APPLYING THE AVALANCHE TERRAIN EXPOSURE SCALE IN THE SWISS JURA MOUNTAINS

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ABSTRACT: The avalanche terrain exposure scale (ATES) was developed by Parks Canada in 2004 as a complementary tool to increase awareness and to communicate the risks encountered when travelling in avalanche terrain. In the meantime, many popular backcountry tours in Canada were rated. More recently, ATES has also been applied in some European countries. We review existing ATES applications as well as other alpine tour rating systems. An adaptation of ATES for a new application in the Swiss Jura, a popular area for snow shoeing and ski touring, is presented. The Jura hills are a low mountain range along the north-western border of Switzerland. There are about 60 popular tours in mostly gentle terrain, yet exposure to avalanche terrain also exists in some locations. We elaborate the requirements of a terrain classification in our particular low mountain range environment. As a result, the adapted technical model and public communication model as well as tour examples from the Swiss Jura are shown. A communication strategy is developed to increase the applicability and acceptance of the classification in Switzerland. A potential expansion to the Swiss Alps is discussed.

KEYWORDS: terrain, avalanche, exposure, terrain classification, education, Swiss Jura

1. INTRODUCTION

An adaptation of the Avalanche Terrain Exposure Scale (ATES) for a new application in Switzerland to the low mountain range called Jura is developed, tested and applied. ATES is a complementary planning tool to increase awareness and to communicate the risks encountered when travelling in avalanche terrain. When travelling in the backcountry in winter, the potential to be affected by an avalanche exists not only on steep slopes, it may also be present on moderately steep slopes. In some places where runout zones of rare and/or large avalanches exist, an exposure is even possible in flat terrain. Statham et al. (2006) developed ATES originally for managing custodial groups in the Canadian national parks, independent of existing avalanche danger ratings. In a further Canadian application, the combination of ATES with avalanche danger ratings was suggested and realized in the Avaluator, a rule-based graphical reduction system (Haegeli et al., 2006). Recently, ATES was applied in the USA (Campbell et al., 2012) and in Europe in the Spanish Pyrenees (Gavaldà et al., 2013) and in the Scandinavian mountains (Engeset, 2013; Wikberg et al., 2013). Current applications vary from trip planning to terrain zoning and from avalanche education to work-place safety. So far, ATES was not used in Switzerland. In Switzerland, the information on difficulties of individual winter backcountry tours is generally given in mountain guide books by difficulty grades, similar to rock climbing difficulty grades. The avalanche danger is given twice per day during wintertime in the Swiss avalanche bulletin, by the avalanche danger levels.

The Swiss Jura is a low mountain range apart from the Alps with less serious terrain than in the Alps. It is a popular area for ski touring, snow shoeing and winter hiking by beginners, less experienced or pleasure backcountry recreationists. Avalanche incidents are very seldom. An avalanche danger rating in the Swiss avalanche bulletin is issued for the Swiss Jura only in the case of danger level 3 (considerable) or above (WSL, 2013). We see a great benefit in the application of ATES in the Swiss Jura because firstly, the traditional tour difficulty grades are mainly based on slope angle and hazard of falling, but not specifically on exposure to avalanches. Secondly, the avalanche bulletin is not available for all danger levels in the Swiss Jura. The aim of our collaboration is to develop and offer a classification system to be used by guide book authors which gives backcountry users additional information on the exposure to avalanches for tour planning in the Swiss Jura. After adapting the original ATES model to the specifics of our low mountain range, the classification is applied to 62 winter tours in the Swiss Jura. We present the distribution of the classified tours and examples from each class.

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The ATES application in the Swiss Jura is discussed in terms of strengths and limitations as well as in the realm of existing, traditional tour grading systems. It is proposed to apply ATES commonly in Swiss Jura guide books. Because guide books have different origins in Switzerland, it is important to consult the Swiss mountain interest groups and associations to increase the awareness, applicability and acceptance of ATES.

2. BACKGROUND

The Swiss Jura is a sub-alpine, fold-mountain range along the north-western border between Switzerland and France (Figure 1).

