TERRAIN SELECTION TACTICS IN HELICOPTER SKIING – MANAGING AVALANCHE RISK DURING THE 2022-23 DEEP SLAB SEASON

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ABSTRACT: Managing snow avalanche risk during guided helicopter skiing operations is critical for guest and worker safety. The 2022-23 winter snowpack in British Columbia Canada involved the development of a deep persistent slab avalanche problem that persisted for the majority of the winter in many areas. Canadian Mountain Holidays (CMH) operated 11 distinct guided helicopter skiing operations with over 3,500 skier-runs per day during the peak operational season which results in an expansive amount of avalanche terrain utilized each day. Selecting terrain that minimizes hazard yet provides a positive skiing experience for guests is a core daily decision-making process for individual guides in the field, guiding teams deciding on run lists, and mountain safety managers at CMH. This paper discusses specific tactics that were used during the 2022-23 season to manage the deep persistent slab problem which included magenta run list coding, extensive explosive control, and seasonal closures of terrain:

- Magenta run coding – the magenta coding is a run list procedure that purposely slows the opening of new terrain – either previously not investigated during the season or closed due to the presence of a persistent avalanche problem – for 24 hours.
- Terrain elimination - runs with high severity terrain and increased uncertainty regarding the deep persistent slab problem were closed for the remainder of the season. This was done with the intention of simplifying the terrain selection process.
- Explosive control work – control work was increased to protect overhead terrain and cautious interpretation of results were used.

Statistics describing the effect of these tactics are presented along with a discussion of the benefits and potential drawbacks with the intention of promoting the development of improved terrain selection decisions for the guided mechanized backcountry skiing industry.

KEYWORDS: Guided helicopter skiing, terrain selection tactics, avalanche risk management, deep persistent slab avalanche problem.

1. INTRODUCTION

Canadian Mountain Holidays (CMH) provides guided helicopter skiing at 11 remote areas in British Columbia, Canada. Over 3,000,000 acres of skiable terrain is accessed by up to 30 helicopters providing an average of 3,500 skier runs each day for guests travelling from around the world. Access to these remote and difficult to access places provides many guests with life changing experiences, however flying and skiing in remote backcountry mountains in winter demands strategic and focused practices to manage the associated avalanche and flying risk.

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While many factors affect the terrain and run use decisions by the guides (e.g. flying conditions, guest experience, wildlife concerns, efficient use of flying time) minimizing exposure to avalanche hazard is core to daily operations and is the focus of this paper (e.g. Thumlert and Haegeli, 2018; Sterchi, et al., 2019). All CMH areas code a run list in the morning meeting based on the assessed avalanche (e.g. persistent slab problem) and mountain hazards (e.g. crevasses) for the day. Regular operations include coding runs as:

- Green – open for guiding.
- Red – closed for guiding.
- Yellow – conditionally open. That is, some definitive condition must be met prior to the run being open for guiding such as the assessment for the presence of wind slabs, or an assessment by the snow safety guide.

Often runs are opened (greened) for specific lower-exposure lines within the run, with higher consequence higher-exposure lines remaining closed for guiding. Lead guides then select available runs from the run-list to put together a suitable ski program for the day that balances managing the risk, guest experience, and program efficiency. Individual guides then manage the avalanche hazard on the runs for their group with further terrain selection techniques (e.g. steering around a steep roll) and group management (e.g. spacing the group out across higher consequence slopes). Selecting appropriate terrain given the avalanche hazard conditions is the primary avalanche risk mitigation strategy used in helicopter guiding.

Another common risk mitigation tactic used by most areas is explosive testing and control. Explosives are used to control the timing of release of avalanches that threaten ski lines and helicopter landing sites. Explosives are also used to test the reactivity of the snowpack providing high quality data for avalanche hazard forecasting. Explosives are not used to manage all the skiing terrain as there are too many terrain features to manage effectively. Explosive use also creates a skiing hazard with post control debris, and explosive use that does not create an avalanche does not guarantee that the hazard has been eliminated.

