PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE August 2021

PROJECT AND RESEARCH UPDATES

PCIC Responds to the Extreme Heat Wave

The recent extreme heatwave that gripped Western North America shattered many long-standing temperature records over a region that spans from southern Yukon to Oregon state, north to south, and from the Pacific coast to the Rocky Mountains, east to west. PCIC collaborated on a rapid attribution analysis of the event that garnered substantial global media attention. PCIC has also fielded numerous media requests before, during and after the event well into July.

The heatwave was caused by a very strong area of high pressure sometimes called a "heat dome." Such high-pressure systems divert moist air from a region while simultaneously trapping heat near the surface, thus causing warm, dry conditions at the surface. High-pressure areas are a common occurrence in our region during the summer, bringing warm weather and clear skies, but the size and strength of this one was exceptional. In his interviews with the media, PCIC Climatologist Faron Anslow detailed the causes for this event and explained that this is the sort of event that can be expected more often as the climate changes. Excerpts from these interviews appeared in the *Globe and Mail*, CBC, Global News and in Victoria's own *Times Colonist*.

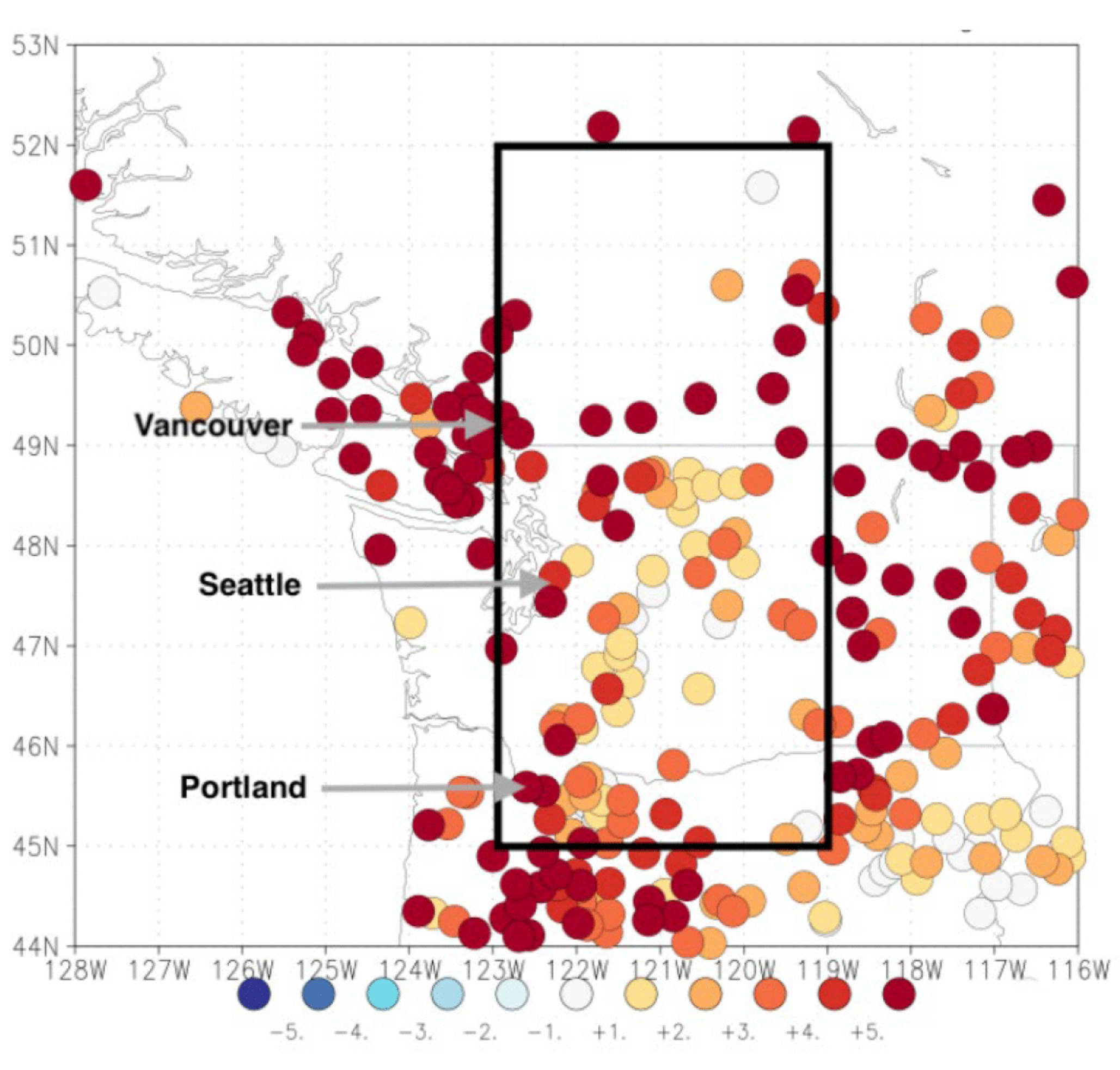

Figure 1: This figure shows the anomalies of the highest daily maximum temperature in degrees Celsius for 2021, relative to the entire record available in the Global Historical Climatology Network Daily dataset. The black box indicates the region studied in the rapid attribution analysis of the event. This analysis assumes that the rest of the summer will not exceed the temperatures of the June heatwave.

The rapid attribution analysis began as the hottest day of the heat wave was still unfolding. The effort drew together long records of temperature data from weather stations, reanalysis data (in which weather observations are made into coherent representations of earth's atmosphere using weather models) along with climate model output across a region that included parts of Washington State, Southern BC and Northern Oregon (see Figure 1). The authors found that the occurrence of the heatwave would have been "virtually impossible" without anthropogenic climate change. They estimated that such an event remains exceptionally unusual in our region in the current climate, with an estimated probability of occurrence of about 0.1% per year. That probability is estimated to increase rapidly