

**ANALELE
UNIVERSITĂȚII DIN CRAIOVA
- SERIA GEOGRAFIE -**

**ANNALS
OF THE UNIVERSITY OF CRAIOVA
- SERIES GEOGRAPHY -**



ANII 2012-2013, VOL. XV

EUC

EDITURA UNIVERSITARIA

2012-2013

**ANNALS OF THE UNIVERSITY OF CRAIOVA
- SERIES GEOGRAPHY -**

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ISSN: 1224-4112**

**LATE SPRING COLD WAVES.
CASE STUDY: THE COLD WAVE IN THE INTERVAL 25-29
MARCH 2013**

**VALURILE DE FRIG DE LA SFÂRȘITUL PRIMĂVERII. STUDIU
DE CAZ: VALUL DE FRIG DIN INTERVALUL 25-29 MARTIE 2013**

Octavia Bogdan¹, Andreea Floriana Marinică², Ion Marinică³

Abstract: The paper analyzes the issue of late spring and early autumn cold waves. We present an evaluation criterion of these climatic hazard phenomena with a high degree of danger, which can damage the crops in their different development stages, vulnerable to the temperatures severe fall. The main climatic hazard phenomenon associated with these is the late spring and early autumn frost. Their occurrence can lead to significant economic damages. The paper analyzes weather severe cooling in the interval 25-29 March 2013. Taking into account global climate warming and the increase of weather variability, it is expected that the frequency of these phenomena increases, as well as the degree of crop damage. The paper is useful to researchers in climate domain, agrometeorologists, master graduates and students.

Key-words: late spring and early autumn cold waves, cold advections, late spring and early autumn frosts.

Cuvinte cheie: valuri de frig de la sfârșitul primăverii și începutul toamnei, advecții ale aerului rece, înghețurile târzii de primăvară și timpurii de toamnă.

INTRODUCTION

The phenomenon of global warming continues although the report from November 2010 of Met Office appreciated that the rate of global warming has decreased (Vicky Pope, Chief Met Office, specialist in climatic sciences, <http://www.metoffice.gov.uk/> target="_blank">Met). It shows that beginning with '70's, on long term, global warming was about 0.16°C, and it slowed down in the interval 2001-2010, reaching values of 0.05-0.13°C. Vicky Pope declared that: "the warming tendency has slightly fallen, yet there is still a warming, which does not vary faster than before." The causes of this slowdown are due to the increase of

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industrial NO_x concentration, such as sulfur-base compounds, released in the atmosphere, which reflect solar radiation, producing an effect of cooling. NASA has a satellite, which monitor permanently the changing thermal field of our planet especially in the arctic zone, making images of Terra's thermal field.

However, as a proof of the heat accumulation in the terrestrial atmosphere and the continuation of global warming, a study carried out in 2012, under the coordination of Martin P. Tingley and Peter Huybers in Harvard University, department of Earth and Space Sciences, published in Nature magazine, showed that people from Northern Hemisphere, in the countries with the highest extreme temperatures located at latitudes higher than 45°N, confronted in the last years with the highest extreme temperatures in the last 6 centuries.

The frequency, with which the extreme temperatures were registered during the last summers, is a record in the last 600 years.

The study was carried out by analyzing three types of approaches of the extreme temperatures in the last centuries. The results show that the *Summers of 2005, 2007, 2010 and 2011 have been more warmish than any other summer in 1400 and up to present, in terms of average space distribution. The summer of 2010 has been the warmest in the last 600 years in Western Russia and probably the warmest in Greenland and Canada's arctic zone.*

The results are the same with ours from the studies on climatic variability in Romania, in different regional areas, especially in South-West.

The researches show that there is a direct connection between very cold winters in the last ten years in Europe and Asia and global climate warming. Although, apparently, the cold which came over Europe is slightly compatible with an increase of the temperature mean, as the prognoses showed, up to 6°C, until the end of this century, the lower and lower temperatures and the polar cold waves during winter, in the Northern Hemisphere, are the clear proof that global warming and climate changes are real and serious, (Business Recorder). The severe cold during winters is the consequence of arctic icecap melting, which lost 20% of its surface in the last 30 years because of the excessive heat during summers. Other studies show that this icecap could totally disappear during the summer months in this century, because sunrays, which will not be reflected by ice back in the atmosphere, will warm up even more the terrestrial surface in this area. Then, we will have an important warm flow, which will go upward in the atmosphere which we do not have when everything is covered by ice. It is a huge change (Stefan Rahmstorf, specialist in climate, Institute of Potsdam - Germany). The effect will be the formation of an anticyclonic field located in such manner that will push the advection of polar air clockwise (natural circulation in anticyclone), that is towards Europe (study published in *Journal de Recherche Geophysique*, 2013). According to this study, the phenomenon can be already felt, its effect consisting in the colder and colder and longer winters in Europe. *These anomalies could triple the probability of having extreme winters in Europe and Northern Asia*, (Vladimir Petouchov, study coordinator).

