11th European Conference on Severe Storms, Bucharest Romania – 8 to 12 May 2023

Extreme rainfall in Karlovo valley

Boryana Markova[1], Krasimir Stoev[1], Viktoria Kleshtanova[1,2], and Anastasiya Kirilova[1]

[1]National Institute of Meteorology and Hydrology, Sofia, Bulgaria
email: boryana.markova@meteo.bg
[2]Faculty of Physics, Sofia University, Bulgaria

INTRODUCTION

The heavy rainfall in the western part of Karlovo municipality leads to a broken dam on the Stryama River and a partial state of emergency for all western villages: Rozino, Slatina, Stoletovo, Karavelovo and Bogdan, announced early in the morning on September 2, 2022. The material damage is significant: the village of Bogdan is completely flooded and cut off from land, houses destroyed, bridges washed away, roads impassable, railway transport stopped, as well as electricity supply, water supply cut off (photos). About 20 people were rescued by helicopter from the most affected village of Bogdan, and many from the other villages were evacuated by boat.

Photos from www.24chasa.bg

AIM

The aim of the present work is synoptic analysis of a precipitation situation in early September 2022, which led to significant damage to settlements in the Karlovy valley with recorded 24-hour rainfall amounts of 200 mm.

SYNOPTIC CLASSIFICATION

From 1906 to 2022, 31 cases of precipitation with a daily total sum of more than 60 mm were observed (Table 1 and 2, and Fig. 1). Synoptic conditions were analyzed for 20 cases from 1906 to 1975. The National Centers for Environmental Prediction (NCEP, www.wetterzentrale.de/topkarten/fsres.2eur.html) reanalysis archive was used for the analysis. This analysis was used for manual circulation classification.

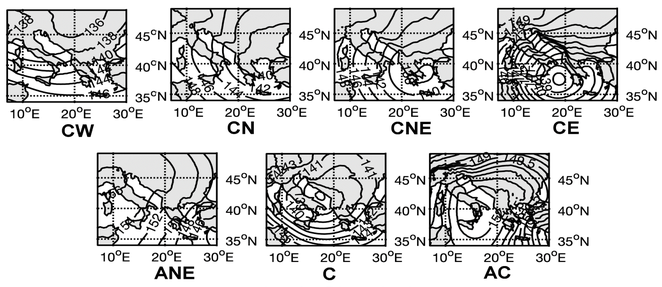

Fig. 1. Circulation type

Table 1.

Circulation type	Number of days
C	6
CNE	11
CW	2
CN	2
CE	1
AC	2
ANE	7

For the period from 1975 to 2022 software from Cost733class was used. Cost733class software version 1.2 (Philipp et al., 2016) is a software package for creating, comparing, visualizing and evaluating meteorological and circulation type classifications.

The circulation classification with ten types includes: eight main types of directions (W, SW, NW, N, NE, E, SE and S); one cyclonic type (C); and one anticyclonic type (AC). For the 26 circulation types, there are two additional groups: eight types of anticyclonic direction (AW, ASW, ANW, AN, ANE, AE, ASE and AS) and eight types of cyclonic direction (CW, CSW, CNW, CN, CNE , CE, CSE and CS).

❖ *The 11 of 31 cases was observed in CNE circulation.*

Table 2. Amount of precipitation over 60 mm according to NIMH data.

data	mm	type
5.6.1906	82	CNE
20.8.1906	69	CW
19.7.1914	62	CNE
29.6.1915	65	CNE
20.7.1915	72	CNE
2.9.1916	104	CNE
10.8.1926	116	ANE
24.6.1932	62	CNE
1.8.1935	66	ANE
4.7.1939	68	ANE
5.9.1944	72	AC
6.9.1944	89	ANE
25.6.1947	66	CNE
20.8.1949	72	CN
7.7.1955	69	CNE
4.7.1956	78	CNE
27.6.1957	98	ANE
15.7.1968	64	CW
7.9.1969	85	ANE
15.8.1981	60	CE
15.6.1983	64	C
24.5.1985	86	AC
17.7.1998	104	ANE
13.7.2005	72	CN
28.7.2014	126	C
3.9.2014	73	C
6.9.2014	74	C
16.9.2014	64	C
28.9.2015	71	CNE
16.7.2016	118	C
2.9.2022	227	CNE

SYNOPTIC SITUOATION ON 2.09.2022

On 31 August 2022, a baric trough descends to the Central Mediterranean at an isobaric surface height of 500 hPa from the north, which on 1 and 2 September moves to the east and affects the weather of the Balkan Peninsula (Fig.2). On September 1 and 2, 2022, during the passage of the frontal system associated with the Mediterranean cyclone, a convergence zone is created in Central Bulgaria (type circulation CNE, Fig. 1). Cool air invades from the east-northeast and creates conditions for the development of thunderstorms.

