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THE CHARACTERISTICS OF EXTREME AIR TEMPERATURES IN THE ARAD URBAN AREA

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Résumé: ***Les caractéristiques des températures extrêmes de la région de la ville d'Arad***. Le présent article se propose d'étudier la variation de la moyenne des températures extrêmes pour la période 1954-2007 et les conditions dans lesquelles on a enregistré les températures extrêmes absolues à la station météorologique Arad.

Mots-clés: moyenne des minimales, moyenne des maximales, températures extrêmes absolues.

Introduction

Air temperature is an element which shows great variability in both time and space. Temperature characteristics in a region are determined by several factors, including air circulation, characteristics of the active layer, landform, hydrographic network, and vegetation. In addition, geographic location, the arrangement of large landform units and the presence of human settlements also have an important impact on the characteristics of air temperatures in the area one investigates.

1. Methodology

For the present study, I have used the usual research methods in the field of general climatology. The extreme temperature values observed at the meteorological station in Arad during a 54-year period (1954-2007) have been processed through the methods of mathematical statistics and graphical representation. Subsequently, I was able to determine the importance of extreme temperatures in understanding the general climatic features of an area.

2. Results and discussion

2.1. Mean daily minimum temperature

The average of daily minimum air temperature is a parameter of high importance for several economic branches (agriculture, construction, transport). The mean daily minimum temperature at the Arad meteorological station is 5.0 degrees centigrade (5.0°C).

During winter months values are mostly negative, but there are records of negative values for early spring months (March) or late fall months (November) as well. Also, there have been cases of positive values in winter months. For instance, records show positive values for January in two years (3.7% of the total number of cases), 1994 (0.2°C) and 2007 (0.3°C), while in 1988 the average was 0.0°C. These values are generated by warm air invasions during winter, in the context of the intensification of cyclonic activity in the Mediterranean Sea Basin (see Table 1).

Table 1. Average, maximum, and minimum values of monthly mean minimums (Arad, 1954-2007)

Mean min.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average	-4.9	-3.7	0.5	4.4	9.3	12.5	13.8	13.6	10.2	5.3	1.8	-2.8	5.0
Maximum	0.3	2.6	4.8	8.2	12.5	15.7	17.1	17.7	14.4	11.7	6.3	3.0	7.0
Minimum	-12.9	-15.4	-4.5	1.7	8.0	10.4	12.2	11.6	7.0	2.1	-4.7	-8.4	4.1

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For December, the mean minimum takes positive values in 22% of the cases, while in February positive values occur less frequently: 18.5% of the total number of years investigated. The lowest value of the mean minimum, -15.4°C, was reported in February 1956. The highest value of the mean minimum for the cold season was 3.0°C, reported in December 1960.

For the spring season, multiannual values of the mean minimum range from 0.5°C in March to 9.3°C in May. Negative values of the monthly average of minimum temperatures were observed only for March (the lowest was reported in 1987: -4.5°C), at an incidence rate of 31.4%. The highest value for springtime, 12.5°C, was reported in May 2003.

Among multiannual values of the mean medium for the summer season, the highest appears in July, 13.8°C, and the lowest – in June, 12.5°C. The lowest monthly average was reported in June 1984 (10.4°C), whilst the highest was observed in August 1992: 17.7°C, the highest value of the monthly average of minimum temperatures for the entire period analyzed.

During fall, values are positive with the exception of November, when negative values occur at an incidence rate of 18.5%. The lowest mean minimum was reported in November 1988 (-4.7°C) and the highest (14.4°C) – in September 1994.

2.2. Mean daily maximum temperature

The mean daily maximum has a multiannual value of 16.2°C for the years 1954-2007. Most monthly averages of daily temperatures are positive, but there have been cases of negative values, in winter. The incidence rate of negative averages for January is 16.7% and the lowest negative value, -6.0°C, was reported in 1964. For February, negative values are less frequent (11.1%); the lowest mean was reported in 1956 (-4.4°C). For December, negative values are even rarer (7.4% incidence rate), and the lowest mean of daily maximum temperature was observed in 2001: -1.2°C. These low values of maximums are brought about by invasions of Arctic air masses from Northern and North-Eastern Europe, which can, if corroborated with a stable anticyclonic regime and snow cover, cause radiative cooling and air stagnation over our country for an extended period of time. In January 1964, both the mean maximum (-6.0ºC) and the monthly mean (-9.4ºC) were the lowest in the interval 1961-2007 (see Table 2).

