PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC UPDATE

CURRENT WORK: CMIP5 STREAMFLOW PROJECTIONS USING STATISTICAL EMULATION

Streamflow projections produced by PCIC have so far been based on downscaled climate inputs from global climate models (GCMs) contributing to the World Climate Research Program's (WCRP) Coupled Model Intercomparison Phase 3 (CMIP3) project. Given that GCM uncertainty is a large part of streamflow projection uncertainty, we wanted to quickly update our work using the new GCMs contributing to the fifth phase of the same project (CMIP5), to investigate whether they present a different picture of future streamflow change.

The original projections were generated using the Variable Infiltration Capacity (VIC) hydrology model with statistically downscaled climate projections from a subset of CMIP3 climate experiments (using 8 GCMs and 3 emissions scenarios). For the updated projections we used a computationally-efficient statistical model to emulate the projections made by the VIC model, forced with temperature and precipitation changes based on all available CMIP5 runs (approximately 400 runs; based on emissions scenarios known as Representative Concentration Pathways (RCPs).

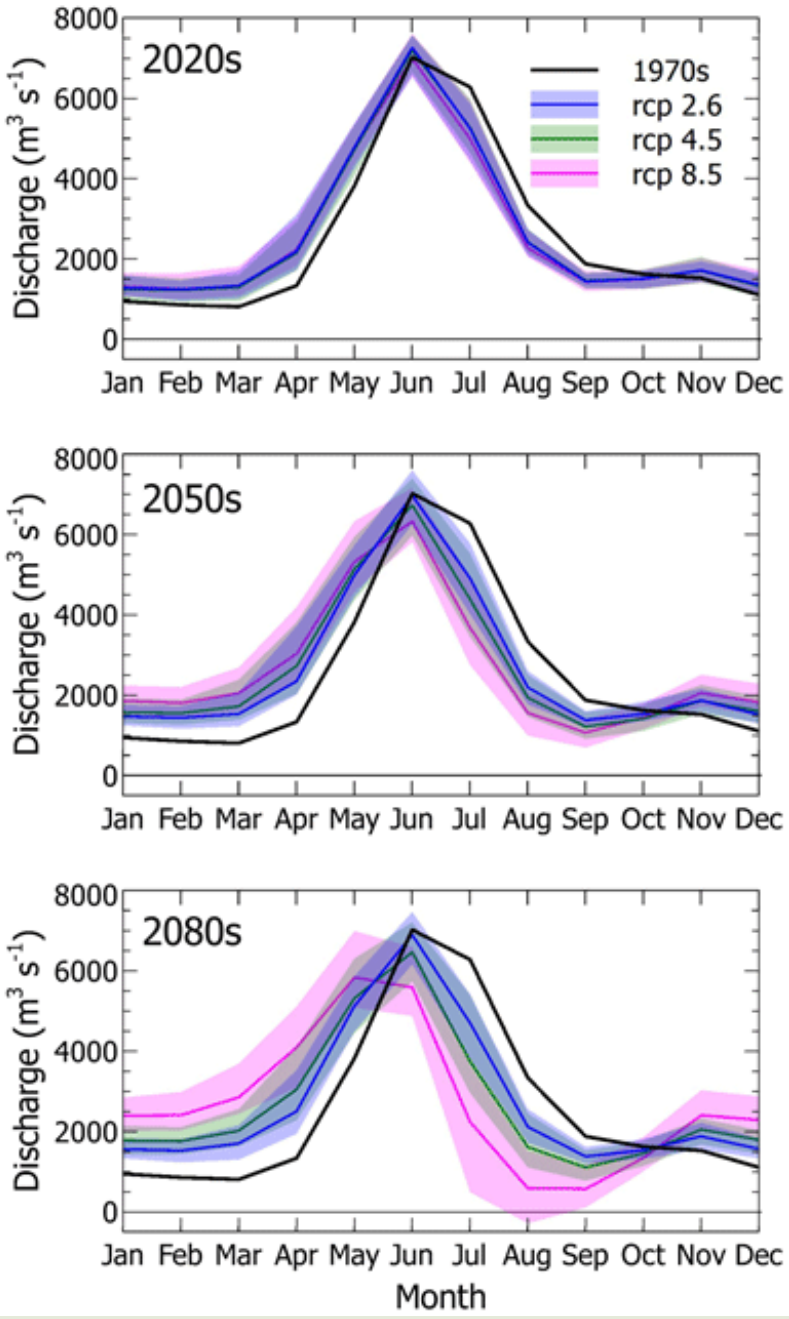

Figure: CMIP5 RCP2.6, 4.5 and 8.5 2020s, 2050s and 2080s streamflow projections for the Fraser River at Hope. Results are given for each ensemble as the median (solid line) and 95% range (shading). The labels 2.6, 4.5 and 8.5 refer to the forcing from carbon dioxide in Watts/m^2 in year 2100 under the different RCPs considered.

We studied the use of the methodology on a few large BC basins, results are shown for the Fraser River (Figure). All results indicate that streamflow changes projected using CMIP5 models, for three time periods and three emissions scenarios, are qualitatively similar to those projected using CMIP3 models.

In particular, our findings indicate that the projected streamflow response to climate change at these locations is typical of snowmelt-dominated regimes, with increases to runoff in fall and winter, earlier onset of the spring freshet (spring runoff due to snow melt) and reductions to summer discharge. Changes become more severe moving from the 2020s to the 2080s and the prominence of the spring freshet progressively diminishes as more runoff shifts to the winter. During the 2020s the projected monthly streamflow ensembles for the three scenarios are largely indistinguishable, and all three hint at changes in the timing and seasonality of discharge. These trends become larger through the 2050s and 2080s, and by the 2080s the streamflow changes for the individual scenarios are distinguishable. The largest changes are projected for RCP8.5, a business-as-usual scenario, and the smallest changes are projected for RCP2.6, an aggressive mitigation scenario. Projected changes for RCP4.5, a moderate stabilization scenario, are intermediate between RCP2.6 and 8.5.

