

SYNOPTIC AND CLIMATOLOGICAL ANALYSIS OF AUTUMN 2023 FROM THE PERSPECTIVE OF A METEOROLOGIST FORECASTER

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ABSTRACT. Synoptic and Climatological Analysis of Autumn 2023 from the Perspective of a Meteorologist Forecaster .The fall of 2023 was atypical both in terms of recorded temperatures and accumulated precipitation. September and October retained many characteristics of an authentic summer, with this year experiencing up to 22 summer days, 16 tropical days, and 3 heatwave days. The weather conditions this autumn were influenced by the atypical position and evolution of baric centers, as well as the warm advection at the 500hPa level.

Keywords: *Oltenia, summer days, tropical days, heatwave days, baric centers.*

1. INTRODUCTION.

Autumn 2023 was an atypical season for Oltenia in terms of temperature, rainfall and severe weather.

This season started with a month of September that can be characterized as warm in most of the region and range (17 days in which the maximum air temperature exceeded 30°C), isolated heatwave (2 days in which the maximum temperature reached 35°C and when the temperature-humidity index reached and exceeded the critical threshold of 80 units).

The next month of the season, October, was also atypical in terms of temperature regime, as daily maximum temperature records were broken especially in the second part of the month when we also had two days with maximum temperatures $\geq 30^{\circ}\text{C}$.

These first months of the season were deficient in precipitation, although there was no lack of episodes of severe atmospheric instability (torrential downpours, thunderstorms, short-lived wind intensities and gales).

The month of November is also atypical, being mainly characterized by the excessive rainfall in most of the region.

The appearance of the weather, the air temperature (in maximum and minimum values) as well as the rainfall regime were determined by the distribution, positioning and movement of the baric centres influencing the weather in Oltenia.

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The paper provides a comprehensive synoptic and climatological examination of the autumnal season, focusing particularly on the local synoptic conditions conducive to the genesis of meteorological phenomena in the Oltenia region.

This analysis proves beneficial for meteorologists within the operational weather forecasting service, as it delineates the impact of baric centers (including the Azores High, the East European High, the North African High, and the Mediterranean Depression) on weather patterns, contingent upon their spatial distribution across synoptic charts and their temporal evolution within a defined interval.

2. DATA AND METODS

The present study utilized data extracted from the archives of the National Meteorological Administration (ANM), encompassing ground-level pressure fields and geopotential fields at 500 hPa on the synoptic scale. These datasets were acquired through the NCEP/NCAR Reanalysis program, facilitated by the NOAA Physical Sciences Laboratory (<https://psl.noaa.gov/data/composites/day/>). Additionally, precipitation and temperature parameter graphs were constructed utilizing data sourced from the Climate Prediction Center – NOAA (<https://www.cpc.ncep.noaa.gov/products/timeseries/>).

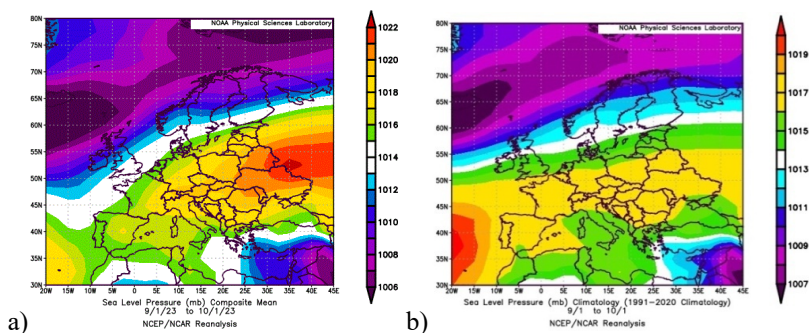
3. RESULTS

3.1. Synoptic and climatological analysis of the months September, October, and November

3.1.1 September

This month retains many characteristics of late summer, with the weather being warm in most parts of Oltenia in recent years. Episodes of severe weather (heavy rainfalls, thunderstorms, intensified winds, storms, hail) are increasingly frequent, and these are being warned, including through red nowcasting codes.

