with precipitation*" being understood *the 24-hour interval during which the measured amount of precipitation is  $\geq 0.1$  mm* (Marin, 1986; Mihăilă, 2006; Dragotă, 2006; Croitoru, 2003; The climate of Romania, 2008; etc.). Then, the mean, maximum and minimum monthly number of days with precipitation, the frequency of these days, their temporal and spatial variability were analyzed. In the last part of the paper, the influence of the days with precipitation on human health was discussed.

## RESULTS AND DISCUSSION

In the period 1961-2016, in Maramureş County, the mean annual number of days with precipitation ranged between 157-194 days, being higher at Iezer and lower at Baia Mare. This number increases from the west to the east, once with the altitude of the landforms, but also from the south to the north, once with the latitude, which influences the fallen precipitation amount.

### Monthly mean number of days with precipitation

In Maramureş County, the most days with precipitation are recorded in *May-July* and *November-February* (Fig. 1). At higher stations, the intervals slightly differ. Thus, the intervals favorable to precipitation's fall are May-July and December-January at Ocna Şugatag and the longer interval between December and July at Iezer.

In the period May-July, between 13-16 days with precipitation/month occur, on average, on the territory of the county (and 18-19 days/month at Iezer), and in the period November-February also occur between 13-16 days/month (but with 15-17 days/month at Iezer).

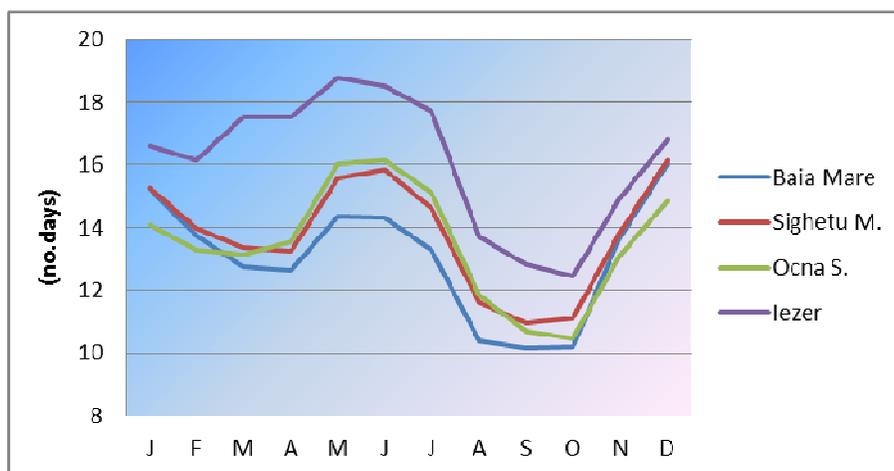


Fig. 1. The mean monthly number of days with precipitation in Maramureş (1961-2016)

The maximum of days with precipitation is recorded in *December* at the low stations Baia Mare and Sighetu Marmăţiei (with an average of 16 days/month), followed by the May-June interval (14-16 days/month). At the high stations – Ocna Şugatag and Iezer – the maximum occurs in the *May-June* interval (with an average of 16 days/month at Ocna Şugatag and 19 days/month at Iezer). In these three months, the cyclones crossing Europe have a high frequency over the territory of our country. As a consequence,

December is the month of maximum cloudiness, when the stratiform clouds have high frequency, generating long-lasting rainfall, and June is the month of maximum rainfall. Higher stations do not record the largest number of days with precipitation in December, due to the lowered ceiling of the stratiform clouds, which generates precipitation at the foot of the mountains. Instead, in the warm season, due to the altitude, the dynamic convection of the air associated with the thermal one, make the frequency of the convective clouds to be higher in the high mountain regions.

The fewest days with precipitation are reported in the *August-October* interval, at all stations (Fig. 1). Between 10-12 days/month are recorded now, on average, over most of the analyzed territory and more at Iezer (13-14 days/month).

The minimum of days with precipitation are reported in *September* at the low stations Baia Mare and Sighetu Marmăției (with an average of 10-11 days/month) and *October* at the high stations Ocna Șugatag and Iezer (with an average of 10 days/month at Ocna Șugatag and 12 days/month at Iezer). The cause lies in the persistence of the anticyclonic barric formations in these months, which generate beautiful, stable weather.

