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A BLIZZARD EPISODE IN OLTENIA (S-W ROMANIA)

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ABSTRACT. Blizzard phenomena is a complex atmospheric event, in which the snow that falls or has fallen is blown away by the wind, so that the visibility decrease significant enough and the assessment of the simultaneous snow fall is impossible (Țîșlea, D. et al. 1965). The region of Oltenia is featured by a climate with Mediterranean influences, with the dominance of northwest and east winds (Roșu, Al. Et al. 1971). The contact between the cold and the warm air masses leads to the increase of the horizontal baric gradient, which causes strong wind intensification. Due to the geographical position of the Carpathian chain, the penetration of colder and denser air is directed towards the east and the south of Romania, thereby has an impact on the study area (***Climate of Romania 2008). Out of all the natural phenomena during the cold season, blizzard is by far the most versatile, with a heavily impact on society and environment (Teodoreanu 2004). The purpose of this paper is to emphasize the hydro-meteorological outcome of the 2018 blizzard episode from February 24^{th} to March 2^{nd}. In order to achieve this, we will identify the spatial and temporal variability of the hazard in the region of Oltenia, the atmospheric mechanism of this late blizzard occurrence, its climatic characteristics and the consequences on the rivers runoff regime. We will analyze the synoptic conditions under which the blizzard appeared, the recorded meteorological data and a series of hydrological data from the stations located on the main rivers (Jiu, Olt and Danube) in order to determine the synoptic weather pattern, the successive number of days with blizzard, the dominant direction and the average and maximum wind speed, the average and maximum amount of precipitation, as well as for the thickness of snow layer and the daily liquid levels and flows.

Keywords: Oltenia, blizzard, precipitation, snow

1. THE SYNOPTIC CONDITIONS

The 2018 Oltenia blizzard episode from February 24^{th} to March 2nd was a typical meteorological phenomenon for this region and had its maximum intensity in this area on February 26^{th} and 27^{th}.

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The weather was colder than usual for the end of the second month of the year, as from a few days before the blizzard. This situation happened due to the ingress of a cold air mass of continental polar origin (Fig. 1), related to a wide extension over Central and Eastern Europe, therefore over Romania too, of the Scandinavian Anticyclone. The presence of this high-pressure area over Romanian territory represented the first necessary ingredient for the blizzard phenomenon to manufacture.

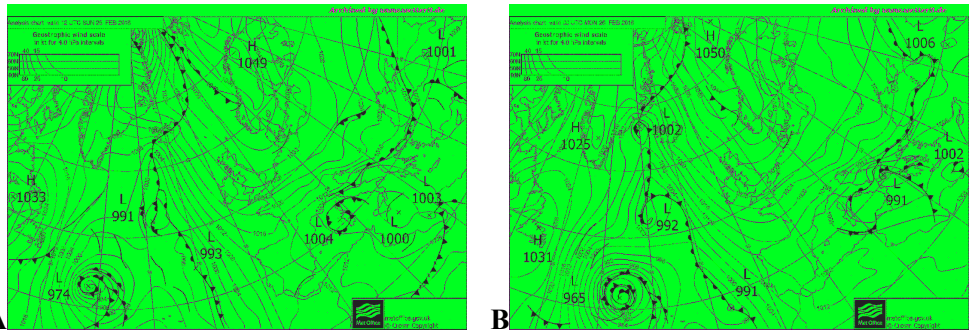


Fig. 1. ***Synoptic context at ground level over Europe for 2018 February*** 25^{th} ***(A) and*** 26^{th} ***(B) (source: http://www1.wetter3.de/Archiv/)***

The Omega type blockage (Fig. 2) favored the large expansion in time and space of the cold air mass, which initially due to the low moisture intake did not cause significant precipitation. This blocking circulation has the potential to intensify the phenomena up to the threshold of severe weather.

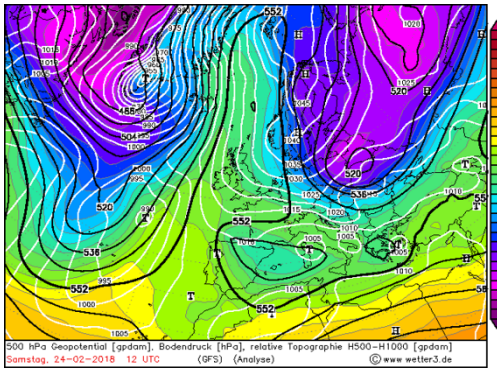


Fig. 2. ***Geopotential at 500 hPa level (black lines), ground pressure (white lines) and geopotential difference between 500 and 1000 hPa levels over Europe for 2018 February*** 24^{th}***(source: http://www1.wetter3.de/Archiv/)***

The phenomena, namely: heavy snowfall and wind gusts, have become more frequent since February 26^{th} morning and during most of that day. This development was possible due to the coupling between the anticyclone already established over our country and the Mediterranean cyclone arisen in the eastern basin of the Mediterranean Sea, that traveled on a classical trajectory to the Black Sea basin, gradually crossing the southern half of our territory (Fig. 3).

