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PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE OCTOBER 2018

IN THE NEWS: IPCC SPECIAL REPORT ON GLOBAL WARMING OF 1.5ºC

On Monday, October 8th, the Intergovernmental Panel on Climate Change (IPCC) released a Special Report on Global Warming of 1.5 ºC. Approved in Incheon, Republic of Korea on Saturday, the report is the work of 91 authors and review editors. The report discusses the current warming that we have seen and the mitigation pathways that are compatible with limiting global warming to 1.5ºC and 2ºC. These two temperatures are the global temperature change limits agreed upon at the 21st Conference of the Parties of United Nations Framework Convention on Climate Change in Paris, in 2015. The report also examines what the impacts of 1.5ºC of warming may be and how they differ from 2ºC of warming. Finally, the report discusses the global response to climate change and how climate change mitigation efforts can be dovetailed with sustainable development goals.

The report notes that human activities have resulted in a global warming of about 1°C (±0.2°C) above the pre-industrial (1850-1900) temperature average, as of 2017. This warming has been proceeding at a rate of about 0.2°C per decade in recent decades, and has been felt unevenly, with greater warming over land than over the ocean and greater warming in the Arctic than elsewhere. At this pace, the Earth is likely to warm by 1.5°C (in terms of a decadal average) sometime between 2030 and 2052.

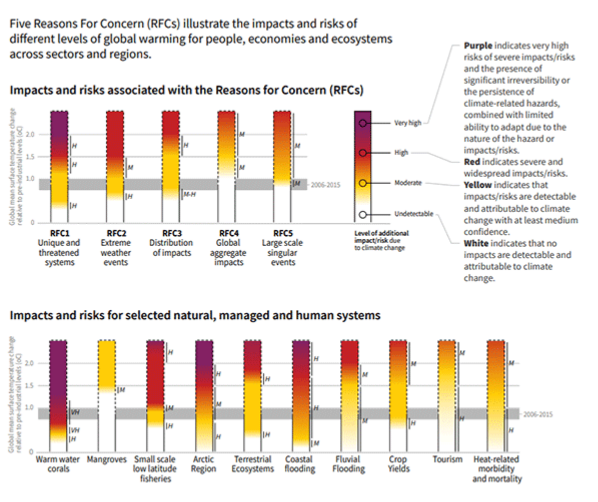

Figure 1: This figure, from the IPCC's Special Report on Global Warming of 1.5 ºC, shows five integrative Reasons For Concern (RFCs, upper panel) and impacts and risks for natural and human systems (lower panel). Colours indicate impacts and risks as determined by expert judgment. Impacts and risks in the lower panel are selected for illustrative purposes. For an explanation of the RFCs, see the full report. Image credit: IPCC.

While a global warming of 1.5°C will bring impacts with it, these would be lesser in magnitude than the impacts that follow from 2°C of warming (Figure 1, which will be SPM2 from the Summary for Policymakers). Such impacts include changes to the average temperature at a location, heat extremes, precipitation extremes, drought, sea level and resulting impacts to ecosystems and human communities. For instance, the report notes that sea level rise could be smaller by about a tenth of a metre at 1.5°C of warming as compared with 2°C of warming. This figure, though it may seem small, has significant implications for risk from flooding, salt water intrusion and storm surge events. The report notes that it would mean that, "up to ten million fewer people would be exposed to related risks [of sea level rise]." Compared to 2°C of warming, 1.5°C of warming may also cut the number of people exposed to water stress due to climate change, by half, and that meeting this limit could spare between 1.5 and 2.5 million square kilometres of permafrost (an area roughly the size of British Columbia, Alberta and Yukon combined) from melting. Keeping temperatures to the lower limit should also reduce the number of people susceptible to poverty and exposed to climate-related risks by several hundred million, by 2050. The story is similar across most of the areas that the report examines, from impacts to agriculture and potential human health impacts from disease, to impacts on the geographic range of flora and fauna—projected impacts, while present, are lesser at 1.5°C, and often substantially so.

As far as impacts to Canada are concerned, the report highlights the increased risks to Western Canada from heavy precipitation events and general risks to Canada from increased wildfires. While the report does not discuss British Columbia in particular, greater climate impacts to the province and surrounding regions can be expected with higher global temperatures.

