

THE CLIMATIC RECORD OF THE EARLIEST SPRING IN ROMANIA, REGARDING THE SOUTH-EAST PART OF THE COUNTRY – SPRING 2016

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ABSTRACT: The climatic record of the earliest spring in Romania, regarding the south-east part of the country – Spring 2016. In the past 30 years it has been an increasing frequency of early SPRING ARRIVAL. Therefore, vegetation development started in early February. In March, the warm weather continued almost throughout the month, and the hoarfrosts from March became hereby destructive. Frequently, the vegetation in April was in very advanced stages. Even though the temperatures rose in April, cooling in April and late spring hoarfrosts have occurred and caused considerable damage. In this study we analyze the climatic macroprocesses that led to the apparition of an absolute climate record for the earliest spring arrival in 2016. The work is useful to anyone interested in climate change in Romania.

Key-words: early spring arrival, global warming, warm winters.

1. INTRODUCTION

Global warming has many consequences on the environment and society across the globe. The year 2015 was the first year that global average temperature exceeded by 1°C the global average temperature of the last century.

Globally, **December 2015 was the warmest month** for extended areas of the Northern Hemisphere. Thus, in the United States, **December 2015** was the warmest last month of the year ever recorded since 1880, when the first weather measurement was made; and on the whole, 2015 ranked second among the warmest years in this country, according to data published by the National Oceanic and Atmospheric Administration (NOAA) (quoted by AFP⁴). „Exceptionally, for the

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⁴ AFP = Agence France-Presse – the oldest world's news agency, founded in 1835 by Charles-

first time in 121 years, this month was not only the hottest, but also the most humid December recorded in annals” (Jake Crouch, climatologist at the National Center for Environmental Information under NOAA). On the opposite side of the Northern Hemisphere, just a few days before Christmas, were recorded temperatures of 11.2°C to Kokemaki in Finland, 12.6°C at Stockholm, 11.3°C at Tallinn in Estonia, the 16.9°C at London, 11.0°C at St. Petersburg and 5.0°C at 2500 km east from Moscow. December 2015 was the warmest month of the year-ending month ever recorded on Earth in the 136 years of measurements are taken.

In January 2016, the average temperature on the planet at the soil surface was **with 1.56°C higher than the average of the XXth century**. Globally, **the months December, February and March were considered “torrid”**, due to their large deviations from the annual average temperature. **In May 2016**, the planetary “climatic pendulum” (Southern Oscillation - El Niño) was decreasing and it is appreciate that its frequency has increased. However, for Europe, the “climatic pendulum” is the North Atlantic Oscillation (NAO) and a change of sign it was felt in the first part of May.

In Romania, the hottest period of **December** was recorded within **22-28.XII**. The year 2016, when the maximum temperature values reached in some areas of the country 20.0°C, and 19.3°C in Oltenia, in the Polovragi Sub Carpathian Depression on 28.XII.2015. The types of atmospheric circulation that prevailed in December were specific for warm winters and if it persisted in **January**, it would have *caused a top very warm winter month*. Changing of air circulation types occurred in the last two days of December, prompting the installation of specific atmospheric circulation for **very cold winter months**. But at planetary level, **January 2016 was the warmest month of the beginning of the year on Earth** since temperature records are kept (National Oceanic and Atmospheric Administration - NOAA) (AFP). Overall, the average temperature at the ocean and land’s surface was with 1.04°C higher than the average of the twentieth century, which makes January 2016 the warmest first month of the year since 1880 so far, surpassing the previous record set in 2007, when were 0.16°C above the average temperature of the previous century (NOAA). According to the latest data from the National Oceanic and Atmospheric Administration of America, **13 of the 15 largest monthly temperature anomalies⁵** in the Earth’s

Louis Havas, the father of global journalism.

⁵ In large part, these global temperature anomalies were explained by the particularly intense phase of El Niño in 2016 as one of the strongest El Niño ever recorded (the most intense in the last 50 years). On 24.V.2016, the Australian Bureau of Meteorology (A.B.M.) said that the 2015-2016 El Niño ended because the surface temperatures across the tropical Pacific have declined in the past two weeks. Temperature peaks typically occur towards the end of El Niño, according to Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colorado. A.B.M. states that there are 50% chances that La Niña, another phase of ENSO associated with unusually low surface temperatures in the eastern Pacific, will form this year (2016), which will result in cooler weather for South-East and West Asia and South America.

atmosphere, have occurred since February 2015. The average temperature of land and ocean surfaces **in April was with 1.10°C** higher than the average of the last century. This current year (2016) will almost certainly be the warmest in history, and perhaps the biggest deviation to date.

Also, **January 2016** marked the ninth consecutive month in which the average temperature on Earth outperforms the monthly record, which is a new record and a new proof of global warming. In Oltenia, January was a normal month with a normal average temperature, marked by a blizzard and a cold wave lasting for six days. These rapid changes in the types of time determined, in Oltenia and in the entire country and even across the entire Northern Hemisphere, an exceptional climatic variability of the winter 2015-2016. **The year 2015 registered the first climatic record of global average temperature with 1.0°C above the global average of the last century and of the period of observations from 1880 to 1899 interval** (op. cit.).

Following the increasing frequency of warm winters in Romania, the frequency of liquid precipitation increased in the winter season (Bogdan, Marinică, Mic 2008, Bogdan, Marinică, 2009); (Bogdan, Marinică I, A. F. Marinică 2010), etc.. Regionally, the manifestations of climate disruption are specific for each climatic region. Most winters of the last 26 years have been warm.

In Romania, an intense rainy period began in **September 2013 and continued with some brief interruptions throughout the year 2014 until March 2015.**

During the course of 2013, 2014, 2015 and the first 5 months of 2016, the climate evolution in Romania, went from one extreme to another, and each month was marked by climatic records. These include the record of **all time earliest spring arrival in all climate observations**, that we will analyze it in the following with particular reference to the South-Western Romania, where the climatic process of spring arrival was more pronounced.

