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Interior Range Snowpack Status Report

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Introduction

The snowpack in the Interior ranges is starting to evolve into a situation that looks as though it may cause us long-term concern. As in the previous three winters, we have a weak, shallow snowpack and persistent weak layers. We know from our historical records that this combination tends to lead to dangerous and unpredictable conditions that are difficult for recreational users to manage.

This paper is designed to summarize the situation in the snowpack to date and provide some initial thoughts as to how the current situation may play out. It is intended to augment CAC avalanche bulletins and provide more in-depth information on the location and condition of weak layers within the Columbia Mountains. It also provides several scenarios for how the situation may play out as we enter a transitional period in terms of snowpack stability.

This discussion is intended for recreational backcountry users. Avalanche professionals have in place advanced procedures and guidelines for assessing conditions and managing risk at their individual operations.

The CAC forecast regions this discussion applies to are: North Columbia, South Columbia, Kootenay Boundary, North Rockies and South Rockies regions. Users in other regions may find this information useful, but it is up to you to determine whether the snowpack and conditions in your area resemble the situation described in this paper.

Record low early-season snowpack

A strong La Niña southern oscillation pattern has heavily influenced the regional weather patterns in BC during late 2010 and into early 2011. La Niña winters are associated with a cooling of Equatorial Pacific waters. The effect of this is the Jet Stream has been displaced south from its usual track. As a result, most of the high intensity winter storms have been directed south of the border into the USA, and the interior of BC has stayed unusually dry and cold.

As of January 4, snowpack depths were at or near record low for most areas of the North Columbia, South Columbia and North Rockies regions. For the Kootenay Boundary and South Rockies regions, snow depths were not quite at record low levels but are still within the shallowest quartile.

Temperatures have been consistently cold in the interior regions through most of the season. There have been multiple arctic outbreaks: mid-Nov, early Dec, mid-Dec, around New Year, and another one on the horizon for early to mid-Jan that looks in all likelihood as though it will set up deep and cold.

We know from historical avalanche records that years characterized by low snowfall, especially those accompanied by an early season rain crust, tend to be more dangerous and often difficult for recreationists to manage. The devastating season of 2002-2003 when 29 people were killed in avalanches, the season of 2008-2009 involving the Harvey Pass incident and the season of 2009-2010 involving the Boulder Mountain incident all played out during incremental loading patterns associated with low snowfall years.

Snowpack structure

The following layers provide a brief chronological sequence of the major weak interfaces in the snowpack for the Interior of BC. Regional variations are discussed in Table 1 in the Appendix.

- A significant rain crust was laid down in early November, with a widespread distribution.
- A surface hoar layer was buried on or around Dec 7. This layer is also associated with a thin crust and facets.
- A crust formed during a short-lived period of warming on or around Dec 14. This layer is associated with facets above and/or below this layer.
- A surface hoar layer was buried on or around Boxing Day (Dec 26). On south-facing aspects, this layer is a sun crust.
- A weak layer comprising surface hoar, surface facets and large stellar crystals was buried on or around Jan 3.

We know from experience and research that the biggest factors promoting the healing of weak layers are load, time and a consistent temperature throughout the depth of the snowpack. The shallow snowpack means there is relatively little load. We are still fairly early in the season, so time is not necessarily on our side. Air and snowpack temperatures have been generally cold, which has set up large temperature gradients in the snowpack. All these factors point to a fundamentally weak foundation to the snowpack. If you build a house with a weak, crumbly foundation, the upper storeys will have a tendency to fall down if you build them up too high. In the same way, a fundamentally weak snowpack will not do a good job of supporting subsequent storm loading.

Since the cold temperatures and light loads have not promoted healing of the snowpack, most of the weak interfaces within the snowpack remain a concern. This is particularly pertinent in shallow areas, where faceting will have enhanced the weakness of the snowpack.

Step-down avalanches

When you get several persistent weak layers stacked on top of each other, it dramatically increases the chance of a step-down avalanche. This type of avalanche initiates on one of the upper layers, which is usually, but not always, the uppermost layer. The initial avalanche causes a significant disturbance, which exerts a force on deeper weak layers within the snowpack. If this force exceeds the strength of the deeper weak layers, a failure will occur on this layer as well, and the avalanche "steps down" to this lower failure plane.

