NSERC/Rio Tinto Industrial Research Chair in Climate Change and Water Security

Annual Report – Year 6

(1 July 2024 – 30 June 2025)

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2024-2025 IRC Annual Report

Preamble

June 30th, 2025 marks the completion of the sixth and final year of the Natural Sciences and Engineering Research Council of Canada (NSERC)/Rio Tinto Industrial Research Chair (IRC) in Climate Change and Water Security at UNBC. The 5+1-year program of research started on July 1st, 2019 with the overarching objective 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. Among other research topics, we have elucidated some of the complex interactions between climate change and human interventions on flow volumes and water temperatures in the Nechako River using a combination of in situ observations and computer modelling. This annual report provides a final update on personnel recruitment and training, program management, our field activities and research, communication strategy and community engagement, and the budget.

Tenure

In early 2024, UNBC applied to NSERC for a one-year, no-cost extension to the NSERC / Rio Tinto IRC in climate change and water security. This extension was indeed granted by NSERC and as such, the program of research was extended by one year to officially conclude on June 30th, 2025. Sincere thanks to UNBC, NSERC and Rio Tinto in facilitating this extension to the IRC position so that we could complete several projects that were delayed due to the COVID-19 pandemic. While this extension came with no additional funding, our field activities and research were well supported through a carry-over of funds from Year 5 into Year 6 (see Budget section) and through other efforts including an NSERC Alliance project and by the Nechako Environmental Enhancement Fund (NEEF). Therefore, this report summarizes progress during the sixth and final project year covering 1 July 2024 to 30 June 2025.

Personnel and Training

During the sixth year of activity, a number of highly-qualified personnel (HQP) were retained or recruited to support the IRC program of research. In supporting roles, Justin Kokoszka (ending on 1 December 2024) and Erica Lee (starting 2 December 2024) acted as the research managers (RMs) for the group while Justin also took on the role of data manager (until 30 June 2025). Dylan Broeke also continued to support the team as a Research Skills Trainee and as field crew leader.

Training of graduate and undergraduate students remained central to the objectives of the IRC. Three undergraduate students from UNBC, Kainen Parmar, Lynn Poeppelmann and Maria Tavares, were recruited as field assistants to support our spring/summer 2024 field activities. While her field assistant position ended in August 2024, Maria Tavares continued supporting data management activities the team on a part-time basis during the fall of 2024 and winter of 2025 semesters. During the spring of 2025, the trio of field technicians from 2024 all returned as field and research assistants. Their positions will run until the end of August 2025. They have been responsible for conducting field work across the Nechako Watershed including site visits for data

collection.

Several graduate students were recruited under the IRC umbrella. As of May 2020, a MSc student, Justin Kokoszka, leads a project on the naturalization of flows in the Nechako River using a flow translation approach. Meanwhile, Bruno Sobral began his PhD program in 2020 by investigating atmospheric rivers affecting the Nechako Watershed. In addition, two post-doctoral fellows (PDFs) worked for the IRC program of research over the past year. Dr. Mostafa Khorsandi worked on station-based modelling of water temperature using the Air2Stream model. Another PDF, Dr. Tamar Richards-Thomas, continued exploring three atmospheric rivers that impacted the upper Nechako Watershed during the TRARE field campaign in autumn 2021.

As part of our committed engagement to education and training we implemented a comprehensive training program for returning staff members. This involved a two-week training program covering the following topics: history of the Nechako River Basin and its local and regional significance, administration and communication practices, field safety, site and equipment management, and data management practices. The training also included several day trips focused on building a weather station, coding in the field, data collection, collecting robust field notes, and GPS training.

Research Management

The Science Advisory Board (SAB) formed in late 2019 oversaw the progress of the IRC program of research and met on two occasions during the final reporting period. The SAB comprised five members: Mr. Andy Lecuyer (Rio Tinto), Dr. Ellen Petticrew (UNBC), Mr. James Rakochy (Cheslatta Carrier Nation), Mr. Chelton van Geloven (Lheidli T'enneh First Nation, formerly of the BC Ministry of Forests), and Dr. Francis Zwiers (Scientist Emeritus, Pacific Climate Impacts Consortium). The SAB along with the Director of the UNBC Office of Research and Innovation, Mr. Mark Barnes, met on 2 December 2024 and on 23 June 2025 to evaluate progress with the IRC program of research through online/hybrid presentations by Dr. Déry and the IRC team. The SAB reported to the UNBC Vice-President of Research and Innovation, Dr. Paula Wood-Adams.