with additional warming, rising to 10-20% per year if the global mean temperature rises to a level that is 2°C above preindustrial levels, which could be reached as early as the 2040s with current rates of greenhouse gas emissions. The report, released by the World Weather Attribution initiative, has been covered widely by the international press, with well over 3400 articles published on it and numerous televised and radio interviews by many of the authors. In Canada, Faron contributed to articles by the CBC, *Times Colonist* and the *Globe and Mail* among others, and delivered a special webinar for the Canadian Meteorological and Oceanographic Society on the analysis.

- Read excerpts from Faron's interviews in articles by the Times Colonist, Vice and Global News.
- Read about the rapid attribution analysis from the World Weather Attribution initiative, and coverage from CBC News, CBC News Canada Tonight, the Times Colonist and the Globe and Mail.
- Read a Q&A interview on the report with Faron with UVic News.
- Watch the special webinar for the Canadian Meteorological and Oceanographic Society on the rapid attribution analysis delivered by Faron.

New IPCC Assessment Report Released

The Intergovernmental Panel on Climate Change has just released its sixth comprehensive assessment of the physical science of climate change. To create the report, hundreds of expert authors drew together over 14,000 papers from the peer-reviewed literature into a nearly 4000-page review and summary of the current state of climate science, in one of the largest scientific review efforts in history. The release of the report comes just months ahead of the 26th United Nations Climate Change Conference of the Parties (COP26), to be held in Glasgow, Scotland, beginning on October 31st of this year.

The report echoes and strengthens statements made in previous IPCC assessment reports, finding that "it is unequivocal that human influence has warmed the atmosphere, ocean and land," and that the scale of recent changes to the climate are "unprecedented over many centuries to many thousands of years." The report notes that evidence has grown stronger for observed changes in climate extreme events, such as heatwaves and heavy precipitation, and for the effect of human influence on extreme events. It covers projected future climate change, noting that, absent deep emissions reductions, temperatures will exceed the 1.5°C and 2°C Paris Climate Accord temperature limits by later this century, and that further warming will increase the frequency and intensity of extreme events.

