

## **FAVORABLE CONDITIONS FOR THE RELEASE OF AVALANCHES IN THE 2021-2022 WINTER SEASON – CASE STUDY**

***Dorian-Udo RECKERTH<sup>1</sup>, Narcisa MILIAN<sup>1</sup>***

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**Abstract.** The paper presents and analyzes the synoptic and snow-meteorological conditions that were the basis for the triggering of avalanches in the winter season 2021-2022 from the mountain massifs monitored within the snow program. Data recorded at mountain weather stations with nivometric measurements were used, as well as ground and altitude maps from the GFS archive for the analysis of synoptic situations. The purpose of the presentation is to emphasize the importance of observations and nivometric measurements, as spatial and temporal density, for estimating the avalanche risk at the level of all mountain massifs. The study is part of a larger project, which aims to inventory the cases of avalanches known so far in our country and the favorable conditions for their triggering, to use them for a better estimation of the avalanche risk and the reduction of their effects have these on the environment and people. The meeting of favorable conditions for the triggering of avalanches was due both to heavy snowfalls, high thermal values or their sudden increase, as well as to the transformations that take place inside the snow layer, as a result of which unstable structures are formed.

**Keywords:** avalanche, ground pressure, temperature, snowfall

### **1. INTRODUCTION**

Avalanche triggers have several main causes (unstable fresh snow, wind slabs, internal layers with low resistance, wet snow, landslides), and these causes come together in certain weather conditions that favor them (fresh snow avalanches are generated in following quantitatively significant snowfalls at lower temperatures; slab avalanches occur as a result of strong winds blowing snow near the ridges and depositing it in protected areas, where tight bonds are quickly formed between the fine crystals resulting from snow transport; wet avalanches require temperatures positives or rains; avalanches that occur under the action of surface overloads by dislodging the layer above a layer of low resistance in the interior – which can be an

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<sup>1</sup>SRPV Sibiu, CMR Transilvania-Sud, 550003 Sibiu, Romania; e-mail: [udo.reckerth@gmail.com](mailto:udo.reckerth@gmail.com), [narcisa.milian@gmail.com](mailto:narcisa.milian@gmail.com)

old grain or cupped and faceted crystals, occur through a sequence of weather episodes which generate the structure of the unstable layer and which can be highlighted by surveys s specific). That is why in avalanche forecasting it is necessary to monitor not only the snow cover, but also the weather evolution.

A period with a higher frequency of observed avalanches is analyzed (the period 01 February - 05 March 2022), when several avalanches were reported in the Făgăraș Mountains (5), Bucegi (5), Rodnei (2), Bihorului (1) and Ceahlău (1). Among the recorded avalanche cases, one resulted in two dead victims - the avalanche in Bârcaciu, on March 5, 2022, and two others with partially buried or injured victims: 13.01.2022 in Șerbota and 03.03.2022 near the Papagal slope in Sinaia (Fig. 1).

We have analyzed in the paper the period February 01 - March 07, 2022, with more frequent avalanches observed in the massifs monitored by the National Meteorological Administration through weather stations located at various altitudes, in the main mountain groups. To determine the conditions that led to the triggering of these avalanches, we highlighted the weather evolution starting from January 15, 2022, the date after which the more consistent accumulations of snow began.



**Fig. 1. Avalanche cases during 2021-2022 winter**

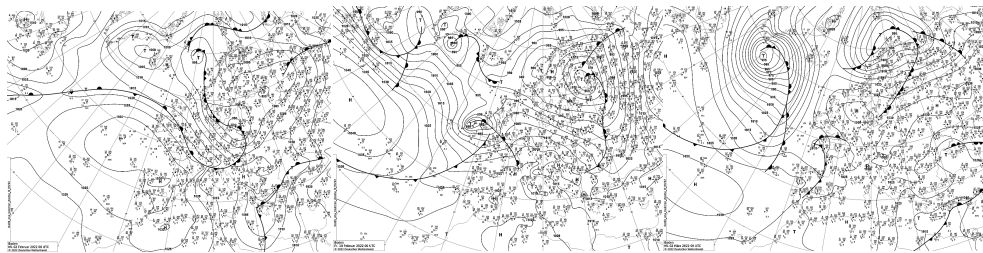
Any meteorological bulletin must take into account the weather forecast of the previous days and its future evolution, because any fall of solid or liquid precipitation and any variation in temperature or wind will be factors that will directly influence the snow layer and its physical characteristics. Any newly deposited snowpack will act as an overburden on the existing layer, and any rain will change the structure of the layer over which it falls, increasing the amount of water in the layer. Also, high

