PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE

VOLUME V NUMBER 3 • SPRING 2012

2011 in BC - normal or not?

A normal year with abnormalities

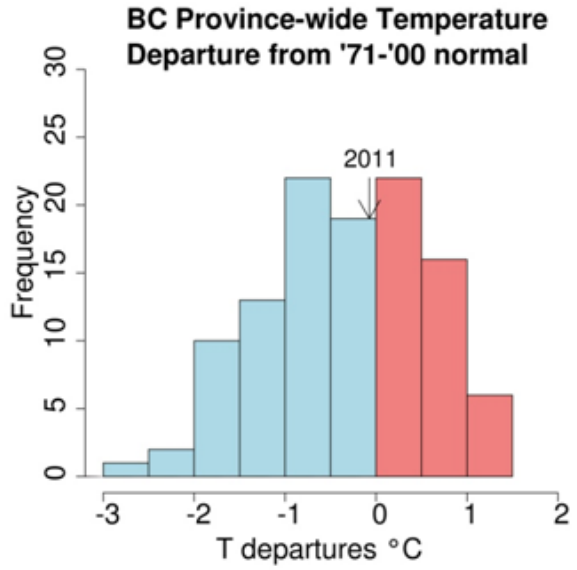
— By Faron Anslow, PCIC Climatologist

Last season's *PCIC Update* reported that the British Columbia-wide mean temperature for the year 2011 was quite close to average relative to what we have come to expect based on climatological averages from 1971—2000. However, despite such "normal" conditions, a number of extreme events occurred – enough to make us ask, "was 2011 really a typical year?" By looking at data from individual stations and regional averages we attempt to describe some of the anomalies British Columbia experienced last year. Where specific stations are mentioned, it is to provide a tangible example of local impacts from these regional, and in some cases province-wide, anomalies and extremes.

The figure to the right shows a histogram of annually averaged, province-wide temperature anomalies relative to the same (1971 – 2000) averaging period using data from 1901 through 2011. An arrow indicates how 2011 fared relative to all 111 years and shows that 2011 would be considered to have been normal relative to 1971 – 2000. Although 2011 was close to a normal year for that period, it was on the warm side, with a temperature 0.2 °C warmer than the median when placed in the context of the 111 year record. According to these data, the coldest year in the record was 1909 with a province-wide anomaly of -2.5 °C; however, this value is uncertain because the number of stations reporting data was small at this time. The warmest year on record occurred in 1987 in association with a strong El Niño, with an anomaly of +1.4 °C. Relative to these years the anomaly for 2011 of -0.1 °C looks pretty tame.

The province-wide temperature anomaly does not tell the whole story for the year, however. As reported previously by PCIC, the spring and early summer of 2011 was cool and wet across much of the province. According to measurements made by Environment Canada, the months of March, April, and May were colder than normal almost everywhere in the province. During the summer months of June, July, and August temperatures remained cold with below normal daily maximum temperatures on average. An interesting twist to the story of cold daily maximum temperatures is that mean daily minimum temperatures were close to normal throughout the first half of 2011. This suggests that cloud cover may have been keeping temperatures cold during the day and warm during the night by restricting the nighttime cooling that occurs when skies are clear.

We can investigate whether cloud cover was important for temperature over the southwestern part of the province, the region in British Columbia where Environment Canada records monthly hours of bright sunshine. Such measurements were made in the cities of Comox , Victoria, and Vancouver, and show that, the



The distribution of province-wide annual average temperature anomalies from 1901 through 2011. The anomaly for year 2011 is shown with an arrow