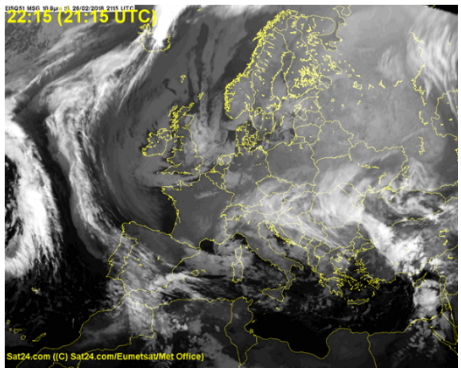
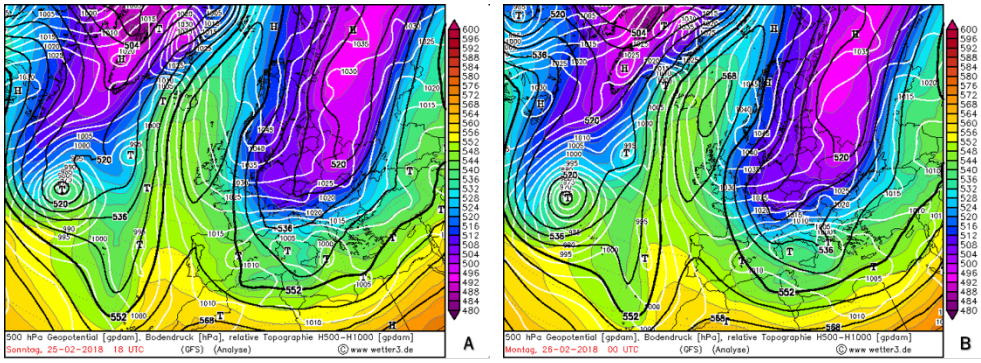


Fig. 3. ***Satellite image over Europe for 2018 February 26th, 21:15 UTC (source: www.wetterzentrale.de)***

The organization of these cyclones is the second needed ingredient for the blizzard occurrence. They are responsible for the advection of warmer and humid air masses (Fig. 5.) that entail heavy rainfall on their route up to the moment of occlusion.



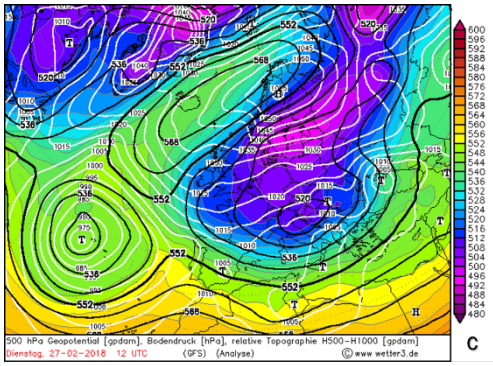


Fig. 4. ***Geopotential at 500 hPa level (black lines), ground pressure (white lines) and geopotential difference between 500 and 1000 hPa levels over Europe for 2018 February 25th (A), 26th (B) and 27th (C) (source: http://www1.wetter3.de/Archiv/)***

According to the atmospheric soundings below it can easily be observed the following: the existent cold air mass close to the surface; wind direction dominant from the east near the surface, fitting the specific trajectory of the cyclone, parallel

with the west-south-west direction in the upper atmosphere; the humid air intrusion from around 800m altitude (900 hPa level).

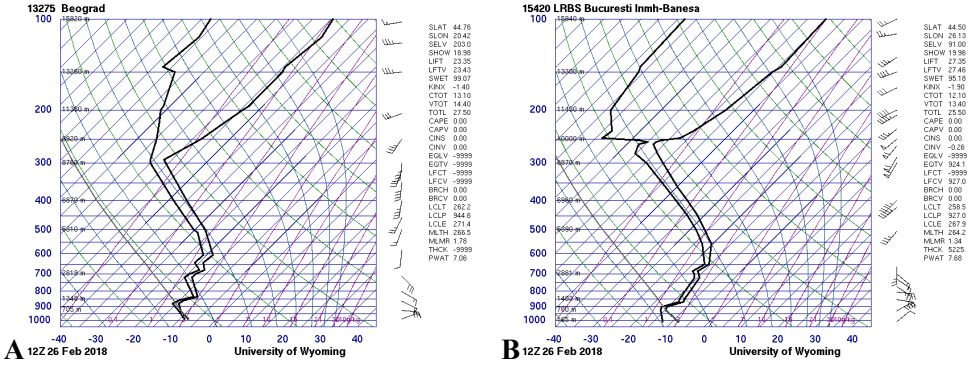


Fig. 5. ***Atmospheric soundings for 2018 February 26^{th}, 12 UTC in Belgrade (A) and Bucharest (B) (source: http://weather.uwyo.edu/upperair/sounding.html)***

According to the classification of the seven baric types that favor the development of blizzards in Romania, this episode can be classified as type I, which involves the existence of an anticyclonic belt in the north or northeast of Romania and the evolution of a depression baric field in the Mediterranean basin. This is also the most frequent and in the same time specific baric pattern of blizzard appearance in our country.

2. METEOROLOGICAL DATA

The recorded meteorological data used in our analysis, were the hourly values for the dominant wind direction, wind speed and snow layer thickness and the three hours precipitation amount.

