HEAT WAVES IN THE SUMMER OF 2017

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Abstract:*The summer of 2017 was a remarkable one in the history of meteorological measurements because of the temperature records registered, but also regarding the effects generated in the socio-economical sphere. Studies worldwide show that heat waves generate the greatest number of human casualties compared to any other extreme weather phenomena such as floods or hurricanes. Also, they affect agricultural fields and forests, drought and fire causing significant damage each year, worldwide. Since its beginning, the summer of 2017 indicated to be a "hot" one. If in the beginning of June only a few daily records of maximum temperatures were registered and deviations of over 5°C from climatological normal values, in the next heating periods at the end of June, over the extent of July, but especially during the beginning of August numerous temperature records were established. In 4-6 August, in the western part of our country the maximum temperatures have exceeded the normal values for this period by 10…12°C, causing accentuated thermal discomfort and the issue of red and orange codes for extreme temperatures. The purpose of this paper is to identify and study heat waves in the summer of 2017, in the western part of Romania. We will try to establish a relation between the evolution of a set of meteorological parameters, on a worldwide, synoptic or local scale and timeframes containting extreme weather from a thermal point of view.*

Keywords*: heat wave, thermal discomfort*

INTRODUCTION

It is known that heat waves are extended periods of excessively hot weather, also generally associated with high levels of humidity. There is no universal definition for a heat wave because the term depends to the normal type of weather in a certain region. Thus, temperatures that are considered normal for a warm climate area can be considered a heat wave in an area with a cooler climate, if they sufficiently exceed the normal climatic values of the concerned area. According to recommendations by the World Meteorological Organization we can define a heat wave as a period of time during which maximum temperatures in the daytime exceed the normal maximum temperatures by 5°C for five consecutive days, the reference time frame for normal temperatures being 30 years (1961 - 1990).

MATERIALS AND METHODS

For the identification of heat waves in the summer of 2017 we used data from 10 weather stations in Banat and weather stations in Crisana. Time frames in which the maximum daytime temperature exceeded the maximum normal for that day by at least 5°C were taken into account for each station, for at least five days. The reference period was 30 years (1981 – 2010). Data analysis identified 3 heat waves in the summer of 2017: between 6 – 12 July, between 19 – 24 July and between 30 July – 6 August.

Further we will analyze the duration and intensity of the heat wave for each of the studied weather stations, followed by its placing in a larger context, to establish a connection between phenomena presented at a local level and the large scale evolution of certain

meteorological parameters. For this study we used reanalysis data from NOAA, NCEP/NCAR, and data from C.M.R Banat - Crișana archive.

RESULTS AND DISCUSSIONS

1. 6 - 12 July 2017

Positive deviations of at least 5°C above the normal climatological conditions were registered in this period for at least 5 days, at 9 out of 10 of the considered weather stations in Banat. For the weather stations in Crisana the maximum time span was 4 days, therefore they were not taken into account. As for the heat wave intensity, considered as the number of consecutive days in which deviation of the maximum temperatures from the normal climatological conditions is equal or greater than 8°C, for the studied timeframe it is noticeable that they were a maximum of 2 days, in comparison to the 5 to 7 days duration of the heat wave (Table 1).

Table 1.

The duration and intensity of the heat wave between 6 - 12. 07.2017

Nr. days/Station	Sânnicolau Mare	Timișoara	Banloc	Caransebeș	Reșița	Oravița	Bozovici	Băile Herculane	Moldova Veche
Nr. days heat wave ($\Delta T_{max} \geq 5^oC$)	5	5	5	6	6	5	6	5	7
Nr. days ($5^oC \leq \Delta T_{max} < 8^oC$)	3	3	3	5	5	3	4	4	5
Nr. days ($\Delta T_{max} \geq 8^oC$)	2	2	2	1	1	2	2	1	2

Analyzing the mean pressure field at sea level (Fig. 1) for the 6 – 12 July timeframe, we can notice that most Europe was in a high atmospheric pressure field, with an over 1023 mb nucleus of the Azoric Anticyclone, the low pressure areas being limited to Northern Europe and the Eastern Basin of the Mediterranean Sea. The 500 mb geopotential height composite mean for the same timeframe (Fig. 2) suggests the penetration of a tropical air mass into the south and center of Europe, the 500 mb geopotential height composite maximum (approximately 5900 m) being recorded in the central-western basin of the Mediterranean Sea.

