PACIFIC CLIMATE IMPACTS CONSORTIUM

2012-2013
CORPORATE REPORT

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PCIC CORPORATE REPORT 2012-2013

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MESSAGE FROM THE CHAIR BOARD OF DIRECTORS
DR. HOWARD BRUNT

It is hard to believe that it is already time for PCIC's fifth annual corporate report, especially given the extraordinary progress it has made toward meeting the organization's core mission and objectives.

PCIC continues to carefully produce scientifically robust, user-driven applied research results and this remains the primary motivation. Over the past year, and building on an already strong foundation of stakeholder involvement, PCIC increased its emphasis on user engagement. I am very pleased with this evolution and find it worth highlighting here.

PCIC's President and CEO, Dr. Francis Zwiers, has developed PCIC into a well-respected regional climate service provider. He has approached PCIC's development in a very methodical way, beginning with a focus on developing a clear scientific program with a well-defined scope. The scientific productivity at PCIC ballooned, with PCIC staff publishing in well-respected academic journals, presenting at national and international conferences, and external research projects to support the productivity of scientific results. Because of this robust scientific foundation of high-quality productivity, PCIC is able to increase its emphasis on user engagement and to attract new partners and clients.

PCIC, already strongly motivated by its users' concerns, has begun to think creatively about how best to communicate the complex results of its applied research programme to users. This emphasis on knowledge mobilization is critical to ensuring that the results of PCIC's work are applied to meet the challenges of global and regional climate change. PCIC is addressing this challenge on two fronts; first, by putting more effort towards ensuring their results are easy to understand by publishing plain language reports; second, through its commitment to the continued development of online web tools that support the dissemination of climate information.

When the Board of Directors discussed PCIC's workplan for 2013-2014, we were delighted to see that user-engagement remains central to PCIC's future plans as it has been throughout PCIC's history. Users can expect to see PCIC doing even more to make its research products accessible to users in industry, academia, government and the general public. Look for more user-friendly publications, seminars, and workshops in each of the three main PCIC pillars. In addition to the contributions PCIC will make through these approaches, the Board is also proud of Dr. Zwiers's leadership in the production of the next IPCC report which will be rolling out over the coming months.

Howard Brunt
Chair, PCIC Board of Directors
Vice-President Research, University of Victoria

Board of Directors March 2013

Howard Brunt (Chair), University of Victoria
Renata Kurschner (Vice Chair), BC Hydro
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Francis Zwiers (Director, President and CEO), Pacific Climate Impacts Consortium
Cassbreea Dewis (Treasurer), Pacific Climate Impacts Consortium
Jamie Millin (Secretary), University of Victoria

MESSAGE FROM THE CHAIR PROGRAM ADVISORY COMMITTEE
THOMAS WHITE

It is with great satisfaction that I help introduce the Pacific Climate Impacts Consortium's (PCIC) fifth annual corporate report. PCIC has defined itself over the past five years as a reliable climate service resource for users in the BC and Yukon Region of Canada.

As the Chair of the PCIC Program Advisory Committee (PAC), I have had the pleasure of witnessing the many ways in which PCIC is committed to providing users with valuable climate information that is utilitarian and easy to access. In particular this year has seen the release of some new and exciting tools.

In October 2012, PCIC launched The Provincial Climate Data Set (PCDS) Portal. The PCDS Portal contains observations of weather and climate variables for all of BC and serves them up via an easy to use web interface. This tool is the culmination of a ground-breaking inter-agency agreement signed by BC ministries, BC Hydro, Rio Tinto Alcan and PCIC.

Other new tools include the Seasonal Climate Maps tool which provides users with static maps showing seasonal temperature and precipitation departures from normal or expected weather conditions throughout BC. PCIC will, over time, extend this work and develop a dynamic mapping tool. I am also looking forward to the release next year of a new data portal that will provide access to new historical climate maps, downscaled climate model data and hydrologic projection data.

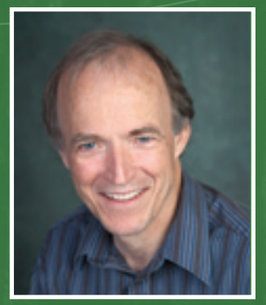
As you read through the remainder of the report, I also encourage you to take note of the contributions that PCIC has made to the climate science community. I am proud to enter another year as the PCIC PAC Chair.

Thomas White
Chair, PCIC Program Advisory Committee
Manager of Science and Adaptation, Climate Action Secretariat, BC Ministry of Environment

Program Advisory Committee March 2013

Thomas White (Chair), BC Ministry of Environment
Daniel Caya, Ouranos
Greg Flato, Environment Canada
Brenda Goehring, BC Hydro
Dirk Nyland, BC Ministry of Transportation and Infrastructure
Stephanie Smith, BC Hydro
Dave Spittlehouse, BC Ministry of Forests, Lands and Natural Resource Operations
Lawrence Pitt, Pacific Institute for Climate Solutions

MESSAGE FROM THE PCIC DIRECTOR
DR. FRANCIS ZWIERS



This has been an extremely satisfying year for PCIC. As you will see from this report, we have not only developed new capabilities and delivered new products and services, but have also contributed significantly to the body of scientific knowledge that is focused directly on PCIC's areas of expertise.

PCIC staff have been able to publish many of the innovations that support, and result from, the products, services and information they develop. This publication record is a strong indicator of the quality and the depth of expertise at PCIC.

Further strength will be developed in the coming year as our participation in the "MEOPAR" Network of Centres of Excellence and two NSERC Climate Change and Atmospheric Research (CCAR) networks begins to come into full swing. Our involvement in these networks involves as many as six young scientists (PhD students, postdoctoral fellows and a research associate) participating in regionally-relevant research on extremes, change in the cryosphere, and related hydrologic impacts. These young people, together with a steady stream of interns and co-op students, are helping to increase the vibrant atmosphere at PCIC.

