Nechako IRC NEWSLETTER

December 2024 | Volume 6 | Issue 4

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."

TERRITORIAL ACKNOWLEDGEMENT

Working on traditional First Nations territories in a scientific context is a humbling and deeply appreciated privilege. The opportunity to work hand-in-hand with Indigenous communities is a gift for which we are sincerely grateful. This collaboration not only enriches scientific understanding but also fosters mutual respect and cultural exchange. We are grateful for the trust and partnership extended to us, and we strive to approach this work with the utmost gratitude and responsibility. We acknowledge that our work takes place within the unceded traditional lands of 15 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

Netʃa koh (Nechako River) at Cottonwood Island Nature Park in Prince George

The Nechako River is referred to as Netʃa koh, meaning 'Big River' in the traditional language of the Dakelh Nations.

CONTENTS

In this issue of the Nechako IRC newsletter you will find updates from the current team of researchers, including updates from the fall season.

HAPPY HOLIDAYS AND SEASON'S GREETINGS!

An introduction from the project leader

Ness Lake—October 2024

Another year is already coming to an end, with a fall season that brought some much needed precipitation and drought relief to the Nechako Watershed. After a couple of weeks of warm, dry weather in early September that fueled wildfires across the Nechako Watershed, conditions cooled down as stormy autumn weather set in the region. Indeed, several atmospheric rivers made landfall near the upper Nechako Watershed yielding copious amounts of precipitation with Kemano observing a total of 767 mm in two months (September and October) alone! Further east, Prince George saw near normal precipitation totals in September and October replenishing dry soils and low water levels in streams, rivers and lakes. The emergence of La Niña in the tropical Pacific Ocean, the cool phase of the El Niño Southern Oscillation, is likely a major contributing factor to the relatively cool, wet conditions this past autumn. La Niña is anticipated to continue through the winter and spring seasons, which generally would lead to below average air temperatures and above average precipitation and snowpack levels in our region. Indeed, the mid-November snowfall and cold temperatures we experienced led to this year's early onset of winter.

The December 2024 issue of the Nechako IRC Newsletter covers a broad range of topics ranging from water temperatures to atmospheric rivers, data management and quality control, and the conclusion of the 2024 field season. Research Skills Trainee Dylan Broeke summarizes this fall's field work activity across the Nechako Watershed including efforts to provide real-time data access to our weather station at Huckleberry Mine and water and sediment sampling at Rhine and Whiting creeks. PhD student Bruno Sobral follows up on the busy fall 2024 atmospheric river season and how these storms replenished the low water levels of the Nechako Reservoir. Post-doctoral fellow Tamar Richards-Thomas reports on the exceptional AR and floods that affected Vancouver Island and the Lower Mainland on BC's Election Day. Post-doctoral fellow Mostafa Khorsandi discusses the outcomes of computer model simulations that explore the potential impacts of future climate change on water temperatures of the Nautley River. Meanwhile, MSc student Justin Kokoszka discusses management for water temperature monitoring with a focus on the Cheslatta System and the relative contributions of regulation and climate change to the monthly median streamflow for the Nechako River at Vanderhoof.

For my part, I provide a brief overview of some analyses of daily water temperatures recorded on the Nechako River in Vanderhoof since 2011. The Water Survey of Canada maintains a hydrometric gauge on the Nechako River near the Burrard Avenue Bridge in Vanderhoof where measurements of water levels, discharge and temperature are conducted. Using these data, thermographs and hydrographs are created to depict the 2011-2024 average daily flows and water temperatures for the Nechako River at Vanderhoof. These conditions are then compared to three most recent years (2022, 2023 and 2024) to highlight the impact of the extended drought on the hydrology and temperatures of the Nechako River. The article also reports on the number of days each year for which daily mean water temperatures surpassed 20°C, a critical threshold for various freshwater fishes.

Stephen Déry

You will also find in this issue of the Nechako IRC Newsletter an update on the NSERC Alliance project that explores, among various topics, thermal refuges in the Nechako River. Here, I provide an update on our contribution to this project including efforts to enhance meteorological and water temperature monitoring across the Nechako Watershed. I also discuss our plans to explore the role of large-scale "teleconnections", which are broad and fluctuating patterns of sea-surface temperatures and atmospheric pressures such as the El Niño Southern Oscillation, and that result in interannual variability in BC's climate.

The outreach section of this newsletter provides information on a presentation I delivered to the Nechako Watershed Roundtable's workshop on "Climate Change Adaptation and Resilience in the Nechako Watershed" held in Prince George on November 29th. This presentation allowed us to share our findings on climate change (both historical and future projections) in the Nechako Watershed with a broad range of interested parties from the Nechako Watershed. You will also find a list of recent media interactions, publications and other community engagement activities our team has been involved in this autumn.

There are some recent changes to the composition of the team as we undergo a transition in personnel in 2025. First, sincere congratulations to Bruno Sobral for successfully defending his doctoral dissertation on Friday, December 13th, which ended up being a lucky day for Bruno! This marks the final stage of his doctoral degree at UNBC and we therefore wish him well in his future endeavors as he remains based in Rio de Janeiro, Brazil. It has been an exceptional pleasure to have Bruno on board for the past four years with your research significantly advancing our understanding of the importance of atmospheric rivers in the Nechako Watershed's hydrology. We are delighted to introduce Erica Lee as the new Research Manager for the team. Erica began her position as Research Manager on December 2nd supporting both the Freshwater Fish Ecology Laboratory led by Dr. Eduardo Martins and the Northern Hydrometeorology Group that I lead. Erica will be overseeing our day-to-day activities and will be providing support to the remainder of the team. Consult Erica's short bio later in this issue of the Nechako IRC Newsletter.

I also take this opportunity to express much gratitude to Justin Kokoszka for his exceptional leadership skills in his role as Research Manager for the past couple of years. As Justin completes his Master's degree at UNBC in early 2025, he is transitioning to a position of Research Associate for the NSERC Alliance project to explore links between atmospheric teleconnections and the hydroclimate of the Nechako Watershed. We are also pleased to have Dylan Broeke, Kainen Parmar, and Maria Tavares continuing to support the NHG into 2025 and anticipate the recruitment of additional team members as new research projects begin.

Wishing everyone across the Nechako Watershed and beyond very Happy Holidays and best wishes for a fantastic 2025!

Stephen Déry

"Wishing everyone across the Nechako Watershed and beyond very Happy Holidays and best wishes for a fantastic 2025!"

THE TEAM

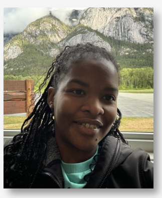
Industrial Research Chair members from the NHG

Stephen Déry
Project Leader

Justin Kokoszka
Research Manager
M.Sc. Candidate

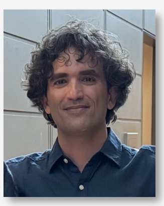
Bruno Sobral
Ph.D. Candidate

Maria Tavares
Database Administrator

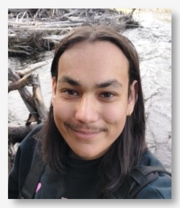


Tamar Richards-Thomas
Post-Doctoral Fellow

Dylan Broeke
Field Crew Team Leader



Mostafa Khorsandi
Post-Doctoral Fellow



Kainen Parmar
Undergraduate student

Lucas Moura
Research Assistant
Newsletter Editor

Erica Lee
Research Manager

New Team Member!

My name is Erica and I will be taking the role of Research Manager for NHG and FFEL. I completed my undergrad at UBC in Natural Resources Conservation, and have previous work experience with fish and wildlife. In my free time I enjoy biking, knitting, cooking, and sharing meals with friends and family. I am really excited to support research at UNBC, and look forward to working alongside communities in the Nechako Watershed.

RESEARCH CHAIR UPDATE

Stephen Déry

It was yet another hot, dry summer in the Nechako Watershed with the persistent drought lowering water levels even further across the region. In particular, the low snowpacks during the winter of 2023/2024 combined with the warm spring of 2024 led to an early snowmelt and low spring freshets in all waterways of the Nechako Watershed. With the passage of the spring freshet, water levels diminished quickly, which led to rapid warming of water temperatures. In this newsletter contribution, the effects of the 2022-2024 drought on water temperatures of the Nechako River at Vanderhoof are explored. The analysis makes use of hourly water temperature data collected by the Water Survey of Canada for the Nechako River at Vanderhoof between January 2011 and October 2024 that are converted to daily means. Daily streamflow recorded by the Water Survey of Canada for the same location is also used to create the corresponding hydrographs. The analyses focus on the number of times water temperatures exceeded 20°C, a critical level for salmonids and other freshwater fish species.