While the report finds that the remaining carbon budget to keep global temperatures under 1.5°C may be larger than that reported in the IPCC's Fifth Assessment Report, current commitments under the Paris Agreement are still insufficient to meet the 1.5°C and 2°C temperature limits. These commitments, if met, would lead to a warming of about 3°C by the end of the century. The report notes that, to stand a good chance of keeping temperatures under 1.5°C (without overshooting the limit and bringing the temperature down later), emissions would need to be reduced by about 45% from 2010 levels by 2030 and brought to zero by 2050. Keeping global temperatures below 2°C requires a lesser reduction in emissions, of about 20% from 2010 levels by 2030 and to zero by 2075. The cost of keeping warming to 1.5°C, in terms of energy-related mitigation investment, is estimated to be between $1.6 and $3.8 trillion by 2050 (when emissions would have to be reduced to zero). This is about 12% more expensive than keeping global temperatures to 2°C. The report does not estimate the cost of inaction, but it is likely to be substantial, with current estimates suggesting that savings from averted climate-related impacts may exceed $20 trillion dollars by the end of the century.

It is important to note that, though the emissions reductions required to meet these limits is formidable, the underlying message is that climate impacts are going to be lesser in magnitude with less warming. So, even if the limit of 1.5°C is missed, keeping global warming to 1.7°C or 1.8°C will mean that we face less significant impacts than if the warming proceeds apace to 2.5°C, 3°C or greater.

Read the full report.

PROJECT AND RESEARCH UPDATES

From Mudslides to Smoke: Precipitation Variability in the Face of BC's Warming Climate

British Columbia has experienced a second consecutive exceptional summer that highlights seasonal variability in a province traversing from one extreme to another. Following last year's record-breaking fire season many hoped that a second, similar year would not be in the offing. However, statistics tell us that the occurrence of one such event does not change the likelihood of any future events. Over the summer, there were 2071 wildfires in the province, setting a new record for area burned, at more than 1,350,000 ha with almost 500 fires active at the end of August. Wildfire resulted in the evacuations of thousands and periods of very poor air quality covering almost half of BC in mid August (Figure 1). An initial analysis of precipitation shows that August was the 13th driest for the province as a whole, with the coast experiencing the brunt of that dryness. However it is easy to forget that, like 2017, the end of spring and early summer were characterized by rainfall, snowmelt and flooding. In fact, in the Peace Region of BC, heavy rains led to flooding and debris flows as late as July.

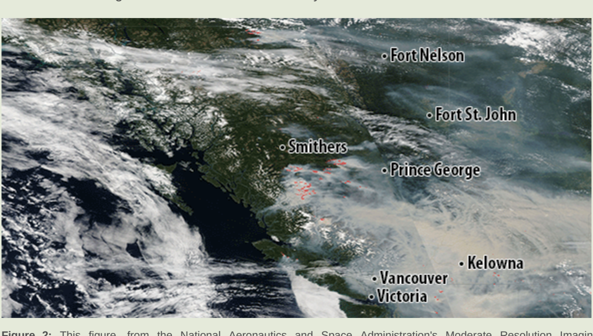

Figure 2: This figure, from the National Aeronautics and Space Administration's Moderate Resolution Imaging Spectroradiometer (MODIS) aboard its Terra satellite, shows the smoke from BC wildfires (visible in the lower right hand side of the image) blanketing BC in mid-August. Red dots indicate the positions of wildfires. Image credit: NASA.

These events reveal temporal and spatial aspects of variability that characterise the weather here in BC and throughout Earth's midlatitudes. Generally, temperature varies more slowly in time (warm or cold days tend to follow or precede other warm or cold days, respectively) and space (areas with warm weather tend to be quite large) than precipitation which varies quickly in time and space. This summer in British Columbia ranks as the sixth warmest on record for average daily minimum temperature, with warmth that was evenly distributed across the province, exemplifying a large, stable pattern of warmth. Precipitation, on the other hand, showed a transition from very wet to very dry in southern and coastal BC, even as the Peace Region remained wet in June and July. Unfortunately, the heat and dryness in southern and coastal BC enabled conditions conducive to wildfire development, culminating in extreme wildfire danger throughout BC in mid-August.