PCIC has harnessed this energy and it is being turned into a plethora of additional new products. These include substantial new data offerings, newly downscaled climate change projections based on global climate simulations produced internationally for the IPCC AR5, data portal upgrades to deliver these new products, improvements to our hydrological model that will allow more reliable projections of changes in stream flow in glaciated basins, and much more. All of this activity is directed towards serving our users and partners, and to ensuring that it is well oriented and meets their needs. We are also taking time over the current year to consult with users in each of our three theme areas. I hope that with these few brief words I've been able to convey to you the excitement, energy, commitment and determination that we feel at PCIC in our quest to serve our users and the people of BC.

Francis Zwiers
Director, Pacific Climate Impacts Consortium

REGIONAL CLIMATE SERVICES

PCIC provides high-quality climate data, analysis and interpretation to stakeholders in the Pacific-Yukon Region of Canada. The easy to access data, tools, reports and peer-reviewed research that we develop help these stakeholders better adapt to the changing climate.

PROVIDING DATA
REGIONAL CLIMATE SERVICES

Weather and climate data is the foundation of regional climate science. At PCIC we both collect and generate data. Our scientists and computer programmers work together to continuously release these data in multiple formats via our website. Users are able to select regions of interest, select subsets of the data and download it in one of several different formats.

OUR DATA LIBRARY IS GROWING

Station data—observational data updated at near real-time and going back more than 140 years for more than 6000 stations. The data collection, known as the Provincial Climate Data Set, includes data from several BC Ministries, BC Hydro, and Rio Tinto Alcan, and comprises a comprehensive data set of weather and climate observations for BC unlike any other in Canada. The data set also includes metadata, including station locations, the parent agency and other related information.

Baseline climate information—high-resolution maps, currently in development, will provide baseline climate information at the neighbourhood scale. Using the PRISM (see p.7) modelling technology, we have developed a beta set of high-resolution climate maps for peer review in anticipation of the public release. An example is illustrated in the figure.

Indices of climate extremes—a set of the CLIMDEX indices computed using climdex.pcic software on 300 runs of climate model output from the fifth phase of the Coupled Model Intercomparison Project (CMIP5, see below). The "CLIMDEX indices" are a standard suite of 27 indices, formulated to describe and evaluate climate extremes.

Downscaled climate data—a subset of the CMIP5 runs based on historical skill and ability to represent a wide range of changes in different variables and regions of Canada, downscaled with statistical techniques to a 10 km spatial resolution and a daily time resolution.

Hydrologic model output—gridded output, such as runoff, snow water equivalent and soil moisture from the VIC hydrology model for all basins modelled by PCIC.

FIFTH PHASE OF THE COUPLED MODEL INTERCOMPARISON PROJECT

In order to develop a set of future projections, evaluate how well current climate models simulate recent past climate and better understand the reasons for differences in climate model output, the World Climate Research Program's Working Group on Coupled Modeling organized a set of coordinated, international climate model experiments. This set of experiments is known as the fifth phase of the Coupled Model Intercomparison Project (CMIP5).

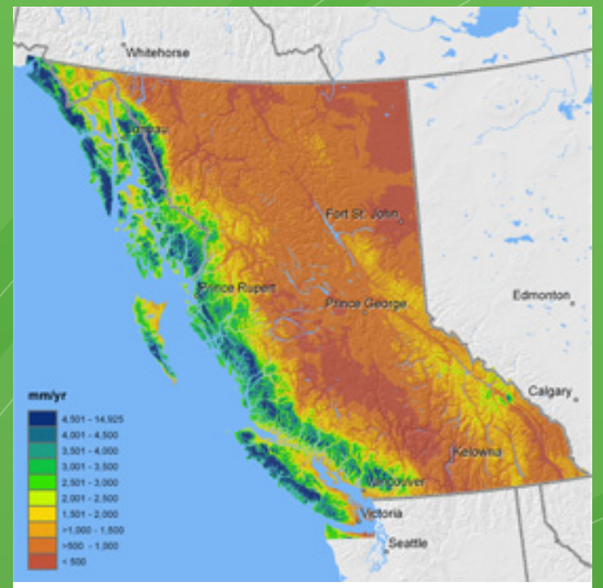
While the models participating in CMIP5 have higher resolution than their predecessors, which participated in the third phase of the Coupled Model Intercomparison Project (CMIP3), there is still a need to downscale global climate models to fine resolutions so that results can be used regionally.

As part of PCIC's Regional Climate Impacts theme, we use statistical methods to downscale global climate model output, comprised of both future projections and simulations of the past climate, for the Pacific-Yukon Region of Canada. This output is also used to drive our hydrological model. The model output from the cutting-edge climate models involved in CMIP5 both drives our current research and affords us an opportunity to revisit and update prior work.

PRISM MAPPING TECHNOLOGY

Parameter-elevation Regressions on Independent Slopes Model (PRISM) is a climate mapping system. The technology uses both climate data, such as point measurements of temperature and precipitation, and expert knowledge of complex climatic factors, such as rain shadows and temperature inversions, to create highly detailed spatial climate data sets (see figure). These data sets include estimates of monthly, yearly and event-based climate variables and are provided at the scale of a few hundred meters.

Working with members of the Oregon State University PRISM group, including PRISM creator Chris Daly, PCIC is collaborating to produce a set of monthly time series for the period of 1971 to the present for British Columbia. The variables covered include monthly maximum, minimum and mean temperature, as well as total precipitation and yearly means. These will allow for a better understanding of the historical evolution of monthly weather anomalies in BC. This project is part of PCIC's Climate Analysis and Monitoring theme, with the goal of creating a series of detailed maps for individual days.

