COOLING AND AVALANCHES

Penelope H. Goddard *Canadian Avalanche Centre, Revelstoke, BC, Canada

ABSTRACT: Avalanches which occur during periods of cooling are important because they can surprise people, even very experienced practitioners. However, the influence of cooling on avalanche activity has not been well studied and is poorly understood.
A survey of 40 avalanche professionals indicates that avalanches sometimes occur when the snow surface is cooling from above-freezing to below-freezing, often leading to unexpected and very large slab failures. Around 360 avalanches were reported from New Zealand, North America, Europe, Asia and Antarctica when snow surface temperatures dropped from 0° C to below 0° C. An avalanche of this type is termed a 'Cool-Down Avalanche' (CDA). This dataset, which spans the years 1960-2010, has been analysed to illustrate common snowpack and meteorological characteristics during CDA activity.
The survey revealed that avalanches also occur during times of rapid cooling within an overall colder temperature regime, without a clear melt-freeze process at the snow surface. Case studies from western Canada during the 2010-2011 winter give examples of avalanches which occurred under such a regime. Challenges for forecasting cooling-related avalanches are discussed.

1. INTRODUCTION

Personal observations and anecdotal evidence suggest that avalanches sometimes release at times of rapid air temperature cooling, when no other mechanism for triggering is apparent. Avalanche release during cooling periods is mentioned in some studies, mainly in relation to glide avalanches (McClung and Schaerer, 2006; Stimberis and Rubin, 2004; Clark and McClung, 1999; Lackinger, 1987). However, current literature does not demonstrate a conclusive understanding of these types of events such that avalanche forecasters can accurately predict them.

A formal survey and informal discussions with avalanche professionals revealed a wide range of experiences and awareness of cooling-related avalanches. At one extreme, a highways forecaster, who has experienced hundreds of cooling-related avalanches, systematically closes the road at the time of day when rapid cooling occurs, to allow a natural avalanche cycle to run. Two seasoned highways forecasters on opposite sides of the world believe that 'surprise' size D4 and D5 avalanches were attributable to rapid cooling. At the other end of the spectrum are numerous experienced avalanche professionals who do not believe that avalanches occur at times of rapid cooling. These people routinely expand access into avalanche terrain at the time of rapid cooling, because of their belief that rapid cooling always greatly enhances stability.

* *Corresponding author address:*
Penelope H. Goddard, Canadian Avalanche Centre, Box 2759, 110 MacKensie Ave, Revelstoke, BC V0E 2S0, Canada; tel 250-837-2141; email pgoddard@avalanche.ca

The purpose of this study is to collate evidence of cooling-related avalanches and highlight common characteristics between events. Challenges for forecasting are also discussed.

The results of this study suggest that large, surprising avalanches sometimes occur during periods of rapid air and snow surface cooling, often surprising very experienced practitioners, both when the surface is changing from melt to freeze, and at overall colder temperatures.

2. METHODS

There are two parts to this study. In Part 1, 40 avalanche professionals answered a questionnaire about their experiences with avalanches which occur during periods of snow surface cooling from 0 °C to below 0 °C. This particular type of avalanche is termed a "Cool-

Down Avalanche" (CDA). The results of the questionnaire have been compiled to draw out common variables during CDA events.

In Part 2, case studies of cooling-related avalanches from western Canada during the 2010-2011 season are presented. These occurred at an overall colder (sub-0 °C) temperature regime, without a clear melt-freeze process at the surface.