The large variability of precipitation is also important to understand when thinking about the short- and long-term future. Precipitation is much more difficult to forecast or project with confidence, leading to uncertainty in our understanding of how it will change in coming months and even in the coming decades, despite our confidence in how temperature will vary on seasonal time scales and high confidence in long-term temperature increases in BC under continued greenhouse gas emissions.

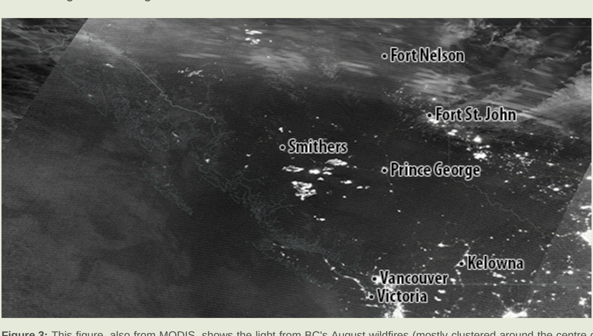

Figure 3: This figure, also from MODIS, shows the light from BC's August wildfires (mostly clustered around the centre of the figure) at night. Image credit: NASA.

Seasonal forecasts from Environment and Climate Change Canada and most other agencies are pointing toward a moderate El Niño event this winter. These events typically bring warmer than normal temperature but, in keeping with the theme of this article, precipitation remains uncertain. Forecasts are showing a 70%-80% likelihood of warmer than normal temperatures in fall and early winter and equal chances of wetter or drier than normal precipitation.

Supporting Agriculture in the Fraser Valley

The agriculture sector is concerned about the potential impacts of climate change, including possible changes in precipitation patterns. To support adaptive planning for the anticipated increase in frequency and magnitude of extreme precipitation events, PCIC partnered on a project with the BC Agriculture & Food Climate Action Initiative, the BC Blueberry Council and other groups in the Fraser Valley. Detailed precipitation projections were generated and shared through the Fraser Valley Climate Adaptive Drainage Management Forum, an event which brought together researchers, agricultural producers and local and provincial and government staff to discuss agricultural drainage challenges (and potential solutions).

The project identified a number of possible next steps including the piloting of drainage area management planning and enhancing professional and informational/technical resources available to producers to support drainage improvements.

Read the report on this project.

New Seasonal Maps Portal

PCIC is pleased to announce the release of its new Seasonal Anomaly Maps Portal that allows users to view maps of monthly weather anomalies, and the historical averages, from 1970 onward using an intuitive online interface. Weather anomalies are the differences between the average, or expected, weather conditions in an area and the actual conditions that occur. Conditions may be drier, wetter, warmer or cooler than the normal weather for that area and time of year. Having access to such information can be useful for planning, as one can understand the historical climate in an area and how it has been changing over time. It also allows users to relate recent anomalous weather in and surrounding the province with conditions and impacts that they have observed.

Check out the new Seasonal Anomaly Maps Portal.

Columbia Basin Trust Workshops

Engaging with regional stakeholders to increase their understanding of, and ability to access, climate data is one of the services that PCIC provides. Recently, PCIC met with consultants local to the Columbia Basin to provide high-resolution climate projection maps, indicators for multiple climate variables and climate extremes indices, along with review and support with the interpretation of climate change information for a series of workshops in the region. This work, part of the Columbia Basin Trust's Climate Action Program, has supported meetings that have occurred with 24 communities and involved over 229 organizations.

Summer Research Visitor: Dr. Jana Sillmann

Dr. Jana Sillmann, Research Director at the Centre for International Climate Research (CICERO) in Oslo, Norway spent the summer with PCIC, which served as an opportunity for her and PCIC's researchers to share their knowledge and research findings, while considering possible future research collaboration.

British Columbia and Norway share several similarities. Both regions experience weather and climates patterns that are shaped in part by their complex topography, northerly latitudes and proximity to the ocean. Both are exposed to atmospheric rivers, which are long, narrow regions of water vapour that snake their way through the higher latitudes and cause the majority of extreme precipitation events in both Norway and BC. Persistent high pressure systems, also called atmospheric blocking, to the south of either region can draw atmospheric rivers into the area. While a high pressure system directly over either region can cause clear skies and dry weather, it can also draw cold air in from the north when it sits off the coast. Because of this, atmospheric blocking can be important for temperature extremes, air quality and precipitation extremes in both regions. Dr. Sillmann's work involves using these connections between such weather or climate patterns and surface extremes (such as heatwaves and extreme rainfall) to improve our understanding of changes in weather extremes and to provide better information to decision-makers.

