HEAVY PRECIPITATION IN THE FĂGĂRAŞ MOUNTAINS, 1-4 JUNE, 1988

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Abstract: The heavy precipitation recorded in the ranges and sub-ranges of the Făgăraş Mountains between June 1–4, 1988 can be classified as extreme weather events. The purpose of this paper is to analyze the meteorological context in which these phenomena occurred. Classical methods of meteorological analysis were employed: the evolution of key meteorological parameters over the territory of our country, the barometric topographic maps from ground level and altitude, that were taken from the archives of the National Administration of Meteorology, and the GFS model (www.wetter3.de).

Keywords: precipitation, meteorological context, barometric centers

1. INTRODUCTION

June is the most unstable summer month. The days with atmospheric instability are mainly due to the intense air movement over the western Atlantic and to the Azores high ridge extending on the mainland, which allows the inflow of moist ocean air (polar or temperate) on the continent. This moisture comes in contact with the warmer air from our country's area and that can cause particular heavy precipitation (*Clima României, pg.38-40*). Cold frontal passages and the cold occluded fronts cause, especially in warm weather, atmospheric instability and the occurrence of associated phenomena. Precipitation is the weather factor with the most uneven territorial distribution for the analyzed area, due to the configuration of the relief standing in the way of air masses, to the slope inclination and orientation.

June is the richest month in precipitation, while the average monthly figure is 60-80 l/sqm in the Romanian Plain and Bârladului Plateau, 80-100 l/sqm in the Western Plain, Transylvania, north-east Moldovia and the Oltenia and Moldovian Subcarpathians, 100-120 l/sqm in the Western Hills, Maramures, Bucovina and Muntenia Subcarpathians and over 120 l/sqm in the Carpathians *(Clima României, pg. 250-251*).

Făgăraş Mountains - Description

The Făgăraş Mountains are part of the Southern Carpathians and stretch between the Piatra Craiului Massif and the Olt Defile, measuring from west to east about 70 km and from north to south about 45 km. The ridges in the north are shorter and steeper than the ones in the south, which are longer and smoother. In

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the north, they are separated from the Făgăraş Depression by a large abrupt tectonic escarpment. The difference in level is greater than 2,000 meters over a distance of only 8-10 km. Due to the more intense glacier erosion manifested in the northern part of the mountains, the valleys are generally short, rough, equidistant and have few branches. The northern branches are mostly steep and rocky near the crest, becoming smoother only where the height falls below 1700 m. The landscape in the high area bears the glacial imprint: glacial basins and valleys, with a U-shaped cross section, separated by sharp crests. In the lower half, the valleys are narrow and deep.

The hydrographic network: the large amount of precipitation led to the formation of a dense network of streams and drained valleys. Throughout the massif and in the basins under the crest, there are springs or lakes with clear water, where the snow lasts until late summer, sometimes remaining there from year to year. The alpine lakes that are located at high altitudes, feed the river streams to which they provide a constant flow. The waters from the Făgăraş Massif are included in two hydrographic basins: the Olt and the Argeş. Olt River gathers its waters from the northern slopes (about 30 branches). The Făgăraş Mountains are crossed by one of the richest river nets in the country, and many springs can be found at altitudes exceeding 2200 m. The rivers have quite large permanent flows, especially from May to July, when snow melting is more intense and when rainfalls are more abundant. An enormous amount of water is drained from the slopes, often causing flooding, because the river Olt cannot absorb this amount of water without overflowing the riverbed.

The massif is exposed to alpine climate conditions with subpolar influences, especially during the cold season. The temperature decreases as the altitude increases. The annual average temperature at the Bâlea Lake weather station (2070 m) is -2^{0}C. The highest maximum temperature recorded was of +24.8 ^{0}C (on 07/24/2007) and the lowest minimum temperature of -31.7 ^{0}C (03/01/2005). There are rare days when the sky is completely clear over the Făgăraş Mountains. The annual average precipitation quantity is of 1253.77 mm (average for period 1979-2010). In winter there are many avalanches which make the traffic on Transfăgărăşan, the alpine road which crosses the mountain since 1974, impossible.

2. THE INTENSITY OF THE PHENOMENA IN THE RANGE AND SUB-RANGE OF THE FĂGĂRAŞ MOUNTAINS

June 1: The weather was hot, with maximum temperatures up to 26^{0}C in the lowlands and between 6–20^{0}C in the mountains, but it became generally unstable. Heavy rainfall and scattered thunderstorms were reported. The amount of water recorded at Bâlea Lake was 12.8 l/sqm and the snow cover measured 94 cm.

