

SYNOPTIC AVALANCHE TRIGGERING CONDITIONS DURING 2014-2015 WINTER

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ABSTRACT. – The paper presents and analyzes synoptic conditions that led to avalanche triggering during 2014-2015 winter, especially for the monitored area of Bucegi and Făgăraș Mountains. Data from daily observations and NCEP reanalysis ground level pressure maps, absolute topography and temperature maps at 500 hPa were used, from <http://www.wetter3.de>. The study is part of Snowball Project, which aims to inventory the cases of avalanches previously known in our country and favorable triggering conditions, for better estimate the risk of avalanche and lower what effects they might have on the environment and people.

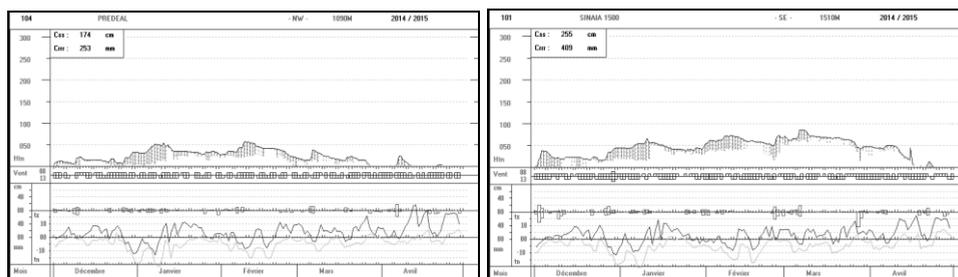
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1. INTRODUCTION

The first snowfall of 2014-2015 winter season was reported in September 23, on high altitudes, without forming a continuous snow layer. On November 17, new snowfall was recorded in most mountain areas and a continuous snow layer was formed at Bâlea-Lac, Sinaia and Vârful Omu meteorological stations. Snow layer was continuous at Bâlea-Lac and Vârful Omu up to May 25 and 31, 2015, and patched until June 24 and 30, 2015.

There have been several heavy snowfalls episodes, with large amounts of snow, thus increasing the risk of triggering avalanches. Snow height measured inside meteorological stations platform reached 244 cm at Bâlea-Lac on April 7, 172 cm at Vârful Omu (between April 7 and 9), 86 cm at Sinaia (March 7 and 8) and 57 cm in Predeal (February 9-10) (fig.1).

The annual schedule of daily meteorological parameters observed at the four stations show the snow thickness variation, as well as alternation of colder with warmer periods, that favored partial snow melting and surface wettness.



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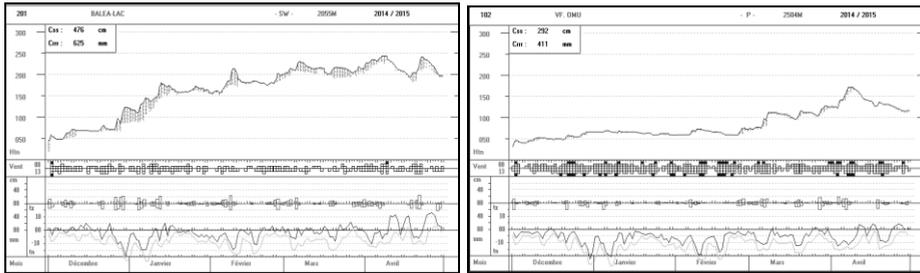


Fig. 1. 2014-2015 winter season - daily meteorological parameters measured at the four meteorological stations within avalanche program

2. ANALYSIS OF THE PHENOMENA

As recorded in the Annual Report (***, Bilanțul nivologic), during the studied winter season, there have been 46 days with 125 reported avalanches, in all mountain areas, most of them in Bucegi and Făgăraș, where the National Meteorological Administration program for snow and avalanches is running.

Of these, 18 occurred on high pressure conditions (ground pressure above 1020 mb), from which 3 on more than 1030 mb. The Azores Ridge acted in 10 cases, the East European Anticyclone in 3 cases, and in 5 cases an anticyclone zone formed by the two Highs. A contact between Azores High and Icelandic Low was recorded in 4 cases (1015 to 1020 mb). Pressure at ground level was lower than 1015 mb in 24 cases, due to the Icelandic Low, with his Trough extended to southern Europe (14 cases), cyclones formed in the Mediterranean (4 cases) or coming from northern Europe (6 cases).

