BACKCOUNTRY RISK ASSESSMENT BASED ON TERRAIN AND SNOWPACK CHARACTERISTICS

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ABSTRACT: Despite an increase in back country travels, in the past 20 years the total number of fatalities remained about constant in the Alps. This decreasing risk of death was accompanied by developments in rescue technology, avalanche forecasts and education. Now, maps of slope incline and snow cover information have become more readily available which have potential to enhance our decision making. We gave existing trip planning strategies a second look and developed a new approach which builds on terrain and snowpack information.

Risk assessment zooms in on the crux-slope. In other words, we learn about conditions when we travel and update our view. With more terrain and snow cover information becoming available beforehand, we suggest one single framework for backcountry risk assessment that takes the user through all zoom levels – from trip planning to slope evaluation. The framework helps to assess the risk which is a combination of the avalanche release probability and potential consequences. To do so, we weigh several aspects regarding either the likelihood of triggering or the consequences. These aspects include, for instance, typical avalanche problems, expected avalanche size or the crack propagation propensity – rather than simple proxies such as slope angle and aspect. Thus, the risk assessment eventually relies on the characteristics at the particular crux slope and a local danger assessment. Based on a local, rather than a regional danger assessment the presented approach circumvents the scale mismatch between slope evaluation and regional forecast. Moreover, due to its strong focus on terrain characteristics the presented approach becomes applicable for freeriding when terrain is often well known. On the other hand, the approach provides guidance in situations when challenging snowpack conditions require careful judgement.

Our approach substantially differs from existing methods in the way that the consequences are considered during trip planning. Also, the regional forecast is downscaled to a local danger description. Moreover, our risk assessment then relies on several terrain and snowpack characteristics rather than on thresholding as such by slope angle limits. As another advantage, we can follow the same line of thought at all zoom levels. In conclusion we see the presented approach as a first, but necessary step towards a comprehensive framework for back country risk assessment.

KEYWORDS: decision making, trip planning, route selection

1. INTRODUCTION

Over the past 20 years the total number of avalanche fatalities was rather stable, although the number of people recreating in the Alps has been growing over this period (Techel et al., 2016) which would indicate a reduced risk of death due to avalanche release. Maybe this risk related to developments in beacon search technology, use of avalanche airbags, popularity of backcountry training classes, better availability of avalanche forecasts, better coverage of professional rescue services or mobile phone reception. Apparently, many factors influence the risk to eventually die in an avalanche. To lower the personal risk prevention programs help to sharpen one's decision making skills.

More recently, the development of geographical information systems has picked up speed and hence, maps with new terrain information are becoming available for many ski touring regions.

So far, trip planning strategies follow a filter approach including trip selection, detailed route selection and finally, single slope evaluation. The first filter often focusses on danger level issued by forecasting services and slope angle. For complete risk estimation, however, also vulnerability and exposure need to be taken into account apart from the hazard. That said, considering avalanche characteristics, which are related to terrain and snowpack characteristics, is common practice to evaluate vulnerability for avalanche risk analysis (e.g. D. M. McClung et al., 2002).

With more detailed information available today

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we want to include readily available terrain and snowpack information into the trip planning scheme – something many decision makers in avalanche terrain already intuitively do.

2. REVIEWING EXISTING TRIP PLANNING STRATEGIES

Common trip planning strategies usually compare current conditions to terrain characteristics. When planning a trip at home we obtain a risk estimate based on danger level and simple terrain parameters such as slope angle. First, we will recall some assumptions behind common trip planning strategies.

2.1 Avalanche danger

The estimated avalanche danger refers to an entire region. As the danger level describes a stability distribution (Schweizer et al., 2002) the stability single slope cannot be estimated by the danger level. Hence, slope evaluation requires some kind of downscaling.

Figure 1: Avalanche size and risk are related.

2.2 Risk

Risk is commonly understood as the intersection of hazard, exposure and vulnerability. Hence, to estimate the risk of a trip or certain route needs to include these elements. Avalanche size, for instance, has been used to analyze the vulnerability of people caught (Jamieson & Jones, 2012) and is effective to define vulnerability scenarios (D.M. McClung & Schaerer, 2006).

