AVALANCHES - EXTREME WINTER EVENTS. MONITORING AND AVALANCHE RISK

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ABSTRACT. This paper presents the avalanches monitored by the National Meteorological Administration within the nivo-meteorological program since february 2004. Daily observations and weekly snow measurements are made at the weather stations from Bucegi Mountains - Vârful Omu (2504 m), Sinaia (1500 m) şi Predeal (1100m) and Făgăraş Mountains – Bâlea-Lac (2055m), to provide data for avalanche risk estimation using the european avalanche danger scale. Increasing winter sport activities had led to several avalanche accidents, some of them fatal.

Keywords: avalanches, snow, measurements, risk

1. INTRODUCTION

Avalanches are one of the most spectacular, but also distructive extreme weather fenomena that cause every year important economic damages (mainly forest) and human victims. Though the Romanian Carpathians are not as high as other massifs – the Alps, for example, a lot of avalanches happen each winter, registering human injuries and fatalities. One of the first mentions about avalanches in the Romanian Carpathians is from april 1704 in the Ceahlău massif; the avalanche stroke the Sihăstria monastery and killed twenty monks (Bălan, 2001).

Several accidents were reported when tourism have developed over the interwar period and mountain clubs have been establisehd: Romanian Alpine Club, Touring Club, SKV (Siebenburgischer Karpatische Verein). Tourism development also led to the first avalanche accidents that were involving tourists, skiers or climbers. Such phenomena and accidents have occurred in all the Carpathians, but most frequently in the Făgăraş and Bucegi Mountains.

In order to protect the tourists, since february 2004 the National Meteorological Administration started a program for snow and avalanche monitoring in Bucegi and Făgăraş Mountains.

The study presents the importance of avalanche monitoring and snow studies in the mountainous areas affected by avalanches, in order to provide a daily estimation of avalanche risk, as well as the evolution and characteristics of the avalanche risk during the winter seasons in the two monitorized massifs.

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2. SNOW AND AVALANCHE STUDIES

First studies about avalanches have been made in 1963 and 1964, when many avalanches occured all over the Carpathians and blocked railways and highways: 150 avalanches in the Maramureşului Mountains, about 30 avalanches in Rodnei Mountains and 20 in Bihor Mountains. After a government decision was released, forest districts have inventoried avalanche corridors (Gaspar et al, 1968).

Using informations from Sibiu and Braşov Mountain Rescue Service, papers or articles (www.dinumititeanu.blogopedia.biz), literature (Voiculescu, 2002), and from the National Administration of Meteorology database, we made a statistics in decades about the avalanche cases with victims and fatalities (fig.1).

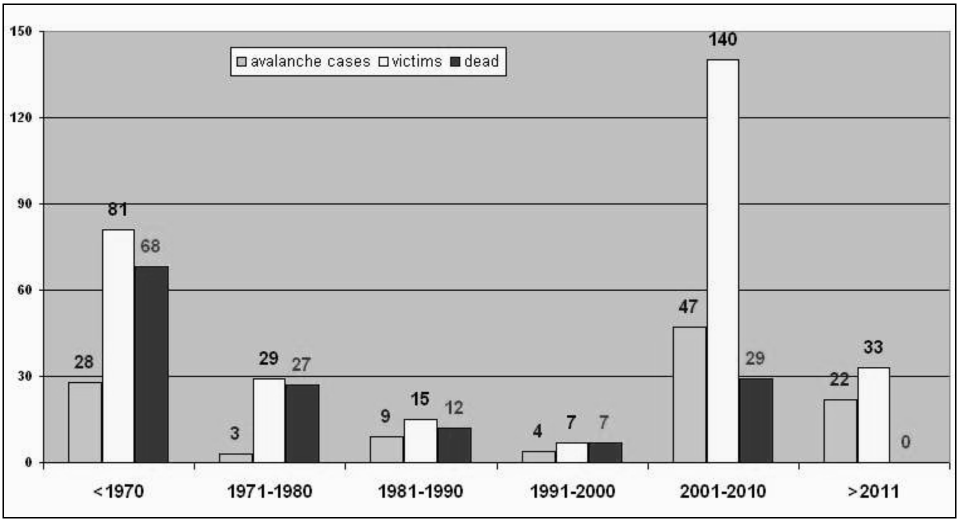

Fig. 1. ***Avalanche cases,number of victims and fatalities in the Carpathians***

