CORPORATE REPORT

2022-2023

PACIFIC CLIMATE IMPACTS CONSORTIUM

Land Acknowledgment

PCIC is situated on the unceded territories of the W̱SÁNEĆ Peoples and of the lək̓ʷəŋən Peoples of the Esquimalt and Songhees Nations. The First Nations of these unceded territories have long been stewards of this land, and their relationships to this land continue to this day. PCIC serves all people of colonially-named British Columbia and is committed to working with the Indigenous Peoples of this region to understand how the climate is changing, the impacts of those changes, and how to suitably adapt.

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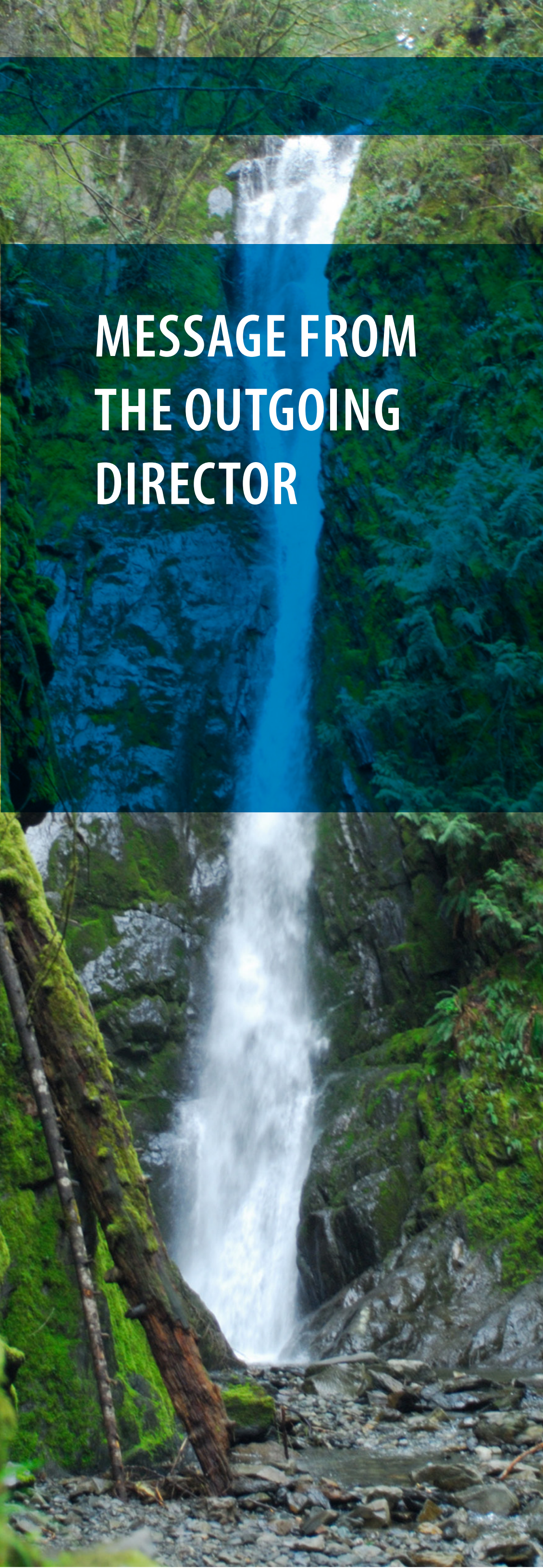


Message from the Outgoing Director

I write this at a time of transition, both for myself and PCIC. It's been immensely satisfying and humbling to have had the privilege of overseeing PCIC's growth and maturation over the past 13 years, as is further discussed in Rachel Goldsworthy's retrospective that appears on Page 2. I've had the opportunity to work with an immensely talented and highly motivated team and to learn from both the team and our wide array of users, who have a fascinating and diverse range of responsibilities and interests. And I've enjoyed the unwavering support of our users, and of PCIC's host institution, the University of Victoria.

Looking forward, I'm extremely thankful that Dr. Xuebin Zhang has accepted the challenge of continuing to lead PCIC's grow and development. Xuebin is a deeply talented scientist with very strong national and international profiles and extensive expertise in climate science and its applications that is the perfect match for PCIC's requirements and the needs of its users. The change in leadership is taking place at a time when both British Columbia and Canada are awakening to the reality of the growing impacts of climate change on our well-being, livelihoods, communities and ecosystems. This awakening creates both opportunities and challenges – opportunities to expand the services we provide, increase their effectiveness and to learn even more from our users, and challenges that come from a broadening scope, greater expectations and an ever-increasing sense of urgency. And it comes at a time of rapid change in the underpinning climate science, with explosive growth in the amount of climate model output and remotely sensed data that is available to climate scientists, and an increasingly strong impetus to provide targeted information at local scales.

The need for location specific information is undeniable. For example, every building that needs to be adapted to climate change and every new structure that is built is located in a specific place and will be exposed to the climate evolution that takes place at that location. But this scale is also the scale at which the effects of chaotic natural climate variable occur most profoundly and at which we still have a great deal to learn about exactly how local land and atmospheric processes will affect the outcomes that we will experience. I'm confident that under Xuebin's leadership, PCIC will continue to excel in meeting the challenge of providing the Province and our partners across the country with the best possible information about evolving climate at impact relevant scales.

- Francis Zwiers

PCIC's Evolution Over the Past 15 Years: A Retrospective by Rachel Goldsworthy

Pacific Climate Impacts Consortium: the name says it all

Since 2010, statistician and climatologist Francis Zwiers has been the director of the Pacific Climate Impacts Consortium (PCIC). Under Zwiers's leadership the institute has almost doubled in size to about 25 staff and increased its budget by more than 250%. But the main change since its founding in 2008, Zwiers says, is that PCIC has expanded beyond its early project-to-project work and is now recognized as an authoritative climate service provider with national impact that is focused on users but also produces and publishes a substantial amount of innovative climate research.

Helping understand and predict climate risks

"We are a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change in our region and also produces climate information products that are used across Canada," Zwiers explains. "We collaborate with climate researchers and regional stakeholders to produce knowledge and tools that support long-term planning and risk management across Canada."

In fact, for scientists, engineers and planners at all levels of government and community, PCIC is one of Canada's leading sources of evidence-based information on future climate change and impacts at the scales that are relevant for climate change adaptation.

"The work that engineers and planners do is place-based," Zwiers says. "They focus on communities, buildings, roads and bridges, etc, that are in specific places – so the challenge we try to tackle is to provide information that is as specific as possible for the place that is of concern." Along with data portals, publication libraries, analysis tools and more, PCIC reaches a broad audience via scientific briefing papers that incorporate current peer-reviewed research findings into reports easily accessed by other scientists and the public. One such report, just as an example, expands on Jain et al's "Observed increases in extreme fire weather driven by atmospheric humidity and temperature" in *Nature Climate Change* (2022).

"[Jain et al's] work underlines the importance of rising temperatures and relative humidity in the occurrence of extreme fire weather," the briefing says, "and is consistent with attribution work on wildfire risk conducted at PCIC. These studies, led by PCIC, detected an anthropogenic influence on extreme fire risk.... Understanding the key drivers of fire weather will help the scientific community to better understand how extreme fire weather will change in the future. This understanding, in turn, will be helpful for informing fire management plans."

Working with governments to foster resilience

PCIC scientists, Zwiers explains, have always had close interactions with multiple federal departments: Environment and Climate Change Canada, naturally; with Fisheries and Oceans Canada to help assess how future river flow and river water temperature may affect salmon in their freshwater habitat; and with the National Research Council to study how climate-sensitive building design criteria may change.

Long-standing partnerships with provincial government agencies include the ministries of Environment and Climate Change Strategy, Transportation and Infrastructure, Forestry and now also include Emergency Management and Climate Readiness. As well, PCIC collaborates extensively with regional and local government, and with BC Hydro and Power Authority, a Crown corporation responsible for generating, purchasing, distributing and selling electricity. Because the province of BC relies on hydroelectric power, the agency has a deep, pressing and growing need for the best hydrologic modelling for future water resources and availability.

"BC Hydro needs authoritative modelling of basins across the province," says Zwiers. "PCIC is an independent source of information, as well as collaborating with BC Hydro's own hydrologic team." In fact, he recently briefed the Crown Corporation's executive team on climate change.

One more example, of many, of an extensive collaborative service is the Western Arctic Weather Data service. Observations of weather and climate variables such as temperature and rainfall for the Northwest Territories and Yukon are collected in a PCIC-maintained database. On an interactive map, users can zoom and pan to a region, filter based on observation dates, weather element, observing agency, region and more. The list of agencies that provide data to PCIC for this program runs to more than two dozen, including the federal Environment and Climate Change Canada, Fisheries and Oceans Canada, Parks Canada and the Geological Survey of Canada; the regional Northwest Territories departments of Transportation and Environment and Natural Resources; Yukon Abandoned Mines, Yukon Water Resources, Yukon Wildland Fire Management; Ekati Diamond Mine; and many others in the private and public sectors.

"The Western Arctic portal is a recent addition to the collection of services we provide," Zwiers says, "but we also have a long-established portal for BC that provides access to weather data from almost 7000 locations across the province."

That portal is an important part of the province's "Climate Related Monitoring Program" (CRMP), which is led by the Ministry of the Environment and Climate Change Strategy and coordinates across basically all agencies that collect weather data in BC. PCIC has the mandate to gather that data all in one place, make it public and utilize it for purposes like climate mapping.

Zwiers says, "The BC and Western Arctic services are unique in Canada in terms of facilitating access to weather data from multiple sources all in one place."

Training Canada's - and the world's - climate professionals

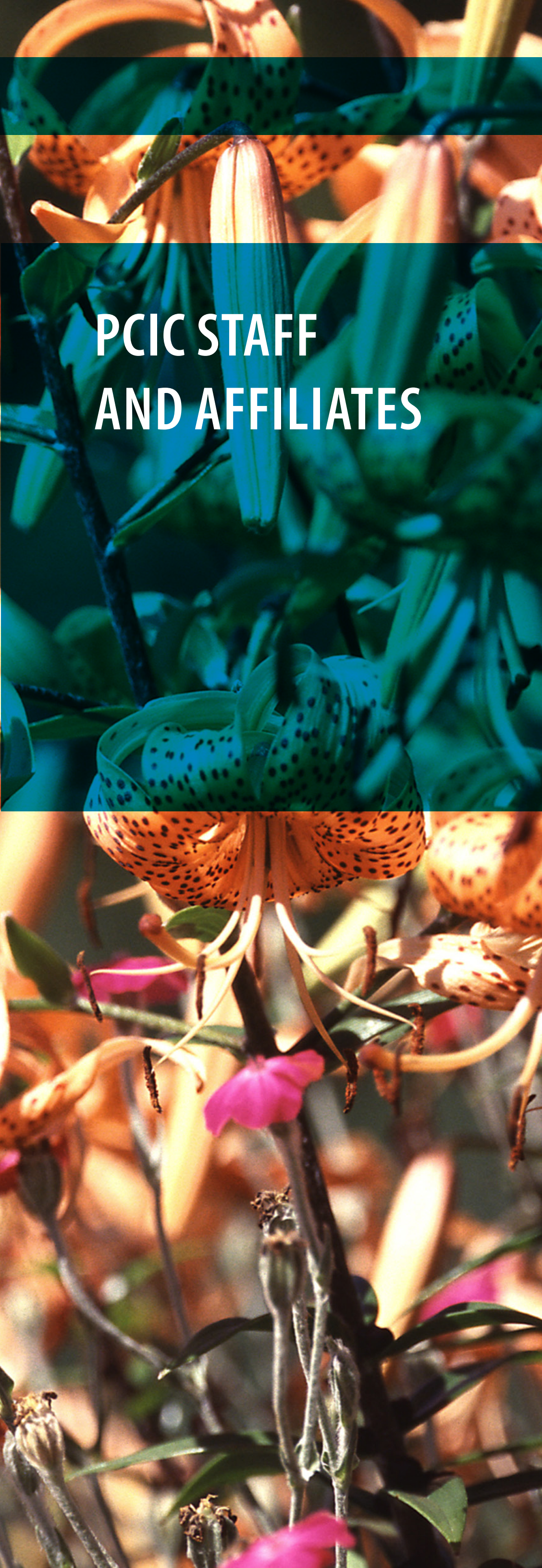
"The importance of our relationships with the users of climate information has become increasingly obvious as concern has mounted about the role that climate change plays in the occurrence and intensity of disasters like wildfires and floods," Zwiers says. "And that makes another facet of PCIC's work more timely and impactful: training of world-calibre scientists and professional development for engineers and scientists in the field."

