

HOT-SPOTS AND HOT-TIMES: EXPLORING ALTERNATIVES TO PUBLIC AVALANCHE FORECASTS  
IN CANADA'S DATA SPARSE NORTHERN ROCKIES REGION.  
INTERNATIONAL SNOW SCIENCE WORKSHOP 2014 IN BANFF, AB

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**ABSTRACT:** Over the past six winters the Canadian Avalanche Centre's (CAC) North Rockies Region accounted for 10% of British Columbia avalanche fatalities. The North Rockies is a large region with a complex continental snowpack, and few avalanche safety operations generating professional quality field-data. Mountain snowmobilers constitute the primary user group, fuelled largely by a booming energy resource industry. User engagement identified a significant desire for full-service avalanche forecast products. However, challenges with remoteness, driving distances, lack of snowpack and weather observations, and limited funding make delivery of avalanche forecasts in this region unrealistic. Additionally, we question the effectiveness of standard avalanche forecasts delivering *regional summaries* to this user group. We present an alternative vision for delivering useful avalanche information. The proposed strategy concentrates on geographic hot-spots to provide *localized information*, and hot-times to benefit the greatest number of people accessing avalanche terrain. Products under development include: web-resources that combine general trip-planning tools with succinct avalanche safety messaging embedded, using the CAC's Avaluator 2.0 decision-support tool to summarize forecast local conditions, and providing modelled snowpack structure information highlighting critical avalanche layers. Through delivery of targeted, locally relevant information in conjunction with outreach and education we hope to better engage backcountry users and improve public avalanche safety in this region. The North Rockies is one example of a more general problem, namely, data-sparse regions. Because the challenges are not unique, solutions proposed for the North Rockies are likely to prove valuable in other CAC regions (e.g. North Shore, Northwest Inland, South Rockies) and throughout Canada (e.g. Yukon, Newfoundland, Labrador & Nunavut).

**KEYWORDS:** forecasting, data sparse, remote, public safety

## 1. INTRODUCTION

The CAC's North Rockies region encompasses 45,164 square km (about the size of Nova Scotia) north of Highway 16 and Wilmore Wilderness Park and south of the Peace Reach of Williston Lake, between Highways 97 and 39 on the west and Chetwynd, Tumbler Ridge, and Grande Cache on the east (see map in Appendix A). The majority of the area is in British Columbia but a small segment in the southeast lies in Alberta (Fig. 1).

The majority of recreational users are local and visiting snowmobilers. Some recreational backcountry skiers utilize the area primarily around Pine Pass, along the southern boundary, and around the middle of the eastern boundary. A few commercial recreation operations exist, notably: a

Ski Resort at Pine Pass, a ski touring operation in the Dezaiko Range, two heli-skiing tenures in the southern part of the region along Highway 16, and several snowmobile clubs that operate trail grooming.



Fig. 1: The North Rockies region.

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Numerous resource extraction industries operate in the North Rockies including mining, oil, gas and forestry. Most winter transportation corridors are on the periphery of the region. Of those that tran-

sect the mountains, there are minimal avalanche problems on highways. The CN rail line is exposed to avalanche terrain and employs a contractor to monitor conditions and mitigate avalanche risk when required.

There are a number of provincial parks, recreation sites, wilderness and protected areas within the region. These see varying levels of winter use from essentially none to very intensive.

Currently, the CAC provides a weekly avalanche report. Issued on Thursdays, this current conditions summary provides information on weather, snowpack, and avalanche occurrences (as best as can be determined). Additionally, some general terrain and travel advice is provided. In the fall of 2012 the CAC received funding and in-kind support to run a pilot project in the North Rockies of BC. The intention of this project was to lay the groundwork for improved public avalanche safety programs and services in this region.

## 2. OPERATIONAL DISCOVERIES

### 2.1 *User Profile*

The North Rockies has a diverse set of users in terms of avalanche training, experience, and risk-tolerance. While pockets of well-informed and aware users exist, the majority of users are relatively unaware of avalanche hazards and many don't see value in avalanche training or developing avalanche safety skills. One specific interest in the North Rockies is the prevalence of generally young males working in resource extraction industries with significant disposable income. This is a hard to reach and somewhat risk-hardened cohort with a relatively low rate of formal avalanche education. If this region was provided with an avalanche forecast, a significant proportion of the users do not have the training or knowledge to use it effectively. Avalanche awareness and avalanche risk culture lags behind most of western Canada.