We have taken under consideration four relevant meteorological stations from Oltenia area: Craiova, Slatina, Caracal and Drăgășani. In the tables below it can be observed the evolution during February 26^{th} and 27^{th}, when the event was at its maximum intensity.

In Table 1 for Craiova meteorological station, shortly after begging of the blizzard the snow layer was 7 cm and by the end of the event touched 46 cm. Wind direction during these two days was mostly east, east-northeast and the wind speed reached maximum in the evening of February 26^{th}.

In Table 2 for Slatina meteorological station, when the blizzard intensified the snow layer was 6 cm and the second day reached 50 cm. Wind direction during these two days was from east sector and the wind speed maximum was at the beginning of the event.

Table 1. ***Meteorological data for Craiova meteorological station for February 26^{th} and 27^{th} (source: Romanian National Meteorological Administration)***

Hourly weather data - Craiova meteorological station						Hourly weather data - Craiova meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow			Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)	Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/26/2018	00	ENE	5.5	0.7	7	2/27/2018	00	ESE	5.9	2.6	34
2/26/2018	01	ENE	8.2			2/27/2018	01	ESE	3.4		36
2/26/2018	02	ENE	6.8			2/27/2018	02	ESE	2.8		38
2/26/2018	03	E	5.2	1.0	7	2/27/2018	03	SE	2.3	1.6	41
2/26/2018	04	ENE	5.5			2/27/2018	04	ESE	2.5		43
2/26/2018	05	ENE	8.8			2/27/2018	05	ESE	2.8		44
2/26/2018	06	ENE	6.3	0.8	7	2/27/2018	06	ESE	3.1	1.2	44
2/26/2018	07	E	6.8			2/27/2018	07	SSE	2.5		46
2/26/2018	08	E	9.4			2/27/2018	08	S	1.4		49
2/26/2018	09	ENE	7.3	1.7	10	2/27/2018	09	SE	0.7	1.8	50
2/26/2018	10	ENE	5.9		11	2/27/2018	10	E	1.8		50
2/26/2018	11	ENE	7		13	2/27/2018	11	ESE	2		50
2/26/2018	12	ENE	6.9	2.8	15	2/27/2018	12	SE	1.9	0.5	50
2/26/2018	13	E	7.3		15	2/27/2018	13	ESE	1.9		48
2/26/2018	14	E	6.6		17	2/27/2018	14	ESE	2.4		48
2/26/2018	15	E	7.3	2.2	19	2/27/2018	15	ESE	2.3	0.0	47
2/26/2018	16	E	6.3		21	2/27/2018	16	E	2.4		46
2/26/2018	17	E	8		21	2/27/2018	17	ESE	3.1		46
2/26/2018	18	E	7.6	1.0	22	2/27/2018	18	E	2.7	0.0	46
2/26/2018	19	E	10.1		23	2/27/2018	19	ENE	2.2		
2/26/2018	20	E	7.1		26	2/27/2018	20	E	4.1		
2/26/2018	21	ESE	5.8	1.4	29	2/27/2018	21	E	5.1	0.1	46
2/26/2018	22	E	6.4		30	2/27/2018	22	E	5.6		
2/26/2018	23	ESE	4.7		32	2/27/2018	23	E	3.3		

Table 2. ***Meteorological data for Slatina meteorological station for February 26^{th} and 27^{th} (source: Romanian National Meteorological Administration)***

Hourly weather data - Slatina meteorological station						Hourly weather data - Slatina meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow			Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)	Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/26/2018	00	E	5.4	0.6	6	2/27/2018	00	ENE	3.4	2.2	17
2/26/2018	01	ENE	5.3			2/27/2018	01	E	2.7		18
2/26/2018	02	ENE	7.7			2/27/2018	02	ESE	2.7		19
2/26/2018	03	E	8.3	0.7	7	2/27/2018	03	ESE	2.9	1.6	20
2/26/2018	04	E	8.5			2/27/2018	04	SE	2.5		22
2/26/2018	05	ENE	7.6			2/27/2018	05	SE	2.9		24
2/26/2018	06	ENE	6.3	0.3	6	2/27/2018	06	ESE	2.3	1.0	25
2/26/2018	07	E	7.3			2/27/2018	07	SE	2.7		26
2/26/2018	08	ENE	7.3			2/27/2018	08	SSV	1.7		28
2/26/2018	09	ENE	7.1	0.4	6	2/27/2018	09	SSE	2.3	2.0	29
2/26/2018	10	ENE	7.7		6	2/27/2018	10	S	2.5		31
2/26/2018	11	ENE	6.9		8	2/27/2018	11	SSV	2.3		32
2/26/2018	12	ENE	7.3	1.7	9	2/27/2018	12	SV	1.9	1.9	33
2/26/2018	13	ENE	5.2		9	2/27/2018	13	SSE	0.7		34
2/26/2018	14	ENE	4.9		10	2/27/2018	14	V	0.8		34
2/26/2018	15	E	6	1.9	11	2/27/2018	15	SE	1.3	0.5	34
2/26/2018	16	E	5.4		11	2/27/2018	16	ESE	1.6		33
2/26/2018	17	E	5.4		11	2/27/2018	17	SE	3.1		33
2/26/2018	18	E	4.7	1.4	12	2/27/2018	18	ESE	2.2	0.0	32
2/26/2018	19	E	3.9		12	2/27/2018	19	E	2.2		
2/26/2018	20	E	5.4		13	2/27/2018	20	ESE	2.4		
2/26/2018	21	E	4.4	1.8	14	2/27/2018	21	E	3.2	0.2	
2/26/2018	22	ENE	4.6		15	2/27/2018	22	ENE	2.9		
2/26/2018	23	E	5		16	2/27/2018	23	E	4.3		

In Table 3 for Caracal meteorological station, shortly after begging of the blizzard the snow layer was 11 cm and the second day reached 35 cm. Wind direction during these two days was also from east sector and the wind speed maximum was on the first day of the high intensity event.