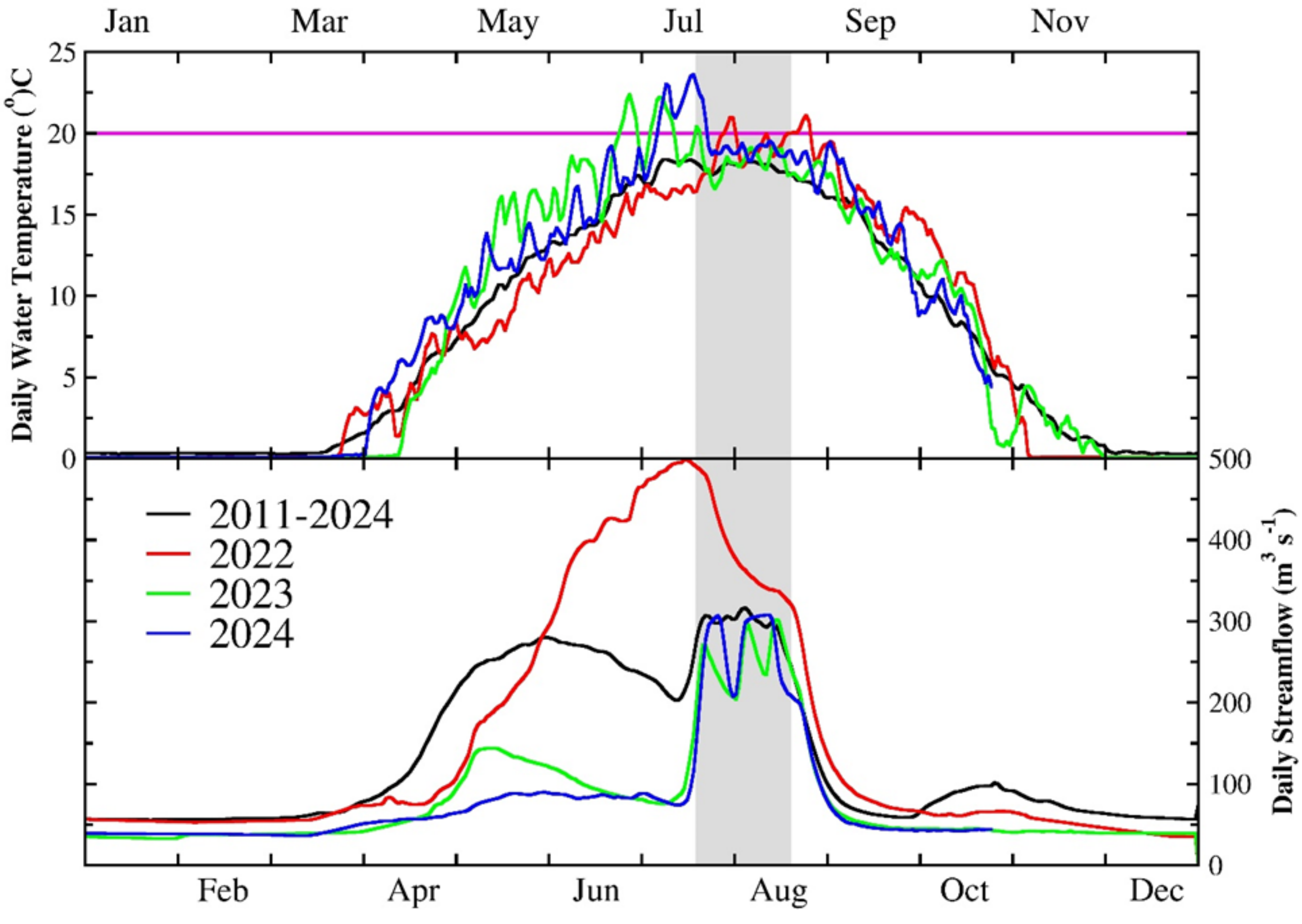


Figure 1: Thermographs (top) and hydrographs (bottom) for the Nechako River at Vanderhoof. Shown on the plots are the 2011-2024 daily average water temperatures (top) and flows (bottom), along with their respective daily data for 2022, 2023, and 2024. The gray shading marks the STMP period (20 July to 20 August of each year) while the horizontal magenta line in the top panel marks 20°C. Data beyond 24 October 2024 are not available.

Figure 1 illustrates the average thermograph (a graphic representing the daily water temperature of a given waterway for a given year) for 2011 to 2024 (**black** line) along with those for recent drought years (2022, 2023 and 2024 as **red**, **green** and **blue** lines, respectively) for the Nechako River at Vanderhoof. Similarly, hydrographs depicting the daily streamflow values are included in a separate panel. The top panel of Figure 1 clearly shows the relatively high water temperatures experienced on the Nechako River during the spring and summer seasons of 2023 and 2024 in response to the persistent drought. In particular, the heatwaves of early July 2024 led to mean daily water temperatures near 24°C. Later in mid-summer, however, water temperatures moderated in response to the Summer Temperature Management Program (STMP) that is activated from 20 July to 20 August each summer that assist up-river salmon migrations in the Nechako Watershed. As such, there were few instances of above 20°C water temperatures along the Nechako River at Vanderhoof during the STMP, noting that the constraint of daily mean water temperatures of ≤20°C is for a site further downstream, at Finmoore just upstream of the confluence with the Stuart River.

During the cool, wet spring of 2022, flows remained high on the Nechako River in Vanderhoof, approaching 500 m^3 s^{-1} in mid-July. With the high flows, water temperatures remained below the 2011-2024 average until mid-July. Mean daily water temperatures then exceeded 20°C on three successive days in late July and early August during another heatwave, but cooled somewhat until the conclusion of the STMP on 20 August 2022. The hot, dry late summer and autumn led to above average daily water temperatures along the Nechako River in Vanderhoof during 2022, a feature not observed in 2023 or 2024.

Table 1 reports the number of days during which mean daily water temperatures surpassed 20°C for the Nechako River at Vanderhoof from 2011 to 2024. Between 2011 to 2017, there were 9 days in total when water temperatures were warmer than 20°C. However, since 2018, the mean daily water temperature for the Nechako River at Vanderhoof exceeded 20°C a total of 76 times.

Table 1: Count of the number of days when mean daily water temperatures exceeded 20°C for the Nechako River at Vanderhoof, 2011-2024.

Year	Count	Year	Count
2011	0	2018	2
2012	0	2019	10
2013	0	2020	0
2014	7	2021	22
2015	0	2022	10
2016	2	2023	16
2017	0	2024	16
Total	**9**	**Total**	**76**

Most often, this threshold was surpassed prior to the STMP (61 times), in late June to mid-July. In particular, the early summer heat dome of 2021 led to a long succession of warm water days. The recent surge in warm water days on the Nechako River is likely a response to the rising air temperatures in association with climate change. Ongoing simulations undertaken with the Air2Stream model by postdoctoral fellow Mostafa Khorsandi, as reported later in this newsletter, suggest this warming trend in water temperatures will accelerate in the coming decades across the Nechako Watershed. It is worthwhile to note that the STMP remains quite effective at moderating water temperatures along this waterway even during heatwaves and droughts such as experienced in the summers of 2022 to 2024. A challenge, however, remains the potentially lethal water temperatures experienced by salmonids and other freshwater fishes outside of the STMP period, particularly in early summer.

Ness Lake during fall—October 2024

"The hot, dry late summer and autumn led to above average daily water temperatures along the Nechako River in Vanderhoof during 2022, a feature not observed in 2023 or 2024."

WATER TEMPERATURE DATA SUMMARY - CHESLATTA LAKE SYSTEM

Justin Kokoszka

Our data team has been hard at work collecting water temperature data across the Nechako River Basin. We are committed to ensuring these data are high-quality and useful for both research and community engagement. Here, we provide a summary of data quality from three of our monitoring sites located in the Cheslatta Lake System (CLS; **Figure 2**).

