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VARIATIONS OF NIVOMETEOROLOGICAL PARAMETERS DURING 2021-2022 WINTER

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ABSTRACT. The paper presents and analyze snow and meteorological parameters of 2021-2022 winter, measured at the weather stations with nivological program (Predeal, Sinaia 1500, Parâng, Semenic, Vlădeasa, Ceahlău-Toaca, Iezer, Călimani, Ţarcu, Bâlea-Lac, Vârful-Omu), as well as the estimated avalanche risk for each monitored massif.

Keywords: avalanches, snow, risk, meteorological and nivological parameters

1. INTRODUCTION

At National Meteorological Administration, meteorological and snow parameters are measured at eleven weather stations within the snow and avalanche program: Vârful Omu (2504 m), Sinaia (1510 m), Predeal (1090 m), Bâlea-Lac (2050 m), Parâng (1548 m), Semenic (1370 m), Vlădeasa 1800 (1836 m), Ceahlău-Toaca (1897 m), Iezer (1785 m), Călimani (2022 m), Ţarcu (2180 m). Based on these data, the avalanche risk is estimated for eight Mountain Massifs: Bucegi, Făgăraş, Parâng-Şureanu, Ţarcu-Godeanu, Vlădeasa-Muntele Mare, Rodnei, Călimani-Bistriței, Ceahlău (Fig. 1).

Daily bulletins that include avalanche risk estimations are issued since January 2005, according to the European Avalanche Danger Scale. Annual reports include studies about the evolution of avalanche risk during winters (***, 2011-2022).

The study aims to present and analyze snow and meteorological parameters evolution during 2021-2022 winter season, which are the basis for estimation of avalanche risk in the monitored mountain massifs. High and very high avalanche risk represents a potential threat to skiers and tourists, because in these cases the snowpack is unstable and poorly bonded on most steep slopes and numerous natural, spontaneous, avalanches can be expected.

Avalanche observations are also taken from local mountain rescue teams. The majority of the avalanche observations can be accessed online in the Annual Report (***, Bilanţul nivologic).

The 2021-2022 winter season started on November 26, 2021 at all mountain weather stations where the nivological program is running. The observation program lasted until April 30, 2022 at Predeal, Sinaia 1500, Parâng, Semenic, Vlădeasa

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stations, May 10, 2022 at Ceahlău-Toaca, Iezer, May 20 at Călimani, Țarcu and June 10 at Bâlea-Lac and Vârful-Omu. At all stations, 3618 observations and 208 snow pits and stratigraphic profiles of the snow layer have been made, the last on May 24, 2022 in Bâlea-Lac. Observations and measurements from the stations were entered into the Gelinivw program. They can be viewed graphically, daily, weekly, monthly and yearly, with the help of the Gelinivw program.

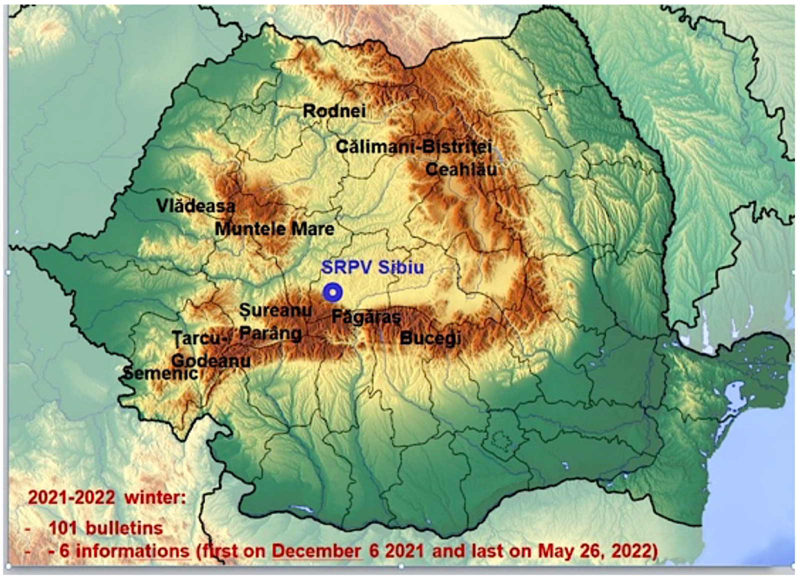


Fig. 1. *Nivological network*

Sibiu Regional Weather Forecast Service is in charge with the interpretation of snow and meteorological data, estimation of avalanche risk, issuance and dissemination of snow and meteorological bulletins for all the monitored mountain massifs (Fig. 1).

The first information of the snow season 2021--2022 was issued on December 6, 2022, and the last on May 26, 2022. For the whole season, a number of 101 bulletins and 6 snow-meteorological information have been made.