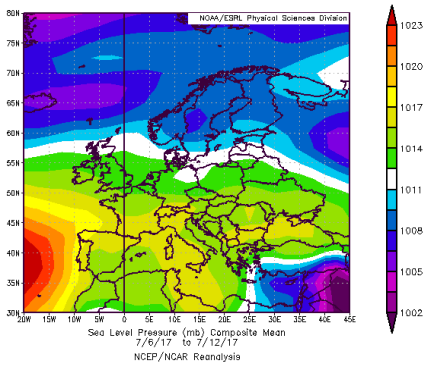

Fig. 1. Sea Level Pressure Composite Mean for 6 – 12.07.2017

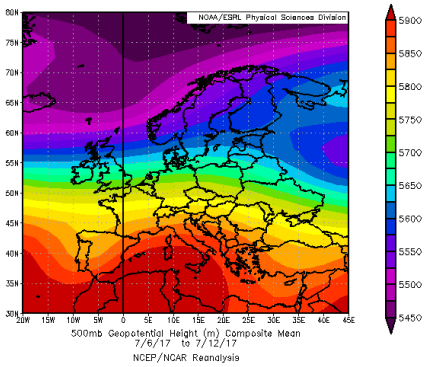

Fig. 2. 500 mb Geopotential Height Composite Mean for 6 - 12.07.2017

Regarding ground pressure anomalies (Fig. 3) and the 500 mb geopotential height (Fig. 4) for the considered period of time we can observe that while the ground pressure values were within normal limits for the western part of our country, the 500 mb geopotential height presented a positive anomaly of over 60 m from the multiannual average, the maximum deviation being registered in the Adriatic Sea region.

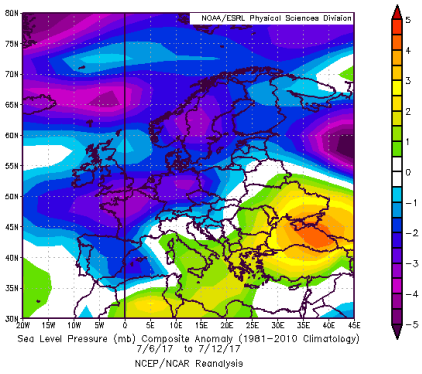

Fig. 3. Sea Level Pressure Composite Anomaly for 6 - 12.07.2017

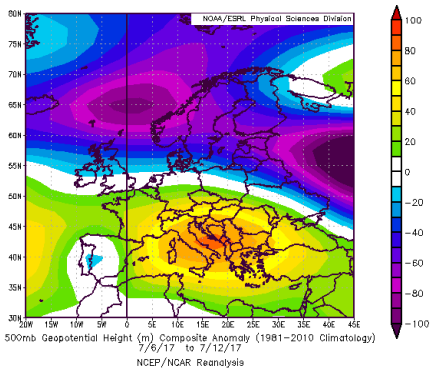

Fig. 4. 500 mb Geopotential Height Composite Anomaly for 6 - 12.07.2017

2. 19 - 24 July 2017

Positive deviations of at least 5°C above the normal climatological conditions were registered in this period for at least 5 days, at only 6 out of 10 of the considered weather stations in Banat and 8 out of the 9 chosen stations in Crisana. The heat wave duration was 5 or 6 days for the weather stations noted in Tables 2 and 3. There is only one day with a deviation of at least 8°C of the maximum temperature above the climatological average, for 4 stations in Banat and only one in Crisana.

