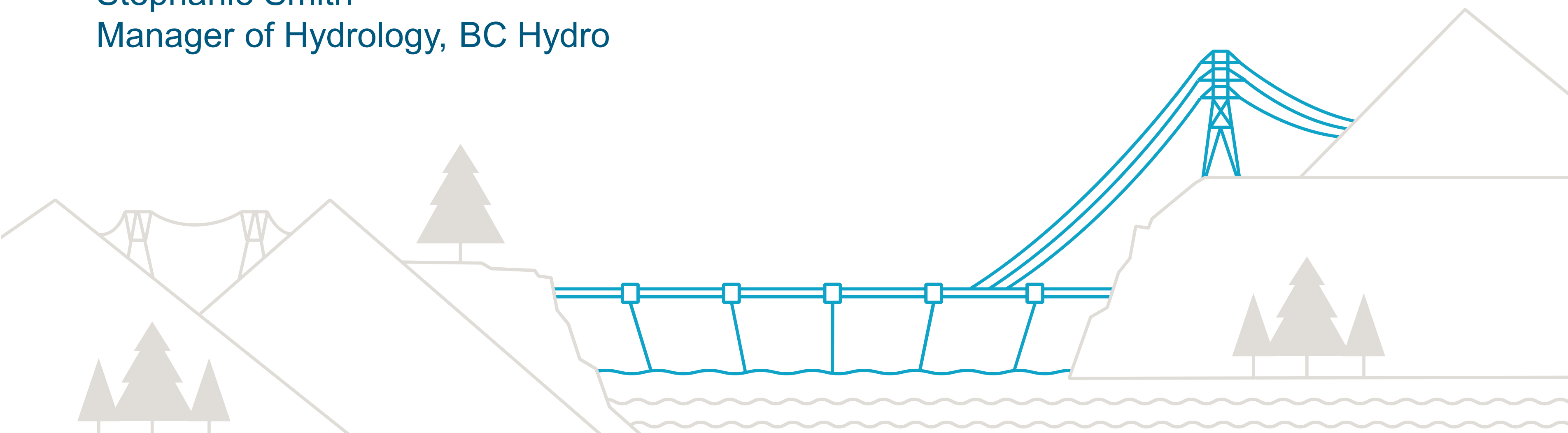
Climate Change in the Columbia Basin

Stephanie Smith
Manager of Hydrology, BC Hydro



June 20, 2017

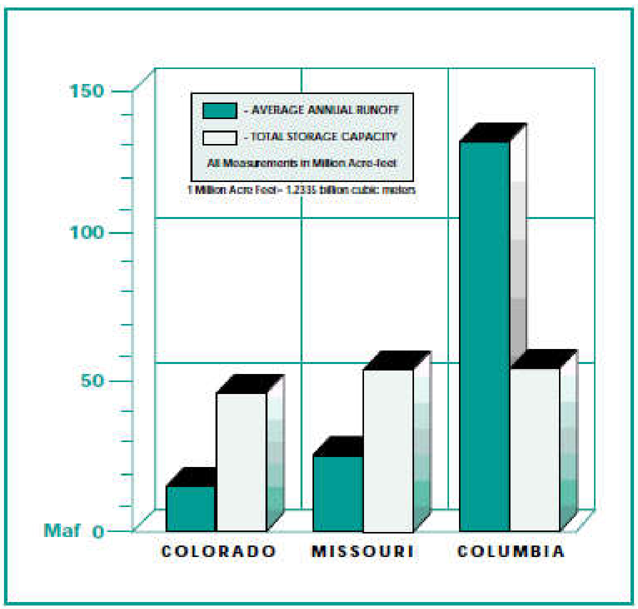
BC Hydro
Power smart

Outline

- Climate change in the Columbia River basin
- What has happened?
- What could happen?
- What can we do about it?

COLUMBIA RIVER BASIN

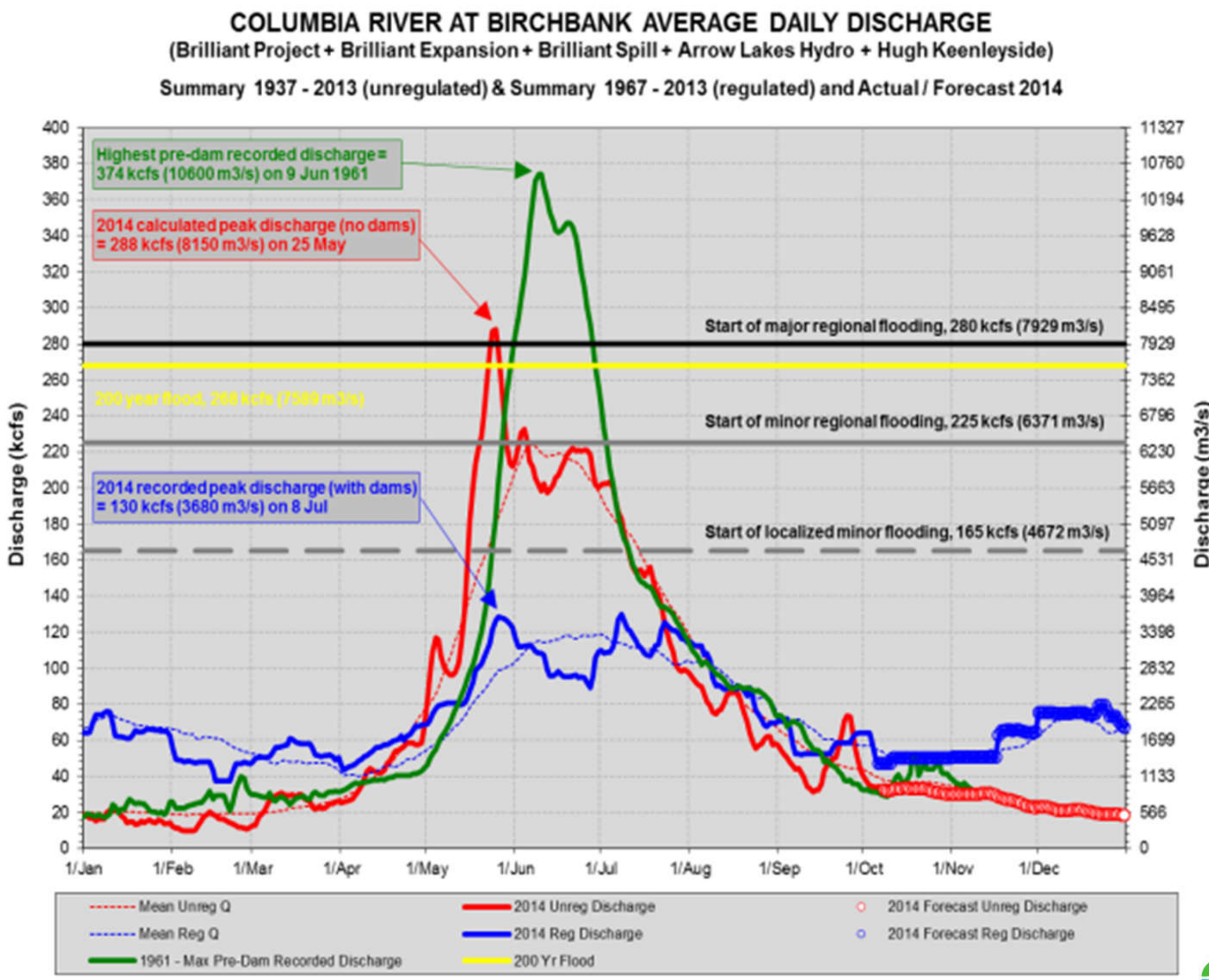
Columbia River Runoff and Storage Compared to the Colorado and Missouri Rivers



The Columbia River has high runoff and a small amount of storage compared to two other large river systems, the Colorado and Missouri.

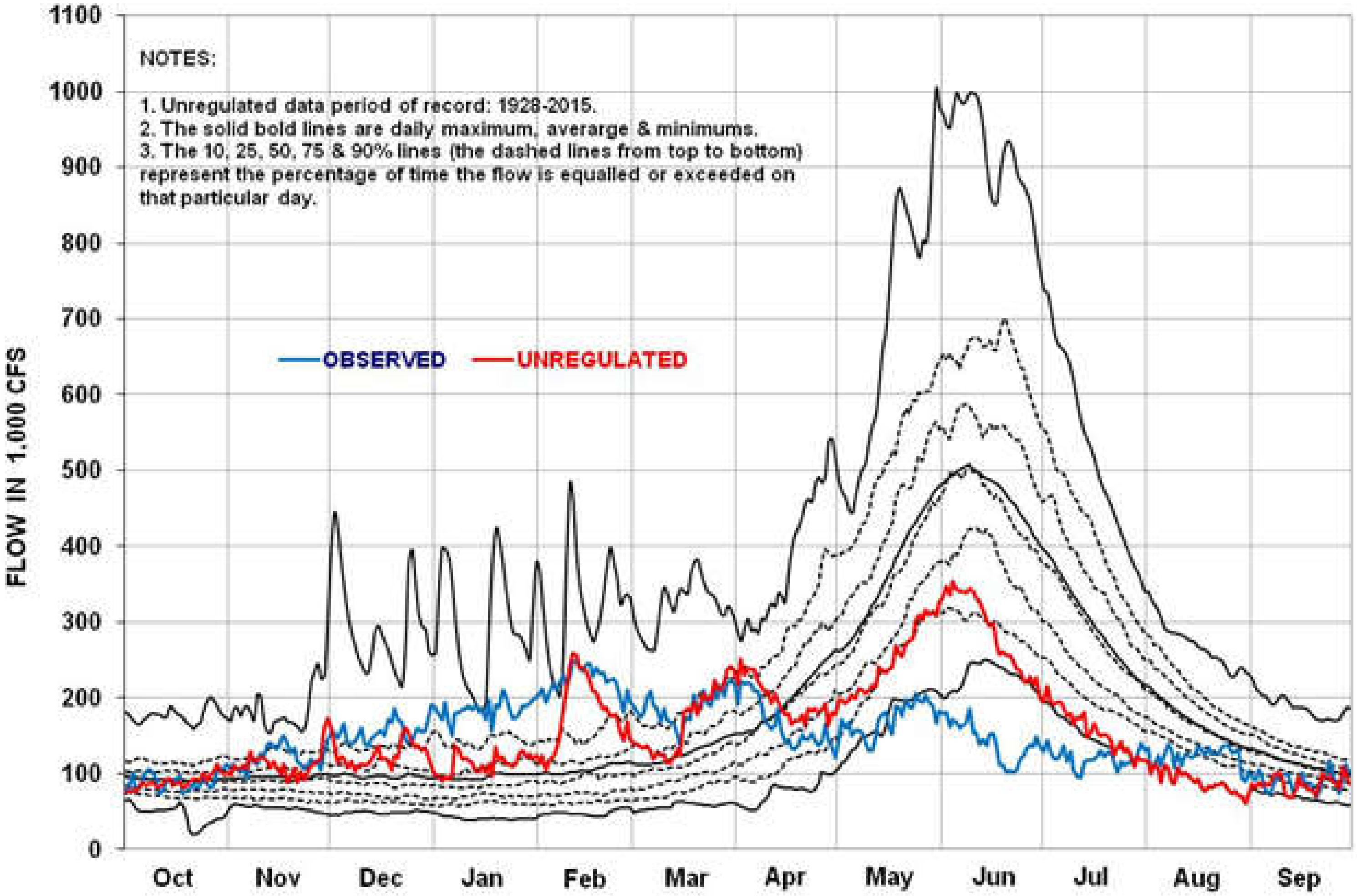
Source: US Army Corps of Engineers

Columbia River at Birchbank



BC Hydro
Power smart

COLUMBIA RIVER STREAM FLOWS AT THE DALLES



Climate Change Assessments

1995 - IPCC second assessment

1990s- early 2000s – Canadian Climate Impacts and Adaptation Research Network (C-CIARN) – initial assessments of change and impacts