2. VARIATION OF NIVOMETEOROLOGICAL PARAMETERES DURING 2021-2022 WINTER

The maximum thickness of the snow layer at the meteorological stations with *nivological program was recorded during the months of March (the majority), April (Vârful Omu, Călimani and Iezer) and February (Vlădeasa). The highest value, 276 cm, was* recorded at Bâlea-Lac on March 8, 2022. More than 200 cm were also recorded at Omu Peak: 222 cm on April 20.

At the other stations, the highest values were: 155 cm at Țarcu (05.03), 123 cm at Călimani (11.04), 115 cm at Ceahlău-Toaca (12.03), 89 cm at Semenic (20.03), 78 cm at Parâng (17.03), 68 cm in Sinaia (08.03), 62 cm in Predeal (05.03), 60 cm in Iezer (05.04) and 27 cm in Vlădeasa (23.02), the lowest value (Fig. 2).

This season, the snow measured over 200 cm was for 68 consecutive days (22 January – 29 March 2022) at Bâlea-Lac and only 18 days (8-25 April 2022) at Vârfu-Omu (Fig. 2).

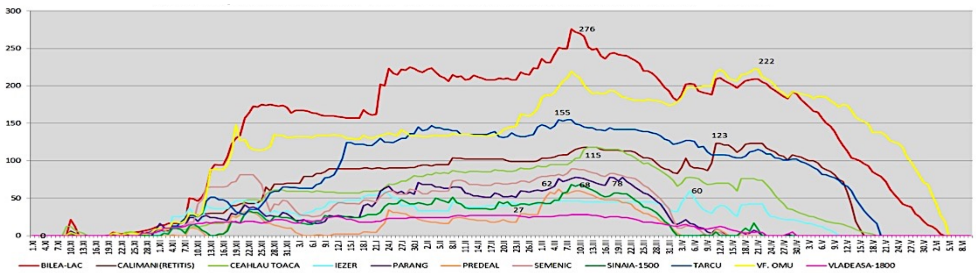


Fig. 2. ***Snow height variations during 2021-2022 winter***

The monthly average of the maximum and minimum temperatures recorded at the meteorological stations with a snow program shows the following (Fig. 3):

In the Southern Carpathians, at stations located at altitudes above 2000 m (Vârfu Omu, Bâlea-Lac, Țarcu), the monthly average of maximum temperatures was negative between December and March, and at Vârful Omu also in April. At lower altitudes (stations Sinaia, Parâng, Predeal), they had negative values only in December and January. As for the monthly average of minimum temperatures, they had negative values at all stations in the November-April interval, and at high stations in October and May (Vârful Omu).

TMAX	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	2,5	1,5	-5,6	-8,4	-6,7	-9,1	-2	4,1	8,5
ȚARCU (2180 m)	4,2	3,6	-3,7	-5,6	-4,5	-5,2	0,1	7,1	11,8
BÂLEA-LAC (2050 m)	4,8	4,6	-3,1	-5,1	-2,7	-3,7	2,9	8,6	11,8
SINAIA (1510 m)	8,3	7,7	0,8	-1,3	2,1	1,1	8,6	15,5	19,6
PARÂNG (1548 m)	7,1	6,2	-0,3	-2,2	0,8	0,8	7	14,4	18,8
PREDEAL (1090 m)	10,2	8,6	1,3	-1,1	3,1	2,8	10,9	17,5	21,2
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	4,2	3	-4	-6,4	-4,9	-4,5	0,2	8,4	13,1
IEZER (1785 m)	6,4	4,6	-2	-4,9	-3,4	-2,2	2,4	10,3	15,4
CEAHLĂU (1897 m)	4,5	4,3	-3,5	-6,4	-4,9	-4,2	1,8	10,6	14,7
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	6,7	4,1	-2,6	-5,4	-3,5	-2,4	2,2	11,1	15,8
SEMENIC (1370 m)	6,4	5	-1,3	-2,5	0,2	1	6,3	14,3	18,5

