PACIFIC CLIMATE IMPACTS CONSORTIUM

2016-2017 | CORPORATE REPORT

REGIONAL CLIMATE SERVICES

The Pacific Climate Impacts Consortium is a leading regional climate services provider, providing data, analysis and interpretation to researchers, industry, policy-makers and planners in British Columbia and surrounding areas. PCIC provides services ranging from self-serve web-based tools and data delivery to performing applied science and developing reports directly with regional stakeholders. The web-based services that PCIC offers span a range of levels, from raw data to high-level overviews that allow users to select and acquire the data and analysis that best suits their needs. In many instances, the needs of PCIC's users will require undertaking applied research, in order to better understand a phenomenon or provide data and projections that were previously unavailable. PCIC also works directly with stakeholders to provide site-specific analysis and to translate and interpret the findings of current climate research. Working directly with stakeholders also allows PCIC to better understand the needs of its users and develop products tailored directly to them. Being a consortium, PCIC also leverages the knowledge and abilities of its partner organizations to research and develop products that will help to inform climate-related decision-making in BC.

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MESSAGE FROM PCIC'S CORPORATE LEADERSHIP

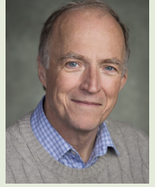
Welcome to this report on PCIC's activities in 2016-2017, which highlights many achievements in the Consortium's delivery of regional climate services. You will read about PCIC's re-engineered and improved VIC-GL Hydrologic Model, the delivery of climate change information for several new regions in British Columbia, engagement with the engineering community, improvements to the Provincial Climate Data Set, and updates to PCIC's online data portal and web-based tools. These, and many other new and ongoing projects, are helping the public and PCIC's stakeholders to assess the impacts of climate change and variability in their regions and account for climate in their planning.

PCIC works closely with its partners to ensure that the information and services they receive is practical and tailored to their needs. In turn, the outcomes of each partnership contribute to the growing body of PCIC's authoritative climate information and climate impacts assessments, and informs its applied climate research program. Every project, therefore, builds leverage and capacity for current and future partners. In this way, PCIC's partnerships are truly synergistic.

We wish to thank all our partners for their collaboration and support, and for their commitment to building stronger, more resilient organizations and communities in our changing climate.

Dr. David Castle
Chair, Board of Directors

Mr. Thomas White
Chair, Program Advisory Committee



Dr. Francis Zwiers
PCIC Director

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SERVICE DELIVERY HIGHLIGHTS

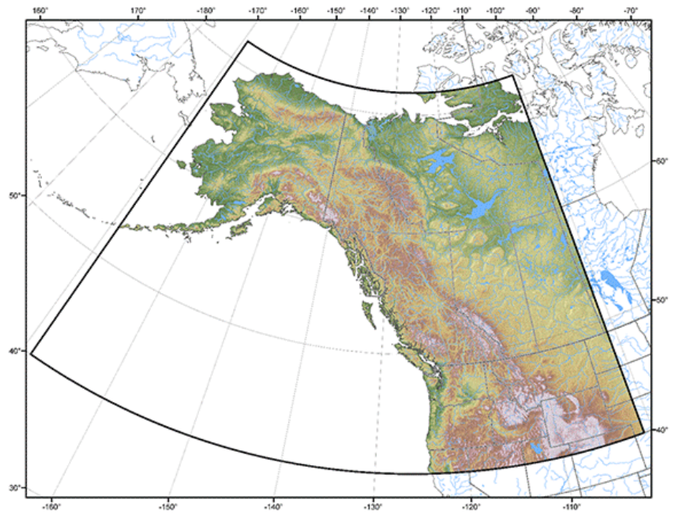
The Earth's changing climate will bring with it impacts that will be felt at the community level. Accordingly, community stakeholders in British Columbia have a need for credible, actionable information so that they can consider climate impacts in their planning. As a regional climate services provider, the Pacific Climate Impacts Consortium provides this information and where necessary, interpretation, to support planning in British Columbia. PCIC's services include modelling, downscaling, data provision, interpretation and applied research.

SERVICE DELIVERY HIGHLIGHTS

VIC-GL Hydrologic Model Ready for Use

Changes to a region's hydrology can have costly impacts, ranging from changes to drinking water availability to changes in flood intensity. Because of this, providing plausible projections of how a region's hydrology may react to climate change is important for regional planners. Working in collaboration with partners from BC Hydro, the University of British Columbia and the University of Northern British Columbia, PCIC has recently upgraded its version of the Variable Infiltration Capacity (VIC) model. These partners provided data, model code, review, financial support and guidance.

The resulting upgraded version of the VIC model, with the ability to model glacier processes, is known as VIC-GL. It has a resolution of one-sixteenth of a degree, which translates to between five-to-six kilometres, depending on the latitude. The updated model directly simulates the accumulation and evaporation of snow and ice and is coupled to a Regional Glaciation Model, developed at the University of British Columbia, that models the required glacier physics, simulating glacier dynamics and area changes. The development of VIC-GL benefited from updated elevation, land cover, soil and climate data as well as several new data sources, including evaporation and transpiration data, satellite snow cover measurements and glacier mass balance data. As an additional benefit, a new meteorological dataset was also developed, matching the resolution of VIC-GL, in order to allow the model to simulate the hydrology of northwestern North America. Taken together, these upgrades will allow the model to better capture the hydrology of parts of BC and surrounding areas (see above figure), which will in turn allow for better assessments of the effects of climate change on water resources and flooding in BC.

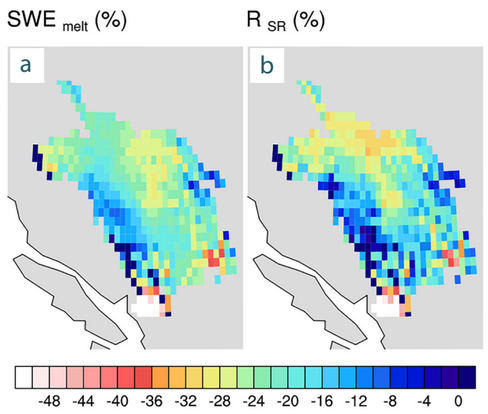


This figure shows the domain for the updated hydrologic model.

Fraser River Basin Climate Impacts

Taking up most of southern BC, at just under 230,000 square kilometres, the Fraser River Basin is home to most of the province's population and a number of ecosystems. Changes to streamflow in the Fraser could have impacts including changes in water availability, flooding, hydroelectric power generation and salmon stocks. PCIC recently participated in a collaborative effort with researchers from the University of Northern British Columbia to investigate how the changing climate might affect streamflow in the Fraser by the 2050s. They found that precipitation is, on average, projected to decrease in the summer, but increase in all of the other seasons. The amount of precipitation falling as snow is projected to be reduced by half and a third of the region's snowpack is projected to be lost, with earlier and weaker snowmelt. The reduced snowmelt and reduced contribution of snowmelt to runoff can be seen in the figure on the right. Taken together, this means more years with long dry summer seasons and reduced flows during the summer and autumn. This research has been published in *The Journal of Hydrometerology*.

Read the paper, here.



This figure shows the projected mean percent change of (a) snow melt, and (b) the contribution of snow melt, to annual runoff generation. The projections are for the 2050s as compared to the 1980-2009 base period, assuming business-as-usual greenhouse gas emissions.