In 2022, just as one example, PCIC provided a workshop for the Canadian Water Resources Association and the Canadian Society for Hydrological Sciences on working with future climate projections for hydrologic modelling. The online session introduced some of PCIC's climate projections that are available for use in hydrologic modelling and introduced core concepts related to temperature and precipitation projections developed at PCIC, among other modelling topics. As with many PCIC educational sessions, the recording from this workshop is publicly available.

A global reputation for engaged climate service and research

PCIC's stellar reputation attracts first-rate researchers. At any time, the roster might include statisticians like Zwiers, regional climate impacts specialists, an expert team of hydrologists, training and engagement specialists, a climate mapper, climate data specialists, programmers and IT experts. Many are early in their careers and bring fresh eyes, ideas and unique skills to the consortium for several years, then apply their expanded skill sets around the world in the private and public sector and in academia. Clearly, PCIC is a place to grow a career as well as the world's knowledge about climate impacts – and how to manage them.

(This article was written and kindly provided by Rachel Goldsworthy and the University of Victoria. It was originally written as an article for Times Higher Education.)



PCIC STAFF AND AFFILIATES

PCIC Staff and Affiliates

Staff list: Md. Shahabul Alam, Mohamed Ali Ben Alaya, Faron Anslow, Charles Curry, Abigail Dah, Rod Glover, James Hiebert, , Shelley Ma, Trevor Murdock (on secondment), Nina Nichols, Stacey O'Sullivan, Dhouha Ouali, Markus Schnorbus, Arelia (Werner) Schoene-berg, Michael Shumlich, Stephen Sobie, Qiaohong Sun, Travis Tai, Kari Tyler, Pei-Ling Wang, Francis Zwiers.

Not pictured: Johnathan Helfrich (co-op student), Tom Kunkel, Samah Larabi, Isabelle Lao, Teresa Rush, Ada Sungar (co-op student), Kathy Veldhoen, Eric Yvorchuk, Lee Zeman.

We were also happy to welcome back Charlie Ballantyne (not pictured) as a contractor this fiscal year.

PCIC Governance: 2022-2023

Board of Directors

Lisa Kalynchuk (Chair), Vice-President Research & Innovation, University of Victoria

David Atkinson, Professor and Chair, Geography, University of Victoria

Jim Barnes, Manager, Corporate Initiatives, Engineering Services, Ministry of Transportation and Infrastructure

Julia Baum, Professor and President's Research Chair, Biology, University of Victoria

Alain Bourque, Directeur Général, Ouranos

Stephen Déry, Professor, Department of Geography, Earth and Environmental Sciences, University of Northern British Columbia

Ellie Farahani, Manager, Canadian Centre for Climate Modelling and Analysis, ECCC

Christopher Kennedy, Professor and Chair, Civil Engineering, University of Victoria

Paul Kushner, Professor, Department of Physics, University of Toronto

Heather Matthews, Director, General Systems Operations, BC Hydro

Ian Mauro, Executive Director, Pacific Institute for Climate Solutions, University of Victoria

Adam H. Monahan, Professor, School of Earth and Ocean Sciences, University of Victoria

Colleen O'Keefe, Senior Legal Counsel, University of Victoria

Sybil Seitzinger, Professor, Environmental Studies, University of Victoria

Francis Zwiers, Director, Pacific Climate Impacts Consortium, University of Victoria

Kathy Veldhoen, Lead, Planning and Operations, Pacific Climate Impacts Consortium (Treasurer)

Jamie Millin, Senior Paralegal, University of Victoria (Secretary)

Programme Advisory Committee

Tina Neale (Chair), Director, Climate Risk Management, BC Ministry of Environment and Climate Change Strategy

Ron Burleson, Director, Planning and Land Use, BC Ministry of Municipal Affairs

David Campbell, Section Head, River Forecast Centre, BC Ministry of Forests

Jeremy Fyke, Coordinator, Canadian Centre for Climate Services, Environment and Climate Change Canada

Nathan Gillett, Manager and Research Scientist, Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada

Colin Mahony, Research Climatologist, Forests Carbon and Climate Services Branch, BC Ministry of Forests

Kate Miller, Manager, Environmental Initiatives, Cowichan Valley Regional District

Ian Pilkington, Chief Engineer, BC Ministry of Transportation and Infrastructure

Stephanie Smith, Manager, Hydrology and Technical Services, BC Hydro

Tim Takaro, Professor, Faculty of Health Sciences, Simon Fraser University

Stephanie Tam, Water Management Engineer, BC Ministry of Agriculture and Food

Francis Zwiers, Director, Pacific Climate Impacts Consortium

Downscaling and Applying Quality Control to CMIP6 Model Output

Partner: **Environment and Climate Change Canada / Environnement et Changement climatique Canada**

PCIC's research team began analyzing and downscaling global climate model (GCM) output from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) in 2021. This work included comparing CMIP6 results with those from the prior CMIP5, downscaling GCM output across Canada one variable at a time using the Bias Correction/Constructed Analogues with Quantile mapping, version 2, method (BCCAQv2), and evaluating several multivariate techniques that treat all variables of interest simultaneously. This year, PCIC scientists extended and completed this work, using the best performing multivariate technique, N-dimensional Multivariate Bias Correction (MBCn) to downscale GCM output across Canada. MBCn retains BCCAQv2's excellent single variable performance, while ensuring that relationships between variables like daily maximum temperature, daily minimum temperature and daily precipitation amount reflect the relationships seen in observations, which increases the our confidence in projected changes in indices that describe compound events based on two or more variables.

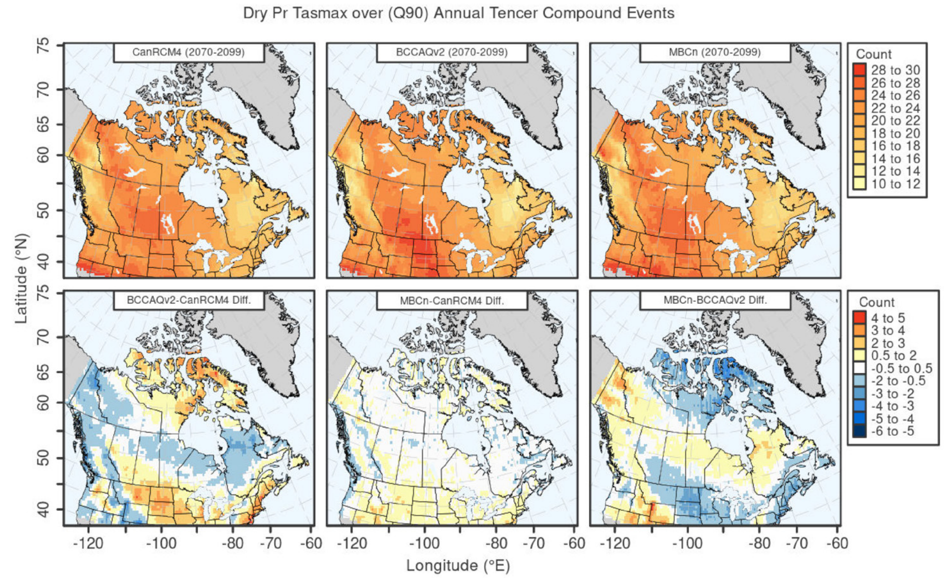


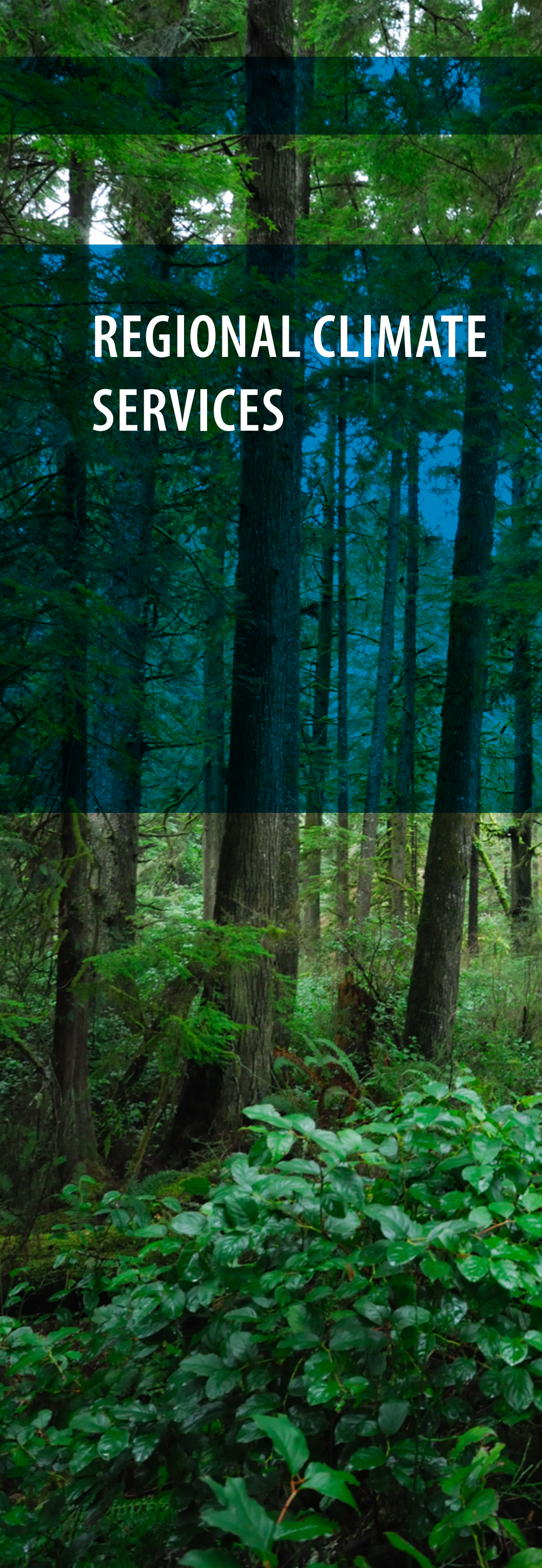
Figure 1 : This figure shows the results of an experiment in which moderate resolution output from the CanRCM4 regional climate model is first coarsened to much lower global climate model resolutions, and BCCAQv2 and MBCn are then used to attempt to recover the information originally present in the CanRCM4 output. The figures show projections of annual number of hot and dry compound events in which the temperature is in the top 10% of hottest days and the daily precipitation is less than 1 mm. and differences in that index between the original CanRCM4 output and the downscaled versions of the coarsened CanRCM4 output. The colours show the average number of projected hot-dry days per year over the 2070-2099 period. The top panels show the number of days in the original model output (top left), the BCCAQv2 reconstruction of the model output from the coarsened version of the model output (top middle) and the corresponding MBCn reconstruction (top right). The bottom panels show the differences as labeled, clearly indicating that MBCn does a much better job that BCCAQv2 of reproducing the relationship between high temperatures and low precipitation that is seen in the original CanRCM4.

As expected, indices that rely solely upon temperature or precipitation don't show much difference between the two downscaling techniques. However, indices that rely on both temperature and precipitation show improved performance. This is especially true for compound extreme events in which daily temperature and precipitation extremes occur together. As shown in Figure 1, the MBCn method better describes the frequency of these events over most of Canada.

