

THE EXCESIVELY RAINY SUMMER OF 2018 IN SOUTH-WESTERN ROMANIA IN THE CONTEXT OF CLIMATE CHANGES

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Abstract. The summer of 2018 was warm and extremely rainy. The rainy summer feature is due to the first two months of summer in which the monthly average rainfall (calculated for the whole region) was very high. In June the monthly average monthly rainfall was 162.8 l / m², and its percentage deviation from normal was 93.4% (almost twice the normal) and in July the average monthly quantities for the whole region was 138.0 l / m² and its percentage deviation from normal 112.4% (more than twice the normal). The average air temperature average was 21.9°C and its deviation from normal 1.2°C, which shows that the summer was warm. The dry and warm weather, usually in summer in Oltenia, started on 2 June, 1818 and extended throughout autumn, seriously affecting the beginning of the 2018-2019 agricultural year by delaying the establishment of autumn crops. Throughout the summer there were 7 overly rainy intervals, which amounted to over 15 days of rain. Due to synoptic situations, usually unusual summer, which caused torrential rains, the summer of 2018 changed the way to achieve seasonal climatic forecasts at three-month intervals at 4-week intervals. This is still a confirmation of the ongoing climate change across the planet, and summer 2018 will remain in the history of the climate as the one that has changed the seasonal weather forecast reference range. The paper is particularly useful to climate scientists and to all those interested in climate and climate change.

Key words: excessively rainy summer, climate change, exceptional rainfall

1. INTRODUCTION

Global warming continued in 2018; 2016 was the warmest year and 2017 was the second year in the history of climate recordings and warmer than 2015 (the first year to exceed the average global temperature of the 20th century with 1.0°C). The Copernicus Program of the European Union for Environmental Monitoring and Civil Security has developed a global warming report in 2017 showing that the global average temperature was 14.7°C and with 1.2°C above pre-industrial times

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(www.copernicus.eu). The global average temperature in 2016 exceeded the record of 2015 by nearly 0.2°C, being also boosted by the El Niño natural climatic process, which takes place every four years and releases heat in the Pacific Ocean atmosphere. The climatic processes in 2018 took place in the absence of El Niño and in the minimum of solar activity. However, the April was the warmest in the history of climate, due to the monthly temperature averages that became absolute climatic records on a large part of Eurasia; in South-Eastern Europe, including Romania, their deviations from normal reached and slightly exceeded 6°C. In Romania, the summer of 2018 was hot and extremely rainy, and in Western Europe the persistence of hot air has caused the exceeding of the absolute maximum temperature of Europe. Thus, in the first 5-6 days of August, the persistent heat wave in Western Europe intensified and on 3.VIII.2018 in the South-West of Spain at Badajos was recorded ***the maximum temperature value of 50.0°C, exceeding so the thermal record of Europe of 48.0°C recorded in Athens on 10.VII.1977*** (<https://www.thesun.co.uk/news/6938664/europe-hottest-day-spain-portugal/>). In Portugal, at Mirandela, on 2.VIII.2018, electronic thermometers in the city indicated 52.0°C. Date of 3.VIII.2018 was declared ***the warmest day in the history of Europe's climate*** (<https://nypost.com/2018/08/03/today-could-be-the-hottest-day-in-the-history-of-europe/>). We will further analyze the climatic events in south-western Romania in the summer of 2018.

2. DATA AND METHODS

To realize this paper I used the results of the daily processing with special software from the weather forecasting, the ANM⁷ data archive, the maps made in the operative activity, the Internet ones were provided by the international analysis and forecast centres as well as the ANM Bucharest. We've used the Microsoft Office features to draw up tables and charts. The paper examines the extremely rainy summer of 2018 in south-western Romania, based on the thermal and pluviometric regime of June, July and August and the thermal and pluviometric regime of the summer of 2018.

3. RESULTS AND DISCUSSIONS

3.1. Climatic characteristics of June 2018

In June 2018, the monthly average temperatures were between 16.9°C at Voineasa and 22.5°C in the extreme west at Dr. Tr. Severin, and their deviations from the averages of the last century ranged between 0.7°C at Bechet in the south

⁷ ANM= Administrația Națională de Meteorologie (National Meteorological Administration)

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region and 3.2°C in the area of the Apa Neagră Subcarpathian depressions. As a result, in most of the region, June was warm with the exception of a restricted area in the Oltenia Plain, where it was thermally normal (N) (Bailești, Bechet), and in the Subcarpathians at Apa Neagră, it was warm⁸ (W) (Table 1). **The monthly average air temperature**, calculated for the whole region, was 20.9°C, and its deviation from last-year average was 1.5°C, confirming that June was warmish (WS) on average for the whole region.

Table 1, The air temperature regime in Oltenia and the minimum and maximum surface temperature values in June 2018 for the area with altitude ≤ 600 m (NVI = average temperature in June for the period 1901-1990, MVI18 = temperature averages in June 2018, Δ = MN = temperature deviation, CH = Hellmann criterion).

Meteorological Station	Hm	NVI	MVI18	Δ=M-N	CH	Tmin air		Tmax air		Tmin soil		Tmax soil	
						(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data
Dr. Tr. Severin	77	20.7	22.5	1.8	WS	10.2	25	33.3	12	9.0	24	63.4	6
Calafat	66	21.0	22.1	1.1	WS	9.8	25	35.2	13	11.7	24	43.7	7
Bechet	65	21.3	22.0	0.7	N	9.4	24	35.0	13	9.9	24	47.1	6
Băilești	56	21.1	21.9	0.8	N	8.2	24	33.7	13	10.5	24	41.7	12
Caracal	112	20.8	22.1	1.3	WS	9.8	24	34.2	13	16.3	24	40.4	1
Craiova	190	20.6	21.6	1.0	WS	9.7	24	32.9	6	10.2	24	58.4	1
Slatina	165	20.5	21.5	1.0	WS	8.6	24	33.5	13	12.7	24	39.7	6
Băcleș	309	19.0	20.3	1.3	WS	8.2	24	30.2	12				
Tg. Logrești	262	18.8	20.2	1.4	WS	5.5	24	31.2	13	7.0	25	56.0	6
Drăgășani	280	19.4	21.1	1.7	WS	9.6	24	31.4	13	14.2	24	35.6	13
Apa Neagră	250	16.6	19.8	3.2	W	5.5	24	30.9	12	8.0	24	37.2	5
Tg. Jiu	210	19.4	21.0	1.6	WS	7.0	24	32.8	13	7.0	24	61.6	13
Polovragi	546	17.7	19.3	1.6	WS	6.8	24	29.6	13	4.2	24	53.3	12
Rm. Vâlcea	243	19.0	20.9	1.9	WS	9.0	24	31.9	20	10.2	24	53.2	7
Voineasa	587	15.3	16.9	1.6	WS	4.1	24	29.5	12				
Parâng	1585					2.4	24	22.6	12				
Average Oltenia	-	19.4	20.9	1.5	WS	7.7		31.7		10.1		48.6	
Ob. Lotrului	1404	10.8	12.1	1.3	WS	-0.3	24	24.4	12				