Theme 1: Hydrometeorological Monitoring and Data Collection

During our sixth year of activity, we maintained a network of 31 water temperature loggers (Figure 1), five tipping bucket rain gauges, and eight complete meteorological stations across the entire Nechako Watershed. Improved monitoring of water temperatures and hydrometeorological conditions across the Nechako Watershed was central to Theme 1 of the IRC program of research. Not only did these data provide high-resolution information on the spatio-temporal variations in water temperatures and rainfall in the Nechako Watershed but also assisted with modeling efforts (Themes 2 and 3).

Over the past year we have continued to fine-tune our field records collection software and field notes recording that include: site visit details, data downloads, equipment deployments/retrievals,

and annotated field photos. These records are stored in a central database for quick reference allowing access to field records, equipment details, in addition to raw data collected in the field. Additionally, we have developed an in-house quality assurance/quality control (QAQC) procedure to enhance our data quality and maintain consistency across all sites. In March 2025, we completed the QAQC of water temperature records and developed a reporting procedure to generate data reports and fulfil specific data requests with ease. Fully updated and quality-controlled water temperature time series and associated metadata were then deposited at Zenodo, a publicly-accessible data repository. In the coming months, we plan to extend our QAQC and data management strategy to our extensive meteorological data collection.

Servicing of the water temperature loggers, tipping bucket rain gauges and meteorological stations was once again generously supported by several First Nations and by Rio Tinto. Cheslatta Carrier Nation provided boat access to reach sites in the upper Nechako Watershed including streams flowing into Tahtsa Lake and to the south shore of the Nechako Reservoir. Tl'azt'en First Nation also provided boat support and staff time to reach Kazchek Creek and the Middle River where water temperature probes were also deployed. Nak'azdli Whut'en provided staff support when accessing streams near Fort St. James. Finally, staff members from Stellat'en First Nation joined some of the field visits at the Endako and Stellako rivers.