For synoptic and mesoscale analysis, averages of sea-level pressure fields and the geopotential field at 500 hPa were used, along with their anomalies, obtained through the NCEP/NCAR Reanalysis program from the NOAA Physical Sciences Laboratory.



**Fig.1.a) Sea Level Pressure (mb)
Composite Mean**

<https://psl.noaa.gov/data/composites/day/>

**Fig.1.b) Sea Level Pressure (mb)
Climatology**

<https://psl.noaa.gov/data/composites/day/>

During this month, most of Europe was under the influence of an anticyclonic belt formed between the Azores High, located in the southwestern extremity of Europe, and the East European Anticyclone situated in the eastern part of Europe.

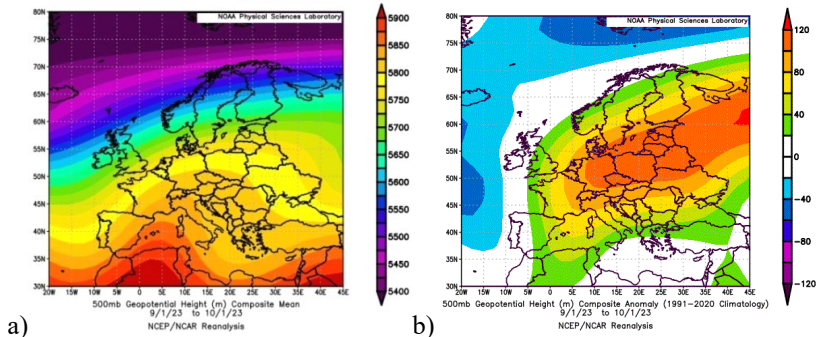


Fig.2.a) 500 Geopotential Height (m) Composite Mean

<https://psl.noaa.gov/data/composites/day>

Fig.2.b) 500 Geopotential Height (m) Composite Anomaly

<https://psl.noaa.gov/data/composites/day>

In the middle troposphere, at the 500 hPa level, most of Europe was under the influence of an extended geopotential ridge over the continent, reaching above the Baltic Sea (Fig.2.a)). The positive geopotential anomaly is highlighted in Fig. 2.b), with values reaching up to 12 dam.

As a result of the evolution of the fields in Fig. 1.a), b) and Fig. 2.a), b), September 2023 was characterized by much warmer weather than usual. The number of tropical days ($T_{max} \geq 30^{\circ}\text{C}$) ranged from 0 days (Polovragi) to 17 days (Calafat).

The highest number of tropical days was recorded in the southern part of Oltenia, ranging from 7 days (Craiova) to 17 days (Calafat). The number of tropical days decreases from south to north as the altitude of the stations increases. At the same time, the number of days with maximum temperatures approaching the thermal normal of the calendar period decreases from north to south.

In September 2023, in the Oltenia region, temperatures characteristic of a heatwave ($T_{max} \geq 35^{\circ}\text{C}$) were recorded on 2 days (13th and 23rd), when the temperature–humidity index (THI), also reached and exceeded the critical threshold of 80 units at four stations.

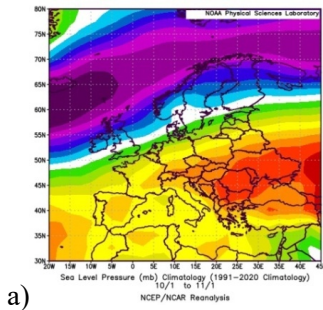
Additionally, on September 24th, daily maximum temperature records were surpassed at two stations (32.8°C compared to 32.6°C in Caracal and 31.1°C compared to 29.7°C in Rm. Valcea), as well as daily minimum temperature records at four stations (16.6°C compared to 15.4°C in Apa Neagra, 18°C compared to 17.5°C in Dragasani, 18.1°C compared to 18°C in Dr. Tr. Severin, and 17.3°C compared to 16.7°C in Rm. Valcea). (processed data from the ANM archive)