2001 – IPCC third assessment / 2007 – fourth assessment

2007-2011 – PCIC /BCH Hydrologic Impacts Assessment

2008-2011 – WC2N Columbia Glacier assessment

2008-2011 – RMJOC Joint U.S. Studies

2013 – IPCC fifth assessment

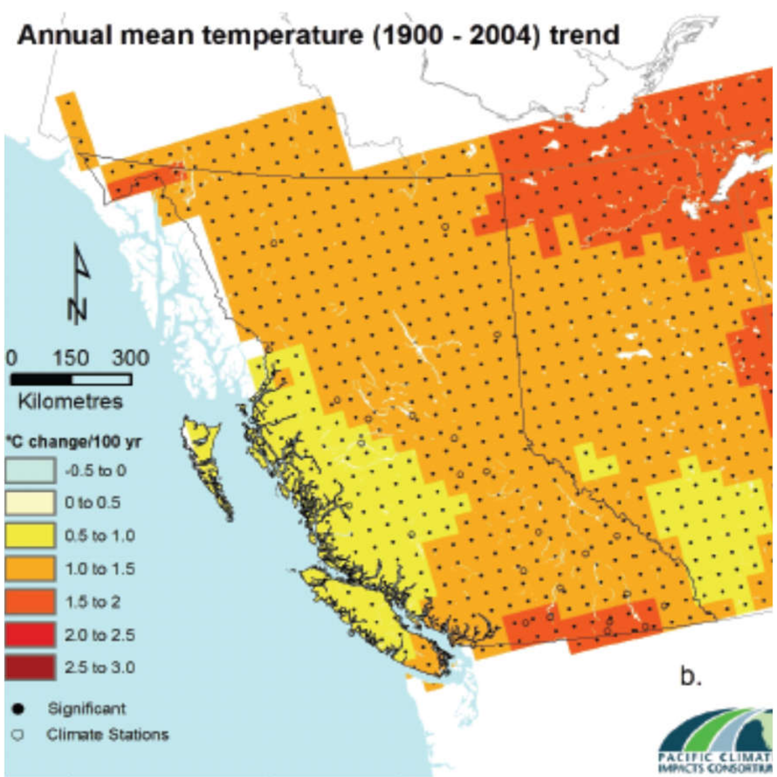
2014-2017 – RMJOC II Joint U.S. studies

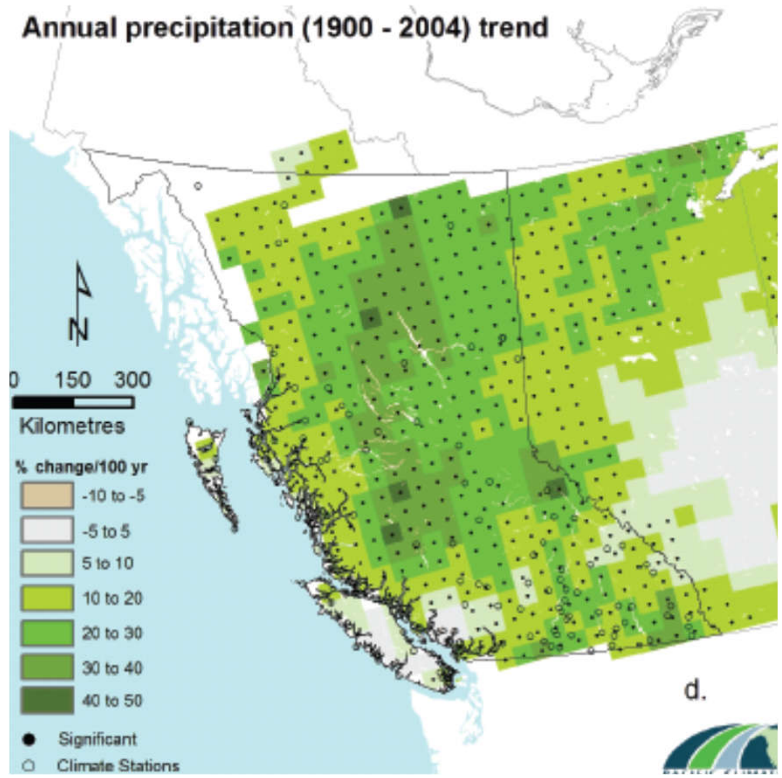
2015-2018 – PCIC / BC Hydro Updated assessments

2007 - 2012 Studies

BC Hydro
Power smart

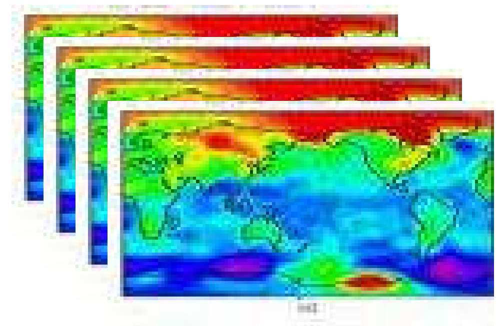
Historical Trends in BC





BC Hydro
Power smart

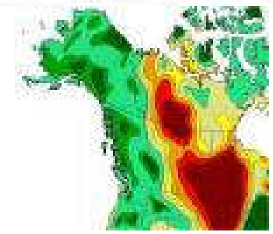
Hydrologic Impact Assessment Process



EMISSION SCENARIOS
Global emissions and land use change based on future socio-economic development

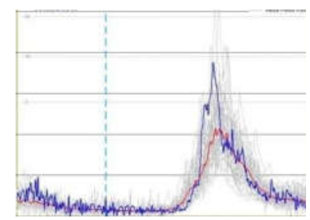
GLOBAL CLIMATE MODELS (GCMS)
Global climate responses to emission scenarios (temperature, precipitation, etc.)

Resolution ~ 200 km grids



STATISTICAL DOWNSCALING
Regional climate responses (orographic and coastal effects, extremes, etc.)

Resolution for model requirements ~ 6 km grids



HYDROLOGICAL MODEL
Changes to the hydrological cycle (snow, glaciers, evaporation, runoff, etc.)

Flow Scenarios

HYDROLOGICAL IMPACTS
Water supply to: reservoirs, hydropower generation, operation of reservoirs, fish and their habitat, etc.

Adaptation (e.g., Reservoir Operations)

PACIFIC CLIMATE IMPACTS CONSORTIUM

You can't do it alone

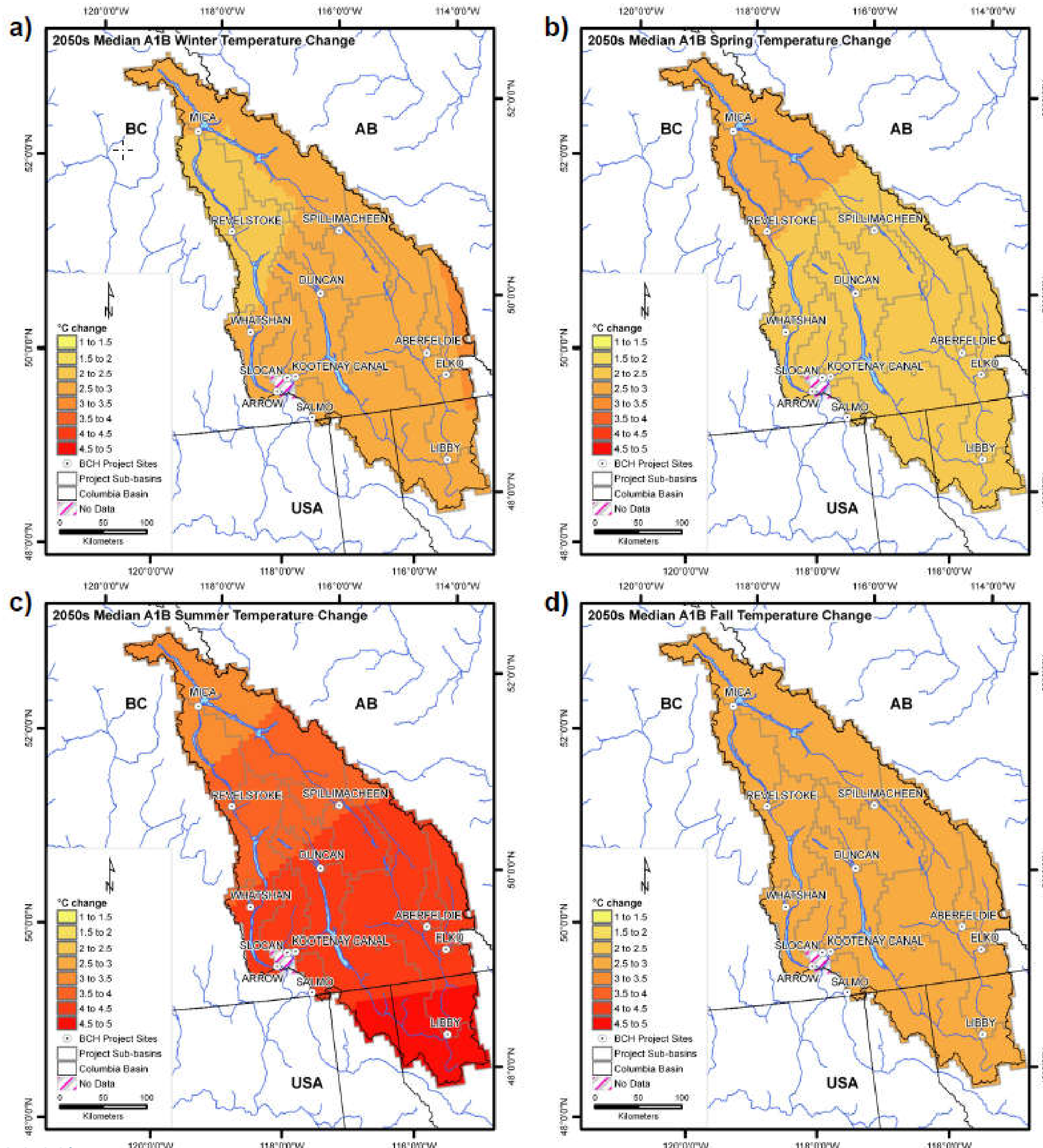
- Pacific Climate Impacts Consortium (PCIC)
  - BC-wide hydro-climatic trend analysis
  - Multi-watershed modeling study
- Western Canadian Cryospheric Network (WC2N)
  - Modeling study of coupled glacier & hydrologic change at Mica basin
- University of Washington (UW) & River Management Joint Operating Committee (RMJOC)
  - Multi-watershed modeling study
  - Development of planning data sets for US agencies in Columbia River basin

