Risk management for the spatial variable snowpack

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As part of discussions on spatial variability – including discussions on CAA courses – over the last five or so years, I have asked many people who work with avalanches how they manage the risk. The ideas that follow are a compilation of their replies and some of my thoughts. Some ideas are established and some may be new. Some suggestions may be practical for particular operations but not others.

Pre-season planning

- Hire experienced people. The more varied conditions they have experienced, the better.
- Identify areas where the ground cover is highly variable, perhaps with summer or fall terrain photos.
- Keep records of areas that have produced unexpected avalanches in the past. Make this information available to new staff, possibly on a map.
- Where practical, for example on a dud search, get winter staff into avalanche terrain when there is no or little snow on the ground so they can observe the ground cover.

Figure 1. Slab avalanche on Mt. Lipalian outside the Lake Louise Ski Area. A skier triggered the slab where the snowpack was thin.

Daily planning

- Relate snowpack distribution and stability to terrain (aspect, elevation, feature, etc.) wherever and whenever possible, verbally, in writing, graphically, and/or on maps.
- Since spatial variations of stability are greater when the snowpack is shallower, interpret snow/weather history in terms of high or low snowpack variability. Relate the current snowpack to previous winters.
- Attempt to identify spatial patterns locally and regionally using the results of skiing, probing, field tests, avalanche observations, and information from other operations.
- Emphasize field time. Have guiding/forecasting staff moving in avalanche terrain - feeling, probing, digging, skiing, etc.Use a wider margin of safety **when** variability is high, e.g. early winter, thin snowpack winter, complex mid-winter snowpack.
- Watch for change in snow distribution as winter progresses.

- When and where the snowpack is especially variable, interpret the results of individual snowpack tests and profiles with reduced confidence.
- Make a plan for focused (but limited) field observations. This plan can arise from knowledge gaps identified during the forecasting process (e.g. checklist).
- Make time to analyze the observations and information from other operations.

Travel and field work

- Ski a lot, probe a lot, test the snowpack. Discuss what you find. Attempt to identify spatial patterns in stability, then verify the suspected patterns where and when practical. Observe profiles and tests where snowpack properties appear average. Supplement these with profiles and tests where snowpack is not average. Some areas of thinner than average snowpack exhibit below average stability.
- Use a wider margin of safety ***when*** variability is high, e.g. early winter, thin snowpack winter, complex mid-winter snowpack.
- Use a wider margin of safety ***where*** variability is high e.g. cross-loaded slopes, boulder field, moraine, buried crusts – recognizing that the stability of late season crusts can vary with subtle aspect changes.
- Where variability is high and risk is low (e.g. boulder field on non-avalanche slope), observe the variability by skiing and probing.
- Where variability is high and risk is high (e.g. boulder field at toe of avalanche slope), avoid the slope or use explosives if practical.
- Manage the group or team to minimize triggering from less stable areas, e.g. areas of thin snowpack, or areas of high variability.
- Explosive testing, try a variety of placements: air, over rocks, thick areas, toe of slope, etc.
- Be aware that even subtle spatial variations in snowpack properties can have affect important effects on stability.
- Stop and visualize snow distribution from a safe place such as the top of a run.
- Use a digital camera to photograph avalanches, unexpected snow distribution, etc. for discussion with other employees.
- Avoid known problem areas
- Make time to analyze the observations.
- Communicate unexpected observations with others who work in the area.

Most profiles and snowpack tests are indicative of average snowpack properties, but the usually elusive areas of minimum stability are important for decision-making. An understanding of the variability will help estimation of minimum stability from indications of average stability.

Uncertainty

Chris Stethem summed up one of these discussions with "greater uncertainty requires a greater margin of safety." Recalling the avalanche triangle with sides for Snowpack – Terrain – People, its worth noting that there is uncertainty associated with all three sides of the triangle. During poor visibility or when we are off known routes, terrain contributes to uncertainty. However, because terrain does not change over time, people and the snowpack are greater sources of uncertainty in most situations. Some guides have emphasized this by saying that "the snowpack is the problem, and terrain is the solution." In unusual snowpack conditions, though, past experience in the terrain should be applied with caution. The attention to human factors in modern avalanche courses can be viewed as a response to the uncertainty due to people. However, the snowpack – and associated weather – is a major source of uncertainty. I hope these preliminary lists include some helpful risk management strategies for the spatially variably snowpack.

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