2. DATA AND METHODS

For **the last 19 years** (1998-2016), the spring arrival index was analyzed at the meteorological stations from Oltenia as the linear trend of variation. Observation data were processed for 912 months/meteorological station and analyzed 19 spatial distribution maps of spring arrival indices in Oltenia. The options provided by the Excel Program were useful in our analysis.

3. ANALISYS OF SPRING ARRIVAL CONDITIONS IN THE YEAR 2016

Spring arrival conditions are given by **the daily average air temperatures that are $\geq 0^{\circ}\text{C}$ between February 1 - April 10, and their sum gives us the spring arrival index** (Table 1).

3.1. Temperature conditions in February 2016

The monthly average air temperature ranged between 3.0°C at Voineasa and 7.3°C at Dr. Tr. Severin, and their deviations from the multiannual averages were between 5.5°C at Apa Neagră and Voineasa and 7.2°C at Caracal, causing the qualifier very warm month (VW), after the Hellmann criterion at all meteorological stations in Oltenia (Table 2).

The average air temperature calculated for the entire region was 5.7°C, and its deviation from the multiannual average was 6.5°C, confirming that February was very hot (Table 2). Daily average values calculated for the entire region were between 0.6°C on 7.II and 12.0°C on 23.II. The warmest period from February and also from the winter of 2015-2016 was 20-24.II, when many absolute temperature averages of February were outclassed, and at the country level, warmest interval was 14-17.II, when was matched the maximum absolute temperature from Romania, in February (26.0°C at Pâtârlagele, Buzău County on 16.II.2016).

Table 1. Spring arrival indices 2016, in Oltenia: Hm = station's elevation; IN = index of multiannual average spring arrival (1901-1990) considered normal; I-2016 = the spring arrival index in 2016; $\Sigma^{\circ}\text{C}$ = sum of daily average positive temperatures for each month (heat units); $\Sigma\%$ = the percentage of average temperatures for each month in the spring arrival index (I-2016); Δ = I-2016 index's deviation towards the multiannual index; $\Delta\%$ = annual index's deviation, in %; IN = spring arrival type⁶; ETI = exceptionally early

Meteorological Station	Hm	February		March		1-10.IV		I-2016	IN	Δ =(I-2016)-IN (°C)	$\Delta\%$	Type
		$\Sigma^{\circ}\text{C}$	$\Sigma\%$	$\Sigma^{\circ}\text{C}$	$\Sigma\%$	$\Sigma^{\circ}\text{C}$	$\Sigma\%$					
Dr. Tr. Severin	77	212.7	33.5	258.4	40.7	164.4	25.9	635.5	357.4	278.1	77.8	ETI
Calafat	66	207.6	34.3	242.3	40.1	154.8	25.6	604.7	343.9	260.8	75.8	ETI
Bechet	65	190.0	32.6	242.4	41.6	150.7	25.8	583.1	320.7	262.4	81.8	ETI
Băilești	56	200.5	34.2	233.1	39.7	153.2	26.1	586.8	316.6	270.2	85.3	ETI
Caracal	112	189.5	33.0	235.3	41.0	149.8	26.1	574.6	294.8	279.8	94.9	ETI
Craiova	190	190.5	33.4	224.7	39.4	155.8	27.3	571.0	282.5	288.5	102.1	ETI
Slatina	165	185.2	32.7	229.7	40.5	152.2	26.8	567.1	257.8	309.3	120.0	ETI
Băcles	309	179.6	33.4	205.5	38.2	153.3	28.5	538.4	236.3	302.1	127.8	ETI
Tg. Logrești	262	152.0	31.0	194.5	39.7	143.4	29.3	489.9	237.3	252.6	106.4	ETI
Drăgășani	280	194.7	33.6	223.6	38.6	160.8	27.8	579.1	257.8	321.3	124.6	ETI
Apa Neagră	250	142.8	29.3	203.8	41.8	141.1	28.9	487.7	234.3	253.4	108.2	ETI
Tg. Jiu	210	166.0	30.5	224.8	41.3	153.4	28.2	544.2	279.5	264.7	94.7	ETI
Polovragi	546	150.7	32.0	174.2	37.0	145.4	30.9	470.3	205.6	264.7	128.7	ETI
Rm. Vâlcea	243	179.1	31.9	229.4	40.9	152.1	27.3	560.6	291.1	269.5	92.6	ETI
Voineasa	587	91.2	25.6	143.7	40.3	121.3	34.1	356.2	154.5	201.7	130.6	ETI
Parâng	1585	52.4	30.6	25.8	15.1	98.0	55.6	176.2	23.0	153.2	666.1	ETI
Media Oltenia		167.8	32.3	205.7	39.6	146.5	28.2	520.3	255.8	264.5	103.4	ETI
Ob. Lotrului	1404	33.8	28.4	26.2	22.0	59.2	49.7	119.2	20.0	99.2	496	ETI

(Source: processed data from CMR Oltenia Archive)

Minimum monthly air temperature values were recorded in the period 6-8.II and ranged between -6.9°C at Tg. Logrești and -2.4°C at Dr. Tr. Severin, and their average for the entire region was -4.5°C (Table 2). There have been 21 days (72.4% of the month's days) in which the average of minimum daily temperature for

⁶ The spring arrival type was established after the spring arrival index, according to a classification of Hellman Type, a criterion established by us (see References, Bogdan, Marinică, Marinică, 2010)

the region was positive. *The coldest morning* was recorded on 7.II with an average of minimum values of -4.1°C . **Cold units**⁷ were insignificant and were registered only in the Sub-Carpathian area, ranging between 1.3 at Apa Neagră and 4.8 at Voineasa, and in the mountain area it was 43.0 at Parâng.

Table 2. Air temperature regime in February 2016, in Oltenia: Hm = station elevation; N = normal value; M = monthly average; Δ = monthly average deviation from the normal; HC = Hellmann Criterion; $T^{\circ}\text{C}$ = min air / date; $T^{\circ}\text{C}$ = max air / date; $T^{\circ}\text{C}$ = min soil / date; $T^{\circ}\text{C}$ = max soil / date; „*” = indicates the new records of absolute maximum temperature at the meteorological stations in question.

