PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE MARCH 2019

PROJECT AND RESEARCH UPDATES

Modelling Fraser River Streamflow Temperature

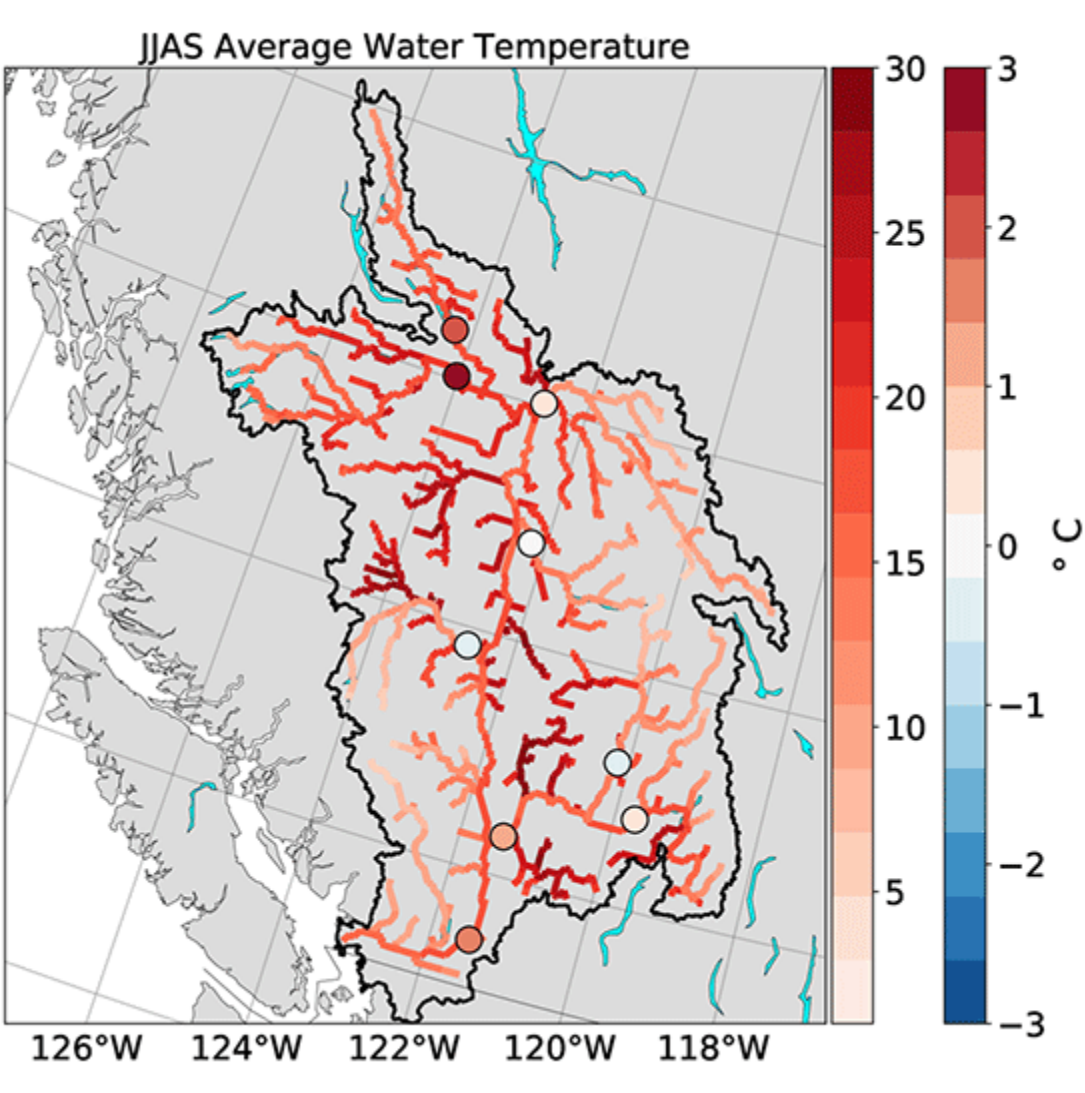

Figure 1: This figure shows the simulated average summer (here, June, July, August and September) temperature of water in the Fraser River Basin for the 1950-2012 period. The leftmost scale bar corresponds to the stream temperatures. The circles on the map represent the bias of the simulated temperatures relative to observed temperatures at locations where long water temperature records are available. The rightmost scale bar corresponds to the temperature bias circles.