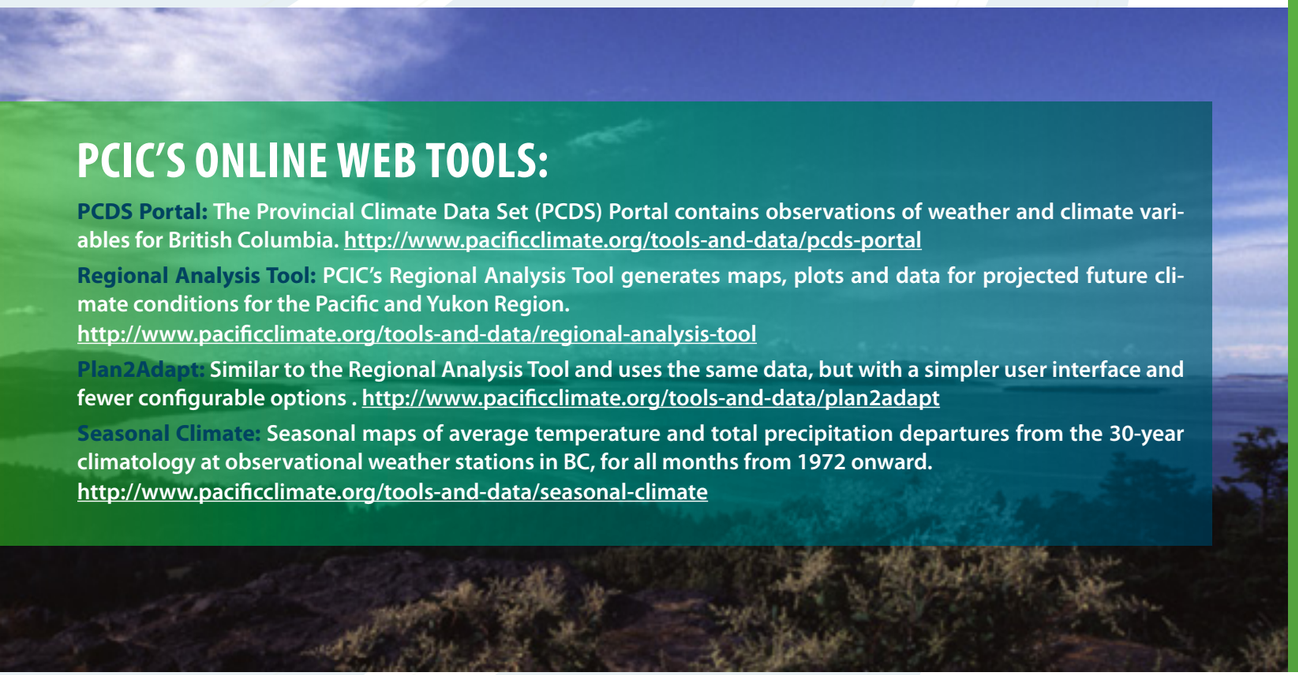


This map shows the average annual precipitation for the period of 1971- 2000 in BC, at a spatial resolution of 800 metres, based on station data from the Pacific Climate Data Set.

PCIC's regional analysis of the impacts of climate change and variability makes use of high-resolution downscaled information. PCIC analyzes change and variability including hydro-climate and climate extremes and makes this information available in usable forms including documented uncertainties.

WEB TOOLS TO HELP USERS UNDERSTAND CLIMATE CHANGE AND VARIABILITY IN THEIR REGION

BC's various regions respond differently to climatic changes. Online tools such as our Plan2Adapt and Regional Analysis Tool allow users to explore projected changes within their region. Plan2Adapt provides temperature, precipitation, snowfall, and other variables in data file, summary table and map formats, for the periods of the 2020s, 2050s and 2080s. Users can also access a brief summary of potential impacts of the climate projections and the affected BC sectors. The Regional Analysis Tool uses the same data as Plan2Adapt but is targeted at the advanced user, providing more options and climate variables. Using the Regional Analysis Tool, users can define their own custom region for analysis, generate maps and plots showing projected changes for that region and compare climate variables for each ensemble of global climate models.



PCIC'S ONLINE WEB TOOLS:

PCDS Portal: The Provincial Climate Data Set (PCDS) Portal contains observations of weather and climate variables for British Columbia. http://www.pacificclimate.org/tools-and-data/pcds-portal

Regional Analysis Tool: PCIC's Regional Analysis Tool generates maps, plots and data for projected future climate conditions for the Pacific and Yukon Region.
http://www.pacificclimate.org/tools-and-data/regional-analysis-tool

Plan2Adapt: Similar to the Regional Analysis Tool and uses the same data, but with a simpler user interface and fewer configurable options . http://www.pacificclimate.org/tools-and-data/plan2adapt

Seasonal Climate: Seasonal maps of average temperature and total precipitation departures from the 30-year climatology at observational weather stations in BC, for all months from 1972 onward.
http://www.pacificclimate.org/tools-and-data/seasonal-climate

PROVIDING ANALYSIS
REGIONAL CLIMATE SERVICES

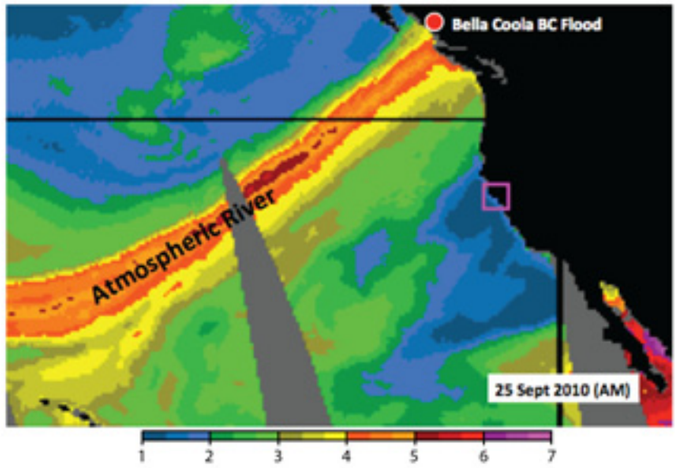
ANALYSING AND UNDERSTANDING CLIMATE EXTREMES

In the past five years, PCIC has developed a set of climate change projections for variables such as average temperature and precipitation. Users concerned with future climate conditions are also interested in understanding potential changes to the frequency of extreme weather events. These events can cause drought, flooding, heat-waves and other phenomena. Responding to this interest, in 2012-2013, we focused on analyzing and understanding heavy precipitation events.

