

## THE HEAT WAVE OF JULY 2007 AND ITS EFFECTS ON THE BIOSPHERE

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**Abstract.** *This paper analyses the evolution of the heat wave that affected Romania within the interval July 15-24, 2007. This was both the most intense and longest heat wave to affect Romania since systematic meteorological remarks are made. This affected the whole country, especially the South and East-except the mountain area where the effects were minimum. The maximum absolute temperature of July was exceeded by 0.7°C - pointing a remarkable stage in the evolution of temperatures of July, that in the context of the global warming has important meanings. The most affected areas were Hungary, Greece, Italy, Romania, Moldavian Republic, Ukraine. The consequences of this evolution were noticed in all fields. This paper is of great use for all those interested in climatology, meteorology, specialists in those fields and also students who are trying to achieve a Master or a Doctor degree.*

**Keywords:** *Heat wave, maximum absolute temperatures, monthly average temperatures, canicular days, thermal comfort index (I. T. M. ), red code.*

**Rezumat. Valul de căldură din iulie 2007 și efectele lui asupra biosferei.** *În lucrare este analizată evoluția 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 și cu durata cea mai mare din toată perioada de când se fac observații meteorologice sistematice în România. A afectat întreaga țară, cu excepția arealului de munte unde efectele au fost minime și în mod deosebit sudul și vestul. Temperatura maximă absolută a lunii iulie a fost depășită cu 0.7°C, marcând un important salt în evoluția temperaturilor lunii iulie, care în contextul încălzirii climatice globale are semnificații importante. Valul de căldură a afectat în mod deosebit Ungaria, Italia, Grecia, România, R. Moldova și Ucraina. Consecințele acestei evoluții au fost resimțite în toate domeniile. Lucrarea este utilă specialiștilor în domeniul climatologiei, meteorologiei doctoranzilor, mesteranzilor, studenților și tuturor celor interesați de problemele climatologiei.*

**Cuvinte cheie:** *val de căldură, temperaturi maxime absolute, temperaturi medii lunare, caniculă, indicele de confort termic ITU, cod roșu.*

### GENERAL

Oltenia is one of our country's regions where the submediterranean influences are superposed with the continental climatic influences. As a result, the summers are hot, with dryness and drought phenomena, the autumns are long with the second annual maximum of precipitations and the winters warm, with tropical air waves melting the snow and causing floods, hurrying the arrival of spring.

In the unperiodic variability of the climatic system, along time, there were several positive and negative deviations when the south territories of Romania were covered with either cold Polar or Arctic air that caused cold, frosty winters with temperature inversions and minimum temperatures below -25°C (the winters: 1941-1942, 1953-1954), or with maritime or continental Tropical air that have determined warm winters with temperatures over 10°-20° C with thin or absent snow layer (the winters: 1920-1921, 1935-1936, 1947-1948, 1990-1991, 2000-2001) or excessively hot summers when the maximum temperature values were exceptional and maintained for long periods of time as absolute monthly maxima temperatures for some meteorological stations or even for the whole country (the summers of: 1916, 1936, 1946, 1951, 1952, 1994, 2000).

In the last period, as a result of the global warming, we assist to the increase of the frequency of these hot summers which are outstanding for the often exceeding of the absolute maximum temperature values confirming a quick evolution of the general heating of the climate.

A special case is constituted by the summer of 2007, which followed the mediterranean winter of 2006-2007 which was very warm in the whole country and especially in the South. The summer of 2007 began with the excessively hot June, that, in its last decade has affected the whole country and especially the South by a strong heat wave. The warm weather was accompanied by a strong drought of a complex type-atmospheric and pedospheric-that, at first, affected seriously the wheat cultures in proportion of 60% at the level of the whole country and then, beginning with the second half of June also the weeding cultures, the vegetal carpet on the meadows, caused the drying out of fountains and had serious economic effects. Then both the drought and the canicular days of July 2007 increased the destructive affects.

The heat wave of July 15-24 2007 was the most intense for this month within the whole period of meteorological observations and marked the exceeding of the monthly absolute thermal maximum of July by 0.7°C - in Calafat we recorded on July 24 2007, 44.3°C that is now the absolute thermal maximum of July in Romania, the old value was 43.5°C recorded in Giurgiu on July 5<sup>th</sup> 2000). The thermal monthly absolute maximum of air of July in the last century-42.9°C- was recorded on July 5<sup>th</sup> 1916 and was exceeded by 0.6°C after 84 years on July 5<sup>th</sup> 2000. To this date we notice a slow evolution of maximum absolute values of July, then, within 7 years another remarkable exceeding by 0.7°C occurred.

We remark that in July 2007 the air temperature reaches and exceeds the climatic threshold of 44°C for the first time. Values of 44°C and above were recorded in Romania once along the history of meteorological remarks only on August 10 1951 when at 4 meteorological stations the temperatures of 44°C and above were reached and exceeded (in Baraganul Brailei, in the Maruntelul Village at the Ion Sion farm - 44.5°C also the absolute maximum of air in Romania and 44°C in Amara-Slobozia and Valea Argovei). In July 2007 temperatures of 44°C and above were registered in Băilești and Moldova Veche 44°C, Bechet 44.2°C, Calafat 44.3°C - which shows a much wider area of extremely hot air related to the last century (Figure no 2).

This intense and persistent hot wave affected Hungary, Greece, Italy, Romania, Moldovan Republic, Ukraine, Turkey and on July 27<sup>th</sup> 2007 the forest fires caused by the heat<sup>1</sup> took place on extended areas and the media considered that de South and East of Europe were “on fire”.

In order to establish the specific of this heat wave, we made synoptic analysis which compered this with another heat waves of July.

The heating process in Europe, especially in the South half began on July 15<sup>th</sup> when the moderate-intensity heat wave—with temperature values of 22-24°C at the 850 hPa izobaric surface level above Germany and Austria-Figure no 1 and air temperature values of 35-37°C at 2 meters altitude.