Fig. 1: Swiss Jura, a low mountain range at the border between Switzerland and France (map source: Swisstopo, 2014).

The area is 4200 km^2 and the highest peaks reach 1600 to 1700 m. Long ridges, stretching at altitudes from 1000 to 1500 m, are characteristic for the Jura. It is mostly forested terrain with a treeline between 1500 and 1600 m. The Jura climate is wet and cold and the area is often exposed to strong westerly winds. The mean January temperature is -2 °C (ETH, 2014). During winter, the mean temperature ranges between -4 °C on the peaks and +3 °C in the valleys. Yet, in the typical closed valleys above 1000 m, very cold air pockets form. With below -40 °C, the lowest temperatures in Switzerland and in France were actually measured in the Jura. The mean annual precipitation in the Swiss Jura is variable and ranges from 2000 mm at the peaks in the western Jura and to 800 mm in the valleys of the eastern Jura (ETH, 2014). Frequent and ongoing precipitation periods occur during winter. South-westerly winds bring rain and thaw in winter. Hence, the weather can change drastically in the Swiss Jura. But if warm periods are short in winter, a persistent snow cover can form. Most snow lies in a belt between La Chaux de-Fonds and Moutier (Figure 1), where a snow depth of one meter at 1000 m is not rare during January and February (Silbernagel, 2010). Apart from snow, this area is also popular for its chocolate and watches.

Generally, the character of the Jura terrain is gentler, the slopes are smaller and the snow depth is less than in the Alps. Exposure to avalanches exists in few and small zones. Avalanche accidents occur but are very rare in the Swiss Jura (Frey, 2011). They amount to only 3 ‰ (9:3000) of the reported accidents in the Swiss Alps from 1936/1937 to 2013/2014. For this period, 14 avalanches in total were reported from the Swiss Jura to SLF. Three people lost their lives (2 victims in 1941, one victim in 1991), four were injured and nine were entrained in avalanches. Looking at the last 20 years, from 1994/1995 to 2013/2014, there are five reported avalanches in the backcountry with eight entrained people (one person injured) in the SLF records. These rare avalanche incidents in the Swiss Jura occur most likely in situations when either strong wind causes snow drifts behind steep ridges and in gullies (Figure 2) or during intense rain on snow events.

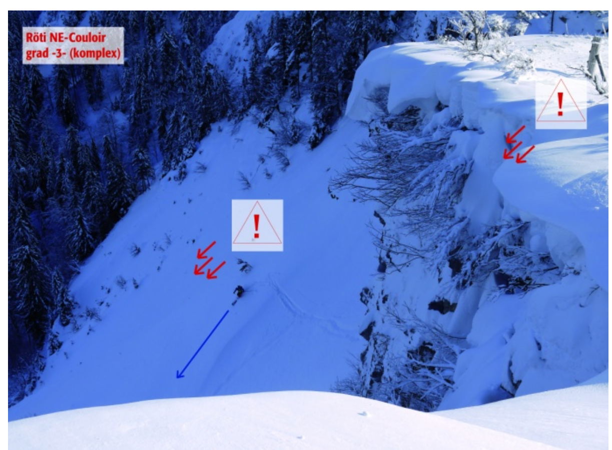

Fig. 2: Descent from the Röti (1395 m), where cornices and snow drift accumulations in steep terrain exist. This Jura tour is rated “complex” (photo: archive topo.verlag).

Due to the locally limited hazard, and due to limited data and observations in the Swiss Jura, the SLF avalanche bulletin offers only limited information for it. While the danger assessments for the Swiss Alps are published twice daily, a danger rating for the Swiss Jura is published only for days with danger level 3 (“considerable”). Since 2005/2006, the avalanche danger level 3 was assessed for the Swiss Jura on 5 days per winter on average and never above level 3. Next to the Swiss avalanche bulletin, private websites such as the Jura Snow Bulletin (Silbernagel, 2010) offer sporadically additional information on snow coverage, snow depths and the avalanche situation in the Swiss Jura since 2005. Information on the difficulty of an individual backcountry tour is generally given in guide books. In Switzerland, the difficulty grades developed by the Swiss Alpine Club (SAC) are mostly used by guide book authors for rating individual tours. The SAC-scale exists for rock climbing, summer and winter alpinism, ski and snowboard touring, hiking and snowshoe touring (SAC, 2012). The main criteria behind the SAC-grades for ski and snowboard touring are slope angle, hazard of falling and existence of bottlenecks. The main criteria behind the SAC-grades for snowshoe touring are slope angle, hazard of falling and avalanche danger. Guide books for the Swiss Jura are published by the Swiss Alpine Club (Burnand et al., 2011) and the topo.verlag (Silbernagel, 2010).