3. RESULTS

3.1. Part 1: The CDA survey

- In order of descending quantity, observations came from New Zealand, North America, Europe, Asia and Antarctica.
- 15 of the 40 respondents had never experienced a CDA. (Many more people elected not to answer the questionnaire at all, due to having never experienced a CDA).
- About 360 CDAs were observed (this number is approximate, as the bulk of observations were poorly recorded, based instead on observers' memories). The observations span the years 1960-2010.
- 98% of observed CDAs were described as slab avalanches; 2% as loose.
- The bulk of the observed avalanches were size D2-D3. 14 were size D4 and 3 were size D5.
- 61% were described as 'glide' releases.
- 20 CDA events occurred within 15-60 minutes of the sun leaving the slope. A further 7 occurred less than 15 minutes after the sun left the slope. Several respondents time active and passive control measures to coincide with these periods.
- 21% of respondents had experienced a close call involving a CDA. These included large avalanches hitting an open highway, burying a ski lift in an area which was open to staff and fully burying people in guided groups.
- 38% of respondents factor CDAs into their decision-making while managing the exposure of people and infrastructure to avalanches. 44% said they do not.
- 7 people who had never had a close call involving a CDA factor the possibility of CDAs into their decision-making. Interestingly, 3 people do not factor CDAs into their decision-making, in spite of having had a close call involving a CDA (including involvement in fatal incidents).

The following comments made by respondents help address some of the reasons why CDAs are rarely factored into operational forecasting:

- "[This is] much too speculative a theory to apply in an operational forecast".
- "I see 'cool-down' as the more stable end of the curve".
- "I don't factor CDAs into management due to a lack of understanding and observations".
- "I don't factor CDAs in, as they seem very rare events".
- "I don't factor CDAs in, as there's no knowledge base, therefore they are hard to estimate".
- "The funny thing is, I probably still guide and operate considering cooling down as a good tick for stability".

3.2 A CDA Case Study

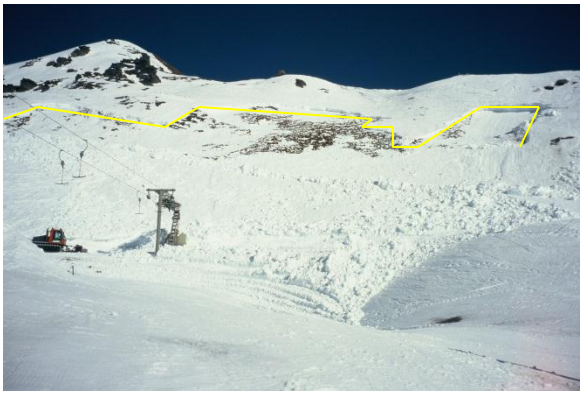

Figure 1. Treble Cone Ski Area, Wanaka, New Zealand. Saddle Basin was closed during the day due to creep and glide concerns. At 5pm the surface was starting to refreeze, so the forecaster gave the OK for groomer operators to go into the basin to work. The avalanche occurred some time during the night, failing on depth hoar at ground. It damaged the lift bull wheel. Photo: Dean Staples



Figure 2. A ski patroller at the crown wall of the Treble Cone avalanche. Hard refrozen snow jutted out like a diving board above soft, moist snow below. Other similarly shaped crown walls were reported from various CDA events. Photo: Dean Staples

3.3 Part 2: Events from western Canada during the 2010-2011 season

The following images show a succession of large avalanches which occurred during periods of rapid cooling in western Canada. Operators described these events as very surprising, eye-opening, historic and unusual. The rough location of the fracture lines has been drawn in.



Figure 3. Monashee Powder Snowcats, Monashees, Overnight 8/9 Jan, 2011. Overnight there was no appreciable new snow, no sign of wind, skies were clear most of the night, and temperatures dropped from -8.5° C to -15° C by morning. It was a size D4 step-down slab, with very wide propagation. The trigger was a small cornice or small slope above. The lead forecaster said “I’m busy rethinking my assumptions/intuition”. (The guides were considering expanding their scope of terrain use that day). Photo: Fiona Coupland





Figures 4 and 5. Kicking Horse Mountain Resort backcountry, Selkirks, overnight 17/18 Jan, 2011. These paths did not avalanche during the preceding prolonged warm storm. They occurred during rapid cooling and strong winds. The air temperature dropped overnight from -5.6° C to -16.4° C at the ski resort’s nearby weather station. Photos: Nicholas Rapaich