temperatures will cause some crystals to melt, and extremely low temperatures will accelerate so-called transformations of fresh or fine snow crystals into faceted or goblet crystals. The wind is one of the main factors in the avalanche risk, as it causes the formation of frequent wind slabs, even in areas with less recent snow, but only on certain favorably oriented slopes.

## 2. SYNOPTIC CONDITIONS

Starting with the second part of January 2022, the weather registered a cooling, and the temperatures were mainly negative, except in February, when there were some warmer passages that brought positive temperatures below 1800 m altitude (Fig. 6), more chosen at the lower altitudes of the Southern Carpathians, but also transient in the rest of the massifs.

The cyclogenesis was active in the Iceland area from January to the end of the first decade of March and several depression cores followed to the east and southeast of Europe, in the vicinity of the Black Sea, with associated fronts that also affected Romania and brought precipitation in the form of snow in all mountain areas and which led to constant increases in the layer. In this interval, a series of periods, lasting several days, were interspersed, in which the Azorean Ridge or the Scandinavian Anticyclone generated high pressure in our country, sometimes united in a belt of high pressure, on a cold background (Fig. 2). Thus, in this interval there were frequent snowfalls, usually associated with intense winds at altitude, but also 2-3 days of good weather and less intense wind.

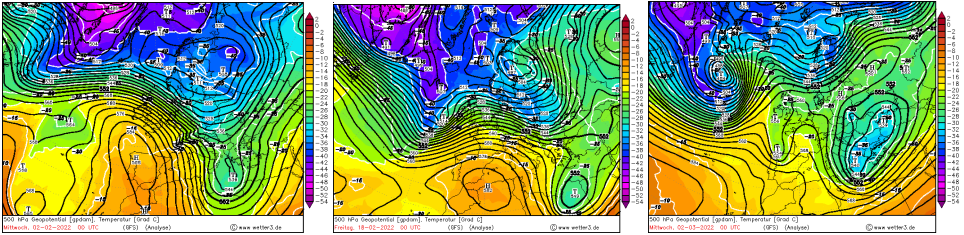


**Fig. 2. 2022.02.02 and 18, 2022.03.02, at 00 UTC – NCEP numerical model – reanalysis.  
Ground level pressure and associated fronts**

In the upper layers of the atmosphere, this interval was characterized by a mass of cold polar air that dominated the north of Europe and the passage of some high-altitude troughs in our country, associated with colder polar air penetrations, but also by some warm ridges which were more active in February 2022 (Fig. 3)

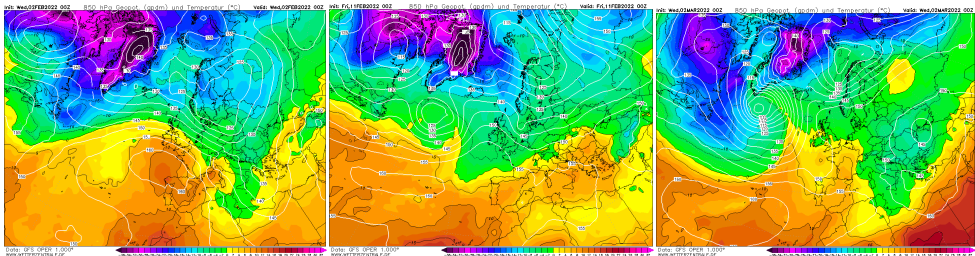
In the maps with ground pressure and associated fronts (Fig. 2) and in those with Geopotential and temperatures at 500 hPa, one can see the sequence of cyclones of Icelandic origin that were generated and which constantly migrated from the west to

the east of Europe, with altitude troughs associated in high layers with colder air masses (on blue background in Fig. 3).

