Glacier and Snow Cover Fluctuation Mapping in Canada

A Global, National and Regional Perspective

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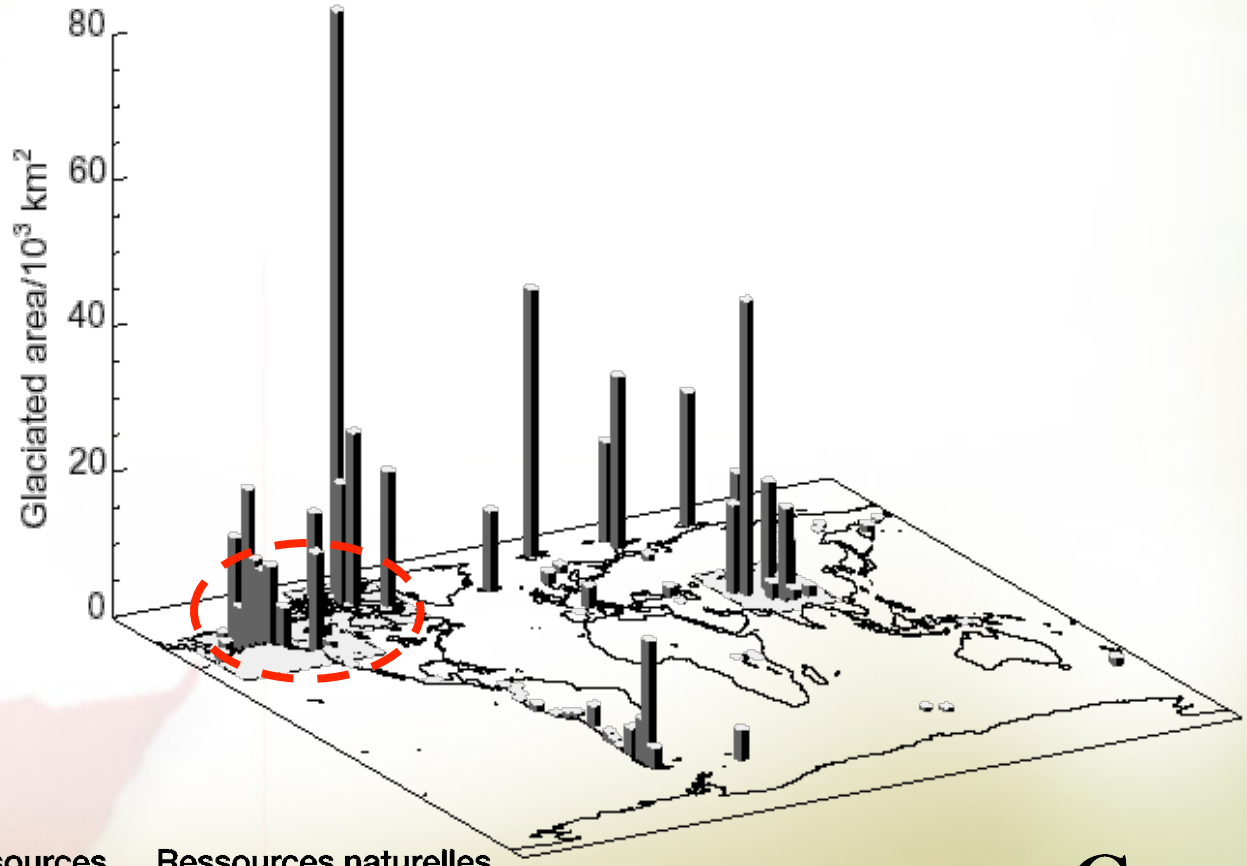
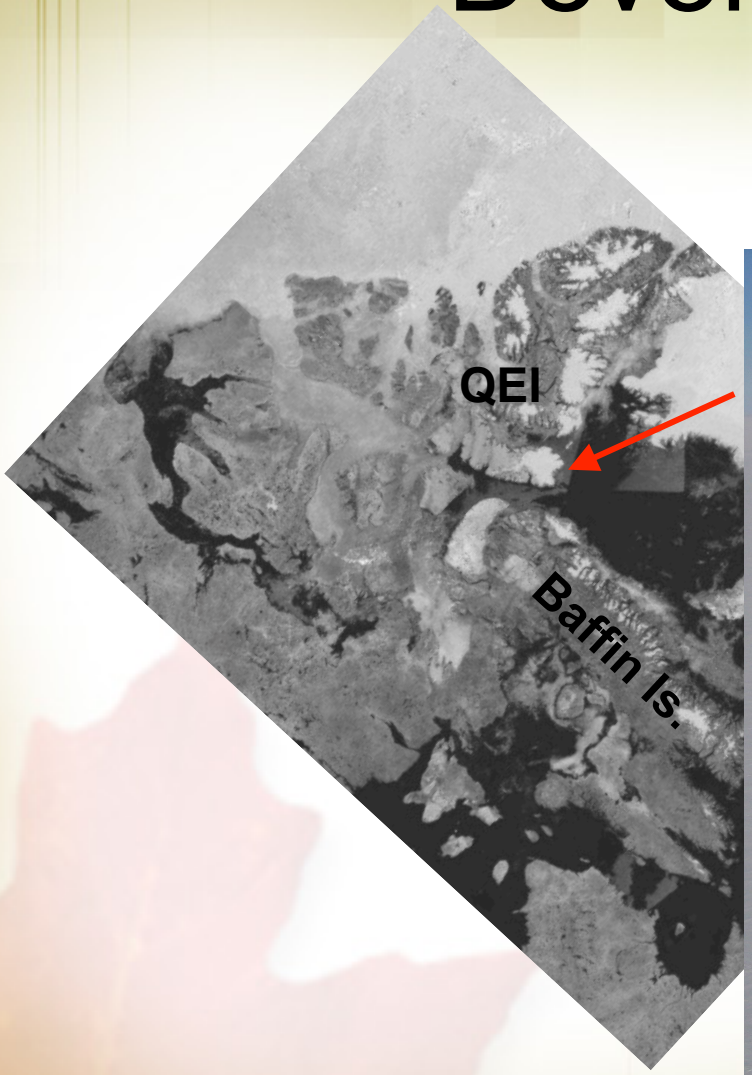
Mountain glacier and ice cap distribution



