Glacier Dynamics

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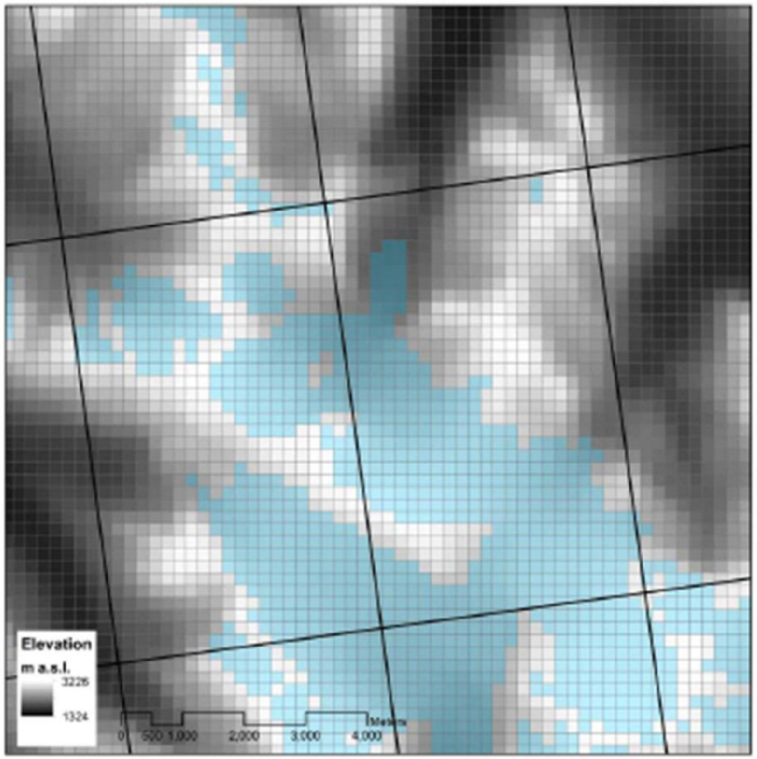
University of Victoria