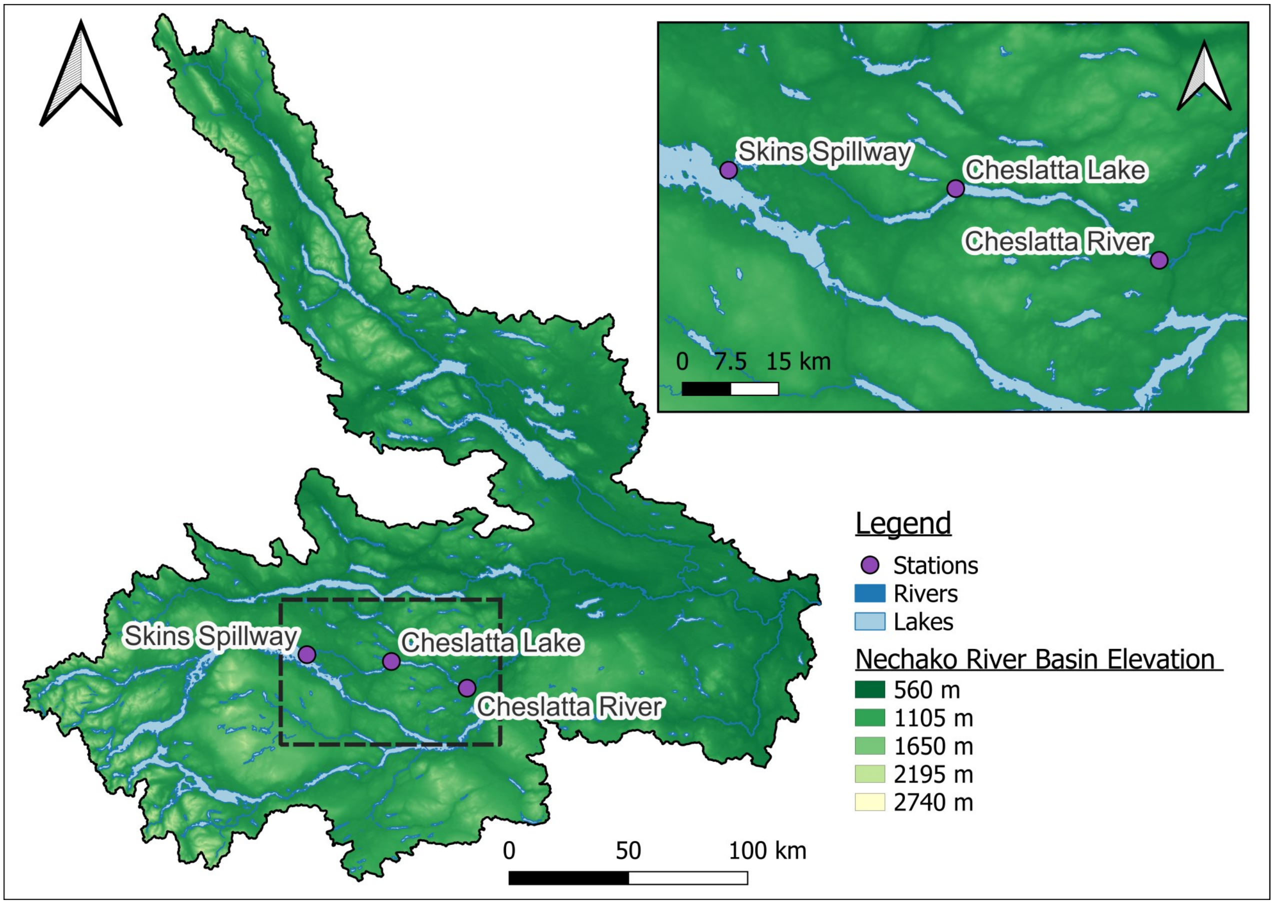


Figure 2: Map of the Nechako River Basin showing the locations of three water temperature monitoring stations in the Cheslatta Lake System.

The three sites are located along a transect of the CLS from west to east and observe water temperature every 15 minutes. The first site, Skins Lake Spillway, is located downstream of the reservoir release structure, the second site is located on the northern shore of Cheslatta Lake, and the third site is situated in the Cheslatta River above Cheslatta Falls. Details on these sites are provided in **Table 2.**

Table 2: Site details.

Station Name	Station Code	Record Start	Record End	Latitude (°N)	Longitude (°W)	Elevation (m)
Skins Lake Spillway	01FW010	2019-08-12	2024-05-18	53.775	125.992	839
Cheslatta Lake	01FW003	2022-06-15	2024-07-18	53.748	125.455	786
Cheslatta River	01FW008	2020-07-31	2024-05-23	53.645	124.976	782

Quality Control

Quality data are crucial for understanding environmental systems. As such, we implemented a comprehensive quality control protocol for our data collection efforts. This includes the flagging of data for a variety of potential quality issues. For example, sometimes our sensors can become frozen within the ice, leading to incorrect temperature measurements. This mainly happens when water levels decrease between the time of deployment and the time of data collection, causing the ice to touch the sensor. Our quality control system uses six main 'flags' to mark the and other potential data issues. These flags are summarized in **Table 3**.

Table 3: Description of quality control flags.

Flag Symbol	Flag Name	Description
B	Below ice	Temperature observed during ice conditions.
M	Missing	No temperature was recorded.
T	Threshold	Temperature above a set threshold. (35°C)
E	Equipment	Temperature is outside the sensor's operating range. (< -20°C or >50°C)
S	Spike	Change in temperature deviates significantly from the expected trend based on previous observations. Indicates the sensor may have been dewatered (i.e. exposed to air).
V	Visit	Temperature observed during a site visit.

Our quality control procedure helps our team to visualize potential data problems. This information is valuable for planning future sensor deployments. For the three sites the predominant flags were M-Missing, B-Below Ice, and S-Spike. The overall distribution of flags for all three sites is presented in **Figure 3**.

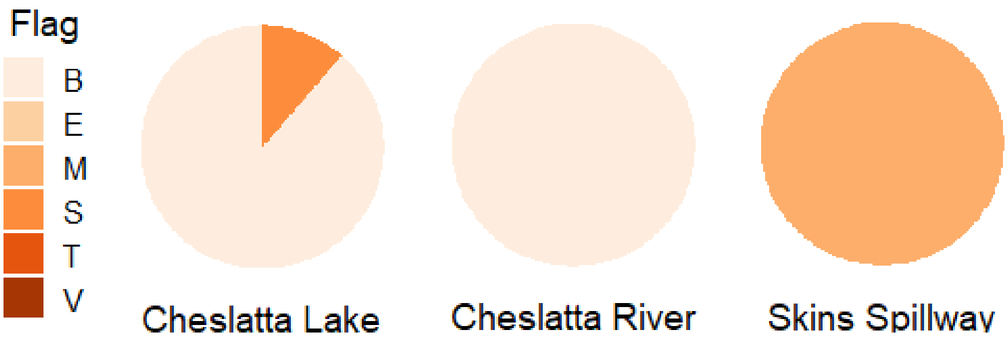


Figure 3: Proportion of flagged observations at each monitoring site. Flags indicate potential data quality issues (see Table 3).

Taking a closer look at the flag distribution for each of the three sites. The Skins Spillway site had 33% of the entire record flagged, all of which were M (Missing). This is because the sensor was lost downstream during high flows in 2021-2022. Meanwhile, the Cheslatta Lake site had 17% of its records flagged with 11% B-flags and 89% S-flags. This likely indicates that the sensor was not deep enough to avoid ice or low water levels. At the Cheslatta River site, the main issue was ice exposure with 11% of its entire record flagged with B-flags. This was likely due to low water levels in the winter of 2023.

To showcase the data collected at each site so far, we removed these flagged data to calculate reliable daily mean temperatures, which are shown in **Figure 4**.

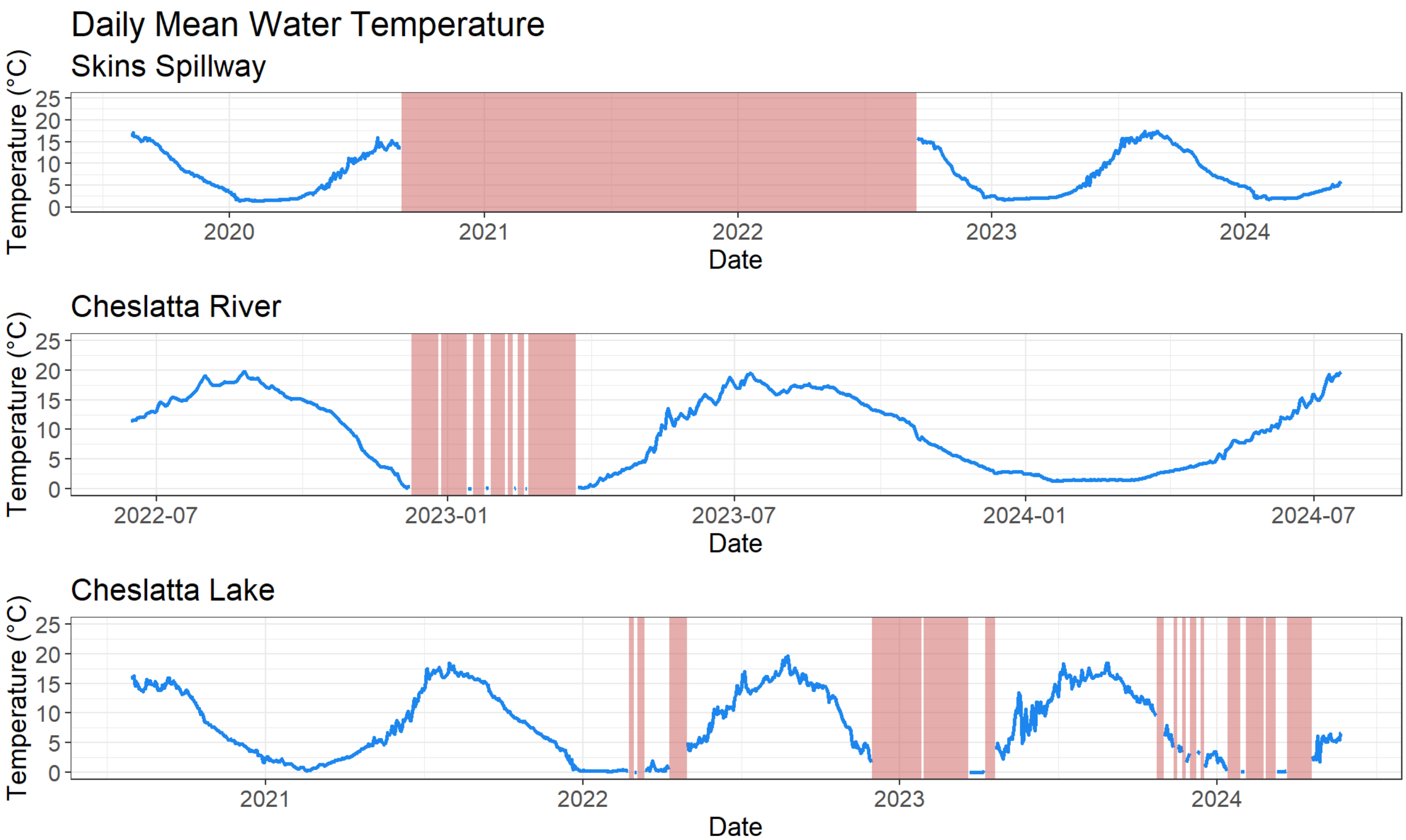


Figure 4: Daily mean water temperature at each monitoring site. Red bars indicate periods where data were flagged and removed due to quality concerns.