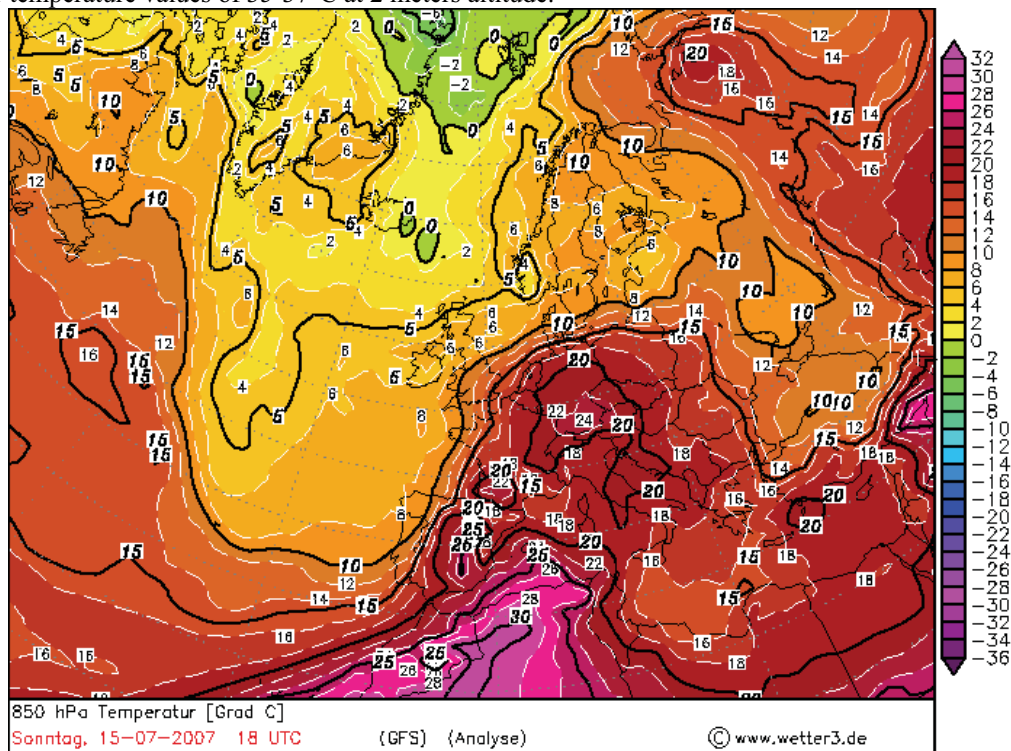


Fig. 1. The thermic field at izobaric surface level of 850 hpa on July 15 2007, 18<sup>00</sup> UTC – Karten Archive.

Fig. 1. Câmpul termic la nivelul suprafeței izobarice de 850 hPa, în data de 15.07.2007 ora 18 UTC (după Karten Archiv).

From the very beginning this heat wave has drawn the attention of forecast meteorologists by the presence of the extremely hot air nucleus with air temperature values at the izobaric sufrage level of 850 hPa of 30°C form the North of Africa that forwarded quickly enough over Tunis Cape and the Mediterranean Sea close to Sardinia and Corsica Islands. The synoptic situation was favourable to the extension of this wave over our country.

### THE SYNOPTIC SITUATION ON JULY 15 2007 AT 00 HOURS UTC

#### *At Ground Level*

We notice that the main baric centers that acted over Europe were:

- The Iceland Depression whose wide field had 2 cyclonic centers: one of them located in The Atlantic to South-West of Great Britain (Fig. 3) with is value at center of 1005 hPa and the second one located over The Scandinavian Half-Island with the same value.

- The Azoric Anticyclon was united with the North-African one and this wide anticyclonic field, in which a secondary center developed over the North Italy, the former Yugoslavia, Romania and Balcanic Half-Island with values of 1020 hPa, dominated the greatest part of Europe (over 2/3 of the South side of the continent). This type of synoptic situation is specific to the positive phase of the NAO which lasted during almost the whole winter, spring and summer.

<sup>1</sup> Canicular days = period of time when the air temperature, measured in standard conditions reaches and exceeds 35°C.

