Western Canadian Cryospheric Network (WC²N)

Investigators:

Andrew Bush (**U. Alberta**); John Clague (**SFU**); Garry Clarke (**UBC**); Stephen Déry (**UNBC**); Peter Jackson (**UNBC**); Shawn Marshall (**U. Calgary**); Brian Menounos (**UNBC**); Dan Moore (**UBC**); Dan Smith (**U. Victoria**); Eric Steig (**U. Washington**); Roger Wheate (**UNBC**)

Research Collaborators:

Doug Clark (**Western Washington University**); Mike Demuth (**Natural Resources Canada**); Howard Conway (**U. Washington**); Kenichi Matsuoka (**U. Washington**); Joseph McConnell (**Desert Research Institute** – U. Nevada); Al Rasmussen (**U Washington**); Sonia Talwar (**Natural Resources Canada**); Paul Whitfield (**Environment Canada**)

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

WC²N
WESTERN CANADIAN
CRYOSPHERIC NETWORK

Western Canadian glaciers

- Natural climate stations

  - Winter ppt; summer temp.

- Critical resource

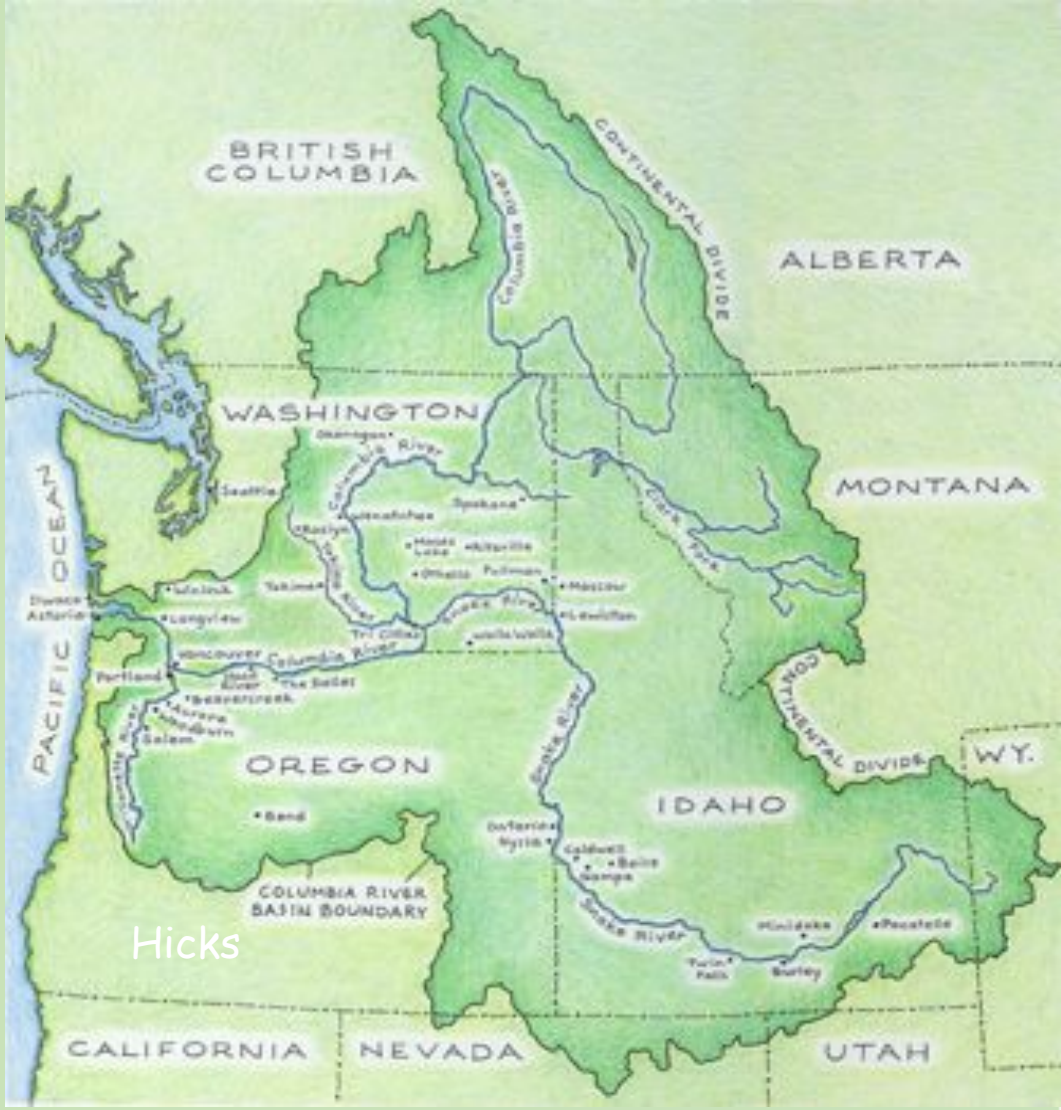
  - 30, 000 km^2 in BC (~ 3% landmass)

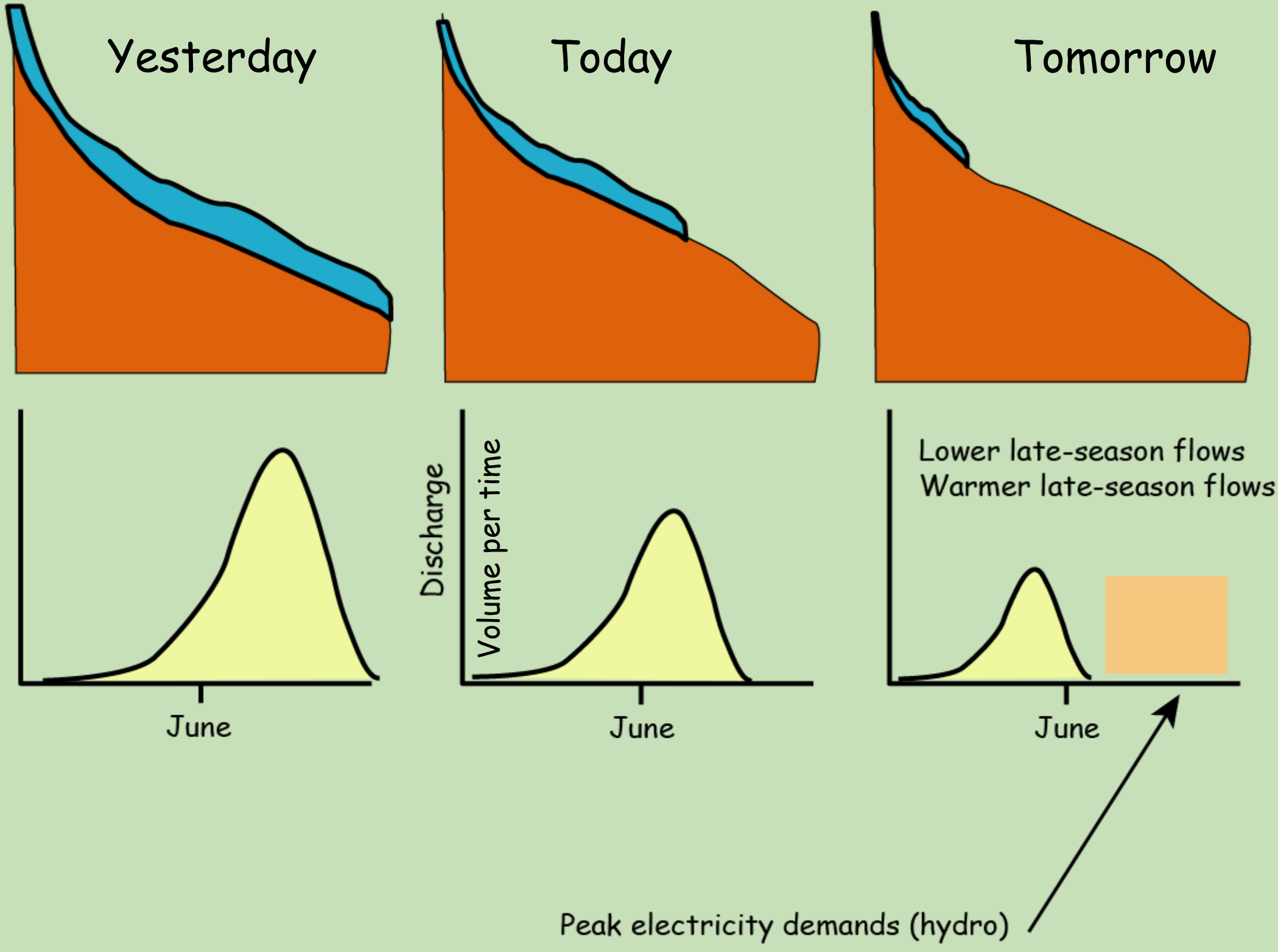
  - Freshwater (Canada and US)

  - Downstream ecosystems vulnerable:

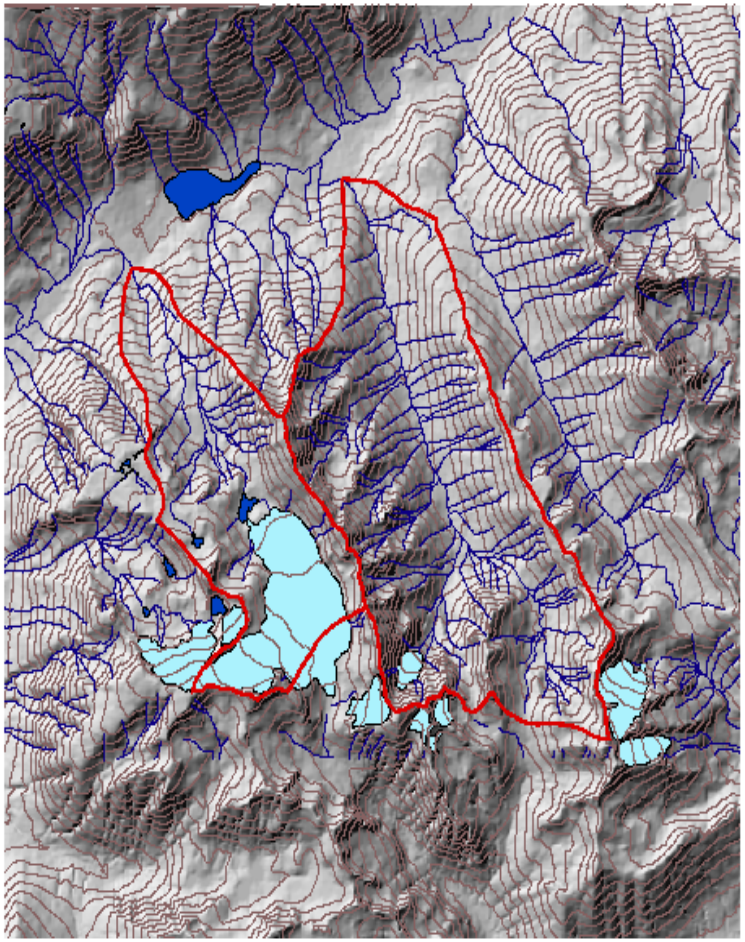
    flow regulators
    thermostats

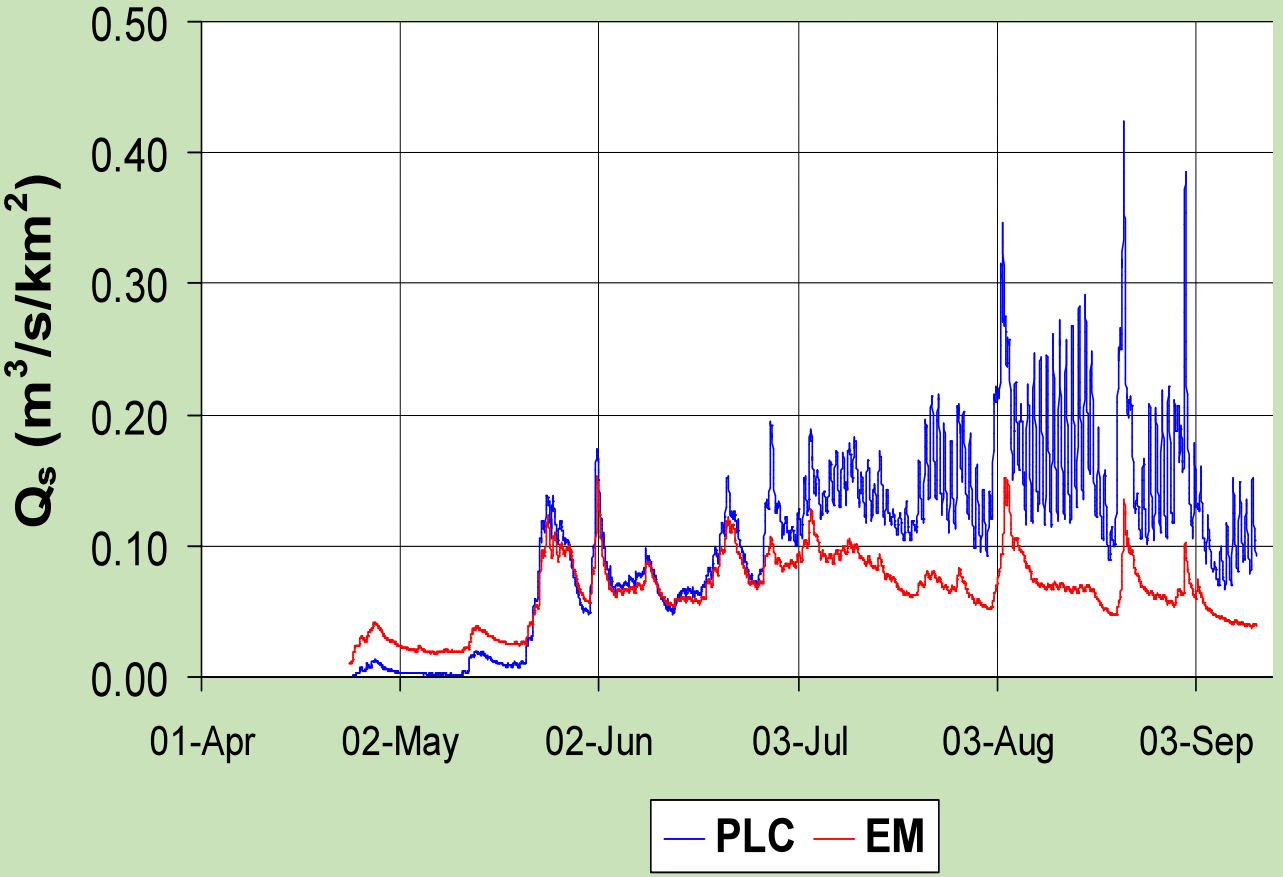
  - Hydro power from surface runoff
    (90% BC; 17% AB)




Yesterday
Today
Tomorrow
Discharge
Volume per time
June
June
Lower late-season flows
Warmer late-season flows
June
Peak electricity demands (hydro)

Characteristics of Glacier Runoff: Place and Eight Mile Creeks, Coast Mountains BC





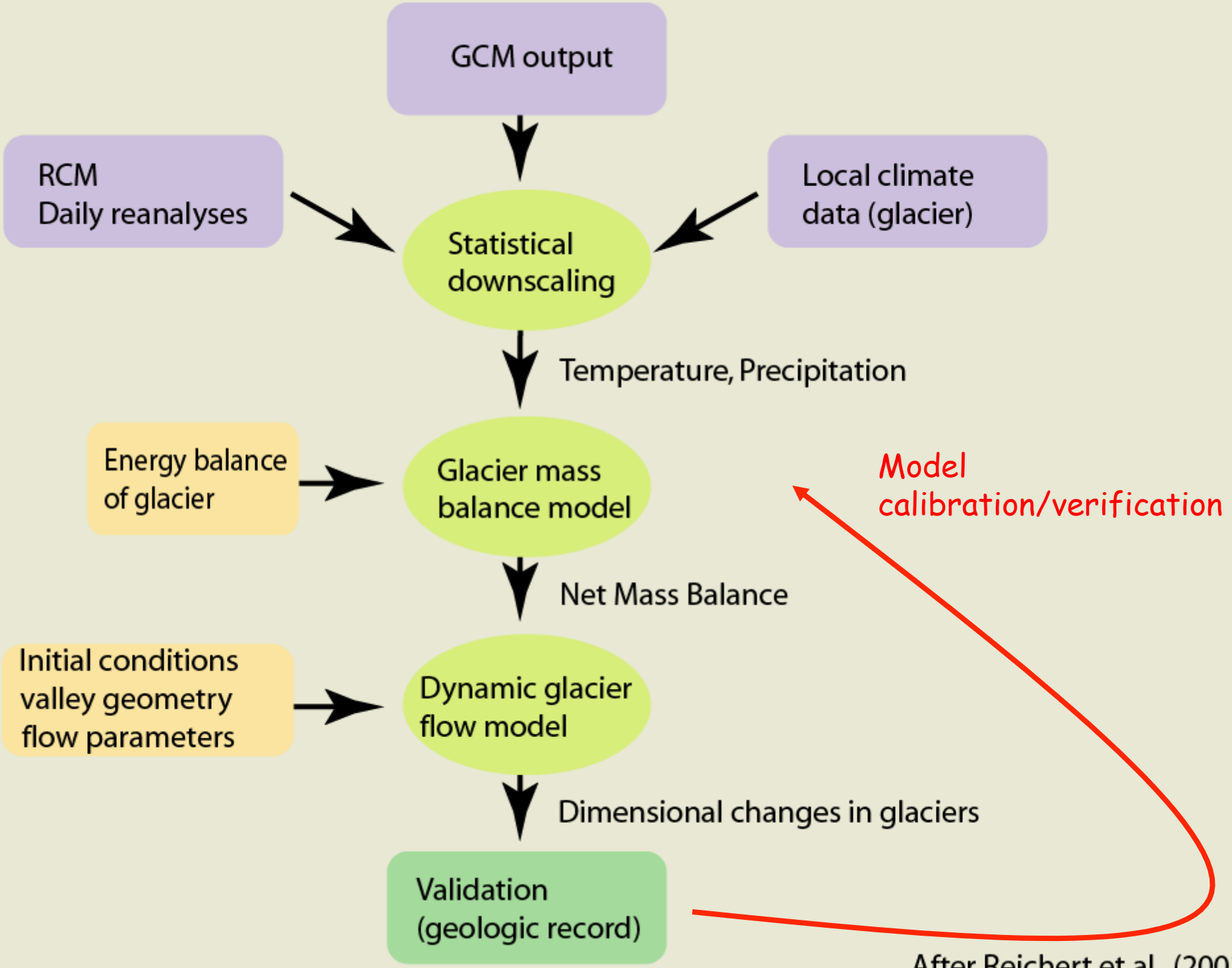
Dan Moore (UBC)

- 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


GCM output
RCM
Daily reanalyses
Local climate
data (glacier)
Statistical
downscaling
Temperature, Precipitation
Energy balance
of glacier
Glacier mass
balance model
Model
calibration/verification
Net Mass Balance
Initial conditions
valley geometry
flow parameters
Dynamic glacier
flow model
Dimensional changes in glaciers
Validation
(geologic record)
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:

