ATES MAPPING AND TYPICAL PROBLEMS IN AVALANCHE ACCIDENTS OR CLOSE-CALLS IN VAL D'ARAN, CENTRAL PYRENEES

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ABSTRACT: This past season 2017-2018 has seen the completion of the ATES mapping for Val d'Aran, and it was the fifth season since the inclusion in the advisory of what is known as "Typical Avalanche Problems". In this paper, accidents and close-calls are looked into in order to test these relatively new information methods and identify trends in the accidentability. For the ATES terrain classification and danger level, data is available from 1995 to 2018, whereas for Avalanche Problems this information exists from the 2013/14 season to date. For each one of the 160 accidents or close-calls analyzed, we examine the characteristics of the avalanche danger and the terrain, looking for relationships between these two variables as well as classifying the accidents in terms of severity, avalanche size or user type.

KEYWORDS: ATES, Typical Avalanche Problems, Avalanche Accidents, Avaluator

1. INTRODUCTION

Val d'Aran counts with a local avalanche center, supported by the local government (Conselh Generau d'Aran) which, among other tasks, monitors the avalanche activity with special attention to human triggered events (Bacardit et al. 2016). In addition, an Avalanche Terrain Exposure Scale (ATES) mapping for Val d'Aran (Spanish Central Pyrenees) has been completed during the season 2017/2018 (See Bacardit et al. in this same conference). Moreover, the daily avalanche advisories issued by the Avalanche Center in Val d'Aran include "Typical Avalanche Problems" since 2013, being one of the European centers with the longest experience in the application of this tool for communicating danger.

1.1. ATES in Val d'Aran

Starting on 2003, Parks Canada developed and implemented the Avalanche Terrain Exposure Scale (ATES), which provides a framework to assess, describe and communicate the complexities of avalanche terrain exposure. This classification system for avalanche terrain consists of two models – technical and public communication. The technical model is designed for users skilled in interpreting avalanche terrain, while the public communication model is designed to easily transmit the same concepts to a less skilled audience. (Statham 2006). In addition, a new set of guidelines for zoning and mapping with ATES, which includes a new technical model, was released recently (Campbell 2012).

In 2006, the Avaluator™ Trip Planner, a rule-based decision support tool for amateur recrea tionists was presented (Haegeli 2006) (Figure 1). The main part of the tool is the Avaluator Card, which provides guidance for trip planning by combining snow and avalanche conditions (vertical axis) with the terrain of the intended backcountry trip (horizontal axis). The card also takes into account the characteristics of the users, specifying what minimum avalanche training level is required (normal/expert/professional) to be able to deal with a particular combination of danger and terrain.

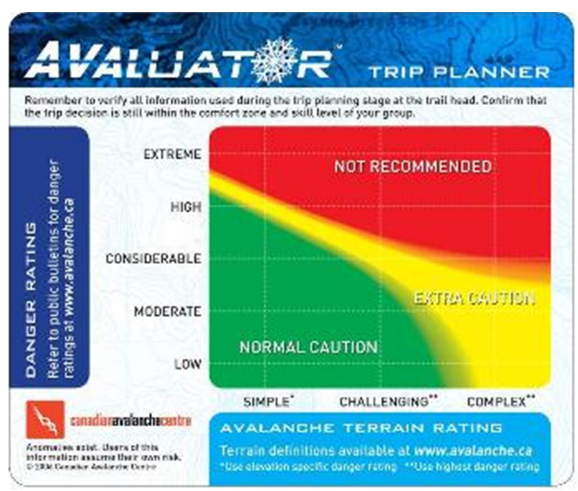

Figure 1: Avaluator™ Trip Planner as can be found in AvCan web site.

The Aran Avalanche Center was pioneer in Europe in the use of the ATES, by mapping a pilot area during the 2010/11 season and having all the avalanche terrain mapped by the end of the season 2017/18 (Bacardit et al. in this conference).

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1.2. *Typical Avalanche Problems in Val d'Aran*

During the last decade, different avalanche services have sought ways to briefly describe the avalanche danger beyond a mere number in a scale. For instance, the AWD Tyrol started working on Avalanche Patterns (Gefahrenmuster) in 2010, and in the same period, the SLF started to include Avalanche Situations in the advisories. Finally, the European Avalanche Warning Services General Assembly of 2017 agreed to use Typical Avalanche Problems (TAP) in the avalanche advisories. This data is located in the upper part of the information pyramid, just under the danger level and the avalanche prone locations. The use of TAP capitalizes on the human brain's capacity to recognize and interpret recurring characteristics and patterns. Each avalanche problem has a different cause and calls for a specific response according to the weather and snow situation.

The Aran Avalanche Center started using the Swiss Avalanche Situations in 2013/14 season. Following EAWS recommendations, it then migrated to the very similar TAP in 2017/2018 winter. Both systems have the same five situations/problems that summarize the main characteristics of the avalanche danger. Counting the two approaches, we dispose of five seasons of avalanche advisories to draw from (more than 700 bulletins).