Projected

Climate Trends

Change to median temperature in 2050's

(compared to 1961-1990)

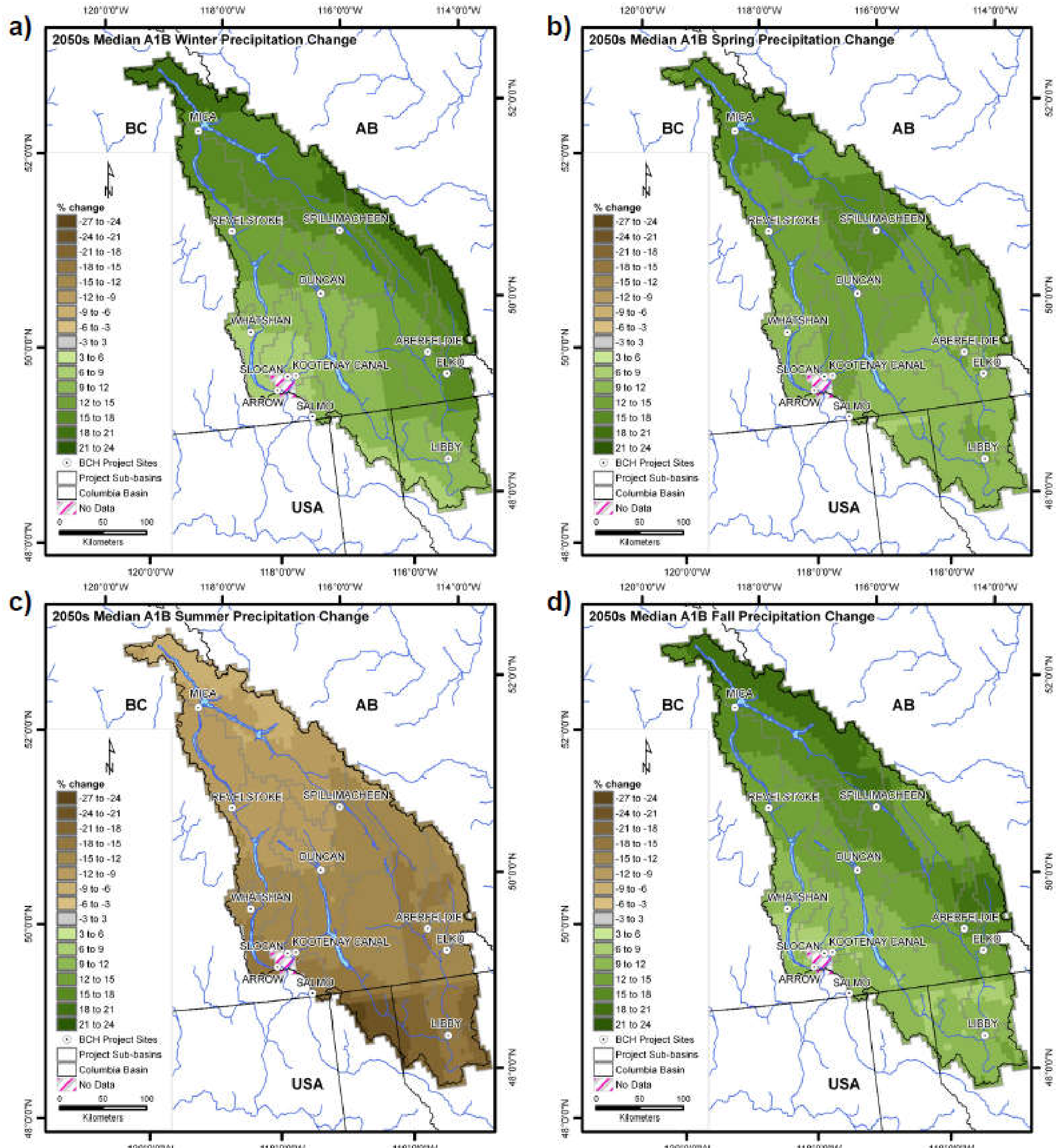


Source: PCIC: Schnorbus et al. (2011)

Projected

Climate Trends

2050s Precipitation

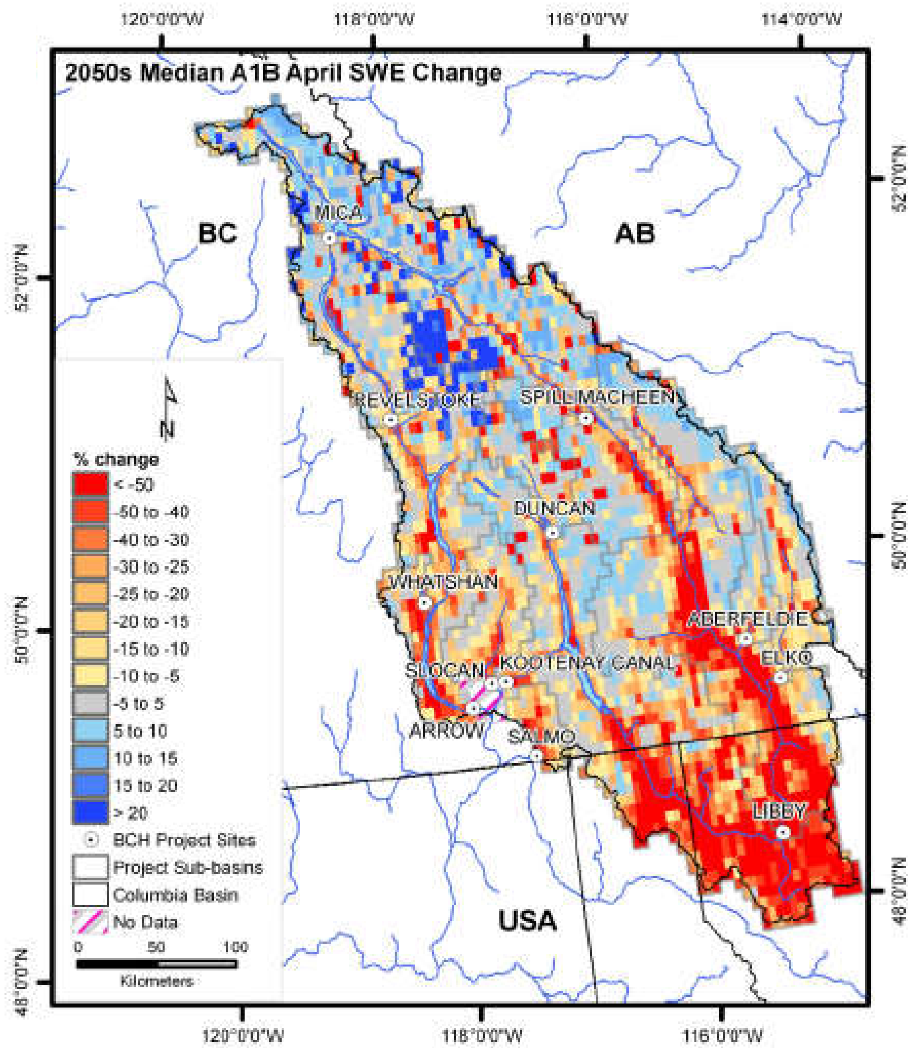


Source: PCIC: Schnorbus et al. (2011)

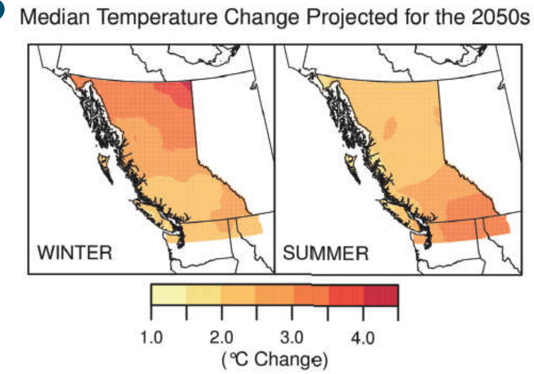
Projected Trends in April Snowpack

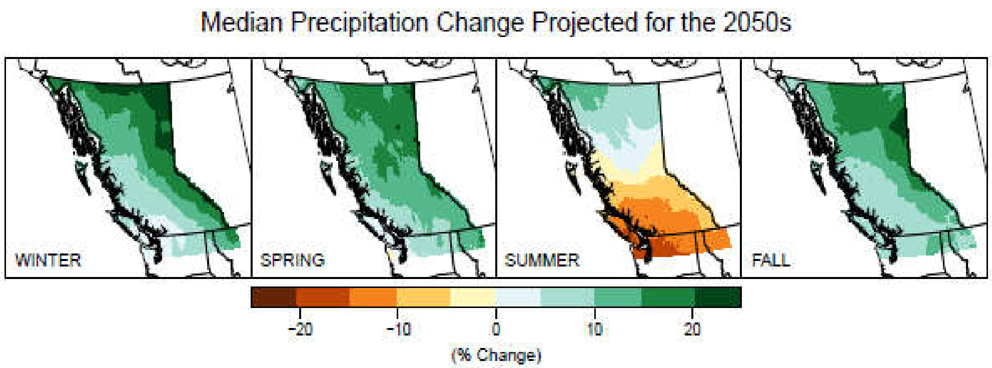
Median April 1 Snow Water Equivalent anomaly

- North-south and vertical gradient
- On average across the basin, median 2050s anomaly of April 1 SWE is (only) -30 mm
- SWE decreases at low elevations are offset by increases at high elevations
- Snow covered area will likely decrease