June 2: The weather was cool and unstable; rain showers and thunderstorms were reported to fall on large areas. In the mountains there were mixed precipitations (rain and sleet during the night). The maximum temperatures did not exceed 22^{0}C in the lowlands and in the mountains they were between 4 and 10.8 ^{0}C. The minimum temperatures decreased in the mountains up to -0.2 ^{0}C, recorded at Bâlea Lake meteorological station. The water quantities were significant, generally exceeding 15 l/sqm, with a maximum of 38.7 l/sqm at Boiţa. The precipitation was abundant in the mountains, 70.8 l/sqm at Bâlea Lake. As a result of precipitation that fell under the form of rain and sleet, the snow cover decreased to 85 cm at Bâlea Lake.

June 3: The weather grew cooler and was unstable. The maximum temperatures increased to 14^{0}C in southern Transylvania, and the minimum to 11^{0}C. In the mountains, the maximum temperatures were between 0 and 7^{0}C, and the minimum between: -2 and 6^{0}C. Precipitation was reported on large areas, rain in the lowlands and mixed precipitation in the mountains, with snow above 2000 m altitude. Larger amounts of water were recorded at the following weather stations: Boiţa 22.6 l/sqm, Făgăraş 39.2 l/sqm. At Bâlea Lake there was reported the record amount of 195.6 l/sqm and 23 cm of fresh snow, the snow cover measuring 108 cm in total on June 3. The wind presented intensification in the mountain area, with blizzards in the high areas.

June 4: The weather got warmer, the maximum temperatures recorded 20^{0}C in southern Transylvania and the minimum temperatures got up to 11^{0}C. In the mountains, the maximum temperatures recorded were between 1.2 and 13.8^{0}C and the minimum temperatures dropped to 0.2^{0}C at Bâlea Lake. The rainfalls narrowed, but in the mountains there were large amounts of water, Bâlea Lake registered 102.2 l/sqm. Precipitation fell under the form of rain in the lowlands, was mixed in the mountains, and snow above 2200 m altitude. The wind intensified on the crests, and blizzards formed. The snow cover increased to 155 cm at Bâlea Lake. The total amount of water recorded between 06/01 and 06/04/1988, was 46.2 l/sqm in Sibiu, 65.4 l/sqm at Boiţa, 58.5 l/sqm in Făgăraş and **381.4 l/sqm** at Bâlea Lake.

3. THE SYNOPTIC AND MESOSCALE ANALYSIS

On 06/01/1988 at 00 UTC, the pressure field at ground level in the lower troposphere was low on most of the continent. Over the Scandinavian Peninsula, a 1005 mb cyclonic core of the Icelandic low was noted. In the west of the British Archipelago there was another core of 1000 mb. The Eastern and Southeastern Europe were also located in the low field, with a pressure of 1015 mb for Romania. The Azores high ridge was active in the south-western Europe (Fig.1). During that day, a cold maritime polar air mass descended on the front of the Azores high, on the north-western part, towards the Genoa Gulf. In contact with the existing tropical marine warm air, it caused the formation of a cyclone in the above mentioned region. The cyclonic core was located after 6 hours over the Adriatic Sea (with a core value of 1010 mb). The cyclone, with a 1005 mb core, moved on the T1 classic trajectory due to the baric configuration. The cyclone was located on the north-west part of Romania on June 1, 18 UTC, after realimentation and revitalisation over the Panonian Plain *(Bordei I., 2009).*

In the medium troposphere, at the 500 hPa level, a wide through which extended to the central-western basin of the Mediterranean Sea had two cut-off type cores incorporated: one located west of the British Archipelago (536 damgp) and the second on the north of the Scandinavian Peninsula (520 damgp). The south-western, eastern and south-eastern parts of the continent were under the influence of a ridge both in the barometric field and the thermal field, with geopotential values of 576 - 584 damgp and temperatures of -10^{0}C. Over Romania, the geopotential at 500 mb was situated within the monthly average of the period (572 damgp and -14^{0}C), our country being on the ascending part of the through elevation. During the day of June 1, the slight decrease (8 damgp) of the thermal and geopotential ridge in the south-eastern Europe allowed the advection of moist tropical sea air masses from the central-eastern basin of the Mediterranean Sea to our country, in the south-western component of air circulation.