(Source: data processed from the ANM Archive)

The maximum monthly temperatures were recorded mostly in the 12.VI and 13.VI dates and ranged between 29.5°C at Voineasa and 35.2°C at Calafat and *their average for the whole region* was 31.7°C. **Canicula** (dog-days) was recorded in one day in a restricted area in the southern Oltenia Plain (Calafat and Bechet). **Scorching heat** was recorded in the Oltenia Plain and in a restricted area of the Tg. Jiu Depression, and the number of days with heat was between 2 days at Tg. Jiu and 7 at Calafat and Bechet. **Monthly air temperature minima** were

⁸ According to Hellmann Criterion for **warm weather**, average temperature deviations from normal range between 1.0°C and 1.9°C, and **hot weather** between 2.0°C and 4.9°C. So "warm weather" has lower average temperatures than "hot weather".

recorded most during 24-25.VI when weather cooling occurred in Southeast Europe and were between 4.1°C at Voineasa (24.VI) and 10.2°C (25.VI) at Dr. Tr. Severin. Weather cooling occurred during 22-25.VI and is atypical because in the last decade of June, the weather is warming up, the astronomical summer begins at 21.VI, and the duration of the daily sunshine exceeds 15 hours⁹ and 30 minutes. On the night of 22/23.VI.2018 it snowed in Făgăraș Mountains and Transfăgărașan. At over 2000 meters altitude, the snow layer had 3-4 centimeters and above, on the peak called " Vânăturea lui Buteanu"¹⁰, the snow had 10 cm. (Transfăgărașan Road officially opens on July 1st) (https://adevarul.ro/locale/pitesti/video-ninsoare-luna-iunie-transfagarasan-imagini-spectaculoase-1_5b2df998df52022f756f0479/index.html). *The synoptic causes* of this cooling is the presence and action of a **cut-off low** in altitude - a cold air nucleus detached from the polar vortex that maintained the weather instability. Cut-off low cores and long wave thalweg are the main causes that keep weather instability and generate precipitation during summer in Romania. During 27-28.VI, massive floods occurred in Muntenia and Moldova as a result of torrential rains.

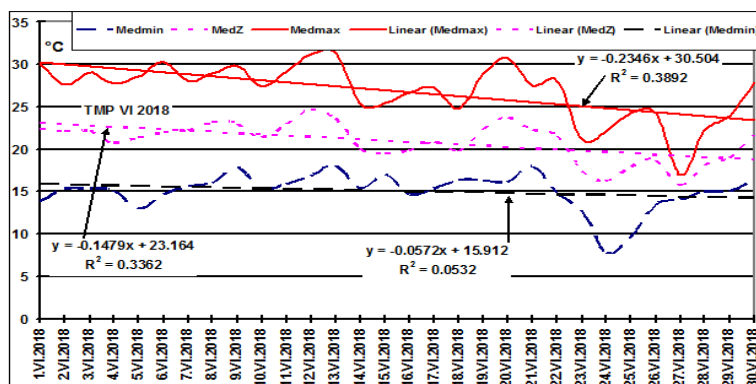


Fig. 1. The variation of the air temperature characteristics in June 2018, calculated for the whole region (average daily minimum, daily average and mean daily peaks) (Source: data processed from the ANM Archive)

⁹ From 22.V to 22.VII, for 62 days, the day's duration is ≥ 15 hours. In the 19, 20 și 24.VI. the daytime duration reaches *the maximum value of 15 hours and 32 minutes* (values calculated for the latitude of the Craiova meteorological station).

¹⁰ "Vânăturea lui Buteanu" Peak (erroneously called Vânătoarea lui Buteanu (Buteanu's Hunt)) is a mountain peak in the Făgăraș Mountains, having an altitude of 2507 m, being the eighth highest peak in Romania, after other peaks of the Făgăraș Mountains - Moldoveanu, 2.544 m, Negoiu, 2.535 m, Viștea Mare, 2.527 m and Lespezi, 2.517 m.

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The graph of parameters variance that characterize the air temperature (the average of the daily minima calculated for the whole region, the daily averages and the average of the daily maxima) had decreasing linear trends (Fig.1), the atypical situation for June. The consequences were on vegetable crops that had periods of stagnation due to low temperatures during the nights, especially during the last half of the month. *The maximum temperature at the soil surface* was registered in different dates from the first 13 days and was between 35.6°C (13.VI) at Drăgășani and 63.4°C at Dr. Tr. Severin (6.VI), and their average for the entire region was 48.6°C. Soil temperature minima were recorded on 24.VI and were between 4.2°C at Polovragi and 16.3°C at Caracal, and their average was 10.1°C. **The monthly rainfall amounts** in June ranged between 65.1 l/m² at Băilești in the Oltenia Plain and 269.6 l/m² at Băcleș in the Mehedinți Hills. At 14 of the 15 weather stations the monthly quantities were ≥ 100.0 l/m² (Table 2) (93.3%).

Table 2, Amounts of rainfall recorded in summer 2018 (Σ) compared to normal (N); $\Delta\%$ = percentage deviation from normal, CH = Hellmann's criterion.

