

April 22, 2020

To:

Heather Woods (CP)

Ross Cloutier and Rob Rohn (HeliCat Canada)

Joe Obad and Walter Bruns (Canadian Avalanche Association)

Mike Wiegele, Bob Sayer and Elias Ortner (Mike Wiegele Helicopter Skiing)

Gilles Valade and Kevin Seel (Avalanche Canada)

Cheryl Goodwin and Gord Ritchie (Avalanche Canada Foundation)

## **RE: 2019/20 Supporter Update of SFU Avalanche Research Program**

On behalf of my entire research team and SFU, I would like to thank all the supporters and collaborating operations for their support of the SARP research program. Our research would not be possible without your financial support and expert input to guide our program. We are grateful for this support and we are looking forward to a productive and long-term relationship between SARP and the Canadian avalanche community.

The purpose of this document is to inform the supporters of the Simon Fraser University Avalanche Research Program (SARP) including the NSERC Industrial Research Chair in Avalanche Risk Management (IRC) about the activities accomplished by the research team between May 1, 2019 and April 30, 2020 and to provide a brief outlook on the planned activities for the next twelve months.

## **1 Team**

Over the last year, the core SARP team consists of the following personnel:

- Dr. Pascal Haegeli (team leader)
- Dr. Simon Horton (postdoctoral fellow)

- John Sykes (PhD student in Geography)
- Florian Herla (PhD student in Geography)
- Brendan Wakefield (MRM student, graduated in August 2019)
- Anne St Clair (MRM student, graduated in September 2019)
- Moses Towell (MRM student, graduated in December 2019)
- Henry Finn (MRM student, graduated in April 2020)
- Katie Fisher (MRM student)
- Amélie Goulet-Boucher (MRM thesis student, since September 2019)
- Heather Hordowick (MRM thesis student, since September 2019)
- Abby Morgan (MRM project student, since September 2019)
- Stan Nowak (PhD student in SFU's Visual Analytics graduate program)

In addition, SARP includes the following affiliate members:

- Grant Statham, Parks Canada (adjunct professor)
- Dr. James Floyer, Avalanche Canada (adjunct professor)
- Dr. Patrick Mair (research associate, statistics)
- Dr. Robin Gregory (research associate, risk communication)
- Rosie Longford (undergraduate student)

## 2 2019/20 Highlights

### 2.1 Securing Additional Research Funding

Since all of the existing SARP students had established funding (NSERC Industrial Research Chair, industry support matched by MITACS, or personal scholarships), securing additional external research funding and getting industry contributions matched was not a major focus over the last 12 months. However, new funding was secured for Dr. Simon Horton to continue his work with SARP:

- **MITACS**
  - Improving avalanche forecasts in data-sparse areas with physical snowpack modelling (Elevate Postdoctoral Fellowship in partnership with Avalanche Canada):  
\$55k for Simon Horton + \$5k in expenses (Sept. 2019 – Aug. 2020)  
(MITACS contribution: \$30k)

In addition, I am a collaborator on a big research funding proposal spearheaded by SFU's Center for Natural Hazards Research:

- **Canadian Foundation for Innovation**
  - An integrated Natural Hazards Facility and Knowledge Portal  
SFU submission for the 2020 Canadian Foundation for Innovation competition  
Collaboration with Dr. Glyn Williams-Jones (SFU Earth Sciences), Dr. Gwenn Flowers (SFU Earth Sciences), Dr. Diana Allen (SFU Earth Sciences), Dr. Bahreyni (SFU School of Mechatronic Systems Engineering), Dr. Dyck (SFU Earth Sciences),

Dr. Nigam (SFU Mathematics), Dr. Pilarczyk (SFU Earth Sciences), Dr. Stead (SFU Earth Sciences), and Dr. Ward (SFU Earth Sciences):  
\$50k for additional GPS trackers

## 2.2 Research Projects

Over the last 12 months, the research efforts of SARP were focused on nine main projects that can be grouped into three overarching themes.