3.1.2. October

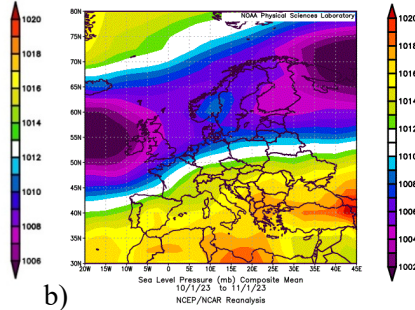
The most stable autumn month is October when, for consecutive days, the weather remains sunny, although the nights become progressively colder. In most parts of the region, the phenomenon of frost appears..

Climatologically, Romania is under the influence of the East European Anticyclone, whose ridge extends above the Alps. (Fig.3.a)).

European Anticyclone and the North African Anticyclone (Fig.3.b), while the northern half of Europe was in a depression field, with a negative anomaly, as observed in Fig.3.b).

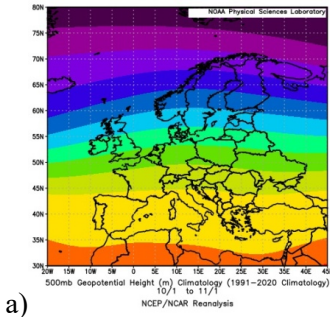


**Fig.3.a) Sea Level Pressure (mb)
Climatology – October**
<https://psl.noaa.gov/data/composites/day/>

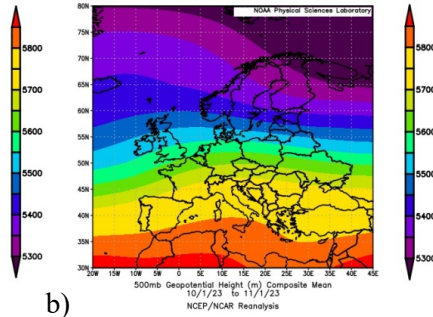


**Fig.3 .b) Sea Level Pressure (mb)
Composite Mean – October**
<https://psl.noaa.gov/data/composites/day/>

In the middle troposphere, at the 500 hPa level, the westward circulation suggested in Fig.4.a) is of interest, while in October 2023, we were under the influence of a geopotential ridge and warm advection, as can be observed in Fig.4.b).



**Fig.4.a) 500 Geopotential Height (m)
Climatology - October**
<https://psl.noaa.gov/data/composites/day/>



**Fig.4.b) 500 Geopotential Height (m)
Composite Mean – October**
<https://psl.noaa.gov/data/composites/day/>

The evolution of baric fields in the middle troposphere, as well as those at the surface (warm geopotential dorsal and the abnormal presence of the North African Anticyclone), led to an exceptionally warm weather in Romania. Therefore, at the national level and implicitly in Oltenia, October 2023 ranks 1st in the list of the

warmest Octobers in Romania from 1961 to 2023, along with October 1966 (source: National Meteorological Administration - ANM).

In this month, the latest heatwave day ($T_{max} \geq 35^{\circ}\text{C}$) in the history of meteorological measurements was recorded on October 21st, when the Bechet meteorological station registered 35°C . This value represents both the daily record and surpasses the previous record of 27.3°C measured in 2019.

October 21, 2023, was an atypical autumn day, as most meteorological stations in Oltenia exceeded the daily temperature records both in maximum and minimum temperatures (Fig.5.a) and b)).

