

SMARTPHONES AS SUPPORT FOR OUT-OF-BOUNDS SKIER DECISIONS

A PILOT STUDY OF HOW INFORMATION ABOUT TERRAIN AND AVALANCHE DANGER IN A MOBILE APPLICATION AFFECTS BEHAVIOUR IN OFF-PISTE TERRAIN

Stefan Martensson¹ *, Petter Palmgren², Jenny Gunnholt³, and Per-Olov Wikberg²

¹ Luleå University of Technology, Sweden

² Swedish Environmental Protection Agency, Sweden

³ Gothenburg University, Sweden

ABSTRACT: In a smartphone, a skier can access avalanche information on the go. This paper shows a new app for making decisions, which combines ATES classification with danger ratings and then presenting this in the form of Avaluator recommendations directly on a GPS-positioned map. We have examined how actual skier behaviour in the terrain is affected by the use of a smartphone as a decision tool. Previous studies on behaviour have mainly focused on surveys or on human factors; it is only now with smartphones with GPS and apps for logging location data that we can study actual movement in the terrain. During 10 weeks, 20 skiers used a GPS-based map app in which they answered questions before and after the day's skiing. The app also logged their actual movements during the day. The questions surveyed the subjective approach to risk and skiing. The experiment was conducted in two phases, first a control phase when the app only showed the current avalanche danger and a GPS-map, secondly an effect phase when the app also showed the combination of terrain and avalanche danger using Avaluator colours (Normal Caution, Extra Caution, Not Recommended) projected directly on map as a layer. Our results show that a mobile application can be a successful way to communicate avalanche information in the future. The results also imply it is better to communicate where to ski than to warn where not to ski. At the individual level, we could also see changes in skier's behaviour when they were given access to avalanche danger and avalanche terrain in a single map view.

KEYWORDS: Avaluator, Human Factors, Decision Making, Risk Management

1. INTRODUCTION

How should information about avalanche danger and avalanche terrain be best communicated to tomorrow's off-piste skiers? That is obviously a difficult question to answer in a simple way. However, what we can guess is that today's analogue way with signs and written texts probably will not work for the future - and digital - off-piste skier: A person who lives his or her life using their smartphone all the time, probably also will go skiing with their smartphone.

1.1 Background

As part of the Swedish National Avalanche Fore-

cast Program the Environmental Protection Agency's Mountain Safety Council asked the Luleå University of Technology to conduct a pilot study on how Swedish avalanche forecasts can best be communicated. The Environmental Protection Agency's Mountain Safety Council had previously begun a classification of avalanche terrain using the ATES and a desire was to include ATES in the same communication solution. The project was implemented in the spring of 2014 as collaboration between the Environmental Protection Agency's Mountain Safety Council, Luleå University of Technology, Gothenburg University and the software company PingPal.

1.2 Problem

McCammon et al. (2008) and later Gunn et al. (2010) identified the out-of-bounds (OB) skiers as a category skier that was markedly different from the traditional backcountry skiers. The OB skiers are also the category of off-piste skiers that is growing the most. Resorts and other information centre needs to rethink how and what information should be communicated. Martensson et al. (2013) showed that Swedish out-of-bounds skiers

* Corresponding author address:

Luleå University of Technology
Department of Civil, Environmental and Natural
Resources Engineering
Division of Mining and Geotechnical Engineering
SE-971 87 LULEÅ, Sweden
tel: +46703771856; fax: +46 920 492818
email: stefan.martensson@ltu.se

despite risk insight, experience, previous incidents, training and equipment still were willing to take risks to ski off-piste.

It is obvious that official and unofficial avalanche information have been successful in spreading knowledge about the phenomenon of avalanches. Few people who get caught in an avalanche are unaware of the danger, even if they do not expect that the accident will hit them there and then.

The two most crucial decisions for people exposing themselves to avalanche danger are where and when to ski. Therefore communication of the current avalanche danger is one of the most important tools in preventing avalanche accidents. However, there are few studies that examine the actual preventive effect this type information have. The evidence suggests that traditional avalanche information have problems with helping people change their own behaviour.