"INDICES THAT RELY ON BOTH TEMPERATURE AND PRECIPITATION SHOW IMPROVED PERFORMANCE [WITH MBCN]. THIS IS ESPECIALLY TRUE FOR COMPOUND EXTREME EVENTS IN WHICH DAILY TEMPERATURE AND PRECIPITATION EXTREMES OCCUR TOGETHER."

Downscaled CMIP6 climate change simulations produced with both BCCAQv2 and MBCn from a suite of 26 global climate models running the SSP1-2.6, SSP2-4.5 and SSP5-8.5 scenarios were supplied to PCIC's partners at Environment and Climate Change Canada. The BCCAQv2 scenarios are available from PCIC's Data Portal and are now displayed on the national platform ClimateData.ca.

While performing this downscaling analysis, PCIC's research team noticed outliers in some of the extreme maximum temperature data. Three participating models were found to have extremely high, sporadically occurring, surface air temperatures at isolated locations during the Northern Hemisphere warm season (May through October). Upon finding the anomalies, PCIC's research team contacted the modelling groups who maintain the models to confirm the issue. They then developed a method to detect the anomalies and replace the affected model output with improved estimates based on well-behaved values from surrounding locations. PCIC's team recently produced corrected versions of the downscaled model runs and have also provided these to our partners at ECCC.



REGIONAL CLIMATE SERVICES

Building the Capacity of Canada's Climate Service Providers

Partner: **Canadian Centre for Climate Services, Environment and Climate Change Canada / Centre canadien des services climatiques, Environnement et Changement climatique Canada**

PCIC continues to work with the Canadian Centre for Climate Services (CCCS) to coordinate and build the capacity of Canada's climate service providers. Together, we are dedicated to delivering regional climate services that are tailored to user needs. This past year PCIC's team continued to provide training to diverse user groups, support the development of training materials and contribute to the development of sector modules on ClimateData.ca.

PCIC participated in three bodies convened by CCCS: the Regional Coordinating Committee, which facilitates coordination between Canada's regional climate service providers, the Training Sub-Group, which supports trainers and coordinates the development of training materials, and the Support Desk Working Group, which advises the CCCS on its responses to user queries. PCIC also participated in the governance and coordination of a broad national collaboration to develop and improve ClimateData.ca, including the Project Management Committee, which ensures coordination between the participants in the collaboration, and the Product and Data Working Groups, which reviews changes to existing online components and provides guidance on new products in development.

"THIS PAST YEAR PCIC'S TEAM CONTINUED TO PROVIDE TRAINING TO DIVERSE USER GROUPS, SUPPORT THE DEVELOPMENT OF TRAINING MATERIALS AND CONTRIBUTE TO THE DEVELOPMENT OF SECTOR MODULES ON CLIMATEDATA.CA."

PCIC's work on outreach materials for the Outreach Working Group included providing feedback on a Map of Adaptation Actions and supporting the development of training materials and programs for the transportation sector of ClimateData.ca.

Supporting and Building onto ClimateData.ca

Partners: **Computer Research Institute of Montréal, Canadian Centre for Climate Services / Centre canadien des services climatiques**

PCIC has been supporting the development of ClimateData.ca as part of a national collaboration that is working to provide Canadians with climate information for planning. This includes the aforementioned downscaled climate model projections from CMIP6, along with support and guidance on its use. This year PCIC participated in the review and quality control of future-projected intensity, duration and frequency (IDF) curves of precipitation that were added to climatedata.ca, which uses a methodology we have applied in other contexts. In addition, PCIC's team participated in the refinement of case studies for the Transportation Module, review of the Buildings Module, and conducted preparations and background research for the upcoming Finance and Marine Modules. Finally, PCIC provided user experience testing and a review of a decision support tool that is currently in development at the CCCS.

Supporting the Cariboo Road Recovery Project

Partner: **BC Ministry of Transportation and Infrastructure**

Scientists at PCIC have been supporting efforts by the BC Ministry of Transportation and Infrastructure (MoTI) to mitigate the future risks to transportation from landslides in the Cariboo Region. Weather-related extreme events pose extreme risks to highway infrastructure in British Columbia. Wildfires, along with changes in rainfall during the spring and summer and changes in the timing of snow melt, have altered the distribution of soil moisture in the Cariboo region, causing several massive slides and substantial damage to roads and highways over recent years. Having knowledge about projected changes to climate in the area can help planners and engineers as they work to rebuild more resilient highway infrastructure. PCIC's team has partly addressed this need by producing a set of climate maps and tables that were delivered to MoTI, including projection information for both the Cariboo Region as a whole and specific sites identified by the team working on the road recovery projects. Two key findings from this work were that the region can expect to see increases in temperature (Figure 2) and precipitation extremes and decreases in snowfall and the number of annual freeze-thaw cycles. Annual average temperatures are projected to increase by 3.2°C by the 2050s relative to the past (1980s) with the frequency of hot summer days (with temperatures over 30°C) projected to increase by 20-30 days per year. In addition, annual precipitation is expected to increase by 15% in the 2050s and annual maximum two- and five-day rainfall are projected to increase by 15% and 12%, respectively, while snowfall

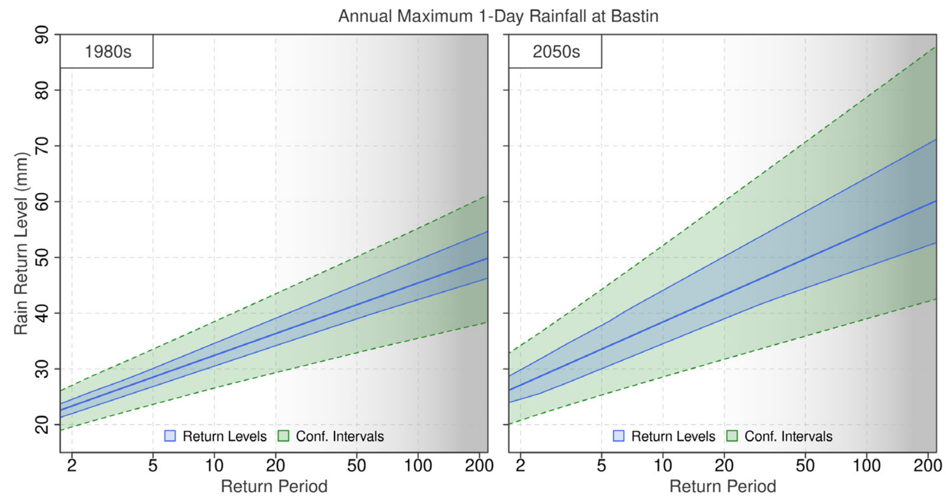


Figure 2 : This figure shows the estimated return levels of annual maximum daily rainfall for Bastin Road for the 1980s (left) and 2050s (right) as taken from downscaled GCM simulations. The blue areas denote the 10th to 90th percentile range of the return level estimates with the ensemble median shown by the central blue line. Green areas denote confidence intervals (5th to 95th) for the ensemble originating from return level estimation and these are bounded by dashed lines. Background gray shading indicates increased uncertainty in estimated return levels for rarer events than seen in the observed record.

is projected to decrease by 25%. PCIC's researchers also cautiously estimated changes in extreme precipitation events with return periods of up to 200 years, which are of particular interest to the Cariboo Recovery team of engineers.

Providing Climate Projections for the City of Terrace

Partner: **City of Terrace**

Municipal governments often find themselves at the leading edge of climate impacts and adaptation challenges because of the extensive responsibilities they have for local infrastructure and services. An example of the way in which PCIC can serve municipalities is a project that it undertook in partnership with the City of Terrace to provide climate information and interpretation to support its adaptation planning. The resulting Climate Projections Report, prepared by PCIC and Pinna Sustainability, provides projections and impacts analysis that serve as the first phase in the development of a Climate Adaptation Plan for the City, to be followed by a risk assessment and an adaptation and mitigation strategy.

"THE OVERALL PICTURE PROVIDED BY CLIMATE CHANGE PROJECTIONS FOR TERRACE IS ONE OF WARMING ACROSS ALL SEASONS, WITH FEWER DAYS WITH FREEZING TEMPERATURES, MORE EXTREME HOT DAYS DURING SUMMER AND AN EXTENDED GROWING SEASON."

Terrace has faced several extreme weather events over the past few years, including the heat dome in summer of 2021 and an extreme cold spell followed by an extreme rainfall event that winter, which overwhelmed its sanitary sewer system. Terrace commissioned this report to inform planning that aims to make the city more climate resilient. The report covers standard climate variables, such as temperature and precipitation, as well as the Climdex indices developed by the Expert Team on Climate Change Detection and Indices, statistics that describe aspects of temperature and precipitation extremes.

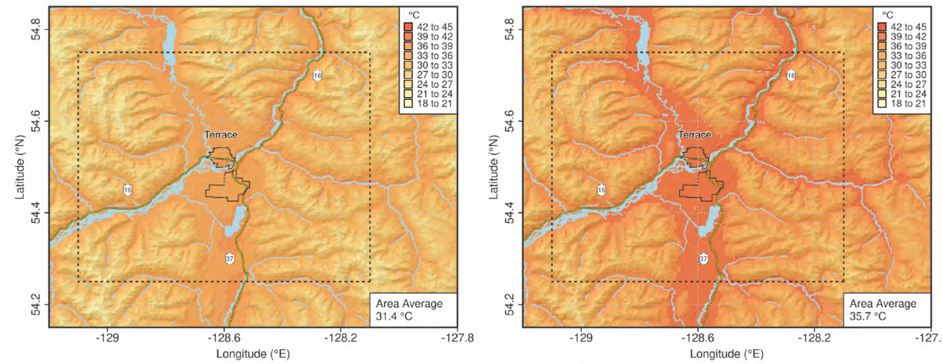


Figure 3: This figure shows the temperature of the 1-in-20 year hottest day in the past (1971-2000 period, left panel) and the projected future period (2041-2070, right panel). Temperatures are as indicated in the legend. The dark outlines near the map centre show the Terrace city limits, while the dashed grey lines encompass the surrounding area that also formed part of PCIC's analysis.

The overall picture provided by climate change projections for Terrace is one of warming across all seasons, with fewer days with freezing temperatures, more extreme hot days during summer (Figure 3) and an extended growing season. Projections also suggest that the region will see an increase in precipitation during all seasons except the summer and a decrease in the amount of precipitation falling as snow.

Expanding PCIC's Engagement with Indigenous Communities

Partner: **BC Ministry of Environment & Climate Change Strategy**

PCIC recently expanded its user engagement and training team, taking on an Indigenous Communities Climate Adaptation Coordinator, and has focused on relationship-building and listening to First Nations to better understand their priorities regarding climate information.

This year PCIC also participated in the Indigenous Climate Resilience Forum, a virtual event to support the resilience of Indigenous communities, and the BC Assembly of First Nations webinar series on climate change. These events are opportunities to share about PCIC's increased capacity and share knowledge around climate data applications and uses. PCIC has also begun to support First Nations and organizations in accessing climate data for their territories to include in risk and adaptation assessment. We recognise that relationship building is a long process involving listening, being responsive to interests, trusting and gaining trust and that what is mentioned here are just the first steps in this process.

"WE RECOGNISE THAT RELATIONSHIP BUILDING IS A LONG PROCESS INVOLVING LISTENING, BEING RESPONSIVE TO INTERESTS, TRUSTING AND GAINING TRUST AND THAT WHAT IS MENTIONED HERE ARE JUST THE FIRST STEPS IN THIS PROCESS."

Ongoing Work to Improve Floodplain Risk Assessments

Partner: **Environment and Climate Change Canada / Environnement et Changement climatique Canada**

Work continued this year on the evaluation of a new reanalysis product for North America, the second version of the Regional Deterministic Reforecast System (RDRSv2.1), produced by ECCC. Reanalysis products are representations of the historical climate that are created from historical observations that are "assimilated" into a global weather forecast models that are run in a hindcast mode. This particular product holds considerable promise as calibration data for the hydroclimatic modelling of key flood basins across Canada. Climate change is likely to affect the magnitude and frequency of flooding events, which are historically responsible for the most costly impacts in Canada.