SERVICE DELIVERY HIGHLIGHTS

Climate Change and BC's Energy Future

PCIC and BC Hydro have developed a long-standing partnership to determine how BC's water resources and electrical energy distribution system may be affected by climate change, and to assist BC Hydro in planning and decision making. One of the key achievements from this partnership over the past year was the completion of a substantially upgraded hydrologic model for BC and the surrounding region that explicitly includes glacier changes. The upgraded model is now being used with the guidance of BC Hydro to produce climate and hydrologic projections at specific project sites in the Fraser, Peace and Columbia river basins. This work has already produced inflow projections that are being used for water license renewal applications and energy planning for projects sites in the Bridge, Shuswap and Alouette Rivers. In addition, this year saw the initialization of a study of the impacts of storm activity on power outage occurrence, enabled by BC Hydro power outage data.

This photograph shows the Mica Dam on the Columbia River, in the study region. Photo: DAR56, Wikimedia Commons, Public Domain.

Engagement with the Engineering Community: An Important and Growing Facet of PCIC's Activities

Many engineering projects can be affected by the changing climate. In particular, two major concerns in BC are flooding and extreme precipitation events. To best develop projects with climate change in mind, engineers require credible climate data and projections, and guidance on their use. Engagement with engineers is important for regional climate service centres, so that climate researchers can better understand their needs and develop products that will be most useful to the engineering community. In addition, engineers may also benefit from direct engagement with climate scientists, to determine how best to understand, and make decisions in the face of, the uncertainties surrounding climate change.

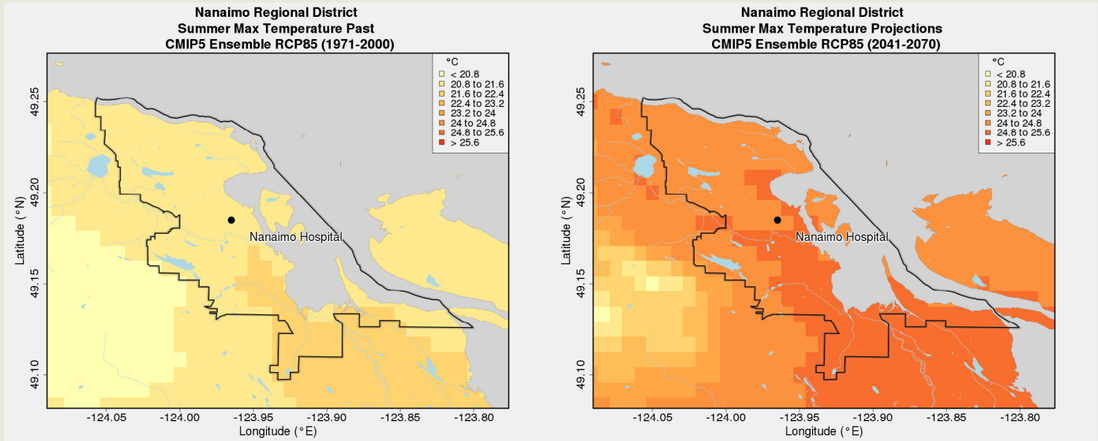
PCIC has been active in this area, creating tools, aiding in the development of guidance documents, providing data and interpretation, and participating in dialogues with the engineering community about approaches for including climate change in the planning of engineering projects.

SERVICE DELIVERY HIGHLIGHTS

Engineering Design Values for Island Health: Nanaimo Regional General Hospital

Located on the east coast of Vancouver Island, the Regional District of Nanaimo is home to over 150,000 people, spread between the cities of Nanaimo and Parksville, as well as several smaller communities. The Nanaimo Regional General Hospital, which serves the people of this region, is part of Island Health's network of facilities. Two construction projects are planned for the hospital, an expansion of its thermal plant and the addition of a new Intensive Care Unit.

Because climate change will affect the future conditions in the area (see figure, below) and because estimates for future climate-related building code parameters are not yet available, Island Health contacted PCIC for guidance and projections of the potential future climate of the region. PCIC provided the necessary parameters as well as projected climate extremes indices and return periods for extreme weather events. In addition, PCIC participated in a dialogue that highlights the fact that both expert opinion and interaction between building professionals and climate scientists are necessary in order to interpret the parameters and other data that PCIC provided.



This figure shows downscaled summer mean daytime high temperatures (the 30-year average of the June, July and August average daytime high temperatures) for the past (1971-2000, left panel) and 2050s (2041-2070, right panel) assuming a business-as-usual (RCP 8.5) greenhouse gas emissions trajectory.

Guidelines for Engineers and Geoscientists in British Columbia

Following from earlier work on the BC Ministry of Transportation and Infrastructure's (TRAN) Technical Circular, which requires that all future work for the Ministry must take climate change into consideration, PCIC has contributed to the development of guidance that was recently issued by Engineers and Geoscientists British Columbia (EGBC). The move toward requiring TRAN infrastructure projects to consider climate change arises because of the vulnerability of infrastructure to the impacts of climate extremes, especially those risks posed by flooding and extreme precipitation.

The new risk assessments must include consideration of the rough "screening-level" climate risk assessment, which considers a full range of climate values, to determine if any vulnerabilities in the project exist that would require a more in-depth assessment. If any are found, a more thorough climate change vulnerability risk assessment must be performed. Climate adaptation options are to be identified and incorporated. The whole process, along with decisions made, must be documented in a design report, a risk assessment assurance statement and a design criteria sheet. PCIC assisted by providing input on climate projections and their interpretation, and reviewing the document at several stages. This process will help guide engineers in their decision making so that future infrastructure will be more resilient in the face of BC's changing climate.

Read the guidelines on the EGBC website.

Read the Technical Circular on the Province of BC's website.

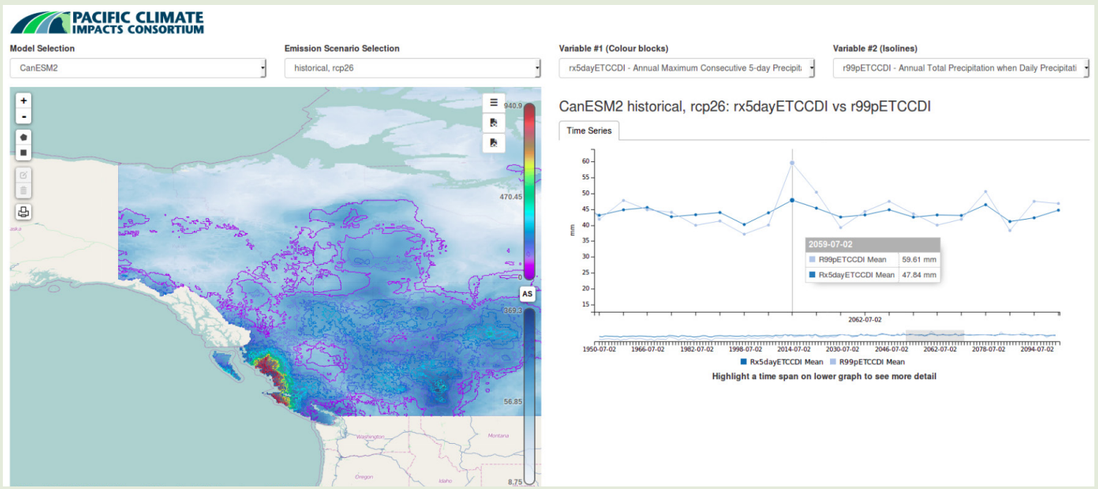
SERVICE DELIVERY HIGHLIGHTS

Climate Tool for Engineers

Enabling design work for climate adaptation requires tools that provide engineering-relevant information about future climate projections. TRAN is therefore partnering with PCIC to build new tools that provide such information to staff and consultants.