#### Maximum monthly number of days with precipitation

In Maramureș County, the maximum monthly number of days with precipitation varied between 19-30 days (Fig. 2). The highest monthly number of days with precipitation occurred in the cold period *December-March* (25-26 days), at most stations and in *May* (30 days) at Iezer station.

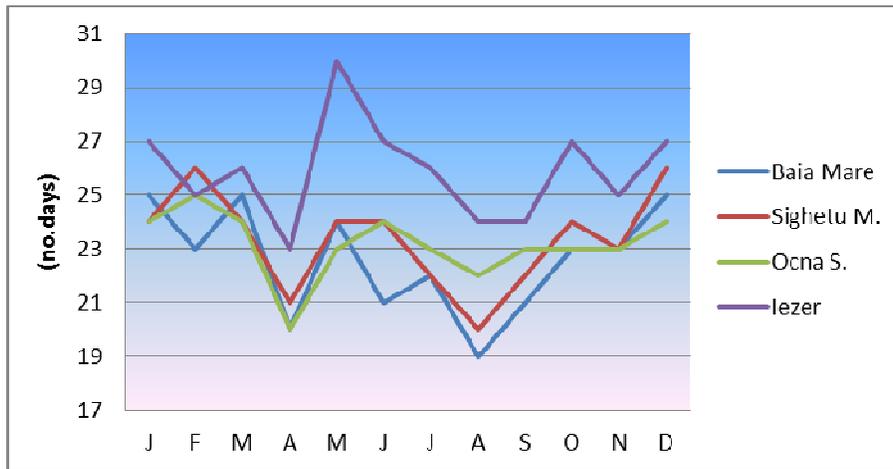


Fig. 2. The maximum monthly number of days with precipitation in Maramureș (1961-2016)

Thus, *May 2010* totaled between 22 days in Baia Mare and 30 days in Iezer, where it has rained almost the whole month. *February 1999* totaled 22 days with precipitation at Baia Mare and Iezer, 25 days at Ocna Şugatag and 26 days at Sighetu Marmaţiei. At the last two stations, the maximum of days with precipitation from the analyzed period was recorded in this month. Also, Sighetu Marmaţiei station recorded a maximum of 26 days in *December 1988*, when it rained between 21 days in Baia Mare and 27 days in Iezer.

Regarding the distribution of the maximum monthly values of the days with precipitation during the period 1961-2016, on the territory of Maramureş County, it can be said that at most stations, *the maximum monthly values have been produced in greater numbers in the first half of the analyzed period (1961-1988) and in smaller numbers in the second half of the period (1989-2016)*. This is attributed to the increase in the frequency of the convective clouds over the last decades, due to the global increase in air temperature, which generates rich but short-lived rainfall. An exception is made only by the northern station of Sighetu Marmaţiei, where the number of cases of the two periods of time is approximately equal.

#### Minimum monthly number of days with precipitation

On the territory under review, the minimum monthly number of days with precipitation varied between 0-10 days (Fig. 3). The lowest monthly number of days with precipitation generally occurred in the *September-December* and *February-March* intervals (0-4 days). The intervals are shorter at Iezer: *September-December* and *February* (1-4 days).

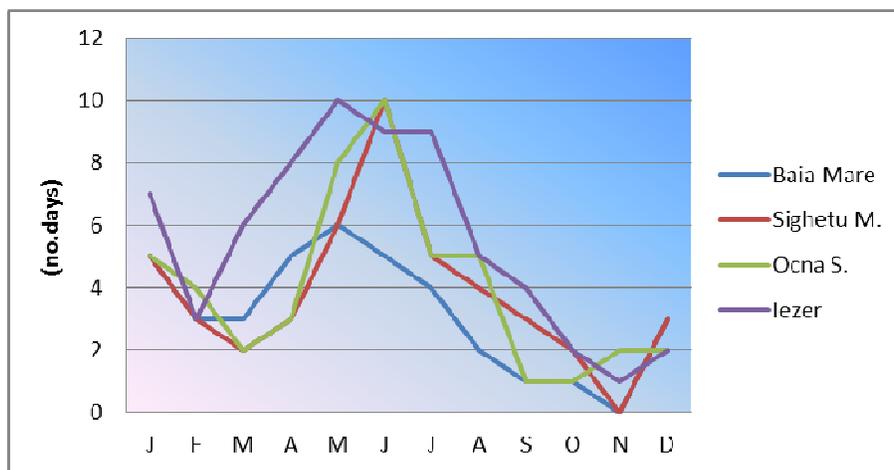


Fig. 3. The minimum monthly number of days with precipitation in Maramureş (1961-2016)

It can be noticed that the interval in which the maximum monthly number of days with precipitation occurs is overlapping, generally, over the interval of the minimum number, in Maramureş County. This fact reveals the occurrence of the pluviometric extremes in the cold months of the year, both drought and pluviometric surplus being reported during these months.