It can be seen that very many cases were reported between 2001-2010. This is due to the fact that since february 2004 the snow and avalanche monitoring program within National Administration of Meteorology started, as a response to the increased request and interest on the avalanche activity. The program was initialized in collaboration with Meteo-France and is also called nivo-meteorological, after the french term „nivologie".

As for the massifs where avalanches with victims occured, most of them were in the Făgăraş Mountains, followed by Bucegi, Ceahlău, Rodnei. For every massif it was taken into consideration the number of avalanche cases, as well as the number of persons caught by the avalanche and the deceased. Though in the Bucegi Mountains there are more tourists and skiers, in fig.2 it can be seen that the number of avalanche cases and victims was higher in Făgăraş. This is also due to the fact that the most dramatic avalanche in Romania happened at Bâlea-Lac in 17th april 1977, when twenty-three people died in an avalanche, all of them from Sibiu; among them there have been sixteen children. Avalanche cases with victims have been also in other massifs, as Piatra Craiului, Retezat, Baiului, Lotrului, Gutâi, Vâlcan, Postăvaru, Ţarcu, Căpăţânii; but the number of people involved or even deceased is much smaller, up to 4.

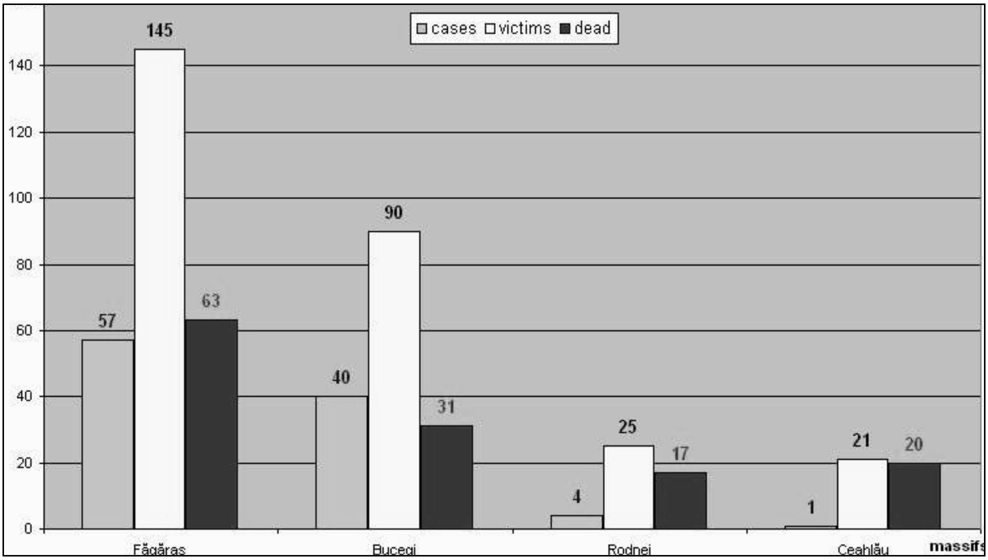

Fig.2. ***Avalanche cases, victims and deceased by massifs; known data until June 2011***

Considering the same data mentioned above, a statistic of the valleys where avalanches with victims where reported can be made. In Făgăraş Mountains, most people envolved in avalanches accidents were in Bâlea Valley. In Bucegi massif, most people trapped by avalanche were in Morarului Valley.

