AVALANCHE CYCLES IN AUSTRIA – AN ANALYSIS OF THE GREATEST EVENTS IN THE LAST 50 YEARS

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ABSTRACT: This paper deals with an analysis of major avalanche cycles in Austria. In particular the effects of certain weather situations on avalanche cycles are investigated.
During the last 50 years an average of 30 persons per year were killed by avalanches in Austria. About one third of all avalanche fatalities occurred as a result of so-called “catastrophic avalanches”. Such avalanches are able to affect developed areas and frequently cause higher damage than in the backcountry. The greatest avalanche cycles in Austria were in 1950/51 with 135 fatalities in total and 1953/1954 with 143 fatalities. The last major cycle was in February 1999, which was characterized by three storm periods and by a huge number of avalanches in the western part of the Tyrol; in Galtür 31 persons were killed, in Valzur 7 fatalities have to be noted.
The findings show that in two third of all investigated avalanche cycles a northwesterly oriented frontal zone was the influencing factor. The remaining cycles were released by low-pressure areas over central Europe and the mediterranean sea, respectively. Hence almost all major events (with the most fatalities) occurred in the northern parts of the Austrian Alps.

KEYWORDS: avalanche accidents, avalanche cycles, avalanche climatology

1. INTRODUCTION

Since 1950 more than 1600 persons were killed by avalanches in Austria which is in average approximately 30 fatalities per year. About two third of all fatalities are backcountry and off-piste skiers.
However, more than 30 % were killed due to so-called “catastrophic avalanches” (avalanches that reach developed areas like buildings, roads and other infrastructure) which seem to be correlated with certain meteorological situations.
According to McClung and Schaerer (1993) three main factors are responsible for the release of avalanches, meteorological factors, snowpack factors and stability factors. While the first class provides indirect evidence about current snow stability, the snowpack and even more the stability factors allow a more certain interpretation of the recent situation (McClung and Schaerer, 1993).
Although the meteorological factors are not sufficient for a detailed forecast (e.g. to predict avalanche hazard on a specific slope) they are a very useful tool to identify a critical avalanche situation.
The influence of weather situations on avalanche cycles was analysed by several authors. Specific studies were done by Calondar (1986) and Hächler (1987) for Switzerland, Fitzharris and Bakkehoi (1986) investigated major avalanche winters in Norway and Birkeland and Mock (2001) analysed the avalanche cycle 1986 in the Western United States.
Detailed analysis for the Austrian Alps are rare. Gabl (1988,1999) investigated a few events, however, a specific analysis for the last 50 years is not yet available.
This paper intends to analyse the effects of certain weather situation on avalanche cycles in the Austrian Alps.
Aim is to find those conditions which are responsible for the release of catastrophic

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year	date	major events	weather situation	affected area
1951	12 - 14 Jan 15 - 16 Jan 19 - 21 Jan	14.1. Badgastein 14 fat 14.1. Heiligenblut 14 fat 20.1. Schwendberg 10 fat 20.1. Lanersbach 9 fat 21.1. Hippach 10 fat 21.1. Kappl 8 fat 21.1. Sölden 7 fat	NW	VI VIII II III V
1954	10 - 12 Jan	11.1. Blons 56 fat 11.1. Bürserberg 15 fat 12.1. Dalaas 10 fat	NW	I II
1968	24 - 27 Jan	27.1. Klösterle 8 fat	NW	I II V VI
1970	19 - 24 Feb	23.2. St. Sigmund 4 fat	TB →eastern Europe	I II V
1975	13 - 19 Mar 27 - 31 Mar 03 - 06 Apr	31.3. Mallnitz 8 fat	TwM TR TR TM	V VI VIII
1984	06 - 09 Feb	08.2. Gargellen 2 fat 08.2. Galtür 2 fat 09.2. Axamer Lizum 3 fat 09.2. Kappl 1 fat 09.2. Ischgl 1 fat 09.2. Trins 1 fat	NW	I II V
1986	28 Jan - 01 Feb	01.2. Obergurgl 1 fat	TwM	V VI VIII IX
1988	10 - 13 Mar	13.3. St. Anton 7 fat	NW	I II
1999	26 - 31 Jan 05 - 09 Feb 17 - 24 Feb	23.2. Galtür 31 fat 24.2. Valzur 7 fat	NW	I II III V