Step-down avalanches are large and dangerous, due to the sheer amount of snow involved with these deep releases. There is a strong relation between the depth of an avalanche and its lateral dimensions, both width and length. Basically, if the avalanche steps down to lower layers, it is also likely to be wider and run further. If you are caught in a large avalanche involving a basal weak layer such as the early November rain crust, your chances of survival will be low. You will most likely be subjected to extreme turbulence and trauma as you are tossed around in the flow of the avalanche. As the avalanche comes to a rest, there is a strong chance of a deep burial due to the amount of snow involved. If terrain traps such as benches, gullies, depressions or road cuts are involved, the chance of a deep burial increase even more. If cliffs or trees are involved, the chances of suffering direct trauma are increased.

Long-range weather forecast

Long-range weather forecasting is fraught with uncertainty. In particular, it is almost impossible to pinpoint the specific timing of storms or associate accurate precipitation amounts to them. However, broad scale trends often show up quite well, particularly for strong, stable weather patterns, such as the one we are likely entering. Here is the current best estimate of the likely weather patterns for the next 10 days or so.

A stormy period starting January 4 more or less ends by January 8. There is much uncertainty regarding the timing, track, and intensity of these storm systems during Jan 6 – 8. Then cold, dry, arctic conditions descend on the whole province for the foreseeable future.

At some point, the arctic air mass will move away and storms will once again bring precipitation to the region. It is impossible to say at this time whether these storms will be intense and sustained, or whether they will be weak and sporadic, resulting in a slow, incremental accumulation of snow. It is also impossible to predict at this time whether the storms will be warm or cold. Given the prevalence of the arctic air mass this season and the strong La Niña conditions in equatorial Pacific waters, my best guess is that storms following the arctic outbreak will be cold and relatively weak. However, this is definitely in the realm of best guess. Below, several possible scenarios are considered.

Scenarios

Initial rapid loading scenario

- Rapid loading from the current storm cycle (Jan 3 to Jan 7) causes widespread failure of the snowpack.
- A widespread natural avalanche cycle occurs.
- Most avalanches initiate on the uppermost weak layer; a large number of releases step down to lower weak layers.
- Lower weaknesses initially dealt with. Probability of triggering a deep slab avalanche decreases immediately following the storm.
- Many shallow bed surfaces are created, where avalanches ran during the major avalanche cycle. These shallow areas experience significant faceting during the likely prolonged arctic outbreak.
- As subsequent storms build up sufficient load, old bed surfaces, as well as other shallow snowpack areas, become the focus for new avalanche activity.
- In the long term, this scenario could give a reasonable outcome, since many of the instabilities in the snowpack will have been cleaned out and the reloaded bed surfaces will be relatively thin, likely suppressing the magnitude of subsequent avalanche releases.

Incremental loading scenario

- Storm snow amounts do not create a widespread natural cycle between Jan 3 and Jan 8.
- Many areas become primed in an unstable state waiting for a trigger (such as a skier or snowmobiler).
- Slab releases are initially small and relatively common.
- The arctic air mass breaks down relatively quickly and new storms bring light to moderate snowfall amounts in successive incremental amounts.
- Slab releases become progressively harder to trigger but more dangerous and destructive when they do release.
- Due to the persistent nature of the weak layers, there is long term, lingering uncertainty about the deep weak layers.

Delayed incremental loading scenario

- Storm snow amounts do not create a widespread natural cycle.
- Relatively small, natural and human triggered avalanches release on the Jan 3 weak layer and in general do not step down to lower weak layers.
- An arctic outbreak sets up a significant new weak layer on the surface some time around mid to late January.
- Weak, sporadic storms incrementally load this weak layer. The snowpack is now poised with two significant upper weak layers as well as mid weak layers and in many places a weak basal crust.
- This scenario is potentially very dangerous, resulting in unpredictable, low probability but high magnitude avalanches.

Delayed rapid loading scenario

- Initial storm snow amounts do not create a widespread natural cycle.
- Relatively small, natural and human triggered avalanches release on the Jan 3 weak layer and in general do not step down to lower weak layers.
- An arctic outbreak sets up a significant new weak layer on the surface some time around mid to late January.
- Intense storms overload the newly formed weak layer causing a widespread natural avalanche cycle which also releases lower weak layers.
- Potential for surprise, as this situation could set up quite rapidly following the break-down of the arctic air mass given the right weather systems. In the long term, slightly better, since many avalanche paths are cleaned out.

