Statistical results from historical avalanche records (High Tatra Mountains, Slovakia)

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A b s t r a c t : Available historical avalanche records for the High Tatra Mts. were transcribed from various paper sources into electronic database (SLPDB) with all available avalanche parameters (including International morphological avalanche classification). Some of them were estimated in order to quantify the avalanche activity, and finally simple quality control rules were applied to the data set.

The systematic recording of all avalanches in selected model valleys comes with the first electronic avalanche database (FoxPro under MS DOS) in winter 1991/92. However, there is remarkable increase in avalanche records since winter season 1979/80. These records are useful for the setting of parameters and the verification of computer-based avalanche forecasting methods.

In recent years the monitoring of avalanches in Slovakia has been improved: more valleys were included into regular observation; helicopter flights with special camera since winter 2004/05 make monitoring easier mainly in secluded valleys.

Some conclusions and long-term avalanche statistics for the High Tatra Mts. computed from collected historical avalanche occurrence records (the first one in 1850) are presented: avalanche accident statistics and typical reasons of avalanche accidents, relation between avalanche danger scale and length of avalanche path. The data show that the chances to survive an avalanche are now higher than they were, probably because of better forecasts, equipment and education of people.

Key words: snow avalanche accidents, historical avalanche records, the High Tatra Mountains, Avalanche Prevention Centre database SLPDB

1. Introduction

There are 6 main avalanche-prone mountain ranges in Slovakia: the Tatras (Western, High, Low, Belianske) and the Fatras (Big, Little). People

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were usually scared of severe conditions and did not visit exposed mountainous areas during winters. Maybe due to better winter equipment the number of visitors increased near the 1930's, and again during the boom of winter sports in the 1960's.

The study area lies within the transition zone from maritime to continental climate; the Koeppen classification is Df and E. Frontal systems connected with cyclones located N, NE and NW from High Tatra Mts. deliver lot of new snow. Frontal systems coming from south can bring snow, but the most of precipitation is usually caught by the Low Tatra Mts. The upper forest boundary is around 1550 m a.s.l., starting zones of avalanches range from 1400 to 2600 m, and the lowest deposition zones are near 1100 m a.s.l. Daily average temperatures usually range here from –12 to +14° C.

2. Data

Older avalanche records were collected by *Andráši (1965)* and *Bohuš (1967)* from yearbooks, articles and books of Hungary-Carpathian Society or Czechoslovak Tourists Club, victims documentation of the TANAP Museum, The Symbolic Cemetery, parish registers, and from trustworthy testimonies of climbers, mountaineers and tourists. Other avalanches were collected from APC yearbooks *(APC, 1981–89)*, *(Samuhel, 1990)*, and the avalanche records on the Mountain Rescue Service website *(www.hzs.sk, 2005)* were checked, too. The paper records (including photos and sketches) for the High Tatra Mts. from 1967/68 up to 1991/92 held in the Avalanche Prevention Centre *(APC, 1967–1993)* were transcribed into the computer database by the author. The first electronic avalanche database (FoxPro under MS DOS) used since 1991/92 was replaced by new database (SLPDB – designed by the author) in winter 2004/05. The SLPDB now contains all known avalanche records from the High Tatra Mts., and both new and historical records from other mountain ranges are being transcribed step by step.

Avalanche records were previously written only if there was a victim or remarkable damage. The systematic monitoring of avalanches took place since 1991/92 in model valleys. Secluded valleys are not visited frequently – they are explored only 1-2 times per winter – recently also by the help of helicopter flights, so that only large and disastrous avalanches are monitored there.

Very few avalanche records are available up to 1979/80: only 2 records on average, except the 1950's – about 7 records each winter – thanks to the professional Tatra Mountain Rescue Service founded in 1950. Remarkable increase in the 1980's (about 20 records each winter) is doubled in the 1990's. The monitoring was scarce during the Velvet revolution (1988/89), but no significant avalanches or accidents occurred.

Even though all known and written historical avalanche records were collected, mainly the older data are not absolutely complete and precise. The number of avalanche victims is reliable since 1950 (*Bohuš, 1970*). Also today's monitoring of avalanches is not ultimately perfect. It is performed mainly by the regional centres of Mountain Rescue Guide, by volunteers, TANAP rangers, meteorological observers, etc.

3. Results

The total number of victims in period 1849/50–2004/05 is 137 (see Tab. 1). The nationality of victims: 50 Czech, 24 Polish, 21 Slovak, 17 Hungarian, 12 German, 1 Austrian and 12 unknown.