All of PCIC's web-based tools are built on the foundation of a strong data-processing pipeline and PCIC has invested substantial effort towards making these processes robust and repeatable. PCIC has created an organization-wide metadata standard for organizing and tracking its data, and has developed a flexible data-processing pipeline that summarizes all different types of climate model output into climatologies at various timescales. As of this writing, the new tool (see figure, below) has access to almost 8,000 different data files representing various models, scenarios, decades and variables. In addition to the back-end upgrades of increased downscaled data and processing capabilities, PCIC has upgraded its web-mapping software to be able to display isolines, such as elevation contours on maps, and has developed front-end capabilities to display dual-variable comparison maps, allowing for isolines to be displayed on top of climate rasters.

Future plans include developing an interface to provide web-based analysis and exploration of future stream flow regimes, so that climate change scenarios using PCIC's hydrologic model can be accessible to engineers, planners and the general public with a few clicks of a mouse.



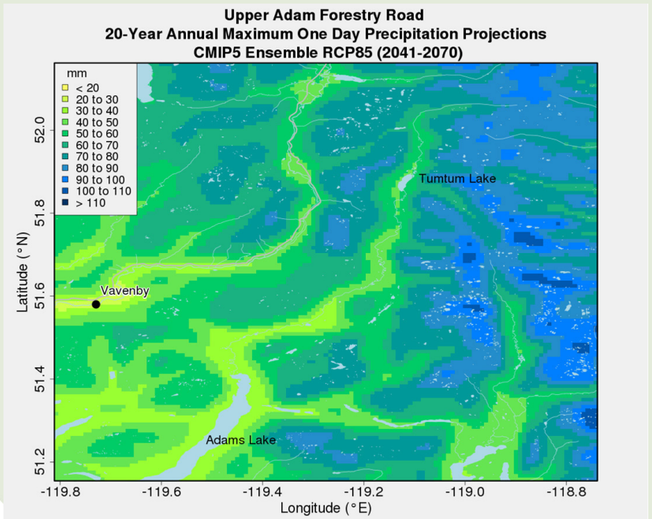
Above is a screenshot of the user interface of the climate tool for engineers that is currently in development. The figure shows two different variables, the monthly maximum consecutive 5-day precipitation (coloured shading in map and dark blue line in plot) and the annual sum of precipitation that falls on days so wet that they are above the 99th percentile of wettest days (isolines in map and light blue line in plot).

SERVICE DELIVERY HIGHLIGHTS

Climate Modelling for Forest Service Roads

Tumtum Lake is located in the Upper Adams River Valley, in the Thompson-Nicola Regional District. It is a popular fishing spot and is currently inaccessible from the north because flooding in the winter of 2014-2015 damaged the Tumtum Forest Service Road. To better understand what climate-related risks may be posed to this area in the future, the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) partnered with PCIC, the BC Ministry of Transportation and Infrastructure (TRAN), and FP Innovations to examine projections of future climate and hydrology for the region. Using observational data and downscaled output from an ensemble of global climate models, as well as gridded hydrologic model output, PCIC scientists determined some of the main projected changes to the region's climate. These include warming during all seasons, wetter winters, drier summers and increases in the frequency of heat and precipitation extremes. Such changes would mean a decrease in weather conditions that affect winter road conditions, such as freezing and thawing, and snowfall, but an increase in risk to drainage structures from increased snowmelt and rain storms, as well as increased fire risks. As can be seen in the figure below, there is a projected increase in the amount of rain falling in extreme rainfall events.

This project is part of a larger, ongoing series of assessments conducted by PCIC in partnership with FLNR, following from earlier work on transportation and infrastructure risk completed in 2014.



The figure shows a projection of 1-in-20-year one-day maximum precipitation in the region for the 2041-2070 period. For this forest road area, this is about a 25% increase from historical (1971-2000) values.

SERVICE DELIVERY HIGHLIGHTS

Collaborative Impacts Assessment Development

Over the past few years, PCIC has been using a new user-led approach to climate impacts assessments, in which the assessments are developed collaboratively. To accomplish this, PCIC provides information about climate projections and interpretation as directed by the user and participates in an ongoing dialogue about the climate change impacts as the report is developed.

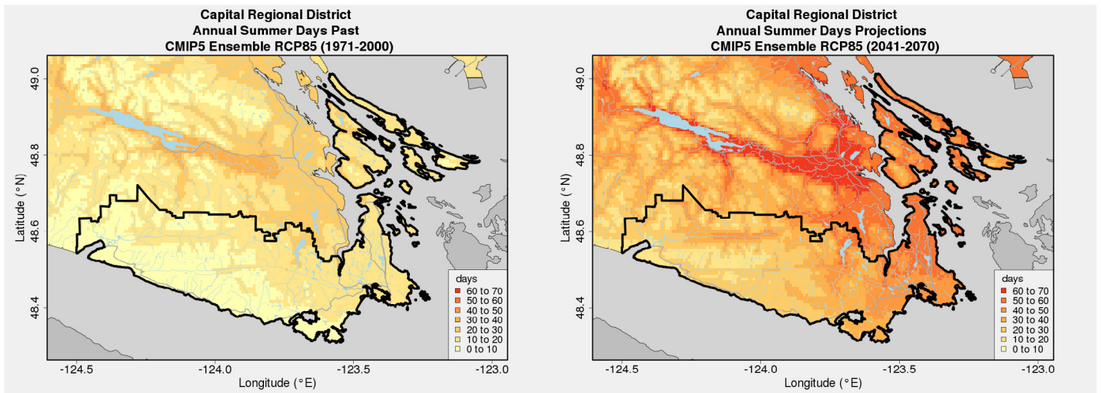
This is a marked departure from preparing detailed technical reports and summary reports directly for users and allows the assessments to be tailored to the individual needs of each set of users. This process increases the lines of communication between PCIC and stakeholders in the regions that PCIC serves, making PCIC services more accessible and helping to direct PCIC's research such that it will be most useful to these regions. The process also allows the end-users to actively consider the impacts of climate change on their operations and planning and to include the findings in reports that are tailored for their audiences, potentially facilitating more consideration of adaptation measures than the prior process.

In this fiscal year, the climate impact assessments for the Capital Regional District, the Cowichan Valley Regional District and the Salish Sea Transboundary Region were developed using this approach. These are discussed in the next three pages. PCIC is excited for the opportunity that this method of report development presents to strengthen ties with the users it serves and provide information that is most useful and relevant.

Capital Regional District

The Capital Regional District (CRD) is home to just under 390,000 people and spans the southern tip of Vancouver Island and the southern Gulf Islands, with an area of just over 2300 square kilometres. Driven by recognition of the need for a climate impacts assessment, the CRD has recently co-developed a report with contributions from PCIC and Pinna Sustainability that examines how climate change may affect the district by the 2050s, assuming a business-as-usual emissions scenario. The projections show a region that is warmer during all seasons, with warm, wet winters and hot, dry summers. Among the main findings of the report are an overall annual warming of the area, of three degrees Celsius. This warming leads to a tripling of the number of days above 25°C, a growing season that is about 20% longer, and over 70% fewer frost days each year compared to the recent past. Precipitation extremes are projected to become more intense and precipitation is projected to increase overall and during every season except summer, when rainfall is projected to decrease by about 20%.

Read the report on the CRD's website.

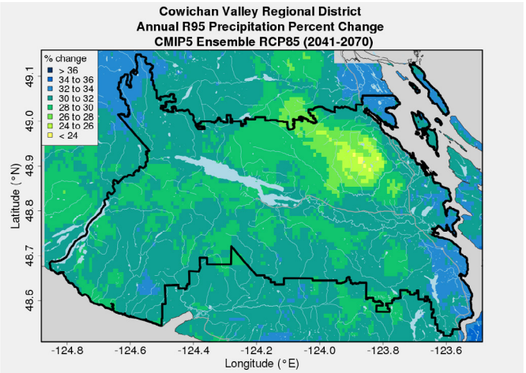


This figure shows the annual summer days (days with temperatures above 25 °C) for the historical period (1971-2000) and the 2050s (2041-2070) taken from an ensemble of global climate models following a business-as-usual emissions scenario. CRD is outlined in black.

