Regional danger ratings
and
the odds of triggering a potentially fatal avalanche

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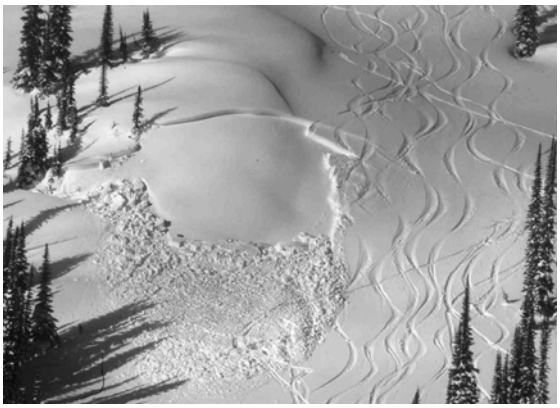
During the small talk before an interview last winter, a reporter said "They went into the mountains when the avalanche danger was Considerable; they must have known someone would die." I countered by saying there were hundreds of skiers and snowmobilers who had enjoyed themselves on mountain slopes over the weekend—without being caught in avalanches. This conversation reminded me that, outside the avalanche community, the public understanding is limited about how the Avalanche Danger Scale relates to triggering harmful avalanches. In response, I dusted off an abstract I had submitted and withdrawn twice, asked Jürg Schweizer and Cora Shea to help with parts of the analysis, and submitted the abstract to the 2009 International Snow Science Workshop (ISSW) in Davos. The abstract is called *Simple Calculations of Avalanche Risk for Backcountry Recreation*. The word "simple" is important—I'll come back to it.

Avalanche risk depends on the probability of an avalanche affecting people (or property) and the expected consequences. For the consequence term in our analysis, we chose to ignore injuries and focus on the probability of death. For any size of avalanche in accident reports, this probability is given in *Avalanche Accidents in Canada 1984-96* on avalanche.ca's Knowledge Centre. The remaining part of the risk calculation is the probability of being caught. Because upwards of 90% of fatal avalanches are triggered by people, we can focus on the *probability of triggering a potentially fatal avalanche*.



What are the odds? This slab in the Selkirks was triggered by the eighth person down the slope.

There are many factors like snowpack conditions, distribution of trigger points, and skilled route selection that could be included in the analysis. Since there are no reliable data for these factors, our risk calculation is thwarted unless we can simplify some and estimate others. We chose to simplify exposure and focus on one factor: the regional danger level since it includes the probability of human-triggering (certain, likely, probable, possible, unlikely) and includes something about the distribution of trigger zones (e.g. avoid steeper terrain). (The US version of the Danger Scale is much clearer about the distribution of trigger zones.)

The Danger Scale does not specify the *exposure* associated with the words like possible, probable, etc. Do these probabilities or likelihoods apply to one person exposed to one trigger zone? To one person exposed to multiple trigger zones on a typical run? To multiple ascents and descents by one person in a typical day? To a typical group during a typical day? To all of the groups in the region? Does the exposure assume skilled route selection, or centre-punching start zones, or a typical mixture of the two? For our estimates of triggering probability, we chose to define one exposure as one person making fresh tracks while directly ascending, traversing or descending a trigger zone *without* skilled route selection. So in our search for a simple risk calculation, triggering by the second or third or tenth person in the up-track was ignored. Skilled route selection was excluded partly because the level of skill and its effect on the triggering probability are even more difficult to estimate. We also wanted to establish a baseline, upon which factors like skilled route selection and recognition of local conditions could be later applied.