Rain event scenario

- A warm, moist storm following the arctic outbreak brings significant precipitation in the form of rain.
- A spectacular, highly destructive avalanche event occurs. For a short period, danger becomes extreme.
- Previous lower instabilities dealt with for the season.
- Focus of new instabilities is bed surfaces and the interface between the resulting rain crust and new snow interfaces.

Please bear in mind that the scenarios presented in this paper are meant as a discussion of potential outcomes rather than a prescriptive recipe of what will happen through the rest of the season. Snowpack structure is highly complex and responds to a wide variety of factors. Different areas may experience different scenarios, or the end result could be a hybrid of two or more of the above scenarios. For updated current conditions, always check the most recent avalanche bulletins at avalanche.ca/bulletins/latest.

I welcome feedback on this paper: this can be sent to jfloyer@avalanche.ca. Specific information pertaining to conditions or reports of avalanche activity can be sent to forecaster@avalanche.ca. If you or a member of your party is involved in an avalanche, please help us by submitting an avalanche incident report online at: avalanche.ca/bulletins/incident-reports/submit.

Appendix: Weak layer regional summary

Table 1. Regional summary of major snowpack weak layers in the Interior snowpack

Weak Layer	Areas	Influence on stability
Early Nov Rain Crust	Particular concern for: • Dogtooth range, N. Purcells • Re-loaded bed surfaces in all regions • Areas where the crust was a little higher when it originally formed. • Smooth, steep faces. Parcells: This is where we have seen the most activity on this layer, especially during a period of reverse loading, where north winds loaded snow onto shallower, faceted aspects. S. Monashees: The crust exists at all elevations but so far has been largely unreactive except for areas in the SW of the region. S. Selkirks: crust prevalent and exists into alpine. Early season releases were notable from steep glacial terrain. N. Monashees and Cariboos: The crust exists but is spotty with variable distribution, both between drainages and by aspect within drainages. N. Rockies: Field information lacking, but I suspect that the crust is not very prevalent. Depth hoar formation at the base of a shallow snowpack could cause a similar type of concern. Kootenay Boundary: Crust exists at all elevations. So far has not been a strong performer. Shallow snowpacks and very strong temperature gradients mean this layer is definitely a strong concern in this region. South Rockies: Good performer in the Lizard range and spotty performer in the Crowsnest/Elk Valley. In eastern areas, crust may have become rotten, but that does not necessarily improve things.	In shallow areas, this layer will likely persist throughout the season. In some places it is directly triggerable. This layer is a very significant concern for step-down, high magnitude avalanches.

Dec 7 Surface hoar / Sun Crust	All areas, TL and ALP. Considered just a sun crust problem in many areas. Most skier-triggered activity has been on southern aspects. On northern aspects, the surface hoar can still be found but is decomposing. Still getting consistent sudden, "pop" results on this layer.	Significant weak layer, still of concern. Likely to be difficult to trigger, but could aid in the step-down process producing large avalanches.
Dec 14 Rain Crust	South Rockies, especially Lizard Range, where it was reported as 5-20cm thick below 1700m and 1-3cm thick between 1700-1900m. Parts of the Kootenay Boundary range South end of South Columbia range	Could be a concern for lower elevation areas within the southern regions. Likely not a widespread concern.
Dec 18 Surface Hoar	Mostly N. and S. Columbias. Not very prevalent layer, mostly around treeline. Mot much activity reported.	Could aid step-down at lower elevations.
Dec 26 Crust /Surface Hoar	Mostly S. Selkirks down into Boundary region and Monashees. Mostly around treeline but into alpine in some locations. Sun crust into alpine. Some activity on this layer.	Likely to stabilize in the long term with more load. In the medium term, could aid step-down avalanches.
Jan 3 Surface Hoar	Still gathering data on this layer, but likely a very widespread layer of concern. Comprises SH to 5-10mm, facets and large stellar crystals (to 5mm).	Watch this space. Has all the hallmarks of a particularly reactive weak layer. Likely reactive to relatively light loads. Soft sub-surface may temper reactivity slightly.

Please note: Weak layers are commonly referred to by their date of burial. The dates of weak layers are approximate and reflect the most common naming conventions given for the whole interior region. Due to variations in weather patterns, the date of burial in your local area and hence the local weak layer name may vary by 1-2 days from those given above.