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# CONSIDERATIONS UPON THE HEAT WAVE FROM JULY 2007

Ion MARINICĂ[1]

**Abstract**. The present paper renders the analysis of the evolution of the heat wave that affected Romania between the 15th and the 24th of July 2007. This was the most intense heat wave registered in July; it also had the longest duration in the entire period since Romania made systematic meteorological observations. It affected the entire country, especially the southern and western regions, with the exception of mountainous area, where the effects were minimal. The maximum temperature for July was exceeded by 0.8°C, outlining an important increase in the evolution of July temperature, which may hold increased significance on the background of global warming. The heat wave mainly affected Hungary, Italy, Greece, Romania, Republic of Moldova, and Ukraine. All activity branches felt the consequences of this evolution. Thus, the paper is extremely useful to the experts in climatology, meteorology, to those who try to achieve a master or PhD thesis, to students and to all those interested in climatologic issues.
**Key words:** heat wave, absolute maximum temperatures, canicular days, red code.

**Rezumat. Consideraţii privind valul de căldură din luna iulie 2007**. În lucrare este analizată evoluţia valului de căldură, care a afectat România în intervalul 15-24 iulie 2007. Acesta a fost cel mai intens val de căldură al lunii iulie şi cu durata cea mai mare din toată perioada de când se fac observaţii meteorologice sistematice în România. A afectat întreaga ţară, cu excepţia arealului de munte unde efectele au fost minime şi în mod deosebit sudul şi vestul. Temperatura maximă absolută a lunii iulie a fost depăşită cu 0.8°C, marcând un important salt în evoluţia temperaturilor lunii iulie, care în contextul încălzirii climatice globale are semnificaţii importante. Valul de căldură a afectat în mod deosebit Ungaria, Italia, Grecia, România, R. Moldova şi Ucraina. Consecinţele acestei evoluţii au fost resimţite în toate domeniile. Lucrarea este utilă specialiştilor în domeniul climatologiei, meteorologiei doctoranzilor, mesteranzilor, studenţilor şi tuturor celor interesaţi de problemele climatologiei.
**Cuvinte cheie:** val de căldură, temperaturi maxime absolute, caniculă, cod roşu.

## *1.Introduction*

*Geographical features of Oltenia.* Oltenia is located in the southwestern part of Romania, within the large Carpathian-Balkan depression, which is somehow closed by these mountains in the western part, but largely opened eastwards. Crossed by the parallel of 45° N. lat. and the meridian of 24° E long., the region stands in front of different air masses; the Carpathian-Balkan mountain chain, through its interaction with air circulation, plays an important role for the climate pattern within this part of Romania, the surface of which is 29,224 sq km representing 12.2% of the total surface of the country (Apostol & al., 1969). It is both exposed to the advection of polar continental and arctic air coming from north and northeast during the cold season and to warm dry, warm humid maritime tropical and to humid maritime polar air masses during the warm season. Oltenia is one of the country regions where sub-Mediterranean influences are quite pregnant and they overlap continental climatic influences. Consequently, summers are hot, with frequent dryness and drought phenomena; autumns are long and there occurs the second annual precipitation maximum, while winters are warm, due to the waves of tropical air that thaw the snow cover and generate floods, speeding up spring arrival.

The climatic system is subject to a non-periodical variability. Thus, there occurred numerous positive and negative deviations when the southern territories of Romania were covered by cold polar or arctic air, which determined freezing winters, temperature inversions, and minimum values of less than -25°C (e.g. 1941-1942, 1953-1954 etc. winters). The penetration of tropical maritime or continental air led to warm winters with temperatures of 10-20°C, thin snow cover or absence of snow (e.g. 1920-1921, 1935-1936, 1947-1948, 1990-1991, 2000-2001 etc. winters) or to extremely hot summers with exceptional maximum temperatures lasting for long periods, which were also absolute maximum monthly values for certain meteorological stations or even for the entire country (e.g. the summers of 1916, 1936, 1946, 1951, 1952, 1994, 2000 etc.).

In the last period, on the background of global warming, we witness an increase of the frequency of these warm summers, with frequent exceeding of the absolute maximum temperatures, which confirms

[1] *MPP1 CMR Oltenia*

a rapid evolution of the climate general warming (Bogdan, Octavia, Niculescu, Elena (1999), Bogdan, Marinică, Ion (2006, 2007, 2008), Octavia, Marinică Ion (2007, 2008).

The summer of 2007 represents such a special case. It came after the Mediterranean winter from 2006-2007, which was warm within the entire country. The summer of 2007 started with an excessively hot June, especially in the last decade, when a strong heat wave affected the entire country, but particularly its southern regions. The warm weather was accompanied by a strong complex drought (atmospheric and pedological), which badly damaged firstly the wheat crops (60%) at the level of the entire country and then, in the second part of June, maize, sunflower, bean crops etc. were also affected, as well as meadow vegetation; it led to the dry up of wells and had severe economic effects. Then, the drought and canicular days from July 2007 worsened the destructive effects and led to the rapid dry up of maize crops, hayfields, and meadow vegetation etc.

***2. Study methodology and data source***

In order to establish the features of this heat wave, we performed a synoptic analysis and compared this wave with other heat waves registered in July. We used hourly synoptic observations from the Romanian meteorological stations, statistical analysis of long data chains that contain the results of the observations and data processing for more than 120 years from the data archives of the Regional Meteorological Center (R.M.C.) Oltenia and the National Administration of Meteorology (N. A. M.) Bucharest. We used the archives of synoptic maps of Wetterzentrale Meteorological Center (Germany) (www.wetterzentrale.de/), the results of the processing made in rapid flux by RMC Oltenia, as well as the results of mathematical and physical models for weather forecast.

***3.Results***

During the analyzed interval, weather warming process in Europe and especially in its southern part started on the 15th of July, when the heat wave, of moderate intensity (22-24°C at the level of 850 hPa isobaric surface above Germany and Austria, fig. no 1 and 35…37°C at 2 m level). From the very beginning, this heat wave drew forecast meteorologists' attention due to the presence of an extremely hot air nucleus, cT (tropical continental), with temperature values of 30°C at the level of 850 hPa isobaric surface. This air mass came from northern Africa, crossing Tunis Cape and the Mediterranean Sea quite rapidly up, to the proximity of Sardinia and Corsica Islands.