PCIC climatologists investigated the historical precipitation events in BC from 1950 onward, drawing comparisons between three recent flooding events and the historical record. Findings were presented at a workshop PCIC co-hosted that explored the state of knowledge around the extreme precipitation events known as 'atmospheric rivers' (see box, below). At the same time, our researchers were downscaling regional climate model simulations and computing precipitation extremes for the same three areas. These projections will be analyzed in depth over the next year, providing information directly to transportation infrastructure planners and informing PCIC's future work on climate extremes.

ATMOSPHERIC RIVERS STATE OF THE KNOWLEDGE WORKSHOP

Atmospheric rivers are thin streams of high water vapour concentration that move moisture from the tropics to the poles, crossing the midlatitudes. Atmospheric rivers can cause extreme precipitation events and consequently, flooding and landslides.

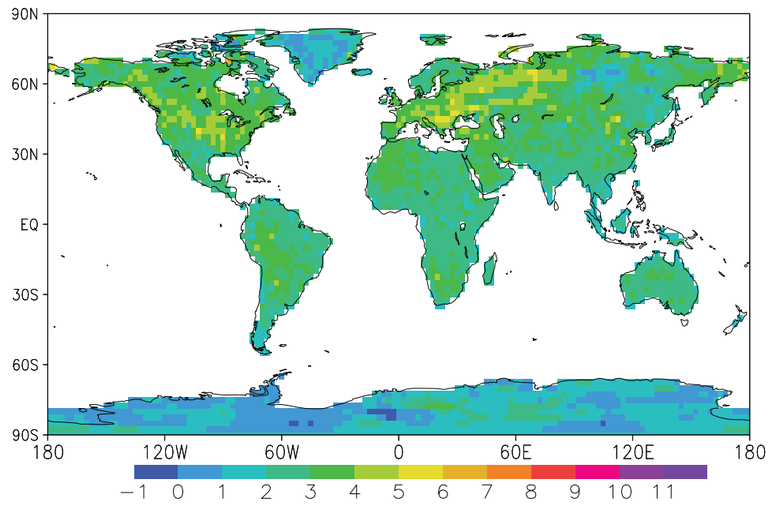


In March, PCIC held the BC Atmospheric River Events: State of the Knowledge Workshop, which brought together experts in a variety of disciplines to assess our understanding of atmospheric rivers, our ability to observe and forecast the phenomenon, our ability to respond to them and how they might change in the future. The workshop report is available at http://www.pacificclimate.org/resources/publications.

This figure shows satellite observations of an atmospheric river at the time of a flood in the Bella Coola region of BC. The physical variable shown is atmospheric moisture content as an equivalent depth of liquid water in centimetres. (Courtesy of Marty Ralph, NOAA.)

OPEN SOURCE SOFTWARE LIBRARY

PCIC has developed a number of software packages for use with climate data in the 'R' programming language, either to solve problems encountered when working with climate data, or to improve upon existing software. An exciting example is our work on climdex.pcic which is now being used around the globe to compute CLIMDEX indices (see figure). The newly developed package is available with the other PCIC software packages in the PCIC software library as open source software and is also being made available via the international R-code repository known as "CRAN".



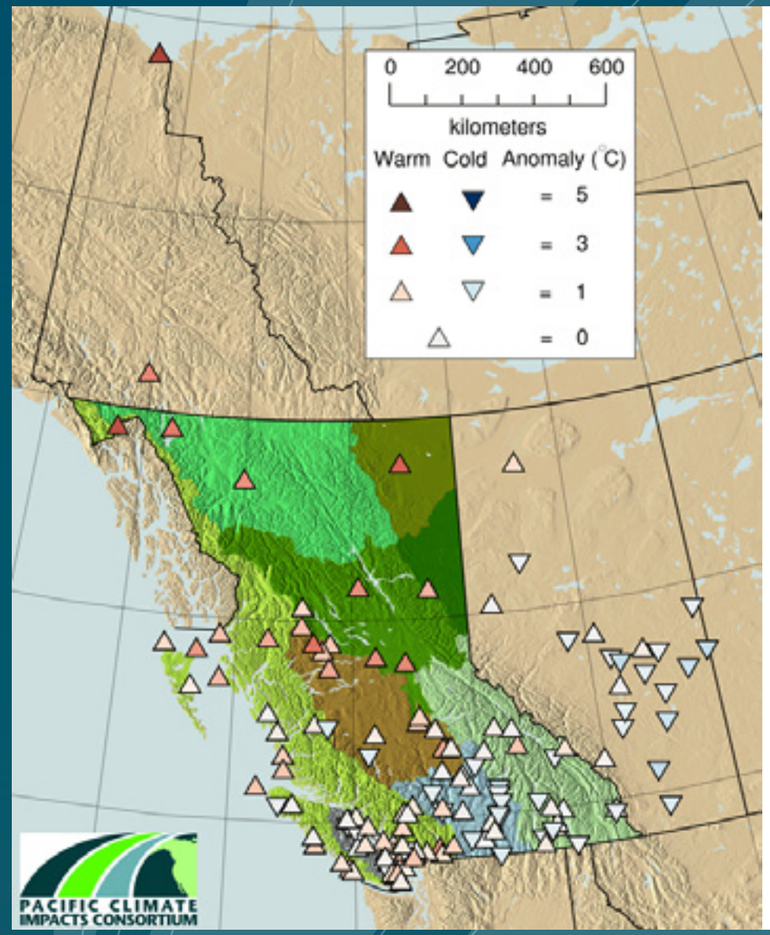
This figure (Sillman et al., 2013) shows the median of time-averaged changes to the climate extremes index TXx (the annual maximum value of the daily maximum temperature) over the 2081-2100 period as compared to the 1981-2000 period, using the averaged output from an ensemble of global climate models. All changes are statistically significant at the 5 % level.