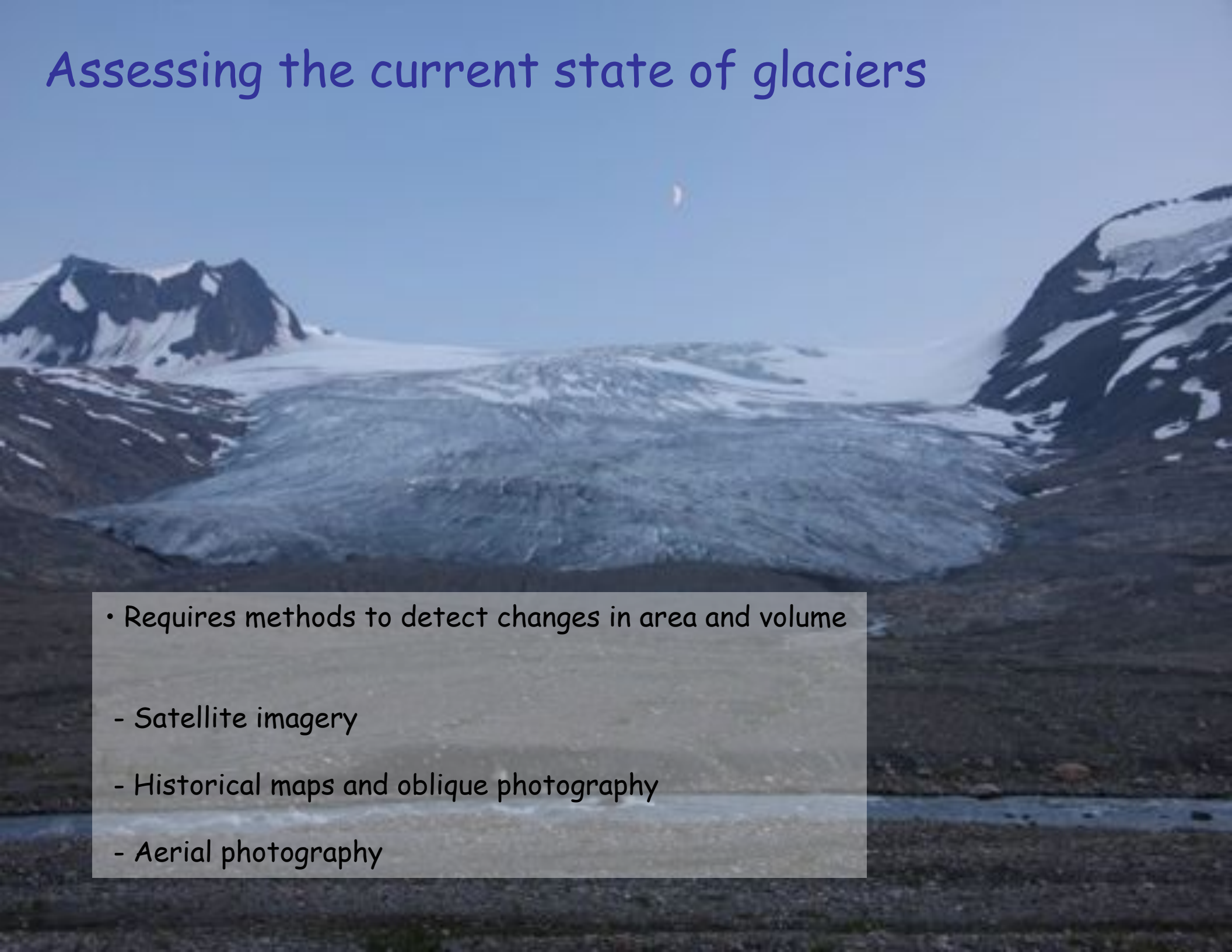
10 Undergraduate Assistants

18 M.Sc. Students

9 Ph.D. Students

7 Post-Doctoral Fellows

Assessing the current state of glaciers



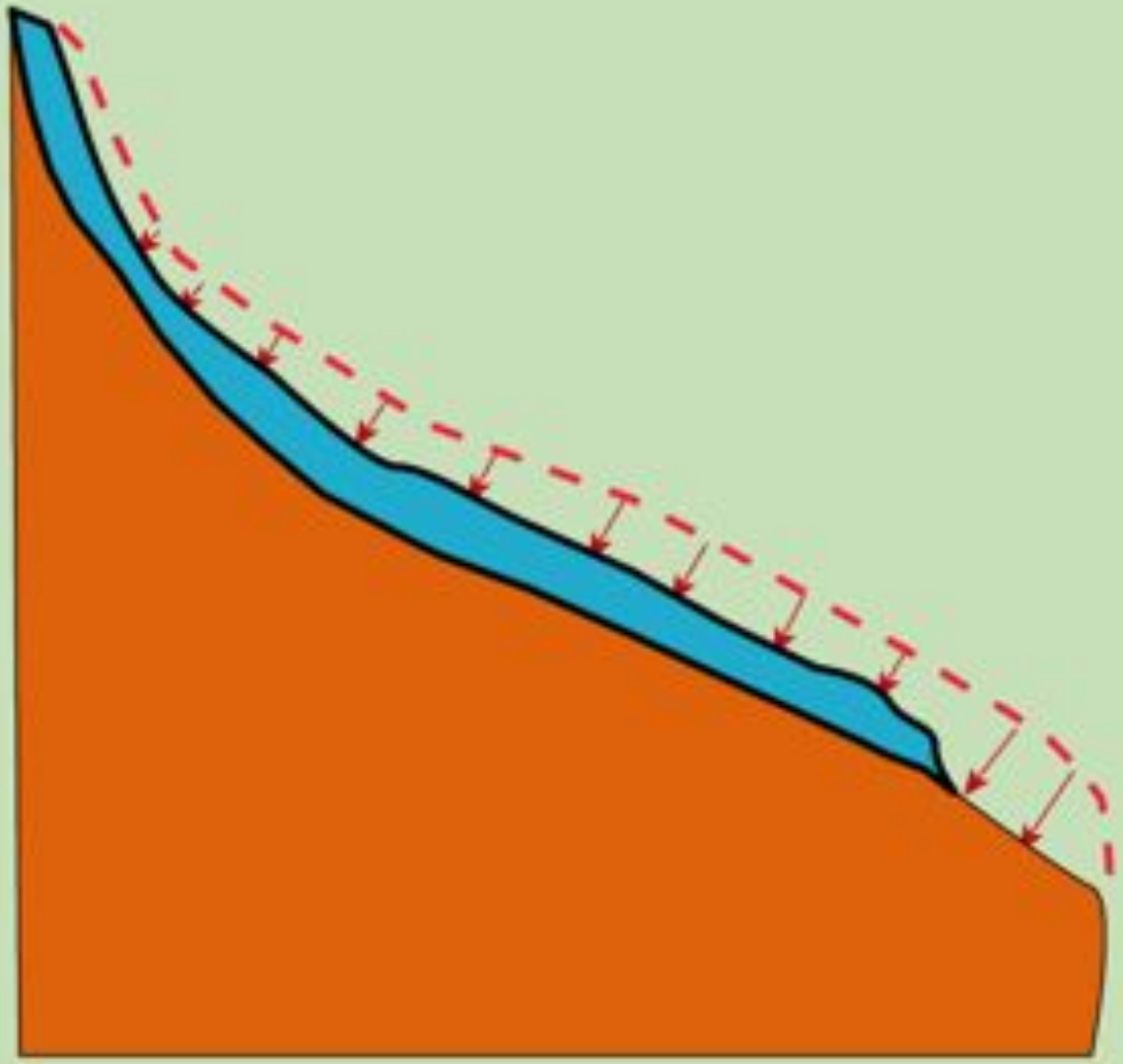
- Requires methods to detect changes in area and volume

- Satellite imagery

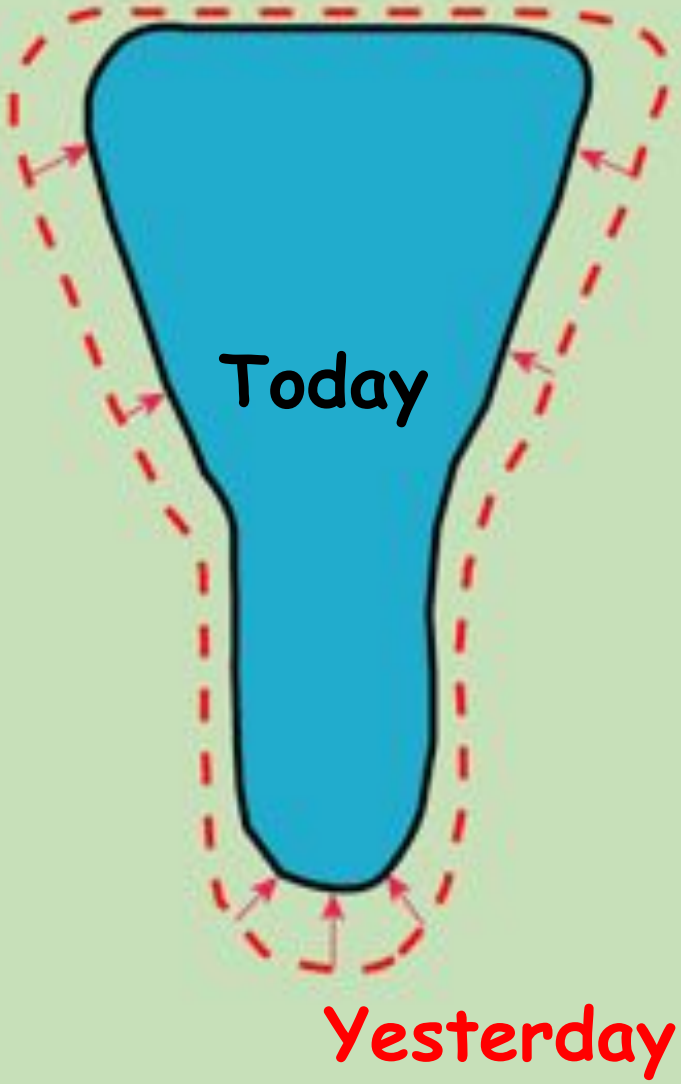
- Historical maps and oblique photography

