# TRENDS OF AIR TEMPERATURE IN BIHOR COUNTY

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***Abstract***

*The paper analyzed the spatial and temporal variability and the linear trend of the average annual air temperature, as well as the variability of the average decennial air temperature.In this respect, the meteorological data on the average annual air temperature were used, from the 7 weather stations located in Bihor County.The analysis period was 1961-2017 (1961-2007 at some stations).The result was thatan important increase in the average annual air temperature was noted at the weather stations in Bihor County, starting with 1994. The hottest years were recorded between 2000 and 2017, and the coldest between 1964 and 1985. The linear trend of the annual average values of air temperature is upward, at all stations.The analysis of the average decennial temperature shows that the first decade (1961-1970) was warmer than the next two (1971-1980 and 1981-1990), and starting with the second decade (1971-1980) there is a continuous increase in air temperature. The average growth rate of temperature from one decade to another was between 0.097°C and 0,778°C.*

**Key words:**air temperature, trend, variability, decade

## INTRODUCTION

Air temperature is a result of the interaction of several factors at ground level, these being: the intensity of solar radiation, the circulation of the atmosphere and the characteristics of the land surface. As a result, it exhibits great variations, both in time and in space, its values depending on the general (or local) circulation of the atmosphere, altitude, latitude, local relief conditions, hydrography, soil type or vegetation type etc.(Climate of Romania, 2008; Şerban, 2010).

The studies of many authors show an increase in global air temperaturein recent years.Another feature of the air temperature of recent years would bethe thermal extremes, caused by heat waves or cold waves, which have become more and more intense and manifest in other seasons, not just in thosecharacteristic to them.In connection with this increase in air temperature, other dangerous meteorological phenomena occur, whose intensity and frequency increase from year to year:more and more intense droughts, increasing amounts of precipitation fallen in short intervals, stronger lightning and thunder, more and more intense squalls, large hailetc.The damage caused by these phenomena is increasingly higher.

These phenomena have a huge impact on human health. Although populations are adapting, high temperatures are associated withthermal discomfort, decreased performance and productivity, sleep disturbances and cardiac and respiratory symptoms. Heat waves can increase mortality due to cardiovascular, cerebrovascular or respiratory problems. Elderly people and patients suffering from heart, lung or psychiatric disorders are at particular risk (Nayha et al., 2013; Haines et al., 2006).On the other hand, the cold waves have beenassociated with exacerbations of asthma or chronic obstructive pulmonary disease and respiratory infections(Hyrkas et al., 2014). Decrease in human body temperature leads to cutaneous vasoconstriction and increased blood pressure, hemoconcentration and vascular thrombosis, as well as increased cardiac load, oxygen deficiency and arrhythmia (Nayha et al., 2011).The sudden transition from high temperatures to low temperatures or vice versa leads to a decrease in general population well-being and an increase in temperature-related mortality and morbidity, especially in vulnerable population groups (European Environment Agency, 2016).

Plants also suffer a lot because ofsudden temperature changes or improperthermal values forthe season:too warm winters cause too early flowering of flowers; too hot seasons of spring or summer cause the premature baking of vegetables or fruits;too warm autumns cause the secondary flowering of fruit trees, etc.

## MATERIAL AND METHOD

In order to highlight the way in which the air temperature has varied, over the years, on the territory ofBihor County,the meteorological data on the average annual air temperature were used, from the 7 weather stations located in the county:Săcueni, Oradea, Holod, Ștei, Borod, Dumbrăvița de Codru and Stâna de Vale (Table 1).The analysis period begins in 1961.But not all stations have data since this year. Some were set up later: 1968 (Holod and Borod), 1979 (Stâna de Vale), 1983 (Dumbrăvița de Codru).

*Table 1*

Altitude and geographic coordinates of the weather stations in Bihor County

| Weather station | Altitude (m) | Geographic coordinates | |
|---|---|---|---|
| | | Latitude (N) | Longitude (E) |
| **Săcueni** | 125 | 47°21’ | 22°06’ |
| **Oradea** | 136 | 47°02’ | 21°54’ |
| **Holod** | 163 | 46°47’ | 22°07’ |
| **Ștei** | 279 | 46°31’ | 22°27’ |
| **Borod** | 334 | 46°59’ | 22°35’ |
| **Dumbrăvița de Codru** | 587 | 46°38’ | 22°10’ |
| **Stâna de Vale** | 1109 | 46°41’ | 22°37’ |

Given the various landforms of Bihor County, the stations are also located at various altitudes, ranging from over 100 m to over 1100 m. Thus, some stations are located in the plain, others in the depressions, and others in the mountain area.

The paper analyzed the average annual air temperature, its spatial and temporal variability and its linear trend, as well as the variability of the average decennial air temperature.

