December 2023

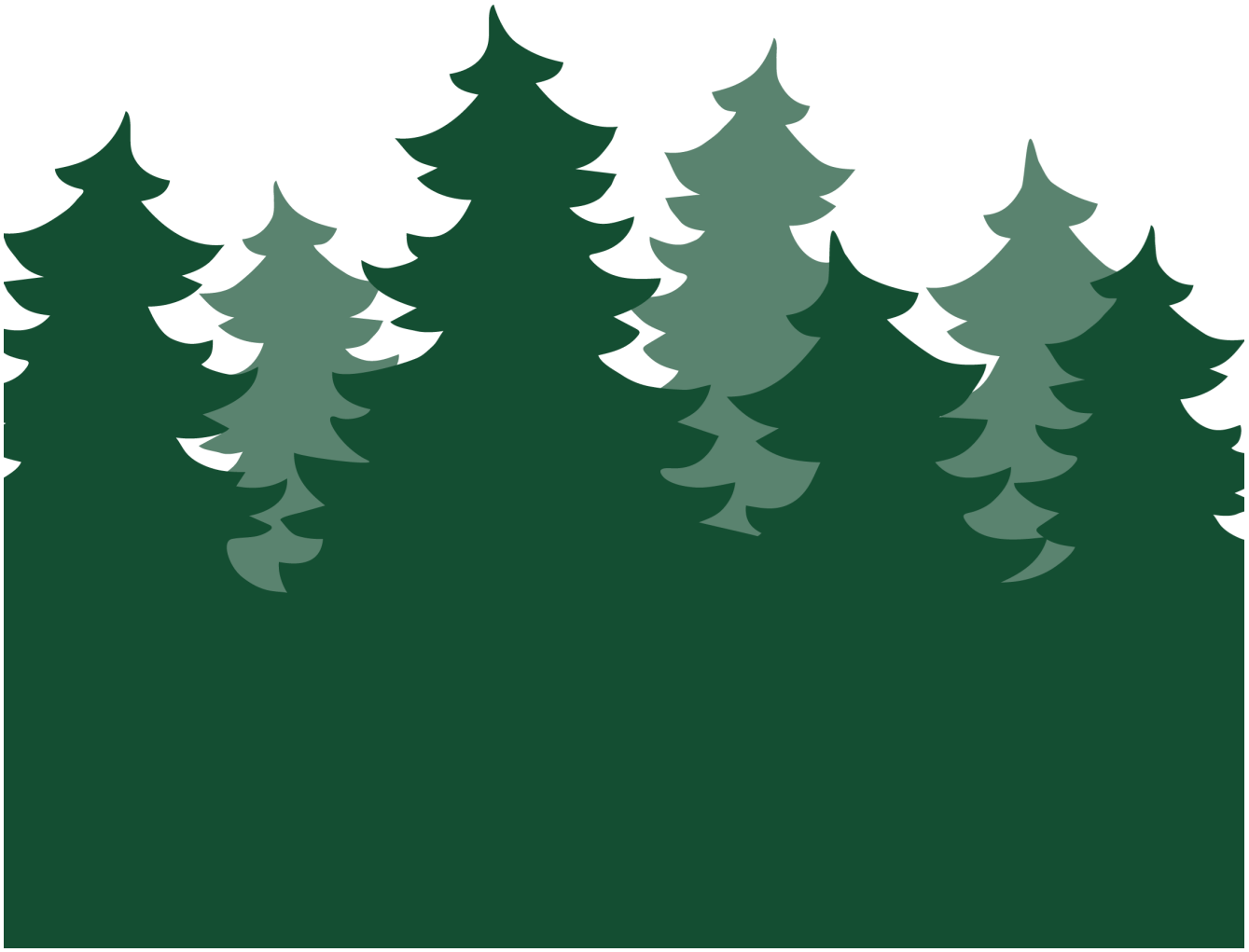
Volume 5 - Issue 4

Nechako IRC NEWSLETTER

Territorial Acknowledgement

Working on traditional First Nations territories in a scientific context is a humbling privilege, and we deeply appreciate it. Collaborating with Indigenous communities enriches scientific understanding and promotes mutual respect and cultural exchange. We are thankful for the trust and partnership extended to us and approach this work with utmost gratitude and responsibility. We acknowledge that our research and work take place within the unceded traditional lands of the following First Nations:

- *Binche Whut'en*
- *Cheslatta* Carrier Nation
- Lake Babine Nation
- *Lheildli T'enneh*
- *Nadleh-Whut'en*
- *Nak'azdli Whut'en*
- *Nee-Tahi-Buhn* Indian Band
- *Saik'uz*
- *Skin Tyee* Band
- *Stellat'en*
- *Takla* Lake
- *Tl'azt'en*
- *Ts'il Kaz Koh* (Burns Lake) Band
- *Wet'suwet'en* First Nation
- *Yekooche* First Nation



CONTENT

Season's Greetings from the NHG! In this holiday edition, check out the latest news from the Northern Hydrometeorology Group (NHG). After a busy summer in the field, our research team also had a productive fall. Flip through to find our newest discoveries on the unceded lands of the Nechako River Basin.

Season's Greetings and Happy Holidays!

Stephen Déry

The end of the fall 2023 semester is fast approaching, meaning that the winter Holiday Season is just around the corner! This past fall was relatively warm and dry yet again, leading to persistent drought conditions in northern BC including the Nechako Watershed. Indeed, since 1 January to 30 November 2023, the Environment and Climate Change Canada weather station at the Prince George Airport has reported only 57% of the precipitation relative to normals. The drought conditions have contributed to exceptionally low water levels in the region's lakes and rivers, with detrimental impacts to ecosystems.