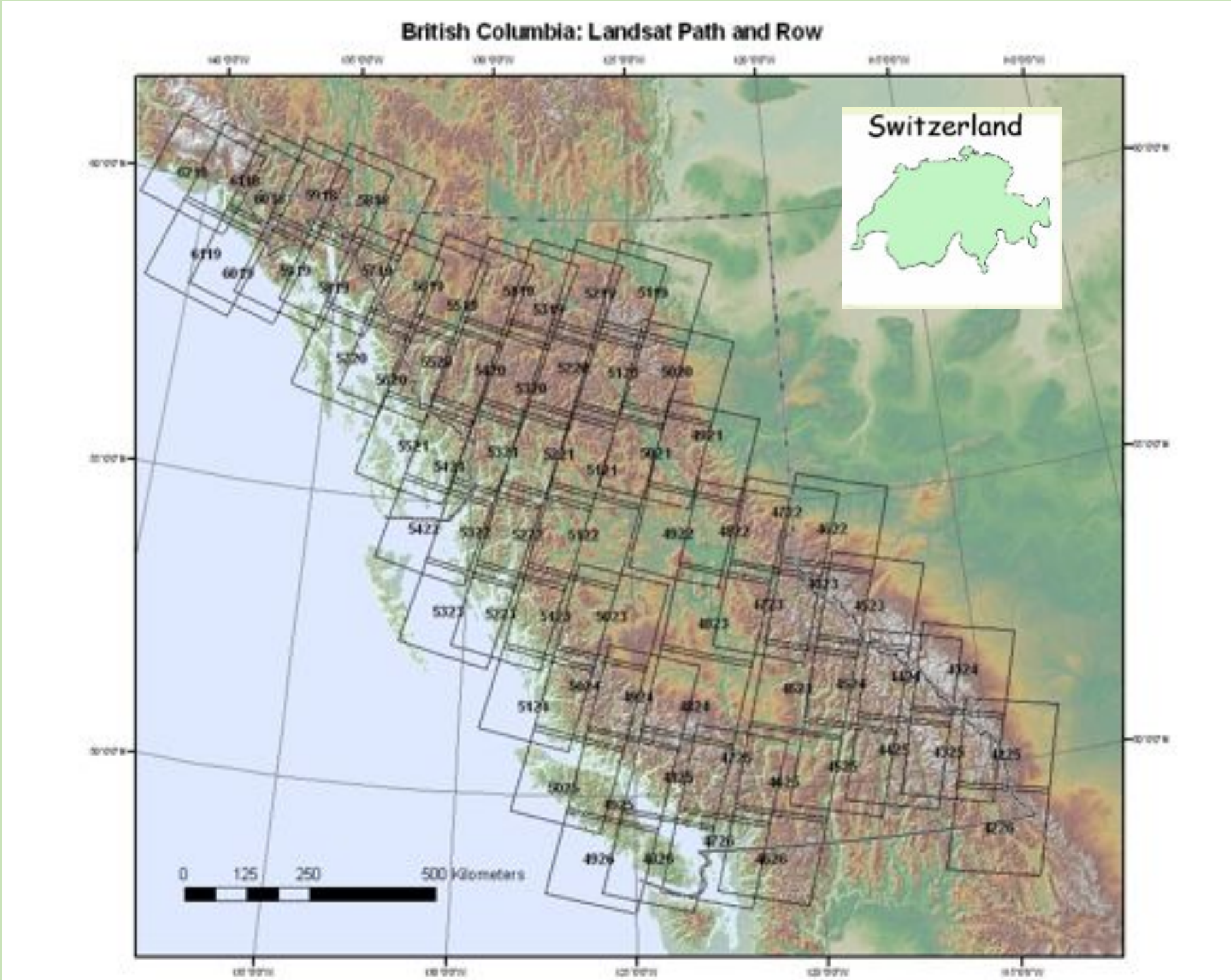
- Aerial photography

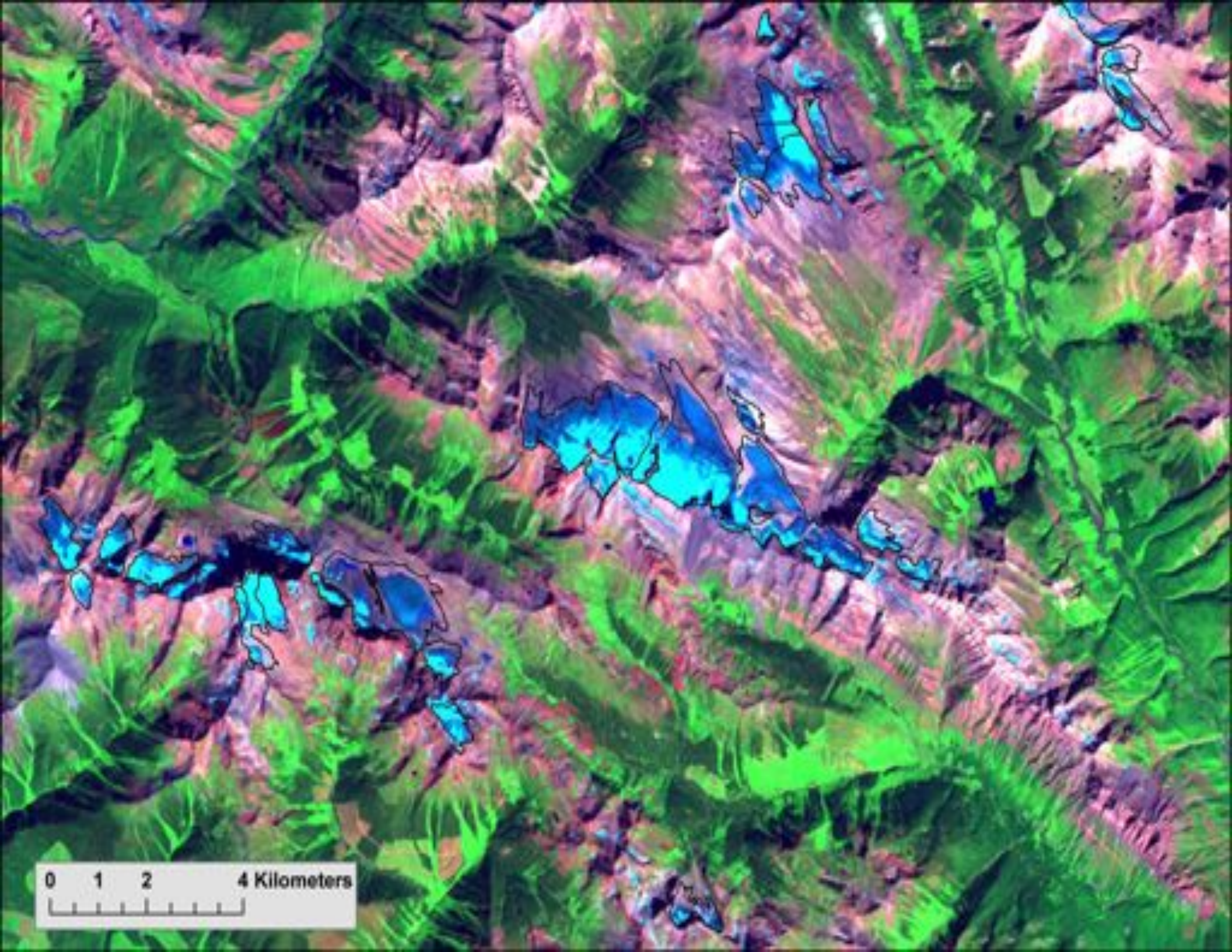
Changes in Glacier Thickness



Changes in Glacier Area

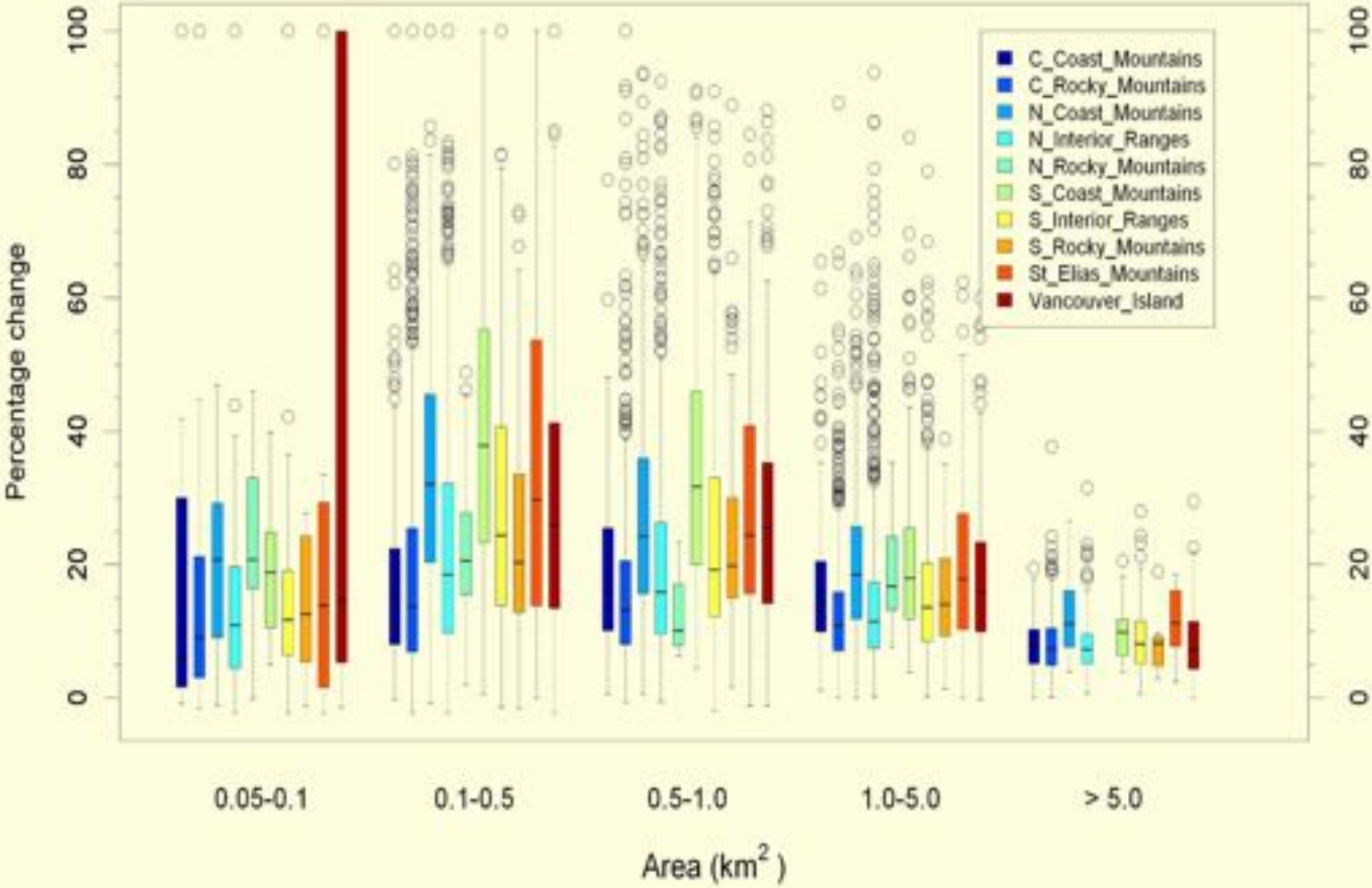



British Columbia: Landsat Path and Row
Switzerland
0
125
250
500 Kilometers


0 1 2 4 Kilometers

	British Columbia	Alberta
Number of Glaciers	~ 15,000	925
Glacier Coverage 1985	28,233 km^2	1,053 km^2
Glacier Coverage 2005	25,177 km^2	786 km^2
Difference	-3,053 km^2 (-11.5%)	-268 km^2 (25.4%)

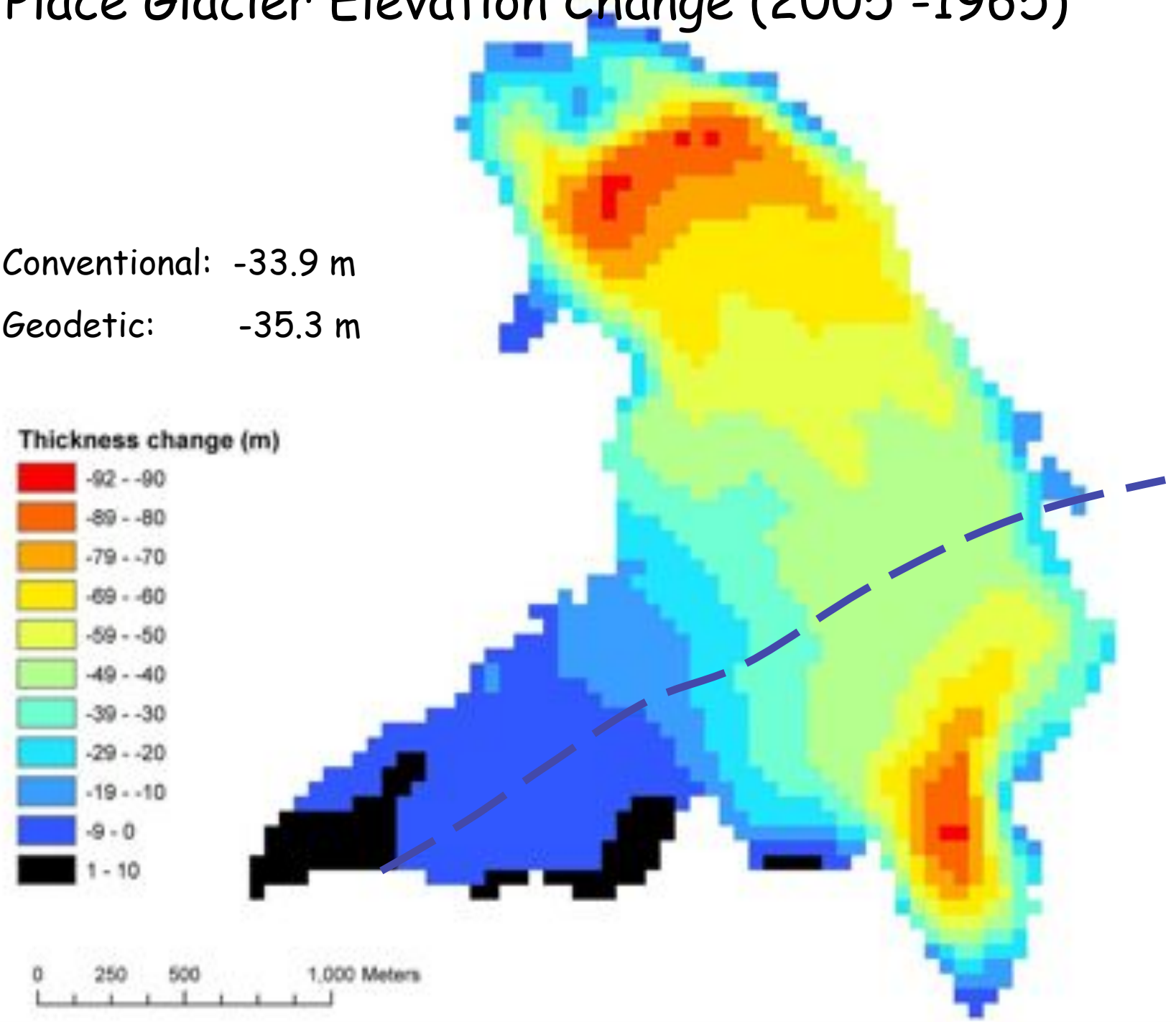
Bolch et al., in press (RSE)