Meteorological Station	Hm	N	M	Δ	HC	T ^o min air		T ^o max air		T ^o min soil		T ^o max soil	
						($^{\circ}\text{C}$)	Date	($^{\circ}\text{C}$)	Date	($^{\circ}\text{C}$)	Date	($^{\circ}\text{C}$)	Date
Dr. Tr. Severin	77	0.9	7.3	6.4	FC	-2.4	6	23.3	22	-4.5	8	25.4	22
Calafat	66	0.4	7.2	6.8	FC	-3.2	7	23.3	22	-4.1	7	24.5	23
Bechet	65	-0.1	6.6	6.7	FC	-5.0	7	24.2	22	-5.0	7	30.0	22
Bailesti	56	-0.1	6.9	7.0	FC	-3.4	8	22.0	22	-5.2	8	28.2	23
Caracal	112	-0.7	6.5	7.2	FC	-3.1	7	22.0	22	-0.9	7/8	19.0	23
Craiova	190	-0.4	6.6	7.0	FC	-3.6	6	21.5	22	-1.6	7	22.4	22
Slatina	165	-0.2	6.4	6.6	FC	-3.8	6	21.9	22	-0.4	8	16.4	16
Bacles	309	-0.9	6.2	7.1	FC	-2.8	7	20.4	22	-	-	-	-
Tg. Logresti	262	-0.7	5.2	5.9	FC	-6.9	6	22.9	16	-5.4	6	24.2	16
Drăgășani	280	-0.2	6.7	6.9	FC	-2.6	6	21.1	22	-5.5	6	26.9	16
Apa Neagra	250	-0.6	4.9	5.5	FC	-7.0	7	22.0	16	-7.0	7	23.5	16
Tg. Jiu	210	-0.4	5.7	6.1	FC	-5.4	7	22.9	16	-6.2	6	26.4	23
Polovragi	546	-1.4	5.2	6.6	FC	-4.6	7	20.9	16	-6.5	8	24.9	16
Rm.Vâlcea	243	0.0	6.2	6.2	FC	-3.9	7	23.1	16	-5.1	6	24.7	23
Voineasa	587	-2.5	3.0	5.5	FC	-6.6	7	20.4	22	-	-	-	-
Parâng	1585	-5.6	0.3	5.9	FC	-8.4	5	12.6	22	-	-	-	-
Media Ol	-	-0.8	5.7	6.5	FC	-4.5	-	21.2	-	-4.2	-	24.3	-
Ob. Lotrului	1404	-5.5	-0.2	5.3	FC	-14.1	12	13.2	16	-	-	-	-

(Source: processed data from CMR Oltenia Archive)

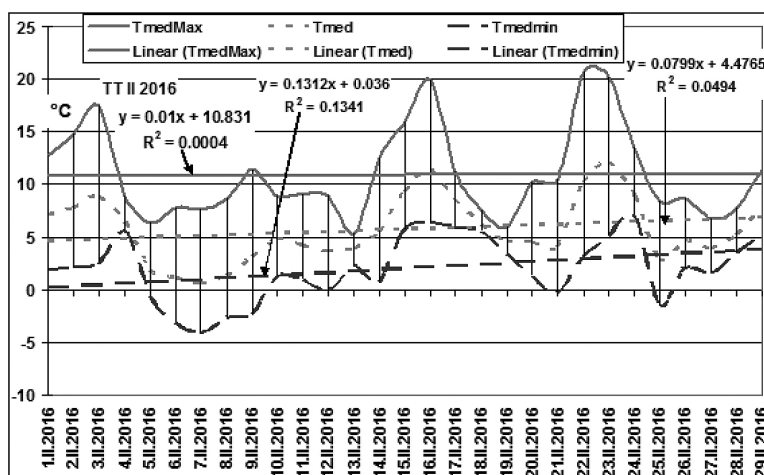


Figure 1. Air temperature variation (daily minimum, average and maximum values) in February 2016, in Oltenia.

⁷ Cold units (for a certain time period) = the sum of daily average negative temperatures (the same are calculated the heat units).

No severe cold was registered in any day. **The heat units** (*the sum of daily average positive temperatures*) were recorded in every day of the month and ranged between 91.2 at Voineasa and 212.7 at Dr. Tr. Severin (Table 1). **The average for the entire region** was 167.8, causing a **February with a spring like thermic regime** and confirming **the thermal translation from spring to winter**.

The hottest morning was on 24.II, with an average minimums for the entire region of 7.0°C. The percentage ratio of these sums from the spring arrival index was between 25.6% at Voineasa and 34.3% at Calafat (Table 1).

The maximum values of monthly temperature in 2016 have been registered in different days: in the Sub-Carpathian area on 16.I; in the Oltenia Plain, southern Getic Piedmont and the Mehedinți Hills on 22.II. Maximum daily temperatures ranged from 20.4°C at Voineasa and Băceș, to 24.2°C at Bechet. **The value of 24.2°C, recorded at Bechet, becomes absolute maximum temperature in February for Oltenia, surpassing after 117 years the old maximum temperature in Oltenia – 24.0°C recorded in 16.II.1899 at Dr. Tr. Severin.**

We specify that the value of 24.0°C from 16.II.1899 was an absolute maximum temperature for the whole country until 27.II.1995, when at Medgidia were recorded 26.0°C, a value that was matched by maximum temperature, registered at Pătârlagele in Buzău County, at 16.II.2016. This shows that **16.II.2016 was the warmest February day in the entire country, not only in Oltenia.**

Climate variability of monthly maximums temperature recorded in February in the history of observations show that: **the absolute maximum temperature of February at Craiova was 23.3°C** recorded in 11.II.1899. *Other maximum temperature values* outstanding for Oltenia were: 22.5°C at Caracal (also in 16.II.1899), 19.5°C at Rm. Vâlcea in 10.II.2001; at Bucharest Băneasa in 27.II.1995 was registered in the value of 23.0°C. Other maximum temperature values recorded in 27.II.1995 in the entire country were: 25.0°C at Călărași, 24.5°C at Cernavodă, 24.5°C at Constanța, 24.0°C at Slobozia, 23.8°C at Adamclisi, 23.5°C at Tulcea (CMR Constanța Archive).