In this month's issue of the Nechako IRC Newsletter, MSc student Justin Kokoszka explores the Nechako River's low water levels this autumn relative to historical conditions. Research Skills Trainee Tamar Richards-Thomas provides an update on the warm, dry conditions in October that led to the low water levels. PhD candidate Bruno Sobral discusses an exceptional atmospheric river event from 2009 that affected the Nechako Watershed. Field Crew Leader Dylan Broeke and Hydrometeorological Technician Kirsten Calder-Sutt provide an update on fall season field activities including the retrieval of water temperature and meteorological data at our many field sites. Finally, MSc student Meng Wang provides a brief summary of his Master's research project that he is embarking on.

As highlighted in the last newsletter, the IRC team saw a transition of personnel in late summer. There has been no new additions to the team this fall, but we are pleased to retain and renew several team members' position. After holding a position as undergraduate student research assistant this past summer, Dylan Broeke has transitioned to a Field Crew Leader position with additional responsibilities that he will retain through 2024. Kirsten Calder-Sutt's position as Research Associate / Hydrometeorological Technician has also been renewed for one year, while Justin Kokoszka has transitioned to part-time Project Manager as he nears the completion of his Master's degree. Finally, we have also renewed the part-time Research Skills Trainee position for Tamar Richards-Thomas until the end of March 2024. Recruitment of two summer field technicians will proceed during the winter to ensure the team is ready for field activities in early May 2024.

The IRC team continues its outreach and communication efforts through various platforms and forums. I participated in Rio Tinto's Water Engagement Initiative during the fall, remaining active in both the Technical Working Group and Main Table meetings. On November 7th, Bruno and I participated in the fall meeting of the Nechako Watershed Roundtable during which we presented an update on our research along with colleagues from UNBC's Integrated Watershed Research Group. Furthermore, I continue interacting with regional media on recent weather conditions and climate change in the Nechako Watershed.

From 18 to 25 November, I had the opportunity to travel to Quebec City and Saguenay to meet several collaborators. Of note, I visited Rio Tinto's team of hydrologists to discuss their operations in the Nechako Watershed including weather and hydrological forecasting. I also had the unique opportunity to visit the Shipshaw generating station on the Saguenay River. Finally, additional meetings with collaborators from the Institut National de Recherche Scientifique and École de Technologie Supérieure led to further planning of a new project focusing on thermal refugia in the Nechako River.

The NSERC/Rio Tinto IRC team thanks members of the many communities across the Nechako Watershed and beyond that fully supported our research and field activities in 2023.

We wish everyone very Happy Holidays, and may 2024 bring you joy, peace, prosperity and good health!

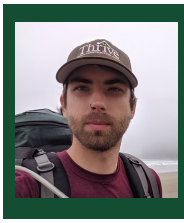
Nechako River at Pulpmill
Photo: Dylan Broeke

The Team

Industrial Research Chair members of the NHG

Stephen Déry

Project Leader

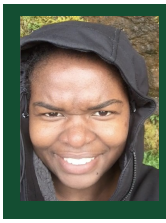


Justin Kokoszka

Project Manager
M.Sc. Candidate

Kirsten Calder-Sutt

Hydrometeorological Technician



Tamar Richards-Thomas

Research Skills Trainee

Dylan Broeke

Field Crew Leader

Meng Wang

M.Sc. student

Bruno Sobral

Research Manager
Ph.D. Candidate

Research Chair Update

Stephen Déry

Water Budget for the Nechako Reservoir

In the last issue of the Nechako IRC Newsletter, I introduced the concept of the water budget for the Nechako Reservoir. The water budget refers to all inputs and outputs of water within a watershed or a body of water such as the Nechako Reservoir, plus any changes in storage. For the Nechako Reservoir, the main inputs of water are inflows from rivers and creeks (90%) and net precipitation (10%), which represents the difference between precipitation onto, and evaporation from, the reservoir. The main outputs from the reservoir are water releases at the Skins Lake Spillway (39%) and water turbined at the Kemano Powerhouse (61%). Long-term changes in storage are relatively insignificant compared to all other terms in the water budget.

The IRC team continues to explore ways to quantify the Nechako Reservoir's water budget including through hydrological modelling and through analysis of observational and reanalysis hydroclimatic data. The results presented here use the latter approach by applying observational data from Rio Tinto and Water Survey of Canada in addition to a reanalysis of the global land surface climate from the European Centre for Medium-Range Weather Forecasts (ERA5-Land). By using these datasets, we are able to construct the daily net precipitation, inflows to, and outflows from, and change in storage of the Nechako Reservoir from 1955 to 2021 (Figure 1).

Looking at Figure 1, a first observation we can make is that the net precipitation (**blue curve**) onto the reservoir is an order of magnitude smaller than the inflows and outflows. Net precipitation exhibits strong seasonality, with peak values during autumn and winter, with a diminished influence in spring and summer. From mid-July to mid-September, net precipitation is often negative, implying that evaporation from the reservoir exceeds precipitation on those days.

Inflows (**black curve**) to the Nechako Reservoir also exhibit strong seasonality, with low flows during winter and early spring as snow continues to accumulate across the reservoir's catchment area. As air temperatures rise above freezing in the spring, inflows increase rapidly, leading to a peak inflow of 570 $m^3 s^{-1}$ on 7 June. This is the so-called spring freshet observed in many snow-dominated rivers of northern British Columbia. Inflows then diminish quickly to a secondary minimum in late September. Thereafter, autumn rainstorms yield a secondary peak in flows during early November before the onset of lower flows in late fall and winter.