A starting point in this study is that people's decisions in avalanche terrain always will be influenced by a number of psychological factors, more than it is possible to explain. Several authors have described that human processes leads to avalanche accidents. Common to these explanations is that they are based on the accidents, trying to find common human factors that may have contributed. A dilemma is that these studies are retrospective; they do not describe the impact of these factors in the field, where and when people made those two crucial decisions about where and when to ski.

Our main thought in this study is therefore to accept this human impact and seek to develop information systems, which are robust and lead to safer behaviours despite it. Making more or less well-founded decisions, biased by human factors, when being exposed to avalanche danger is not something negative, but rather a neutral condition for achieving the objective of good off-piste.

1.3 Research Question

We decided to formulate our problem discussion starting, not traditionally at the danger of avalanches, but the possibility of skiing. Our hypothesis was that the off-piste skiers should be more likely to follow recommendations that show where and when you can ski with a reasonable safety margin, than following general warnings.

Our overall research question can be formulated somewhat as follows: How can we effectively communicate information about avalanche danger and avalanche terrain so that it is perceived as an

opportunity for good skiing instead of a warning for avalanches? Our aims were:

- Develop a mobile app that combines avalanche danger and avalanche terrain in an attractive and easy to use map service
 - Study the practicability of collecting data on off-piste skier's behaviour and decisions in real time
 - Increase knowledge of the correlations that exist between available information avalanche and off-piste skiers practical behaviour
 - Increase knowledge of the correlations that exist between personal factors and off-piste skiers practical behaviour

2. METHOD

2.1 *Test area*

The research was conducted in Hemavan in northern Sweden, an area known for its popular and easily accessible off-piste skiing. Access to the main off-piste areas is via a top ski-lift and then leaving the ski area. Off-piste terrain is reached after a short hike with skis on your shoulder or using skins. All the available terrain is classified based on ATES, see figure 1.

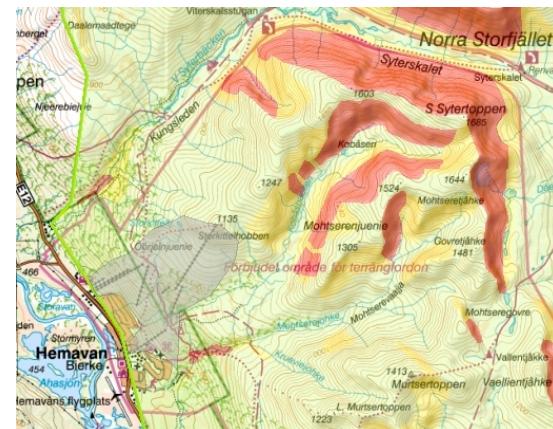


Figure 1: The test area with ATES avalanche terrain

To ensure the quality of the time-dependent information about the current avalanche danger a local avalanche technician was contracted to provide the experiment with daily now-casts.

2.2 Participants

The experimental setup involved the same people using two different versions of the app. This means that the participants had to ski off-piste in

the area regularly throughout the season. A group of 20 participants was chosen with the requirement that everyone would in fact be permanent residents or seasonal workers, this to ensure continuity during the test period and compensate for changes in snow and avalanche conditions and changes in behaviour over the season. For technical reasons, participants must additionally own an iPhone.

2.3 *The Mobile App*

A mobile application (named Pandora's App) was specifically developed for the study. The basis of the app is a mapping application with a high-resolution map. The map is zoomable and shows the current position with an arrow. During the test period, the participants were presented with different types avalanche information as a supplement to the basic map service.

The app also asked the participants a number of questions before, after and during the ski day. All movements in the days were recorded by the app. The app downloaded daily avalanche rating in the morning and was then completely autonomous during the rest of the day. At the end of the day, when connected to Wi-Fi, the app then uploaded the data to a database for further analysis.

2.4 *Disposition of experiments*

The experiments were carried out in three steps; an initial survey, a control phase (phase 1) and an effect phase (phase 2). Participants had access to more and more specific avalanche information during the two phases. All avalanche information in the project was following proven practices. The new idea in the study was that the information communicated was tailored to the participants' position.

2.4.1. *Initial survey*

In an initial survey, participants were asked demographic questions, questions about the experience, knowledge and preferences for risk and danger, and more. After the survey participants installed the app where they also were assigned a unique ID number. The survey responses were then used to correlate the position data for different levels of experience and risk preferences.