Data Summary

Our data reveal some interesting water temperature patterns (**Table 4** and **Figure 5**). All three locations follow a clear seasonal pattern with warmer temperatures in the summer and cooler temperatures in the winter. The Cheslatta River site has the highest overall mean temperatures and greatest day-to-day fluctuation, while Cheslatta Lake is the coldest (0.47 ^{o}C).

Water temperatures generally increase from west to east, with average temperature shown in Table 3. This warming pattern is most apparent in the summer months (see **Figure 5**). However, during the winter months temperatures are warmer at the Skins Lake Spillway site, likely due to the influence of reservoir releases. In the summer, the released water from the reservoir is cooler compared to the shallow stream, while in the winter, it is warmer. This suggests that the reservoir outflow at Skins Lake Spillway has an influence by moderating the temperature and likely explains why this site shows the lowest temperature variability (see **Table 4**).

Table 4: Summary of daily mean water temperature statistics.

Statistic	Skins Lake Spillway (^oC)	Cheslatta Lake (^oC)	Cheslatta River (^oC)
Mean	7.26	8.38	9.63
Median	5.49	7.71	10.57
Maximum	17.39	19.69	19.8
Minimum	1.44	0.02	0.03
Standard Deviation	5.08	5.88	6.30

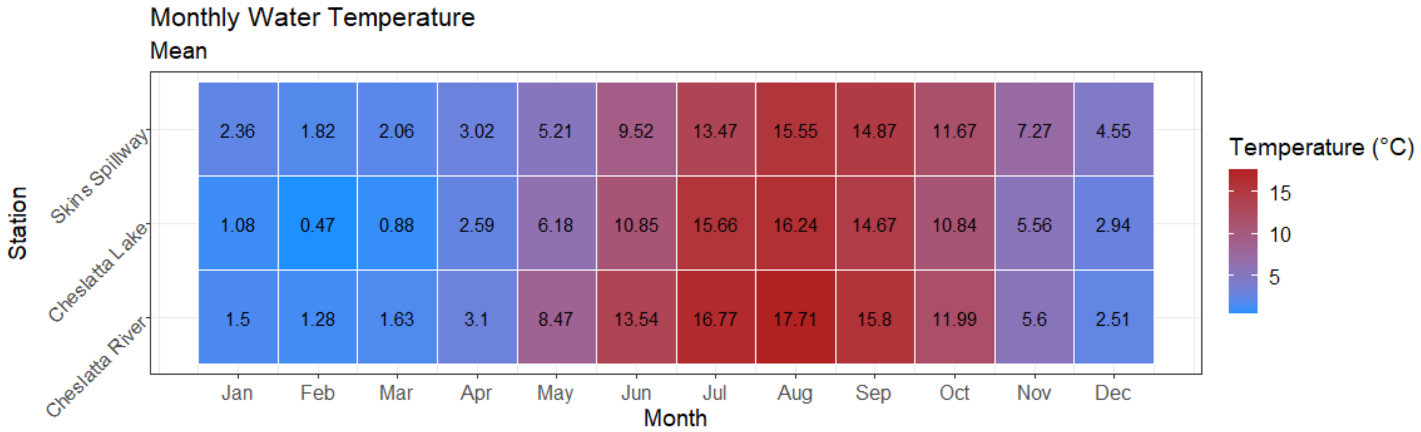


Figure 5: Monthly mean water temperature at each monitoring station.

Concluding Remarks

This data summary of water temperature collected from the CLS highlights the importance of quality data. The insights gained from these data will not only inform our understanding of temperature dynamics within the system but also guide future deployments and data collection strategies in the Nechako Watershed.

FAREWELL

After 2 years as Research Manager, I'll be transitioning to a new role. I'm incredibly grateful for the opportunity to have contributed to the NHG. I'm proud of the work we've accomplished together, and I'm especially thankful for the opportunity to work in Northern BC with such wonderful colleagues. But don't worry, I'm not going far! I'm finishing my thesis and will be staying with the group as a Research Associate in the coming months. I'm excited for this new chapter and to continue collaborating.

FIELD WORK UPDATE

Fall field work update with a focus on the upper Nechako Watershed

Dylan Broeke

Most of the NHG's field work was completed during the summer months except for two water temperature loggers in Fort St. James, and plenty of field work at Huckleberry Mine, 120 km Southwest of Houston, BC. During late September, Dylan Broeke and Justin Kokoszka travelled to Middle River above Trembleur Lake to meet with a local boat driver from Tl'azt'en Nation who assisted with a boat ride up the river to access the two loggers. In late October, Dr. Kristen Kieta and Dylan Broeke travelled to the mine to complete the needed fieldwork quickly before the winter snow landed. Over a 2-day period, over 30 hours were worked to complete upgrades to the weather station and the collection of sediment samplers Dr. Kieta had installed in Rhine and Whiting Creeks.

The upgrades to the weather station (WX) at the mine were needed before the winter hit as the SR50-45 (snow depth sensor) was only delivering NANs to the datalogger. The fix thankfully was relatively simple, and Dylan with Dr. Kieta's help took the sensor off the weather station and changed the transducer which solved the issue once the sensor was wired back to the WX. Another upgrade was the creation of a 15-minute data table in addition to the 1-minute data table that was already present. The 1-minute data table is to directly correlate with the 1-minute data tables of the Parsivel Disdrometer (PD) and Micro Rain Radar (MRR) which are also installed at the mine on separate towers.

Most WX sites within the NHG do not have telemetry connections to allow for remote data collection. The NHG has been working closely with Huckleberry Mine's ITS team for the past few months to create a network connection at the site to make telemetry possible. Dylan worked with Hadleigh Thompson of UQAM, Université du Québec à Montréal who is one of the main leaders for the creation of the site, to bring the station online. The MRR is run and controlled by a micro-PC that they were able to connect to the network and gain remote access to. The WX was also connected to the network and remote access to the WX is now possible through the micro-PC. Dylan and coworker Maria Tavares went back to the mine in mid-November to connect the PC to have all three towers (WX, MRR, PD) on the network and available for remote data collection. This is a large milestone that the NHG and Hadleigh Thompson/UQAM have been working on for 15 months since the construction of the stations.

Dr. Kieta and Dylan also spent several hours in the 1.5°C water of Rhine and Whiting Creeks collecting the sediment samplers, part of an IWRG project, that Dr. Kieta had installed two months prior. These sensors included an ISCO sediment sampler, passive sediment traps, and HOBO water level loggers. During the large atmospheric rivers in early fall, both creeks had heightened water levels which caused the NHG's water temperature logger in Rhine Creek to be lost as well as dislodged a couple of the passive sediment samplers. All the sediment sensors were collected with plans to redeploy them the following field season. While at the creeks, Dylan redeployed a new temperature logger within Rhine Creek and downloaded the data from the Whiting Creek temperature logger.

Some favorite pictures from the Fall field season

Rhine Creek: Dr. Kieta measuring discharge.

The mine site. From left to right: WX, PD, MRR.

Travelling from Huckleberry Mine to the two creeks.

NECHAKO RESEARCH

Explore some of our research!

ATMOSPHERIC RIVER MONITORING DURING FALL 2024

Bruno Sobral

This fall, the NHG has undertaken a focused effort to monitor Atmospheric Rivers (ARs) and their impacts on the Nechako River Basin (NRB), including how they influence sediment transport. In collaboration with Dr. Phil Owens (UNBC) and Dr. Kristen Kieta (postdoctoral researcher at UNBC), we tracked AR events daily, recording information on their intensity, duration, and frequency. We used various tools such as automatic weather stations, sediment transport samplers, weather maps, and accumulation maps. Between August 25 and October 14, we observed a high level of AR activity, averaging one AR event every six days. This monitoring supports our ongoing efforts to understand the impacts of ARs on western Canada and its effects on the NRB.

During the monitored period, nine AR events were recorded and classified using the Ralph et al. (2019) AR scale. On average, these ARs lasted 32 hours, with one AR3 event standing out for lasting 60 hours, though its peak intensity was relatively low at 740 kg m^{-1} s^{-1}. This AR event occurred from September 22 to 25 and was the most notable, reaching mid-level classification on the Ralph et al. (2019) scale and contributing significantly to the region's water resources. The other events were classified as AR1s, with an average intensity of 400 kg m^{-1} s^{-1}, meaning they were less intense and mostly beneficial. Early to mid-fall ARs are often helpful in replenishing water supplies of the NRB, while November is more prone to sequential and potentially harmful ARs.

