Nechako IRC NEWSLETTER

March 2023 | Volume 5 Issue 1

NSERC/Rio Tinto Industrial Research Chair

"To better understand and quantify the roles of climate variability, climate change, and water management on the long-term water security of the Nechako Watershed."

CONTENTS

Winter reflections

In this issue of the Nechako IRC newsletter you will find updates from the current team of researchers. We continue to make progress on many fronts including preparations for the upcoming summer field season that promises to be exceptionally busy.

Anemometer at Ness Lake weather station

Happy Equinox everyone!

An introduction from the project leader

Nechako River at Cottonwood Park in Prince George

Despite a rather slow start to the winter snowpack accumulation, recent snowfalls in northern BC are bringing snowpack levels back to near normal. Indeed, a 3-day storm in January brought at least 30 cm of fresh snow in the Prince George area while another in mid-February dumped nearly 20 cm. As of 9 March 2023, snowpacks are at 99% of normal in the upper Nechako and at 124% in the upper Fraser West (Stuart River Basin) based on data from the BC River Forecast Centre.

These above to average snowpack levels presage a moderate risk for flooding during the spring freshet, depending on how fast the snow melts and whether the season will be relatively wet or dry. The recent warming of tropical sea-surface temperatures in the Pacific Ocean suggest the long-lasting La Niña event is coming to an end. The American National Oceanographic and Atmospheric Administration's Climate Prediction Centre is anticipating a transition to El Niño/Southern Oscillation (ENSO) neutral conditions in spring 2023 and the possible emergence of El Niño later in the year. If so, then this could lead to warmer and drier conditions than normal across the Nechako Watershed.

On behalf of the NSERC/Rio Tinto IRC team at UNBC, I wish everyone a very pleasant and productive spring season! By early May, our team will be out across the Nechako visiting field sites for data collection and equipment maintenance. We therefore hope to see many of you during the warm (and busy) season!

Stephen Déry

Stephen Déry

The Team

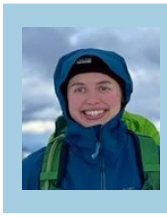
Industrial Research Chair Members from the Northern Hydrometeorology Group

Stephen Déry

Project Leader

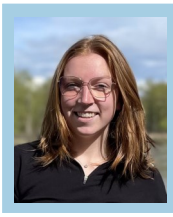
Justin Kokoszka

Research/Data Manager
Outreach Coordinator
M.Sc. Candidate



Kirsten Calder-Sutt

Hydrometeorological Technician



Jade Reynolds

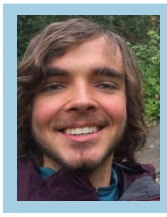
Research Skills Trainee
Data Administrator

Laura-Anne Browning

Research Skills Trainee

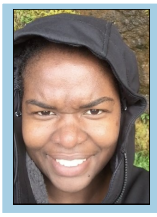
Dylan Broeke

Undergraduate Research Assistant



Spencer Woyke

Undergraduate student



Tamar Richards-Thomas

Research Skills Trainee

Jingwen Wu

Postdoctoral Fellow

Bruno Sobral

Ph.D. Candidate

Farewell to Dr. Lilhare:

We sincerely thank Dr. Rajtantra Lilhare, whose contract as a part-time post-doctoral fellow ends in early spring. Dr. Lilhare has been instrumental in developing historical reconstructions of the hydrology of the Nechako Watershed using the Variable Infiltration Capacity (VIC) model. This is leading to an extensive database of land surface and hydrological conditions for the Nechako Watershed spanning 1950 to present. All the best to Dr. Lilhare in his future endeavors and sincere thanks for your accomplishments over the past couple of years as a key member of the IRC team at UNBC!

Rajantra Lilhare

Research Chair Update

Investigating Water Temperature in the Nechako

Stream temperature sensor

In a collaborative effort, I continue to explore how stream temperatures evolve across the Nechako in response to extreme hydrometeorological events like the 2021 early summer heat dome and the 2022 late summer dry spell. As an example, Figure 1 illustrates the 2022 daily mean water temperatures for four Water Survey of Canada gauging sites: the Fraser River at Shelley, the Stuart River at Fort St. James, and the Nechako River in Vanderhoof and Isle Pierre. Comparing the 2022 water temperatures (red lines) to their respective climatologies (black lines) reveals the below average conditions in spring and early 2022.

Indeed, the spring and early summer of 2022 was cool and wet, leading to relatively cool water temperatures. In contrast, the remainder of the summer and early fall of 2022 was relatively warm and dry. By mid-July, water temperatures reached above normal values and remained in that state well into the fall. By late September and early October, water temperature anomalies were +3 to +4°C above average, reflecting the cumulative effects of the warm, dry fall experienced in northern BC.

Quite unfortunately, a dozen old white sturgeons perished during August 2022. The grey shading in the bottom right panel highlights the period during which the old white sturgeons were found along the banks of the Nechako downstream of Isle Pierre. This corresponds to a period of above average water temperatures in the Nechako River, which could be a potential factor affecting their health. While this may only be coincidence, it does illustrate the dire need to continue monitoring closely environmental conditions including water temperatures across the Nechako Watershed.