One potential application that is being considered at PCIC is whether this reanalysis product can be used to create functions that show the relationships between rainfall intensity, duration and frequency, called IDF curves. Two different types of IDF curves are possible, using two sets of data from within the RDRS reanalysis: one that results from using data from the Canadian Precipitation Analysis (CaPA) to correct the forecast using station- and satellite-based measurements in a post-processing step, and one that comes from the original meteorological forecast. PCIC's team is evaluating both types of curves against IDF curves from observations. One preliminary finding is that, in nearly all regions of Canada, the forecast precipitation exceeds that from the analysis, with the difference becoming greater at shorter durations. The largest differences were found over the southern Prairies, where forecasts might predict too much convective rainfall, and on the eastern slopes of the Coast Mountains of BC, which might be due to the smoothing of the coarser-scale CaPA.

The end goal of this is to develop IDF curves made from the analysis product that will be able to supplement IDF curves from observations. This will make IDF curves available for more locations in Canada. The forecast-based IDF curves may also be able to help forecasters issue weather warnings by translating a forecast precipitation amount into a statement about the rarity of the forecast event, expressed as a return period. PCIC's team is now proceeding with the construction of IDF curves over the entire study area and formulating effective means for visualization of the results in a forecasting context.

Supporting Energy Modelling for Building Professionals

Partner: **Environment and Climate Change Canada / Environnement et Changement climatique Canada**

PCIC continues to work to provide building professionals with meteorological information to support the energy modelling of building designs by providing future shifted weather files based on climate model output from the sixth, and most recent, phase of the Coupled Model Intercomparison Project (CMIP6). Because buildings are long-lived, the future climate conditions that a building will be exposed to are important factors to consider in its design. Weather files are used to represent meteorological conditions for the energy modelling of buildings.

This year, PCIC researchers produced future-shifted versions of the 2020 Canadian Weather year for Energy Calculation weather files (CWEC2020) for all 564 CWEC2020 locations across Canada. These were prepared for 30-year windows from the 2040s to the 2080s, and also at different levels of global warming, ranging from 0.5°C to 3.5°C. As expected, these files show an overall reduction in the need for heating and an increase in the need for cooling, as Canada continues to warm (Figure 4). Projected changes are largest in variables derived from temperature, more moderate for relative humidity, and negligible for surface pressure. Eventually, we anticipate that these updated weather files will be used by public sector organizations and buildings professionals in BC and across Canada.

Both the CWEC2020 files and their future-shifted versions encapsulate a single year of hourly weather from station data designated as a Typical Meteorological Year (TMY). However, the TMY approach has certain drawbacks, including jumps in climate variables across monthly boundaries and a lack of information about climate extremes, such as heat waves or cold spells. To address this, PCIC's team developed new methods to simulate future hourly series of weather file variables, from which other types of summary data could be drawn, such as Extreme Meteorological Years. The results were exhibited at eight selected CWEC2020 sites and provide a more complete picture of weather conditions in both historical and future-simulated climates.

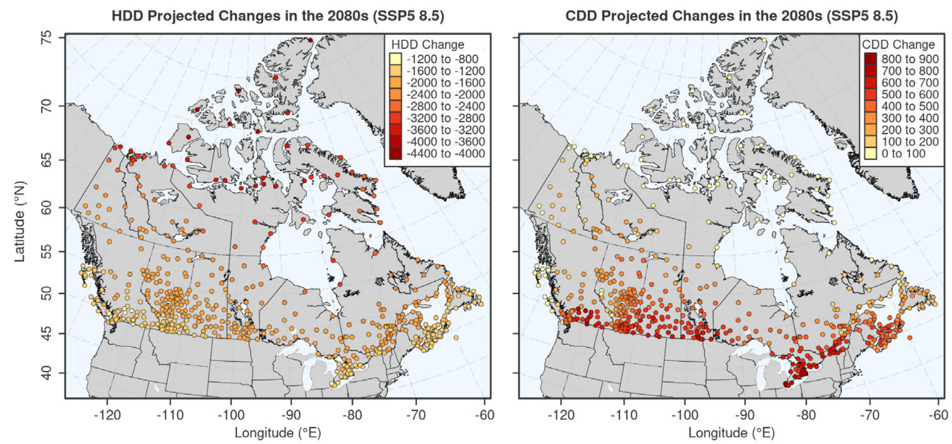


Figure 4: This figure shows the projected changes in heating degree days (a measurement designed to quantify energy needs for heating, left panel) and cooling degree days (a measurement designed to quantify energy needs for cooling, right panel) for the 2080s relative to 1971-2000 for a high-emissions scenario. The overall pattern shows a decrease in energy needs for heating across Canada (a 33% median decrease in HDD) and an increase in energy needs for cooling (a nearly fivefold median increase in CDD—note, however, that historically, CDD has been quite low over most of the country).

Renewed Partnership with BC Hydro Supports Hydrologic Modelling Across the Province

Partner: **BC Hydro**

The relationship between BC Hydro and PCIC is a special one, with BC Hydro sitting at the table at which the concept of the organisation that would eventually become PCIC was first articulated in 2005. This has developed into an 18-year partnership that has allowed for a considerable volume of work studying the climate and hydrology of the province. Among this, it has resulted in hydrologic modelling of the Peace, Fraser and Columbia Basins, information for climate planning and tools to make these products accessible. We are pleased that BC Hydro and PCIC have signed a new agreement that will continue this fruitful partnership for the next four years.

A large portion of our recent work has been the development and deployment of the Raven hydrologic modelling framework to drainage basins in BC. PCIC has adopted Raven because of the framework's flexible, modular nature. This allows Raven to represent physical processes with varying degrees of complexity, depending on the needs of a particular study or project. Raven's modern modular structure also deployed models to be easily updated as improved representations of physical processes are developed.

"[THE 18-YEAR PARTNERSHIP BETWEEN PCIC AND BC HYDRO] HAS ALLOWED FOR A CONSIDERABLE VOLUME OF WORK STUDYING THE CLIMATE AND HYDROLOGY OF THE PROVINCE. AMONG THIS, IT HAS RESULTED IN HYDROLOGIC MODELLING OF THE PEACE, FRASER AND COLUMBIA BASINS, INFORMATION FOR CLIMATE PLANNING AND TOOLS TO MAKE THESE PRODUCTS ACCESSIBLE. WE ARE PLEASED THAT BC HYDRO AND PCIC HAVE SIGNED A NEW AGREEMENT THAT WILL CONTINUE THIS FRUITFUL PARTNERSHIP FOR THE NEXT FOUR YEARS."

Our work this year continued to focus on the Cheakamus Basin, which provides the water to run the Cheakamus generating station. PCIC hydrologists examined changes in streamflow in this basin, studied the effects of different types of calibration methods and examined how fully coupling a glacier model to a hydrologic model affects streamflow projections. In a story common to many BC watersheds, they found that projected summer streamflow will be reduced as the glaciers that feed Cheakamus River become depleted of ice. They also found that different calibration procedures can significantly affect streamflow projections and that fully coupling the glacier model to the hydrologic model such that changes in each model are reflected in the other can more tightly constrain projected streamflow.

Making Large-Domain Hydrologic Modelling More Efficient

Partners: **Global Water Futures, University of Saskatchewan, University of Waterloo, Canada First Research Excellence Fund / Fonds d'excellence en recherche Apogée Canada**

As the climate changes, it will affect the hydrology of BC, with potential impacts on various areas, including water resources, hydropower generation and flooding. To better understand and prepare for these impacts, a solid understanding of the region's hydrology is required, which in turn, requires the development and application of well calibrated hydrologic models.

PCIC scientists are working to make the hydrologic modelling process more efficient by focusing on its most computationally expensive aspect, model calibration.

During calibration, mathematical parameters that represent land surface processes are adjusted to improve the quality of the hydrologic simulation. Hydrologic simulations are more sensitive to some of parameters than others. If these can be efficiently identified, then calibration costs can be reduced by focussing on these "sensitive" parameters. Different parts of a drainage basin may, however, be sensitive to different parameters and thus work this year investigated ways of making the identification of these sensitive parameters more efficient.

> **"USING A COUPLED HYDROLOGIC-GLACIER MODEL ACROSS 25 BASINS IN THE PACIFIC NORTHWEST, PCIC RESEARCHERS [...] FOUND THAT THIS METHOD CAN BE USED TO EFFICIENTLY IDENTIFY SENSITIVE PARAMETERS AT A COST THAT WOULD ONLY BE A SMALL FRACTION OF THE COST OF PERFORMING SENSITIVITY ANALYSES ON ALL BASINS."**

Using a coupled hydrologic-glacier model across 25 basins in the Pacific Northwest, PCIC researchers tested a watershed classification system to see if it could be used to determine which parameters were most important. They found that this method can be used to efficiently identify sensitive parameters at a cost that would only be a small fraction of the cost of performing sensitivity analyses on all basins, thereby efficiently homing in on the parameters that require calibration. In addition, there is the potential that calibrated values of parameters for one drainage basin may then be transferable without further calibration, or only limited recalibration, to other basins belonging to the same classification, which would result in a very significant computational cost reduction.

Expanding Peak Streamflow Modelling

Partner: **BC Ministry of Transportation and Infrastructure**

Floods can cause extensive damage to BC's transportation infrastructure and climate change may worsen these, with increased precipitation and more rapid snowmelt.

PCIC is working to support BC planners as they incorporate information about climate change and weather extremes into their design process for transportation infrastructure. To this end, PCIC hydrologists have continued to extend their work modelling peak streamflow and future design flow values in BC river basins and to provide them as gridded products via a web portal.

Following from last year's work in which PCIC researchers modelled the Fraser River basin, this year PCIC researchers modelled the Peace basin above Peace River, AB. PCIC's team quantified design flood values (Figure 5) for events with return periods ranging from two to 200 years, for historical and future periods and made them accessible as a gridded product via PCIC's Climate Explorer tool at a spatial resolution of 0.0625° (i.e. a grid spacing of about 5-6 kilometres in BC).

"THE NEW PROJECTION RESULTS FOR THE PEACE BASIN SHOW AN INCREASE IN DESIGN FLOOD VALUES FOR MANY LOCATIONS IN THE REGION OVER THE 2011-2040 PERIOD. HOWEVER, RESULTS ARE MORE VARIED LATER IN THE CENTURY AND FLOOD MAGNITUDES MAY GROW LARGER IN SOME BASINS AND SMALLER IN OTHERS."

The new projection results for the Peace basin show an increase in design flood values for many locations in the region over the 2011-2040 period. However, results are more varied later in the century and flood magnitudes may grow larger in some basins and smaller in others. These changes likely reflect regional differences in changing snow dynamics. It should be noted that the shaded bands in Figure 5 reflect the uncertainty in the results that arise from natural internal climate variability. Because this work was undertaken with one emissions scenario, output from one global climate model and one hydrologic model, uncertainty that results from variations in these choices is not reflected in the shaded bands.