TMIN	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	-2,8	-4,4	-10,2	-14	-13	-13,9	-7,6	-1,1	3,4
ȚARCU (2180 m)	-1,2	-2,2	-8,8	-11,4	-10	-10,7	-5,6	2	6,4
BÂLEA-LAC (2050 m)	-0,6	-1,9	-8,3	-11,4	-9,5	-10,7	-4,8	1,9	6,7
SINAIA (1510 m)	0,3	-0,3	-5,4	-8,5	-6,2	-7,1	-0,9	5,4	9,6
PARÂNG (1548 m)	0,6	-0,5	-5,4	-8	-5,8	-6,8	-1,2	5,8	10,6
PREDEAL (1090 m)	0,9	-0,4	-4	-6,6	-5,5	-7	0	5,3	9,5
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	-1,7	-2,7	-8,9	-12,6	-10	-11,3	-5,3	1,8	6,1
IEZER (1785 m)	-1,1	-2,7	-7,8	-11,1	-9,1	-9,7	-4	2,9	6,6
CEAHLĂU (1897 m)	-1,3	-2,1	-8,1	-11,9	-9,4	-10,5	-4,1	2,6	6,9
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	0,1	-2,4	-8	-10,7	-8,6	-9	-3,8	3,6	7,9
SEMENIC (1370 m)	0,8	-0,5	-5,8	-8,1	-5,8	-6,4	-0,9	6,5	10,8

Fig. 3. ***Monthly average of maximum and minimum temperatures in winter 2021-2022***

In the Eastern Carpathians, the monthly average of maximum temperatures was negative at all three stations (Călimani, Ceahlău-Toaca, Iezer) in the December-March interval. As for the monthly average of the minimum temperatures, they had negative values at all stations in the interval October - April

In the Western Carpathians, the monthly average of maximum temperatures was negative at the Vlădeasa station in the December-March interval, and at Semenic only in December and January. However, the monthly average of minimum temperatures was negative at both stations between November and April.

The deviations from the climatological averages (1991-2020) show that they were positive at the maximum temperatures at all stations in the months of November, May, June and February (only in Iezer and Ceahlău slightly negative, of -0.3 degrees), close to normal in December (with very small differences of +/- 0.1

degrees) and negative in January, March (the biggest differences), April (less Iezer, with +0.1 degrees) and October (less Vlădeasa , with +0.2 degrees) (Fig. 4).

TMAX	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	-0,2	2,8	0,1	-1,2	0,5	-4,1	-1,1	0,5	0,9
ȚARCU (2180 m)	-0,4	3,1	0,1	-0,5	0,7	-2	-0,9	1,3	1,9
BÂLEA-LAC (2050 m)	-0,9	3,1	-0,1	-1	0,9	-2,6	-0,6	1,1	1
SINAIA (1510 m)	-1,8	2,3	-0,2	-1	1,8	-2,2	0,1	1,8	2,2
PARÂNG (1548 m)	-2,1	1,4	-0,8	-1,5	1,1	-1,5	-0,6	2	2,6
PREDEAL (1090 m)	-1,9	2	-0,1	-1,5	1,3	-2,5	-0,2	1,3	1,3
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	-0,4	2,6	0	-0,8	0,4	-1,5	-1,7	0,9	1,7
IEZER (1785 m)	-0,1	2,1	0,1	-1,4	-0,3	-1,5	-1,9	0,8	2,5
CEAHLĂU (1897 m)	-1,2	3	0	-1,4	-0,3	-2,1	-1,6	1,3	1,5
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	0,4	2,2	0,1	-1,5	0,1	-1,1	-1,6	2,1	3
SEMENIC (1370 m)	-2,5	1,1	-0,9	-0,8	1,5	-0,7	-1	1,9	2,6

TMIN	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU	-0,2	2,1	0,5	-1,5	0	-3,2	-1,4	0,1	0,9
ȚARCU	-0,3	2,6	0,2	-0,9	0,6	-2,1	-1,5	1,1	1,8
BÂLEA-LAC	-0,5	2,1	0,3	-1,2	0,8	-2,4	-1,6	0,5	1,5
SINAIA	-1,9	1,4	0,8	-0,7	1,2	-2,2	-1,1	0,4	1
PARÂNG	-1,9	1	0,3	-0,8	1,2	-2,2	-1,5	0,6	1,9
PREDEAL	-1,3	1,4	2,1	0,9	1,4	-3	-0,4	0,2	0,7
CARPAȚI ORIENTALI									
CĂLIMANI	-0,7	2,2	0,3	-1,8	0,7	-2,5	-1,7	0,5	1
IEZER	-1,2	1	0	-1,7	0,1	-2,4	-2	0,2	0,3
CEAHLĂU	-1,1	2	0,5	-1,7	0,8	-2,5	-1,4	0,2	0,9
CARPAȚII OCCIDENTALI									
VLĂDEASA	-0,6	0,8	-0,5	-1,7	0,3	-2,2	-2	0,7	1,5
SEMENIC	-1,7	1,2	0,1	-0,9	1,2	-2,1	-1,5	1,1	1,7

Fig. 4. ***Deviation of the monthly averages of the maximum and minimum temperatures in the winter of 2021-2022 compared to the 1991-2020 climatological norm***

As for the average minimum temperatures, they were also positive at all stations in November, December (less Vlădeasa, with -0.5 degrees), February, May, June and negative in October, January (less Predeal, with +0.9 degrees), March (the biggest deviations), April (Fig. 4).