Stephen Déry

"Indeed, the spring and early summer of 2022 was cool and wet, leading to relatively cool water temperatures. In contrast, the remainder of the summer and early fall of 2022 was relatively warm and dry. By mid-July, water temperatures reached above normal values and remained in that state well into the fall. By late September and early October, water temperature anomalies were +3 to +4°C above average, reflecting the cumulative effects of the warm, dry fall experienced in northern BC"

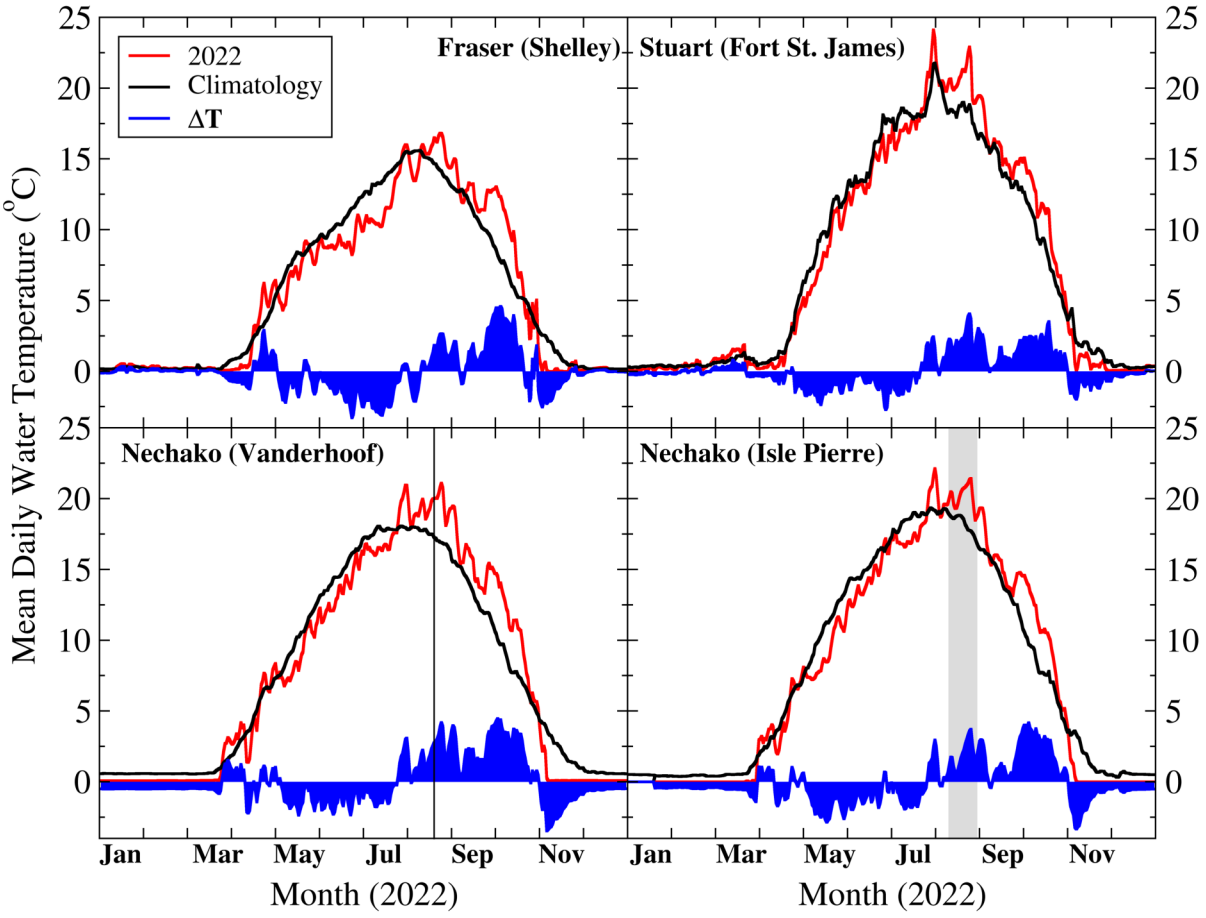


Figure 1: Mean daily water temperatures during 2022 (red lines) versus climatological values (black lines) at four Water Survey of Canada gauging sites in north-central BC. Also shown is the difference (**ΔT**) between the 2022 and climatological values (blue lines) with the baseline set to zero. When **ΔT** is greater than zero, then water temperatures in 2022 were above average, and vice versa. The vertical black line in the bottom left panel marks the end of the Summer Temperature Management Project (20 August) and the grey shading in the bottom right panel denotes the period during which a dozen old white sturgeons perished along the shores of the Nechako River downstream of Isle Pierre.

Research/Data Manager Update

Field work organization, standardization, and data management

Winter has been going well as our team prepares for the busy field season ahead. This summer we hope to complete an extensive inventory of our field equipment, standardize our loggers, and ensure we have complete and up to date technical records for all of our stations. This effort will ensure that all of our field equipment is catered to our growing database.

Jade, Kirsten, and I have been working together to plan our 2023 summer field season. Jade's past field experience has been an asset during this process especially during our equipment testing phase; which is nearly complete. Kirsten has been working diligently to sort out budgets and logistics for our summer field campaign. Additionally, Kirsten has been planning for our new field campaign to monitor extreme weather events across northern BC, i.e. MECHE (Monitoring Extreme Climate and Meteorological Events).

Both Jade and I have been creating and testing our new database field forms to enhance and simplify the collection of data in the field. Laura-Anne Brown and Dylan Broeke have been testing and inventorying equipment using our new inventory and equipment test forms which have been useful in keeping our records standardized and organized.

Since the beginning of February, Jade and I have been compiling, standardizing, and uploading our historical data into our updated database using MS Access software. Our efforts have led to the complete compilation of stream temperature records from 2019 to 2022 as well as meteorological records that date back to 2006.