Meteorological Station	Hm	June 2018				July 2018				August 2018			
		ΣVI	N	$\Delta\%$	CH	ΣVII	N	$\Delta\%$	CH	$\Sigma VIII$	N	$\Delta\%$	CH
Dr. Tr. Severin	77	107.6	72.5	48.4	VR	78.8	49.3	59.8	ER	63.6	38.2	66.5	ER
Calafat	66	103.7	65.6	58.1	ER	100.2	45.6	119.7	ER	9.2	35.6	-74.2	ED
Bechet	65	133.4	62.3	114.1	ER	158.0	46.6	239.1	ER	10.2	37.9	-73.1	ED
Băilești	56	65.1	66.5	-2.1	N	113.7	45.0	152.7	ER	16.8	39.0	-56.9	ED
Caracal	112	128.0	73.7	73.7	ER	110.8	53.8	105.9	ER	8.4	39.9	-78.9	ED
Craiova	190	135.2	71.2	89.9	ER	148.8	51.4	189.5	ER	16.2	42.1	-61.5	ED
Slatina	165	186.2	80.6	131	ER	166.4	57.5	189.4	ER	36.0	46.8	-23.1	D
Băcleș	309	269.6	72.0	274.4	ER	95.9	47.1	103.6	ER	64.7	33.4	93.7	ER
Tg. Logrești	262	109.8	72.3	51.9	ER	169.0	49.5	241.4	ER	41.8	43.6	-4.1	N
Drăgășani	280	202.0	87.6	130.6	ER	176.8	51.6	242.6	ER	49.6	46.4	6.9	N
Apa Neagră	250	142.0	99.2	43.1	VR	91.0	72.7	25.2	R	73.0	60.1	21.5	R
Tg. Jiu	210	103.4	93.0	11.2	LR	139.6	61.9	125.5	ER	76.8	64.3	19.4	LR
Polovragi	546	217.4	112.3	93.6	ER	185.0	88.9	108.1	ER	74.6	76.5	-2.5	N
Rm. Vâlcea	243	234.6	86.9	170.0	ER	130.6	98.0	33.3	VR	28.0	69.4	-59.7	ED
Voineasa	587	189.2	106.7	77.3	ER	152.6	88.6	72.2	ER	30.4	72.8	-58.2	ED
Parâng	1585	277.0	124.1	123.2	ER	191.4	132.1	44.9	VR	140.4	90.6	55.0	VR
Average Oltenia	-	162.8	84.2	93.4	ER	138.0	65.0	112.4	ER	46.2	52.3	-11.6	LD
Ob. Lotrului	1404	315.7				178.4				185.9			

(Source: data processed from the ANM Archive)

Their percentage deviations from the past century averages were between - 2.1% at Băilești and 274.4% at Băcleș, which means an extremely rainy month (ER) in most of the region. The monthly precipitation average for Oltenia was 162.8 l/m² being the rainy month of 2018, and its percentage deviation from normal was 93.4% confirming that June was rainy (ER) for the entire Oltenia region. In June there were four rainy intervals: 9.VI, 13.V, 15-16.VI and 26-29.VI, totalling 7 days. The most rainy day was on the 13th, when the average of the

quantities recorded at the meteorological stations was 28.3 l/m^2 and the highest recorded quantity at the meteorological stations at 55.8 l/m^2 at Bâcleș. *The largest amount of precipitation in 24 hours* in June was recorded at 27.VI in Rm. Vâlcea, 60.0 l/m^2 , and the average for the whole region on this day was 19.5 l/m^2 . *For the entire country*, the maximum daily rainfall in the national observation network was recorded between 27.VI, 08:00, and 28.VI, 08:00 in Rășinari, Sibiu County, 252.0 l/m^2 . For the entire country, the monthly precipitation amount in June 2018 had values higher than 100 l/m^2 in most regions of the country. The largest quantities, over 150 l/m^2 , were recorded mainly in hill and mountain areas. At 11 meteorological stations, the maximum monthly precipitation quantity of June was exceeded and at 5 meteorological stations the absolute maximum precipitations amount dropped in 24 hours for June of the station was exceeded. ***The largest monthly precipitation amount recorded in June 2018 was 338.7 mm at Bâlea Lac meteorological station*** (<http://www.meteoromania.ro/clima/monitorizare-climatica/>). June was the rainiest in Romania in the last 40 years and the second in the last 50 years. There were 1,026 nowcasting yellow storm code warnings, 255 nowcasting orange storm code warnings and a nowcasting red storm code warning of the storm. As a result of these exceptional rainfall on June 29, 2018, ***the supply of water to the soil profile of 0-100 cm*** in the winter wheat crop was within optimal and optimal limits throughout Oltenia's agricultural territory (ANM).

3.2. Climatic characteristics of July 2018

Monthly air temperatures in July were between 17.6°C at Voineasa and 23.8°C at Calafat, and their deviations from the past century average were between 0.0°C at Bechet, Craiova, Bâcleș, Tg. Logrești, Drăgășani and 0.7°C at Tg. Jiu, limits that show July was normal (N) in Oltenia (Table 3). The monthly average air temperature calculated for the whole region was 21.8°C and its deviation from normal of 0.3°C confirmed that July was normal across the region (N).

Monthly air temperature maxima were generally recorded after 20.VII and were between 27.8°C at Voineasa on 30.VII and 34.0°C at Calafat on 22.VII. Average monthly maxima calculated for the entire region was 31.1°C , being 0.6°C lower than June. *Monthly air temperature minima* were recorded on 2.VII and were between 6.0°C at Voineasa (2.VII) and 14.8°C at Bechet on 6.VII, and the average was 10.5°C . *The maximum temperatures* at the soil surface were registered at different dates and were between 34.5°C at Drăgășani on 22.VII and 64.3°C at Dr. Tr. Severin on 25.VII and the average for the whole region was 49.2°C . *Soil temperature minima* were recorded on 1 and 2.VII and were between 5.0°C at Polovragi and 17.2°C at Caracal, and their average for the whole region was 11.9°C . While in South-Eastern Europe, July temperature was close to normal in the extreme west of the continent, the persistent heat wave determined peak record highs.

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Table 3. The air temperature regime in Oltenia and the minimum and maximum surface temperature values in July 2018 for the area with altitude ≤ 600 m (NVII = average temperature in July for the period 1901-1990, MVII'18 = temperature averages in July 2018, $\Delta = M-N$ = temperature deviation, CH = Hellmann criterion).

