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To:
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Ross Cloutier and Rob Rohn (HeliCat Canada)
Joe Obad and Walter Bruns (Canadian Avalanche Association)
Elias Ortner (Mike Wiegele Helicopter Skiing)
Gilles Valade and Kevin Seel (Avalanche Canada)
Fabian Karg and Kevin Williams (Avalanche Canada Foundation)

RE: 2021/22 Supporter Update of SFU Avalanche Research Program

As for everybody else, the SFU Avalanche Research Program is currently transitioning back to more normal research operations after COVID-19. We feel very fortunate and are grateful that we only had to slightly change our research projects and that our funding situation was not affected significantly, but we also acknowledge that working remotely, having students spread across the world and only having limited interactions with our industry partners has impacted our research program in considerable ways. Our focus for the near future will be to re-energize the research program and rekindle the collaborations with all of our partners.

On behalf of my entire research team and SFU, I would like to thank all the supporters and collaborating operations for their continued support of our research program during these challenging times. Our research would not be possible without your financial support and expert input. We are grateful for this support, and we are looking forward to continuing our work with 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, 2021 and April 30, 2022 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, transitioned to Avalanche Canada in Sept, 2021)
- John Sykes (PhD student in Geography)
- Florian Herla (PhD student in Geography)
- Stan Nowak (PhD student in SFU's Visual Analytics graduate program)
- Anne St Clair (PhD student in REM)
- Katie Fisher (MRM thesis student, graduated in August 2021)
- Abby Morgan (MRM project student, graduated in December 2021)
- Heather Hordowick (MRM thesis student, graduated in April 2022)
- Amélie Goulet-Boucher (MRM thesis student)
- Rosie Langford (MRM thesis student)
- Annelise Neweduk (MRM project student since September, 2021)

In addition, SARP includes the following affiliate members:

- Grant Statham, Parks Canada (adjunct professor)
- Dr. James Floyer, Avalanche Canada (adjunct professor)
- Dr. Patrick Mair, Harvard University (research associate, statistics)
- Dr. Reto Rupf, Zurich University of Applied Sciences (research associate, tourism)

2 2021/22 Highlights

2.1 Research Projects

Over the last 12 months, the research efforts of SARP were focused on 13 main projects that can be grouped into four overarching themes.

2.1.1 Decision-Making and Risk in Mechanized Skiing

- **Small-scale terrain choices in mechanized backcountry skiing operations (John Sykes)**
  John has finalized his work on adjusting the Swiss probable release area model (developed by Yves Bühler) to Canadian conditions. This work has been written up in a manuscript that is currently under review for publication in the journal *Natural Hazards and Earth System Science*. The reviewer comments have been positive, and we will be finalizing the revisions of the manuscript in early summer.
  The results of this research provide the foundation for meaningfully examining the GPS tracks that the SARP team has been collecting over the last few years, and we are looking forward to conducting this research over the next 12 months. Note that John's research was on hold between Nov. 2021 and May 2022, as he was working as an avalanche forecaster for the Chugach Avalanche Center in Alaska for the winter.

2.1.2 Avalanche Hazard Modelling in Support of Operational Avalanche Forecasting

- **Operationalizing of snowpack modelling (Simon Horton)**
  Simon's MITACS Elevate Fellowship with Avalanche Canada concluded on August 31, 2022. His main research focus during the last year of his fellowship was on developing meaningful approaches for examining the quality of the precipitation input to snowpack simulations using a variety of sources of precipitation information. This work was recently completed, and the resulting manuscript was recently submitted for publication in the journal *The Cryosphere*. Simon also created a snowpack simulation dashboard within Avalanche Canada's AvID system to allow avalanche forecasters to get operational experience with snowpack model simulations and familiarize themselves with their strengths and weaknesses.
  Simon has now transitioned from SFU to being an employee of Avalanche Canada. However, I have an agreement in place with Avalanche Canada where I am still using funding from the NSERC IRC to support his research on snowpack modelling since it is crucial for the research objectives of my program and I believe that his efforts provide long-term value to the entire community. Simon is still closely involved with the research group and contributes to projects of other students.

