PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE MARCH 2018

PROJECT AND RESEARCH UPDATES

2017 in Climatological Context

Globally, 2017 was slightly cooler than 2016, but among the top-three warmest years within multiple records extending back into the 1800s. After back-to-back global temperature records, the transition to less-than-record-breaking temperature may have seemed unremarkable, but the third-warmest ranking took place despite the occurrence of a La Niña event, which historically have reduced global mean temperature, making that level of warmth worth noting. Despite BC having nine months of cool and wet conditions, 2017 was the 19th warmest for temperature overall in the province, the 14th warmest for average daily minimum temperature, and the 32nd warmest for average daily maximum temperature where province-wide estimates are reliable from 1900 to present. The year was also drier than normal in terms of precipitation at the 25th driest among 68 years of reliable record dating from 1950. The story for 2017 lies in how a single season was able to unpredictably offset nine months of cold and wet conditions.

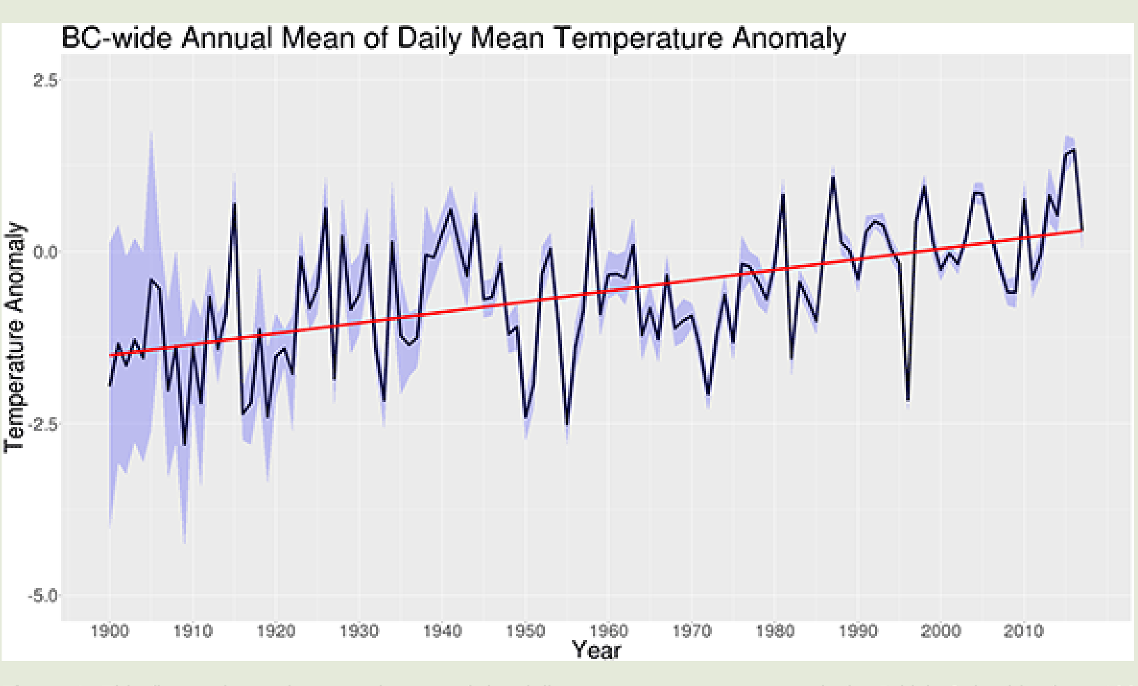

Figure 1: This figure shows the annual mean of the daily mean temperature anomaly for British Columbia, from 1900 through to the end of 2017..