Following our data compilation phase, Jade and I will be performing a standardized quality assurance procedure on our data to ensure a consistent procedure for checking the quality of our data. We hope to have these data submitted to the Nechako Watershed Portal and available to the public by the end of April. In the meantime, Jade is completing uploads of our current monitoring locations within the Nechako Basin for the Nechako Portal.

Lastly, I have been engaging with the Nechako Portal team to assist with development of learning modules regarding the Nechako Watershed. My contribution has been centered on providing insight on technical data within the watershed as well as providing data collected by the NHG.

Justin Kokoszka

New Members

We welcome three new members to the IRC team!

Ness Lake weather station

Jade Reynolds

We are pleased to also announce the return of Jade Reynolds to the IRC team this winter. Jade was one of our summer field technicians during 2022 and after a 2-month break to complete her bachelor's degree at UNBC, returned to the NHG.

Jade graduated from UNBC in December with her Bachelor of Science in Biology and as of February 1st, accepted the role of Research Skills Trainee to continue her work with the NHG in data management and environmental monitoring.

For the winter months, her focus will be on data entry, working with Justin on the database, and equipment testing, working with Kirsten to ensure all new equipment is up and running for the numerous deployments for this summer. Once the snow melts, she will also be focusing on site visits, as she did last summer, and new deployments around northern BC. With over 40 sites plus new deployments, Jade imagines this summer will be very busy and adventurous. She's very excited to have the opportunity to work with the NHG again and can't wait to see what this season brings!

Jade Reynolds

Dylan Broeke will be graduating in April 2023 with a BSc of Physical Geography from UNBC. I have grown up outside, in the mountains, and in my workshop. As I came to UNBC from the Sunshine Coast in Southern BC, UNBC's sense of community and the proximity to the outdoors compelled me.

After working through different courses and field schools focusing on weather, geology, soils, mountains, and hydrology, I am excited to continue my experiential learning working through the NHG. I will be working as a field technician for the NHG building and maintaining weather and stream temperature stations, collecting data, compiling equipment inventory, and much more. I am looking forward to working with the NHG and the knowledge and experience this can bring me.

Dylan Broeke

Dylan Broeke

Dylan Broeke has joined the NHG as an Undergraduate Research Assistant. Dylan will be assisting with the summer 2023 field season as well as our new MECHE program. Welcome Dylan!

Laura-Anne Browning

We welcome Laura-Anne Browning as our newest Research Skills Trainee. In addition to assisting with summer 2023 field work, Laura-Anne will also be compiling a technical report on past and current stream temperature monitoring efforts across the Nechako Watershed.

Laura-Anne will graduate with a B.Sc. in biology at the University of Northern British Columbia in May 2023. During her degree, Laura-Anne completed an undergraduate thesis with the Insect Ecology Lab at UNBC, where she gained extensive research and field work experience while completing her own project and working as a research assistant with other students.

During her time with the NHG, Laura-Anne will be responsible for assembling and organizing information on water temperature monitoring efforts in the Nechako Watershed into a technical report and performing other water temperature data analysis. Other responsibilities include organizing meteorological equipment and assisting in site visits to water temperature loggers and CAMnet weather stations during the summer period.

Laura-Anne Browning

Field Work

Preparation, planning, and testing!

Kirsten Calder-Sutt

Winter's close draws nearer and nearer, and the NHG has been growing and shifting gears in preparation for the warm season ahead. Considering our multi-talented team and the amount of preparation going into our field work this summer, I am quite confident we are setting ourselves up for a very successful field season.

Equipment testing

We have received a great deal of new equipment which must be inventoried and tested prior to being deployed. Recently, Jade, Dylan, Laura-Anne and I have been inventorying and testing equipment and ensure it is field-ready using our new inventory and equipment testing protocols.

Field work planning

This spring and summer, our team will deploy 2-3 new weather stations and make visits to all of our stream temperature monitoring sites and weather stations across the Nechako Basin. Before the season begins, our field team will participate in Swiftwater and First Aid training. We now have a tentative field itinerary (thanks, Jade!) and equipment is being prepared for individual sites. I am currently finalizing the purchase of a new field truck for our team, which will be very helpful in carrying out our summer plans.

MECHE preparation

Preparations for MECHE (Monitoring Extreme Climate and Hydrometeorological Events) are well underway. We have been busy working on the equipment set-up and logistics including several meetings with our project collaborators at the Université du Québec à Montréal (UQAM), who are offering specialized training for equipment at the end of March.

Nechako Research

Explore some of our research!

12 - Streamflow and Climate Change

Postdoctoral fellow, Jingwen Wu, explores changes in daily streamflow across the Nechako Reservoir due to future climate conditions.

14 - Atmospheric Rivers

PhD candidate Bruno Sobral discusses the important role atmospheric rivers play in replenishing water resources across the Nechako Watershed.

16- Winter Streamflow

MSc student Justin Kokoszka presents a comparison of this year's winter streamflow against averaged winter flows for regulated and naturalized conditions.

18 - TRARE Research

Undergraduate student, Spencer Woyke, presents preliminary findings for his undergraduate thesis that utilized data collected during our Tahtsa Ranges Atmospheric River Experiment (TRARE) campaign from 2021.

19 - Spring snowfall

Research Skills Trainee, Tamar Richards-Thomas, explores snowfall conditions in Prince George during the month of February.