- **Snowpack modelling in support of operational decision-making (Florian Herla)**
  Over the last 12 months, Florian has developed methods for averaging and clustering simulated snow profiles, which is a challenging task due to the complexity of the data. The methods that Florian developed are the foundation for presenting and processing large volumes of snowpack simulations in a meaningful way.
  The next step of Florian's research will examine how the simulated snowpack structure compares to the weak layers highlighted in public avalanche bulletins, and whether the simulations provide a meaningful picture of the characteristics and spatial distribution of the weak layers. This project represents an important step in the validation of large-scale snowpack simulations and is critical for having an informed understanding about the operational value of snowpack models.

- **Designing for ambiguity (Stan Nowak)**
  Stan continued his research on understanding avalanche forecasting practices to better inform the design of data visualizations and recording methods for avalanche hazard assessments. While he has developed various data visualizations as a consultant for the AvID project of Avalanche Canada (weather observations, avalanche observations, MIN reports, revised avalanche bulletin map), his PhD research focuses on how avalanche forecasters can better document and share their judgments and reasoning process. The goal of this research is to improve efficiencies and consistency by making it easier for forecasters to share the less tangible metadata of their assessment process. Stan has developed various prototypes for the recording of this information based on interviews and is currently conducting a diary study with a select number of forecasters to examine the usefulness of the proposed tools.

- **Considerations for adding and eliminating avalanche problems (Heather Hordowick)**
  In the winter of 2020/21, Heather conducted 22 long semi-structured interviews with forecasters from four different agencies (Avalanche Canada, Banff NP, Glacier NP, and Kananaskis Country) to better understand the factors forecasters consider when adding and removing either storm or wind slab avalanche problems or persistent or deep persistent slab avalanche problems. Over the last 12 months, Heather has synthesized the collected information into a comprehensive overview of avalanche forecaster practices that highlights similarities and differences in approaches between and within participating agencies. The outcome of this research will help forecasters have informed conversations on how to address existing forecast inconsistencies, and it will help researchers to better understand the processes behind the avalanche bulletin dataset. Heather has presented the results of her research at avalanche forecaster training sessions of Avalanche Canada and Parks Canada in the fall of 2021, and she successfully defended her Masters thesis on April 20, 2022. A copy of Heather's thesis is available on our website at https://avalancheresearch.ca/pubs/2022_hordowick_mrm/.

2.1.3 Avalanche Terrain Mapping

- **Automated Avalanche Terrain Mapping (John Sykes)**
  In addition to his research on the application of probable release area models at CMH Galena, John has continued his collaboration with researchers from Norway and Montana State University as well as Grant Statham to improve a GIS algorithm for automatically mapping avalanche terrain according to the Avalanche Terrain Exposure Scale (ATES). We are now able to create draft ATES maps over large areas in a fairly efficient way. However, local calibration of the algorithm is important and subsequent validation by local experts is critical to ensure the automatically created ATES maps represent the local terrain meaningfully. John is currently drafting two manuscripts about this work for publication in academic journals.

2.1.4 Public Avalanche Risk Communication

- **Evaluating alternative information presentations and the effect of interactivity to avalanche risk communication (Katie Fisher)**
  Katie completed her research on information presentation in avalanche bulletins in the summer of 2020, and successfully defended her Masters thesis on August 17, 2021. Her research examined a) how the presentation of the avalanche problem aspect and elevation information affects bulletin users' ability to use this information, b) how interactive feedback affect participants' ability to use avalanche problem information, and c) who is paying attention to the travel advice statements and can these statements be made more effective. The results of this research provide tangible guidance on how to improve the effectiveness of avalanche bulletin websites.
  Katie's research resulted in three publications in peer-reviewed academic journals, which is exceptional for a Masters thesis. Katie's Masters thesis is available on our website at https://avalancheresearch.ca/pubs/2021_fisher_mrm/.