The monthly average of precipitation recorded at the weather stations was in excess of the 1991-2020 climatological norm in December and April (less Țarcu, with a small negative deviation of -1.6 mm/sq), January (at Țarcu +9 ,8 mm/sq m, Bâlea-Lac +49.6 mm/sq m, Călimani +61.6 mm/sq m, Iezer +73.3 mm/sq m and Vlădeasa +15.7 mm/sq m), and in the rest, it was deficient (Fig. 6).

PRECIPITAȚII	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	23,9	16,5	87	35,2	44,5	66,2	85,2	66,5	69,8
TARCU (2180 m)	21,2	45,8	118,7	79,8	55	34,3	60,4	55,9	26,9
BÂLEA-LAC (2050 m)	46,6	67,8	234,3	133,8	63,5	85,8	134,2	106,4	112,8
SINAIA (1510 m)	32,8	33,6	106,7	45,8	44,1	39,1	165,1	106	69,4
PARÂNG (1548 m)	20,9	68,9	124	87	29,4	35,7	148,4	103,4	12
PREDEAL (1090 m)	37	27,9	132,2	41,6	32	34,1	101,8	104,2	98,2
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	10,3	33,7	123,7	97,4	39,6	36,2	142,8	58,5	72,7
IEZER (1785 m)	20,1	94,5	161	138,5	66,3	14,3	226,6	94,9	
CEAHLĂU (1897 m)	8,7	18,4	69,4	23,9	22,8	32,3	72,4	52,1	52,9
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	23,4	51	133,2	78,5	45,8	24,6	89,3	54,5	41,4
SEMENIC (1370 m)	40,4	64,1	161,1	56,6	70,4	28,3	168,2	83,8	29,3

GROSZ	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	1	1	79	133	141	191	203	146	5
TARCU (2180 m)	0	1	36	104	137	143	111	40	0
BÂLEA-LAC (2050 m)	1	3	101	180	213	238	197	97	1
SINAIA (1510 m)	0	0	14	29	42	49	2	0	0
PARÂNG (1548 m)	0	1	24	37	59	65	6	0	0
PREDEAL (1090 m)	0	0	11	10	21	44	1	0	0
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	0	1	36	86	99	108	107	36	0
IEZER (1785 m)	0	0	31	43	39	44	35	4	0
CEAHLĂU (1897 m)	0	2	28	62	86	102	65	9	0
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	0	0	16	21	26	24	7	0	0
SEMENIC (1370 m)	0	0	47	44	68	75	3	0	0

Fig. 5. ***Monthly average of precipitation and snow cover thickness during 2021-2022 winter season***

PRECIPITAȚII	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU	-36,4	-32,5	30,5	-16	-6	2,3	20,6	-31,7	-70,1
ȚARCU	-43,5	-17,2	49,9	9,8	-11,4	-27,1	-1,6	-40	-92,3
BÂLEA-LAC	-46	-17,3	144,7	49,6	-15,3	-5,1	41,3	-26,7	-66,1
SINAIA	-55,6	-32,9	38,6	-9,4	-7,1	-20,1	91,6	-19,4	-78,3
PARÂNG	-49,8	13,1	71,5	38	-14,8	-23,5	69,1	-17,1	-127,6
PREDEAL	-31,7	-20,5	84,9	-5,5	-11,8	-26	29,8	-11,2	-41
CARPAȚI ORIENTALI									
CĂLIMANI	-49,6	-21,7	77,7	61,6	-8,5	-15,6	90,6	-40,5	-55,5
IEZER	-84,6	5,2	76,3	73,3	-4,5	-76,3	137,6	-51,1	-96,7
CEAHLĂU	-32,3	-6,4	38,8	-1,1	-5,5	-4	22,9	-30,3	-69,5
CARPAȚII OCCIDENTALI									
VLĂDEASA	-50,3	-13,2	55,4	15,7	-13,4	-43,4	22	-50,6	-117,4
SEMENIC	-45,9	-7,6	85,3	-19,8	3,7	-41,6	75,6	-49	-128