Meteorological Station	Hm	NVII	MVII'18	$\Delta=M-N$	CH	Tmin air		Tmax air		Tmin soil		Tmax soil	
						(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data
Dr.Tr.Severin	77	23.0	23.6	0.6	N	11.9	2	33.6	29	11.0	2	63.4	25
Calafat	66	23.2	23.8	0.6	N	14.6	2	34.0	22	14.7	2	40.0	22
Bechet	65	23.0	23.0	0.0	N	14.8	6	33.4	22	14.7	1	47.0	6
Băilesti	56	22.8	22.9	0.1	N	12.4	2	32.1	6	14.3	1	41.8	6
Caracal	112	22.9	23.0	0.1	N	13.8	2	33.0	22	17.2	2	42.3	6
Craiova	190	22.3	22.3	0.0	N	12.3	2	32.7	22	13.4	2	62.6	6
Slatina	165	22.0	22.2	0.2	N	12.1	2	33.3	22	13.5	2	39.0	26
Băcleș	309	21.3	21.3	0.0	N	10.3	2	31.0	29				
Tg.Logrești	262	20.7	20.7	0.0	N	7.1	2	30.8	29	7.5	2	52.2	6
Drăgășani	280	21.7	21.7	0.0	N	12.1	2	31.3	22	13.7	2	34.5	22
Apa Neagră	250	20.5	21.0	0.5	N	9.0	2	30.9	29	10.3	2	52.6	20
Tg. Jiu	210	21.3	22.0	0.7	N	8.9	2	32.7	29	8.4	2	59.6	6
Polovragi	546	19.7	20.1	0.4	N	7.3	2	28.6	29	5.0	2	49.2	6
Rm. Vâlcea	243	21.2	21.7	0.5	N	10.7	2	31.3	20	11.2	2	55.5	6
Voineasa	587	17.1	17.6	0.5	N	6.0	2	27.8	30				
Parâng	1585					4.1	2	21.5	29				
Average Oltenia	-	21.5	21.8	0.3	N	10.5		31.1		11.9		49.2	
Ob. Lotrului	1404	12.5	13	0.5	N	2.3	3	22.3	21				

(Source: data processed from the ANM Archive)

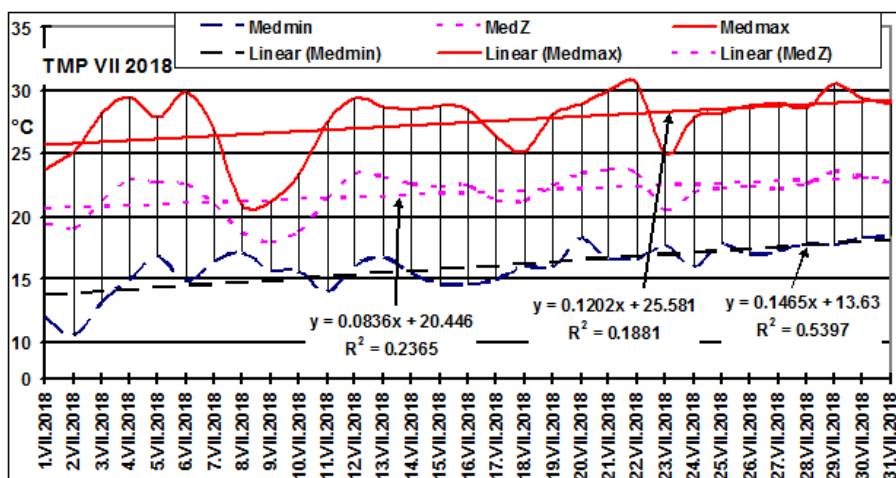


Fig. 2. The variation of the air temperature characteristics in July 2018, calculated for the whole region (average daily minimum, daily averages and average daily peaks) (Source: data processed from the ANM Archive)

Thus, in Northern Finland at Kevo (69°34'51"N, 26° 42'56"E), a record temperature of 32.7°C was recorded on the 17.VII. As a result of this persistent heat wave, the giant tick indicated its presence north of the polar circle (60°N). On 9.VII in Oltenia the temperature maxima ranged between 18.6°C at Băcleș and 24.1°C at Bechet, and in Siberia at Oimeakon the temperature was 31.0°C and at Yakutsk 34.0°C. During 1.VII in Oltenia temperature maxima were recorded between 22.4°C at Voineasa and 25.7°C at Caracal, and in the vast area between the Azov Sea and the Caspian Sea and north of the Caucasus area, maximum temperatures of 40.0°C and 41.0°C were common. *The variation graph* of the parameters that characterize the air temperature (the average of the daily minimums calculated for the whole region, the daily averages and the average of the daily maxima) had linearly increasing trends (Figure 2), and the fastest rising curve was the minimum temperature curve.

Monthly rainfall in July ranged between 78.8 l/m² at Dr. Tr. Severin and 185.0 l/m² at Polovragi, and their percentage deviations from normal were between 25.2% for Apa Neagră and 242.6% at Drăgășani (Table 2). As a result, July was excessively rainy (ER) in most of Oltenia except for a restricted area at Apa Neagră where it was rainy (R). At 13 meteorological stations of 16, monthly precipitation quantities were ≥ 100.0 l/m², ie 81.3% of the stations.

The monthly average was 138.0 l/m² being the second rainy month of 2018, and its percentage deviation from normal was 112.4% confirming that July was excessively rainy (ER) for the entire Oltenia region. Three rainy intervals were registered in July: 7-9.VII, 26-27.VII and 30-31.VII, the latter continuing on 1.VIII, thus totalling 8 days. The highest amount of rainfall recorded in 24 hours was 70.4 l/m² at Tg. Logrești on 9.VII. *The most rainy day during the summer of 2018* was 9.VII with the average rainfall for the entire region of 32.1 l/m². *For the entire country, the maximum daily rainfall* in the national observation network was recorded in the interval 8.VII, 08:00 - 9.VII, 08:00 in the commune of Marca, Sălaj County - 210.5 l/m². At country level, the largest monthly precipitation amount recorded in July 2018 was 339.2 l/m² at the Bâlea-Lac meteorological station. In July, the instability of the weather was highlighted and 547 yellow storm code warnings and 146 orange code warnings (ANM) were formulated. On July 31, 2018, **the moisture reserve on the 0-100 cm soil profile** in the non-irrigated corn crop was within optimal limits, on almost the entire Oltenian agricultural territory. Locally in central and eastern Oltenia, there were slight excesses of water in the soil.