In contrast to the inflows to the Nechako Reservoir, outflows (**red curve**) show only modest seasonality given these represent flows at two points of regulation. As the BC Works aluminum smelter in Kitimat operates on a continuous basis 365 days a year, its consumption of hydropower from the Kemano Powerhouse is nearly constant across the year, reflecting the high outflows across all seasons. Outflows increase in the spring as excess water is at times released from the Skins Lake Spillway to minimize downstream flooding and to prevent the Nechako Reservoir from exceeding full capacity.

Peak outflows occur from mid-July to mid-August when the Summer Temperature Management Program (STMP) is implemented. During the STMP, additional water is released at the Skins Lake Spillway to limit daily water temperatures to 20°C or less on the Nechako River at Finmoore (just upstream of the confluence with the Stuart River). Following the STMP, outflows diminish to values typically observed in autumn and winter at about 175 m^3 s^{-1}.

Finally, the daily change in storage (**orange curve**) reflects the sum of all other water budget terms. When negative, this implies a net loss of water from the Nechako Reservoir, while a positive value indicates a net gain of water in the Nechako Reservoir. The change in storage therefore reflects the seasonality of all other water budget terms, being positive from late April to mid-July, and otherwise negative. Thus the net increase in storage occurs during the spring freshet while losses occur throughout the remainder of the year. While the change in storage generally does not equal zero on a daily basis, across a longer period of time (e.g., one year) it approaches zero.

Figure 1 illustrates only the mean daily water budget terms for the Nechako Reservoir from 1955 to 2021. In a future issue of the Nechako IRC Newsletter, we will explore how the water budget terms are evolving in response to climate change and changes in water management in the upper Nechako Watershed.

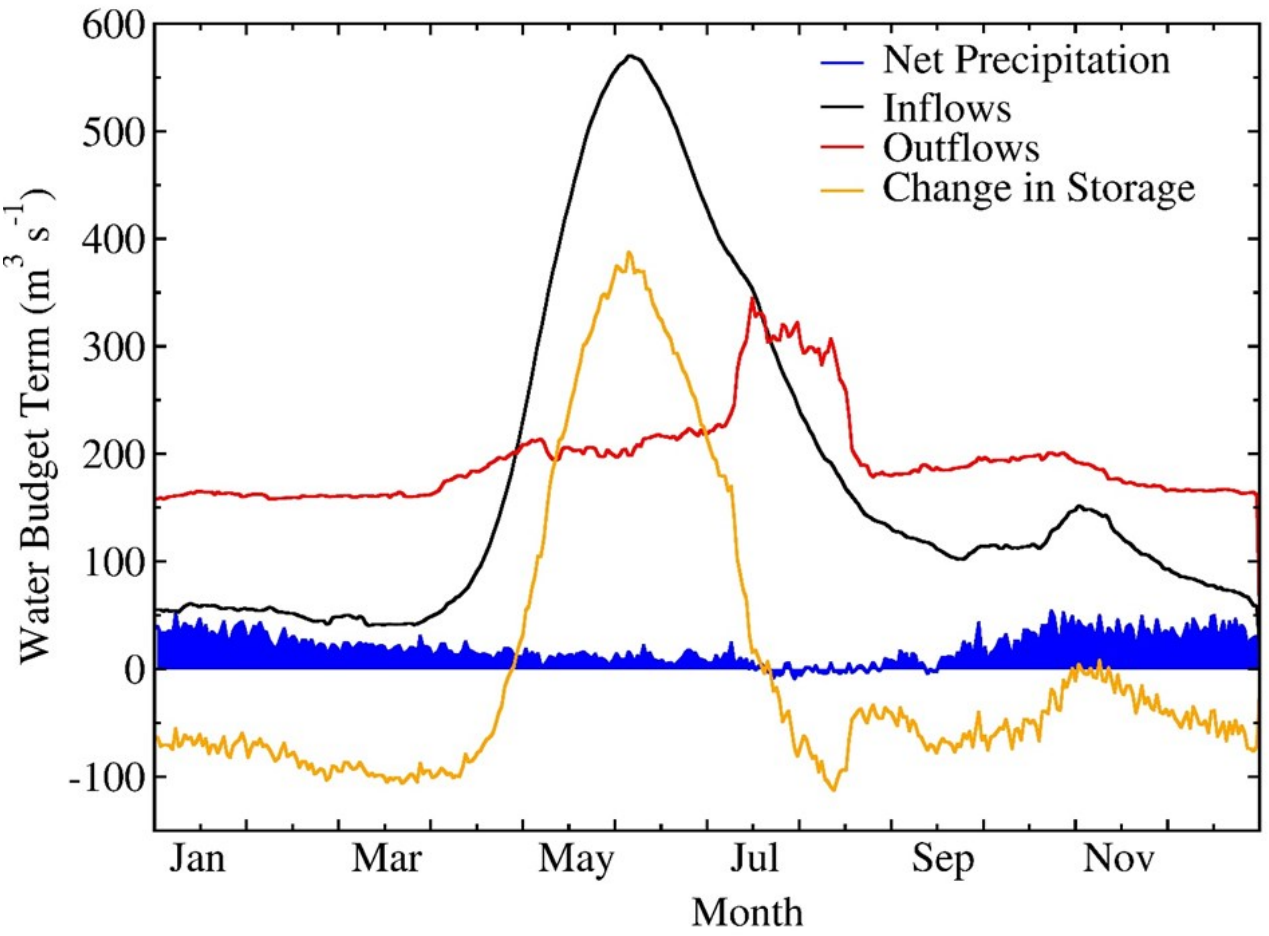


Figure 1- Mean daily water budget terms (in units of cubic meters per second, m^3 s^{-1}) for the Nechako Reservoir, 1955-2021. Positive values of net precipitation indicate that precipitation exceeds evaporation on that day, while negative values imply that evaporation from the reservoir exceeds precipitation on that day. Positive values of a change in storage indicate a net gain of water by the Nechako Reservoir, while negative values reflect a net loss of water from the reservoir .