GROSZ	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU	-3,6	-14,1	36,6	72	67,6	99,8	96,5	72	-8,8
ȚARCU	-1,5	-7,5	8,3	48,4	58,6	54,3	48,2	27,7	-0,1
BÂLEA-LAC	-4,4	-20,8	29	66,1	56	47,6	3,6	3,9	-8,6
SINAIA	-0,8	-5,2	-5,5	-7,4	-8,9	4,7	-11	-0,1	0
PARÂNG	-0,8	-4,5	6,6	2,6	6,9	18,9	-6,4	-0,2	0
PREDEAL	-0,6	-5,4	-4,7	-20,5	-21,4	13,7	-5,9	-0,2	0
CARPAȚI ORIENTALI									
CĂLIMANI	-2,3	-8,3	8,2	41	33,5	28,9	50,4	29,1	-0,1
IEZER	-1,6	-5,3	17,8	21,7	10,7	5,7	7,6	1,2	0
CEAHLĂU	-2,7	-5,7	5,4	21,5	30,4	41,6	21,8	4,6	-0,1
CARPAȚII OCCIDENTALI									
VLĂDEASA	-1	-4,2	4,5	4,2	7,4	8	0,8	-0,4	0
SEMENIC	-1	-5,7	24,1	-7,4	-9	1,5	-19,2	-0,3	0

Fig. 6. ***Deviation of monthly precipitation and snow cover thickness from winter 2021-2022 compared to the climatological norm 1991-2020***

Taking into account the temperature values recorded between December and April, we can say that the snow cover remained, without essentially melting, until the beginning of April, then marked an increase again, especially at the higher stations, during April, going to decrease significantly in May at the high stations and from April at the low ones, where the precipitation was mainly in the form of rain (Fig. 2)

The degree of ground coverage with snow, expressed in percentages, shows that it was higher (or equal) than the climatology average in the period December - April and May (at Vârful Omu and Călimani) and lower in the other months, very low in November and May (Fig. 7). The snow layer was continuous at all the meteorological stations from December to March, except Predeal with only February and March. Also, on high altitude stations, snow layer remained continuous until May and also June for the highest station, Vârful Omu (2504 m) (Fig. 7).

ACOPERIRE ZĂPADA	X	XI	XII	I	II	III	IV	V	VI
CARPAȚII MERIDIONALI									
VF.OMU (2504 m)	35,5	46,7	100	100	100	100	100	100	10
ȚARCU (2180 m)	12,9	20	100	100	100	100	100	54,8	0
BÂLEA-LAC (2050 m)	16,1	56,7	100	100	100	100	100	83,9	0
SINAIA (1510 m)	12,9	6,7	100	100	100	100	33,3	0	0
PARÂNG (1548 m)	3,2	23,3	100	100	100	100	63,3	0	0
PREDEAL (1090 m)	0	3,3	80,6	77,4	100	100	30	0	0
CARPAȚI ORIENTALI									
CĂLIMANI (2022 m)	9,7	23,3	100	100	100	100	100	38,7	0
IEZER (1785 m)	3,2	0	100	100	100	100	100	12,9	0
CEAHLĂU (1897 m)	3,2	43,3	100	100	100	100	100	19,4	0
CARPAȚII OCCIDENTALI									
VLĂDEASA (1836 m)	9,7	20	100	100	100	100	83,3	0	0
SEMENIC (1370 m)	0	20	100	100	100	100	46,7	0	0

Fig. 7. ***Monthly average of the degree of snow cover in the winter of 2021-2022***

3. AVALANCHE CASES

Analyzing the avalanche cases reported and recorded in each massif, (noted with red vertical lines on the graphs), it is observed that they occurred in conditions of predominantly negative temperatures, the formation of wind slabs, and, especially in March, after successive snowfalls, also accompanied by strong wind and formation of new wind slabs (Fig. 8).

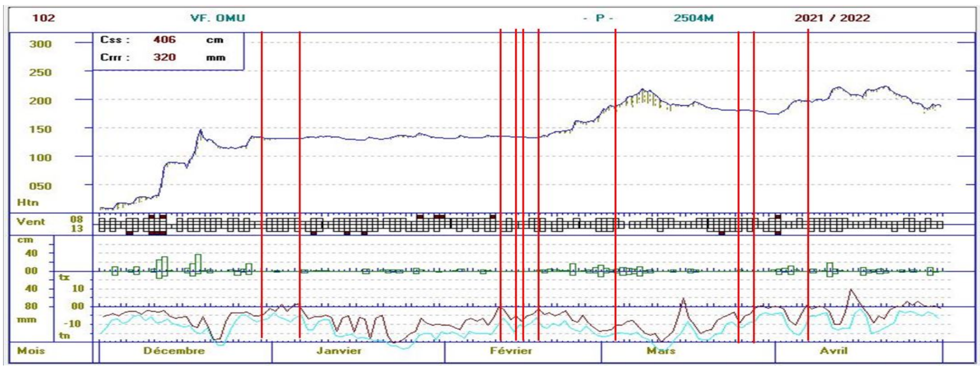


Fig. 8. ***Meteorological and nivological parameters with avalanche activity during 2021-2022 winter in Bucegi Massif, Vârful-Omu meteorological station***