PROVIDING INTERPRETATION
REGIONAL CLIMATE SERVICES

REGULARLY PRODUCING SEASONAL CLIMATE MAPS

PCIC scientists have created a set of maps for departures in temperature and precipitation in BC (see figure). These maps use weather station data and visually illustrate departures from the 1971-2000 mean, in both monthly and seasonal averages, for the time period of 1972 onward. The seasonal climate maps are a regular product for which new maps will be released near the 15th of each month.

See our website for more information: http://www.pacificclimate.org/tools-and-data/seasonal-climate



This map indicates that maximum daily air temperature for the month of June, 2013 was near or slightly warmer than normal at weather stations throughout the southern half of BC, very slightly cooler than normal over Alberta and warmer than normal in northern BC and in the two locations where data were available for Yukon. The background colors indicate the eco provinces of BC. The anomalies plotted on this map indicate locations where active weather and climate monitoring is taking place. The PCDS contains data from a much larger collection of observation locations which reflects the waxing and waning of the meteorological network in the province through time.

PROVIDING INTERPRETATION
REGIONAL CLIMATE SERVICES

Providing regional climate information specific to user needs involves extending our data and analysis resources. The 'interpretation' of climate information can take the form of technical reports developed specifically for the user, plain language summaries of PCIC publications and scientific articles, presentations, or user-consultation.

DEVELOPING USER-SPECIFIC CLIMATE INFORMATION

Climate summaries for BC's resource regions—the BC Ministry of Forests Lands and Natural Resource Operations commissioned a series of two-page climate summary reports for each of BC's eight 'resource regions' (see figure below).

An example of a resource region climate summary report (shown: Kootenay-Boundary Region).

These reports summarize the historical climate trends, future climate projections and discuss potential impacts resulting from the projected changes in each region. The summaries will be updated over time utilizing new research as it is released, including the results from the fifth phase of the Coupled Model Intercomparison Project (CMIP5, see p. 6).

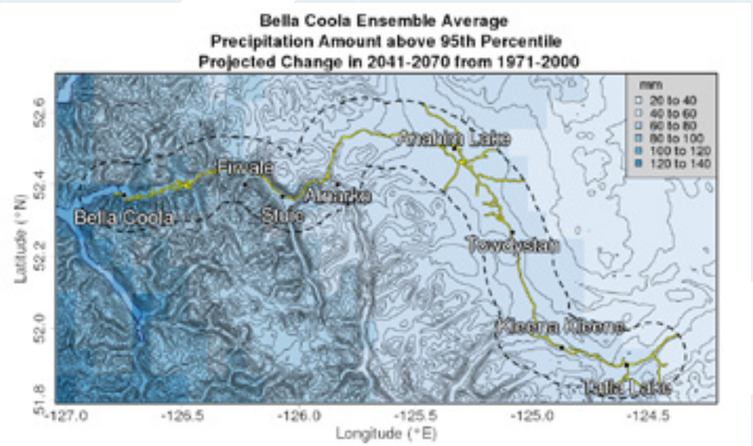
Transportation Infrastructure and Climate Risk—the BC Ministry of Transportation and Infrastructure is seeking to better understand the vulnerability of highways to extreme precipitation events, by studying three events in detail: September 2010 in Bella Coola (see figure below), September 2011 in Stewart, and July 2011 in Pine Pass. PCIC is assisting in the risk assessment (see figure on opposite page), which should result in recommendations for best practices for general use.

Hydrologic Impacts of Climate Change—PCIC is working closely with BC Hydro, one of our original users and collaborators, to estimate the hydrologic impacts of climate change including how climate change affects water supply and the seasonal timing of reservoir inflows. In addition to responding to requests for information and analysis, PCIC Hydrologists are busy expanding on the scope of their analysis. Within the next two years PCIC will incorporate the CMIP5 results into our hydrologic findings as well as expand the geographical scope to all BC watersheds. Hydrologic model output will also be made available via the PCIC website.

Flooded region in the Bella Coola Valley (image courtesy Ministry of Transportation and Infrastructure)

BC Agriculture's Climate Action Initiative—the BC Agriculture and Climate Change Adaptation & Risk Opportunity Assessment conducted a series of workshops in Peace River, Cowichan Valley, and Delta during the last year. Regional adaptation strategy reports were developed on the basis of these workshops. PCIC provided analysis of historical climatology, variability, trends and future projections as well as assisted with interpretation of results in development of the regional strategies, and attended one of the workshops.

Regional adaptation strategy reports are available at http://www.bcagclimateaction.ca/adapt/regional-strategies/



This figure shows the projected change in precipitation amount that occurs during extreme precipitation events, specifically the total amount that occurs above the 95th percentile of daily precipitation, for the period of 2041-2070 relative to a 1971-2000 baseline.

The values are obtained from an ensemble of 10 regional climate model simulations from the North American Regional Climate Change Assessment Program that have been statistically downscaled to 10 km resolution from their original 50 km scale. Bella Coola experienced severe flooding in 2010 when an extreme precipitation event occurred over successive days. The flooding caused damage to the town and several sections of highway resulting in its closure. This figure illustrates that under projected climate change, the amount of precipitation that occurs during those types of events is expected to increase with large increases expected near Bella Coola. The yellow line shows the stretch of highway used for this report and the dotted line indicates 10 km surrounding the highway, which is the area considered for this project.

REGIONAL CLIMATE SERVICES
PROVIDING INTERPRETATION

TRANSLATING RECENT CLIMATE RESEARCH

This year we launched an ongoing series of short, plain-language summaries of articles from the climate science literature, chosen for their regional relevance. This service is motivated by our commitment to knowledge transfer with our users. Our 'PCIC Science Briefs' explain and place in context the results of articles at the cutting edge of climate science, as well as discussing the potential implications of the research for the Pacific and Yukon Region.