The number of people endangered, caught and easily injured is not complete, because not all accidents are known and recorded. Serious accidents when a rescue action was organized are well documented. The chances to survive an avalanche are now higher: while 42% of people caught in avalanche died in the 1980's, since the 1990's it is around 24% (see Fig. 1). The highest frequency of recorded avalanches was on a single slope in the Mengusovská Valley, where 15 avalanches were triggered in 20 years.

Both the visit rate and number of accidents usually peak after Christmas, and again from mid February to the end of March (see Fig. 2).

The most frequent reasons of accidents:

- Ignoring Mountain Rescue Guide warnings
- Insufficient knowledge of terrain and climbing
- Underestimating of self capabilities

- Continuing in tour in spite of severe weather
- Traversing without sufficient distances on wrong place
- Descent through the centre of channel
- Taking a tour on sunny day after strong snowstorm
- Entering on snow cornice
- Insufficient or bad equipment (map, mobile phone, avalanche transceiver, probe, shovel, . . .)
- No information left in starting point (hut, cottage)

Tab. 1. Avalanche accident statistics (1849/50–2004/05) and the number of recorded avalanches (1849/50–2002/03) for the main valleys of the High Tatra Mts. People endangered by avalanche (E), caught (C), buried totally (B), injured easily (IE) and seriously (IS), and number of victims (†). Number of avalanches (A) was estimated up to 2002/03. The accidents and avalanches that could not be assigned to any valley are included in the last row

No.	Valley	E	C	B	IE	IS	†	A
1	Kôprová	12	5	0	0	0	3	68
2	Beliansky p.	7	0	0	1	1	0	1
3	Važecká	0	0	0	0	0	0	0
4	Furkotská	27	25	0	0	0	0	11
5	Mlynická	27	14	4	3	1	4	22
6	Mengusovská	162	113	17	15	14	36	338
7	Štôlska	2	2	2	0	0	2	2
8	Batizovská	9	4	1	1	1	2	20
9	Velická	72	43	8	11	9	16	48
10	Slavkovská	25	15	1	0	0	1	7
11	Veľká Studená	107	60	13	15	3	17	357
12	Malá Studená	90	63	13	8	0	16	206
13	Skalnatá	56	38	6	1	3	8	64
14	K. Bielej vody	104	60	5	10	4	20	138
15	Bielovodská	26	13	2	2	1	5	60
16	Javorová	18	12	3	3	0	4	34
Sum	**High Tatras**	**753**	**474**	**75**	**71**	**37**	**137**	**1462**

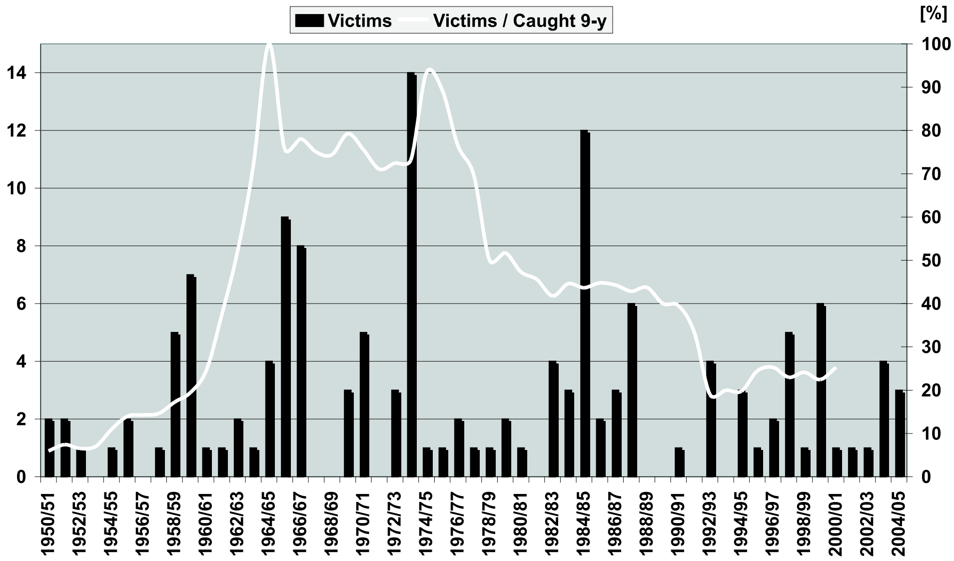

Fig. 1. Number of avalanche victims and the mortality of people caught in avalanche (9-year running average; 1950/51-2004/05). Note the rapid increase of victims around 1960's, when winter tourism boom began. The chances to survive for the people caught in avalanche increased in the 1980's above 50%; and since the 1990's about 3 of 4 people caught in avalanche survive.