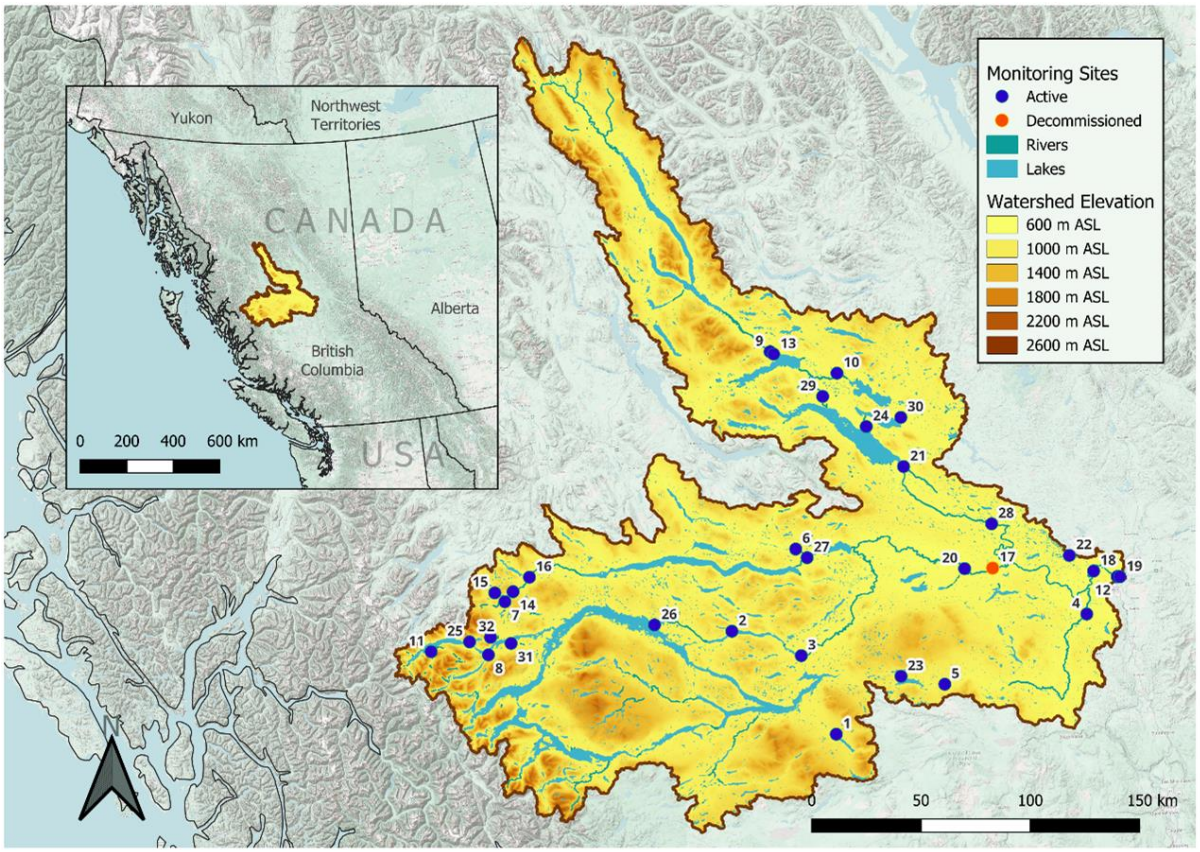

Figure 1: Map of active (as of 30 June 2025, blue dots) water temperature logger sites across the Nechako Watershed.

Following collaborative planning efforts between the Northern Hydrometeorology Group, the Cheslatta Carrier Nation, BC Ferries and WaterBridge Equipment Ltd., a full weather station was successfully installed at Francois Lake on 21 May 2025. The new weather station is located on the rooftop of the BC Ferries building on the north shore of Francois Lake. Then on 18 June 2025, another new weather station was deployed on private property near Isle Pierre. A class of grade 8 students from Prince George Secondary School (PGSS) participated in the deployment of this weather station. Sensors include a sonic ranger, two temperature probes, a compact digital weather sensor (ClimaVUE50) and a radiometer. Together, these instruments measure the following parameters: snow depth, soil, snow (in winter) and air temperature, incoming and outgoing solar and infrared radiation, relative humidity, vapour pressure, barometric pressure, wind speed, wind direction, total precipitation, and lightning strikes. These new weather stations will provide useful meteorological data in areas where data gaps previously existed.

We continue our efforts to organize our monitoring data into a centralized database, promoting data shareability, and enhancing data quality. This initiative ensures easy access to information, facilitates collaborative research, enables efficient analysis, and ensures the longevity of data collected through the IRC program. Additionally, the database includes a system to track and maintain equipment, ensuring accurate and reliable data collection.

Theme 2: Atmospheric and Terrestrial Rivers

Over the past academic year (2024-2025), MSc student Justin Kokoszka continued working on his assessment of regulation and hydroclimate influences on historical streamflow within the Nechako River Basin. Naturalized streamflow has been reconstructed using a flow translation method with reservoir inflow data as a proxy for uninfluenced upstream flow. In summary, these proxy data were translated downstream to Vanderhoof and Isle Pierre while accounting for lake attenuation, water travel time, missing contributing area, and additional flows from gauged tributaries. Both the naturalized and observed streamflow time series were then evaluated for the principal indicators of change in terms of ecologically significant metrics using principal component analysis. These metrics were then evaluated for inter-annual variability in terms of long-term trends and significant change points. The results from these analyses were then used to estimate the relative contribution of change due to regulation and hydroclimate providing a unique insight into hydrological change along the Nechako River. The project is in the final writing phase with a thesis defense likely in early fall 2025.

Also over the past year, Bruno Sobral completed his work on atmospheric river (AR) research by successfully defending his PhD dissertation on 13 December 2024. In October 2024, Chapter 3 of his dissertation was published in *Hydrological Processes* under the title "Water budget input linked to atmospheric rivers in British Columbia's Nechako River Basin". Dr. Sobral is now preparing the last data chapter of his PhD dissertation as a manuscript to be submitted to *Weather and Climate Extremes*.