2. DATA SET

Most of the avalanches involving people are reported to the center through the "Obs Lauegi" observation network, a dense group of observers made up by guides, ski patrollers, local SAR members and backcountry enthusiasts. In many cases the forecasters visit the avalanche site to collect data about the accident. This data set is made up by 160 accidents from the last 20 seasons, of which 50 belong to the last 5 seasons and include TAP data.

The avalanche danger is taken from the avalanche advisories issued by the Catalan Avalanche Service (1997 to 2012) and by the local Aran Avalanche Center once they become available (2012 – 2018). Both the highest forecasted danger level and the avalanche danger of the site are considered (taking into account aspect and elevation), whenever this last is available. As expected, most of the accidents occur with danger 3 (75,6% and 69,4% respectively), with significant amounts occurring in danger 4 (15,6% - 12,5%) and danger 2 (8,1% - 15,0%). Very few (0,6% - 3,1%) happened when the forecasted avalanche danger was 1.

About the terrain, it should be noted that terrain classification was not available at the time most of the accidents took place. For those for which this information is available, accidents happen mostly in Complex terrain (66,3%) and Challenging terrain (32,5%), with very few in Simple terrain (1,3%).

Almost half of the accidents implied mechanically assisted skiers and boarders (45% ski resort, 4% heli-skiing) and the other half, human powered recreationists (49% ski touring, 1% snow-showing, 1% climbing). The environment in which they were acting was in bounds 20%, sidecountry 35% and backcountry 47,5%.

Avalanches were in many cases size 2 (53,1%) and size 1 (38,7%) in the destructive avalanche size scale, with 8,1% of cases being size 3. They caused a 74,4% of close calls without consequences, a 15,6% of minor accidents (half buried victims, injuries) and a 10% of severe accidents (complete burials, deceases).

3. RESULTS AND DISCUSSION

3.1 *Danger Ratings vs. Terrain Class*

When the Avaluator was presented in Telluride's ISSW, it was stated that the lines that split the chart in 3 colors were obtained by a "consensus between more than thirty avalanche professionals" (Haegeli 2006). In this same conference it was shown that the Prevention Values using the most permissive boundaries (no-go in red zone, go in yellow and green zone) using data from Western Canada accidents was of about 40%, whereas using the most conservative (no-go for the red and yellow areas) was of about 75% (McCammon 2006). In our sample (Figure 2) the Prevention Values are much higher: using the avalanche danger forecasted for the elevation and aspect (when different to the higher danger level), the prevention values are 56% (no go in red zone) and 92% (no go in red and yellow zone). As observed in countless studies, most of the accidents occur in danger 3, but the difference between Complex (44%) and Challenging (24%) terrains is significant.

Av Danger (site)	Simple	Challenging	Complex	
4	0,6%	4,4%	7,5%	N=160
3	0,6%	24,4%	44,4%	
2	0,0%	3,8%	11,3%	
1	0,0%	0,0%	3,1%	

Figure 2: Forecasted avalanche danger on the accident aspect and elevation vs. ATES classification. Colors represent the Avaluator TM Trip Planner recommendations (green: Normal caution; yellow: Extra caution; red: Not recommended).

Severity **1**

Av Danger	Simple	Challenging	Complex	
4	0,8%	5,0%	8,4%	N=119
3	0,8%	27,7%	40,3%	
2	0,0%	2,5%	11,8%	
1	0,0%	0,0%	2,5%	

Severity **2 and 3**

Av Danger	Simple	Challenging.	Complex	
4	0,0%	2,4%	4,9%	N=41
3	0,0%	14,6%	56,1%	
2	0,0%	7,3%	9,8%	
1	0,0%	0,0%	4,9%	

Figure 3: Forecasted avalanche danger for the accident site vs ATES terrain classification, split by the severity of the accident (1: without consequences; 2: half-buried, injured; 3: fully buried, severely injured, deceased).

If we split the sample by the severity of the accident (Figure 3) we observe a shift to the right of the most serious involvements: severe accidents tend to occur more frequently in Complex terrain (76% of cases) than in Challenging (24%). This fact can be explained by the presence of terrain traps as one of the parameters taken into account in the terrain classification.

In the same way, it is interesting to see how the avalanche size tends to increase with the complexity of the terrain (Figure 4). Whereas for size 1 avalanches 55% of the accidents were in Complex terrain, 65% of size 2 and 100% of size 3 avalanches took place in this terrain class, with a shift to the higher avalanche danger as well (from 8% to 38%). This is not surprising if we consider that big, open slopes, capable of producing bigger avalanches, are usually included in the Complex terrain category.

3.2 <u>Typical Avalanche Problems</u>

In the 50 cases where TAP was available, the most frequent scenario was Wind-drifted Snow (56,0%). New Snow and Persistent Weak Layer scenarios were responsible for 20% and 22% of the accidents. Only one case occurred when Gliding Snow was the main problem in the forecast, and curiously, none happened in a Wet Snow situation.