In Făgăraş Mountains, at Bâlea-Lac meteorological station, avalanches occured în January in conditions of negative temperatures, snow and the formation of wind slabs, in February after significant snowfall increases and slightly positive values of daytime temperatures, and in March after successive snowfalls, wind slabs and transformations within the snow layer, in conditions of predominantly negative temperatures (Fig. 9)

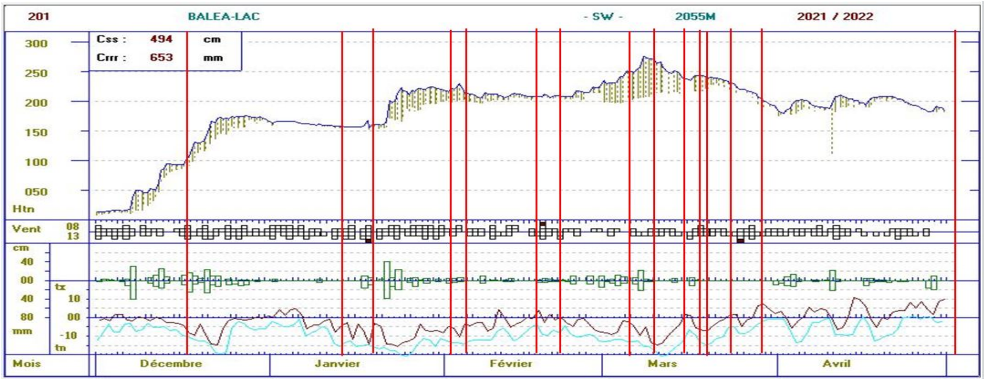


Fig. 9. ***Meteorological and nivological parameters vs with avalanche activity during 2021-2022 winter in Făgăraș Massif, Bâlea-Lac meteorological station***

In the area of the Iezer meteorological station, the recorded avalanche cases were related to significant snowfalls, accompanied by wind intensifications and the formation of wind plates or high temperature values (Fig.10).

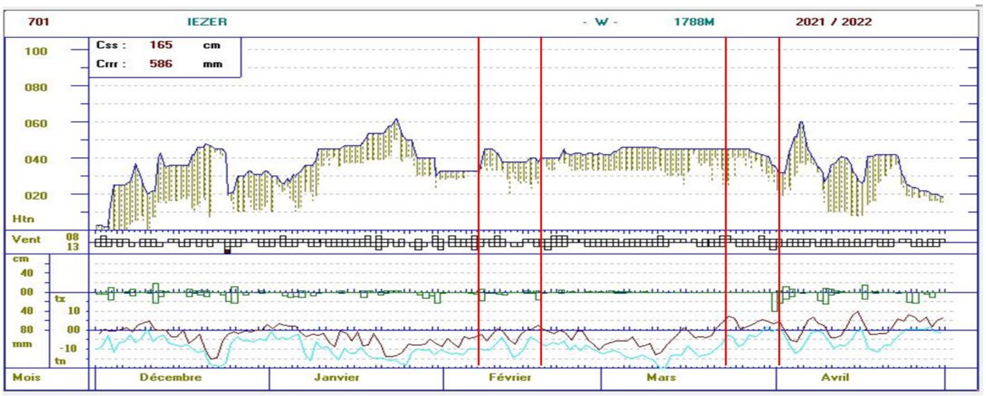
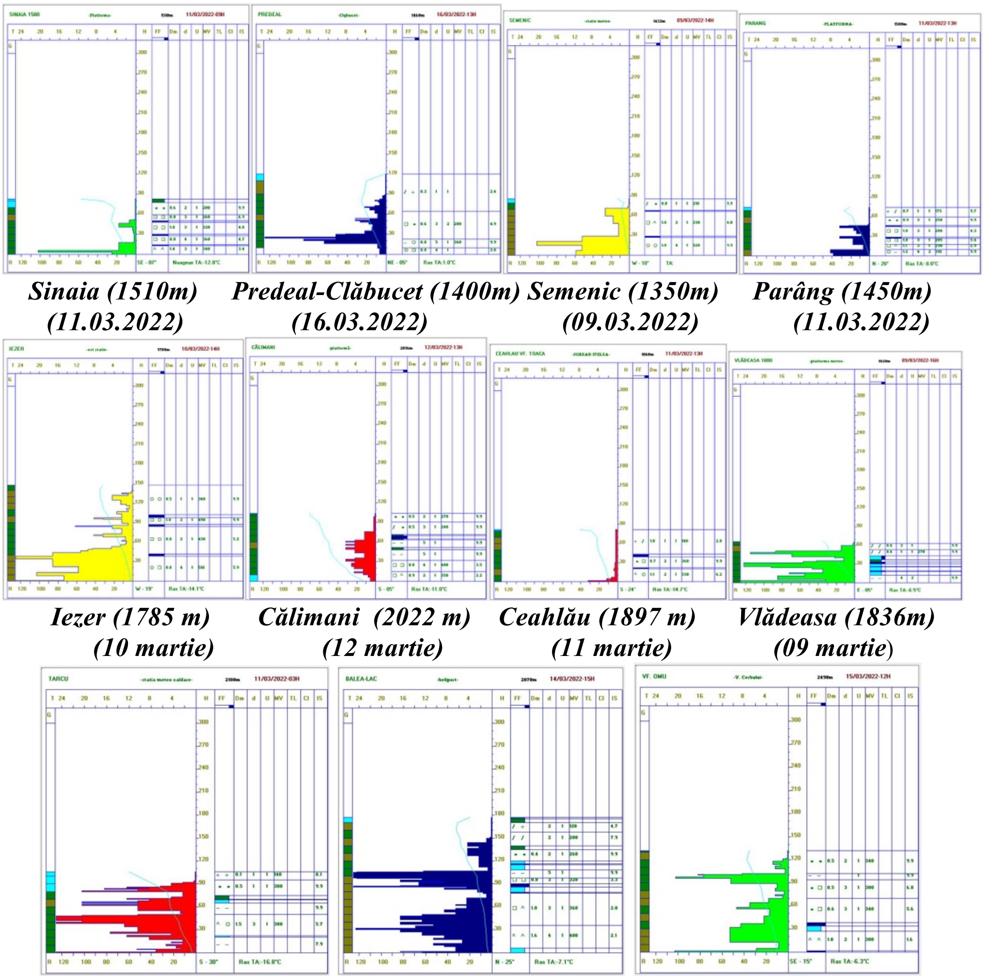


