PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE December 2022

PROJECT AND RESEARCH UPDATES

An Unprecedented Warm and Dry Start to Autumn in Southern BC Gives Way to a Cooler Winter Forecast

Figure 1: This photograph shows the Fry Creek wildfire on the east side of Kootenay Lake in Southern BC, on September 9th, 2022. Photo: BC Wildfire Service.

A ridge of high pressure over southern British Columbia that persisted through September and most of October brought unseasonably warm, dry weather to the region, delaying the start of the rainy season. Such high pressure systems are common here in summer and divert moist air from the region while trapping heat near the surface. As a result, longstanding daily temperature records fell across southern British Columbia, with parts of the region, including Victoria, Vancouver and Abbotsford, seeing their warmest September to date in the instrumental record. Victoria and Abbotsford also experienced their driest September on record. Temperature records continued to fall into the middle of October. The warm, dry conditions fueled a wildfire season with more than 1,700 wildfires recorded across the province this year, above the average of 1,403 per year over the last ten years and above the 1,610 wildfires seen in 2021. While the number of wildfires was above normal, the total area burned was below normal. These fires, along with others burning in the U.S. as far south as California, brought smoke to central and southern BC, impacting air quality over large parts of the province.

Looking to the coming months, the Environment and Climate Change Canada (ECCC) seasonal prediction system calls for a transition to wetter than average conditions in southeastern BC and colder than average conditions throughout the province. La Niña remains in place in the central equatorial Pacific. La Niña typically affects North American weather during winter and into spring and is responsible for about 20% of the seasonal variability that we experience. Typically La Niña coincides with colder temperatures over BC, with more precipitation over the southern half of the province. This translates to deeper than normal snowpacks in winter and often cool conditions persisting into spring. The current forecast from the National Oceanographic and Atmospheric Administration indicates that La Niña is strongly favoured to continue throughout the winter. It is important to note that the forecast is for averages across a season and will still be made up of weather that can include periods of sunshine, strong storms, cold air outbreaks and snow.

Continued Refinement of PCIC's Downscaling Methods

PCIC continues to work on the ongoing refinement of the downscaling methods that it uses and recently partnered with Environment and Climate Change Canada (ECCC) to evaluate some new methods and observational datasets for training the methods.

The method that PCIC currently uses, Bias Correction/Constructed Analogues with Quantile mapping, version 2, (BCCAQv2), while performing well, treats only one variable at a time. Thus, it does not consider how extremes of minimum and maximum temperature and precipitation are related. Treating one variable at a time can occasionally lead to situations where the downscaled daily maximum temperature value for a given day and location may be lower than the corresponding downscaled daily minimum temperature value. Accounting for the relationships between these variables will help avoid such errors, and may also improve the timing and intensity of precipitation events in the downscaled data. PCIC's team therefore evaluated several multivariate techniques that consider these variables simultaneously, taking advantage of relationships between the variables to be downscaled. The best performing of these methods, the Multivariate Bias Correction algorithm (MBCn), gave single-variable results that were found to be very similar to those from BCCAQv2, but provided a substantially improved representation of the relationships between the variables in downscaled scenarios.

PCIC researchers also evaluated several potential downscaling training datasets, and settled on a blended dataset that uses PCIC's Pacific Northwest North America Meteorological dataset (PNWNAmet) over western Canada and an updated version of the so-called "ANUSPLIN" dataset (produced by Natural Resources Canada) over eastern Canada, with a smooth transition between the two. The result is a training dataset that has better performance in the mountainous west than the competitor datasets that were considered. PCIC scientists are now using this blended training dataset in combination with the MBCn downscaling method to produce the new, Canada-wide downscaled CMIP6 scenarios. These scenarios will be provided on the Statistically Downscaled Climate Scenarios page of PCIC's Data Portal alongside downscaled CMIP6 scenarios that were recently produced with BCCAQv2 and the "ANUSPLIN" training dataset.