2.4.2. *Control Phase (phase 1)*

In addition to the basic map service, the current avalanche danger rating was shown in an information text box at the top, according to the international avalanche scale. This is information that

is generally available for most mountain areas around the world and is considered in the study as a reference, see figure 2.

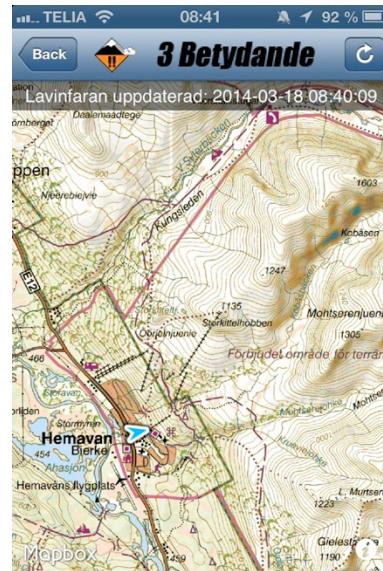


Figure 2: Phase 1 - map and the current avalanche danger at the top

2.4.3. *Effect Phase (phase 2)*

During this phase, the avalanche danger and ATES ratings were combined to visual recommendations as polygons in the map. The algorithm used for the calculations in the app was the Avaluator basic matrix (Haegeli et al., 2006), see figure 3.

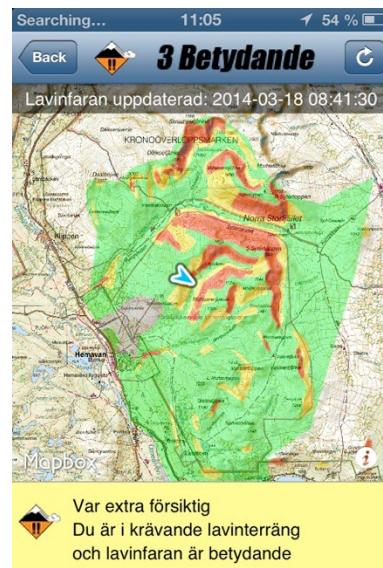


Figure 3: Phase 2 - Map and Avaluator colours and advice at the bottom

The Avaluator algorithm can be used as a simple matrix that weighs the current avalanche danger and difficulty of the terrain into a recommendation. In this study, the mobile app plotted the different matrix conditions (Normal Caution, Extra Caution, Not Recommended) directly on a map as colour layers. When the participants entered an area with new conditions they were highlighted by a visual and audible signal that they had to confirm.

2.4.4. Collecting Position Data

The participants' position every 60 meters was logged in the mobile app and sent to a database in the evening when the participants were connected to Wi-Fi. This means that each position can be linked in time to an avalanche danger and in space to a certain ATES level. The Avaluator matrix recommendations are considered as reference for the participants' exposure to the "objective" avalanche risk.

2.4.5. Collecting Query Responses

The mobile app also asked simple questions before, after and during the ski day. The questions before were to describe the internal and external factors that were important for off-piste skiing that day. Participants also answered what type of terrain they pre-planned to ski. In addition, participants also filled in a checklist of what safety equipment they were bringing, see figure 4.



Figure 4: A Checklist for the day as a question

At noon, the app asked the participants if they had decided where they wanted to ski. The purpose of this question was to study the dimension of planning and foresight. The answers can also interpret

the factors that influence the crucial decisions to ski or not to ski a certain slope.

Finally, after the day the participants were asked a series of questions on today's skiing and choices. They were asked to evaluate various factors that contributed to today's choices. A final question is how many in the group who skied together.

3. RESULTS

When compiling the data we revealed that eight participants had enough off-piste skiing in both phase 1 and phase 2 to be further evaluated. Other participants had either skied mostly in phase 1 or phase 2. These eight individuals were analysed more in detail.

During Phase 1, the runs are relatively concentrated and a few runs are also skied in "Complex" avalanche terrain, see figure 5.