The increase of climate variability led to the increase of the frequency of warm winters, and during a calendar year rapid changes of weather type can be observed, from an excessively warm to an excessively cold weather, from an excessively droughty to an excessively rainy weather.

In some years, warm weather prolongs in the first two winter months, and the excessively cold weather with snowstorms and snowfalls appears in the last month of winter as for example the winter of 2011-2012. Other times, cold winter arrives early in November and continues until the end of March and the beginning of April (from example 1995-1996).

The winter of 2012-2013 represented a new exception in what the climatic variability in Romania concerns. The winter specific phenomena appeared relatively early in most part of the country, and in the South-West (where usually winter phenomena appear after 20 December) they appear early in the first decade of December. Then, in January and February, weather was warm, without a snow layer and with predominantly liquid precipitation. The same weather aspect perpetuated in most part of March and in the last five days of March a wave of cold air and snowfalls covered a part of the continent, including Romania, causing the extension of the snow layer on the continent and its formation in Romania.

In Poland the maximum temperature values fell below -5.0°C , and the daily minimum values below -24.0°C and 20 persons died of cold.

In some parts of Romania (North-East and North-West) it was snowstorm, and some roads were blocked. The border crossings with Hungary and Republic of Moldova were closed. In some counties, including the municipality of Bucharest classes in schools were suspended (the central heating had been closed about 2 weeks ago, and its turning on again was difficult). In Suceava County, in Iiteni, the snowstorm covered the houses with snow heaps with a height of 2.5-3.0 m.

Warm weather, which has last previously this phenomenon for 84 days with preponderantly positive minimum temperatures and maximum temperatures that reached values of $10-14^{\circ}\text{C}$, led to the continuation of the vegetation stages in some species of plants, in autumn crops and some species of fruit trees as for example the apricot tree. On 18 March 2013, the apricot tree had floral buttons, and the flowering was imminent. A part of the migratory birds had already come from tropical countries and some of them died because of the frost and of the snow layer which made impossible their feeding. The phenomenon of frozen soil and lake surfaces occurred.

After the cold wave and snowfalls which formed a snow layer in the interval March 25-28, 2013, a significant part of the floral buttons fell as a consequence of frost, and in some crops, as for example vegetable crops from the unheated solariums and rape, total damages and/or plant damages occurred.

The cold waves during winter which lead to massive cooling are characterized by average temperature values $\leq -10^{\circ}\text{C}$ and minimum temperature values of $\leq -30^{\circ}\text{C}$ (Bogdan and Niculescu, 1999, p. 30).

From a calendar point of view March is the first spring month, but the spring equinox which, usually, occurs on 21 (most often according to astronomers on March 20), shows that astronomically winter continues up to March 20. Consequently, the instructions on observing and codifying meteorological phenomena indicate the issue of some warning messages for frost and hoar frost phenomena which occur on this date, *these being considered late spring frost and hoarfrosts*. In some years, the late snowfalls which appear after this date and the intense weather cooling cause significant damages of crops, vineyards and crops from unheated solariums, especially if they occur after a period of warm winter. The snowfalls are sometimes accompanied or followed by wind gusts that cause solarium destruction or electricity cut down, which amplifies the damages because of the heat break down in those with heating systems working on electricity. March is the last month of the cold season, and usually after the spring equinox the daily thermal balance becomes positive.

Regarding the weather cooling or warming, *Weather Diagnosis and Forecast, terminology and symbols*, state standard STAS 12977-91 (entered into force on April 1, 1991) shows that: *depending on the deviations size nuances can be made: slightly cold weather (deviations of 2...3°C), cold weather (deviations of 4...6°C), very cold weather (deviations of 7°C or more)*.

Consequently, these forecasts can be a criterion to evaluate weather cooling occurred in the interval March 25-29, 2013, even if this intense weather cooling did not have the characteristics of a winter cold wave, taking into account also the late calendar period of its occurrence.

Starting from these forecasts we can formulate the following criterion⁴ (table no. 1) for the evaluation of spring late cold waves.