At Bucharest was registered the absolute maximum of February on the same day (16.II.2016): 24.1°C at Bucharest Băneasa, 24.7°C at Bucharest Afumați, 25.7°C at Bucharest Filaret and 22.8°C at Fundulea. February is the first month of the year when the maximum daily temperatures can easily reach and exceed 25°C, thus registering on small areas "days of summer"⁸.

Data analysis from the archives shows that after 1990, the climatic warming was well evidenced in February. Given that the date 16.II is with 11 days earlier than the date 27.II, and that February 2016, in terms of heat, was a real month of spring, as were February 2002 and 2007, we can conclude that warming in February was much more intense since 2000.

The analyze of average, minimum and maximum temperatures and of deviations from the annual average (calculated for the period 1901-1990), shows that

⁸ It is called *day of summer* a day when the maximum temperature reaches 25°C.

February 2016 is the warmest month when meteorological observations were made, being an absolute climatic record not only for Oltenia, but also for the entire country. The maximum values recorded at the meteorological stations Bechet (24.2°C/22.II.2016), Rm. Vâlcea (23.1°C/16.II.2016), Tg. Logrești (22.9°C/16.II.2016), Drăgășani (21.1°C/22.II.2016) and Polovragi (20.9°C/16.II.2016) became absolute maximum temperature values for these stations in February.

In February 2016 there were registered **four heat waves** in the periods: **1-4.II, 8-12.II, 14-17.II, 20-24.II**, and on 29.II another heat wave started, that has developed between **29.II-3.III.2016**. Thus, in February there were 19 days very hot. **The hottest day of February for heat, according to daily maximums**, was on **22.II** with the maximums average calculated for the region of 20.7°C.

On the soil surface, the monthly minimum temperatures were recorded in 6, 7 and 8.II, ranging between -7.0°C at Apa Neagră, and respectively -0.4°C at Slatina, and their average for the region was -4.2°C. **Monthly maximum temperatures at the soil surface** were recorded in 16, 22 and 23.II, and ranged between 16.4°C on 16.I at Slatina, Olt County, and 30.0°C on 22.II at Bechet in Dolj County, and their average for the region was 24.3°C. **The soil was kept thawed in most of the month** except for a few mornings when superficial frost occurred.

Air temperatures variation graph in February 2016 shows upward trends for the average, minimum and maximum daily temperatures (Figure 1). The fastest increase was registered for minimum temperatures, while the maximum temperature increased more slowly.

As a result of the thermal regime of a warm, spring like month, fall crops resumed slowly their phases of vegetation, tree buds have developed, and on 17.II the weeping willow buds have opened; white magnolia bloomed in 27.II, at 2.III appeared the first almond blossom and the first flowers of cherry plum tree appeared on 4.III. Migratory birds have arrived early, and pigeons and collared dove had chickens at the end of February. Bees came to pick pollen and propolis in many days. Creatures maintained their activity throughout February.

3.2. Temperature conditions in the month of March 2016

The monthly average air temperatures were positive every day and have ranged between 4.6°C at Voineasa and 8.3°C at Dr. Tr. Severin, and the monthly average was 6.5°C. Deviations to the monthly multiannual values were between 2.1°C at Craiova, Bailesti and Băcleș, and 2.7°C at Caracal and Tg. Logrești, indicating, after the Hellmann Criterion, a hot month for the entire region. The deviation of the calculated monthly average for the region to normal was 2.3°C, which confirms the classification of warm month (C) (Table 3). The warmest day, after the daily average values, was on 31.III with averages between 10.1°C at Voineasa and 16.2°C at Craiova and Drăgășani, and the average for the region was 13.9°C, the highest the whole month.

Table 3. Air temperature regime in March 2016 in Oltenia and the maximum and minimum temperature values at the soil surface. Hm = station altitude; N = normal value; M = monthly average; Δ, average monthly deviation from normal; CH criterion Hellmann; T°C min air / date; T°C max air / date; T°C min soil / date; T°C max soil / date
(Source: processed data from CMR Oltenia Archive)

Meteorological Stations	Hm	N	M	Δ	CH	T°C min air		T°C max air		T°C min soil		T°C max soil	
						°C	Date	°C	Date	°C	Date	°C	Date
Dr. Tr. Severin	77	5.9	8.3	2.4	C	-2.2	17	25.0	31	-4.6	26	42.2	31
Calafat	66	5.6	7.8	2.2	C	-1.9	26	25.4	31	-3.0	26	27.5	31
Bechet	65	5.4	7.8	2.4	C	-3.8	17	24.8	31	-2.1	17	40.1	31
Băilești	56	5.4	7.5	2.1	C	-3.1	17	24.8	31	-4.8	17	37.1	30
Caracal	112	4.9	7.6	2.7	C	-1.9	26	23.7	31	-0.1	17	26.8	31
Craiova	190	5.1	7.2	2.1	C	-2.4	17	23.3	31	-1.0	17	29.3	31
Slatina	165	5.0	7.4	2.4	C	-2.4	17	23.3	31	-1.1	17	28.7	31
Băcleș	309	4.5	6.6	2.1	C	-1.9	26	22.2	31	-	-	-	-
Tg. Logrești	262	3.6	6.3	2.7	C	-4.9	17	22.8	31	-5.4	17	32.4	31
Drăgășani	280	4.7	7.2	2.5	C	-0.8	20	23.0	31	-4.4	17	30.5	31
Apa Neagră	250	4.2	6.6	2.4	C	-5.0	17	22.8	31	-3.8	18	26.5	30
Tg. Jiu	210	4.8	7.3	2.5	C	-3.9	17	23.8	31	-3.6	17	39.2	31
Polovragi	546	3.0	5.6	2.6	C	-3.3	17	20.4	31	-6.4	17	29.2	31
Rm. Vâlcea	243	5.0	7.4	2.4	C	-2.7	17	23.3	31	-3.5	17	40.6	31
Voineasa	587	2.4	4.6	2.2	C	-4.9	17	19.8	31	-	-	-	-
Parâng	1585	-3.1	-0.8	2.3	C	-7.8	26	12.0	31	-	-	-	-
Media Oltenia	-	4.2	6.5	2.3	C	-3.3	-	22.5	-	-3.4	-	33.1	-
Ob. Lotrului	1404	-2.4	-0.2	2.2	C	-11.2	26	12.0	31	-	17	-	-