Table 2. Average, maximum, and minimum values of monthly mean maximums (Arad, 1954-2007)

Mean max.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average	2.2	3.9	10.4	17.1	22.1	26.3	29.1	28.7	24.1	17.1	10.1	3.7	16.2
Maximum	8.8	11.3	16.4	21.1	27.7	30.4	31.6	33.9	28.1	21.8	17.3	8.8	19.1
Minimum	-6.0	-4.4	5.4	12.7	17.7	22.2	24.6	24.3	18.0	12.7	3.9	-1.2	14.6

The highest value of the mean maximum for winter months was reported in February 1990: 11.3°C.

For springtime, the highest average of daily maximum temperatures was reached in May 2003 (27.7°C). The lowest value of the mean maximum for this season, 5.4°C, was reported in March 1987.

1992 brought the highest mean maximum of all the years in the period under analysis: 33.9°C, in August. However, the most frequent maximum annual values of the mean daily maximum occur in July (48%), while in August the incidence rate is 42%; in June annual maximum means occur at a 8% rate (4 cases reported in 54 years). In 1955 the highest mean maximum was reported in July and August alike.

For fall, the highest values of the mean maximum are characteristic of September; the maximum was 28.1°C, in 1994. The incidence rate of maximum means for fall months

is 100% in September. The highest annual value of the fall mean maximum was 19.1°C (reported in 2000), the lowest was 14.6°C (in 1956 and 1980), which amounts to a 4.5°C multiannual amplitude.

2.3. Absolute extreme temperatures

These values represent singularities, limits within which temperature fluctuation occur. Their exceptional character is accounted for by the uniqueness of the relevant report in the whole series of values recorded at a given station.

2.3.1. Absolute minimum temperature

The absolute minimum temperature recorded at the meteorological station in Arad is -30.1°C, on February 6th 1954 (see Table 3). This value was reported in the joint context of an Arctic air mass coming from Northern Europe and the expansion of the Eastern European anticyclone toward Central Europe. On February 5th an anticyclonic nucleus formed over our country, with a central pressure of 1030 hPa; the following day, it moved toward Western Europe, making room for the cold air which eventually caused, under clear sky conditions and in the presence of snow cover, the absolute minimum for Arad (see Figure 1).

Table 3. Highest (M) and lowest (m) monthly minimums (Arad, 1896-2007)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
M	-3.4	0.9	1.3	3.1	10.0	13.9	17.0	16.3	12.7	7.5	1.8	-1.9	-6.4
m	-29.8	-30.1	-21.5	-7.5	-2.3	0.8	5.4	5.1	-2.4	-9.5	-14.4	-23.0	-30.1