The 2022-23 winter involved lower than average snowfall during the early winter months which led to the development of weak facets at the base of the snowpack and a deep persistent slab problem which lingered for most of the season. This paper describes and discusses specific risk management strategies employed by the CMH guiding teams to manage this specific avalanche problem.

2. THE 2022-23 DEEP SLAB PROBLEM

The 2022-23 can be characterized as lower than average snowfall with a well-developed persistent basal facet weakness. The low early season snowpack delayed the operational season for many CMH lodges due to hazardous and poor-quality ski conditions. The weak basal facets created a deep slab problem that persisted throughout the winter in all the CMH areas and across most of Western Canada. Figure 2-1 shows modelled snowpack data for three sites in the Columbia Mountain range demonstrating the deep persistent avalanche problem that lingered for the season. Figure 2-2 shows Height of Snow and Air Temperature data from six automated weather stations illustrating the early season conditions that led to the development of the basal facets.

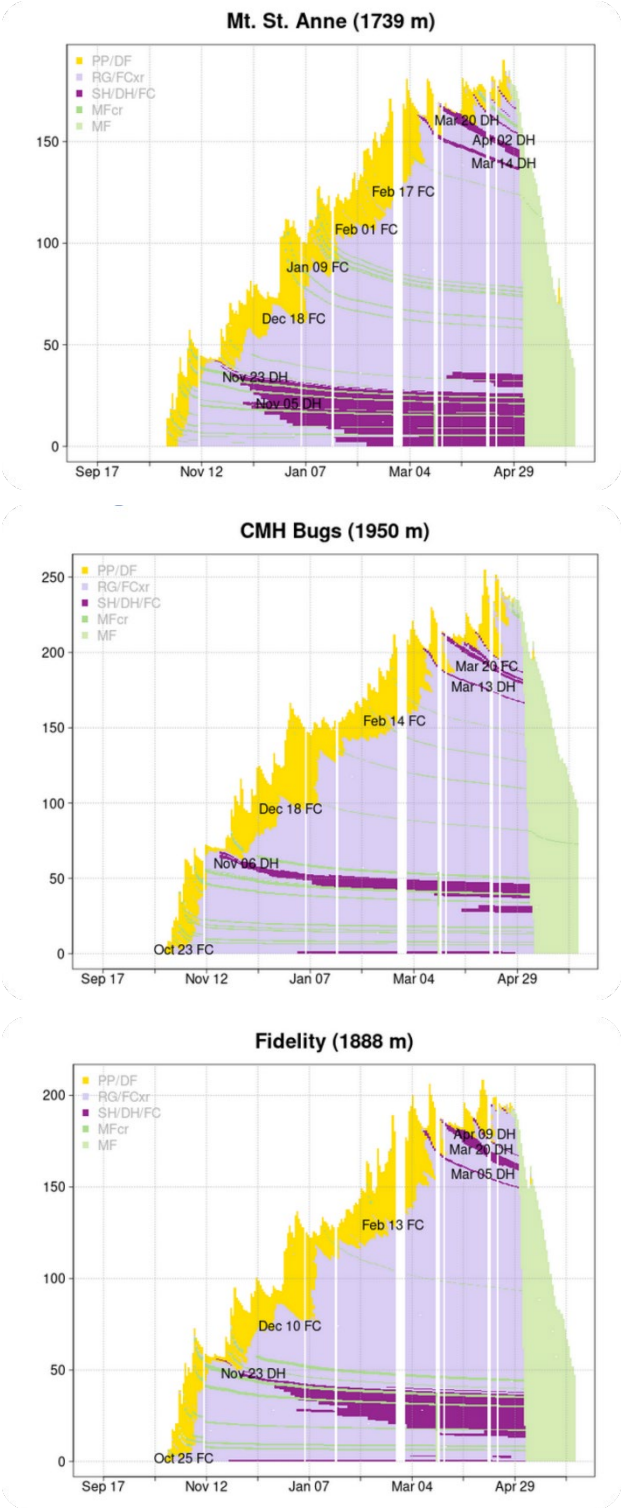

Figure 2-1: Modelled snow cover data from three locations in the Columbia Mountain range in British Columbia showing weak faceted crystals (dark purple) near the base of the snowpack – Mt. St. Anne, CMH Bugaboos, and Mt. Fidelity (Source Avalanche Canada).