Table 1: Major avalanche cycles in Austria. The general weather conditions were classified according to the method from Lauscher (1972), NW…. north-westerly flow, TB…low-pressure area over the British Isles, TwM… low-pressure area over the western mediterranean sea. TR…meridional trough, TM…. low-pressure area over central Europe. The numbers in the fifth column (affected area) correspond with the classification from Wakonigg (1975), I – X…. regions with similar snow conditions (details see text).

avalanches. The results could be used to identify critical situations in time.

2. DATA AND METHODOLOGY

The avalanche cycles were selected according to the consequences of the events, including not only the number of fatalities but also the number of avalanches in a certain period and the effects (damages…) of avalanches.
In particular I used the records of Fliri (1998) as well as the statistics of the Federal Research Centre for Forests (Luzian, 2002).
The included cycles are listed in chronological order in the first and second column of Tab. 1.
To analyse the events data from the Central Institute for Meteorology and Geodynamics were used, in particular the relevant weather charts. The general weather situation was classified by the method from Lauscher (1972).
Besides I used the scheme from Steinacker (1991) who created a classification for the Eastern Alps based on the flow direction in lower atmospheric levels.
The affected area was specified by the classification of Wakonigg (1975).
Wakonigg divided Austria into 10 similar regions depending on the sum of new snow.
The regions I, II, III and IV are characterized by abundant precipitation (due to fronts from west and north-west). These zones are located in the northern part of the alps and indicate a ozeanic climate.
The intermountain climate prevails in the eastern part of the central Alps (region VI).
The regions V and VIII describe a continental climate (with significant less precipitation than in the regions I, III and IV), it can be found in the western part of the central Alps.
The region X is a small zone in the southern part of Austria. It is influenced in particular by fronts from the south-west.

3. RESULTS

As shown in the third column of Tab. 1 there is at least one major event with several fatalities in each cycle.
The most disastrous events were in Blons where 56 persons were killed on Jan.11, 1954 (Gemeinde Blons, 2004) and in Galtür (1999) with 31 fatalities (Höller and Schaffhauser, 2000).
In the forth column of Tab.1 the general weather conditions according to Lauscher (1972) are shown.
It can be seen that the avalanche cycles in 1951, 1954, 1968, 1984, 1988 and 1999 were released by similar synoptic situations (northwesterly flow - NW) which are characterized by an area of high pressure over the Bay of Biscaya and an area of low pressure over Scandinavia. The result is a northwesterly oriented frontal zone which regularly leads to high precipitation rates (new snow) in the northern part of the Alps. Synoptic charts from these periods are shown in Fig. 1.
The avalanche cycle in 1970 was governed by low-pressure areas moving from the British Isles to eastern Europe. The flow was characterized by westerly and northwesterly winds; as a consequence the Alps received plenty of new snow, in particular the federal states of Tyrol, Salzburg and Vorarlberg.
The cycle in 1975 can be divided into three parts. The first was from March 13 to March 19 with a low-pressure area over the western mediterranean sea and a trough over northern Europe (March 15 to March 16).
The second part of the cycle was mainly governed due to a expanded and fluctuating low between the mediterranean sea and Skandinavia (March 27 to March 31).
In the third part of the cycle (April 3 to April 6) a low-pressure area was located over central Europe. These weather conditions resulted in heavy snowfall, in the central Alps (Tyrol, Salzburg and Carinthia), especially in the south and south-west.
The situation in 1986 (Jan 28 to Feb. 1) was characterized by a trough of low pressure which moved from France to the western part of the mediterranean sea and led to heavy snowfall in the south.
The flow directions according to Steinacker (1991) are shown in Table 2.
It is obvious that the northwesterly flow was prevailing, especially in 1968, 1988 and 1999.
While in these periods the low-pressure area was over Scandinavia (with a high over the Bay of Biscaya) the westerly and northwesterly flow in February 1970 was released by moving

