PUBLIC AVALANCHE FORECAST CHALLENGES: CANADA'S LARGE DATA-SPARSE REGIONS

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ABSTRACT: The Canadian Avalanche Centre (CAC) provides regional avalanche forecasts to recreational backcountry users for large areas in western Canada. This programme is unusual in that historically, the CAC does not deploy field teams to make observations or collect data. Data sharing between professional avalanche safety operations, primarily using Canada's InfoEx™ service, provides an engine that supports and powers the CAC's long-standing forecast regions. Responding to increasing need and calls for improved services, the CAC's expanding regional forecast network faces the challenge of providing new services in large, data sparse areas A discussion of commonalities and differences between South Rockies, Bighorn, North Rockies, and Klondike regions highlights some of the strategies used to build local avalanche safety capacity, including collaboration with sponsors and stakeholders to hire field teams. This is a marked departure from our past and some of this winter's lessons, successes and ongoing challenges are discussed. Ideas for future development are outlined, including the development of observer networks, creating support tools to encourage their participation, and providing resources that promote self-sufficiency through leveraging existing decision-tools like the CAC's Avaluator 2.0™ or Online Trip Planner.

1. INTRODUCTION

The Canadian Avalanche Centre (CAC) delivers public avalanche safety products. Geared to the recreational public, the CAC's avalanche safety information and programming includes avalanche awareness and education (e.g. Avalanche Awareness Days, Backcountry Avalanche Workshops, etc.), training (e.g. Avalanche Skills Training program), and the production and distribution of Avalanche Bulletins. Avalanche Bulletins include regional Avalanche Forecasts, Avalanche Information Reports (i.e. current condition information), and Special Public Avalanche Warnings (Kelly et al. 2006). Based on field conditions, the CAC's Public Avalanche Warning Services (PAWS) produces and distributes these time-sensitive, regional bulletins and warnings for large regions for Western Canada from Revelstoke BC.

2. FORECASTING PROCESS

The CAC's data driven avalanche forecasts, information reports, and special warnings follow a traditional analysis using weather, snowpack, and avalanche occurrence data. Analysis of current and forecast conditions is closely coupled with bulletin production using the custom forecasting software AvalX described by Statham et al. (2012). Our programme is unusual in that historically the CAC relied exclusively on data collected by others, primarily other professional avalanche safety operations. Canada's InfoEx™ system allows for the daily exchange of avalanche information between professional operations subscribing to the service and provides an engine that powers the CAC's long-standing forecast regions. This professionally collected and exchanged information is supplemented by a wide range of additional data sources including weather data loggers and amateur field observations.

Our ability to provide timely and credible Avalanche Forecasts and Reports is challenged in data-sparse areas. Compared to our long-standing traditional forecast regions, these areas pose challenges in terms of:

- the density of field observations, both professional-level and amateur.
- the consistency of observations over time, independent of weather, snow conditions, or day of the week.
- the quality of observations in terms of reliability, clarity, or trustworthiness.

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Non-professional observations often require higher levels of evaluation and interpretation.

Addressing the need to deliver public avalanche safety programs and services in data-sparse regions required fundamental changes to the PAWS structure and systems.

3. DATA-SPARSE REGIONS

The CAC works in four "data-sparse" regions: South Rockies, Bighorn, North Rockies and Klondike. Table 1 provides an overview of their characteristics. Common to these areas is a proven or increasing need, as well as call for improved services. Metrics used to assess regional priorities include fatality & incident statistics, recreational use patterns, and local stakeholder support for programme development.

Table 1. Summary of Data-sparse regions characteristics.

Region	Perceived Need	Collaborations	Program Status
South Rockies	• Pattern of fatal accidents & ongoing incidents. • Highly variable & complex snowpack and terrain. • High snowmobile use.	• Corporate sponsorship (Teck Coal) • Non-organized individuals.	• CAC Field Team • Daily Avalanche Forecast
Bighorn	• Historical fatality records.	• Lacking	• Weekly Information Report
North Rockies	• Patern of fatal accidents & ongoing incidents. • Highly variable & complex snowpack & terrain. • High snowmobile use	• Non-organized individuals. • Discussions with provincial government agencies ongoing.	• Weekly Information Report
Klondike	• Intermittent fatal accident & incident history. • User numbers increasing – including skiers, sledders, and kiters. • Scope of activities expanding.	• Yukon Avalanche Association established. • Funding for pilot project secured (National Search & Rescue Secretariat New Initiative Funds grant)	• CAC Field Team • 2 Remote Weather Stations • Weekly Regional Information Report (first season) • Daily Local Conditions Report (when team is in the field)

Additionally, programme development was spurred by the British Columbia Coroner Services Death Review Panel Report recommendation that the CAC pursue "decreasing the size of bulletin regions and increasing the coverage and frequency of forecasts" (BCCS 2009). Differences between regions, both in terms of needs and available resources, suggested no single universal strategy or solution would be successful.

The single biggest change to the CAC PAWS resulting from initiatives in data-sparse regions is to actively collect data with dedicated CAC field teams. Similarly, the Yukon Avalanche Association deployed three remote weather stations to collect mountain weather data. Plans exist to add more stations in both Klondike and North Rockies regions. Field teams and weather stations allow CAC forecasters to direct the targeted collection of field data and reduces the CAC's reliance on professional third party data in these regions. The creation of field teams is a milestone for our organization and a turning point in its history.

The number, size, distribution, and remoteness of data-sparse mountainous regions with both avalanche terrain and increasing recreational use are daunting. It seems unrealistic to think deploying field teams and remote weather stations is a viable option for all areas in need. Research into coupling the snowpack evolution model SNOWPACK with a Numerical Weather Prediction model (NWP) may provide valuable

Class 2 information for infrequently monitored areas (Bellaire & Jamieson 2012).