The synoptic causes of these two extremely rainy summer months were the following: During the summer, a Scandinavian Anticyclone in tandem with the Arabian Cyclone periodically caused cool and humid air circulation in the North or North-East direction to the Black Sea and Romania. This process has generated retrograde cyclones of the Black Sea that have caused significant rainfalls

throughout Eastern Europe. By the way of settlement, the presence of the Carpathians and the Black Sea (cold continental sea) in the back of the Arabian Cyclone, the Black Sea cyclones are usually retrograde or at a certain stage of their existence they are downgrading. This type of atmospheric circulation in Europe began with the late snowfall of late February 2018 and repeated throughout the spring and summer of 2018. In the earlier part of the Arabian Cyclone the warm air of the Arabian Peninsula and the Persian Gulf is pushed far north into the Don and Volga Plain generating drought and heat in Russia. The Scandinavian Anticyclone was formed as a secondary centre in the Azoric Anticyclone field developed on the Atlantic and pushed the United Kingdom and Scandinavia to the Golfstream. The cold seas from the north and east of the Scandinavian Peninsula have limited its development, and the presence of hot air from the Russian Plain brought by the Arabian Cyclone has also hampered the expansion of the Scandinavian Anticyclone to the north-east. There has been a huge airblock movement on Europe, and east and south-east Europe have been in the north-eastern and northern traffic of the atmospheric dam. Such types of synoptic situations were uncommon in the warm season until this summer. They cause precipitations difficult to predict because cloudy systems appear daily in their movement from N-E to S-E and are organized as an atmospheric front quite late when approaching the territory of the country or even over Romania's territory. The high frequency of these types of synoptic situations in the summer of 2018 caused a change in the way weather forecasts¹¹ were produced from three-month intervals to four-week intervals across the continent of Europe. ***The synoptic situations of the summer of 2018 are a clear signal of climate change, which also determines the change of the types of atmospheric circulation in the summer¹² and not only during this season.*** Thus summer 2018 will remain in the history of European meteorology as ***the summer that changed the type of seasonal weather forecasts.***

3.3. Climatic characteristics of August 2018

Monthly air temperature averages were between 18.4°C at Voineasa and 24.9°C at Dr. Tr. Severin and their deviations from the averages of the last century ranged from 1.0°C at Bechet and Tg. Logrești and 2.7°C at Dr. Tr. Severin, which according to Hellmann's criterion shows that August was a warmish month (WS) in

¹¹ ***The seasonal climatic forecasts*** are elaborated by the European Center for Medium-Range Forecasting (ECMWF) in Reading, England, and have an average of about 60%. Monthly average temperature distribution and monthly rainy distribution are estimated, and extreme events with a short duration can't be predicted using this product (ANM).

¹² Typically, large amounts of precipitation in Romania and especially in the south of the country have been attributed to the evolution of Mediterranean Cyclones over Romania or the Balkan Peninsula and Southeastern Europe.

most of the region (Table 4). *The average air temperature* calculated for the entire region was 23.0°C being the highest of the year confirming that August was the hottest month of 2018. Its deviation from normal was 1.9°C, which confirms that the month August was warmish (WS). *Monthly air temperature maxima* were between 30.1°C at Voineasa and 36.3°C at Bechet and their average for the whole region was 33.0°C, being the highest average of the monthly maximums throughout the year 2018. *The monthly minima air temperature* were between 10.4°C at Voineasa and 16.2°C at Dr. Tr. Severin, with the average for the entire region of 15.3°C, being the highest throughout the year. *The variance graph of the parameters* that characterize the air temperature (mean daily average for the whole region, daily averages and average daily peaks) had slightly decreasing linear trends for daily averages and average daily minima (Fig. 3) and slightly increasing for daily maxima. **On Europe**, the heat wave that has stayed in Western Europe throughout the summer intensified much in the first 5-6 days of August, and on 3.VIII.2018 in the South-West of Spain at Badajos was recorded **the maximum temperature value of 50.0°C surpassing Europe's thermal record of 48.0°C recorded in Athens on 10.VII.1977**

(<https://www.thesun.co.uk/news/6938664/europe-hottest> -Day-Spain, Portugal /). In Portugal, at Mirandela, on 2 June, 1818, electronic thermometers in the city indicated 52.0°C.

Table 4, The air temperature regime in Oltenia and the minimum and maximum surface temperature values in August 2018 for the area with altitude ≤ 600 m (NVIII = average temperature in August for the period 1901-1990, MVIII = temperature averages in August 2018, Δ = M-N = temperature deviation, CH = Hellmann Criterion)

Meteorological Station	Hm	NVIII	MVIII	Δ =M-N	CH	Tmin air		Tmax air		Tmin soil		Tmax soil	
						(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data
Dr. Tr. Severin	77	22.2	24.9	2.7	W	16.2	15	35.4	18	14.8	15	62.8	16
Calafat	66	22.7	24.8	2.1	W	14.8	13;14	35.5	22	17.6	14	42.9	22
Bechet	65	22.4	23.4	1.0	WS	11.8	14	36.3	26	14.9	14	50.4	15
Băilești	56	22.5	24.2	1.7	WS	14.1	12	34.0	5	14.4	29	45.4	29
Caracal	112	22.4	24.6	2.2	W	15.9	12	34.8	26	20.1	16	36.3	20;21
Craiova	190	22.2	24.0	1.8	WS	14.1	12	33.8	18	16.4	16	62.4	16
Slatina	165	22.2	23.6	1.4	WS	13.8	12	34.0	18	16.2	12	38.0	18
Băceș	309	20.9	22.8	1.9	WS	15.2	28	31.9	18				
Tg. Logrești	262	20.2	21.2	1.0	WS	11.2	16	33.5	18	12.0	16	53.2	26
Drăgășani	280	21.5	23.8	2.3	W	15.9	12	33.4	18	17.5	16	47.5	18
Apa Neagră	250	20.1	21.6	1.5	WS	13.2	14	32.6	18	14.6	17	48.5	18
Tg. Jiu	210	20.9	23.0	2.1	W	13.7	16	34.4	18	13.5	16	55.6	10
Polovragi	546	19.4	21.4	2.0	W	14.2	12	31.1	18	11.8	12	50.1	30
Rm. Vâlcea	243	20.5	23.1	2.6	W	14.5	16	34.4	18	14.5	12	56.8	18
Voineasa	587	16.3	18.4	2.1	W	10.4	15	30.1	6				
Parâng	1585					10.3	27	22.1	7				
Average Oltenia	-	21.1	23.0	1.9	WS	13.7		33.0		15.3		50	
Ob. Lotrului	1404	11.8	13.5	1.7	WS	4.8	20	24	18				