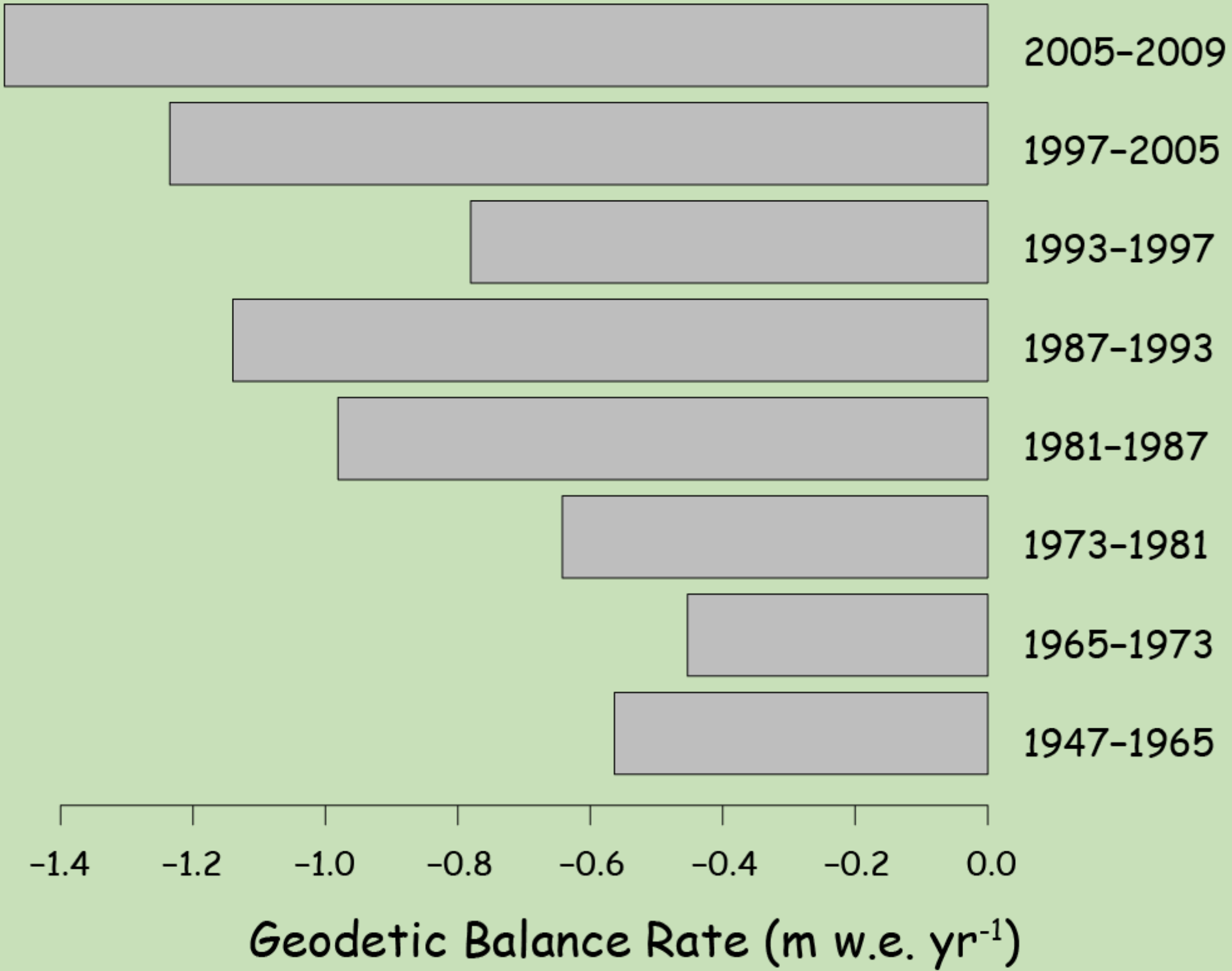

Percentage change
0
20
40
60
80
100
C_Coast_Mountains
C_Rocky_Mountains
N_Coast_Mountains
N_Interior_Ranges
N_Rocky_Mountains
S_Coast_Mountains
S_Interior_Ranges
S_Rocky_Mountains
St_Elias_Mountains
Vancouver_Island
0.05-0.1
0.1-0.5
0.5-1.0
1.0-5.0
> 5.0
Area (km^2)

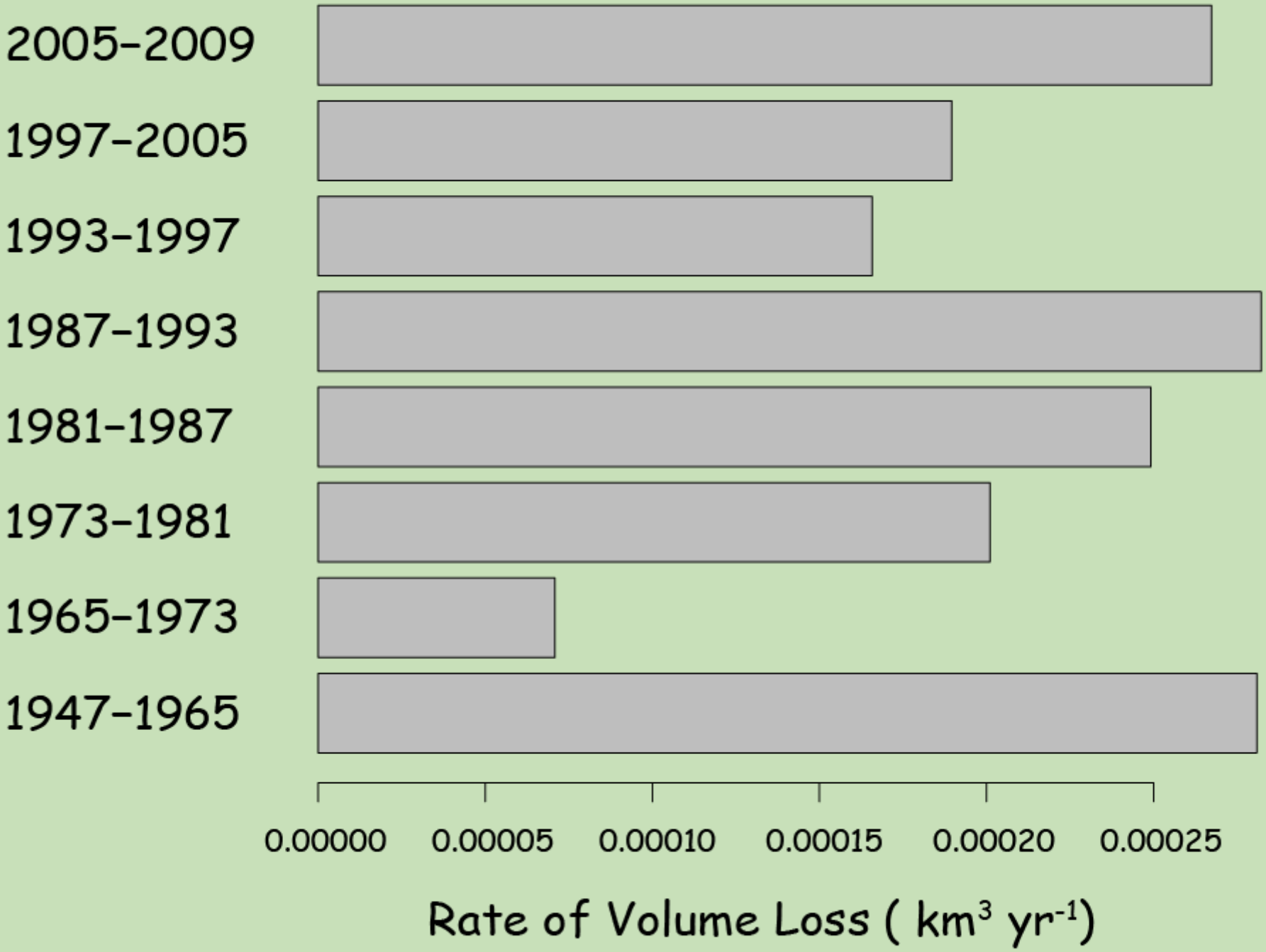
Place Glacier Elevation Change (2005 -1965)

Conventional: -33.9 m

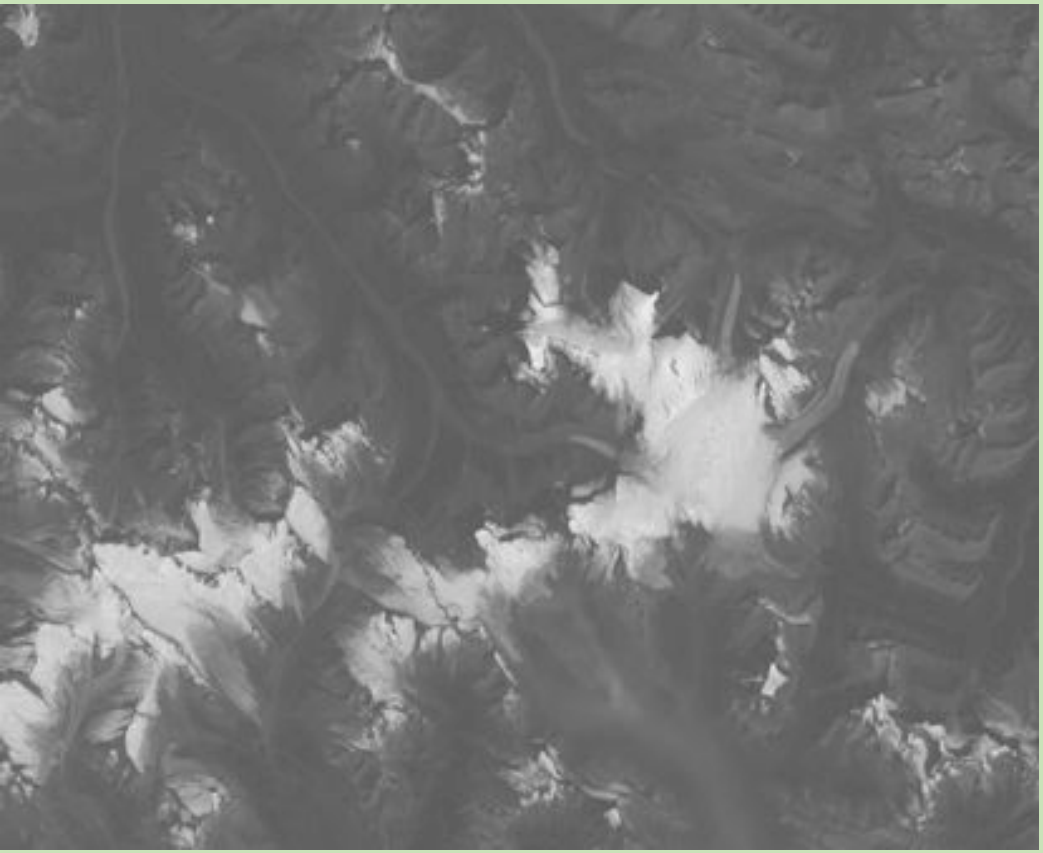
Geodetic: -35.3 m

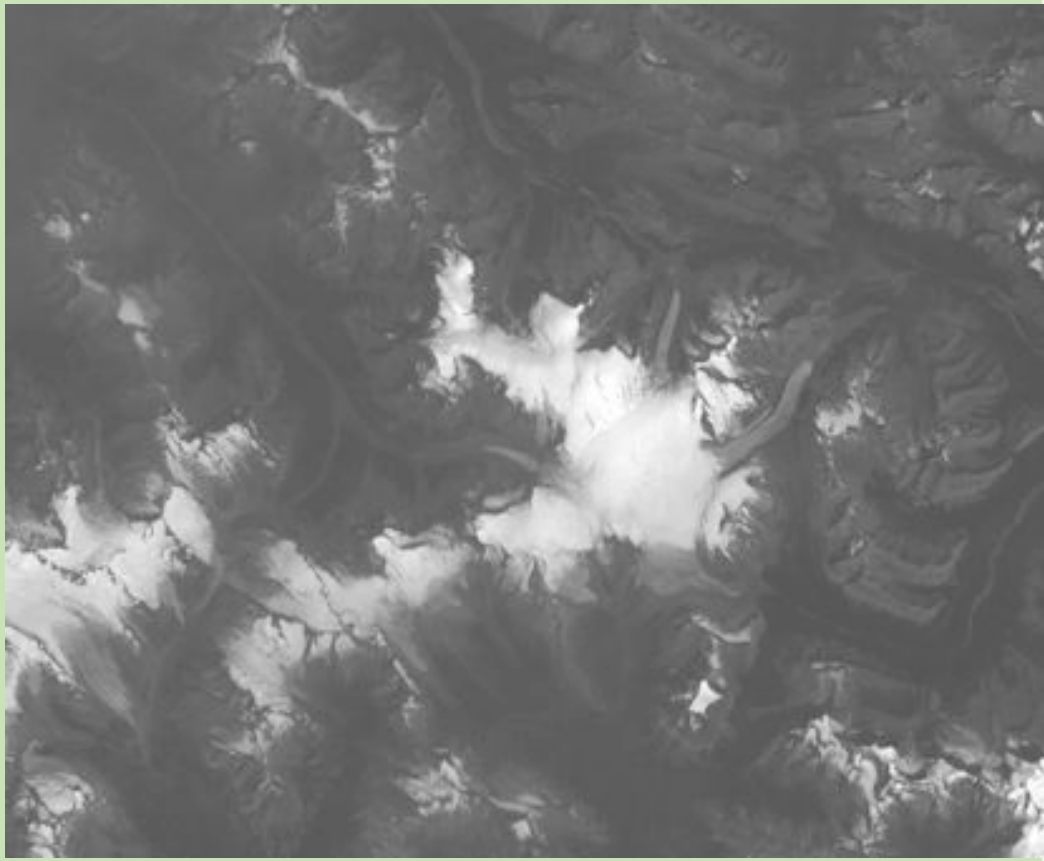



2005–2009
1997–2005
1993–1997
1987–1993
1981–1987
1973–1981
1965–1973
1947–1965
−1.4
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
Geodetic Balance Rate (m w.e. yr-1)


2005–2009
1997–2005
1993–1997
1987–1993
1981–1987
1973–1981
1965–1973
1947–1965
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
Rate of Volume Loss (km³ yr⁻¹)