Table no. 1. *Weather types depending on the deviation ($\Delta T^{\circ}\text{C}$) of the daily air temperature means from the normal values (N).*

$\Delta T^{\circ}\text{C}$	Weather characteristic	Abreviere
$>10^{\circ}\text{C}$	Excessively warm	EW*
$7.0...10.0^{\circ}\text{C}$	Very warm	VW
$4.0...6.9^{\circ}\text{C}$	Warm	W
$2.1...3.9^{\circ}\text{C}$	Slightly warm	SW
$-2.0...+2^{\circ}\text{C}$	Thermally normal	N
$-3.9...-2.1$	Slightly cold	SC
$-6.9...-4.0$	Cold	C
$-10.0...-7$	Very cold	VC
$<-10^{\circ}\text{C}$	Excessively cold	EC*

(Source: procession according to the criterion from the *State standard STAS 12977-91*, page 14, the end lines marked with an asterisk are proposed by us, because the thermal deviations can be higher in some situations).

⁴ Criterion proposed by us (table 1), is also useful for the study of autumn early and spring late heat waves

The meteorological instructions for the issue of warnings related to short term dangerous meteorological phenomena (1-7 days, entered into force on March 12, 2008) show that for extreme minimum temperatures **a yellow code** warning is issued if these are comprised between -25°C and -15°C and **an orange code** warning if they fall below -25°C , and these codes are valid for areas with altitudes less than 800 m and provided that the low temperature is maintained at least two consecutive days (the local climatic characteristics will be taken into account). No norms are stipulated for orange code of low temperatures (although there were cases in which it was issued, when temperatures fell below -35°C). It is not specified if these refer to the winter season or to the entire cold season.

Our opinion is that these are useful for **winter season, when temperature frequency** $< -15^{\circ}\text{C}$ is extremely high. The criterion proposed by us is useful for the autumn early cold waves (from October and November) and the late spring cold waves (from March which are a part of the cold season and sometimes even the ones from April and the first decade of May) (table 1).

Weather late intense cooling, of spring, occurred also in April; we give as example the snowfall in the night of April 14/15, 1996, when it snowed in most of the country, and in the southern half of Oltenia the snow layer had thicknesses between 20 and 25 cm.

For May, the extremely late weather intense cooling is well known, in the interval May 7-9, 2011 when during the night of May 7/8, 2011 it snowed and a snow layer was formed in the north of Moldavia, in Suceava, Harghita, Covasna, Braşov and Sibiu Counties and Prahova Valley. On that date, the vegetation was in advanced development stages, trees were blossomed, vineyards and orchards were in leaf with sprouts growing etc., and the destructions caused by weather intense cooling, which has lasted for three days have been important. The cooling was then followed by some mornings with hoarfrosts.

For the autumn early cold waves we give as example the intense cooling associated with abundant snowfalls and snowstorm on November 5, 1995 which brought the winter with the longest duration of the snow layer in the history of meteorological observations (Marinică, 2006; Bogdan, Marinică, 2007).

2. The daily extreme temperatures in the interval 25-28 March 2013

On March 25, 2013 the minimum temperature values registered at the meteorological stations from Oltenia were negative excepting one single value (Dr. Tr. Severin in the extreme west of the region); they were comprised between -2.8°C in Polovragi and 0.5°C in Dr. Tr. Severin.

The mean of the minimum temperature values for the entire Oltenia was -1.7°C .

In the same day, **the maximum thermal values** were negative in most part of the region and were comprised between -2.2°C in Băcleş and 1.5°C in Voineasa, and **the mean of the daily maximum temperature values for the entire**

region was -0.3°C , thus a winter day⁵ being registered in most part of the region (Table 2).

Table no. 2. Maximum (Tmax) and minimum temperature (Tmin) values registered during the cold wave in the period 25-29 March, 2013 ($^{\circ}\text{C}$).