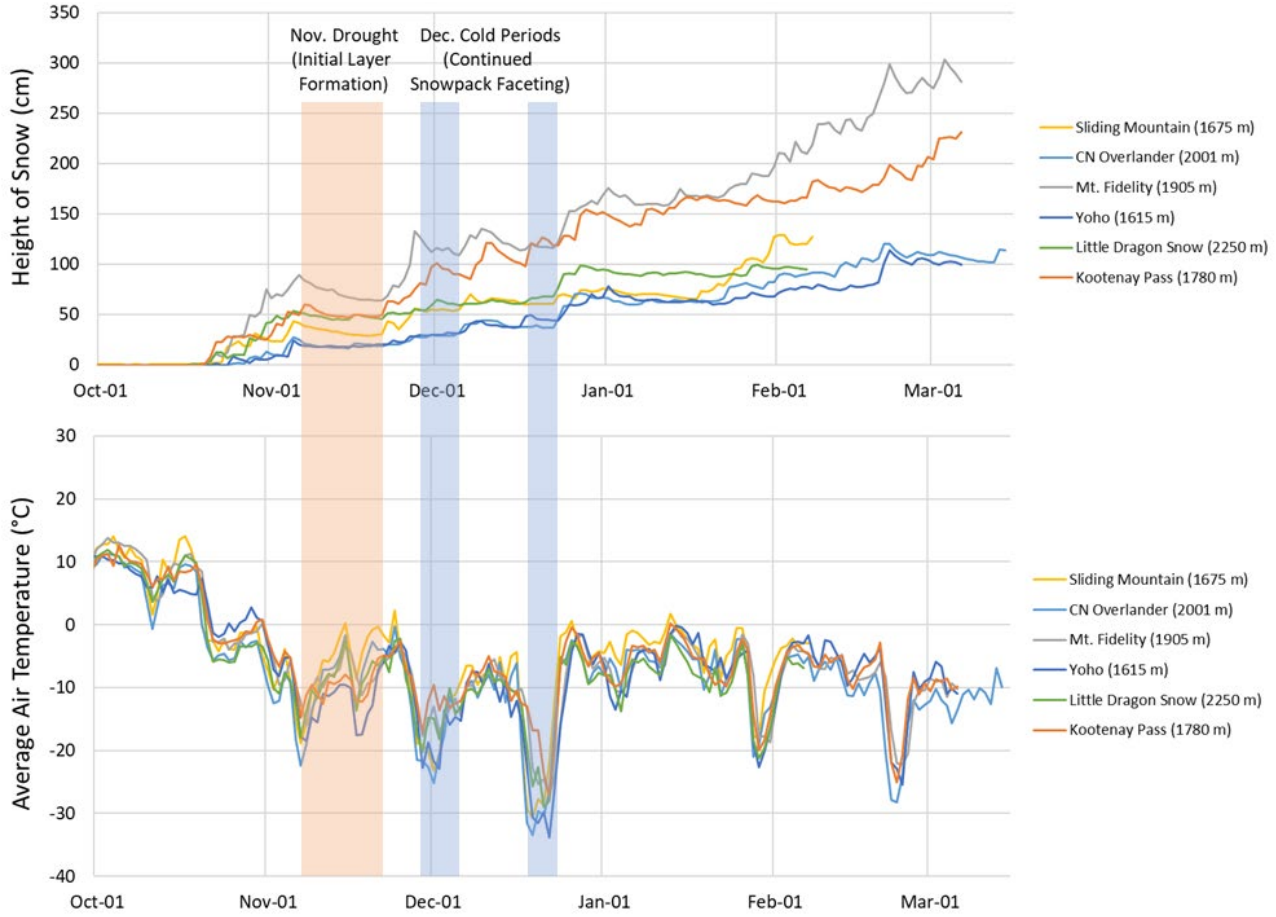

Figure 2-2: Automated weather data from six stations chosen to represent the regional weather patterns in Western Canada for the Rocky and Columbia Mountain ranges – Sliding Mountain, Overlander Mountain, Mt. Fidelity, Yoho, Little Dragon Snow, and Kootenay Pass. The shaded orange area highlights the November low snowfall period, and the shaded blue areas highlight cold temperatures across the region. These conditions led to the formation of a deep persistent slab problem that lingered throughout the winter (source Avalanche Canada).

3. OPERATIONAL RISK MITIGATION TACTICS

In late January CMH initiated specific operational risk mitigation tactics intended to manage the increasing uncertainty and potential consequence of large destructive deep slab avalanches. The specific procedures and strategies discussed below include: 1) magenta run list coding, 2) terrain elimination, 3) increased explosive control. While the actual actions performed when enacting these procedures varied across CMH areas and amongst guiding teams, the main intention of these tactics was to *"ensure that that the ski programs in each area operate with a larger margin of safety concerning hazards presenting in their area"*.

3.1 Magenta run list coding

Magenta run list coding is a terrain selection strategy employed to encourage conservative run selection by slowing down the opening of new terrain. The procedure used during the 2022-23 season followed these steps:

- Any time the guiding team decides to open a run that has been coded Black (uncoded), it will be automatically coded Magenta for 24 hours.
- Any time the guiding team decides to open a run that has been coded Red (closed) for more than seven days or if the closure is due to the presence of a persistent weak layer(s), it will be automatically coded Magenta for 24 hours.
- Magenta runs are not skied that day and the decision to open them is re-visited the following day – i.e. 24 hours later.