The synoptic situation was favorable for the extension of this heat wave over our country, as well.

*3.1 The analysis of the synoptic situation from the 15th of July 2007, 00 UTC.*

*At the surface level.* It can be noticed that there were many main baric centres above Europe. The Iceland Depression was a vast field, which emphasized two cyclonic centres, one located above the Atlantic Ocean, southwest of the Great Britain (fig. no. 3), with a central pressure of 1005 hPa and the second one centred on the Scandinavian Peninsula, of 1005 hPa.

The Azores Anticyclone was united with the North-African one and this vast anticyclone field, dominated most of Europe (more than 2/3 of the southern part of the continent). A secondary center developed within it and reached 1020 hPa, covering the north of Italy, the Former Yugoslavia, Romania and the Balkan Peninsula. It is worth mentioning that this type of synoptic situation characterizes the positive phase of the North-Atlantic Oscillation, phase that persisted almost the entire winter, in spring and summer.

The subsequent evolution confirmed these forecasts. Temperature increase occurred slowly from one day to another, but in the last three days (22, 23, 24) it accelerated and, thus, on the 24th of July 2007, canicular days reached their maximum in our country (fig. no. 1 and 2).

*At the surface level*

At this hour, it can be noticed the presence of a weak depression field above the Balkan Peninsula, less than 1010 hPa, which triggers air weak southern circulation (reduced wind velocity) in the air layer located in the proximity of the soil. Thus, it favoured the penetration of the extremely hot air mass from the Balkan Peninsula toward our country (fig. no. 4).

*3.2. The analysis of the synoptic situation on the 24th of July 2007, 00 UTC.*

At the level of the 500 hPa isobaric surface, one may notice that air circulation is tropical continental (cT) and, in northern Africa, there appears a nucleus of high geopotential, its central values exceeding 590 damgp. The field of relative topography 500/1000 emphasizes warm air penetration in the lower troposphere but at great distance, north of our country (fig. no. 4).

The thermal field at the level of 850 hPa isobaric surface displays the 24°C isotherm located in the south of our country (Oltenia), while the 25°C isotherm is south of the Danube (fig. no. 5). This means that extremely hot air continues to penetrate toward southwestern Romania.

On the 24th of July 2007, the penetration of extremely hot air above Romania continued. Thus, the phase of maximum temperature increase at the

2 m standard level and at the soil surface occurred between 4 p.m. and 6 p.m. RSH (RSH = Romanian summer hour), when there were registered the maximum thermal values for this date in our country, many of them becoming absolute thermal maximum values for July (fig. no. 2).

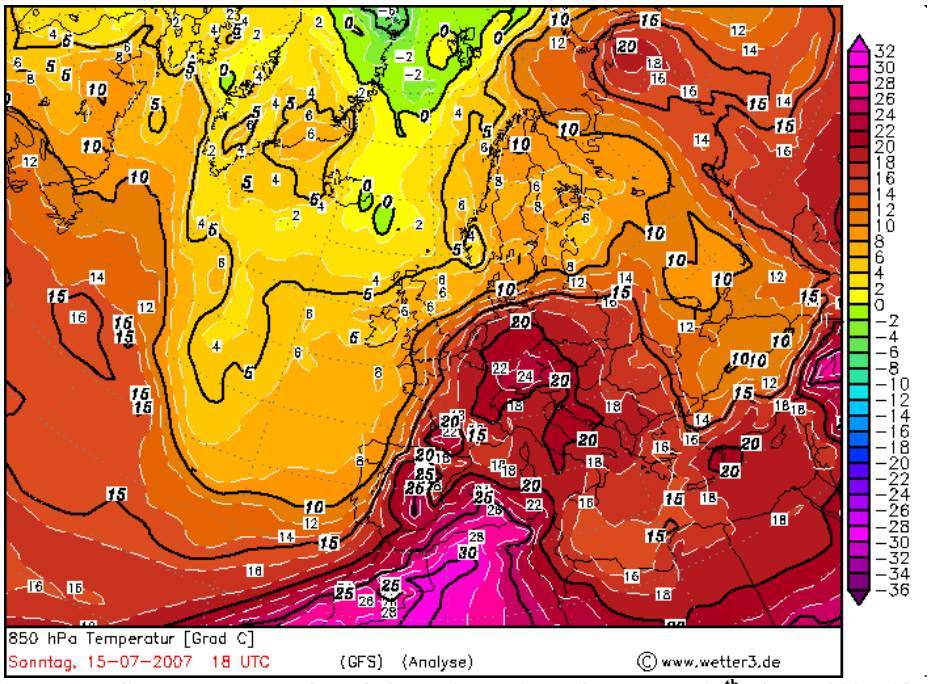


**Fig. 1 Thermal field at the level of the 850 hPa isobaric surface on the 15th of July 2007, 18 UTC, at the initial stage of the heat wave (after Karten Archiv)**

