2010-2011

PCIC Corporate Report

Pacific Climate Impacts Consortium

University of Victoria

Board of Directors (March 2011)

Program Advisory Committee (March 2011)

Thomas White *(Chair)*, BC Ministry of Environment
Daniel Caya, Ouranos
Sean Darling, BC Ministry of Agriculture
Greg Flato, Environment Canada
Dirk Nyland, BC Ministry of Transportation and Infrastructure
Patrice Rother, BC Hydro
Stephanie Smith, BC Hydro
Dave Spittlehouse, BC Ministry of Forests, Lands and Natural Resource Operations

PCIC Staff (March 2011)

Francis Zwiers, *Director, President and CEO*
Andrew Weaver, *Senior Scientist*
Anne Berland, *Analyst-Hydrology*
David Bronaugh, *Programmer/Analyst*
Gerd Bürger, *Climate Scientist*
Cassbreea Dewis, *Lead, Planning and Operations*
Hailey Eckstrand, *GIS Analyst*
Leslie Gallacher, *Administrative Assistant*
James Hiebert, *Lead, Computational Support*
Greg Maruszeczka, *Webmaster/Editor*
Trevor Murdock, *Lead, Regional Climate Impacts*
Paul Nienaber, *Programmer/Analyst*
Dave Rodenhuis, *Associate Climatologist*
Markus Schnorbus, *Lead, Hydrologic Impacts*
Rajesh Shrestha, *Hydrologist*
Stephen Sobie, *Regional Climate Impacts Analyst*
Derek van der Kamp, *Research Assistant*
Arelia Werner, *Hydrologist*

PACIFIC CLIMATE IMPACTS CONSORTIUM

University House 1
PO Box 3060 Stn CSC
University of Victoria
Victoria, BC Canada V8W 3R4
Phone: (250) 721-6236
Fax: (250) 721-7217

http://pacificclimate.org

Cover Photos : top: morihuis; centre: Ellen Atkin (Getty Images), ***Aerial view of the Stave Lake dam near Mission, B.C., Canada***; bottom: Francis Zwiers

PACIFIC CLIMATE IMPACTS CONSORTIUM

Photo: Francis Zwiers

The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada. PCIC collaborates with climate researchers and regional stakeholders to produce knowledge and tools in support of long-term planning and adaptation.

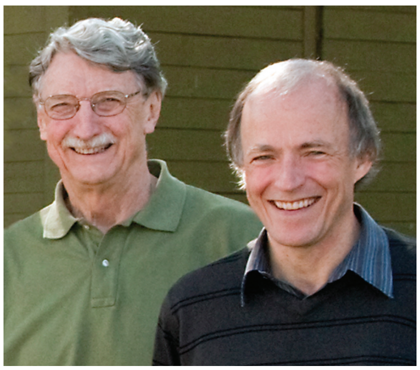
PCIC applied research programs are organized in three interrelated themes: Hydrologic Impacts, Regional Climate Impacts, and Climate Analysis and Monitoring. This corporate report highlights major PCIC accomplishments during the period April 2010-March 2011.

Year in Review 2010

Leadership Transition

For four years, Dave Rodenhuis led PCIC through its pioneering phase to become a stable organization with a clear mission and vision. He worked tirelessly, building the consortium from a small group of six to a staff of 17, securing long-term funding through an endowment from the BC government, and establishing lasting partnerships with climate stakeholder groups such as BC Hydro. In 2010, Dave decided it was time to take on new challenges and focus full time on building the Climate Analysis and Monitoring program at PCIC. After an exhaustive search for his replacement, the selection committee chose Francis Zwiers to lead PCIC during its next phase of development. Francis has an extensive background in climate research and significant experience managing large research organizations. Through his vision, the consortium is entering a new phase in its development as it seeks to become a premier regional climate service centre.

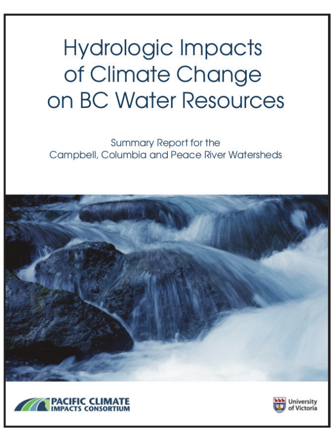
Photo: University of Victoria



Dave Rodenhuis (left) and Francis Zwiers

Hydrologic Impacts Program Phase 1 Completion

The PCIC Hydrologic Impacts program reached a major milestone in 2010 with the completion of the first phase of its collaborative research program with BC Hydro, aimed at assessing the impacts of temperature and precipitation changes on streamflow for three BC watersheds: the Campbell River, Upper Columbia River and Upper Peace River (p. 22). In April 2010, PCIC presented initial results at a joint PCIC-BC Hydro workshop held in Burnaby, BC, titled "Assessing Hydrologic Impacts on Water Resources in BC: Current Accomplishments and Future Vision." The workshop was well attended by BC Hydro representatives and other climate stakeholders. Building on the feedback received during and after the workshop, the PCIC hydrology team continued their analysis well into the fall of 2010 before preparing project reports describing research methods and final results. Detailed project reports, as well as a summary document, are available through the PCIC website (http://pacificclimate.org/resources/publications).



Hydrologic Impacts of Climate Change on BC Water Resources

Summary Report for the Campbell, Columbia and Peace River Watersheds

PACIFIC CLIMATE IMPACTS CONSORTIUM

University of Victoria

Strengthened Partnerships with Stakeholders

Partnerships and collaborations are the foundation of PCIC's operating model. Building and strengthening these relationships improves PCIC's ability to deliver stakeholder driven results. In this regard, it was a banner year for strengthening PCIC partnerships with a number of stakeholder groups. PCIC entered into a new collaborative agreement with long-time partner the Columbia Basin Trust and initiated a new partnership with Environment Canada's Climate Research Division (CRD), which supported PCIC's investigation of fire-weather risk and climate change (p. 14). Also this year, the BC Ministry of Transportation and Infrastructure, pleased with the results from its 2009 Coquihalla Highway infrastructure project with PCIC, chose to work with the consortium on a similar project concerning the Yellowhead Highway (p. 12).

New Website Launched

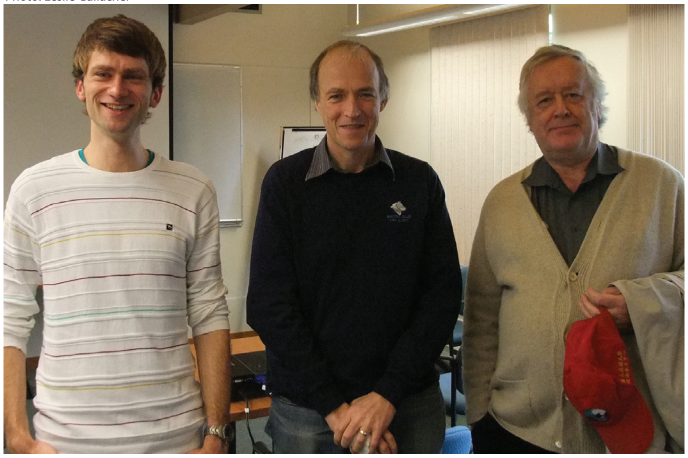
When staff envisioned a complete redesign of the PCIC website in 2009, they favoured a dynamic online resource that would become the foundation for building a relationship with climate stakeholders on the worldwide web. In an effort to achieve this vision, PCIC set out on an ambitious project to completely overhaul the PCIC website from static html to a dynamic database-driven system. Maintaining the PCIC philosophy of providing quality scientific information to

interested stakeholders, the website is a main entry point for accessing online tools like the Regional Analysis Tool and Plan2Adapt as well as news and events, project reports and other PCIC publications.

Strengthening Partnerships with Research Groups

PCIC partners with other climate research groups and climate service centres in order to access the most up-to-date scientific and technical expertise, build synergies, and share information. PCIC and the Pacific Institute for Climate Solutions have initiated a partnership with the Institute for Coastal Research, Helmholtz-Zentrum Geesthacht in Germany, to co-host a regional climate services workshop in November 2011 that will explore the ways in which climate information is communicated to stakeholders. Another significant new partnership for PCIC was formed when the consortium and the PRISM group at Oregon State University signed a three-year collaborative agreement to transfer PRISM technology to PCIC for producing high-resolution time series maps for BC. This agreement is an essential step in the ongoing development of PCIC's Climate Analysis and Monitoring theme. PCIC also actively maintains many long time partnerships with groups at the University of Victoria, the University of Washington, Ouranos, and Environment Canada.

Photo: Leslie Gallacher



German climate researchers Oliver Krüger (left) and Hans von Storch (right) with PCIC Director Francis Zwiers (centre) at the University of Victoria in December 2010.

Promoting Dialogue and Sharing Knowledge

Inviting distinguished scientists to visit PCIC at the University of Victoria campus and publicly share results from their

Photo: Pacific Climate Impacts Consortium

work with colleagues and students promotes dialogue and knowledge transfer within the climate science community. Between April 2010 and April 2011 PCIC sponsored and hosted more than a dozen guest seminars on a broad range of topics, from groundwater hydrology to the design of 'green' buildings to statistical modelling of climate extremes. Roughly half of these lectures were hosted in partnership with the Pacific Institute for Climate Solutions through the highly successful Pacific Climate Seminar Series.

During this same period, PCIC provided workspace and support to two visiting doctoral students, one from Germany and the other from Austria, so they could benefit from the consortium's in-house expertise in statistical downscaling of climate extremes.

Message from the Chair, Board of Directors

Photo: University of Victoria

At the University of Victoria, PCIC's success has contributed to the university's vision to "integrate scholarship, teaching and real-life involvement" for the betterment of society. British Columbia's climate is changing and these changes will have an impact at the local and regional scale. In order to adapt to changes in climate, planners and decision makers need to understand the scale and scope of the projected impacts. The PCIC mission is critical. The goal is to quantify the impacts of climate change and variability on the local and regional physical environment. The path to accomplish that goal requires strategic direction and strong leadership. As Chair of the PCIC Board of Directors, I am grateful to my colleagues who contribute leadership, passion and skill to the PCIC mission. The Board of Directors functions as a team of highly skilled executives with experience in finance, law, government, and academia.

PCIC actively participates in university culture by hosting seminars and collaborating with our other world class climate research groups. As a regional climate service, PCIC serves the needs of climate stakeholders in the Pacific and Yukon Region by providing access to climate information for a variety of time horizons and geographic scales. In 2011, PCIC will host a workshop to further explore the concept of regional climate services.

This past year brought more developments that are positive to our organization. Early in 2010, a search for a new Director, President and CEO was initiated, culminating in the hiring of Dr. Francis Zwiers. Dr. Zwiers came to PCIC after a highly successful career at Environment Canada. His research on climate variability and change is internationally recognized and he has earned a reputation as a world-class scientist. He has served as a Coordinating Lead Author for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report and was honoured by selection as a Vice-Chair of the Bureau of the IPCC Fifth Assessment Report.