The value of strong collaborations with local stakeholder groups cannot be overstated. Collaborating with the Yukon Avalanche Association allowed a new program to be established during the winter of 2011-12 (Smith & Sharp 2012); a result that could not be achieved by either of our organizations independently. This collaboration mirrors aspects of the North Shore Avalanche Advisory Group (NSAA) which was created to improve avalanche safety in the North Shore Mountains, a small area overlooking metro Vancouver. Pertinent to building programs in data-sparse regions, the NSAA shows that success and sustainability improves with broad based local stakeholder involvement that includes both governance and financial commitments.

Overseeing and managing field teams, some more than 2000 km away, sparks a host of issues that are easy to underestimate. Some of the issues and insights from our first winter with dedicated field programmes include:

- Field Monitoring: workers in avalanche terrain require a robust monitoring & communication system. Worker safety regulations such as lone worker or remote worksite regulations were applicable. A third party dispatch service was retained to allow filing of trip plans, and more importantly ensure that alarms were triggered when teams became overdue, and that all plans were successfully closed.

- Field Communication: diversity between regions created a diverse set of communication solutions ranging including cell phones, VHF radios, satellite phones, and SEND devices (e.g. SPOT). Teams carried a minimum of two different communication systems, of which one could be a one-way transmission (e.g. SPOT). Unsurprisingly, improving field communications remains a goal.

- Emergency Response: Emergency Response Plans went largely untested during our first winter! However, we face a host of inter-jurisdictional nightmares. Workers reside and are employed in one province but conduct field work in another (BC::Alberta; Yukon::BC). In Klondike, it's possible that the closest, but inaccessible, rescue resources are a few kilometers away in Alaska. Additionally, response plans must assume that Revelstoke head office has no tacit knowledge about the terrain, conditions, or resources available in the event of an emergency.

- Head & Satellite Office Communication: Time zones, offsets in the beginning and ending of shifts, part-time or irregular schedules, and differences in scope of interest (a field technician is focussed on a single region, a Revelstoke based forecaster may be working on four regions on any given day) complicate the relationship between field- and office-based sides of the CAC team. Better integration of Revelstoke and regional teams through work-place exchanges, more frequent and structured phone discussions, and improved oversight are planned.

- Field Observation Documentation & Communication: Compiling, displaying and communicating field data, which is collected in a variety of analog and digital forms, is not a trivial task. One field team goal is to document and improve knowledge of their area for the benefit of Revelstoke-based forecasters, collaborating agencies & stakeholder groups, and public users. An Avalanche Atlas is a standard tool in most professional avalanche safety operations. Sharp et al. (2012) describe initial progress in developing such an avalanche atlas for the Klondike region. An avalanche atlas for a regional public avalanche forecasting and safety programme has very different needs and functions than what is commonly found in a highways or ski area atlas.

4. FUTURE DEVELOPMENT

There is no single, simple strategy that can address the challenges posed by data-sparse regions in Canada. Like most public avalanche safety programmes, innovative and targeted initiatives that are sensitive to specific contexts and problems are the most promising route to incremental success. Possible initiatives include:

- Develop and promote observer networks through training opportunities and reward systems. Field observations from non-professional, minimally or moderately trained recreationists is required; both in terms of gaining information from the field and for

building sustainable community support.

- Create support tools that encourage collecting field observations and sending that information to the forecasting office. Easy to use online forms or apps provide a structure that prompts users to provide the most important information, helps organize their thoughts, and motivates their participation. We want to incorporate ideas about crowd sourcing & social media practices to leverage acceptance. Compatibility (and interaction) with existing and widely used social media services is a good thing in terms of building a user base.

- Rethink regional boundaries with a focus on "hot spots". Data-sparse areas in Alberta, British Columbia, or Yukon are often characterized as expansive regions with users clustered in localized intense use areas. These areas are where the highest quality and quantity of data is collected and where users will most likely benefit from CAC public safety products.

- Rethink the range of services that are valuable for accident prevention. Data sparse areas may not support full-fledged Avalanche Forecasts, identical to those offered in southern British Columbia; however, providing a subset of the components that make up these forecasts may be feasible in data-sparse regions. For example, a regional data stream could conceivably support the identification of Avalanche Problems but not provide for a credible analysis of Danger Ratings. Providing timely advice on Avalanche Problems would leverage standard recreational training (CAC AST2 course) tools and curriculum and help users select a general yet appropriate risk management strategy. Thematically based on Avalanche Problems, the field-book Decision Making in Avalanche Terrain (Klassen 2010) provides an integrated approach to avalanche safety that includes Problem Development, Avalanche Activity Patterns, Field Recognition & Assessment, and Risk Management Strategies (including timing, terrain, and human factors). A limited service of this nature, while not a standard CAC avalanche forecast, would encourage the use of empowering tools and promote self-sufficiency through adopting a robust approach to managing one's own avalanche risk.

- Klassen (2012) elsewhere in this volume makes a case for integrating avalanche hazard information with terrain. Leveraging existing decision support tools, including the CAC's Avaluator 2.0™, the CAC's online Trip Planner, and Avalanche Terrain Exposure Scale (ATES) mapping in data-sparse areas where formal danger ratings are not currently available could support improved decision-making and avalanche safety.

- Products and services developed for targeted for specific data-sparse regions could prove valuable for more general avalanche safety problems scattered throughout Canada such as Newfoundland and Labrador or Nunavut.

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