

CLIMATIC CHANGES IDENTIFIED IN THE WESTERN PART OF ROMANIA. TREND OF THE MAIN METEOROLOGICAL PARAMETERS OVER A LONG PERIOD OF TIME (1961-2020)

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Abstract. Climate change generates not only concern about the climate future of the planet, but also great material damages, in the most diverse areas of social life, causing phenomena that seem to irreversibly change the face of the world and implicitly the general conditions of life. The series of meteorological data (air temperature and atmospheric precipitation), from the Lugoj meteorological station were used to identify and highlight the conditions of occurrence and manifestation of climate changes that took place in the western part of Romania and in the last 60 years, from 1961 until 2020. Climatic elements and phenomena are interconnected to such a great extent that on a global scale it is necessary to recognize a "climate system", governed by its own laws, which determine both its configuration at a given moment and its evolution over time. As a consequence of the global climate changes we are witnessing, it can be observed, analyzing the variability and evolution trend of the thermal regime of the air over the last 60 years, that the evolution trend of the multi annual average temperature at the Lugoj meteorological station is increasing with a value of about 1.7° C. In the context of global climate changes, the distribution of precipitation by seasons in this part of the country where the Lugoj meteorological station is situated, follows quite different trends over the last 60 years, namely: a constant trend is recorded in summer, a trend decreasing in spring and winter is recorded decrease and in the fall there is a more pronounced upward trend, which in total cancels the decreases during the spring and winter.

Keywords: climate change, air temperature, atmospheric precipitation, Lugoj meteorological station.

INTRODUCTION

According to the World Health Organization (WHO), the "climate change and global warming" are the greatest challenges of humanity in the twenty-first century. They threaten all aspects of our life (Organization WH [2018](#)).

The expression "global warming" usually refers to the observed rise in average global temperature in the last decades in terms of frequency and intensity and the term "climate change" refers to observed measurable changes of the climate over a long period of time.

Climatic elements and phenomena are interconnected to such a great extent that on a global scale it is necessary to recognize a "climate system", governed by its own laws, which determine both its configuration at a given moment and its evolution over time (Stângă, 2007).

MATERIAL AND METHODS

THE STUDY AREA

In order to identify climate changes in the western part of Romania, we chose as a case study the Lugoj meteorological station founded in 1896. This station is situated at an altitude of 121 meters, in the Lugoj Plain, a sub-unit of the Western Plain, which penetrates deep into the Timiș and Bega river valleys (Dunca, 2018).

The general characteristics of the climate in this lowland sub-unit are marked by the diversity and irregularity of atmospheric processes. The predominant air masses during spring

and summer are the oceanic ones, which come from the west and which bring important precipitation, sometimes even in winter, and from September to February, the dominant are the continental polar air masses, which come from the east (Arba, 2016).

In this part of the country, the influence of cyclones and warm air masses, which come from the Adriatic Sea and the Mediterranean Sea and which cause early and complete thawing in winter and suffocating heat waves in summer, is felt quite strongly (Arba, 2013).

The series of meteorological data from the Lugoj meteorological station used to identify and highlight the conditions of occurrence and manifestation of climate changes that have occurred in this part of the country belong to a period of a 60 years.

The established period covers the interval 1961-2020, being selected taking into account the recommendations of the World Meteorological Organization (WMO) regarding the establishment of standard climatic periods for the 20th century, for a minimum of 30 years.

CASE STUDY

Air temperature is one of the most important climatic parameters, which shows spatial-temporal variations related to the factors that influence it, namely: latitude, altitude, dynamics of air masses, physical-geographical conditions etc. (Sandu et al., 2008).

Within Banat, the air temperature regime presents a series of features and an uneven distribution, as a result of the interaction of dynamic processes with the great diversity of the mentioned physical-geographical conditions (Dunca, 2018).

The analysis of the air temperature at the Lugoj meteorological station reveals the moderate character of the climate in this part of the country, with oceanic influences from the west and sub-mediterranean influences from the southwest, and the multi-annual average value of the temperature at this station is over 10°C (10.9°C), is specific to the plain area in which it falls and is due to the highest values of the radiative and caloric balance in Banat region (table 1).