The sum of daily positive averages calculated for the entire month were between 143.7°C at Voineasa and 258.4°C at Dr. Tr. Severin, and for the entire region an average of 205.7°C. Percentage reports of these sums from the spring arrival index values ranged from Polovragi at 37.0% to 41.8% and Apa Neagră, with an average for the entire region of 39.6% (Table 1), with the largest contribution to the spring arrival index.

Maximum monthly temperature values were recorded on the last day of the month and ranged from 19.8°C at Voineasa to 25.4°C at Calafat, and their average for the region was 22.5°C (Table 3).

The weather warming in March 2016 (with maximum temperature $\geq 10.0^\circ\text{C}$) occurred in the time periods: 1-3.III, 5-10.III, 17-21.III and 26-31.III, totaling 20 warm days.

Minimum monthly air temperature values were mostly recorded on 17.III and ranged between -5.0°C on Apa Neagră in 17.III and -0.8°C at Drăgășani in 20. III, and their average for the region was -3.3°C (Table 3).

Territorial variability of air temperature in March is determined also by the increases of monthly average temperatures in March compared to the last month of winter – February, which are between 4.3°C at Tg. Logrești and 5.6°C at Caracal, and the overall increase of monthly average is 5.0°C, the first large monthly average temperature increase during the year, such setting out the arrival of spring and announcing that a warm season will follow. In all lowland and

hill-plateau regions, average temperatures exceeded 0°C, reaching up to 5 ... 6°C in the West Plain, in southern Oltenia and Muntenia.

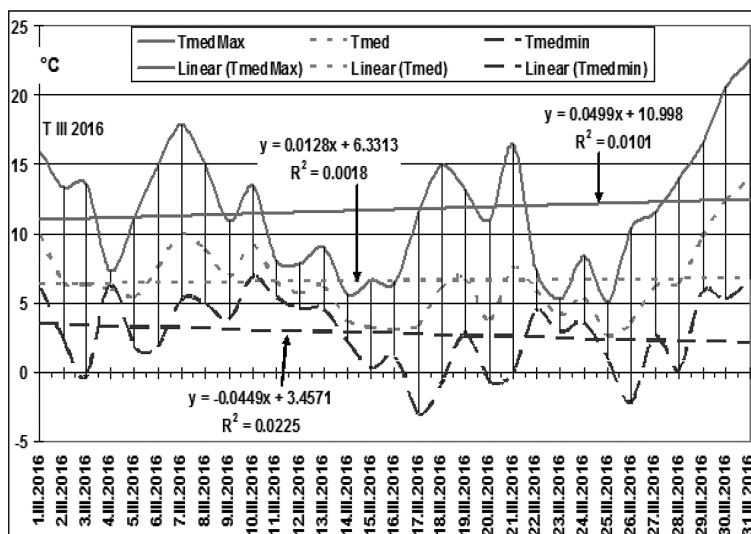


Figure 2. Air temperature variation (daily minimum, average and maximum values) in March 2016. (Source: processed data from CMR Oltenia Archive)

Even in the mountain area with medium altitudes (1300-1500 m) from the Southern and Western Romanian Carpathians, the monthly average temperatures exceed 0°C. Only in certain limited areas in size, from the intramontane depressions in eastern Transylvania, negative average temperatures have persisted, but not lower than -1°C, and on the highest peaks of the Carpathians, the monthly average values were maintained between - 6 and -4°C.

Exceptional maximum temperature values in the country

In certain exceptional circumstances, the maximum temperatures of this month exceeded 30°C, making it the first month of the year when thermal maxima reached and exceeded 30°C, marking an important temperature jump to the temperatures in January and February, which are typical winter months. **The absolute maximum air temperature in Romania for this month is 32.8°C, recorded on 30.III.1952 at Odobești, and in the same day were recorded 30.8°C at Constanța and Călărași, and 30.4°C at Giurgiu and Sibiu (according to the NMA website), characteristic values for summer days (according to some sources these values were recorded on 29.III.1952).**

March is the last month of the cold season (astronomically speaking) and the first calendar month in which diurnal thermal maxima can reach and exceed 30°C.

Variation diagrams of air temperature in March 2016 (the daily minima, daily average and daily maxima) showed increasing linear trends for daily average maxima and daily average temperature values, and insignificant decreasing trends for daily temperature minima (Figure 2). The fastest increasing trend was that of average daily maxima.

At soil surface, the monthly temperature maxima were mostly recorded on 31.III and ranged between 26.5°C at Apa Neagră and 42.2°C at Dr. Tr. Severin, and the average for the entire region was 33.1°C. **Monthly minimum temperatures at soil surface** were mostly recorded in 17.III and ranged between -6.4°C at Polovragi and -0.1°C at Caracal, and their average for the region was -3.4°C.

3.3. Thermal conditions of the first 10 days of April 2016

Spring arrival indice's calculation is made taking into account only the positive daily average temperatures from the first decade of April, so the discussion will focus only on this decade. **Throughout the country**, April 2016 was the warmest recorded after 1961. **The first decade of April** was hot, with the maximum temperature values ranging between 27.0°C recorded on 7.IV at Voineasa and 30.4°C on 6.IV at Calafat and Băilești. **The lowest minimum daily temperature** ranged between 1.1 °C at Tg. Logrești and Voineasa, recorded on 4.IV, and 7.1°C at Bâcleș on 3.IV. In six mornings, the average minimum temperature for the whole region exceeded 9.0°C. **The highest minimum temperatures** ranged between 7.7°C at Voineasa on 9.IV and 17.7°C at Dr. Tr. Severin on 8.IV, and their average for the region was 13.4°C. **Decade average temperature** ranged between 12.1°C at Voineasa and 16.4°C at Dr. Tr. Severin, **the average for the decade⁹ in the entire region** was 14.7°C. **The averages of the first decade** were higher than the monthly averages, exceeding them with differences between 0.5°C at Caracal and 1.4°C at Dr. Tr. Severin.