### 2.2 *Climate*

In general terms, the avalanche climate of the North Rockies is Continental. As Tremper (2008) describes, "Temperatures are cold (-30 to -10 Celsius). Storms occur less often and deposit relatively smaller amounts of low-density snow. Common weak layers include faceted snow, depth hoar and surface hoar – weak layers that are very persistent through time."

Five distinct sub regions have been identified: McGregor, Tumbler, Kakwa, Pine Pass and McBride. It's not uncommon for each of the sub regions to have drainages with deeper snowpacks that more closely resemble an Intermountain avalanche climate. Significant variation, even within the sub-regions means that relying on observations from only one or two sub-regions would not effectively describe regional avalanche problems.

### 2.3 *Operational Challenges*

North Rockies fieldwork requires extensive travel, flexible schedules, and lots of money. A field team operating in the region requires a truck with a sled deck or trailer, two snowmobiles, ski equipment, safety equipment, communication devices, computers, etc. The combined cost of driving, snowmobiling, hotel, meals and wages for a two person team is approximately \$1500 CAD per day.

While some areas are accessed via groomed trails, access in many places is difficult. Accessing the majority of the riding areas requires intermediate/advanced snowmobile handling skills and/or long travel distances on groomed trails. Many areas are not signed and routes are based on local knowledge. As a result the learning curve for field personnel is steep.

Staffing field based programs using locals is challenging, due to the low number of trained professionals in the region. Better regional data coverage could be achieved by including recreational observations.

## 3. OPERATIONAL SUCCESSES

### 3.1 *Outreach and Education*

Outreach and education has been a primary focus of North Rockies operations. Without awareness and knowledge, even the best avalanche safety products and services are ineffective. Users need to be aware there's an avalanche problem, know where to look for training and decision-making support, and understand how to use available products, services, and tools. A concerted effort was made to expand past efforts to include children and youth through school programming and presentations. Formal avalanche safety programs for youth (day time programming in schools) and adults (evening programming) were offered in communities throughout the region.

### 3.2 *Public Field Observations & Data Stream*

A major upgrade to CAC Mobile, the CAC's app for mobile devices, was released in February 2014. This upgrade included the first implementation of a recreational observer network that allows public users to submit basic field observations, and view the observations of others. While designed for peer-to-peer sharing, it presents a new data stream available to CAC Avalanche Forecasters. Development work on this app continues; enhancements available next winter will include the ability to submit and view observations through a web browser which allows for expanded services beyond mobile devices, and share posts through social media. We expect that the ability to submit more detailed observations and seamless integration with social media like Facebook will drive uptake of this exciting new tool dramatically.

### 3.3 *Research into Avalanche Forecasting Support Tools*

The CAC is collaborating with the Applied Snow and Avalanche Research Group, University of Calgary (ASARC) on a forecasting decision support tool. Weather Forecast Models (LAM and GEM) are used to drive the snowcover evolution model SNOWPACK to generate summarized snow profiles highlighting at a glance critical layering for forecasters. Bellair (2013), Schirmer (2014), During the 2013/2014 season in the North Rockies we pursued model validation in the Pine Pass area. Improvements to Northwest Avalanche Solutions remote weather station supported model development by allowing an analysis of differences between weather forecasts and actual weather at this location. Snowpack field data collection supported the analysis of differences between modeled and observed snowpack structure.

This research initiative is well suited for large, remote, data-sparse areas beyond the North Rockies. If successful, it could provide forecasters with information about snowpack structure in general, and the formation and evolution of critical avalanche layers specifically (Fig. 2). Additionally, by supporting a targeted field-data collection strategy, field teams could be deployed less frequently with improved effectiveness and efficiency.

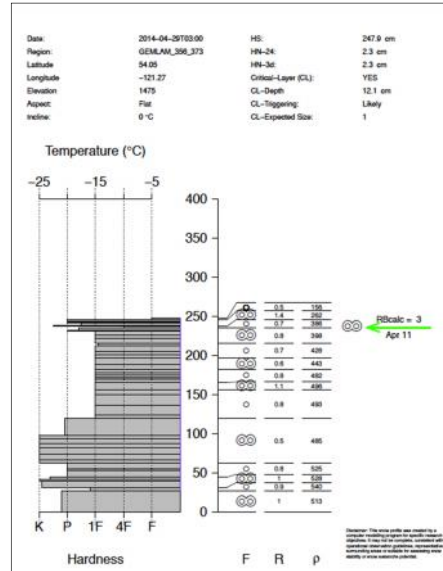


Fig. 2: SNOWPACK generated profile.

