

## SOME ASPECTS REGARDING THE CURRENT CLIMATIC TRENDS IN ORADEA, IN THE GLOBAL WARMING CONTEXT

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### Abstract

*To highlight the climatic effects of global warming in Oradea city, we have analyzed, in this paper, some climatic elements that best highlight it: air temperature, precipitation, thunderstorms and hail. For these elements we have analyzed their annual average, maximum and minimum values for the period 1961-2011, as well as their linear trend, which revealed their evolution. The result was that the average annual temperature in Oradea has been rising over the 51 years analyzed. The increasing trend can be explained also, by the growth of the city area and by the increased traffic in the city and its outskirts, in recent years. The annual precipitation amounts have been increasing in Oradea, but the increase was reduced. In the last interval of years, 1996-2011, both the rainiest and the driest years were recorded. This can be attributed to the global warming of the atmosphere, which results in the occurrence of pluviometric extremes. In the recent years one could notice that the thunderstorms may occur even in the winter months. The linear trend of the annual number of days with thunderstorms is slightly increasing. The hail was present in Oradea particularly between the years 1970-2001. Towards the end of the analyzed period, it decreased in frequency. This does not mean, however, that it has not occurred in these years across Oradea city or its surroundings, but rather that it was absent in the area of the weather station Oradea. The linear trend of the annual number of days with hail is constant.*

**Key words:** trend, global warming, air temperature, precipitation, thunderstorm, hail.

### INTRODUCTION

In recent years, global warming has become a very topical subject, increasingly debated by scientists and media, as it has an impact both on the environment and on human society.

Global warming has led, in our country, to a number of changes in the environment, manifested by long periods of drought, alternating with periods of excessive rainfall and many dangerous meteorological phenomena, noticed because of their high intensity and frequency, such as: extremely abundant rainfall, with torrential character, high intensity thunderstorms, large hail, heat waves alternating with cold waves, intense squalls and even tornadoes. All these have caused extensive damage in several areas: economy (especially agriculture), environmental protection, health etc.

Thus, the study below started from this premise, especially the negative effects generated by this global phenomenon that has multiple implications in all fields.

## MATERIAL AND METHODS

To highlight the climatic effects of global warming in Oradea city, we have analyzed, in this paper, some climatic elements that best highlight it. For these elements we have analyzed their annual average, maximum and minimum values for the period 1961-2011, as well as their linear trend, which revealed their evolution. The analyzed climatic elements were: air temperature, precipitation, thunderstorms and hail.

In the paper we used monthly and annual meteorological data for the climatic elements listed above. The data come from the archives of the Oradea County Weather Station.

## RESULTS AND DISCUSSION

### 1. Trends of air temperature in Oradea

Air temperature is the climatic element that best highlights the global warming of the Earth's atmosphere. Its effects are reflected by the occurrence of thermic extremes, namely the *heat waves*, generated by the advections of warm, tropical air, as well as the *cold waves*, generated by the advections of cold, arctic air.

Thermic extremes have begun to be increasingly common in recent years, both in our country and in many regions of the world.

The *annual average temperatures* recorded, at the weather station Oradea, values between 9.0°C and 12.0°C, ranging around the multi-annual average value of 10.4°C (during 1961-2011) (Fig. 1). This multi-annual average value of temperature is a characteristic of lowland regions of our country, a region where the weather station Oradea is located.

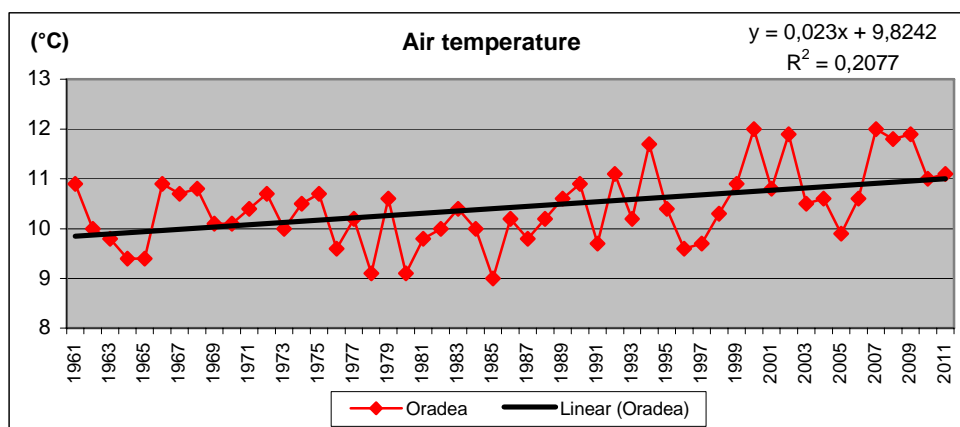


Fig. 1. Annual average air temperature and their linear trend, at the weather station Oradea (1961-2011)