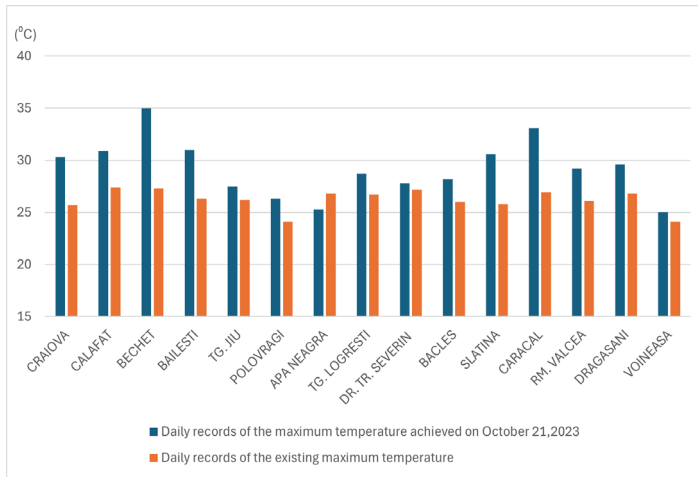


Fig.5.a) Comparison of the maximum records (processed data in operational service)

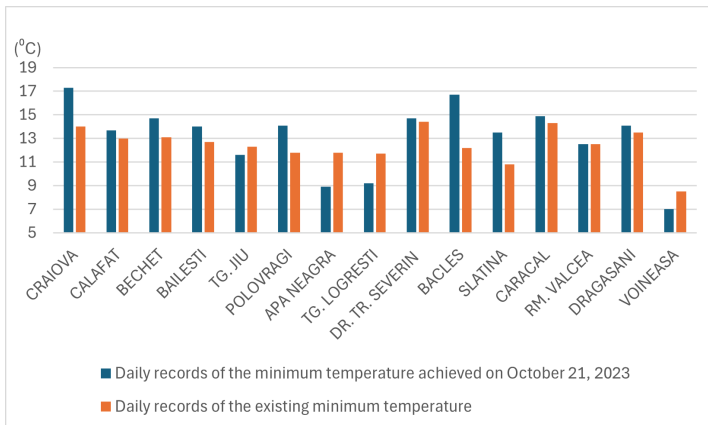


Fig.5.b) Comparison of the minimum records (processed data in operational service)

Daily maximum temperature records were also surpassed over relatively extensive areas (12 stations) on October 23, and isolated instances occurred on October 24 (two stations) and October 27 (one station). Regarding minimum temperatures, daily records were exceeded in much more limited areas on October 24 (5 stations), October 27 (4 stations), October 23 (1 station), and October 31 (1 station).

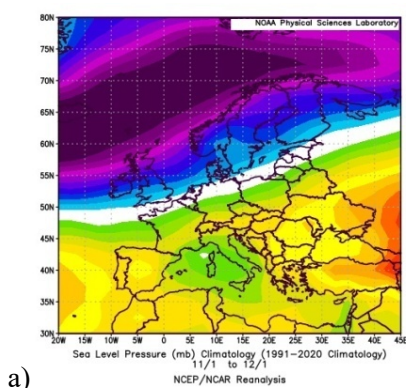
An important characteristic of October 2023 was the high number of summer days. In the southern half, there were between 11 (Craiova) and 20 (Bechet) summer days, while in the northern half, there were between two (Polovragi) and 10 (Dragașani) summer days.

Similar to September, October was also a month with a deficit in terms of precipitation, even though there were a few episodes where atmospheric instability manifested through isolated thunderstorms accompanied by rainfall.

3.1.3 November

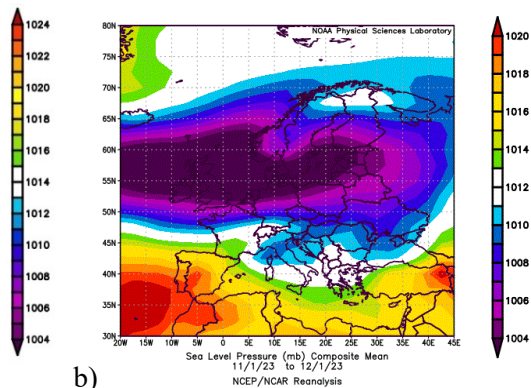
November is the last month of autumn and, at the same time, can be considered the beginning of winter, especially due to nights with negative temperatures when ground frost is encountered. Particularly in the mountains, precipitation is predominantly in the form of snow, and the phenomenon of blizzard can be encountered.