Note that **the second decade of April was the warmest** and on 18.IV monthly maxima were recorded between 26.8°C at Polovragi and 33.1°C at Calafat. **The coldest decade was the third one**, and **the minimum monthly temperature were registered in 27.IV**, ranging between -2.4°C Voineasa and 2.5°C at Bâcleș. This type of temperature variation, with intensive cooling in the last decade, represents a **thermal anomaly for April**. On 27.IV hoarfrost occurred throughout the country, being particularly intense and destructive and affecting all crops and vegetables, including the acacia flowers, thus threatening beekeeping. Variation in air temperature (daily minimum, maximum and average values) in April 2016 had a decreasing trend for all three parameters. The fastest decrease was for maximum air temperature.

The variability in air temperature in the first decade of April, shows that over time, **the highest April temperature values were recorded in the first decade. Thus, the absolute maximum temperature across the country is 35.5°C**,

⁹ Decade = 10 days (some Romanian researchers translated into Romanian the English term *decade* (meaning 10 years) as *decadă*, meaning 10 days, creating a great confusion)

registered on 10.IV.1985 at Bechet, just 19 days after the vernal equinox. Also at this time (10.IV.1985), in Oltenia were also recorded 35.1°C at Băilești and 34.5°C at Calafat, values that have reached and slightly exceeded the heat threshold.

The sums of daily average air temperatures ranged between 121.3°C at Voineasa and 164.4°C at Dr. Tr. Severin, and their percentage ratio from the spring arrival indices ranged from 25.6% at Calafat to 34.1% at Voineasa (Table 1), which shows that the warm weather from the first decade had significant contributions to achieving spring arrival indices. **The sum average for the first decade temperatures** for the entire region was 146.5°C, and its percentage contribution to spring arrival average index was 28.2%.

4. SPRING ARRIVAL INDICES FOR 2016.

They ranged between 356.2°C at Voineasa and 635.5°C at Dr. Tr. Severin (Table 1). Their average for the entire region Oltenia was 520.3°C. The highest values of these indices, over 600.0°C, were recorded in the extreme southwestern part of the region, where the advections of warm air were more intense and more frequent (Figure 3).

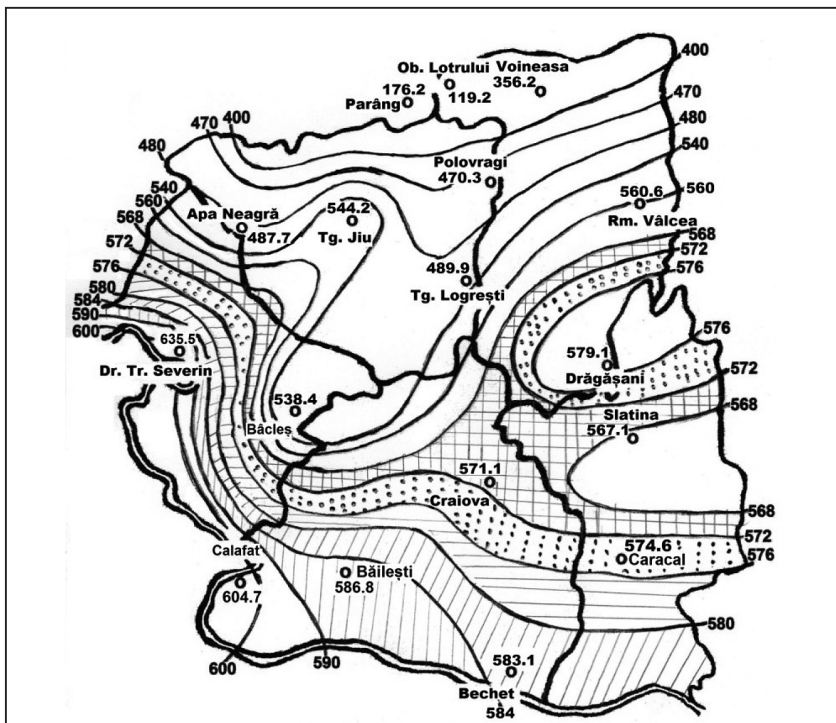


Figure 3. Spring arrival indices in oltenia, 2016

Deviations of spring arrival indices ranged between 201.7% at Voineasa and 321.3°C at Drăgășani, and the percentage deviations between 75.8% at Calafat in the extreme southwestern and 130.6% in the innermountain depression Voineasa. These high percentage deviations determined, according to the classification of spring arrival types, an excessively early type for the Oltenia region (Table 1). Excessively early spring arrival is also confirmed by the deviation of average spring arrival index for the region (103.4). The highest percentage deviation were recorded in the mountain area of Oltenia, an aspect permanently met in temperature rises, which shows that the mountain area heats up more quickly than the lower regions, thanks to their southern exposure and especially to their situating's over thermal inversion layer in the lower regions.

5. SPRING ARRIVAL INDICES IN THE PERIOD 1998-2016

The analysis of these indices (Table 4) shows that in 2016 spring arrival indices have exceeded by far all indexes registered in this period of 19 years at most weather stations (82.4%), except for three meteorological stations: Calafat with a maximum of 610.0°C, Apa Neagră with a maximum of 563.8°C, and Voineasa with 404.1°C, these records were registered in 2002.

Table 4. Spring arrival indices for each year in the period 1998-2016, in Oltenia: IN = normal multiannual index (1901-1990); I-2016 = the index for 2016; Imax = maximum index in the period 1998-2016 / year of production; IM = indices average (1998-2016); Δ = deviation of IM to IN.