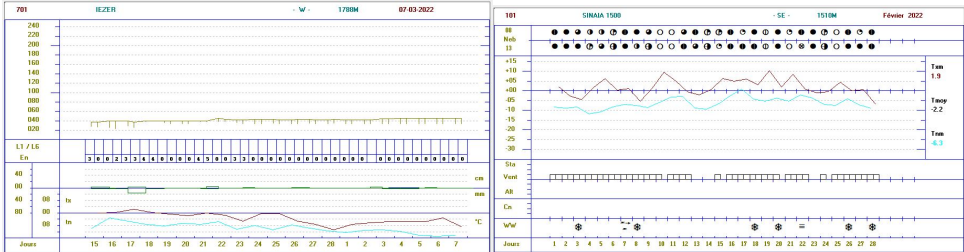


**Fig. 3. 2022.02.02 and 18, 2022.03.02, at 00 UTC – NCEP numerical model – reanalysis. Geopotential and 500 hPa temperature**

The 850 hPa level isotherms were broadly between 0 and -10 degrees Celsius, with short passages where they were positive, especially in the Southern Carpathians (February 6-7, February 10-12, February 16-23, February 26). The coldest periods were in the periods 18-19 January, 21-26 January, 28 February-02 March and 07-13 March (Fig. 4 and 5).



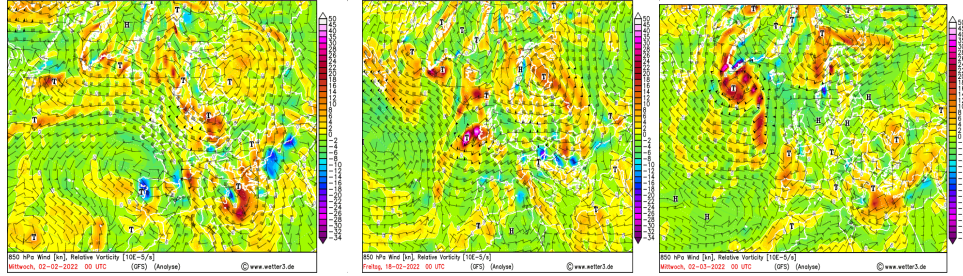
**Fig. 4. 2022.02.02 and 11, 2022.03.02, at 00 UTC – NCEP numerical model – reanalysis. Geopotential and 850 hPa temperature**



**Fig. 5. Evolution of maximum and minimum temperatures the snow cover at Iezer and Sinaia meteo stations, to highlight the warmer periods during February (Gelinivw)**

In Table 1 we have listed the maximum wind gusts in m/s recorded by the weather station Vârful Omu (2504m), representative station for the mountain ridges and for

the winds responsible for the formation of wind slabs in the ridge area. Similar gusts were recorded by other altitude stations such as Țarcu or Reșița-Călimani. As we stated in the introduction, the entire period had constant winds, with some more intense passages in which 100 km/h were exceeded. Strong high winds are also highlighted in the GFS 850 hPa wind maps (Fig. 6)



**Fig. 6. 2022.02.02 and 18, 2022.03.02, at 00 UTC – NCEP numerical model – reanalysis.**  
*Wind at 850 hPa, Relative vorticity*