The driest months were: *November 2011*, when 0 days with precipitation were recorded in Baia Mare and Sighetu Marmăţiei, 1 day at Iezer and 2 days at Ocna Şugatag; *October 2000*, when there were 1 day with precipitation at Baia Mare and Ocna Şugatag and 2 days at Sighetu Marmăţiei and Iezer; *October 1995*, with 1 day at Baia Mare, 2 days at Ocna Şugatag, 3 days at Sighetu Marmăţiei and 5 days at Iezer; *September 1986*, which totaled 1 day in Baia Mare and Ocna Şugatag, 3 days in Sighetu Marmăţiei and 8 days in Iezer.

In conclusion, it can be noticed that on the territory of Maramureş County, both the wettest and the driest months occurred in the last years of the analyzed period (2000-2011). Moreover, the pluviometric extremes were reported in consecutive years (2010-2011).

#### **Influence of the days with precipitation on human health**

Medical and psychological studies made in the last years have attempted to determine how weather influences our mood. Even though some researchers concluded that weather has little influence on our mood, most of the studies suggest that the influence of weather is more prominent ([https://psychcentral.com/blog/archives/2014/08/29/can-weather-affect-your-mood/Grohol J.M.](https://psychcentral.com/blog/archives/2014/08/29/can-weather-affect-your-mood/Grohol); [https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard T.J.](https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard)).

Small studies involving a small number of subjects have shown that rainy days have decreased concentration and increased sleepiness, while pleasant weather was related to higher mood and good memory ([https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard T.J.](https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard)).

More extensive studies have shown that weather does not only affect our cognitive functions. Insufficient exposure to sunlight may cause circadian rhythm disturbances (such as sleep disturbances, insomnia) or even depressive disorder. Sunlight has been found to have a significant effect on fatigue and it can reduce the influence of precipitation and air pressure on fatigue. Vitamin D<sub>3</sub>, which is produced in skin exposed to sunlight, has been found to change serotonin levels in the brain, which could explain the changes in mood. Because low levels of serotonin in the brain are associated with depressive disorders, it is understandable why lower levels of vitamin D<sub>3</sub> may be responsible for negative mood and fatigue (Denissen et al., 2008).

Studies in psychology and economics have found a link between human aggression, heat and extreme rain, respectively. It seems that people show aggressive or violent behavior towards others when the ambient temperature is higher, even though the psychological mechanism that links temperature and aggression is still unknown. In addition, the rates of personal violence are also higher during extreme rainfall events (Hsiang et al., 2013).

Humid weather can affect human health through the pathogens. Infectious diseases can occur when pathogenic organisms enter into the body of a susceptible human host. The most commonly pathogens, such as bacteria (e.g. *Streptococcus*, *Legionella*), viruses (e.g. common cold, flu) or fungi (e.g. *Aspergillus fumigatus*) become more aggressive in conditions of high humidity. Non-infectious diseases, such as allergy, can also occur due to humid weather. Allergic rhinitis and allergic asthma, made by mold or mites, are aggravated by moisture. In addition, cold humid weather aggravates various forms of arthritis and chronic degenerative rheumatism (Baughman, Arens, 1996).

Rains can also affect human health indirectly, through the atmospheric pollutants, such as sulfur oxides and nitrogen oxides. During the rains, these gases can interact with water in the atmosphere to form acidic aerosols (acid rain). These aerosols containing fine particles of nitrate and sulphate can be inhaled by people and thus can cause various disorders. Dry cough, headaches, neck irritations or sore throat and respiratory diseases such as asthma and bronchitis can be caused by acid rain (Baughman, Arens, 1996).

There were two large industrial companies in Maramureş County: Phoenix and Romplumb, which represented significant sources of air pollution through their specific activity. Pollutants from the two companies were mainly, powders containing heavy metals and arsenic, sulfur oxides (SO<sub>2</sub>, SO<sub>3</sub>), nitrogen oxides etc.