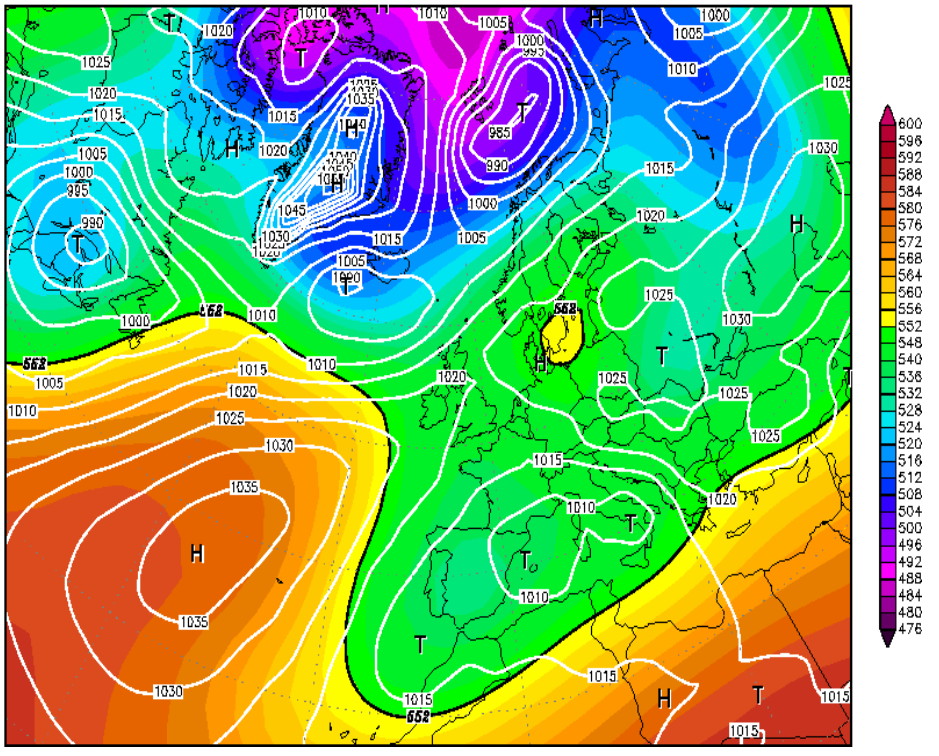

Figure 1. 500 hPa geopotential height and sea-level pressure on February 6th 1954
(sursa: http://www.wetterzentrale.de/topkarten/fsreaeur.html)

Table 4. Annual minimum values (Arad, 1961-2007)

Month	Nov.	Dec.	Jan.	Feb.
Annual minimum (ºC)	-13.9 / -14.4	-20.8	-29.8	-24.2
Year	1975 / 1988	2001	1963	2005
Incidence rate	4%	27%	51%	18%

The annual minimum was most often reported in January (51% incidence rate), but there have been cases when it occurred even in November (see Table 4).

The absolute minimum temperature for spring months was reported in March 1996: -16.8°C. In 96% of the years investigated the minimum temperature for this season occurred in March; in 2 years, it was reported in April (1978 and 2002). The lowest temperature recorded in April during the last 100 years was -7.5°C, while in May the lowest was -2.3°C (in 1962).

During summer, monthly minimums are all positive. The absolute minimum temperature of the summer season was reported in June 1977: 0.8°C. Most summer minimums occurred in June, at an incidence rate of 62%; for August the incidence rate is 27%. In 11% of the cases the absolute minimum temperature of summer was reported in July.

With September, minimums become negative. The lowest temperature for this month in the last century was -2.4°C, reported in 1970. The lowest fall temperatures occur in November (84% of the cases) and two of them are coincident with the annual minimum (1975 and 1988). In 16% of the years the fall minimum was recorded in October, a month whose absolute minimum in the last 100 years was -9.5, reported in 1997 (see Figure 2).

The analysis of the evolution of annual minimum temperatures over the last 54 years shows a slight upward tendency (see Figure 3).

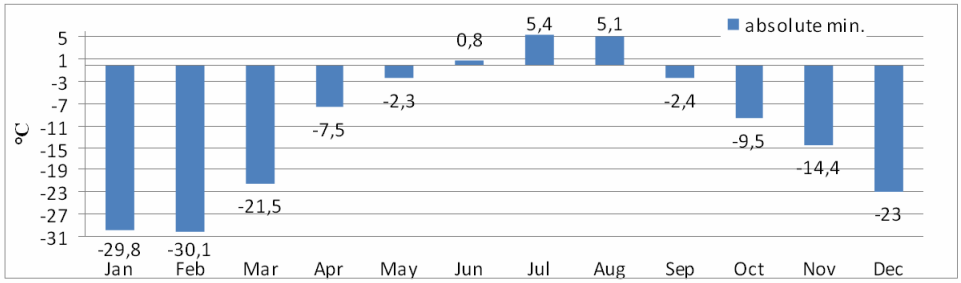

Figure 2. Monthly absolute minimums (Arad, 1896-2007)

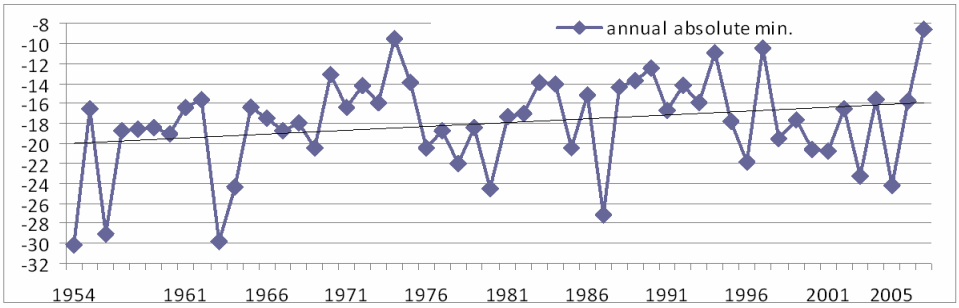

Figure 3. Annual minimum temperatures and their linear tendency (Arad, 1954-2007)