SERVICE DELIVERY HIGHLIGHTS

Cowichan Valley Regional District

Growing from a community-driven process, the Cowichan Valley Regional District (CVRD) has co-developed a report with PCIC and Pinna Sustainability, using input from a variety of regional stakeholders. With a population of just over 80,000 people, the district stretches in a band across southern Vancouver Island, just north of the CRD, and includes three Gulf Islands. Echoing the findings of the CRD report, the CVRD is projected to experience an annual warming of three degrees Celsius in a business-as-usual emissions scenario, with warming during all seasons and increased precipitation during all seasons, save summer, which is projected to be drier on average. The warming is expected to bring a doubling of the number of days above 25°C, and a growing season that is almost 30% longer. The number of frost days each year is expected to decrease by over 60%. Extreme precipitation is projected to increase, as are dry spells in summer.



This figure shows the percent change in precipitation falling on those days with rain so intense that it is in the upper 5% of rainiest days, for the 2050s (2041-2070) compared historical period (1971-2000). The future projections are downscaled from an ensemble of global climate models following a business-as-usual emissions scenario. CVRD is outlined in black.

Comparing the CVRD and CRD reports highlights some of the differences for each region, many of which are only apparent in the high-resolution projections. Though these areas share similar geography, the impacts sections of the reports differ, in part due to each region's priorities. PCIC is excited for this opportunity to strengthen ties with the users it serves and provide users with tailored information that is relevant to their needs.

Read the report on the CVRD's website.

Salish Sea Transboundary Region

Stretching across almost 17,000 square kilometres, from the north end of the Strait of Georgia to the south end of Puget Sound, and encompassing the area from the mainland to where the Strait of Juan de Fuca meets the open ocean, the Salish Sea contains many vital marine and coastal ecosystems. Because of its importance to a large number of cities and coastal communities, and because it contains both US and Canadian waters, Environment and Climate Change Canada (ECCC) and the US Environmental Protection Agency signed a Joint Statement of Cooperation on the region in 2000. This led to the Salish Sea Transboundary Ecosystem Indicators project, which uses a suite of indicators as metrics for tracking the progress of sustainable management of the region. However, these indicators are themselves going to be affected by climate change.

This was the motivation for a recent study, commissioned by ECCC and prepared with the participation of PCIC, that examines what climate observations and projections are available for the region, as well as how these data and variables differ across the Canada-US border.

Above is a map of the Salish Sea transboundary region.

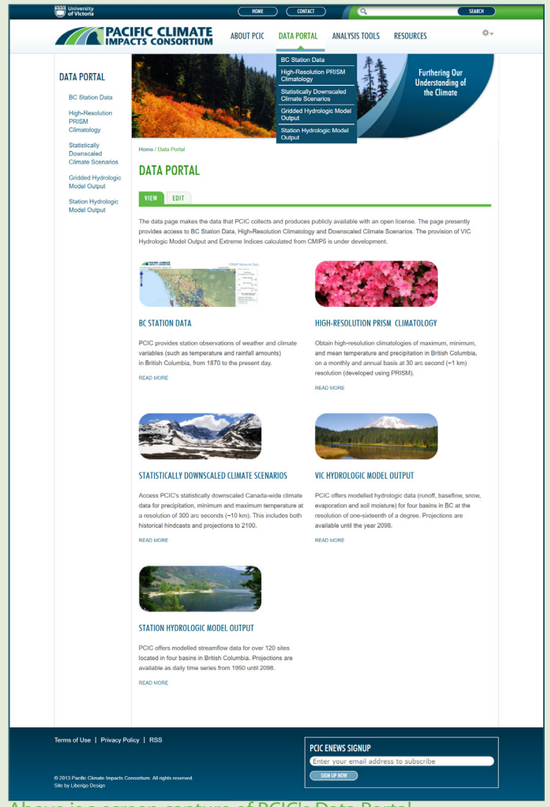
The report finds that the existing data sets are limited and that these data sets have important differences due to things such as weather station density, data processing and the instruments used for weather measurements. The future projections also differ due to the choices of climate models being used in each area. The study outlined several potential methods for dealing with the cross-border discrepancies, including using regional climate models driven by reanalysis to attempt to reconcile the disparities in climate baselines across the border. In the future, this work may help government agencies to better manage the region in the face of the changing climate.

SERVICE DELIVERY HIGHLIGHTS

PCIC's Data Portal: Updates and Ongoing Use

Both climate researchers and community planners have a need for easily accessible observational data and climate projections, the latter taking the form of output from climate models and hydrologic models. Providing this data and model output is one of the services that PCIC offers. Through its Data Portal (see figure on opposite page) PCIC provides station data, high-resolution PRISM climatologies, hydrologic model output and statistically downscaled output from global climate models, 24 hours a day, every day. This year PCIC served approximately 1,100 users through its data portal, serving up roughly 46 terabytes of data from more than 48,000 download requests. In addition to the updates to the Data Portal discussed below, PCIC added another roughly 30 million station observations to the Provincial Climate Data Set.

Keeping this service running smoothly and making sure that it is as useful as possible to PCIC's users is a priority of PCIC's Computational Support Group. While the Data Portal is constantly being updated as new observations and model output become available, and new tweaks are made to make it run a little more quickly, it has also seen some more substantial updates this year. These updates will make it more user friendly and easier to maintain in the future.



Above is a screen capture of PCIC's Data Portal.

On the front end, the Computational Support Group has added a "point" tool that allows users accessing PCIC's gridded data products to easily download data for a single grid box. In addition, an option has been added so that users may now download an entire time series with a single click. This is in addition to several minor bug fixes. On the back end, the updates have been more extensive and PCIC's team has added a new software suite for code testing and guides for development and deployment.

Visit PCIC's Data Portal to see the data products that it offers.

SERVICE DELIVERY HIGHLIGHTS

The Growing Provincial Climate Data Set

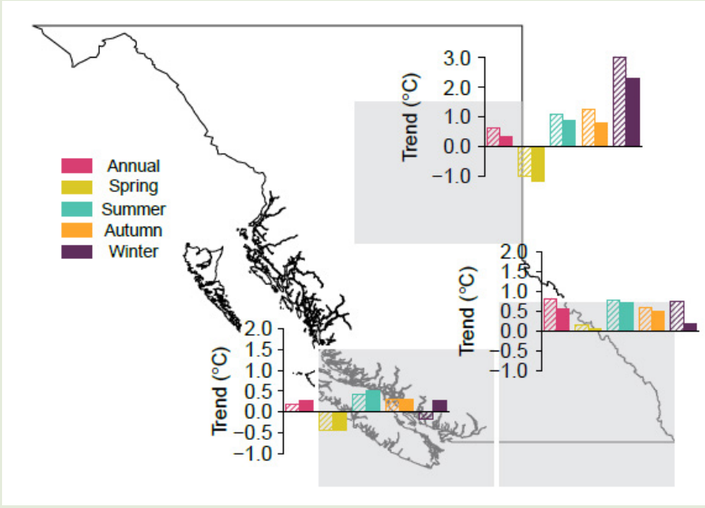
One of the major products that PCIC provides through its Data Portal is the Provincial Climate Data Set (PCDS). This data set provides users with observational data from weather stations in British Columbia. Environment and Climate Change Canada's (ECCC) observational network is relatively comprehensive over the regions of the province that are highly populated, but it is sparse in high elevations and remote regions. The data comprising the PCDS draws partially from ECCC's network, amounting to 87 million observations from 1900 locations. However, the majority of the data are from provincial ministries, and crown and private corporations. These add another 435 million observations from an additional 5300 observation sites, improving data coverage by adding hourly observations in many cases and data from sites in remote locations.