At the level of 500 hPa, geopotential values ranged from 520 to 576 dmgp. Of these, in 5 cases the values were lower than 530 dmgp, 7 between 530 and 550 dmgp and 13 between 550 and 560 dmgp, 19 between 560 and 570 dmgp and 2 over 570 dmgp, with the highest value of 576 dmgp. The most common height structure was the trough associated to the Icelandic Low. In 16 cases, over our country was the ascendent part of the Trough (with a the southwestern circulation), in 9 cases the downlink, and in 3 cases cyclonic nuclei crossed the country. The associated Azores Ridge was present in 20 cases.

The values of the 850 hPa level isotherm were less than -10 degrees in 1 case, between -10 and -5 degrees in 6 cases, between -5 and -1 degree in 11 cases, -1 to 1 degree in 7 cases; 1 to 5 degrees in 9 cases; 5 to 10 degrees in 6 cases; 10 to 15 degrees in 5 cases and more than 15 degrees in 1 case.

3. SYNOPTIC CONDITIONS FOR AVALANCHE PERIODS

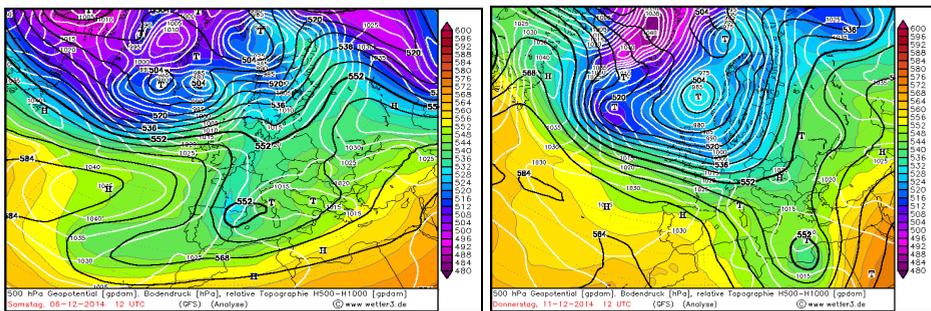
3.1. November 28 – December 14, 2014

During this period there have been three intervals with heavy snowfall: from november 28 to December 2, with snow increase from 24 to 45 cm at Vârful

Omu and 41 to 60 cm at Bâlea-Lac; December 2 to 4, with 38 cm deposited snow in Sinaia and December 6 to 9, with 23 cm new snow in Bâlea-Lac.

Until December 6, the Eastern European High was active over the country, then moved northeast to Romania, with a widening Icelandic Trough in altitude. An anticyclonic belt was formed in the northern part of country between Eastern European and the Azores High, which will remain until the end of the interval, with the associated Icelandic Trough in altitude (fig.2).

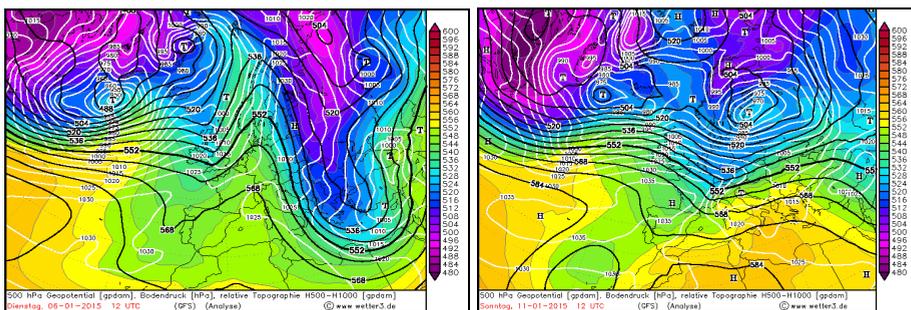
Field ground pressure values were of 1020 to 1025 mb, except on December 7 and 8, when they dropped to 1017 mb. Into the medium troposphere, the geopotential values were of 552-568 hPa, with 552-554 hPa between December 7 to 11. At the level of 850 mb, isotherm value ranged from -2 to +2 degrees, except on December 11, when they fell to -4 degrees.



**Fig. 2. 2014.12.08 and 11, at 12 UTC – NCEP numerical model – reanalysis.
Ground-level pressure, absolute topography and 500hPa geopotential**

3.2. January 5 to 11, 2015

Azores Ridge (1035 mb) withdrew on January 4, with Icelandic Low deepening east to Romania (direct polar circulation); our country was at contact between the two baric systems (ground pressure was of about 1020 mb). From January 6, Azores Ridge advanced again over our country, with a correspondent structure in altitude, increasing ground pressure to 1035 mb and geopotential values (fig.3)..