Comparing Models

Spatial Scale and Spatial Representation

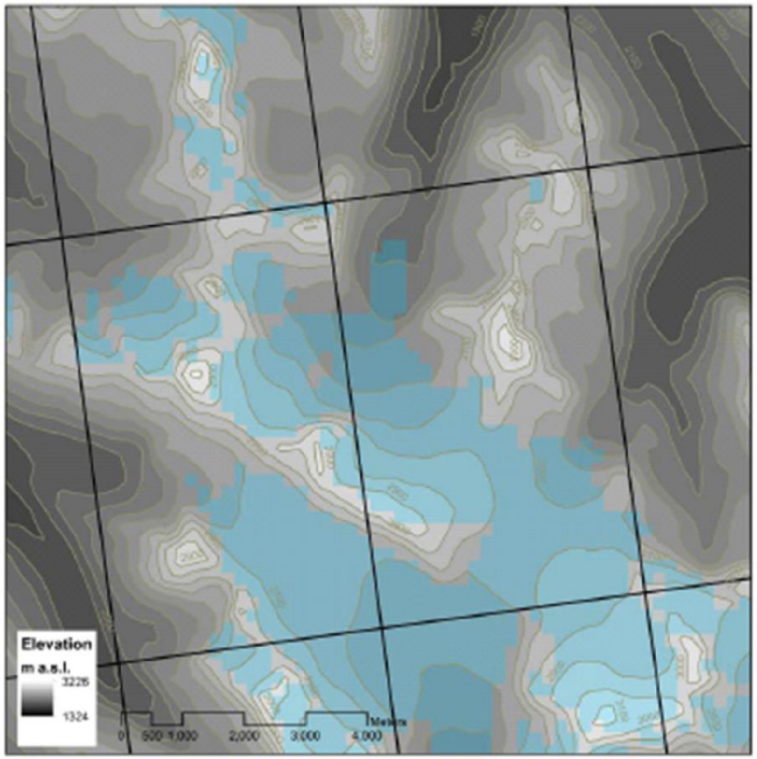
Regional Glaciation Model

- Spatially explicit -



VIC Model

- Conceptualized -



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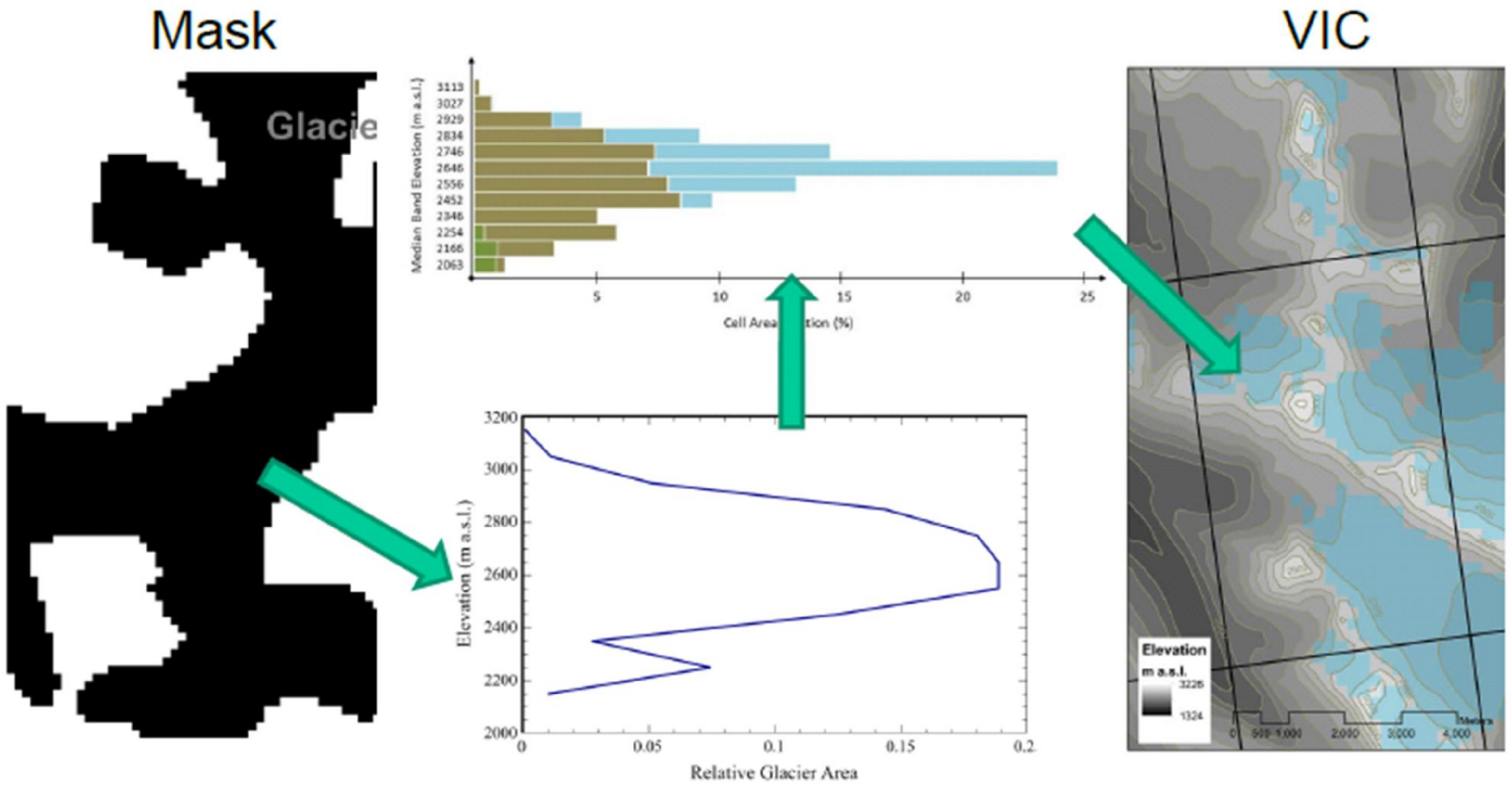
Linking Models

Glacier Area data from RGM pixels to VIC HRUs



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PCIC Time Line

Hydrologic Impacts

Code Parallelization – done

Glacier dynamics –state updating – July 2016

New routing model (RVIC) – Done

Calibration of Columbia Basin – Sep 2016

Projections for Columbia – Dec 2016

BC Hydro Workplan

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Incorporating Climate Change Scenarios

Environmental Assessments for new hydro generation resources

- "Site C": third hydro dam project on Peace River – Environmental Impact Assessment
- John Hart generating station refurbishment – Regulatory Approval process
- Additional generating units at Columbia River generating stations

Long-term planning processes

- 20-year integrated electricity plan – supply *and* demand
- Columbia River Treaty Review process
  - Joint set of scenarios agreed with U.S. and Canadian parties
- Water license review process