Table 2.

Duration and intensity of the heat wave between 19 - 24. 07.2017 for weather stations in Banat

Nr. days/Station	Timişoara	Banloc	Oravița	Bozovici	Băile Herculane	Moldova Veche
Nr. days Heat wave ($\Delta T_{max} \geq 5°C$)	6	6	6	6	5	6
Nr. days ($5°C \leq \Delta T_{max} < 8°C$)	6	6	5	5	4	5
Nr. days ($\Delta T_{max} \geq 8°C$)	0	0	1	1	1	1

Table 3.

Duration and intensity of the heat wave between 19 - 24. 07.2017 for weather stations in Crișana

Nr. days/Station	Săcuieni	Oradea	Borod	Holod	Ştei	Chişineu-Criş	Gurahonț	Arad
Nr. days Heat wave ($\Delta T_{max} \geq 5°C$)	5	5	6	6	6	6	6	6
Nr. days ($5°C \leq \Delta T_{max} < 8°C$)	5	5	6	6	6	6	5	6
Nr. days ($\Delta T_{max} \geq 8°C$)	0	0	0	0	0	0	1	0

From a synoptic point of view, sea level pressure composite mean (Fig. 5) for the 19 – 24 July 2017 period presented relatively high values over the entire European continent, reaching 1020...1022 mb in the northern and south-western extremities. The cyclonic nuclei maintained their influence only in the British Isles area (1006...1010 mb) and in the Eastern basin of the Mediterranean Sea (with low values, under 1002 mb). The 500 mb geopotential height presented high average values in the considered timeframe for Southern, Center and partially even Northern Europe, the geopotential ridge extending towards the Baltic Sea and the Scandinavian Peninsula. The geopotential values exceeded 5900 m, especially in the south-western extremity of the Mediterranean Sea.

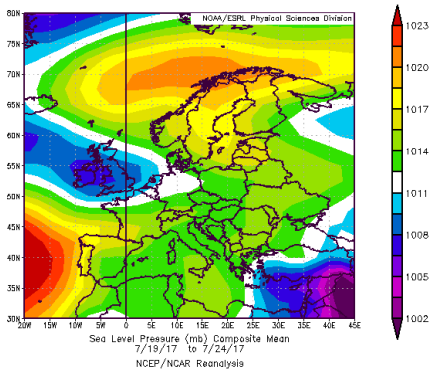

Fig. 5. Sea Level Press
Mean for 19 - 24

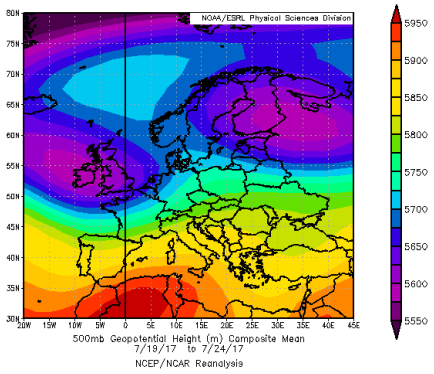

Fig. 6. 500 mb Geopotential Height Composite Mean for 19 - 24.07.2017

As for ground pressure deviation in relation to the climatological normal values (Fig. 7) we can find two noteworthy opposing nuclei, a negative one in the British Isles area and a positive one in the northern extremity of the Scandinavian Peninsula, with an over 8 mb difference each in relation to the multiannual average, while most of Europe was in close to average limits (the eastern part), or even slightly under the climatological average (the western and central parts). Although the 500 mb geopotential height (Fig. 8) deviated approximately 150 m from the climatological averages for the studied period in the North Atlantic, the entire European continent showed positive deviations of 30…60 mb at most,