The winters of 2016/2017 and 2017/2018 were both so-called La Niña winters. La Niña is a climate pattern with cool sea surface temperatures in the eastern or central Equatorial Pacific. This pattern influences the climate nearly worldwide, and is associated with colder than normal temperatures in western North America during late fall, winter and spring. Winter 2016/2017 was cold and snowy in southern BC where La Niña impacts are typically strongest. In northern BC, where La Niña has weaker impacts, the winter was nearer normal, to slightly warm and dry. Spring was cool and extremely wet with record precipitation recorded throughout southern BC where major impacts from flooding were felt. Late fall was also similarly cool and wet, with a late October and early November Arctic air outbreak setting numerous daily low temperature records. These seasonal results align with typical La Niña conditions, and leave summer as the last season standing to sway 2017 into warmer than normal conditions.

The crux of 2017–what kept it from being a cool year overall–was an extremely hot summer with extreme daily maximum temperature conditions, both in monthly average and for daily records in the southeast. An outbreak of dry lightning in early July ignited the worst fire season on record for BC in terms of area burned and number of fires. These fires consumed 1.2 million hectares of forest land, cost approximately half a billion dollars for fire suppression and culminated in the burning of the majority of forest cover within Waterton National Park. Wildfire displaced about 65,000 British Columbians, destroyed huge swathes of property and resulted in poor air quality throughout southern British Columbia, northern Washington, Idaho and Montana. All of this happened despite indications of a very slow fire season after the cool and wet spring. The hot summer events illustrate the challenges of seasonal prediction, especially in summer in British Columbia when large-scale weather patterns are least active. Although not a remarkable year on the long-term average, 2017 demonstrated that climatic surprises can spring up suddenly during any season. PCIC is undertaking an "event attribution" study to better understand the wildfires of 2017.

Applying the Updated VIC Model to New Regions

PCIC's Hydrologic Impacts (HI) Theme is currently applying the updated VIC-GL model, now capable of modelling glacier processes in addition to hydrological processes, to a number of BC's major basins. The updated model is running simulations over a domain covering in excess of one million square kilometres, including the major drainage basins of the Columbia, Fraser and Peace, plus several smaller watersheds on Vancouver Island. Understanding projected future changes to the hydrology of these regions will allow planners to have more information from which to base their decision-making. As a part of this modelling effort, the HI Theme has completed the statistical downscaling of 38 climate experiments from the fifth phase of the Coupled Model Intercomparison Project. These include multiple runs from six global climate models, being driven by two emissions scenarios and amounting to a total of 5270 simulation years.

The HI Theme is also developing assessments of the impacts of climate change on future flood hazard changes on the Fraser River and on future low flow changes into Comox Lake. Hydrologic projections for both the Peace and Columbia rivers are underway. These will be relevant for determining potential future changes in hydro-power generation and the possible re-negotiation of the Columbia River Treaty. In addition, PCIC's researchers have integrated a water temperature model into the VIC-GL model. Test applications of the integrated model are currently running, simulating the Stellako, Stuart, Baker, Quesnel and Nicola sub-basins of the Fraser River. The team is also working on ways to more accurately represent the temperature of headwater inflow (the water flowing into a river) particularly as this pertains to glacier runoff.

Engagement with First Nations Communities and Engineers

PCIC's Regional Climate Impacts Theme has recently undertaken several projects with First Nations communities, agricultural producers, and engineers in BC. This work aims to help communities identify some of the region-specific impacts that climate change may bring and support engineers in working with climate change information in their design process.

PCIC welcomes the opportunity to work with First Nation communities. To advance this, PCIC jointly presented with Indigenous and Northern Affairs Canada's (INAC) First Nation Adapt Program. The webinar, *Information and Funding for First Nations Climate Change Adaptation Planning*, was part of the BC Regional Adaptation Collaborative (RAC) program, and was aired on January 25th, 2018. It is available online, here. The webinar provided an opportunity to share the types of climate change information and services PCIC can offer to communities preparing to adapt, and helped promote funding opportunities for First Nation communities to assess, prepare and plan for climate change impacts.

PCIC has had the opportunity to work with a couple of First Nation communities over the past year. This includes participating in the development of the report, *Climate Projections for the Cowichan Valley*, with Cowichan First Nation. PCIC looks forward to participating in further dialogue on climate change and adaption with First Nation communities across the province. In April, PCIC will be providing information on future climate projections and participating in a climate adaptation workshop with Splatsin First Nation, the southernmost tribe of the Shuswap Nation.