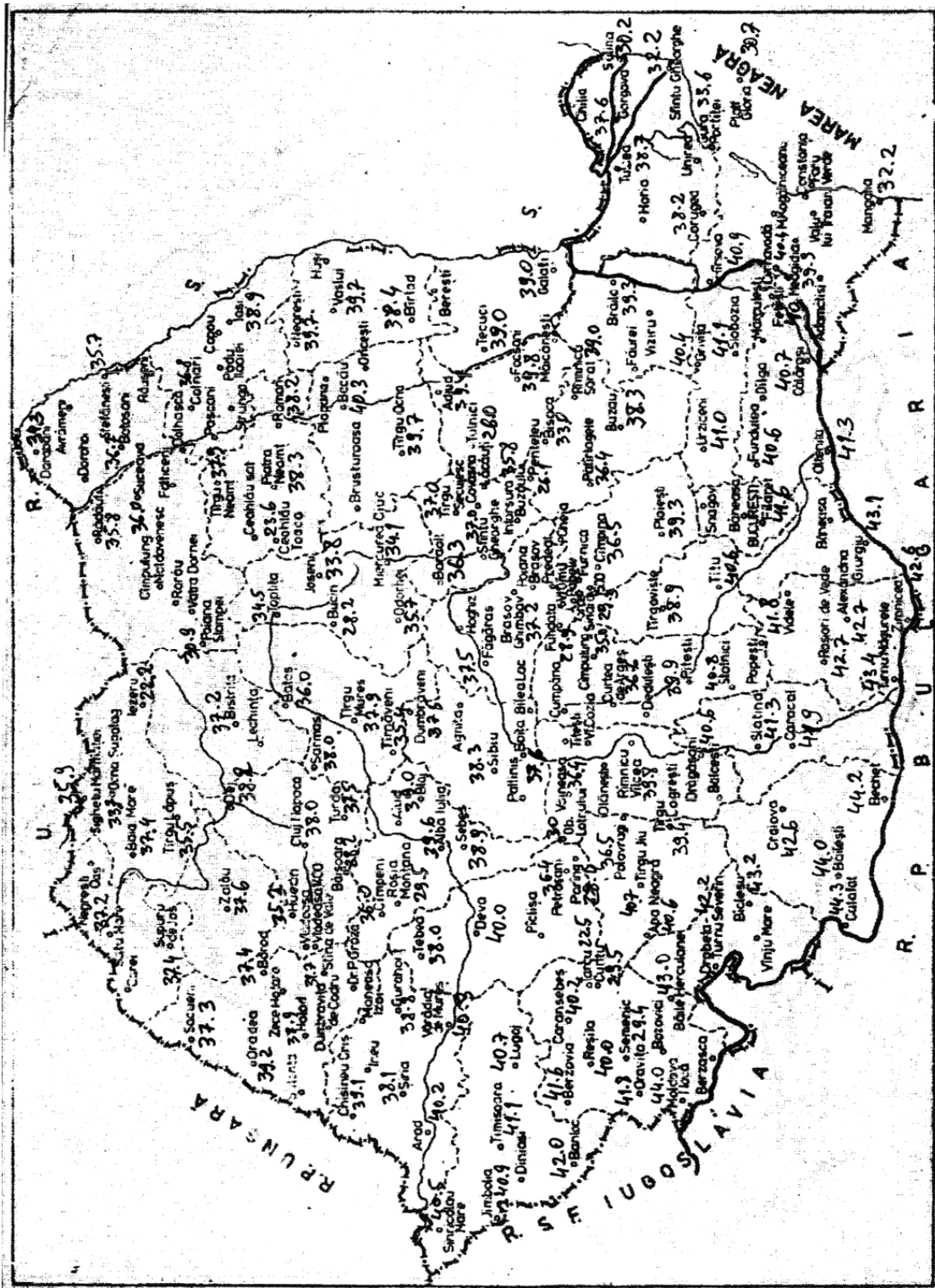


Fig. 2. The maximum values of the air temperature in Romania au July 24 2007.



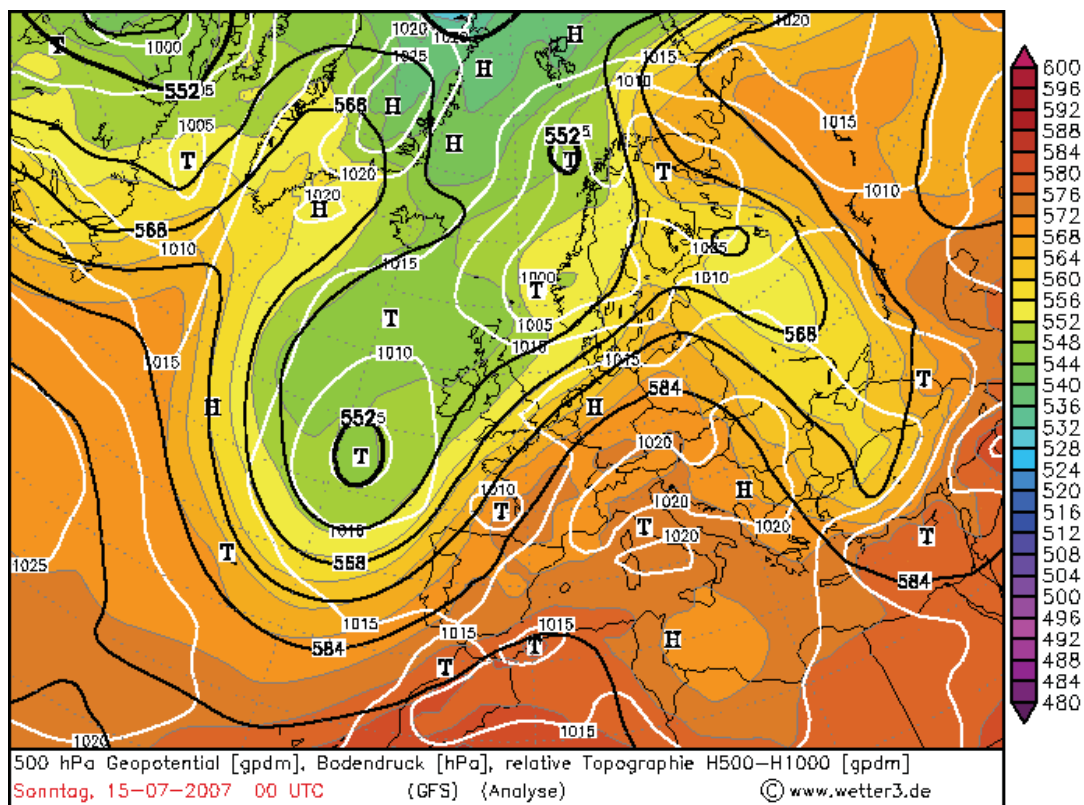


Fig. 3. The synoptic situation at ground level, the geopotential field at isobaric surface level of 500 hPa and the relative topography TR 500/1000, on July 15 2007, 18 UTC-Karten Archive.

Fig. 3. Situația sinoptică la sol, câmpul de geopotential la nivelul suprafeței izobarice de 500 hPa și topografia relativă TR 500/1000 hPa, în data de 15.07.2007 ora 18 UTC. (după Karten Archiv).

The subsequent evolution confirmed these forecasts. The temperature increase was slow from a day to another, but in 22, 23, 24 of July it accelerated so that on July 24 the “peak” of the canicular days was reached in our country.

### THE SYNOPTIC SITUATION ON JULY 24 2007 AT 00 HOURS UTC

#### *At Ground Level*

At this time there is a weakly depressionary field centered over the Balcanic Half-Island with values below 1010 hPa which determined a weak South air circulation (with low speeds of wind) in the air layer in the proximity of the ground and so it favoured the penetration of the extremely hot air mass over the Balcanic Half-Island towards our country (Fig. 4).

At the isobaric surface level of 500 hPa it is observed that the air circulation was of continental-Tropical type (cT) and in the North Africa a high geopotential nucleus was situated, with values in the center above 590 damgp. The relative topography field 500/1000 shows the hot air shift to the lower troposphere much to the North of our country (Fig. 4).