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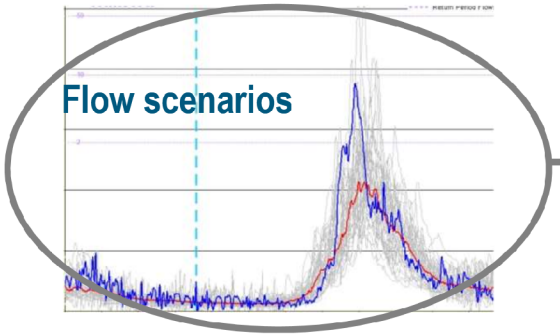
Generation Impact Assessment

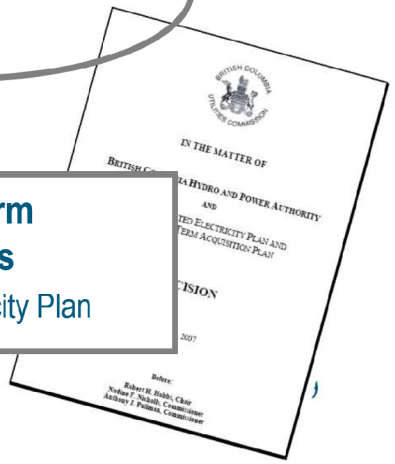
Resource Adequacy



Long-term planning models

Assess impact on
Finance, Environment, Society
- Energy capability
- Operating criteria
- Dam safety

"Average Water"



Develop long-term acquisition plans
Integrated Electricity Plan

Acquire resources
Build, Buy, Conserve

Operate with new resources and operating criteria

Transmission Risk Assessment

System Resiliency

Identify
- Climate scenarios

Evaluate
- System risks

Plan Response
- Mitigation strategy

Implement
- Approved projects



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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?

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Climate Change Impact Assessment

Research Plan & Overview Study Summary

May 6, 2008

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BC Hydro's Climate Change Impact Assessment

- **BC Hydro's system operation is dependant on the weather:**
  - **Inflows to hydro projects depends on:**
    - **Precipitation, amounts and timing,**
    - **Temperature, controls snow accumulation and melt**
  - **Loads**
    - **Peak loads are dependant on temperature**
  - **Prices**
    - **Wholesale energy prices are affected by temperature**
      - **Air conditioning loads in southwestern US in summer**
      - **Heating loads locally and in Alberta in winter**
- **How is Climate Change and Variability going to affect these weather related drivers?**

BC Hydro Action Plan

- **Fund directed research**
  - through Pacific Climate Impacts Consortium
    - http://pacificclimate.org/
  - $200,000 year for 4 years
- **Develop revised weather and inflow records**
  - For use in system planning studies
  - To quantify expected effects of climate change on:
    - Operating performance in terms of:
      - generation, instreamflows, reservoir levels, spills, etc.
    - Relative to our baseline historical record.

Climate Impact Assessment

- **Objectives**
  - **Quantify probably climate change characteristics in terms of:**
    - **Precipitation amounts and seasonal pattern**
    - **Temperature values and seasonal pattern**
  - **Use these modified weather records to:**
    - **Simulate alternative runoff patterns**
    - **Simulate alternative load patterns**
  - **For use in system planning studies by:**
    - **Simulating system operations under these modified weather drivers**
    - **Compare against baseline simulations using historical weather records**

Current Status

- **Climate Overview Study Complete**
  - ***Hydro-climatology and Future Climate Impacts in British Columbia, PCIC, Nov 16, 2007***
    - http://www.pacificclimate.org/publications/ClimateOverview.v2.0_PCIC.pdf

- **Research Plan Complete**
  - **Development of Diagnostic Hydrologic Models**
    - **Models used to generate climate change adjusted inflow sequences**
    - **1st stage is to model Columbia Basin**
  - **Diagnostic Climate Model**
    - **Regional Climate Model at a spatial resolution matching the hydrologic model**
  - **Extensions of the Overview Study**

Climate Overview Study Objectives

- Provide high level review of available data and studies
  - Analysis of historical hydro-climatic trends and variability using latest data and most recent techniques
  - Projections of future climate using most up-to-date:
    - Global Climate Models (GCM) and
    - Canadian Regional Climate Model data
  - Synthesis of all recent publications