Next to the guide books that are essential for tour planning, individual risk assessment and decision making in the backcountry is supported by rule-based avalanche risk assessment tools. Two popular examples are the Graphical Reduction Method (GRM) in Switzerland (Harvey et al., 2012) and the Avaluator in Canada (Haegeli, 2006, 2010). These trip planning tools generally make use of terrain characteristics and avalanche danger ratings. For the Swiss Jura, there is virtually a lack of avalanche information, because difficulty grades in guide books are not focused on avalanche terrain exposure and the avalanche bulletin is not available on a daily basis and not for all danger levels. For these reasons, we develop ATES for the Swiss Jura for application in future guide books. Because in the Swiss Jura the exposure to avalanches is in small, defined zones, the area actually lends itself to an application of ATES.

3. METHOD

To apply ATES for Swiss Jura winter tours, rather slight changes were made to the original ATES classification by Statham et al. (2006). Because the original classification was designed for alpine terrain (Rocky Mountains), adaptations were necessary to correct for the specifics of our low mountain range. The classification of the Swiss Jura winter tours was performed manually by an expert and was based on the systematic framework given by the adapted ATES technical model (Table 1). The expert is the author Daniel Silbernagel, certified mountain guide and author of Swiss Jura guide books. He has long experience and detailed terrain and avalanche knowledge of the individual winter tours in the Swiss Jura, which is necessary for ATES classifications. After preliminary tests and fine-tuning of the classification, the technical ATES model was applied to 62 popular Swiss Jura winter tours. These 62 tours are about two-thirds of all existing Swiss Jura winter tours. In case the results of the classifications were ambiguous, a second expert was consulted. The classification is documented on an analysis sheet for each tour. Table 1 shows the adapted ATES technical model for the Swiss Jura, and Table 2 the adapted ATES public communication model. The definition of avalanche size is according to WSL (2013).

In the following is a list of all changes made to the original ATES model (Statham et al., 2006), which are due to the adaptation to the specifics of our low mountain range or else are due to added detail for clarity:

- Name of class 2: changed from Challenging to Variable (partly challenging)
- Slope angle: the distribution of slope angles for class 1 was added for clarity
- Forest density: the typical forest structure in the Swiss Jura is either dense or thin
- Avalanche frequency: avalanche size for class 1 was limited to size 3 (originally ≥ 2)
- Start zone density: more detail on limited open terrain, separation of start zone and runout zone characteristics for clarity
- Glaciation: not applicable
- Addition of “Zones with hazard of falling, cornices”

Tbl. 1: ATES technical model for the Swiss Jura (based on v. 1/04, Statham et al., 2006).