- The opening of a run must include a check by a guide to evaluate current hazards.

The procedure ensures that both new terrain and avalanche terrain with persistent slab problems are investigated thoroughly before opening and the decision process to open the terrain is granted additional time.

3.2 *Terrain elimination*

The terrain elimination tactic was utilized to remove potential high consequence terrain susceptible to deep slab avalanches from the run list for the operating season. Eliminating these runs reduced overall exposure to the large deep releases and simplified run lists so that terrain decisions for the guides were consequently simplified. In practice this tactic varied across areas. Some teams tacitly removed runs. That is, experienced guides and guiding teams naturally removed this higher severity terrain through daily discussions and run list coding without explicitly removing runs from the list. Other teams employed a more explicit process where lead guides individually created a list of specific runs to be removed and then met to collaboratively decide on the seasonal closures. Overall, the tactic encouraged guides to reduce terrain susceptible to producing large deep slab avalanches.

3.3 *Explosive use*

Increased explosive use was encouraged to help further reduce uncertainty wherever possible. Explosives are typically used to: 1) test the reactivity of the snowpack, 2) reduce overhead exposure from large slopes and/or cornices, 3) maintain select ski slopes with slab developing over weak layers (e.g. surface hoar).

4. RESULTS

4.1 *Distinct run use*

Both the Magenta run coding and terrain elimination tactics resulted in less terrain being utilized throughout the season by the guiding teams. Figure 4-1 shows the number of distinct runs per year – i.e. unique runs used and not number of skier runs. We observe lower than average runs used during the 2022-23 season, i.e. less overall terrain skied. Note, both the 2020 and 2021 season totals were reduced due to COVID.