"This AR event occurred from September 22 to 25 and was the most notable, reaching mid-level classification on the Ralph et al. (2019) scale and contributing significantly to the region's water resources."

ARs have been particularly beneficial for the Nechako Reservoir this fall, causing water levels to rise steadily and approach near-freshet conditions. At Skins Lake Spillway, water levels have increased by about 80 cm since the AR3 event, demonstrating how ARs play an important role in sustaining the region's water budget. Along with hydroclimatological observations, we collected sediment samples to study how ARs affect sediment movement in the basin's streams and rivers. These samples, along with weather station data, will also help validate ERA5-Land data and pinpoint areas where sediment transport might negatively impact aquatic habitats. This monitoring effort will provide valuable insights into how ARs affect sediment dynamics and water resources in the NRB.

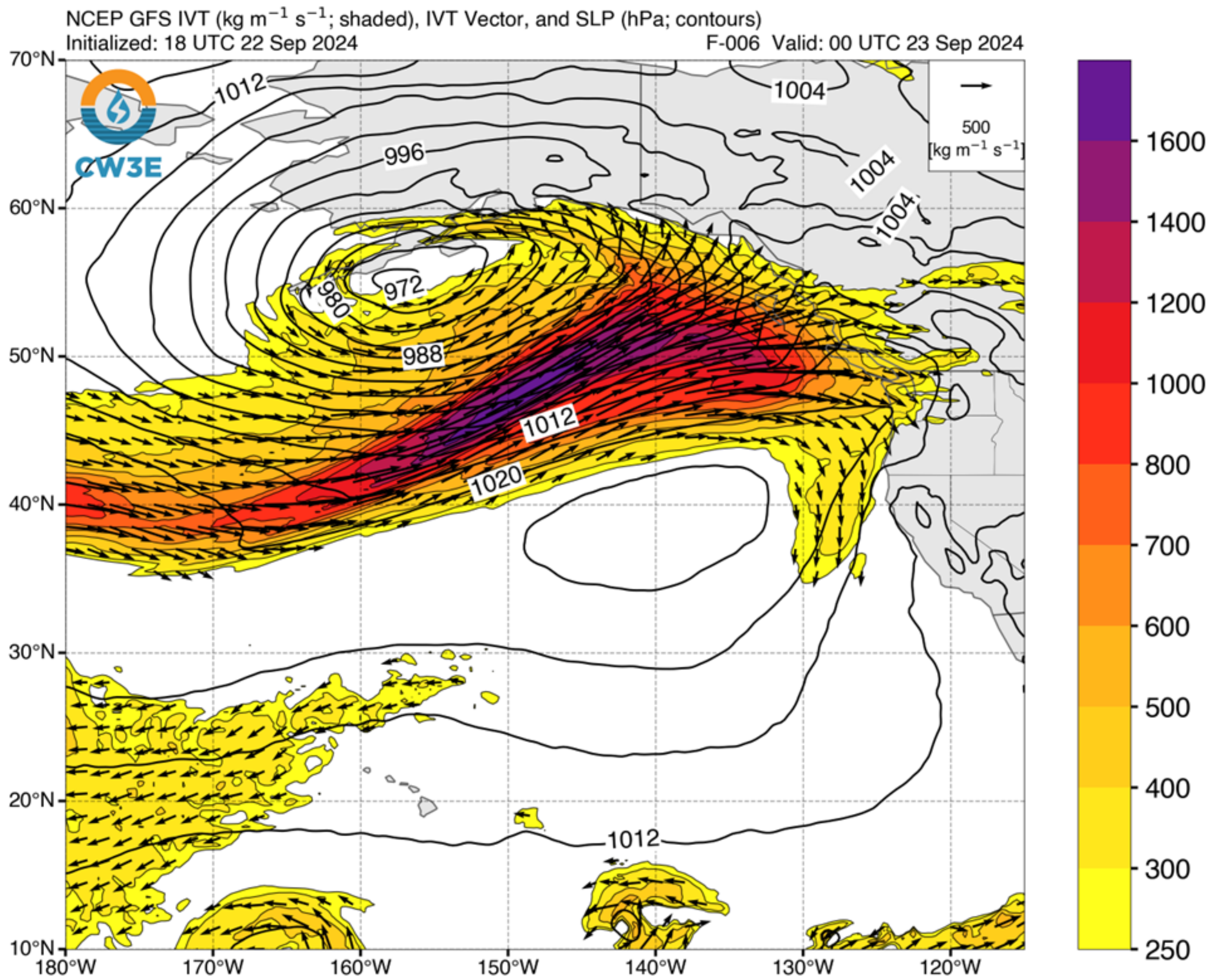


Figure 6: Integrated water vapour transport of the AR3 occurred on 22-25 September according to the NCEP GFS model. Source: https://cw3e.ucsd.edu/ivt_iwv_nepacific/).

ATMOSPHERIC RIVER IN SOUTHERN BRITISH COLUMBIA IN OCTOBER 2024

Tamar Richards-Thomas

As we are currently in the peak season for atmospheric rivers (ARs), October 2024 saw the effects of ARs in southern British Columbia. A category 4 AR made landfall along BC's southern coast on Friday, 18 October 2024 **(Figure 7)**, bringing moisture and copious rainfall to the Lower Mainland, including Vancouver.

Regions, such as West Vancouver, experienced up to 135 mm of rain **(Figure 8)** an order of magnitude greater than the previous historic record of approximately 35 mm in 1970. West Vancouver reported the highest daily total precipitation as intense moisture from the AR moved inland. This total precipitation corresponds to an air temperature of 11.5 °C within the region **(Figure 8),** lower than the monthly high of 20.6 °C recorded on 12 October 2024. Other surrounding regions also saw increased rainfall.

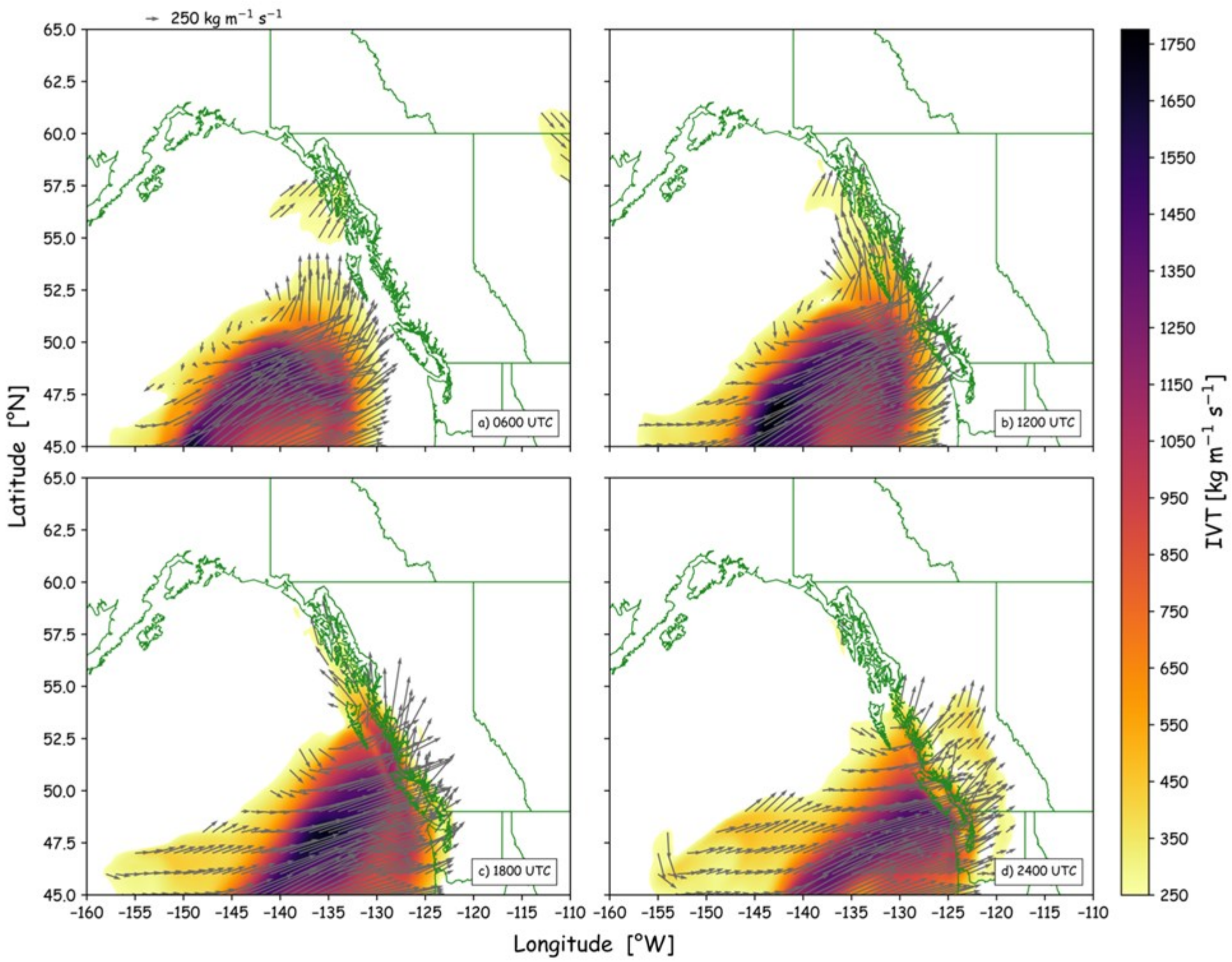


Figure 7: Snapshots of the Integrated Water Vapour Transport (IVT, colour shaded; kg m^{-1} s^{-1}) distributions and IVT vectors (gray arrows) on 18 October 2014 at a) 0600 UTC, b) 1200 UTC, c) 1800 UTC, and d) 2400UTC. Data Source: European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis on pressure levels (ERA5).