Research Manager Update

Bruno Sobral

Dear Colleagues,

In this issue of the newsletter, I will provide an update on the main activities of the NHG over the past three months, as we have been actively working to enhance our research operations. There was considerable interest in our research, and improving stakeholder communication through publications, interviews, meetings, and roundtables has been a focus, ensuring transparency and timely updates on our ongoing research. Also, supporting new graduate students has been rewarding. We recognize the value they bring to our group, and supporting their initial stages of research facilitates integration into the UNBC environment.

In late November, the NHG successfully delivered another presentation to the Scientific Advisory Board (SAB) of IRC. Group preparations for the meeting included creating concise materials outlining our research progress and plans, and questions were answered during the meeting to clarify employed methods and presented results. We thank the SAB members for their insightful contributions to the group's research.

Internally, we are also implementing MS Teams and SharePoint channels to improve communication, file sharing, and efficiency within the team. Our lab and warehouse received a well-deserved clean-up and look tidy for the winter season, as our team anticipates lots of indoor work focusing on data quality assurance and control (QAQC) and input to our new NHG climate database coming up soon. Thanks to Kirsten and Dylan for their outstanding efforts in organizing our NHG spaces at UNBC.

There has been increasing collaboration between the NHG and Nechako Portal personnel to enhance portal functionalities, focusing on optimizing data flow among research groups and uploading climate data. Data security remains a priority, and the team is working on new regular data backup protocols to cope with recent changes in UNBC's data storage policies. Recent NHG team discussions have also included new ideas on how to restructure our online archive for better accessibility and smooth access by all. I appreciate everyone's hard work in the NHG and look forward to moving our projects further in Winter 2024!

Fall 2023 field work

Kirsten Calder-Sutt

The past couple of months have been exceptionally full of work trips far and near. From deploying new stream temperature (ST) systems locally to doing road trips as far as Terrace, the field work was full of surprises, obstacles, and cold weather. With just Dylan and Kirsten remaining to complete this work, it has definitely been a push to the end. Despite the extended field season (ending November 2), we were lucky enough to escape the snow for every trip except for the final day.

Over the month of October, two new systems were deployed locally on the Nechako riprap that allow the logger to slide down inside a PVC pipe instead of having the logger system get stuck under the riprap once thrown into the river. This system was deployed at two Nechako ST sites around Prince George, where two cinderblocks holding our previous enclosures were stuck and out of reach.

Dylan Broeke

Our final site visit of 2023, a re-visit to our Cheslatta Lake weather station, was a wild drive through an incoming snowstorm. Despite the quickly accumulating snow, we were able to connect with the station and upload new code to have the data stored correctly. This too came with complications as naturally, the prepared code decided not to work with all the sensors, so adjustments had to be made in the field. Next time, we will bring an umbrella!

This marks the end to one of the longest field seasons to date, with trips ranging from the end of April to early November. The season was not short on its complications: destruction by curious grizzly bears, a widespread and impactful wildfire season, and incredibly low stream levels were just a few of the issues we faced. Regardless, with a little patience and a great deal of troubleshooting, we were able to work our way through all of the challenges we encountered. Most every station under the NHG has now been visited and/or built this season.

Figure 2 - OTT Parsivel Disdrometer set up at Terrace. Photo: Dylan Broeke

We are now turning our attention to the onerous task of compiling and entering all of our hard-earned data, both recent and historical, into our up-and-coming database. This will be followed by conducting quality assurance and control (QAQC) of the data. Another major task on our list is preparation for next season, including the development of our first-ever official set of field training modules. Our hope is that these modules will enable a smoother transition for next year's field staff and ensure a comprehensive transfer of knowledge for future iterations of the NHG!

MECHE Observatory

What is MECHE?

The overarching goal of MECHE (Monitoring Extreme Climate and Hydrometeorological Events) is to better quantify and comprehend extreme climate and weather events in western Canada. This goal is to be accomplished by setting up a variety of specialized meteorological equipment across two primary sites and analyzing the resulting data.

Fall 2023: At the end of October, we travelled back to Terrace to deploy one final piece of MECHE equipment at the UNBC Northwest campus. We successfully deployed an OTT Parsivel Disdrometer, which is now officially collecting data! The task of achieving a daily feed of data from our Terrace MECHE site is ongoing, but we are working closely with the UNBC ITS team to get this up and running over the winter. We also aim to add automation to several steps of our data download and back-up process, which will involve further collaboration with UQAM.

We are proud of our 2023 successes with the MECHE Observatory, and we look forward to seeing how this project continues to unfold in 2024!

Figure 3 - Field Crew Leader, Dylan Broeke, showing the new ST system he developed and deployed at Nechako at Miworth.
Photo: Kirsten Calder-Sutt.

Figure 4 - Weather station at Terrace
Photo: Kirsten Calder-Sutt.