2.3 On-site route selection

Detailed on-site route selection is part of freeriding when we access slopes mostly from the top. In such settings decisions are often based on small terrain features or escape routes. Including terrain characteristics in the decision making process vulnerability can be taken into account (Haegeli et al., 2006). Especailly when we make on-site decisions on the probability or consequences of release we want to include local terrain and snow cover information.

After all, the information on terrain and snowpack is becoming available. So the time is ripe to make some room in our trip planning schemes.

3. PLANNING SCHEME

We suggest one single framework for backcountry risk assessment that takes the user through all zoom levels – from trip planning to slope evaluation:

- Evaluating the hazard
- Estimating the release consequences
- Selecting effective measures
- Assessing the risk

The framework helps to assess the risk which is a combination of the avalanche release probability and potential consequences.

Figure 2: Scan QR-code to assess trip planning schemes for use in trip planning and in the field.

3.1 Hazard evaluation

To identify crux slopes we recommend first considering all steep slopes with a slope angle >30° along the intended route as slopes inclined steeper than the friction angle of snow (van Herwijnen & Heierli, 2009) may slide. From that selection we may drop out:

- Slopes above our route that we actually do not cross – provided remote triggering is unlikely.
- Slopes that are not mentioned in the danger description of the forecast as they have a significantly lower release probability (Schweizer et al., 2002). Slopes steeper than 40° do not drop out.

The first section is facilitated by slope angle maps. For these crux slopes we carry out a local danger assessment which is based on observed signs of instability, the current avalanche problem and weather trends to anticipate short-term changes.

To assess the likelihood of triggering we consider the propensity of failure initiation and crack propagation. We can adjust our evaluation if we

observe recent tracks provided loading and wetting are not occurring. In addition, we evaluate other possible hazards, such as serac falls or other groups being on the same route. The probability of triggering a certain slope is higher in case:

- Failure initiation is not unlikely along the intended route.
- Crack propagation initiation is not unlikely along the intended route.
- Additional hazards are present such as additional people travelling on the same route.
- No recent tracks are observed or the slope is current loading or wetting.

3.2 Possible release consequences

To assess the consequences of a release or burial we suggest considering the size of the slope, the quality of meeting points, the possible release mass (which may differ from the size of the slope) and terrain traps. Severe consequences are expected in the following situations:

- A release will find you most likely being seriously caught or injured.
- Meeting points avoiding multiple burial situations are unavailable.
- A release would bring into motion large amounts of snow either due to release depth or area.
- Terrain traps increase the consequences of being caught.

3.3 Effective Measures and risk

Effective measures are mostly directed towards mitigating the consequences of a release or burial. Hence, from the list of consequences we can often deduce effective measures. Still, some measures, such as spreading out in an avalanche slope, can also reduce the likelihood of triggering. Having selected measures, we check the remaining risk and decide whether to go or not.

4. DISCUSSION AND CONCLUSIONS

The presented risk assessment scheme includes typical avalanche problems, expected avalanche size or the crack propagation propensity – rather than simple proxies such as slope angle and aspect. Thus, the risk assessment eventually relies on the characteristics at the particular crux slope and a local danger assessment. Based on a local, rather than a regional danger assessment the presented approach circumvents the scale mismatch between slope evaluation and regional forecast.

Moreover, due to its strong focus on terrain characteristics the presented approach becomes applicable for situations when the terrain is well known. On the other hand, the approach provides guidance in situations when challenging snowpack conditions require careful judgement.

Our approach substantially differs from existing methods in the way that the consequences are considered during trip planning. Also, the regional forecast is downscaled to a local danger description. As another advantage, we can follow the same line of thought at all zoom levels.

In conclusion we see the presented approach as a first, but necessary step towards a comprehensive framework for back country risk assessment. Further refinement and simplification may be possible in the future but starting with a comprehensive scheme at first seems essential.

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