Table 1.

Variation of the average monthly temperature at the Lugoj meteorological station (1961-2020)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Multiannual average
-0.5	1.6	5.9	11	16.3	19.5	21.2	20.8	16.3	11.1	6.2	1.3	10.9

Source: Data processed according to the Archives of the Banat-Crişana Regional Meteorological Center, Timișoara

Compared to the multi-annual average value of the temperature, throughout the analyzed period (1961-2020), the average annual air temperature showed quite large non-periodic variations, depending on the frequency and intensity of the advection of different air masses (fig. 1).

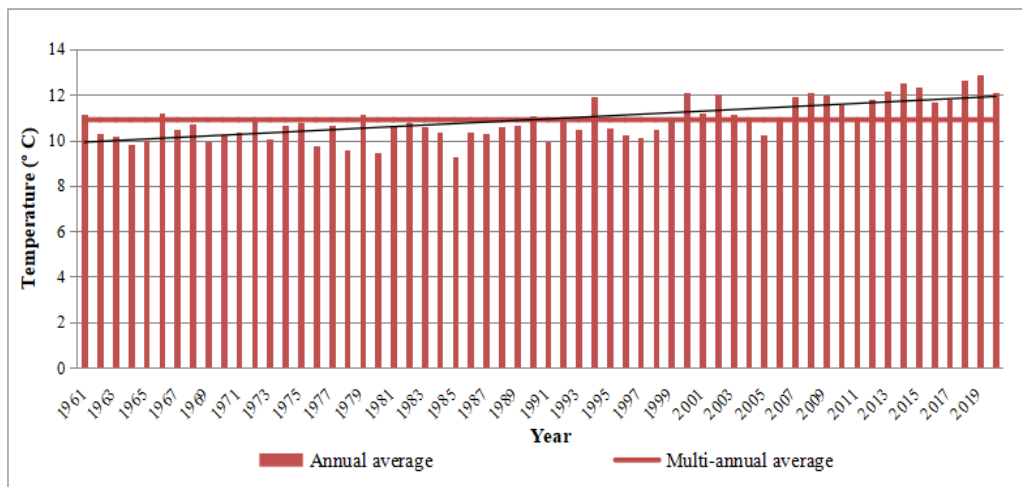


Figure 1. Average annual temperature variation at Lugoj meteorological station (1961-2020)

As a consequence of the global climate changes we are witnessing, it can be observed, analyzing the variability and evolution trend of the thermal regime of the air over the last 60 years, that the evolution trend of the multi-annual average temperature at the Lugoj meteorological station is increasing with a value of about 1.7° C.

Dividing the analyzed period into equal 10 years intervals (1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010 and 2011-2020), it can be seen that this growth starts to be visible with the transition from the interval 1981-1990, to the interval 1991-2000, when the multi-annual mean temperature increases by 0.3° C.

Further in the analyzed period, the transition to the next interval is achieved with an increase of 0.6° C in the multi-annual average temperature, and the transition to the last interval is made with the highest increase in the multi-annual average temperature of 0.7° C.

However the growth trend identified for this western part of the country is lower compared to the regions in the eastern and southern part of the country, where it is more pronounced (Sandu et al., 2008).

From the analysis of the variation of average monthly temperatures at the Lugoj meteorological station, it can be seen that the coldest month of the year is January (-0.5° C) and the warmest month of the year is July (21.2° C), and the annual average amplitude is 21.7° C, a high value, but specific to the lowlands plains in this part of the country, where the highest values of the annual amplitude are recorded.

From the analysis of the variation and evolution trend of the average temperature in January, it can be seen that the evolution trend in the 20th century is increasing, with a more pronounced growth trend at lowland meteorological stations, such as the Lugoj meteorological station is (Sandu et al., 2008).

The analysis of the average temperature of July, which is the hottest month of the year, highlights a trend of temperature evolution, more moderate and more diversified.