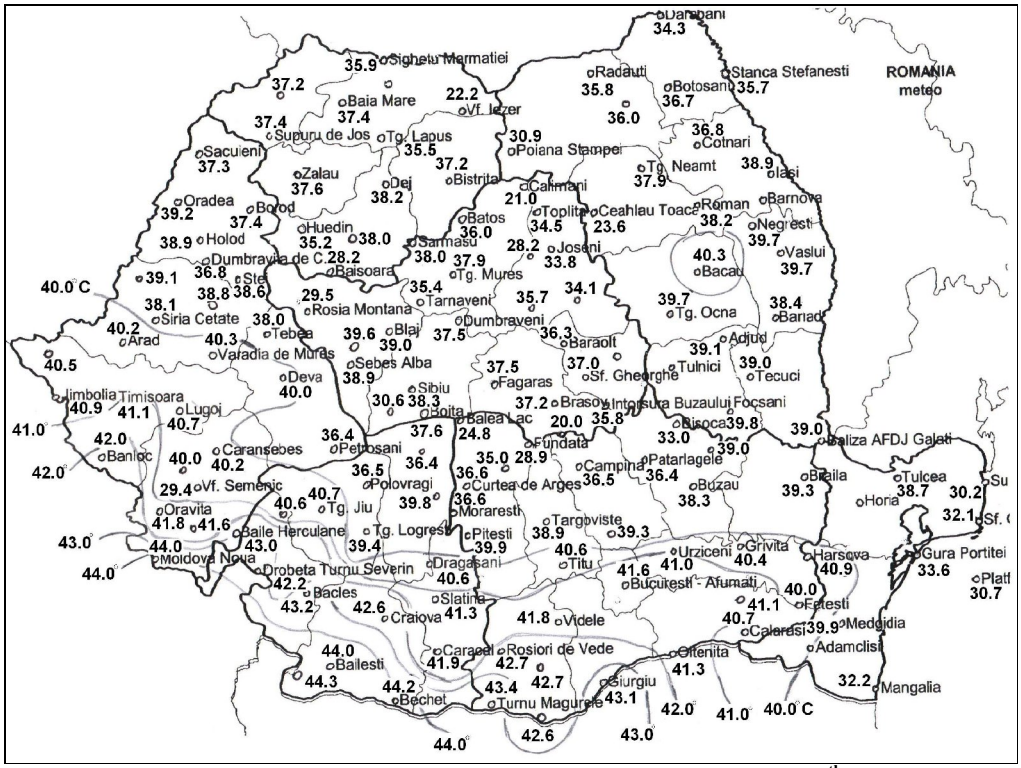


**Fig. 2. Air temperature maximum values registered in Romania on the 24th of July 2007 (Source: processed data from the Archives of M.R.C. Oltenia)**

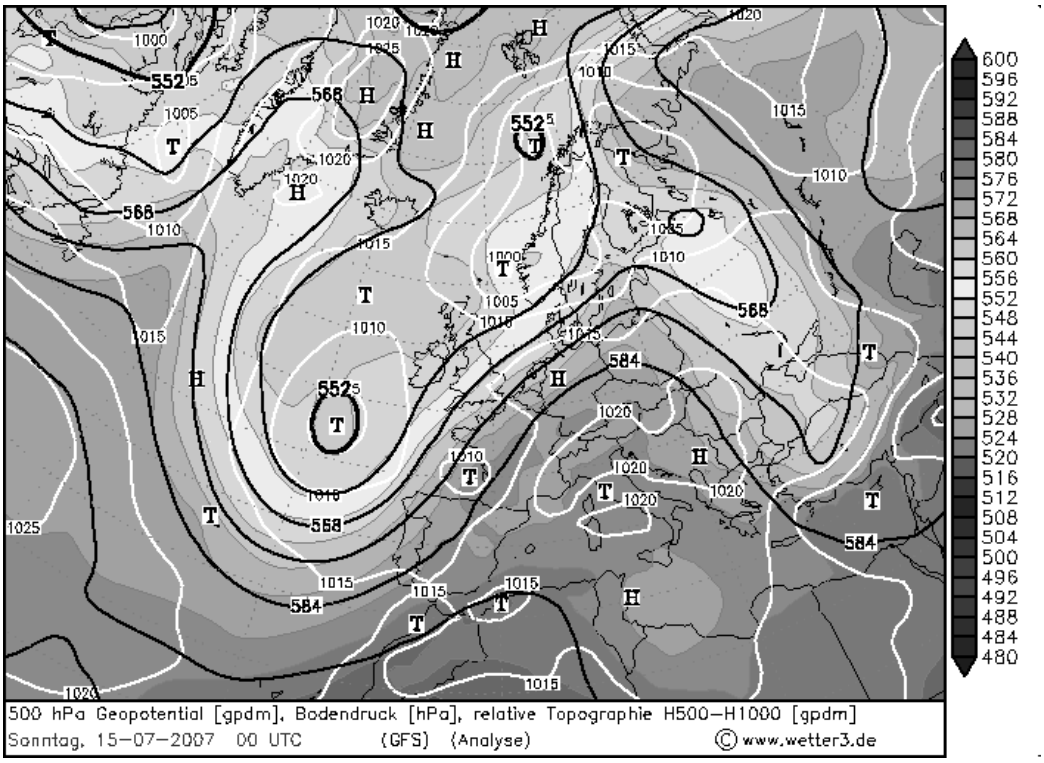


**Fig. 3 Surface synoptic situation, geopotential field at the level of 500 hPa isobaric surface and relative topography TR 500/1000 hPa, on the 15th of July 2007, 18 UTC (after Karten Archives)**