(Source: data processed from the ANM Archive)

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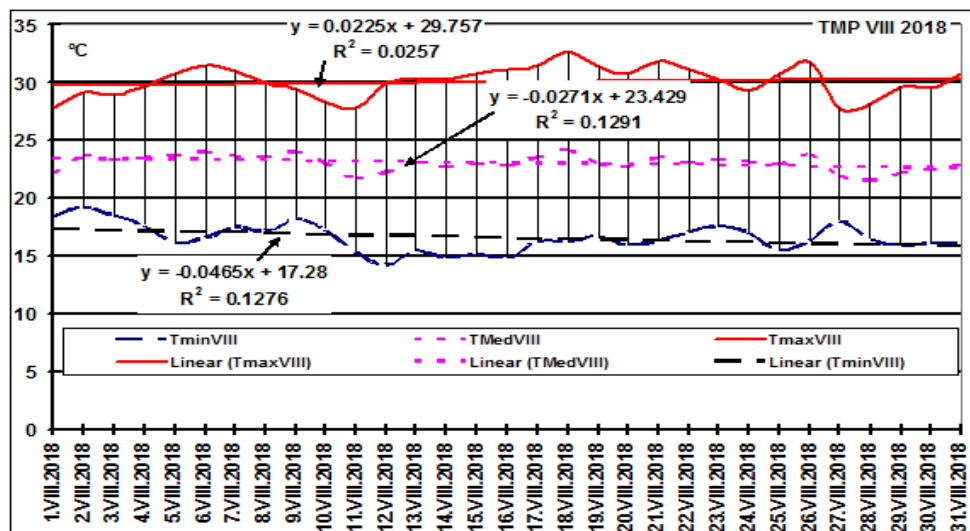


Fig. 3. The variation of air temperature parameters in August 2018, calculated for the whole region (daily minimums, daily averages and average daily peaks)
(Source: data processed from the ANM Archive)

The date of 3.VIII.2018 was declared the warmest day in the history of Europe's climate (<https://nypost.com/2018/08/03/today-could-be-the-hottest-day-in-the-history-of-europe/>), thus confirming the continuation of global warming, although the El Niño climatic process was absent and the Sun was at the lowest level of activity. **The maximum surface temperatures** were recorded at different dates, ranging from 36.3°C at Caracal and 62.8°C at Dr. Tr. Severin, and their average for the entire Oltenia region was 50.0°C, being the highest of the year. **Soil temperature minima** ranged from 11.8°C at Polovragi and 20.1°C at Caracal, and their average for the entire region was 15.3°C.

Monthly rainfall quantities in August amounted to 8.4 l/m² at Caracal in the Romanați Plain and 76.8 l/m² at Tg. Jiu and their percentage deviations from the averages of the last century ranged between -78.9% at Caracal and 93.7% at Băcleș in the Mehedinți Hills. According to the Hellmann Criterion, August was excessively dry (ED) in most of the Oltenia Plain (Table 2) and in the Olt Corridor at Rm. Vâlcea, in the mountain area at Voineasa. Extremely rainy was in restricted areas in the extreme western part of the region at Dr. Tr. Severin and in the Mehedinți Hills at Băcleș. Average monthly rainfall for the entire region was 46.2 l/m², and its percentage deviation from normal was -11.6%, indicating that "on average" was little dry (LD) in August. In August there was only one rainy day

(1.VIII) and 28 days with insignificant or absent precipitation. For 1.VIII, the mean rainfall rate for the whole region was 13.4 l/m^2 , and the highest 24-hour amount at the meteorological stations was 33.2 l/m^2 at Tg. Jiu. On 31 August 2018, the moisture reserve on the soil profile of 0-100 cm in the non-irrigated corn was within satisfactory limits, close to optimal and optimal isolation, on almost the entire Oltenian agricultural territory. Soil deficiencies in the soil (moderate, strong and extreme soil drought) were recorded in the southern and eastern regions.

The synoptic causes of August's dry and warm weather were: the restructuring of the atmospheric circulation due to the eastward movement of the anticyclonic core above the Scandinavian Peninsula, and the integration of the western, south-western and southern components of air circulation at certain time intervals, the dissipation of the atmospheric dam persisted in the first two months of the summer.

3.4. Climatic characteristics of the entire summer of 2018

The average air temperature averages were between 17.6°C at Voineasa and 23.7°C at Dr. Tr. Severin, and their deviations from the averages of the last century were between 0.6°C at Bechet and 1.7°C at Dr. Tr Severin, Apa Neagră and Rm. Vâlcea, which according to Hellmann's criterion means a warm summer (C) in most of the region (Table 5)

The average air temperature average for the whole region was 21.9°C , and its deviation from normal was 1.2°C , which confirms that "on average" in summer 2018 was warm (W). *The seasonal rainfall* precipitation ranges ranged between 195.6 l/m^2 at Băilești and 477.0 l/m^2 at Polovragi, and their percentage deviations from multiannual averages were between 31.9% for Apa Neagră and 182.1% for Băcleș, which according to the criterion Hellmann means that the summer of 2018 was excessively rainy (ER) in most of the region, with the exception of some restricted areas in Băilești, Apa Neagră and Voineasa.

The mean annual rainfall for the whole region was 347.0 l/m^2 , and its percentage deviation from normal was 72.3%, which confirms that the summer 2018 was "on average" excessively rainy (ER).

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Table 5. Thermal and total rainfall regime in the summer of 2018 (Hm = altitude of meteorological station, V2018 = average temperature values in the summer of 2018 (°C), NtV = normal values of summer average temperatures (°C), $\Delta = V-N$ (°C) = deviations summer average temperatures from normal, SV2018 = summer precipitation in 2018, NV = normal summer precipitation (l/ m²), $\Delta = S-N$ = deviations from normal (l/m²), $\Delta\%$ = percentage deviations from normal, CrH = Hellmann criterion).