Dr. Tamar Richards-Thomas completed an analysis of the transport of atmospheric moisture associated with three atmospheric rivers that occurred during the TRARE field campaign in the fall of 2021. A key aspect of this research was the consistency of atmospheric moisture fluxes that led to significant precipitation accumulations in the upper Nechako Watershed. This work was published in a special collection of the journal *Discover Atmosphere*. As well, a paper describing the experimental design and two case studies from TRARE was also published in the same special collection of *Discover Atmosphere*.

Theme 3: Water Temperature and Hydrological Modeling

In spring 2024, Dr. Mostafa Khorsandi calibrated the Air2Stream model for multiple monitoring stations over the Nechako Watershed using measured streamflows, water temperatures, and air temperature data from the ERA5-Land dataset. The calibrated models for each station provide estimates of water temperature for the past and the future. The first fulfilled goal was to fill missing records in the water temperature time series. Historical water temperatures were successfully reconstructed as hindcast modeling using the calibrated models for each station. On the other hand, by forcing the calibrated models with the naturalized flows for the Nechako River at Vanderhoof and Isle Pierre stations, daily water temperatures were simulated for the naturalized condition (e.g., the hypothetical scenario with absence of the Kenney Dam and Skins Lake Spillway in the watershed). Finally, Mostafa's research on the hindcast simulations was published at *Science of the Total Environment* with another manuscript in preparation focusing on future climate change impacts on water temperatures.

Communication Strategy

Over the past year we maintained a comprehensive communication strategy to ensure information on the IRC program of research was disseminated widely and in a timely fashion. This included a dedicated website, presence on social media (e.g. Twitter, ResearchGate and Rio Tinto's Facebook page), MS Teams and a Slack workspace to facilitate interactions between the IRC team members. Dr. Déry was also profiled on NSERC's online Chairholder database. The IRC team prepared a quarterly newsletter posted on the IRC website and emailed to our extensive distribution list (135 individuals and organizations) to disseminate further information on the IRC to the general public. Dr. Déry was interviewed a dozen times over the past year by various media outlets including on his perspectives of recent drought and low streamflow conditions in northern BC.

Dr. Déry delivered several presentations over the past year to a wide range of stakeholders in the Nechako Watershed and beyond. For instance, he delivered a presentation on climate change in the Nechako Watershed at the spring technical meeting of the Nechako Watershed Roundtable in Fort St. James on 2 June 2025. In May 2025, Dr. Déry provided an update on IRC-related research to the True North 2025 Business Development Forum held in Prince George, BC. Dr. Déry also delivered two guest lectures in geography courses at UNBC during which IRC-related research on

atmospheric rivers was profiled. Finally, Dr. Mostafa Khorsandi delivered an oral presentation at the 2025 joint CMOS/CGU congress in Saskatoon, Saskatchewan.

As results continue to emerge from the IRC program of research, conference presentations and peer-reviewed publications will continue in the coming year. The following provides a list of recently published papers and conference presentations from the past year.

Recent Journal Articles

Hurley, K. M., Morris, J. E., Cardinal, E., Gilbert, D. E., Kaveney, A. R., Sobral, B. S., Thompson, H. D., Thériault, J. M, and Déry, S. J., 2025: The Tahtsa Ranges Atmospheric River Experiment (TRARE): Experimental design and case studies, *Discover Atmosphere*, **3**, 12.

Kokoszka, J. E., Broeke, D., Calder-Sutt, F., Khorsandi, M., Tavares, M. A. and Déry, S. J., 2025: Updating "Sub-hourly water temperature data collected across the Nechako Watershed, 2019-2021" to 2024 and with supplemental sites, *Data in Brief*, **61**, 111710.

Richards-Thomas, T. and Déry, S. J., 2025: Moisture transport to British Columbia's Upper Nechako Watershed associated with three atmospheric rivers, *Discover Atmosphere*, **3**, 9.

Khorsandi, M. and Déry, S. J., 2025: A novel method for frequency analysis of high water temperatures using temperature duration curves in a partially regulated watershed, *Science of the Total Environment*, **968**, 178863.

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.

Conference Presentations

Khorsandi, M. and Déry, S. J. 2025: A novel method for frequency analysis of high water temperatures using temperature duration curves in a partially regulated watershed, 2025 joint congress of the Canadian Meteorological and Oceanographic Society and Canadian Geophysical Union, Saskatoon, Saskatchewan, 29 May 2025.