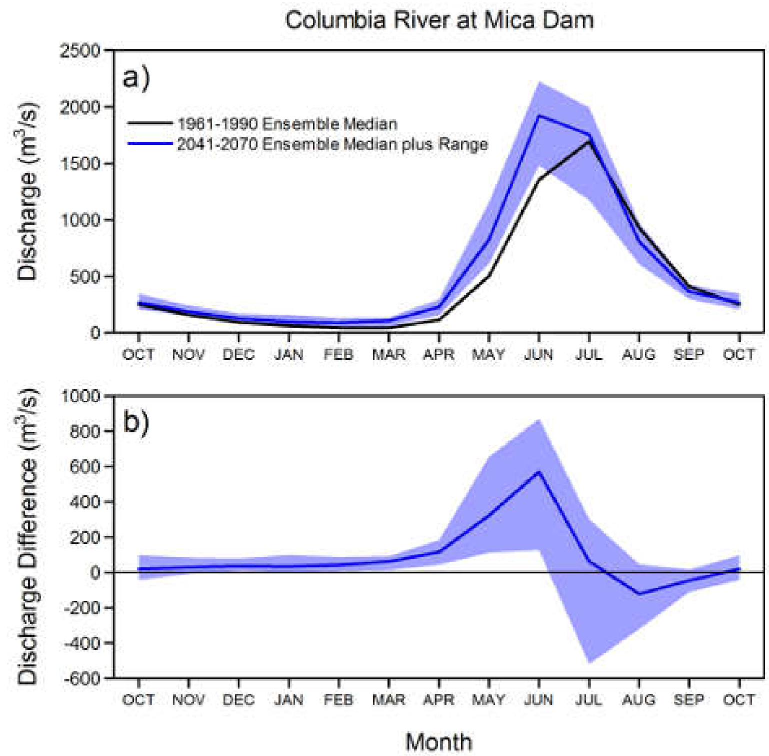
Hydrologic Impacts - Results





- By 2050:
  - 1.4 – 3.7 °C increase in mean temperature
  - 0 – 18% increase in annual precipitation
  - Modest increase in annual water supply
  - Significant change in timing of runoff

- By 2100:
  - 44 – 100% loss of glaciers in Upper Columbia River

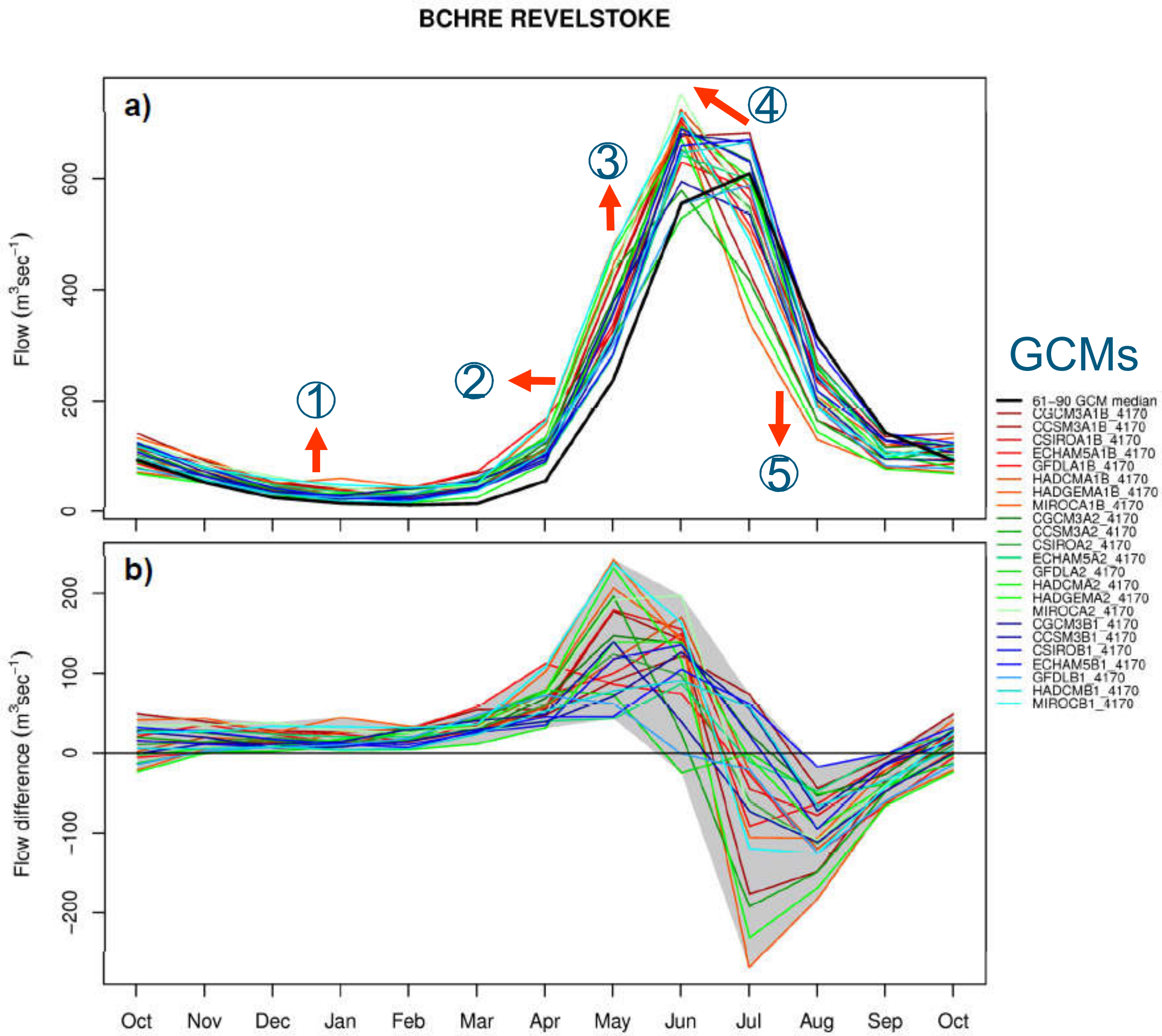


PACIFIC CLIMATE IMPACTS CONSORTIUM

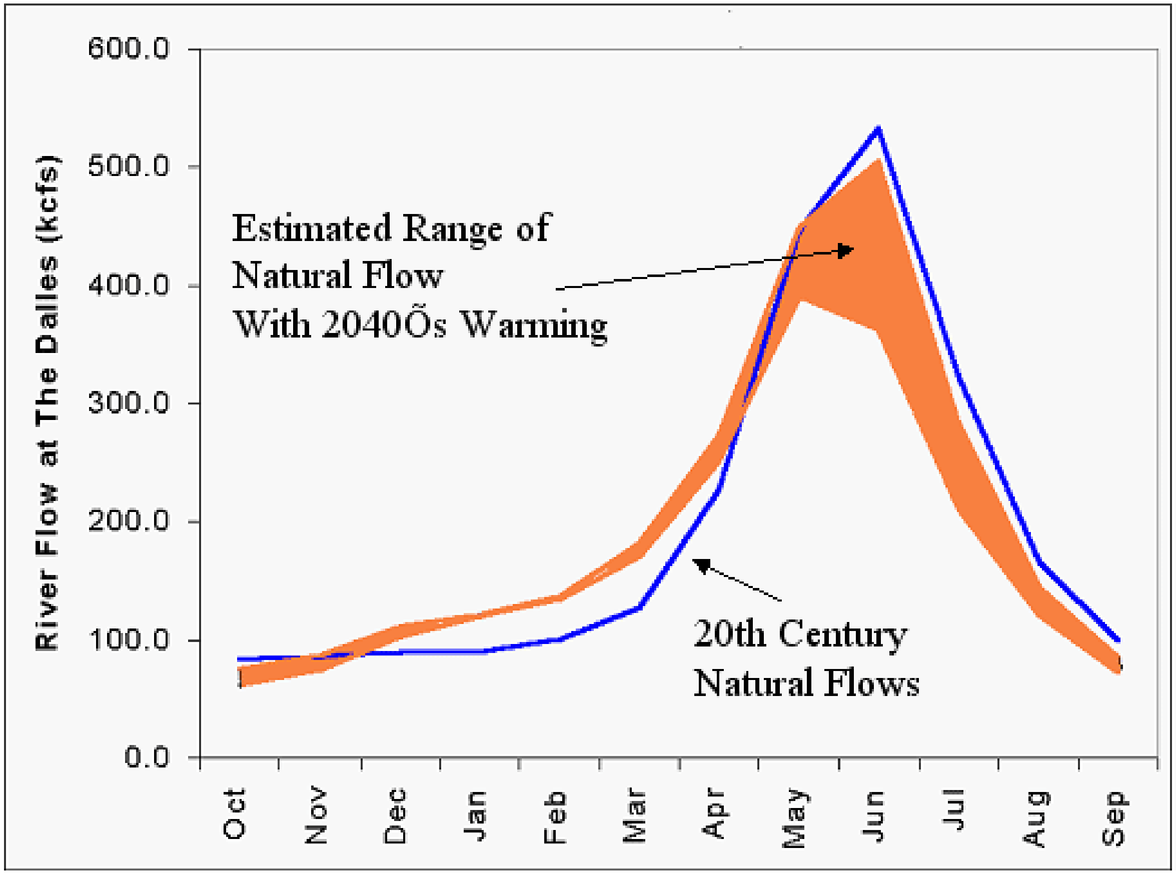
Projected Trends in Monthly Inflows

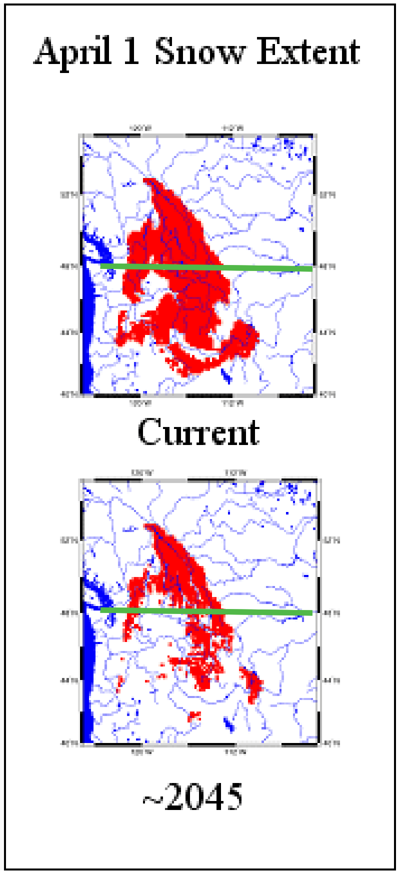
REVELSTOKE

1) Higher winter baseflow
2) Earlier spring melt
3) Higher spring melt
4) Earlier peak
5) Lower summer flow