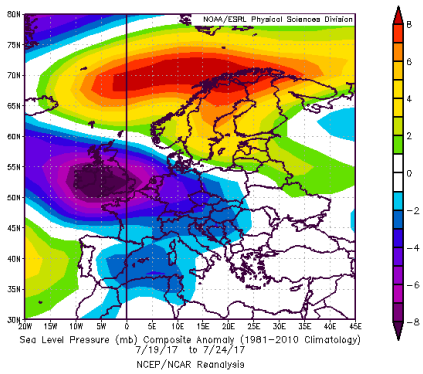

Fig. 7. Sea Level Pressure Composite Anomaly for 19 - 24.07.2017

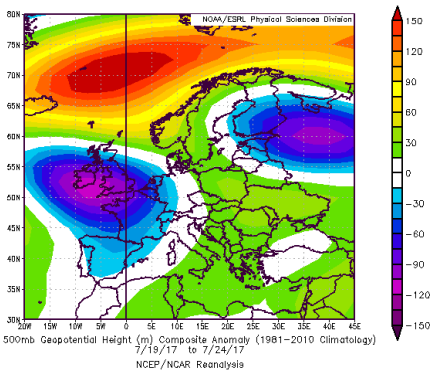

Fig. 8. 500 mb Geopotential Height Composite Anomaly for 19 - 24.07.2017

3. 30 July – 6 August 2017

This heat wave extended over all the western part of the country. Positive deviations of at least 5°C over the climatological normal values were recorded for 6 to 8 consecutive days at all the considered weather stations (10 in Banat and 9 in Crisana). As for the intensity of the heat wave, it is noticeable that in Banat (Table 4) between 2 and 4 days recorded deviations of at least 8°C over the climatological normal values, the greatest variations reaching 12,5°C in the last days of the considered timeframe.

Table 4.

Duration and intensity of the heat wave between 30.07 - 06. 08.2017 for weather stations in Banat

Nr. days/Stations	Sânnicolau Mare	Timișoara	Lugoj	Banloc	Caransebeș	Reșița	Oravița	Bozovici	Băile Herculane	Moldova Veche
Nr. days Heat wave ($\Delta T_{max} \geq 5^oC$)	6	7	7	8	7	6	7	8	7	8
Nr. days ($5\,^oC \leq \Delta T_{max} < 8^oC$)	3	4	3	4	5	4	4	4	3	5
Nr. days ($\Delta T_{max} \geq 8^oC$)	3	3	4	4	2	2	3	4	4	3

Tabelul 5.

Duration and intensity of the heat wave between 30.07 - 06. 08.2017 for weather stations in Crișana

Nr. days/Station	Săcuieni	Oradea	Borod	Holod	Ștei	Chișineu-Criș	Gurahonț	Arad	Vărădia de Mureș
Nr. days Heat wave ($\Delta T_{max} \geq 5^oC$)	6	7	6	7	6	6	7	6	6
Nr. days ($5\,^oC \leq \Delta T_{max} < 8^oC$)	2	4	3	4	3	2	4	2	4
Nr. days ($\Delta T_{max} \geq 8^oC$)	4	3	3	3	3	4	3	4	2

In Crisana (Table 5) the heat wave lasted for 6 – 7 days, in 2 to 4 of these deviations equal or greater to 8oC above the climatological normal values, the maximum variation reaching 12,3°C.

Daily temperature records were registered during this period both for maximum and minimum values, moreover, on 5-6 August, 4 of the weather stations taken into account indicated the highest temperatures for the month of August in the history of recording. Thus, on the 5th August 2017 monthly records were registered at Arad (40,8 °C as opposed to the previous 40,4 °C), Bozovici (40,5 °C as opposed to the previous 39,2 °C) and Baile Herculane (41,5 °C as opposed to the previous 41,2°C) and on the 6th August 2017 monthly records were registered at Moldova Veche (41,7 °C as opposed to the previous 41,0 °C).

For 4 – 6 August, the National Meteorological Administration emitted a red and orange code (Fig. 9 and 10) for heat wave, extreme temperatures and accentuated thermal discomfort. The forecast included maximum temperature levels of 39 - 40 °C, minimum values of 22 - 25 °C, and for the temperature-humidity index (ITU) values over the critical 80 units threshold, reaching 82 – 84 units in all plain and plateau regions.