**Table. 1. Maximum gusts (m/s) recorded at the weather station Vârful Omu (2504 m)**

|           |    |    |    |         |           |    |    |         |
|-----------|----|----|----|---------|-----------|----|----|---------|
| 2022-2-1  | 12 | 12 | 12 | VF. OMU | 2022-2-18 | 29 | 29 | VF. OMU |
| 2022-2-2  | 20 | 20 | 20 | VF. OMU | 2022-2-19 | 22 | 26 | VF. OMU |
| 2022-2-3  | 28 | 29 | 28 | VF. OMU | 2022-2-20 | 17 | 20 | VF. OMU |
| 2022-2-4  | 20 | 21 | 20 | VF. OMU | 2022-2-21 | 15 | 16 | VF. OMU |
| 2022-2-5  | 25 | 28 | 25 | VF. OMU | 2022-2-22 | 16 | 17 | VF. OMU |
| 2022-2-6  | 23 | 25 | 23 | VF. OMU | 2022-2-23 | 22 | 22 | VF. OMU |
| 2022-2-7  | 25 | 27 | 25 | VF. OMU | 2022-2-24 | 20 | 27 | VF. OMU |
| 2022-2-8  | 34 | 30 | 34 | VF. OMU | 2022-2-25 | 16 | 16 | VF. OMU |
| 2022-2-9  | 34 | 34 | 34 | VF. OMU | 2022-2-26 | 08 | 08 | VF. OMU |
| 2022-2-10 | 16 | 17 | 16 | VF. OMU | 2022-2-27 | 14 | 10 | VF. OMU |
| 2022-2-11 | 17 | 18 | 17 | VF. OMU | 2022-2-28 | 20 | 16 | VF. OMU |
| 2022-2-12 | 17 | 17 | 17 | VF. OMU | 2022-3-1  | 30 | 30 | VF. OMU |
| 2022-2-13 | 10 | 10 | 10 | VF. OMU | 2022-3-2  | 20 | // | VF. OMU |
| 2022-2-14 | 10 | 11 | 10 | VF. OMU | 2022-3-3  | 20 | // | VF. OMU |
| 2022-2-15 | 13 | 14 | 13 | VF. OMU | 2022-3-4  | 06 | 06 | VF. OMU |
| 2022-2-16 | 19 | 19 | 19 | VF. OMU | 2022-3-5  | 00 | // | VF. OMU |
| 2022-2-17 | 23 | 29 | 23 | VF. OMU |           |    |    |         |

### 3. AVALANCHES

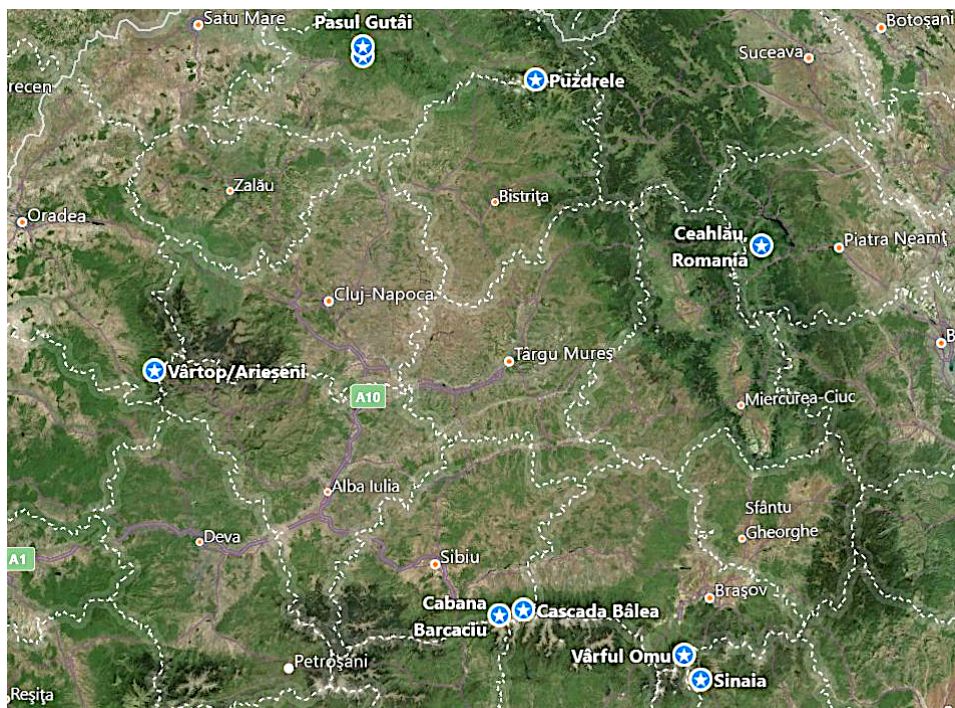
As a result of the gradual accumulation of snow in the second part of January, more consistent in the Southern Carpathians, the first recorded avalanches of February took place in the Bâlea Valley, near the Bâlea-Lake meteorological station. We specify that only known and observed avalanches are recorded, but many avalanches occur in hard-to-reach areas in winter, without being reported.