The rivers that wind their way through the landscape of British Columbia are vital to its ecosystems. For instance, the temperature of the Fraser can significantly affect the pre-spawning mortality rate of these salmon. To explore the history of water temperatures in BC's rivers and how they may change in the future, PCIC's Hydrologic Impacts theme is coupling a water temperature model to the hydrologic model that they use, VIC-GL. As an initial test, they are using the expanded version of VIC-GL to examine past Fraser River water temperatures, with the objective of ultimately creating a reanalysis of Fraser River water temperatures that is constrained by available historical water temperature observations (see figure) that will cover the period of 1945 to the present day. It is anticipated that this spatially and temporally complete water temperature dataset, together with corresponding streamflow data, will, in time become a valuable asset for Fraser River ecosystem studies. This study will also provide the basis for projections of future changes in water temperatures.

Recently Published Wildfire Research

During the scorching 2017 wildfire season 1300 wildfires burned a record 12,000 square kilometres in BC, an area a little larger than a third of Vancouver Island. In addition to forcing thousands of BC residents from their homes, the wildfires cost the province more than half a billion dollars and resulted in the longest state of emergency in the province's history, at ten weeks.

Recent research by researchers at PCIC and Environment and Climate Change Canada used an event attribution method and output from regional climate models to determine the effect of anthropogenic climate change on several key aspects of these wildfires. These included the maximum temperatures in the region, the area burned and aspects of the fires' behaviour as characterized by a set of wildfire indices. The researchers found that anthropogenic climate change had a large influence on the 2017 wildfires, contributing 95% to the probability of extremely warm temperatures, increasing the expected area burned by a factor of seven-to-eleven times and making high values of fire weather indices indicating elevated fire risk two-to-four times more likely than would have been expected in an earlier period with weaker human climate influences. This research has been featured on CBC News and in the Times Colonist.

The CBC News article can be found, here.

The Times Colonist article can be found, here.

The original paper can be found in Earth's Future.

The press release from Environment and Climate Change Canada can be found, here.

The press release from the University of Victoria can be found here.

PCIC Climate Explorer Released

PCIC is pleased to announce the release of its new PCIC Climate Explorer tool, PCEX. The new tool provides access to high-resolution downscaled global climate model projections run under three different greenhouse gas emissions scenarios. Using an easy point-and-click interface, users can define specific regions of interest, then compare, plot and download multiple variables for that area, including temperature, precipitation and climate extremes indices. Coinciding with the release of PCEX are two instructional videos to help users get started with using the new tool. PCEX is a modern replacement for PCIC's Regional Analysis Tool, which will be discontinued in September of this year. The development of PCEX was supported by the BC Ministry of Transportation and Infrastructure.

Begin using PCEX.

New Collaboration Between the Canadian Centre for Climate Services and PCIC

A new collaboration between the Canadian Centre for Climate Services and PCIC has attracted media attention, following its announcement on February 12th by the Minister of Environment and Climate Change, Catherine McKenna. The collaboration will be supported by a federal investment of $1.25 million dollars over five years, which PCIC will use to provide training in the use of the climate data that it offers. This will allow them to better understand the kinds of data that PCIC provides, how to access and work with it, and the types of information that can be obtained from the data. The federal investment will also allow PCIC to further improve its user engagement activities. To accomplish this, PCIC has established a User Engagement and Training Specialist position, which will allow for the development and delivery of a training curriculum for a broad range of climate information users. This collaboration has been reported on in a news release by Environment and Climate Change Canada, and by both the Times Colonist and the University of Victoria.