Meteorological Station	25.III.2013		26.III.2013		27.III.2013		28.III.2013		29.III.2013	
	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
Dr. Tr. Severin	0.5	0.8	-0.8	1.4	-1.1	3.1	-0.8	2.6	0.5	2.5
Calafat	-0.7	-0.2	-1.7	0.5	-1.9	-0.4	-1.5	2.9	0.5	1.9
Bechet	-1.1	-0.5	-1.9	1.3	-1.9	1.7	-1.4	3.4	0.9	3.8
Băilești	-0.6	0.0	-2.5	0.7	-2.4	-0.2	-2.4	2.5	0.0	2.3
Caracal	-1.5	-1.1	-2.6	0.4	-2.9	-0.6	-2.0	1.8	0.5	2.3
Craiova	-2.1	-1.6	-3.4	0.1	-3.3	-0.8	-2.7	2.4	-0.2	1.2
Slatina	-2.0	-1.5	-3.3	1.0	-3.1	0.4	-2.6	2.8	-0.1	1.2
Băcleș	-2.3	-2.2	-3.2	-0.5	-3.9	-1.0	-3.1	0.0	-1.2	0.2
Tg. Logrești	-1.3	-0.6	-1.5	2.3	-2.7	0.1	-2.9	2.2	-1.1	1.3
Drăgășani	-2.4	-1.9	-3.2	0.6	-3.8	-0.8	-3.2	3.2	-1.1	0.6
Apa Neagră	-0.4	0.4	-2.2	1.8	-2.2	0.0	-2.5	1.4	-0.6	2.4
Tg. Jiu	-0.1	1.2	-1.1	2.8	-1.9	0.4	-1.7	2.6	0.0	2.5
Polovragi	-2.8	-1.0	-2.2	1.7	-3.9	-1.6	-5.2	-0.5	-2.5	1.4
Rm. Vâlcea	-1.2	1.1	-0.4	3.9	-2.4	0.7	-2.2	3.4	0.2	2.1
Voineasa	-0.4	1.5	-1.6	3.1	-1.0	1.5	-2.7	1.8	-1.1	1.2
Parâng	-8.6	0.1	-7.2	-3.0	-8.6	-4.0	-9.9	-2.5	-8.7	0.3
Mean/Oltenia	-1.7	-0.3	-2.4	1.1	-2.9	-0.1	-2.9	1.9	-0.9	1.7
Ob. Lotrului	-5.0	-1.2	-6.4	-1.2	-5.1	-0.6	-7.4	3.2	-7.0	0.0
Halânga	0.5	0.8	-0.6	2.2	-1.2	1.4	-0.8	2.5	0.8	2.5

(Source: processed data)

On 26 March, 2013 the minimum temperature values were comprised between -3.4°C in Craiova and -0.4°C in Rm. Vâlcea, and *the mean of the minimum thermal values for the entire region* was lower than in the previous day with 0.7°C , registering the value of -2.4°C .

On the same date, *the daily maximum thermal values* were comprised between -0.5°C in Băcleș in Mehedinț Hills and 3.9°C in Olt Couloir in Rm. Vâlcea, and *the mean of the daily maximum temperature values was 1.1°C* , higher with 1.4°C than in the previous day, due to some short insulation intervals in the high area compared to the low area characterized through thermal inversion, which increased the mean for the entire region.

On March 27, 2013 the minimum temperature values were comprised between -1.0°C in Voineasa and -3.9°C in Polovragi and Băcleș, and *the mean of the minimum thermal values for the entire region* was -2.9°C , lower with 0.5°C than in the previous morning, due to the continuation of the cold air advection, as well as of the nocturnal radiation in the presence of the snow layer.

⁵ Winter day = day in which the maximum air temperature is $\leq 0^{\circ}\text{C}$

The daily thermal maximum values on March 27 were comprised between -1.6°C in Polovragi and 3.1°C in Dr. Tr. Severin, and *the mean for the entire region* was -0.1°C which again means a winter day according to the value of most maximum temperatures, and also to the mean of these maximum thermal values.

On March 28, 2013 the minimum temperature values were comprised between -0.8°C in Dr. Tr. Severin and -5.2°C in Polovragi (thus we notice that in Subcarpathian Depressions air temperature continued to fall), and *the mean of the minimum thermal values was -2.9°C* , equal with the one from the previous day.

The maximum thermal values on March 28 were comprised between -0.5°C in Polovragi and 3.4°C in Bechet, and *their mean for the entire region* was 1.9°C registering a slight increase of 2.0°C compared to the previous day.

On March 29, 2013 the minimum temperature values were comprised between -1.2°C in Băcleș and 0.9°C in Bechet, and *the mean of the minimum thermal values* was -0.9°C thus registering an increase of 2.0°C compared to the previous morning.

The maximum thermal values on March 29 were comprised between 0.2°C in Băcleș and 3.8°C in Bechet, and *the mean of the daily maximum temperature values* was 1.7°C registering a fall of 0.2°C compared to the previous day.

The intensity of weather cooling was calculated by applying the above criterion (table 1) for the daily extreme temperature means (the means from the minimum and maximum thermal values) which are closed to the daily means, the results thus obtained being significant⁶.

On March 25, 2013 the means of the daily extreme temperature values were comprised between -1.9°C in Polovragi and 0.7°C in Dr. Tr. Severin, and *their mean for the entire region* was -1.0°C (table 3).