3. SNOW AND AVALANCHE PROGRAM WITHIN THE NATIONAL ADMINISTRATION of METEOROLOGY

3.1. Observational network

The observational network includes meteorological stations from mountainous regions high frequented by hikers and skiers: Bucegi, Baiului and Făgăraş Mountains. The stations are situated between 1090 and 2500 m and cover most of the mountain area: Vârful Omu - 2504 m, Sinaia – 1510m (Bucegi), Predeal – 1090 (Baiului) and Bâlea-Lac – 2055m (Făgăraş Mountains.). Between 2006 and 2009 observations have been made also in Postăvaru – 1784m (Postăvaru Massif), until the meteorological station was closed.

The observations within the program are made daily and weekly. Daily observations are made twice a day, at 06 and 12 UTC, and includes meteorological data, specific snow characteristics (snow temperature at 10 cm below surface, snow type, snow crystal type at the surface and their medium diameter, depth penetration of the nivological sonde into the snow layer), informations about avalanches occurred in the visible area: number, short description, type, declanchement altitude, exposure and a local estimation of the avalanche risk degree.

Every weekly measurementes concern the snowpack structure and determine: the resistance of the snowpack, every internal snow layer, with their grain types, density, hardness and humidity, together with every 10 cm of snow temperature.

All the data are written into GELINIV, an Integrated Software for Snow Data Analysis developed by CEN (Centre d'Études de la neige) Météo France.

Simulation and forecasting the evolution of the snow cover and avalanche risk is made using the CROCUS MEPRA PC Version Roumanie 2004 software, a program that simulates physical processes within the snowpack and assess snowpack stability at different elevations, slopes and aspects of the considered massifs (Administraţia Naţională de Meteorologie,2008).

3.2. Avalanche risk estimation

Estimating the avalanche risk for a specific mountainous region requires a good knowledge of the area (relief, climate), good weather forecast and a most accurate snow metamorphosis forecast. Weather and snow parameters evolution are evaluated in order to estimate the probability of avalanche occurrence in the monitorized area, information about the place, the time and the probability of release for a specific type of avalanches (slab or sluff, large or small, wet or dry). All these are summarized in a degree of avalanche hazard.

The avalanche risk is estimated using the European Avalanche Danger Scale. This is a 5-level risk scale undertaken by the European countries since 1993, and since 1996 by Canada and United States (fig.3) (www.slf.ch/lawineninfo/).

Danger level	Icon	Snowpack stability	Avalanche triggering probability
5 - Very high		The snowpack is poorly bonded and largely unstable in general.	Numerous large-sized and often very large-sized natural avalanches can be expected, even in moderately steep terrain.
4 - High		The snowpack is poorly bonded on most steep slopes.	Triggering is likely even from low additional loads** on many steep slopes. In some cases, numerous medium-sized and often large-sized natural avalanches can be expected.
3 - Considerable		The snowpack is moderately to poorly bonded on many steep slopes*.	Triggering is possible, even from low additional loads** particularly on the indicated steep slopes*. In some cases medium-sized, in isolated cases large-sized natural avalanches are possible.
2 - Moderate		The snowpack is only moderately well bonded on some steep slopes*, otherwise well bonded in general.	Triggering is possible primarily from high additional loads**, particularly on the indicated steep slopes*. Large-sized natural avalanches are unlikely.
1 - Low		The snowpack is well bonded and stable in general.	Triggering is generally possible only from high additional loads** in isolated areas of very steep, extreme terrain. Only sluffs and small-sized natural avalanches are possible.

Fig.3. *Avalanche danger scale (http://www.avalanches.org/basics/degree-of-hazard/)*

The operational work within the National Administration of Meteorology was materialized in daily bulletines since January 2005. The bulletins are delivered to the local authorities, Mountain Rescue Services and mass-media. For avalanche risk estimation the meteorological stations Vârful Omu, Sinaia and Predeal are taken into account for the Bucegi Mountains, and Bâlea-Lac for the northern part of the Făgăraş Mountains.