- **Public perception and use of avalanche danger scale (Abby Morgan)**
  Using survey data collected by Henry Finn in the spring of 2019, Abby examined how bulletin users understand and use the avalanche danger ratings in their trip planning process. The results of her research provide an important user perspective on the strengths and weaknesses of the danger scale as an avalanche risk communication tool. Abby successfully defended her thesis on December 17, 2021, and her thesis is available on our website at https://avalancheresearch.ca/pubs/2021_morgan_dangerscale/. Abby is currently working on a manuscript to publish her results in a peer-reviewed journal.

- **Role of social media in avalanche risk management decision among recreationists (Amélie Goulet-Boucher)**
  Over the last 12 months, Amélie continued to analyze her interview data to better understand how social media plays a role in recreationists' avalanche risk management decisions and for what reasons. The results of this research will help avalanche warning services use social media more efficiently and potentially adjust their products to better serve the community. In addition, the results will help avalanche safety educators to highlight the benefits and challenges of social media in their courses. Amélie presented the results of her research at Avalanche Canada's forecaster training last fall, various public avalanche awareness workshops (CSAW, NSAW, NRSAW) and the annual meeting of the Society for Risk Analysis. Note that Amélie's research has been on hold since November 2021, since she worked full-time as a ski guide during the winter.

- **Comprehensive framework for avalanche risk communication and education (Anne St Clair).**
  The overarching theme of Anne's PhD project is to systematically examine, design or evaluate avalanche awareness initiatives in a variety of contexts. In preparation for her research, Anne has been developing a theoretical framework that takes a detailed look at all the different factors that affect the effectiveness of avalanche risk communication and education initiatives. The objective is to provide a comprehensive and unifying foundation for the design and evaluation of avalanche awareness initiatives in different contexts.

- **Avalanche safety in remote Artic (Anne St Clair).**
  One of the contexts of interest in Anne's PhD research is avalanche safety in remote communities in the Canadian Arctic. In preparation for this project, Anne has been establishing important connections with relevant collaborators in the Arctic including Andrew Maher (Park Canada; super intendant), Jason Carpenter (Arctic College) and Dr. Gita Ljubicic (McMaster University). The current intent is for Anne to visit one or two Arctic communities in the fall of 2022 and/or spring of 2023 to establish first direct connections with local communities and learn about the potential interest in avalanche safety.

- **Identifying and examining field avalanche risk management practices among winter backcountry recreationists (Rosemary Langford)**
  The objective of Rosemary's research is to identify and characterize avalanche risk management practices of recreationists traveling in the winter backcountry: How do recreationists assess risk in the backcountry? What cues, observations, and supports do recreationists use to inform decisions in the field? How do they combine these cues, observations, and supports to make decisions? This research builds on the research of Anne St Clair and Henry Finn who looked at recreationists' trip planning practices and expands it to decision making in the field. The findings of this research will provide the empirical understandings necessary to make the design of avalanche information products and curricula more evidence-based and resonate better with the increasingly diverse backcountry user audience.

- **Avalanche bulletin user research in Euregio (Austria/Italy) and Switzerland (Pascal Haegeli, Annelise Neweduk)**
  We continued with the development of a research panel for avalanche bulletin user research in Europe in collaboration with the Euregio avalanche warning services (Tyrol, South Tyrol and Trentino) and Switzerland. To complement the Euregio signup survey we launched during the 2020 winter, we implemented a signup survey for Switzerland in the fall of 2021. As of now, approximately 6,000 recreationists and avalanche professionals have completed the signup survey. In April of 2022, we launched the first research survey, which aims to better understand how people understand and use the existing products. This research builds on and expands our existing research on avalanche bulletin users in North America. So far, slightly over 2,000 recreationists have completed it. Note that the design of this survey required a considerable redesign of our survey infrastructure because the survey was simultaneously released in four languages.