In its news release, Environment and Climate Change Canada drew attention to the $1.9 billion in property damages that extreme weather events caused in Canada last year. Increasing the capacity of PCIC's users to use climate data will allow for greater ability to plan for and adapt to the changing climate.

The Times Colonist article is available, here.

The UVic News article is available, here.

The Environment and Climate Change Canada news release can be read, here and en Français.

Recent Research on Precipitation Extremes

Extreme precipitation and flooding can have costly impacts and thus understanding how these may change as a result of anthropogenic climate change is important for planning and the design of future infrastructure. Ongoing research at PCIC is focused on several aspects of precipitation extremes.

One such line of investigation seeks to understand potential changes to Probable Maximum Precipitation (PMP). PMP is essentially the maximum amount of precipitation that could theoretically fall over a given area and time. It, and a related parameter called the probable maximum flood, are widely used in the design of dams and associated infrastructure, such as spillways. Research conducted at PCIC has resulted in an approach to estimating PMP (Ben Alaya et al., 2018) that is based in the theory of multivariate extreme value analysis. Amongst other advantages, the method makes it possible to quantify the uncertainty of the PMP estimates that it produces. The results of two further studies in which the new technique has been applied are currently under consideration for publication in scientific journals. The first of these studies compares PMP estimates derived from the output of two Canadian regional climate models and three reanalysis datasets, can concludes that while there are some differences between the regional climate models, PMP estimated from the models could serve as a basis for flood studies at the basin scale. The second of these studies considered projected changes in PMP. The researchers also developed new methods (Ben Alaya et al., 2018) to compare past and future estimates of PMP that don't rely on stationarity, the assumption that the climate is unchanging in the past and future periods being compared. Design floods are the largest floods selected for the safety evaluation of a given structure. Estimates of floods that are likely to occur in a region once in a hundred or thousand years are useful for design flood evaluation.

Another line of investigation that is currently being undertaken focuses on the limitations of the use of extreme value theory to estimate very long return-period climate extremes. As well as documenting the limitations of standard methods that are used to estimate, for example, the expected size of a 100-year rainfall event, work is also being undertaken assess a more physically based method that has the potential to overcome those limitations

Both lines of investigation are being supported by the Global Water Futures Climate-Related Precipitation Extremes project.

See also: **Ben Alaya, M. A.**, **F. W. Zwiers** and X. Zhang, 2018: Probable maximum precipitation: its estimation and uncertainty quantification using bivariate extreme value analysis. *Journal of hydrometeorology*, **19**, 4, 679-694, doi: 10.1175/JHM-D-17-0110.1.

Incorporating the Findings of Climate Science into Engineering Design

As part of PCIC's ongoing efforts to support engineers in their efforts to account for climate change in their projects, PCIC is providing interpretation and information for a BC Housing led project that is seeking to develop training materials to inform engineers and other building professionals on how to incorporate future conditions into their design designs. Momentum at PCIC has been building in this area, with this work following from three earlier projects. In the first project, PCIC provided building code parameters, projections of extreme indices and guidance on data use to Island Health, for new construction and renovation projects at the Nanaimo Regional General Hospital. Interest in this project led to presentations at meetings for Engineers and Geoscientists BC, BC Hydro, the Canadian Health Engineering Society, and several others. PCIC then worked with Vancouver Coastal Health to help produce a regional climate impacts report which will be used to inform several health care infrastructure projects in the region. PCIC researchers have also worked with UBC and consulting engineers to develop an online interface for providing "future-shifted" weather files that incorporate future climate projections into weather files that are widely used in the energy modelling that is carried out to inform building design.