### 2.2.1 Decision-Making and Risk in Mechanized Skiing

- **Terrain perception among ski guides (Brendan Wakefield)**

An accurate perception of the skiing terrain is critical for making informed decisions about whether it is appropriate to ski a specific run. Existing research on avalanche terrain has primarily focused on simple terrain characteristics (e.g., incline, aspect, vegetation) that can be easily extracted from existing terrain datasets (e.g., DEM, TRIM). However, over their careers, guides develop a much more detailed understanding of the terrain that goes beyond these simple characteristics. Using a website for ski run characterization developed with the help of Roger Atkins and Clair Israelson, Brendan collected detailed ski run characterizations from the guiding teams at Northern Escape Heliskiing and Selkirk Tangiers Heliskiing for approximately 100 ski runs in total. His analysis explicitly quantified the trade-offs between accessibility, skiing experience, hazard potential, and operational benefits for the first time. This work offers an important steppingstone for examining the terrain choices of guides in more detail and properly isolating the effect of avalanche hazard. Visit [http://www.avalancheresearch.ca/pubs/2019\\_wakefield\\_terraincharacter/](http://www.avalancheresearch.ca/pubs/2019_wakefield_terraincharacter/) for a copy of Brendan's thesis.

- **Small-scale terrain choices in mechanized backcountry skiing operations (John Sykes)**

Building on previous SARP research on decision-making and risk in mechanized skiing, John's PhD project aims to extract knowledge and meaningful decision aids from the GPS tracks that have been collected at collaborating operations over the last few winters. For this project, we established an exciting research collaboration with Dr. Yves Bühler and Stephan Harvey at the WSL Institute for Snow and Avalanche Research SLF in Davos, Switzerland. The objective of the collaboration is to use the advanced avalanche terrain mapping algorithms that have been developed at the SLF and adjust them to the needs in Canada. The resulting terrain maps are then used as the foundation for a meaningful analysis of the collected GPS tracks. Key milestones that John achieved during the last twelve months include the purchase of high-resolution satellite imagery and development of a 5-m digital elevation model for the primary study area (CMH Galena), passing his comprehensive exam and developing his research proposal (defense on May 11, 2020). In addition, John received a ThinkSwiss Research Fellowship from the Swiss government in support of a research visit at the SLF (CHF 4,800). The research visit was originally scheduled for June to August 2020. However, the plans for his visit are currently on hold due to COVID-19.

- **HeliCat Canada Incident Reporting and Exchange (HIRE)**

Accurate incident information is critical for gaining a better understanding of the risks involved in mechanized skiing and developing effective mitigation strategies. In the fall of 2019, HeliCat Canada and SARP launched the new HeliCat Canada Incident Reporting and Exchange (HIRE) system at <https://hire.avalancheresearch.ca/>. The objectives of the HIRE system are to a) allow operations to track incidents and associated injuries in an efficient way; b) raise the situation awareness around incidents in the mechanized skiing community by facilitating the confidential sharing of select incident information; c) collect exposure information (e.g., guest ski days, guide days) in an efficient way; and d) build the foundation for evidence-based incident prevention initiatives in the future. In the first winter season, six operations submitted a total of 70 incidents to the HIRE system.

## 2.2.2 Patterns in Avalanche Hazard and Avalanche Hazard Modelling

- **Regional summaries and visualizations of modelled snowpack observations (Simon Horton, Stan Nowak)**

Snowpack models fed by numerical weather models have tremendous potential for offering insight into snow and avalanche hazard conditions in areas that are otherwise data sparse. However, the data volume of hundreds of simulated snow profiles is overwhelming and not useful for practitioners. To-date, Simon and Stan's research has focused on how to best summarize and visualize the modelled snowpack information to give practitioners meaningful and efficient insight about the key features expected in the snowpack and their variability. The results of this research have been described in a peer-reviewed paper, which has been reviewed, and we have recently submitted our revisions. You can access the paper at <https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-344/>.

- **Snowpack modelling in support of operational decision-making (Florian Herla)**

The long-term objective of Florian's project is to make snowpack modelling more useful for operational decision-making by developing an approach that allows practitioners to correct snowpack models based on operational observations. Over the last 12 months, Florian's explorations have focused on how to assess the similarity of snow profiles (modelled and observed) with a computer algorithm. The ability to compare snow profiles from different sources and levels of detail is an important steppingstone for the development of data assimilation approaches over large spatial areas. We are currently in the final stages of writing a paper for publication in a peer-reviewed journal. After submitting this paper, Florian will focus on preparing for his comprehensive exam and finalizing the research proposal for his PhD.