## 4. ANALYSIS

The best chance for improving public avalanche safety in the North Rockies is through closely coupling general avalanche education and outreach with tangible products and services. Initial work in the region identified a significant desire for a full-service public avalanche forecast, identical to what the CAC provides in other regions of British Columbia and Alberta. User groups increasingly express frustration and disappointment in the CAC's weekly regional summary of current conditions. CAC field teams report North Rockies recreationists don't feel they benefit from our weekly regional conditions summary; many say they no longer consult it as part of their trip-planning process. We believe user sentiment is primarily based on two factors:

- North Rockies weekly conditions reports are too generic and they are too repetitive week after week
- Users lack the level of skill and understanding required to apply broad regional statements about the past to a specific location in the future.

On its own, even the best regional summary or avalanche forecast is ineffective if users don't understand its content or how to implement the advice provided.

CAC Avalanche Forecasters who regularly prepare the weekly report also express frustration with their perception of the limited value of providing a weekly regional conditions summary. Fore-

caster sentiment is based on the limitations imposed by a paucity of data, including:

- Data Density – available information is not uniformly distributed throughout the large region, it is concentrated from a few accessible and heavily used areas.
- Data Frequency – irregular and sporadic reporting creates significant data gaps and forecasting blind spots
- Data Reliability – accuracy of field observations vary dramatically depending on the observers' skill and training.

Criticisms of current CAC offerings are founded in a valuable kernel of wisdom: together, general education and field-tools<sup>1</sup> function like rungs on a ladder. When both education and decision-aids are available, preferably in multiple forms for various tiers of users, people can ascend the ladder. McCammon (2004)

Alternatives to regional Public Avalanche Forecasts and Conditions Reports are provided in the next section. Options presented strive to be pragmatic in remaining mindful of costs, achievable within the constraints of available data, and perceived as valuable by local users. CAC forecasters and recreational users converge on a similar solution: provide timely, localized information for specific riding areas. There should be a strong correlation between the information users *desire* and what experts believe is *needed*.

A localized approach to avalanche safety information may be more effective if:

- Anchoring content to a specific location makes it less abstract.
- Many users recreate at the local area(s) selected. Confirming a tangible set of expected conditions is less complex than adjusting expectations, based on a general summary statement.
- It is easier to apply adjustments to tangible, localized information (for example “it snows twice as much at location B compared to location A”) compared to applying

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<sup>1</sup> Field tools is used broadly to include **devices** like the CAC's Avaluator 2™ Decision Support Tool, **products** like regional Public Avalanche Forecasts, and **services** such as blog posts. Common to these devices, products, and services is time- or location-sensitivity, tackling field-specific issues, and providing risk-management advice.

a deductive-like process to derive localized information from generalized regional summary statements.

Given the current weekly report's shortcomings, there is little downside risk of replacing it with something less effective. Successes will likely be transferrable to other CAC regions. If we are correct that localized, specific information is beneficial to North Rockies users, the likely outcome is higher user acceptance (and higher use).

## 5. FUTURE WORK: OPPORTUNITIES & RECOMENDATIONS

### 5.1 Hot-Spots: Possible Products for a Different Sort of Region

It's reasonable to assume any future North Rockies initiatives will need to function in an environment of limited resources and capacity. Furthermore, it's unlikely this data-sparse region will transform into one that is data-rich. Finally, the North Rockies will not suddenly become less remote. These are important parameters to account for when considering future programs and services. This section proposes five ideas based on the proposed strategy of providing *localized information*.

**1. Define the North Rockies region based on high use riding areas where the majority of recreational activity occurs.** (Fig. 3) These small geographic areas would create a cluster of small “hot-spots” upon which the CAC can focus data collection, analysis, and safety messaging. This is a fundamentally different approach than drawing a perimeter line around an entire mountainous area and providing summary information that is applicable to the entire geographic area.

Carefully chosen, most users are likely to recreate in or near hot-spots. These users would benefit from safety products that are anchored on their specific areas of interest, and provide information tailored to these locations. Users recreating outside these clusters could very well experience a different set of conditions, possibly following some sort of distance-decay function. In other words, the farther one is from a hot spot, the more likely conditions will be different.<sup>2</sup> This idea needs to be communicated through maps and other means,

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<sup>2</sup> This is a highly simplified “rule of thumb”. Avalanche phenomena don't easily fit distance-decay functions.

but is not terribly problematic.<sup>3</sup> The model is easily scaled by adding or removing locations as resources or recreational activity change. This approach strives to serve the greatest number of users with the limited funding and resources available.