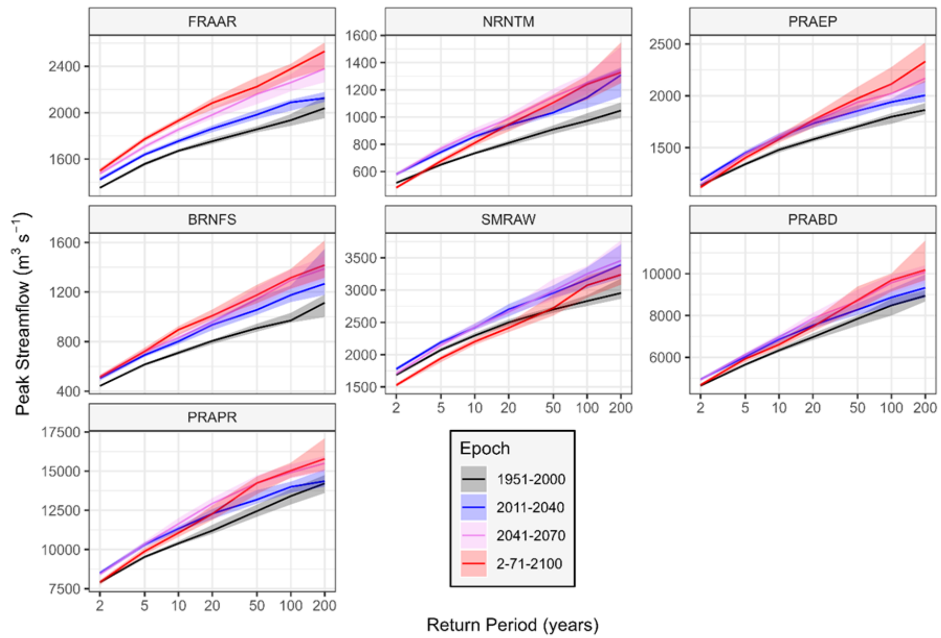


Figure 5: This figure shows plots of design streamflow (the volume of water passing by a location over time) versus return periods (in years between events, on average) for four periods or epochs at the outlets of six sub-basins and the Peace River basin. These outlets are: the Finlay River sub basin (FRAAR), the Nation River (NRNTM), the Pine River (PRAEP), the Beatton River (BRNFS), the Peace River at Bennet Dam (PRABD), the Smoky River (SMRAW), and the entire Peace River domain (PRAPR). The medians are given by the solid lines and the shaded ribbons indicate 95% confidence intervals.

HYDROLOGIC MODELLING TO SUPPORT FISH HABITAT ANAGEMENT

New Developments in BC Salmon Habitat Management

Partners: **British Columbia Salmon Restoration and Innovation Fund, Fisheries and Oceans Canada, Pacific Region / Fonds de restauration et d'innovation pour le saumon de la Colombie-Britannique, Pêches et Océans Canada , Pacific Region / Pêche et Océans Canada, région du pacifique**

PCIC has continued to work with the Department of Fisheries and Oceans to characterize how the freshwater habitat of salmon may change in the future, and to make that information available to fisheries managers and others. To this end, PCIC researchers have completed hydrologic projections for the entire Fraser River basin and a large section of coastal watersheds, for a total area of about 405,000 square kilometres. Projections of future water temperature in those watersheds are underway and have been completed for the Fraser basin. In addition, PCIC hydrologists have been developing new high-resolution watershed simulations using the Raven model, which can account for the intricacies of these small areas, for a small selection of drainage basins that have historically been well studied by salmon biologists.

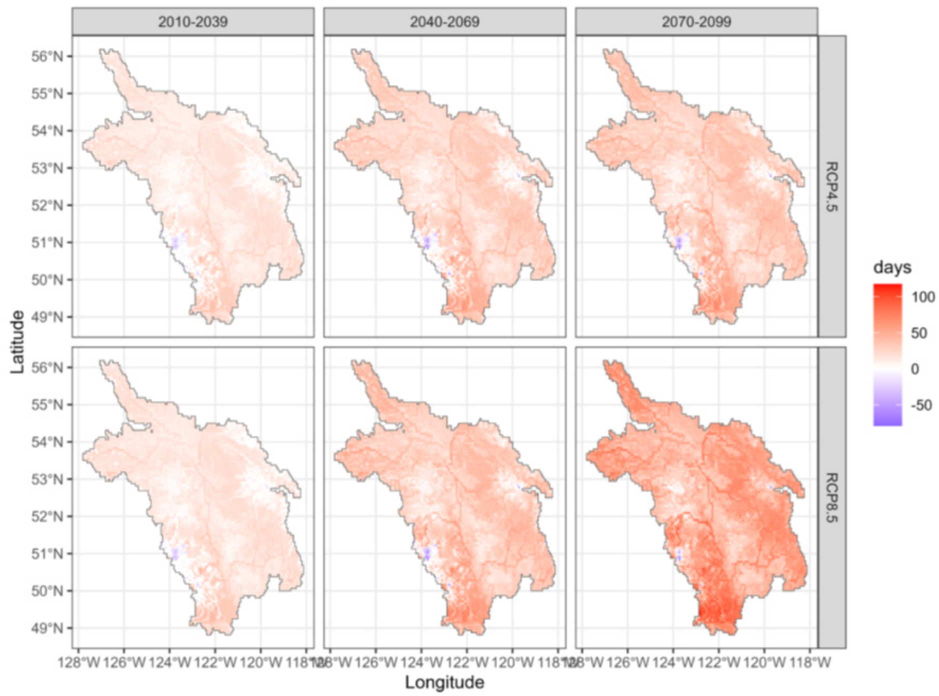


Figure 6: This figure shows the projected change in the Fraser basin in the average number of days each year with water temperature over 19°C by period (columns) and emissions scenario (rows), with Representative Concentrations Pathway 4.5 (RCP4.5) being a moderate emissions scenario and RCP8.5 being a high-emissions scenario.

Part of this work has also included the development and calculation of a number of hazard exposure indicators for salmon. For example, salmon mortality during migration is known to be sensitive to water temperature, with water temperatures exceeding about 19°C being of particular concern.

This preliminary work found that the number of days exceeding this threshold will increase with increased warming (Figure 6) and that the number of days with low flows (smaller than the 5% lowest historical flows) will decrease. High flows (greater than the 95% highest historical flows) tend to show projected increases in the drier interior regions and decreases in the mountainous regions of the Coast and Rocky Mountains.

The results of this work will be delivered to fisheries managers and others on the Salmon Climate Information Portal, which is in development. An "alpha" version of this tool is operational, and allows for the selection of watersheds, temperature and streamflow variables, climate models, and emissions scenarios completed and a new beta version is under development. This tool will allow for a connection between the information available from hydrologic and climate models about streamflow and temperature, and specific watersheds or salmon populations of interest.

Projections for the Future of Nechako River Fish Habitat

Partners: **Institut national de la recherche scientifique, University of British Columbia, L'Université du Québec à Montréal, Natural Sciences and Engineering Research Council of Canada / Le Conseil de recherches en sciences naturelles et en génie du Canada, Rio Tinto, Ouranos, École de Technologie Supérieure**

PCIC's team continues to model the streamflow and temperature of the Nechako River to develop an understanding that will support reservoir management operations. The Nechako River is a tributary of the Fraser River and is a valuable habitat for a variety of fish species, including different types of salmon. It is fed from the Nechako Reservoir, held behind the Kenny Dam. To manage water temperature in the river during the salmon migration period, water is released from the Nechako Reservoir via the Skins Lake Spillway, 75 kilometres west of the dam. In prior years, PCIC researchers developed a linked hydrological, hydrodynamic and water quality model to simulate the temperature of the Nechako Reservoir at different depths.

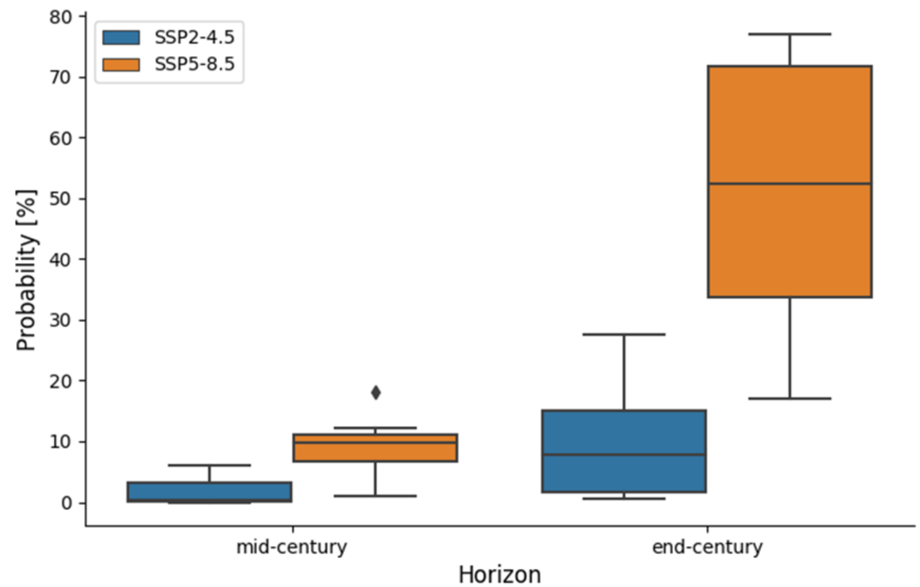


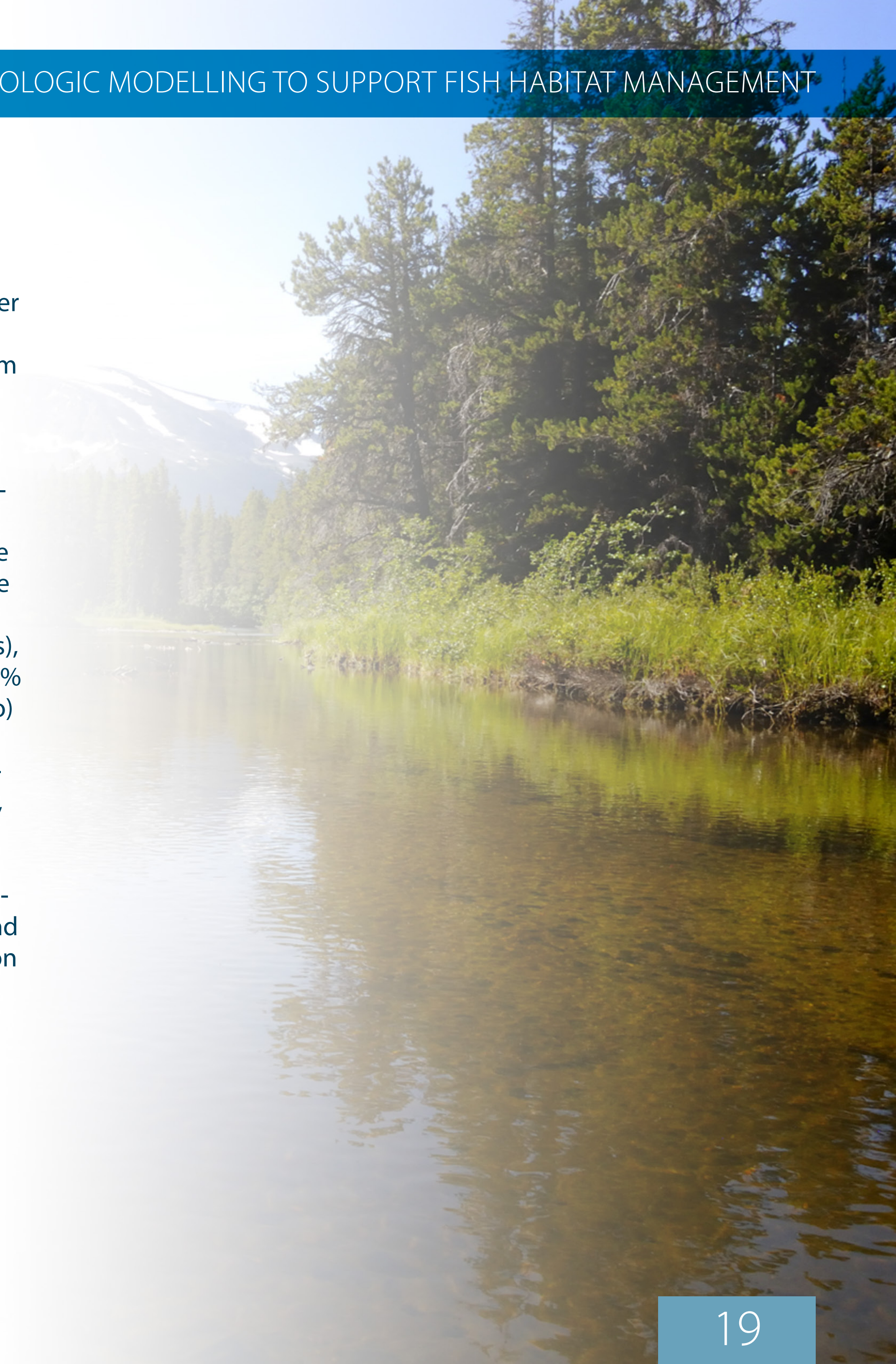
Figure 7: Projected probability of outflow temperature at Skins Lake Spillway (SLS) exceeding 20 °C during the Summer Temperature Management Protocol period (i.e., sockeye migration period from 20th July to 20th August) as inferred from a model of the Nechako Reservoir and its surrounding catchments when driven by climate data from a CMIP6 multi-ensemble model. The probability of simulated SLS water temperature exceeding 20 °C during the baseline period (1981-2010) is 0. The "box and whiskers" plots represent the distribution of the probabilities of daily water temperature at the SLS exceeding 20 °C. The top and bottom "whiskers" indicate the highest and lowest values, the tops and bottoms of the boxes indicate the first and third quartiles (25% and 75%), the lines inside the boxes indicate the median (second quartile, 50%) values, and dots indicate individual data points.