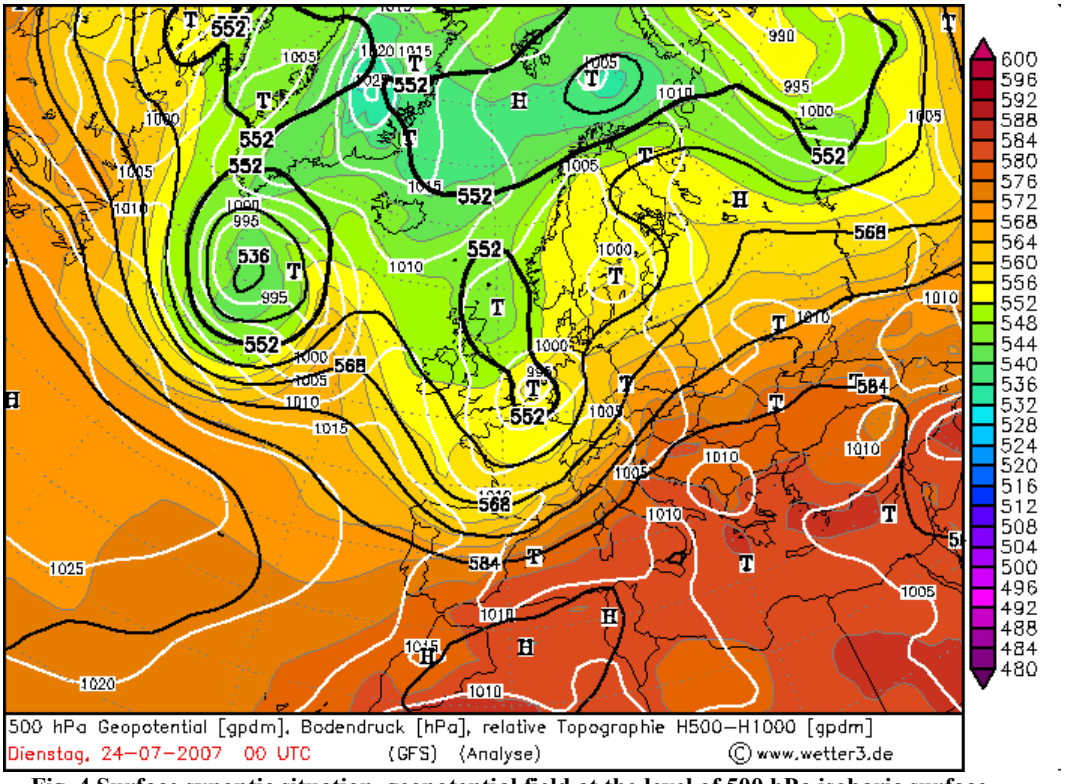


**Fig. 4 Surface synoptic situation, geopotential field at the level of 500 hPa isobaric surface and relative topography TR 500/1000 hPa, on the 24th of July 2007, 18 UTC, at the beginning of the maximum phase of the heat wave (after Karten Archives)**

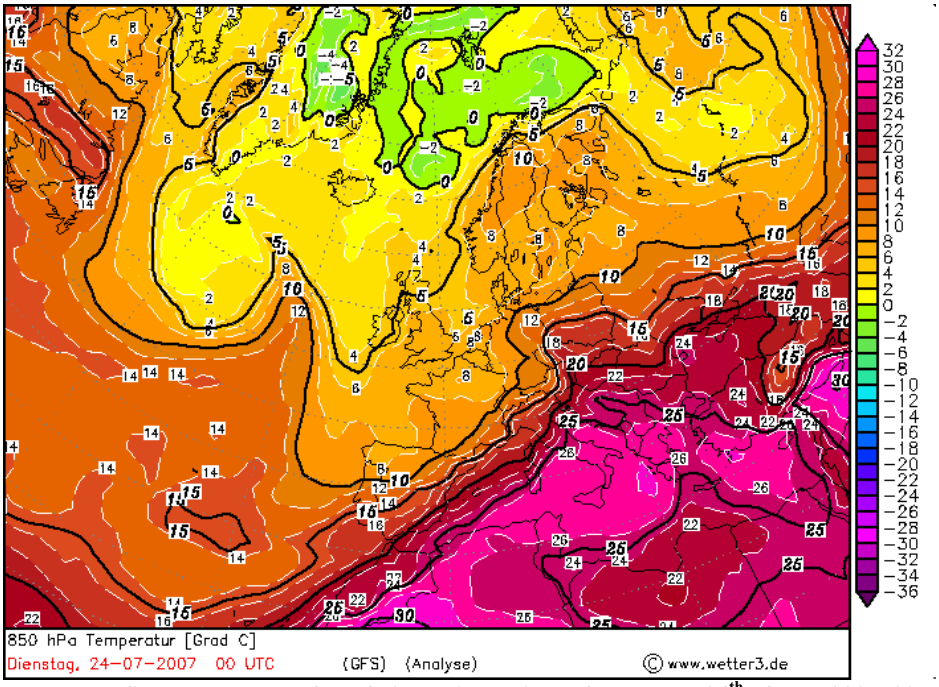


**Fig. 5 Thermal field al the level of the 850 hPa isobaric surface on the 24th of July 2007, 00 UTC, at the beginning of the maximum phase of the heat wave (after Karten Archives)**

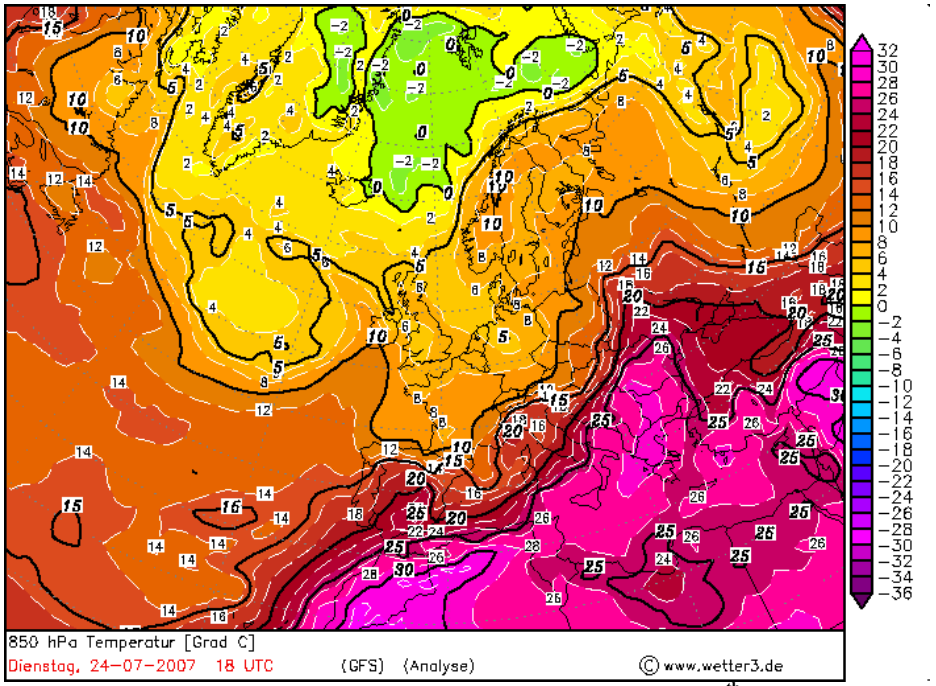


**Fig. 6 Thermal field al the level of the 850 hPa isobaric surface on the 24th of July 2007, 18 UTC, at the summit of the maximum phase of the heat wave (after Karten Archives)**

The summit of the maximum phase of hot air penetration above Romania was reached at 18 UTC (9 p.m. RSH), when the 30°C isohypse was placed above the southwestern part of the country at the level of 850 hPa (about 1,520 m according to the geopotential map for the 850 hPa level, fig. no. 6).