Table 3. ***Meteorological data for Caracal meteorological station for February 26^{th} and 27^{th} (source: Romanian National Meteorological Administration)***

Hourly weather data - Caracal meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/26/2018	00	E	6.7	0.8	11
2/26/2018	01	E	8.3		
2/26/2018	02	E	8.1		
2/26/2018	03	E	7.5	0.8	11
2/26/2018	04	E	8.2		
2/26/2018	05	E	8.4		
2/26/2018	06	E	7.1	0.4	12
2/26/2018	07	E	7.6		
2/26/2018	08	E	8		
2/26/2018	09	E	8	0.4	12
2/26/2018	10	E	7.3		12
2/26/2018	11	E	7.3		13
2/26/2018	12	E	6.4	1.4	14
2/26/2018	13	E	6.9		14
2/26/2018	14	E	6.3		14
2/26/2018	15	E	4.9	1	15
2/26/2018	16	E	6.6		15
2/26/2018	17	E	7.7		16
2/26/2018	18	E	7.9	1.6	17
2/26/2018	19	E	6.1		17
2/26/2018	20	E	5.7		17
2/26/2018	21	E	5.4	1	19
2/26/2018	22	E	5.3		19
2/26/2018	23	ESE	3.8		20

Hourly weather data - Caracal meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/27/2018	00	ESE	2.2	2.2	22
2/27/2018	01	E	4.2		24
2/27/2018	02	E	4.8		25
2/27/2018	03	ESE	4	1.0	27
2/27/2018	04	ESE	6.5		28
2/27/2018	05	SE	1.9		29
2/27/2018	06	SE	1.8	1.5	31
2/27/2018	07	SE	1.5		32
2/27/2018	08	SE	0.9		33
2/27/2018	09	SE	1.6	1.6	33
2/27/2018	10	ESE	2.3		34
2/27/2018	11	ESE	4.4		35
2/27/2018	12	ESE	5.6	1.4	35
2/27/2018	13	ESE	4.4		35
2/27/2018	14	ESE	4.4		35
2/27/2018	15	ESE	3.5	0.2	35
2/27/2018	16	E	3.7		35
2/27/2018	17	ESE	2.9		34
2/27/2018	18	ENE	3.3		34
2/27/2018	19	ENE	3.1		34
2/27/2018	20	E	3.4		
2/27/2018	21	E	7.7		
2/27/2018	22	E	8.1		
2/27/2018	23	E	6.7		

In Table 4 for Drăgășani meteorological station, shortly after begging of the blizzard the snow layer was 9 cm and the second day reached 29 cm.

Table 4. ***Meteorological data for Drăgășani meteorological station for February 26^{th} and 27^{th} (source: Romanian National Meteorological Administration)***

Hourly weather data - Drăgășani meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/26/2018	00	ENE	6.6	0.9	9
2/26/2018	01	E	6		
2/26/2018	02	E	5.7		
2/26/2018	03	E	6.2	1.0	10
2/26/2018	04	E	6.1		
2/26/2018	05	E	5.1		
2/26/2018	06	E	4.6	1.1	11
2/26/2018	07	E	4.8		
2/26/2018	08	E	5.4		
2/26/2018	09	E	4.7	0.6	12
2/26/2018	10	E	4.2		12
2/26/2018	11	E	5.3		12
2/26/2018	12	E	8.5	0.5	13
2/26/2018	13	E	7.7		13
2/26/2018	14	E	7.9		14
2/26/2018	15	E	6.7	0.9	14
2/26/2018	16	E	7.2		14
2/26/2018	17	E	6.3		15
2/26/2018	18	E	6.5	1.3	15
2/26/2018	19	ESE	4.8		15
2/26/2018	20	ESE	5.4		16
2/26/2018	21	ESE	2.6	1.6	16
2/26/2018	22	ESE	3.6		16
2/26/2018	23	E	2.9		17