Multiple sources of information

- surface and geodetic mass balance measurements
- ice cores
- remote sensing (form and flow)
- legacy mapping and photography
- indirect landscape evidence (moraines and trim lines)

Devon Ice Cap, NU



A. Laurence Gray photograph

Facts and Figures

Devon Ice Cap

- With an area of ~14,000 km^2 and a maximum ice thickness of ~880m, the Devon Ice Cap holds about 10% of all glacier ice in the Canadian Arctic
- Melting it entirely would raise global sea level by 1 cm
- The rate of mass loss has been increasing steadily since the mid 1980s, with mass loss rates since 2008 being roughly 3.5 times greater than the 50-year average

Arctic Archipelago

Summary Regional Perspective

- Summer melt rates on Canadian Arctic ice caps have increased greatly in the past decades
- The present thermal state of the ice caps resembles that last seen c. 3 – 4 k years ago
- The increase in the rate of mass loss makes the Canadian Arctic Archipelago the single largest contributor to eustatic sea-level rise outside Greenland and Antarctica
- This estimate has been, in-part, enabled by improved estimates of iceberg calving

Facts and Figures

Illecillewaet (*Swift Flowing Water*) Glacier

- c. 1.6 km retreat since 1887
- Part of an observing system planned for the Columbia River Basin that will, in-part, support modeling requirements, trans-boundary objectives and the Columbia River Basin Treaty reconsideration
- Canada portion of the Basin (15%) generates 30-40% of the run-off