Fig. 10. ***Meteorological and nivological parameters with avalanche activity during 2021-2022 winter in Rodnei Massif, Iezer meteorological station***

The profiles made between March 9-16, 2022, show the important differences in snow thickness, structure, stratigraphy and resistance, at different meteorological stations, depending on the altitude, but also on the orientation of the slopes where the surveys were made (Fig. 11).



Sinaia (1510m) (11.03.2022) ***Predeal-Clăbucet (1400m) (16.03.2022)*** ***Semenic (1350m) (09.03.2022)*** ***Parâng (1450m) (11.03.2022)***

Iezer (1785 m) (10 martie) ***Călimani (2022 m) (12 martie)*** ***Ceahlău (1897 m) (11 martie)*** ***Vlădeasa (1836m) (09 martie)***

Țarcu (2100 m) (11 martie) ***Bâlea-Lac (2050 m) (14 martie)*** ***Vârfu Omu (2504) (15 martie)***

Fig. 11. ***Resistance, temperature and stratigraphic profiles (Gelinivw archive)***

4. AVALANCHE RISK ESTIMATION

Estimating the avalanche risk at one mountain massif scale is made in accordance with the European avalanche risk scale. Maximum estimated avalanche risk for one day is considered the highest between all monitored mountains. For this season, the maximum avalanche risk estimated coincided with the estimated risk values for Făgăraş Mountains at altitudes over 1800 m. In percentage, the most frequently used was the significant one (3), in all the massifs, followed by the moderate one (2), high (4) and reduced (1) for the other massifs. The very high risk (5) was not issued this season for any massif (Fig. 12).

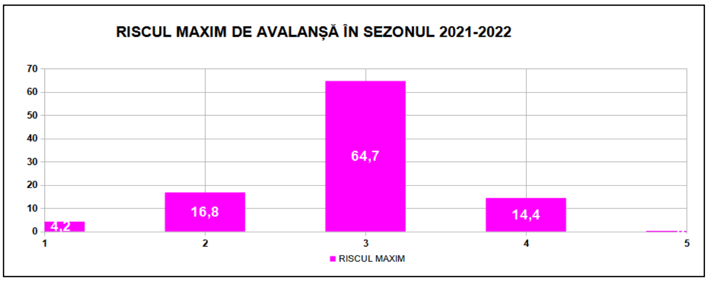


Fig. 12. ***Maximum avalanche risk estimated during 2016-2017 winter***

Comparing the estimated avalanche risk at altitudes higher than 1800 meters, it is observed that high risk (4) was used only for Făgăraş (14.4%) and Bucegi (9.0%), whith a higher percentage used for Făgăraş Mountains – (Fig. 13).

