Western Canadian Cryospheric Network (WC²N)

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Research Partners:
BC Hydro; BC Ministry of Sustainable Resources Management; BC Parks; BC Ministry of Environment (MoE); Columbia Basin Trust (CBT); Fisheries and Oceans Canada (DFO); Environment Canada - Cryosphere System in Canada (CRYSYS); Environment Canada - Meteorological Service of Canada (MSC); Global Land Ice Measurement from Space (GLIMS); Natural Resources Canada - National Glaciology Programme (NGP); Natural Resources Canada - Terrain Sciences Division National Snow and Ice Data Center (NSIDC); Parks Canada
Western Canadian glaciers

- Natural climate stations
  - Winter ppt; summer temp.

- Critical resource
  - 30,000 km² in BC (~3% landmass)
  - Freshwater (Canada and US)
  - Downstream ecosystems vulnerable:
    - flow regulators
    - thermostats
  - Hydro power from surface runoff
    (90% BC; 17% AB)
Yesterday

Today

Tomorrow

Volume per time

Discharge

Volume per time

Lower late-season flows
Warmer late-season flows

June

June

June

Peak electricity demands (hydro)
Research Objectives

1) Document N. Pacific climate variability and glacier extent (400 yrs to present)

2) Detail meteorological processes and their links to glacier nourishment (glacier mass balance)

3) Predict how glaciers will respond to projected climate change over the next 50-150 years
Model calibration/verification

GCM output

Statistical downscaling

Temperature, Precipitation

Glacier mass balance model

Net Mass Balance

Dynamic glacier flow model

Dimensional changes in glaciers

Validation (geologic record)

RCM Daily reanalyses

Local climate data (glacier)

Energy balance of glacier

Initial conditions valley geometry flow parameters

After Reichert et al., (2002)
To Date:

17 Publications
+
4 Manuscripts Currently Under Review

In refereed journals including:

Annals of Glaciology
Journal of Climate
Hydrological Processes
Journal of Glaciology
Journal of Geoscience Education
Journal of Applied Meteorology and Climatology
44 Highly Qualified Personnel Trained

Including:
10 Undergraduate Assistants
18 M.Sc. Students
9 Ph.D. Students
7 Post-Doctoral Fellows
Assessing the current state of glaciers

- Requires methods to detect changes in area and volume
  - Satellite imagery
  - Historical maps and oblique photography
  - Aerial photography
Changes in Glacier Thickness

Changes in Glacier Area

Today

Yesterday
<table>
<thead>
<tr>
<th></th>
<th>British Columbia</th>
<th>Alberta</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Glaciers</strong></td>
<td>~ 15,000</td>
<td>925</td>
</tr>
<tr>
<td><strong>Glacier Coverage 1985</strong></td>
<td>28,233 km²</td>
<td>1,053 km²</td>
</tr>
<tr>
<td><strong>Glacier Coverage 2005</strong></td>
<td>25,177 km²</td>
<td>786 km²</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td>-3,053 km² (-11.5%)</td>
<td>-268 km² (25.4%)</td>
</tr>
</tbody>
</table>

Bolch et al., in press (RSE)
Place Glacier Elevation Change (2005 -1965)

Conventional: -33.9 m
Geodetic: -35.3 m
Rate of Volume Loss (km³ yr⁻¹)

- 2005-2009
- 1997-2005
- 1993-1997
- 1987-1993
- 1981-1987
- 1973-1981
- 1965-1973
- 1947-1965
Columbia Icefield (20 and 30 August, 2009)

SPOT5
2.5 m resolution
Low gain
Assessing the fate of glaciers

• Requires knowledge of climate forcing, local meteorology, topography, and flow dynamics

• Topographic complexity of western Canada imposes challenges for modelling regional-scale changes in glacier cover

  - Variable mass balance gradients (net mass balance vs. altitude)

  - Glaciological models are spatially biased toward single ice body (single small glacier or large ice sheet)
Distributed Glacier Melt Modeling

• **Issue:** energy balance models require fields of temperature, vapor pressure, and wind speed

• **Methods:** Field observations used to develop empirical and physical models to account for glacier boundary layer effects
Future Fate of Glaciers

- Challenges in modeling glacier fate in western Canada
  - climate downscaling
  - glacier dynamics

- require models to be run with high spatial resolution
Western Canadian Topography (32 km - NARR)
Western Canadian Topography (90 m - SRTM DEM)
Observed Balance (1985-1999)

Modeled Mass Balance (1979-2008)

5 km
Athabasca Glacier, Alberta
LANDSAT image

Time: 2001 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B
Time: 2002 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2010 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2020 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2040 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2060 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2080 AD
Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2090 AD