This year, PCIC maintained the ongoing incorporation of near real-time data from provincial, BC Hydro, and ECCC networks, and streamlined the process of computing station anomalies from the station climate normals completed for the PRISM 1981–2010 climate mapping project. The work of expanding the PCDS is supported by PCIC's involvement in the development of the second Climate Related Monitoring Program agreement between several BC ministries, BC Hydro, Rio Tinto and new partners in municipal and regional district weather monitoring networks. PCIC is participating in the effort, led by the BC Ministry of Environment and Climate Change Strategy, to renew the agreement and expand the number of contributing networks.

BC Station Data Quality Control and Homogenization

PCIC has been undertaking a data homogenization project aimed at ensuring that temperature and precipitation observations at stations in BC are suitable for climate analysis. This homogenization work includes making corrections for biases and errors that show up when stations are moved or equipment is changed. The first phase of this project was a proof-of-concept, supported by the BC Ministry of Environment and Climate Change Strategy, and aimed at testing homogenization approaches in northeastern BC and over Vancouver Island on monthly averages of daily minimum and maximum temperature. Work over the past year has been dedicated to the second phase, which is supported by ECCC and expands the spatial coverage of the project to the entire province and the time scale to daily measurements for temperature. It also includes the application of homogenization to monthly precipitation totals as well. This year PCIC completed the monthly homogenization and initial trials of daily homogenization on minimum and maximum temperatures.

The project has thus far resulted in an analysis of climatic trends calculated with the raw data and a set of homogenized results. This analysis allows PCIC's researchers to see how homogenization and error correction affects the trends in the observational data, so that PCIC can better understand how the climate of BC has changed over time. For example, one finding of this research is that the climate trends in the homogenized data are of similar sign to those in the raw observations, but typically smaller in magnitude or of reduced statistical significance. This can be seen in the northeastern part of the province in the figure below, which shows the effects of homogenization on the seasonal trends over three BC regions. Overall, this work will help to provide greater utility from the data that PCIC delivers though its Data Portal and a better understanding of historical climate change in BC.



This figure shows the 1990-2015 trend (°C over the 26-year period) for daily minimum temperature by season for raw and homogenized data over three regions in BC as indicated by gray shading. The results using raw data are represented by the striped bars and the results using homogenized data are shown as solid bars.

Understanding User Engagement with PCIC's Tools

One of the primary methods by which PCIC serves regional stakeholders is through the use of online tools. These tools include Data Portal pages that serve up observational data and model output, and the three tools available from the Analysis Tools section of PCIC's site (see figure on right). The first of these is Plan2Adapt, which provides high-level overviews of projected changes to climate, with maps, plots, data and some analysis of potential impacts. The second is the Regional Analysis Tool, which is similar to Plan2Adapt, but with more configurable options. The third tool is a set of Seasonal Maps, which show how the conditions of each season vary from the 30-year climatological average.

PCIC recently conducted an online survey of the users of its tools, which was distributed widely by several partner organizations. The resulting data was analyzed in order to determine how well its tools are meeting its users' needs, with a special emphasis on the engineering community. Tracking those needs and how online tools are used in their current implementation helps PCIC to further refine its services, develop new products, and ensure that its users get the data and analyses that they need in the most convenient and effective manner possible.

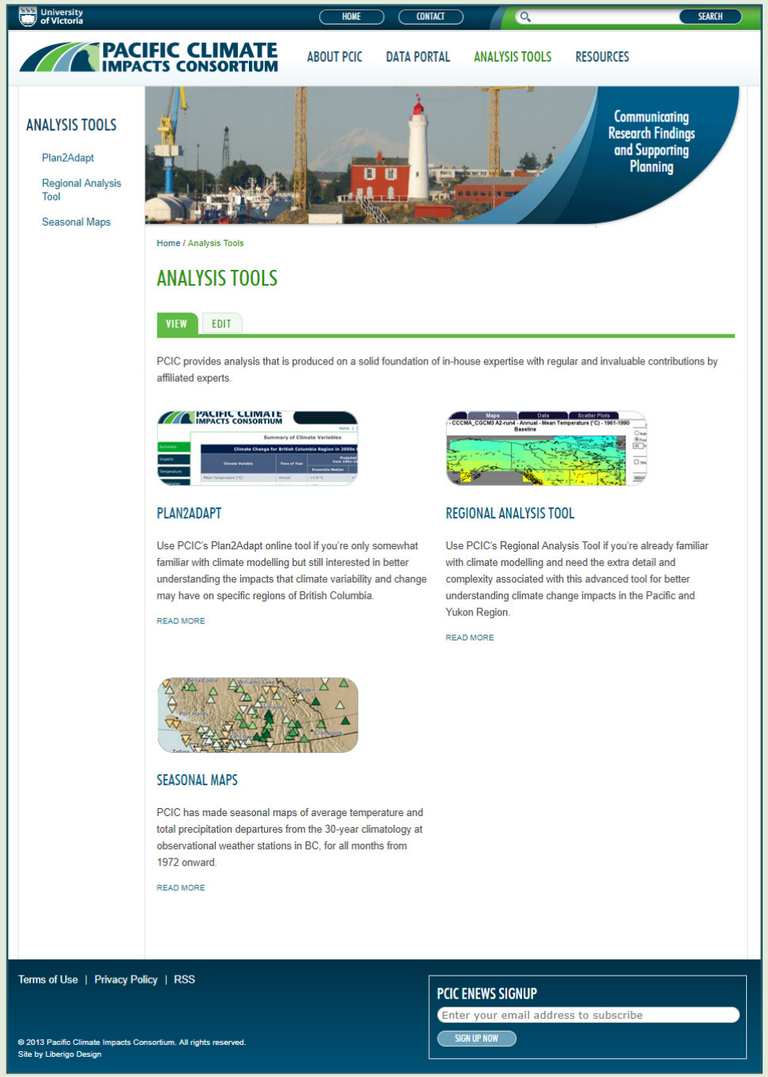
See a PowerPoint presentation summarizing some of the key findings in PCIC's Publication Library, here.

ClimDown Downscaling Package Released

PCIC recently released a software package that implements a statistical downscaling method that was developed in-house. This package, called ClimDown, uses an updated version of the downscaling method called Bias Correction/Constructed Analogues with Quantile mapping reordering, that is highly computationally efficient and corrects for the tendency of many statistical downscaling methods to project changes in extremes that are too large. Downscaling methods such as these are used to help with planning and research at the scale of the communities. The release of ClimDown and other tools like it that are developed as an ongoing part of PCIC's projects reflect PCIC's commitment to sharing its knowledge and methods with the broader research and user community.

To access or learn more about ClimDown and the other software that PCIC offers, visit its software library.

SERVICE DELIVERY HIGHLIGHTS



Above is a screen capture of PCIC's Analysis Tools landing page.

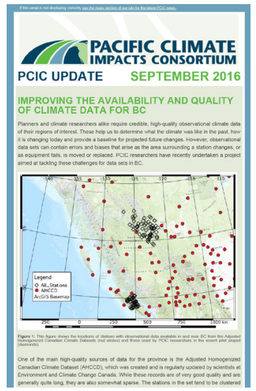
COMMUNICATING CLIMATE SCIENCE

Scientific findings need to be communicated at different levels of technical detail for different audiences. Products such as data, peer-reviewed research and technical reports are useful for those engaged in climate research, engineering and technical consulting. Other products, such as high-level summaries and presentations are also needed to provide an overview for policy development and community planning. To meet these needs, PCIC provides a variety of materials to communicate our findings, work and the current state of knowledge in the fields that we work in, from data and peer-reviewed research to high-level overviews.