US Columbia Basin Projected Impacts

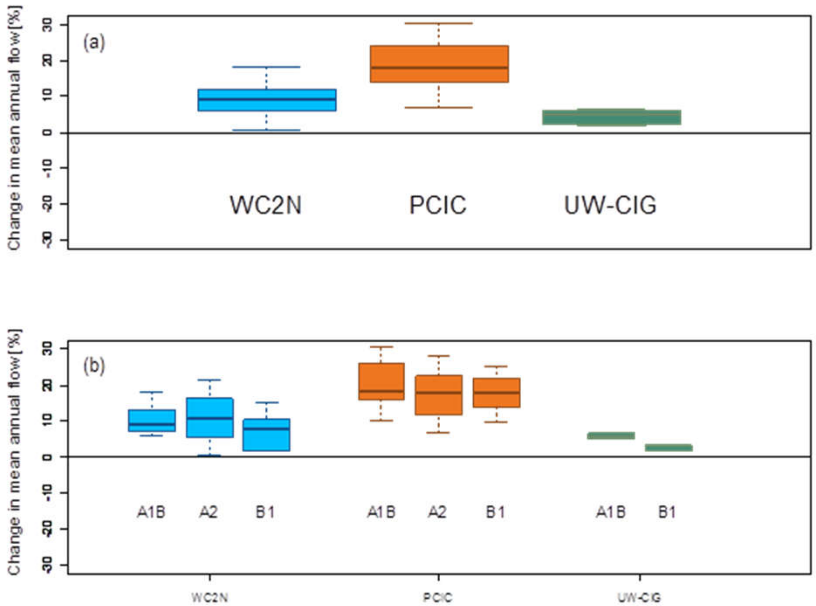


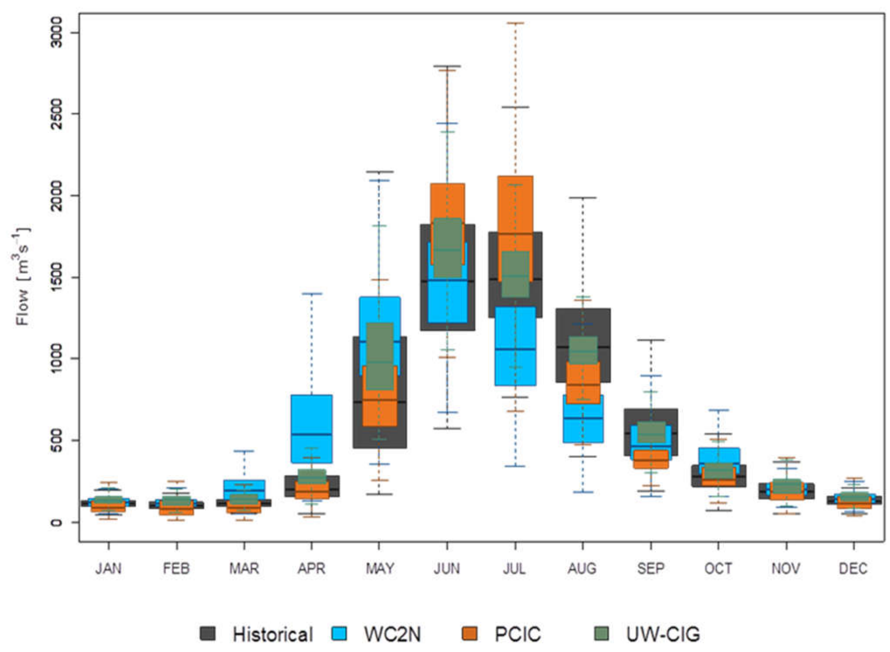


Source: University of Washington Climate Impacts Group

Modelling Uncertainty

Example: Multi-Agency ensemble of Mica flow projections

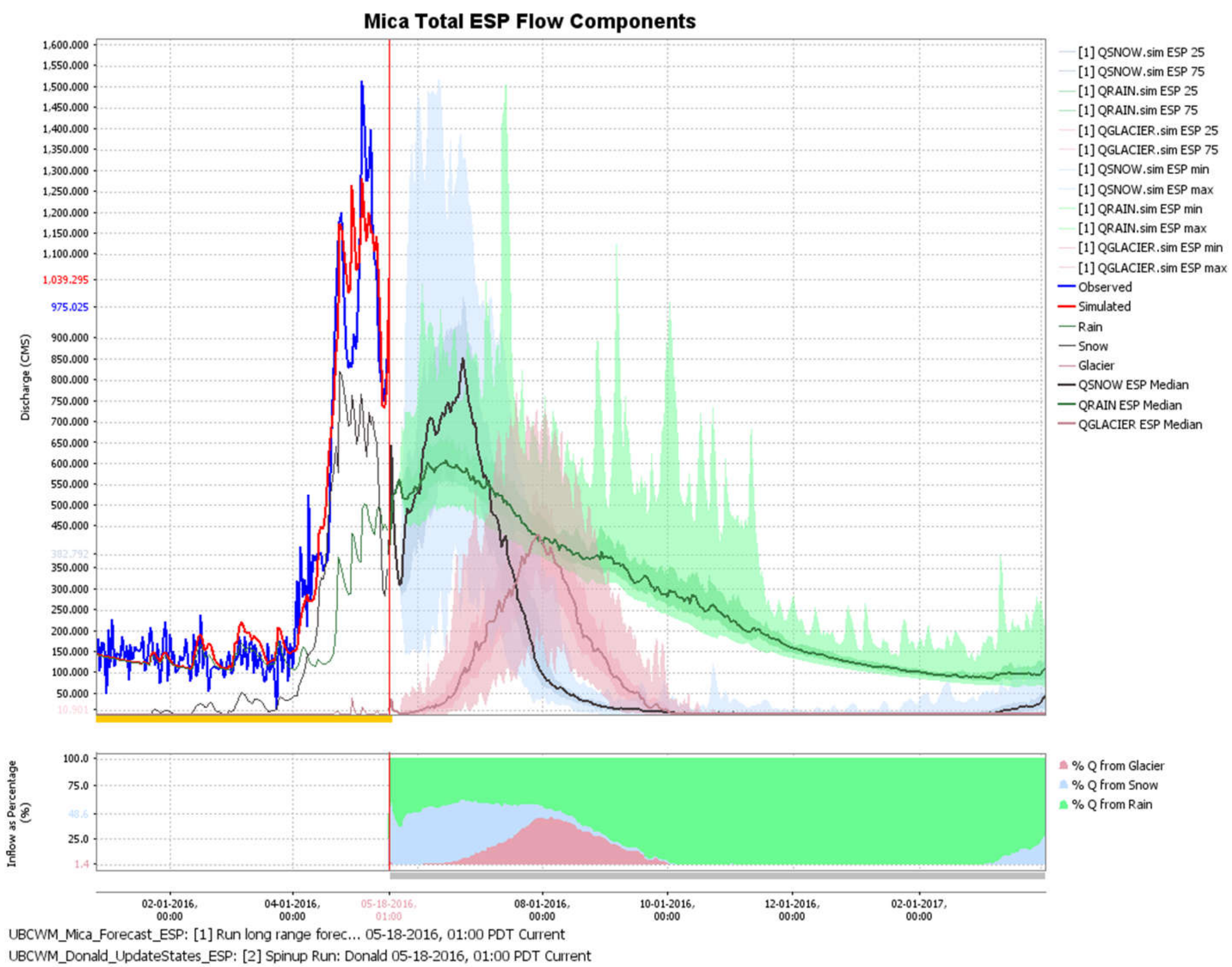




BC Hydro
Power smart

Flow components

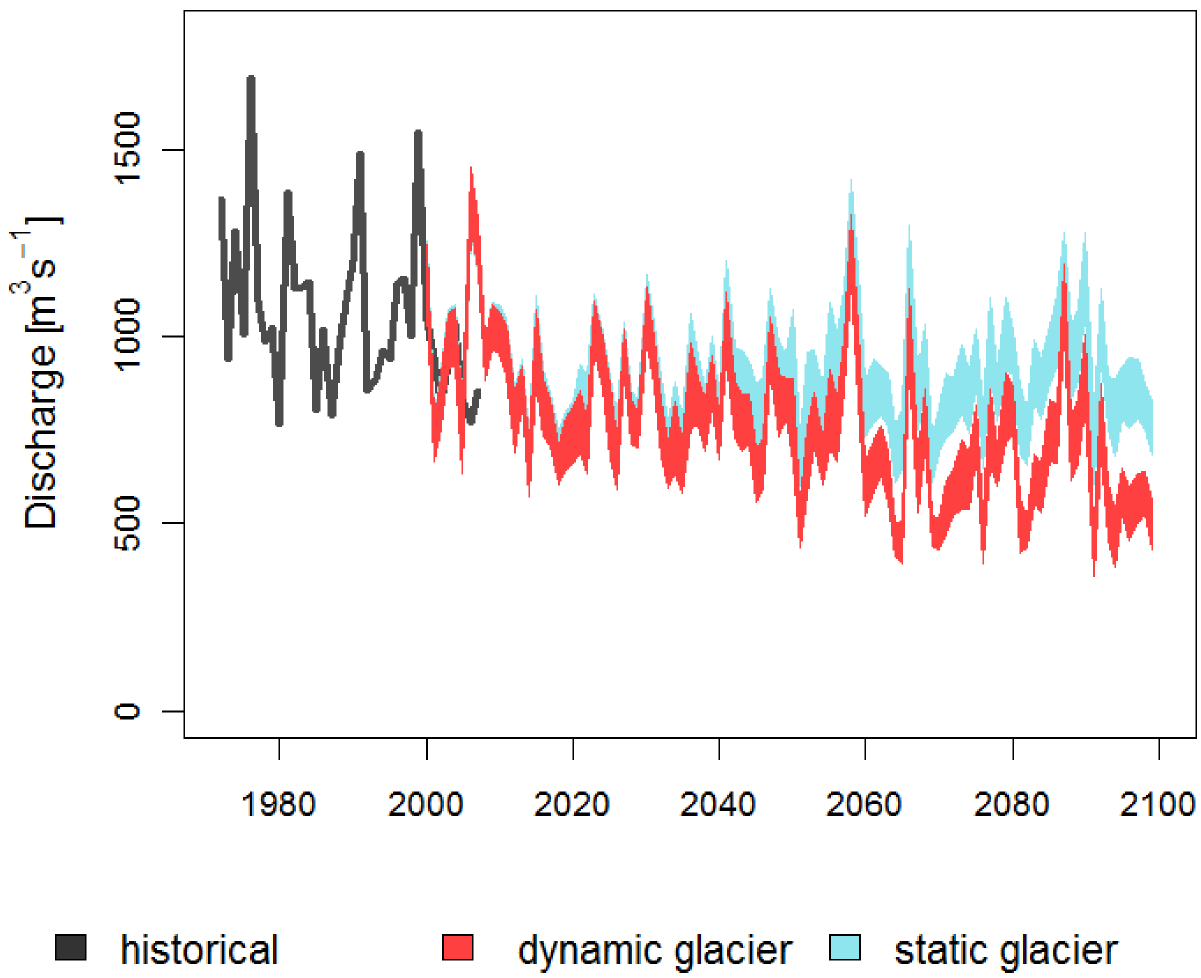
Expect high glacier contribution….