The lowest annual average value of 9.0°C was recorded in 1985, which was the coldest year of the analyzed period. The highest annual average value rose to 12.0°C and occurred in 2000 and 2007, which were two excessively warm and dry years in the whole country.

Figure 1 shows that during the first part of the analyzed period, from 1961 to 1991, temperatures were lower, while in its second part, between 1992 and 2011, temperatures began to rise more. The warmest years were 1994, 2000, 2002 and the interval 2007-2009. The coldest years were 1978, 1980 and 1985.

An analysis of *the linear trend* for the studied period (1961-2011) shows that it is *increasing*. So, the average annual temperature in Oradea has been rising over the 51 years analyzed. This trend concurs with the one found by many Romanian and foreign climatologists, who noted the air temperature increase in recent years in our country and in many parts of the Globe, particularly in the Northern Hemisphere (Litynski et al., 2003; Luterbacher, Xoplaki, 2003; IPCC, 2007, <http://www.ipcc.ch>; Fratianni, Acquaotta, 2010; Cuccia et al., 2010; Vasenciuc, Dragotă, 2002; Tudose, Moldovan, 2006; Măhăra, 2006; Teodoreanu, 2007; Șerban, 2010 etc.).

The increasing trend can be explained, in the case of Oradea, also by the growth of the city area and by the increased traffic in the city and its outskirts, in recent years, since the city's ring road went into use, the road that crosses the area adjacent to the weather station. The great urban concentration, with its many asphalt surfaces, leads to the formation of so-called "heat islands" that amplify the diurnal thermic values, especially in warm semester of the year.

## **2. Trends of precipitation in Oradea**

The Crisurilor Plain has a *temperate continental climate, with prevalent oceanic influences*, as it is wide open to West, to the Pannonian Plain, and therefore exposed to frequent advections of moist air masses from the West. This causes the moderate character of the rainfall regime in Oradea.

However, pluviometric extremes are recorded here as well, materialized in long-term *drought*, and also *rainfall excess*, both considered climatic hazards. As in other regions of the country and in Oradea as well, pluviometric extremes have become increasingly common in recent years, as a consequence of global warming.

During 1961-2011, at the weather station Oradea the annual precipitation amounts ranged between 364.2 mm in the driest year, 2000 and 884.0 mm in the rainiest, 1996 (Fig. 2). The average multi-annual precipitation amount is 617.1 mm during the period under review.

The annual precipitation amounts varied widely over the years, the fluctuations occurring due to the dependence of precipitation to the general circulation of the atmosphere, which is interconnected with land surface.

In general, the maximum amounts exceeded 700 mm and even 800 mm and the years with values above 800 mm were: 1974, 1996, 1999, 2001 and 2010. They were the rainiest years. It is noted that these years were recorded especially in the latter part of the analyzed period (1996-2010). The large amounts of precipitation at the end of analyzed period are due to the air temperature growth, which resulted in an intense thermic convection.