Science Briefs and Newsletters

PCIC's Science Briefs are contextualized, plain language summaries of current research that are chosen for their relevance to PCIC's regional stakeholders. This year PCIC released three Science Briefs covering the following topics: the computer modelling of storm surge events in the Strait of Georgia, possible changes to atmospheric river events in coastal BC, the effect that the tropical Pacific Ocean may have had on winter temperatures over the early 2000s and the attribution of greening on land in the northern extratropics to human influence.

Through its newsletter, PCIC Update, PCIC provides commentary on recent climate-related developments in the news and shares recent happenings at PCIC with its users. This year PCIC released three newsletters. These have included commentary on the winter of 2016-2017, PCIC's data homogenization work, progress on hydrologic modelling on the Fraser, the National Academy of Science's report on extreme weather, and write-ups on several papers released by PCIC researchers as well as conferences that PCIC scientists have attended.


PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE SEPTEMBER 2016

IMPROVING THE AVAILABILITY AND QUALITY OF CLIMATE DATA FOR BC

Planners and climate researchers alike require credible, high-quality observational climate data of their regions of interest. These help us to determine what the climate was like in the past, how it is changing today and provide a baseline for projected future changes. However, observational data sets can contain errors and biases that arise as the area surrounding a station changes, or as equipment fails, is moved or replaced. PCIC researchers have recently undertaken a project aimed at tackling these challenges for data sets in BC.

Figure 1: This figure shows the locations of stations with observational data available in and near BC from the Adjusted Homogenized Canadian Climate Datasets (mid-century and those used by PCIC researchers in the recent pilot project (thermometer).

One of the main high-quality sources of data for the province is the Adjusted Homogenized Canadian Climate Dataset (AHCCD), which was created and is regularly updated by scientists at Environment and Climate Change Canada. While these records are of very good quality and are generally quite long, they are also somewhat sparse. The stations in the set tend to be clustered


PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC SCIENCE BRIEF: HUMAN-INDUCED GREENING OF THE NORTHERN EXTRATROPICAL LAND SURFACE

Figure 1: 1981-2011 Leaf Area Index trends, from Mao et al. (2016).

Recent research by Mao et al. (2016) published in Nature Climate Change finds that the observed greening of the land surface between 30-75° north over the 1982-2011 period is largely due to anthropogenic greenhouse gas emissions.

Satellite records that extend back to the early 1980s show an overall, long-term greening trend' over the Earth's surface'. This global trend in increased leaf coverage has been attributed to a number of factors. The most important of these is the increasing concentration of carbon dioxide in the atmosphere, which plants use for photosynthesis and growth. Another factor is the natural addition/uptake of nutrients required for growth, as deposited into ecosystems.

Still others include the direct effects of climate change and changes in how land is used and managed, such as for forestry and agriculture. The greening is apparent on a global average, but is not uniform, with some areas, such as parts of northwestern North America and South America showing the opposite trend. Changes in forest vegetation due to climate change can affect the climate system and resulting changes to ecosystem services. They can also affect climate" through changes in the amount of evaporation and transpiration, reflected sunlight or ecosystem carbon dioxide uptake or release. Changes to forest cover may also be related to climate change elsewhere through long-distance "teleconnection" patterns".

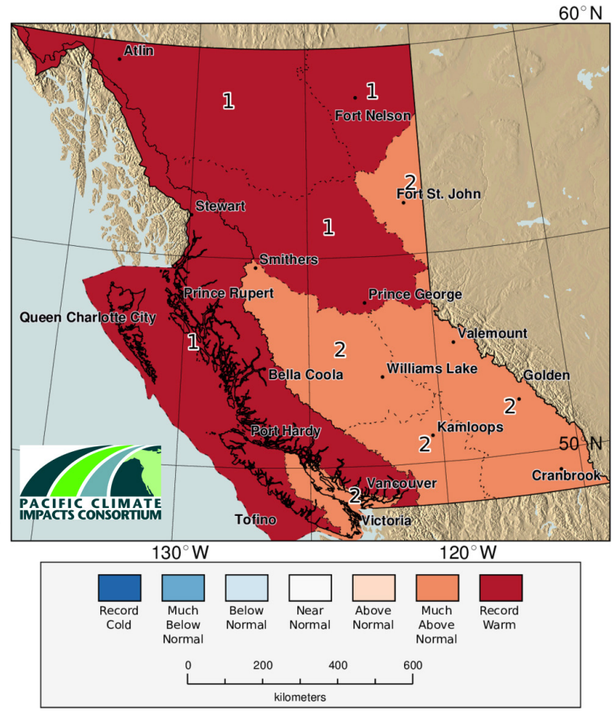
Examples of a PCIC Update newsletter (left) and Science Brief (right) published this year.

COMMUNICATING CLIMATE SCIENCE

PCIC Statement on the Climate of 2016: Another Record Warm Year

To help PCIC's users better understand the changing climate, and place new weather records and extreme weather events into their climatic context, a part of PCIC's communications efforts are focused on plain language discussions of recent events. So, when global temperature records were broken once again, with 2016 being the hottest year in the instrumental records of both the National Aeronautics and Space Administration and National Oceanic and Atmospheric Administration, PCIC scientists released a short article on the topic in its January 2017 newsletter. In brief, the article explained that the causes were a mix of anthropogenic influences and a strong El Niño. The article also discussed how 2016 was a record warm year for the province of BC, largely due to the extremely warm daily minimum temperatures throughout the year. This can be seen in the figure on the right.

Read the newsletter from PCIC's online Publications Library.



This figure shows the 2016 annual mean regional average temperature anomalies for daily minimum temperature within BC's ecoprovinces (dashed lines). Colours indicate whether the averages are near normal, above or below normal, much above or below normal or record setting. Numbers printed within each ecoprovince indicate the rank of the current year within the available 117 year historical record from record warmest (1) to record coldest (117). The dark red colours indicate extremes. In comparison, average daily maximum temperatures were near normal across most of BC.

COMMUNICATING CLIMATE SCIENCE

Participation in the Peer-Reviewed Literature

In order to share their findings with other researchers, stay at the cutting edge of their fields and ensure that their methods are subjected to rigorous review, PCIC researchers actively publish in the peer-reviewed literature. This work benefits all of the parties involved, as researchers can work together across institutions and nations to push back the boundaries of human knowledge, refine each other's methods and models, and constantly learn from each other's efforts. This process then benefits PCIC's users directly, as PCIC's team can leverage the research community's ever-increasing knowledge base on the climate system, and provide better tools and data to the stakeholders PCIC serves. A full list of this year's publications is available at the end of this report.

Links to PCIC's peer-reviewed publications are available from PCIC's online Publications Library.

Presentations Delivered by PCIC's Team

PCIC scientists present their research at a number of large and small conferences each year. This allows staff to discuss current avenues of research, network, hear about major new developments in the field, have their research critiqued and share what they have found with their peers. PCIC's staff are also invited as speakers, to share their particular expertise on various aspects of the climate system with the research community. This year, PCIC presented at the International Meeting on Statistical Climatology, the American Geophysical Union's Fall Meeting, the Northwest Climate Conference, the Free and Open Source Software for Geospatial conference, Pycon, the National Conference of the Canadian Water Resources Association, and the Joint Annual Meeting of the Canadian Meteorological and Oceanographic Society and the Canadian Geophysical Union.

View selected presentations from PCIC's online Publications Library.