The air temperature data has been obtained from the database of the National Meteorological Administration of Romania and from the website www.meteomanz.com.

**RESULTS AND DISCUSSION**

In Bihor County, the multi-annual average air temperature has values ranging from 4.0°C to 10.6°C(Table 2).These values are distributed as follows: 4.0°C at the highest stationStâna de Vale; between 9.3-9.9°C at the stations with medium altitudes Ştei, Borod and Dumbrăviţa de Codru; between 10.3-10.6°C at the western lower stations. It is highlighted the distribution of the multi-annual average air temperature according to the altitudinal and latitudinal position of the weather stations. Thus, on the territory of the county the temperature decreases from west to east, once with the increase of the altitude of the relief, but also from south to north, once with the increase of the latitude.

*Table 2*

The multi-annual average temperature and the warmest/coldest years at the weather stations in Bihor County

| Weather station | Analyzed period | Multi-annual average temp.(°C) | The warmest year/ value(°C) | | The coldest year/ value(°C) | |
|---|---|---|---|---|---|---|
| **Săcueni** | 1961-2008 | 10,5 | 2007 | 12,2 | 1980 | 9,0 |
| **Oradea** | 1961-2017 | 10,6 | 2014 | 12,8 | 1985 | 9,0 |
| **Holod** | 1968-2007 | 10,3 | 2000 | 12,0 | 1980 | 9,1 |
| **Ștei** | 1961-2007 | 9,8 | 2000 | 11,4 | 1980 | 8,6 |
| **Borod** | 1968-2007 | 9,3 | 2007 | 11,3 | 1980 | 8,2 |
| **Dumbrăvița de Codru** | 1983-2007 | 9,9 | 2000 | 11,7 | 1985 | 8,6 |
| **Stâna de Vale** | 1979-2007 | 4,0 | 2002 | 5,4 | 1985 | 3,1 |

From figures 1-4, wenotice that the average annual air temperature has a similar temporal variability at the 7 stations, showing the sameincreases and decreases in values. If in the first part of the analyzed period – 1961-1993 – the values are lower, starting with 1994 there is an importantincrease of the temperature values.We can say that *the first three decades were colder, while the last two and half decades were hot*.

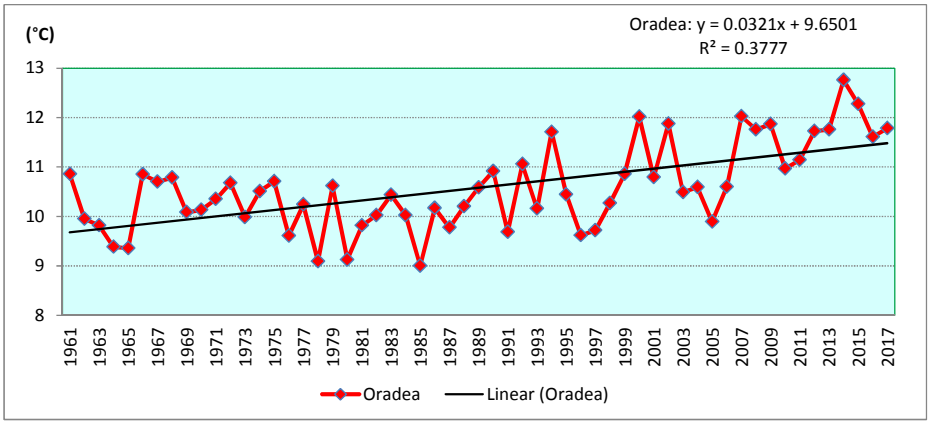


Fig. 1. The variation of the average annual air temperature and its linear trend at Oradea weather station(1961-2017)

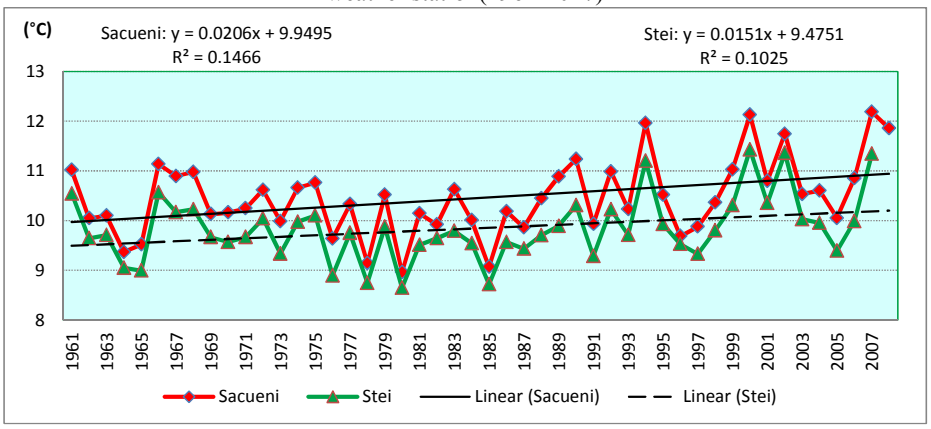


Fig. 2. The variation of the average annual air temperature and its linear trend at the weather stations Săcueni (1961-2008) and Ștei (1961-2007)