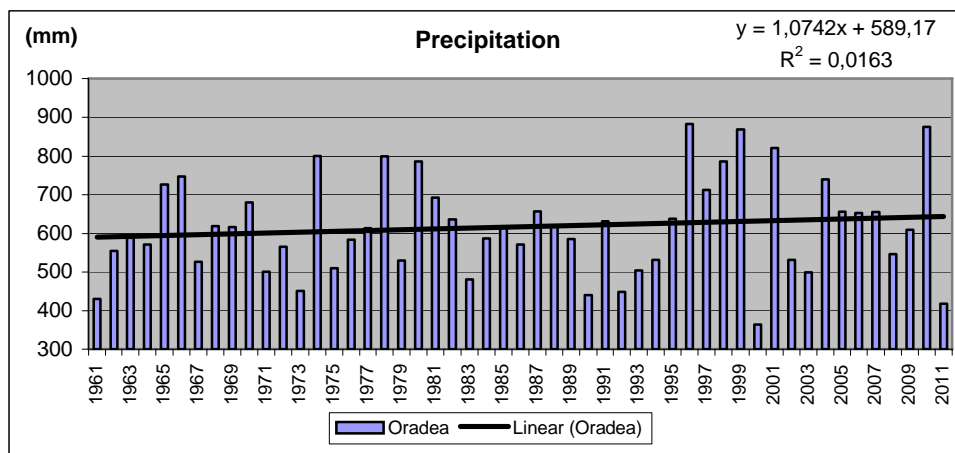


Fig. 2. Annual precipitation amounts and their linear trend, at the weather station Oradea (1961-2011)

The annual minimum precipitation amounts had values of less than 450 mm. The years with the lowest values were: 1961, 1990, 1992, 2000 and 2011. These were the driest years. In this case as well it is noticed that the driest years occurred especially in the second part of the analyzed period.

It is noted that in the last interval of years, 1996-2011, both the rainiest and the driest years were recorded. This can be attributed to the global warming of the atmosphere, which results in the occurrence of pluviometric extremes.

By analyzing the *linear trend* for the studied period, 1961-2011, we find that it has an *increasing* tendency. So, the annual precipitation amounts have been increasing in Oradea during the 51 years analyzed, but the increase is reduced.

### 3. Trends of thunderstorms in Oradea

Thunderstorms are complex atmospheric phenomena that consist of repeated lightning, accompanied by thunder. Thunderstorms are climatic

hazards specific to the warm semester of the year, but exceptionally they may also occur in the months of the cold semester.

In the recent years one could notice that the thunderstorms have become more numerous and intense, and they may occur even in the winter months (Fig. 3). This is attributed to the Cumulonimbus clouds with great vertical development, formed under conditions of enhanced dynamic or thermic convection, so the phenomenon can be linked to the global warming of the atmosphere.

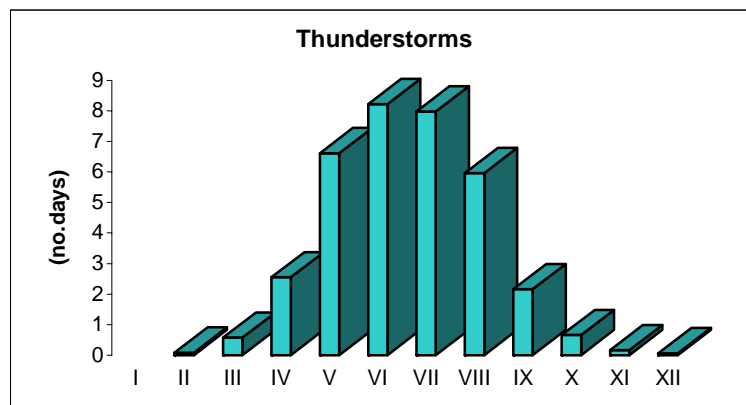


Fig. 3. Monthly average number of days with thunderstorms at the weather station Oradea (1961-2009)

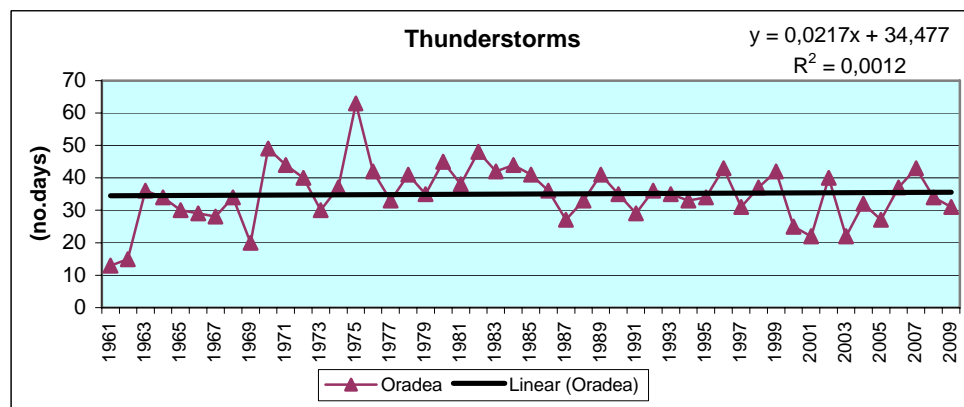


Fig. 4. Annual number of days with thunderstorms and their linear trend, at the weather station Oradea (1961-2009)

At the weather station Oradea, during 1961-2009, the annual number of days with thunderstorms ranged between 13 and 63 days (Fig. 4). The multi-annual average number for the analyzed period is 35 days. The year

with the greatest annual number of days with thunderstorms was 1975 and the year with the lowest number was 1961, a dry year.