The thermal field of the izobaric surface level of 850 hPa showed the izotherm of 24°C in the South of our country (Oltenia) and the izotherm of 25°C to the South of the Danube (Fig. 5). This shows the continuation of the penetration of the considerably hot air to the South-West of Romania.

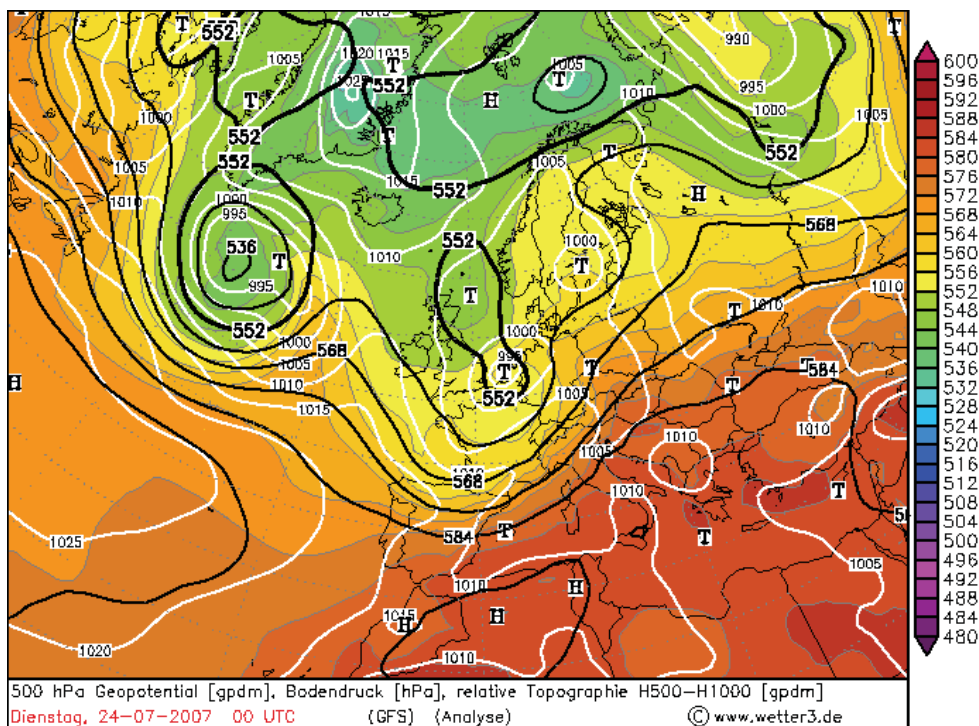


Fig. 4. The synoptic situation ground level, the geopotential field at izobaric surface level of 500 hPa and the relative topography TR 500/1000, on July 24 2007, 18 UTC – Karten Archive.

Fig. 4. Situația sinoptică la sol, câmpul de geopotential la nivelul suprafeței izobarice de 500 hPa și topografia relativă TR 500/1000 hPa, în data de 24.07.2007 ora 18 UTC, la momentul începutului fazei maxime a valului de căldură (după Karten Archiv).

On July 24 2007, the extremely hot air penetration over Romania continued so that the air heating maximum phase at 2 meters altitude took place between the hours 16-18, the summer hour of Romania, when the maximum temperature values of July 24 in our country were recorded-many of them becoming absolute thermal maxima of July (Figure no 6).

The maximum phase apogee of the hot air penetration over Romania occurred at the hours 18 UTC when the isohypse of 30°C was located over the South-West at the level of 850 hPa (about 1520 meters altitude-Figure no 8).

In all the systematic meteorological remarks history such a situation was never encountered on our continent.

In the same time with the shift of the cold front from the West of Europe to out country, a strong advection of hot air took place in front of this (Fig. 8).

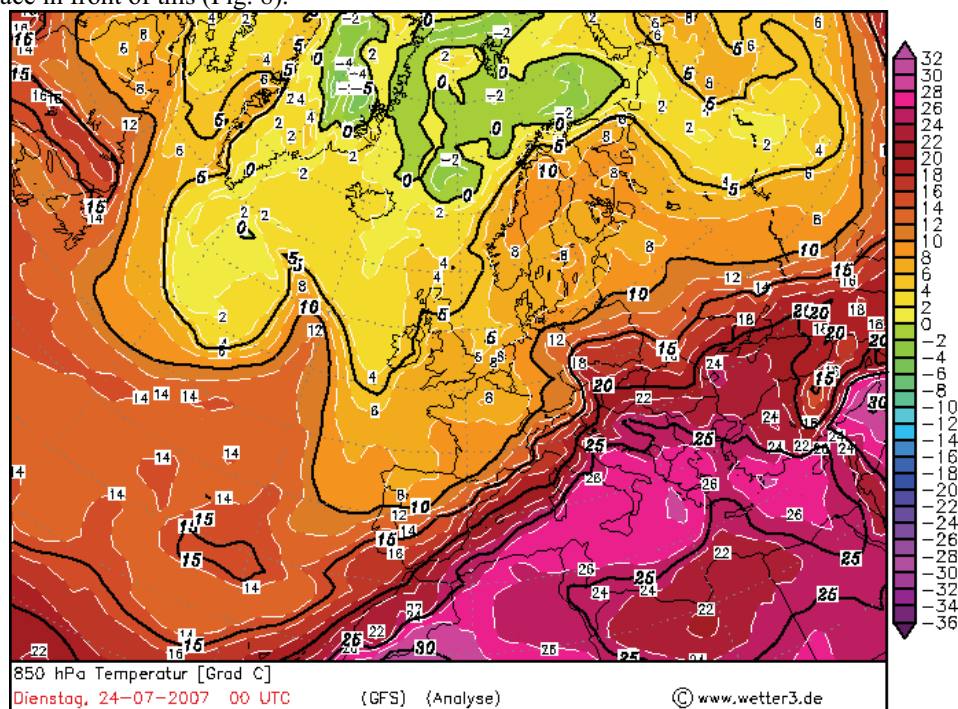


Fig. 5. The thermic field at izobaric surface level of 850 hPa on July 24 2007, 00<sup>00</sup> UTC – Karten Archive.