- Read the report, *Climate Change 2021: The Physical Science Basis. Contribution of Working Group 1 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.
- Read the Summary for Policy Makers.
- Access these and other reports, along with errata, regional facts and an interactive atlas on the IPCC's website.

Evaluating the Latest Climate Model Results

Output from a new generation of global climate models (GCMs) is now available. PCIC scientists are analysing this output and preparing to use it to update and improve the products that we offer to our users. Here we provide a first look at this new output and how it compares to results from the last generation of climate models over Canada and BC.

The newly-released model simulations are part of the sixth Coupled Model Intercomparison Project (CMIP6) that is expected to eventually supersede the output from CMIP5. The results from CMIP5 are currently the basis for most studies of the projected impacts of climate change used at PCIC and elsewhere, including the Intergovernmental Panel on Climate Change's *Fifth Assessment Report*. CMIP6 has however replaced CMIP5 in the newly released IPCC *Sixth Assessment Report* and will also gradually become the basis for PCIC's studies of projected change. In addition to using the latest generation of GCMs, with their improved resolutions and updated representations of the Earth system, CMIP6 uses new greenhouse gas emissions scenarios to drive these models. The new scenarios combine recently developed Shared Socioeconomic Pathways (SSPs) that illustrate different ways that societies may develop, in terms of things such as population, policies and economic growth, with Representative Concentration Pathways (RCPs), that describe future greenhouse gas emissions, to form an SSP-RCP framework, generally referred to simply as, "SSPs" as shorthand, that can be used to evaluate the effects and impacts of projected future climate change. These SSPs replace a prior, more limited set of RCPs used for CMIP5. As part of the evaluation of these new CMIP6 results, PCIC has been comparing simulations against observational data over the past, and comparing differences in projected changes between CMIP6 and CMIP5 across Canada and in BC.

