

THE VARIATION OF TEMPERATURE AND RAINFALL IN THE MUNICIPALITY OF CLUJ-NAPOCA IN THE INTERVAL 1979-2019

Svetlana MICLE¹, Sorin Daniel VATCA¹, Sorin MICLE², Mihai VOEVOD¹,
Maria-Olivia MOLDOVAN¹, Adriana Paula DAVID¹, Ovidiu RANTA¹, Calin TOPAN¹

¹University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca,
3-5 Calea Manastur Street, Cluj-Napoca, Romania

²Technical College of Transports Transylvania of Cluj-Napoca, 21 Bistritei Street,
Cluj-Napoca, Romania

Corresponding author emails: sorinv@usamvcluj.ro, miclsvetlana@yahoo.com

Abstract

The city of Cluj-Napoca is located in the central part of Transylvania. It covers an area of 179.5 km², at an average altitude of 335 m. The climate of Cluj-Napoca is moderately continental, characterized by cold winters, with temperatures often below freezing (0°C or 32°F), and mild or pleasantly warm summers and the precipitation amounts to 595 millimetres. Meteorological data were provided by the meteorological station ADSCON Telemetry of University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca. In this study it was determined and analysed the annual average temperature, monthly temperature and the minimum and maximum average and monthly precipitation and annual average. Due to the geographical positioning, the city of Cluj-Napoca presents a tendency to increase the temperature and the precipitations are maintained in the normal regime with small seasonal changes.

Key words: climatic parameters, deviation, rainfall regime, thermal regime.

INTRODUCTION

Climate refers to the average weather of an area including the general patterns of atmospheric conditions, seasonal variation and weather extremes averaged over a long period (Vinay, 2009). Climatic conditions over an area are determined by the temperature, rainfall, wind, humidity, atmospheric pressure etc. (John, 2012).

Climate plays an important role in every sphere of human activity (Dhorde et al., 2009). Temperature and rainfall are the most important factors that determine the climate of an area. Changes in temperature and rainfall patterns are observed along with increasing frequency and intensity of extreme weather events such as floods, droughts, heat waves, tornadoes (Kamlesh Pritwani, 2019). InterGovernmental Panel on Climate Change (IPCC, 2007) stated a 0.6°C (0.4 to 0.8°C) increase of global temperature during the period of 1901 to 2001, indicating warming of the earth in the last few decades. However, IPCC (2013) mentioned that the global surface temperature towards the end of the 21st century is likely to exceed 1.5°C relative to 1850 to

1900 for all RCP model scenarios except RCP2.6. Most scientists believe that the warming of the climate will lead to more extreme weather patterns (heat, waves, droughts, strong winds, and heavy rains) such as: more hurricanes and drought, longer spells of dry heat of intense rain (depending on where you are in the world). Scientists have pointed out that Northern Europe could be severely affected with colder weather if climate change continues as the arctic begins to melt and send fresher waters further south (Reddy, 2015; Lusted Marcia Amidon, 2018).

The consequences of these changes pose significant risks to human health, agriculture, freshwater supplies, and supply of other natural resources that are vital to our economy, environment, and quality of life (Mall et al., 2017; Barnes et al., 2013; Yang et al., 2015).

MATERIALS AND METHODS

The city of Cluj-Napoca is located in the central part of Transylvania (Figure 1). It covers an area of 179.5 km², at an average altitude of 335 m. The climate of Cluj-Napoca is moderately continental, characterized by cold

winters, with temperatures often below freezing, and mild or pleasantly warm summers and the precipitation amounts to 595 millimetres.



Figure 1. Cluj-Napoca City (Source: http://apmcj.anpm.ro/upload/72057_01-Cadru%20natural.pdf)

Some West-Atlantic influences are present during winter and autumn. Winter temperatures are often below 0°C (32°F), even though they rarely drop below -10°C (14°F). On average, snow covers the ground for 65 days each winter.

In summer, the average temperature is approximately 18°C (64°F) (the average for July and August), despite the fact that temperatures sometimes reach 35°C (95°F) to 40°C (104°F) in mid-summer in the city centre. Although average precipitation and humidity during summer is low, there are infrequent yet heavy and often violent storms.