STAFF PROFILE: YAQIONG WANG

Yaqiong Wang works in PCIC's Climate Analysis and Monitoring theme, where she is currently applying extreme value analysis techniques to snow data. Extreme snowfall can bring risks to structures when loads from the weight of the snow are high enough to endanger the building. "Dangers increase when extreme snow is combined with a heavy rainfall event," she explains, "so I am investigating rain-on-snow events to understand this risk."

Yaqiong completed her Masters degree in Geography from UVic while working in the CAM theme, where she was focused on homogenizing observed weather data from hundreds of locations in BC that PCIC takes in and stores. Homogenization attempts to remove artefacts from weather data that are due to non-climatic factors, such as changes in observing instruments or their locations. Such improved data provides a more reliable basis for users interested in understanding how climate has changed over time.

Referring to the opportunities that working with PCIC's data presents, Yaqiong says, "the BC Climate Related Monitoring Program's data sharing agreement has provided abundant data" for her work. Yaqiong is motivated by the desire to provide reliable scientific information to solve real problems using her expertise in climate science, especially the problems facing communities that may experience greater climate risks. "The earth's climate and human well-being are intertwined and both are important to me," she says, "I'm curious about what data tell us, what methods to select based on a specific [user] need, and how to communicate the results, this is what drives my work."

PCIC Director Elected as Fellow by American Geophysical Union

Each year the American Geophysical Union, the world's largest organization of Earth and space scientists, elects a small number of Fellows as a way of recognizing their exceptional achievements, dedication and leadership. PCIC Director Francis Zwiers was among those elected in 2018. Dr. Zwiers has been a member of the AGU for a decade, over which time he has served as an Associate Editor of the Journal of Geophysical Research – Atmospheres and has been invited on multiple occasions as a speaker at the AGU's Fall Meetings.

Read more on the 2018 AGU Fellows.

PCIC and Director Featured in UVic's Edge Campaign

The University of Victoria recently featured PCIC and its director, Dr. Francis Zwiers, in a short video as part of the University's annual "Edge" advertising campaign (see this link). The video highlights Dr. Zwiers's research and participation in the Intergovernmental Panel on Climate Change, and PCIC's role in conducting scientific research to help British Columbians better understand and mitigate the risks that climate change poses to the province. The video also highlights A False Creek, a piece of public art on Vancouver's False Creek by artists Rhonda Weppler and Trevor Hamovsky. The piece uses chromatic blue stripes that wind their way up ten Cambie Bridge pilings and fifteen lampposts along an area near the sea wall, to illustrate potential sea level rise.

Watch the video, here.

New Projects

PCIC has initiated several new projects in partnership with the BC Ministry of Forestry, Lands, Natural Resource Operations and Rural Development, Toquaht First Nation, Interior Health, the BC Ministry of Transportation and Infrastructure, the Regional District of North Okanagan and Fraser Health.