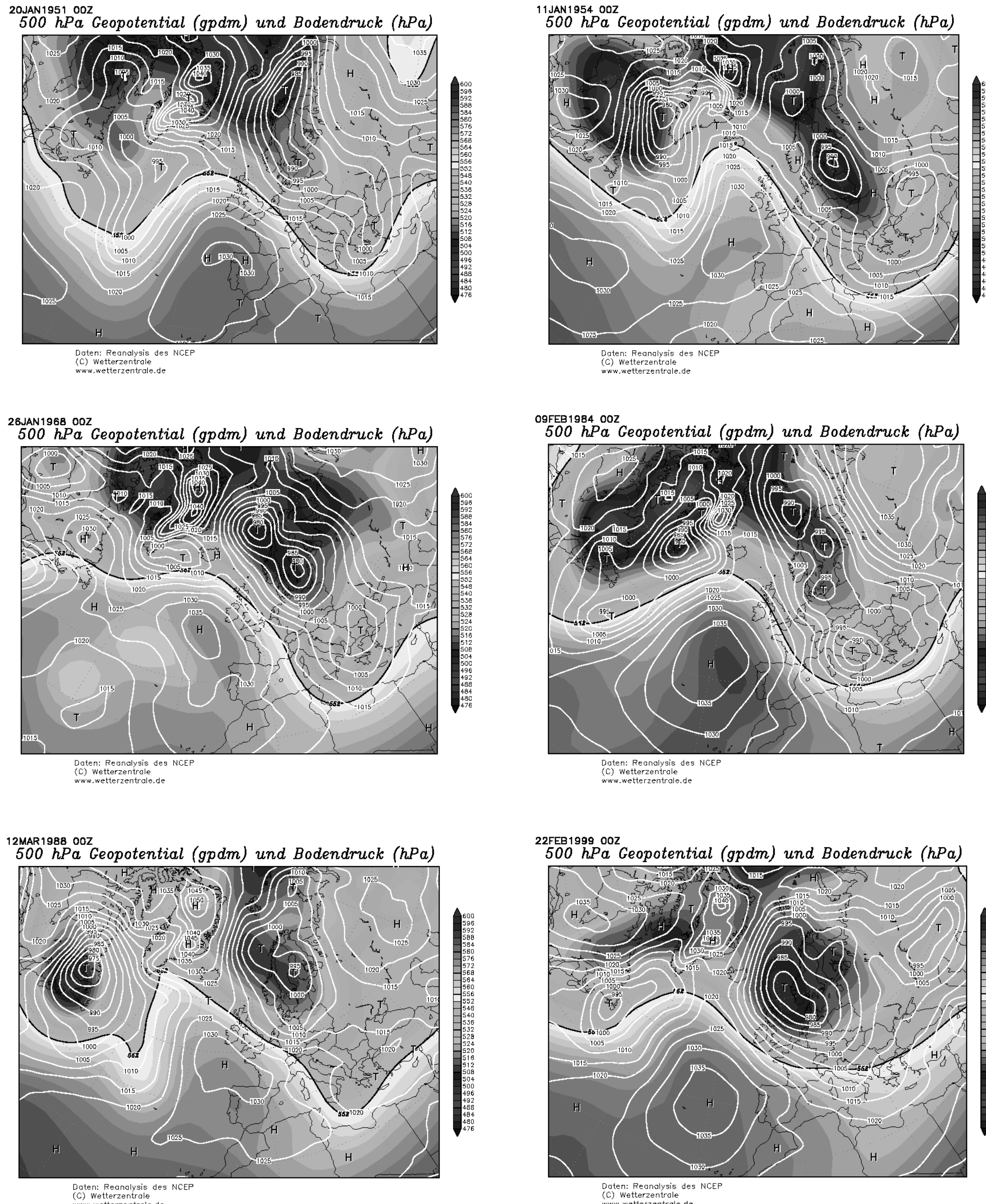

Figure 1: Weather charts from 20 Jan. 1951, 11 Jan. 1954, 26 Jan 1968, 9 Feb. 1984, 12 Mar. 1988 and 22 Feb.1999 (wetterzentrale.de/topkarten/fsreaeur.html)