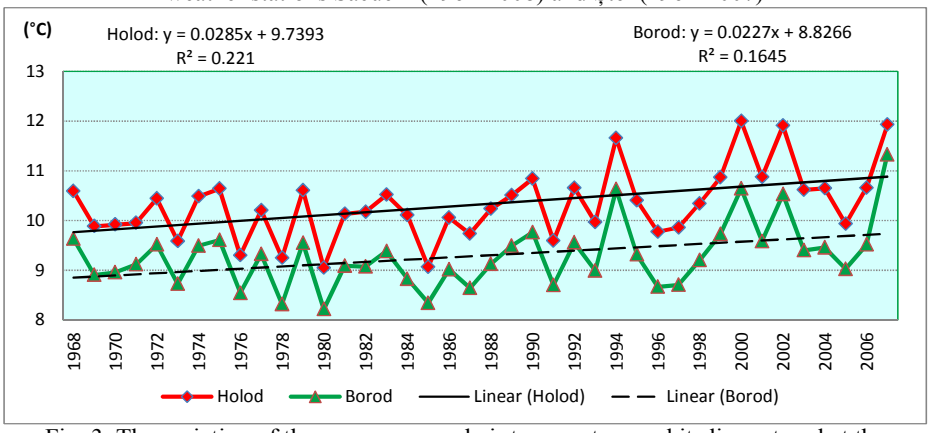


Fig. 3. The variation of the average annual air temperature and its linear trend at the weather stations Holod and Borod (1968-2007)

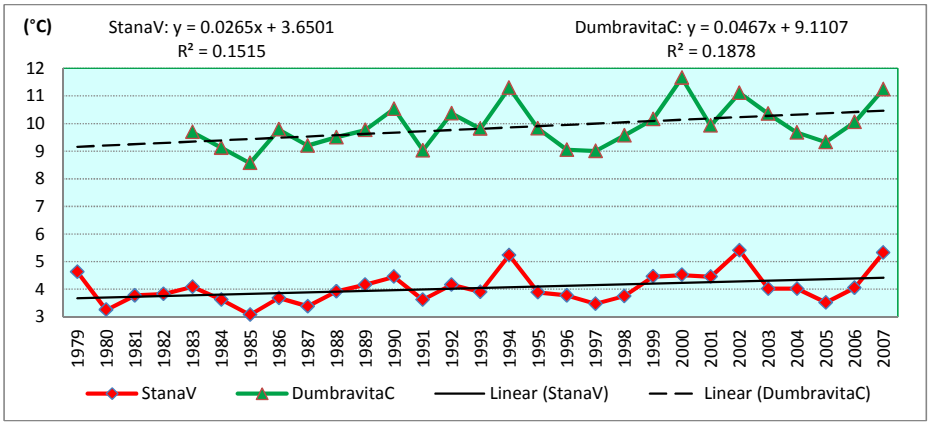


Fig. 4. The variation of the average annual air temperature and its linear trend at the weather stations Stâna de Vale (1979-2007)and Dumbrăvița de Codru (1983-2007)

The warmest year was registered in the period 2000-2014, in Bihor County (Table 2). Thus, the hottest year was **2014**at Oradea (12.8°C), **2007** at Săcueni and Borod (12.2°C and 11.3°C, respectively), **2000** atHolod, Ștei and Dumbrăvița de Codru (between 11.4-12.0°C) and **2002** at Stâna de Vale (5.4°C). The record of the hottest year in 2007 or 2000, at many of the stations, is due to the shorter set of data we had available.

In addition to the years stated above, other warm years were: 2015, 2009, 2017, 2008, 2013, 2012, 1994, etc. It is noted that most of these years were recorded after 2000.

The coldest years in Bihor County were **1980**, atSăcueni, Holod, Ștei and Borod (with an average annual temperature between 8.2-9.1°C) and **1985** at the other stations (with values between 8.6-9.0°C and only 3.1°C at Stâna de Vale) (Table 2). Other cold years were:1978, 1965, 1964, 1976, etc.

*The linear trend* of the averageannual values of air temperature is *upward*, at all 7 stations analyzed (Fig. 1-4). So, during the study period 1961-2017, the air temperature was increasing. This increase is due to the very high values of recent years, which were very warm. Thus, the interval of 2007-2017 had average annual values ≥ 11°C atOradea station, these years being extremely hot.