**Fig. 3. 2015.01.06 and 11, at 12 UTC – NCEP numerical model reanalysis.
Ground-level pressure, relative topography, 500hPa geopotential**

After January 9, Azores Ridge withdrew, Icelandic Low descended, with associated structures in altitude. Geopotential values at 500 hPa marked a significant drop in December 6 (544 to 528 hPa), and then increase to 552-556 hPa. (fig.3).

The temperature at 850 hPa level decreased to -10 degrees on January 5, to -14 degrees on January 7, then increased to -9 degrees in January 8, -2 degrees in January 9 and 10, then to 4 degrees in January 11.

3.3. January 26 – February 13, 2015

During this time, frequent avalanches occurred in all mountains - there are records from Făgăraș, Vlădeasa, Bucegi, Latoriței, Parâng, Rodnei Mountains.

The period was characterized by significant changes in the ground pressure field. With the Azores Ridge withdrawal on 26 January and widening Icelandic Trough, ground pressure field marked a sharp decline from 1022 to 990 mb (between 30 January and 1 February), then gradually increased to 1022 mb on February 7, followed by another accentuated decline on 8 February (to 1005 mb, with a rapid transition of a cold front) and then forming an anticyclone belt between the Azores and the East European High, with gradual ground pressure increase up to 1030 mb (fig.4).

In middle troposphere, the associated Icelandic Trough persisted up to 11th February, together with the advance of the Azores Ridge to west. The values of 850 hPa level isotherm has maintained from -6 to -2 degrees between January 26 and February 4, except on January 30, when increased to 0 degrees. It then increased again to 0 degrees on February 6, felt sharply to -8 degrees in February 7 and to -12 degrees on February 9 and 10, and then again to -1 degree by the end of the interval (fig.4).

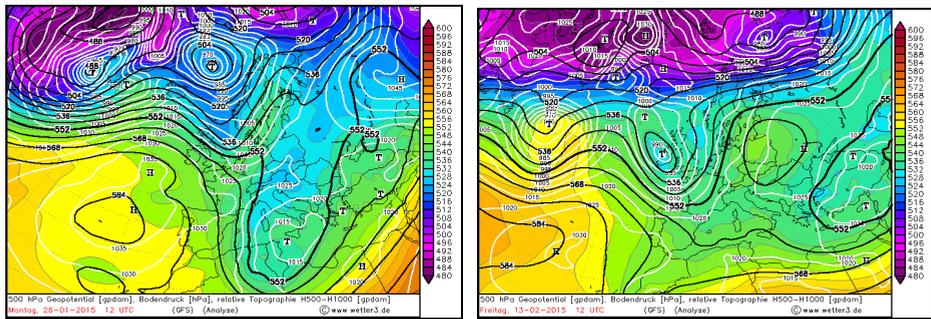


Fig. 4. 2015.01.26 and 03.16, at 12 UTC – NCEP numerical model reanalysis. Ground-level pressure relative topography, 500hPa geopotential

Between 5 and 10 February, significant snowfall have been recorded, with snow height rising from 160 to 214 cm in Bâlea-Lac and from 33 to 56 cm in Sinaia (between 6 and 9 February). The weather has cooled markedly since February 7 – from maximum temperatures of -3...-2 degrees at Bâlea-Lac, to values of -14 degrees on February 11 and night temperatures felt to -17.7 degrees. At Vârful Omu, maximum temperatures decreased to -19 degrees and the minimum to -23 degrees. Last two days of the interval, the weather has warmed significantly, to maximum temperatures of

+0.9 degrees at Bâlea-Lac and +7.6 degrees at Sinaia (from -13.8, -8.7 degrees respectively on previous day) and avalanches were recorded each day.

3.4. February 26 – March 1, 2015

During this period, over our country passed several frontal systems. Ground pressure field values were of 1015-1018 mb, with an 550-552 dmgp geopotential associated Icelandic Trough on altitude. Isotherms at 850 hPa values were slightly positive (0-2 degrees), and air circulation from the southwest sector (fig.5).

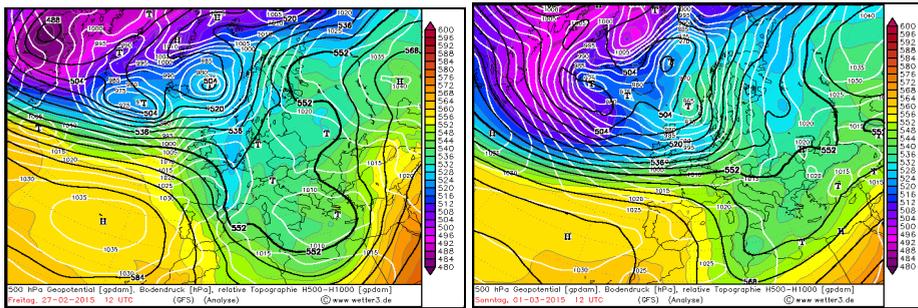


Fig. 5. 2015.02.26 and 03.01, at 12 UTC – NCEP numerical model – reanalysis. Ground-level pressure, absolute topography and 500hPa geopotential