Their deviations from the multiannual average values (normal values calculated for the interval 1961-1990) were comprised between -10.6°C in Slatina and -5.4°C in Voineasa, and *the mean deviation for the entire region* was -8.6°C .

According to the above criterion, *the thermal time types* were comprised between *cold* (C) in Voineasa and Parâng and *excessively cold* (EC) in Craiova, Slatina and Drăgășani, and according to the mean deviation for the entire region, weather was *very cold* (VC).

The spatial-temporal extension of the very cold time (VC) was of 70.6% compared to the region area, of the *excessively cold* (EC) *time* was of 17.6% and of the *cold time* of 11.8%.

On March 26 the means of the daily thermal extreme values were comprised between -1.9°C in Băcleș and 1.8°C in Rm. Vâlcea, and *their mean for the entire region* was of -0.6°C .

⁶ We opted for this approach because we do not have the multiannual daily means, but, in exchange, we have the multiannual daily means of the thermal extreme temperature values.

Their deviations from the multiannual average values were comprised between -10.5°C in Slatina and -5.5°C in Voineasa and for the *mean of the entire region, the deviation was -8.6°C*.

The thermal time type on that date were comprised between cold (C) in the high area in Rm. Vâlcea, Voineasa, Parâng (due to the thermal inversion) and excessively cold (EC) in Băilești, Craiova, Slatina and Drăgășani, and according to the *thermal mean deviation for the entire region* weather was *very cold* (VC).

The spatial-temporal extension of the very cold time (VC) was 58.8%, of the excessively cold time (EC) 23.5% and of the cold time 17.7%, which show the severe cooling.

On 27 March the means of the daily thermal extreme values were comprised between -2.8°C in Polovragi and 1.0°C in Dr. Tr. Severin, and *the mean for the entire region* was -1.5°C, lower compared to the previous day with 0.9°C.

Table no. 3, Weather types during the cold wave in the interval⁷25-29 March, 2013 (MEx=mean of the daily thermal extreme temperature values on that date, N=multiannual mean of the daily thermal extreme temperature values on that day considered to be normal; ΔT° = deviation from the normal (MEx-N), WT= weather type.)

Meteorological Station	25.III.2013				26.III.2013				27.III.2013			
	MEx	N	ΔT°	WT	MEx	N	ΔT°	WT	MEx	N	ΔT°	WT
Dr. Tr. Severin	0.7	9.2	-8.5	VC	0.3	9.5	-9.2	VC	1.0	9.9	-8.9	VC
Calafat	-0.5	9.2	-9.7	VC	-0.6	9.4	10.0	VC	-1.2	9.9	11.0	EC
Bechet	-0.8	9.0	-9.8	VC	-0.3	9.3	-9.6	VC	-0.1	9.6	-9.7	VC
Băilești	-0.3	9.0	-9.3	VC	-0.9	9.3	10.2	EC	-1.3	9.9	11.2	EC
Caracal	-1.3	8.3	-9.6	VC	-1.1	8.9	10.0	VC	-1.8	9.4	11.1	EC
Craiova	-1.9	8.4	-10.2	EC	-1.7	8.8	10.4	EC	-2.1	9.0	11.0	EC
Slatina	-1.8	8.9	-10.6	EC	-1.2	9.3	10.5	EC	-1.4	9.4	10.8	EC
Băcleș	-2.3	7.6	-9.9	VC	-1.9	8.1	10.0	VC	-2.5	8.4	10.9	EC
Tg. Logrești	-1.0	7.7	-8.6	VC	0.4	7.8	-7.5	VC	-1.3	8.3	-9.6	VC
Drăgășani	-2.2	8.4	-10.5	EC	-1.3	8.8	10.1	EC	-2.3	9.2	11.5	EC
Apa Neagră	0.0	7.6	-7.6	VC	-0.2	7.6	-7.8	VC	-1.1	8.1	-9.2	VC
Tg. Jiu	0.6	8.3	-7.8	VC	0.9	8.4	-7.6	VC	-0.8	9.0	-9.7	VC
Polovragi	-1.9	6.6	-8.5	VC	-0.3	6.9	-7.1	VC	-2.8	7.3	10.0	VC
Rm.Vâlcea	-0.1	8.3	-8.3	VC	1.8	8.4	-6.7	C	-0.9	8.9	-9.8	VC

⁷ We do not take into account Halânga and Ob. Lotrului meteorological stations for the general mean calculated for the entire region, since they comprise short data ranges, but present them orientatively.