For example, Coquitlam received over 250 mm of rain. The AR made an approximate landfall along BC's southern coast. This AR also tragically resulted in two direct human casualties caused by the flooding in Port Alberni and Bamfield. This AR-related event led to the destruction of several homes and properties in Lower Mainland and surrounding areas caused by flooding as well as mudslides (e.g., in Coquitlam). This event extends the list of documented floods in Richards-Thomas et al. (2024) from 2000 to 2021. The Integrated Water Vapour Transport (IVT) exceeded 250 kg m^{-1} s^{-1} (up to 1770 kg m^{-1} s^{-1}).

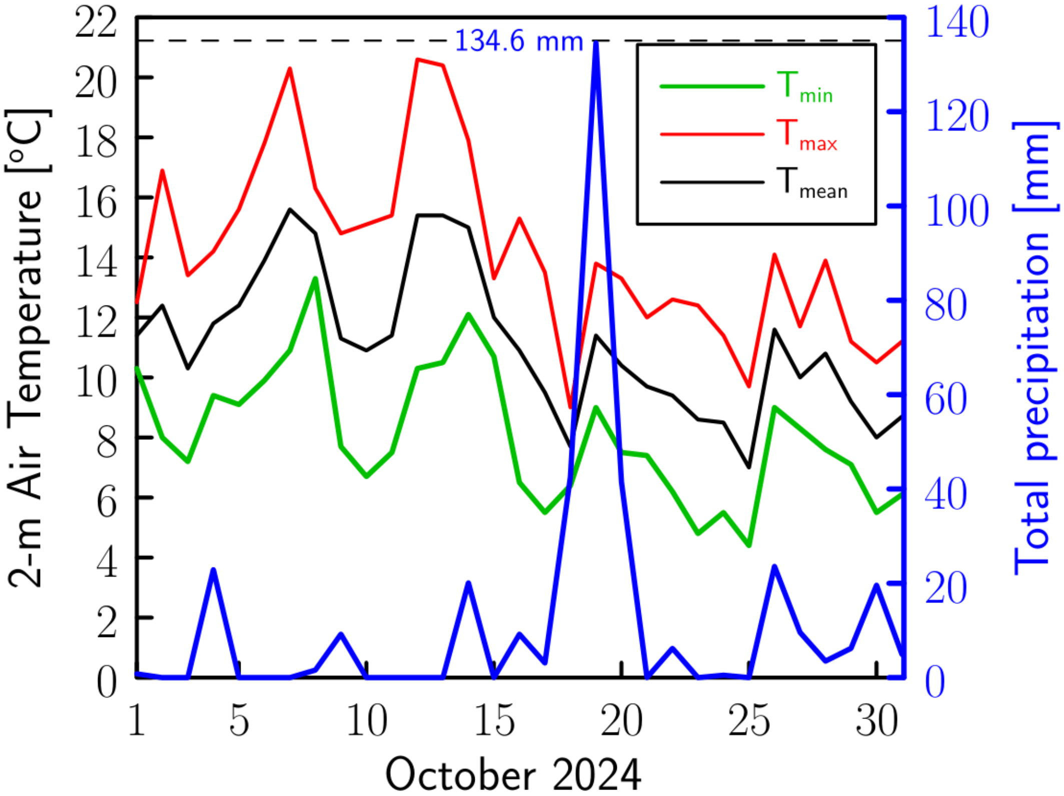
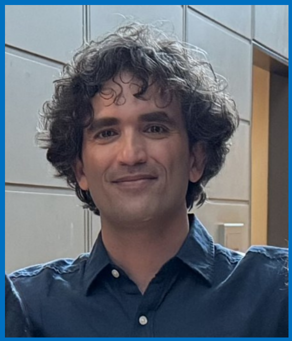


Figure 8: The daily max (T_{max}), min (T_{min}) and mean (T_{mean}) temperatures and total precipitation (mm) recorded at West Vancouver Auto Station, British Columbia in October 2024. Data Source: Environment and Climate change Canada.

"Regions, such as West Vancouver, experienced up to 135 mm of rain an order of magnitude greater than the previous historic record of approximately 35 mm in 1970."

FUTURE WATER TEMPERATURE SCENARIOS FOR NAUTLEY RIVER, BRITISH COLUMBIA



Mostafa Khorsandi

Climate change is significantly impacting the Nechako Watershed, a vital salmon habitat and home to numerous First Nations communities in British Columbia. The watershed is experiencing multiple stressors, including drought, reduced snowfall, and warming temperatures. Nautley River, a crucial tributary, supports various fish species, particularly sockeye salmon.

In a previous study at UNBC, we calibrated the Air2Stream model for the Nautley River near Fort Fraser using flow and water temperature observations from 2008-2023 and air temperature data from the ERA5-Land reanalysis dataset. The model demonstrated strong performance with a Root Mean Square Error (RMSE) of 1.24° C, Kling-Gupta Efficiency (KGE) of 0.97, and Nash-Sutcliffe Efficiency (NSE) of 0.91. The calibrated model provided the hindcast simulation for the 1981-2023 period.

To project future water temperatures, we employed 15 climate models under two Shared Socioeconomic Pathways (SSP2 and SSP5). Future streamflow data for the Nautley River were obtained from the Variable Infiltration Capacity (VIC) model. Using the calibrated Air2Stream model, input streamflow, and projected air temperatures, we simulated water temperature for three 30-year periods: baseline (1991-2020), near-future (2041-2070), and far-future (2071-2100).

Our results indicate a significant increase in water temperature under both SSP scenarios **(Figure 9)**. A detailed analysis of daily water temperatures reveals a clear warming trend **(Figures 10 and 11).**

Implications

The Summer Temperature Management Program (STMP) regulates water releases in the Nechako River to mitigate high-temperature impacts downstream of Skins Lake Spillway. While Nautley River is not directly affected by STMP, its warming waters can influence downstream temperatures, particularly after the confluence with the Nechako River.

Our simulations show that daily mean water temperatures exceeding 20°C, previously confined to the STMP period, will extend to July-October in the near-future and June-October in the far-future. Additionally, the duration of the freezing season (temperatures below 1°C) will decrease significantly, impacting aquatic species.

Conclusion

The projected increase in water temperature highlights the urgent need for effective water release management, protective policies, and nature-based solutions. These changes pose significant threats to migratory fish species and the First Nations communities that rely on them.

We are currently extending this analysis to other stations within the Nechako Watershed to assess the spatial variability of climate change impacts on water temperature. The findings from this research will be published in scientific journals.