Finally, work done by the Regional Climate Impacts theme for various engineering projects has developed into a larger dialogue with engineers. PCIC has attended engineering association meetings and presented seminars on incorporating climate change information into engineering designs for several groups. These include three meetings in late 2017: the Annual Public Sector Organizations Symposium put on by the Climate Action Secretariat, BC Hydro's semi-annual Energy Manager's Conference, and the Annual General Meeting of Engineers and Geoscientists BC. Further presentations on the topic include a Climate-Resilient Design Seminar Series that Engineers and Geoscientists of BC are putting on in Vancouver, Kelowna, and Prince George in April and May, and a keynote lecture at the Canadian Healthcare Engineering Society BC Chapter AGM in June.

New Projects

PCIC has recently signed the following agreements:

- BC Ministry of Agriculture: *Gap analysis of weather station data in BC agricultural regions*;
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development: *Climate change scenario modeling for Fraser River Watershed (Phase 1)*;
- Fraser Basin Council: *Northeast Climate Risk Network*;
- BC Ministry of Transportation and Infrastructure: *Climate tool for engineers (Phase 4).*

STAFF PROFILE: DR. FARON ANSLOW

Faron Anslow is a climatologist and the lead of the Climate Analysis and Monitoring Theme at PCIC. He came to PCIC via a graduate and post-doctoral career investigating the impacts of climate change on alpine glaciers and how glacier changes reflect the larger scale climate that they are responsive to. Faron was driven toward this avenue of research by a passion for understanding weather and climate, and a desire to do field work in the mountains of western North America and elsewhere. "I love observing how complex the world is and then trying to understand that complexity with science," says Faron. He jokes that "In the mountains everything is laid bare and stark, making observation easy—when the weather is good!" Over the course of his prior research career, Faron investigated the climate linkages between western North America and other parts of the globe while developing data analysis skills to glean scientific understanding from large data sets. Faron explains that these together "represented a perfect stepping stone to exploring the climate of British Columbia" and to beginning work at the Pacific Climate Impacts Consortium in April of 2011.

In a broad sense, Faron's research at PCIC focuses on the climate of BC as recorded by weather observations made throughout the province and from nearby states and provinces. In doing this, Faron oversees the maintenance, curation and delivery to the public of all available historical and ongoing weather observations made in British Columbia by the Meteorological Service of Canada, BC Ministries, BC Hydro and Rio Tinto. A new agreement is being finalized to extend this work for another eight years and to include new partners Metro Vancouver and the Capital Regional District. "The agreement and the dataset are unique in Canada" Faron says, and "data delivery through PCIC's web pages represents a valuable data source for users to understand the climate of their areas and how it is changing."

Faron uses this observational climate data for several projects to help further inform British Columbians. First, he uses a model to analyze the long-term average climate of BC at a very high spatial resolution to enable users to assess temperature and precipitation averages at scales as small as 800 metres. Speaking of the uses for such data, Faron explains: "This information is invaluable for determining things like crop growing conditions, average rainfall for drainage considerations, and as a basis for developing input to many kinds of process models used in the province." Second, Faron has been working with UVic Geography master's student Yaqiong Wang, to improve the quality of the data and its suitability for climate change analysis through a process of data homogenization. That work corrects for inaccuracies in observational data that arise from changes in the observing environment of a station through time. Unpacking the sources of such error, Faron says, "it would include things like encroaching vegetation, station moves or changes in instrumentation." Third, Faron is currently working to analyze the suitability of the current observing network for capturing the variability of weather observed in British Columbia. This work is being done for BC's Ministry of Agriculture. Reflecting on the goal of this work, Faron explains that it will "help them understand where they may need more observational data to understand BC's agricultural environment." Finally, Faron performs ongoing analysis of monthly, seasonal, and annual climate anomalies for BC which serve to inform British Columbians about evolving drought or heat wave conditions and their context in the long-term climate of the province, of which the story that opens this newsletter is an example.