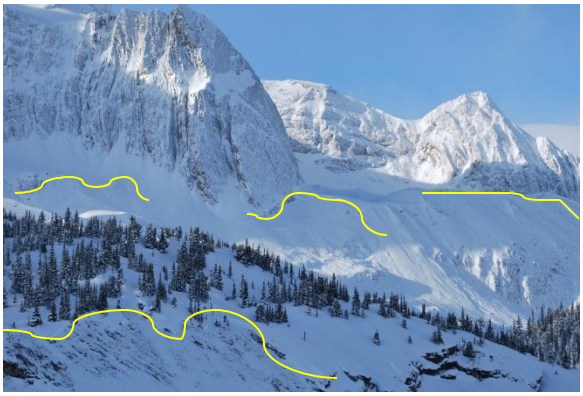

Figure 6. Mistaya Lodge, western Rockies. Overnight 17/18 Jan, 2011. These failed after a storm ended which had deposited 1 m+ snow. There was overnight air temperature cooling from -3° C to -13° C and wind (however, many of the slopes which avalanched were not lee to the wind). More than 20 avalanches released, size D1 to D3.5 (many D2-2.5) with crowns 100-150 cm; some up to 200 cm deep. Several avalanches were observed in unusual locations. They failed on an early-season persistent weak layer. Photo: Dave Birnie



Figure 7. Lanark path, Rogers Pass, 8am, 18 Jan, 2011. The avalanche was size D4.5 and damaged 10 acres of forest. It failed on facets/crust at ground. The air temperature dropped from -3° C to -17° C overnight prior to the event. The avalanche cycle was considered to be over. It failed near the time that sun first hit the slope. Photo: BC Ministry of Transportation – Avalanche and Weather Programs

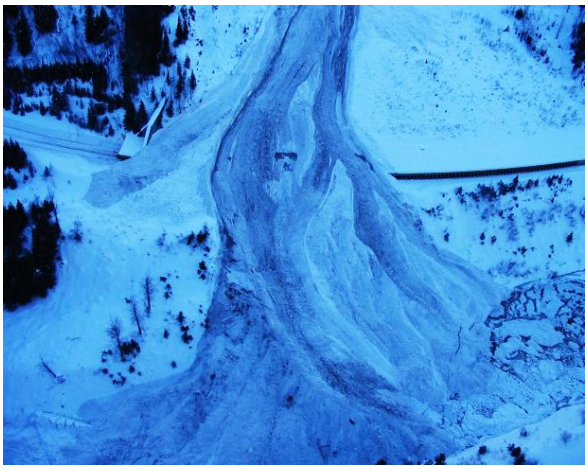

Figure 8. Lanark path runout. Photo: BC Ministry of Transportation – Avalanche and Weather Programs



Figure 9. Castor Peak, Glacier National Park, 8am, 18 Jan, 2011. Under the same weather conditions affecting the Lanark Path, this widely-propagating avalanche occurred. A second, historic avalanche occurred around the same time on nearby Crawford Peak, destroying mature timber in the runout. The surprising nature of the events observed on 18 Jan led to the Canadian Avalanche Centre issuing a warning message to operators: “Notable avalanche activity: We have received a couple of reports of large, unusual avalanches that occurred this morning as the temperatures were cooling…”.
Photo: Kevin Boekholt



Figure 10. Hilda Peak, Valkyr Range, 20 Jan, 2011. This size D4 avalanche was an isolated event which occurred post-cooling. There were no other large natural avalanches during the cycle. It destroyed mature forest.
Photo: Ryan Glasheen