Meteorological Station	Hm	Thermal Regime (°C)				Pluviometric Regime (l/m ²)				
		NtV	V2018	$\Delta=V-N$	CrH	SV2018	NV	$\Delta=S-N$	$\Delta\%$	CrH
Dr. Tr. Severin	77	22.0	23.7	1.7	W	250.0	160.0	90.0	56.3	ER
Calafat	66	22.3	23.6	1.3	W	213.1	146.8	66.3	45.2	ER
Bechet	65	22.2	22.8	0.6	WS	301.6	146.8	154.8	105.4	ER
Băilești	56	22.1	23.0	0.9	WS	195.6	150.5	45.1	30.0	VR
Caracal	112	22.0	23.2	1.2	W	247.2	167.4	79.8	47.7	ER
Craiova	190	21.7	22.6	0.9	WS	300.2	164.7	135.5	82.3	ER
Slatina	165	21.6	22.4	0.8	WS	388.6	184.9	203.7	110.2	ER
Băcleș	309	20.4	21.5	1.1	W	430.2	152.5	277.7	182.1	ER
Tg. Logrești	262	19.9	20.7	0.8	WS	320.6	165.4	155.2	93.8	ER
Drăgășani	280	20.9	22.2	1.3	W	428.4	185.6	242.8	130.8	ER
Apa Neagră	250	19.1	20.8	1.7	W	306.0	232.0	74.0	31.9	VR
Tg. Jiu	210	20.5	22.0	1.5	W	319.8	219.2	100.6	45.9	ER
Polovragi	546	18.9	20.3	1.4	W	477.0	277.7	199.3	71.8	ER
Rm. Vâlcea	243	20.2	21.9	1.7	W	393.2	254.3	138.9	54.6	ER
Voineasa	587	16.2	17.6	1.4	W	372.2	268.1	104.1	38.8	VR
Parâng	1585					608.8	346.8	262.0	75.5	ER
Average Oltenia	-	20.7	21.9	1.2	W	347.0	201.4	145.6	72.3	ER
Ob. Lotrului	1404	11.7	12.9	1.2	W	680.0		680.0		

(Source: data processed from the ANM Archive)

3.5. DISCUSSIONS

In total during the summer there were recorded 7 excessively rainy intervals: 9.VI, 13.VI, 15-16.VI, 26-29.VI, 7-9: VII, 26-27.VII and 30.VII -1.VIII. totalling 15 days. Although the average monthly rainfall for the entire Oltenia region was 162.8 l/m² in June and 138.0 l/m² in July, **the most rainy day in the summer** was 9.VII when the average rainfall recorded for the entire Oltenia region was 32.1 l/m². At 9.VII, at 4 meteorological stations in Oltenia (25.0%), rainfall was > 50.0 l/m², 52.6 l/m² at Rm. Vâlcea, 55.6 l/m² at Băilești, 59.4 l/m² at Drăgășani and 70.0 l/m² at Tg. Logrești¹³. Warm and dry weather quickly settled from 2.VIII and extended almost all of the autumn, causing a difficult beginning of the 2018-2019 agricultural year. Significant droughts for agriculture that have gradually interrupted the drought have been recorded since the 18th century, and the sharp cooling of the weather has led to the appearance of snow and temporary snow layer since the 19th century. The precipitations of November 2018 were

¹³ A large amount was also recorded at Polovragi, 49.2 l/m².

determined by the same types of synoptic situations as those during the summer. As a result, the establishment of autumn crops in many areas in Romania was delayed, and important areas planted with rape were dismantled due to the particularly uneven and large-scale growth. **The agricultural year 2017-2018** was excessively rainy, with an average rainfall for the entire region of 896.9 l/m^2 , and its percentage deviation from the normal of 32.8% and warm with the annual average of 9.9°C (calculated for the whole area with altitude $\leq 600\text{m}$) (except in the mountain area) and with the previous year's average deviation of 2.0°C . To these characteristics, the summer of 2018 had an important contribution. The 2017-2018 agricultural year was particularly favourable for corn crops and had the best agricultural result in history. Record production of wheat and corn had placed agricultural turnover close to 8 billion euros (KeysFin¹⁴ experts). Apple production has been very big and, in general, large production has been achieved on all fruit varieties, except for varieties affected by late harvests and late frosts (apricots and peaches). Romania has taken the title of the largest European corn producer (General Association of Maize Producers - AGPM). In barley and barley, Romania had a good production, much higher than in the previous year. *The synoptic situations* that were common in the summer of 2018 have a common specificity, namely the presence of atmospheric blockage in most of Europe. In Romania, during the two extremely rainy months of the summer (June and July), in all situations, the instability of the weather increased during the afternoons as a result of the overlapping of the front processes over those caused by the development of the afternoon atmospheric convection processes. During the night the weather improved.

The synoptic situation of 9.VII.2018. From 12 UTC, at ground level above Europe, the position of the baric centres shows the vast field of the Azoric Anticyclone in Western Europe extending northwards with a centre above the United Kingdom (pressure $\geq 1030 \text{ hPa}$) and further united over the Novaia Zemlia islands with the anticyclone field located to the east of Europe (Fig. 4). Eastern Europe is dominated by a vast field of low pressure, with more cyclone nuclei: one located in the Eastern European Plain with pressure values $\leq 1005 \text{ hPa}$, the other north-east of the Black Sea with centre values $\leq 1010 \text{ hPa}$, all of which united with the vast Cyclonic field, quasi-stationary in the summer of the Arabic Cyclone. At an altitude of 500 hPa , there is a large atmospheric blockage movement (the isohypses of the geopotential field are in the form of the letter " Ω "), which for Eastern Europe induces air circulation in the northern and northeastern sector by admitting a mass of humid and cool air (mP + cP).

¹⁴ KeysFin is an economic analysis company that provides information about companies in Romania and abroad through specific tools. KeysFin is one of the leading providers of business information solutions in the market and the partner of internationally-known companies.