A comparison between the greatest estimated avalanche risk over the past winters shows that the most used was level 3 - considerable. The greatest avalanche risk is considered for both mountainous regions – Bucegi and Făgăraş. The very high (5) and low (1) avalanche risk were used rarely. The data are taken from the National Administration of Meteorology annual Snow Reports from 2004 to 2011 (fig.4).

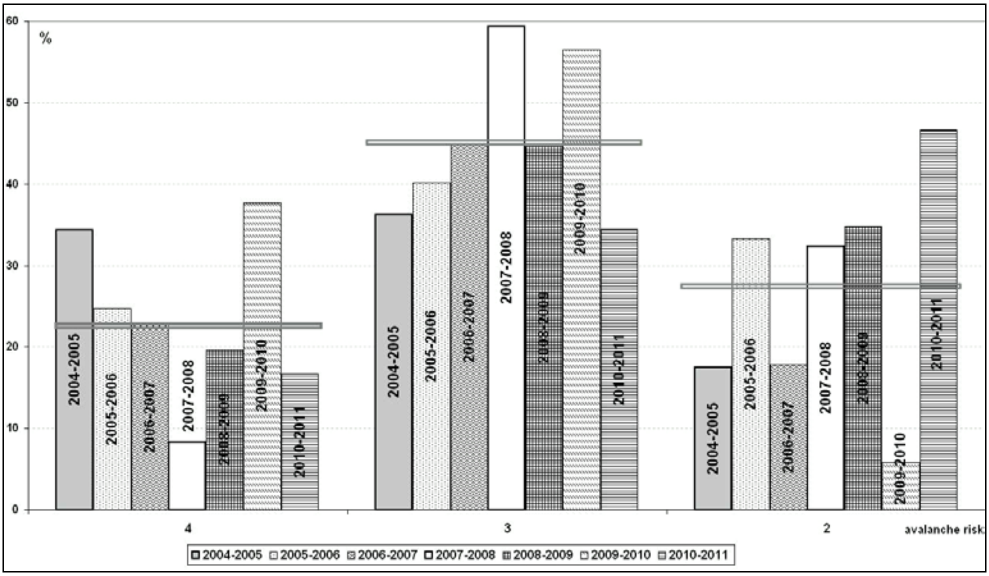

Fig.4. ***Greatest avalanche risk estimated daily for every winter since 2004 (%), compared with the average values (horizontal lines)***

A higher avalanche risk was estimated in case of heavy or abundant precipitations, as well as the metamorphosis of snow crystals inside the snowpack have formed instable structures that could favorise avalanche release.

The observed avalanches happened as well to a high (4) and very high risk (5), as to a considerable (3) or moderate (2). The avalanches have been triggered spontaneously or by the skiers, hikers or snowboarders, and some of them were fatal. As to the period of time, avalanches happened all over the winter season, when the snowpack was more consistent, but most of them occurred between february and april.

Using the avalanche data gathered since the beginning of nivo-meteorological program, for the monitorized area (Făgăraş and Bucegi Mountains) most avalanches occurred on march (30%), than in april (21,5%), february and may (13,4%) (fig.5).