Columbia Icefield (20 and 30 August, 2009)

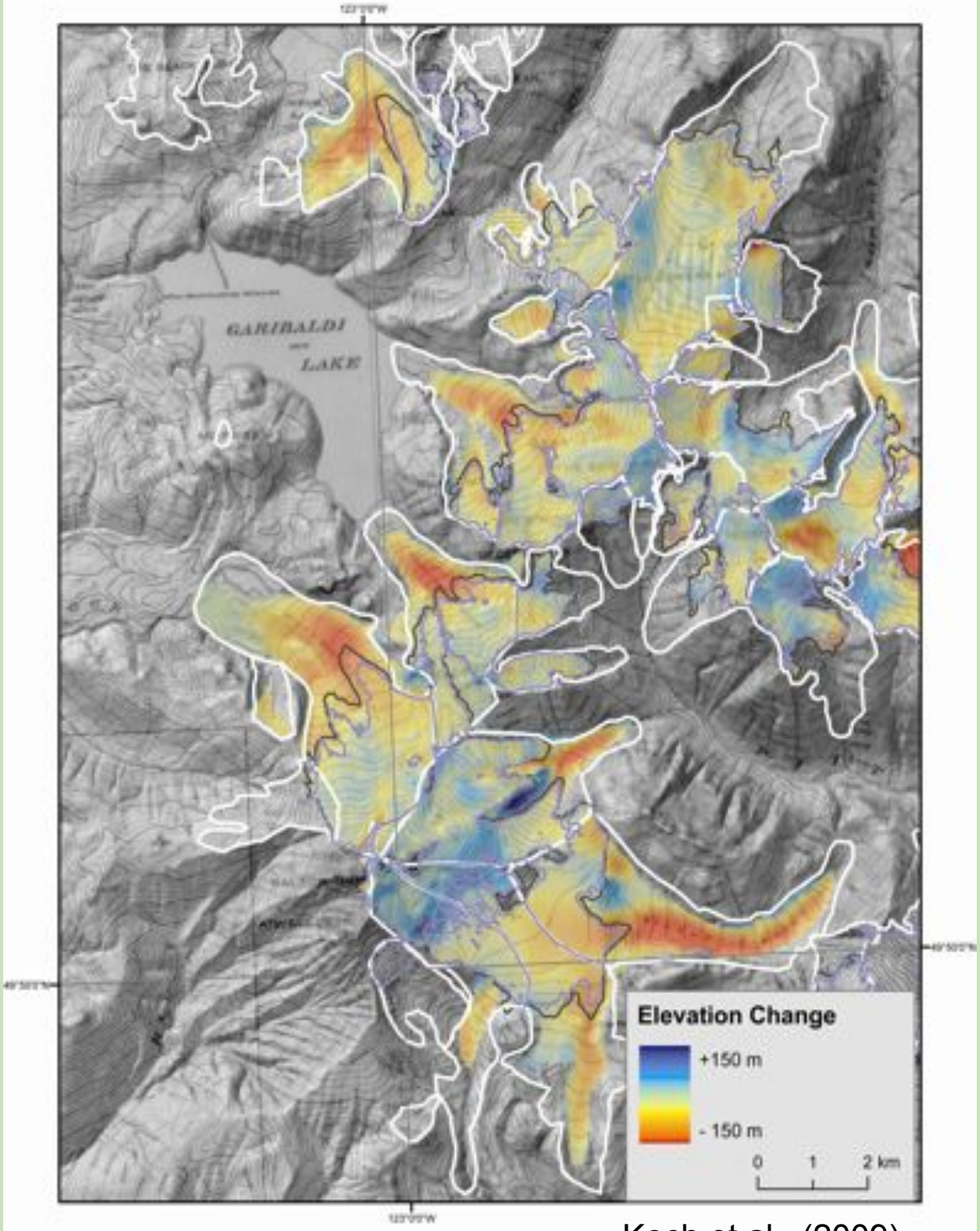




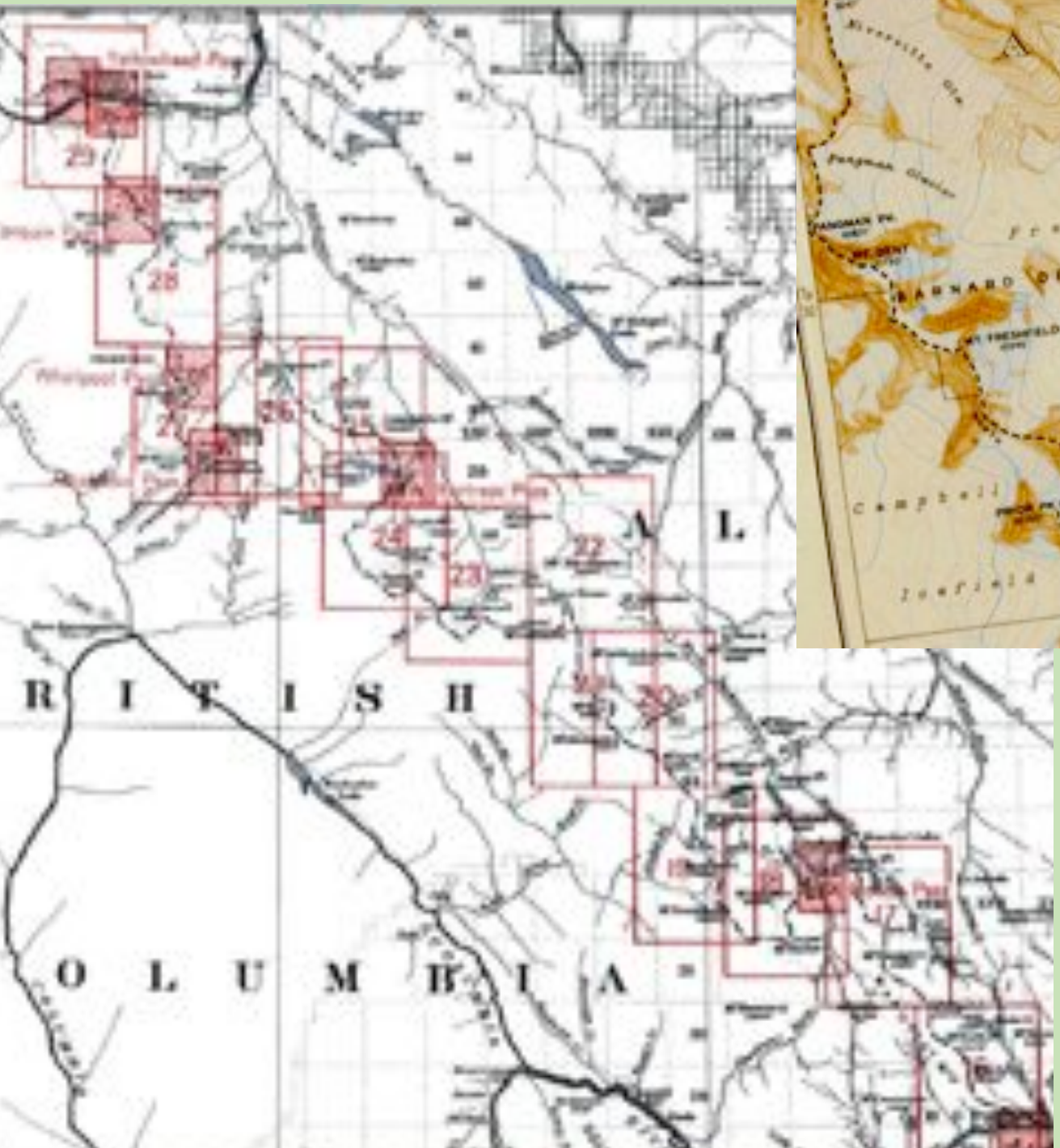
SPOT5

2.5 m resolution

Low gain



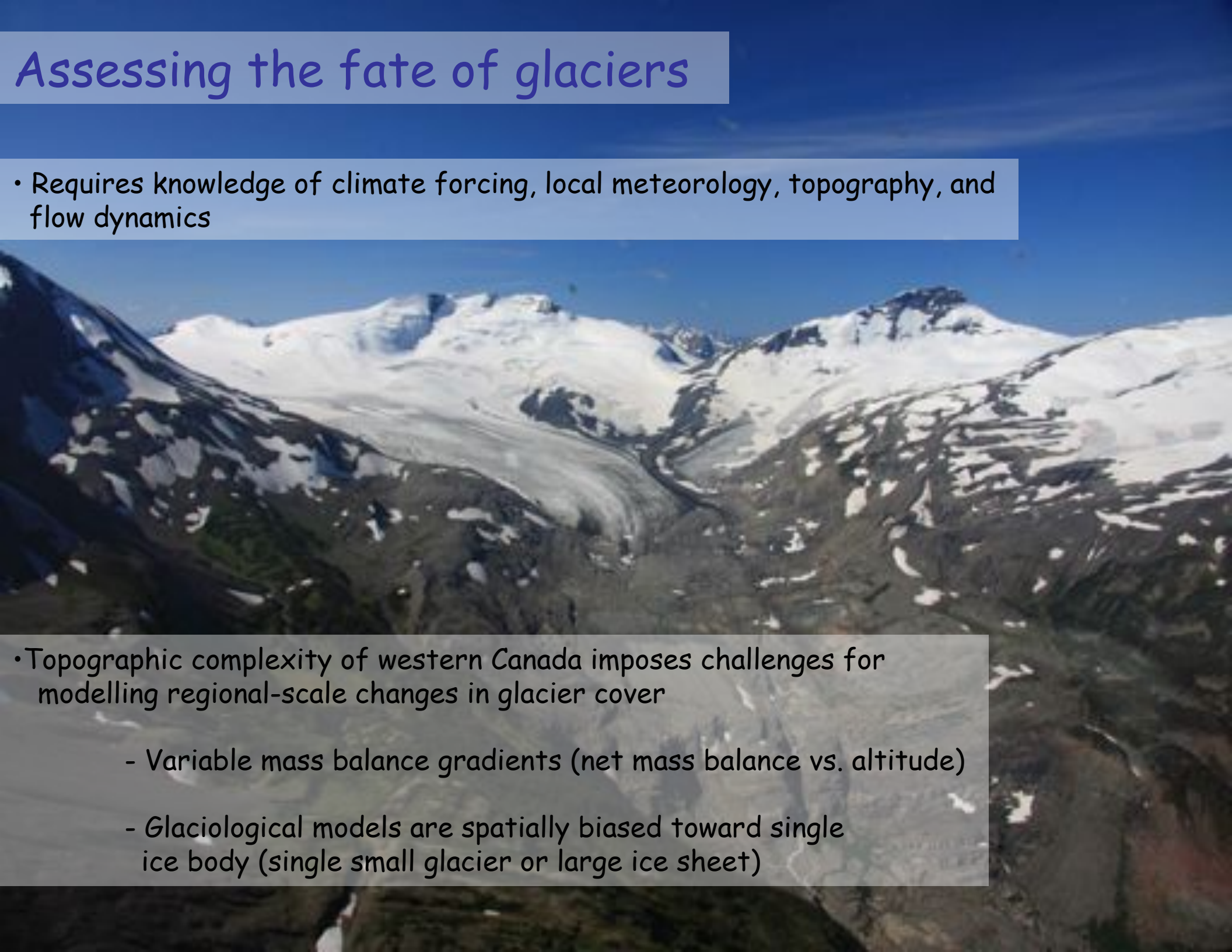
Koch et al. (2009)