Meteorological Stations	Hm	N	M	Δ	CH	T°min air		T°max air		T°min soil		T°max soil	
						°C	Date	°C	Date	°C	Date	°C	Date
Dr. Tr. Severin	77	5.9	8.3	2.4	C	-2.2	17	25.0	31	-4.6	26	42.2	31
Calafat	66	5.6	7.8	2.2	C	-1.9	26	25.4	31	-3.0	26	27.5	31
Bechet	65	5.4	7.8	2.4	C	-3.8	17	24.8	31	-2.1	17	40.1	31
Băilești	56	5.4	7.5	2.1	C	-3.1	17	24.8	31	-4.8	17	37.1	30
Caracal	112	4.9	7.6	2.7	C	-1.9	26	23.7	31	-0.1	17	26.8	31
Craiova	190	5.1	7.2	2.1	C	-2.4	17	23.3	31	-1.0	17	29.3	31
Slatina	165	5.0	7.4	2.4	C	-2.4	17	23.3	31	-1.1	17	28.7	31
Băceș	309	4.5	6.6	2.1	C	-1.9	26	22.2	31	-	-	-	-
Tg. Logrești	262	3.6	6.3	2.7	C	-4.9	17	22.8	31	-5.4	17	32.4	31
Drăgășani	280	4.7	7.2	2.5	C	-0.8	20	23.0	31	-4.4	17	30.5	31
Apa Neagră	250	4.2	6.6	2.4	C	-5.0	17	22.8	31	-3.8	18	26.5	30
Tg. Jiu	210	4.8	7.3	2.5	C	-3.9	17	23.8	31	-3.6	17	39.2	31
Polovragi	546	3.0	5.6	2.6	C	-3.3	17	20.4	31	-6.4	17	29.2	31
Rm. Vâlcea	243	5.0	7.4	2.4	C	-2.7	17	23.3	31	-3.5	17	40.6	31
Voineasa	587	2.4	4.6	2.2	C	-4.9	17	19.8	31	-	-	-	-
Parâng	1585	-3.1	-0.8	2.3	C	-7.8	26	12.0	31	-	-	-	-
Media Oltenia	-	4.2	6.5	2.3	C	-3.3	-	22.5	-	-3.4	-	33.1	-
Ob. Lotrului	1404	-2.4	-0.2	2.2	C	-11.2	26	12.0	31	-	17	-	-

(Source: processed data from CMR Oltenia Archive)

In 2016, the average of spring arrival indices calculated for the entire region, of 520.3°C, is the largest of all in this time period and the only one exceeding 500.0°C (Table 4).

Note early spring arrivals in 2010 and 2012, with an average spring arrival index calculated for the entire region which differs only by a tenth of a degree (339.3°C and 339.4°C) and the increasing and generalizing trend of excessively early spring arrival.

Table 5. The matrix of spring arrival types after the annual index in Oltenia, between the years 1998-2016

Meteorological Station	I-1998	I-1999	I-2000	I-2001	I-2002	I-2003	I-2004	I-2005	I-2006	I-2007
Dr. Tr. Severin	Ti	PTi	Ti	Ti	FTi	T	PTi	PT	N	FTi
Calafat	FTi	Ti	FTi	Ti	ETi	PT	PTi	PT	N	FTi
Bechet	Ti	Ti	FTi	Ti	ETi	T	Ti	PT	N	FTi
Băilești	Ti	Ti	FTi	Ti	ETi	T	Ti	PT	N	ETi
Caracal	Ti	Ti	FTi	FTi	ETi	T	PTi	N	PTi	ETi
Craiova	FTi	Ti	FTi	FTi	ETi	T	Ti	N	PTi	ETi
Slatina	FTi	FTi	ETi	ETi	ETi	PT	PTi	PTi	PTi	ETi
Băcleș	FTi	Ti	ETi	ETi	ETi	T	Ti	PTi	PTi	ETi
Tg. Logrești	Ti	Ti	Ti	FTi	ETi	PT	Ti	PTi	PTi	ETi
Drăgășani	FTi	FTi	ETi	ETi	ETi	PT	FTi	PTi	PTi	ETi
Apa Neagră	FTi	Ti	ETi	ETi	ETi	N	PTi	PTi	Ti	ETi
Tg. Jiu	Ti	PTi	Ti	FTi	ETi	PT	PTi	N	PTi	ETi
Polovragi	FTi	Ti	Ti	ETi	ETi	T	PTi	N	PTi	ETi
Rm. Vâlcea	Ti	Ti	Ti	FTi	ETi	T	ETi	N	PTi	ETi
Voineasa	FTi	PTi	ETi	ETi	ETi	PT	ETi	PTi	Ti	ETi
Parâng	FTi	ETi	ETi	ETi	ETi	N	PTi	ETi	ETi	ETi
Media Oltenia	FTi	Ti	FTi	FTi	ETi	T	ETi	N	PTi	ETi
Ob. Lotrului	FTi	FTi	ETi	-	ETi	ET	PTi	ETi	-	-

Meteorological Station	I-2008	I-2009	I-2010	I-2011	I-2012	I-2013	I-2014	I-2015	I-2016	
Dr. Tr. Severin	FTi	PTi	PTi	N	PTi	N	FTi	N	ETi	
Calafat	FTi	PTi	PTi	N	Ti	N	Ti	N	ETi	
Bechet	FTi	Ti	PTi	N	PTi	PTi	FTi	N	ETi	
Băilești	FTi	Ti	PTi	N	Ti	N	FTi	PTi	ETi	
Caracal	FTi	PTi	PTi	PTi	PTi	PTi	FTi	PTi	ETi	
Craiova	ETi	Ti	PTi	PTi	Ti	N	ETi	PTi	ETi	
Slatina	ETi	Ti	Ti	PTi	Ti	PTi	ETi	PTi	ETi	
Băcleș	ETi	Ti	Ti	Ti	FTi	N	ETi	PTi	ETi	
Tg. Logrești	ETi	FTi	FTi	FTi	PTi	N	ETi	PTi	ETi	
Drăgășani	ETi	FTi	Ti	Ti	Ti	PTi	ETi	Ti	ETi	
Apa Neagră	ETi	ETi	FTi	Ti	Ti	PTi	ETi	PTi	ETi	
Tg. Jiu	FTi	Ti	PTi	PTi	Ti	PTi	ETi	PTi	ETi	
Polovragi	ETi	Ti	PTi	Ti	Ti	PTi	ETi	PTi	ETi	
Rm. Vâlcea	FTi	Ti	PTi	PTi	PTi	PTi	ETi	PTi	ETi	
Voineasa	ETi	ETi	-	-	Ti	N	ETi	PTi	ETi	
Parâng	ETi	ETi	ETi	ETi	ETi	ETi	ETi	N	ETi	
Media Oltenia	ETi	Ti	Ti	PTi	Ti	PTi	ETi	PTi	ETi	
Ob. Lotrului	ETi	ETi	-	-	ETi	PTi	ETi	N	ETi	