OUTREACH

PCIC scientists are often called upon to share their expertise and findings with planners, fellow researchers and the general public. PCIC's presentations are delivered at a level suited to each audience's needs and are of use for planning and furthering climate research. In cooperation with the Pacific Institute for Climate Solutions, PCIC also helps to facilitate the sharing of knowledge and findings by visiting researchers through the Pacific Climate Seminar Series. Some of the highlights from this year's events are presented as follows.

PCIC Director Presents Wildland Fire Canada Keynote Address

Every two years, scientists and planners in forest management meet to network, share and keep up to date on recent research, and discuss best practices at the Wildland Fire Canada Conference. This past year, the conference was held in Kelowna and PCIC Director Francis Zwiers was invited to deliver a keynote lecture, sharing his knowledge on the science of extreme event attribution. Because wildfire risk is tied to extreme climate events, whenever a large wildfire breaks out, some of the questions that arise are, "Was this fire caused by climate change?" and, "Was this fire more likely to occur because of climate change?" Dr. Zwiers discussed the types of answers that climate science can provide.

In his talk, *The Emerging Science of Attributing Causes to Extreme Events*, he gave an overview of the current state of the art in detection and attribution analysis for extreme climate events. He discussed how such events are relevant to wildfires, including work conducted at PCIC on the Fort McMurray wildfire of 2016. Dr. Zwiers also explained how the type of question that is asked can affect the answer given by a detection and attribution analysis. Different definitions for events and different focus points for research—for example, focusing on the intensity of events as opposed to their frequency—can result in quite different answers in terms of the extent to which events can be attributed to human influence. While in Kelowna for the conference, Dr. Zwiers also presented a public talk on the same subject.

Dr. Zwiers's talk is available from PCIC's Publication Library, here.

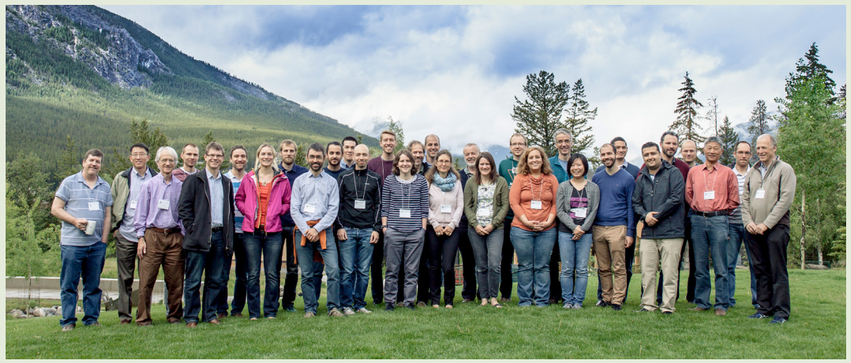
13th International Meeting on Statistical Climatology and Banff International Research Station Workshop on Extremes

In June of 2016, researchers from across the world came to the 13th International Meeting on Statistical Climatology (IMSC) held in Canmore, Alberta, and the Uncertainty Modelling in the Analysis of Weather, Climate and Hydrological Extremes workshop at the Banff International Research Station for Mathematical Innovation and Discovery (BIRS). These events were opportunities for statisticians and scientists studying the Earth's climate to meet and share findings, best practices and develop new directions in research.

The IMSC is a series of meetings that has been bringing together Earth scientists and statisticians to improve statistical practice in climate science and atmospheric science since 1979. PCIC lent its services to organize this most recent IMSC, built the conference's website and put together the schedule of oral and poster presentations. In addition, PCIC Director Francis Zwiers delivered the Chair's invited address, titled, "Our shared responsibility as users of statistics and consumers of results from its application in the climate sciences." This was followed by the workshop at nearby BIRS, for which Dr. Zwiers was a co-organizer. This conference explored topics such as how to work with the statistics of climate and hydrologic extremes as the climate continues to change, and how to develop models of extremes that handle weather extremes that are highly dependent on the areas in which they occur.

To visit the 13th IMSC's website, click here. For the schedule of oral and poster presentations, click here.

To find out more about the BIRS Workshop, click here.



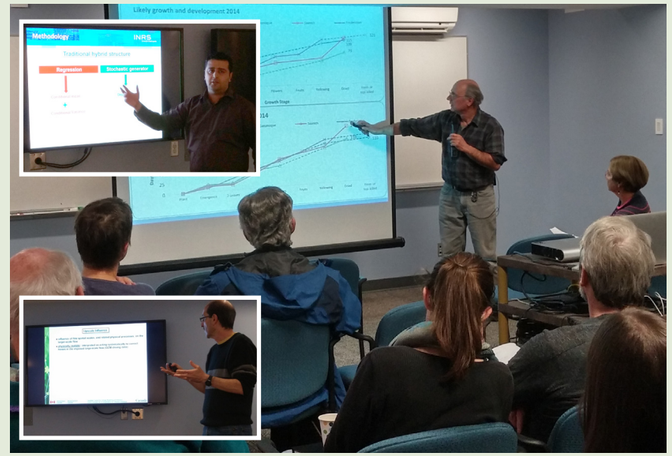
Above are the attendees of the Modelling in the Analysis of Weather, Climate and Hydrological Extremes workshop at BIRS, with Dr. Zwiers on the far right.

OUTREACH

The Pacific Climate Seminar Series

PCIC and its sister institute, the Pacific Institute for Climate Solutions (PICS), have a large, extended network that runs throughout multiple research communities, from the disciplines that make up climate science, to engineering and policy. In an effort to share the knowledge of these communities with each other and the general public, PCIC and PICS team up each year for the Pacific Climate Seminar Series.

This year, the seminar series included lectures from UVic's Dr. Iman Moazzen, PCIC's Dr. Charles Curry and Susanne Moser of the Woods Institute for the Environment at Stanford University. Starting in September Dr. Rod Davis from UVic's School of Environmental Studies delivered a lecture, which was followed by talks from PCIC's Dr. Mohamed Ali Ben Alaya, the Royal British Columbia Museum's Dr. Richard J. Hebda, Dr. Werner A. Kurz of the Canadian Forest Service, Dr. Kristie Ebi from the Center for Health and the Global Environment at the University of Washington, and Dr. John Scinocca from the Canadian Centre for Climate Modelling and Analysis. The topics included the potential contribution of BC's forest sector to climate mitigation, coordinated global and regional climate modelling, statistical downscaling, ecosystem resilience and the health risks that accompany climate change.



Above are some photographs taken at the talks delivered as a part of this year's Pacific Climate Seminar Series. The main panel is from Dr. Hebda's talk and the insets are from Dr. Ben Alaya's talk (upper) and Dr. Scinocca's talk (lower).

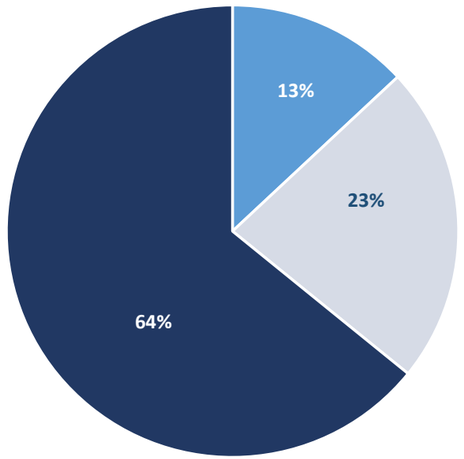
PCIC OPERATIONS AND FINANCE

PCIC OPERATIONS & FINANCE

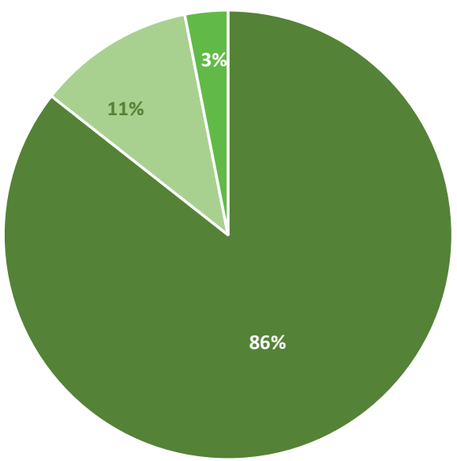
Operational Statement

PCIC has continued to maintain its financial stability by maximizing leveraging opportunities and managing expenses to match resources. PCIC obtains revenue from three primary sources: an endowment that was placed at UVic by the BC Government in 2008, long-term agreements with key partners, and short-term contracts with users who have specific requirements. Users and stakeholders provided 36% of 2016-2017 revenue; however, this value is much greater if one takes into account in-kind contributions and direct leverage with the endowment. Investment in our talented team, comprised of 16 staff, one PCIC-supported graduate student, one co-op student and five externally supported postdocs and students, remained stable at 86% of our budget. As a not-for-profit corporation, PCIC carefully manages its expenditures to stay within its funding envelope.