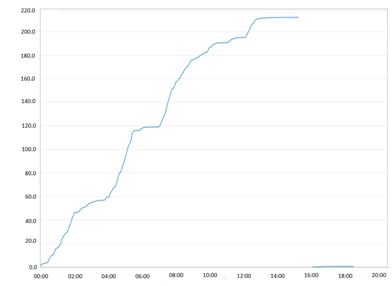

Fig.3. Amount of precipitation in mm at Klisura precipitation measuring station from 00:00 (UTC+03:00) to 20:00 (UTC+03:00) on 2.09.2022.

In the rain gauge station Klisura, from the automatic observation system of the NIMH, the precipitation is insignificant before 00:00 (UTC+03:00). In two hours, the amount of precipitation is more than 40 mm, and in the next almost 4 hours, another 80 mm was recorded, until about 06:00 (UTC+03:00), the total amount is nearly 120 mm (Fig.3). After a temporary interruption (until around 07:00 (UTC+03:00)) the precipitation continued and at 15:00 (UTC+03:00) the amount is already 221 mm (Fig. 4).

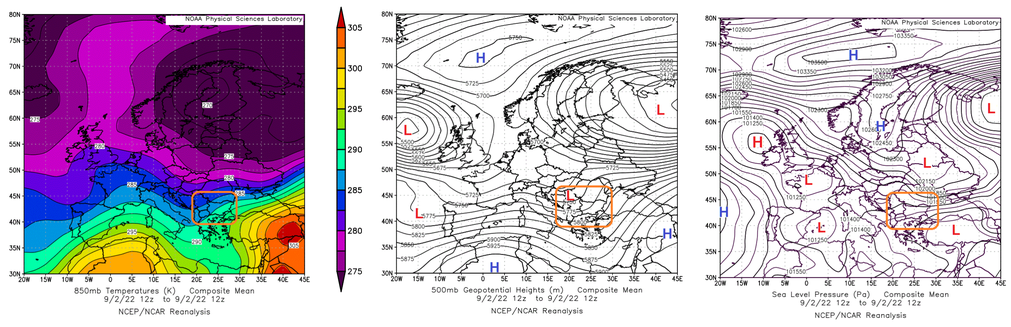

Fig.2. 500 hPa Geopotential height, 850 hPa temperature and mean sea level pressure with marked lows (L) and highs (H) on 02.09.2022 at 12 UTC; red contours – Bulgaria. https://psl.noaa.gov/data/composites/hour

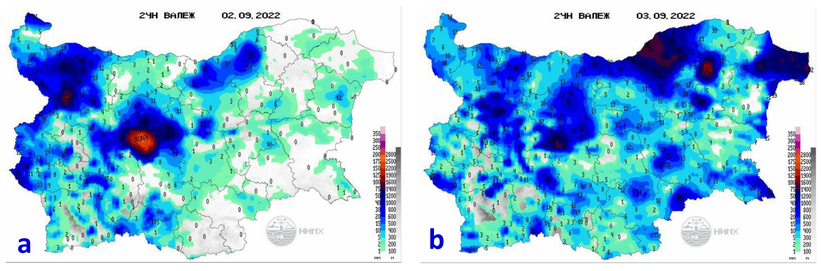

Fig. 4. Amount of precipitation from a) 01.09.2022 at 08 (UTC+03:00) to 02.09.2022 at 08 (UTC+03:00) and b) 02.09.2022 at 08 (UTC+03:00) to 03.09.2022 at 08 (UTC+03:00) according to NIMH operational data. The color scale shows the amount of precipitation, and the grey scale shows the altitude.

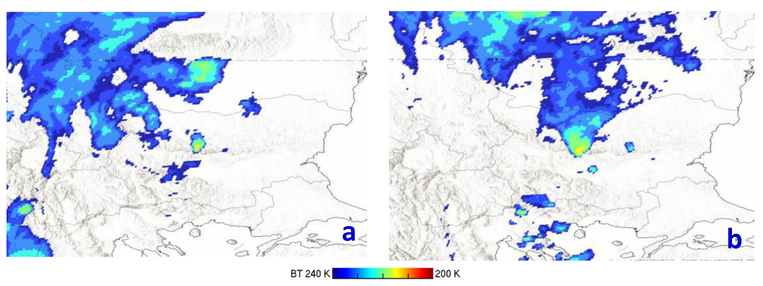

Fig. 5. IR 10.8 Image on 02.09.2022 at a) 03 UTC and b) 09 UTC, https://eumetrain.org/.