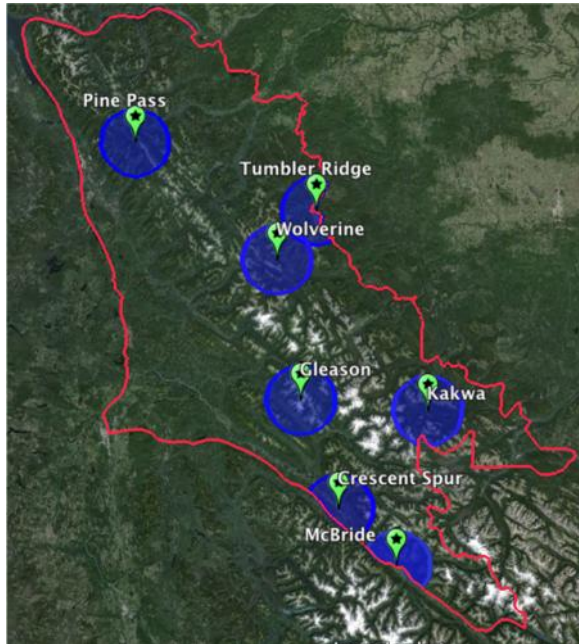


Fig. 3: Potential HotSpot Locations (shown with the existing North Rockies region outline).

**2. Embed avalanche succinct basic avalanche safety messaging in a trip-planning tool.** People need to travel long distances to access riding areas in the region. Therefore they undertake a trip-planning process to make a go or no-go decision. The variables in this calculus are roads (are they open or closed, is the driving fast or slow), weather (will there be visibility to ride when we get there), and local riding conditions (is there fresh powder or only old tracks). A series of automated webpages that merge the best sources of road, weather, and new snow information for specific (localized) riding areas are likely to be a popular, valuable resource for the region. This presents an opportunity to add an avalanche safety section and embed one or two key avalanche safety messages. Although they could be custom messages

<sup>3</sup> . In fact, most CAC avalanche forecast areas have geographically concentrated data sources, popular riding areas, and messaging that focus on these parts of the region; however, this is not necessarily transparent to users of our products.

based on a detailed forecasters analysis, other options include:

- Selecting a canned travel advice message (which are somewhat “evergreen”) based on a cursory analysis of recent weather only. These could be a sub-set of existing AvalX travel statements.
- Statement of pertinent field-observations that would likely help fill a data gap and improve one’s risk management that day. (e.g. direct people to watch temperatures, new snow amounts, wind effect, dig in the snow to look for something, etc.).<sup>3</sup>
- Directing people to a key terrain or snow-pack question on the Avaluator 2.0™, and explaining why it’s particularly important today.
- Providing a single “Avalanche Problem” (e.g. Loose Snow, Wind Slab, Deep Persistent Slab, etc.), consistent with those used in CAC Avalanche Forecasts, together with links to additional information about what the problem is, how it typically is formed, where it’s typically found, and ideas for how to manage it.

Given that messaging is for the location from which the data are sourced, this need not be an onerous or time-consuming endeavour. However messaging needs to be derived from empirical data and grounded in a documented analysis process.

**3. Develop and promote a public observer network (aka crowd-source data stream).** The CAC’s Observer Network was inaugurated this past winter through the CAC Mobile App, and used enough to show its untapped potential.<sup>4</sup> It is important to build enough momentum for the product that it becomes “self-sustainable”. In this context, sustainability means a high enough density and frequency of field observations (preferably from a broad group of public recreationists) that

<sup>4</sup> The Observation Network is a component of the Public Data Stream Project and is receiving major enhancement and de-bugging during summer 2014. New functionality includes web-browser implementation which will broaden its usage beyond mobile devices and provide URLs for specific posts. This, together with additional development work, will allow for integration with popular social media services. One goal is to ensure user uptake reaches some critical mass such that the network is “self-sustaining” in the sense of becoming a “go to place” for avalanche information.

people will regularly visit the site to see what's new, contribute their field-observations, and "tag", "like", or "share" what they find interesting in their social media circles.

#### 4. Tweetcast: use Twitter as a distribution channel for North Rockies avalanche information.



Fig. 4: An example of a Tweetcast with a photo attachment.