The international 5-level scale of avalanche danger was in Slovakia introduced into operation in winter 1994/95. Note in Fig. 3, that the danger levels 4 and 5 occur very rarely. To increase the number of days with high (4) and very high (5) avalanche danger, a backward reconstruction was performed on historical avalanche records.

Beside the meteorological factors, we can take into consideration the number of avalanches, their harm effects and the length, to assess the major avalanche activity in history. The typical avalanche length for each avalanche danger level can be found in Tab. 2.

The major avalanche situations in history were selected according to the following criteria:

- at least one avalanche longer than 450 m recorded within the period
- estimated avalanche danger level 4 or 5; the subjective estimation was based on the avalanche size (length or volume), the type of release

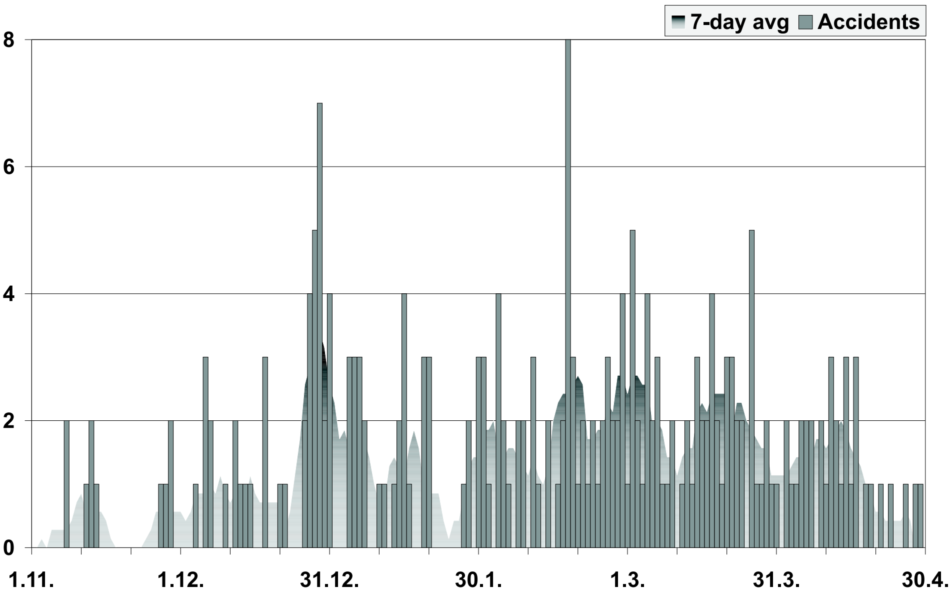

Fig. 2. Seasonal course of avalanche accidents with 7-day running average.