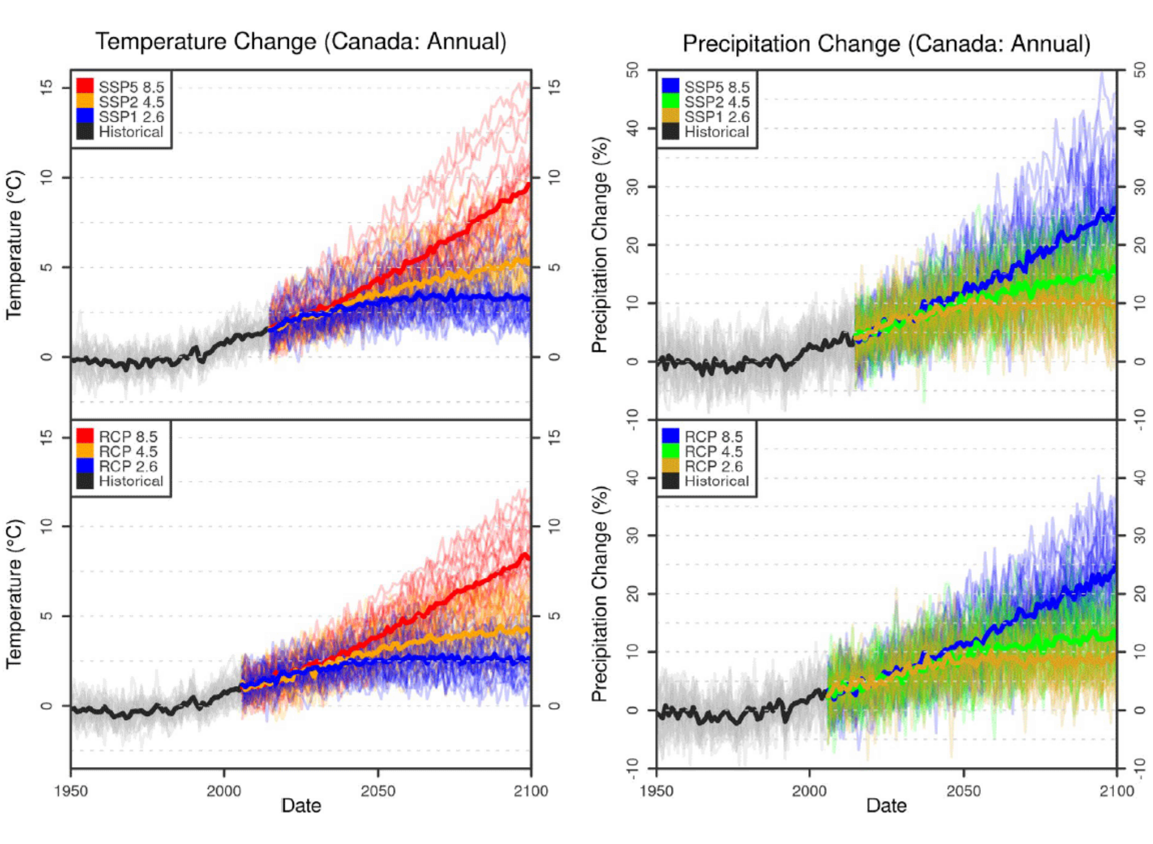

Figure 2: This figure shows the annual average temperature anomalies in degrees Celsius (left panels) and precipitation anomalies in percent (right panels) for Canada from CMIP6 (top row) and CMIP5 (bottom row), relative to 1971-2000. Individual GCM simulations are displayed with thin lines and the medians for the ensemble are shown as thick lines for each emissions pathway.

We begin by looking at the results for Canada. Somewhat more warming is projected across the country in CMIP6 compared to CMIP5—and this is also true of precipitation, to a lesser degree—mainly in the highest emissions pathway, and toward the end of the 21st century (Figure 2). Similar results have been found for other locations and globally, and it appears that stronger responses to similar climate forcings in a minority of CMIP6 models is the cause. Ongoing research continues to investigate how to best present these results and whether to give all CMIP6 GCMs equal weight.