Harnessing Twitter effectively will require adopting and promoting a standard hashtag (e.g. #NRavy, #CACNR, #AvyCanNR) that individuals, stakeholders, agencies, and media use and monitor. It will also require CAC forecasters to monitor and regularly feed the hashtag. Therefore it's preferable for the PAWS office to tweet directly rather than indirectly via the Communications Department. Content could vary depending on conditions or the resources (workload) at any given time.

- Use it as a broadcast channel that points to other resources such as a highly relevant public field-observation on CAC Mobile, a recent incident or near-miss, or a pertinent professional blog post
- Provide an Avalanche Forecast in 140 characters, or at least a piece of forecast-like content (e.g. terrain or travel advice,

or alert people to be watchful for some particular current condition, (Fig. 4).

- Close data gaps by prompting users to search out some relevant avalanche parameter in the field. For example if a snowpack evolution model predicts critical avalanche layer development or crossing a critical load thresholds we could help focus people on digging to confirm the layer is present or to pay attention to downed avalanche observations.

#### 5. Make better use of the Avaluator 2.0™ decision support tool. The Avaluator 2.0™ is well placed as a valuable resource in the North Rockies because it helps focus users' field observations, develops users' decision-making skills, and provides tangible localized advice. Specific ideas for how to leverage the Avaluator include:

- Use the CAC blog to publish hypothetical Avaluator analyses. This could take the form of a terrain photo, possibly with an imagined route or decision point added, and a completed Avaluator Slope Evaluation Card. The Slope Evaluation displays what a CAC Forecaster thinks is likely, based on their analysis of available data. This could take both a descriptive and prescriptive approach in that conditions data support the ticking of check-boxes whereas terrain choices are just that – they're choices. Hence the terrain components could be completed in a way that suggests what choices could be made to manage one's risk in that general area (or the specific terrain in the photograph). An example of a somewhat similar blog post and video can be viewed at <http://blogs.avalanche.ca/terrain-is-today-the-day>
- Provide Danger Ratings for specific hot spot(s) locations, without completing the full AvalX analysis process commonly used to create Public Avalanche Forecasts in Canada.
- Develop a technique that allows users with minimal training to approximate the local danger rating. The Avaluator relies on the input of published, professional generated danger ratings. This limits its effectiveness in areas like the North Rockies where Danger Ratings are not provided. Currently the CAC provides general advice on what to do if you are travelling where Danger Ratings are not available. A more

formalized technique would cement the Avaluator's place as a key decision-support tool for people recreating in data-sparse areas throughout Canada.

### 5.2 *Hot-Times: flexible timing for delivery of avalanche safety products*

The CAC has always provided products on a defined schedule for good reason. Users expect timely information that is updated in a predictable way, whether that is daily, weekly, or three times per week. Three ideas are presented for how to introduce flexibility into the timing of updates in ways that meet the needs of users yet improve affordability.

Update information on a regular cadence (e.g. daily, every second day, Monday-Wednesday-Friday, etc.), but focus on a subset of locations, or even a single hot-spot, and rotate through these locations. Potential benefits include:

- A simpler and quicker forecaster analysis.
- Forecasters could focus on areas where current or interesting data is available.
- Forecasters could focus on dynamic areas with changing conditions.
- Encouraging public users to submit their observations through CAC Mobile because they see how their contributions make a difference in terms of "value-added" professionally create products and services.

If resources permit deployment of a CAC field-team, focus and direct their fieldwork using weather station data, public field observations and snowpack evolution modeling of critical avalanche layers. Professional field-team observations can in turn direct the targeting and timing of product updates.

Increase services during previously defined high use periods, namely weekends, long weekends, and holidays (especially Easter and spring break). Despite shift workers likely being a significant user group that aren't confined to this sort of timing, high use periods follow the typical patterns.

## 6. SUMMARY

Over the past several years, especially the last two, the CAC has undertaken reconnaissance work, provided outreach and education events for adults and youth, engaged in strengthening stakeholder relations, solicited corporate sponsorship, improved our understanding of various user

groups frequenting the region, developed our understanding of avalanche climates, and explored popular riding areas. Despite the many accomplishments, opportunities remain to build on this and other foundational work.

The North Rockies are a prime contender to become an incubator for new products and services. There is little downside risk to implementing new ideas in the region in-so-far-as the existing conditions report is of little value to the average North Rockies User. Good communication and relations with local user groups in the area could provide valuable opportunities to measure the effectiveness and success of any new products and services as they are introduced. Avalanche fatality statistics show a real need for public avalanche safety products and services. What we've learned from the past several winters confirms this need, and suggests developing alternative products and services based on a localized approach to avalanche safety information rather than a traditional regional summary.

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