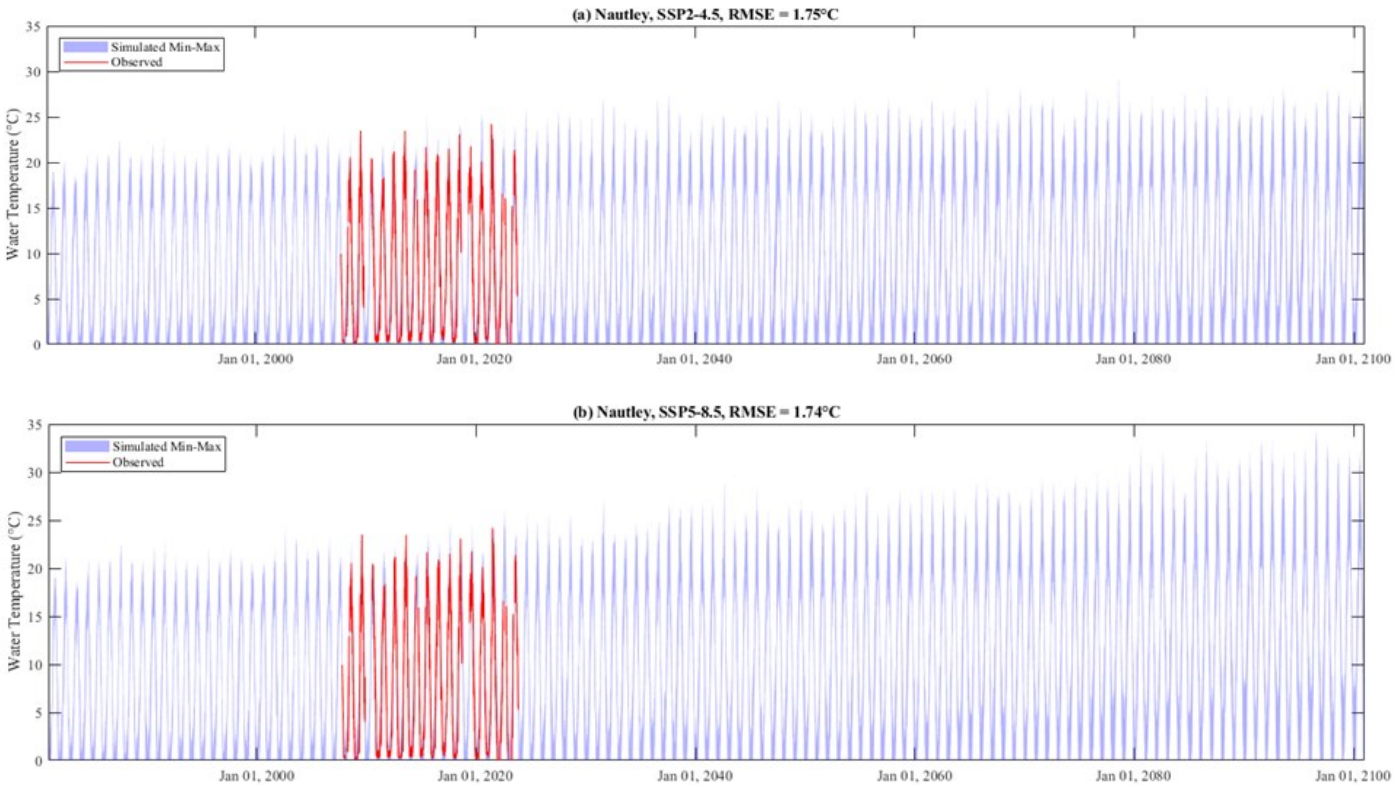


Figure 9: Projected water temperature variability for Nautley River under different climate change scenarios (SSP2-4.5W/m² and SSP5-8.5W/m²). Observed temperatures (red lines) are compared to model simulations (blue shaded area). RMSE quantifies model accuracy which is calculated using the observations and mean of the 15 time series.

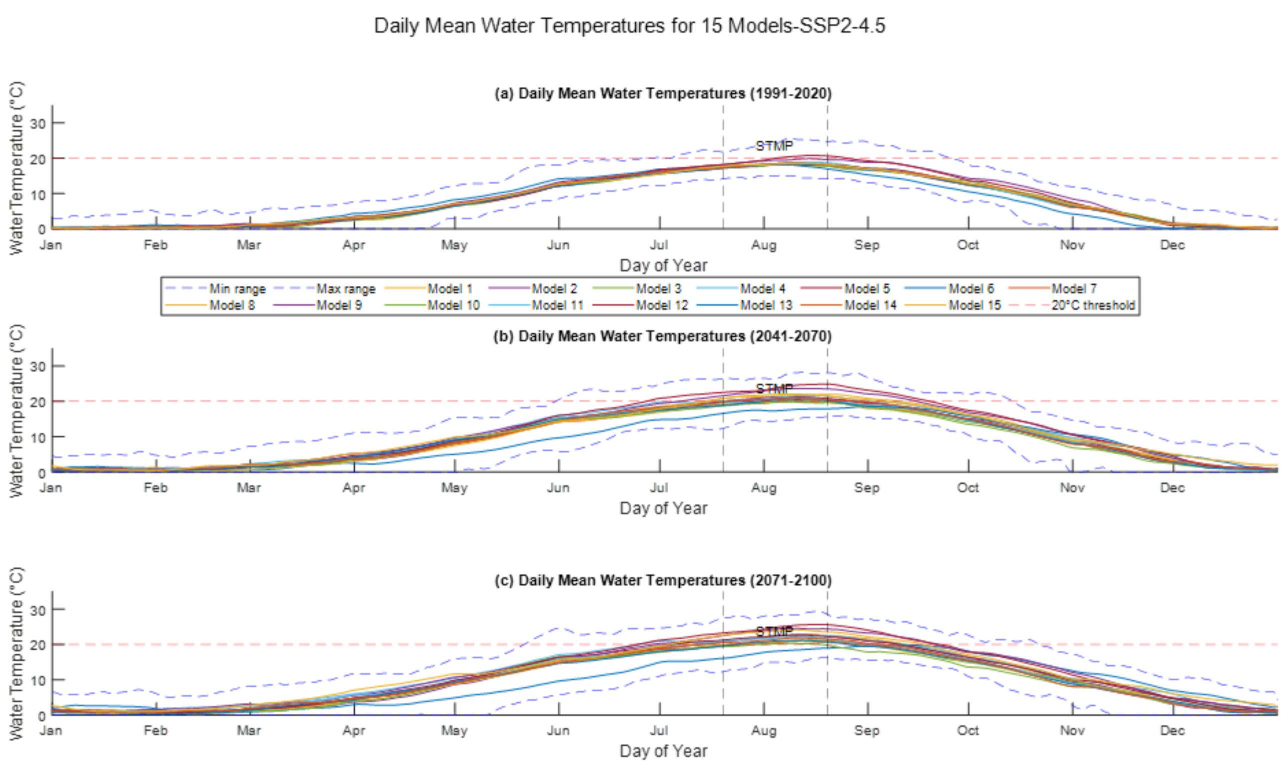


Figure 10 : Daily mean water temperature projections for Nautley River under SSP2-4.5W/m² for three time periods: baseline (1991-2020), near-future (2041-2070), and far-future (2071-2100).

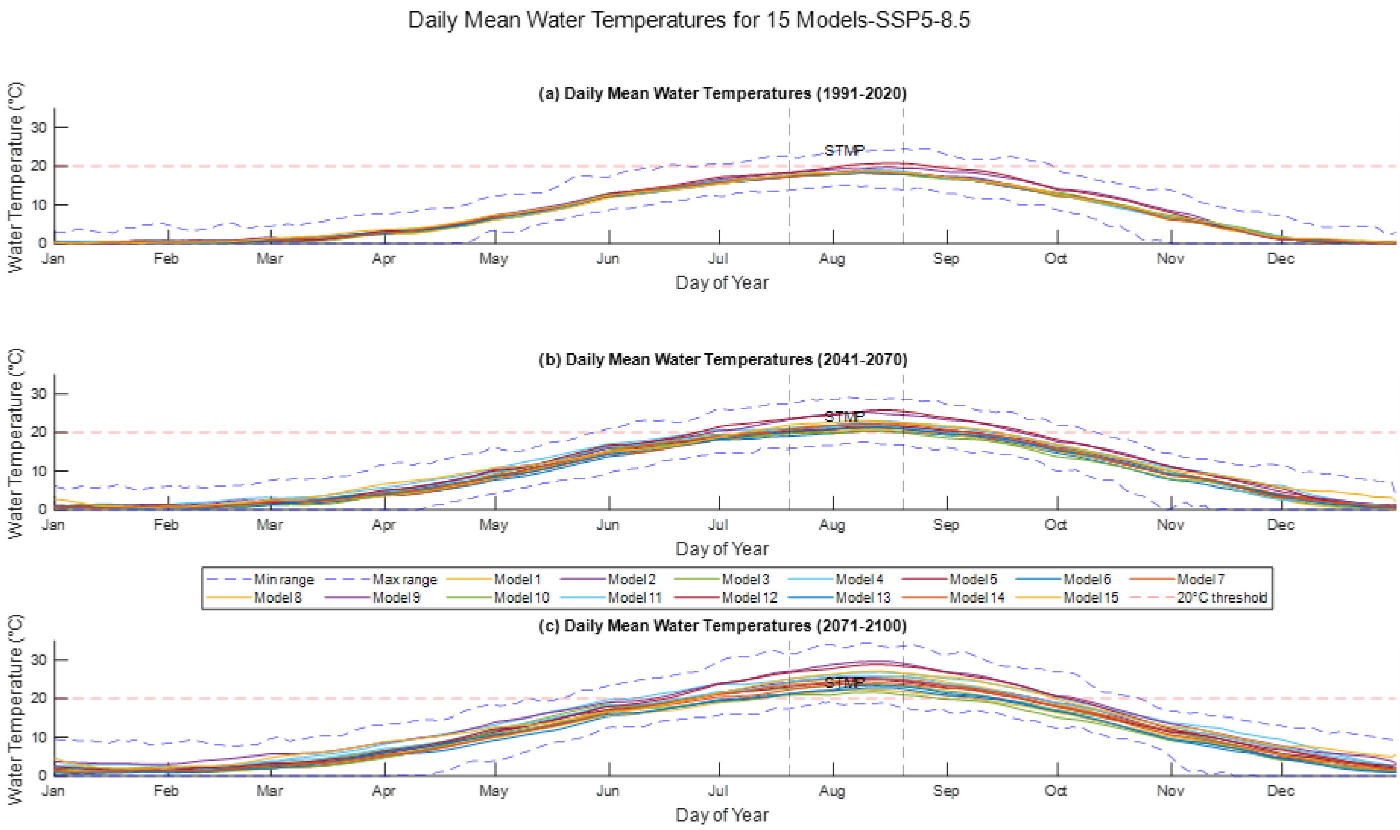


Figure 11: Daily mean water temperature projections for Nautley River under SSP5-8.5W/m² for three time periods: baseline (1991-2020), near-future (2041-2070), and far-future (2071-2100).