	1 - Simple	**2 - Variable** (partly challenging)	**3 - Complex**
Slope angle	Generally < 30º (95%), 5% < 35°, 0% > 35°	***Mostly moderately steep to steep ≤ 35°, isolated slopes >35º***	***Variable, with large proportion > 35°***
Slope shape	Plane, uniform	Rather plane, some convexities, slope toes	Convoluted, complex, channelled, gullies
Forest density	Dense forest	Thin forest	Open terrain
Terrain traps	Minimal, some creek slopes or cutbanks	Some depressions, gullies and/or overhead avalanche terrain	***Many depressions, gullies, cliffs, hidden slopes above gullies, cornices***
Avalanche frequency (events per years)	1 event per 30 years = size 2 or 3	1 event per 1 year for < size 2 ***1 event per 3 years for ≥ size 2***	1 event per 1 year for < size 3 ***1 event per 1 year for ≥ size 3***
Avalanche start zone density	Isolated small slopes or creek slopes > 30°	Isolated avalanche start zones	Multiple avalanche start zones
Avalanche runout zone characteristics	Isolated, defined zones, smooth terrain transitions, broad and unconfined deposits	Partially abrupt terrain transitions, depressions or gullies with deep deposits	Multiple converging runout zones, confined deposition area, steep avalanche paths overhead
Interaction with avalanche paths	No avalanche paths, runout zones only	Single avalanche paths or paths with bifurcations	***Numerous and overlapping avalanche paths and runout zones***
Route options	Numerous options, terrain allows multiple choices	Some options of varying exposure, possibilities to avoid avalanche paths exist	***Limited possibilities to reduce exposure, avoidance not possible***
Exposure time	None, or limited exposure in crossing isolated small slopes or runout zones only	***Isolated exposure in start zones and paths***	***Frequent exposure to start zones and paths***
Zones with hazard of falling, cornices	None	***Isolated zones with hazard of falling exist, mainly with low visibility***	***Very steep terrain with potential falling hazard***

The explanations on the application of the technical model were adopted in full from Statham et al., (2006, p. 494) and are therefore cited: *"Any system for integrating multiple avalanche terrain variables into discreet categories will by nature present grey areas. In an attempt to minimize these, and to weight particular attributes, the following statement accompanies Table 1. Any given piece of mountain terrain may have elements that will fit into multiple classes. Applying a terrain exposure rating involves considering all of the variables described above, using some default priorities. Terrain that qualifies under an italicized descriptor automatically defaults into that or a higher terrain class. Non-italicized descriptors carry less weight and will not trigger a default, but must be considered in combination with the other factors."*

Tbl. 2: ATES public communication model for the Swiss Jura (based on v. 1/04, Statham et al., 2006).

Description	Class	Terrain Criteria
Simple	1	Exposure to low angle or primarily forested terrain. Some locations may involve the runout zones of rare avalanches. Many options to reduce or eliminate exposure.
Variable **(partly challenging)**	2	Exposure to well defined avalanche release zones and paths or terrain traps; Options exist to reduce or eliminate exposure with careful route finding. Isolated locations with hazard of falling exist, mainly with low visibility.
Complex	3	Exposure to multiple overlapping avalanche paths or large expanses of steep, open slopes; multiple avalanche starting zones and terrain traps below; Minimal options to reduce exposure. Multiple locations of extreme terrain with hazard of falling.

4. RESULTS OF THE ATES APPLICATION TO SWISS JURA WINTER TOURS

According to the classification scheme in Table 1, 62 winter tours in the Swiss Jura were classified with the avalanche terrain exposure scale. Of these, 12 tours were rated class 1, 38 tours class 2 and 12 tours class 3. Because the majority (80 %) of all tours fall into class 1 and 2, ATES is quite suitable and useful for the Swiss Jura. The typical backcountry user in the Swiss Jura (beginner, less experienced, pleasure backcountry recreationist) may benefit from the differentiation in the lower classes in particular.
Figures 3 and 4 illustrate two mapped tour examples rated ATES class “simple” and “variable”.

5. CONCLUSION AND DISCUSSION

The Canadian avalanche terrain exposure scale ATES was successfully adapted for a low mountain range, the Swiss Jura. We followed other European countries, who adopted the original three-class model. The idea of a fourth ATES class (class 0 = no avalanche exposure) was discussed but rejected. Due to limited spatial resolution and data available for the tour analysis, the lowest class has to include at least an exposure to deposit zones of very rare avalanches.

The adapted technical model for tour analysis and classification as well as the public model for communication are presented and the changes made to the original version are listed. The classification was applied to 62 individual winter tours in the Swiss Jura, which is mostly frequented by less experienced winter recreationists on touring skis, snow shoes or by foot. The classification was carried out manually by a mountain guide and guide book author with special expertise in the Swiss Jura. To reduce subjectivity, ambiguous classifications were carried out by at least two experts. Exposure to avalanches exists in the Swiss Jura in small, defined zones. Most of the Jura winter tours fall in class 1 (simple) or 2 (variable). There are only few tours in terrain with a complex alpine character. We assume, that in the Alps, the distribution would be reversed, with most tours in the highest class. For the Swiss Pre-Alps, however, an application for winter tours seems feasible.