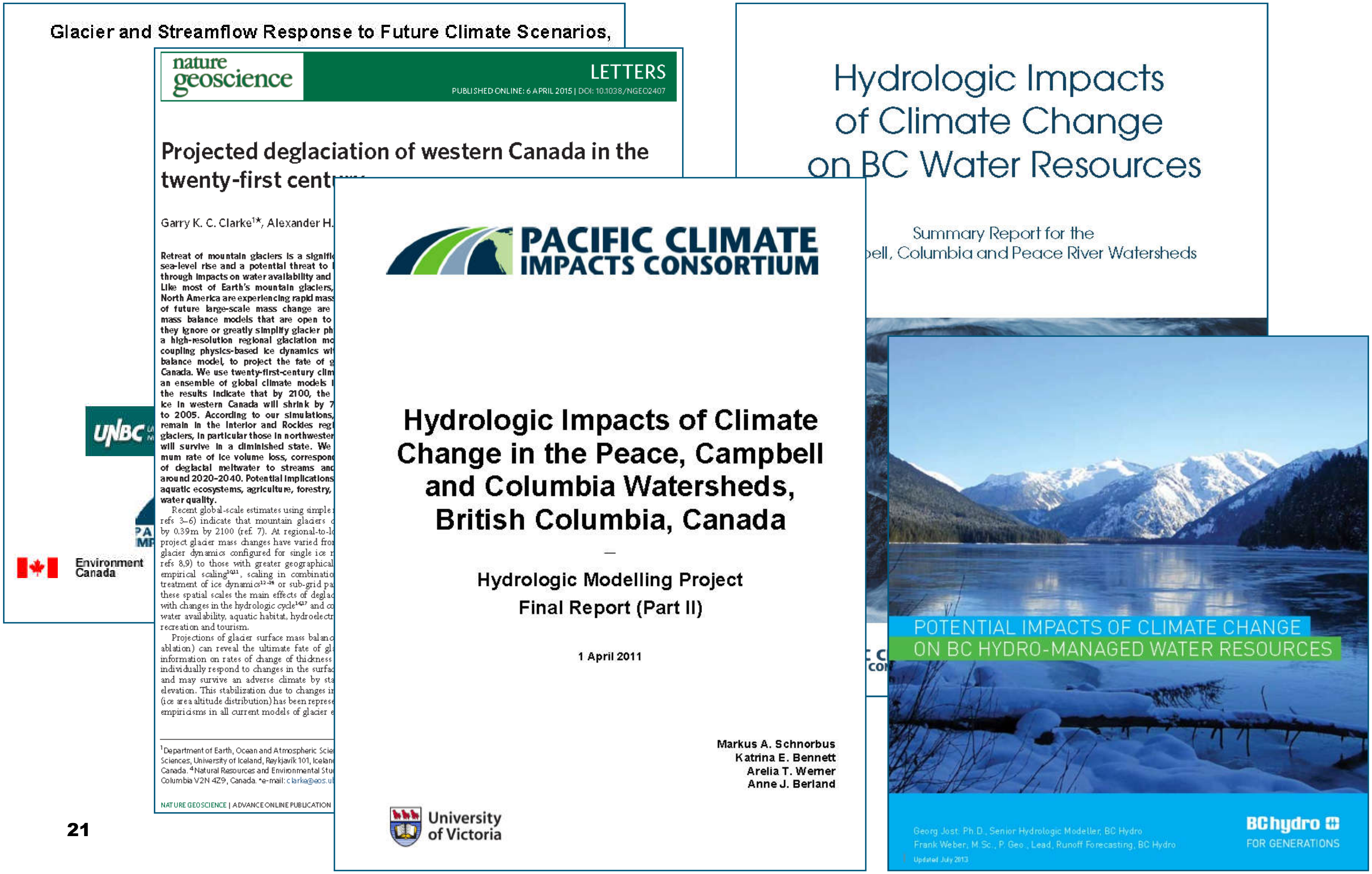
BC Hydro
Power smart

Projected Mean August Inflow at Mica

static vs. dynamic glaciers



Results & Reports



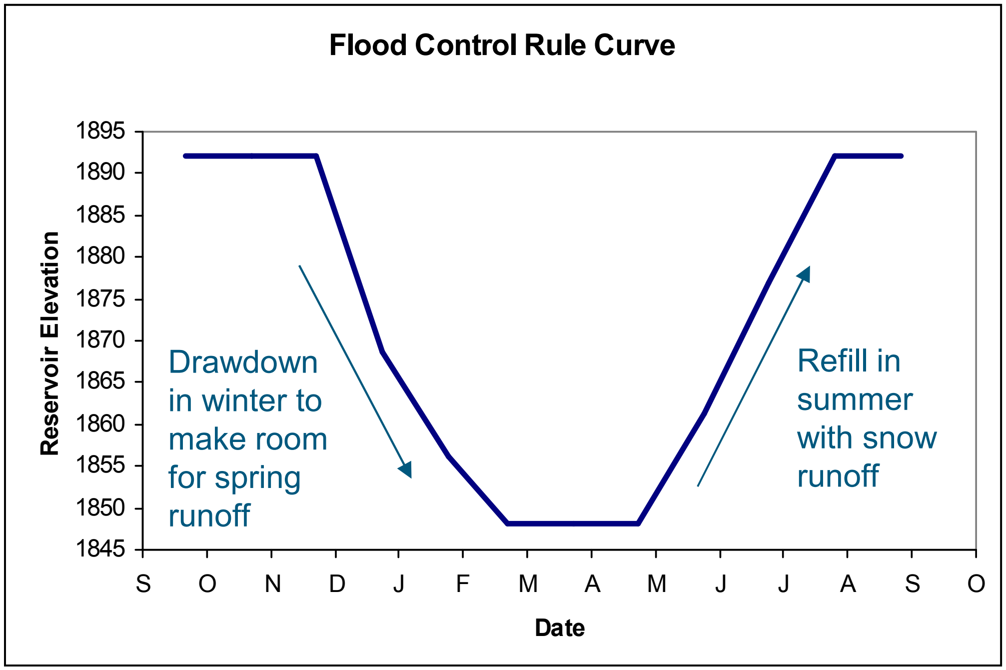
What does this mean for the Treaty Review?

US and Canada agree:

- Same or more water available, particularly in Canadian Columbia
- Timing of runoff is changing
  - Potential impacts for Flood Control
  - Lesser impacts to Generation
  - Potential impacts to fish flows
  - Snow pack storage decreasing – particularly in the U.S.

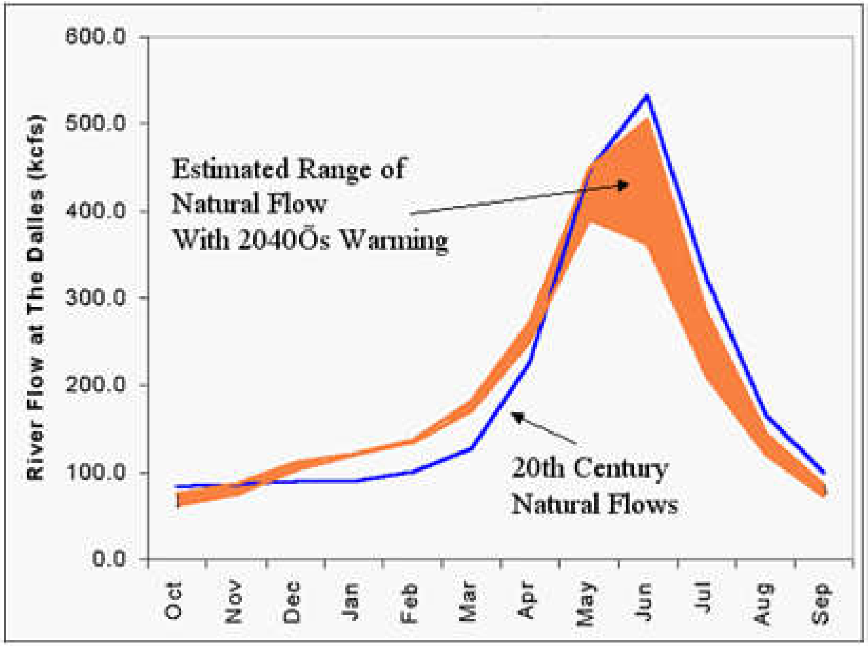
Considerations for Flood Control

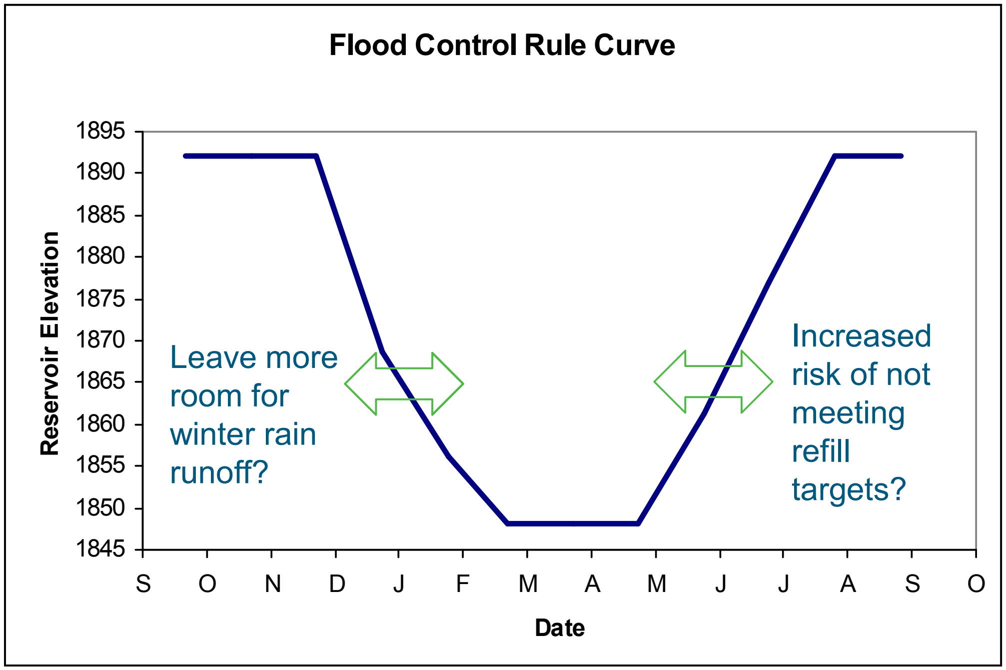
- Space required for flood control is based on:
  - snowpack,
  - rainfall during the refill season (spring and summer), and
  - shape and timing of the runoff.
- Based on April – August water supply forecast



Currently

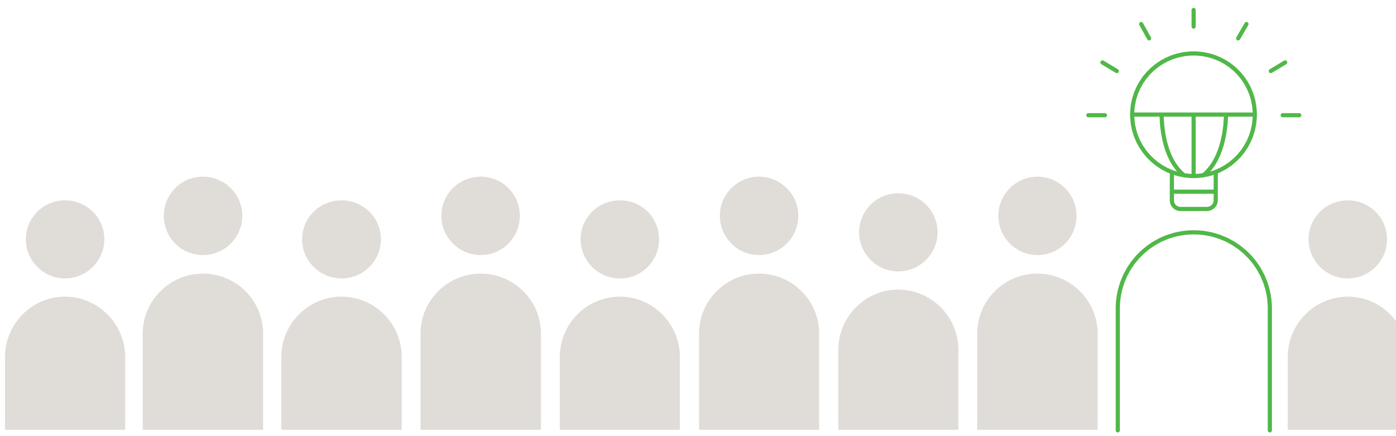
Considerations for Flood Control





How might flood control planning change?