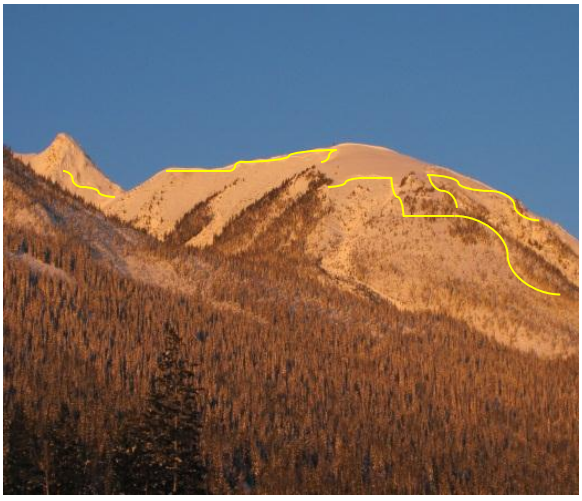

Figure 11. Dogtooth Range, Selkirks, overnight 7/8 Feb, 2011. There had been no avalanche activity during marked warming on 7 Feb. Overnight, the air temperature dropped from -10° C to -17° C and these and other large slabs released. Photo: Thomas Exner

4. CONCLUSIONS

4.1 Part 1 Conclusions

- CDAs were observed around the world.
- Accidents and near-misses have occurred when operators have re-opened previously closed terrain assuming that cooling means dramatically improved stability.
- Some operators actively manage the CDA hazard through closures or explosives control, which are timed to coincide with rapid cooling or surface refreezing.
- They were rarely observed overall – many experienced practitioners have never experienced a CDA.
- There's a feeling that they are too difficult to predict, so there's a tendency to ignore them when making decisions.

4.2 Part 2 Conclusions

The following were common factors in the events shown in Part 2:

- Heavy storm loading occurred prior to the event.
- All but one failed on a persistent weak layer.
- Rapid air temperature cooling occurred, often of around 7-10° C overnight.
- They were mostly very large events with wide propagation.
- In every case, experienced locals were surprised by the events.

4.3 Challenges for forecasting: attitudes and conventional wisdom

There remains a limited understanding of the mechanisms behind avalanche release during times of rapid cooling. However, it seems clear that avalanches sometimes do occur under these conditions, often conflicting with conventional wisdom. For many professionals, avalanche forecasting and terrain management techniques rely on the premise that cooling always promotes stability. However, unexpected and often very large avalanches suggest this logic may sometimes be flawed.

Perhaps this type of event will move from the realm of myth into forecasters' consciousness as better recording and analysis of these events evolve. The scope for further study of this topic is immense.

ACKNOWLEDGEMENTS

Thanks to the following for their contribution: Bill Atkinson, Mark Austin-Cheval, Ried Bahnson, BC Ministry of Transportation – Avalanche and Weather Programs, Canadian Avalanche Centre, Peter Bilous, Dave Birnie, Stewart Blennerhassett, Kevin Boekholt, Jay Bristow, Wayne Carran, Howard Conway, Rosco Davies, Jef Desbecker, Thomas Exner, Ryan Glasheen, David Hamre, John Hooker, Andy Hoyle, Damian Jackson, Dan Kennedy, Karl Klassen, Mark Klassen, Brett Kobernik, Gary Kuehn, Chris Landry, John Mletschnig, Jane Morris, Shaun Norman, Tom O'Donnell, , Christine Pielmeier, Tarn Pilkington, Nicholas Rapaich, Tim Robertson, Davie Robinson, Mike Rubenstein, Mark Sanderson, Mark Sedon, Ron Simenhois, Jim Spencer, Dean Staples, John Stimberis, Frank Techel, Craig Wilbour and Henry Worsp.

REFERENCES

McClung, D.M. and P.A. Schaerer. 2006. *The Avalanche Handbook. 3rd Ed*., Seattle, WA, The Mountaineers, p.102.

Stimberis, J and C. Rubin, 2004. Glide avalanche detection on a smooth rock slope, Snoqualmie pass, Washington, Proc. Int'l. Snow Science Wksp. 2004

Clark, J. and D.M. McClung. 1999. Full-depth avalanche occurrences caused by snow gliding, Coquihalla, British Columbia, Canada. Journal of Glaciology, 45(150), 539-546.

Lackinger, B. 1987. Stability and fracture of the snow pack for glide avalanches. International Association of Hydrological Sciences Publication 162 (Symposium at Davos 1986 – Avalanche Formation, Movement and Effects, 229-240.