Snow height had risen by 20 cm (Bâlea-Lac), maximum temperatures were positive on low altitude meteorological stations (Predeal and Sinaia), varied around 0 degrees at Bâlea-Lac and remained negative at Vârful Omu. Several slab avalanches were recorded every day in Bucegi and Făgăraș Mountains.

3.5. March 7 to 22, 2015

Ground pressure field was high, due to the Azores Ridge, with values up to 1037 mb, and associated ridge on middle troposphere (up to 568 dmgp). On March 11, both ground pressure and geopotential at 500 hPa decreased significantly because of Trough lowering from north, that remained over the country until March 14, retreated on the northern Black Sea and then coming back on a retrograde path, with a cold core over the country. Isotherm at 850 hPa level increased from -8 degrees on the first day to +1 degree on March 9, then decreased and remained at -2 degrees until March 17, felt back to -8 degrees on March 19 and finally increased to +2 degrees on March 22 (fig.6).

3.6. March 26 to 30, 2015

The interval was characterized by the presence of the Icelandic Trough and advance of a Mediterranean Low to south and then east of the country. Frontal systems were active in western Romania from March 22 to 27, together with

Icelandic Low descent, then an occluded front over the country up to March 30. In middle troposphere, an associated Icelandic Trough was also active. Ground pressure field gradually decreased from 2012 to 1003 mb, the 500 hPa geopotential from 562 to 548 dmgp and the 850 hPa isotherme from +5 to 0 degrees (fig.7).

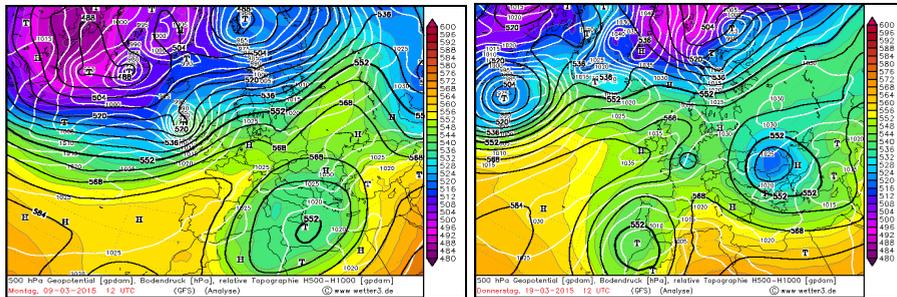


Fig. 6. 2015.03.09 and 19, at 12 UTC – NCEP numerical model – reanalysis.
Ground-level pressure, absolute topography and 500hPa geopotential

Maximum temperatures were positive at Bâlea-Lac, Sinaia and Predeal and around 0 degrees at Vârful Omu. Every day were recorded mixed precipitation, mostly snow over 2000 m altitude, where a new snow layer of 10 to 22 cm has formed (at Bâlea-Lac and Vârful Omu). Daily melting avalanche occurred.

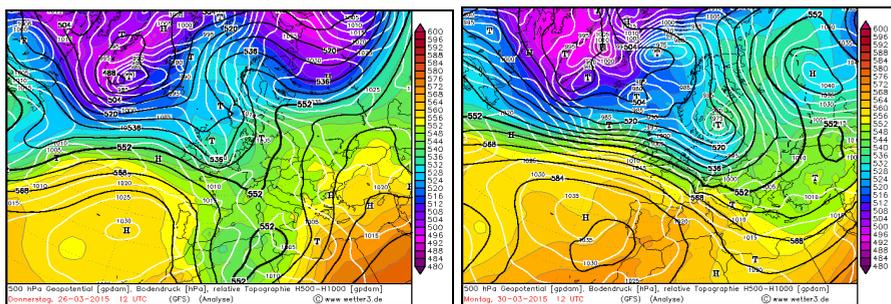


Fig. 7. 2015.03.26 and 30, at 12 UTC – NCEP numerical model – reanalysis.
Ground-level pressure, absolute topography and 500hPa geopotential

3.7. April 10 to 16, 2015

Until the end of that period, the Azores Ridge persisted over the country, with ground pressure field values decreasing gradually from 1027 to 1020 mb. On the last day, the Azores Ridge withdrew and the Icelandic Low descent. In the middle troposphere, the associated Azores Ridge also persisted over the country, with geopotential values of 564...568 dmgp. In lower troposphere, the 850 hPa isotherm increased from 4 to 8 degrees (on April 12 and 13), then varied widely, from 0 degrees on April 14, to +4 and +10 degrees (in April 1 and 16) (fig.8).