What can we do?



BC Hydro
Power smart

Use New Climate Science

Climate update

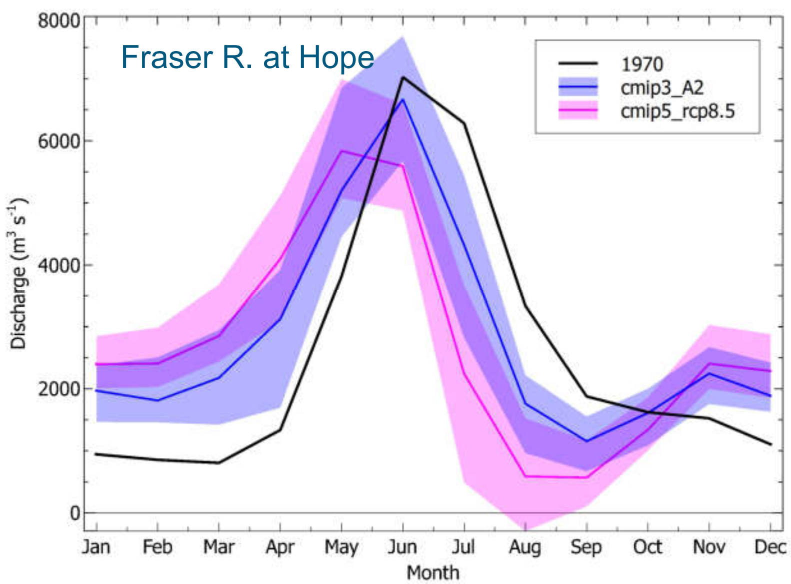
Intergovernmental Panel on Climate Change released their 5th Assessment Report

- Updated emissions scenarios (RCPs)
- Updated global climate models (CMIP5)

- Preliminary assessment of the results show consistent results with previous studies, but with accelerated timing

Projected Streamflow

2080s CMIP3 A2 versus CMIP5 RCP8.5

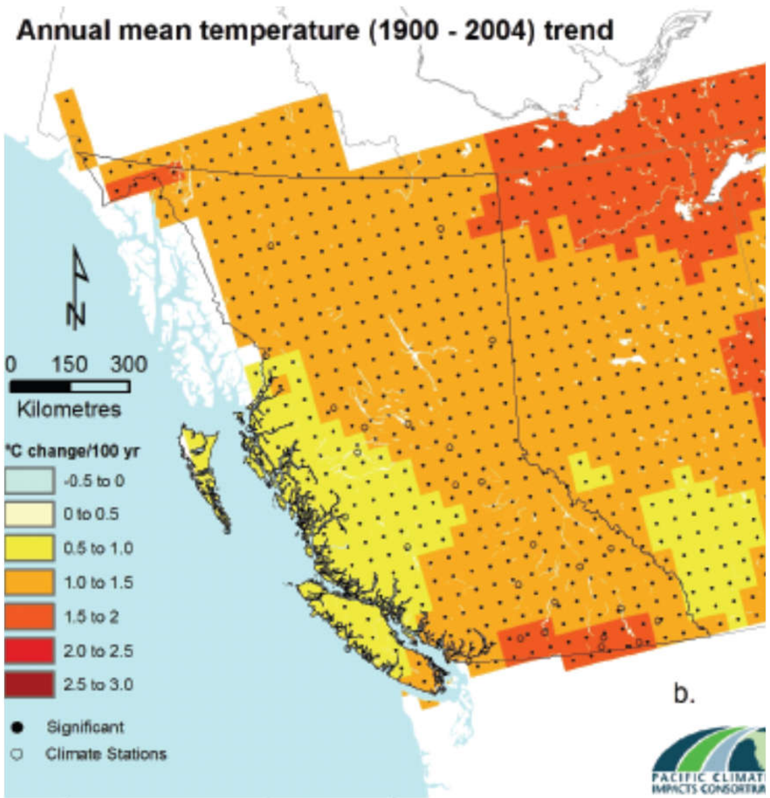


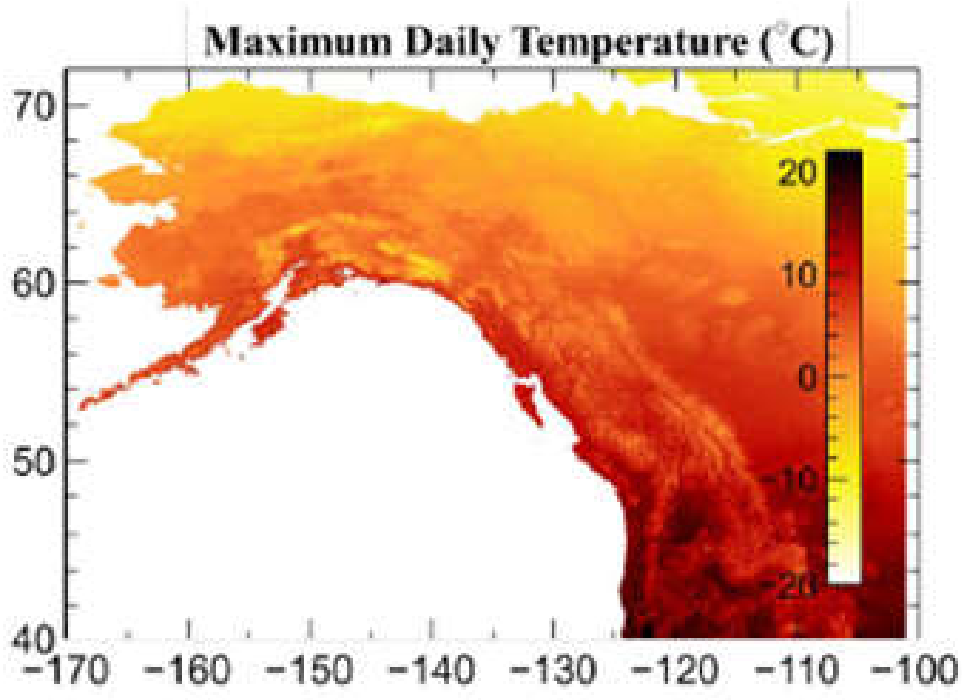
Source: PCIC

BC Hydro
Power smart

Expand Domain of interest

Improve resolution





PACIFIC CLIMATE IMPACTS CONSORTIUM

2007 2017

BC Hydro Power smart

Learn from previous research

BC Hydro renewed funding for Pacific Climate Impacts Consortium

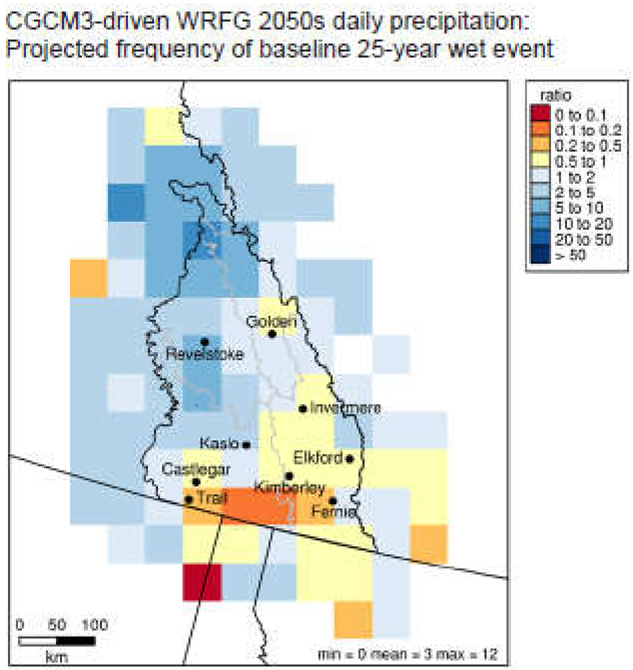
PCIC 2015-2018

- Expand region to whole Columbia Basin
- Incorporate new CMIP5 emission scenarios / GCMs
- Improve hydrologic model
- Incorporate glacier dynamics
- Explore impacts to severe / extreme events
- Investigate potential changes to low frequency dry sequences
- Quantify uncertainty

BC Hydro
Power smart

Stretch the science

Climate "Extremes" and Variability



From: "Climate Extremes in the Columbia Basin" – PCIC with funding from Columbia Basin Trust

Assessments of changes to variability and extremes

- Still emerging science
- Assessing impacts to climate indices (eg growing degree days), quantile projections, storm patterns, return periods

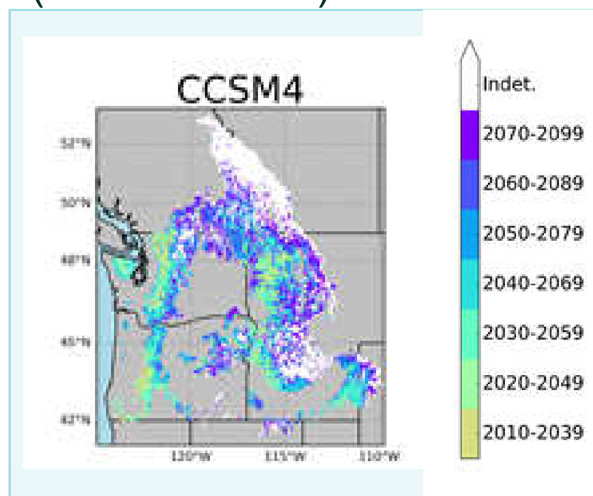
BC Hydro
Power smart

Continue to Work with U.S.