2.2 Data Collection and Infrastructure

During the 2021/22 winter season data collection efforts have been limited to the following effort.

- **Collection of GPS tracks of professional terrain choices**
  With the mechanized skiing industry resuming regular operations this winter, we continued with the collection of GPS tracks with a limited number of collaboration operations. This winter, our data collection efforts were limited to Mike Wiegele Helicopter Skiing and CMH Galena.

- **Access to avalanche bulletin information**
  We updated our research database infrastructure to handle avalanche bulletin information from Avalanche Canada's new AvID application, so that it can be seamlessly integrated into our research project. This means that we have continuous avalanche bulletin records back to the winter of 2009/10.

2.3 Securing Additional Research Funding

Over the last 12 months, we were able to secure the following funding in addition to the existing contributions from our Canadian industrial partners.

I am a co-investigator on a **SAR-NIF project** of the National Search and Rescue Secretariat in collaboration with Dr. Alexandre Langlois of the University of Sherbrooke and Drs. Fortin and Vionnet at Environment and Climate Change Canada (ECCC). The main goal of the proposed project is to increase the quality of precipitation forecasts over mountain regions in winter by integrating a variety of snowpack observations to the Canadian Precipitation Analysis (CaPA) product. Since precipitation is one of the key sources of uncertainty in avalanche forecasting, the improved precipitation analysis and forecasts have great potential to improve snowpack simulations. While most of the funding of this project goes to ECCC and the University of Sherbrooke, approx. $50k of the overall budget is earmarked to fund my incoming Master student Kelsea Krawetz for two years. The objective of Kelsea's research will be to examine the impact of the improved precipitation forecasts on snowpack simulations.

In addition, I am in the final stages of formalizing a **research contract with the Colorado Avalanche Information Centre** (CAIC) for conducting avalanche bulletin user research in Colorado. This is a collaboration with the CAIC and the Social Science Research Group at the US National Center for Atmospheric Research (NCAR) in Boulder, CO. The SFU portion of the budget of the proposed project (approx. $200k) will fund Eeva Latosuo for the duration of her PhD studies (2022-2026).

2.4 Outreach

2.4.1 Peer-reviewed Publications

We submitted/published a total of **eight academic peer-reviewed papers** over the last 12 months:

1. Horton, S., and Haegeli, P. (submitted). Evaluating regional-scale snowpack models with snow depth observations. Submitted to *The Cryosphere* for publication on April 19, 2022.
2. Herla, F., Haegeli, P., and Mair, P. (in review). Brief communication: A numerical tool for averaging large data sets of snow stratigraphy profiles useful for avalanche forecasting. Published by *The Cryosphere* as a discussion paper on February 6, 2022. doi: 10.5194/tc-2022-29.
3. Sykes, J., Haegeli, P., and Bühler, Y. (under revision). Automated snow avalanche release area delineation in data sparse, remote, and forested region. Published by *Natural Hazards and Earth System Science* as a discussion paper on November 16, 2021. doi: 10.5194/nhess-2021-330.
4. Fisher, K., Haegeli, P., Mair, P. (revisions in review). Travel and terrain advice statements in public avalanche bulletins: A quantitative analysis of who uses this information, what makes it useful, and how it can be improved for users. Revisions submitted for publication in *Natural Hazards and Earth System Science* on April 27, 2022.

5. Gain, A. K., Bühler, Y., Haegeli, P., Molinari, D., Parise, M., Peres, D. J., Pinto, J.G., Schröter, K., Trigo, R.M., Llasat, C.M., and Kreibich, H. (2022). Brief communication: Key papers of 20 years in Natural Hazards and Earth System Sciences. *Natural Hazards and Earth System Science*, 22(3), 985-993. doi:10.5194/nhess-22-985-2022.
6. Fisher, K., Haegeli, P., & Mair, P. (2022). Exploring the avalanche bulletin as an avenue for continuing education by including learning interventions. *Journal of Outdoor Recreation and Tourism*, 37, 100472. doi:10.1016/j.jort.2021.100472.
7. Fisher, K., Haegeli, P., Mair, P. (2021). Impact of information presentation on interpretability of spatial hazard information: Lessons from a study in avalanche safety. *Natural Hazards and Earth System Science*, 21(10), 3219-3242. doi:10.5194/nhess-21-3219-2021.
8. St Clair, A., Finn, H., and Haegeli, P. (2021). Where the rubber of the RISP model meets the road: Contextualizing risk information seeking and processing with an avalanche bulletin user typology. *International Journal of Disaster Risk Reduction*, 102626. doi:10.1016/j.ijdrr.2021.102626.