2.3.2. Absolute maximum temperature

The absolute maximum temperature recorded at the Arad station is 40.4°C, on August 16th 1952. This value was reached in the context of a tropical continental air mass advection from Northern Africa; the extremely high temperature was caused by the expansion of a low-pressure field over Central and Western Europe and a maximum over the Black Sea. Southern circulation between these two baric formations heavily intensified, leading to the transport of an excessively hot air mass over our country (see Figure 4).

The annual maximum temperature is most frequently recorded in July (46%) and August (almost 42%). For June the incidence rate is significantly lower: only 6.6%. There have been two years when the annual maximum occurred in May and September respectively, and one year (1975) when the annual maximum was reported for both August and July, taking the same value: 31.2°C (see Table 5).

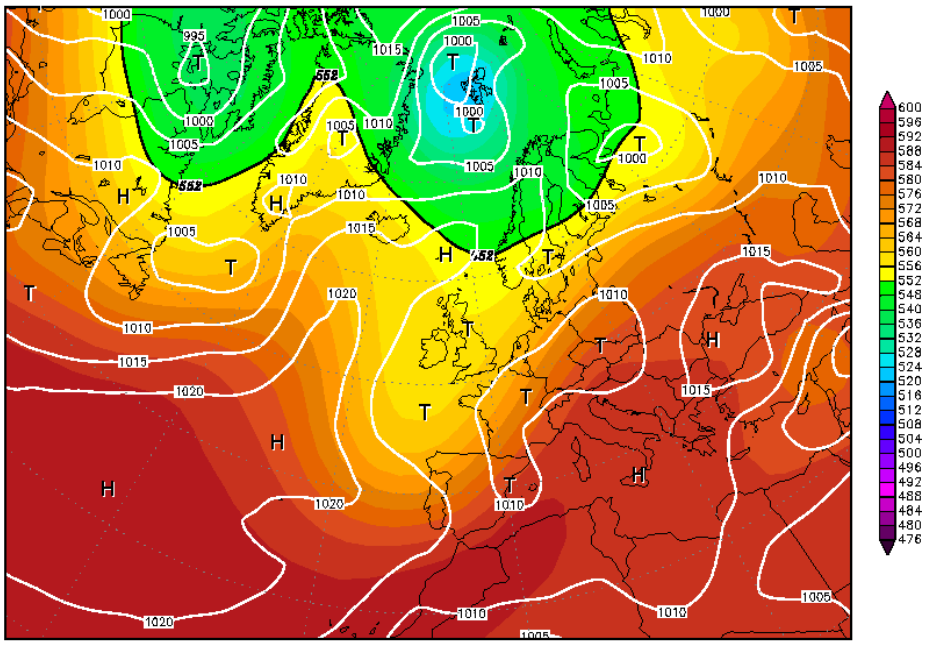

Figure 4. 500 hPa geopotential height and sea-level pressure on August 15th 1952
(sursa: http://www.wetterzentrale.de/topkarten/fsreaeur.html)

Table 5. Annual maximum values (Arad, 1961-2007)

Month	May	June	July	August	September
Annual maximum (ºC)	32.8ºC	34.8 / 37.4	40.2ºC	39.1ºC	33.4ºC
Year	1969	1982 / 2002	2007	2000	1970
Incidence rate	2.2%	6.6%	44.4%	42%	2.2%

During winter months absolute maximum temperatures take positive values. The highest temperature for the cold season was reported in February 1925: 20.0°C. In fact, most winter maximums occur in February (51.1%). In 27% of the cases the highest winter temperature was reported in December and in 20% of the cases – in January. In 1981, the maximum winter value, 13.0°C, was reported in both February and December; this one occurrence amounts to 1.9% of the years.

For the spring season, maximums were reported in May in 91% of the cases. The highest air temperatures in spring may also occur in April, but the incidence rate is hardly

noticeable: 6.6%. During the time interval investigated, the season maximum was once recorded in March: 1991, 25.6°C. The absolute spring maximum occurred in 1968 and it reached 34.0°C. In 1969 the May monthly maximum, 32.8°C, was at the same time the maximum annual temperature.