U.S. Studies

Joint studies: River Management Joint Operating Committee (RMJOC II)

- Incorporate new CMIP5 emission scenarios (RCP 4.5 & 8.5)
- Improve hydrologic model
- Snow pack trend projections
- Quantify uncertainty
- Update Hydro-regulation studies
- Assess impacts to water temperature
- Assess impacts to forecast procedures → Flood risk management



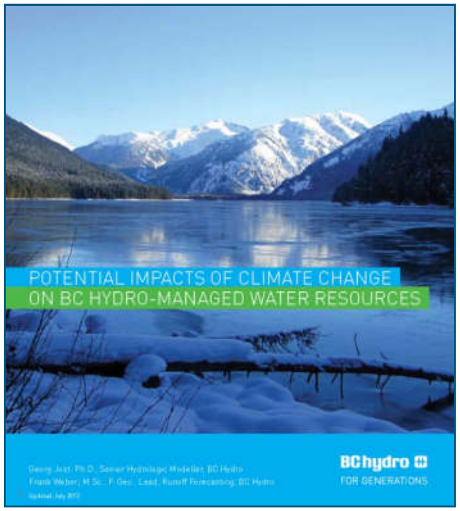
U. Washington

BC Hydro
Power smart

Incorporate and Communicate Results

BC Hydro

- Update historical inflow trend assessment
- Future scenarios →BC Hydro Planning Models
    - Integrated Electricity Plan
    - Environmental assessments
    - Water license renewals
    - Columbia River Treaty
- Update Communications

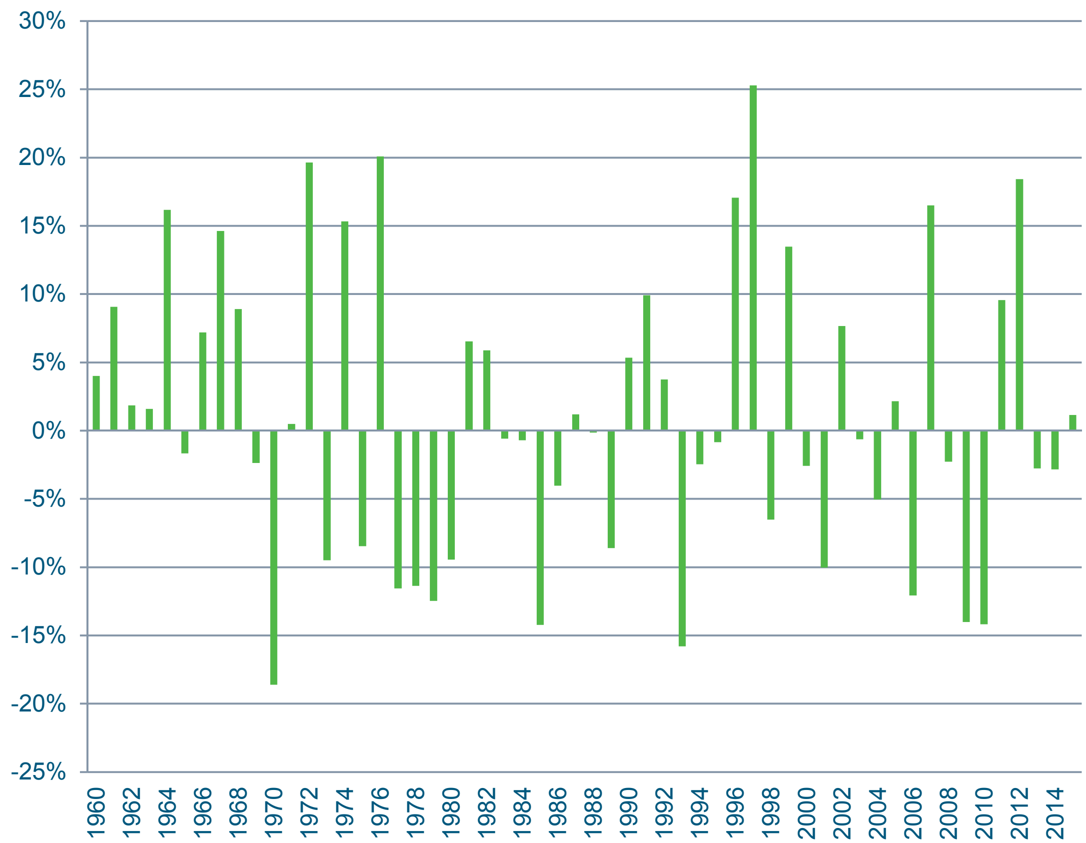


BC Hydro
Power smart

Resilience

BC Hydro has the tools, plans, and expertise to manage across a wide range of conditions and situations

Are we ready?



System Annual Inflow deviation from normal 1960-2015

Horse Creek Recreation Site on Kinbasket Reservoir, September 2013

Low water levels on the Cowichan River have raised concerns. The Ministry of Forests, Lands and Natural Resource Operations says the latest alert comes five days earlier than the one it issued last year, when the drought conditions lasted until September. BRUCE STOTESBURY / TIMES COLONIST

BC Hydro
Power smart

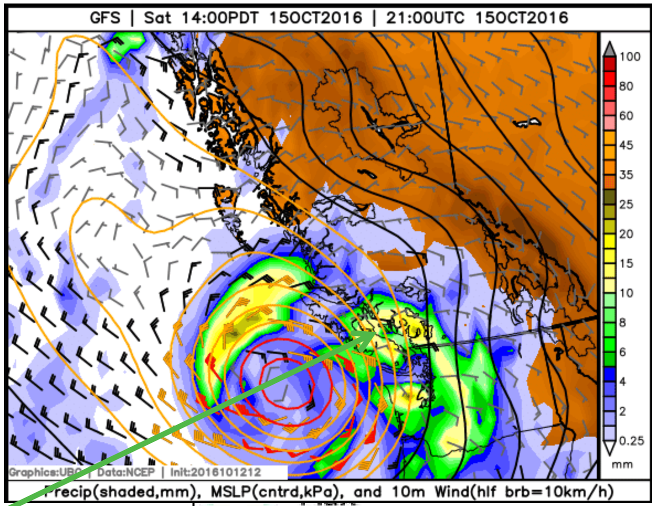
Improve our tools

Investing in new and improved forecasting and planning tools

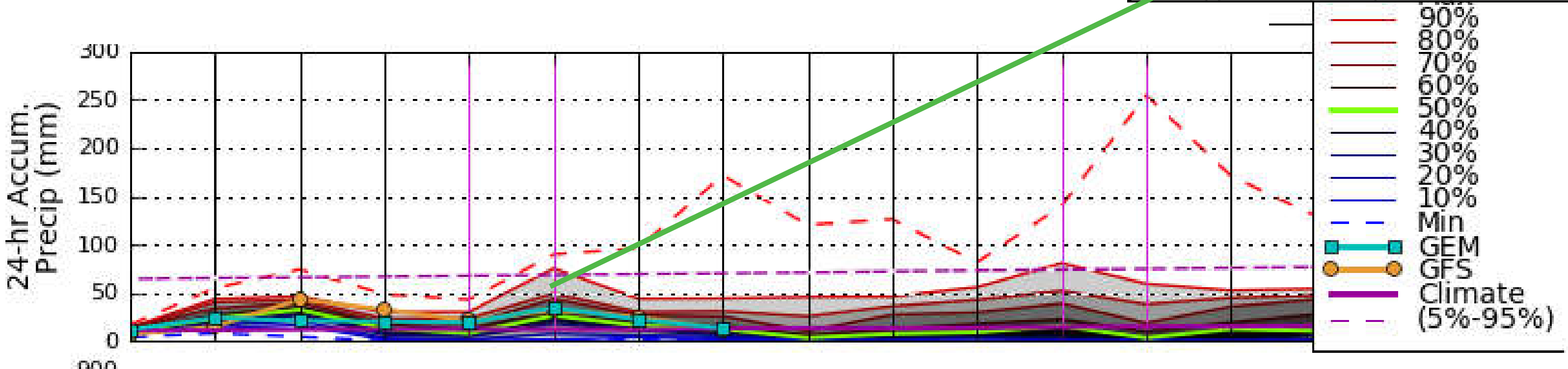
Enhanced weather forecasting

Flexible hydrologic models

Incorporating uncertainty



Point Precipitation forecast range



BC Hydro
Power smart

Monitoring – what we measure

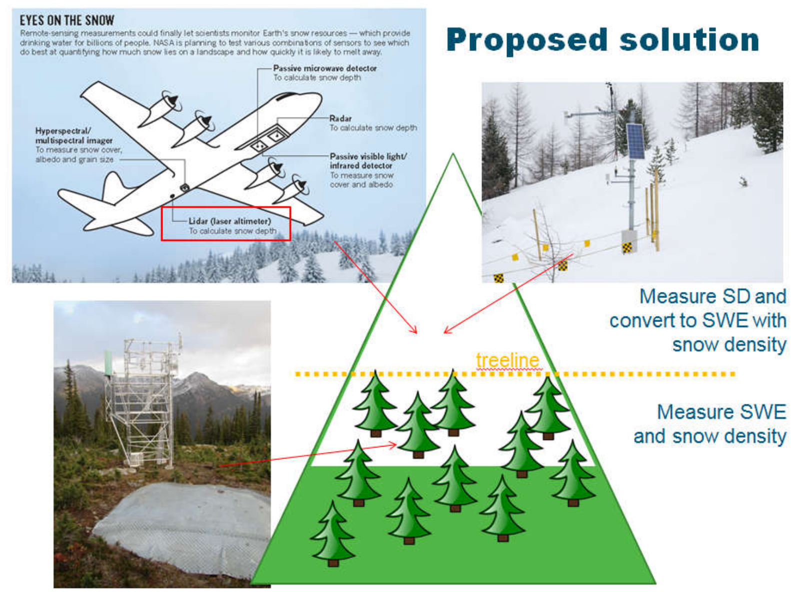
Climate | Snow | Surface Water | Glaciers




Adding new monitoring

Traditional and innovative technologies

- Increased monitoring
  - Four new snow monitoring stations
  - Columbia glacier research network
  - High elevation snow monitoring
    - MODIS satellite - snow cover
    - LIDAR remote sensing



Answering Key Questions

New Communications Plan

Are storms getting stronger/ more frequent?

What is the probability of extended drought?

How might demand change?

What information should we include in design decisions?

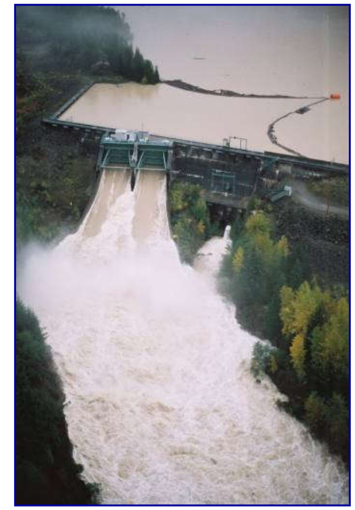
How will climate change impact water temperature? Will it impact fish?

Was that storm attributable to climate change?

What is the variability in future projections?

How certain are you?

What does it mean to be a climate-resilient business?



Understand your risks and vulnerabilities

Involve your stakeholders (internal/external)

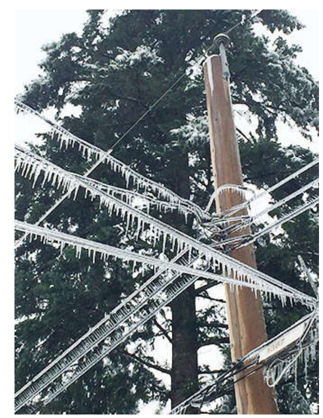
Start with highest impact areas

Leverage and share resources (government / academic / industry associations)

Build local capacity / innovation

Adapt existing tools / practices

Take advantage of times of renewal



BC Hydro
Power smart

Questions

BC Hydro
Power smart