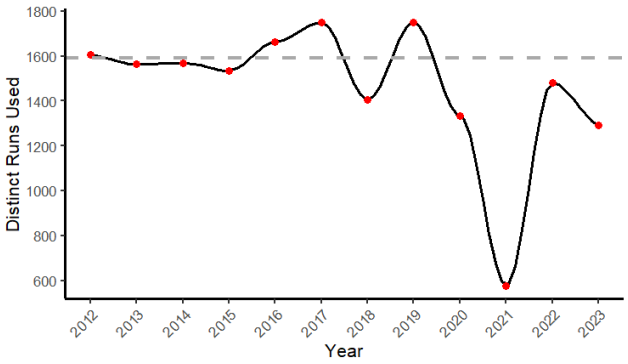

Figure 4-1: Distinct runs (i.e. unique runs regardless of number of times skied) by year shown as red dots with a smoothed trend line (black line) and the mean annual number (grey dashed line).

4.2 *Notable avalanches*

Notables are close calls with guests involved in avalanches, avalanche incidents, or significant anomalous avalanches. Notables are reported, shared, and tracked with the intention of learning, increasing safety, and hopefully reducing the chance of a different guide having an avalanche event due to the same circumstances. Figure 4-2 shows notables per month of operation involving Size 2 or larger avalanches as red dots. The grey dashed line shows the average for all months, the red dashed line shows the average for March, and the black solid line shows a smoothed trend line. We observe a decrease from the average after the specific risk management tactics were initiated in late January of 2022-23. The average for March is larger than other months and likely can be attributed to increased complexity in the avalanche hazard (e.g. cornices are larger, presence of glide cracks, common spotty surface hoar layers, buried sun crusts on solar aspects). Note COVID decreased notables during the 2019-20 and 2020-21 seasons.

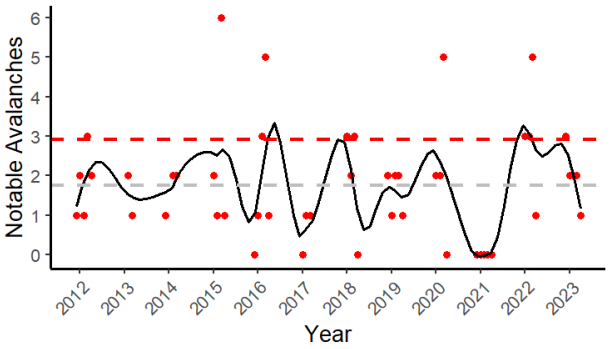

Figure 4-2: Notable avalanches of Size 2 or larger by operational month shown as red dots with a black smoothed trend line. The red dashed line shows the average for March and the grey dashed line shows the average for all months.

4.3 *Increased explosive use*

The 2022-23 season set a record for explosive use by CMH as seen in Figure 4-3. Explosive use has overall been increasing when comparing the average for all years on record (grey dashed line) to the last five years (red dashed line), likely in response to increasing operational programs (i.e. more guests), and evolving explosive and terrain use practices.

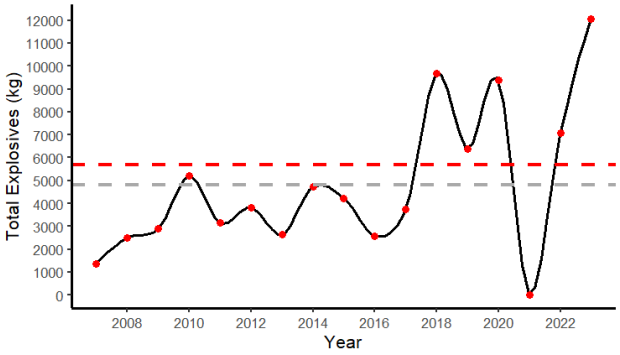

Figure 4-3: Total mass of explosives used by year (red dots) with a black smoothed trend line. The grey dashed line shows average from 2007 to present and the red dashed line shows average for the last five seasons.