Community Engagement

The success of the IRC relied on a broad communication strategy and community engagement. To that end, efforts were routinely made to communicate with First Nations as to where field work and other research is being undertaken as part of the IRC. Over the past year, we maintained our engagement with four First Nations: Cheslatta Carrier Nation, Stellat'en, Nak'azdli Whut'en, and Tl'azt'en First Nations. Most of the IRC team travelled to Cheslatta Territory on 20 May 2025 to

meet representatives from Cheslatta Carrier Nation. This included a presentation on the Nation's history and the geography their traditional territory covers.

We continued to entertain a wide range of discussions with many individuals and organizations across the Nechako Watershed during field work across the upper Nechako Watershed. This included several site visits in 2024 and 2025 at Huckleberry Mine for discussions with the mine's general manager, Mr. Marke Wong. We also connected with staff members of the Fisheries and Oceans Canada's Nadina River Spawning Channel where a new weather station is now installed. We anticipate continued interactions with members of the community this summer as we return to our field sites for data collection and as we finalize the commissioning of the MECHE observatory at Huckleberry Mine.

Dr. Déry remained engaged in Rio Tinto's Water Engagement Initiative (WEI) and participated in main table and technical working group meetings over the past year. Further, Dr. Déry and Lucas Macedo Moura (IWRG Research Manager) participated in and presented at the Nechako Watershed Roundtable's (NWR's) annual meeting on 25 September 2024 online and the spring technical meeting on 2-3 June 2025 in Fort St. James. Dr. Déry has also represented UNBC and the Integrated Watershed Research Group at monthly NWR Core Committee meetings starting in May 2024. Dr. Déry has also engaged in the UNBC-Nechako Valley Working Group by attending its bi-monthly meeting and participating and presenting at the annual general meeting of the Nulki-Tachick Lakes Stewardship Society.

Industrial Partner Engagement

Dr. Déry interacted on a regular basis with Rio Tinto, the industrial partner via email, phone, online and in person meetings. The principal contact person at Rio Tinto for research was Andy Lecuyer, while for outreach, interactions were facilitated by Lianne Olson (Senior Advisor, Community Social Performance) and Devrie Sanghera (Business Partner, Communities & Social Performance). Additional communication with Alec Mercier and Marco Latraverse on the water management team proceeds on a periodic basis for the exchange of data and metadata, information on Rio Tinto's operations and system in the Nechako Watershed, and to identify monitoring and information gaps in the basin.

Over the past year we maintained close collaboration with Scott Klassen of Avison Management Services for periodic site visits of UNBC meteorological equipment at Chedakuz Creek and at Eutsuk Narrows. Alec Mercier also continued to provide up-to-date streamflow and water temperature data at the Kemano Powerhouse and other key sites that were integrated into multiple IRC projects. Finally, Andy Lecuyer has provided continuous support by sharing his knowledge on Rio Tinto's operations across the Nechako Watershed.

Budget

The IRC program of research was supported equally by NSERC and Rio Tinto with a total budget of $1.5M over six years. Approximately one third of this budget supported Dr. Déry's salary and benefits. With the release of these funds and to fulfil the requirements of NSERC's IRC program, UNBC hired in September 2020 a new tenure-track faculty member (Dr. Siraj ul Islam) to build institutional capacity in hydrometeorology. As of 30 June 2025, available funds for Year 6 were disbursed mainly for the support of HQP (83.3%) with other expenses related to field work, materials and supplies, travel to conferences, etc. (16.7%). As of 30 June 2025, we expended 97.7% of the overall allocated funds for the entire IRC program of research. The remaining 2.3% in the budget are outstanding charges that will be processed during July 2025. As such we will have used the entirety of the NSERC / Rio Tinto IRC budget over the 6-year program of research.

While NSERC and Rio Tinto provided the bulk of the funding for the IRC program of research, extra support was secured through the Canada Water Agency (two successful applications in 2024/2025). Successful applications to the Nechako Environmental Enhancement Fund (NEEF) and to NSERC's Alliance program also secured additional funding that partly supported our field activities in the Nechako Watershed during the 2024 and 2025 summer field seasons. In late spring 2024, we secured $17K through to the Partnering Fund of the Real Estate Foundation of BC to extend research on the atmospheric river phenomenon in the Fraser River Basin.