PACIFIC CLIMATE SEMINAR SERIES

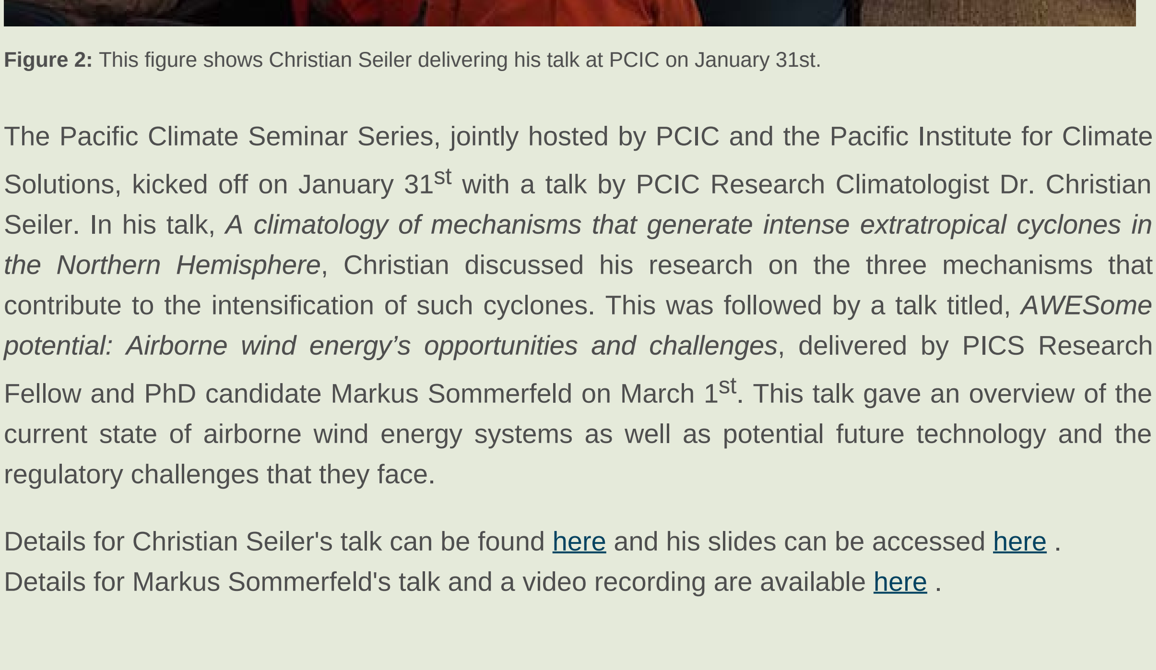

Figure 2: This figure shows Christian Seiler delivering his talk at PCIC on January 31st.

The Pacific Climate Seminar Series, jointly hosted by PCIC and the Pacific Institute for Climate Solutions, kicked off on January 31st with a talk by PCIC Research Climatologist Dr. Christian Seiler. In his talk, *A climatology of mechanisms that generate intense extratropical cyclones in the Northern Hemisphere*, Christian discussed his research on the three mechanisms that contribute to the intensification of such cyclones. This was followed by a talk titled, *AWESome potential: Airborne wind energy's opportunities and challenges*, delivered by PICS Research Fellow and PhD candidate Markus Sommerfeld on March 1st. This talk gave an overview of the current state of airborne wind energy systems as well as potential future technology and the regulatory challenges that they face.

Details for Christian Seiler's talk can be found here and his slides can be accessed here .
Details for Markus Sommerfeld's talk and a video recording are available here .

STAFF CHANGES

This winter has seen PCIC undergo several changes in staffing. PCIC Affiliate Dr. Dhouha Ouali moved from her role as a Research Associate with the Marine Environmental Observation Prediction and Response Network to her new role as the Project and Knowledge Mobilization Manager of the Climate-Related Precipitation Extremes project, within the Global Water Futures program (GWF). Former PCIC Affiliate Dr. Charles Curry joined PCIC's staff as a Research Associate. PCIC also welcomes Dr. Kai Tsuruta, who has joined PCIC as a Hydrologic Scientist after completing his second PhD, in forestry, from the University of British Columbia. Dr. Tsuruta's efforts at PCIC will be focused on a multi-model hydrological study that aims to develop and adapt models to inform future water-related decision making as part of the GWF program.