IPCC 5TH ASSESSMENT REPORT PUBLIC BRIEFING

Working Group One's (WG1) contribution to the fifth Assessment Report of the Intergovernmental Panel on Climate Change, the Physical Science Basis, was released on September 27th. Seven years in the making and involving 259 scientists from around the world, the report outlines the present state of global climate science. To help BC residents understand what the global report means for them, PCIC and the Pacific Institute for Climate Solutions hosted two special briefings on the report with a combined attendance of roughly 800 people. The first meeting was held in Vancouver, for the general public and the second was held in Victoria, for public servants.

Dr. Greg Flato, research scientist and manager of the Canadian Centre for Climate Modelling and Analysis, and coordinating lead author of Chapter Nine of WG1's contribution to the latest IPCC report, discussed the close agreement between climate models and observations, the increase in atmospheric greenhouse gas concentrations over the industrial period and subsequent global warming, as well as some of the impacts that have been observed. Dr. Flato also discussed the projections for future climate change under the different Representative Concentration Pathways (RCPs) considered by the IPCC.

Dr. Francis Zwiers, PCIC's Director, also serves as Vice Chair of IPCC's WG1. He detailed some changes that have already been observed in BC's climate and discussed what future climate projections hold in store for BC, including new research results from PCIC. PCIC's findings indicate that, under a moderate RCP4.5 emissions scenario temperatures are projected to increase by 2.9 degrees Celsius in the winter and 2.4 degrees Celsius in the summer, and frost free days are expected to decrease by 31 days per year, by 2100. (Note that frost-free days have already decreased by 24 days, since 1900.)

Read about/watch a video of the Vancouver briefing.

FIRST MEETING IN APPLIED RESEARCH SERIES

At the outset of 2013, PCIC set a goal to further strengthen its provision of climate services. As part of this goal, on October 10th, PCIC held its first meeting of a three-part series that is structured around PCIC's three applied research themes. The meeting, which was held at the Inn at Laurel Point in Victoria, focused on PCIC's Climate Analysis and monitoring theme, which provides access to information about the past and present climate for British Columbia. Meetings on PCIC's Regional Climate Impacts and Hydrologic Impacts themes will

be held in the coming months. The series is intended to serve as a two-way exchange between users of PCIC services and PCIC scientists and product developers.

Read more about this meeting and others in the series.