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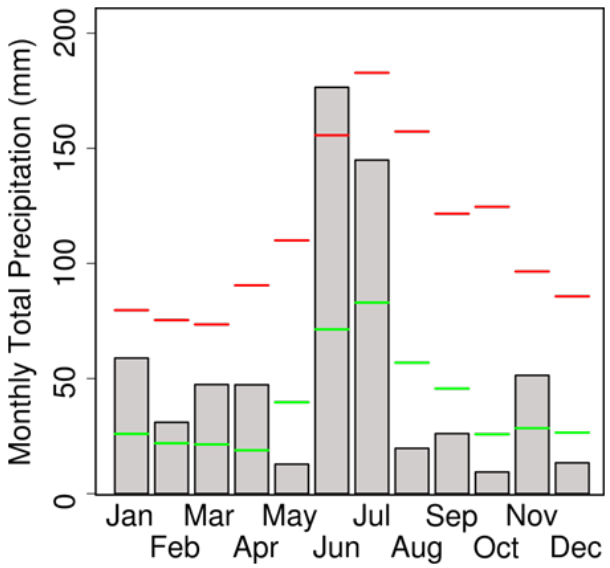
months from March through July were all less sunny than normal based on the station averages for those months. While Comox was sunnier than average in April, its station set new station records for lowest number of hours of bright sunshine in the months of March and July and Vancouver nearly tied its record for the month of May. The sunshine data support the notion that spring and early summer were cloudier than normal, and thus subject to daytime cooling and nighttime warming owing to cloud cover. Larger scale data sets, such as the atmospheric reanalysis from the U.S. National Centers for Environmental Prediction, support these observations. They indicate that for the months of March through July the province had generally cloudier than average conditions, with suppressed radiative heat loss to space, except in the northwest quarter. The most extreme anomalies were centered over the southwest corner of the province where the station records were broken.

These cloudy conditions coincided with one of the rainiest June and July periods that the northeastern part corner of the province has ever seen. On June 23rd, 2011 a moisture laden storm approached the Peace River region of British Columbia. The winds in the weather system pushed moisture from east to west, causing rain to be rung out from air being driven over the northern Rocky Mountains. Such storms are common in spring and early summer on the east side of the Rocky Mountains, but this particular storm had a lot of moisture and the easterly winds blew for several days. The result was a new record for daily rainfall amount in Chetwynd, where 72 mm fell on June 24th, and a record monthly total for Fort St. John where 176.5 mm fell in June (as seen in the figure below). Stations from other observing networks in the region recorded much more. The BC Forest Service station Lamoray recorded 125 mm on the 25th, and many stations in the region recorded twice their monthly normal precipitation in only a few days.



Monthly total precipitation climatology, record prior to 2011, and 2011 amounts for Fort St. John, BC; one of the locations of the extreme rainfall event of late June, 2011. The precipitation climatology is shown by the green dashes, the records prior to 2011 are indicated by the red dashes and the 2011 monthly total amounts are indicated by the grey bars. The broken June record is clearly indicated.

All of this rainfall lead to flooding that washed out highways 97 and 29, caused damage to the CN railway, closed provincial parks, and flooded the town of Chetwynd. Insult was added to injury when, in early July, a second storm added more rain to the already saturated landscape. The figure to the left shows that the measured precipitation amount in July was 1.7 times greater than expected from climatology.

The remainder of the year was close to normal over the province, with a slightly warmer and drier than normal late summer and fall. The year concluded with increasing warmth and low precipitation over the province, with extremely warm and dry conditions in the northern half and southeastern quarter of the province. These patterns continued into the winter of 2011/2012 leading to exceptional warmth in the southeast of the province and record breaking warmth over the prairies of Alberta.

So, although 2011 was near normal in terms of the annual mean of mean daily temperature, a number of extreme events and anomalous conditions occurred in 2011, with record breaking precipitation in the northeast, extensive cloud cover in the southwest and unusual warmth nearly province-wide as the year came to a close. In total, the cold, wet first half of the year led to one of the least active fire seasons with the fewest fire starts observed in decades across the province. PCIC will be monitoring seasonal weather to see what 2012 holds.

Acknowledgements: Data for the Peace River region were assembled by Vanessa Foord of the BC Forest Service. Information on the 2011 fire season was provided by Eric Meyer of the BC Ministry of Forests, Lands, and Natural Resource Operations.

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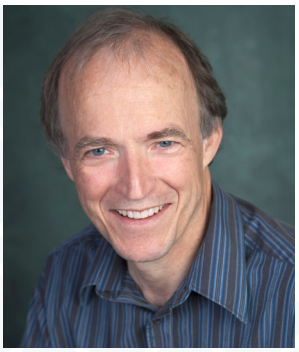


PERSPECTIVE

Message from the Director

Like many organizations, PCIC's "year" begins on April 1 rather than January 1. As with the secular calendar, the passage into the new year is both a time of reflection and celebration. The current passage into a new year coincides with the end of an intense period of reflection on PCIC and its directions that has resulted in a revised overarching strategic plan for the Consortium.