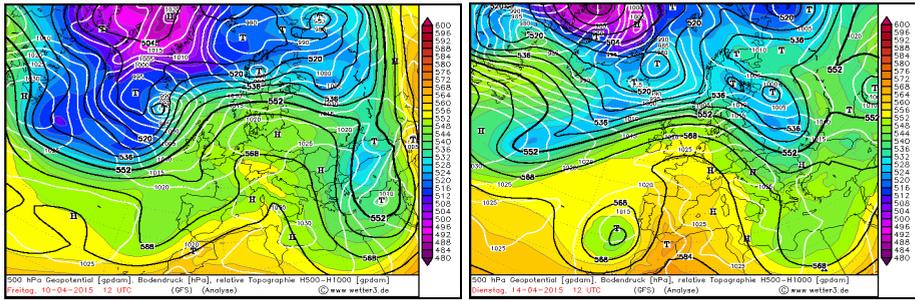


Fig. 8. 2015.04.10 and 14, at 12 UTC – NCEP numerical model – reanalysis. Ground-level pressure, absolute topography and 500hPa geopotential

Daytime temperatures recorded at all meteorological stations were positive, reaching +15.9 degrees at Bâlea-Lac, +16.8 degrees in Predeal, +14.9 degrees in Sinaia and +3.8 degrees at Vârful Omu. Night temperatures were negative at altitudes above 2000 m and positive at lower altitudes. Snow melted fast, from 234 to 206 cm at Bâlea-Lac, 166 to 140 cm at Vârful Omu, 48 to 10 cm at Sinaia, 11 to 0 cm in Predeal. Melting avalanches were recorded almost every day.

3.8. April 23 – May 05, 2015

After a period with important snowfall, until April 28, with the withdrawal of Azores Ridge and lowering of Icelanding Trough, ground pressure field over the country was about 1020 to 1016 mb. Between April 28 and 30, a frontal system moved from west to east, then a depression field remained, with frontal systems on May 3 to 5 and ground pressure of about 1010 mb. In the middle troposphere, geopotential field was high (558 to 576 dmgp), with a persistant ridge, and in the lower troposphere temperature ranged from +4 to +10 degrees (April 26 to 28), decreased again at +4 degrees on April 29 and then increased to +14 degrees on May 5 (fig. 9).

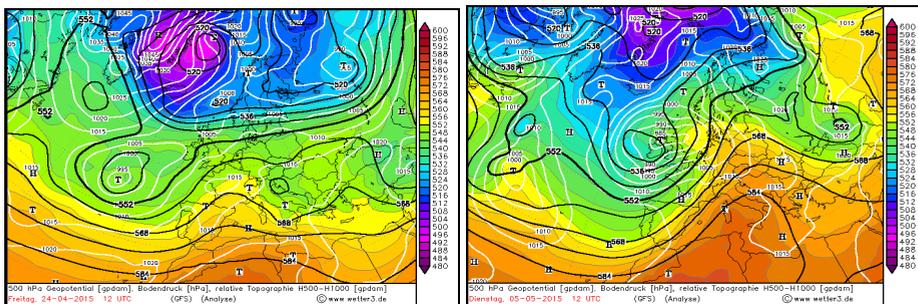


Fig. 9. 2015.04.24 and 05.05, at 12 UTC – NCEP numerical model – reanalysis. Ground-level pressure, absolute topography and 500hPa geopotential

Temperatures were generally positive, both diurnal and nocturnal, except the ones from Vârful Omu. Snow was melting accelerated, from 241 to 164 cm at

Bâlea-Lac, 130 to 106 cm at Vârful Omu and totally disappeared in Predeal and Sinaia. Several melting avalanches were recorded.

5. CONCLUSIONS

The presented cases show that avalanches occur under different synoptic conditions and during the whole winter season. Though most of them happen after important snowfall or abruptly increasing temperatures, the triggering conditions also depend on snow crystals transformations within the layer, especially on the formation of faceted, unstable crystals inside.

The increasing number of winter hikers and skiers in all Romanian mountains demand special measurements, in order to avoid any human life loss, but also to prevent massive accidents with significant economic damage. Though, permanent snow and avalanche recording measurements are needed, especially in areas with high tourist potential.

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