Dr. Zwiers replaces outgoing Director, President and CEO Dr. Dave Rodenhuis, who has provided PCIC with a lasting legacy of dedication, enthusiasm and perseverance, and continues to contribute to PCIC's mission through his role as Associate Climatologist. Dr. Zwiers' perspective will contribute to the continued development of PCIC's strategic vision and set the stage for the coming years.

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

Photo: Greg Maruszeczka

PCIC Board of Directors (left to right): Don Barnhardt, Pierre Baril, Howard Brunt, Terry Prowse, Asit Mazumder, Francis Zwiers, Jamie Millin and James Mack.

Message from the Chair, Program Advisory Committee

Photo: Courtesy of Thomas White

I am pleased to be the incoming Chair of the PCIC Program Advisory Committee (PAC), having joined the committee in September 2010. The PAC provides direction and advice to the Director of PCIC on scientific content and priorities, stakeholder needs and participation in projects. I also serve as the PAC representative for the BC Ministry of Environment and am excited to utilize the PAC as a venue for active collaboration with PCIC. My PAC colleagues represent various stakeholder agencies and research groups. Our common desire is to foster a successful organization in PCIC that supports stakeholder efforts to prepare for the impacts of climate change by providing the most up-to-date scientific information and tools.

At the start of my term I was introduced to a thriving organization actively involved in a number of challenging and important projects in collaboration with PAC members and other stakeholders. This past year saw the culmination of a four-year project providing analysis of the future hydrologic changes of three important BC watersheds in collaboration with BC Hydro. In addition, PCIC used its collaboration with the BC Ministry of Transportation and Infrastructure and the Columbia Basin Trust to enhance its capacity to assess extremes at a regional scale.

The collaboration between the BC Ministry of Environment and PCIC was strengthened through the considerable progress that PCIC made developing its Climate Analysis and Monitoring (CAM) program. Within this program, PCIC signed a new Memorandum of Understanding with the BC Ministry of Environment that will improve access to meteorological data. In addition, PCIC and Oregon State University initiated a three-year collaborative project to produce high-resolution climate maps of British Columbia. Finally, PCIC hired a climatologist to support the CAM program and its goals. These developments strengthen the province's Climate Related Monitoring Program and add another dimension to the climate services PCIC is able to offer regional stakeholders.

PCIC's ability to collaborate with a diverse group of stakeholders will continue to serve it well as provincial ministries begin to develop climate adaptation strategies and BC municipalities continue to consider adaptation in their land use planning. In addition, BC Hydro and PCIC will continue to collaborate to provide regional information on the hydrologic impacts of climate change on British Columbia water resources.

I look forward to the coming year as the demand for climate information to inform adaptation in the province continues to grow and PCIC continues to provide regional climate services to meet that need. As Chair of the PCIC Program Advisory Committee, I will continue to support the consortium in fostering new stakeholder relationships. I look forward to the many opportunities that lie ahead.

Thomas White
Chair, PCIC Program Advisory Committee
Science and Adaptation, BC Ministry of Environment

Photo: University of Victoria

PCIC Program Advisory Committee (left to right): Dave Spittlehouse, Dirk Nyland, Francis Zwiers, Lee Thiessen, Cassbreea Dewis, Stephanie Smith, Sean Darling, Andrew Weaver.

Message from the PCIC Director

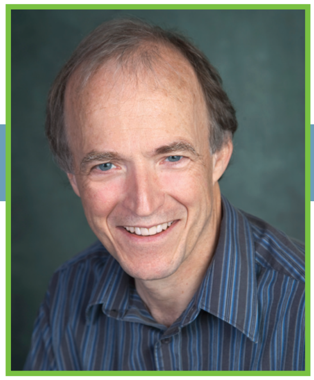


Photo: University of Victoria

For me, this message marks the end of a beginning that has spanned a bit more than half a year. In that time I've discovered a vibrant, dedicated organization that is working hard to satisfy BC's need for high quality climate information, and I feel privileged and humbled to be able to serve at its helm. I have also come to appreciate deeply the legacy that has been developed by Ben Kangasniemi, Dave Rodenhuis, Lee Thiessen and others who have contributed to PCIC's vision and development. PCIC enjoys tremendous support from its users and members, including the University of Victoria, key BC government ministries, BC Hydro, Environment Canada, the Columbia Basin Trust, and numerous others.

This report gives but a small retrospective glimpse of the organization's capabilities and activities, and the range of topics to which it has applied itself. We have learned a great deal about the hydrology of the province and how it will change in the future. We are also becoming more confident in our ability to downscale global scale climate change projections to regional and local scales through the critical evaluation of a variety of downscaling techniques. As well, we have developed an enormous amount of climate information for adaptation planning by municipalities and regional councils, for highways development and planning, and for the assessment of climate-related impacts like future forest fire risk.

In partnership with the Pacific Institute for Climate Solutions, the BC government, and Oregon State University, PCIC is also deeply engaged in an ambitious effort to improve the completeness and quality of BC's historical climate record. That record, and information derived from it, is crucial for the continued development and resilience of the BC economy in the face of a variable and changing climate. To this end, PCIC is accessing, inventorying, compiling, and evaluating historical and current meteorological data from more than 1,500 observing stations across the province. These data will become part of an extensive Provincial Climate Dataset and will be used to develop improved climate products of unprecedented quality and detail for the province.

The coming year will bring many new exciting opportunities and challenges. PCIC and BC Hydro have entered into a new and strengthened long-term agreement that will significantly broaden our engagement with BC Hydro. Under the new agreement PCIC will continue to improve our understanding of the future of BC's water resources, and provide information on other aspects of climate variability and change. We will also participate in an NSERC, BC Hydro and Rio-Tinto Alcan funded collaboration between the University of Victoria and Ouranos to develop new very high resolution long-term climate change projections for BC and Québec using the Canadian Regional Climate Model. In addition, we are actively developing engagements with a broadening group of stakeholders. In partnership with others, we look forward to being able to continue to serve BC and our stakeholders by developing the capacity within the province to deliver high quality regional climate services across a range of time scales, including past, present, and future.

Francis Zwiers
Director
Pacific Climate Impacts Consortium

Photo: University of Victoria

PCIC staff (left to right): Leslie Gallacher, Markus Schnorbus, Rajesh Shrestha, Cassbreea Dewis, Arelia Werner, David Bronaugh, Faron Anslow, Greg Maruszeczka, Derek van der Kamp, Stephen Sobie, Trevor Murdock, Hailey Eckstrand, Anne Berland, Gerd Bürger, Dave Rodenhuis, and Francis Zwiers.

Regional Climate Impacts Projects 2010-2011

Photo: Francis Zwiers

The projects within the Regional Climate Impacts theme respond to the needs of regional climate stakeholders seeking a greater understanding of the potential impacts of climate variability and change at the regional scale. This includes knowledge of current trends and estimates of scientific uncertainty as well as the significance of climate model output, statistical descriptions, and climate model diagnostics.

Projected Climate Change in the Atlin-Taku Area of British Columbia

Team: Trevor Murdock (PCIC)
Stephen Sobie (PCIC)

Project Overview

This project was a collaborative effort with the Northern Climate Exchange at Yukon College to determine projections of future climate change in the area covered by the Atlin-Taku Land Use Plan in northern British Columbia.

Of particular concern for the Atlin-Taku region is the limited number of transportation links in the area, which could be impeded by changes in snowfall during winter or by an increased risk of forest fire in summer. Additionally, a run-of-river power production facility was recently constructed at Pine Creek to supply Atlin with electricity. Such facilities rely on sustained water levels so future changes in the regional hydrology could affect the facility's ability to generate electricity, possibly forcing a return to diesel generators as a source of power in the region.

Methods

Simulations from three different global climate models (GCMs) driven with standard greenhouse gas emissions scenarios were used to determine projected future climate impacts. The projected climate for the 2050s (2041-2070) relative to a historical baseline (1961-1990) was shown at high resolution using an elevation correction method based on PRISM and ClimateWNA.

In addition to the standard emissions scenarios, five other emissions trajectories comprising both higher-intensity emissions and emissions reduction scenarios were analyzed using the University of Victoria Earth System Climate Model.

The impacts of future climate change

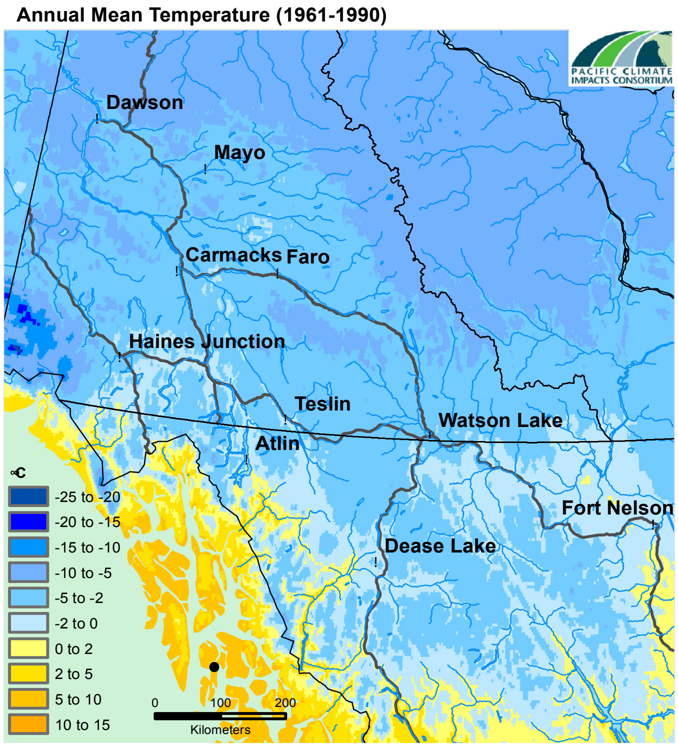


Figure 1 – Maps showing the historical (1961-1990) baseline using PRISM data and future projected (2041-2070) mean annual temperatures for the area covered by the Atlin-Taku Land Use Plan using CGCM3 A2 Run 4 (far right).

were identified in terms of ecosystem effects, specifically in the shifts from one biogeoclimatic zone to another due to changes in such parameters as Growing Degree Days (GDD), Frost Free Days (FFD) and the Summer Heat to Moisture Index (SHMI).

Results

Historical temperature and precipitation records for the Atlin-Taku region supplied by Environment Canada's CANGRID reveal that some climate change has already occurred during the period 1951-2007. These changes consist of statistically significant increases in mean annual temperature (0.2°C to 0.3°C per decade) and increases in mean annual precipitation (5% per decade) that vary both by season and location.

Analysis of projections from the full range of emissions scenarios indicate that the Atlin-Taku region will likely experience between 1.7°C and 2.7°C of warming by the middle of the 21st century, at least a 1.0°C increase even if net global greenhouse gas emissions are reduced to zero by 2050. Looking further into the future, the region could experience mean annual temperature increases of up to 6.0°C by 2100 and 9.0°C by 2200 under the highest-intensity emissions scenarios. The maps in Figure 1 provide an illustration of how projected temperature changes for the 2050s might manifest in the Atlin region.