During fall maximum temperatures occur most frequently in September (95.6% of the years). In 1970 the monthly maximum temperature for September, 33.4°C, was also the annual maximum. The fall maximum was reported in October in two years, which amounts to a 3.7% incidence rate. The lowest values for this season were recorded in November, whose highest monthly maximum in the interval analyzed was 25.3°C (in 1997). The highest maximums for the other two fall months, September and October, were 39.6°C (in 1946) and 32.5°C (in 1932) respectively (see Table 6 and Figure 5).

Analyses show an upward tendency of the annual maximum temperature in the period 1954-2007 (see Figure 6).

Table 6. Highest (M) and lowest (m) monthly maximums (Arad, 1896-2007)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
M	16.6	20.0	28.0	32.8	35.0	37.7	40.2	40.4	39.6	32.5	27.7	18.4	40.4
m	0.0	4.3	10.0	18.8	24.1	27.4	30.2	30.3	24.2	19.2	9.0	6.1	31.6

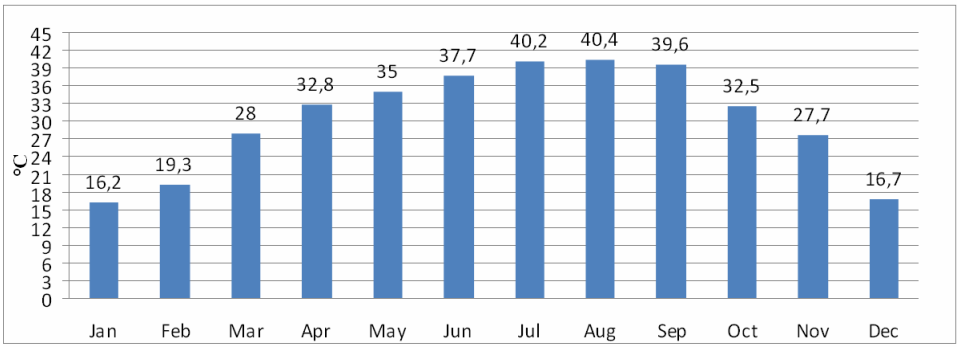

Figure 5. Monthly absolute maximums (Arad, 1896-2007)

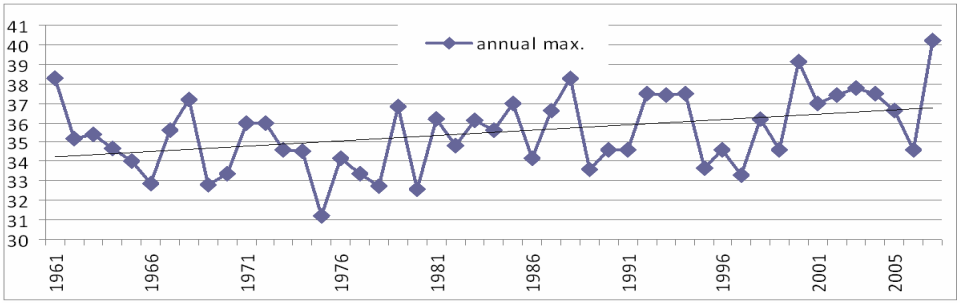

Figure 6. Annual maximum temperatures and their linear tendency (Arad, 1961-2007**)**

Conclusions

Mean minimum daily temperature takes predominantly negative values in winter months, although such values can occur in the end of fall and the beginning of spring, as well. Mean maximum daily temperature generally takes positive values, but there have been cases – in winter – when the value was negative.

Due to oceanic and sub-Mediterranean influences, the climate in the Arad city area is moderate, as proven by the moderate values of the minimum temperature recorded in Arad, in comparison to other cities in the Eastern and Southern plains of Romania: -34.0ºC in Focşani, -36.3ºC in Iaşi, -35.5ºC in Craiova, -34.8ºC in Alexandria (Bogdan & Niculescu, 1999).

On account of the same influences, absolute maximum temperatures are lower than those reported for the Romanian Plain: 44.5ºC in Ion Sion, 44.0ºC in Slobozia, 42.9ºC in Alexandria, 42.8ºC in Giurgiu, 43.2ºC in Turnu Măgurele, 43.5ºC in Strehaia (Bogdan & Niculescu, 1999).

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