- **Linking avalanche problems to modelled weather and snowpack observations (Moses Towell)**

The objective of Moses' project was to explore whether it is possible to use modelled weather and snowpack observations to predict the presence of avalanche problems. For this pilot study, we modelled the evolution of the seasonal snowpack for several

seasons at multiple locations in Glacier National Park and examined the relationship with the avalanche problems published in the public avalanche bulletins using a classification tree algorithm. The results of Moses' analysis confirmed the influence of the expected weather and snowpack variables and provided useful additional insight into forecaster practices when making decisions about avalanche problems. This study provides an important step for integrating avalanche problems and the Conceptual Model of Avalanche Hazard (Statham et al., 2018) into existing weather and snowpack model chains and making avalanche bulletins in Canada more consistent. Visit [http://www.avalancheresearch.ca/pubs/2019\\_towell\\_avprobmodel/](http://www.avalancheresearch.ca/pubs/2019_towell_avprobmodel/) for a copy of Moses' thesis.

### 2.2.3 Public Avalanche Risk Communication

- **Examining use, comprehension and application of information provided in Canadian avalanche bulletins (Anne St Clair and Henry Finn)**

Anne and Henry's projects were part of Avalanche Canada's AvID initiative. The objective of these research projects was to better understand how recreationists use, understand and apply the information currently provided in Canadian avalanche bulletins and to provide recommendations for presentation alternatives. In a first step, Anne used the information collected in 46 in-person, semi-structured interviews to identify and describe the typical avalanche bulletin use patterns. The resulting avalanche bulletin user typology provides an important foundation for the development of new avalanche warning products that are tailored to the needs of the different user groups. Henry developed a comprehensive online survey for examining bulletin comprehension in model detail. He was particularly interested in the question whether recreationists that self-identify as a particular bulletin use type actually have the skills necessary to use the provided information in a proficient way. His detailed analysis of 3,000 survey responses uncover possible shortcomings in avalanche awareness education and highlight new opportunities in avalanche risk communication. Visit [http://www.avalancheresearch.ca/pubs/2019\\_stclair\\_avbullusertypology/](http://www.avalancheresearch.ca/pubs/2019_stclair_avbullusertypology/) for a copy of Anne's thesis on avalanche bulletin user types. Henry's thesis will be posted on our website in early summer.

- **Evaluating alternative information presentations and an interactive approach to avalanche risk communication (Katie Fisher)**

The objective of Katie's project is to build on the results of Anne and Henry's projects and examine the effect of alternative information presentations and interactivity on avalanche bulletin user comprehension and decision-making. To explore this topic, we designed a new online survey with a route ranking exercise where participants need to assess the exposure of hypothetical backcountry routes in relation to different avalanche bulletin scenarios. The location information of the avalanche problems is provided in a variety of formats and participants are randomly assigned to different types of feedback between exercises. The survey was launched on March 23, 2020 and

we had 3,400 completed responses by April 22, 2020. Katie will analyze the data over the summer, and we will present her results in the fall.

- **A framework for better understanding the recreational exposure to avalanche hazard (Rosie Langford)**

To be most effective, avalanche warning services must have an in-depth understanding of the size and the characteristics of the winter backcountry recreation community. Meaningful estimates of the size of the community are important for estimating overall and activity-specific accident and fatality rates and having a clear understanding of temporal trends of these rates is critical for assessing the effectiveness of existing avalanche awareness initiatives and identifying particularly-at-risk backcountry user segments for new campaigns. However, no country has so far implemented a comprehensive system for effectively monitoring and characterizing winter backcountry users as a whole. To address this issue, this project evaluated 22 established visitor monitoring methods for their suitability to provide insight into winter backcountry use numbers. Since none of the methods alone can offer a spatially comprehensive and temporarily continuous overview of backcountry use, we present five possible combinations of methods that can address the needs of avalanche warning services. This study was funded by the Mountain Safety Council of the Swedish Environmental Protection Agency, and the completed report was delivered on January 25, 2020.