Streamflow and Climate Change

Assessing the impacts of climate change on streamflow in the Nechako River Basin

Streamflow refers to the amount of water that flows in a river or stream over a specific period of time. It is an important measure of water availability and plays a crucial role in the environment, economy, and human life. According to data from Environment and Climate Change Canada, climate change is expected to cause changes in temperature and precipitation patterns in the Nechako River basin. These impacts are expected to continue and intensify in the coming years, which could ultimately affect the inflow of water into the reservoir. The Nechako Reservoir is an important source of water for downstream communities and industries, including agriculture and mining, and is also a critical component of the Kemano hydroelectric facility, which generates electricity, primarily for the Rio Tinto aluminum smelter in Kemano, BC. Therefore, understanding how climate change will affect the hydrology of the basin is critical for predicting future water availability in the reservoir, the amount of electricity that can be generated from the facility and also have significant impacts on fish populations and the ecological health of the reservoir.

In this section, we will be exploring the changes in daily streamflow across the Nechako Reservoir from 1981 to 2010, as well as the projected future changes from 2041 to 2070 and 2071 to 2100. To conduct this analysis, we generated historical and projected future streamflow data from VIC (Variable Infiltration Capacity) hydrological model. The results clearly demonstrate that there are two peak flows during all historical and future periods, one in the summer and the other in the winter. However, we observed a reduction in the amount of summer peak flow over time, while the winter peak flow increased (as shown in Figure 1). This trend can be attributed to future warming, which causes an increase in temperature during spring, leading to earlier snowmelt and subsequently, a decrease in summer peak flow. On the other hand, the increased winter temperature results in a shift from snowfall to rainfall, causing the peak flow during winter to increase. Moreover, we also observed a shift in the timing of the summer peak flow, occurring one month earlier for the first thirty years (2041-2070) and two months earlier for the second thirty years (2071-2100). Overall, our result could provide valuable insights and information for managing water resources, developing flood and drought management plans, and improving the efficiency of water resource utilization in response to hydrological changes.

Jingwen Wu

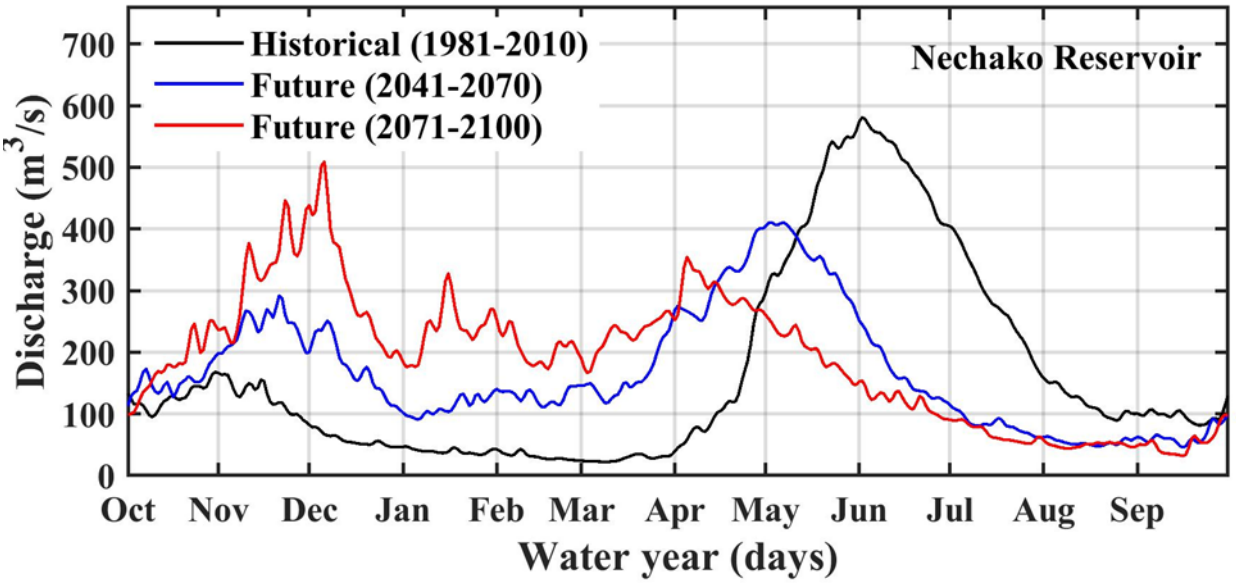


Figure 1 Historical (1981-2010) and future (2041-2070 & 2071-2100) daily streamflow changes across the Nechako Reservoir

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"We observed a reduction in the amount of summer peak flow over time, while the winter peak flow increased…attributed to future warming, which causes an increase in temperature during spring, leading to earlier snowmelt and subsequently, a decrease in summer peak flow...increased winter temperature results in a shift from snowfall to rainfall, causing the peak flow during winter to increase. "

Atmospheric Rivers

Investigating the Impact of Atmospheric Rivers on Hydroclimate Variables in the Nechako River Basin

In this edition of the IRC Newsletter, I want to share some results of my research at UNBC on the impact of atmospheric rivers (ARs) on the hydroclimate of the Nechako River Basin (NRB). ARs play a crucial role in shaping the region's precipitation patterns, bringing much-needed water resources but also leading to natural hazards such as flooding and landslides. Despite their benefits of water replenishment, the relationship between ARs and precipitation can be complex in regions of mountainous terrain.