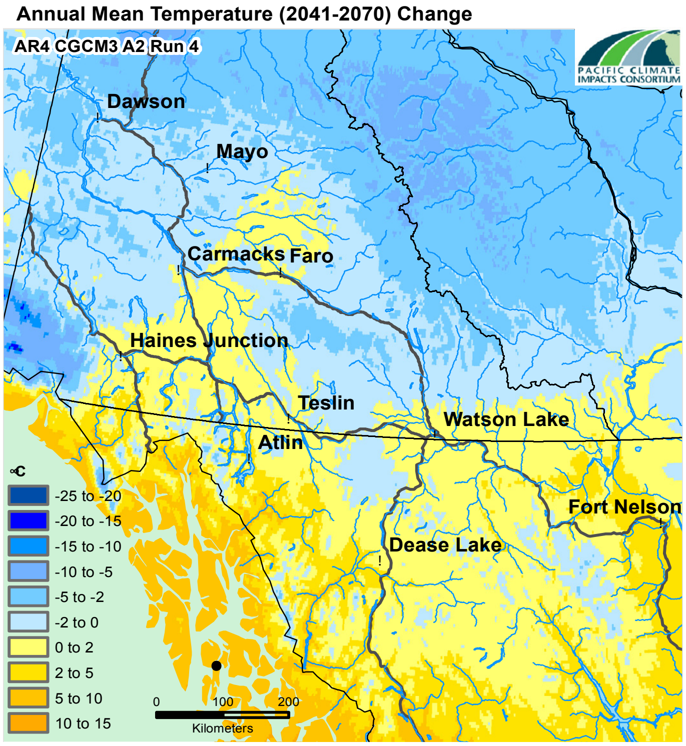
Accompanying this future warming is a shift in precipitation type from snow to rain. Mean annual snowfall is projected to decrease by up to 40% by 2100. The combined temperature and precipitation increases lead to increases in GDD, FFD and SHMI, resulting in reduced alpine vegetation and a shift to warmer biogeoclimatic zones in the inland portions of the Atlin-Taku region.

For all projected increases, climate variability in the form of the El Niño/La Niña Southern Oscillation and the Pacific Decadal Oscillation will act to moderate or enhance the changes, depending on their phases.

Results from this project have been used to inform the design and implementation phases of the Atlin-Taku Regional Land Use Plan.

Acknowledgements

Northern Climate Exchange, Yukon College • Canadian Parks and Wilderness Society – British Columbia chapter (CPAWS-BC) • Johnny Mikes and Chloe O'Loughlin (CPAWS-BC) • Jim Pojar, Claudia Howers, Gregory Kehm, Juri Peepre, Scott McNay (Impacts Researchers) • Dr. Shawn Marshall (University of Calgary), reviewer



ATLIN AND THE NORTHERN CLIMATE EXCHANGE

The Northern Climate Exchange initiated its first community-based adaptation workshop in 2007. The small northern BC community of Atlin was chosen as the pilot community due to its interest in climate change and high level of commitment to climate change adaptation. The Northern Climate Exchange involved PCIC scientists from the outset with PCIC providing regional scale climate modelling results that indicated the Atlin area will receive more precipitation and experience rising temperatures in the future, with seasonal variation. Atlin residents have been concerned about the effects of variable precipitation on forest fires, based on observations of increasing fire risk (even aged stands reaching maturity) to the community. These findings and the advice of other climate experts led to a community vulnerability assessment and in 2010, to the completion of a Community Adaptation Plan.

Regional Analysis of Extremes for Columbia Basin Trust Communities Adapting to Climate Change

Team: Trevor Murdock (PCIC)
Hailey Eckstrand (PCIC)
James Hiebert (PCIC)
David Bronaugh (PCIC)
Gerd Bürger (PCIC)

Project Overview

The objective of this project was to contribute to a greater understanding of future climate extremes affecting the Columbia Basin. Future climate change projections will be used by communities undertaking climate adaptation plans and workshops with the support of the Columbia Basin Trust (CBT).

These projections typically focus on changes in average values for temperature and precipitation over 30-year periods. This provides an overall assessment of the changing climate but does not necessarily assist in local adaptation decision-making, since impacts are often felt most directly through extreme events.

Methods

The assessment of projected changes in extremes was carried out in two ways. First, output from regional climate models was evaluated using a set of standard indices of climate extremes developed by the World Meteorological Organization Expert Team on Climate Change Detection and Indices. Second, a sophisticated statistical method called extreme value analysis (see, for example, von Storch and Zwiers 1999) was used to estimate changes in long-return period extreme events, such as warm temperatures that might be expected to recur only once every 25 years.

To ensure relevance to regional decision-making, PCIC solicited input from several contributors to CBT climate adaptation projects. The feedback was collected through a series of webinars conducted by PCIC.

Results

Figure 2 shows that the extreme warm day events that would be expected to recur about once in 25 years on average historically (based on the 1971-2000 climate) are projected to occur 2.4 to 10 times as often in the future (2050s). In general, we see a pattern of larger increases in extreme temperature for the southeastern portion of the basin.

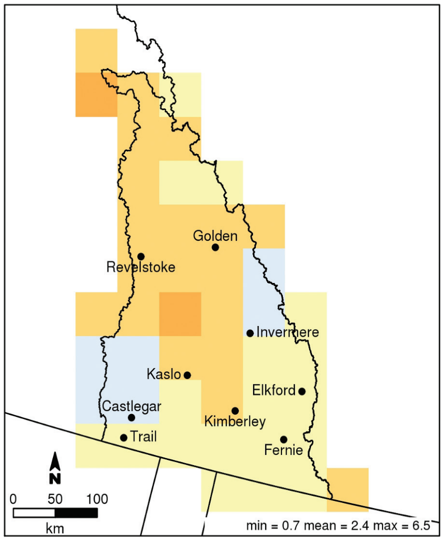
References

von Storch, H. and F.W. Zwiers, 1999: *Statistical Analysis in Climate Research*. Cambridge University Press, 484 pp.

Acknowledgements

Columbia Basin Trust: Ingrid Liepa, Kindy Gosal, Michelle Laurie, Cindy Pearce, Greg Utzig, Mel Reasoner, and Meredith Hamstead

CCSM driven MM5I

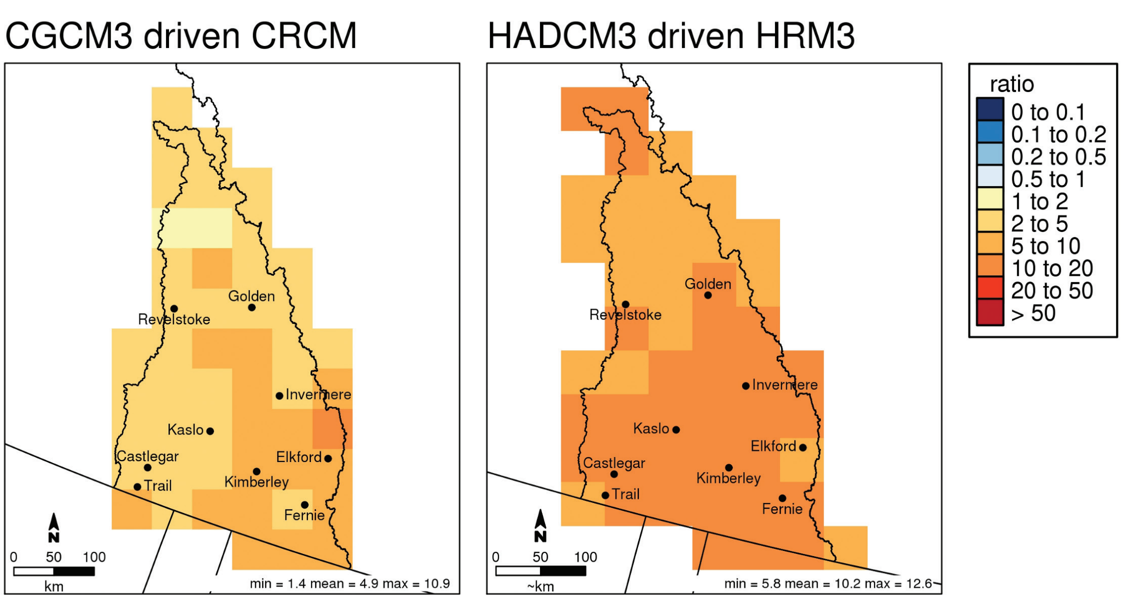


COLUMBIA BASIN TRUST
a legacy for the people

The Columbia Basin Trust (CBT) was created to promote social, economic and environmental well-being in the Canadian portion of the Columbia River Basin. In this role, CBT has made it a priority to help basin communities understand how projected climate change will impact their lives. To assist them, PCIC established a long-standing and mutually beneficial working relationship with CBT in 2005 by partnering with a variety of academic institutions to begin an assessment of the regional impacts of climate change in the Columbia Basin.

With the assistance of PCIC and other partner organizations, the CBT released a scientific report in late 2006 that detailed projected climate change impacts for the Canadian portion of the Columbia River Basin. Two years later, the CBT launched its Communities Adapting to Climate Change Initiative (CACCI). In its first phase the City of Kimberley and the District of Elkford used PCIC-prepared climate change scenarios to identify potential local impacts, vulnerabilities and risks to assist those communities in the development of implementation strategies. During the second phase of CACCI in 2010, CBT asked PCIC to provide basin communities with the best available scientific information on climate change in the region in support of community planning processes.

Figure 2 – Maps showing how much more often the baseline 25-year return period warm event is projected to occur in future (as ratio of occurrence in 2050s to 1971-2000) for the Canadian portion of the Columbia Basin. Shown are three of six projections representing (from left to right) low, medium and high estimates, averaged over the basin. CCSM, CGCM3 and HadCM3 are global climate models developed in the US, Canada and UK, respectively. MM5I, CRCM and HRM3 are regional climate models developed in the US, Canada and UK. The global and regional climate model simulations analyzed here used the IPCC SRES A2 emissions scenario. Regional simulations are courtesy of the NARCCAP project.



Infrastructure and Climate Risk on the Yellowhead Highway

Team: Gerd Bürger (PCIC)
James Hiebert (PCIC)
Trevor Murdock (PCIC)

Project Overview

Following on the success of its 2009 climate assessment project on British Columbia's Coquihalla Highway, PCIC was asked to provide a similar assessment for the Yellowhead Highway between Priestly Hill and Vanderhoof. In both assessments, past and future simulations of the impact of climate change on highway infrastructure were investigated.

Using downscaled results from several climate models, present and future estimates for temperature and precipitation were made, including a probability assessment of climate extremes. This study used regional climate model (RCM) simulations provided by NARCCAP, evaluated for the highway areas and with climate parameters and meteorological events that were defined by provincial and local engineers.