### 2.3 Data Collection and Infrastructure

The collection of research data and the development of the necessary infrastructure continued over the last twelve months. The most important efforts included:

- **Collection of GPS tracks of professional terrain choices**

Our GPS track data collection efforts continued during the 2019/20 winter season. This winter we had 40 GPS units in the field and worked with five operations:

- CMH Galena
- Mike Wiegele Helicopter Skiing
- Monashee Powder Snowcats
- Northern Escape Heliskiing
- Selkirk Tangiers Helicopter Skiing

As of April 22, 2020, the complete GPS track dataset consists of 10,533 tracked guide days including slightly more than 70,500 ski runs under a wide variety of conditions. Collaborating operations can access their own tracks using an online viewer.

- **Idealized snow profiles**

To facilitate the snowpack modelling research objective in the IRC, SARP continued their collaboration with Mike Wiegele Helicopter Skiing to capture and archive their operational idealized snowpack profiles during the 2019/20 winter season. This information is critical for our projects on snow profile aggregation and making snowpack

modelling more accessible for practitioners. We also digitized two previous seasons of idealized MWHS snow profiles into CAAML format to allow numeric analysis.

- **Operational snowpack modelling**

The evolution of the seasonal snowpack was modelled daily at roughly 45,000 grid points in western Canada from three different weather forecast models using the research computing resources accessible to us from Compute Canada. The modelled grid points covered all of Avalanche Canada's forecast regions and encompassed and most of the areas of interest for industrial supporters (e.g., Mike Wiegele Heliskiing, Whistler Heliskiing, Bella Coola, Mica Heliskiing). Collaborating operations are able to access summaries of our model runs within their area on a password-protected page at <http://www.avalancheresearch.ca/>.

## 2.4 Outreach

### 2.4.1 Peer-reviewed Publications

**Three academic peer-reviewed publications** were either submitted, revised or published over the last 12 months:

1. Horton, S., Nowak, S., and Haegeli, P. (under revision). Enhancing the operational value of snowpack models with visualization design principles. Revisions submitted to *Natural Hazards and Earth System Science Discussion* on April 2, 2020. doi: 10.5194/nhess-2019-344.
2. Haegeli, P., Rupf, R., and Karlen, B. (in press). Do avalanche airbags lead to riskier choices in the backcountry? Accepted in *Journal of Outdoor Recreation and Tourism* on November 14, 2019. doi: 10.1016/j.jort.2019.100270
3. Sterchi, R., Haegeli, P., & Mair, P. (2019). Exploring the relationship between avalanche hazard and run list terrain choices at a helicopter skiing operation. *Natural Hazards and Earth System Science*, 19(9), 2011-2026. doi: 10.5194/nhess-19-2011-2019.

Several additional research articles are currently in preparation and close to submission.

In addition, our backcountry monitoring project for the Mountain Safety Council of the Swedish Environmental Protection Agency resulted in a **substantial report**, which we sent out for peer-review before submission.

4. Langford, R., Haegeli, P., and Rupf, R. (2020). *How much recreational exposure to avalanche terrain is there? An overview of possible approaches for monitoring winter backcountry use for public avalanche warning services*. Peer-reviewed report prepared for Swedish Environmental Protection Agency, Mountain Safety Council, p. 172.

### 2.4.2 Publications in Community Journals

Over the last 12 months, my research team and I published **5 articles in community journals**.

1. St. Clair, A., Finn, H., Haegeli, P., Klassen, K., and Gregory, R. (2020). How getting to know the recreational audience can improve the effectiveness of the avalanche bulletin. *The Avalanche Review*. 38(4).

2. Haegeli, P., Rupf, R., and Karlen, B. (2020). Lawinenairbags & Risikoverhalten [German]. *Bergundsteigen*, 2020-1, 68-75.
3. St. Clair, A., Finn, H., Haegeli, P., Klassen, K., and Gregory, R. (2020). How getting to know the recreational audience can improve the effectiveness of the avalanche bulletin. *The Avalanche Journal*. 123, 28-31.
4. Horton, S. (2020). The future of avalanche forecasting. *The Avalanche Journal*. 123, 22-25.
5. Nowak, S. (2019) What can visual analytics do for avalanche forecasting? *The Avalanche Journal*. 122.