2016-2017 REVENUE



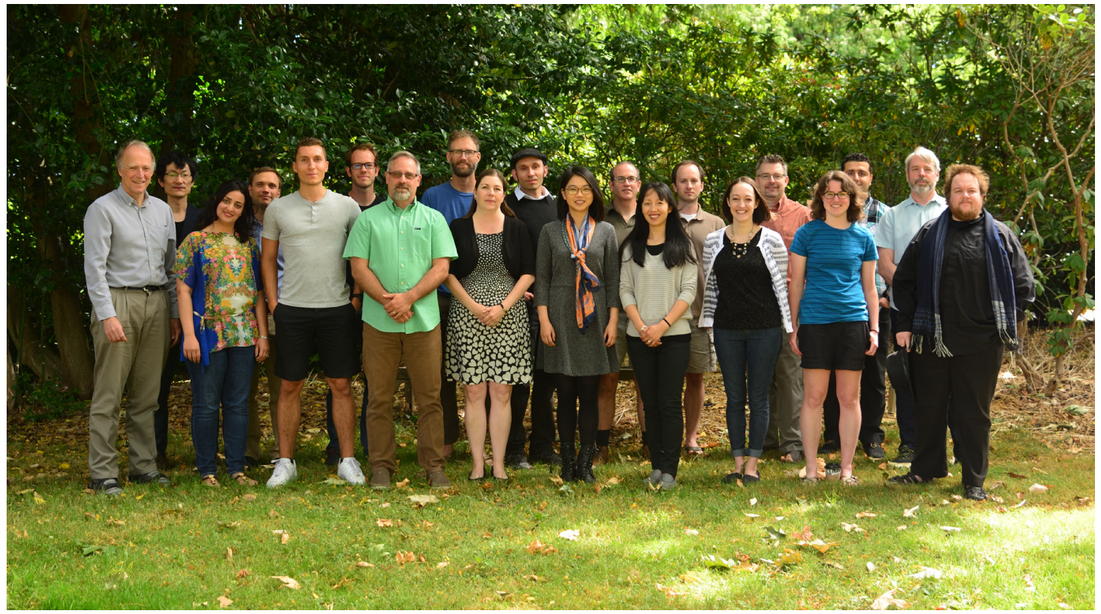
2016-2017 EXPENSES



PCIC OPERATIONS & FINANCE

PCIC Staff

PCIC maintains its position as a leading provider of regional climate services through its investment in a talented team with wide-ranging skill sets. Grouped around PCIC's core research themes as well as operations and computational support, this small team efficiently leverages and distills a huge volume of scientific knowledge in the service of regional stakeholders in British Columbia.



PCIC staff and seven affiliates, left to right: Francis Zwiers, Chao Li, Dhouha Ouali, Christian Seiler, Anthony Constantin, Gildas Dayon, Markus Schnorbus, Faron Anslow, Kathy Veldhoen, Michael Shumlich, Yaqiong Wang, Charles Curry, Shelley Ma, Stephen Sobie, Megan Kirchmeier-Young, Trevor Murdock, Katherine Pingree-Shippee, Mohamed Ali Ben Alaya, Rod Glover and Lee Zeman. Not pictured: Arelia (Werner) Schoeneberg, Matthew Benstead and James Hiebert.

PARTNERS

PARTNERS

PCIC Partners

BC Hydro
BC Ministry of Agriculture
BC Ministry of Health
BC Ministry of Municipal Affairs and Housing
BC Agriculture and Food Climate Action Initiative
BC Agricultural Research & Development Corporation
BC Ministry of Environment and Climate Change Strategy
BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
BC Ministry of Transportation and Infrastructure
Bonneville Power Administration
Capital Regional District
Canadian Centre for Climate Modelling and Analysis
Canadian Network for Regional Climate and Weather Processes
Canadian Sea Ice and Snow Evolution Network
City of North Vancouver
City of Vancouver
Columbia Basin Trust
Cowichan Valley Regional District
Compute Canada
Engineers and Geoscientists BC
Engineers Canada
Environment and Climate Change Canada
Fraser Basin Council
Great Northern Landscape Conservation Council
Island Health
Metro Vancouver
Marine Environmental Observation Prediction and Response Network
National Research Council Canada
Natural Resources Canada
North Pacific Landscape Conservation Council
Okanagan Basin Water Board
Oregon State University, PRISM Climate Group
Ouranos Inc.
Pacific Institute for Climate Solutions
Resort Municipality of Whistler
Rio Tinto Inc.
Simon Fraser University
Université du Québec à Montréal
University of British Columbia
University of Northern British Columbia
University of Saskatchewan
University of Washington, Climate Impacts Group
University of Victoria
World Climate Research Programme

PUBLICATIONS

PUBLICATIONS

PCIC Publications

Murdock, T.Q., **S. R. Sobie**, H. D. Eckstrand and E. Jackson, 2016: *Georgia Basin: Projected Climate Change, Extremes, and Historical Analysis*. The Pacific Climate Impacts Consortium, 69 pp.

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The Pacific Climate Impacts Consortium, 2016: *PCIC Update, September 2016*. The Pacific Climate Impacts Consortium, 3 pp.

The Pacific Climate Impacts Consortium, 2017: *Science Brief: Human-Induced Greening of the Northern Extratropical Land Surface*. The Pacific Climate Impacts Consortium, 3 pp.

The Pacific Climate Impacts Consortium, 2016: *Science Brief: Storm Surges and Projected Changes to Atmospheric River Events in Coastal BC*. The Pacific Climate Impacts Consortium, 5 pp.

The Pacific Climate Impacts Consortium, 2016: *Science Brief: Tropical Pacific Impacts on Cooling North American Winters*. The Pacific Climate Impacts Consortium, 3 pp.

Co-Produced Publications & Reports

The Capital Regional District, **The Pacific Climate Impacts Consortium** and Pinna Sustainability, 2017: *Climate Projections for the Capital Region*. The Capital Regional District, 66 pp.

The Cowichan Valley Regional District and **The Pacific Climate Impacts Consortium**, 2017: *Climate Projections for the Cowichan Valley Regional District*. The Cowichan Valley Regional District, 52 pp.

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Pouliotte, J. and **T. Murdock**, 2017: *Historical and Projected Climate Trends in the Georgia Basin. Project report for Environment and Climate Change Canada*. The Pacific Climate Impacts Consortium, 29 pp.

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Gagné, M.-È., **M.C. Kirchmeier-Young**, N.P. Gillett and J.C. Fyfe. 2016: Arctic sea ice response to the eruptions of Agung, El Chicón and Pinatubo. *Geophysical Research Letters,* **122**, 15, 8071–8078, doi:10.1002/2017JD027038.

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