Nechako Research

13 - Notable AR Event

PhD candidate Bruno Sobral highlights notable atmospheric river conditions that impacted the Nechako in late October 2009

Research Skills Trainee, Tamar Richards-Thomas, explores the warm temperatures in Prince George over the 2023 Thanksgiving weekend

15 - Warm temperatures in Prince George

16 - 2023 Fall streamflow

MSc student Justin Kokoszka analyses fall of 2023 streamflow compared to historical measurements

MSc student Meng Wang shows how he is setting up research questions to study the stream temperatures in the Nechako Watershed

17 - Nechako Watershed Water Temperature

Ness Lake, BC
Photo: Stephen Déry

Notable AR event in 2009

Bruno Sobral

In this edition, I will briefly present another interesting Atmospheric River (AR) event, which will be an important component of Chapter 4 in my PhD dissertation. Chapter 4 will analyze three distinct notable AR events within the Nechako Watershed, focusing on their climate variability and spatial impacts. Using ERA5 data, the assessment is centered on the AR event that occurred from October 27-31, 2009.

During this AR event, the west side of the Nechako registered a substantial total precipitation of approximately 146 mm, with the peak intensity occurring on October 29. Using accumulation maps for average water vapour column and integrated water vapour transport, denoted as (a) and (b) respectively, the event exhibited a typical southwesterly orientation, mirroring the prevalent AR shape pattern that frequently makes landfall in British Columbia. Maps (c), (d), and (e) delineate convergence, total precipitation, and snowfall totals for the AR event. By correlating total precipitation (d) with temperatures (f in ◦C), the snowfall map reveals precipitation predominantly in the coast mountains of the Nechako.

The greatest precipitation totals occurred just southwest of the Nechako, where the elevated Coast Mountains acted not only as an orographic barrier but also contributed to cooling the air, diminishing its capacity to retain water vapour, resulting in precipitation. This impact is seen in the runoff map (h – in mm), amplified by the rocky coastal system with limited water absorption capacity, intensifying high-peak flows. Notably, the discharge in the Kemano River (station 08FE003) surged from 62 to 594 m^3/s within only 24 hours, from October 29-30, validating the AR's potential to induce flash floods.

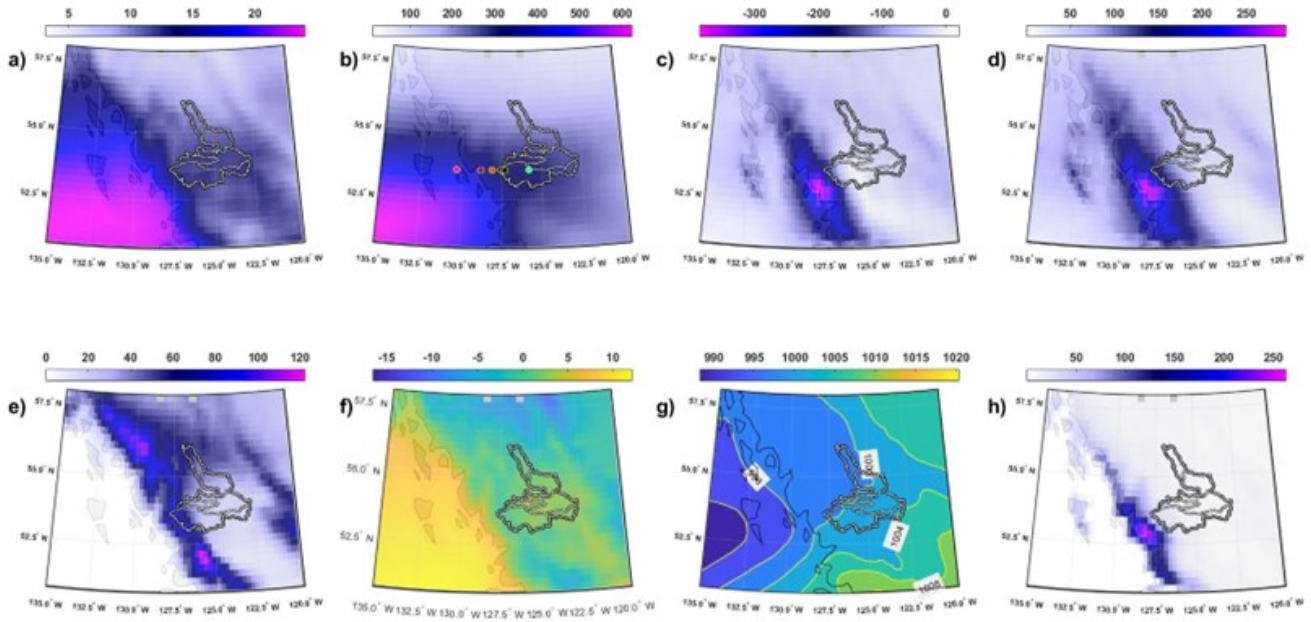


Figure 5: Climogram of the 2009 AR event with (a) average total column of water vapour (mm), (b) average integrated water vapour transport (IVT), c) accumulated convergence (negative values) (mm), d) accumulated precipitation (mm), e) accumulated snow (mm), f) average 2-metre temperature (°C), g) mean sea-level pressure during peak of convergence and h) accumulated runoff.