During spring and autumn, temperatures vary between $+13^{\circ}\text{C}$ (55°F) to $+18^{\circ}\text{C}$ (64°F), and precipitation during this time tends to be higher than in summer, with more frequent yet milder periods of rain.

Meteorological data were provided by the meteorological station ADSCON Telemetry of University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca.

In this study were determined and analysed the annual average temperature, monthly temperature and the minimum and maximum average and monthly rainfall and annual average in the period of 1979 to 2019.

RESULTS AND DISCUSSIONS

Temperature

Air temperature is an important climatic factor along with precipitation. The analysis of this parameter at the weather station in Cluj-Napoca reveals an average annual temperature of 8.3°C , with average amplitude of 4.1 given by the values: the maximum average of 11.3°C registered in 2019 and the minimum average of 7.2°C , registered in 1985. In figure 2 we can observe a colder period recorded in 1980 with 7.5°C and 1985 with 7.2°C . In the period 1981-1997 we can observe a more constant temperature than normal with small deviations and a warmer period between the period 1998-2006. Between 2007 and 2019 we can see a significant increase in the frequency of hot years. The annual thermal average exceeding the multiannual average with over 2°C in 6 situations over a period of 5 years (2014, 2015, 2017-2019).

The evolution of temperatures on seasons shows a slight non-uniformity in recent years due to the phenomenon of climate change with very hot summers and cold winters. Winter is a cool season with temperatures falling below -20°C . The lowest temperature was recorded on January 23, 1963 with -34.2°C , low temperatures were also recorded on January 13, 1985 with -26°C . In the last 20 years there have been no temperatures below -23°C . Spring is a transitional season with higher temperatures. In March there are usually winter manifestations with moderate snowfall and low temperatures until mid-April. In May, temperatures were higher than normal.

Summer is a hot season with temperatures between $20-30^{\circ}\text{C}$. But sometimes there are high temperatures such as $+38.5^{\circ}\text{C}$ on August 25, 2012, the previous record being $+38^{\circ}\text{C}$ recorded on July 24, 2007. The hottest summer days are July and August. But most of the time the temperature felt is higher than the temperature recorded due to several factors such as humidity and wind. In the city of Cluj-Napoca due to the phenomenon of climate change in the summer periods there are several days with temperatures exceeding $+30^{\circ}\text{C}$.

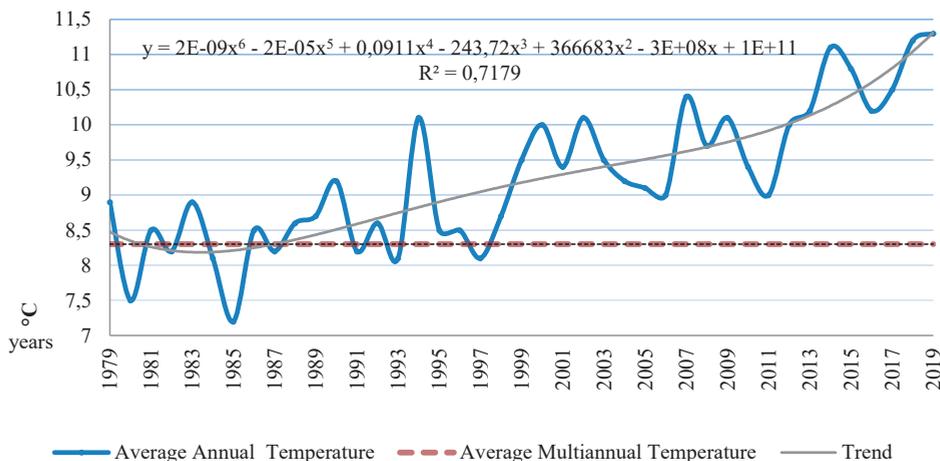


Figure 2. The average annual temperature variation compared to the multiannual average and their trend of evolution in Cluj-Napoca, between 1979 and 2019

Autumn is colder in Cluj-Napoca due to the air front coming from northern Europe. Until mid-September, summer temperatures can still be recorded, after which it gradually cools down. The transition from summer to autumn is quite fast and most days are recorded with rainfall and windy days. Thus, at the end of October, at the beginning of November, the frequency of days with temperatures below 0°C increases. But during the days there are positive temperatures between 5 and 15°C. Table 1 shows the deviation of the annual thermal averages between the period of 1979 to 2019.