Anne also published an article about the results of her research in the **AIARE Instructor Newsletter** in March 2020.

6. St. Clair, A., Finn, H., Haegeli, P., Klassen, K., and Gregory, R. (2020). Serving Bites That Students Can Chew: A framework for recognizing when and how to introduce complexity into avalanche education. *AIARE Instructor Newsletter*, March 2020.

### 2.4.3 Presentations at Academic Conferences

My research team gave **two presentations at academic conferences over the last 12 months**. Both of these presentations were at the 2019 Annual Meeting of the Society for Risk Analysis in Arlington:

1. St Clair, A., Finn, H., Haegeli, P., Klassen, K., and Gregory, R. (2019). What can they learn? Using learning outcomes to improve the link between risk communication and intended response. Oral presentation at the *2019 Annual Meeting of the Society for Risk Analysis* in Arlington, VA, December 8-12, 2019.
2. Finn, H., St Clair, A., Haegeli, P., Gregory, R., and Klassen K. (2019). Are they really as prepared as they think they are? Investigating self-assessment bias in a risk communication survey. Poster presentation at the *2019 Annual Meeting of the Society for Risk Analysis* in Arlington, VA, December 8-12, 2019.

### 2.4.4 Technology Transfer

Over the last twelve months, core SARP members gave **14 presentations at association meetings and early season staff training sessions**. In addition to presentations in Canada, we also presented to avalanche professionals in the United States and Europe. In total, an estimated 500 avalanche professionals were reached with these presentations (1,320 if each presentation is counted individually).

1. Herla, F., Horton, S., and Haegeli, P. (2019). Developments for the operational use of snowpack models. *CMH Guides' Training* at Sun Peaks. Nov. 26, 2019 (size of audience: approx. 50).
2. Haegeli, P., and Sykes, J. (2019). Capturing operational risk management expertise in mechanized skiing and developing tools to make this expertise more accessible. *CMH Guides' Training* at Sun Peaks. Nov. 26, 2019 (size of audience: approx. 50).

3. Haegeli, P. (2019). Introduction of HIRE (HeliCat Incident Reporting and Exchange) System. *Annual General Meeting of HeliCat Canada* in Victoria, BC. October 21, 2019 (size of audience: approx. 80).
4. Haegeli, P., St Clair, A., Finn, H., Gregory, R., and Klassen K., (2019). How do recreationists use, understand and apply avalanche bulletin information? Invited presentation at the *2019 National Avalanche Center Virtual Meeting* on November 14, 2019. (size of audience: approx. 50)
5. Herla, F., Horton, S., and Haegeli, P. (2019). Developments for the operational use of snowpack models. *Avalanche Canada Forecaster Training* in Revelstoke. Nov. 13, 2019 (size of audience: approx. 20).
6. Fisher, K., St Clair, A., Finn, H., and Haegeli, P. (2019). Could the avalanche bulletin be more effective? *Avalanche Canada Forecaster Training* in Revelstoke. Nov. 13, 2019 (size of audience: approx. 20).
7. Haegeli, P., St Clair, A., Finn, H., Gregory, R., and Klassen K., (2019). How do recreationists use, understand and apply avalanche bulletin information? Invited presentation at the *20th Assembly of European Avalanche Warning Services* in Oslo, Norway, June 14, 2019. (size of audience: approx. 50)
8. Haegeli, P., Rupf R, and Karlen, B. (2019). Do avalanche airbags lead to riskier choices in the backcountry? *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150).
9. Horton, S., and Haegeli, P., (2019). What if you could dig two thousand pits a day? *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150).
10. Towell, M., and Haegeli, P. (2019). Exploring the link between modeled weather and snowpack conditions and avalanche problems. *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150)
11. Nowak, S., Bartram, L., and Haegeli, P. (2019). Designing visualizations for avalanche forecasters. *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150)
12. St Clair, A., Finn, H., Haegeli, P. Gregory, R., and Klassen K. (2019). Could the avalanche bulletin be more effective? *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150)
13. Finn, H., St Clair, A., Haegeli, P. Gregory, R., and Klassen K. (2019). Survey insights – Probing for population-wide patterns of avalanche bulletin use in North America. *Spring Meeting of Canadian Avalanche Association* in Penticton, BC. May 9, 2019 (size of audience: approx. 150)