The *linear trend* of the annual number of days with thunderstorms, over the period 1961-2009, is *slightly increasing*. Figure 4 shows that thunderstorms were present in Oradea, particularly between the years 1970-1985. Between 1986 and 1995, thunderstorms decreased in frequency and their decrease is attributed to the large number of dry years in this period. In the last part of the analyzed period (1996-2009), thunderstorms fluctuated around the multi-annual average value, presenting lower values in some dry years and higher in some rainy years.

#### 4. Trends of hail in Oradea

Hail is a climatic hazard specific to the warm semester of the year. It causes serious local damage within a brief period of time, according to the trajectory of the cloud that generated it. The damage depends on the size and density of the hailstones.

In recent years, in our country hail began to have increasing sizes or deposits as a layer of ice. This phenomenon is related to the occurrence of large Cumulonimbus clouds with great vertical development, which, in turn, are the consequence of the increase in the air temperature, thus the global warming.

During 1961-2011, the annual number of days with hail ranged, at the weather station Oradea, between 0 and 3 days (Fig. 5). The variations are due to the general circulation of the atmosphere, the features of the land surface and the solar radiation regime. The multi-annual average number for the analyzed period amounted to only 1 day.

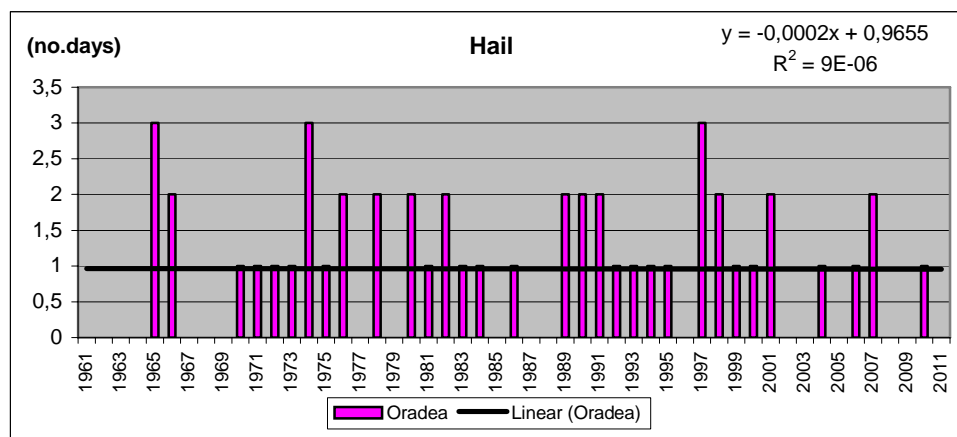


Fig. 5. Annual number of days with hail and their linear trend, at the weather station Oradea (1961-2011)

The years which recorded the largest annual number of days with hail were: 1965, 1974, and 1997. These years have totalled 3 days with such phenomenon.

Throughout the period under review, there were a total of 19 years in which the phenomenon was absent (this means that it was not present on the weather station platform).

Figure 5 shows that hail was present in Oradea particularly between the years 1970-2001. Towards the end of the analyzed period, it decreased in frequency. This does not mean, however, that it has not occurred in these years across Oradea city or its surroundings, but rather that it was absent in the area of the weather station Oradea.

The *linear trend* of the annual number of days with hail during the period 1961-2011, is *constant*.

## CONCLUSIONS

Global warming has caused a number of changes in the environment, manifested by increased frequency and intensity of climatic hazards. In Oradea, climatic effects of global warming have been emphasized, during the years 1961-2011, by the growth trends of annual values of some climatic elements, such as air temperature, precipitation and thunderstorms. Of these, the highest growth is recorded for air temperature. Only the annual number of days with hail remained constant during this time.

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