This year PCIC researchers examined the ability of reservoir managers to meet trade-offs between operational requirements and environmental needs to limit fish thermal stress in a changing climate. Specifically, they examined the reliability and vulnerability of the Nechako Reservoir to meet hydropower production commitments and fisheries needs under two projected Shared Socioeconomic Pathway scenarios (the medium-emissions SSP2-4.5 and the high-emissions SSP5-8.5).

PCIC's team used a coupled hydrological-water temperature model that they calibrated to observed discharge and water temperature observations. For simulations of past conditions, the model was forced using reanalysis data, created using historical observations that are "assimilated" into a global weather forecast model. For the future projections the model used output from climate models.

"PROJECTED CHANGES IN THE TIMING OF WATER AVAILABILITY HAVE LITTLE TO NO INFLUENCE ON THE ABILITY OF THE RESERVOIR TO MEET HYDROPOWER GENERATION COMMITMENTS. HOWEVER, IN ORDER NOT TO COMPROMISE RESERVOIR SAFETY, LARGER WATER RELEASES WILL BE REQUIRED, POSSIBLY ENDANGERING DOWNSTREAM FISH HABITAT THROUGH SCOURING. FURTHERMORE, WATER TEMPERATURES ARE PROJECTED TO EXCEED 20 °C, A LEVEL THAT IS DETRIMENTAL TO MIGRATING SOCKEYE SALMON, MORE FREQUENTLY."

They found that projected changes in the timing of water availability have little to no influence on the ability of the reservoir to meet hydropower generation commitments. However, in order not to compromise reservoir safety, larger water releases will be required, possibly endangering downstream fish habitat through scouring. Furthermore, water temperatures are projected to exceed 20 °C (Figure 7), a level that is detrimental to migrating sockeye salmon, more frequently. This temperature threshold is rarely exceeded in the recent climate (~1% of the time based on 2005-2019 observations), but is projected to be exceeded 8% (median of mid-emission scenario) to 52% (median of high-emission scenario) of days during the sockeye salmon migration season (i.e., July 20th to August 20th) by the end of the century. Hence, there is a need to adapt reservoir operations to ensure reservoir safety and mitigate adverse effects on salmon habitat.



SERVING HIGH-QUALITY METEOROLOGICAL DATA TO BC AND BEYOND

Data Improvements for the Pacific Climate Data Set

Partners: British Columbia Ministry of Environment and Climate Change Strategy, British Columbia Ministry of Agriculture and Food, British Columbia Ministry of Forests, British Columbia Ministry of Transportation and Infrastructure, Rio Tinto, BC Hydro, Environment and Climate Change Canada / Environnement et Changement climatique Canada, Metro Vancouver, The Capital Regional District, Pacific Climate Impacts Consortium

PCIC's team have improved data intake methods and the user interface for the Pacific Climate Data Set (PCDS), and are working toward improved climate maps and developing station climatologies for three reference periods. The PCDS holds a vast amount of climate data (Figure 8) from across British Columbia, from the 1870s to the present day, and new observations are added hourly. This data is made available to users via PCIC's BC Station Data portal, and is used at PCIC for a wide range of applications, including creating climate maps using the Parameter Regression on Independent Slopes Method (PRISM) and for the State of the Pacific reports.

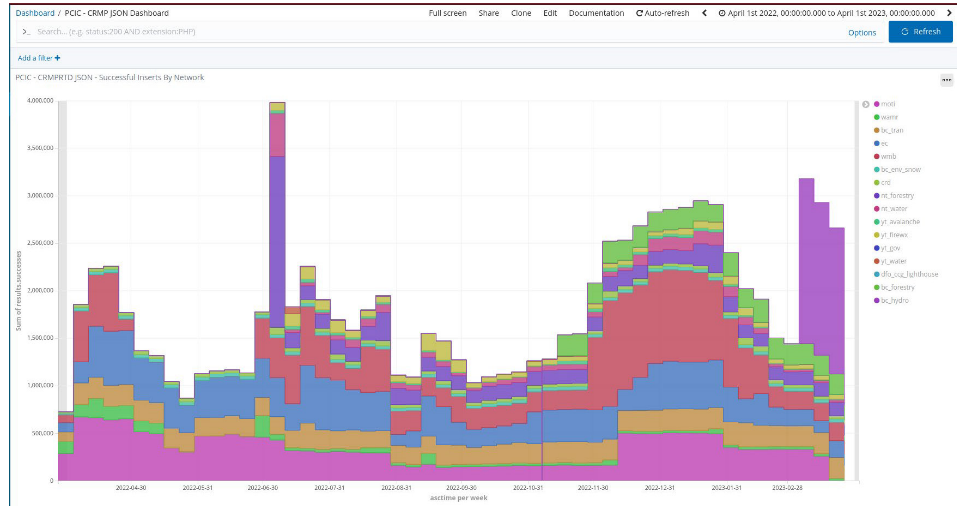


Figure 8: This figure shows the amount of data added to the PCDS from each network over the 2022-2023 fiscal year. The number of observations are displayed on the vertical axis and the date is shown on the horizontal axis. The bars indicate the number of observations added in a given week and are colour coded as per the source network, as indicated in the legend on the right.

PCIC upgraded the PCDS to take in BC Hydro data with a 15-minute temporal resolution and integrate high-frequency data of this kind into the regular feeds for the PCDS. This is high-quality data from one of PCIC's oldest partners, collected with very high standards. BC Hydro's high-frequency data had previously been ingested manually, once a year. Automated ingestion of this data will improve the efficiency of our work to keep the PCDS up to date, ensure that the data are available for rapid use at PCIC, and provide users with timely, almost real-time access to BC Hydro station data.

Access to the PCDS is now provided by an updated and substantially improved data portal. The new user interface is more responsive and has specific map projections for BC for improved visualization. It also allows users to apply multiple data filters, allowing users to better customise their desired data sets. In addition, PCIC's team provided more in-application tooltips and help information and, on the back end, updated to a contemporary software library that will allow for easier code maintenance and better overall structure.

A limitation of the PCDS is that it currently only provides users with information about the climate "normals" that prevailed during the 1971-2000 climate normals period. The World Meteorological Organization (WMO) recommends that climate normals, which describe typical climate conditions for a given location, be updated to the most recent 3-decade period at the end of each decade. Work was therefore initiated at PCIC to calculate annual, seasonal, monthly and daily maximum and minimum temperature and precipitation climatologies for the 1981-2010 and 1991-2020 climate normal periods using standard WMO recommended methods. In addition, the 1971-2000 climatologies were also recalculated using the same methods. Analysis of the changes in our climate since the 1971-2000 period, and consideration of methods to improve the coverage for locations where climate normals can be reported has been initiated. Also, planning is underway to provide normals for all three periods to PCIC's users via the PCIC Data Portal.

Data Portal for Canada's Western Arctic

Partner: **Government of the Northwest Territories**

This fiscal year a new station data portal for Canada's Western Arctic was completed (Figure 9). While the new portal, developed in partnership with the Government of the Northwest Territories, is focused on providing data for the regions of Yukon and the Northwest Territories, it also contains data for the most northerly portions of western and central Canada, from BC to Manitoba, and Canada's Western Arctic more broadly, including Nunavut. The portal allows users to filter stations by variable, network and observation frequency. It also provides easy access to station metadata, such as station location and elevation. Currently, more than 302 million observations are available from 798 stations. The portal uses a map projection specific for the region that allows for a better representation of the local geography. The user interface for the portal has the same extensive suite of features that have been implemented in the new portal for accessing the Pacific Climate Data Set, and thus amongst other features, users can select stations for which they would like data by drawing a polygon around their area of interest.

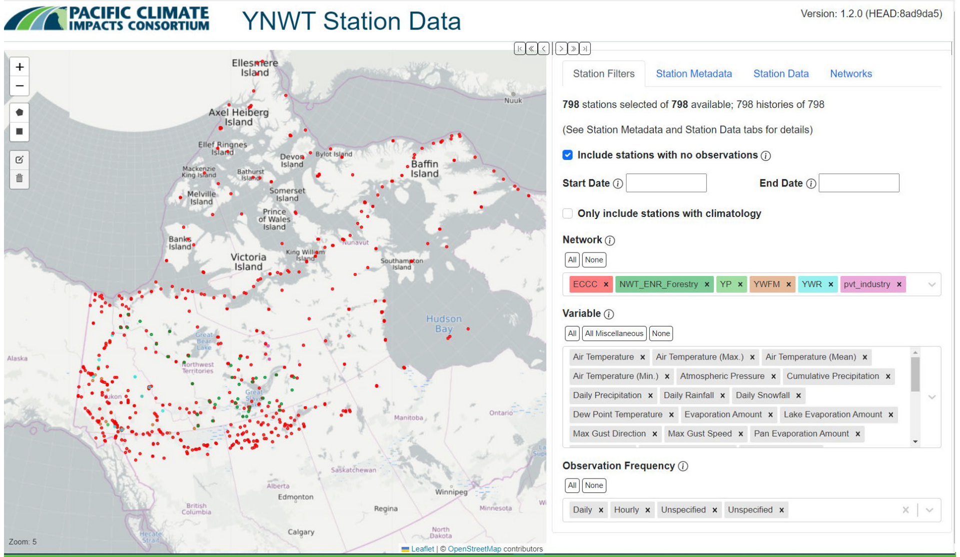


Figure 9: This figure shows the user interface for the Data Portal for Canada's Western Arctic. The dots on the map indicate station locations and are colour-coded by network.