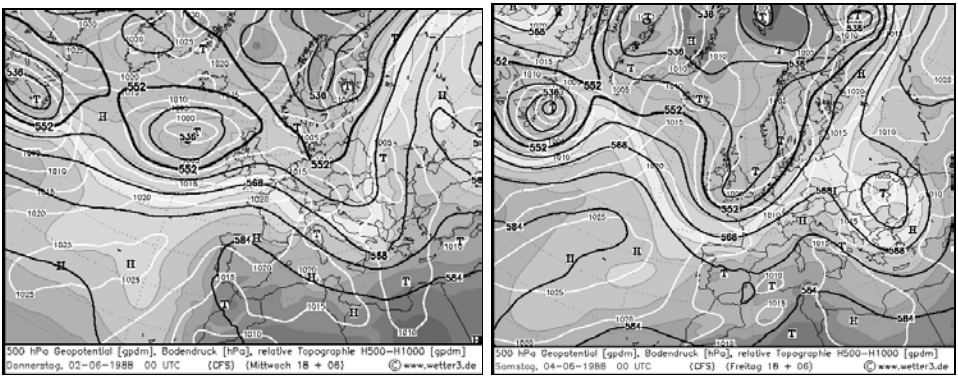

Figure 1. ***NCEP numerical model - analysis. Absolute topography at 500hp (dmgp, black lines), ground-level pressure (hPa, white lines) and relative topography 1000-500hp (dmgp, colors) - from June 2 at 00 UTC and June 4 at 00 UTC***

In the time interval June 2, 00 UTC and June 3, 00 UTC, the ground pressure in Romania decreased constantly. An important factor for the weather evolution was also the movement of the through from the medium troposphere to the east of the country, with a delay as compared the ground pressure field (Fig.1).

On June 2 at 00 UTC, at the 850 mb level, an increased frontal activity was obvious over the Romanian geographical space, associated with the mature cyclone, which went over the Beschizi Mountains (Fig.2). The core at that level showed a cyclonic west deviation from the core position on the ground. At the 700 mb level, the absolute barometric topographic map shows a deepening of the through on the western half of Romania.

At the 500 mb level, the eastern half of the country was still on the upward slope of the through elevation (contour line of 564 damgp), the axis of which was situated west of the country (Fig.2). After 12 hours (June 2 at 12.00 UTC), a cut-off type cold core was isolated in north-western Romania within this through, with a value of 556 damgp and temperature of -20^{0}C. In this synoptic context, our country and the Balkan Peninsula were still under the influence of an air movement from south-west, which favored the warm moist air advection from the Adriatic Sea to the ground and at altitude during June 2 (10^0C isotherm was positioned in the center of the country at 850 mb) (Fig. 2).

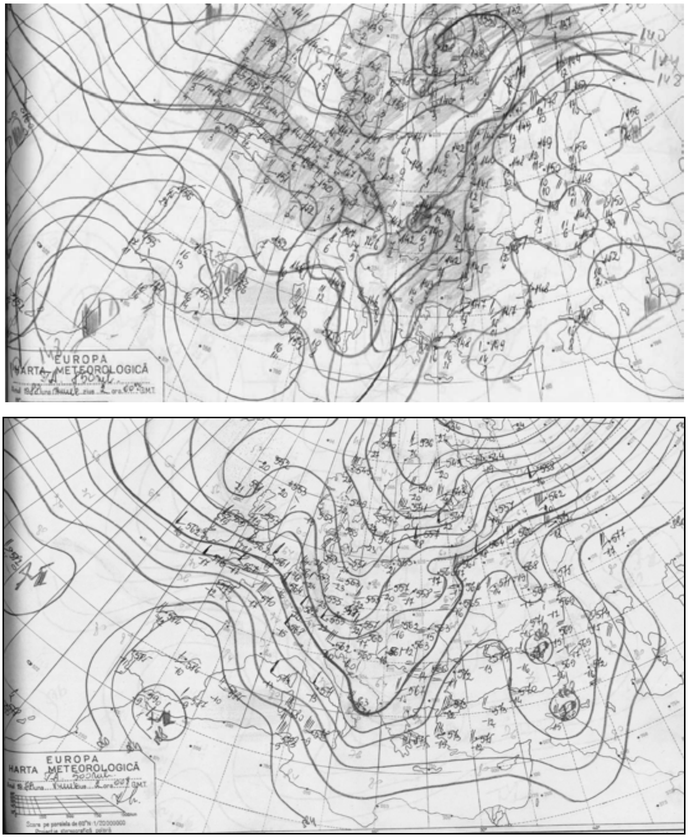

Figure 2. ***TA Maps at 850mb (geopotential field, wind, isotherms, fronts and atmospheric humidity areas), and 500 mb: geopotential field and wind: 06/02/1988 at 00 UTC (from National Administration of Meteorology archive)***

Our country was under the influence of fronts associated to the cyclone. In the first part of June 2, the evolution of phenomena was determined by the crossing of the warm front. Along with the altitude through that was approaching and the cold front at the ground level, the atmospheric instability grew. Thunderstorms were reported even in the warm sector of the cyclone. The forced upward movement on the massif slopes led to the development of vertical clouds of Cumulonimbus type and of associated phenomena. This is the imprint of the orography in the air flow, leading to an increased intensity of the weather phenomena.