Methods

Two downscaling approaches were applied in the Yellowhead project: probability mapping and statistical downscaling.

a) Probability Mapping

Probability mapping is used to estimate climate change induced shifts in the frequency of climate or weather extremes (e.g., localized heavy rainfall events) using RCMs. When a heavy localized rainfall event is recorded at a particular weather station, the average rainfall over a larger area such as that represented by an RCM gridbox (approximately 50 km x 50 km) will be considerably less than the heavy localized precipitation experienced at the station. The most extreme events are thus not directly represented in the RCM, which provides only area averages over entire gridboxes. To relate the amount of heavy precipitation at a station to a different (lower) threshold in the RCM that corresponds to the heavy rainfall event, the threshold for defining the event must itself be downscaled.

To illustrate this, Figure 3 depicts the process for a normally distributed quantity such as temperature. The mapping is defined by identifying corresponding station and RCM quantiles (cf. the empirical transformation of Panofsky and Brier [1958]), and is applied to future RCM events.

b) Statistical Downscaling

In addition to the extremes addressed by threshold mapping, there is a need to consider changes to rare extreme events, such as those which would be expected to recur once every 100 years, on average. It is generally not possible to estimate the actual size of a typical 100-year rainfall event for the end of the 21st century using probability mapping alone. One possible solution to the problem is to use a full statistical (empirical) downscaling model. The goal is to obtain a quantitative link between large-scale atmospheric circulation and local-scale climate or weather events. This link is usually estimated from historical records of large-scale fields using reanalyses and small-scale station observations by using a statistical model. This model is applied to simulated future atmospheric fields to obtain future climate data for the station in question.

For the Yellowhead assessment PCIC applied the Expanded Downscaling

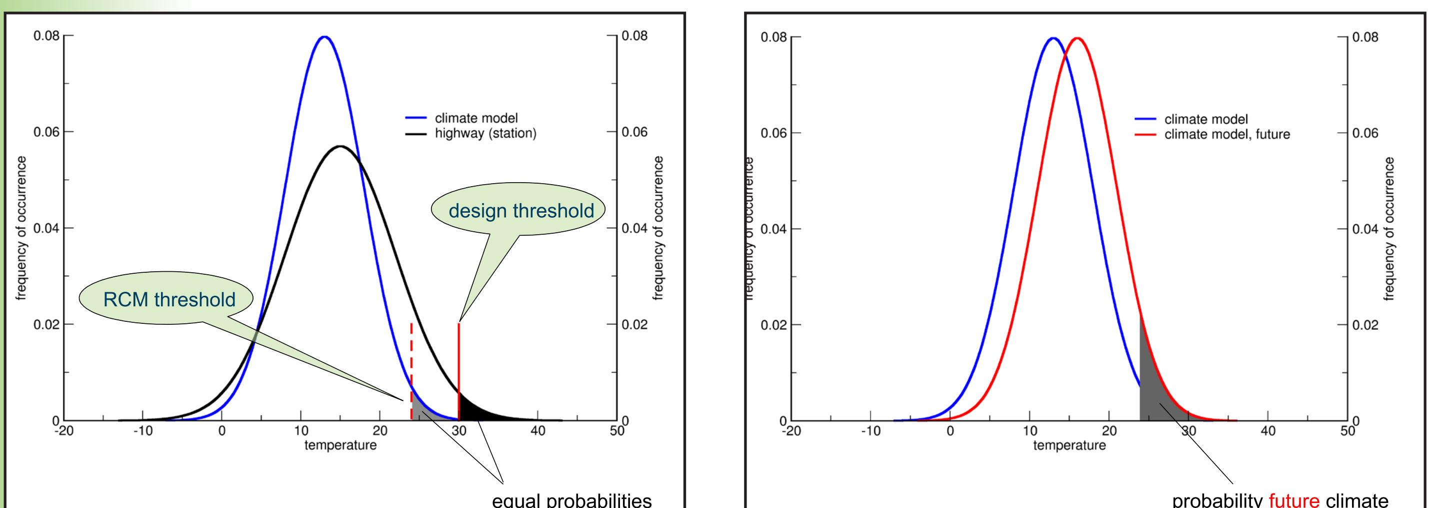


Figure 3 – Probability mapping. Local (station) and regional (RCM) scales of equal probability are identified, and future probabilities are derived directly from the RCM.

(EDS) method. EDS simulates local events as closely as possible and consistent with the prevailing atmospheric circulation (Bürger 1996). At the same time the EDS method generates local covariability that is realistic enough to be used for studying the impact of climate on weather extremes such as floods and droughts, and driving corresponding impact models.

Results

In general, the results from both probability mapping and statistical downscaling project an increase in temperature and precipitation for the study area. This trend towards a warmer and wetter future climate is highlighted in the more specific impacts highlighted below.

a) Probability Mapping

For the Yellowhead Highway, probability mapping reveals that rising temperatures will have the greatest impact on cold extremes. Low temperature events of -35°C or colder are projected to occur less frequently in the future, less than once per year instead of the current rate of five times per year. Similarly, an increase in the occurrence of very hot days (i.e., greater than 35°C) is projected. Most models project an increase in heavy precipitation events (more than 35 mm per day), though the actual probability (one such event every 30 years) is uncertain due to the small sampling size. All models agree that ground freeze, where maximum daily temperature is less than -5°C, will occur less often in the future.

A very important quantity for engineering purposes is snow accumulation but only one model, the Canadian Regional Climate Model (CRCM), reported results for snow accumulation, which limits confidence in future predictions for this quantity. However, the CRCM clearly projected a decrease in snowpack, a result corroborated by statistical downscaling.

b) Statistical Downscaling

EDS-based statistical downscaling produces daily time series of present and future climate for three variables: minimum temperature, maximum temperature and precipitation. From these variables, annual time series can be derived for the 27 Climdex indices used by the World Meteorological Organization to monitor climate extremes.

For example, future projections show a dramatic decrease in the number of frost days as well as an increase in the length of the growing season. Also estimated were the extremes for each of the three variables. Despite considerable uncertainty surrounding these estimates, a significant increase in the 100-year event for precipitation (42-66 mm per day) was projected. For maximum temperature the 100-year event increases from 39°C to 42°C, while the corresponding minimum temperature event increases from -55°C to -50°C.

References

Bürger, G, 1996: Expanded Downscaling for Generating Local Weather Scenarios. *Climate Research*, 7, 111-128.

Acknowledgements

BC Ministry of Transportation and Infrastructure: Dirk Nyland and Jim Barnes.

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Transportation and Infrastructure

As part of its contribution to implementing the BC Climate Action Plan, the BC Ministry of Transportation and Infrastructure (MoTI) has committed to reducing carbon emissions in their sector. As well, the MoTI has taken steps to support adaptation to the present and future impacts of climate change and variability in the province. Through its partnership with PCIC, the ministry is engaging in projects aimed at better understanding the potential effects of climate change on transportation infrastructure such as roads and bridges. In 2009 the BC MoTI partnered with PCIC on a pilot project to establish climate change specific parameters for infrastructure planning. The BC MoTI and PCIC continue to collaborate on the development of methods for providing probability estimates of extreme weather events on the Coquihalla Highway.

Future Projections of Fire Weather Severity in Southeast British Columbia

Team: Derek van der Kamp (PCIC)
Gerd Bürger (PCIC)

Project Overview

Wildfire is a significant source of ecosystem disturbance and property damage in British Columbia and climate plays a significant role in determining wildfire severity. Building on the experiences of previous studies, this project produced statistically downscaled projections of future fire weather severity for seven meteorological stations in southeast British Columbia using global climate models (GCM) and the Canadian Fire Weather Index (FWI) system.

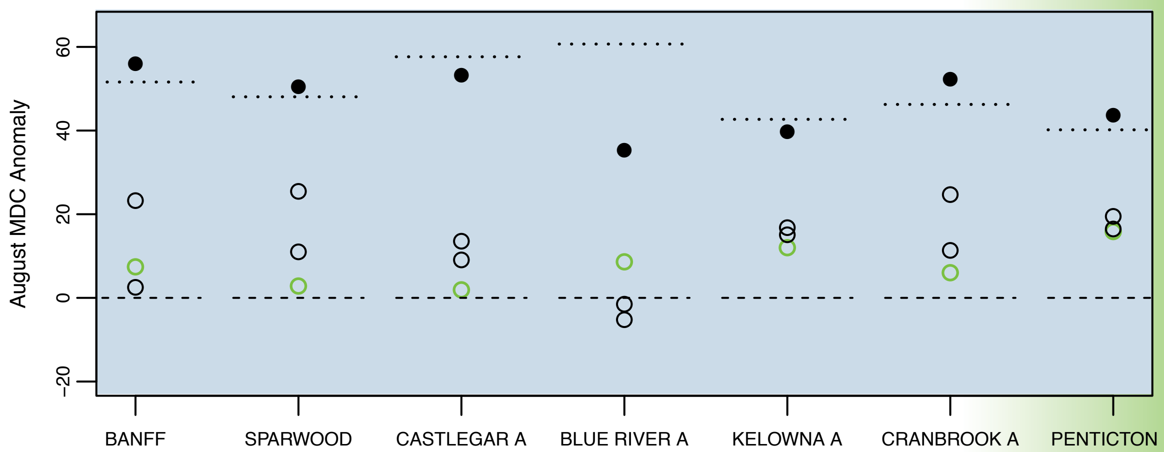
Methods

The project team developed a technique in which projections of wildfire severity were made for a number of stations within southeast BC using Expanded Downscaling (EDS), a multivariate technique that accounts for the unique climatology of each station (Bürger 1996). The EDS approach uses multivariate linear regression to connect large-scale predictors which are well-simulated by GCMs (e.g., winds in the mid-troposphere) to local variables at specific stations. EDS places constraints on these regressions by maintaining both the variability and covariance across all stations and variable types. The EDS method provided future daily time-series for four climate variables required as input to the FWI system: temperature, precipitation, relative humidity, and wind speed. This was done at each station and for each combination of GCM and emissions scenario. Output from two GCMs and two different emissions scenarios provided a range of plausible future climate projections for the fire weather indices in the study area.

Results

Before applying the EDS procedure to future climate projections, PCIC assessed its ability to downscale historical observations. While the downscaled temperatures were generally accurate, downscaling of precipitation proved problematic. Moreover, the EDS routine had significant difficulty in downscaling wind speed, consistent with the findings of a previous PCIC project aimed specifically at downscaling surface winds in BC. Consequently, a decision was made to focus on the Monthly Drought Code (MDC), a component of the FWI system which requires only monthly values for temperature and precipitation, avoiding the need to simulate daily values and wind speed. The MDC has been shown to correlate well with the severity of the wildfire season. Preliminary results show that while temperatures are projected to increase by between 1°C and 4°C for the 2080s (2071-2100), there is no obvious systematic shift in precipitation for southeastern BC. Significant negative and positive changes in MDC were calculated, depending on the station. Consequently, the results do not indicate any significant region-wide changes in fire weather severity as represented by the August MDC (Figure 4). This contrasts with results from previous studies which suggested significant increases in fire weather severity for southeastern BC (Flannigan et al. 2005). In these studies, changes for a specific variable were drawn solely from the raw GCM output for that variable, while the changes produced by the EDS are a function of changes in a variety of predictor GCM fields. This difference may explain a considerable portion of

Figure 4 – Anomalies of August MDC values for the 2050s at all seven Environment Canada stations used in this study. Results are provided for CGCM3 A1B (black) and ECHAM5 A2 (green). Solid circles indicate statistically significant anomalies at the 5% level (determined by a two-sample t-test). The gray dotted lines indicate the average historical standard deviation of August MDC at each station.



the discrepancy between results. Also, the emissions scenarios used here generally result in cooler and wetter projections relative to those used previously.