Study Results - Historical Trends

- Significant increase in temperature and precipitation across the BC over historical record
  - Winter minimum temperatures increase at rate of +1 to +3°/ 100 yrs
    - Stronger increase in the north
  - Summer maximum temperatures cooling in the ~ -1°/100yrs north and warming in the south 0 to 2°/ 100 yrs
  - Strong positive trend in precip (>10% / 100yr) across the province except for Vancouver Island and South Coast (no significant trend)
  - Highest trend in precip.
    - central plateau and Peace Basin (>20% /100 yr)

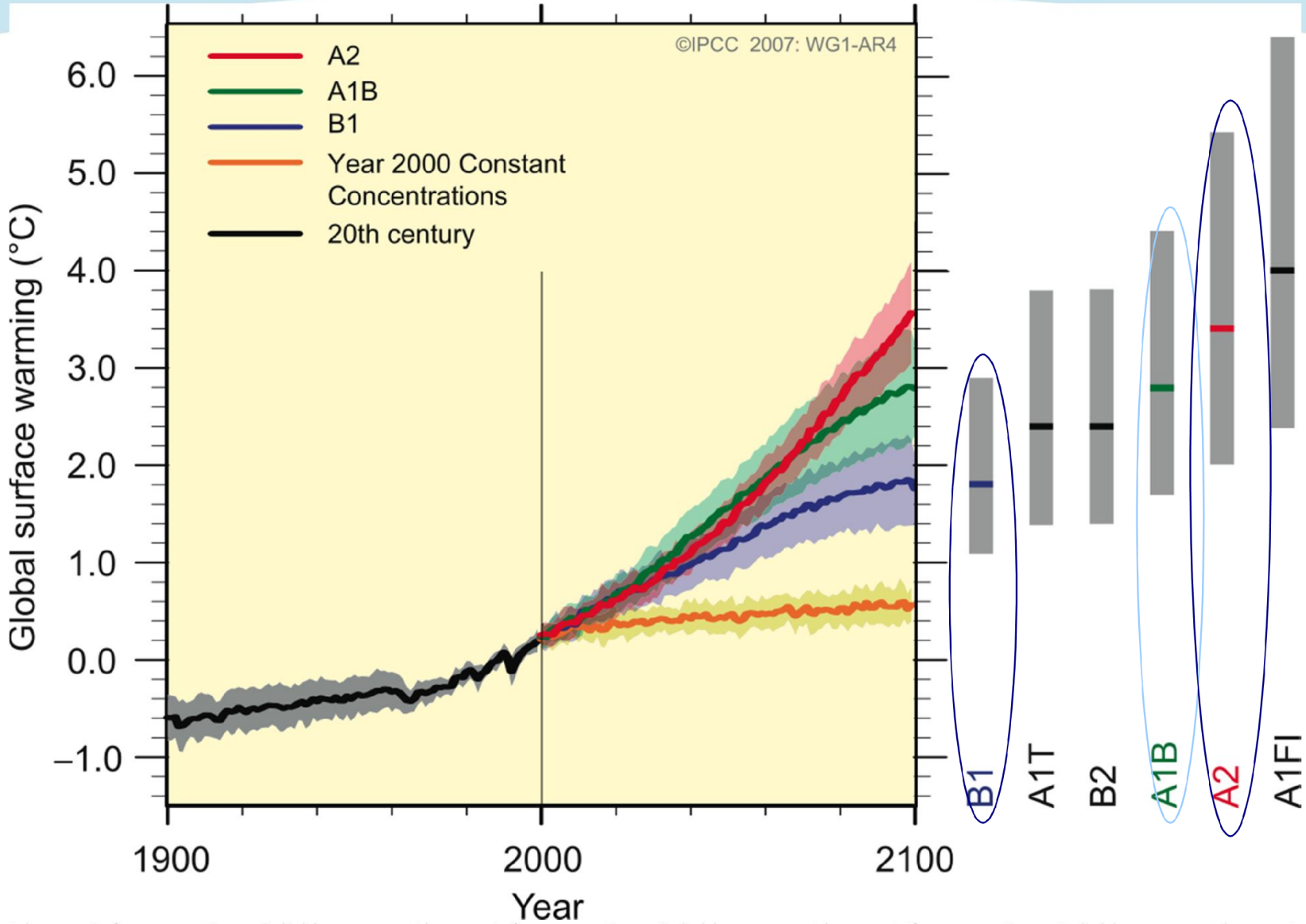
- Significant glacial depletion
  - particularly below 2000 m across the province
  - except in northwest corner of the province