On June 2, in the time interval 06-18 UTC, rainfall was reported to have fallen over extended areas, except for Oltenia and the south-eastern part of the country. The water quantity was up to 52 l/sqm in Moldavia, 40 l/sqm in Muntenia, 26 l/sqm in the Apuseni Mountains, 60 l/sqm in the Făgăraş Mountains, 32-34 l/sqm in the Bucegi Mountains and up to 50 l/sqm on the western slopes of the Eastern Carpathians; in the rest of the country, there were light rainfalls.

Between June 2 at 18 UTC and June 3 at 00 UTC, the mediteraneean cyclone ocludded over the Polish Plain. On the same time, a low field was located over southern Moldavia due to the falling of the tropopause (fig.4).The area of precipitation was limited towards the country's eastern half. Significant quantities of water were recorded in Moldavia (between 20 and 67 l/sqm), Muntenia (between 20 and 30 l/sqm, with a maximum of 44 l/sqm in Bucharest). Mountain precipitation was in the form of sleet; there were 96 l/sqm in the Făgăraş Mountains, 42-48 l/sqm in the Bucegi Mountains and Curvature Carpathians.

During the day of June 3, 1988, the cyclonic core located on southern Moldavia deepened to 998 mb, moved to nort-west part of the Black Sea east, where it remained for the next 24 hours, due to the blockage that was still exerted by the heat and geopotential ridge from the east part of the continent (576 damgp and temperature of -10 ^{0}C). The core evolved very little towards the filling stage, the value of geopotential at 850 mb increased by 2 damgp (Fig. 3).

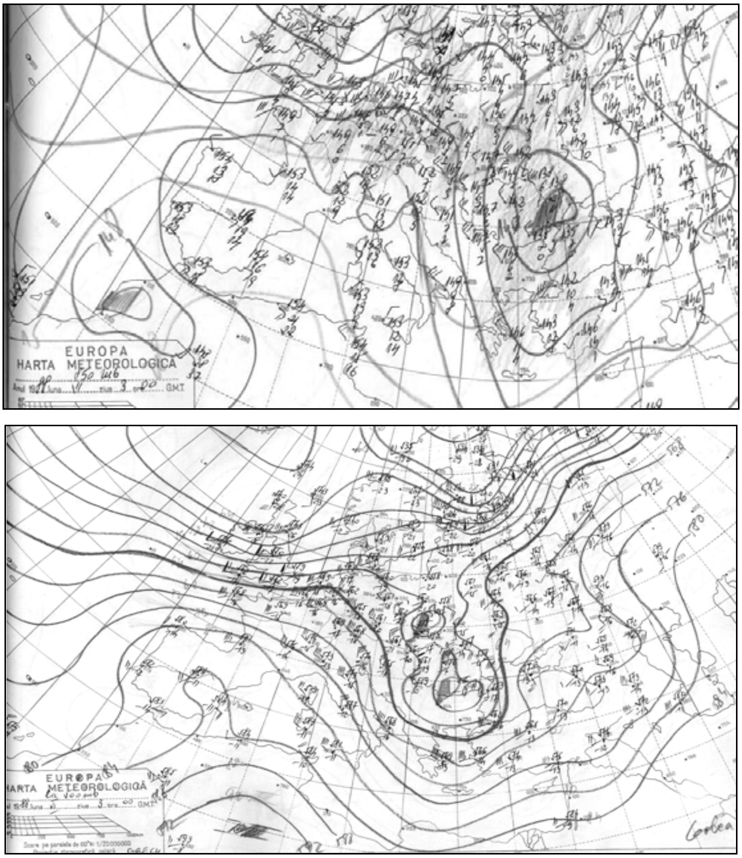

Figure 3. ***June 3,1988,00 UTC: TA maps at 850MB (geopotential field, isotherms, wind, and wet areas) and at 500 mb (geopotential field and wind)***

(from National Administration of Meteorology archive)

Due to the cold air advection on the front of the Azores High ridge, at the 500 mb level, the through continued to widen, its axis was oriented from north to south over Romania the cold core was located above the Southern Carpathians. The weather cooling continued, especially in the northern half of the country, due to a cold air advection of polar origin, the air movement at 500 mb was from the north. Between 850 mb and 700 mb the air movement shifted, towards north-west (at the 850 mb level the temperature decreased to 5 ^{0}C (Fig. 3).