Acknowledgements

Climate Data and Analysis Section of Environment Canada • Steve Taylor (Canadian Forest Service) • Daniel Perrakis and Eric Meyer (BC Ministry of Forests, Lands and Natural Resource Operations)

References

Bürger, G., 1996: Expanded Downscaling for Generating Local Weather Scenarios. *Climate Research*, 7, 111-128.

Flannigan, M.D., B.D. Amiro, K.A. Logan, B.J. Stocks, and B.M. Wotton, 2005: Forest Fires and Climate Change in the 21st Century. *Mitigation and Adaptation Strategies for Global Change*, 11, 847-859.

Environment Canada | Environnement Canada

Environment Canada (EC) plays an important role in support of regional climate services. As a federal department, Environment Canada acts as a service provider to regional climate service organizations, offering access to climate model output and results from other national research initiatives.

PCIC has longstanding collaborative relationships with Environment Canada research centres like the Canadian Centre for Climate Monitoring and Analysis (CCCma) and the Water & Climate Impacts Research Centre (W-CIRC). In the past year, PCIC had the opportunity to strengthen that relationship to include EC's Climate Data Analysis section by working on a project exploring the potential for using statistical downscaling to assess local changes in fire weather severity. While the geographical scope for this work was limited to southeastern BC, project results and methods should have application across the country.

Downscaling Intercomparison Project

Team: Gerd Bürger (PCIC)
Trevor Murdock (PCIC)
Arelia Werner (PCIC)
Stephen Sobie (PCIC)

Project Overview

The objective of PCIC's Downscaling Intercomparison Project was to provide a rigorous evaluation of the comparative strengths and weaknesses of several popular statistical methods of downscaling climate extremes.

Meeting the need for practical local-scale climate information is a key challenge for climate scientists working from large-scale global climate models (GCMs). GCMs typically simulate values for temperature and precipitation as averages over fairly large spatial areas, leaving analysts guessing about potentially important local variations within those areas. Such local-scale information is required to understand the possible impacts of climate variability and change on climate extremes.

To bridge the gap between global scale GCM output and local scale impacts, climate scientists have developed a number of downscaling techniques, using either regional climate models or various statistical methods. A large number of statistical downscaling approaches are available, and thus some guidance on which method is most appropriate for a particular application and locale is desirable.

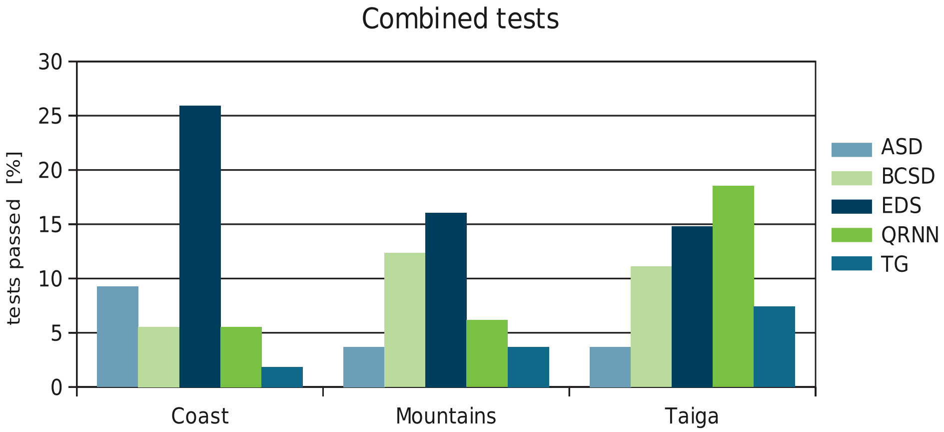


Figure 5 – Graph showing the percentage of tests passed for each of the five statistical downscaling methods, across all 27 Climdex indices and grouped by major climate region. EDS appears to have performed best overall, and overwhelmingly so on the BC coast, though QRNN performed better in the northern taiga region of the province.

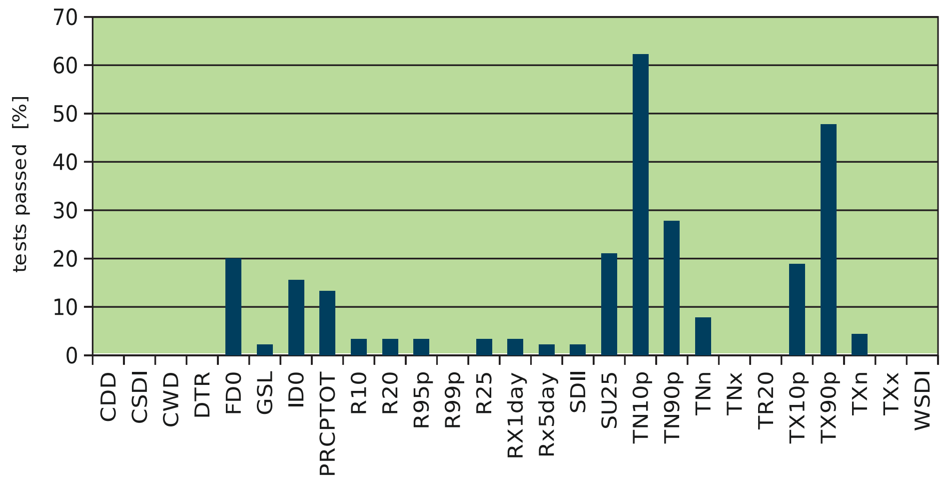


Figure 6 – Graph showing the percentage of tests passed across all five statistical downscaling methods and study areas for each of the 27 Climdex indices for representing climate extremes. For detailed definitions of each index see http://cccma.seos.uvic.ca/ETCCDI/list_27_indices.shtml.

Methods

Initially, five methods were compared: Automated Statistical Downscaling (ASD), Bias-Corrected Spatial Disaggregation (BCSD), Expanded Downscaling (EDS), Quantile Regression Neural Networks (QRNN) and TreeGen (TG). These techniques were tested for their ability to represent local climate extremes in British Columbia, a region that presents a significant challenge for downscaling due to its widely varying topography. The performance of the various techniques was assessed through the use of the so-called Climdex indices, a set of 27 climate indicators used by the World Meteorological Organization for measuring climate extremes.

Temperature and precipitation data from seven meteorological stations in four different climate zones of British Columbia were used to determine values and distribution for each index. Three statistical tests were applied for each combination of downscaling method and index in order to ascertain the method's ability to reproduce the distribution of each index.

Results

Initial results appear to favour EDS overall as the most reliable method among the five downscaling techniques tested for representing climate extreme indices in the study areas. However, individual test results vary widely by region and by index. Figure 5 and Figure 6 show summarized results of the model intercomparison by study region and index, respectively. These results are being submitted for publication in a peer reviewed scientific journal. Additional downscaling methods and study areas are planned for inclusion in the project's final report, expected in December 2011.

Photo: iStockphoto

Ripening grapevines in British Columbia's Okanagan valley. Assessing the possible future impacts of climate variability and change at the local level using large-scale global climate model results can be a particular challenge for climate scientists in BC due to the province's widely varying topography.

Acknowledgements

BC Ministry of Forests, Lands and Natural Resource Operations, Future Forests and Ecosystems Scientific Council (FFESC) • BC Ministry of Environment

BRITISH COLUMBIA
The Best Place on Earth

MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

The BC Ministry of Forests, Lands and Natural Resource Operations is a long time partner of PCIC and very concerned with climate change and its implications. In March 2011, the ministry was restructured to include additional sectors and renamed accordingly. Its Senior Research Climatologist Dave Spittlehouse has championed several collaborative projects with PCIC. Past projects have focused on improvements to the ClimateWNA database and production of high spatial resolution climate projections. In 2010, PCIC and the ministry embarked on a project to further develop databases created through past projects, focusing on creating a time series of drought indices for the province. PCIC's Downscaling Intercomparison Project is another example of collaboration between the two parties, the results of which will allow ministry staff and PCIC to select the most appropriate downscaling method for various applications and different regions.

Corporate Connections

Pacific Institute for Climate Solutions
Knowledge. Insight. Action.

The Pacific Institute for Climate Solutions (PICS) is hosted and led by the University of Victoria in collaboration with the University of British Columbia, Simon Fraser University and the University of Northern British Columbia. From mitigation to adaptation, PICS researchers, fellows and associates work on applied solutions to the challenges faced by policymakers, planners and communities in a changing climate. The institute is headquartered alongside PCIC at the University of Victoria and is a natural partner to the consortium's physical science based applied research. Together, they host a multidisciplinary lecture series that aims to bring diverse academic and practitioner communities together to discuss pertinent climate related topics. In addition, PCIC and PICS are collaborating to advance the work of the BC government's Climate Related Monitoring Program.

PICS also engaged PCIC scientific expertise in the development of its Climate Change 101 online short courses, designed for educating the BC public service and the general public on climate change fundamentals. The course places regional emphasis on climate change adaptation and mitigation while considering climate change in a global context. PCIC Director Francis Zwiers along with PICS Executive Director Tom Pedersen provided the content for Module 1, the first of four modules titled "Climate Science". Module 1 provides an understanding of the scientific basis for changes in the Earth's climate, both natural and human-induced. PCIC will also be contributing content and scientific advice during the development of the upcoming second module on adaptation.

British Columbia
The Best Place on Earth
Ministry of Environment

The BC government is preparing for climate change. Policymakers realize that while mitigation efforts may delay the effects of climate change and reduce impacts over the long term, the earth will continue to warm, leading to more extreme weather, changes in precipitation patterns, and rising sea levels.

The BC government has developed a framework for addressing the impacts of climate change through planned adaptation, part of the BC Climate Action Plan. This adaptation strategy has three defining goals:

- *build a strong foundation of knowledge and tools to help public and private decision makers across BC prepare for climate change*
- *make adaptation part of the BC government's business, ensuring that climate change impacts are considered in planning and decision-making across government*
- *assess risks and implement actions in key climate-sensitive sectors*

To this end, the BC Ministry of Environment provided base funding to PCIC through an endowment established specifically to support climate change research in the province. This endowment supports PCIC's core capacity to provide climate services to address user needs.

Hydrologic Impacts Projects 2010-2011

Photo: BC Ministry of Transportation and Infrastructure

Projects within the Hydrologic Impacts theme address the vital importance of water, and are concerned with estimating the effects of climate variability and change on the water resources of British Columbia using hydrologic models and regional climate model output.