ERA5 data reveal that the western side of the Nechako Reservoir received ~34 mm of accumulated precipitation on October 29 and ~38 mm on October 30. At Whitesail Creek (station 08JA029), flow escalated from 0.04 to 0.5 m^3/s between October 29 and 30, representing a more than 12-fold increase in just 24 hours. Furthermore, data from Whitesail Creek also indicate an interruption of recording after registering 0.54 m^3/s on October 31, suggesting potential malfunction due to escalating high flows caused by the AR. Close to the Nechako, at the Nadina Lake outlet (station 08JB008), discharge experienced a significant surge from 1.24 to 7.9 m^3/s in 48 hours, a sixfold increase. Map g (in hPa) illustrates that during the convergence peak, the Nechako found itself in the middle of an atmospheric pressure gradient, with the most affected areas closer to the low of the system (west in the map).

This noteworthy AR event's climatological analysis will be further expanded in Chapter 4, along with two other events, incorporating additional resources to depict and characterize the events on spatial and temporal scales. Through the examination of significant AR events like this, we aim to enhance the understanding of their profound impact on the Nechako and their contribution to the water resiliency of the watershed.

A warm Thanksgiving in Prince George

Tamar Richards-Thomas

The City of Prince George experienced a record-breaking Thanksgiving weekend on the 7 – 8 October 2023, according to the measured air temperatures provided by Environment and Climate Change Canada at Prince George Airport Auto station (Figure 1). The air temperature rose to a maximum of 22.6 °C and 22.5 °C on Saturday (7 October) and Sunday (8 October), respectively. The air temperatures recorded on Saturday and Sunday broke over a decade long record (2010) of 21.4 °C and an eight decade long record (1943) of 21.7 °C, respectively.

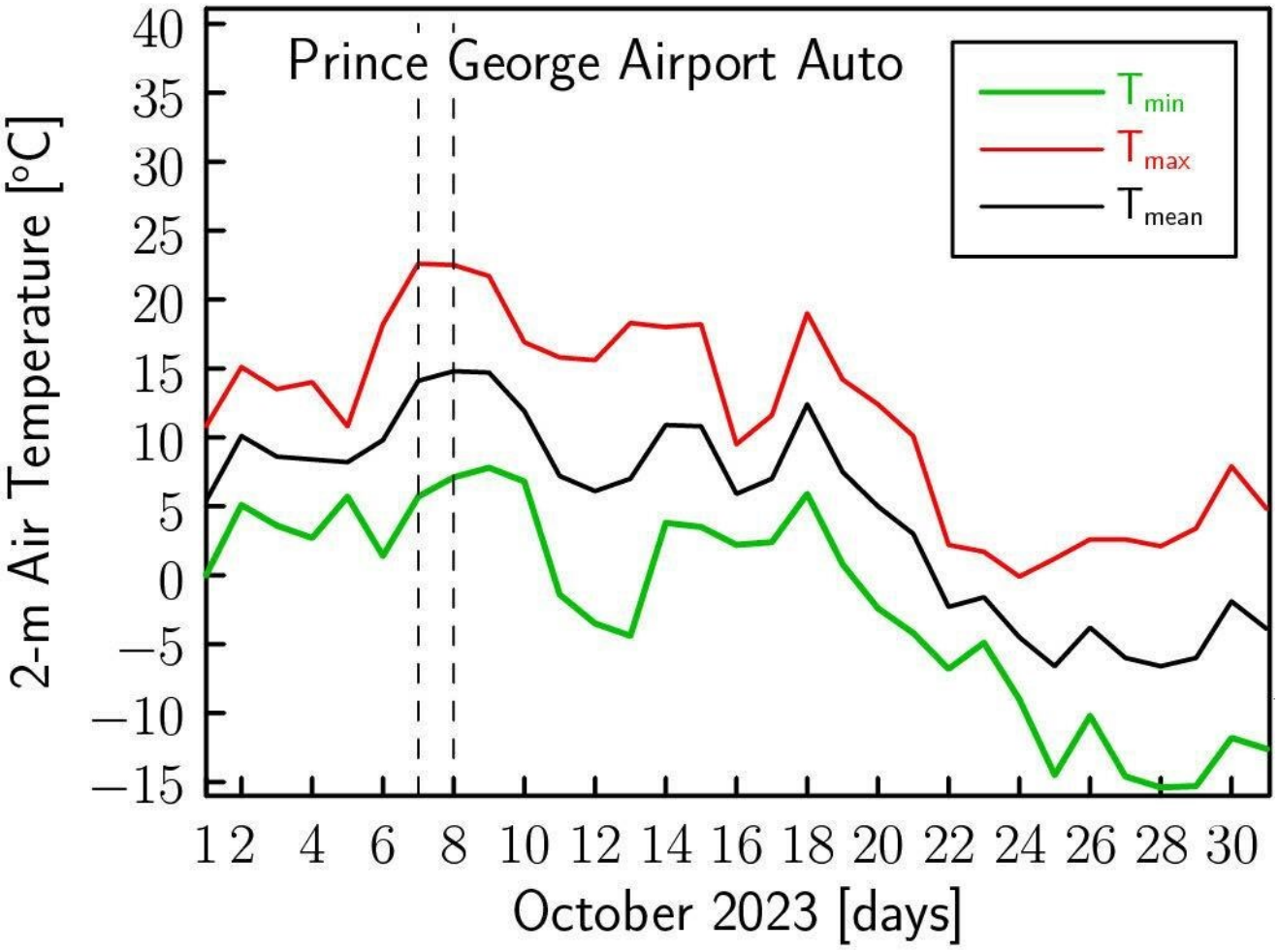


Figure 6: The daily max (Tmax), min (Tmin) and mean (Tmean) temperatures recorded at Prince George Airport Auto in October 2023.