5. DISCUSSION

The overall conservative mindset and specific tactics implemented to manage the 2022-23 deep slab problem were effective in adding margins of safety and reducing uncertainty for operational programs. The tactics led to less overall terrain skied, less notable avalanches, and more explosives used.

Although many CMH areas operating in deeper snowpack areas (e.g. Cariboos, Valemount, Monashees, Gothics, Adamants, Revelstoke, Galena, Kootenay) did not observe the anticipated increased deep slab avalanche activity, the uncertainty with how a snowpack comprising of a deep weakness would react was present for the full operating season. Shallower snowpack areas (e.g. Bugaboos, Purcells, parts of Bobbie Burns) did observe increased deep slab activity.

The following discussion explores some of the nuances, unintended consequences, and opportunities for improvement in managing deep slab avalanche problems in future.

5.1 Added operational cost

Increased explosive use and added run investigation increased guide hours and flying time which added to the overall cost of operations. Often two dedicated snow safety guides were used to accomplish the explosive and run investigation objectives. Strategies to efficiently combine explosive objectives with concurrent run investigation were widely employed to maintain fiscal responsibilities.

5.2 Increased terrain use on open runs

The Magenta run coding and increased run investigations slowed the process of opening terrain. A consequence of tactics was that open runs were used more heavily often leading to more terrain on those open runs being skied. Guides had to continually balance reduced ski quality (e.g. skiing tracked terrain, skiing terrain with poor snow quality) with stepping out onto steeper or more hazardous terrain within the open runs.

An example of this was during the warmer spring months. Runs facing solar aspects were closed during the spring warmup to reduce exposure to potential deep slab avalanches. Multiple melt-freeze events stabilized the runs suitable for skiing early in the operational day (i.e. corn skiing), however these runs were closed for longer than seven days and had to be investigated by guides prior to re-opening. Thus, the solar runs were not available, and programs used higher elevation north facing glacier runs extensively leading to increased exposure to crevasse hazard and steeper slopes on those runs.

Additional diligence was required by the guiding teams to ensure the program does not increase overall risk by limiting exposure on open runs.

5.3 Program quality and efficiency

Limiting the variety and quantity of available ski terrain can adversely affect the quality and efficiency of programs. Specific runs are valuable for helicopter ski programs because they are strategically located and connect a sequence of runs efficiently. Efficient connection of runs improves efficiency of flying time, limits waiting time for guests, and can improve the overall ski experience. Therefore, when these strategic runs are not available it challenges the lead guides to meet the guest ski quality expectations while managing flying hours.

5.4 New snow instabilities

Managing new snow instabilities with the Magenta run coding process and increased run investigations is not always practical - particularly for overhead terrain that threatens ski runs. New snow instabilities are often responsive to weather inputs such as increased loading due to snowfall or wind transport, and warming due to ambient temperature increases or solar radiation. Slopes often stabilize rapidly when the higher weather inputs decrease (e.g. strong winds trigger a widespread wind slab avalanche cycle with the released slopes stabilizing rapidly after the avalanche and reduced wind transport). Days with these increase weather inputs are sometimes referred to as “high input days”. Guiding teams should be encouraged to close terrain for new snow instabilities in response to high input days, however guides are reluctant to do this if closures result in the requirement of the run to be investigated and an additional 24 hours of closure. The seven-day procedure was developed to address this situation. Runs can be closed and then re-opened without the Magenta process provided they haven’t been closed for longer than seven days.

6. CONCLUSION

Low early season snowfall and cold temperatures led to the development of a deep persistent slab problem in Western Canda. To manage this unique hazard, CMH initiated specific risk management tactics that includes Magenta run list coding, increased run investigations, and increased explosive use. The overall intention was that ski programs operate with a conservative mindset and additional margins of safety. The tactics resulted in less terrain used, lower notable avalanche events, and increased explosive use.

7. ACKNOWLEDGEMENT

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