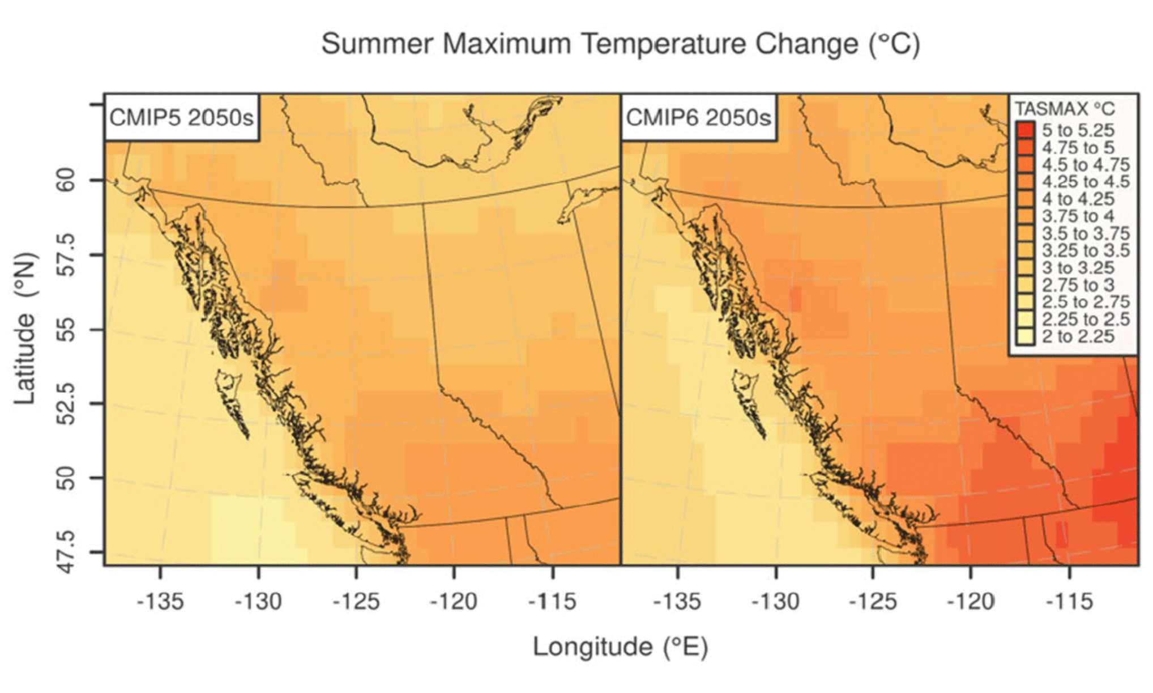

Figure 3. This figure shows the change in summer mean daily-maximum temperature over BC and surrounding areas. Two high-emissions scenarios are used here: in the left panel, CMIP5 RCP8.5 ensemble mean results for the 2050s are contrasted with those from CMIP6 SSP5-8.5 on the right. All changes are relative to a 1971-2000 baseline period.

As with the global and Canadian projections, CMIP6 shows more warming over BC than CMIP5, though this is not true for all variables across all seasons. Comparing the projected changes to summer maximum temperatures by the 2050s using comparable emissions scenarios, the CMIP6 projections show more warming across the whole province by about half to three-quarters of a degree Celsius (Figure 3). However, CMIP6 projections show less warming in winter minimum temperatures in the province than is found in CMIP5 projections. For projected changes to precipitation, the differences between CMIP5 and CMIP6 are smaller, and both show a wetter northern BC and a drier southern BC (Figure 4), with the line of zero change being about 54° north, roughly the latitude of Prince George and Kitimat.