14. Haegeli, P. (2019). Update on SFU Avalanche Research Program. *Spring Meeting of HeliCat Canada* in Penticton, BC. May 6, 2019 (size of audience: approx. 100)

Unfortunately, I had to decline an invitation of the New Zealand Mountain Safety Council to give a keynote presentation at the 2019 Southern Hemisphere Alpine Conference in Christchurch due to a scheduling conflict with the Assembly of the European Avalanche Warning Services in Oslo.

#### 2.4.5 Public Outreach

Over the last twelve months, core SARP members **participated in seven public avalanche awareness events** reaching an estimated 2,500 recreationists.

1. Finn, H., St Clair, A., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? Invited presentation at the *North Rockies Snow and Avalanche Workshop* in Whitefish, MT, November 16, 2019. (size of audience: approx. 300).
2. St Clair, A., Finn, H., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? How getting to know the bulletin audience can improve avalanche risk communication. Invited presentation at the *Elk Valley Snow and Avalanche Workshop* in Fernie, BC, November 10, 2019. (size of audience: approx. 300).
3. St Clair, A., Finn, H., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? How getting to know the bulletin audience can improve avalanche risk communication. Invited presentation at the *Bend Snow and Avalanche Workshop* in Bend, OR, November 9, 2019. (size of audience: approx. 300).
4. St Clair, A., Finn, H., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? How getting to know the bulletin audience can improve avalanche risk communication. Invited presentation at the *Wyoming Snow and Avalanche Workshop* in Jackson Hole, WY, October 26, 2019. (size of audience: approx. 300).
5. Haegeli, P., Rupf R, and Karlen, B. (2019). Do avalanche airbags lead to riskier choices in the backcountry? Invited presentation at *EPFL/ETHZ Café Scientifique* in Vancouver, BC. November 6, 2019. (size of audience: approx. 30)
6. Finn, H., St Clair, A., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? Invited presentation at the *Northwest Snow and Avalanche Workshop* in Seattle, WA, October 20, 2019. (size of audience: approx. 650).
7. St Clair, A., Finn, H., Haegeli, P., Gregory, R., and Klassen, K. (2019). Could the avalanche bulletin be more effective? How getting to know the bulletin audience can improve avalanche risk communication. Invited presentation at the *Colorado Snow and Avalanche Workshop* in Breckenridge, CO, October 4, 2019. (size of audience: approx. 650).

Simon Horton also represented the snowpack modelling research of the SARP team at two Avalanche Canada outreach events (Canuck Splitfest in Revelstoke on January 10, 2020, and Backcountry Avalanche Workshop in Kimberly on January 21, 2020)

SARP research also attracted media attention. The most prominent mention was an article published in the magazine of the Swiss Alpine Club:

- Jacquemart, M. (2020). Wie ein Lawinenairbag uns beeinflusst – Risikobereitschaft mit Lawinenairbag [German]. Die Alpen 2020/02. [available online at <https://www.sac-cas.ch/de/die-alpen/wie-ein-lawinenairbag-uns-beeinflusst-21911/>].

## 2.5 Award and Recognitions

In the last twelve months, my research team and I received the following recognitions:

- John Sykes: ThinkSwiss Research Fellowship (CHF 4,800) from the Swiss government in support of a 3-months research stay at the WSL Swiss Institute for Snow and Avalanche Research SLF in Davos, Switzerland.

## 2.6 University Teaching

A major focus of the last twelve months was the development and first offering of a new **university course in avalanche risk management** (REM427/627) at SFU. The objective of the course is to provide students with an interdisciplinary overview of avalanche risk management that covers the physical processes involved in avalanche formation, the characteristics of terrain threatened by avalanches, the methods used for assessing avalanche hazard and mitigating the risk, and the medical aspects of avalanche survival. Students completing the course have a comprehensive understanding of how avalanche risk affects Canadians and how it is managed in different contexts. To link the theoretical concepts discussed in class to practice, the course included two guest lectures (Brian Gould and Cam Campbell) and a capstone project where groups of students were connected with practitioners in specific avalanche risk management operations (mechanized skiing operations, remote mine with access road, transportation corridor, ski area) to discuss how avalanche risk is managed in real life. See <http://www.avalancheresearch.ca/rem-427/> for a more complete overview of the course content and learning objectives.