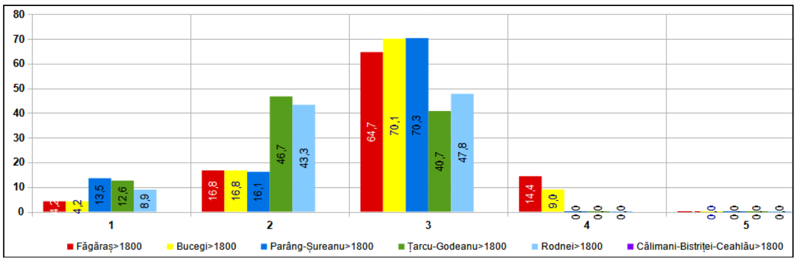


Fig. 13. ***The use of avalanche risk in the 2021-2022 winter, at altitudes > 1800 m***

At altitudes lower than 1800 m, the most often estimated avalanche risk was moderate (2) in all massifs, with a higher percentage in Ţarcu-Godeanu and Parâng-Şureanu (91.2%), followed by Rodnei (89.3%), Călimani-Bistriței-Ceahlău (85%), Vlădeasa-Muntele Mare (81.1%), Bucegi (72.1%), Făgăraş (58.6%).

For Făgăraş and Bucegi, the significant risk (3) followed, in the proportion of 28.6% and 25.0% respectively, and for Vlădeasa-Muntele Mare, Rodnei, Călimani-Bistriței-Ceahlău, low risk (1), in the proportion of 18.9%, 9.3%, 9.3% (fig.14), then low risk (1) for the Făgăraş massif (...%), Bucegi (2.9%), Ţarcu-Godeanu and Parâng-Şureanu (3.7%), respectively significant risk for the Rodnei massif (1.4%) and Călimani-Bistriței-Ceahlău (5.7 %).

No high (4) or very high (5) risk was estimated for any of the massifs

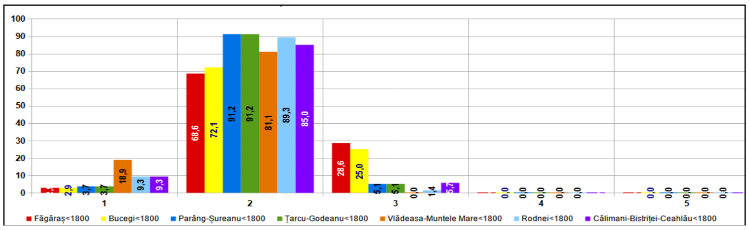


Fig. 14. ***Use of avalanche risk in the 2021-2022 winter, at altitudes < 1800 m***

Regarding the relationship between estimated avalanche risk and recorded avalanche cases, most avalanches occurred on days when the estimated avalanche risk is significant (3) – 21 days. On the days when the estimated avalanche risk was high (4) and moderate (2), 3 cases were recorded (Fig.15).

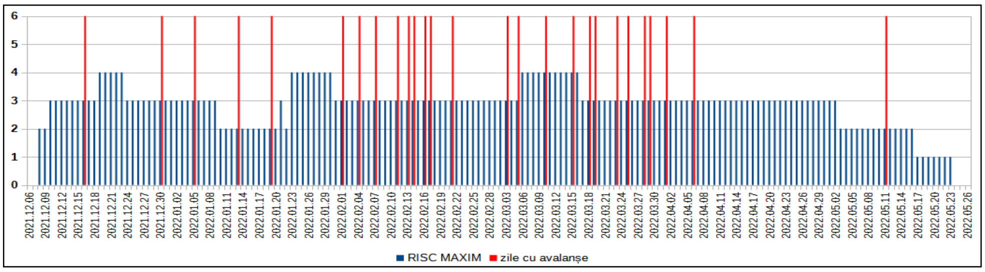


Fig. 15. ***Estimated avalanche risk vs days with recorded avalanches, 2021-2022 winter***

4. CONCLUSIONS

Avalanche risk estimation is a complex process, which combines precise measurements of meteorological and nivological parameters (specific to snow), a good knowledge of the targeted terrain and above all a local meteorological forecast as accurate as possible. The purpose of issuing the avalanche risk is primarily aimed at saving human lives, so the expansion of the monitored areas at the level of the entire country, in the mountain massifs where avalanches occur frequently, some with soldiers and with victims, is imperatively necessary.

The presented parameter variations and avalanche situations show that avalanches occur mainly under the direct influence of heavy snowfall or increasing temperatures, but also because of snow crystals transformations within the layer, especially on the formation of faceted, unstable crystals inside.

Even so, to avoid any human life loss, but also to prevent massive accidents with significant economic damage, permanent snow and avalanche measurements are needed, especially in areas with high tourist potential.

Because of the variety of conditions that can lead to instability of snow, every risk situations should be studied, in order to create a pattern of avalanche danger (Green et al. 2006) and improve avalanche risk forecasting.

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