During my studies, I encountered several complexities when trying to estimate the contribution of ARs to the hydroclimate of the NRB. Working with data in different time scales, I had to adapt two existing databases, the six-hourly AR Catalogue data of Gershunov et al. (2017) and the hourly data of the ERA5-Land product (Muñoz-Sabater et al., 2021), into a daily scale. The new daily scale associated AR events of different intensities (counted in AR days) with total precipitation, rain, snow and snow water equivalent (SWE). This approach enabled me to estimate the daily contribution of ARs to these climate variables in each sub-basin of the NRB.

The results of my data analysis from 1950 to 2021 on the impact of ARs on the hydroclimate of the NRB reveal the significant influence of ARs on the region. The analysis found that ARs accounted for 21-25% of the annual precipitation totals in the westernmost sub-basins of the NRB, with nearly one-third of the rain in the Upper Nechako and Stellako being attributed to ARs. Nearly 20% of the snow in the Upper Nechako and Upper Stuart is linked to ARs, while SWE linked to ARs is higher in the Upper Stuart. A northwest-to-southeast reduction pattern in the contribution of ARs is observed across all variables, including snow and snow water equivalent.

The easternmost sub-basin, the Chilako, is the least affected by ARs. Rain totals are more influenced by ARs than other variables due to high AR activity in the fall when temperatures are often above freezing. Interestingly, during fall, nearly half of the rainfall is attributed to ARs, whereas only 24% is attributed to snowfall. These preliminary results highlight the crucial role that ARs play in shaping the hydroclimate of the NRB and emphasize the importance of understanding the relationship between ARs and the hydrological cycle in Western Canadian watersheds.

Bruno Sobral

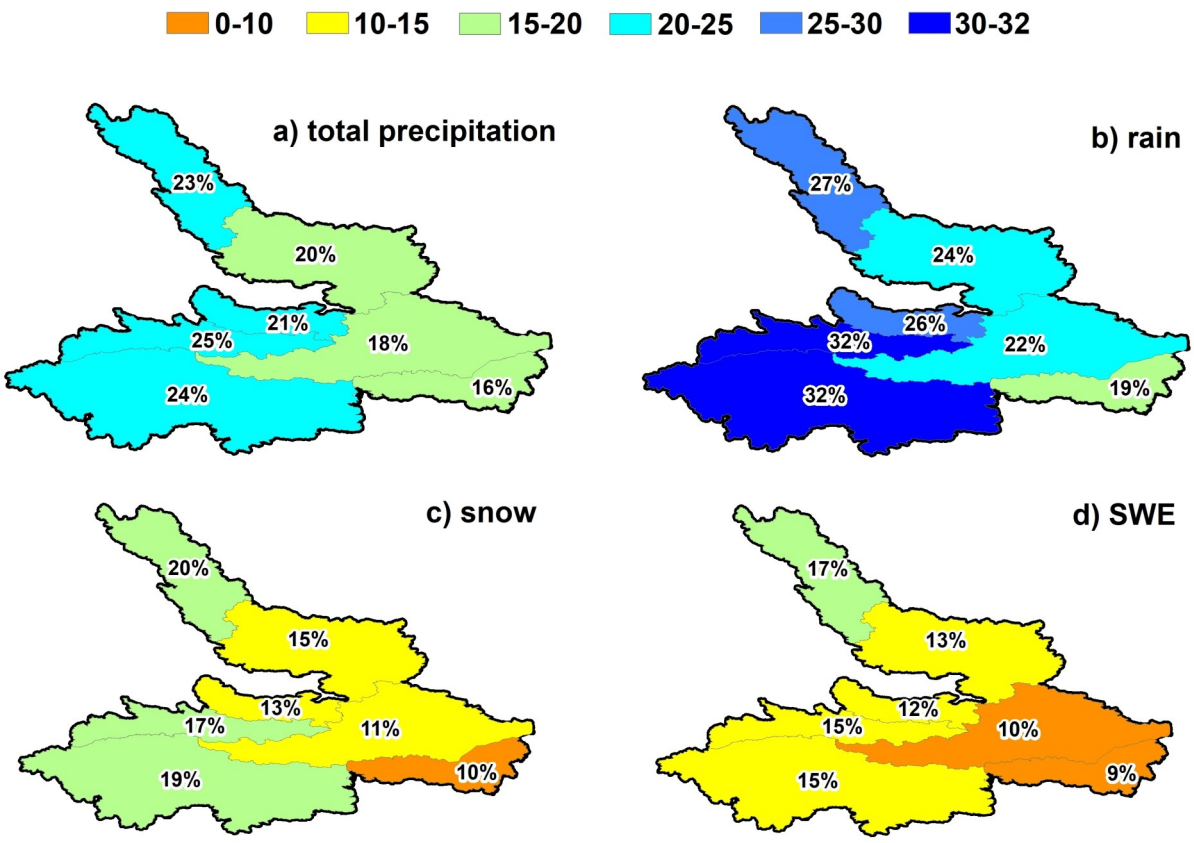

Figure 1 – Annual AR-related percentual contribution to different climate variables in the NRB

"Nearly 20% of the snow in the Upper Nechako and Upper Stuart is linked to Atmospheric Rivers, while Snow Water Equivalent linked to Atmospheric Rivers is higher in the Upper Stuart."

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Winter Streamflow

A comparison of winter streamflow at Vanderhoof

In this section, I investigate streamflow for the 2022-23 winter season (Dec—Feb) by comparing streamflow with the 30-year average (1980-2020) for both regulated and naturalized streamflow along the Nechako River at Vanderhoof.