In the entire history of the systematic meteorological observation in Europe, there has never been registered such a situation (with values of the thermal field of more than 30°C at 850 hPa, in the south of Romania).

As the cold front advanced from the west of Europe toward our country, there developed a strong warm air advection in front of it (fig. no. 7). We mention that the maximum phase of the warming processes usually occur 12 hours before

the penetration of the cold front and the displacement of the warm air due to this dynamic process.

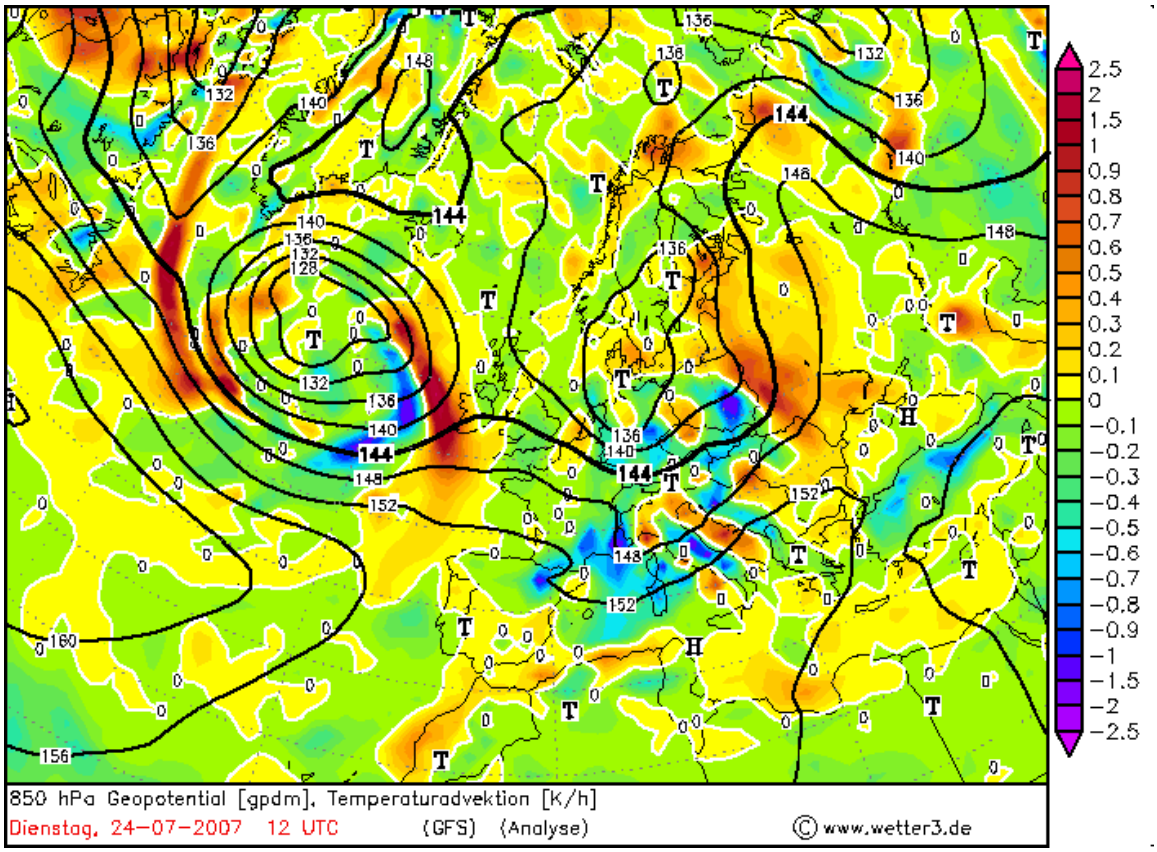


**Fig. 7 Geopotential Field at the level of the 850 hPa isobaric surface and temperature advection (in Kelvin degrees/hour), on the 24th of July 2007, 12 UTC, at the summit of the maximum phase of the heat wave (after Karten Archives)**

An important increase of the air temperature may also be a consequence of the compression thermo-adiabatic process induced by the force exerted by the cold front upon the obstacle, in this case the extremely hot air. The displacement of warm air usually occurs during night, when the rapid advancement of the cold front is possible as temperature drops.

The cooling occurred on the 24th/ 25th of July 2007, at night, and it was significant (10-15°C lower than the maximum values registered the previous day). However, from the meteorological point of view, weather was still warm, the temperature maximum values locally exceeding 35°C, even the next day. In the southeast of the country, the temperature minimum values registered in the morning, on the 25th of July 2007, were extremely high, due to the easternward movement of the altitude warm air nucleus on the one hand, and, on the other, to the fact that warm air advection in front of the cold front maintained and even intensified during night.

Among the thermal minimum values of more than 25°C, registered in the morning, on the 25th of July 2007, we mention: 25.4°C at Bucureşti Filaret, 25.1°C at Slobozia, 25.2 at Turnu Măgurele, 25.5°C at Oltenița, 26.2 at Giurgiu and Alexandria, 26.7°C at Feteşti, 27.0°C at Zimnicea, and 27.1°C at Călăraşi.