Also like BC, Norway produces most of its electricity from hydropower. Statkraft, Norway's national hydropower company, currently uses weather forecasts in the management of its operations. In order to prepare for the impacts of climate change, Dr. Sillmann has overseen the creation of a future scenario, in which climate model projections were used to drive the Norwegian weather forecast model, to create a narrative that shows how climate change may affect hydropower generation and vulnerability to future extreme precipitation in the region. This narrative-based approach is useful because it follows how people relate to weather, and can be used complementary to an ensemble-based approach, which uses many models to gather various statistics and provides estimates on likelihoods of future extreme precipitation under different socio-economic and emission scenarios.

As in BC and Canada in general, engineers and scientists in Norway are concerned about incorporating climate change information into intensity, duration and frequency estimates (so called "IDF curves") of precipitation events that are used to design infrastructure, such as bridges, roads and buildings. The Norwegian Climate Service Center developed a tool for plotting IDF curves for any location in the country. PCIC scientists are also working on IDF curves and delivering data to regional stakeholders via online tools, and this provides a fruitful ground for discussion and further collaboration.

New Projects

PCIC has recently signed the following agreements:

- Environment and Climate Change Canada: *Climate Services in British Columbia*;
- BC Agricultural Research and Development Corporation: *Climate Change Adaptation Program.*

STAFF PROFILE: MATTHEW BENSTEAD

Matthew Benstead is PCIC's Systems Administrator and supports and maintains the computation, storage, and network infrastructure used at PCIC. He also continually looks for opportunities to improve service and reliability for PCIC's users. Matthew came to PCIC after receiving his B.Eng in Computer Systems, and working for many years as a system administrator for a large multinational technology corporation.

One of Matthew's focuses at PCIC is the standardization of PCIC's systems to improve deployment times, ease of management and reliability. One aspect of this has been to expand PCIC's use of automation tools for server deployments and configuration management. Matthew explains that, "this has allowed us to deploy services more quickly, and with greater reliability on a number of different platforms." He continues, "Earlier this year we tripled the capacity of our job queuing system without increasing the effort needed to maintain it. This has not only benefited our internal users but also allowed us to more easily deploy services, and spend more time on development and planning instead of on repetitive tasks ."

PCIC's Computational Support Group also recently migrated the PCIC Data Portal from an older, legacy system into the Compute Canada cloud. Referring to this Matthew continues, "we made use of automation software to quickly build a stable system, and modified the application to run in a containerized environment which has increased our ability to deploy new versions more quickly and reliability." The project also included improvements to centralized logging which allows PCIC to more easily detect issues and respond to problems in its Data Portal, while helping manage resource usage and allocation. Reflecting on this, Matthew says, "I found this project particularly rewarding because it let us modernize a large application while using a number of different tools to offer a much better service to our users."

PACIFIC CLIMATE SEMINAR SERIES

Figure 4: This figure shows Dr. Jana Sillmann delivering her talk on July 4th.

The Pacific Climate Seminar Series continued through the summer and into the fall, with two talks delivered by Dr. Jana Sillmann, Research Director at the Center for International Climate Research–Oslo and one given by PCIC Postdoctoral Fellow Dr. Whitney Huang. The first of Dr. Sillmann's talks, titled, *Understanding and modeling weather and climate extremes: Challenges and opportunities for science and society*, was held on July 4th. The second, titled, *Perspectives from climate services in Europe*, was held on August 28th. Dr. Huang's talk, *What can we learn about temperature extremes from millennial-scale equilibrium climate simulations?*, was held on September 19th.

Details for the next talk in the series will be announced, shortly.

Details for Dr. Sillmann's first talk can be found here and more information on her second talk can be found here. More on Dr. Huang's talk can be found, here.

PCIC STAFF NEWS

This summer PCIC was happy to welcome Drs. Qiaohong Sun and Whitney Huang. Dr. Sun is a postdoctoral researcher who is contributing to a Global Water Futures project, where her work is focused on the physical processes that affect short-duration precipitation extremes. Dr. Huang is a joint postdoctoral researcher with PCIC and Professor Adam Monahan of the UVic School of Earth and Ocean Sciences, whose position is jointly sponsored by the Canadian Statistical Sciences Institute and the Statistical and Applied Mathematical Sciences Institute located in North Carolina. His research focuses on modelling concurrent wind and precipitation extremes. PCIC's Computational Support Group also welcomes Owen Scholes, an undergraduate student from Quest University who will be interning at PCIC for the month of September, where he will be helping to implement machine learning algorithms to perform automated data cleaning on the Provincial Climate Data Set.