Naturalized streamflow (streamflow without regulation) at Vanderhoof was estimated by routing reservoir inflow data downstream while adding flow from unregulated tributaries (Terrier et al., 2020). Flow contribution from missing drainage areas were corrected for by using a multiplier. Streamflow data were obtained from the Water Survey of Canada and reservoir inflow data were provided by Rio Tinto. It is important to note that this naturalization technique does not account for additional factors including, agriculture, deforestation, and wildfires; all of which can influence streamflow. However, this method provides a unique opportunity to investigate the influence of both regulation and recent meteorological conditions on streamflow in the Nechako River Basin.

Results for the analysis are depicted in figure 1 where we can see the distribution of streamflow magnitudes for averaged regulated and naturalized conditions at Vanderhoof, as well as flows from the 2022-23 winter season (Dec-Feb). The median for during this winter season at Vanderhoof (36.8 m^3/s) was 24% lower than the regulated average (45.4 m^3/s) and 36.7% lower than the naturalized average (113.6 m^3/s). These results suggest that both climate and regulation have contributed to decreased winter flows this year. We can see that regulated winter flows have exhibited much less variability compared to those for the naturalized record. This makes sense as water is stored and diverted at the reservoir, leaving much less opportunity for variable flow rates downstream. Streamflow for this winter season exhibited significantly less variation compared to both the regulated and naturalized conditions. This may be the result of the relatively dry fall/winter conditions as well as the sustained cool air temperatures experienced in the Nechako Basin this winter.

Lastly, the minimum and maximum flows for this winter season were 44.4 m^3/s and 35.2 m^3/s, respectively, which are well within the average range but remain on the lower end of the average regulated condition between 45.4 m^3/s and 127.0 m^3/s. Again, this may be the result of the cool and dry conditions seen over the past fall and winter. Furthermore, winter flows at Vanderhoof fall below the averaged range for the naturalized condition between 48.7 m^3/s and 321.0 m^3/s. This suggests that both local climate conditions as well as regulation have led to relatively low flow conditions at Vanderhoof this winter.

With an already decreased streamflow due to regulation, this analysis shows the compounding effects that local climate conditions may have on streamflow. As part of my graduate thesis work I aim to investigate these influences individually in order to better understand how regulation, climate change, and climate variability influence streamflow both individually and together.

I hope that this research will provide a unique insight to help manage water resources within the Nechako River Basin. Stay tuned for our next newsletter where I will compare streamflow conditions in the Nechako for the upcoming spring season!