Thus, during the period 01-04 February 2022, several small or medium-sized dry snow avalanches were observed in the Bâlea-Lake resort area, at altitudes of 2000-2500 m.

On February 7, two low-altitude avalanches were reported in Bihor and Maramureș counties, which temporarily blocked two roads (DN75 in the Vârtop area and DN18 in the Gutâi pass area).

During the period 11-14 February 2022, several small avalanches, dry or wet, were observed in the high area of the Bucegi Mountains, against the background of

slightly warmer weather during that period, which determined some superficial flows under the action of the sun.



**Fig. 7. Avalanches observed in the period 01.02-05.03.2022 in the monitored massifs**

Between February 16-21, avalanches were reported in several massifs, on February 16 in the Ceahlău massif, on February 17 two avalanches in the Rodnei massif (at Cabana Puzdrene and on Valea Șuilor) and one in Bucegi, and on February 21 in Bălea-Lake area.

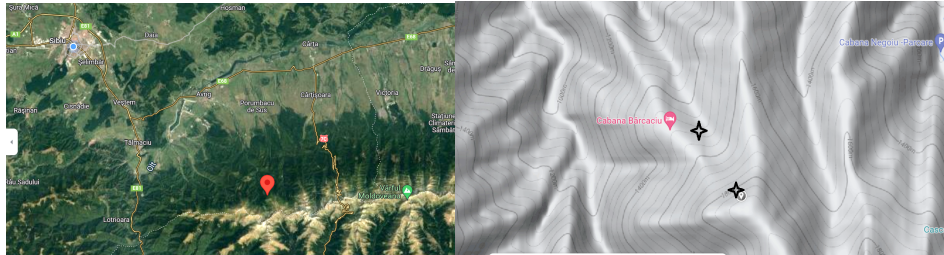
At the beginning of March, avalanches were recorded only in the Southern Carpathians, near the Papagal Slope in Sinaia on March 3, with 2 victims caught and released relatively quickly, several small avalanches in the Bălea-Lake area on March 4, and the only avalanche with two deceased victims took place on March 5 above the Bărcăciu Hut in the Făgăraș Mountains, two mountain rescuers on a hiking trail triggering a slab avalanche at approximately 1900 m.

The new avalanche classification grid of the European Avalanche Warning Services (EAWS) divides avalanches into small, if the flow is 10-30 m and involves a volume of up to 100 mc of snow, medium if the flow is 50-200 m and the volumes of up to 1000 m<sup>3</sup>, large if the flows are several hundred meters and the volumes up to 10000 m<sup>3</sup>, very large if the avalanche corridor is 1-2 km and the volumes up to 100,000 m<sup>3</sup> and extreme if they exceed 2 km and 100,000 m<sup>3</sup>.

#### 4. CASE STUDY – THE AVALANCHE NEAR THE BÂRCACIU CHALET - 05.03.2022

In 2021-2022 there were 58 reports with 6 persons trapped and 2 deaths. Those are only the avalanches observed near the observation points, and one report can contain several avalanches observed at once.

Bellow, we have described the avalanche from 05 march 2022, who was triggered near Bârcaciu Chalet, by two skiers at 1900 m, on a NV slope. The avalanche had 1000 m in length, 50-60 m width and 600 m in altitude. The crown thickness was 40-60 cm and it was a dry snow slab avalanche.