In addition, PCIC's team is investigating the length of the downscaling training datasets used to tune the parameters of the downscaling methods that we use. They are working to determine whether BCCAQv2 (and MBCn) can be trained successfully with observational datasets that are shorter than the training sets that PCIC has employed in the past, which were about 60 years long. The initial results of this work, which used ECCC's Regional Deterministic Reforecast System version 2.1 (RDRSv2.1) reanalysis of historical surface data, indicated that in many instances the shorter training datasets work as well as the longer ones. If these results hold more generally, this opens up a wider range of possibilities for the use of new observational datasets for the downscaling of coarse-gridded climate models. The RDRS product, for example, offers a wider array of variables than previous datasets used as downscaling targets at PCIC. In tandem with MBCn, this should result in a better representation of multivariate climate indices and improved hydrologic modelling.

Analysing Climate Change Impacts on the Nechako River

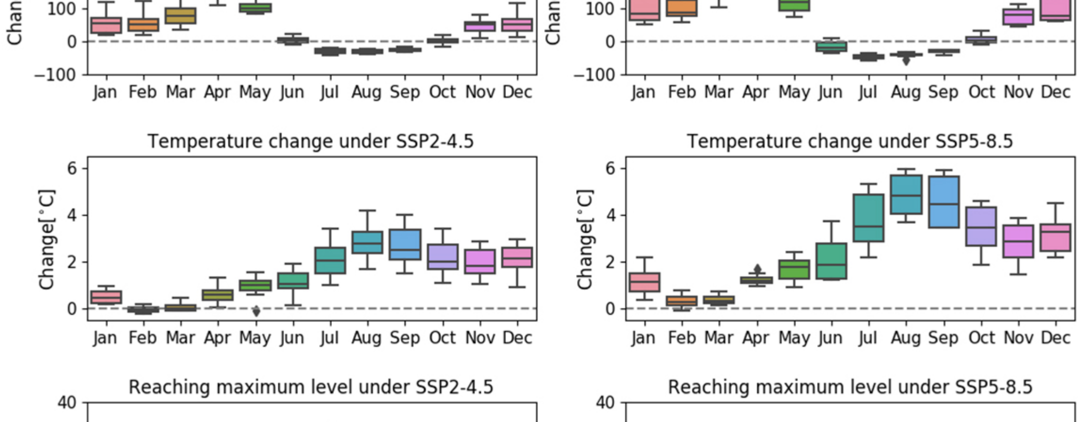

Figure 2: This figure shows the projected monthly inflow change into the Nechako reservoir (first row) and the projected change in temperature of water released at the Skins Lake spillway (SLS) (second row) relative to the reference period (1981-2010). The projected risk of reaching maximum reservoir operational level is shown in the third row. The projected change is calculated under SSP2-4.5 and SSP5-8.5 scenarios at the end of the century (2070-2099).

PCIC researchers have examined the effect of projected changes in climate on power generation, reservoir levels and water temperature for the Nechako Reservoir. They found that, while climate change is projected to have little to no influence on the Nechako hydropower generation, it is projected to require larger water releases from the Skins Lake Spillway into the Nechako River. This could have a negative impact on salmon habitat by decreasing the survival rates of salmon from their eggs to fry stages because of scour (the removal of river sediment). The efficiency of the summer water temperature management is also projected to be reduced due to an increased number of days with outflow water temperature exceeding 20 °C at the Skins Lake Spillway. This could cause additional thermal stress for salmon in the river.

The Nechako River is one of the main tributaries of the Fraser River and a habitat to several fish species. It begins at the Kenney Dam, a rockfill dam on the Nechako Reservoir, flows north to Fort Fraser, then east to Prince George where it joins the Fraser River. Water from the reservoir is used to generate electricity, primarily for smelting aluminum at Kitimat. During the period over which salmon migrate along the Nechako, the water temperature of the river is managed to ensure that migrating salmon are not exposed to excessively warm water. To do this, water is released from the Nechako Reservoir into the river via the Skins Lake Spillway, 75 kilometres west of the dam. To understand the potential impact of climate change on hydropower generation, flood control and Nechako Fisheries Conservation Program (NFCP) requirements, a linked hydrological, hydrodynamic and water quality modelling framework has been developed by PCIC researchers to examine multiple aspects of the reservoir, dam and river system. Their work will be used to inform reservoir management.