Controversially, we also excluded avalanche size (or consequence) from the triggering probability for a specific level of regional danger because:

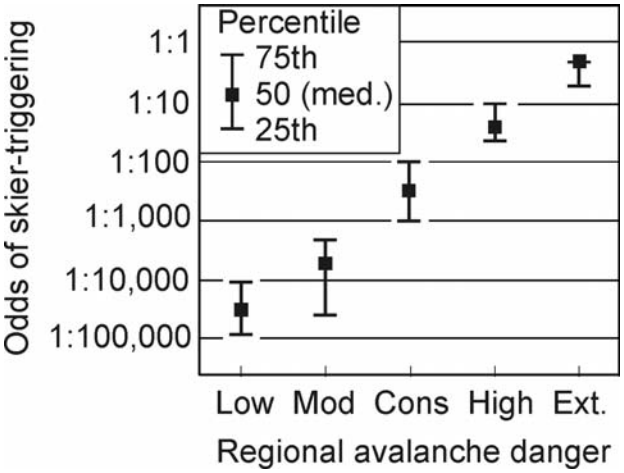
- avalanche size is not explicitly in the danger scale we have used in North America since 1996 (although many skilled regional forecasters probably consider the expected avalanche size or consequence when rating the regional danger.)
- we restricted our analysis to potentially fatal avalanches, thus ignoring smaller avalanches
- we wanted to keep our first risk calculation simple by concentrating on one strong factor, in this case, the regional avalanche danger rating. (Remember, I had previously withdrawn the abstract twice.)

Alas, there are no data on the probability or odds of triggering a potentially fatal avalanche in a trigger zone at any level of regional danger. However, in analyses of other risks, such as various types of failures of nuclear power plants, the unknown probabilities are estimated by experts. My first attempt at writing a survey for experts was poor. Fortunately, Pascal Haegeli recommended a book on designing this type of survey (Morgan and Henrion, 1990). One of the many good ideas in the book is how to deal with factors which are not in the survey but which some respondents may consider important—like avalanche size in our survey. Respondents are encouraged to estimate the average odds after considering the real variability in unspecified factors.

After many drafts and approval by the University's Ethics Board, the survey was e-mailed to selected regional forecasters, senior guides and consultants (experts!) in Canada and the US. Many clearly expressed their concerns about the simplifications behind the survey. For example, two people thought avalanche size should have been explicitly included in the survey, and two thought the same about the area of the forecast region. While the previous paragraphs may partly explain some of the assumptions, I should have expected their reaction to the simplifications:

"Reluctance to simplify interpretations" is characteristic of people who are good at *managing the unexpected* (Weick and Sutcliffe, 2001), and that includes avalanche risk.

Twenty-three experts with an average of 28 years of experience responded to the survey. This is enough to provide a first look at the expert-estimated odds of a skier-triggering a potentially fatal avalanche while making fresh tracks in a single trigger zone without skilled route selection. Sure, there are some strong simplifications. For each rating of regional avalanche danger, the graph shows the median estimate and the range of the middle 50% of estimates. For example, when the avalanche danger is Considerable the median odds of triggering is 1:300, and 50% of experts estimated the odds of triggering to be between 1:100 and 1:1000. Note that the left axis has a probability scale. The median odds of triggering increase roughly by about 10 times for each step in the danger scale. The biggest jump (multiplicative increase) in triggering odds is between Moderate and Considerable Danger, and the lowest jump is between Low and Moderate—both of which warrant further analysis.



For each level of the regional avalanche danger, the graph shows the estimated odds of skier-triggering a potentially fatal avalanche while making fresh tracks in one trigger zone without skilled route selection. The whisker or bar shows the range of the middle 50% of estimates, i.e. from the 25th to the 75th percentile. A square marks the median or 50th percentile.

Although the full range of estimates for any danger level is not shown, it is clear that the uncertainty in the estimates is greater for lower levels of danger. This uncertainty can be due to many sources including: variability in the factors not specified in the survey; ambiguity in the survey; and uncertainty that is inherent to triggering within a forecast region. The final graph of triggering odds as well as the initial simple risk analysis will be presented at the ISSW in Davos in September 2009.

So what? Well, a missing piece of the recreational avalanche risk puzzle is emerging from the fog. However, I doubt the graph will mean much to the public. Nevertheless, the estimated odds may help those of us who work with avalanches to explain triggering odds and avalanche risk to others. Perhaps the estimated odds can be used to freshen and re-phrase some important messages. For example, the odds of triggering a potentially fatal avalanche can be decreased by:

- skilled route selection (which requires experience),

- seeking out areas or slopes within the forecast region where human triggering of harmful avalanches is less likely, or
- turning around or choosing more cautious routes when signs or clues indicate higher levels of local danger.

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