After a summer filled with fruitful collaboration and discussion on climate services and climate extremes events, PCIC wishes farewell to Dr. Jana Sillmann. PCIC also wishes farewell to Dr. Christian Seiler, Dr. Chao Li, and Nikola Rados. Dr. Seiler joined PCIC in September 2013 as a research fellow examining the dynamics of coastal storms and became a PCIC Research Climatologist in 2016. PCIC wishes him all the best with his research at his new position with Environment and Climate Change Canada. Dr. Li joined PCIC as a research associate in 2016, where his research focused on short-duration precipitation extremes. Dr. Li leaves PCIC for a professorship at East China Normal University, in Shanghai. PCIC extends a congratulations to him on his professorship and wishes him good luck in his future research endeavours. Nikola Rados spent the summer with PCIC's Computational Support Group as an intern, where he helped in the development the digital pipeline between stations and networks. PCIC wishes Nikola all the best with his studies.

PUBLICATIONS

PCIC Science Brief: On Paris Climate Accord Emissions and Temperature Limits

PCIC's latest Science Brief covers three recent articles from the journal *Nature Climate Change* that examine greenhouse gas emissions budgets and pathways consistent with the Paris 1.5°C and 2°C warming limits. Using global climate model projections, Tokarska and Gillett (2018) calculate a new median remaining carbon budget of 208 billion tonnes from January 2016 that is consistent with limiting warming to 1.5°C. Tanaka and O'Neill (2018) use an integrated assessment model and find that meeting the Paris temperature limits may not require net zero greenhouse gas emissions, that reducing emissions to zero doesn't necessarily result in meeting the Paris temperature limits by the end of the century, and that imposing both temperature and emissions limits causes temperatures to decline after meeting the initial temperature limit. Using an integrated assessment model van Vuuren et al. find that implementing strategies such as making large-scale lifestyle changes and using efficient technologies for the production of energy and materials can slightly reduce, but not eliminate, the need for negative emissions.

Read the latest Science Brief.

PEER-REVIEWED PUBLICATIONS

Kharin, V.V., G.M. Flato, X. Zhang, N.P. Gillett, **F.W. Zwiers** and K. Anderson, 2018: Risks from climate extremes change differently from 1.5C to 2.0C depending on rarity. *Earth's Future*, **6**, 5, 704-715, doi:10.1002/2018EF000813.

Mueller, B.L., N.P. Gillett, A. Monahan and **F.W. Zwiers**, 2018: Attribution of Arctic sea ice decline from 1953 to 2012 to influences from natural, greenhouse-gas and anthropogenic aerosol forcing. *Journal of Climate*, **31**, 19, 7771-7787, doi:10.1175/JCLI-D-17-0552.1.

Ouali, D. and A.J. Cannon, 2018: Estimation of rainfall intensity–duration–frequency curves at ungauged locations using quantile regression methods. *Stochastic Environmental Research and Risk Assessment*, **32**, 10, 2821–2836, doi:/10.1007/s00477-018-1564-7.

Teufel, B., L. Sushama, O. Huzly, G.T. Diro, D.I. Jeong, K. Winger, C. Garnaud, R. de Elia, **F.W. Zwiers**, J.R. Gyakum, D. Matthews and V.-T.-V. Nguyen, 2018: Investigation of the mechanisms leading to the 2017 Montreal Flood. *Climate Dynamics*, doi:10.1007/s00382-018-4375-0.

Tsuruta, K., M.A. Hassan, S.D. Donner and Y. Alila, 2018: Development and application of a large-scale, physically-based, distributed suspended sediment transport model on the Fraser River Basin, British Columbia, Canada. *Journal of Geophysical Research: Earth Surface*, doi: 10.1029/2017JF004578.

Wan, H., X. Zhang and **F. Zwiers**, 2018: Human influence on Canadian temperatures. *Climate Dynamics*, doi:10.1007/s00382-018-4145-z.

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