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

In addition, we were involved in the following reports:

1. Campbell, C., and Haegeli, P. (in press). Snow avalanches. Chapter in the BC Disaster Risk Reduction Pathway Project of NRCan. https://www.drrpathways.ca/.
2. Nadeau, M, Crowe, T., Atleo, C., Doyon, A, and Haegeli, P. (2021). HeliCat Canada Indigenous Engagement Toolkit – A Guide to Establishing and Maintaining Relationships with Indigenous Peoples. Report prepared for HeliCat Canada, p. 63.

2.4.2 Masters and PhD theses

Since May 1, 2021, three students completed their studies and published their Masters theses:

1. Fisher, K. (2021). How can avalanche bulletins be more useful for recreationists? Exploring three opportunities for improving communication of avalanche hazard information. M.R.M. thesis, 2021-08. School of Resource and Environmental Management. Simon Fraser University, Burnaby, B.C.
2. Morgan, A. (2021). A user perspective on the avalanche danger scale – Insights from North America. M.R.M. research project no. 778, 2021-12. School of Resource and Environmental Management. Simon Fraser University, Burnaby, B.C.
3. Hordowick, H. (2022). Understanding Avalanche Problem Assessments: A Concept Mapping Study with Public Avalanche Forecasters. M.R.M. thesis, 2022-04. School of Resource and Environmental Management. Simon Fraser University, Burnaby, B.C.

2.4.3 Publications in Community Journals

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

1. Haegeli, P. and SARP Research Team (2022). How precise do people think the aspect information is? The Avalanche Journal, 127, ??-??.

This article was also published in the Avalanche Review (TAR) of the American Avalanche Association.

2.4.4 Presentations at Academic Conferences

While COVID19 continued to prevent us from attending international conferences in person, we gave **three presentations** at the virtual 2021 Annual Meeting of the Society for Risk Analysis.

1. Goulet-Boucher, A., and Haegeli, P. (2021). Is social media helping skiers, snowmobilers and snowshoers to be safe from snow avalanches or is it getting them into troubles? Oral presentation at the virtual 2021 Annual Meeting of the Society for Risk Analysis, December 6-9, 2021.
2. Fisher, K., and Haegeli, P. (2021). Testing improvements to avalanche terrain exposure communication in daily hazard forecasts. Lightning talk presentation at the virtual 2021 Annual Meeting of the Society for Risk Analysis, December 6-9, 2021.
3. Haegeli, P., and Fisher, K. (2021). Enhancing the value of hazard communications with education interventions. Lightning talk presentation at the virtual 2021 Annual Meeting of the Society for Risk Analysis, December 6-9, 2021.

2.4.5 Technology Transfer

Over the last 12 months, core SARP members gave **11 online and in person technology transfer presentations** to avalanche safety practitioners in Canada, the United States and Europe. In total, an estimated 610 avalanche professionals were reached with these presentations (2,150 if each presentation is counted individually).