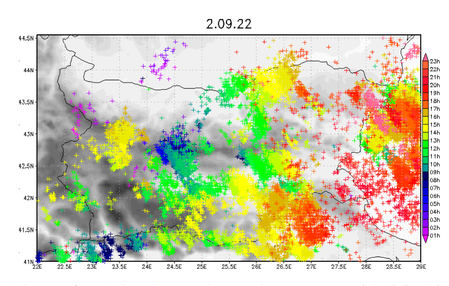

Fig. 6. Flashes location on 02.09.2022 according to operational data of ATDnet.

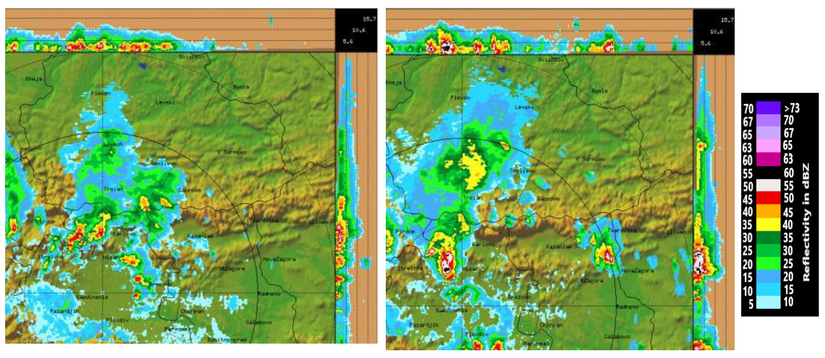

Fig. 7. Radar reflectivity from meteorological radar located at Golyam chardak, district of Plovdiv, Agency Hail Suppression on 02.09.2022 at a) 07:00 (UTC+03:00) and b) 12:06 (UTC+03:00).

Table 3. Classification functions and skill scores POD and FAR at the discrimination between severe (F > 0) and non-severe storms (F < 0).

Function	POD	FAR
F=0.0004*CAPE-0.2988*Li+0.0167*K-1.4965	0.87	0.38

The classification function F (Table 3) was calculated using the proximity sounding from Klisura, a town situated near to the region where the thunderstorms occurred.

The development of clouds were traced from satellite images (enhanced IR 10.8). The precipitation area that caused the flash flood remained in the Karlovo area for 16 hours (according to the satellite images from 21 UTC on 01.09.2022 to 12 UTC on 02.09.2022) (Fig. 5 and 7).

In the late afternoon of 1 September 2022, cumulonimbus were developed. At 21 UTC there was intensive rainfall that continues until about 06 UTC on 2 September.
Significant amounts were registered in the early morning hours (Fig. 4a) when active thunderstorm activity was also observed (Fig. 6). The maximum radar reflectivity was 50 dBz (Fig. 7a).
On 2 September 2022, precipitation in the area continued (Fig. 4b). Around noon developed thunderstorms and the maximum reflectivity of the cloud cell was 60 dBz (Fig. 7b).

The environmental conditions were analyzed. For the present study using the proximity aerological sounding (model GFS http://ready.arl.noaa.gov) at 0000, 0600, 1200 and 1800 UTC, the next classification function F (Ivanov et al., 2016) combination of three instability indices (CAPE, Lifted Index and K Index, see Table 3 and 4) was calculated.

Table 4.

DATA	UTC	CAPE	Li	K	F
1.09.2022	0	0.0	4.3	30	-2.28
1.09.2022	6	0.0	3.2	31	-1.93
1.09.2022	12	383.0	-1.3	33	-0.41
1.09.2022	18	0.0	2.5	35	-1.66
2.09.2022	0	0.0	3.3	33	-2.05
2.09.2022	6	0.0	0.6	33	-1.6
2.09.2022	12	244.0	-1.1	34	-0.5
2.09.2022	18	0.0	3.3	33	-1.93

❖ *These results demonstrate that additionally "special" combinations of atmospheric thermodynamic characteristics are required for the development of extreme rainfall. Due to the limited number of the studied cases, the results presented here have to be considered only as a first step to the study of the environmental conditions at the development of heavy rainfall over Bulgaria.*

REFERENCES

Ivanov, I., Ivanova, V., Markova, B., 2016: Intensive precipitation and flood in northeastern Bulgaria on 19 of June 2014, doi:10.17378/AWC2016_25

Philipp, A., Beck, C., Huth, R., and Jacobeit, J., 2016: Development and comparison of circulation type classifications using COST733 dataset and software. Int. J. Climatol. 36, 2673–2691. doi: 10.1002/joc.3920