Justin Kokoszka

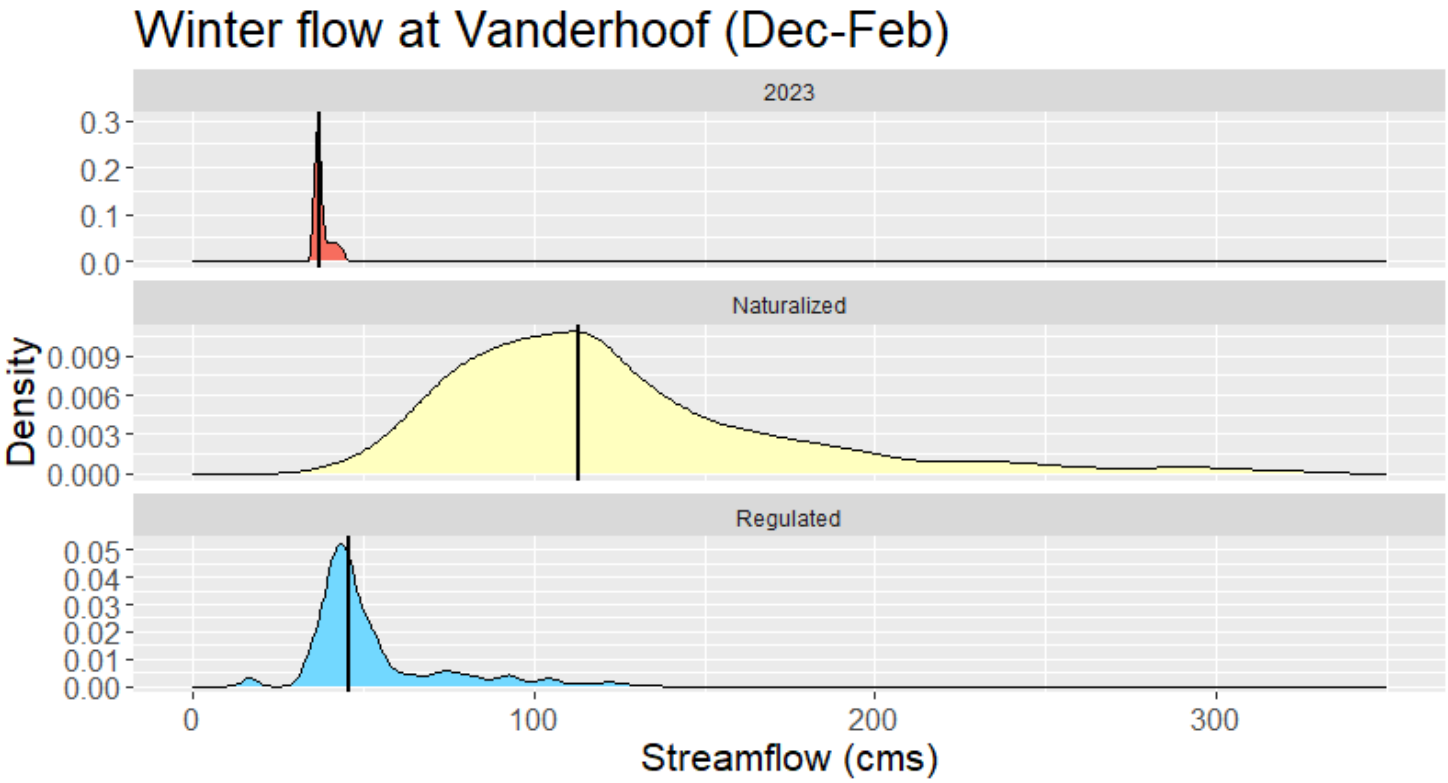

Figure 1 – Density plot showing the distribution of winter streamflow (Dec-Jan) for the Nechako River at Vanderhoof over three conditional time frames: this years winter season (regulated; 2023), averaged winter flow for naturalized conditions (1980-2020), and averaged winter flows for regulated conditions (1980-2020). Median values are indicated by the vertical black lines.

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Terrier, M., Perrin, C., de Lavenne, A., Andréassian, V., Lerat, J., Vaze, J., 2021. Streamflow naturalization methods: a review. Hydrological Sciences Journal 66, 12–36.

TRARE Research

An undergraduate thesis project

Over the past two semesters, I have been working on an undergraduate thesis that concerns the hydrometeorological impacts of atmospheric rivers (ARs) on the upper Nechako Watershed using data from sites involved in the TRARE field campaign. I have looked into three research topics associated with three storm events recorded during TRARE for my thesis: precipitation advection, precipitation types (at the surface and aloft), and hydrological responses (i.e. stream temperature and water level changes).

Here I will speak on my findings on the hydrological responses at Rhine Creek and Whiting Creek associated with the three storm events. As observed in Figure 1, a water level increase of 400 mm occurred during the first storm event (labelled as Event 3), while minor water level increases occurred during the other two events (Events 5 and 10). This result suggests that flooding of headwater streams is possible in the upper Nechako Watershed, which implicates the potential of mass wasting events in this region.

Spencer Woyke

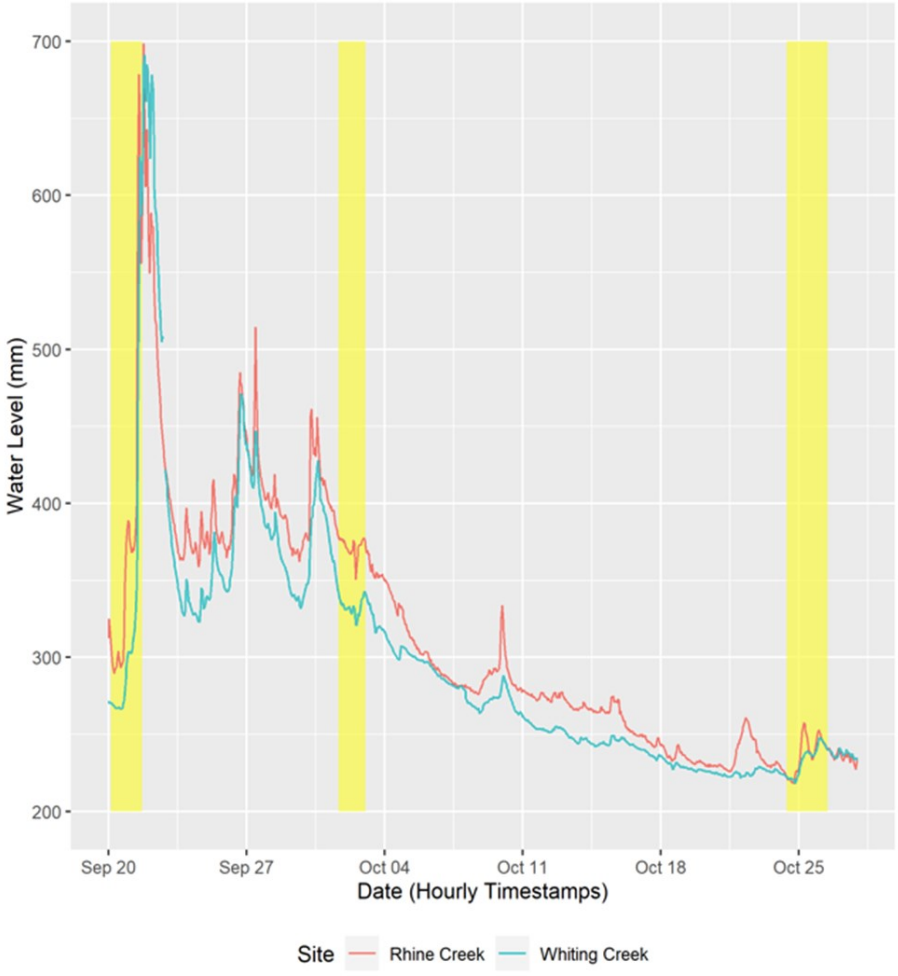


Figure 1. Hourly mean water levels at Rhine Creek and Whiting Creek over the duration of the TRARE field campaign. Yellow highlights indicate periods of AR events (in the order of Event 3, 5, and 10 from left to right).

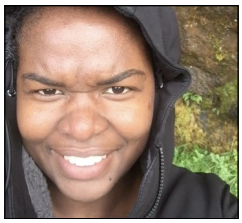
Snowfall

A snowy February in Prince George

Prince George typically receives approximately 30 cm of precipitation as snowfall in February. However, in February 2023, this amount doubled to 60.2 cm, with snowfall occurring on 20 - 21 February (Figure 1b) and 25 February (figure 1b). This increase in snowfall was influenced by a moist air mass from the Pacific that collided with a cold front from the north, triggering a winter storm warning for our local region.