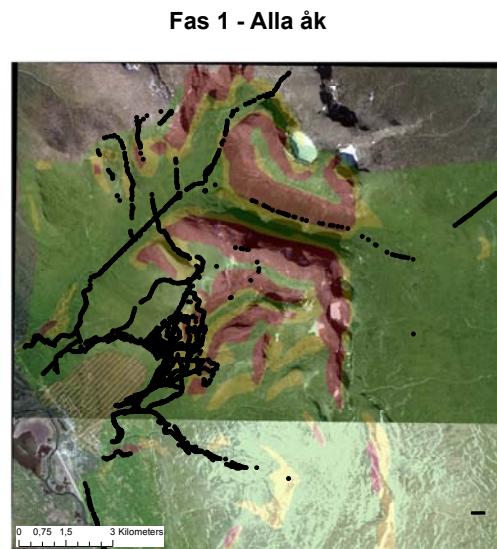


Figure 5: All runs skied in phase 1

During phase 2 it appears that more runs are skied in comparison with the number of phase 1. The runs are more scattered throughout the area. The participants have completed several runs through "Complex" avalanche terrain. Even more runs appear to have been skied within "Challenging" avalanche terrain, see figure 6.

Fas 2 - Alla åk

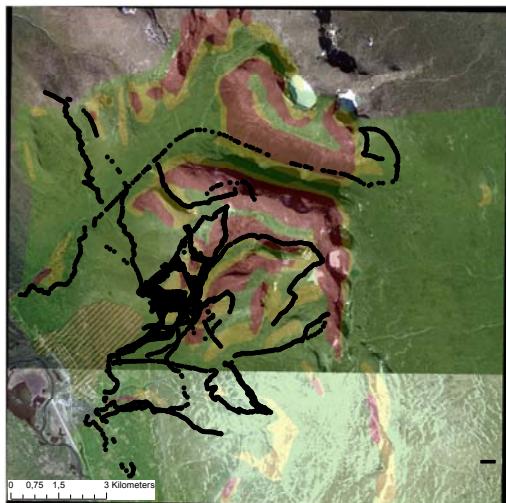


Figure 6: All runs skied in phase 2

Each run was analysed in detail by measuring the amount of time spent in different levels of the Avaluator space-time; Normal Caution, Extra Caution, Not Recommended Conditions, see Figure 7.

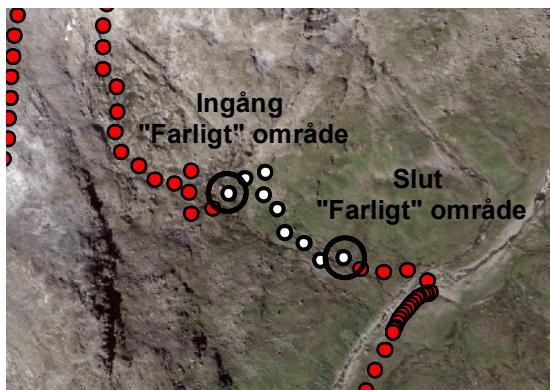


Figure 7: Entrance and ending coordinates of one of the "Not Recommended" areas, used to calculate risk exposure in minutes

As the main purpose of this study was to develop the app and to explore potentials for further research we should not overestimate our results in general terms. The experiment consisted of too few participants, and the winter was, as regards to avalanches, with little variation in avalanche danger. All of this of course affects our results. But you can still see some interesting parts.

Among other things, we saw a clear correlation between age and exposure to risk. The lower the age, the more time they spent in dangerous conditions. Some participants also did so many runs in

both Phase 1 and 2 that it is possible to see differences in behaviour at the individual level, see individual 498033422 below.

To give an example of the potential of our proposed method, we examined an individual nearer. Figure 8 shows his/her aggregate runs in Phase 1 and Phase 2. Here you can see that the individual moved through "Complex" terrain during Phase 1. In phase 2, he/she totally avoided these conditions, which might be a change caused by information in the app.