(Legend: ET = excessively late, FT = very late, T = late, PT = a little late, N = normal, PTi = little early, Ti = Early, FTi = very early, ETi = exceptionally early (according to Bogdan, Marinică, Andreea Floriana Marinică 2010) (Source: processed data from CMR Oltenia Archive)

The spring of 2016 holds the absolute climatic record for the earliest spring arrival from all the climate observations in the history of Romania, not only in Oltenia, because the temperature values in Banat, Moldova and eastern Wallachia from 1.II-10.IV.2016 were higher than in Oltenia (as shown above).

The earliest spring arrival values, after the spring of 2016, in descending order of average values for spring arrival index, calculated for the entire Oltenia were the years: 2002 with I-average of 499.4°C (with a difference of only 6 tenths of a degree from the value of 500.0°C); 2014 with I-average of 460.7°C, and 2007 with I-average of 471.4°C (Table 4).

Spring arrival indices averages calculated for the period 1998-2016, ranged between 264.0°C at Voineasa and 448.1°C at Dr. Tr. Severin and their average for the entire region was 367.6°C (Table 4). The deviations of average spring arrival indices compared to normal (IN) ranged from 90.7°C at Dr. Tr. Severin and 150.3°C at Drăgășani, and 61.1°C in the mountain area at Parâng.

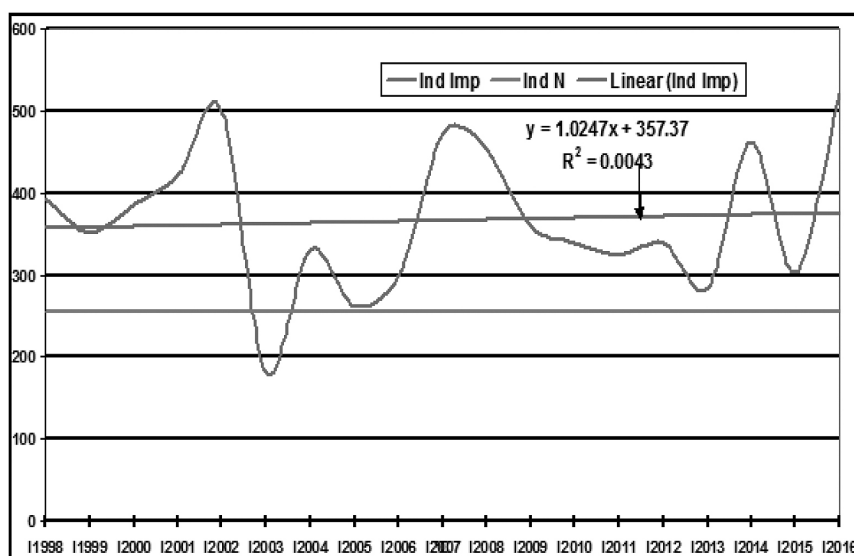


Figure 4. The variation of average spring arrival index calculated for the entire Oltenia region between the years 1998-2016 (Source: processed data from CMR Oltenia Archive)

The percentage deviations of average values for the period 1998-2016 compared to the normal values ranged from 25.4% at Dr. Tr. Severin and 70.9% at Voineasa, which shows that most spring arrival were early, an aspect supported by the graph in Figure 4. In the high mountain area, at Parâng, the percent deviation was 265.7%, confirming that most spring arrivals in this area were exceptionally early.

The variation of average spring arrival index, calculated for the entire Oltenia region, between the years 1998-2016, presents a strong increasing linear trend, with a growth rate of 1.0247 (Figure 4).

6. CONCLUSIONS

After the warm winter of 2015-2016, the warm weather continued, and February and March were warm, with maximum temperature values equaling or exceeding the climatic records; the spring arrival from 2016 has been excessively early, not only in Oltenia but also in the entire country.

The spring of 2016 holds the absolute climatic record for the earliest spring arrival from the entire climate observations in the history of Romania, not only in Oltenia, because the temperature values in Banat, Moldova and eastern Wallachia from 1.II-10.IV.2016 were higher than in Oltenia, with an average spring arrival index for the whole region of 520.3°C, the first value that exceeds 500.0°C.

The earliest spring arrival in the line of meteorological observations, in a decreasing order of all average spring arrival index values, calculated for the entire region of Oltenia, were the years: 2002 with I-average of 499.4°C (only 6 tenths of a degree less than the amount of 500.0°C), 2007 with I-average of 471.4°C and 2014 with I-average of 460.7°C.

The standard deviation for the period 1998-2016, compared to normal values, ranged from 90.7°C at Dr. Tr. Severin and 150.3°C at Drăgășani, which shows that most spring arrivals were early, an aspect supported also by the graph in Figure 4. In the high mountain area of Parâng, the deviation was of 61.1°C, confirming that most spring arrivals in this area were exceptionally early.

Average spring arrival index variation, calculated for the entire region of Oltenia between the years 1998-2016, has a strong increasing linear trend, with a growth rate of 1.0247.

Early spring arrivals represent a climate risk, particularly because late spring hoarfrosts catch the vegetation in advanced stages of development, and the destruction they determine are considerable.

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