The Science Briefs produced so far covered topics as diverse as ice core results from the Eclipse Ice Field, the differing abilities of statistical and physics-based models to simulate El Niño, the effect of pine-bark beetle infestation on water quality and the potential impacts of changes to future precipitation on automobile collisions in Greater Vancouver.

PCIC Science Briefs are available from our Publications Library:

http://www.pacificclimate.org/resources/publications

CONNECTING WITH OUR COMMUNITY

PCIC scientists gave numerous presentations directed at user groups over the past year. This past year PCIC presented to several BC Ministries, to the Association of Professional Engineers and Geologist of BC at the Forest Nursery Association of BC, and at other climate service organizations including Environment Canada, Ouranos, the Ontario Climate Consortium and others. PCIC scientists also gave several presentations to a multidisciplinary audience at UVic, providing guest lectures and participating in events organized by other research centres.

SCIENTIFIC AND INFORMATION RESOURCES

To provide high-quality regional climate services, PCIC relies on its exceptional personnel and on partnerships with researchers from other institutions. The relationships that we build with these researchers and our user base, combined with our commitment to a transparent and flexible operational ethic, allows PCIC to provide climate data, analyses and interpretations that are consistently at the forefront of regional climate science.

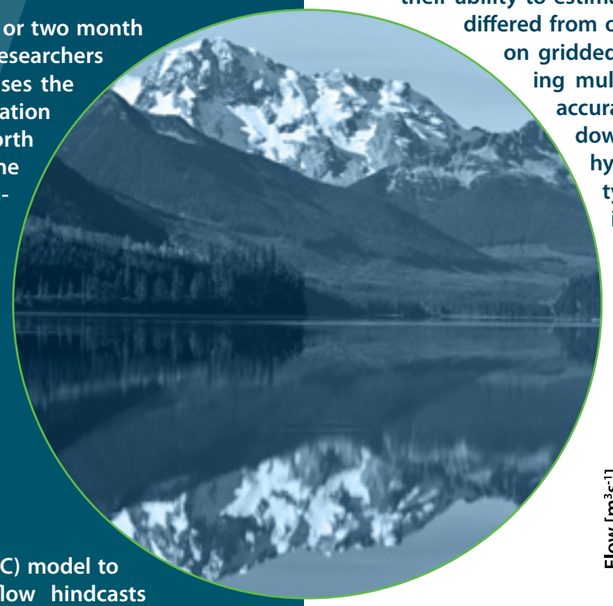
APPLIED RESEARCH
SCIENTIFIC AND INFORMATION RESOURCES

PCIC undertakes applied research projects that support our service objectives with the aim of developing the quality and quantity of PCIC's scientific and information resources.

EVALUATING THE POTENTIAL TO FORECAST CLIMATE EXTREMES

PCIC is actively working to provide and assess the skill of climate models and hydrological models in predicting extremes, via the project "Predicting Climate Extremes on Seasonal to Decadal Time Scales." PCIC scientists have been researching three areas: statistical models for extremes, climate extremes prediction and streamflow extremes prediction. The goal of this research is to evaluate the extent to which it might be possible to make skillful seasonal predictions of both climate and hydrological extremes.

Over this past year, our research in these three areas has shown several results: Using a set of statistical post-processing techniques, PCIC scientists have determined that ENSO forecast skill can be improved relative to the raw dynamical model ensamble, and that this improvement is the equivalent of a one or two month increase in lead time. PCIC researchers have shown that El Niño increases the likelihood of extreme precipitation events over much of southern North America and that it decreases the likelihood of extreme precipitation events in northern regions. La Nina events have roughly the opposite effect. Research into possible skill improvements for streamflow event forecasting is ongoing.



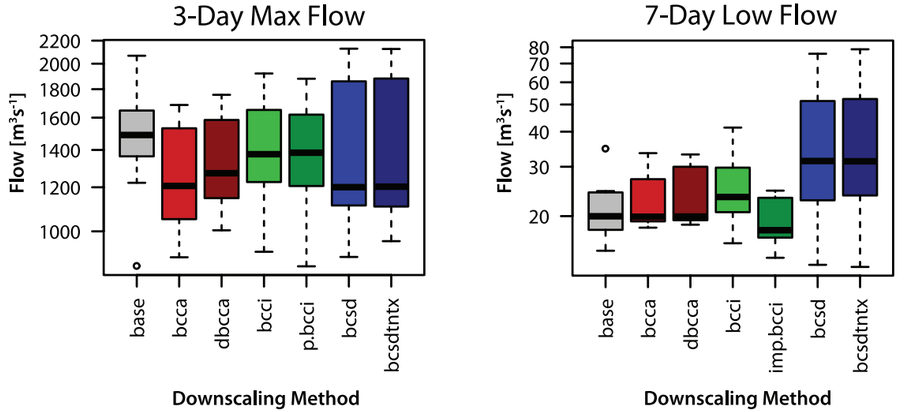
CAN STREAMFLOW PREDICTIONS BE IMPROVED?

Currently, operational forecasts, such as those generated at BC Hydro, use past weather observations to represent possible future weather sequences that can be used to force a hydrology model during the forecast period. The effect of the climate state, such as ENSO, is taken into account by weighting the past observations based on climate state at the time the forecast is issued. Researchers at the Canadian Centre for Climate Modelling and Analysis have developed a new long-range (up to 12 months in advance) forecasting system based on their state-of-the-science climate model. These dynamic forecasts are being used at PCIC in combination with the Variable Infiltration Capacity (VIC) model to produce experimental streamflow hindcasts with a lead time of up to 12 months, initially for the Fraser River at Hope, British Columbia. The intent of the project is to evaluate whether the coupling of climate forecasts to VIC might provide more skillful streamflow forecasts than the current operational forecasting method. Three methods are being tested and preliminary results suggest that modest improvements in skill may be possible for long-lead streamflow forecasts issued at the beginning of winter.