Hourly weather data - Drăgășani meteorological station					
		Wind		Precipitation for 3 hours	Layer of snow
Date	Hour	Direction (°)	Speed (m/s)	(mm)	(cm)
2/27/2018	00	E	4.2	0.9	17
2/27/2018	01	ENE	5.7		18
2/27/2018	02	E	5.6		19
2/27/2018	03	E	4.7	2.0	20
2/27/2018	04	SE	3.1		20
2/27/2018	05	SSE	2.4		21
2/27/2018	06	S	2.7	3.4	23
2/27/2018	07	SSV	1.7		25
2/27/2018	08	SSV	2.5		27
2/27/2018	09	SSV	2.6	2.2	28
2/27/2018	10	SSV	1.9		28
2/27/2018	11	S	1.1		29
2/27/2018	12	S	1.5	1.7	29
2/27/2018	13	S	2		29
2/27/2018	14	SE	1.5		28
2/27/2018	15	SE	0.9	0.0	27
2/27/2018	16	S	1.6		26
2/27/2018	17	SE	1.6		26
2/27/2018	18	SE	4.3	0.1	26
2/27/2018	19	ESE	2.7		
2/27/2018	20	E	2.4		
2/27/2018	21	E	5.2	0.2	
2/27/2018	22	E	6.3		
2/27/2018	23	E	8.7		

Wind direction during these two days was mostly east, east-southeast and the wind speed reached maximum in the afternoon of February 26^{th}.

All of the information regarding the thickness of the snow layer from the tables above can be much easily observed in Fig. 6 below.

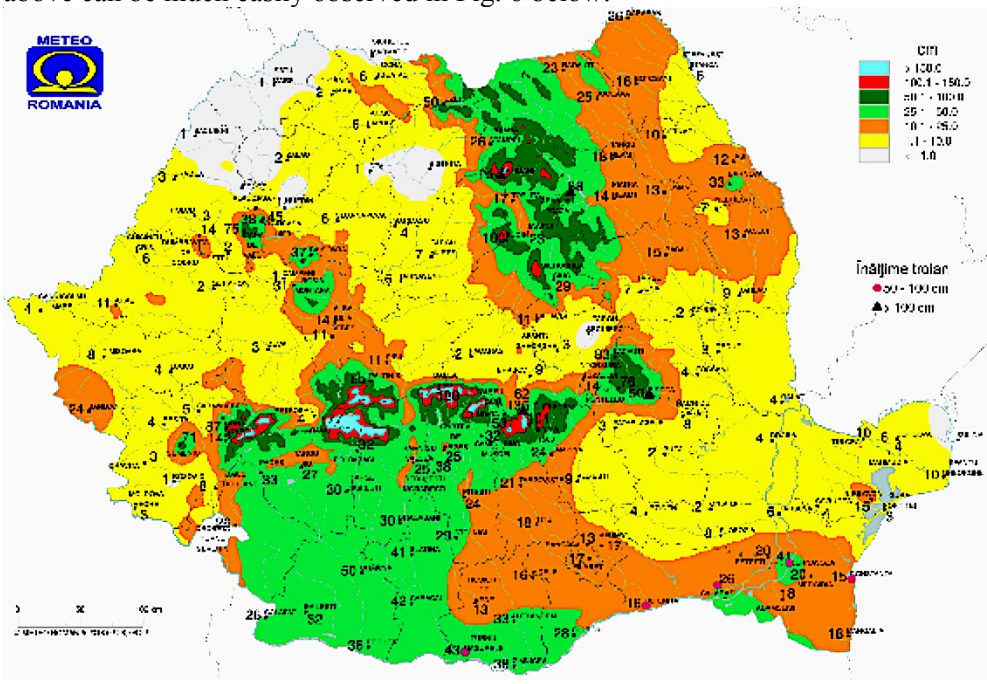


Fig. 6. ***Snow layer in Romania for 2018 February*** 28^{th}***, 06 UTC (source: Romanian National Meteorological Administration, www.meteoromania.ro)***

3. HYDROLOGICAL DATA

Regarding the hydrological data, they come from a series of hydrometric stations, located on the rivers in the Oltenia region, namely Jiu, Olt and Danube. There were taken under analysis the followings: average and maximum daily liquid levels and flows, as well as the recorded amount of precipitation during the research time span. The eleven hydrometric stations considered are: Rovinari, Filiași, Podari, Zaval (on the Jiu River); Râmnicu Vâlcea, Oteteliș, Reșca (on the Olt river); Gruia, Calafat, Bechet, Corabia (on the Danube river).

In the graphical representations of the liquid levels (Fig. 7. and Fig. 8.) is to be observed a similar, constant, without major changes evolution for both maximum and average levels, for all eleven stations. The highest levels were recorded at the following stations on the Danube River: Gruia and Bechet, and for the Jiu and Olt Rivers: Podari and Reșca. At the opposite side, the lowest levels were at the Osteteliș station on the Olt River.

All recored levels between February 24^{th} and March 3^{rd} were lower than the established defense quotas.