Fig. 5. Câmpul termic la nivelul suprafeței izobarice de 850 hPa, în data de 24.07.2007 ora 00 UTC (după Karten Archiv).



Fig. 6. The thermic field at 2 m altitude on July 24 2007, 17<sup>00</sup> UTC – NAM Archive.

Fig. 6. Câmpul termic la înălțimea de 2m, în data de 24.07.2007 ora 17 UTC. (după Karten Archiv).

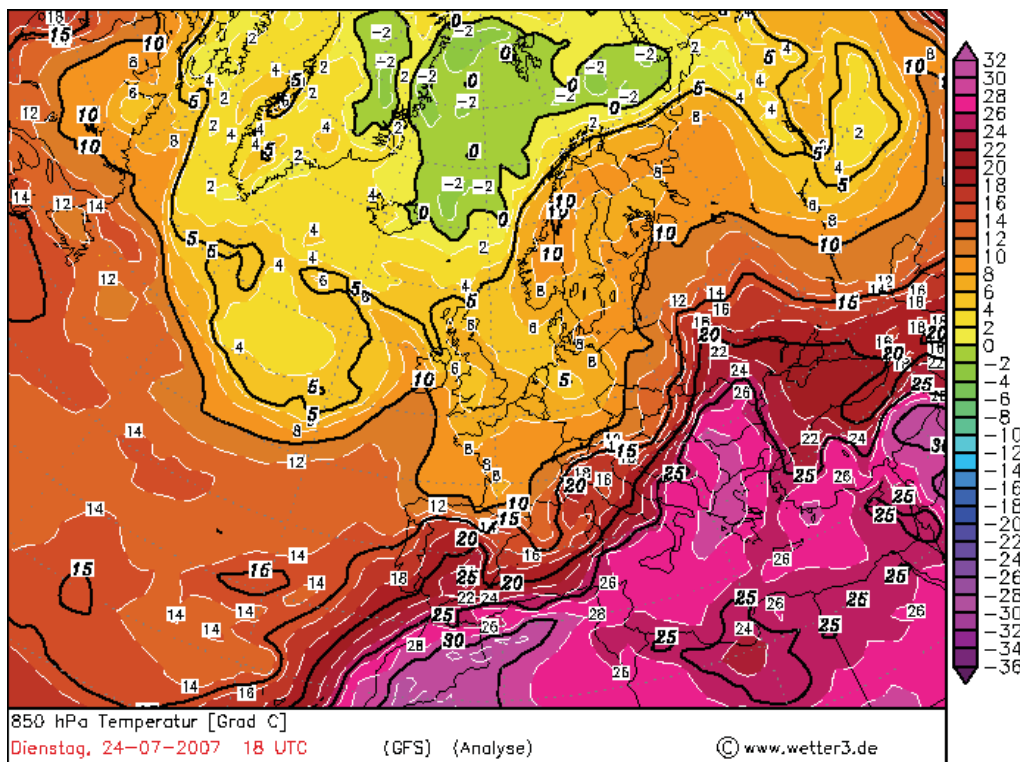


Fig. 7. The thermic field at izobaric surface level of 850 hPa on July 24 2007, 18<sup>00</sup> UTC – Karten Archive.

Fig. 7. Câmpul termic la nivelul suprafeței izobarice de 850 hPa, în data de 24.07.2007 ora 18 UTC. (după Karten Archiv).

The maximum phases of the heating processes are reached generally 12 hours before the penetration of the cold front and hot air mass dislocation, because of this process of dynamic nature. An important growth of air temperature can be taken into account and as a result of the compressing thermodynamic process produced by the forcing caused by the cold front on the obstacle generated by the extremely hot air. The hot air dislocation takes place in general at night, when, together with the temperature decrease the quick advance of the cold front is possible.

The cooling took place at night on July 24/25 and was considerable (by 10°C -15°C at maximum values related to the previous day) however, meteorologically, the weather remained hot, with maximum temperature values that locally exceeded 35°C the next day.



In the South-West of the country, the minimum values of temperature recorded in the morning on July 27 2007 were extremely high as a result, on the one hand of the shift to the East of the hot air nucleus in altitude and on the other hand of the continuation and intensifying of the advection of hot air before the cold front at night.

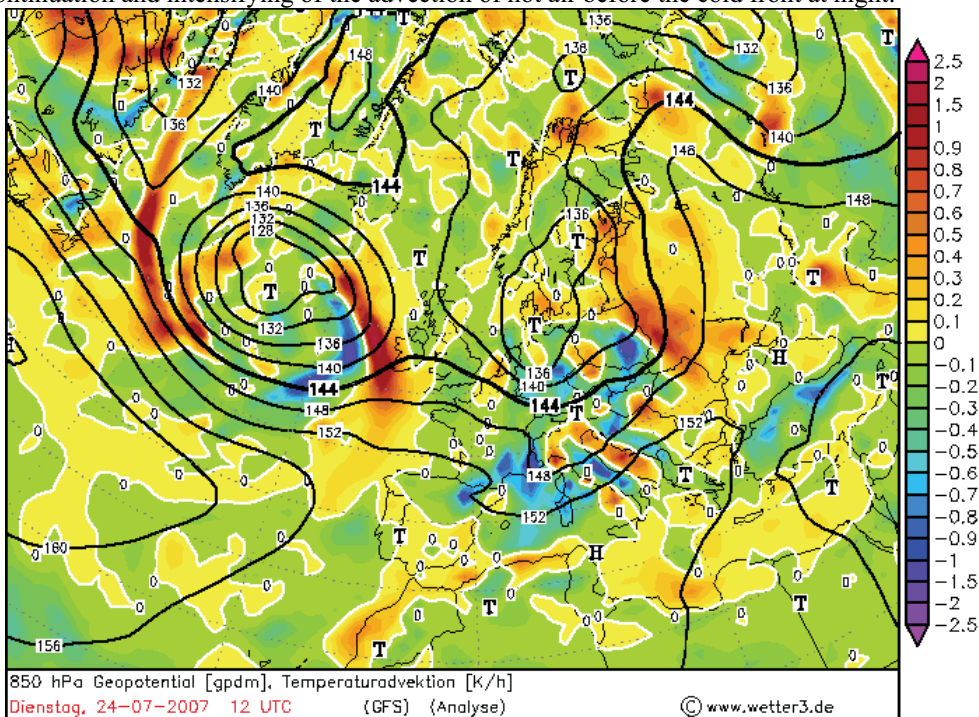


Fig. 8. The geopotential field at the isobaric surface level of 850 hPa and the advection of temperature (in kelvin degrees/hour) on July 24 2007 at 12 UTC – Karten Archiv.