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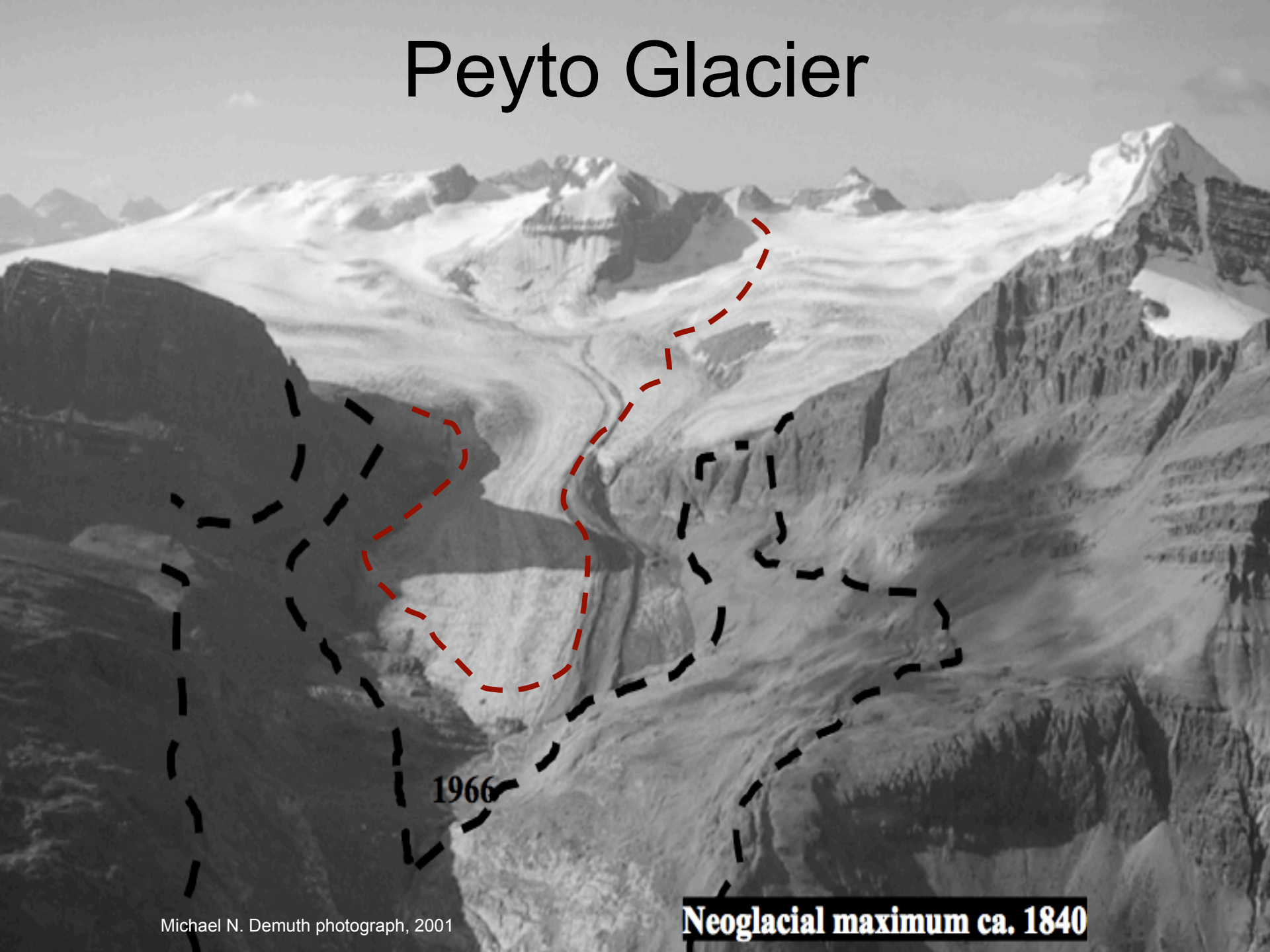
Facts and Figures

Columbia Icefield

- Configuration is such that it sheds water into three major river basins and three oceans
- Total volume is unknown
- Present area c. 205 km^2 with previous extents not well documented
- Outlet glaciers are in strong retreat. The Athabasca Glacier has retreated c. 1.5 km in the last century