Synthesis Project - Hydrologic Modelling and RCM Diagnostics

Team: Rajesh Shrestha (PCIC)
Anne Berland (PCIC)
Markus Schnorbus (PCIC)
Arelia Werner (PCIC)

Project Overview

Projected future changes in precipitation and temperature are likely to affect hydrologic processes, such as snow accumulation and melt, evapotranspiration and runoff generation. Therefore, an assessment of climate change impacts on the hydrological cycle is important for long-term water resource management in the province. This project assessed the robustness of results obtained using two fundamentally different approaches to projecting changes in the hydrological cycle.

Methods

The Hydrologic Modelling project used an ensemble of bias-corrected and statistically downscaled global climate model projections (referred to as EGB) of temperature and precipitation. The EGB results were subsequently used to drive the Variable Infiltration

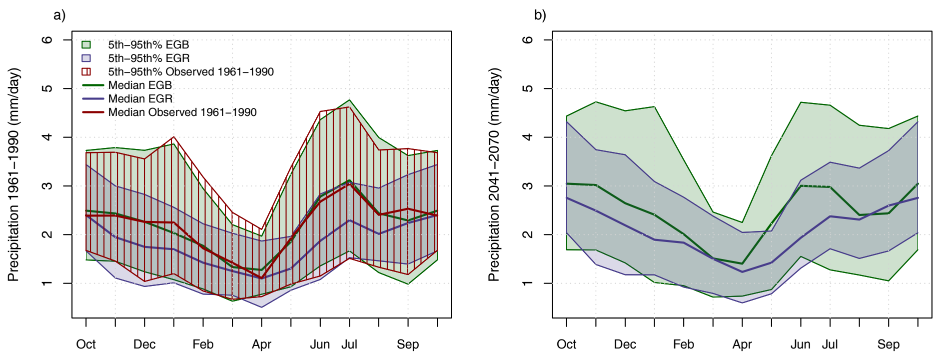


Figure 7 – EGB and EGR monthly average precipitation in the Peace River watershed for a) baseline (1961-1990) and b) future (2041-2070) periods. Temperature for the baseline period is also compared with observations.

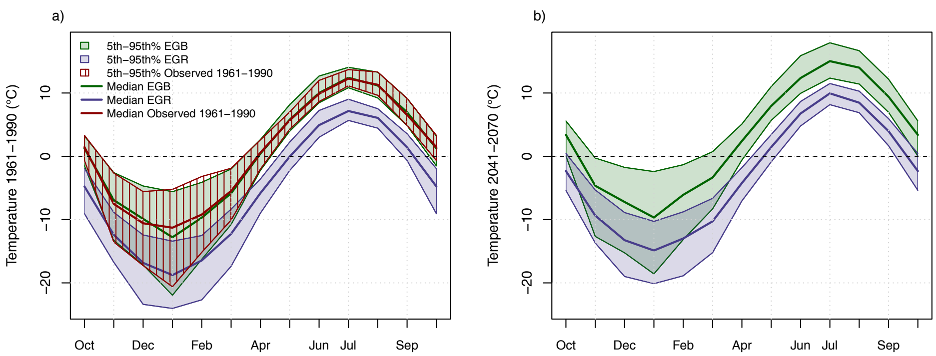


Figure 8 – EGB and EGR temperature in the Peace River watershed for a) baseline (1961-1990) and b) future (2041-2070) periods. Precipitation for the baseline period is also compared with observations.

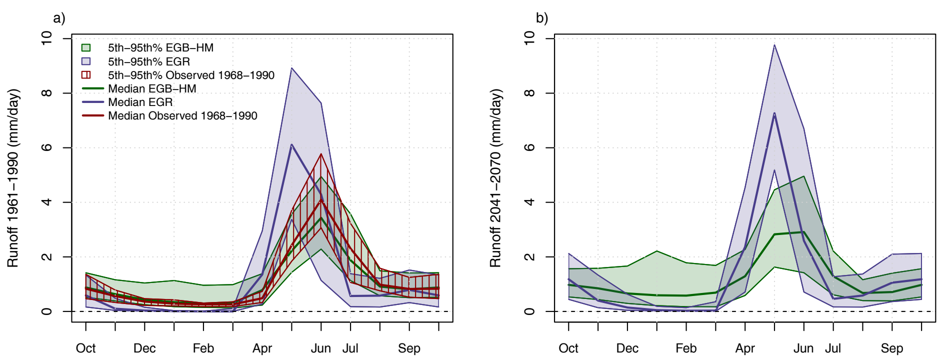


Figure 9 – EGB-HM and EGR monthly average runoff in the Peace River watershed for a) baseline (1961-1990) and b) future (2041-2070) periods. Runoff for the baseline period is also compared with observations (1968-1990).

Capacity hydrologic model to provide historical and future hydrologic projections (referred to as EGB-HM). In contrast, the Regional Climate Model Diagnostics project analyzed dynamically downscaled raw output from the Canadian Regional Climate Model, driven by multiple runs of the Canadian Coupled Global Climate Model. This ensemble of regional climate model results (referred to as EGR) provided historical and future projections of both climate and hydrology. A comparative analysis of model output from the two approaches was conducted, including a comparison of results for precipitation, temperature, evapotranspiration, snowfall, snow water equivalent and runoff.

Results

Results from the synthesis project validate the work from the Hydrological Modelling and RCM Modelling projects but also revealed some interesting differences between the two approaches. Specifically, monthly precipitation and temperature output of the EGB and EGR methods show appreciable differences in magnitude and range (Figure 7 and Figure 8, respectively). Since EGB output is bias-corrected and scaled to match observations, it corresponds much more closely with observations. These differences in downscaled precipitation and temperature between EGB and EGR are also reflected in future projections.

However, the two approaches project similar changes in the climate and hydrologic variables, namely:

- Temperature is projected to increase in all seasons, with higher increases in winter (Peace) or summer (Upper Columbia).
- Both approaches project increases in precipitation. Seasonally, the output projects higher precipitation increases in autumn, winter and spring, and lower increases (Peace) or decreases (Upper Columbia) in summer.
- Both approaches project an increase in runoff and shifts to an earlier occurrence of spring runoff peaks for both watersheds. Both approaches also project increases in total runoff volumes, which may be accompanied by a decrease in summer runoff in both watersheds. Projected changes for other hydrologic variables are also similar between the two approaches.

Full results for this project can be found in Shrestha et al. (2011).

References

Shrestha, R.R., A.J. Berland, M.A. Schnorbus, A.T. Werner, 2011: Climate Change Impacts on Hydro-Climatic Regimes in the Peace and Columbia Watersheds, British Columbia, Canada. Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC. 37 pp.

Acknowledgements:

BC Hydro • Biljana Music (Ouranos) • Marco Braun (UQAM/Ouranos) • Daniel Caya (Ouranos)

OURANOS

Ouranos is a Montréal-based consortium whose members include the Québec government, Hydro-Québec, Environment Canada, Université du Québec à Montréal, Institut national de la recherche scientifique, Université Laval and McGill University. Manitoba Hydro, Ontario Power Generation, Rio Tinto Alcan and l'École de technologie supérieure are affiliated members of Ouranos. Its mandate is to provide the regional climate information and scientific support required for detailed climate impacts and adaptation projects. This mandate aligns with PCIC's to create the basis for a natural working partnership between the two consortia.

Ouranos is a valuable source of scientific expertise for PCIC as well as a supplier of regional climate model projections. Past collaborations with Ouranos have capitalized on its specialized expertise in regional climate modelling applied to hydrology. In 2010, Ouranos scientists worked alongside other PCIC partners to assess projected future climate and hydrologic impacts on key BC watersheds using regional climate model output. Future collaboration is expected to lead to continual refinements in this promising area.

Hydrologic Modelling in the Peace, Campbell and Columbia Watersheds

Team: Markus Schnorbus (PCIC)
Katrina Bennett (PCIC)
Arelia Werner (PCIC)
Anne Berland (PCIC)

Project Overview

The main objective of the Hydrologic Modelling project was to estimate the hydrologic impacts of future climate change on select BC watersheds. Hydroelectricity is the largest source of electric power generation in the province and much of it is generated by BC Hydro in the Peace and Columbia River systems. To assess the hydrologic impacts of climate change a high-resolution, physically-based macro-scale hydrologic model was applied within the Peace, Campbell and Upper Columbia watersheds in British Columbia (Figure 10). These three watersheds contain numerous important BC Hydro facilities for hydroelectric generation and represent a range of hydro-climatic regimes. Streamflow projections were made for several locations within the study areas, corresponding to current BC Hydro facilities, potential sites for future hydroelectric development, and several natural drainages.

This project was also reported on in the *PCIC Corporate Report 2009-2010* while results were still preliminary. It was completed in December 2010.

Methods

This study used a set of eight global climate models (GCMs) driven by three SRES emissions scenarios, intended to capture a range of high, medium and low projected greenhouse gas

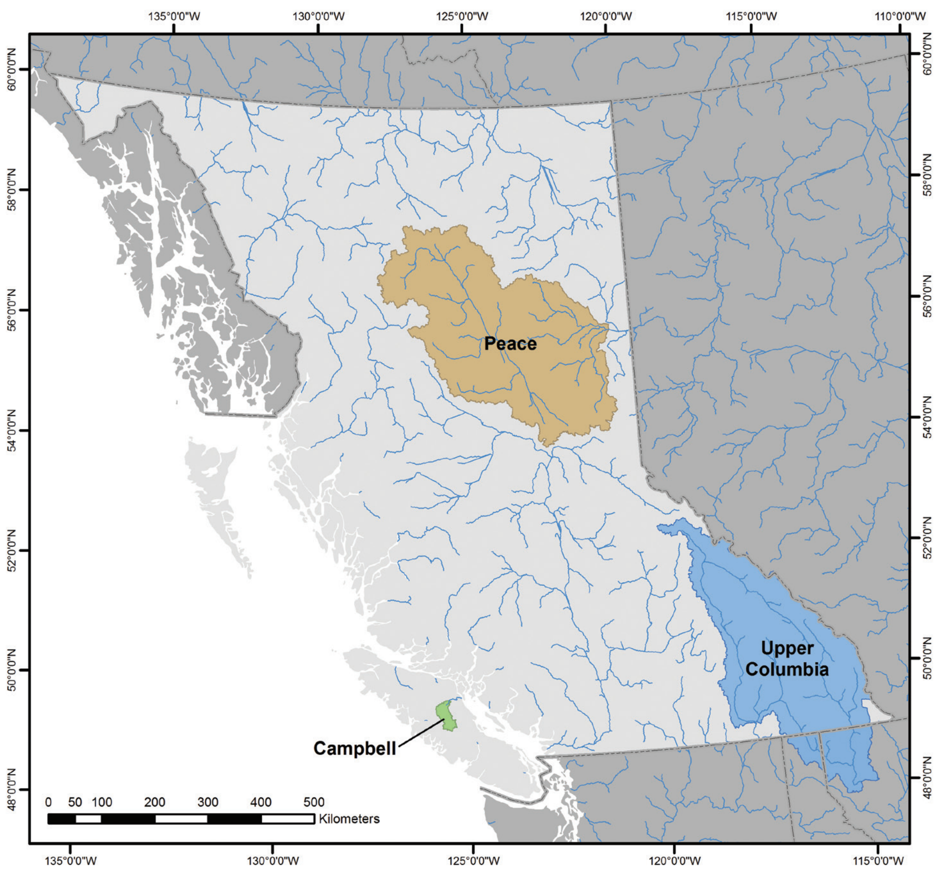


Figure 10 – Map of British Columbia showing major river systems as well as the PCIC study areas on the Peace River (tan), Upper Columbia River (blue) and Campbell River (green).