DOWNSCALING EXTREMES

PCIC scientists recently examined several statistical downscaling methods to see how they performed for climate variables that are relevant for hydrology. Similar to previous downscaling inter-comparison work completed at PCIC, several downscaling methods were tested for their ability to estimate climate extremes. This study differed from other previous work by focusing on gridded downscaling methods and using multiple reanalyses to gauge their accuracy. It also went on to run each downscaled climate field through a hydrologic model to test their ability to capture hydrologic extremes in the snow-dominated Peace River Basin. In general, the Bias Correction and Spatial Disaggregation (BCSD) method, which uses monthly global climate model (GCM) data produces results that compare favourably to other methods that use daily GCM data, though BCSD is not as good for representing extremes where the timing of precipitation events is important, such as seven-day low flow events.

PCIC has used the BCSD method to downscale all 23 CMIP3 scenarios used for projecting future changes in the Peace, Columbia, Fraser and Campbell River basins and for multiple projects conducted by stakeholders across BC (see figure, below). These results add confidence to recent findings of these projects and also inform future use of BCSD projections by PCIC staff and stakeholders.

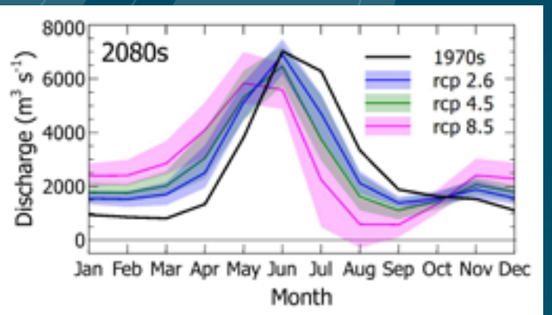


These plots show the 3-day maximum flow (left) and 7-day low flow (right) for the 16000 km² sub-basin of the Peace River, Finlay River above the Akie River. Each "box and whisker" plot represents the distribution of flows over 1992-2000, grey for the gridded-observations and colour for the 7 gridded downscaling methods as driven by ERA40 reanalysis data. The black band inside each box is the median (50th percentile) value, the top and bottom are the 75th and 25th percentile, respectively and the ends of the whiskers extend from the 13th percentile to the 88th percentile of streamflow, with dots representing values that lie outside of this range.

APPLIED RESEARCH
SCIENTIFIC AND INFORMATION RESOURCES

STREAMFLOW PROJECTIONS USING STATISTICAL EMULATION

Recent streamflow projections produced by PCIC were based on downscaled output from GCMs contributing to CMIP3. Given that GCM uncertainty is a large part of projection uncertainty, the question arises: do the new GCMs contributing to CMIP5, based on new emissions scenarios, present a different picture of future streamflow change? The original projections were generated using the Variable Infiltration Capacity (VIC) hydrology model with statistically-downscaled climate projections from the output of a carefully selected subset of CMIP3 experiments. To quickly update previous work with the new CMIP5 projections, PCIC sought an alternative approach. We used a statistical model to emulate the projections made by the VIC model, for the original CMIP3 runs. This was then applied to the new CMIP5 climate change projections. Results for the Fraser River indicate that streamflow changes projected using CMIP5 scenarios are qualitatively similar to those from CMIP3, increased runoff in fall and winter, earlier onset of spring streamflow due to thawing and reduced summer discharge, with changes increasing progressively, further into the future. When comparing CMIP3 to CMIP5 using similar emissions scenarios, results show that CMIP5-based changes are more severe, suggesting that CMIP5 models have a more sensitive response to comparable radiative forcings than CMIP3 models (see figure). Results are qualitatively similar for the Peace River at Taylor.



This figure shows projected streamflow for three CMIP5 scenarios (RCP 2.6, 4.5 and 8.5) comparing results for the 2080s (median values in solid colours and range of values in shaded colours) with those of the 1970s historic period (solid black). The results show that changes under representative concentration pathways that result in greater atmospheric greenhouse gas concentrations are more severe.

INCLUDING GLACIERS IN THE VIC MODEL

Runoff in many watersheds throughout the Western Canadian Cordillera is influenced by glacier melt in the late spring through early fall. Given the sensitivity of glacier mass balance to climatic change, assessment of the hydrologic impacts of climate change requires the capability/technology to accurately model glacier mass balance and dynamics processes. To this end, the Pacific Climate Impacts Consortium is currently updating the VIC model to include the ability to model these important cryospheric processes. Work is currently underway to refactor the VIC code and incorporate the necessary algorithms and subroutines to model the vertical glacier energy and water balance and glacier water storage and discharge. Subsequent work will involve the coupling of the VIC model with an external glacier dynamics model, to capture the effect of changes in glacier area on runoff, expanding on earlier work in which glacier mass balance was approximated using permanent snow cover. With these capabilities, the hydrologic impacts group at PCIC will be able to provide more accurate updated assessments of climate change impacts in previously modelled watersheds and previously un-studied regions of the province.

BUILDING PARTNERSHIPS
SCIENTIFIC AND INFORMATION RESOURCES

Building strong partnerships, collaborations, and relationships with both researchers and users is imperative in order for PCIC to provide robust and useful climate information. All of the projects listed in the pages of this report demonstrate PCIC's connectedness with our user base, academic researchers, or both.

To provide an array of climate data, PCIC worked with a diversity of organizations such as BC Ministries, BC Hydro, the PRISM group at Oregon State University, and Environment Canada. Similarly to provide analysis products, PCIC built partnerships with organizations and users from a variety of professional backgrounds such as engineers, foresters, and policy makers to understand their needs and customize elements of our tools and reports to meet these needs.

The strength of our partnerships depends on PCIC engaging in two way conversations with users. Thus, PCIC continues to strengthen our capacity to translate complex scientific information to accessible formats for users. This year we launched new products such as the Science Briefs and continued to improve our website interface.