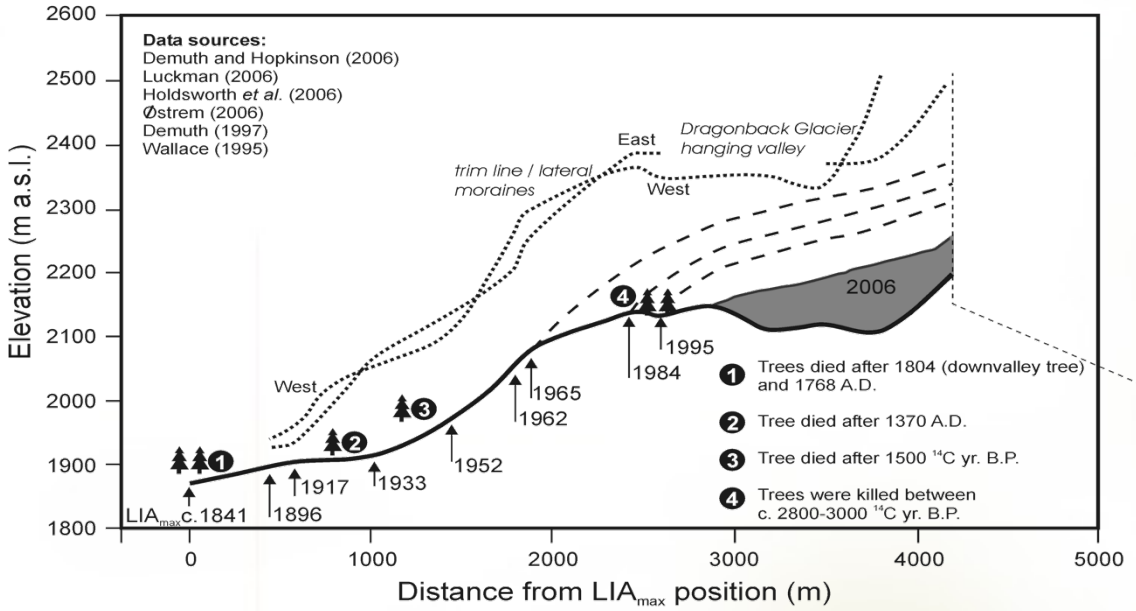
Peyto Glacier



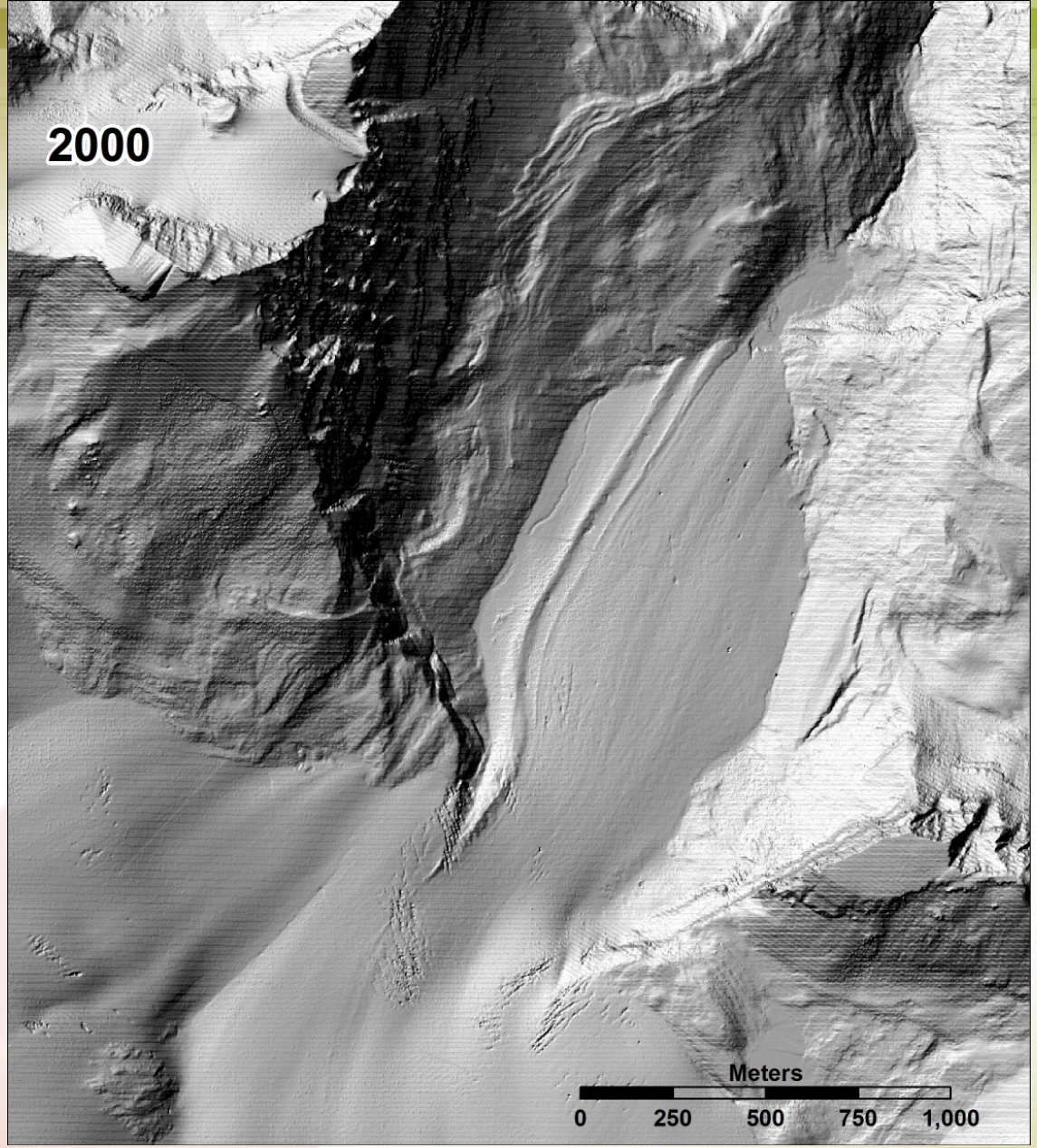
Facts and Figures

Wapta/Waputik Icefield

- Since 1896, Peyto Glacier has lost c. 70% of its mass and it has retreated nearly 2 km