Table 1. The deviations of the thermal values from the multiannual thermal average and the rating of the years between 1979 and 2019 in Cluj-Napoca

Year	Annual average °C	Deviation	Description
1979	8.9	0.6	slightly warm
1980	7.5	-0.8	breezy
1981	8.5	0.2	breezy
1982	8.2	-0.1	breezy
1983	8.9	0.6	slightly warm
1984	8.1	-0.2	breezy
1985	7.2	-1.1	cold
1986	8.5	0.2	breezy
1987	8.2	-0.1	breezy
1988	8.6	0.3	breezy
1989	8.7	0.4	breezy

1990	9.2	0.9	slightly warm
1991	8.2	-0.1	breezy
1992	8.6	0.3	breezy
1993	8.1	-0.2	breezy
1994	10.1	1.8	warm
1995	8.5	0.2	breezy
1996	8.5	0.2	breezy
1997	8.1	-0.2	breezy
1998	8.7	0.4	breezy
1999	9.5	1.2	warm
2000	10.0	1.7	warm
2001	9.4	1.1	warm
2002	10.1	1.8	warm
2003	9.5	1.2	warm
2004	9.2	0.9	slightly warm
2005	9.1	0.8	slightly warm
2006	9.0	0.7	slightly warm
2007	10.4	2.1	warm
2008	9.7	1.4	warm
2009	10.1	1.8	warm
2010	9.4	1.1	warm
2011	9.0	0.7	slightly warm
2012	10.0	1.7	warm
2013	10.2	1.9	warm
2014	11.1	2.8	very warm
2015	10.8	2.5	warm
2016	10.2	1.9	warm
2017	10.5	2.2	warm
2018	11.2	2.9	very warm
2019	11.3	3	very warm

The maximum negative deviations are between -1.1°C in 1985 the year being characterized as cold and -0.8°C in 1980, the year being characterized as breezy. The deviations of the annual positive thermal averages show maximum values of $+2.1^{\circ}\text{C}$ in 2007, $+2.8^{\circ}\text{C}$ in 2014, $+2.5^{\circ}\text{C}$ in 2015, $+2.2^{\circ}\text{C}$ in 2017 the years being characterized as warm and in 2018 and 2019 the years have been characterized as very warm, respectively $+2.9^{\circ}\text{C}$ and $+3^{\circ}\text{C}$.

Rainfall

The precipitation regime in Cluj-Napoca municipality is influenced by the geographical positioning and the circulation of air masses with western predominance. The analysis of the annual values of precipitation and the multiannual average is 590.08 mm.

The graphical analysis (Figure 3) highlights the years 1982, 1983, 1990, 1996, 1998, 2000, 2001 with precipitations recorded below 300 mm/year. In recent years we can see an increase in annual quantities of positive precipitation compared to the multiannual average (1994, 2010, 2014 and 2016).

The evolution of the average precipitations over seasons presents a non-uniformization from year to year. In winter, the rainfall regime is deficient compared to the other seasons. The average rainfall in December is 33.2 mm and in January registering 26 mm. February is the driest month of the year with precipitations below 23.2 mm. The form of rainfall is solid but due to climate change the weight of rainfall in the form of rain is increasingly common in recent years.