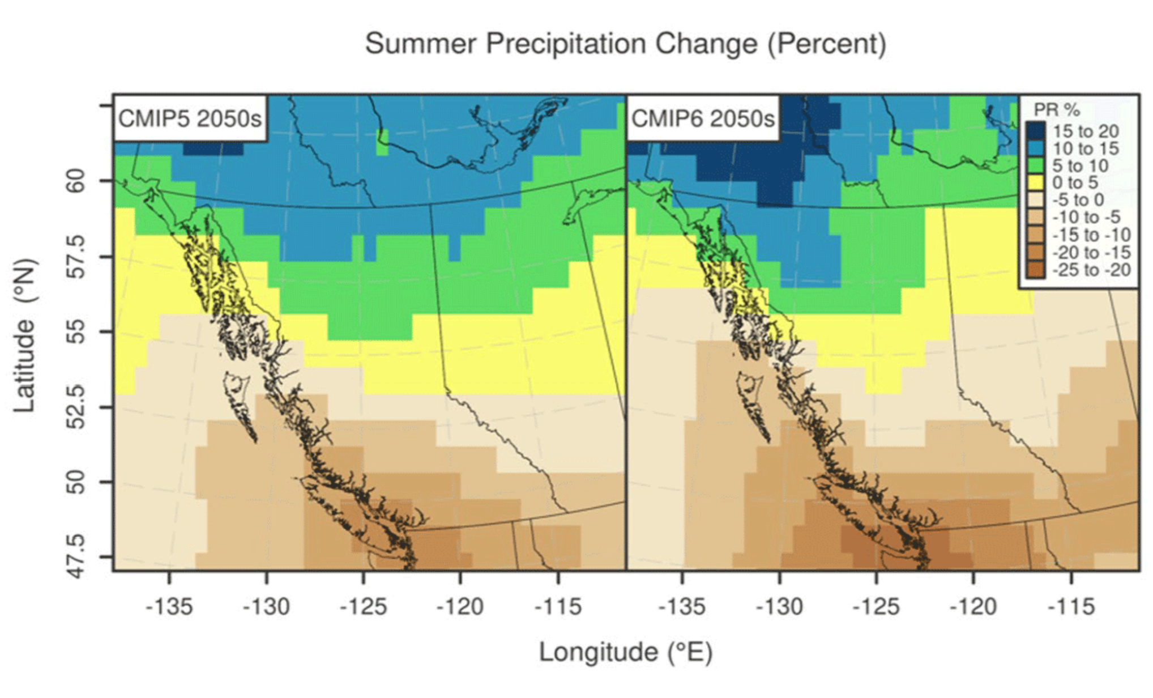

Figure 4. This figure is similar to Figure 3, but shows the percent change in summer daily precipitation relative to 1971-2000.

The improved understanding gained through analysing the most recent CMIP results will allow PCIC to provide better information to decision makers in BC and help to inform their planning with the most up-to-date results from the world's climate modelling groups.

Collaborating With Forest Ecologists to Improve BC Climate Mapping

The year 2020 is behind us and with the beginning of a new decade comes the close of a World Meteorological Standard 30-year climate normal period—in this case, the 30 years spanning 1991 to 2020, inclusive. With the closing of a climate normal period comes the analysis of the data from that period, to determine a new reference climatology, both for individual weather stations and for the province of BC as a whole.

PCIC uses a climate mapping system called the Parameter-elevation Regression on Independent Slopes Model (PRISM) to produce detailed 30-year climate normals for the province. PRISM is an "expert system," meaning that the technology combines known systematic relationships between climate and landscape properties with the knowledge of an expert operator. Expertise and experience are therefore needed to produce the best quality climate maps. The vegetation that naturally grows in a given location can be seen as a reflection of the local climate, and thus forest ecologists, with their detailed understanding of the province's ecology, have been contributing their insights to the mapping process.

Forest ecologists within the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) have compared their understanding of on-the-ground vegetation to PCIC's detailed PRISM climate maps for the 1971-2000 and 1981-2010 periods, noting inconsistencies between the two. Efficiently transferring these insights to PCIC so that they could be used to improve climate mapping proved to be difficult however, and thus PCIC has recently developed a web-tool that facilitates this exchange of knowledge. The tool, which is being used by FLNRORD forest biologists, enables the comparison of PRISM climate maps with topographic features, observational data, and BC's biogeoclimatic zones. This tool allows forest ecologists to highlight regions with potential mapping errors in the province and will be used in a wider review in coming months. The information that is gathered will be used in the development of new PRISM climate maps.

Ongoing collaboration with the forest ecologist community and additional engagement with other users and producers of climate data will be critical for improving climate maps for the newly complete climate-normal period. The resulting updated maps will be of use to planners looking for information about the historical climate of the province. They will also be added to PCIC's PRISM data portal and will used as the basis for constructing updated monthly timeseries maps, amongst other data products.

STAFF PROFILE: DR. QIAOHONG SUN

Dr. Qiaohong Sun is a PCIC post-doctoral scientist who has been supported by both PCIC and the Pan-Canadian Global Water Futures (GWF) research program. Dr. Sun earned her PhD and MSc in Global Environment Change at Beijing Normal University, China. Reflecting on this time, she says, "As a grad student, I was working on the reliability of so-called 'real' observed datasets, such as precipitation and temperature data, and how much the climate had changed in the past over China, especially in terms of climatic extremes."

Dr. Sun's work at PCIC is centered around using different statistical methods and high quality long-term observational data to study changes in extreme precipitation. Discussing this work, she says, "One thing I find interesting about studying precipitation extremes is that changes in extremes depend greatly on the temporal and spatial scales that we consider." She continues, "We can't confidently assess local changes in extreme precipitation because the signal from climate change is still mostly hidden within the natural noise, but we can get some robust information at the larger spatial scales."