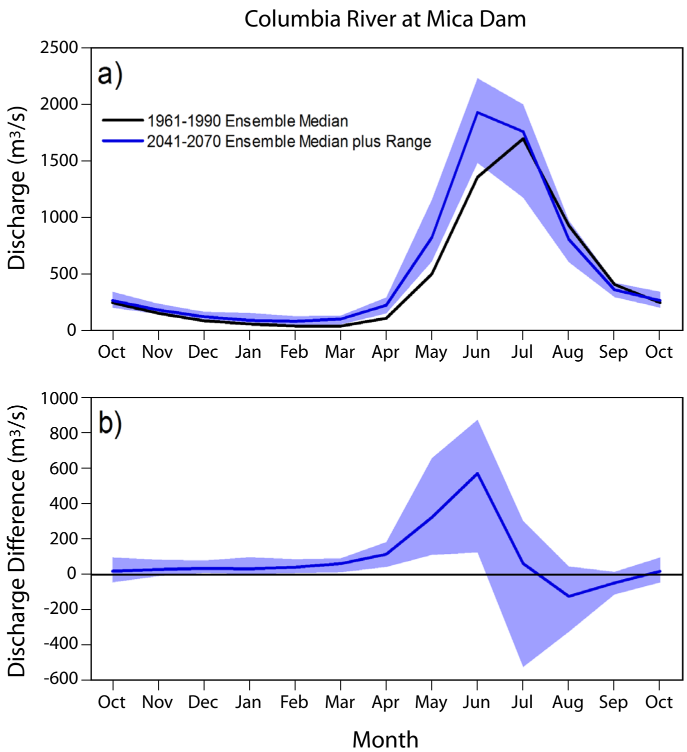


Figure 11 – Hydrographs showing median monthly discharge rates for the Upper Columbia River at Mica Dam. The black line shows the modelled historical pattern of streamflow while the blue line represents the median discharge for all models and emissions scenarios used in the study. The blue shaded areas illustrate the range of results from the various models and emissions scenarios used. The bottom graph shows the same results as the top graph but presents them as a change in discharge rate compared to the baseline period.

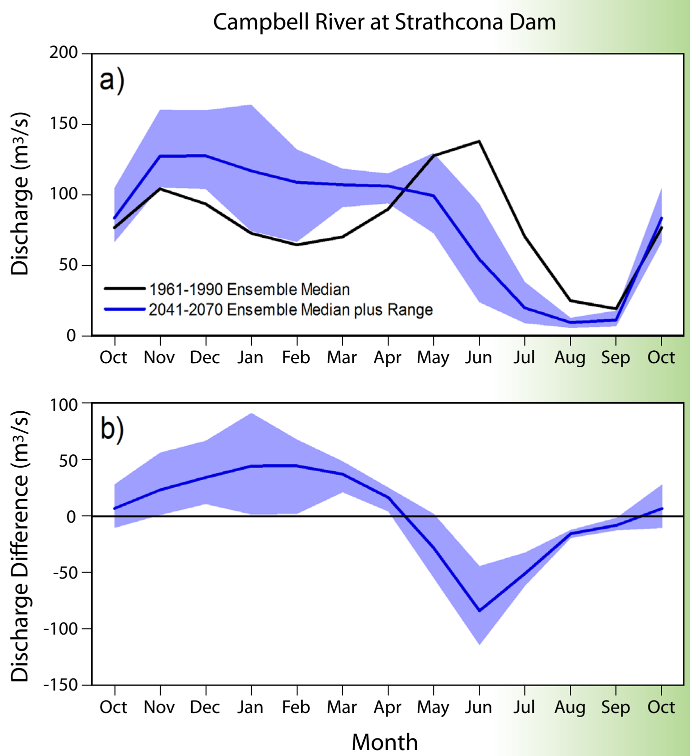


Figure 12 – Hydrographs showing median monthly discharge rates for the Campbell River at Strathcona Dam. The black line shows the modelled historical pattern of streamflow while the blue line represents the median discharge for all models and emissions scenarios used in the study. The blue shaded areas illustrate the range of results from the various global climate models and emissions scenarios used. The bottom graph shows the same results as the top graph but presents them as a change in discharge rate compared to the baseline period.

concentration increases and to project a wide range of potential climate responses for the 2050s (2041-2070) period. GCM results were statistically downscaled and used to drive the Variable Infiltration Capacity (VIC) hydrology model at high spatial resolution. This methodology of selecting multiple GCMs coupled to three emissions scenarios covers a wide range of potential future climates for BC and explicitly addresses both emissions and GCM uncertainty in the final hydrologic projections.

Results

Projected climate and hydrologic results for the three watersheds are summarized below:

- All projections indicate higher temperatures in all seasons and all study areas by the 2050s, with strong agreement across GCMs and emissions scenarios.
- Precipitation projections are less robust for the 2050s (i.e., the range of individual GCM projections includes both positive and negative changes), but suggest increased precipitation in the winter, spring and fall for all study areas under all emissions scenarios.
- Annual discharge in the Peace River and Upper Columbia study areas is projected to increase at the majority of locations studied for all emissions scenarios. Annual discharge changes for the Campbell River study area are expected to be negligible.
- Monthly streamflow projections for locations on the Upper Columbia show a consistent trend towards higher future discharge during

fall and winter, an earlier onset of spring melt, and reduced discharge during late summer and early fall (Figure 11). Changes in the timing and duration of the spring melt result in the largest absolute changes in monthly discharge. Differences in the monthly discharge response between the three emissions scenarios are negligible. Monthly streamflow projections for the Peace River are similar.

- Monthly streamflow projections for the Campbell River study area show a strong shift in seasonality due to a transition from a hybrid rainfall-snowmelt regime to an almost exclusive rainfall regime (Figure 12). This transition is expected to result in large increases in fall and winter discharge, and decreases in spring, summer, and early fall discharge, including a longer and more severe low flow period.

References

Werner, A.T., 2011: BCSD Downscaled Transient Climate Projections for Eight Select GCMs Over British Columbia, Canada. Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC, 63 pp.

Schnorbus, M.A., K.E. Bennett, A.T. Werner and A.J. Berland, 2011: Hydrologic Impacts of Climate Change in the Peace, Campbell and Columbia Watersheds, British Columbia, Canada. Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC. 157 pp.

Acknowledgements

BC Hydro • BC Ministry of Environment

BC hydro

FOR GENERATIONS

In December 2010, PCIC and BC Hydro successfully completed a four-year collaborative research agreement governing a series of hydrological studies on BC watersheds. In March 2011, PCIC published four peer-reviewed project reports detailing the results of this important work on the potential impacts of climate variability and change in the Upper Peace, Upper Columbia and Campbell River basins. These reports contribute to BC Hydro's ongoing commitment to supporting an enhanced provincial capacity for climate change adaptation. Through its commitment to another four-year agreement with PCIC (2011-2015) BC Hydro has further demonstrated its support for directed applied research on climate change impacts and the sustainable operation and planning of BC Hydro facilities into the future.

As an active member of both PCIC's Program Advisory Committee and its Board of Directors, BC Hydro has been instrumental in guiding the direction of the consortium over the last four years. The corporation has benefited from PCIC work in calculating future hydrological conditions, including streamflow projections in the 2050s period, and in developing a greater understanding of climate change impacts on water resources in the province.

Climate Analysis and Monitoring Projects 2010-2011

Photo: iStockphoto

The projects within the Climate Analysis and Monitoring theme support the BC government's Climate Related Monitoring Program (CRMP) through the development of an integrated climate dataset for all of BC, including the production of detailed climate maps of the Pacific and Yukon Region of Canada.

Climate Analysis and Monitoring (CAM) - Data Inventory

Team: Dave Rodenhuis (PCIC)
Faron Anslow (PCIC)
James Hiebert (PCIC)
Hailey Eckstrand (PCIC)

Project Overview

The Climate Analysis and Monitoring Program (CAM) at PCIC is a multi-year project under the Climate Related Monitoring Program (CRMP), developed to support the Climate Change Adaptation Strategy of the BC government. The BC Ministry of Environment leads this multi-agency program. The CAM project and its subprojects were founded on the understanding that monitoring changes in the current climate is essential for the preparation of climate change adaptation and mitigation strategies. Moreover, analyses of climate anomalies are needed to highlight climate variability in the midst of ongoing climate change, or to interpret and attribute extreme weather/climate events. While the existing observational database hosted by Environment Canada is critically important, it is insufficient to define the climatic conditions of British Columbia, characterized by widely varying topography and a scarcity of historical data.

The Data Inventory Project is a phase of CAM. Throughout 2010 and the early part of 2011, its focus has been on the development of an inventory of available weather data collected from regional networks in the province to determine its potential use for climate analysis and monitoring.

The sources for this data were identified during the data inventory project and are the initial elements in the development of the Provincial Climate Data Set (PCDS) at PCIC. In addition to working with Environment Canada, PCIC has also engaged with researchers at Oregon State University's PRISM Climate Group to obtain and apply PRISM technology to the development of monthly climate maps for the 1971–2000 climate normal period and monthly climate time series for BC using the PCDS.

Methods

The project team's first task was to establish an inventory of stations and available data from the CRMP BC provincial network. Inventory development consists of five steps:

- identification of station locations and their basic attributes (e.g., elevation) within the nine EcoProvinces of BC (Figure 13);
- organization of existing observational data (transferred to PCIC in disparate formats) into a common framework for access, quality control, and analysis;
- an assessment of time gaps in the data relative to neighbouring Environment Canada stations;
- an assessment of data quality for each network through the application of basic quality control procedures to all variables in the PCDS;
- follow-up meetings with each

PRISM CLIMATE GROUP

In the late 1990s, the BC government collaborated with the PRISM Climate Group at Oregon State University (OSU) to develop digital precipitation and temperature maps for BC. The maps are generated from datasets that use the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system. PRISM Climate Group Director Christopher Daly developed PRISM, a knowledge-based system that uses point measurements of precipitation, temperature and other climatic factors to produce continuous digital grid estimates of yearly and event-based climate parameters. This system provides the ability to update BC climate maps to improve accuracy and resolution. Recognizing the opportunity presented by this technology and the prospect of developing other historical and future datasets important to BC, such as dew point maps, time series grids, and improved downscaled estimates, PCIC and OSU have entered into a three-year collaborative agreement.