Using this framework and output from an ensemble of global climate models, PCIC's researchers found that climate change is projected to shift the Nechako hydrological cycle from a snow-dominated regime to a rainfall-dominated regime with a short freezing season. As a result of this, monthly inflows are projected to increase during the cold period and decrease during summer (Figure 2) for both the middle (2040-2069) and end of the century (2070-2099) compared to a 1981-2010 reference period. The projections indicate that the reservoir will continue to be able to provide adequate water for power generation throughout the century under both high- and medium-emissions scenarios. It is also projected to meet the NFCP requirements. However, the risk of reaching maximum operational water levels in the reservoir is projected to increase from a range of 1%-9% over the reference period to 12-33% by the middle and end of the century, with a higher risk over the summer months. This risk would require increasing water releases through the Skins Lake Spillway, which could increase the disturbance and removal of sediment from banks and spawning beds in the Nechako River.

The temperature of water released at the Skins Lake Spillway is projected to increase year-round except in February and March (Figure 2). The highest increases are projected to occur in July and September for both time periods and emissions scenarios. The chance of water temperatures exceeding 20°C is projected to increase at Skins Lake Spillway but remains low under the medium-emissions scenario by the middle (0 % to 6%; not shown) and end (1% to 28%) of the century. Under the high emissions scenario, the projected probability is higher, particularly at the end of the century, with a median value of 52% (17-77%, min-max) compared to mid-century (1% to 18%; not shown). Water released at Skins Lake Spillway is subject to further heating as it travels through the Nechako River to reach Finmoore, the temperature constraint location, upstream at the Stuart River.

Working With Hydrologic Projections

Over the summer, 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 recording from this workshop is now available. The workshop introduced some of the future climate projections available from PCIC that are available for use in hydrologic modelling. It also introduced core concepts related to the use of statistically downscaled temperature and precipitation projections developed at PCIC, as well as recent Coupled Model Intercomparison Projects (CMIP5 and CMIP6) and global climate models (GCMs). The webinar also provided suggestions for working with future climate information in hydrological projections.

- Watch the recording.

The Pacific Climate Seminar Series

On the 26th of October, Dr. Samah Larabi kicked off the fall session of the Pacific Climate Seminar Series with her talk on *the Reliability of the Nechako Reservoir to meet hydropower production and fisheries needs under climate change*. This was followed on December 8th by a talk delivered by Yongxiao Liang on *Constraining climate model projections of 21st Century global and regional warming*.

- Watch a recording of Samah's talk, here.
- Yongxiao Liang's talk will be available on the talk's page, shortly.

STAFF PROFILE: SAMAH LARABI

Dr. Samah Larabi is a hydroclimate scientist with PCIC who first joined the Hydrologic Impacts theme as a postdoctoral fellow in spring of 2019. She holds a PhD in Water Sciences from the Institut National de la Recherche Scientifique, Eau Terre Environnement (INRS-ETE) in Quebec after earning an engineering degree in mathematics and modelling from Polytech Graduate School of Engineering in Clermont-Ferrand in France. Her research as a graduate student was focused on developing efficient methods for hydrologic model calibration.

Samah chose this field after her internship at the Hydrosciences Laboratory in Montpellier, France, during the final year of her engineering degree. There she used climate model output to study the evolution of future precipitation extremes in the Languedoc-Roussillon region of France. Speaking of this, Samah expresses how fulfilling she finds doing applied science research that can make a difference for others: "It was interesting to apply and learn about new statistical methods to help understand climate and environment related issues that have direct impact on people." Working in hydroclimate science allows her the ability to benefit others directly, and to learn about new approaches in modelling and modelling tools. Samah finds the challenge of developing and working with these modelling approaches deeply interesting in its own right: "Often, coupling different models is required to represent the complex interactions between the climate and the land surface." Samah explains how her ongoing research examining the impact of climate change on the Nechako Reservoir requires coupling together different models—hydrologic, stream water temperature, hydrodynamic and reservoir operation models—with climate model output, bringing these together, "to provide a sort of complete picture of how climate change could affect hydropower generation, reservoir operations efficiency, water temperature and fish habitat." Reflecting on this, Samah says, "It is a fun challenge to implement different models where each has its own complexity."