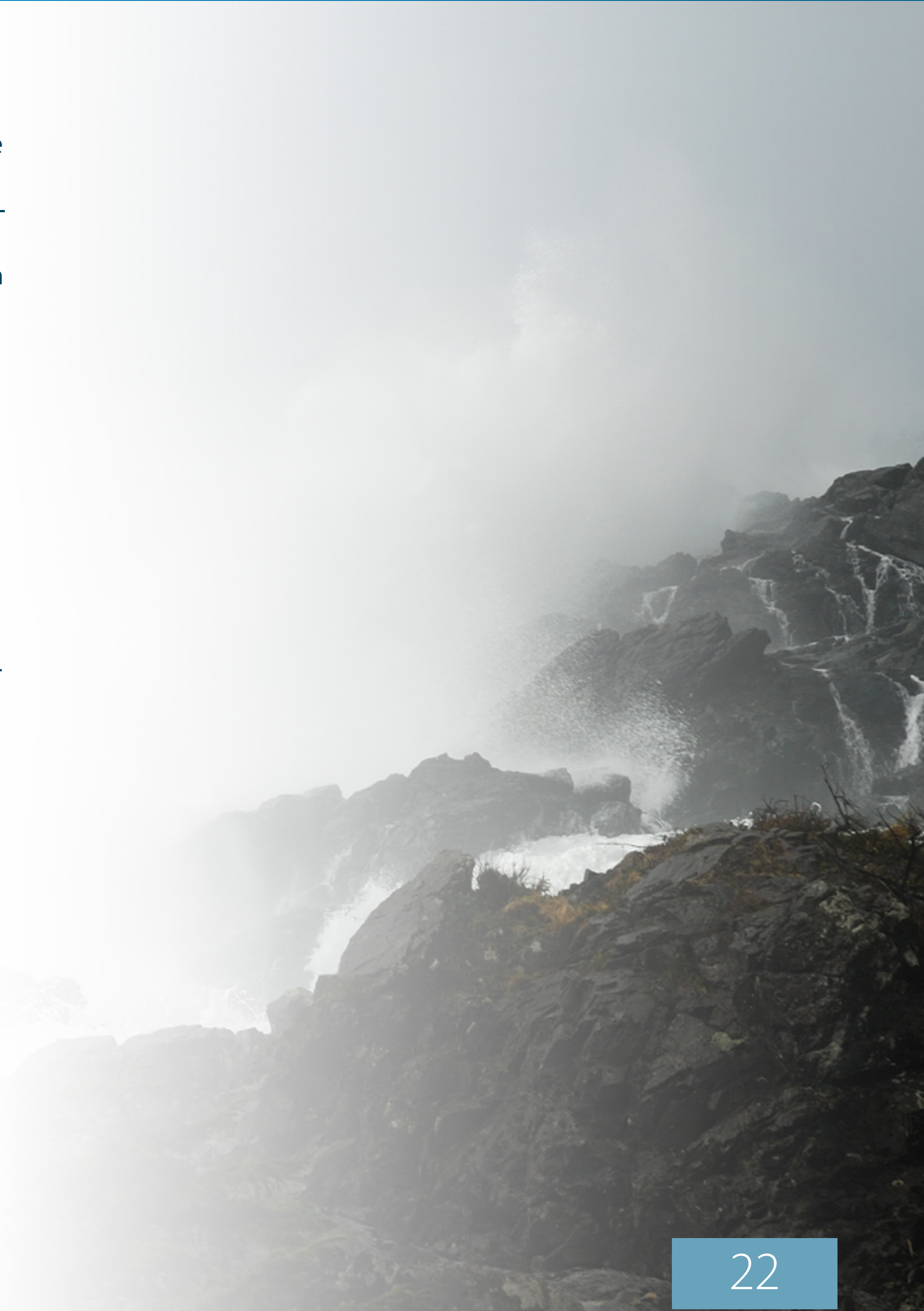
New PRISM Climatologies

Partners: **Bonneville Power Administration, National Oceanic and Atmospheric Administration Northwest River Forecast Center (NWRFC), Oregon State University (OSU) PRISM Group, Agricultural Climate Information Service of Alberta**

PCIC is developing new high-resolution monthly temperature and precipitation normals for British Columbia for the most recent 1991-2020 climate normals period.

"DATA FOR THE COLUMBIA BASIN, INCLUDING UP-TO-DATE DETAILED PRISM CLIMATOLOGIES, ARE CRITICAL FOR MODELLING AND UNDERSTANDING ITS HYDROLOGY. THIS WORK WILL HELP TO MEET THAT NEED."

This work draws on station data held in the PCDS that is collected throughout British Columbia and is being augmented by data provided by the OSU PRISM group and the Agricultural Climate Information Service of Alberta. This additional data is used to ensure that our BC PRISM maps perform well even at the edges of our province and that maps for BC will seamlessly blend with maps for adjacent jurisdictions. This work is supported, in part, by our colleagues at the Bonneville Power Administration and the NWRFC because of their interests in the trans-border Columbia River Basin. The Columbia basin is massive, being the fourth largest river on the continent as measured by streamflow, and covers over 668,000 kilometres, from BC and Alberta in the north through the United States, extending southward into Washington, Montana, Idaho, Oregon and touching parts of Wyoming, Nevada and Utah. It is used for power generation more than any other river in North America. Data for the Columbia Basin, including up-to-date detailed PRISM climatologies, are critical for modelling and understanding its hydrology. This work will help to meet that need.



ONLINE
TOOL
DEVELOPMENT

Completion of the Design Value Explorer

Partners: **National Research Council Canada / Conseil national de recherches Canada, Infrastructure Canada and Environment and Climate Change Canada / Environnement et Changement climatique Canada**

The Design Value Explorer (DVE), which is a unique tool developed at PCIC that provides Canada's building professionals with historical and projected future design values for all of Canada in both English and French, was released this year and announced through a joint release with the Government of Canada. The DVE (Figure 10) was developed through support from Infrastructure Canada and the National Research Council of Canada's Climate Resilient Buildings and Core Public Infrastructure initiative, and by the provision of meteorological station data by ECCC's Meteorological Service of Canada. Design values are engineering variables derived from local climate information. They are used in building and bridge design, and provide information about temperature, wind, precipitation, and moisture. Using the DVE, users can access historical and future design values via an interactive map, through which they can zoom in on regions of interest, display and download the values at any location. In many jurisdictions building codes are tied to weather conditions and design values at the city hall. The information from the DVE radically expands the availability of quality data beyond core municipalities. Users can also access the values in a table of over 600 locations that match those found in the National Building Code of Canada. The tool uses a novel spatial interpolation method developed by PCIC researchers to estimate values for locations in between weather stations, especially useful in BC as the distance between weather stations can be quite large, with the possibility of radical climate differences in between stations.

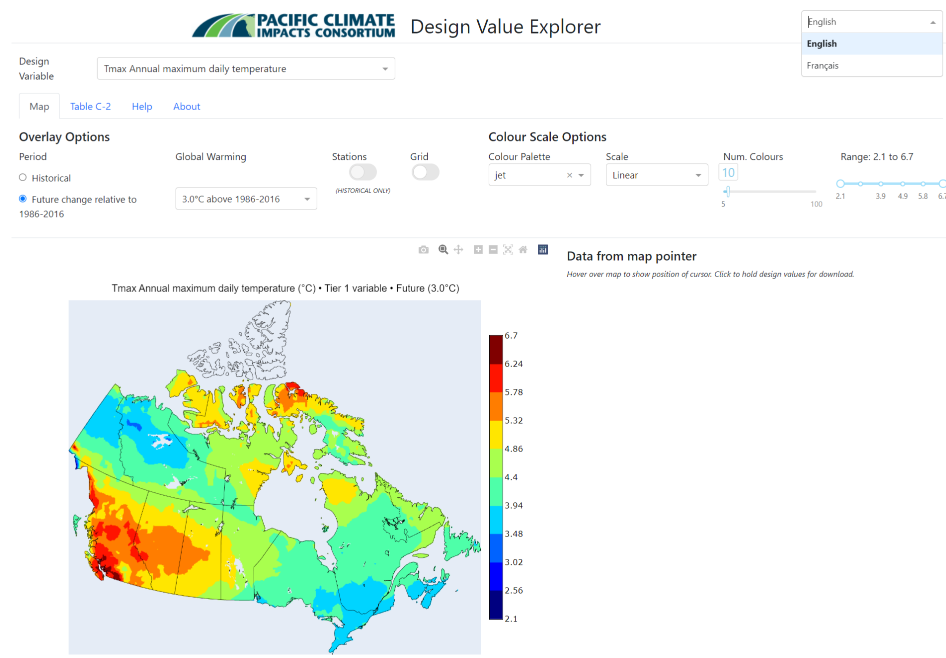


Figure 10: This figure shows the user interface for PCIC's Design Value Explorer, with language options in the top right corner.

New Developments in Sharable Climate Analysis Infrastructure

Partners: **Canada Foundation for Innovation/ Fondation canadienne pour l'innovation, British Columbia Knowledge Development Fund, University of Toronto, Ouranos, Computer Research Institute of Montréal, McGill University, Concordia University**

PCIC's team continues to develop software tools and set up new hardware to further the Data Analytics for Canadian Climate Services (DACCS) project. DACCS aims to create a distributed system in which computational resources (called "nodes") are located in close proximity to data storage systems, bringing analysis tools to the data rather than moving data to the analyst. Users can then send requests for analyses to the nodes and subsequently receive the resulting output for their consideration and use. This saves time and resources because users don't need to move enormous data sets around the internet at relatively slow speeds and it makes climate analytics more accessible, by allowing users broad access to data and powerful analysis tools and scientific software.

As a demonstration of the system's capabilities, PCIC researchers have developed a Jupyter Notebook (a type of interactive computing platform) for launching on-demand requests to calculate streamflow from the output of PCIC's hydrologic models (Figure 11). Streamflow is calculated by routing the surface runoff that these models produce in each grid box through a drainage network that is designed to emulate the river systems that flow through a given drainage basin. Having the ability to do such routing calculations on demand using the flexible DACCS system will, amongst other things, allow users to experiment with different routine models for the same drainage basin. In addition, the team is developing a Jupyter Notebook that runs the Climate Imprint downscaling method on small spatial domains. This will allow for the production of high resolution (800 m) climate chance scenarios. On the hardware side, PCIC's team is setting up a DACCS data server node at UVic and a management system that will manage all of the software components that must be installed in a DACCS node. After testing is done, these will be publicly opened up to registered users.