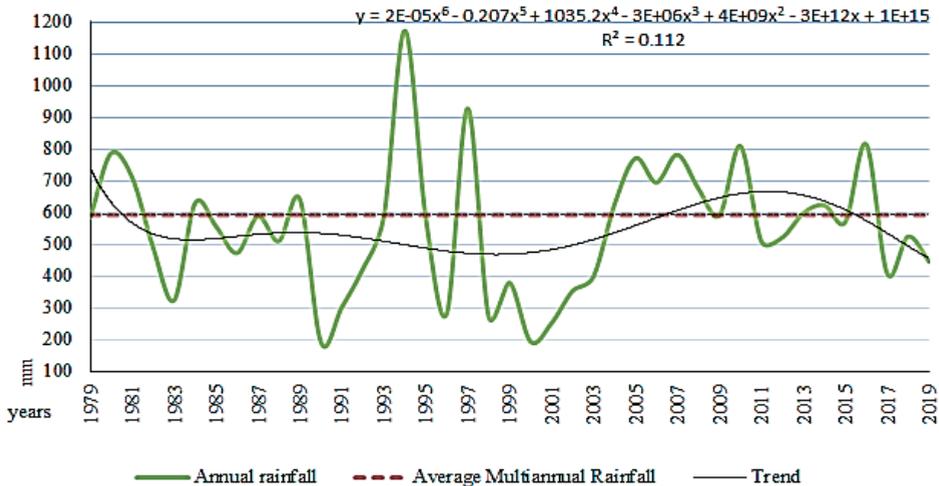


Figure 3. The variation of the average annual precipitation amounts compared to the multiannual average and the evolution trend in Cluj-Napoca, between 1979 and 2019

In the spring, the most abundant precipitation is recorded starting with the second half of March. The average rainfall in March is 25 mm, in April is 42.8 mm and in May 74.3 mm. In summer, the largest amount of precipitation is recorded due to the phenomenon of climate change in a very short time. In June, the highest precipitation amounts are recorded on average 86 mm. In July there was 84.3 mm and in August there was a decrease of the precipitation regime by 66.8 mm. In the summer months there are also severe weather events such as: thunderstorms, electric shocks

and hail. In autumn, the precipitation regime is deficient in the month of September, with an average of 32.7 mm, in October 29.7 mm and in November 30.1 mm. At the beginning of November, the first signs of winter usually appear: haze, frost, pole, snow.

Table 2 shows the amount of annual precipitation between 1979 and 2019. The smallest precipitation amounts were recorded in 1983, 1990, 1991, 1992, 1996, 1998, 1999, 2000, 2001, 2002, 2003 and 2017 with precipitation amounts between -28.59 and 67.25 mm, years characterized by excessive

drought. The highest amounts of precipitation were recorded in the years 1980, 1994, 1997, 2005, 2007, 2010 and 2016 with precipitation amounts between 30.22 and 1170.18 mm, being characterized as excessively rainy. In the rest of the years, rainfall was recorded in the limit of normal values.

Table 2. The deviations of the annual precipitation quantities from the multiannual average and the grading of the years between 1979-2019 in Cluj-Napoca

Year	Annual Sum	Deviation	Deviation %	Description
1979	583.66	-7.14	-1.20	Normal
1980	785.57	197.77	33.47	Excessive rainy
1981	710.13	119.33	20.19	Very rainy
1982	489.47	-101.33	-17.15	Very dry
1983	323.85	-266.95	-45.18	Excessive dry
1984	627.40	36.6	12.58	Rainy
1985	555.77	-35.03	-5.92	Normal
1986	471.7	-119.1	-20.15	Very dry
1987	587.23	-3.57	-0.6	Normal
1988	509.52	-81.28	-13.75	Drought
1989	640.31	49.51	8.38	Slightly dry
1990	192.01	-398.79	-67.5	Excessive dry
1991	301.51	-289.29	-48.96	Excessive Dry
1992	421.88	-168.92	-28.59	Excessive dry
1993	585.78	-5.02	-0.84	Normal
1994	1170.18	579.38	98.06	Excessive Rainy
1995	582.99	-7.81	-1.32	Normal
1996	281.98	-308.82	-52.27	Excessive Dry
1997	925.63	334.83	56.67	Excessive rainy
1998	273.12	-317.68	-53.77	Excessive dry
1999	378.42	-212.38	-35.94	Excessive dry
2000	193.43	-397.37	-67.25	Excessive dry
2001	251.75	-339.05	-57.38	Excessive dry
2002	352.55	-238.25	-40.32	Excessive dry