Fig. 8. Câmpul de geopotential la nivelul suprafeței izobarice de 850 hPa și advecția de temperatură (în gade Kelvin/oră), în data de 24.07.2007 ora 12 UTC. (după Karten Archiv).

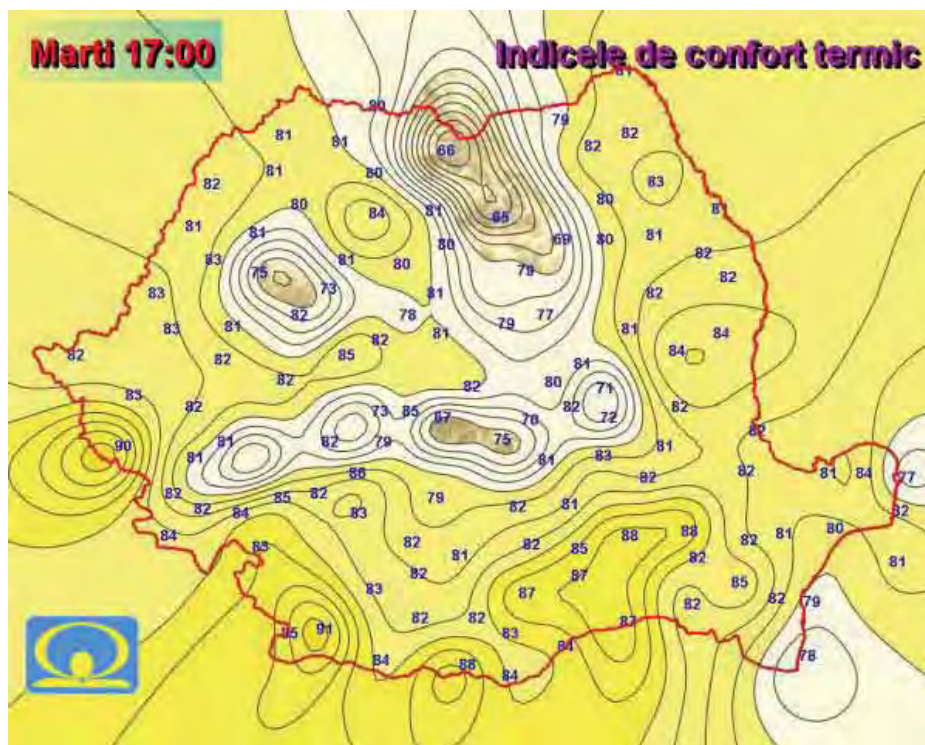


Fig. 9. The values of ITM, au July 24 2007, at 17 - the summer hour of Romania–NAM.

Fig. 9. Valorile indicelui de confort termic ITU, în data de 24.07.2007 ora 17 OVR, la momentul apogeului fazei maxime a valului de căldură. (după ANM).

From the thermal minimum values of above 25°C recorded in the morning of July 25 we specify: 25.4°C in București Filaret, 25.1°C in Slobozia, 25.2°C in Turnu Măgurele, 25.5°C in Oltenița, 26.2°C in Giurgiu and Alexandria, 26.7°C in Fetești, 27.0°C in Zimnicea and 27.1°C in Călărași.

The values of the thermal comfort index (ITM) reached and exceeded the critical threshold of 80 in the whole country and even in the mountains (Fig. 9).

In Oltenia-Calafat-on July 24 2007 in only 10 minutes the temperature increased by 0.7°C between 16<sup>10</sup>-16<sup>20</sup> the summer hour of Romania from 43.6°C to 44.3°C which shows both the intensifying of the hot air advection and the quickness of the air temperature growth.

### CONSEQUENCES OF THIS SITUATION-EFFECTS ON THE BIOSPHERE

The drought in the summer of 2007 brought about the destruction of cultures and vegetations in many counties of our country and especially in the South and East ruining the balance of life and caused the death of animals, the drying out of fountains and water runnings. In the fish lakes the excessive heating of the water produced the release of a great amount of Oxygen from the water into the atmosphere which led to the suffocation of fish, and, consequently, the damages were considerable. The vegetation drying made the bees stop having a normal collection so that a lot of bee families remained without food reserves, the artificial feeding being required. The insects, as for example: wasps, mosquitos, spiders, flies became aggressive attacking repeatedly people and animals.

In the vegetables gardens due to the intense heating, even under irrigation conditions we obtained low-quality goods and the price of vegetable and fruit was high for the rest of the summer and autumn.

This extremely intense thermal wave accentuated the drought, the vegetation dried on wide areas, the cultures were gravely affected, the forest and vegetation burst into flames at an average of 170-175 times per day.

The researchers have shown that the most vulnerable sectors of society in case of high temperatures are the old, the very young, the sick or those who work in open air.

With reference to the heat waves, the general secretary of WMO, Mr Michel Jarraud said "Because of the lack of the spectacular and immediate violence of a Tropical cyclon or of a rapid flood and because of the less evident death tribute, no sufficient attention was paid to the heat waves. However, the heat waves are considered one of the most dangerous natural disasters. The Guide<sup>2</sup> shall act as a catalyser for bringing together important factors in the fields of climate, health, from the agencies for reply in case of emergency situations, decision factors as well as the people for taking some actions regarding the heat management as a risk factor."

It is very possible that the heat waves occur further on and become more and more frequent, being able to affect the good health of millions of people in certain areas of the world, especially those with a very reduced capacity of adaptation.