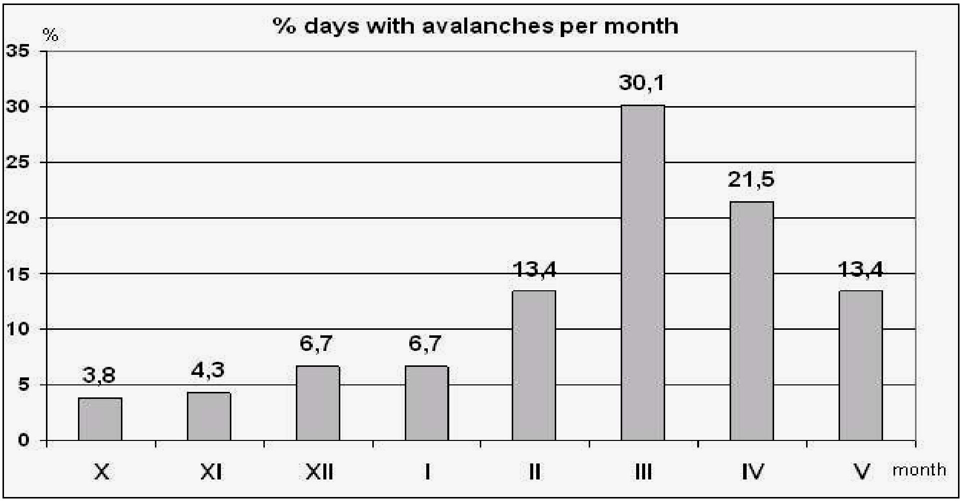

Fig.5. ***Avalanche accidents from january 2004 to june 2011; data within the nivo-meteorological program in National Administration of Meteorology***

Between the two massifs, the avalanche risk estimated for Făgăraş turned to be higher than in Bucegi for every winter. This is due to the fact that in Făgăraş the amount of snow is usually higher than in Bucegi, and the orographical aspects are more favorable to avalanche releases – all the northern part of the Făgăraş mountains is very steep, with glacier valleys over 2000 m. However, in some days, the estimated avalanche risk in Bucegi was higher than in Făgăraş.

If we examine the days when avalanche accidents occurred (with people involved, even fatal accidents) in relation to the forecasted danger level, it can be seen that most of the accidents occurred by a considerable 3 level risk (fig. 6).

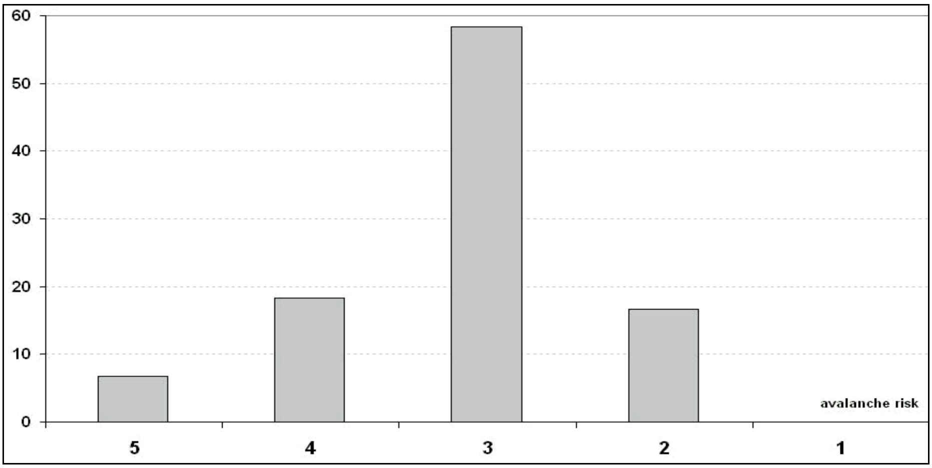

Fig.6. ***Avalanche risk cases when people were involved***

Level 3 is mostly used when the snowpack is moderately to poorly bounded on many steep slopes. Avalanche triggering is thus possible, even from low additional loads, particularly on indicated steep slopes. In some cases medium-sized, or in isolated cases large-sized natural avalanches are possible (fig.3). This means that for a 3 level, people are more responsible for avalanche triggering.

This data can be utilised as a sign how the avalanche danger scale is used by the forecasters to signalize a certain risk to the public and as well how the public uses bulletins to make avalanche safety decisions (Greene et al,2006).

4. CONCLUSIONS:

Avalanches are one of the most powerfull and distructive extreme events, causing economic injuries, as well as victims or fatalities. Because the number of winter hikers and skiers are increasing every year, the daily snow and avalanche bulletin is a useful tool for everyone, from skiers to local authorities and Mountain Rescuers. The number of people interested in the avalanche risk has greatly increased since the beginning of the nivological program in National Administration of Meteorology. Therefore, better communication and a continuing public education is needed for a better understanding of the specific informations transmitted. Thus, the number of human avalanche involvements could be reduced and avalanche safety decisions could be more efficient.

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