1. Horton, S., and Herla, F. (2022). Avalanche forecasting and SNOWPACK – Operational use and research in Canada. Oral presentation at the monthly online meeting of the Austrian Avalanche Association (OeGSL Semmelnar), April 26, 2022. (size of audience: approx. 100).
2. Hordowick, H, and Haegeli, P. (2021). Avalanche Problem Type Assessments. Online Parks Canada avalanche forecaster training. November 24, 2021 (size of audience: approx. 25).
3. Hordowick, H, and Haegeli, P. (2021). Avalanche Problem Type Assessments. Avalanche Canada avalanche forecaster training. November 16, 2021 (size of audience: approx. 35).
4. Goulet-Boucher, A., and Haegeli, P. (2021). Taking a look at recreationists use of social media and how it applies to decision making in avalanche terrain. Avalanche Canada avalanche forecaster training. November 16, 2021 (size of audience: approx. 35).

5. St Clair, A., Finn, H., and Haegeli, P. (2021). A framework for matching risk messages with user processes—Lessons from avalanche risk communication. Presentation at the Canadian Association for Wilderness Medicine 2021 online conference. Nov. 5-7, 2021. (size of audience: approx. 100).
6. Haegeli, P., and Walcher, M. (2021). Risk of death and major injury from natural hazards in mechanized backcountry skiing in Canada. Presentation at the Canadian Association for Wilderness Medicine 2021 online conference. Nov. 5-7, 2021. (size of audience: approx. 100).
7. Nowak, S. (2021). Interactive visualizations for avalanche hazard assessment. Virtual Spring Meeting of Canadian Avalanche Association. May 12, 2020 (size of audience: approx. 350).
8. Horton, S. (2021). Anticipating persistent problems in coastal areas – Lessons from operational snowpack modelling this season. Virtual Spring Meeting of Canadian Avalanche Association. May 12, 2020 (size of audience: approx. 350).
9. Goulet-Boucher, A., and Haegeli, P. (2021). Recreationists use of social media and how it applies to decision-making in avalanche terrain. Virtual Spring Meeting of Canadian Avalanche Association. May 12, 2020 (size of audience: approx. 350).
10. Fisher, K., and Haegeli, P. (2021). Insights into Travel and Terrain Advice. Virtual Spring Meeting of Canadian Avalanche Association. May 12, 2020 (size of audience: approx. 350).
11. Statham, G., and Sykes, J. (2021). Automated ATES mapping. Virtual Spring Meeting of Canadian Avalanche Association. May 12, 2020 (size of audience: approx. 350).

2.4.6 Research project development brainstorming

In anticipation of the end of the NSERC Industrial Research Chair, I hosted three online brainstorming sessions for industry representatives to discuss ideas for future research directions. I organized three separate sessions:

1. Research needs in public avalanche safety (May 25, 2021)
2. Research needs in mechanized skiing (Nov. 5, 2021)
3. Research needs in other professional avalanche safety contexts (Nov. 10, 2021)

Each of these sessions included approximately 8-12 industry representatives, and we used and online whiteboard to share and organize research ideas. The outcomes of these brainstorming sessions will be used as the foundation for future research proposals.

2.4.7 Public Outreach

COVID-19 also still made connecting with the public more challenging this year, but the online format of many public avalanche awareness events made it possible for us to attend without the need to travel. Over the last twelve months, core SARP members **participated in six public avalanche awareness events** reaching an estimated 1,350 recreationists (2,000 if each presentation is counted individually).