Following the analysis of the mean sea-level pressure field as well as the climatological one (relative to the reference period 1991-2020) in Fig.6. a) and b), it can be observed that in November 2023, the Azores High and the East European Anticyclone formed a belt over the southern extremity of Europe much farther south than it should have been. Romania was in a low-pressure system and not under the influence of the ridge of the East European Anticyclone.



a)

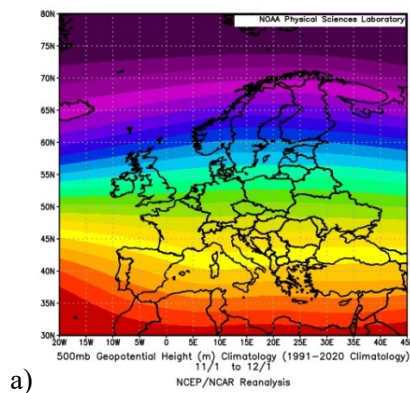
**Fig.6.a) Sea Level Pressure (mb)
Climatology – November,**
<https://psl.noaa.gov/data/composites/day/>



b)

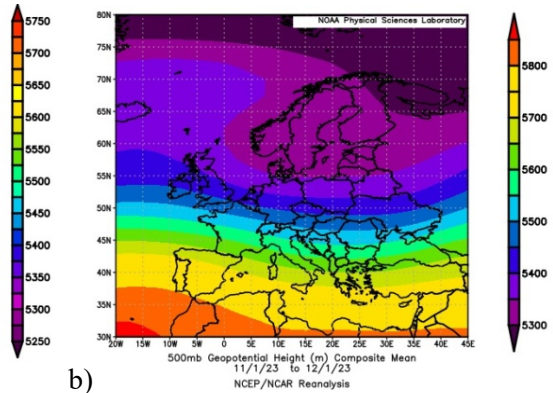
**Fig.6.b) Sea Level Pressure (mb)
Composite Mean – November**
<https://psl.noaa.gov/data/composites/day/>

At the 500 hPa level, in November, most of Europe was under the influence of a low geopotential field resembling a trough. From Fig.7 a) and b), a negative geopotential anomaly of ~8 dagmp can be observed.



a)

Fig.7.a) 500 Geopotential Height (m) Climatology - November
<https://psl.noaa.gov/data/composites/day/>



b)

Fig.7. b) 500 Geopotential Height (m) Composite Mean -November
<https://psl.noaa.gov/data/composites/day/>

In this synoptic context, the weather in Oltenia was mostly warm throughout the period, but there were also days with frost ($T_{min} \leq 0^{\circ}\text{C}$), ranging from one day in Calafat to 13 days in Apa Neagra. The number of days with minimum temperatures below freezing decreases from north to south and from west to east in the northern half, while it increases from west to east in the southern half.

From pluviometric perspective, November was surplus in precipitation, with recorded water quantities ranging from 67.43 mm in Râmnicu Vâlcea to 145.6 mm in Calafat (Fig. 8).

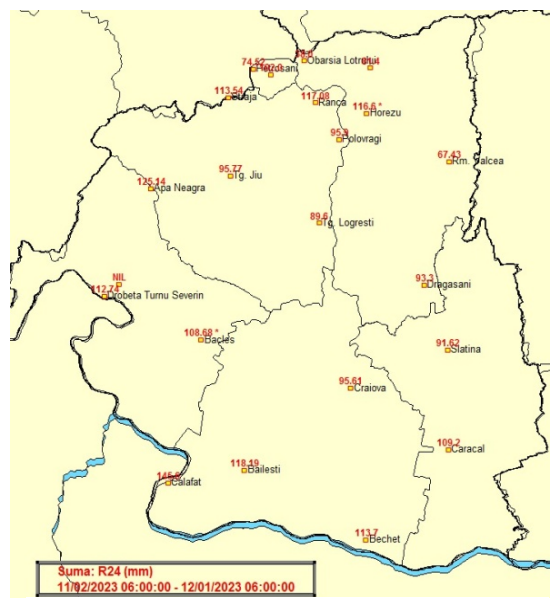


Fig.8 The accumulated water quantities in November 2023 (Source: ANM).