Size **1** (N= 62)

Av Danger (loc)	Simple	Challen.	Complex
4	1,6%	1,6%	4,8%
3	0,0%	33,9%	30,6%
2	0,0%	8,1%	16,1%
1	0,0%	0,0%	3,2%

Size **2** (N=85)

Av Danger (loc)	Simple	Challen.	Complex
4	0,0%	7,1%	4,7%
3	1,2%	21,2%	51,8%
2	0,0%	1,2%	9,4%
1	0,0%	0,0%	3,5%

Size **3** (N=13)

Av Danger (loc)	Simple	Challen.	Complex
4	0,0%	0,0%	38,5%
3	0,0%	0,0%	61,5%
2	0,0%	0,0%	0,0%
1	0,0%	0,0%	0,0%

Figure 4: Forecasted avalanche danger for the accident site vs ATES terrain classification, split by destructive (D) avalanche size.

TAP: **NS** (N= 10)

Av Danger (loc)	Simple	Challen.	Complex
4	0,0%	0,0%	10,0%
3	0,0%	30,0%	10,0%
2	0,0%	20,0%	30,0%
1	0,0%	0,0%	0,0%

TAP: **WD** (N=28)

Av Danger (loc)	Simple	Challen.	Complex
4	0,0%	0,0%	0,0%
3	3,6%	14,3%	67,9%
2	0,0%	3,6%	7,1%
1	0,0%	0,0%	3,6%

TAP: **PWL** (N=11)

Av Danger (loc)	Simple	Challen.	Complex
4	0,0%	0,0%	0,0%
3	0,0%	27,3%	63,6%
2	0,0%	0,0%	0,0%
1	0,0%	0,0%	9,1%

Figure 5: Forecasted avalanche danger for the accident site vs ATES terrain classification, split by Typical Avalanche Problem (TAP) (NS: New Snow; WD: Wind-drifts, PWL: Persistent Weak Layer) for that date and site.

Splitting the sample results in small groups, some strong trends can be identified. Accidents in New Snow situations occur clearly in less demanding terrain than in Wind-drifted and Persistent Week Layers (Figure 5). This can be related with the terrain choices after a significant snowfall, when users tend to stay in smaller and less exposed slopes

Regarding the relationships between the TAP and other variables, first of all we observe a strong concentration of accidents in days and sites were avalanche danger was 3 and the TAP was Wind-drifted snow, with more than 51% of the sample (Figure 6)

TAP					
NS	0,0%	8,5%	8,5%	2,1%	N=50
WD	2,1%	6,4%	51,1%	0,0%	
PWL	2,1%	0,0%	21,3%	0,0%	
	1	2	3	4	Av Danger

Figure 6. Typical Avalanche Problem vs forecasted avalanche danger for the site of the accident.

Accidents in New Snow situations correspond frequently to smaller avalanches, a data which is consistent with the choice of smaller slopes after a snowfall. In Wind-drifted Snow situations size 2 avalanches prevail, while size 3 avalanches abound when the main TAP in the forecast was Persistent Weak Layers (Figure 7).

TAP				
NS	55,6%	44,4%	0,0%	N=9
WD	25,0%	71,4%	3,6%	N=28
PWL	36,4%	54,5%	9,1%	N=11
	1	2	3	Size

Figure 7. Typical Avalanche Problem vs avalanche destructive size.

Finally, we look into the environment of the accident sites in relation to the TAP, and we observe that in-bounds accidents occur in New Snow and Wind-drifts situations, while the presence of active buried PWL gains weight as we move away from ski resorts (Figure 8).

TAP			
NS	44,4%	0,0%	22,7%
WD	55,6%	82,4%	40,9%
PWL	0,0%	17,6%	36,4%
	IB	SC	BC
	N=9	N=17	N=22

Figure 8. Typical Avalanche Problem vs accident site environment (IB: In-bounds; SC: Side-country, BC: Back-country).

4. CONCLUSIONS

After this study, we can affirm that combining the ATES with avalanche advisories by means of the Avaluator Trip Planer is a powerful tool for recreationists in the Pyrenees, with high prevention values. The fact that these values are higher than in Canada can be explained in two very different ways: it could be due to a more conservative ATES mapping and avalanche advisories in Val d'Aran than in Canada, or to a more aggressive choice of terrain by the Aran mountaineers that leads to more people recreating in the upper and right sides of the Avaluator.

The rest of the study confirms the applicability of the ATES mapping in a range like the Pyrenees, by showing increases in severity and avalanche size as you move upwards and to the right in the Avaluator chart. Regarding the TAP, it is remarkable to see how accidents happen mainly with Wind-drifted Snow situations, avalanche danger 3 and in Complex terrain. The lack of PWL accidents inside ski resorts confirms the fact that specific information for in-bounds users is necessary, which reflects the actual snowpack conditions of heavily skied areas.

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