Autumn Flows in the Nechako

A review of seasonal flow conditions

Justin Kokoszka

Our investigation of autumn streamflow for the Nechako River at Vanderhoof for 2023, compared to historical data from 1955-2022, gains additional relevance in the context of current hydroclimatic cycles. Notably, we are currently in the warm phase of the Pacific Decadal Oscillation (PDO), coupled with the occurrence of an El Niño (ENSO) year. These two phenomena are usually associated with warmer and drier conditions across British Columbia (BC) and are likely interacting to amplify the current drought conditions across the province and within the Nechako River Basin (NRB; Figure 1). In 2023, the median daily streamflow was observed at 53.9 cubic metres per second (m^3s^{-1}), a significant decrease from the long-term average of 108.5 m^3s^{-1}. This reduction is a critical indicator of how regional hydrological systems may be influenced by these larger climatic cycles.

This analysis also reveals how seasonal patterns might become altered when PDO and ENSO are in-phase. Typically, there is a slight increase in streamflow during the autumn season due to seasonal storms. However, this expected pattern was subdued in 2023. Furthermore, the total flow during the autumn season showed a decrease to 0.45 cubic kilometres (ckm) in 2023, compared to the norm of 0.85 ckm. This, along with a 47% decrease in average daily change in water volume, underscores the impact of the current drought conditions, a likely result of the combined effects of the warm PDO phase and El Niño conditions.

Understanding the interplay between climate change and the phases of PDO and ENSO is crucial in interpreting changes in streamflow. This investigation emphasizes the need for continued study of climate variability in conjunction with climate change and their combined effects on hydrological systems. It also highlights the importance of integrating knowledge about natural climatic cycles with our observations of changing climate patterns and human impacts within the NRB. Such comprehensive understanding is vital for developing effective water management strategies as well as preparation for future climatic uncertainties, ensuring a balance between the resilience of ecosystems and human water use.

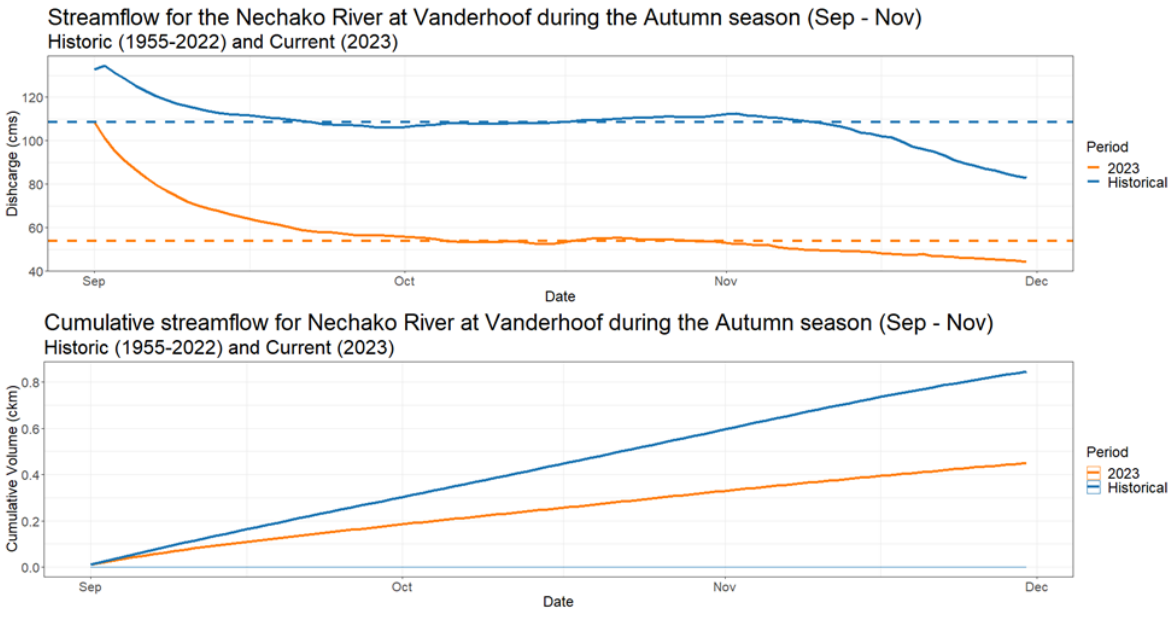
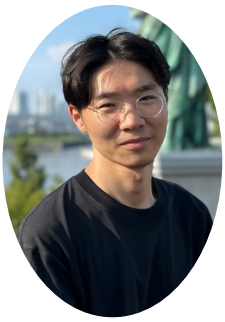


Figure 7: Streamflow (top) and cumulative volume (bottom) for Vanderhoof during the 2023 autumn season (Sep to Nov) and historical seasonal average (1955 - 2022). Seasonal median flows are indicated by the dashed-lines. Flow and volume are scaled in cubic metres per second (m^3s^{-1}) and cubic kilometers (ckm), respectively.

Setting up research questions to study stream temperatures in the Nechako Watershed



Meng Wang

For my study on the Nechako watershed, I plan to concentrate on an in-depth analysis of basic data for each stream within the watershed. This includes a comprehensive assessment of key statistical metrics such as average, standard deviations, maximum and minimum values, and other relevant parameters. By compiling and analyzing these fundamental statistics, my objective is to develop a detailed profile for each stream, identifying unique characteristics and trends. This analysis is crucial in understanding the overall water temperature systems in the Nechako watershed and forms the foundation of my research.