The dispersion of pollutants into the atmosphere is influenced by the processes taking place in the air. Thus, in winter, when the number of rainy days is high in Maramureş County, the concentrations of sulfur oxides and nitrogen oxides in the atmosphere are diminished due to their washing by rain and snow, but the probability of acid precipitation and the illnesses deriving therefrom increases. In the summer when it is drought, there is more dust in the atmosphere due to soil erosion and lack of precipitation. In the areas affected by the pollutant emissions from the Romplumb and Phoenix Companies, the powders containing heavy metals and arsenic reached the ground. By soil erosion, they come back into the air. Thus, in the summer, due to the dust and also the content of heavy metals from powders, the population suffers from respiratory diseases

([https://www.cjmaramures.ro/comunicate/.../1249\\_ca83e62b26288ea9692fbfcee3d7aa/Ciceu Z.](https://www.cjmaramures.ro/comunicate/.../1249_ca83e62b26288ea9692fbfcee3d7aa/Ciceu Z.)).

Studies carried out both in Maramureş County and in Baia Mare City, in 2010, by Maramureş County Public Health Directorate, in collaboration with the Maramureş Environmental Protection Agency, highlighted some results. Thus, concerning the general morbidity (disease rate per 1000 inhabitants), it was found to have been relatively low in 2010. Furthermore, the data indicate that the morbidity through respiratory diseases was due to the following conditions: acute upper respiratory tract infections, bronchitis and acute bronchiolitis, bronchial asthma. These results were in relation with high levels of sulfur dioxide and nitrogen oxides in atmosphere. Concerning total mortality (deceased per 1000 inhabitants), there was a pronounced increase in the county compared to Baia Mare.

S.C. Romplumb S.A. Baia Mare ceased its activity in January 2012. As the air quality has improved since this year, especially for the SO<sub>2</sub> indicator, an improvement in the health of the population is also estimated in the future ([http://www.rowater.ro/dasomes/sgamaramures/Documente%20Consultarea%20Publicului/Proiect%20PLAM%20versiunea%203%20\(2013\)%20-%20consultare%20publica/Partea%20II\\_PROFIL%20DE%20MEDIU.pdf](http://www.rowater.ro/dasomes/sgamaramures/Documente%20Consultarea%20Publicului/Proiect%20PLAM%20versiunea%203%20(2013)%20-%20consultare%20publica/Partea%20II_PROFIL%20DE%20MEDIU.pdf)).

## CONCLUSIONS

The mean monthly number of days with precipitation shows that in Maramureş County, the most days are recorded in May-July (13-19 days/month) and November-February (13-17 days/month). The fewest days are reported in the August-October interval (10-14 days/month).

The highest monthly number of days with precipitation occurred in the cold period December-March (25-26 days), at most stations and in May (30 days) at Iezer station. The maximum monthly values have been produced especially in the first half of the analyzed period (1961-1988). The lowest monthly number of days with precipitation generally occurred in the September-December and February-March intervals (0-4 days).

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Weather influences our mood. The rainy days decrease concentration and increase sleepiness, cause circadian rhythm disturbances or even depressive disorder, affect human health through the pathogens, which become more aggressive etc. Rains can also affect human health indirectly, through the atmospheric pollutants, such as sulfur oxides and nitrogen