The increase of the average temperature of July in recent years can be attributed to global warming, because comparing the values of the intervals delimited by ten years, was found a difference of 2° C between the first interval and the last interval.

Analyzing the average seasonal temperature at the Lugoj meteorological station it can be seen that it varies from one season to another, the hottest season being the summer (20.4° C)

and the coldest being the winter (0,7° C). Like the average annual temperature and the average seasonal temperature follow the same upward trend, which can be attributed to global warming. This increase begins to be visible from the 1991-2000 interval to the 2001-2010 interval, when the mean seasonal temperature increases by 0.5° C during the summer and the winter, by 0.4° C during the autumn and by 1.1° C during the spring.

The multi-annual average temperature of the cold season (October-March), calculated for this station has a rather high value of 4.3° C and the multi-annual average temperature of the warm season (April-September) has a value of 17.6° C. And in the case of the seasonal average temperature was found an increase value of temperature, more pronounced and more obvious in the cold season (1.8° C) and less pronounced in the warm season (1.0° C).

The atmospheric precipitation regime during a calendar year results from the interaction of genetic factors (at the continental level) with local factors.

The characteristics of the general circulation of the atmosphere and the particularities of the active surface are the fundamental causes that determine the complex genesis of precipitation, their regime and their territorial distribution on the surface of the Banat region (Stanciu, 2005).

The Romania territory due to its geographical position on the globe and the within the European continent, is under the influence of baric centers, which act in Europe in the zone of interference of tropical air masses with polar ones, which is why the most significant amounts of precipitation have fell in periods with persistent cyclonic activity, and the lowest when anticyclonic areas dominated (Sandu et al., 2008).

Due to the geographical position of the Lugoj meteorological station in the western part of the country and at a low altitude, the annual amount of precipitation is lower, but thanks to both the oceanic air masses coming from the west and the humid Mediterranean air masses coming from the south-west, the annual amount of precipitation is higher compared to other parts of the country, as the Romania Plain, located in the south part of Romania.

The varied natural conditions from this region determines the great differences in their vertical distribution, depending on the altitude, the exposure of the slopes and the constitution of the relief forms. The multi-annual average amount of precipitation increases as the relief steps increase in altitude, so with a gradual increase in relief altitude, from the western part to the eastern part of Banat region, an increase in the amount of precipitation is observed.

The analysis of the variation of the monthly amount of precipitation at the Lugoj station, reveals the moderate character of the climate, in this part of the country and reveals a rather high multi-annual average amount of precipitation (680.6 mm), for this plain area in comparison with the values of other plain areas from the southern part of the country (table 2).

Table 2.

Variation of the monthly amount of precipitation at the Lugoj meteorological station (1961-2020)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Multiannual average
45.3	40.3	40.2	57.7	75.9	90.2	65.1	58.3	53.1	48.3	49.1	57.2	680.6

Source: Data processed according to the Archives of the Banat-Crişana Regional Meteorological Center, Timişoara

One of the poorest months of the year is October (48.3 mm). Although cyclonic activity intensifies in this month, the gradual decrease in air temperature proves to have the dominant role in decreasing the amount of precipitation.

The richest month of the year is June (90.2 mm), the month which almost the entire territory of Romania country receives the highest amount of precipitation.

In the analyzed period (1961-2020) the average annual amplitude at this station has a value of 50.0 mm, an the precipitation regime has an irregular character, because the values of the annual amounts of precipitation showed quite large non-periodic variations, depending on the frequency and intensity of advection different air masses during a calendar year (fig. 2).