The values of the thermal comfort temperature humidity index (THI) reached and exceeded the critical threshold 80 in the entire country, even in the mountainous area (fig. no. 8). In Oltenia, at Calafat, on the 24th of July 2007, in only ten minutes, from $4^{10}$ p.m. RSH and $4^{20}$ p.m. RSH, air temperature increased from 43.6°C to 44.3°C (0.7°C in ten minutes), which emphasizes both the intensity of the warm air advection and the rapidity of air temperature increase

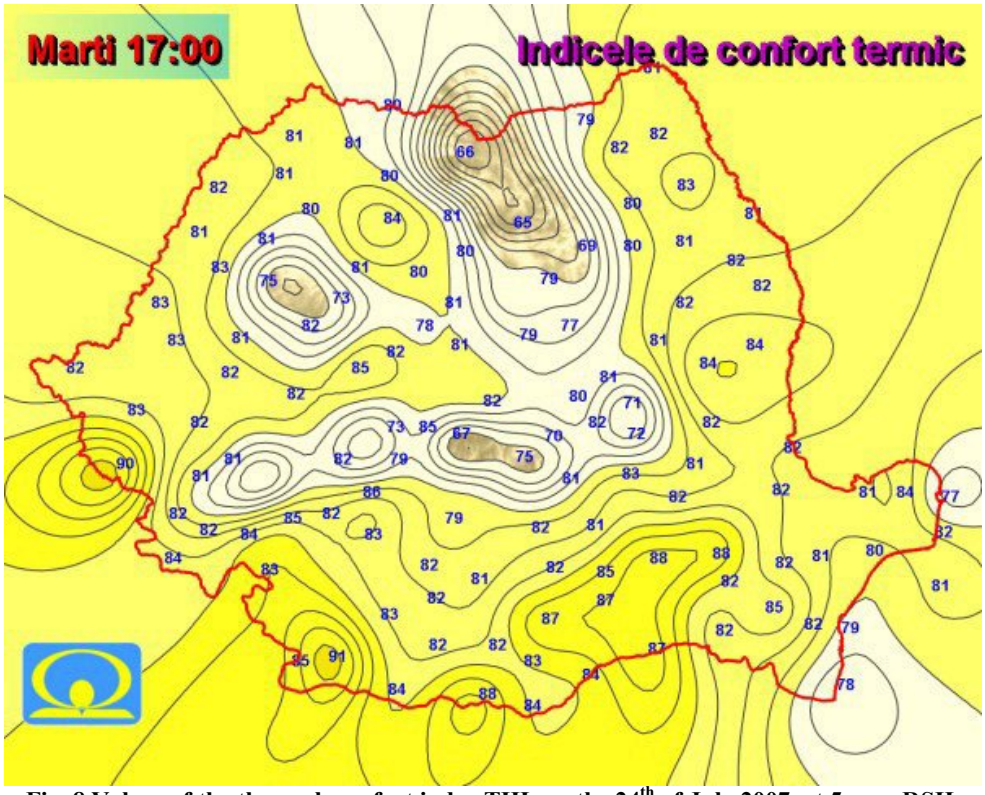


**Fig. 8 Values of the thermal comfort index THI, on the 24th of July 2007, at 5 p.m. RSH, at the summit of the maximum phase of the heat wave. (after NAM)**

## 4. Discussions

The heat wave registered between the 15th and the 24th of July 2007 was the most intense for this month for the entire period of meteorological observations. The maximum thermal value of July was exceeded with 0.7°C (at Calafat, there were 44.3°C on the 24th of July 2007, value that presently represents the absolute thermal maximum of July for Romania – the former absolute maximum value was 43.5°C, registered at Giurgiu on the 5th of July 2000). The former maximum value of July, registered in the last century, at Alexandria, on the 5th of July 1916, had reached 42.9°C, but it was exceeded with 0.6°C, 84 years later, on the above mentioned date. Thus, up to that date, we notice a slow evolution of the absolute maximum values in July, but, then, in seven years, there occurred a spectacular 0.7°C increase.

**The evolution of the temperature maximum values in July**

The next graphic (fig. no. 9) renders the evolution of the maximum temperatures registered in July:

-the 5th of July 1916, 42.9°C at Alexandria in Teleorman County, located in the proximity of Oltenia; this value represented the absolute thermal maximum of July for 84 years.

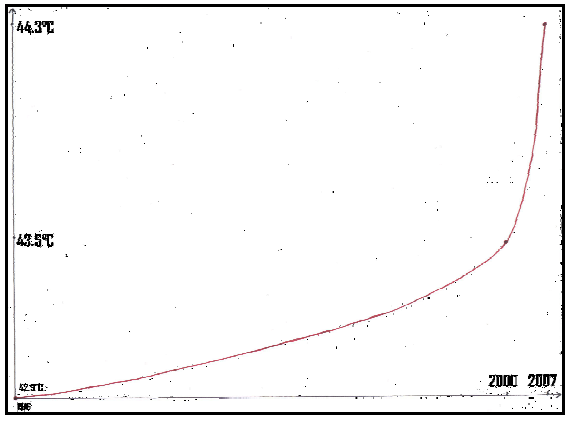


**Fig. 9 Variance of the temperature absolute maximum values in July starting with 1916.**
**(Source: processed data from the N. A.M. Archives)**

-the 5th of July 2000, 43.5°C at Giurgiu in Giurgiu County, near Oltenia; it became the absolute thermal maximum of July for 7 years.

-the 24th of July 2007, 44.3°C at Calafat in Dolj County, in Oltenia, the present absolute thermal maximum of July.

Consequently, one may notice the increase tendency: 1916-2000 a 0.6°C increase in 84 years, 2000-2000 a 0.8°C increase in just seven years (for this parameter there are only these three values). It results a rapid decrease reported to the time scale.

We notice that, in July 2007, air temperature reaches and exceeds the 44°C climatologic threshold for the first time. Values of 44°C and even higher have been registered only once in Romania since meteorological observations were performed. It is about the 10th of August 1951, when four meteorological stations registered 44°C or more (within the Bărăganul Brăilei Plain, at Mărunțelul settlement, Ion Sion farm, 44.5°C, which is the absolute thermal maximum of Romania and 44.0°C at Amara-Slobozia and Valea Argovei). In July 2007, 44°C or more were registered at the following meteorological stations – Băileşti and Moldova Veche 44.0°C, Bechet 44.2°C, and Calafat 44.3°C, which signify that the area affected by extremely hot air is much larger as compared to the previous century (fig. no. 2).