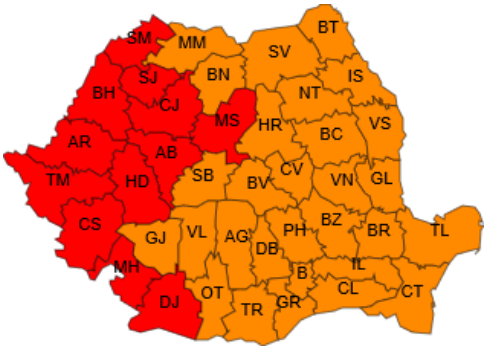

Fig. 9. Red code for 4 - 5.08.2017

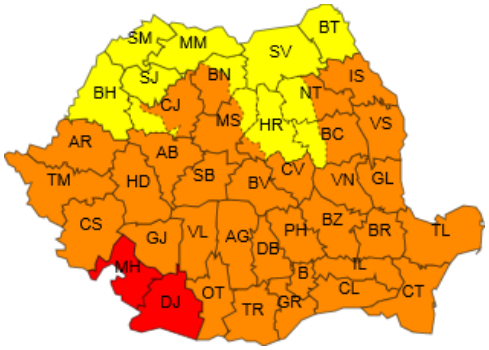

Fig. 10. Orange code for 6.08.2017

On a European Level, orange and red codes for high temperatures were emitted in the Southern and Central-East parts, Italy, Croatia, Slovenia, Bosnia, Serbia, Hungary, Romania, Slovakia and Poland being the most affected countries (Fig. 11).

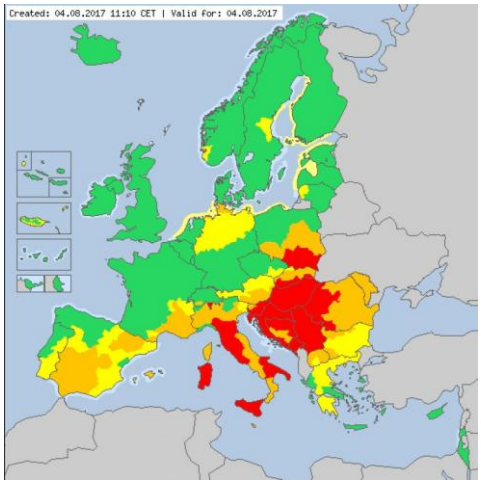

Fig. 11. Meteoalarm 04.08.2017

As for the synoptic context for the 30 Julie – 6 August timeframe we can observe: the sea level pressure composite mean (Fig. 12) indicated relatively high values, of approximately 1016 – 1018 mb, for Central and Southern Europe reaching 1020 mb in the Western extremities, the low pressure nuclei and the corresponding frontal systems being located in the Northern extremity of Europe and in the Eastern Basin of the Mediterranean Sea. The 500 mb geopotential height composite mean for the studied timeframe (Fig. 13) shows an extension of the North-African Anticyclone ridge over South-Western Europe, reaching values of over 5900 m in our country's area.