"The projected increase in water temperature highlights the urgent need for effective water release management, protective policies, and nature-based solutions. These changes pose significant threats to migratory fish species and the First Nations communities that rely on them."

NSERC ALLIANCE

A NSERC ALLIANCE PROJECT UPDATE by Dr. Stephen Déry

The Northern Hydrometeorology Group (NHG) is also involved in the NSERC Alliance project led by Dr. André St-Hilaire at the Institut National de Recherche Scientifique (INRS). Here, we provide a brief update on our contributions to the NSERC Alliance project and discuss plans for future research.

In the first year of activity, our focus was on the acquisition and deployment of new meteorological equipment and water temperature data loggers. Three new, research-grade meteorological stations were acquired from Campbell Scientific Canada allowing our team to collect important atmospheric variables in data sparse regions of the Nechako Watershed. To date, we have set up two of the three weather stations, with one deployed at Nulki Lake in collaboration with the Nulki-Tachick Lakes Stewardship Society, and the other at the Nadina River Spawning Channel **(Figure 12)**, a Fisheries and Oceans Canada facility. A third weather station will be commissioned during spring or summer 2025 along the shores of François Lake in cooperation with Cheslatta Carrier Nation. The weather stations comprise 3-m tripods upon which sits a water-proof enclosure housing a 12-volt battery and data logger. Sensors measure air temperature, relative humidity, wind speed and direction, atmospheric pressure, precipitation, snow depth, incoming/outgoing solar and infrared radiation, and soil temperature, among other variables. Data are collected every 15 minutes and stored by the data logger. The meteorological data will assist with our interpretation of fluctuations in water temperature and also support computer modeling efforts led by our project colleagues.

Another component of this effort is monitoring water temperatures across the Nechako Watershed. In 2019, we initiated a water temperature monitoring network across the Nechako Watershed with support from the IRC program of research that now consists of over 30 sites including several locations on the Nechako River. Until recently, our monitoring generally made use of Onset HOBO Pendant® MX2201 water temperature loggers. While the MX2201 data loggers performed generally well, they were upgraded to their MX2203 counterparts **(Figure 13)** during the 2024 field season through the NSERC Alliance project. These upgrades were undertaken to improve data continuity owing to their longer battery lives, stronger durability to the harsh environment including ice, strong current and shaking. As the main theme of the NSERC Alliance project is thermal refugia in the Nechako River, developing long-term, gap-free time series of sub-hourly water temperature is of primary importance.

All water temperature data collected in the Nechako Watershed since 2019 are undergoing rigorous quality assessment and quality control (QA/QC) using an automated strategy. Once completed, these time series will be deposited at Zenodo, a publicly-accessible data archive, in addition to the Nechako Watershed Portal. As well, we will likely post our water temperature measurements on other data portals such as "rivtemp.ca" and metadata at the Pacific Salmon Foundation's "Pacific Freshwater Temperature Monitoring Map" (https://experience.arcgis.com/experience/c435a5188ec54d5bbc10b85f6af99d05) to provide further access to our database. A manuscript describing the database of water temperature collected in the Nechako Watershed is currently in preparation for submission to the academic journal "Data in Brief" published by Elsevier. In a future issue of the Nechako IRC Newsletter, we will share links to the database and to the article once fully published.

Aside from our ongoing monitoring efforts, the NHG will embark in 2025 on a project exploring the role of large-scale teleconnections on snowpack levels and water temperatures in the Nechako Watershed. Large-scale teleconnections are inherent features in the climate system that lead to natural climate variability. British Columbia's (BC's) climate is impacted by several teleconnection patterns including the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). These large-scale climate oscillations exhibit warm and cool phases at interannual to interdecadal time scales, thereby leading to variability in our climate. For instance, the warm phase of ENSO is known as "El Niño" that generally results in warm, dry conditions in BC leading to drought conditions and active wildfire seasons as seen in the summers of 2022, 2023 and 2024. There is some measure of predictability of the different phases of large-scale teleconnections. For instance, Columbia University's International Research Institute for Climate and Society (https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/) produces a seasonal forecast with probabilities of the emergence or persistence of the warm, cool or neutral phases of ENSO.

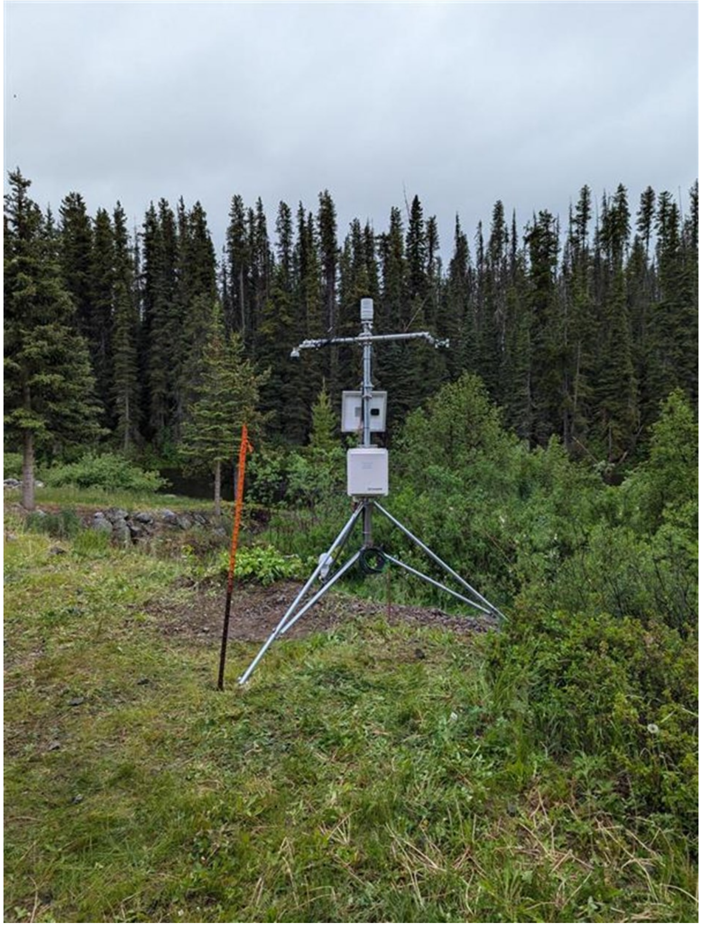


Figure 12: Nadina River Spawning Channel weather station deployed during the 2024 summer field season. The weather station is positioned on the banks of the Nadina River just downstream of Nadina Lake and waterfalls that prevent further upriver migrations of salmon.

Our efforts will therefore focus on the relationships between various phases of large-scale teleconnection patterns that affect the Nechako Watershed. We will distinguish the cool season snowpack levels and warm season water temperatures associated with the warm, cool and neutral phases of ENSO, the PDO, and other teleconnection patterns. This will also allow potential seasonal forecasts of snowpack levels and water temperatures across the Nechako Watershed. The study will make use of computer model data for both snowpack accumulations and water temperatures. Following the completion of his Master's degree, Justin Kokoszka will transition to a Research Associate position to tackle this project. Research results will therefore be provided in future issues of the Nechako IRC Newsletter.

Figure 13: HOBO Tidbit MX2203 data logger.

OUTREACH

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

Presentations

- Déry, S. J., Owens, P., Martins, E., Parkes, M., Moura, L., and Jalil, A., 2024: Update from UNBC's Integrated Watershed Research Group (IWRG), Nechako Watershed Roundtable annual meeting, virtual, 25 September 2024.
- Déry, S. J., 2024: Climate change in the Nechako Watershed, Climate Change Adaptation and Resilience in the Nechako Watershed workshop, Nechako Watershed Roundtable, Prince George. BC, 29 November 2024.
- Broeke, D. and Dery, S. J., 2024: Nulki Lake Weather Station - Project Update, Annual General Meeting of the Nulki-Tachick Lakes Stewardship Society, 14 December 2024.

Publications

- Sobral, B. S. and Déry, S. J., 2024: Water budget input linked to atmospheric rivers in British Columbia's Nechako River Basin, Hydrological Processes, 38(10), e15301. https://onlinelibrary.wiley.com/doi/10.1002/hyp.15301

Media interactions

- 2024/09/17 - Rising water temperatures and the potential appearance of Peach Blossom Jellyfish in northern BC, CKPG News
- 2024/09/24 - Current wet spell alleviating the long-term drought in northern BC, CKPG News, CKPG
- 2024/11/29 - Climate change in the Nechako Watershed, CKPG News, CKPG

Community Engagement

- Nechako Producers Group meetings on 11 September and 25 November.
- Nechako Watershed Roundtable core committee meetings (10 September, 8 October, 12 November) and annual meeting (25 September).
- Water Engagement Initiative technical working group meeting (9 October) and main table meeting (5 December).
- NEWSS Beaver Dam Analogue project update (3 October) and site visit (8 November)
- Pacific Salmon Foundation working group on water temperature monitoring in BC and the Yukon (29 October)

Contact Information

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