The course was taught for the first time in the spring semester of 2020 (Jan. – Apr.) to a class of 14 students (8 undergraduate and 6 graduate students). Students taking the course came with a wide range of different backgrounds including students without any winter backcountry recreation experience. The response to the course was overwhelmingly positive with 10 out of 11 students filling out the course evaluation giving the course an A grade.

I will likely be able to teach this course every second winter. Before teaching the course again, I would like to have its content reviewed by a variety of avalanche safety experts to make sure there are no gaps and the course meshes well with other educational opportunities in the avalanche community. Please let me know if you or somebody in your organization is interested in contributing.

## 2.7 Student Training

Since my research program does not have a field program, I am using the following approaches to train my students in addition to the supervision of their personal research projects:

- Organizing visits to collaborating operations;
- Weekly group meetings where we discuss current avalanche conditions (winter only) and research papers on special topics.

Suggestions for how to better train students for industry needs are welcome.

## 2.8 Other Relevant Activities

One of my roles at SFU is the Directorship of SFU's **Centre for Tourism Policy and Research (CTPR)**, a research centre that was established in the late 1980s to support BC's tourism industry with policy relevant research. I am excited that SFU and the CTPR are the Canadian academic partners for HeliCat Canada's newly established Wildlife & Environmental Research Fund. I believe that the CTPR offers the avalanche and backcountry tourism community an exciting opportunity for accessing high-quality interdisciplinary research expertise in relevant topics including indigenous relations, reconciliation and indigenous capacity building, climate change impacts and decarbonization, sustainability initiatives and economic development in rural communities. Please let me know if you have any needs in these areas, and I am happy to connect you to suitable researchers at SFU.

## 2.9 Challenges

### 2.9.1 Data Breach on January 14, 2020

On January 14, 2020, one of our database servers was hacked by an unauthorized programmer, who stole several research databases. It was a Ransomware type attack

(<https://en.wikipedia.org/wiki/Ransomware>) where hackers steal information and threaten to release it to the public or use it for criminal activities unless a ransom is paid. The stolen databases included stripped down versions of the GPS tracking databases and the incident record database that Matthias Walcher collected for his incident study in the winter of 2017 ([http://www.avalancheresearch.ca/pubs/2019\\_walcherother\\_riskinmechskiing/](http://www.avalancheresearch.ca/pubs/2019_walcherother_riskinmechskiing/)).

Incident records in the stolen database included operation names, counts of fatalities and individuals who sustained injuries, and generic descriptions of these injuries. While the database did not include any explicit patient records, narratives of some incidents might have included names. The complete dataset consisted of 999 incident records from a total of 52 operations. The HeliCat Canada Incident Reporting and Exchange (HIRE) system was not affected by the breach.

Investigations by my IT system administrator indicated that it was likely a brute force attack directly on the database engine at 13:41 PST. I noticed the issue at roughly 15:40 PST, and we immediately shut down the virtual machine that hosted the databases and tightened the security on all other research database servers. The data was easy to restore as we routinely backup all of our database servers. However, due to privacy concerns we immediately informed all of the affected operations (incl. HCC and CAA), and I reported the incident to SFU's IT services, SFU's Information and Privacy Officer (Alexandra Wieland), SFU's Chief Information

Security Officer (Keir Novik), and SFU's Office for Research Ethics (Jeff Toward), who oversees any research involving human subjects. After consultation with all the stakeholders, we decided to simply ignore the demand and not to pay the ransom.

To prevent unauthorized access to our research data in the future, we have substantially increased the security of our data infrastructure. All students and authorized collaborators now have to log into a virtual private network (VPN) with before they can access any of our research databases. Databases that need to be directly connected to the internet (e.g., HIRE, online GPS track viewer) can only be accessed from the computer that hosts the online interface. We are confident that the new arrangement ensures the security of any data collected by or shared with the research team.