PACIFIC CLIMATE SEMINAR SERIES

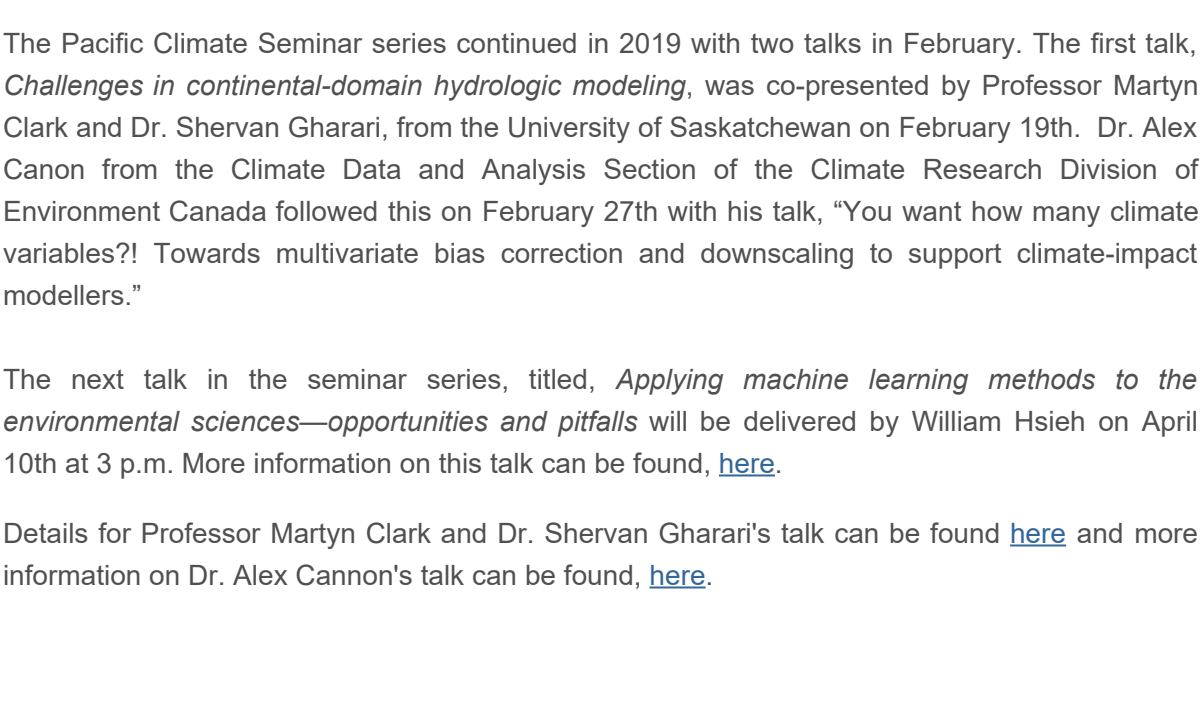

Figure 2 This figure shows Dr. Alex Cannon giving his lecture on February 27th.

The Pacific Climate Seminar series continued in 2019 with two talks in February. The first talk, *Challenges in continental-domain hydrologic modeling*, was co-presented by Professor Martyn Clark and Dr. Shervan Gharari, from the University of Saskatchewan on February 19th. Dr. Alex Canon from the Climate Data and Analysis Section of the Climate Research Division of Environment Canada followed this on February 27th with his talk, "You want how many climate variables?! Towards multivariate bias correction and downscaling to support climate-impact modellers."

The next talk in the seminar series, titled, *Applying machine learning methods to the environmental sciences—opportunities and pitfalls* will be delivered by William Hsieh on April 10th at 3 p.m. More information on this talk can be found, here.

Details for Professor Martyn Clark and Dr. Shervan Gharari's talk can be found here and more information on Dr. Alex Cannon's talk can be found, here.

PCIC STAFF NEWS

The past few months have seen PCIC bid a fond farewell to PhD Student Yaheng Tan and Hydroclimate Scientist Dr. Gildas Dayon, who both joined PCIC in 2017. Yaheng's research at PCIC was focused on atmospheric river events over western North America, their features and how they may change in the future. Yaheng has returned to Sun Yat-sen University to complete her doctoral studies. Gildas's work at PCIC was focused on the impacts of internal climate variability on the hydrological cycle of BC and streamflow temperature modelling. Gildas will be joining the Toulouse Weather Forecast Centre as a Hydrologist, where he will be working on seasonal forecasting of streamflow. We wish Yaheng and Gildas all the best in their future endeavours.

Over the same period, PCIC has been happy to welcome Kari Tyler, Nic Annau, Charlotte Ballantyne and Nikola Rados. Kari is a User Engagement and Training Specialist who is developing and helping to deliver a training curriculum to help PCIC's users access and work with PCIC's services. This work is a part of the collaboration between the Canadian Centre for Climate Services and PCIC, as mentioned earlier in this newsletter. Nic is a Scientific Software Developer who is designing software to update, analyze, and derive engineering design values from observational data. Charlotte is a Climate Data Analyst in the Climate Analysis and Monitoring theme, where she is working on improving future PRISM maps and adding climate records to the Provincial Climate Data Set. Nikola is spending his second term as a co-op student at PCIC, and working on conversion of the Plan2Adapt tool so that it can interface with the same extensive database that supports the newly developed and released PCIC Climate Explorer.