The ATES classification can now be offered to guide book authors for low mountain winter tours. As shown in our particular case of the Swiss Jura, tours classified by ATES can, in the absence of avalanche danger ratings, offer additional guidance for winter backcountry recreationists. This added-value is given in particular during the tour selection and planning phase. It is noted however, that ATES is not a stand-alone planning tool, but is always to be used in combination with tour descriptions, maps and available difficulty ratings in guide books, and with all available weather, snow and avalanche information and if available, avalanche danger ratings. The combination of all available information is essential in planning backcountry winter tours.

A broadly accepted avalanche terrain classification that is used commonly in guide books could also, to some extent, fill the gap of missing regular avalanche danger bulletins in low mountain ranges such as the Swiss Jura. Further advantages of ATES are also seen as an aid in teaching terrain in snow and avalanche classes. Because ATES is a new method in Switzerland, we seek to consult

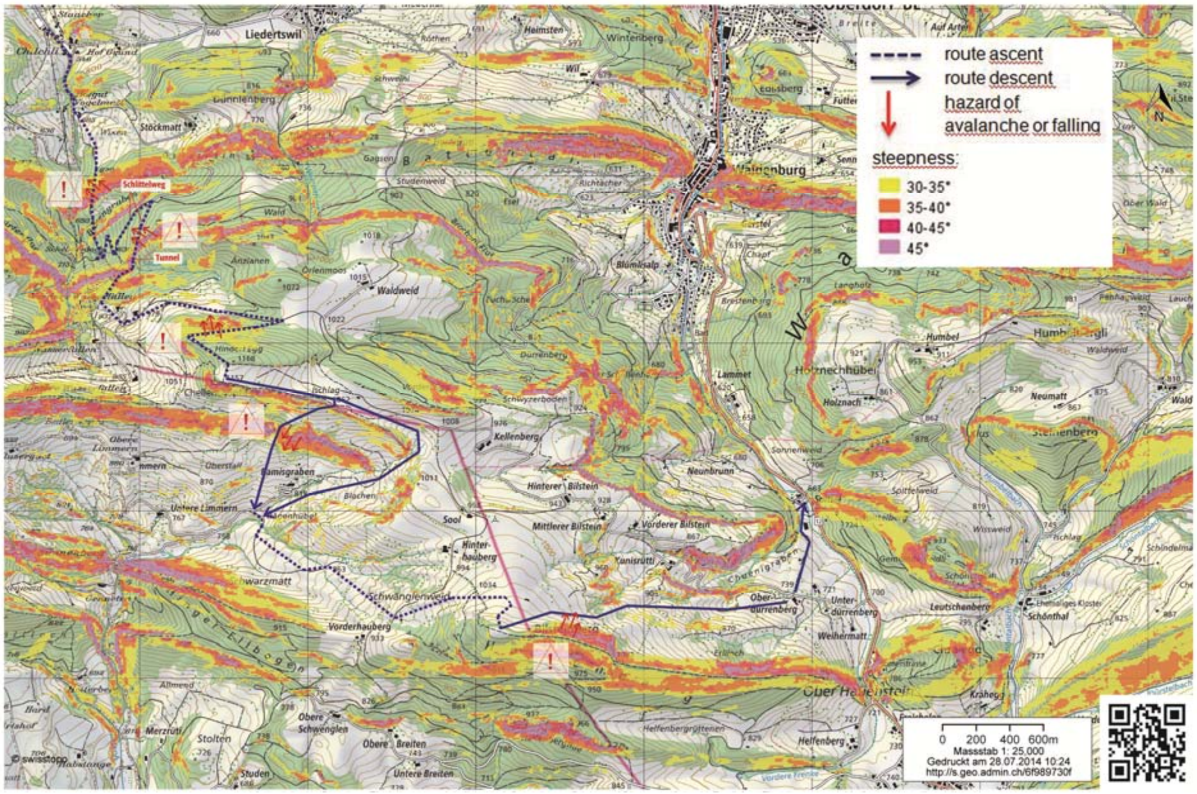

Fig. 3: Example of mapped Jura tour Bilsteinberg, ATES rating “simple” (map source: Swisstopo, 2014).