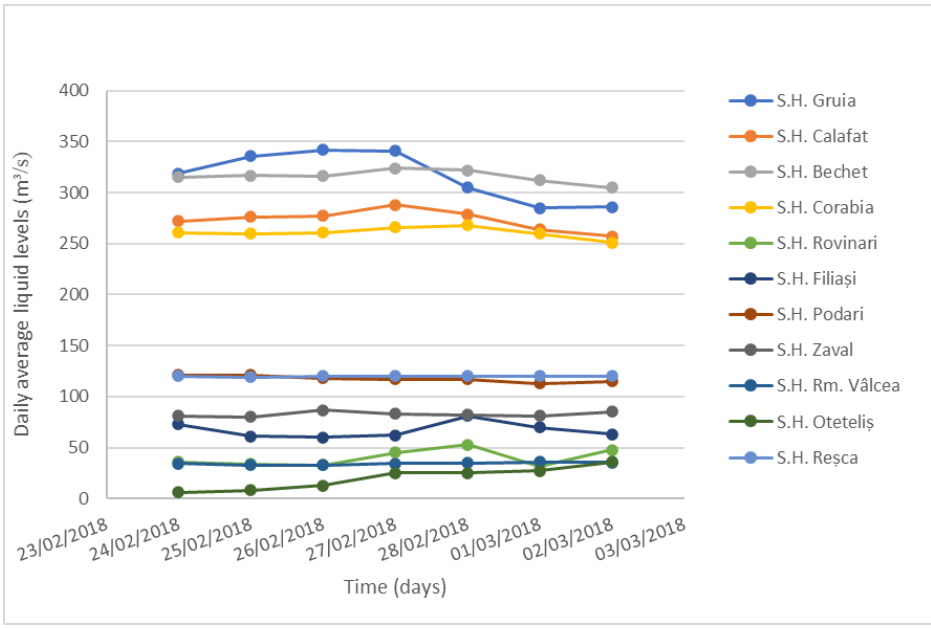


Fig. 7. ***Daily average liquid levels evolution in Oltenia between February 24^{th} and March 3^{rd} (source: National Institute for Hydrology and Water Management)***

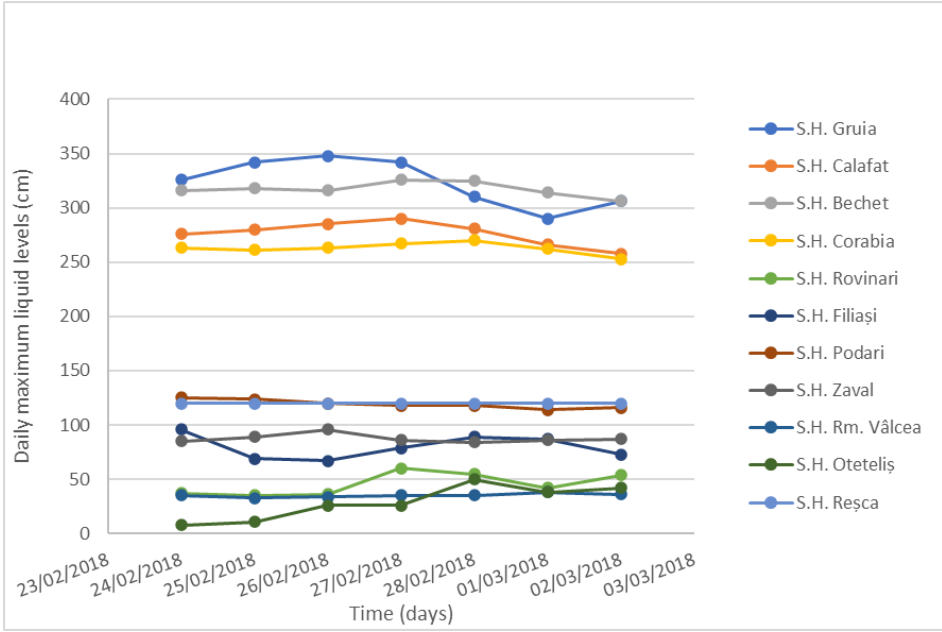


Fig. 8. ***Daily maximum liquid levels evolution for the hidrological stations on the Jiu, Olt and Danube Rivers in Oltenia region between February 24^{th} and March 3^{rd} (source: National Institute for Hydrology and Water Management)***

According to the evolution presented in Fig. 9. and Fig. 10. the average and maximum daily flows at the hydrometric stations in the Danube basin for Oltenia region, in the analyzed period the identified variations are relatively small. The lowest values are for Gruia and the highest ones for Bechet and Corabia with values around 6400 m^3/s. The greatest flows were recorded throw the middle of the time span.

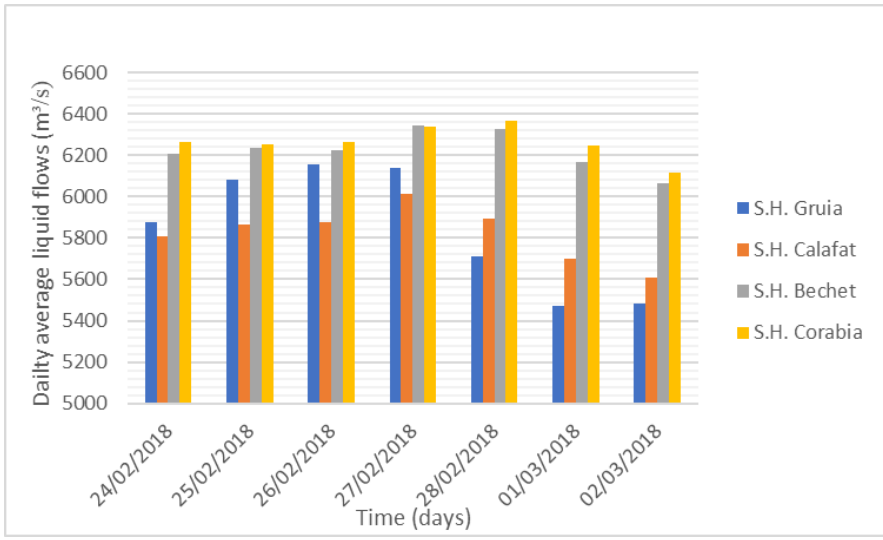


Fig. 9. ***Daily average liquid flows evolution for the Danube Rivers basin in Oltenia between February 24^{th} and March 3^{rd} (source: National Institute for Hydrology and Water Management)***