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## REFERENCES

1. Baughman A.V., Arens E.A., 1996, Indoor humidity and human health – Part I: literature review of health effects of humidity-influenced indoor pollutants. *ASHRAE Transactions: Research*, 102(1), pp.193-211
2. Bogdan O., 2000, Precipitațiile atmosferice. Un risc climatic în Subcarpații Getici. *Comunicări de Geografie*, vol.IV, Ed. Univ. din București, pp.133-144
3. Boroneaț Constanța, Rîmbu N., 2003, Moduri ale variabilității deceniale a precipitațiilor din timpul iernii în regiunea atlantico-europeană și legătura acestora cu anomaliile circulației atmosferice și a temperaturii suprafeței mării. *Analele Univ. Ovidius, Seria Geografie*, vol.1, Ovidius University Press, Constanța, pp.32-42
4. Croitoru A.E., 2003, Determinarea structurii perioadelor ploioase și secetoase. În vol.: *Indici și metode cantitative utilizate în climatologie*. Ed. Univ. din Oradea, pp.71-74
5. Denissen J.J.A., Butalid L., Penke L., van Aken M.A.G., 2008, The effects of weather on daily mood: a multilevel approach. *Emotion*, 8(5), pp.662-667
6. Dragotă C.S., 2006, Precipitațiile excedentare în România. Ed. Academiei Române, București, pp.53-57
7. Hsiang S.M., Burke M., Miguel E., 2013, Quantifying the influence of climate on human conflict. *Science*, 341(6151), 1235367
8. Marin I., 1986, Măsurători și calcule în meteorologie și climatologie. Univ. din București, *Facult. de Geol. și Geogr.*, pp.29-33, 98-100
9. Mihăilă D., 2006, Câmpia Moldovei - Studiu climatic. Ed. Univ. Suceava, pp.255-261
10. Șerban E., 2008, Aspects concerning the rainy spells in the Western Plain of Romania. *Intern. Conf. „Regional disparities: typology, impact, management”*, 20-22 Oct. 2006, *Romanian Review of Regional Studies*, Cluj-Napoca, vol. 4/ issue 1, pp.77-86
11. Șerban E., 2010, Hazarde climatice generate de precipitații în Câmpia de Vest situată la nord de Mureș. Ed. Univ. din Oradea, Oradea, pp.220-232
12. Șerban E., 2016, Anomalies of precipitation in Maramureş during the period 1961-2013, analyzed by the SPA method. *Natural Resources and Sustainable Development*, vol.8, Ed. Univ. din Oradea, pp.180-187
13. Tudose T., Șerban E., Harpa G.V., 2016, Climate Variability of the Rainy Periods between 1961 and 2013, in Maramureş, Romania. 16<sup>th</sup> International Multidisciplinary Scientific GeoConferences SGEM, 28 June-6 July, 2016, Albena, Bulgaria, SGEM2016 Conference Proceedings, Book 4, Volume 2, Thomson Reuters, ISI Web of Science/Web of Knowledge, pp.275-282
14. Zăpârțan M., Laslo V., Agud E., 2014, Ariile protejate formă de conservare a biodiversității plantelor. Ed. Școala Ardeleană Eikon, Cluj-Napoca, 385 pp.
15. \*\*\*, 1987, *Geografia României*, vol.III: Carpații Românești și Depresiunea Transilvaniei. Ed. Academiei R.S.R., București, pp.55-88
16. \*\*\*, 2008, *Clima României*. A.N.M., Ed. Academiei Române, București, pp.278-280

17. \*\*\*, 2016, Plan de menținere a calității aerului pentru județul Maramureș. Consiliul Județean Maramureș, [https://www.cjmaramures.ro/comunicate/.../1249\\_ca83e62b26288ea9692fbfcee3d7aa/Ciceu\\_Z](https://www.cjmaramures.ro/comunicate/.../1249_ca83e62b26288ea9692fbfcee3d7aa/Ciceu_Z).
18. \*\*\*, 2016, Raportul județean privind starea mediului pentru anul 2016, Județul Maramureș. APM Maramureș, [http://www.anpm.ro/documents/23445/33730177/01\\_CAPITOLUL+I.+CALITATEA+SI+POLUAREA+AERULUI+INCONJURATOR.pdf/f972a585-1686-44b2-935b-c9b6f0614ce9](http://www.anpm.ro/documents/23445/33730177/01_CAPITOLUL+I.+CALITATEA+SI+POLUAREA+AERULUI+INCONJURATOR.pdf/f972a585-1686-44b2-935b-c9b6f0614ce9)
19. <https://psychcentral.com/blog/archives/2014/08/29/can-weather-affect-your-mood/> Grohol J.M., Can Weather Affect Your Mood?
20. [https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard T.J., Does Weather Affect Your Mood?](https://psychcentral.com/blog/archives/2017/06/02/does-weather-affect-your-mood/Borchard_T.J.,_Does_Weather_Affect_Your_Mood?)
21. [http://www.rowater.ro/dasomes/sgamaramures/Documente%20Consultarea%20Publicului/Proiect%20PLAM%20versiunea%203%20\(2013\)%20-%20consultare%20publica/Partea%20II\\_PROFIL%20DE%20MEDIU.pdf](http://www.rowater.ro/dasomes/sgamaramures/Documente%20Consultarea%20Publicului/Proiect%20PLAM%20versiunea%203%20(2013)%20-%20consultare%20publica/Partea%20II_PROFIL%20DE%20MEDIU.pdf)
22. [www.meteomanz.com](http://www.meteomanz.com)