Comparing the stations between them, it follows that the most pronounced upward trends of temperature are those from Oradea ($R^2$=0.3777) and Holod($R^2$=0.221) stations. Șteistation has the smallest values of the trend. However, this comparison is less important, given the different analysis period of the stations.

Many Romanian and foreign climatologists, who have conducted studies on air temperature variability in our country or in different regions

of the Globe, have found that the values of this meteorological element have increased in recent years/decades or have found positive trends over long periods of time(Litynski et al., 2003; Wang et al., 2004; Fratianni, Acquaotta, 2010; Cuccia et al., 2010; Tang et al., 2010; Nastos et al., 2011; IPCC, 2013, 2014, http://www.ipcc.ch; Măhăra, 2006;Tudose, Moldovan, 2006; Teodoreanu, 2007; Climate of Romania, 2008; Şerban, 2010 etc.). Some authors have put these trends on account of the global warming of the Earth's atmosphere, due to the increase in greenhouse gases concentrations.

In the case of large cities, such as Oradea, the increase in air temperature can also be attributed to the expansion of the city and to the growth of paved areas, which make a major contribution to the amplification of the "urbanheat island", with effects that can be felt in any season.

The average annual air temperature was averaged over the 6 decades of the analyzed period 1961-2017, resulting in the average decennialtemperature (Fig. 5). Depending on the period under review, the weatherstations have or don't have values in certaindecades. Only Oradea station has the most values, but even here the last decade (2011-2017) isincomplete.Also, the other stations don'thave the decade 2001-2010 entirely.

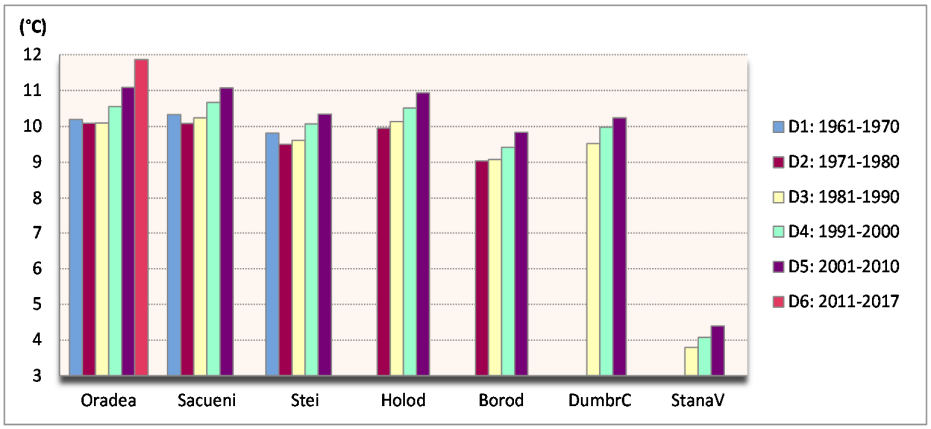


Fig. 5. The average decennial air temperatureat the weather stations in Bihor County (1961-2017)

The figure shows that the first decade (1961-1970) was warmer than the next two (1971-1980 and 1981-1990), *and starting with the second decade (1971-1980) there is a continuous increase in average decennial temperature*.The warmest decade was the last (2011-2017), and the coldest was the second decade (1971-1980), at all stations.

Thus, in Oradea the average decennial temperature increased from 10.09°C in the 2nd decade (D2)to 11.86°C in the 6th decade (D6), in

Săcuenifrom 10.08°C (D2) to 11.08°C (D5), at Ștei from 9.50°C (D2) to 10.34°C (D5), at Holod from 9.95°C (D2) to 10.94°C (D5), etc. At the weather stations in Bihor County, the average growth rate oftemperaturefrom one decade to another was 0.097°C from D2 to D3, 0.400°C from D3 to D4 and 0.377°C from D4 to D5. The averagedecennial temperature increased by 0.778°Cfrom D5 to D6, at Oradea station.

**CONCLUSIONS**

On the territory of Bihor County, the multi-annual average air temperature decreases from west to east, once with the increase of the altitude of the relief, but also from south to north, once with the increase of the latitude.An important increase in the average annual air temperature is noted at all weather stations, starting with 1994. We can say that the first three decades were colder, while the last two and half decades were hot.

The hottest years were recorded between 2000 and 2017, and the coldest between 1964 and 1985.The linear trend of the annual average values of air temperature is upward, at all stations.

The analysis of the average decennialtemperatureshows that the first decade (1961-1970) was warmer than the next two (1971-1980 and 1981-1990), and starting with the second decade (1971-1980) there is a continuous increase in air temperature.The average growth rate of temperature from one decade to another was between 0.097°Cand 0,778°C.

The increase in air temperature in recent years leads tomany negative effects, among whichwe mention the health status of the population, changes in ecosystems, etc.

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