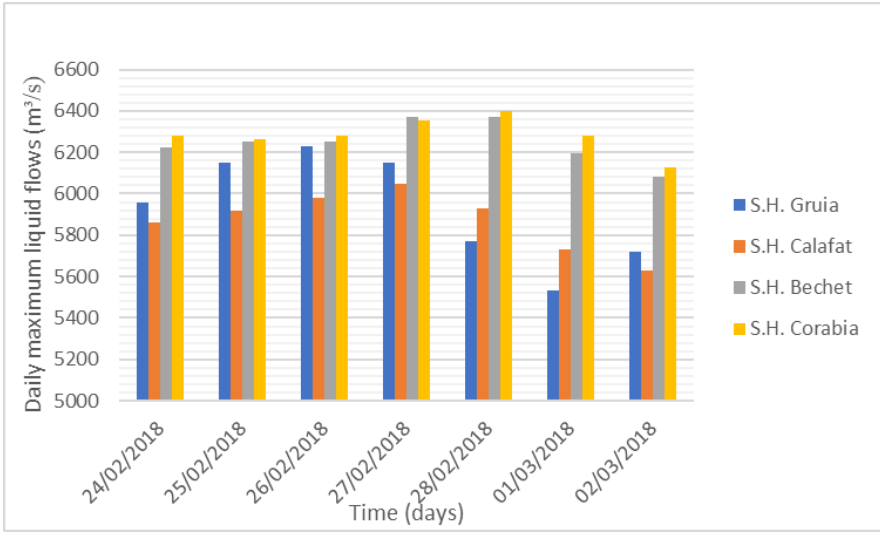


Fig. 10. ***Daily maximum liquid flows evolution for the Danube Rivers basin in Oltenia between February 24^{th} and March 3^{rd} (source: National Institute for Hydrology and Water Management)***

In the graphics below (Fig. 11. and Fig. 12.) among the analyzed stations, Râmnicu Vâlcea, Oteteliș and Reșca on the Olt river have recorded the lowest values for the average and maximum daily flows (below 10 m^3/s), compared to the others.

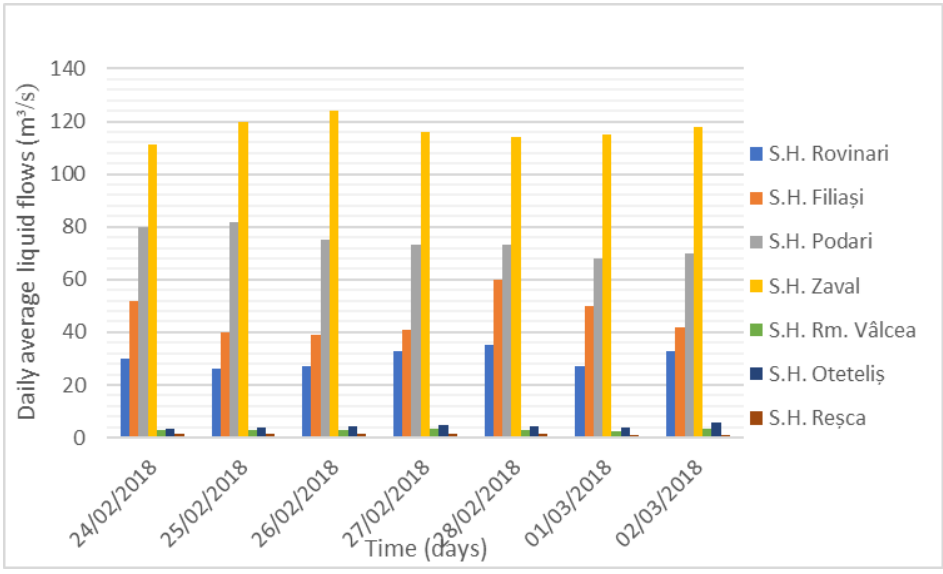


Fig. 11. ***Daily average liquid flows evolution for Jiu and Olt Rivers in Oltenia region between February 24th and March 3rd (source: National Institute for Hydrology and Water Management)***