4. Haegeli, P., (2022). Forecaster chat with Pascal Haegeli: Could the avalanche forecast be more effective? Online, moderated by John Sykes. January 11, 2021 (size of audience: approx. 100)
5. Goulet-Boucher, A., and Haegeli, P. (2021). Taking a look at recreationists use of social media and how it applies to decision making in avalanche terrain. Virtual 2021 North Rockies Snow and Avalanche Workshop. November 11, 2021 (size of audience: approx. 200).
6. Haegeli, P., St. Clair, A., Finn, H., Fisher, K., and Morgan, A. (2021). How to make avalanche bulletins more effective Lessons from studying user practices. Eastern Snow and Avalanche Workshop. October 27, 2021 (size of audience: approx. 100).
7. Sykes, J. (2021). Automated Avalanche Terrain Exposure Scale Mapping. Invited presentation at the 2021 Wyoming Snow and Avalanche Workshop, Jackson Hole, WY, October 22-23, 2021. (size of audience: approx. 250).
8. Haegeli, P., and Fisher, K., (2021). Making it easier for the reader of our backcountry avalanche forecasts. Invited pre-recorded presentation at the 2021 Wyoming Snow and Avalanche Workshop, Jackson Hole, WY, October 22-23, 2021. (size of audience: approx. 250).
9. Goulet-Boucher, A., and Haegeli, P. (2021). Taking a look at recreationists use of social media and how it applies to decision making in avalanche terrain. Virtual 2021 Northwest Snow and Avalanche Workshop. October 17, 2021 (size of audience: approx. 350).
10. Goulet-Boucher, A., and Haegeli, P. (2021). Effect of social media on avalanche risk. Virtual 2021 Colorado Snow and Avalanche Workshop. October 14, 2021 (size of audience: approx. 350).
11. Herla, F., Horton, S., and Haegeli, P. (2021). Creating regional snowpack summaries from model simulations and starting a large-scale validation project. Virtual 2021 Colorado Snow and Avalanche Workshop. October 14, 2021 (size of audience: approx. 350).

We have also strengthened our outreach efforts by launching the **SARP Instagram channel** (https://www.instagram.com/sfu_avalancheresearch/). Thanks to Rosemary Langford for spearheading this initiative. Our goal is to use this channel to interact with the recreational and professional avalanche safety communities more actively.

2.5 University Teaching

I taught my course on **avalanche risk management** (REM427/627) for the second time in the spring term of 2022, and 14 students (11 undergraduate and 3 graduate students) completed the course. See http://www.avalancheresearch.ca/rem-427/ for a detailed overview of the course content.

I would like to thank Wren McElroy (6 Point Engineering), Julie McBride (BC MoTI), Niki LePage (Island Lake Lodge) and Ryan Harvey (Kicking Horse Mountain Resort) for acting as industry contacts for the final group project in the course.

To ensure that this course is up-to-date and contributes meaningfully to other education opportunities in the Canadian avalanche community (both recreational and industrial), I would like to have the course content reviewed by industry experts.

2.6 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; and
- Weekly group meetings where we discuss current avalanche conditions (if applicable only) and research papers on special topics.

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

2.7 Other Relevant Activities

2.7.1 Justice, Equity, Diversity and Inclusion (JEDI)

We continue our efforts to actively contribute to a more just, equitable, diverse and inclusive society. You can find our positionality statement with tangible action items on our website at https://www.avalancheresearch.ca/jedi/.

2.7.2 HCC Indigenous Engagement Toolkit

I had the pleasure to participate in the SFU research team that developed the Indigenous Engagement Toolkit for HeliCat Canada. The research team consisted of Moe Nadeau, Tyla Crowe, Dr. Andréanne Doyon, Dr. Cliff Atleo and me. The toolkit was presented to the HeliCat Canada membership during the remote fall AGM on Oct. 26, 2021.

2.7.3 CMH Terrain Knowledge Capture

We continue to support the terrain knowledge capture initiative of Canadian Mountain Holidays, which uses the questions of a ski run characterization survey we developed in 2019. This service is provided for a minimal fee to cover the cost associated with setting up and maintaining a dedicated survey instance for CMH.

2.8 Challenges

2.8.1 Work environment and mental health of students

While the direct impacts of COVID-19 on daily activities are becoming smaller, I feel that the pandemic has changed the research environment considerably with significant long-term consequences. With students returning home and working remotely, we have partially lost the

research group feel, and peer-support has become substantially more difficult. The remoteness has also made it more difficult to support students especially in the more challenging early and final stages of their research projects.

In addition, connecting with industry collaborators has become more difficult for obvious reasons, but I would like to rekindle these relationships again. At the same time, people's familiarity to Zoom/Teams has made it easier to connect with international collaborators and invite them to research group meetings.