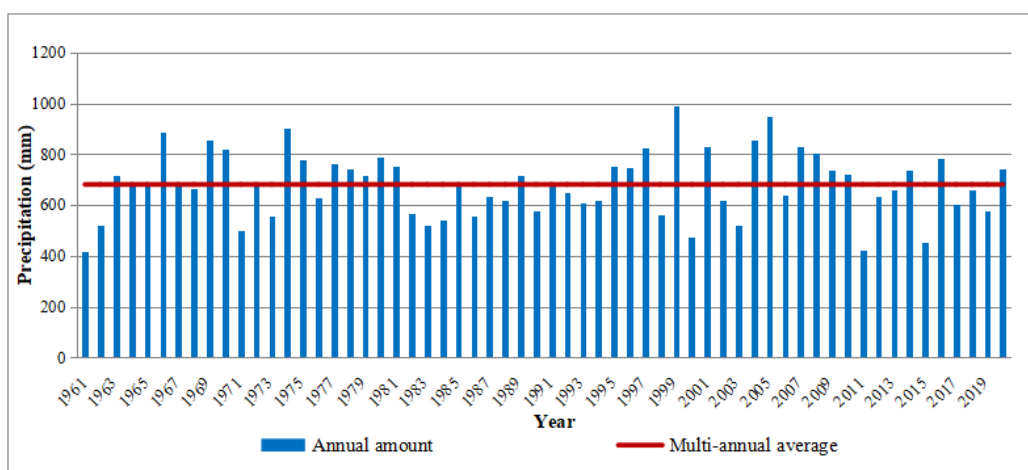


Figure 2. Variation of the annual amount of precipitation at the Lugoj meteorological station

The growth trend of the precipitation amount is a consequence of the global climate changes we are witnessing, caused by human activity and the intense process of urbanization and industrialization, which determined, especially during the second half of the 20th century, an increase in the number of cloud condensation nuclei and an increase in the frequency of atmospheric precipitation.

The range with the lowest multi-annual average rainfall is 1981-1990 (616.6 mm) and the one with the highest multi-annual average rainfall is 2001-2010 (750.6 mm).

The distribution of precipitation during the year is also different by season, with summer recording the highest amount of precipitation (213.5 mm), approximately 31.37% of the annual amount and winter the lowest (142.9 mm) with a weight of about 20.99% of the total amount.

In the context of global climate changes, the distribution of precipitation by seasons in the part of the country where the Lugoj meteorological station is situated follows quite different trends over the last 60 years. These trends are: a constant trend in the summer, a decreasing trend in the spring and winter, and a sharper increasing trend during in the autumn, which in total cancels out the declines during in the spring and in the winter.

At the latitude of Romania country and in the physical-geographical conditions of Romania, the regime of atmospheric precipitation during the year is characterized by rather large variability, which can cause the phenomenon of drought and excess rainfall, which can cause the formation of extreme hydrological phenomena such as floods (Arba, 2012).

In the warm season (April-September) of the year, the most pronounced variability is recorded and the amount of precipitation with the largest share of the annual amount (58.80%) is added up, which is an important climatic parameter for different branches of activity, in especially for agriculture.

In the cold season (October-March) of the year generally the lowest amounts of precipitation are recorded, which add up to the lowest annual amount (41.20%). This is due to

the the low water vapor content of the air masses, conditioned by the low values of temperatures.

CONCLUSIONS

In the context of global climate changes, the distribution of precipitation by seasons in this part of the country where the Lugoj meteorological station is situated, follows quite different trends in the analyzed period (1961-2020), namely: a constant trend is recorded in summer, a trend decreasing in spring and winter is recorded decrease and in the fall there is a more pronounced upward trend, which in total cancels the decreases during the spring and winter. As a consequence of the global climate changes we are witnessing, it can be observed, analyzing the variability and evolution trend of the thermal regime of the air over the last 60 years, that the evolution trend of the multi-annual average temperature at the Lugoj meteorological station is increasing with a value of about 1.7° C. The growth trend of the precipitation amount is a consequence of the global climate changes we are witnessing, caused by human activity and the intense process of urbanization and industrialization, which determined, especially during the second half of the 20th century, an increase in the number of cloud condensation nuclei and an increase in the frequency of atmospheric precipitation. The range with the lowest multi-annual average rainfall is 1981-1990 (616.6 mm) and the one with the highest multi-annual average rainfall is 2001-2010 (750.6 mm).

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