3.2. A comparative synoptic and climatological analysis between the autumns of 2022 and 2023, relative to the reference period of 1991–2021.

3.2.1 Synoptic analysis

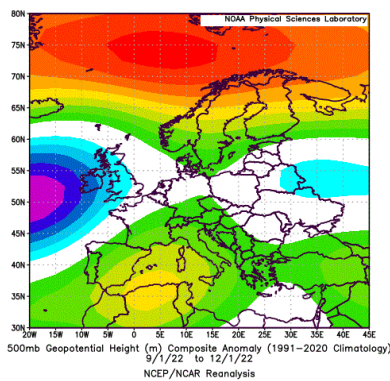


Fig.9.a) 500 Geopotential Height (m)
Composite Anomaly - Autumn 2022
<https://psl.noaa.gov/data/composites/day/>

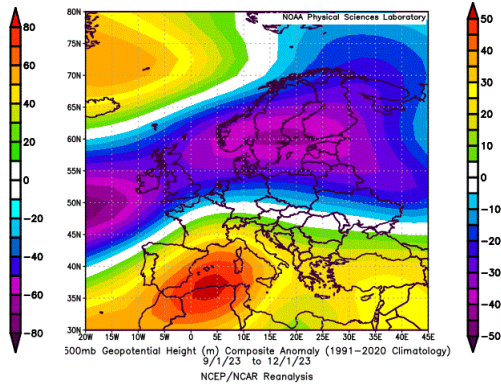


Fig.9.b) 500 Geopotential Height (m)
Composite Anomaly - Autumn 2023
<https://psl.noaa.gov/data/composites/day/>

Upon comparing the two maps (Fig. 9.a and Fig. 9.b) representing medians alongside the anomaly of the geopotential field at the middle troposphere level for the years 2022 and 2023 respectively, it becomes apparent that in 2023, a negative anomaly of up to 4.5 damgp was observed above Central Northern Europe. In contrast, in 2022, the negative anomaly was confined primarily to the western and eastern extremities, with the highest values recorded over the Atlantic Ocean.

While in 2022, a geopotential field over Romania exhibited values akin to those typical of the autumn season, the notable aspect in 2023 is the presence of a positive anomaly, notably observed above the southern region of the country (up to 1.5 damgp).

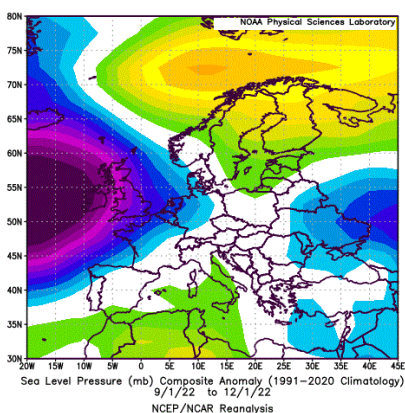


Fig.10.a) Sea Level Pressure (mb)
Composite Anomaly – Autumn 2022
<https://psl.noaa.gov/data/composites/day/>