In addition to the basic data analysis, my research will extend to an in-depth study of the diurnal patterns across various time spans within the Nechako watershed. The goal of this aspect of the study is to closely observe and comprehend the changes in environmental parameters throughout the day, as well as over distinct time periods. This investigation into diurnal patterns is aimed at gaining a deeper understanding of the dynamic responses and adaptations of the streams to the daily and seasonal environmental change. This part of the analysis will also enhance understanding of the whole system.

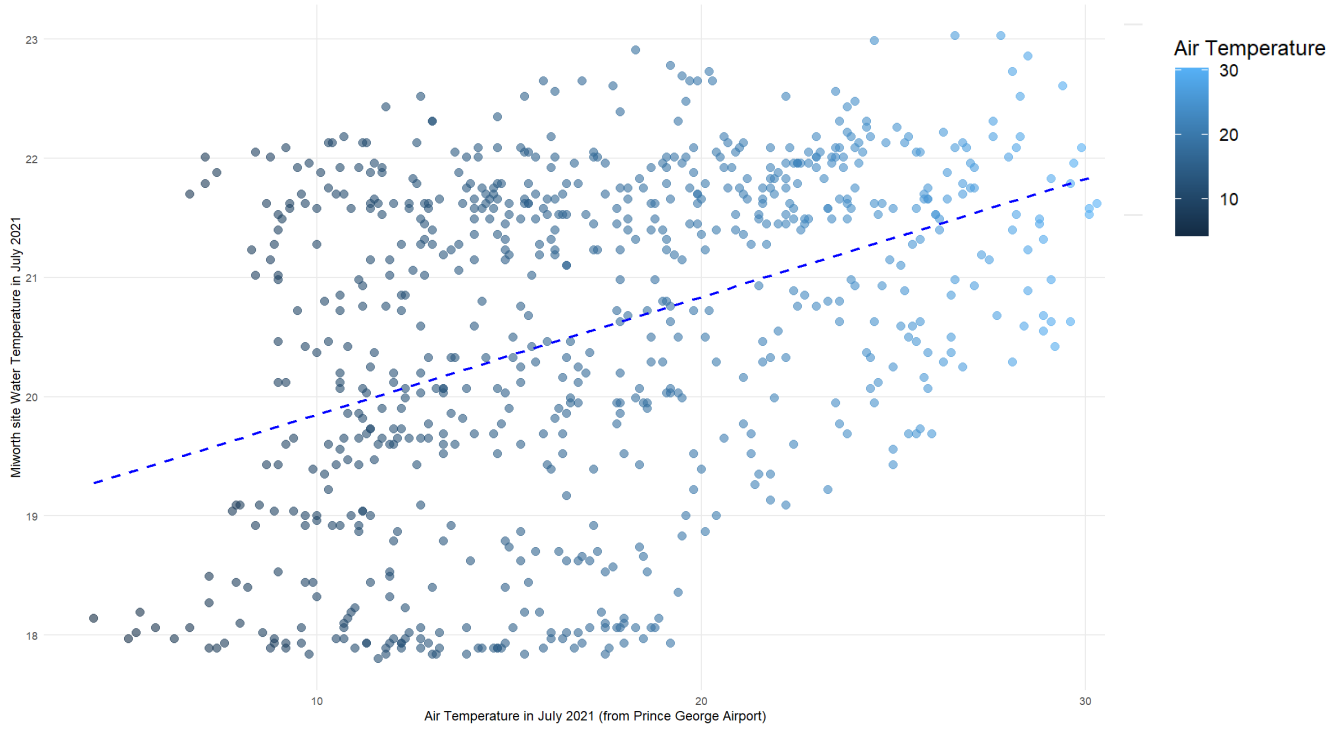


Figure 8: Scatter plot for water temperature in the Nechako River at Miworth and air temperature from Prince George Airport in July 2021. The line (**dashed blue**) represents the linear regression and the colour of the points represent air temperature.

Outreach

1. **2023/09/27** - Stephen presented his team's research on climate change and water security in the Nechako Watershed to representatives from the German Research Foundation who were visiting the UNBC campus.
2. **2023/10/05** - Stephen conducted an interview with CKPG News on the continuing drought conditions in northern BC
3. **2023/10/12** – Stephen delivered a guest lecture in GEOG 416 – Mountains, during which some of the IRC's research was profiled.
4. **2023/11/04** - Stephen attended the annual general meeting of the Nulki-Tachik Lakes Stewardship Society
5. **2023/11/06** - Stephen attended a meeting of the Nechako Valley Group.
6. **2023/11/07**—Bruno and Stephen attended the fall 2023 meeting of the Nechako Watershed Roundtable and presented an update on recent progress on integrated research across the Nechako Watershed
7. **2023/11/08** - Stephen participated in the main table meeting of the Water Engagement Initiative (WEI). He also continues to serve on the WEI's Technical Working Group.
8. **2023/12/01** - Ian Gregg of CFURadio 88.7 FM interviewed Stephen to discuss the persistent drought across northern BC. Link
9. **2023/12/06** - Stephen participated in the WEI's main table meeting. Phase 1 of WEI is now complete.
10. **2023/12/07** - Stephen was interviewed by CKPG about the undergoing research at UNBC as part of an institutional interview with Dr. Paula Wood-Adams regarding the university's position in the Top 50 Canadian Research University Rankings

Stephen Déry

RioTinto

NSERC CRSNG

UNBC

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NHG Northern Hydrometeorology Group

Weather Station in Terrace, BC
Photo: Kirsten Calder-Sutt