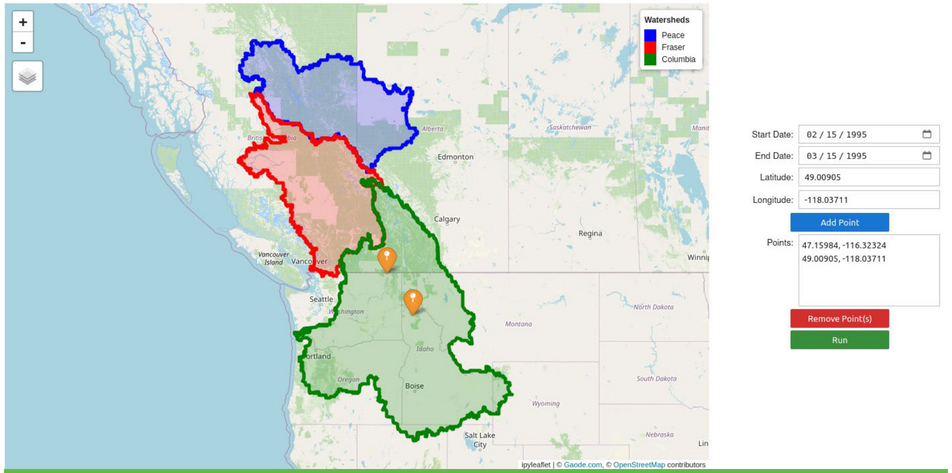


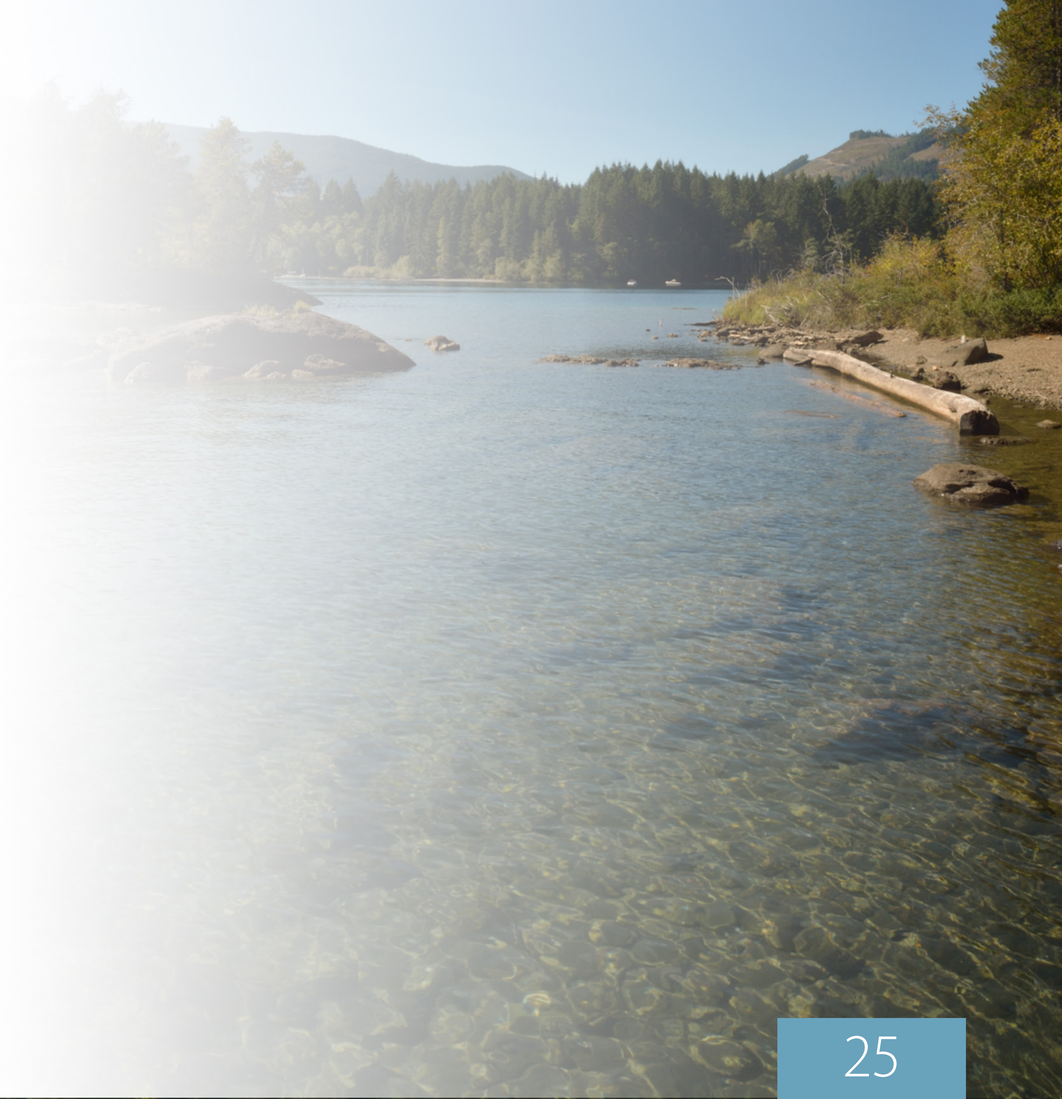
Figure 11: This figure shows the Jupyter Notebook front end that connects to the Osprey application at PCIC, which runs the routing model from the Variable Infiltration Capacity hydrologic model (RVIC), allowing users to determine streamflow at a given location.

PCIC COMMUNICATIONS

PCIC Communications

PCIC delivers multiple forms of communication and outreach in order to keep PCIC's users up-to-date with the work of its scientific team, as well as with pertinent findings from the research literature. PCIC's researcher team also actively share their findings with the broader scientific community, through peer reviewed journals, conferences and other activities.

Over the past fiscal year, PCIC delivered seminars on topics including Reducing Uncertainty Surrounding Climate Change Using Emergent Constraints; two seminars on using constraints to reduce uncertainty on global and regional climate change; Climate change, extreme precipitation events and some implications for risk analysis and the reliability of the Nechako Reservoir to meet hydropower production and fisheries needs under climate change. PCIC also released two Science Briefs on: The Accelerated Loss of Western Canadian Glaciers and Trends in Canadian Snow Cover Over Recent Decades. PCIC's team presented at multiple workshops and conferences, sharing their knowledge with the public, planners, and the broader scientific community. An example of this is an introduction to the Buildings Module on ClimateData.ca, a module overview and case study panel discussion.



Operations and Finance

Thanks to the continued support of our partners and users, PCIC continued to enjoy a stable funding and operational environment in fiscal-year 2022-2023 in support of its programs and service delivery to its partners, stakeholders and the public. PCIC provided service via more than 20 user-commissioned projects, externally funded research grant programs and other projects.

PCIC continues to maintain and advance relationships with over 50 partners from several federal and provincial government ministries, municipalities and other organizations within and outside of BC and Canada. Short-term and long-term agreements with our partners provided 59% of our revenue, with the balance provided by an endowment administered by the University of Victoria.

With its most important resource always being its staff, 93% of PCIC's expenditures supported the salaries of 30 staff members and their professional development. The remaining expenses supported operational expenses including computing resources, staff recruiting and general office expenses.

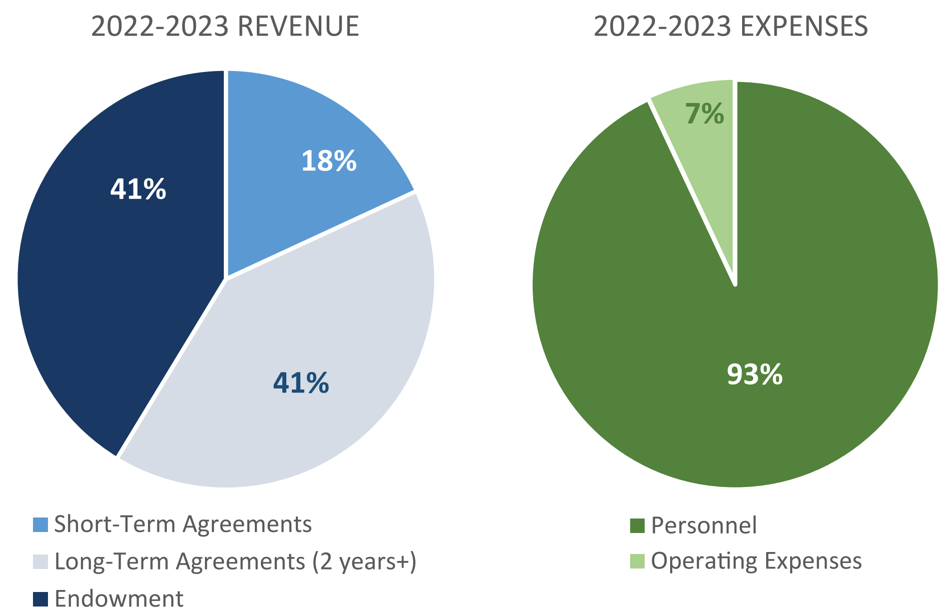
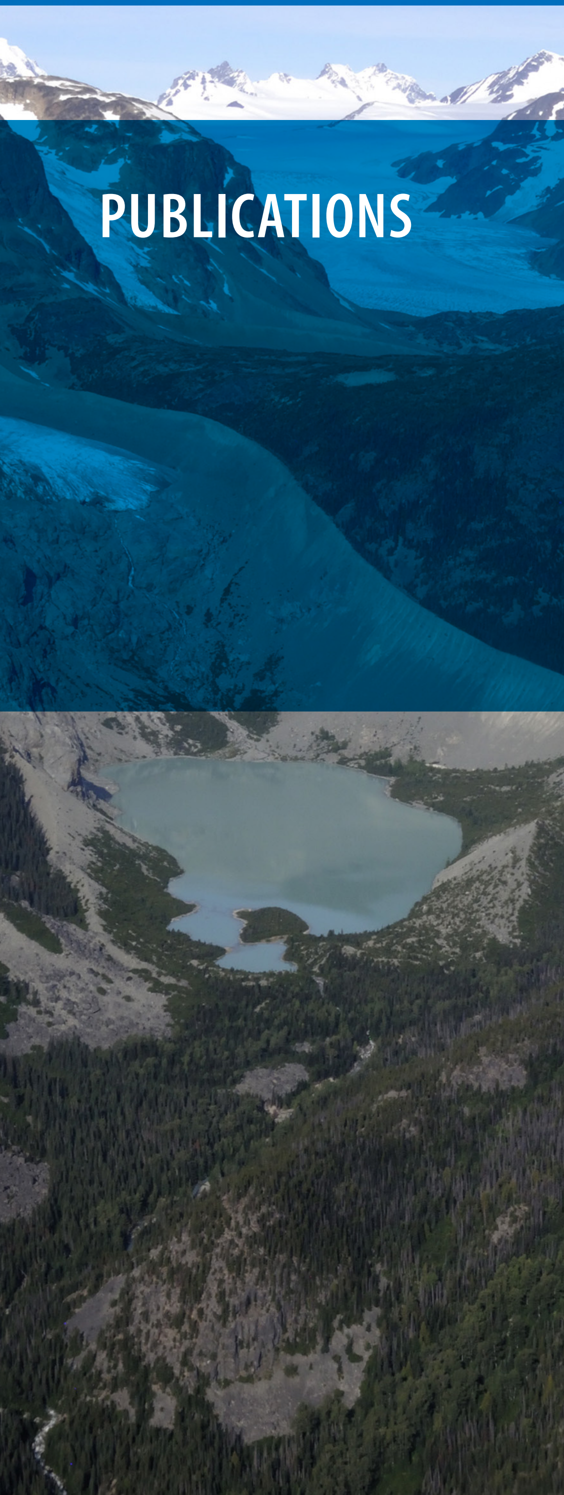


Figure 12: This figure shows a breakdown of PCIC's revenue (left) and expenses (right) for the 2022-2023 fiscal year.

Our staff continued to work productively and collaboratively within PCIC and with our partners. We express our sincere appreciation for the dedication, hard work and teamwork of our very talented staff, the University of Victoria's excellent supporting infrastructure and the ongoing commitment of our partners.

In keeping with its strategic goals to 1) engage in partnerships that support and enable service delivery, 2) empower PCIC staff to innovate and develop, and 3) achieve and maintain operational and managerial excellence, PCIC will continue to commit to long-term financial sustainability by managing the resources entrusted to it efficiently and to the greatest possible benefit of users and stakeholders.

PUBLICATIONS



Peer Reviewed Publications and Book Chapters

1. Dean, C.B., A.H. El-Shaarawi, S.R. Esterby, J. Mills-Flemming, R.D. Routledge, S.W. Taylor, D.G. Woolford, J.V. Zidek and **F.W. Zwiers**, 2022: Canadian Contributions to Environmetrics. In press, *Canadian Journal of Statistics*, doi:10.1002/cjs.11743.
2. Diaconescu, E., H. Sankare, K. Chow, **T.Q. Murdock** and A.J. Cannon, 2022: A short note on the use of daily climate data to calculate Humidex heat-stress indices. *International Journal of Climatology*, **42**, 10, doi:10.1002/joc.7833.
3. Gillett, N.P., A.J. Cannon, E. Malinina, **M. Schnorbus**, **F. Anslow**, **Q. Sun**, M. Kirchmeier-Young, **F. Zwiers**, C. Seiler, X. Zhang, G. Flato, H. Wan, G. Li and A. Castellan, 2022: Human influence on the 2021 British Columbia floods. *Weather and Climate Extremes*, **36**, 100441, doi:10.1016/j.wace.2022.100441.
4. **Lao, I.R.**, C. Abraham, E. Wiebe and A.H. Monahan, 2022. Temporal and Spatial Structure of Nocturnal Warming Events in a Midlatitude Coastal City. *Journal of Applied Meteorology and Climatology*, **61**, 9, doi:10.1175/JAMC-D-21-0205.1.
5. **Lao, I.R.**, A. Feinberg and N. Borduas-Dedekind, 2023: Regional Sources and Sinks of Atmospheric Particulate Selenium in the United States Based on Seasonality Profiles. *Environmental Science and Technology*, **57**, 19, 7401–7409, doi:10.1021/acs.est.2c08243.
6. **Larabi, S.**, **M. A. Schnorbus** and **F. Zwiers**, 2022: A coupled streamflow and water temperature (VIC-RBM-CE-QUAL-W2) model for the Nechako Reservoir. *Journal of Hydrology: Regional Studies*, **44**, 101237, doi:10.1016/j.ejrh.2022.101237.
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