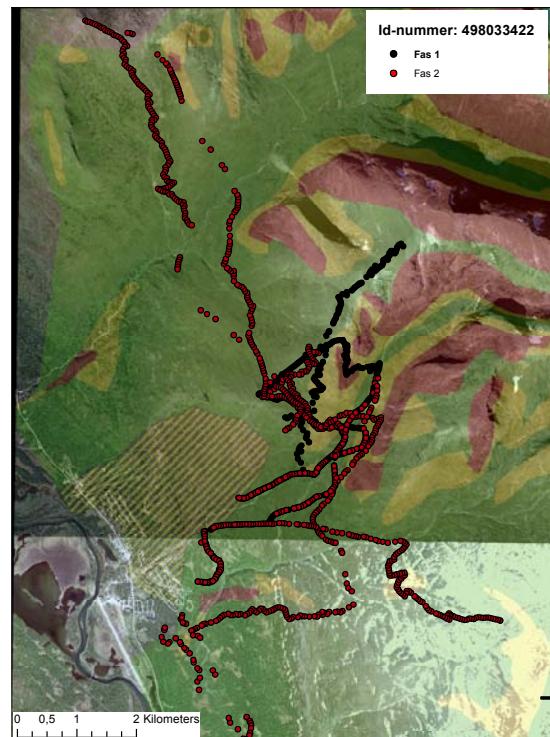


Figure 8: All tracks made by user 498033422 during phase 1 and phase 2

In phase 2, the person also changed direction when skiing, which is enlarged in figure 9. This can be due to many factors, but it can be assumed that the direction of change was made because of the information in the app.

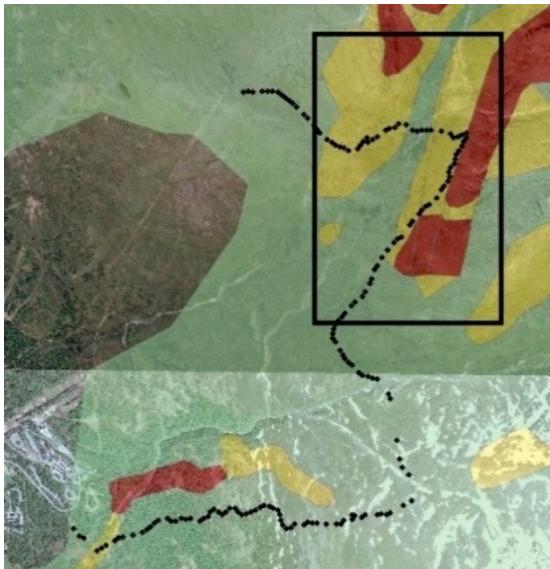


Figure 9: User 498033422 shows a change-of-direction during phase 2

4. DISCUSSION

Avalanche Information aims to help people to adapt their skiing to the current avalanche danger. For avalanche information to be considered effective, it should be seen that higher avalanche danger leads to individuals choosing safer terrain, and vice versa. A comparison over time should thus reveal if the app makes it easier and more attractive to follow the experts' advice.

The avalanche scale can also measure compliance in phase 1; recommendations in the avalanche scale are the same if only expressed in general terms. This way of evaluating can be affected by that external and internal factors vary during the season, such as length of the day and the tours will be longer, more courage. Even if a person is following Avaluator based information the risk acceptance may increase during the period.

Data logs can be evaluated in several ways. The first is to see if the participants' exposure to avalanche risk changes during the two phases. This evaluation is also a measure of the extent to which the participants follow the experts' advice.

Another way to measure the effect of the app is to compare to which extent the test group adapts the choice of terrain at different avalanche danger. We know from previous studies that off-piste skiers are willing to expose themselves to avalanche danger for the sake of good skiing. Avalanches occur on steep slopes, and this is often the most attractive terrain for skiers. One hypothesis is that

the app can affect skiers to avoid the most dangerous terrain in the most dangerous days, while it is less likely that dedicated off-piste skiers should reject steep skiing for a whole season.

Some skiers have a strong motivation to ski steep, dangerous avalanche terrain, and we can evaluate under which conditions they choose to do so. If avalanche information is to be considered effective, there should be a correlation between higher avalanche danger and increase of runs in easier terrain and lower avalanche danger when the participants choose the more dangerous terrain.

The difference from the analysis of the "total risk" is that this method does not value the choice of terrain, but rather when they choose different types. This method should therefore be less sensitive to whether participants' general behaviour, motivation and risk acceptance change during the test period.

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