Regional Climate Cycles

- Strongest Global Climate Cycles affecting on BC are:
- El Niño -Southern Oscillation (ENSO)
  - Sea surface temperature in equatorial Pacific – 2 to 7 yr period
  - El Niño - warmer (+2° to +5°C), dryer (-2 to -15%) BC winters
  - La Nina – cooler (0° to -4°C), wetter (+2 to +15%) BC winters
- Pacific Decadal Oscillation (PDO)
  - North Pacific Sea surface temperature cycle – 25 yr period
  - Warm phase +1 to + 4°C increase in BC winter mean temperature
  - Cool phase 0 to -3 °C decrease in BC winter mean temperature
  - Strongest influence in Peace Basin

Climate Change Projections

- Focus on Temperature and Precipitation
  - Based on multiple Global Climate Model (GCM) runs
  - Compared to 1961-1990 historical baseline
  - Canadian Regional Climate Model (CRCM)
    - A2 GHG Scenario (most likely level of achievable GHG reduction)
- 2050's
  - Temperatures + 2° in south to +3°C in the north
  - Precipitation 0% in south coast and Rockies, +10% Central Plateau trending to +20% in the north



Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations.

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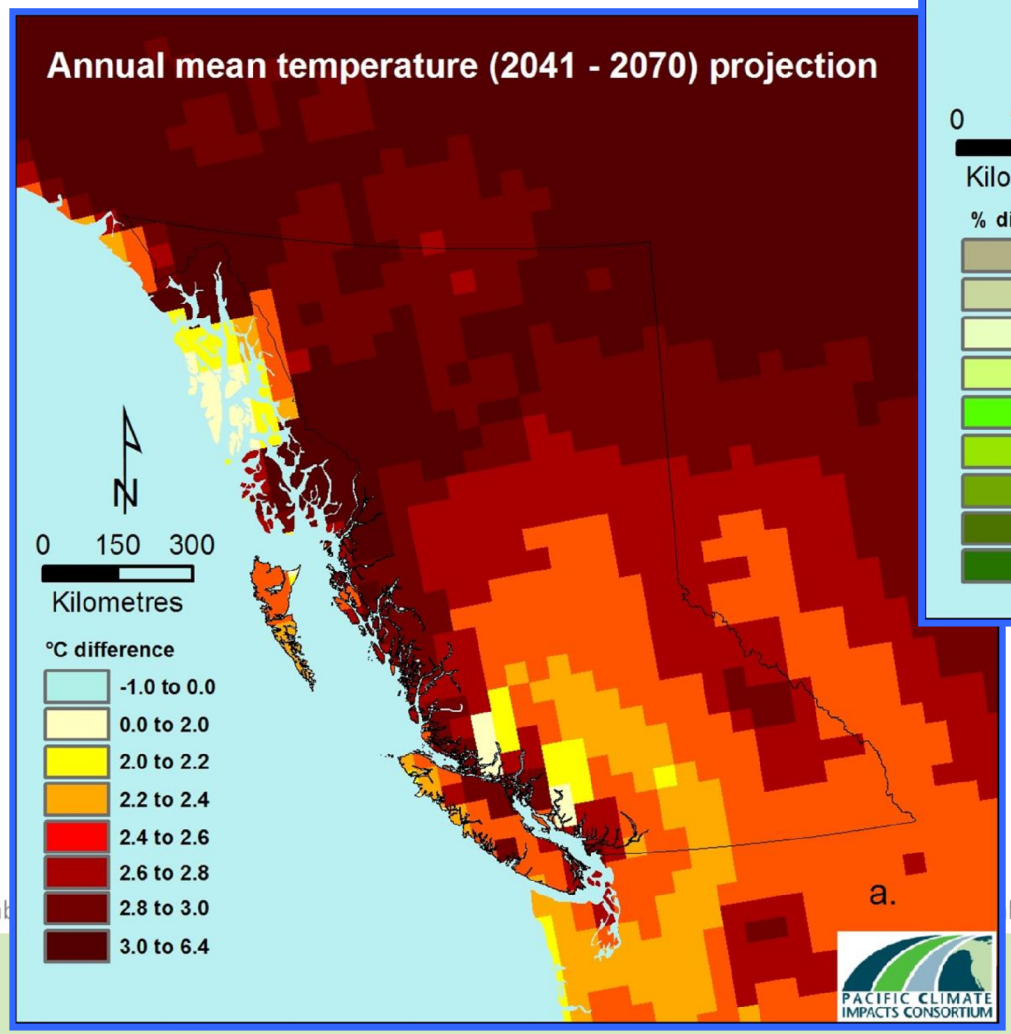
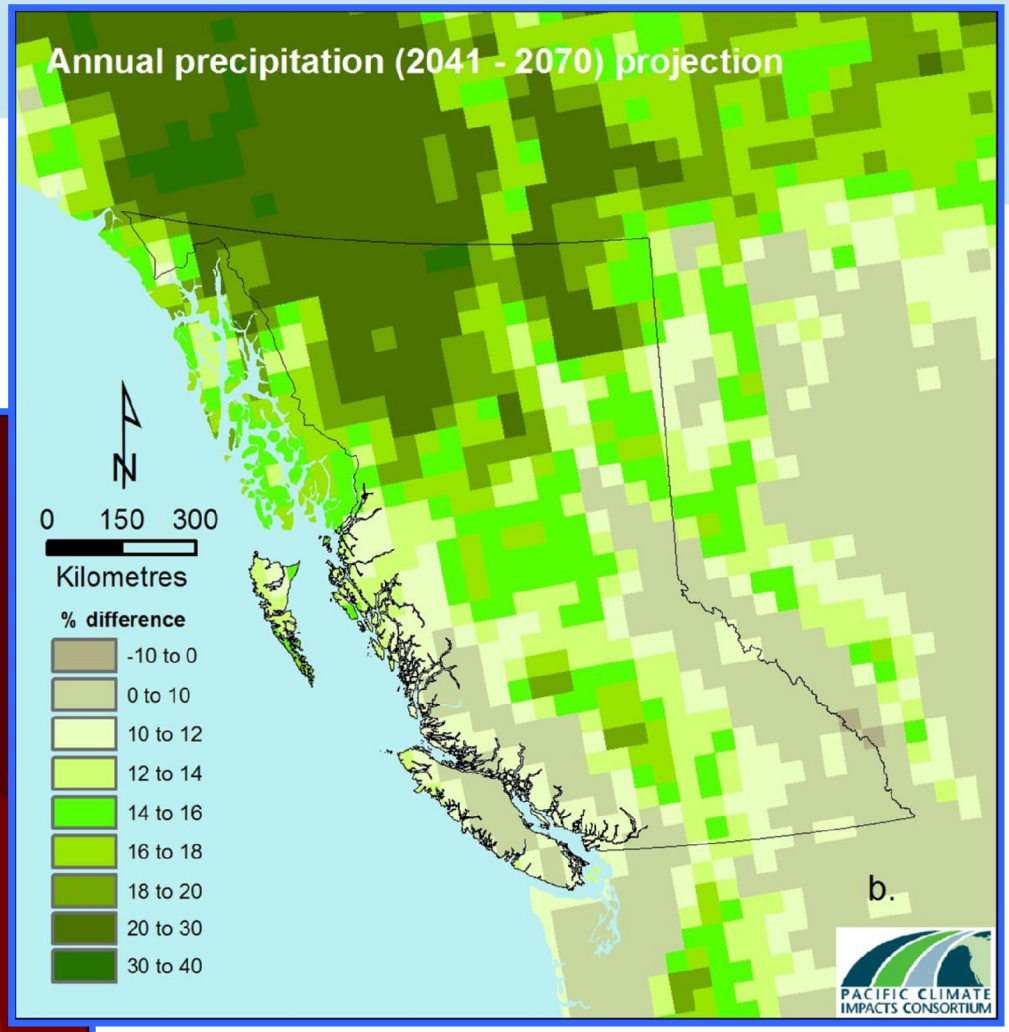
IPCC AR4 Figure SPM.5

2050s Projections





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Expected Effects on Hydrology

- **Annual runoff** volumes will remain the ***same or increase*** due to a projected increase in precipitation. Generally, large increases in fall, winter and spring precipitation outbalance the losses from glacial melt.
- **Fall runoff** will **increase** due to an increase in fall precipitation and a larger portion of rain compared to current conditions.
- **Winter runoff** will **increase** in response to higher fall runoff.
- **Spring runoff** will significantly **increase** due to an earlier spring freshet;
- **Summer runoff** will significantly **decrease** due to the earlier spring freshet.
  - Reduced glacial runoff and reduced summer precipitation in the Columbia basin will also contribute to reduction of summer runoff.
- The **spring freshet** will be up to 2 weeks **earlier.**

Simulated Runoff using Historical and Climate Adjusted Weather data