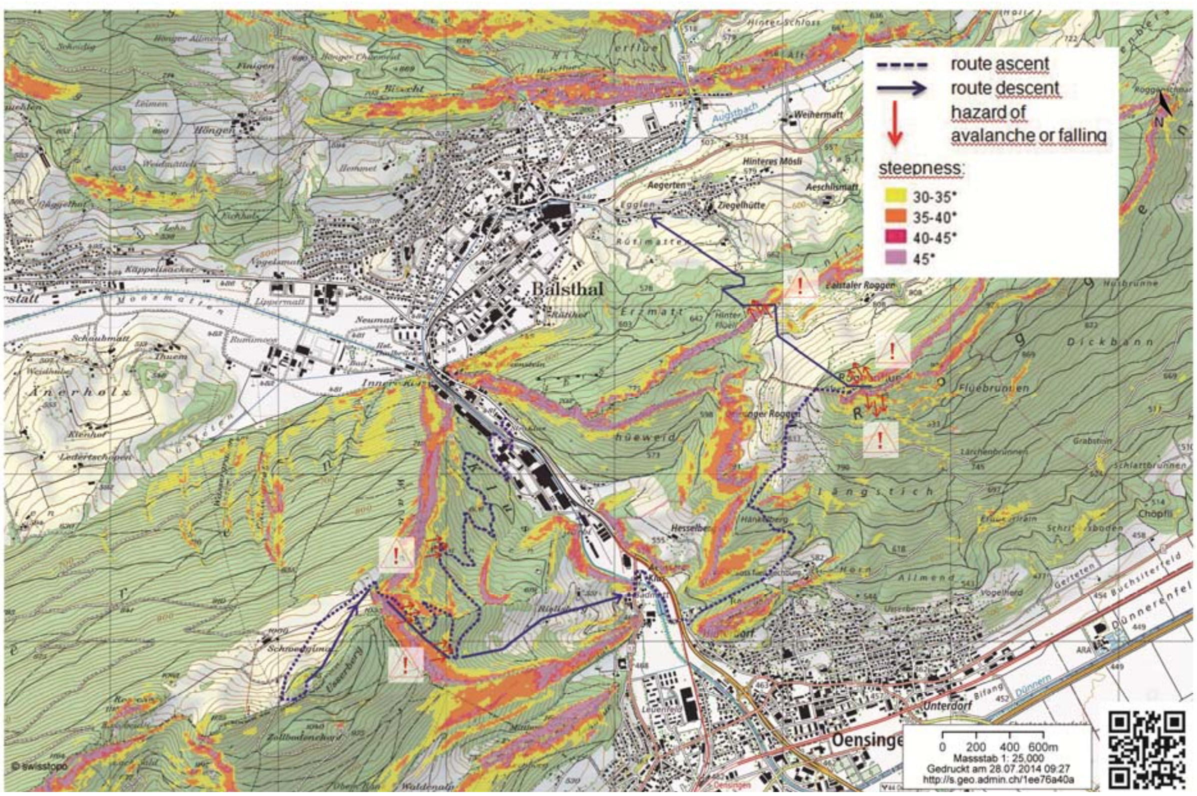

Fig. 4: Example of mapped Jura tour Balsthaler Klus, ATES rating “variable” (map source: Swisstopo, 2014).

and to collaborate with the main Swiss mountain interest groups and associations. We will introduce ATES to the Swiss avalanche training core team (KAT), where these interest groups are represented. We are convinced that our collaboration will increase the awareness, applicability and acceptance of ATES in Switzerland in the future. In this context, an implementation of ATES on ski-touring and snowshoeing topographic maps 1:50'000 (Swisstopo, 2014) is discussed for uniform map-visualization in Switzerland.

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