This intense and persistent heat wave affected Hungary, Italy, Greece, Romania, the Republic of Moldova, Turkey and Ukraine, and, on the 27th of July 2007, forest fires provoked by canicular days[1] covered extended surfaces and mass-media appreciated that the south and the east of Europe were "in flames" (news on the 27th of July 2007).

Consequences. *The drought registered in the summer of 2007 provoked crops and vegetation damage in many counties of the country, especially in the south and east, unbalancing life, causing animals' death and drying up wells and streams etc.*

Consequently, thermal maximum values exceeded the climatologic threshold of 44°C in the southwest of the country.

In Romania, 12 deaths were registered only on the 24th of July 2007, a total of 19 people being declared dead during the entire hot interval (July 16-24, 2007). The press indicated a number of 33 dead people till the 30th of July, as canicular afternoons continued till the 29th of July (on the 28th and the 29th, air temperature reached maximum values of 39°C in Oltenia, locally, in the southern half of the region). In the night of July 29/30, 2007, weather cooling in Romania was significant, and thermally speaking, it came back to normal.

This extremely intense heat wave strengthened drought in our country. Vegetation dried up on large surfaces, crops were badly damaged, and forest fires started, an average of 170-175 fires per day. Electric power consumption at national level was twice greater than normally and, due to the fact the grid was overloaded, there occurred frequent power breaks.

In Romania, for the first time, it was released the ***red code warning*** for canicular days. Consequently, a series of ***measures considered adequate for population's protection*** were taken:
- setting up first aid points in the streets of the cities.
- setting up certain teams able to help people at need – for example, shopping first necessity products, such as mineral water, bread etc.

There were also some measures we consider inadequate or even contraindicated:
- closing certain public institutions;
- stopping public transport in some cities;
- sending community police in markets to force merchants to close their sale points etc.

This heat wave caused serious problems to population and biosphere, generally, not only in Oltenia. Extremely severe forest and vegetation fires burst in Southern Europe, mainly in Greece, Italy, Bulgaria, and Spain (especially on the Canary Islands). In Greece, the forest from the proximity of Athens, considered the only green "lung" of this city completely burnt. Tourists were jeopardized by these fires, and there were registered some casualties.

We mention that Greece registered temperatures of 45°C; on the 24th of July 2007, at Veliko Târnovo in Bulgaria, there were registered 44.5°C.

We also mention that severe floods occurred in China during the same period; large surfaces were affected and 700 people died.

*Causes triggering these climatic changes* are:
- *natural causes*, mainly related to the increase of solar radiation intensity and other cosmic causes. We mention that the forecasts of the research team of ***Cosmic Research Center Colorado***, led by Douglas Beseker, estimate that solar activity will reach a maximum by the end of 2011 and the middle of 2012.

This continuous increase of solar activity will have as consequence the development of a maximum number of solar spots. The average will be 90…140 new solar spots higher than before, which means the increase of solar radiation intensity with important consequences for global warming phenomenon. We expect the thermal equator of the planet to extend in latitude and, thus, intensely heated areas will become vaster. There would occur *strong magnetic storms* that cause damages to electromagnetic equipments on the Earth. Presently, the solar activity forecast is required by many companies interested in protecting their electronic equipments.

[1] The term of ***canicular days*** characterizes those weather situations when air temperature, measured in standard conditions at the meteorological stations, reaches or exceeds the 35°C threshold (***dog days weather***).

We exemplify through the position of the thermal equator of the planet, above the western hemisphere, at the level of 850 hPa, on the 24th of July 2007, 00 UTC (fig. no. 10). In this figure, we may notice the large northward extension of the thermal equator, marked by two strong "lobes", one starting from Northern Africa toward our country. It represented the heat wave that affected Europe and Western Turkey. The other lobe started from the Arabian Peninsula toward Eastern Turkey.

Causes are linked to the North-Atlantic Oscillation (NAO), as well.

- during the positive phase of the North-Atlantic Oscillation, the increase of the number of days with insignificant precipitation (0-5 l/sq m) and the drastic decrease of the days with significant precipitation or even their total lack during drought periods;
- during the negative phase of the North-Atlantic Oscillation, the increase of rain showers' frequency, leading to catastrophic floods.