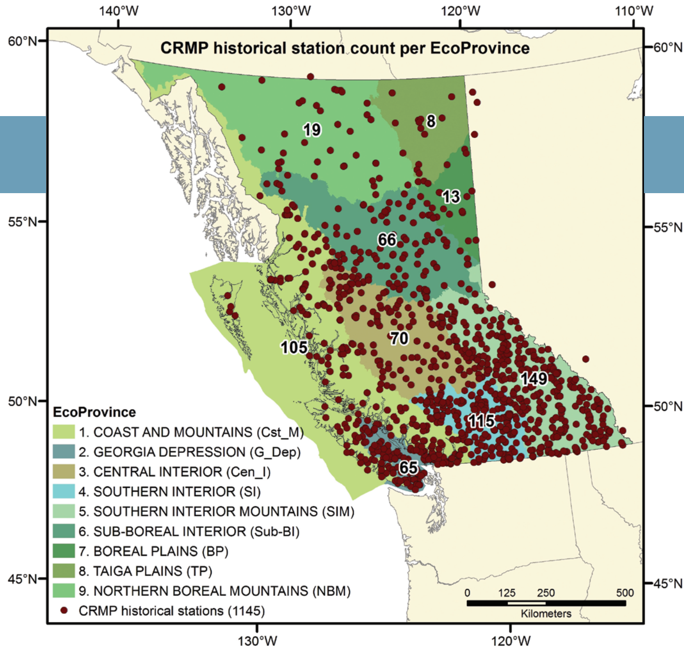


Figure 13 – Map showing the distribution of stations from the CRMP Network and the number of stations in each EcoProvince of British Columbia. The regions are defined at: http://www.env.gov.bc.ca/ecology/ecoregions/polareco.html

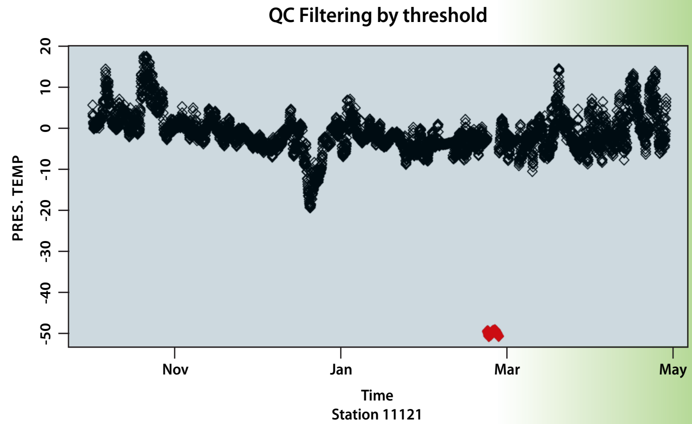


Figure 14 – An example graph showing the distribution of temperature values after quality control analysis, which is used to detect and flag 'out of range' station measurements (depicted as red dots in the figure).

CRMP NETWORK

The BC ministries of Environment, Transportation and Infrastructure, Forests, Lands and Natural Resource Operations, and Agriculture, together with BC Hydro, Rio Tinto Alcan and PCIC, signed an agreement establishing the Climate Related Monitoring Program to make long-term meteorological data available for professional users involved in climate change analysis. Data products derived from this information will be made available through the PCIC website under the Climate Analysis and Monitoring theme. The CRMP network is an extensive resource that includes more than 1,500 monitoring stations throughout British Columbia with some location records dating back as far as 1917.

network coordinator to review the results and ensure that the shared datasets are as complete as possible.

Results

A foundation has been laid for a major component of PCIC's Climate Analysis and Monitoring (CAM) program. At the outset, seven provincial networks contributed data from more than 1,145 historical observational sites (Figure 13) and more than 612 active sites. In addition, three more datasets have been identified, and historical records dating back to 1917 have been recovered. The observations of daily maximum temperature, minimum temperature, and precipitation will form the basis for the province-wide dataset. This set will be composed of historical data and current observations that will be used to supplement monthly climate records from Environment Canada. The acquired data was assessed in terms of temporal coverage and quality. The quality checking has been non-destructive – suspect measurements are flagged for further inspection or exclusion. The completion of quality control will be conducted jointly with the PRISM Climate Group for the purposes of developing provincial climate maps. The completed inventory of data from CRMP provincial networks will form the foundation for developing a high resolution, monthly climatology for British Columbia, as well as a 50-year time-series of monthly temperature and precipitation, resolved for any point in the province.

Acknowledgements

BC Ministry of Environment • BC Ministry of Forests, Lands and Natural Resource Operations • Pacific Institute for Climate Solutions • PRISM Climate Group, Oregon State University

Treasurer's Report

Cassbreea Dewis, Treasurer, PCIC Board of Directors

As a not-for-profit, federally incorporated entity, PCIC financial statements are independently audited according to generally accepted accounting principles and following Canadian auditing standards. The 2010-2011 PCIC financial statements mark my fifth consecutive year as PCIC treasurer. In that time, PCIC has developed into a mature organization with a full roster of scientific staff, long-term funding agreements with stakeholder organizations, a steady rotation of shorter term stakeholder agreements, and stable year-to-year revenue and expenses.

The 2010-2011 financial statements, illustrated in the pie charts below, describe an established organization. This past year was PCIC's third year receiving revenue from the BC government endowment that provides base funding to the consortium. In addition, PCIC participated in funded projects with BC Hydro, Environment Canada and several BC government ministries, including Environment, Transportation and Infrastructure, and Forests, Lands and Natural Resource Operations. PCIC and the Pacific Institute for Climate Solutions (PICS) also initiated a partnership around the CAM program, partially funded through PICS. Each of these partnerships results from longstanding relationships between PCIC and climate stakeholder groups.

In 2010-2011, PCIC revenue amounted to approximately $1.5 million, matching its expenses as it did in the previous fiscal year. Personnel costs represent the most significant expense for PCIC, encompassing 79% of our annual expenditures. Costs associated with PCIC's continued investment in projects carried out by other institutions (subprojects in Figure 15), staff travel, and invited guests support the consortium's ability to deliver regional climate services to stakeholders.

After five years of significant annual growth, PCIC has now reached a steady-state in its year-to-year operations. A period of incremental growth and development is expected as new projects take priority and gain momentum. However, the pace of change has slowed, allowing PCIC staff to engage deeply with PCIC stakeholders and their projects.

Expenditures 2010-2011

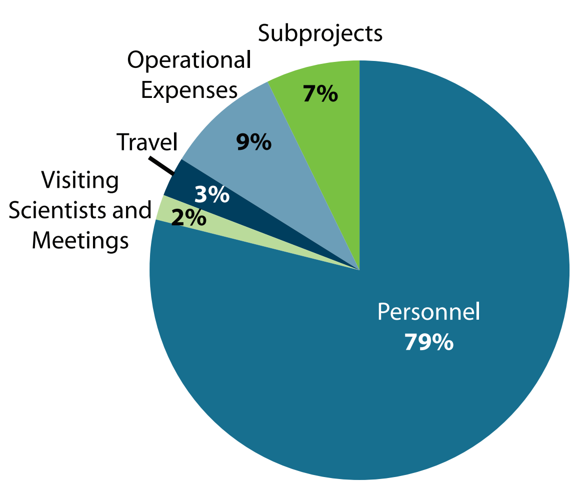


Figure 15 – Chart showing proportional PCIC expenditures during the 2010-2011 fiscal year.

Revenue by Source 2010-2011

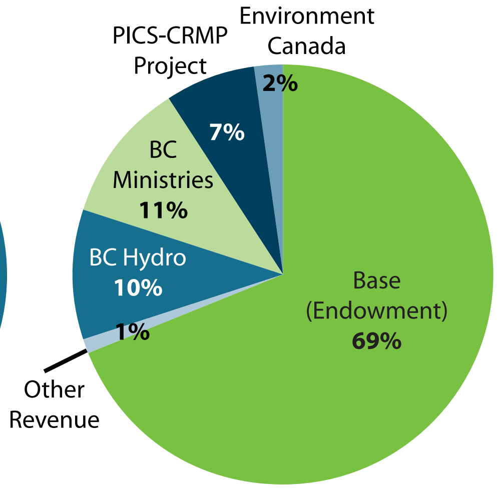


Figure 16 – Chart showing proportional PCIC revenue by source for the 2010-2011 fiscal year.

Intergovernmental Panel on Climate Change Fifth Assessment Report Progress

Francis Zwiers,
PCIC Director and IPCC Bureau Member for the Fifth Assessment Report

A key source of information for PCIC is the globally coordinated scientific effort that is undertaken to support the delivery of IPCC assessments. The IPCC Fourth Assessment Report (AR4), which was delivered in three volumes in 2007, and was supported by the World Climate Research Programme "CMIP-3" coordinated climate model inter-comparison project. This project produced an extensive archive of climate model simulations of historical and projected future climates, a resource that PCIC has mined extensively for use in its projects. In addition, the AR4 provided authoritative assessments of the physical climate science (via the Working Group I report), the state of knowledge on vulnerability, impacts and adaptation science (via the Working Group II report), and the possibilities for mitigation (via the Working Group III report). These reports have proven to be extremely useful to PCIC and its stakeholders.

Planning for the IPCC Fifth Assessment (AR5) was initiated immediately after the release of the AR4, and its production is now well underway with release of AR5 products anticipated to begin in September 2013. In parallel with the AR5 assessment effort, the global climate modelling community is undertaking an extensive new set of coordinated climate simulation experiments (dubbed CMIP-5), including a new class of comprehensive climate models that encompass key physical and biogeochemical processes, and a new suite of future emissions scenarios. In the coming years these global efforts will provide PCIC and its stakeholders with a substantial increase in the quantity and quality of information available for quantifying impacts and supporting adaptation in the province.

In addition to the planning and execution of the AR5, the IPCC has also undergone an extensive review by the InterAcademy Council, and has taken significant action to respond to its recommendations, further increasing the confidence that policymakers and other users may have in IPCC products. The IPCC has made significant changes to the procedures that are used to prepare IPCC reports, including (i) changes related to the selection of authors and review editors, (ii) action to further improve the review process, and (iii) the implementation of a detailed protocol for dealing with alleged errors in a transparent and timely manner. These changes, together with changes in the governance of the IPCC, improvements to its communications strategies, and the adoption of a conflict of interest code for all authors, review editors and bureau members, ensure that the IPCC will continue to provide rigorous, comprehensive, and extensively reviewed assessments of the state of the science.

PACIFIC CLIMATE
IMPACTS CONSORTIUM

University House 1
PO Box 3060 Stn CSC
University of Victoria
Victoria, BC Canada V8W 3R4
Telephone: (250) 721-6236
Fax: (250) 721-7217

http://pacificclimate.org

Graphic Design: Morihuis <morihuis@shaw.ca>