### 2.9.2 COVID-19

Like everybody else, our research group has been affected by COVID-19. On March 12, 2020 all SFU faculty members and students were told to stay home, and all university business was moved online. All of our research activities and meetings have been conducted online since then.

In comparison to other segments of the avalanche safety industry, the impact of COVID-19 on our research group has been relatively minor. The transition to working online was fairly smooth, and research activities have so far continued as planned. Nobody lost any data collection opportunities or needed to redesign their research projects. The biggest impacts include:

- Postponement of John Sykes' research visit in Switzerland
- Cancellation of Spring Meetings
- Postponement of International Snow Science Workshop

I suspect that we will be working remotely at least until the start of the next academic year at the beginning of September. During this period, I perceive the design of new projects with the students that started last fall as the biggest challenge.

### 2.9.3 Other Challenges

In my opinion, the operational challenges for my program are:

- Maintaining a continuous and meaningful connection with supporting organizations and practitioners to ensure the research we work on is meaningful to the community;
- Providing my students with the training they need to allow them to start a promising career in the avalanche community.

Any guidance on these challenges are welcome.

## 3 Outlook for Next 12 Months

### 3.1 Personnel

The following individuals will be joining the SARP team in the fall of 2019:

- Rosie Langford (Masters student; REM thesis stream)

- Anne St Clair (PhD student)

Rosie has been working with SARP as an undergraduate student for a long time, and Anne is returning to us to continue her academic training after working for Avalanche Canada as a forecaster for a winter.

## 3.2 Priorities

The main focus for the next twelve months is to catch up and make substantial progress on the Industrial Research Chair Program. While the International Snow Science Workshop has been cancelled, I want to make sure we do not lose momentum in our research program, and we succeed in publishing our research in a timelier fashion.

### 3.2.1 Research

- Continue on existing research projects with Simon and John.
- Develop PhD full research proposals with Florian and Stan.
- Develop MRM thesis projects with Amélie and Heather.
- Develop and complete MRM term project on avalanche danger rating with Abby.
- Submit Bret's second paper on the effect of climate oscillations on the nature of avalanche hazard in western Canada.
- Turn Taylor, Brendan and Moses' thesis into research articles and submit them to peer-reviewed journals by the end of the summer.
- Publish Anne and Henry's research in a peer-reviewed journal.
- Bring Katie's survey project to completion and submit a research article for publication by the end of the year.
- Submit several papers on summarizing and visualizing simulated snowpack information with Simon, Stan and Florian.
- Write a position paper on how to conduct social science research in support of public avalanche safety more effectively.
- Strengthen industry participation in HIRE.

### 3.2.2 Funding

- Continue to secure matching funds for unmatched contributions from partners (Avalanche Canada and Avalanche Canada Foundation) whenever possible. For this summer, the focus will be on securing matching funding for the research of Amélie and Abby.
- If meaningful and if there is sufficient capacity, submit NSERC Discovery grant application on examining the effect of climate change on avalanche hazard in western Canada.
- Start discussing funding possibilities with industry partners for after the end of the NSERC Industrial Research Chair (August 2022).

### 3.2.3 Outreach

- Attend the 2020 Annual Meeting of the Society for Risk Analysis (December 2020).
- Continue to build research network outside of traditional avalanche research fields within SFU (e.g., big data, visualization) and beyond (e.g., risk communication).

- Strengthen public outreach with social media, practical resources on website, presentations, and articles published in the Avalanche Journal and presentations.
- Strengthen connection with operators and avalanche professionals by visiting them and connecting them with students more frequently.

#### 3.2.4 Student Training

- Develop a better plan for giving students the opportunity to go into the field and connect with collaborating operations and avalanche professionals in a meaningful way.

#### 3.2.5 Anticipated Challenges

- Last year, I highlighted that the program has grown tremendously since it started in the fall of 2015, and that I was concerned about reaching the limit of my capacity. I still have concerns about this, and I am hoping to use this year to catch up and work on the backlog of publications before further growing the research program.

## 4 Questions

If you have any question about SARP's research activities, please contact me anytime either by email ([pascal\\_haegeli@sfu.ca](mailto:pascal_haegeli@sfu.ca)) or phone (778-782-3579 or 604-773-0854).