As a result of this situation of the canicular days when the thermal maxima exceeded the climatic threshold of 44°C, in Romania we recorded only on July 24 2007 a number of 12 deaths and during the whole extremely hot interval (16-24 July 2007) 19 people died and until July 30 the information in the newspapers indicated 33 deaths as the afternoon heat lasted until July 29 (on July 28, 29 2007 in Oltenia we recorded maximum values of air temperature of 39°C locally in the South half of the region). At night on July 29/30 the weather cooling was significant and the temperatures became normal.

The electric current consumption at national level was double related to the normal one and because of the overstraining of the electric energy network many blackouts appeared.

In Romania a RED CODE meteorological warning for extreme heat was giving for the first time. As a result, the authorities took a series of adequate measures for people protection such as:

-creation of some first-aid points in the street of cities;

-creation of some teams who helped people with special needs to buy prime-necessity goods as mineral water, bread.

Some of the adopted measures were totally inadequate and even not indicated such as:

-closing some public institutions;

-stopping common ways of transport like buses in some cities;

-“refilling” with proximity police in market places to force people to close their business.

These measures were meant to be good for the population – in fact they made things even worse. What measures would have been taken in case of a major accident, chemical or nuclear? Stopping the common way of transport can affect badly some essential functionalities of strategic importance for the city like energy plants (workers cannot be on time for their job), water supplying, all sorts of communications and others. In countries where these temperatures are frequent during the summer, measures like these are not taken (for example in Italy, Greece, etc.)

As appreciated by the Mayor of Craiova, July 24 was an ordinary day and the people withstanding properly the heat did not suffer from the excessive heat.

Extremely serious forest and vegetation fires broke out in the South of Europe and especially in Greece, Italy, Bulgaria, Spain (Canary Islands). In Greece the forest near Athens, considered the only green “lung” of this metropola has burned completely. The tourists on the beaches were endangered by the fires that made several victims between them. We mention that in this interval in Greece temperatures of 45°C were frequent, and on July 24 2007 the value

<sup>2</sup> The Guide for the putting in action of warning systems related to the effects of the heat on health decides who is under heat-risk, evaluates heat risks, presents the science and the methods associated with the warning systems showing the essential elements of the plans to be considered in the case of a hot summer. The climatic component is strongly related to the Meteorological and Hidrological National Services and also the WMO. Another important role is that of the social and the public health sectors.



44.5°C was recorded in Veliko Tarnovo in Bulgaria. In contrast, the floods in large areas of China that caused 700 deaths took place in the same period of time.

## CONCLUSIONS

According to The National Administration of Meteorology (NAM):

In Romania along the whole period of meteorological measures in standard conditions (meteorological shelter at 2 meters above the ground), we registered 220 cases when the maximum temperature reached and exceeded 40°C. These values were recorded in the South and South-East of the country, especially after 1985. The most frequent situations were encountered in Turnu Magurele-16 times, Roșiorii de Vede-14 times, Giurgiu-13 times, Bechet and Zimnicea-10 times, Călărași-9 times and Bucharest-Filaret-8 times. The absolute maxima for July were generally registered on July 4-5 2000 at meteorological stations and exceeded 42°C on July 5 2000 at Giurgiu 43.5 °C were registered and this represented the absolute maximum for July until 2007 when on July 24 at Calafat 44.3°C were recorded. In the same day, temperature of over 44°C were registered in Bechet 44.2°C, Moldova Noua, Moldova Veche, Bailești-44°C.

Analysing the data of more than 100 years from 9 meteorological stations which are representative for Romania we observe that the maximum period of Tropical days of July was 24 in 1904 at Drobeta Turnu-Severin. Such periods were also recorded in Bucharest-Filaret-22 days, Calarași-19 days and Constanța-12 days in 2002.

These results support one on the conclusions of the Forth Report of IPCC, which points out an increase in the frequency and intensity of the extreme phenomena derived as an intensification of the global warming. Significant modifications of the climate which can be considered indexes of the local change in climate in Romania are:

- the increase in frequency and intensity of the heat waves in the warm season from 2-3 every 10 years to 5-6 or even more, and for those of June the frequency is almost 10 times bigger than in the previous century.
- the canicular days do not last only several days, they can last up to 3 weeks and sometimes more
- the increase in the summer days<sup>3</sup>, tropical days, and tropical nights
- the very early apparition of intense heat waves in the South-West of our country (Oltenia) starting with the first decade of April so that it seems that spring has disappeared and the summer starts abruptly.
- the frequency of the apparition of warm winters has doubled-form 1-2 a decade to 2-4 and tendency is that of growth.
- the decrease of the frequency of winter phenomena or even the lack of these.
- more and more drought periods and the extension of the affected area.
- in Oltenia the intensifying of these phenomena and processes of aridity as a direct consequence of what we have shown above.
- a diminuation or even lack of cold waves in some winters.
- the excessively hot and droughty summers.
- an early arrival of spring and longer and warmer autumns are more and more frequent.
- Oltenia is one of the most affected regions of the country where the changes in climate have a strong impact.
- in the positive phase of the NAO<sup>4</sup> we notice a rise in the number for the days with little rain-between 0 and 5 l/m<sup>2</sup> –and a dramatic decrease or even the disappearance of significant precipitations in the droughty periods.
- in the negative phase of the NAO more and more frequent rainfalls which lead to overdestructive floods appear.

All these produced important phenomena of meteo-climatic risk. That caused both material and human loss making the poorness even more striking in the severely affected places.

### ***The causes of these changes in climate are:***

*NATURAL*-related to the increase of the intensity of the solar radiation and cosmic causes. A team of researchers from the Cosmic Research Center-Colorado, led by Douglas Beseker estimate that the solar activity will reach its peak between the end of 2011 and the middle of 2012.

This continuous increase of the solar activity will lead to a large number of sun spots that will grow by 90-140 on average and the consequences on the context of the global warming will be major. It is possible that the thermic equator of the planet will extend in latitude and the intensely heated zone of the Earth to widen.

In Figure no 10 we can see the extension to the North of the thermical Equator with two "lobes" that migrate towards our country: one from the North of Africa-which affected Europe and the West of Turkey and the other one from the Arabian Peninsula to the East of Turkey.