**Fig. 8.** *We have pointed with stars the starting point of the avalanche at ~1900m and the end point at ~1300-1400 m, near Bârcaciu Chalet.*

In the previous 10 days, there were moderate snowfalls that gathered ~20-30 cm of new snow, with constant winds of 60-70 km/h at 2000 m altitude, from NE, N and NV, which formed the slab that cracked under the 2 skiers. The risk issued was 3 the day before de accident and 4 the day after, due to the constant snowfalls in the last days corelated with the constant wind at the ridges level. The accident took place at 16.05 pm.



**Fig. 9.** *Pictures from the avalanche near Bârcaciu Chalet*

The snow pit made in 01 march 2022 at Bâlea-Lac, the nearest measure point to the avalanche, showed a layer of fresh snow with low resistance over a crust, over which it can slide. The reason that there is no slab present here, is because the station

is placed in a valley at 2000 m, protected from the strong winds that usually blow the ridges. But this station is a good landmark, because it's placed also on a northern slope, like the area affected by the avalanche, at a similar altitude and in the proximity (~15 km)

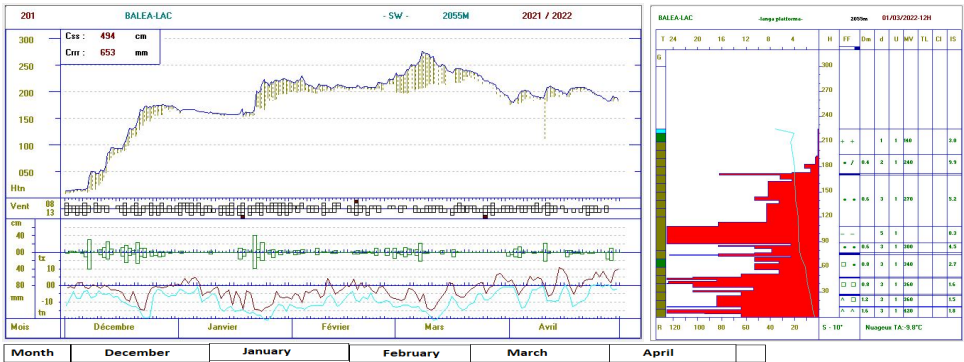


Fig. 10. Seasonal variation of snow cover, Tmax, Tmin, wind, survey 01.03.2022 - Bâlea Lac

### 5. CONCLUSIONS

From the analysis of the situations that generated the series of avalanches from February to March, we can conclude that the succession of fast-moving cold troughs, which are usually also accompanied by intense winds and moderate amounts of precipitation, will lead to gradual accumulations of snow in all massifs, but especially on the slopes exposed to the wind. The air circulation being in these situations from the predominantly north-western sector, with temporary northern or western components, the northern slopes of the Southern Mountains, the western slopes of the Eastern Carpathians or the western and northern slopes of the Western Carpathians will be more exposed. Here the snow accumulations will be more consistent than those on the opposite slopes. Near the ridges, however, northerly, northwesterly, and westerly winds will create wind slabs, especially on the southern, southeastern, and eastern slopes, due to the intense winds that will break up the snow and carry it over the ridges several hundred meters down the slopes and on the valleys located immediately after the ridge area. A particular case is represented by the northern edges of the Făgăraș Mountains that separate the descending valleys towards the north and which are extremely close to each other, here the intense winds can transport the blown snow from one western slope to the next, over the entire valley, thus generating multiple slabs of wind on different exposures and at different altitudes, thus making the northern edge of the Făgăraș Mountains the most dangerous area for the risk of avalanches, especially considering the inclinations of the slopes which are often around 40 degrees. Wind slabs form almost

instantaneously during snow transport and can remain dangerous for several weeks after formation, provided temperatures remain below zero.

At the same time, at lower altitudes on the slopes exposed to the wind, more important accumulations are created, which on the background of warmer days with slightly positive temperatures can generate wet flows or avalanches, which sometimes reach populated or circulated areas (the case of avalanches from Vârtop and Șuitor area).

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