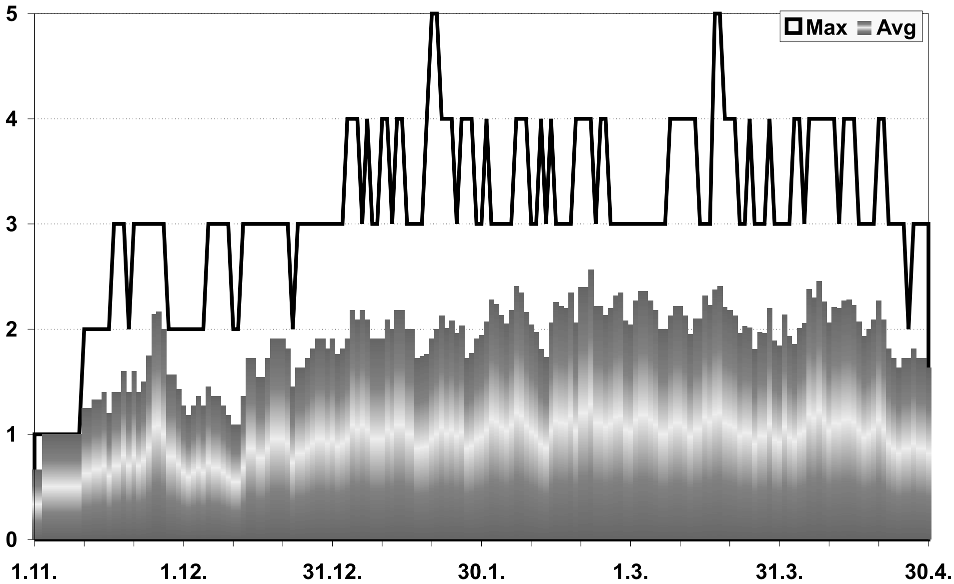

Fig. 3. Seasonal course of avalanche danger level (absolute maximum –MAX, long-term average – AVG) for the period 1994/95–2004/05.

(spontaneous or mechanical) and the number of avalanches. The meteorological conditions, if available, were analyzed, too.

Extreme wet avalanches occurred in March - April 1911, March 1945, April 19, May 9, 1958, and large moist avalanches in April 13–16, 1995 and March 19–20, 2000.

Extraordinary large powder snow avalanche may occur in September (September 26, 1913 - 1500 m long)! Major dry snow avalanches are recorded in January 1917, December 22, 1921, December 1944, March 5–11, 1956, February 10, 1985, February 6–8, 1992, January 11–14, 1995, February 6–13, 1999, February 24, 2001. Three fatal accidents claimed 14 lives on January 20, 1974. In 1982/83 and 1984/85 there occurred several episodes with many avalanches of medium size. Probably the most active avalanche period for the recent decades was January 19–23, 2000.

Still there are problems with the avalanche monitoring – especially during the misty and windy weather conditions. Some avalanches are not dated precisely, and only probable period is known. Backward reconstructions based primarily on weather were made to assess the probable date of avalanche occurrence.

Tab. 2. Average (AVG), second quartile (Q2) and third quartile (Q3) of avalanche length for each avalanche danger level (international 5-level scale)

Avalanche danger level	Avalanche path length [m]		
	Q2	AVG	Q3
1	150	350	450
2	300	380	500
3	350	440	550
4	480	570	800
5	750	830	1050

4. Conclusions

The Avalanche Prevention Centre in Slovakia plans to introduce into operation some supporting tools for the avalanche forecasting (the nearest neighbour method) and later apply other suitable methods (neural networks,

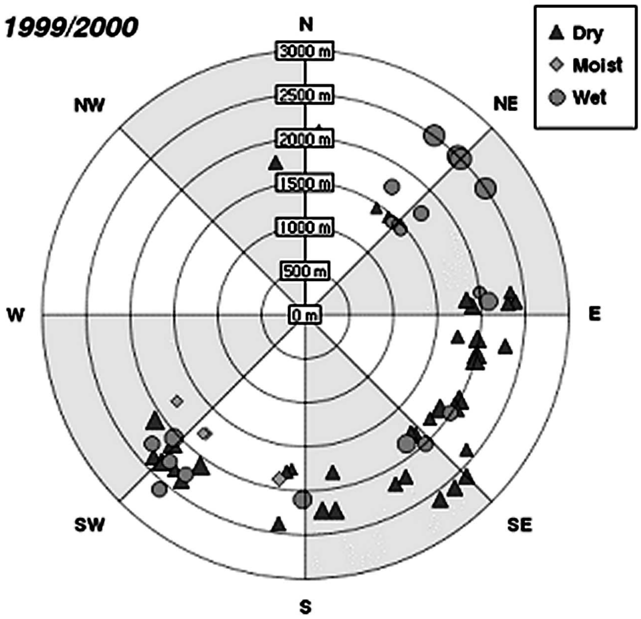

Fig. 4. Dry, moist and wet avalanches distribution in altitude with their exposition in major avalanche winter 1999/2000. The size of mark is proportional to the avalanche length. Generally, the most of avalanches occur on slopes with expositions from south to east.

classification trees, expert system). Quantified avalanche activity based on analysis of historical records, even though subjective, is very valuable for these models. Enlargement of snow observing sites and meteorological station network will continue. The databases used in the APC should become transformed into one unified structure. Digital elevation model with the layer of avalanche paths (currently on paper maps) and vegetation cover could be used for the visualization of avalanche danger in a map. Historical records from other mountain ranges will be inserted into the SLPDB database.

Acknowledgments. Thanks go to the Avalanche Prevention Centre for providing avalanche data and for help with backward reconstruction, dating and probable location of avalanches in terrain.

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