NEWSWORTHY SCIENCE

PCIC has released two new Science Briefs. The first covers a recent article in *Nature Climate Change* that examines the discrepancy between observed global warming over the last 20 years in models and observations. The second is on an article in *Environmental Research Letters* that examines the cooling trend in eastern North American and northern Eurasian winters.

Recent research published in *Nature Climate Change* by Fyfe (2013) et al. finds that observed warming over the periods 1993-2012 and 1998-2012 is significantly less than that simulated by climate models, though models successfully simulate the rate of warming over the 1900-2012 period. Some potential explanations for these discrepancies are offered.
Access this Science Brief.

In their 2012 *Environmental Research Letters* article, Cohen and colleagues examine why it is that, while the Arctic has experienced nearly twice the warming that the rest of the world has seen over the past 40 years, winters in eastern North America and northern Eurasia have become cooler, with more extreme weather over the past two decades. They find that these trends could be due to increased high-latitude moisture and snow cover, and probably cannot be attributed to internal variability alone.
Read this Science Brief.

PCIC WELCOMES NEW STAFF AND RESEARCH ASSOCIATES

PCIC is taking advantage of term funding opportunities and collaborative partnerships to augment its scientific capacity, by bringing in new researchers to PCIC to work on directed projects.

PCIC welcomes the following people to our staff. Stephanie Saal is a new Research Intern who is working on hydrology and GIS projects as she continues with her Master's degree at the Karl-Franzens University of Graz, in Austria. Amina Khan joins us as a Science Horizons-funded Hydrology Analyst, analyzing and managing water temperature data for watersheds in BC. James Stone, a new co-op Programmer and Analyst is working on modifications and upgrades to the VIC hydrology model.

PCIC also extends a warm welcome to the research associates who are joining us as part of our collaborate research projects. Katie Pingree-Shippee (PhD Student) and Christian Seiler (Post-Doctoral Researcher) will be working on climate change and extreme events with PCIC

and the Marine Environmental Observation, Prediction and Response (MEOPAR) Network. Reza Najafi (Post-Doctoral Researcher) will be working from PCIC with the Canadian Sea Ice and Snow Evolution (CanSISE) Network, to examine changes to snow and sea ice. Kirian Whan (Post-Doctoral Researcher) will be studying change in extremes at regional scales, at PCIC, with the Canadian Network for Regional Climate and Weather Processes.

PCIC's professional staff are our most important asset, providing the leading-edge expertise that allows us to meet our research and service goals. As our research team grows, our ability to investigate questions of interest to—and provide services for—our regional stakeholders also increases, enabling us to provide a greater volume of trustworthy climate information in the form of tools, data and analysis.

THE 4TH ANNUAL PACIFIC NORTHWEST CLIMATE SCIENCE CONFERENCE, SEPT. 5TH AND 6TH, 2013

PCIC Scientists were among the climate scientists, resource managers, decision-makers and science communicators that gathered in Portland on September 5th and 6th to discuss the changing climate and our response to it. The Governor Hotel in Portland hosted two days of presentations on climate modeling, adaptation, science communication and economics.

Find out more about this event.

RECENT PAPERS AUTHORED BY PCIC STAFF

Fyfe, J.C., N.P. Gillett and **F.W. Zwiers**, 2013: Overestimated global warming over the past 20 years. *Nature Climate Change*, **3**, 767-769, doi:10.1038/nclimate1972.

Peng, Y., V.K. Arora, W.A. Kurz, R.A. Hember, B. Hawkins, J.C. Fyfe and **A.T. Werner**, 2013: Climate and atmospheric drivers of historical terrestrial carbon uptake in the province of British Columbia, Canada, *Biogeosciences Discussion*, **10**, 13603-13638, doi:10.5194/bgd-10-13603-2013.

Werner, A.T., **M.A. Schnorbus**, **R.R. Shrestha** and H.D. Eckstrand, 2013: Spatial and temporal change in the hydro-climatology of the Canadian portion of the Columbia River Basin under multiple emissions scenarios. *Atmosphere-Ocean*, **51**, 4, 357-379, doi:10.1080/07055900.2013.821400.

Zhang, X., H. Wan, **F.W. Zwiers**, S.-K. Min, G.C. Hegerl, 2013: Attributing intensification of precipitation extremes to human influence. Accepted in *Geophysical Research Letters*.

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