	1968	1970	1975		1984	1986	1988	1999	
	Jan	Feb	Mar	Apr	Feb	Jan	Mar	Jan	Feb
1									
2									
3				SW					
4				var					
5				var					NW
6				var	W				NW
7					var				NW
8					var				NW
9					N				var
10							NW		var
11							NW		
12							var		
13			E				var		
14			gr						
15			gr						
16			gr						NW
17			var						NW
18			var						NW
19		NW	var						W
20		W	var						W
21		W	NE						W
22		NW							NW
23		NW							NW
24	NW	var							NW
25	NW								
26	N							var	
27	var		SW					var	
28			var			var		var	
29			W			S		N	
30			var			SE		NE	
31			NE			SE			

Table 2: Flow directions in the relevant avalanche periods (according to Steinacker, 1991) N.. north; NE….northeast, E..east, S…south; SE… southeast, SW…southwest, W…west, NW…northwest, var…variable.

lows from the British Isles to eastern Europe. The greatest differences can be seen in 1975 and 1986. In 1975 the flow was variable in many cases which was due to different low-pressure areas over central Europe. In 1986 the flow was from southeast which was released by a low-pressure area over the western part of the mediterranean sea. This situation led to heavy snowfall in the south (Carinthia, eastern Tyrol) and in parts of the central Alps. Fig. 2 shows the weather chart form January 31, 1986.

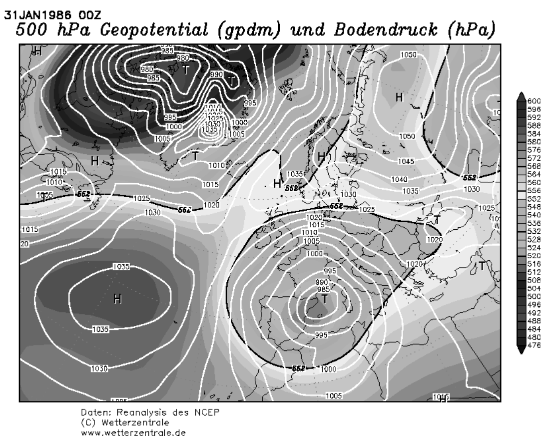

Figure 2: Weather chart from Jan.31, 1986 (wetterzentrale.de/topkarten/fsreaeur.html)

The affected areas are shown in the fifth column of Tab. 1 (according to the classification from Wakonigg, 1975)
The northern and northwestern part of the Alps (regions I, II , III and partly VI) receive plenty of snow when a frontal zone is approaching from the northwest. On the other hand the southern Alps (regions VIII and IX) are affected only by flow from the south (southeast to southwest).
The region V may be influenced from both directions but does not receive as much snow as the boundary of the Alps.
In this paper nine major avalanche cycles from 1951 to 2006 (55 years) were investigated. The data indicate that every 6 years (in average) a great cycle has to be expected. Although this is only an estimation it corresponds well with findings from Föhn (1975) who found for Switzerland a interval of 7 years.

4. DISCUSSION AND CONCLUSIONS

Of all investigated avalanche cycles about two third occurred due to a northwesterly oriented frontal zone.
The remaining cycles were released by low-pressure areas over central Europe and the mediterranean sea, respectively.
Consequently almost all major events (with the most fatalities) occurred in the northern parts of the Austrian Alps.
Only a few events (with a higher number of fatalities) are documented from the southern Alps (e.g. Heiligenblut, Mallnitz).
The investigation indicates that there is a strong relationship between certain weather situations and avalanche cycles.
However, these findings are valid only for catastrophic avalanches. Avalanches in the backcountry (released by skiers or mountaineers) are not always correlated with certain weather conditions.

5. ACKNOWLEDGEMENTS

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