While many factors contribute the mental health situation of students, the fact that I currently have three students affected by mental health challenges is having a considerable impact on the research program and makes me wonder about how to best re-establish and further enhance the support for students as we transition back into amore normal research environment.

2.8.2 Other Challenges

In my opinion, the main operational challenges for my program remain:

- Maintaining a continuous and meaningful connection with supporting organizations and practitioners to ensure the research we work on is meaningful to the community; and
- 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 is welcome.

3 Outlook for Next 12 Months

3.1 Context

The NSERC IRC will formally conclude on August 31, 2022, and with that, the existing funding commitments with Canadian industry partners are coming to an end as well. However, I have sufficient funding left from savings to continue the IRC research projects for another year, and NSERC has approved a no-cost extension until August 31, 2023.

Informal conversations with most existing industry partners have indicated that they are satisfied with the research program and are interested in continuing their support. However, these commitments will have to be formalized over the next 12 months. While NSERC has cancelled the IRC funding program, there are other opportunities to get industry funding matched, such as NSERC Alliance and MITACS. While these program might require a little bit more administration, they are potentially more scalable and allow the research program to be more flexible.

3.2 Personnel

We will have three new team members join the SARP team in the fall of 2022:

- Griffin Slimkowitch (Masters student; REM project stream)
- Kelsea Krawetz (Masters student; REM thesis stream)
- Eeva Latosuo (PhD student)

While Griffin will be working on a smaller project in public avalanche risk communication that has not been defined yet, Kelsea and Eeva are joining the program for specific projects that have been funded already. Kelsea will be examining the effect of improve precipitation forecasts on our snowpack model simulations (SAR-NIF project in collaboration with Environment and Climate Change Canada and University of Sherbrooke), and Eeva Latosuo will be conducting avalanche risk communication research funded by the Colorado Avalanche Information Center.

3.3 Priorities

The main focus for the next twelve months is to complete the research of Industrial Research Chair Program and further develop the public avalanche risk communication research. We have several applied research publications in the pipeline that need to be published in a timely fashion. In addition, I would like to continue the conversation with industry partners about possible research directions beyond the current funding commitments and the end of the Industrial Research Chair.

3.3.1 Research

- Develop snowpack modelling research agenda with Avalanche Canada
- Continue existing research projects with John, Florian, and Stan.
- Publish ATES research with John.
- Finalize PhD research proposals with Anne.
- Publish the research results of Henry, Abby, Amelie and Heather in academic journals.
- Complete MRM thesis projects with Rosie and Anneliese.
- Write a position paper on how to more effectively conduct social science research in support of public avalanche safety.
- Analyze first avalanche bulletin user survey for Euregio and Swiss Avalanche Warning Service and design survey for next winter.
- Design avalanche bulletin user study framework for Colorado Avalanche Information Center.
- Building on our bulletin user research in Europe and Colorado, establish an equivalent research panel for continuous bulletin user research in Canada.

3.3.2 Funding

- Collaboratively establish research priorities and funding possibilities with Canadian industry partners beyond the existing commitments (end date: August 2022) and the NSERC Industrial Research Chair (extended end date: August 2023).
- Explore possibilities for other NSERC and SSHRC funding opportunities

3.3.3 Outreach

- Attend the 2022 IGS International Symposium on Snow (September 2022) and the 2022 Annual Meeting of the Society for Risk Analysis (December 2022).
- Continue to build a research network outside of traditional avalanche research fields within SFU (e.g., big data, visualization) and beyond (e.g., risk communication).

- Further strengthen public outreach with brief research videos on social media, practical resources on the 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.

3.3.4 Student Training

- Once appropriate again, 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.

3.3.5 Anticipated Challenges

- With the NSERC IRC concluding at the end of August, my teaching and administrative responsibilities at the university will increase. My teaching load will change from 1.5 courses per year to 3 courses per year. Furthermore, I am currently chairing the resource and environmental management undergraduate programs at SFU, which means that my administrative duties at the university have increases significantly.

4 Questions

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