The plan that has emerged articulates a clear vision for PCIC as an impartial, informed and authoritative climate service provider that is responsive to the needs of its members and stakeholders across the province. Consequently, it describes PCIC's service objectives for the next several years, and describes the strategic investments in applied climate science that we will have to make in order to meet those objectives. Those targeted applied science investments are detailed in the ambitious research plans that are introduced in the accompanying articles in this issue of *PCIC Update*.

The newly developed plans set specific goals and objectives for the coming two years, and place our planned short term evolution into a longer term (5-year) context. However, the needs of our stakeholders and climate science itself will, no doubt, evolve enormously over the next couple of years even as we implement the plans that we have developed, and thus we intend to update our strategic and research plans in consultation with our members and stakeholders on roughly a two year cycle, each time resetting near term objectives to respond to changing priorities and requirements, while keeping the potential longer term evolution of the science and our user's needs in view.

We look forward with genuine excitement to the challenge of putting all this planning into action and delivering to our users, useful and actionable information. In fact, we are already well on the way towards doing this, as the articles elsewhere in *PCIC Update* attest. See, for example, Faron Anslow's analysis of the BC's climate in 2011 and Rajesh Shrestha's article on the future of the annual streamflow of the Fraser River. Any comments or suggestions that you might have on these plans and their implementation would be more than welcomed!

PROJECT FOCUS

Hydrologic Impacts of Climate Change in the Fraser River Basin

— By Rajesh Shrestha, PCIC Hydrologist

The Fraser River system is the largest basin in British Columbia covering a drainage area of about 230,000 square kilometers. The basin is highly heterogeneous with elevation extending from the sea level to about 4000 m, and average annual precipitation ranging from 200 mm to 5000 mm. Precipitation in the basin is influenced by elevation with higher elevation mountainous areas receiving higher precipitation compared to the rest of the basin. Given such physiographic and climatological variability, a spatially varied hydrologic response to climate change can be expected. Additionally, since the basin is home to about 63% of BC's population, the changes to its hydrologic regime could have significant implications.

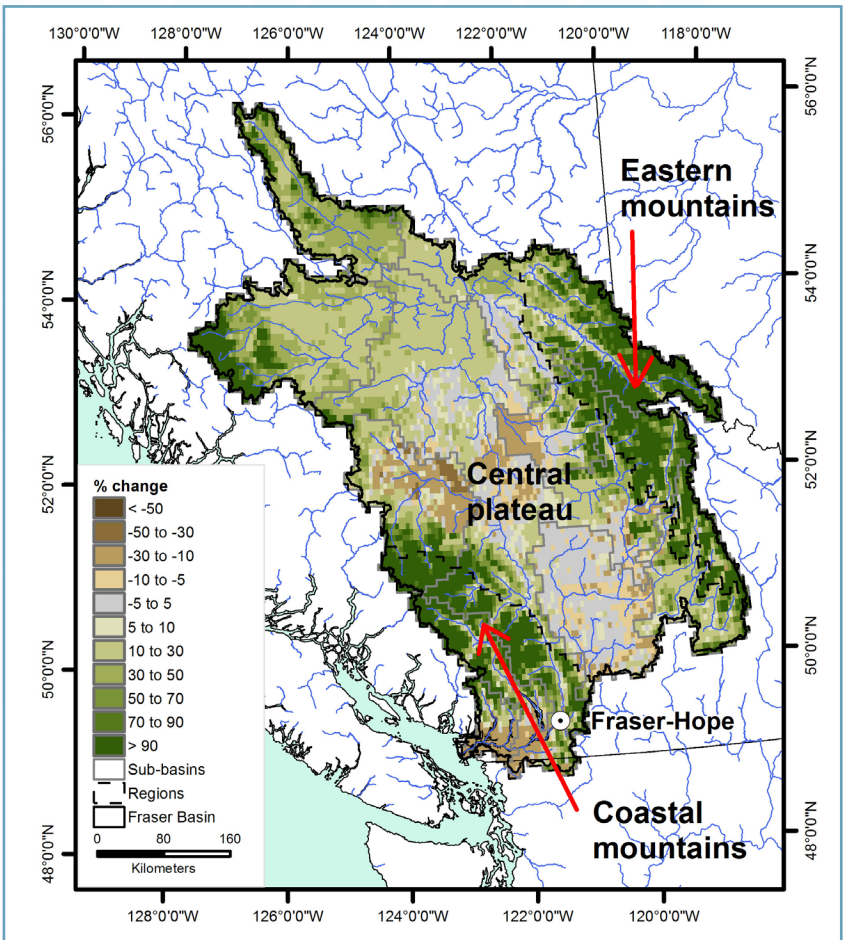
This study provides an assessment of spatial and temporal variability of climate-induced hydrologic changes in the Fraser River basin. PCIC employed the macro-scale Variable Infiltration Capacity (VIC) hydrologic model to simulate 30-year baseline (1970s) and future (2050s) hydrologic regimes based on climate forcings derived from an ensemble of 23 global climate models (GCMs) (7 GCMs x 3 emissions scenarios + 1 GCM x 2 emissions scenarios). A method called Bias Corrected Spatial Disaggregation (BCSD) was used to statistically downscale the GCM outputs to the high resolution required by the VIC model. The spatial variability of the future changes was considered by sub-dividing the basin into 61 sub-basins and three regions (eastern mountains, central plateau and coastal mountains).