PUBLICATIONS

PCIC Science Brief: Sea Level Rise Observations and Acceleration

PCIC's most recent Science Brief covers three papers that explore changes in sea level rise in models and observations. Publishing in *Geophysical Research Letters*, Yi et al. (2017) examine the rate at which sea level rise is accelerating and find that the rate of acceleration over the 2005-2015 period is three times the rate over the 1993-2014 period and an order of magnitude larger than the acceleration over the 1920-2011 period. In a pair of articles published in the *Journal of Climate*, Slangen et al. (2017) and Meyssignac et al. (2017) analyze the ability of climate models to simulate both global and regional sea level rise. After bias corrections are included, they find that the models explain about three-quarters (75% ± 38%) of the observed 20th Century sea level rise and all (105% ± 35%) of the observed sea level rise over the period from 1993-1997 to 2011-2015. Their results also show that regionally, climate models underestimate the amount of sea level rise that occurred, but the models do show reasonable agreement for interannual and multidecadal variability.

Read the latest Science Brief.

PEER-REVIEWED PUBLICATIONS

Bonnet, R., J. Boé, **G. Dayon** and E. Martin, 2017: Twentieth-century hydrometeorological reconstructions to study the multidecadal variations of the water cycle over France. *Water Resources Research,* 53, 8366–8382, doi:10.1002/2017WR020596.

Curry, C.L. and F.W. Zwiers, 2017: Examining controls on peak annual streamflow and floods in the Fraser River Basin of British Columbia. *Hydrology and Earth System Sciences*, doi:10.5194/hess-2017-531, submitted.

Hiebert, J., A. Cannon, A. Schoeneberg, S. Sobie and T. Murdock, 2017: ClimDown: Climate Downscaling in R. *The Journal of Open Source Software*. **3**, 22, 360, doi:10.21105/joss.00360.

Kushner, P.J., L. Mudryk, W. Merryfield, J.T. Ambadan, A. Berg, A. Bichet, R. Brown, C.P. Derksen, S.J. Dery, A. Dirkson, G. Flato, C. Fletcher, J. Fyfe, N. Gillett, C. Haas, S. Howell, F. Laliberte, K. McCusker, M. Sigmond, R. Sospedra-Alfonso, N. Tandon, C. Thackeray, B. Tremblay, **F.W. Zwiers**, 2017: Assessment of Snow, Sea Ice, and Related Climate Processes in Canadas Earth System Model and Climate Prediction System. Published for discussion (under review), *The Cryosphere*, doi:10.5194/tc-2017-157.

Li, C., Y. Fang, K. Calderia, X. Zhang, N.S. Diffenbaugh, A.M. Michalak, 2018: Widespread persistent changes to temperature extremes occurred earlier than predicted. *Nature Scientific Reports*, **8**, 1007, doi:10.1038/s41598-018-19288-z.

Naveau, P., A. Ribes, **F.W. Zwiers,** A. Hannart, A. Tuel, P. Yiou, 2017: Revising return periods for record events in the climate event attribution context. *Journal of Climate,* doi:10.1175/JCLI-D-16-0752.1.

Sgubin, G., D. Swingedouw, **G. Dayon**, I.G. de Cortázar-Atauri, N. Ollat, C. Pagé and , C. van Leeuwen, 2018: The risk of tardive frost damage in French vineyards in a changing climate. *Agricultural and Forest Meteorology*, **250–251**, 226-242 doi:10.1016/j.agrformet.2017.12.253.

Snauffer, A., W. Hsieh, A. Cannon, and **M. Schnorbus**, 2017: Improving gridded snow water equivalent products in British Columbia, Canada: multi-source data fusion by neural network models. Published for discussion, *The Cryosphere*, doi:10.5194/tc-2017-56.

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