R I T I S H
O L U M B I A


CLEARWATER FOREST
A L B E R T A
CONWAY
BARNARD DENT
GROUP

Assessing the fate of glaciers

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



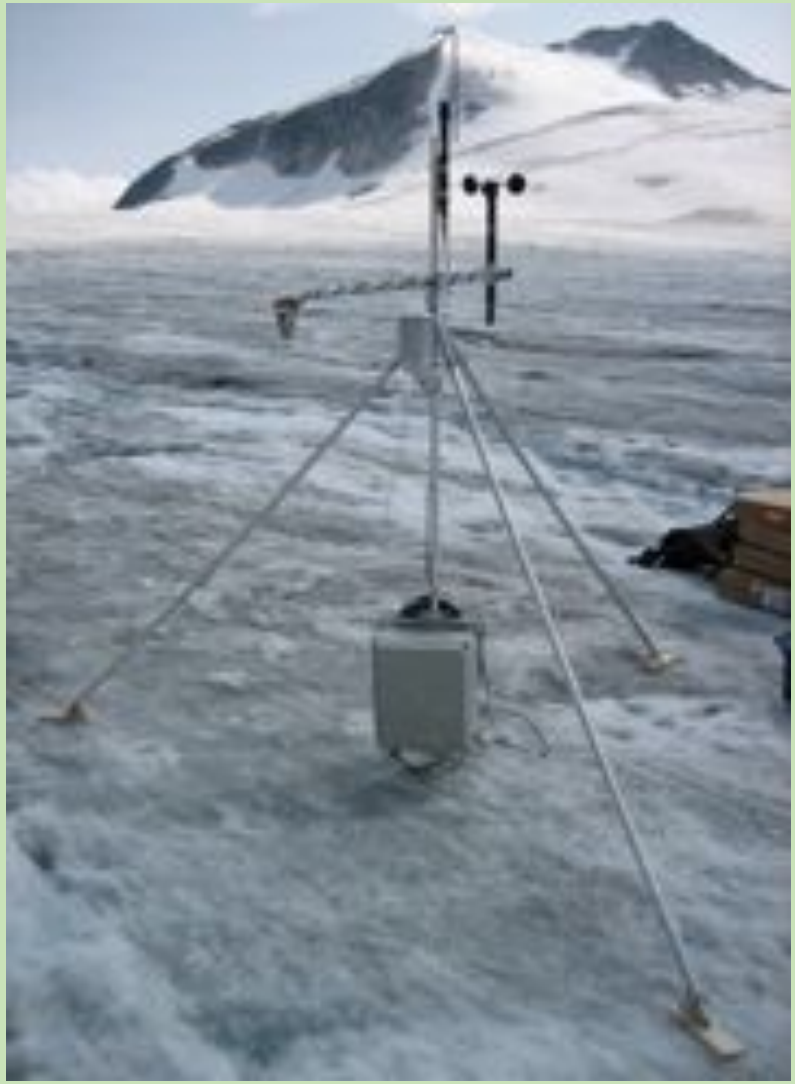
- Topographic complexity of western Canada imposes challenges for modelling regional-scale changes in glacier cover

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

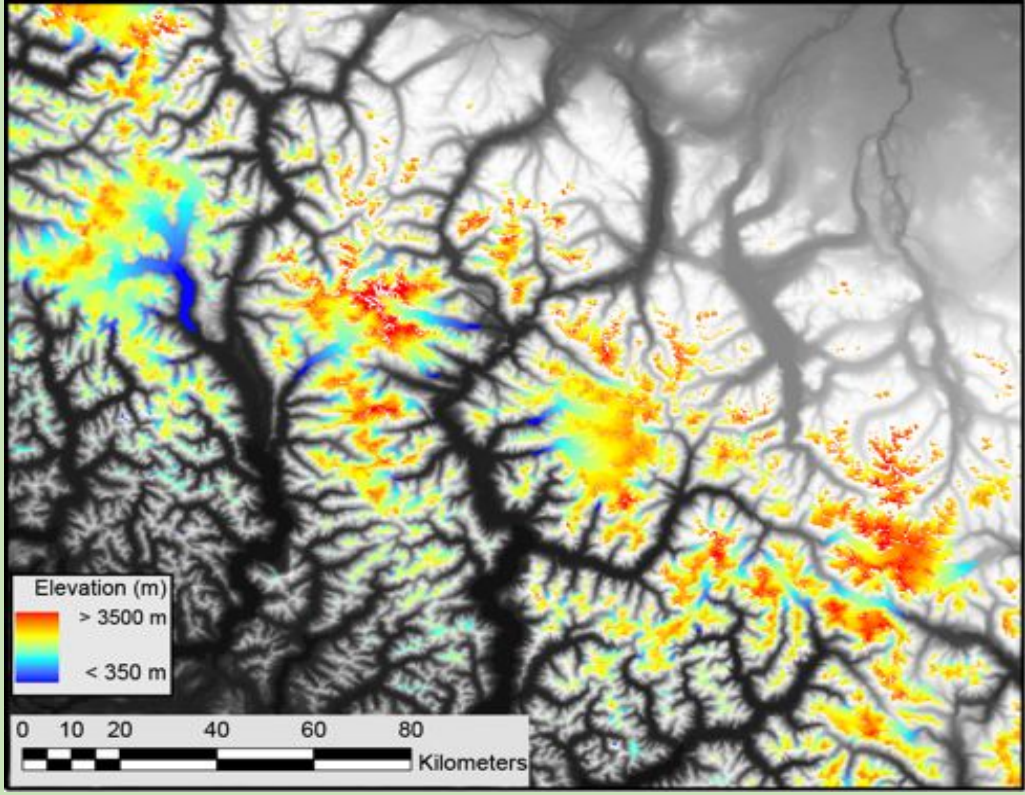
  - Glaciological models are spatially biased toward single ice body (single small glacier or large ice sheet)

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



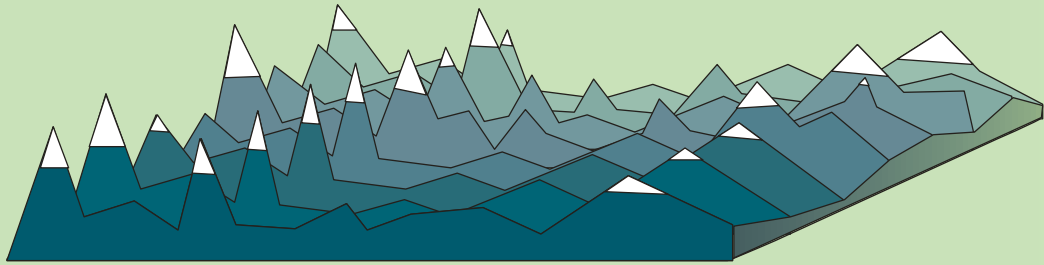
Future Fate of Glaciers



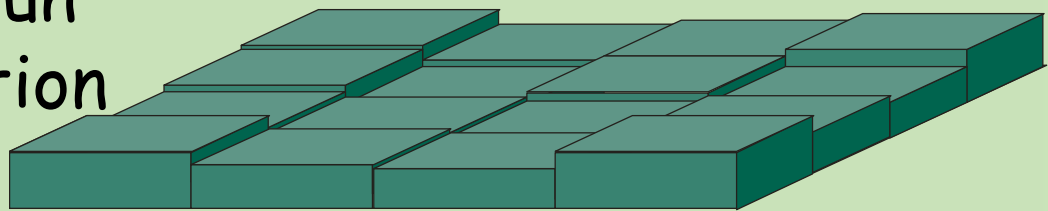
- Challenges in modeling glacier fate in western Canada