PUBLICATIONS

PCIC Corporate Report Released

PCIC is pleased to announce the release of its 2017-2018 Corporate Report. PCIC continued to grow over the 2017-2018 fiscal year across multiple sectors and continued to work with its partners to advance climate science knowledge and deliver services that are driven by user needs. The Report outlines PCIC's efforts to rise to the challenges that climate change presents for climate services in BC and the surrounding area.

Read the 2017-2018 Corporate Report.

New PCIC Science Brief

PCIC is pleased to announce the release of its most recent Science Brief describing a paper in *Atmosphere-Ocean* by Fortin et al. (2018) in which the authors examine the Canadian Precipitation Analysis (CaPA). CaPA is a near real-time precipitation product covering all of North America that is produced by Environment and Climate Change Canada. The authors review papers that evaluate CaPA and papers on the applications of CaPA for various types of research.

Read the new Science Brief, here .

PEER-REVIEWED PUBLICATIONS

Curry, C.L., S.U. Islam, **F.W. Zwiers** and S.J. Dery, 2019: Atmospheric Rivers Increase Future Flood Risk in Western Canadas Largest Pacific River. *Geophysical Research Letters*, **46**, 1651-1661, doi:10.1029/2018GL080720.

He, Y., N.A.McFarlane, and A.H. Monahan, 2019: A New TKE based Parameterization of Atmospheric Turbulence in the Canadian Global and Regional Climate Models. *Journal of Advances in Modeling Earth Systems*, early online view, doi: 10.1029/2018MS001532.

Islam, S. Ul, **C.L. Curry**, S.J. Dery and **F.W. Zwiers**, 2019: Quantifying projected changes in runoff variability and ow regimes of the Fraser River Basin, British Columbia. *Hydrology and Earth System Sciences*, **23**, 811-828, doi:10.5194/hess-23-811-2019.

Ji, D., S. Fang, **C.L. Curry**, H. Kashimura, S. Watanabe, J.N.S. Cole, A. Lenton, H. Muri, B. Kravitz and J.C. Moore, 2018: Extreme temperature and precipitation response to solar dimming and stratospheric aerosol geoengineering. *Atmospheric Chemistry and Physics*, 18, 10133-10156, doi:10.5194/acp-18-10133-2018.

Kirchmeier-Young, M.C., N.P. Gillett, **F.W. Zwiers**, A.J. Cannon and **F.S. Anslow**, 2019: Attribution of the Influence of Human-Induced Climate Change on an Extreme Fire Season. *Earth's Future*, doi:10.1029/2018EF001050.

Li, C., **F.W. Zwiers**, X. Zhang and G. Li, 2019: How much information is required to well-constrain local estimates of future precipitation extremes? *Earth's Future*, doi:10.1029/2018EF001001.

Seiler, C., 2019: A Climatological Assessment of Intense Extratropical Cyclones from the Potential Vorticity Perspective. *Journal of Climate*, early online access, doi: 10.1175/JCLI-D-18-0461.1.

Tsuruta, K., M.A. Hassan, S.D. Donner, Y. Alila, 2019: Modeling the effects of climatic and hydrological regime changes on the sediment dynamics of the Fraser River Basin, British Columbia, Canada. *Hydrological Processes*, doi: 10.1002/hyp.13321.

Werner, A.T., R.R. Shrestha, A.J. Cannon, **M.S. Schnorbus**, **F.W. Zwiers**, **G. Dayon** and **F. Anslow**, 2019: A long-term, temporally consistent, gridded daily meteorological dataset for northwestern North America. *Nature Scientific Data*, 6, 180299, doi:10.1038/sdata.2018.299.

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