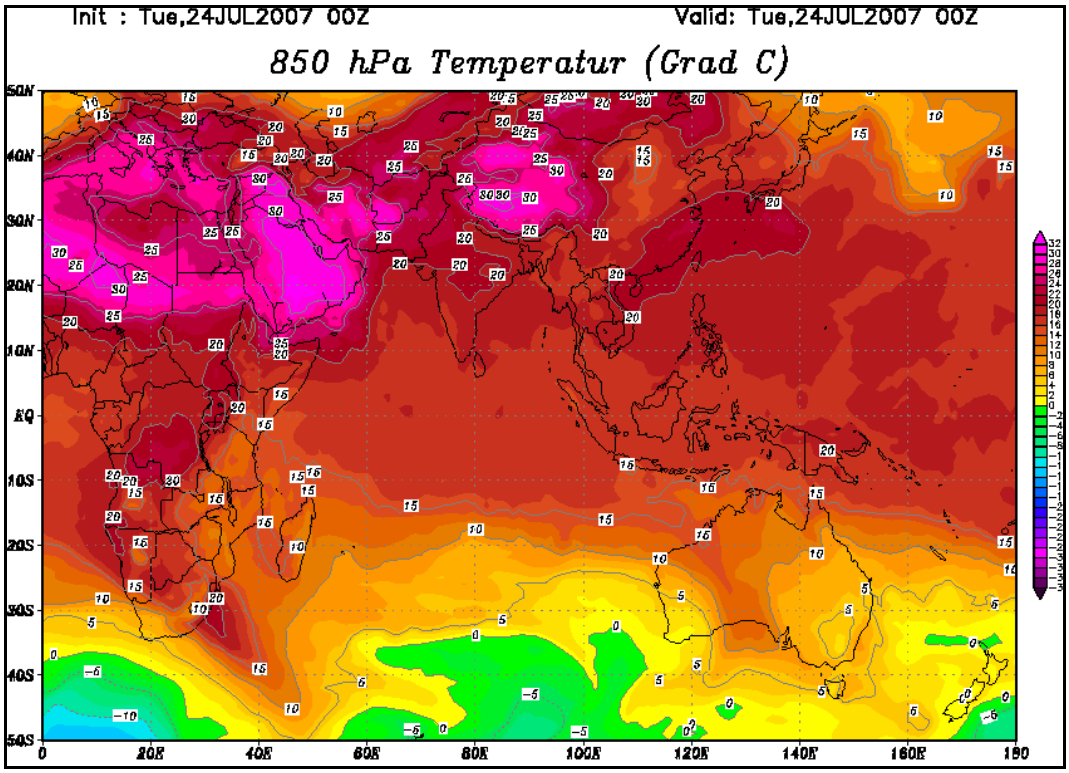


**Fig. 10 Thermal field at the level of the 850 hPa isobaric surface above the eastern hemisphere on the 24th of July 2007, 00 UTC, at the start of the maximum phase of the heat wave.**
**This marks the position of the thermal equator of the planet (the area with more than 25°C temperatures) at this moment (after Karten Archives).**

Such an evolution may bring, in a short period, to the extension of the transition climate from the temperate continental toward the Mediterranean climate with exceptional consequences for the biosphere.

- *anthropogenic causes* induced by pollution of the atmosphere with greenhouse gases, of the environment and, mainly, of the terrestrial surface with different substances; we also mention massive clearings, different works that modified the albedo of the terrestrial surface increasing the absorbed heat amount and the transfer to the atmosphere, which, in its turn, modified atmospheric and oceanic circulation.

- *local causes that locally amplify warming phenomena: for Oltenia,* an important part is played by the interaction of air circulation, at mesoscale, with local landforms and the relief of the Balkan Peninsula. The penetration of warm air within Oltenia is achieved along two corridors: one for the warm air coming from the west of the continent – The Danube, and the second for extremely hot Mediterranean air coming from the south or southwest, on the Timok Valley. The second corridor displays an important role in highlighting the peculiarities of the climate, especially in the area of Bechet- Calafat-Cujmir-Vânju Mare- Dr. Tr. Severin – Halânga, which is

emphasized by the above-mentioned maps and whenever warming occurs in this part of the country.

### *5. Conclusions*

The present study has a general and practical importance as we emphasize the occurrence of an exceptional heat wave, of a climatic record for these phenomena, which is confirmed by the site of the NMA Bucharest that describes the situation as it follows:

*In Romania, in July, there have been registered 220 cases when the maximum temperature was equal or higher than 40$^0$C since meteorological measurements of air temperature were performed in standard conditions (namely in the meteorological shelter, 2 m above the ground surface). These values were registered in the south and southeast of the country, especially after 1985. The most frequent situations were signaled at Turnu Măgurele (16 times), Roşiori de Vede (14), Giurgiu (13), Bechet and Zimnicea (10), Călăraşi (9), and Bucureşti-Filaret (8).*

*Also in July, the absolute maximum temperatures at the meteorological stations were mostly registered between the 4$^{th}$ and the 5$^{th}$ of July 2000 and they exceeded 42$^0$C. On the 5$^{th}$ of July 2000, at Giurgiu, there were registered 43.5$^0$C and this was the absolute maximum temperature of July for the entire country till 2007. On the 24$^{th}$ of July 2007, this record was exceeded at Calafat, where temperature reached 44.3$^0$C. On the same day, temperatures above 44$^0$C were also registered at Bechet (44.2$^0$C), Moldova Nouă* (at Moldova Veche also 44.0$^0$C) *and Băileşti (44.0$^0$C).*

*From the analysis of the data of nine meteorological stations with data chains of more than 100 years and considered representative for the Romanian territory, it was noticed that the duration of the interval with tropical days (daily maximum temperature higher or equal to 30$^0$C) in July was of 24 days in 1904 at Drobeta-Turnu Severin. Great periods were also registered in 2002 at other stations located in the south of the country – 22 days at Bucureşti-Filaret, 19 days at Călăraşi, and 12 days at Constanţa.*

*These results confirm one of the conclusions of the 4$^{th}$ Report of IPCC, according to which it clearly appears an increase of the frequency and intensity of extreme weather phenomena as a consequence of the intensification of climate global warming phenomenon* (according to the data posted on the site of the NAM, *inmh.ro,* in July 2007).

***This heat wave as well as other meteorological risk phenomena studied by the author confirms significant climatic changes*** that also represent ***indicators of climatic change at regional level***. We mention for Oltenia:

- increase of the frequency and intensity of heat waves in the warm semester from 2… 3 per decade to 5…6 or even more; for June, the present tendency is that of ten times increasing frequency as compared to the last century;
- increase of the duration of canicular days from several days to 2…3 weeks or even more;
- increase of the number of summer days, tropical days, and tropical nights;
- extremely early occurrence of intense heat waves in the southwest of the country (Oltenia), starting with the first decade of April, which gives us the impression that spring disappeared and summers suddenly start;
- higher frequency of warm winters, from 1…2 per decade to 2…4 or even more, with a tendency of increase; some winters displayed a Mediterranean character in the south of the country, especially in Oltenia (for example 2006-2007);
- lower frequency of winter climatic phenomena or even their total lack;
- higher frequency and duration of droughts, as well as an extension of the surfaces affected by them;
- intensification of aridization phenomena and processes in the south of Oltenia, as a direct consequence of the above-mentioned phenomena;
- diminution of the intensity and frequency of cold waves in winter, or even their absence;
- excessively hot and dry summers.
- earlier arrival of spring, more frequent longer and warmer autumns;
- ***Oltenia is among the most affected regions in Romania***, climatic changes having a strong impact here.

All these led to the occurrence of important meteorological-climatic risk phenomena, which determined important material damage and casualties. They affected population and economy and consequently, poverty tendency, especially within rural areas, increased.

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