RESULTS

The results show varied future hydro-climatic responses for the three regions of the Fraser River basin. The projected changes are affected by considerable uncertainties due to large differences amongst the three emissions scenarios and their ensemble GCM members. However, the direction of change is mostly consistent amongst the three scenarios and their ensemble members. Considering the inter-quartile range of 23 simulations and comparing the baseline 1970s to the future 2050s, PCIC hydrologists found:

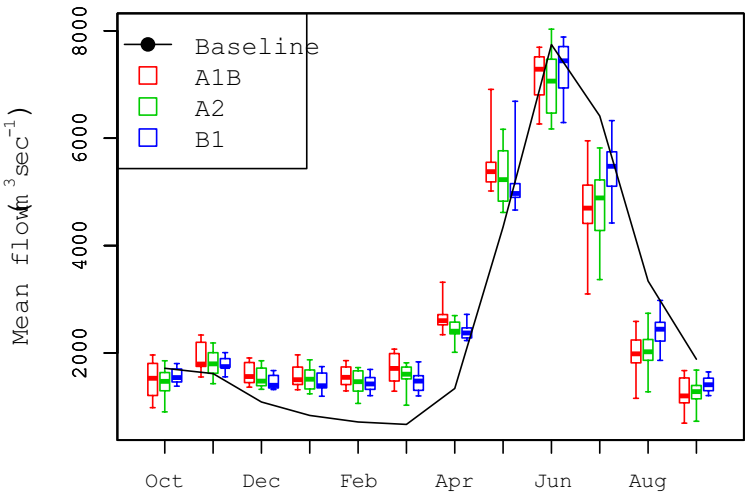
- In the eastern mountains, annual precipitation is projected to increase by 6% to 13% and annual runoff will increase by 3% to 13%
- In the central plateau, annual precipitation is projected to increase by 2% to 10% and annual runoff is projected to change by -6% to 9%
- In the coastal mountains, annual precipitation is projected to change by 0% to 7% and annual runoff is projected to change by -1% to 8%

The projected runoff changes also vary by season in the three regions. An example of the spatially variability of projected spring runoff changes is illustrated in the figure below, which shows higher runoff changes in the eastern and coastal mountains compared to the central plateau region. The proportion of annual runoff that occurs in winter is projected to increase in all three regions, indicating transition from a snow-dominated hydrologic regime to one in which rainfall plays a more important role.



Spring runoff change [%] (2050s versus 1970s) obtained from the median of 8 GCMs for the A1B emissions scenario

Overall, throughout the Fraser Basin, increased autumn, winter and spring precipitation, and decreased summer precipitation are projected for the 2050s. Increases in winter and spring flows and decreases in summer flow, and a smaller increase or decrease in autumn flow are projected. For instance, for the Fraser-Hope hydrometric station, the winter and spring flow are projected to increase by 56% to 85% (interquartile range) and 37% to 56%, respectively, and summer flow to decrease by 13% to 23%. The mean annual peak flow is projected to occur about 10 days earlier. The annual peak flow is projected to occur between 5 and 15 days earlier. Overall, such changes in the runoff timing and the seasonal distribution of runoff could have implications for water availability, especially in the dry central plateau region.