  - climate downscaling

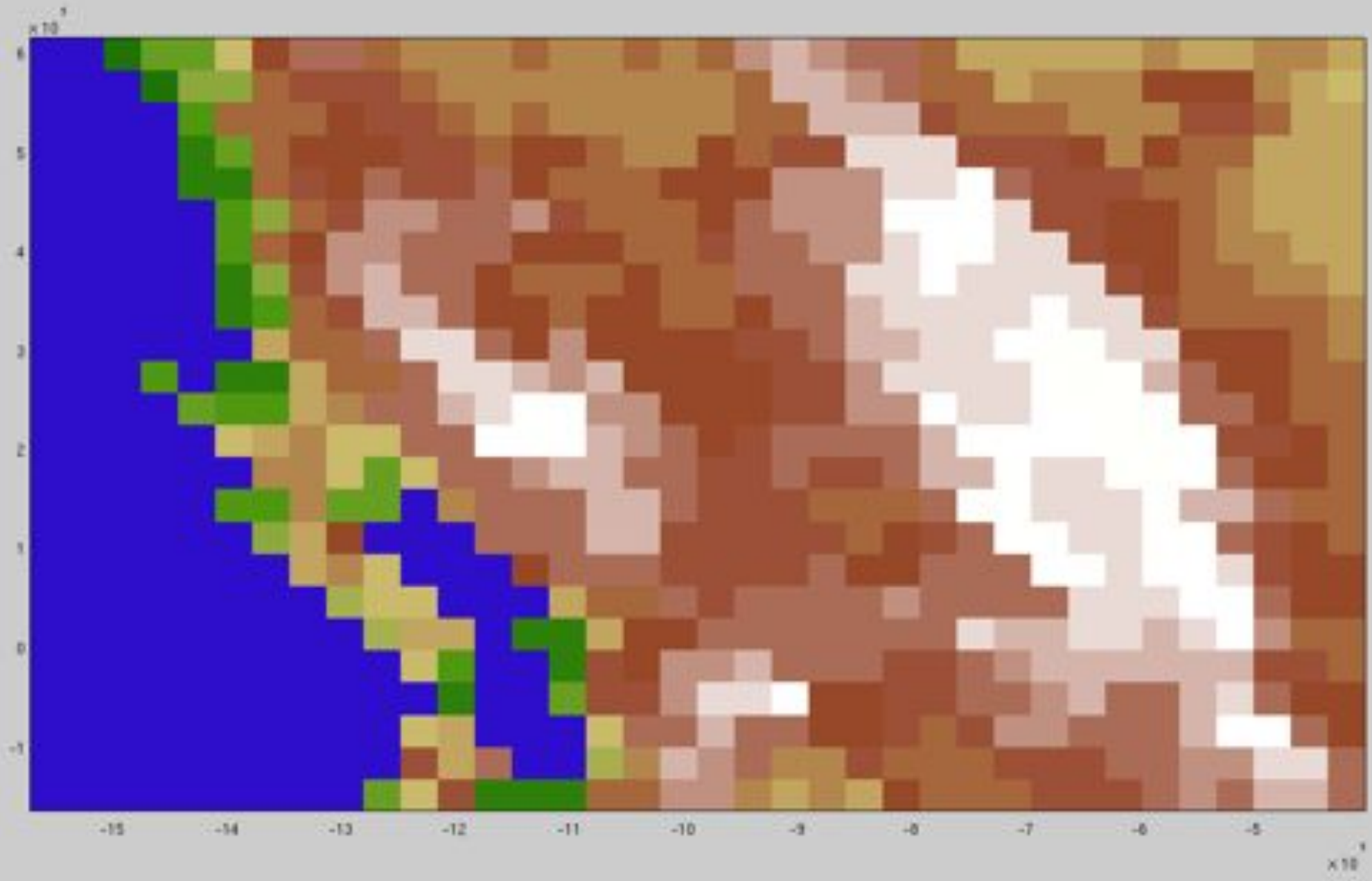
  - glacier dynamics



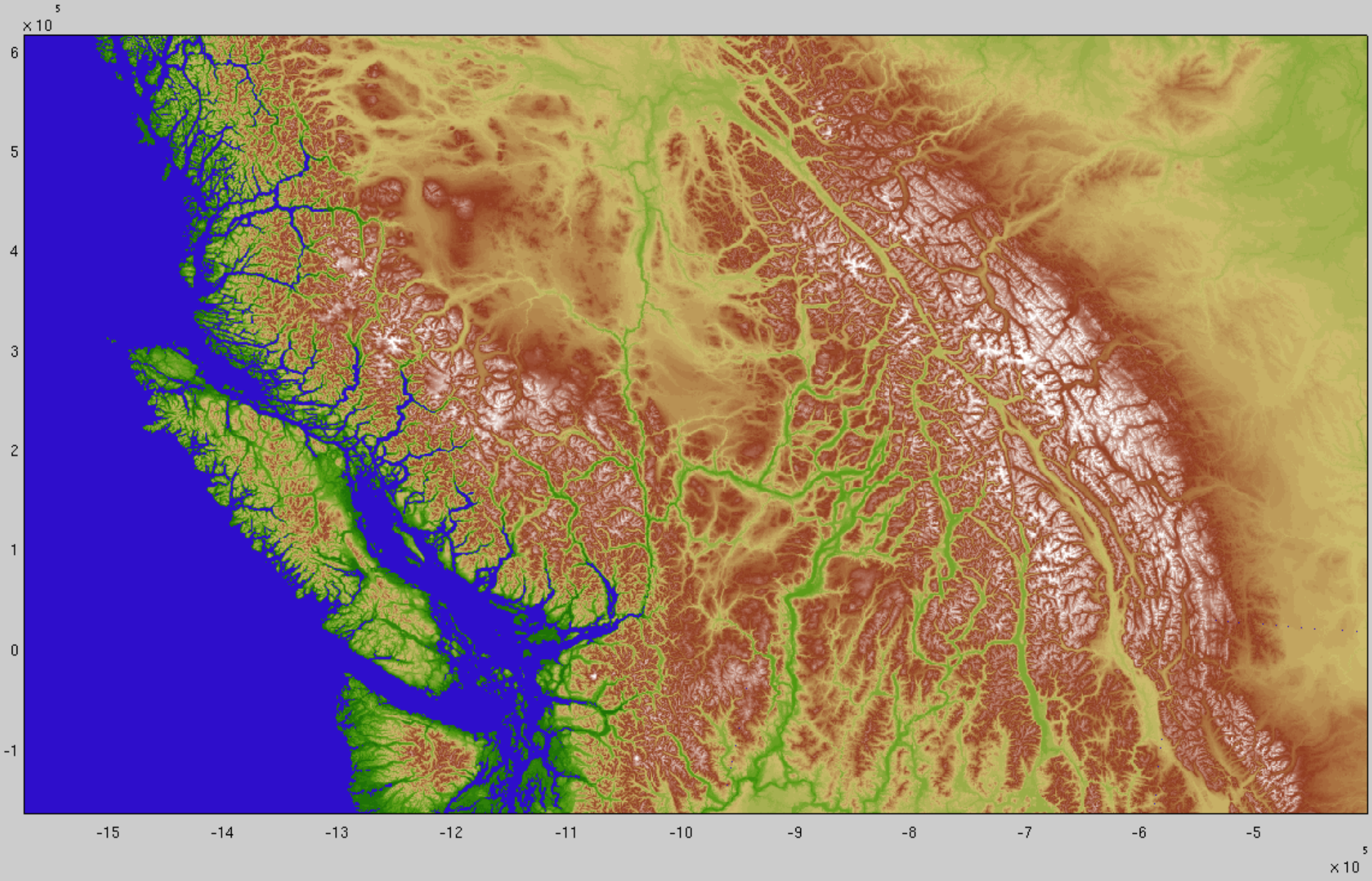
  - require models to be run with high spatial resolution



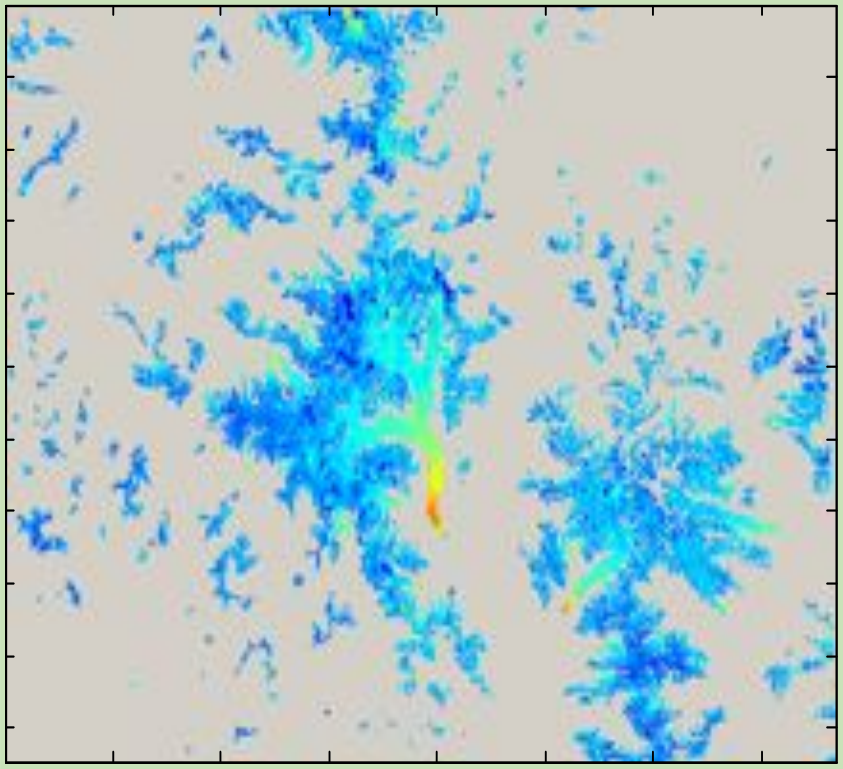
Western Canadian Topography (32 km – NARR)



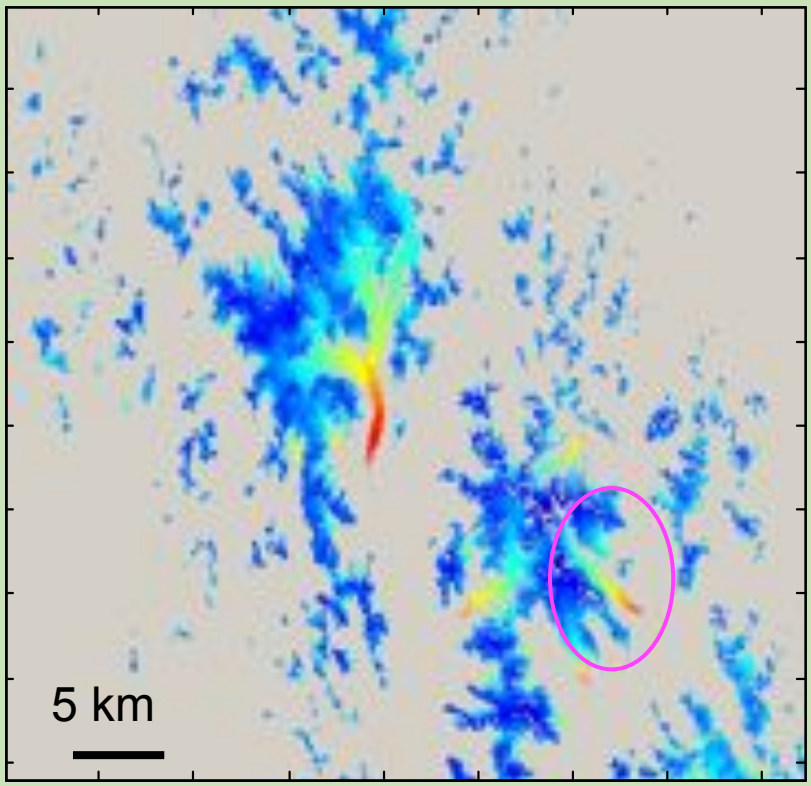
Western Canadian Topography (90 m – SRTM DEM)

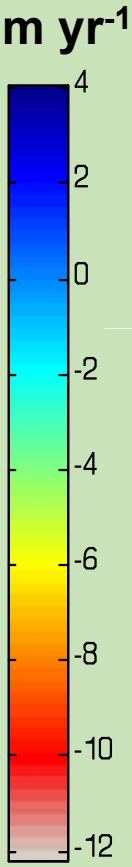


Observed Balance (1985-1999)



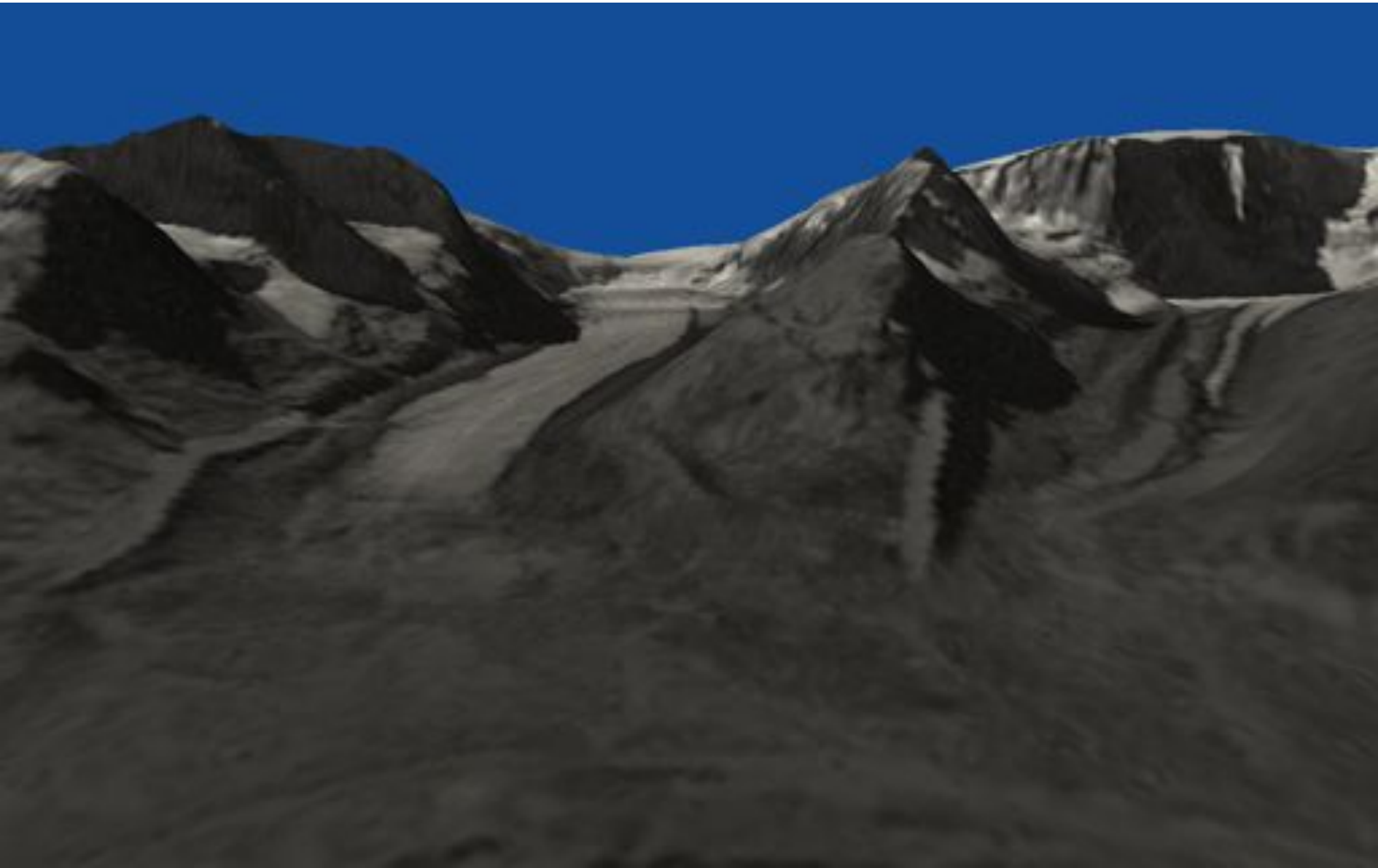
Modeled Mass Balance (1979-2008)





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: 2030 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2040 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2050 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2060 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2070 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2080 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2090 AD

Athabasca Glacier, Alberta
CGCM3.1 Scenario A1B

Time: 2100 AD