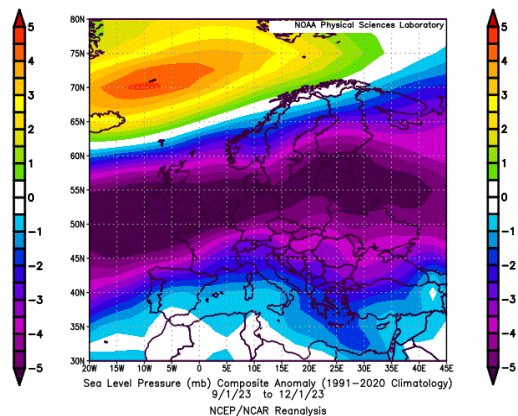


Fig.10.b) Sea Level Pressure (mb)
Composite Anomaly – Autumn 2023
<https://psl.noaa.gov/data/composites/day/>

Negative deviations of values are also evident in the maps presented in Fig.10.a) and Fig.10.b), representing anomalies of the surface pressure field for 2022 and 2023. In 2022, these deviations reached up to 4.5 mb solely over the Atlantic Ocean, whereas in the analyzed year (2023), negative deviations were observed across the entire European region.

In these synoptic contexts, the evolution of meteorological parameters exhibited notable distinctions. The deviation of the average annual temperature across the country from the median of the reference period 1991 - 2020 increased in 2023 relative to 2022. Regarding the precipitation regime, it exceeded normal levels in September and November 2022, as well as in November 2023 compared to the median of the standard climatological interval (1991 - 2020).

3.2.2 Climatological analysis of meteorological parameters: temperature and precipitation.

For illustrative purposes, two stations were chosen, one situated in the northern half (Târgu Jiu - Gorj County) and the other in the southern half (Craiova - Dolj County) of the region, each equipped with comprehensive datasets. Employing the "Climate Prediction Center" program (NOAA), graphs were generated to depict the daily average temperature and accumulated daily precipitation relative to the climatological norm of the reference period 1991-2020 for the autumns of 2023 and 2022.

From the analysis of the maps displaying daily average temperatures (Fig.11 and Fig.12) during the autumns of 2023 and 2022, respectively, at the two studied stations, an increase is observed in both the number of days with daily average temperatures exceeding the climatological averages specific to the reference period and the magnitude of the positive deviation. Consequently, there were 8 days during which the deviation of the daily average temperature was negative, at both the Craiova and Târgu Jiu weather stations.

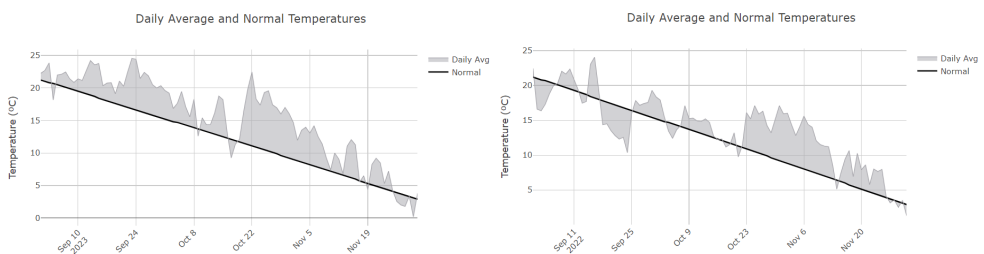


Fig.11: Graphs illustrating the evolution of daily average temperatures at the Craiova weather station for the years 2023 and 2022

<https://www.cpc.ncep.noaa.gov/products/timeseries/>

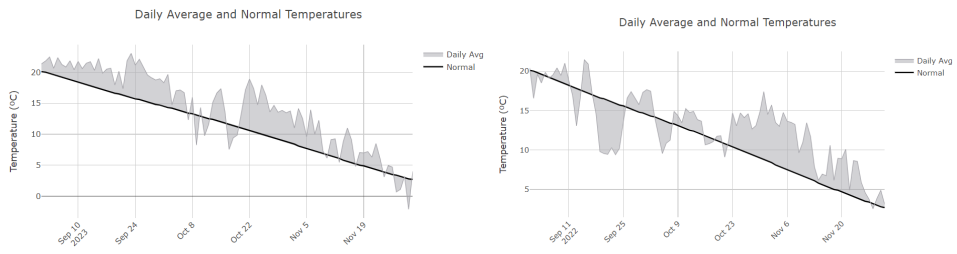


Fig.12 Graphs illustrating the evolution of daily average temperatures at the Tg. Jiu weather station for the years 2023 and 2022