Baseline (1970s) and future (2050s, for three emissions scenarios A1B, A2 and B1) flow responses for the Fraser-Hope hydrometric station. Each box plot illustrates the median and inter-quartile range, and the whiskers upper and lower limits of the 30-year means of GCM ensembles

The results of this study provides stakeholders with hydro-climatic projections for the sub-basins and regions of the Fraser river basin that can be used for local-scale adaptation in this important water resource system in the province. For more details readers are referred to our article, "Modelling spatial and temporal variability of hydrologic impacts of climate change in the Fraser River basin, British Columbia, Canada," published in the *Hydrological Processes* journal and available through the PCIC Publications Library: http://pacificclimate.org/resources/publications.

New IPCC SREX Report Released

The impacts of climate extremes on natural and human systems depend on many factors, including exposure, the vulnerability and resilience of the systems and these impacts can affect the future vulnerability of a system.

Policies to avoid, prepare for, respond to and recover from climate disasters can reduce the associated impacts on both natural and human systems, and increase the resilience of systems to climate extremes.

The recently released IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) provides policy-makers with detailed information on the human and economic costs of climate-related disasters and the physical and social variables that cause and exacerbate them.

The report was compiled by 220 authors, from 62 countries and subjected to 18,784 comments from expert reviewers, in 3 rounds of formal review. It includes information and new conclusions from a large number of new studies and is available as a free download from the IPCC SREX website: http://ipcc-wg2.gov/SREX/

PCIC on the Road

PCIC's applied research relies heavily upon engaging with our professional communities. Every so often, in pursuit engagement, greater understanding, and professional development, our staff members leave University House 1 at UVic and participate in professional workshops. Staff use the opporunity to promote PCIC's services and engage partners in the profesional and research communities. This spring season three of the PCIC technical staff ventured out and we have asked them to report back on their experiences.

James Hiebert, Lead Computational support on PyCon 2012

In March, I attended the PyCon 2012 conference in Santa Clara, CA. This meeting is the annual gathering of the community of software developers who use and develop the Python programming language.

My goals for the conference were primarily to continue to develop ideas regarding the direction of PCIC's web services, particularly with respect to our data portal since most of the back-end is written in Python. With the conference being right in the heart of Silicon Valley, this was a very good venue to meet these goals. The meeting was sponsored by many of the biggest innovators of the web: Google/YouTube, Facebook, Dropbox, Mozilla, Twitter and plenty of other household web names.

I came away from the conference with a variety of technical tips and tricks that will aid our software development; however, one of my bigger takeaways was the progress on the performance of high level languages, Python in particular. In the sciences we tend to write or inherit a lot of low level C and Fortran code. While some claim that the choice in languages is the single biggest factor in program run time, in reality, computational performance is impacted more by algorithm design, strategies for concurrency and caching, and intelligent reduction of expensive I/O, than by the choice of language. Therefore, using a high level language that offers compact, expressive, and elegant syntax allows scientists to rapidly prototype and apply the scientific method to their code as well as whatever scientific hypothesis you are testing. This is particularly true with a language like Python, that has a vast community of intelligent people and innovative companies collaborating on its improvement. Throughout the week, I witnessed numerous case studies where people were handling extremely heavy computations and high data volumes with Python, using a fraction of the development time that you would use when writing comparable applications in C or Fortran.

The conference was extremely valuable and interesting; I also won free admission to next year's conference (by placing in the top three in the PyCon 5k), so hopefully I'll be back in 2013 to continue engaging with the Python community.

Hailey Eckstrand, GIS Analyst on FOSS4g

I recently attended the conference FOSS4g (Free and Open Source Software for Geospatial) in Washington, DC. The FOSS4g meeting showcased powerful tools for building mapping systems and analyzing geospatial data. I attended the conference with two of PCIC's online tools in mind: the Data Portal (www.pacificclimate.org/tools-and-data/data-portal) and Plan2Adapt (www.pacificclimate.org/tools-and-data/plan2adapt).

The Data Portal is in active development and will be used to improve public access to the large amounts of climate and hydrological data PCIC collects through its applied research projects. Plan2Adapt is undergoing upgrades. It is designed to enable access to region-specific climate change information through the generation of high-resolution maps, graphs and data tables based on a standard set of climate model projections. Both of these tools will include the functionality of multi-zoom level web base maps (think Google Maps) focused on British Columbia.