Samah's research at PCIC covers several different projects. These include studying the effects of climate change on the Nechako Reservoir's hydrothermal regime, testing process-based parameter estimation methods for large-scale hydrologic models as part of the Global Water Futures pan-Canadian research program that will improve hydrologic modelling efficiency, and testing and implementing the new Raven hydrologic framework being employed by PCIC hydrologists. Samah expands on the benefits of this latter project: "Raven is a highly flexible hydrologic framework that allows us to quickly adapt model structure depending on the questions we aim to answer" - this allows PCIC's hydrologists to study the whole watershed, using various different model components to represent different parts of the system, as opposed to traditional hydrologic models that are fixed in their structure and features.

PCIC STAFF NEWS

The end of the summer and the fall has seen a number of staff changes at PCIC. To begin with, we have said goodbye to former Climate Analysis and Monitoring (CAM) Theme Lead Dr. Faron Anslow, Post-Doctoral Research Hydrologist Dr. Md. Shahabul Alam and Assistant Programmers (co-op) Ada Sungar and Marie Whibley. Faron was instrumental in the development of PCIC's CAM Theme, leading multiple major projects at PCIC, including the development of the Pacific Climate Data Set and the use of the Parameter Regression on Independent Slopes Model (PRISM) at PCIC. It is with deep gratitude that we wish Faron the best as he transitions to an entirely different career path. Shahab conducted important work modelling salmon habitats in BC coastal regions, while both Ada and Marie contributed to the development of application software that will become part of the national, CFI funded, Data Analytics for Canadian Climate Services (DACCS) project. PCIC wishes Shahab success in his future research endeavours and Ada and Marie all the best in their studies.

At the same time as these staff have been outgoing, PCIC has welcomed Nina Nichols as Indigenous Communities Climate Adaptation Coordinator and Abigail Dah as Climate Data and Mapping Research Assistant. Nina will be supporting increased collaborations with indigenous communities in BC and Abigail will be helping expand PCIC's downscaling capabilities to address requirements at even higher resolution than the downscaling products PCIC offers today.

Staff changes always create a mixture of emotions. It is invariably somewhat difficult when talented and highly productive people move on to new opportunities, but their success in pursuing those opportunities is also a strong mark of success for PCIC. It is extremely satisfying for us to have the opportunity to mentor the talented young people who join us and ultimately to see them move to new opportunities in the rapidly expanding climate services domain after having further developed their talent and their capabilities while at PCIC.

PUBLICATIONS

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 (https://onlinelibrary.wiley.com/doi/10.1002/cjs.11743). Early online view, *Canadian Journal of Statistics*, doi:10.1002/cjs.11743.

Diaconescu, E., Sankare, H, Chow, K, **Murdock, T.Q.**, Cannon, A.J. 2022: A short note on the use of daily climate data to calculate Humidex heat-stress indices (https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.7833). *International Journal of Climatology*, 42, 10, doi: org/10.1002/joc.7833.8.

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(https://journals.ametsoc.org/view/journals/apme/61/9/JAMC-D-21-0205.1.xml), **61**, 9, 1139-1157. doi:10.1175/JAMC-D-21-0205.1.

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 (https://www.sciencedirect.com/science/article/pii/S2214581822002506). *Journal of Hydrology: Regional Studies*, 44, 101237, doi:10.1016/j.ejrh.2022.101237.

Li, M., C. Li, Z. Jiang, X. Zhang and **F.W. Zwiers**, 2022: Deciphering China's complex pattern of summer precipitation trends (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022EF002797). *Earth's Future*, **10**, doi:10.1029/2022EF002797.

Zwiers, F.W. and X. Zhang, 2021: Translating science into actionable policy information – a perspective on the IPCC process. Included as a chapter in the forthcoming *Applied Data Science: Data Translators Across the Disciplines*, Woolford, D., D. Kotsopoulo and B. Samuels, eds., Springer Interdisciplinary Applied Sciences.

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