<https://www.cpc.ncep.noaa.gov/products/timeseries/>

Upon studying the precipitation quantities at the two stations and comparing them to the specific climatological norms for the period, it is notable that they were below normal in 2023 at both stations throughout the entire autumn period. In contrast, during the autumn of 2022, this situation was observed only at the Craiova station in November.

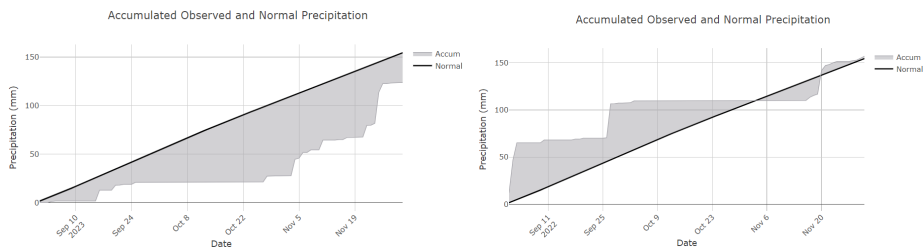


Fig.13 Graphs representing the evolution of daily accumulated precipitation at the Craiova weather station for 2023 and 2022

<https://www.cpc.ncep.noaa.gov/products/timeseries/>

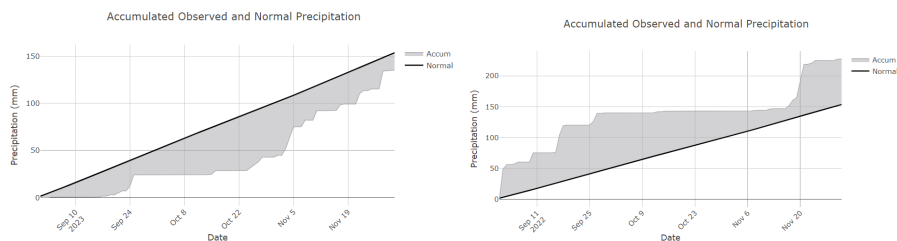


Fig.14 Graphs representing the evolution of daily accumulated precipitation at the Tg. Jiu weather station for 2023 and 2022

<https://www.cpc.ncep.noaa.gov/products/timeseries/>

CONCLUSIONS

Autumn 2023 was influenced by the positive deviation of the geopotential field at the 500 hPa level in the southern half of Europe and negative deviations in the northern half. At the surface level, the pressure field deviations were predominantly negative across the entire Europe. Thus, we had an autumn where the thermal deviation was positive, ranging between 1°C and 5°C.

From a pluviometric perspective, although the first two months of autumn had a deficit in precipitation, overall the accumulated precipitation quantities for the entire period (September–November) were close to the normal multi-year averages, as November was pluviometrically surplus.

At Craiova, the highest temperature deviation was on September 23, reaching 7.7°C, representing 45.8% of the normal value. In Târgu Jiu, the largest deviation occurred on September 23, with 7.15°C, representing 44.96% of the normal value.

Regarding precipitation, the deviations were negative at both analyzed stations, with the recorded quantities representing 48.39% in Târgu Jiu and 39.46% in Craiova of the climatological norms specific to the reference period.

Upon comparing the meteorological parameters (temperature and precipitation) for the autumns of 2023 and 2022, it was noted that the deviation of the average annual temperature across the country from the median of the reference period 1991 - 2020 increased in 2023 compared to 2022. Regarding the precipitation regime, it exhibited above-normal levels in September and November 2022, as well as in November 2023, in comparison to the median of the standard climatological interval (1991 - 2020).

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