At the meeting, I was able to speak with many developers and authors about the software PCIC uses to create base maps and put them on the web. Through these conversations and the conference sessions, I learned methods to make our web maps both perform better and look nicer. I also found out about new functionality that can be expected in the upcoming major software releases. The Open Source Geospatial community is very alive in DC and it was exciting to see new free open source software being developed.

PCIC on the Road...

Stephen Sobie, Regional Climate Analyst on the 4th NARCCAP Users' Workshop

I recently attended the 4th NARCCAP Users' Workshop. NARCCAP is a

group set up to study climate change in North America. It coordinates the production of regional climate model simulations over the North American continent and acts both as a distributer and source of expertise for the model data. The workshop brought together people involved with regional climate change science from different perspectives – from climate modellers to impacts researchers like us at PCIC. It was a way for the staff at NARCCAP to update everyone on how the project is progressing (it's now in its final stages) and for users of the climate model data to share both with the staff and with each other how we've been using the data.

There were a number of presentations by representatives from the modelling groups describing how well their models represent various aspects of the climate system. Several also talked about how they were working to find clearer and more effective ways to illustrate model uncertainty. The NARCCAP staff laid out the timeline for completing the remaining model simulations and highlighted all of the new analysis tools that they're sharing online. Several impacts analysts like myself presented on how we're using the regional climate models to look at local climate change or specific issues like flooding. There was a real variety of talks in this area.

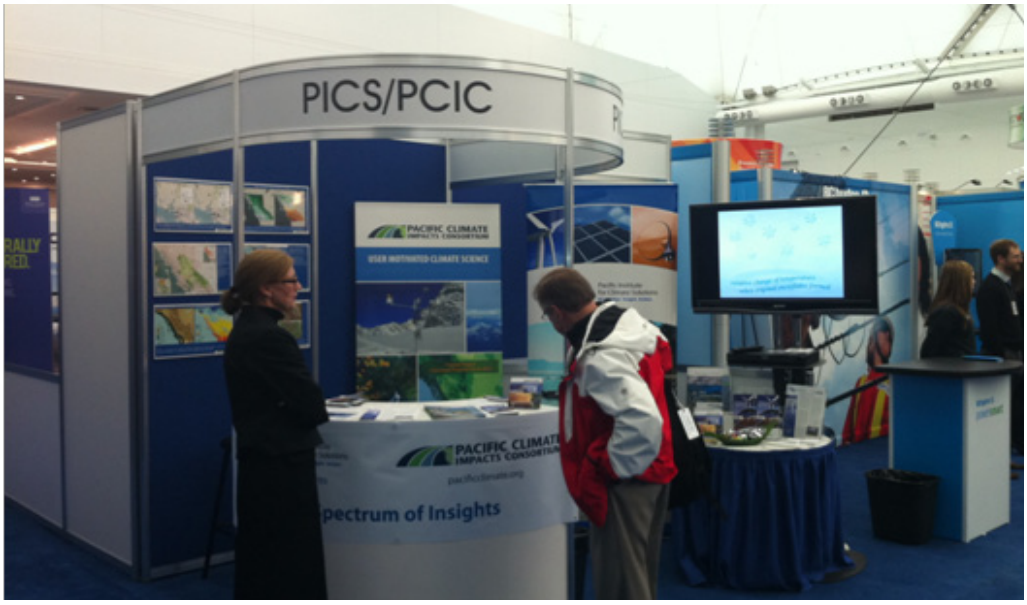
Learning about all of the new tools that the NARCCAP staff have made available was really useful. I'll be taking advantage of these tools to help me analyze model data in the projects I'm involved with. I learned about some new ways to look at model data when performing impacts analysis and I hope to make use of them in my analysis.

PCIC and PICS 'Spectrum of Insights' at GLOBE 2012

PCIC and our sister organization the Pacific Institute for Climate Solutions (PICS) were co-exhibitors at the GLOBE 2012 Trade Fair March 14-16 (www.2012.globeseries.com). The conference and trade fair, held at the Vancouver Convention Centre, was the 12th biennial GLOBE event. Since 1990, GLOBE has attracted leaders in environmental business, providing a venue for discussions around advances in corporate sustainability, climate change adaptation and carbon management initiatives, and energy development and water consumption.