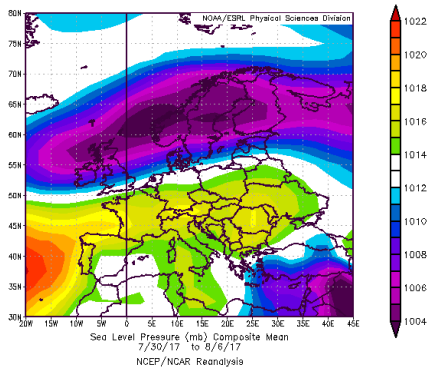

Fig. 12. Sea Level Pressure Composite Mean for 30.07 - 06.08.2017

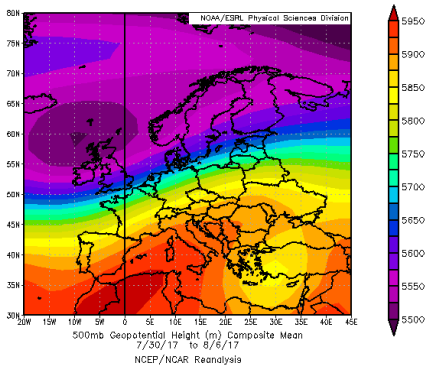

Fig. 13. 500 mb Geopotential Height Composite Mean for 30.07 - 06.08.2017

This blockage structure allowed hot and dry tropical air to transfer and rest above Southern and Central Europe, which generated the heat wave encountered in the end of July and beginning of August 2017. Regarding the sea level pressure anomalies (Fig. 14) and the 500 mb geopotential height (Fig. 15), we can note that the negative anomalies can be found in the Northern and North-western part of Europe, reaching 8 mb, 90 m respectively, while the positive anomalies affected the South-East of Europe (including our country) with levels of up to 2 mb for sea level pressure, on a 500 mb level the positive deviations being much greater, with values of 30 – 90 m for most part of Europe, or even greater in the central and eastern area, including our country.

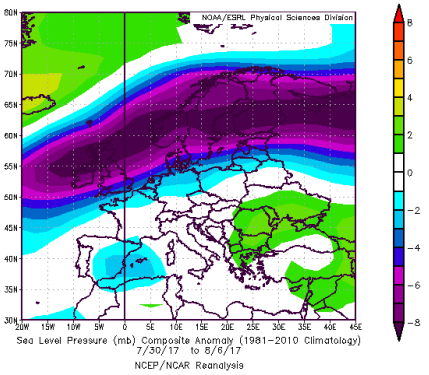

Fig. 14. Sea Level Pressure Composite Anomaly for 19 - 24.07.2017

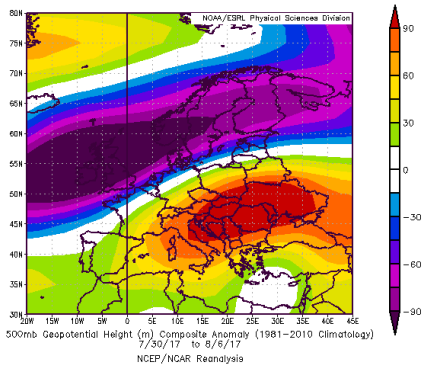

Fig. 15. 500 mb Geopo
Composite Anomaly for

CONCLUSIONS

Analysing the heat waves in July in regard to thermal aspects of weather, reflected in measurements result and processed data and also the reanaysis data of a set of synoptic meteorological parameters we can conclude:

- although the second heat wave in July covered a greater expansion area and in some cases even a longer duration, its intensity was lower than that of the first wave.

- if during the first heat wave the 500 mb geopotential height exceeded the multiannual average with over 60 m, during the second heat wave, the entire European continent recorded positive deviations of up to 30…60m, which could explain the lesser intensity of this heat wave in relation to the first one we studied. Conversely, the extension of the positive anomaly field on the SE-NW direction suggests a certain blockage level of the negative anomaly nuclei (with values of 80 up to 120 m lower than average) in north-eastern and north-western Europe, which could explain the extent, both in time and in space, of this heat wave in relation to the first one we studied. The extent of the high pressure field, which in the case of the second heat wave covered even Northern Europe while in the first case the Northern part of the continent was under the influence of a vast area of low pressure and the associated frontal systems, also support this conclusion.

Regarding heat wave at the end of July and beginning of August, the reasons for which it surpassed the previous two in duration and intensity could be the following:

- the existence of a blockage structure that allowed hot and dry tropical air to transfer and rest above Southern and Central Europe;

- the position of positive anomaly nuclei of the 500 mb geopotential height and their extent all over central and eastern Europe, as well as their much greater value, reached over our country.

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