PCIC's applied scientific research flourishes because of the strong relationships and collaborative projects PCIC maintains with academic research groups in BC and across Canada. These relationships include exchanges of expertise, data, climate model output, and joint authorship on papers and reports. Our publications list and the report section 'developing scientific and information resources' are a testament to the strength of these relationships over the past year.

LOCAL GOVERNMENT, PROVINCIAL MINISTRIES AND OTHER PARTNERS

Adaptive Resource Management, Ltd.

Agriculture and Agri-Food Canada

BC Hydro

BC Ministry of Agriculture

BC Ministry of Community Development

BC Ministry of Forests, Lands and Natural Resource Operations

BC Ministry of Transportation and Infrastructure

Canadian Centre for Climate Modelling and Analysis (CCCma)

Capital Regional District

City of North Vancouver

City of Surrey

City of Vancouver

City of Victoria

Climate Action Secretariat, Ministry of Environment

Climate Data and Analysis Section, Environment Canada

Columbia Basin Trust

Corporation of Delta

Dalhousie University

Fraser Basin Council

Future Forests Ecosystem Scientific Counsel

Helmholtz-Zentrum Geesthacht

Institute for Coastal Research (Germany)

Living Rivers Society

Marine Environmental Observation Prediction and Response Network (MEOPAR)

Metro Vancouver Regional District

Natural Resources Canada

Ouranos Scientific Symposium

Pacific Institute for Climate Solutions (PICS)

PRISM Climate Group, Oregon State University

University of Toronto

University of Victoria

Université du Québec à Montréal

University of Northern British Columbia

FINANCES, APRIL 2012 - MARCH 2013
OPERATIONS

Fiscal year 2012-2013 was an extraordinary year for PCIC. This year we sustained a strong financial condition, increasing our annual funding envelope and consistently producing new products and services.

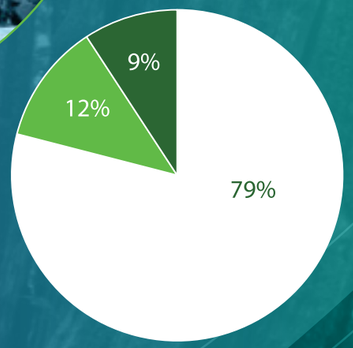
The financial stability PCIC continues to enjoy is imperative for allowing our staff to innovate and produce new tools. An endowment, granted to UVic in 2008 to support PCIC and our sister organization, the Pacific Institute for Climate Solutions, continues to be the pillar of our financial strength. The financial security provided by the endowment allows PCIC to maintain a long-term budgetary outlook. It also provides assurances to strategic funding partners that we have the resources to produce results. Short-term agreements and long-term agreements with strategic partners provide the balance of our revenue as is indicated on the 'Revenue 2012/13' pie chart.

The past year marked the half-way point of many long-term projects and agreements. As we work to complete the work on these agreements, we also continue to look for new strategic opportunities that will support the financial strength of PCIC while also serving to improve access to past and future climate information.

As in every report prior, PCIC's most important asset, and our largest expense continues to be our investment in human resources. However, over the past year we have increased our expenditures on computer hardware, specifically server hardware. As we grow in our ability to serve data via our website to our users, our need for robust storage only continues to grow. Accordingly, we will continue to make these important investments.

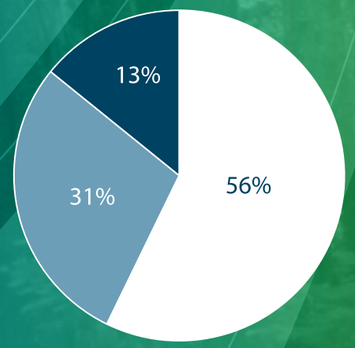
Looking forward, PCIC will continue to work to maintain low operating costs while serving users high quality climate information. Leveraging the endowment, we will continue to seek strong strategic partnerships and engage in new opportunities.

EXPENSES



- Personnel, salaries and benefits
- Operating expenses
- External agreements, subprojects

REVENUE



- Endowment
- Long-term agreements (2 years +)
- Short-term contracts

STAFF AND ASSOCIATES, SEPTEMBER 2013
OPERATIONS

Staff:
Francis Zwiers, *Director, President and CEO*
Faron Anslow, *Climatologist*
David Bronaugh, *Programmer/Analyst*
Alex Cannon, *Research Climatologist*
Cassbreea Dewis, *Lead, Planning & Operations*
James Hiebert, *Lead, Computational Support*
Amina Khan, *Hydrology Analyst*
Shelley Ma, *Administrative Assistant*
Trevor Murdock, *Lead, Regional Climate Impacts*
Paul Nienaber, *Programmer/Analyst*
Stephanie Saal, *Research Intern*
Markus Schnorbus, *Lead, Hydrologic Impacts*
Raj Shrestha, *Hydrologist*
Michael Shumlich, *Scientific Information Specialist*
Stephen Sobie, *Regional Climate Impacts Analyst*
James Stone, *Programmer Analyst*
Basil Veerman, *Geospatial Programmer/Analyst*
Arelia Werner, *Hydrologist*

Associates:
Katherine Pingree-Shippee, *PhD Student, Geography, UVic*
Drew Snauffer, *PhD Student, EOAS, UBC*

Back row (left to right): David Bronaugh, Stephen Sobie, Basil Veerman, James Stone, Alex Cannon, Paul Nienaber, Trevor Murdock, Drew Snauffer, Amina Khan, Cassbreea Dewis, Francis Zwiers and Rajesh Shrestha. **Front row:** Markus Schnorbus, Shelley Ma, Arelia Werner and Michael Shumlich. (Not pictured: Faron Anslow, James Hiebert, Katherine Pingree-Shippee and Stephanie Saal.)

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PUBLICATIONS, MAR. 2012 - SEPT. 2013

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PEER-REVIEWED PUBLICATIONS
PUBLICATIONS, MAR. 2012 - SEPT. 2013

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