GLOBE 2012 saw more than 400 international environmental organizations participate in the trade-fair portion of the event. It was an opportunity for PCIC and PICS to promote the spectrum of insights that we offer, from educational short courses and research support (PICS) to regionally downscaled future climate projections and data provision (PCIC). Visitors to the exhibit included national and international leaders in business and the environment, most of who were learning about the two organizations for the first time. PCIC and PICS staff spent the three days educating a diverse and business-savvy stream of visitors.

The joint exhibit showcased *Climate Insights: Bite Size*, a series of YouTube videos designed to explain climate science basics in an interesting format (see page 9). The videos, produced by PICS, are the outcome of collaboration between PICS and PCIC expertise. In addition, a series of six posters promoted PCIC's regional climate service provision and provided examples of PCIC's work.



A Renewed Outlook:

PCIC's three new five-year research plans define a renewed vision for the PCIC applied research program

As part of a year-long exercise to renew the PCIC strategic vision, PCIC is announcing the release of an updated Strategic Plan for the period 2012-2016. In support of PCIC's regional climate service objectives, PCIC's lead scientists in each theme have now also published five-year research plans that define the theme's applied research objectives. The strategic plan and research plans are available on the PCIC website publications library (www.pacificclimate.org/resources/publications).

Regional Climate Impacts:

The research plan for Regional Climate Impacts outlines an applied science program focused on improving the availability and relevance of future projections of climate change and impacts. Activity over the first two years (2012-2013) will be focused on: (i) evaluating the emerging international archive of climate change simulations produced through the World Climate Research Program Coupled Model Intercomparison Project phase 5 (WCRP CMIP5) and (ii) developing strategies to efficiently represent the diversity of results that CMIP5 will provide under the new "Representative Concentration Pathways" greenhouse gas emissions scenarios. Current impacts research is largely based on the WCRP CMIP3 experiment that was developed for the IPCC 4th Assessment Report (published in 2007). With new climate modelling experiments (CMIP5) that exploit updated greenhouse gas forcing scenarios at our disposal, PCIC will maintain and improve our ability to provide relevant future projections. Further development of the research program (2013-2016) will extend the updated scenarios to the analysis of indices of extremes and will allow the analysis of climate change impacts on the physical environment of the PCIC study region.

Hydrologic Impacts:

The planned Hydrologic Impacts research activity will expand the spatial and temporal hydrologic modeling domains, building on previous applied research. Spatially, the hydrologic modelling capability previously applied to the Columbia, Fraser and Campbell basins will be expanded to include all drainage areas encompassed by the Pacific and Yukon Region of Canada. The spatial extension will coincide with improvements to PCIC's hydrologic modeling technology. In particular, we will be able to simulate changes in glacier and ice-cap mass balance in order to better represent variation in the long-term storage and release of water in basins containing glaciers and ice-caps.

The research plan for Hydrologic Impacts also anticipates that there will be stakeholder requirements for hydro-climatic information on multiple time scales and defines applied research objectives to address this need and the possible extension of results to assess impacts on water resources. The first two years of activity (2012-2013) will focus on both the short-term and long-term time scales by: (i) evaluating the potential for a dynamical hydro-climatological forecast system and (ii) providing projections of hydro-climate variability to year 2100, including extreme hydrologic events. In the longer term, the plan anticipates the experimental problem of assessing the skillfulness of near-term hydrologic predictions (2014-2016).

Climate Analysis and Monitoring:

The Climate Analysis and Monitoring (CAM) theme at PCIC is focused on providing reference climate data to users and interpreting recent seasonal weather in light of climatology using climate data available for the province. This first two years of activity (2012-2013) will be aimed at establishing the Provincial Climate Data Set (PCDS) and generating high-resolution climate maps from those data. Analysis of seasonal weather and the production of Seasonal Climate Reviews will accompany this work from the onset. Much of this work is governed by pre-existing agreements with the BC government and Oregon State University's PRISM Climate Group. Further development of the program (2014-2016) includes expansion of the Seasonal Climate Reviews, generation of time-series maps of monthly and then daily weather variables, examination of specific scientific questions that arise from CAM activities, and the introduction of new ways to serve the public's need to access the work of CAM.