A sharp peak in the total precipitation of 12 to 14 mm on 20 February 2023 (Figure 1b), and 8 mm to 15 mm on 25 February 2023 (Figure 1b), although mean temperature of at and above (approximately 0.4 ° C) 0 °C was recorded on 20 February for the three Environment Climate Change Canada (ECCC; Figure 1) stations. This increase in temperature led to a sharp decrease in temperature as low as -26.2 °C on 24 February that rose to a maximum of -12.8 °C on 25 February without the effects of windchill (Figure 1a).

The total precipitation reported on the days of the snowfall is up to an order of magnitude greater than those reported on the days before the snowfall. The quantity of total precipitation, either as rainfall or snowfall, was not provided by EC. These usual increase in total precipitation (e.g., snowfall) as compared with those reported over long periods for the region has gained the attention of the Northern hydrometeorology Group (NHG).



Tamar Richards

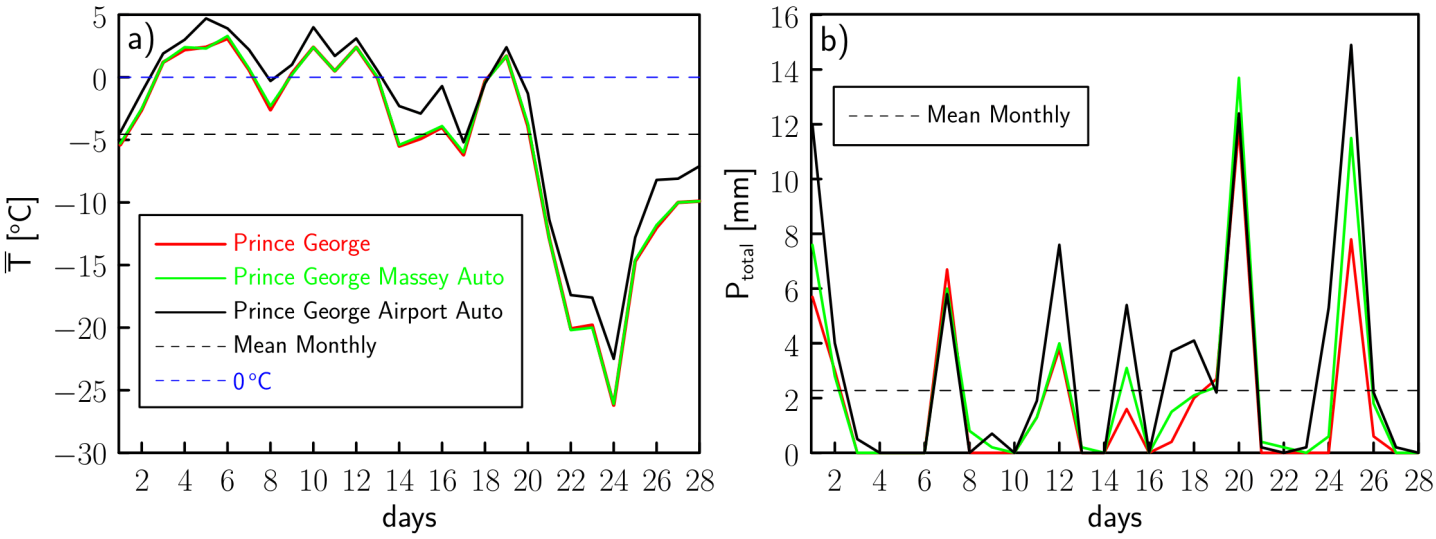


Figure 1: The daily a) temperature and b) total precipitation recorded over the month of February 2023 for Environment Climate Change Canada stations, Prince George (ID 1096439, red solid), Prince George Massey Auto (ID 1096454, green solid), and Prince George Airport Auto (ID 1096454, black solid).

Outreach

Communicating our findings through various means continues to be a top priority!

Climate Science Informal Seminar

On 16 February 2023, Stephen delivered a talk entitled "Nechako Watershed stream temperature monitoring and research, 2019-2023" as part of the Climate Science Informal Seminar series at UNBC supported by both the Canadian Meteorological and Oceanographic Society and the Pacific Institute for Climate Solutions. YouTube link here.

BC Interior & Yukon Centre - Nechako Watershed Stream Temperature Monitoring & Research, 2019-2023

Integrated Watershed Research Group

Stephen presented an overview of recent research on the theme of climate change and water security during an event organized by UNBC's Integrated Watershed Research Group on 1 March 2023.

As part of this event, members of the IRC team (Bruno, Jade, Jingwen, Justin, Kirsten, and Tamar) held a "Trivia Night in the Nechako" during a breakout session that followed the main presentations. Sincere thanks to all of you who joined us for this informative session on the ongoing research at UNBC.

Water Engagement Initiative

As of early December 2022, Stephen has been able to attend meetings of the Water Engagement Initiative's Technical Working Group and participated in the Main Table meetings held on 7-8 March 2023.

Media Interviews

Jan 5 2022 was the fifth driest year on record in Prince George, CKPG News

Jan 10 The unusually dry year of 2022 in Prince George and across northern BC, Prince George Post.

Check out our website! "https://web.unbc.ca/~sdery/irc"

Contact Information

UNBC IRC Research Program, 3333 University Way, Prince George, BC V2N 4Z9
Phone: 250-960-5193
Email: irc@unbc.ca