Recently, Dr. Sun has been working on updating global figures on extreme precipitation. This process involves collecting high-quality station data for extreme precipitation and using different statistical techniques to evaluate the possible change in behavior of these precipitation data. Speaking of this, she says, "We recently published a paper that provides convincing evidence that extreme precipitation has intensified on global and continental scales, and the intensification is also clear at the regional scale in some regions." Dr. Sun and colleagues found that changes in the intensity of extreme one-day rain storms were statistically significant at about 10 percent of stations over global landmasses, which is four-times higher than what researchers would expect to see in an unchanging climate. Their results show that the intensity of extreme precipitation has increased by about seven percent for every degree of global warming. "These results remind us that governments, engineers and the public should prepare for a future in which precipitation extremes will become more intense."

Dr. Sun is currently developing a novel detection and attribution analysis method that is being applied directly to station data and will avoid some of the difficulties involved in verifying model-based estimates of the unforced variability of precipitation extremes. "Our results so far confirm findings from previous studies that the influence of anthropogenic forcings on extreme precipitation can be detected over the global land area and continental regions," she explains, "and thus substantially increases confidence in detection and attribution findings concerning extreme precipitation."

NEW PCIC SCIENCE BRIEF

PCIC recently released a new Science Brief that covers part of the discussion surrounding the designation of "business as usual" often given to Representative Concentration Pathway 8.5, an emissions scenario used to create future climate projections. Recently, some scientists have taken issue with this description, saying it is unrealistic and may hinder the goal of emissions reductions policy. Others argue that, in fact, RCP 8.5 is the scenario that most closely tracks cumulative emissions to date, that it is thus of the most use for planning out to the middle of the century. Through the lens of four recent articles in *Nature* and the *Proceedings of the National Academy of Sciences*, we unpack the key arguments and evaluate what these differing perspectives can tell us about the ultimate objective of emissions scenarios as tools for exploring future climate change.
Read the new Science Brief.

PCIC STAFF NEWS

The late spring and summer have seen a number of staff changes at PCIC. PCIC bids a fond farewell to Hydrologic Scientist Dr. Kai Tsuruta, Assistant Programmer Cairo Sanders, Climate Data Analyst Charlotte Ballantyne and Research Associate Yaqiong Wang. We wish them all the best in their future endeavours. We extend our gratitude to outgoing Administrative Assistant, Shayna Thompson and welcome Teresa Rush. PCIC also welcomed Eric Yvorchuck back for the summer as an Assistant Programmer (Co-op), allowing him to continue his work on the Data Analytics for Canadian Climate Services project. We are also happy to announce that PCIC Content Development and User Engagement Assistant Stacey O'Sullivan has moved from her former co-op position to PCIC staff.

PUBLICATIONS

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Philip, S.Y. et al. (F. Anslow is sixth author), 2021: *Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021*. World Weather Attribution Initiative, 37 pp.

Tai T.C., U.R. Sumaila and W.W.L. Cheung, 2021: Ocean acidification amplifies multi-stressor impacts on global marine invertebrate fisheries. *Frontiers in Marine Science*, **8**, 596644, doi: doi:10.3389/fmars.2021.596644.

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Tsuruta, K. and M.A. Schnorbus, 2021: Exploring the operational impacts of climate change and glacier loss in the upper Columbia River Basin, Canada. *Hydrological Processes*, **35**, 7, e14253, doi:10.1002/hyp.14253.

Wang, J., C. Li, F. Zwiers, X. Zhang, G. Li, Z. Jiang, P. Zhai, Y. Sun, Z. Li and Q. Yue, 2021: On the Optimal Design of Field Significance Tests for Changes in Climate Extremes. *Geophysical Research Letters*, **48**, 9, e2021GL092831, doi:10.1029/2021GL092831.

Our address is:
Pacific Climate Impacts Consortium
University House 1
2489 Sinclair Road
University of Victoria
Victoria, British Columbia
Canada V8N 6M2