What are the potential impacts of climate change on water flows in the Columbia Basin?

Overall Changes in Hydrology

The Canadian portion of the Columbia River Basin is projected to experience both increases in precipitation and temperature in the twenty-first century that will alter the hydrologic cycle as a result of changes in snowpack and the seasonal timing of runoff.

Most large rivers in the upper Columbia Basin are strongly snowmelt dominant, and are sufficiently cold in winter that they remain snowmelt dominant even in a substantially warmer climate. Figure 1, below, for example, shows that while the warmer portions of the Basin in the U.S. experience substantial losses of snowpack as the climate warms, most of the watersheds in Canada's portion of the Basin in BC retain their snowmelt-dominant character in the simulations even at the end of the twenty-first century.

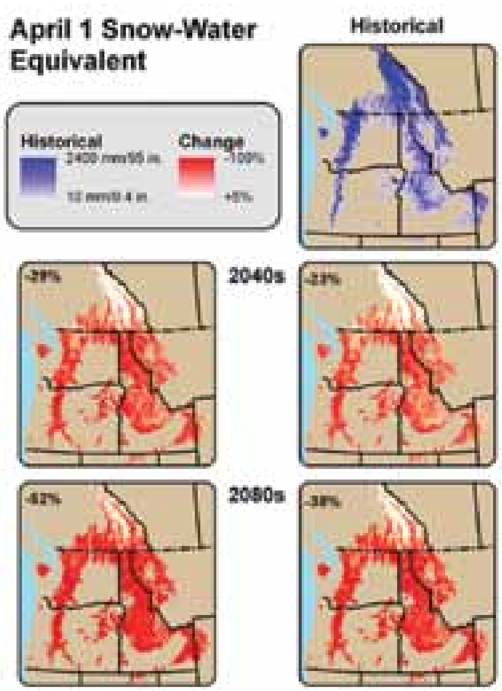

Figure 1. *Simulated historical April 1 Snow Water Equivalent (SWE) and percent changes in April 1 SWE for two emissions scenarios and two future time periods extracted from Composite Delta VIC scenarios. Inset numbers at the upper left in the future projections are the percent changes in April 1 SWE averaged over the entire domain.*

Simulated monthly hydrographs for naturalized conditions, without dams or extractions for water supply, show moderate shifts in stream flow timing from summer to winter (i.e. increases in winter flow and decreases in summer flow), with peak spring flows occurring roughly one month earlier by the 2080s.

These changes in seasonal stream flow timing are generally very modest in comparison with other parts of the Columbia Basin. Thus, overall impacts to summer water availability in the locations of the CRT dams are expected to be less severe than in most other parts of the Basin.

Columbia River at Hugh Keenleyside Dam

combined flow (in):

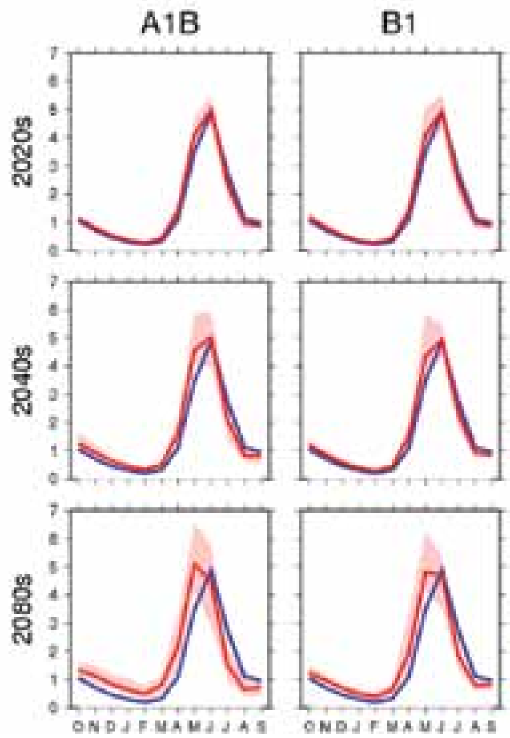

Figure 2. *Monthly hydrographs for natural flow conditions (expressed as inches of runoff over the total Basin area) for the Columbia River at Hugh Keenleyside Dam. Blue lines show average historical values (1916 to 2006) (repeated in each plot). Pink bands show the range of nine to 10 Hybrid Delta climate change scenarios for B1 and A1B emissions scenarios for three future time periods. Dark red lines show the average of the climate change ensemble.*

Climate Change in the Columbia Basin

Changes in Hydrologic Extremes: Floods and Low Flows

Projected changes in natural flood risks due to projected climate change in snowmelt dominant rivers in BC are generally small, with the 100-year flood increasing or decreasing in magnitude by a few per cent (Hamlet et al. 2012). Changes in simulated extreme low flows are not generally very sensitive to climate change in BC. In some very cold basins, extreme low flows in the winter actually increase in magnitude due to warming and increased winter runoff. Loss of glacier mass, which is not included in the simulations shown, may produce larger reductions in summer low flows in basins with significant glacial coverage.

Effects to Managed Reservoir Levels

Seasonal water levels in managed reservoirs (e.g. Kinbasket and Arrow Lakes) and Kootenay Lake, will likely be affected by these changing stream flow patterns. For the changing hydrographs shown in Figure 2, for example, increasing flow in winter may require less drafting of storage for hydropower production, resulting in higher lake levels in winter and spring. However, flood control storage requirements, which may not change very much, may limit this effect in some years. Evacuation of reservoirs for flood control may need to occur earlier in the water year to account for changing peak flow timing and spring refill may also need to start earlier in the water year if reservoirs are to successfully refill (Lee et al. 2009). The dates when reservoirs refill are likely to shift earlier in the water year (Lee et al. 2009). In dry years it may be increasingly difficult to maintain reservoirs at optimal levels for recreation throughout the summer.

Can the CRT account for potential climate change impacts and if so, how?

In summary, climate change will have an impact on hydrological systems' operations with regard to coordinated flood control between Canada and the U.S. A slightly earlier, sharper spring freshet period combined with increased likelihood of extreme weather, including potential increases in winter precipitation and rain on snow events, will change historic stream flow patterns. The large reservoir systems in place, and their ability to capture water, may enable us to better manage the impact of low flows in drier summer months. Dams and the existing reservoir system act as an excellent adaptation strategy that acts to mediate impacts of potentially more extreme weather. Current coordinated flood control agreements will need to acknowledge these changes in the hydrologic system.

References:

Hamlet, A.F., P. Carrasco, J. Deems, M.M. Elsner, T. Kamstra, C. Lee, S-Y Lee, G. Mauger, E. P. Salathe, I. Tohver, L. Whitely Binder, 2010b: Final Project Report for the Columbia Basin Climate Change Scenarios Project, [www.hydro.washington.edu/2860/report/].

Hamlet, A.F., M.M. Elsner, G. Mauger, S-Y Lee, I. Tohver, 2012: An Overview of the Columbia Basin Climate Change Scenarios Project: Approach, Methods, and Summary of Key Results, Atmosphere-Ocean (in review).

Lee, S-Y., A. F. Hamlet, C. J. Fitzgerald, and S. J. Burges, 2009: Optimized Flood Control in the Columbia River Basin for a Global Warming Scenario, ASCE J. Water Resources Planning and Management, DOI 10.1061/(ASCE)0733-9496(2009), 135:6(440), 135(6) 440-450.

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