Serious magnetic storms will damage the electro-magnetic equipments on Earth. Nowadays, the forecast of the solar activity is highly requested by a growing number of companies in order to protect their machines.

Such an evolution might lead-relatively soon-to the extension of the transitional climate from the continental to the mediterranean with serious consequences on the biosphere.

<sup>3</sup> Summer day = day in which the maximum temperature of air reaches 25°C

Tropical day = day in which the maximum temperature of air reaches 30°C

Tropical night = night in which the minimum temperature of air does not go below 30°C

<sup>4</sup> NAO = North Atlantic Oscillation

*ANTROPICAL*-due to the pollution of the atmosphere with greenhouse gases of the environment and the Earth crust with several substances, the massive deforesting-works which modified the terrestrial albedo so that the quantity of retained heat that is transferred later on to the atmosphere-modifying the atmospheric and oceanic circulation-is growing.

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### 850 hPa Temperatur (Grad C)

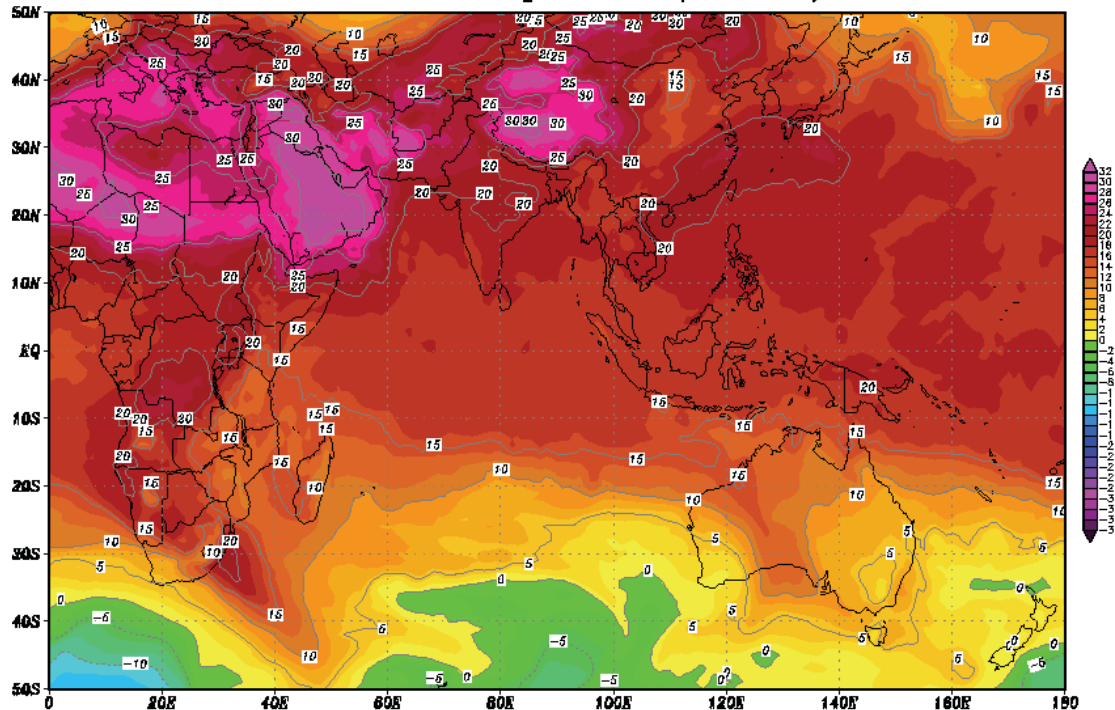


Fig. 10. The thermic field at izobaric surface level of 850 hPa over the Eastern Hemisphere on July 24 2007, 00<sup>00</sup> UTC–Karten Archive.

*LOCAL*-in Oltenia a special role is played by the interaction between the air circulation, at mesoscale with the local relief and that of the Balcanic Half-Island. The penetration of the warm air mass is made on two passages: one for the warm air from the West of the continent on the passage of the Danube and the second one for the extremely hot air which comes from the South or South-West on the valley of Timok river. This second passage has a special role in revealing the climate in the region of Bechet-Calafat-Cujmir-Vânju Mare-Drobeta Turnu Severin-Halanga, this fact being shown in the maps presented in our paper and each time heating phenomena are produced in this part of Romania.

### BIBLIOGRAFIE

- BĂLTEANU DAN. 1982. *Inielişul de gheaţă*. Edit. Şt. şi Encicl. Bucureşti: 110 pp.
- BĂLTEANU DAN. 1992. *Natural hazards in Romania*. R. R. Géogr. **36**: 44-75.
- BĂLTEANU DAN, ALEXE RĂDIŢA. 2001. *Hazarde naturale şi antropogene*. Editura Corint.
- BĂLTEANU DAN. & ŞERBAN MIHAELA. 2003, 2004. *Modificări globale ale mediului* (două ediţii). Edit. CREDIS Bucureşti.
- BĂLTEANU D. & TRANDAFIR P., editori. 2004. *Hazarde naturale şi tehogene în România: Tornada de la Făcăeni, 12.08.2002. Cauze, consecinţe, percepţie, management*. Edit. Telegrafia Bucureşti: 55 pp.
- BOGDAN OCTAVIA. 1992. *Asupra noţiunilor de hazarde, riscuri şi catastrofe meteorologice/climatice*. SC. Geogr. **XXXIX**: 99-105.
- BOGDAN OCTAVIA & NICULESCU EL. 1999. *Riscurile climatice din România*. Acad. Rom. Inst. de Geogr. Bucureşti.
- BOGDAN OCTAVIA & MARINICĂ ION. 2007. *Hazarde meteo-climatice din zona temperată. Geneză şi vulnerabilitate cu aplicaţii la România*. Edit. Lucian Blaga Sibiu: 434 pp.
- MARINICĂ ION. 2006. *Fenomene climatice de risc în Oltenia*. Edit. MJM Craiova: 386 pp.
- ŞTEFAN SABINA. 2004. *Fizica Atmosferei Vremea şi Clima*. Edit. Universităţii Bucureşti: 422 pp.

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