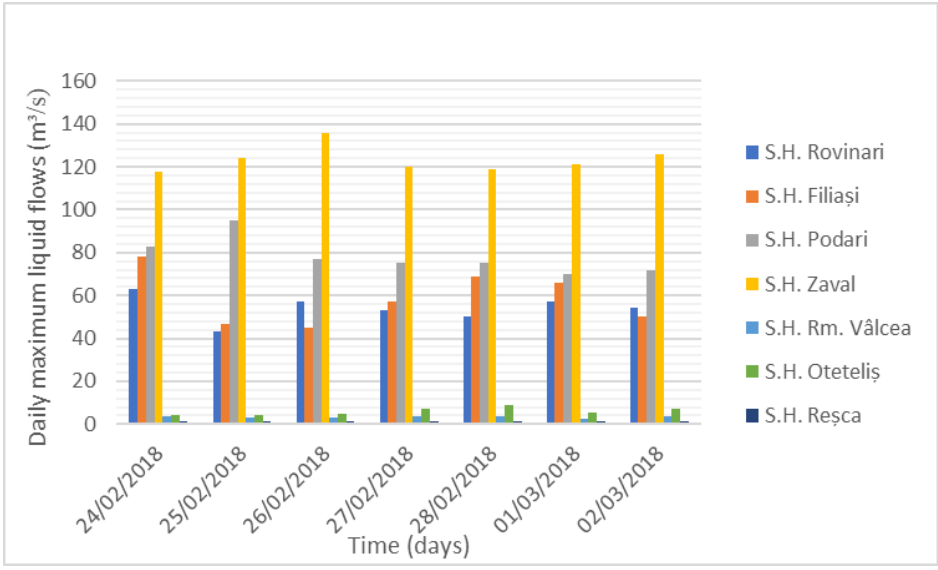


Fig. 12. ***Daily maximum liquid flows evolution for Jiu and Olt Rivers in Oltenia region between February 24th and March 3rd (source: National Institute for Hydrology and Water Management)***

On the other hand, the highest average and maximum daily flows were recorded at Zaval on the Jiu River (124 m^3/s and 136 m^3/s), both on February 26^{th}.

In Fig. 13. the highest value for the amount of precipitation recorded during the blizzard episode is 64 l/m^2 at the hydrometric stations Podari on the Jiu River on February 27^{th}. On this day, all seven station from Jiu and Olt Rivers recorded significant amounts of precipitation. Zaval hydrometric station had a total amount of 141 l/m^2 during the entire period. The lowest values for the amount of precipitation were recorded in the Oltenia region on February 24^{th} and March 1^{st}.

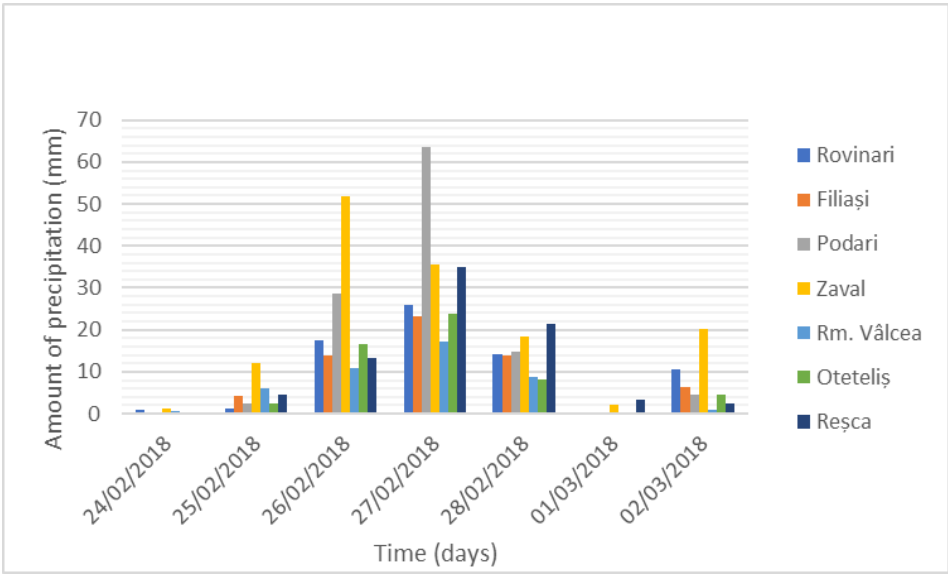


Fig. 13. ***Evolution of the amount of precipitation for Jiu and Olt Rivers in Oltenia region between February 24^{th} and March 3^{rd} (source: National Institute for Hydrology and Water Management)***

Between February 24^{th} and March 3^{rd} for every hydrometric station located on the rivers Jiu, Olt and Danube in the Oltenia region no flood phenomena was registered. However, phenomena determined by the meteorological conditions of the blizzard were reported, such as: layer of snow with different thicknesses for all hydrometric stations, ice on the shore at Râmnicu Vâlcea and Oteteliș stations and ice on certain sectors of the river, also for Râmnicu Vâlcea station.

CONCLUSIONS

In order for a blizzard to develop in Romania a coupling mechanism is needed: a high-pressure area in the north or north-east of Romania, an anticyclone with continental polar characteristics (cold and dry) and a low-pressure area evolving over our country with warmer and humid air.

The numerical weather forecast models captured well enough the evolution of the blizzard episode, but also the cold wave before that. Romanian National Meteorological Administration issued warnings: an orange alert for very low temperatures during both night and day and a mixed yellow (counties in the north of Oltenia and towards the end only for the southern ones) and orange (counties in the south of the region) alert for the blizzard.

The effects consisted in: a snow layer recorded both at the meteorological and hydrological stations, wind gusts and ice on the rivers.

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