OTHER PCIC NEWS

PCIC welcomes research assistant from Germany

Hannah Imhof arrived at PCIC on April 10th to support Faron Anslow's work in the Climate Analysis and Monitoring theme until the end of June. She completed her B.Sc. in Meteorology at the University of Munich last summer, and has been working to gain experience with weather and climate data analysis since then. After having processed precipitation data from a Micro-Rain-Radar during an internship in fall and winter at the Institute of Atmospheric Physics of the German Aerospace Centre, she wanted to gain insight into climate research since the topic of climate change was the reason Hannah studied Meteorology in the first place.

Hannah's goal to combine work on a climate focused project by doing an internship in southern British Columbia led her to contact the Pacific Institute for Climate Solutions who referred her to PCIC.

Her project at PCIC is to apply quality control and correct precipitation data in the provincial climate dataset. This work combines understanding the errors that may occur when measuring precipitation in cold climates (such as gauge capping, freeze up, overflow, etc.) with an understanding of the annual climatological cycle of precipitation throughout British Columbia. Hannah and Faron are also reviewing key papers in the scientific literature detailing the drivers of climate variability in BC and across the globe such as the El Nino Southern Oscillation and the North Atlantic Oscillation. After leaving PCIC, Hannah will begin a Master's program in meteorology at the Karlsruhe Institute of Technology in October.

PICS online climate change courses go "bite size"

Learning about the scientific causes of climate change just got easier with the online launch of "Climate Insights: Bite Size", the latest product in the free, web-based "Climate Insights 101" series produced by the Pacific Institute for Climate Solutions (PICS) in partnership with PCIC.

The bite-sized videos available on You-Tube [link) are short, lively and easily digestible mini-lessons condensing content from the first module of Climate Insights 101: "Climate Science Basics".

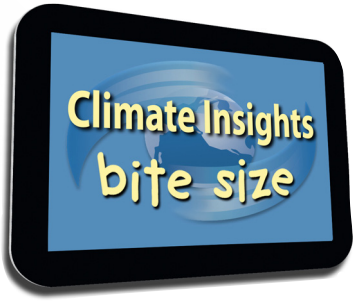
Released in February 2012, topics covered in the videos include:

- CO_2 and the Greenhouse Effect
- More than just CO_2
- Human Influence
- Mother Nature's History Book
- The Influence of Natural Events
- Is the Earth Actually Cooling?
- Examples of Global Warming
- Threat Posed by Acidification
- What is a Climate Model?
- Projecting Future Climate

The content for Module 1 and the bite size videos has been provided by PICS Executive Director Tom Pedersen and PCIC Director Francis Zwiers with input from Environment Canada and the BC Ministry of Environment.

Module 2 (regional climate change and its impacts), Module 3 (adaptation) and Module 4 (mitigation) are currently in production and are planned for release within the coming year.

The full short course is available at:
http://www.pics.uvic.ca/insights/



Recent PCIC Publications

- The PCIC Downscaling Intercomparison Project results are now published, providing insight into how five statistical downscaling methods compare in their representation of climatic extremes. Published in the *Journal of Climate*, ***Downscaling extremes - an intercomparison of multiple statistical methods for present climate,*** is also available for download from the PCIC Publications Library: http://pacificclimate.org/resources/publications.

- The City of Prince George worked with PCIC and other climate research partners to examine climate adaptation options for Prince George, BC. As part of that process, the partners held a workshop with City staff and community stakeholders to build local capacity and initiate an adaptation strategy. Past climate trends and future scenarios were used to gain a better understanding of the changes occurring and expected in the region. The highest priorities identified for Prince George relate to forest fires, flooding, emergency response to extreme events, water supply and transportation infrastructure. Further results are published in the article ***Planning for climate change adaptation: lessons learned from a community-based workshop*** in the journal, *Environmental Science and Policy* and is available for download from the PCIC Publications Library.

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PACIFIC CLIMATE IMPACTS CONSORTIUM

Thank you for your continued interest in the ***Pacific Climate Impacts Consortium****, a regional climate service centre at the University of Victoria providing practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada. We are committed to working with climate researchers and regional stakeholders to produce knowledge and tools in support of long-term planning and adaptation. Visit our website for free online access to PCIC resources.*

PCIC UPDATE is published four times per year in spring, summer, autumn and winter.

Editor: Michael Shumlich