Between 06-18 UTC, rainfall was reported over extended areas in Moldavia, Transylvania, the eastern part of Muntenia and Dobrogea, under the influence of the cyclonic regtion located on east Romania. Yet significant quantities of water were recorded in Moldavia and Dobrogea (up to 20 -25 l/sqm) and in the mountain area up to 40 l/sqm in Bucegi, and 100 l/sqm on the north side of the Făgăraş Mountains. In the mountain area, at over 2000 m altitude, snowfall was recorded.

On 06/04/1988 at 00 UTC, the ground pressure increased to 1010 mb in Transylvania. The 1005 mb cyclonic core located in south-western Ukraine had altitude correspondents along the entire tropospheric column (Fig. 1) and gradually entered the filling phase, which was completed only on June 6. In the interval between June 3 at 18 UTC and June 4 at 06 UTC there were light rain showers over large areas in Moldavia, eastern Muntenia, Transylvania and Dobrogea; in the Făgăraş Mountains there were 91 l/sqm and in the Bucegi Mountains 20 l/sqm.

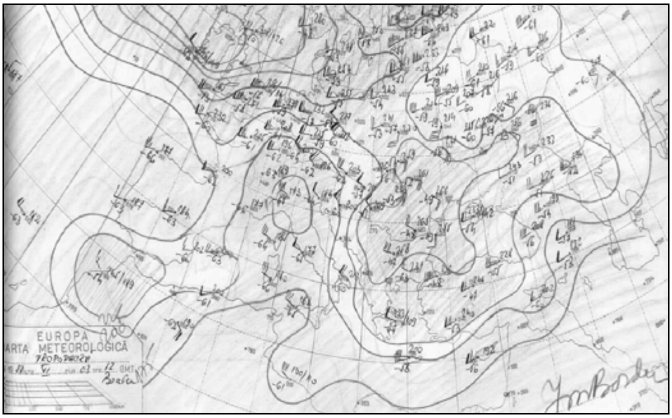

Figure. 4. ***The tropopause pressure field from: 06/03/1988 at 12 UTC***
(from National Administration of Meteorology archive)

On June 2, at 00 UTC, the pressure field analysis indicated the presence of tropical warm air over the country area in the tropopause. Over the next 12 hours, the polar tropopause was located on the western half of the country, and the high tropical tropopause moved to the south-east, so that the maximum tropopause folding area was oriented from the north-west towards the south-east part of the country. Due to the advancement of the Azores ridge towards the western part of Romania, the tropical warm tropopause extended towards the central-east Europe, and implicitly towards Romania, and the low, cold tropopause of polar origin migrated towards the south-east, having the lowest value over the west part of the Black Sea *(Moore J.T., 1999),* (Fig.4).

4. CONCLUSION

The severe weather episode from 1 to 4 June 1988, which generated heavy rainfall on the north side of the Făgăraş Mountains, can be attributed to the well-organized cyclonic activity along the tropospheric column. In terms of weather, the territory of our country was first influenced by a low of Mediterranean origin, that followed the T1 classic trajectory and then occluded over the Polish Plain. The trajectory of the mediterranean cyclone was influenced by the medium troposphere structure and the lifetime by the subjacent surface *(Bordei I.,2009).* Weather evolution over Romania on the next days was influenced by the cyclone located first over southern Moldavia, than in the east.

The cyclogenetic ground activity was associated with a medium troposphere through powered from high troposphere by the cold air penetration marked by the decrease of the tropopause level.

In the area of interest, the orographic forcing, the orientation of slopes, the opening of the valleys to the mesoscale airflow put their mark on the intensity of phenomena, thus causing heavy rains on the north side of the Făgăraş Mountains.

To understand the consequences that certain weather situations have, it is necessary to analyze the upper tropospheric layer structures up to the tropopause level, too, as the information from the lower layers of the troposphere are not ample enough for the purpose.

The presented case fit in the modern theory regarding the intrusion of tropospheric cold air or stratospheric dry air into the lower troposphere, wich determine similar cyclogenetic processes.

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