2003	398.05	-192.75	-32.62	Excessive dry
2004	624.87	34.07	5.76	Normal to rainy
2005	769.36	178.56	30.22	Excessive rainy
2006	693.69	102.82	17.41	Very rainy
2007	780.83	190.03	32.16	Excessive rainy
2008	674.10	83.3	14.09	Rainy
2009	590.09	-0.71	-0.12	Normal
2010	807.78	216.98	36.72	Excessive rainy
2011	508.49	-82.02	-13.88	Drought
2012	520.74	-70.06	-11.85	Drought
2013	596.57	6.51	1.10	Normal
2014	622.85	32.05	5.42	Normal
2015	569.72	-21.08	-3.56	Normal
2016	813.35	222.55	37.66	Excessive rainy
2017	407.95	-182.85	-30.94	Excessive dry
2018	523.75	-67.05	-11.34	Drought
2019	444.98	-145.82	-24.68	Very dry

CONCLUSIONS

Due to the geographical positioning, the city of Cluj-Napoca presents a tendency to increase the temperature and the precipitations are maintained in the normal regime with small seasonal changes.

The analysis of the temperature in Cluj-Napoca between 1979 and 2019 established that there is a sharp increase in the temperature values after 2000. The hottest years were 2014, 2015, 2017, 2018 and 2019, with a difference from the multiannual temperature included in range +2.2 °C and +3°C. The smallest deviation from normal was recorded in 1985 with -1.1°C.

The increase of precipitation is not as great as the increase of temperatures but it is maintained in normal parameters with positive or negative deviations from the normal. The highest amount of precipitation was recorded in 1994 with 1170.18 mm. The smallest amount of precipitation was recorded in 1996 with 281.98 mm.

It can be said that the city of Cluj-Napoca is affected by climate change and its consequences. It is expected that in the coming years there will be fluctuations of the weather through very high temperatures and without precipitation or through abundant precipitation in short intervals. It is also possible that the city of Cluj-Napoca could not cope with this uncontrolled growth of the population and its irreversible changes that already impose natural limits by destroying the environment. Thus, it is urgent to prepare local and national climate change strategies.

REFERENCES

- Barnes, C., Alexis, N., Bernstein, J., Coh, J. (2013). Climate Change and our Environment: the effect on respiratory and Allergic Disease. *J Allergy Clin Immunol Pract*, 1(2), 137–141.
- Dhorde A, Dhordel A. and Gadgil A. S. (2009). Long-term Temperature Trends at Four Largest Cities of India during the Twentieth Century. *Journal of Industrial Geophysics*, 13(2), 85–97.
- IPCC (2007). Summary for policy makers. In: Solomon, S, Qin, D, Manning, M, Chen, Z, Marquis, M, Averyt, KB, Tignor, M, Miller, HL (Eds.), *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.
- IPCC (2013). In: Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.
- John P.P.J. (2012). Seasonal Variation in Water Temperature on the South East Coast of Tamil Nadu, India. *Journal of Environmental Science, Computer Science and Engineering & Technology*. 1(3), 488–491.
- Kamlesh Pritwani (2019). *Sustainability of Business in the context of environmental management*, Boca Raton, USA: CRC PRESS House.
- Lusted Marcia Amidon (2015). *Extreme weather events*. New York, USA: Greenhaven House.
- Mall, R., Gupta, A., Sonkar, G. (2017). 2 - effect of climate Change on Agricultural Crops. *Curr. Develop. Biotechnol. Bioeng*. 23–46.
- Reddy P.P. (2015). *Climate resilient agriculture for ensuring food security*. India: Springer Publishing House.
- Vinay K. (2009). *Complete Biology For Medical Entrance Examinations*. New Delhi, India: Tata McGraw-Hill Publishing Company Limited House.
- Yang, J., Graf, T., Ptak, T. (2015). Impact of climate change on freshwater resources in a heterogeneous coastal aquifer of Bremerhaven, Germany: a three-dimensional modeling study. *J. Contam. Hydrol*. 177-178, 107–121.