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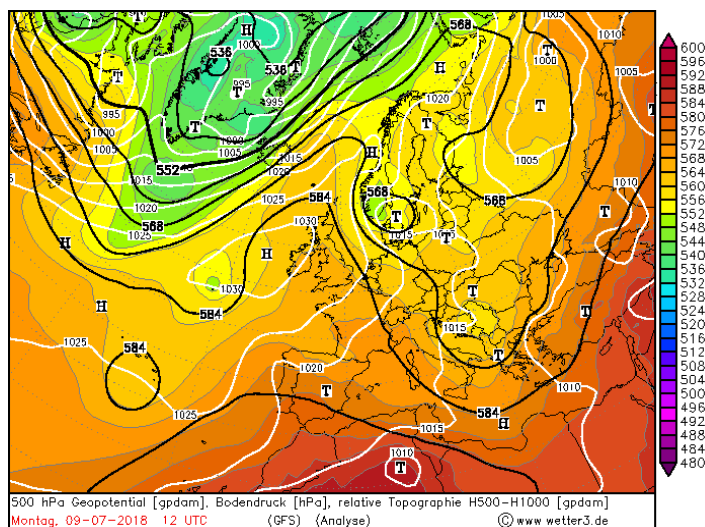


Fig. 4. The synoptic situation across Europe at ground level (atmospheric pressure) overlaps with the altitude geopotential field at the surface of 500 hPa (about 5000 m altitude) and the relative bar graph field TR500 / 1000 on 9 .VII.2018 hour 12 UTC (after www.wetterzentrale.de).

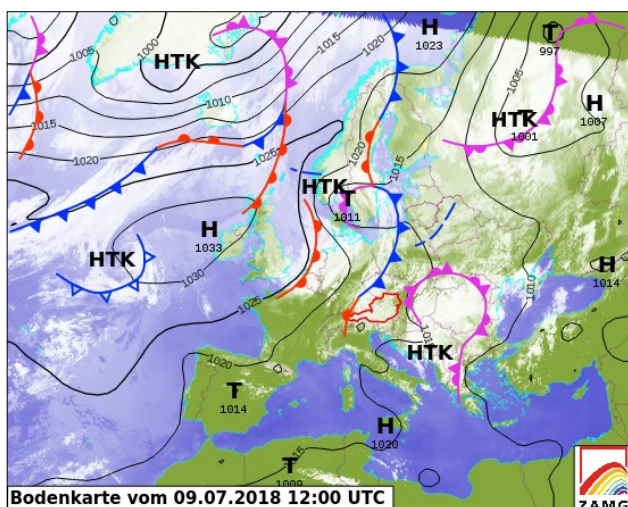


Fig. 5. The pressure field over Europe and cloudy systems on 9.VII.2018, 12 UTC. (after www.zamg.ac.at).

The field of the relative baric topography shows a cool air nucleus located southwest of Romania, which led to the organization of the cloudy system in the form of a cyclone that evolved to intermediate levels in the atmosphere (Figure 5). An important contribution to the development of cloudy systems and torrential rains was the advection of wet air above the Black Sea and even above the Mediterranean Sea (Figure 5). Extremely hot air persisted above Western Europe and east of the Black Sea (Figure 6).

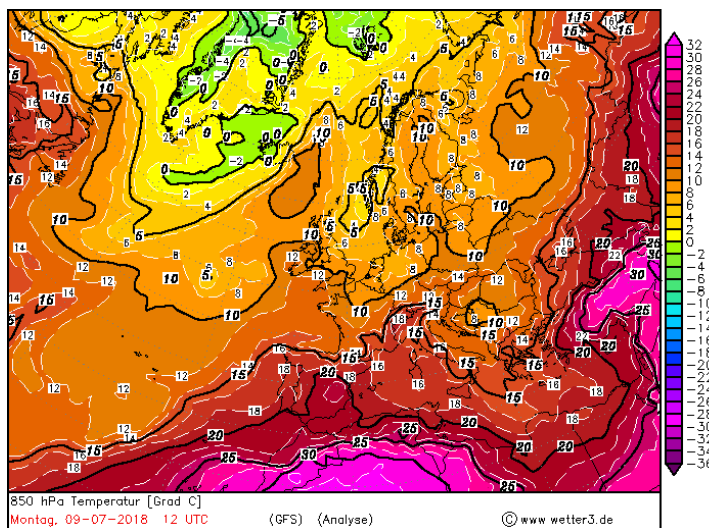


Fig. 6. Temperature field over Europe on 9.VII.2018 at 12 UTC. (after www.wetterzentrale.de).

Synoptic situations of this type have been repeated since 26.II.2018 and in all 7 intervals with exceptional instability of the summer weather in 2018.

4. CONCLUSIONS

In south-western Romania the summer of 2018 was warm and extremely rainy (ER). Torrential rains have affected the entire country in the first two months of the summer. Since 2.VIII.2018 the warm and dry weather has been installed and persisted almost in the autumn until the 18th century, and since the 19th century the cooling of the weather has caused precipitation in the form of rain, snow and the appearance of the temporary snow layer. The translation of the summer season to autumn was thus produced. The rains were accompanied by hailstorms and wind intensities, which also had a squall. In some areas of the country tornadoes have

occurred. In July, the instability of the weather was highlighted and 547 yellow storm code warnings and 146 orange code warnings (ANM) were formulated. June was the mostly rainy in Romania in the last 40 years and the second in the last 50 years. There were 1,026 nowcasting yellow storm code warnings, 255 nowcasting orange storm code warnings and a nowcasting red storm code warning of the storm. Exceptional rainfall rates, especially during the first two months of the summer, caused a very good 2017-2018 crop year to be recorded for corn crops. This has resulted in the best agricultural result in history. Record production of wheat and corn has placed agricultural turnover close to 8 billion euros (KeysFin experts). Romania has taken the title of the largest European corn producer (General Association of Maize Producers - AGPM). For barley and two-row barley, Romania had a good production, much higher than in the previous year. The synoptic situations that were common in the summer of 2018 have a common specificity, namely the presence of atmospheric blockage in most of Europe. In Romania, during the two extremely rainy months of the summer (June and July), in all situations, the instability of the weather increased during the afternoons as a result of the overlapping of the front processes over those caused by the development of the afternoon atmospheric convection processes, and in the course of the night it improved. ***These synoptic situations of the summer of 2018 are a clear signal of climate change, which also determines the change of the types of atmospheric circulation in the summer and not only during this season.*** Thus the summer of 2018 will remain in the history of European meteorology as ***the summer that changed the type of seasonal weather forecasts.*** The date of 3.VIII.2018 was declared ***the warmest day in the history of Europe's climate,*** confirming the continuation of global warming, although the El Niño climate process was absent and the Sun at the minimum of activity.

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