- The Icefield complex drains into the South and North Saskatchewan, and Columbia River Basins



Animation courtesy Chris Hopkinson and Michael N. Demuth, C-CLEAR – GSC-Glaciology

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Peyto Glacier

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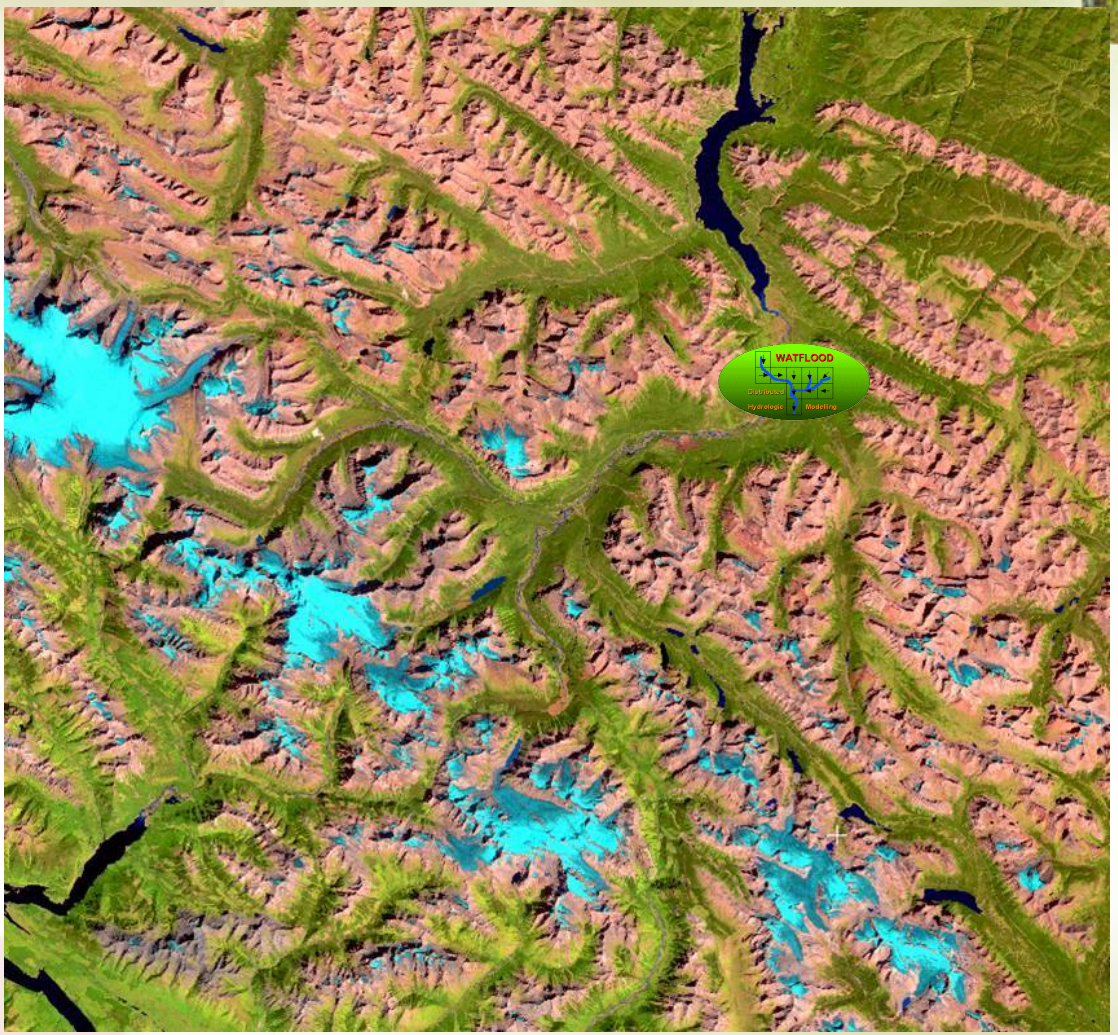
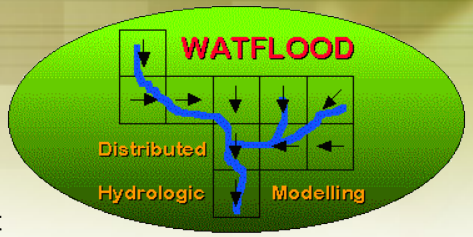
Rocky Mountains/Interior Range

Summary Regional Perspective

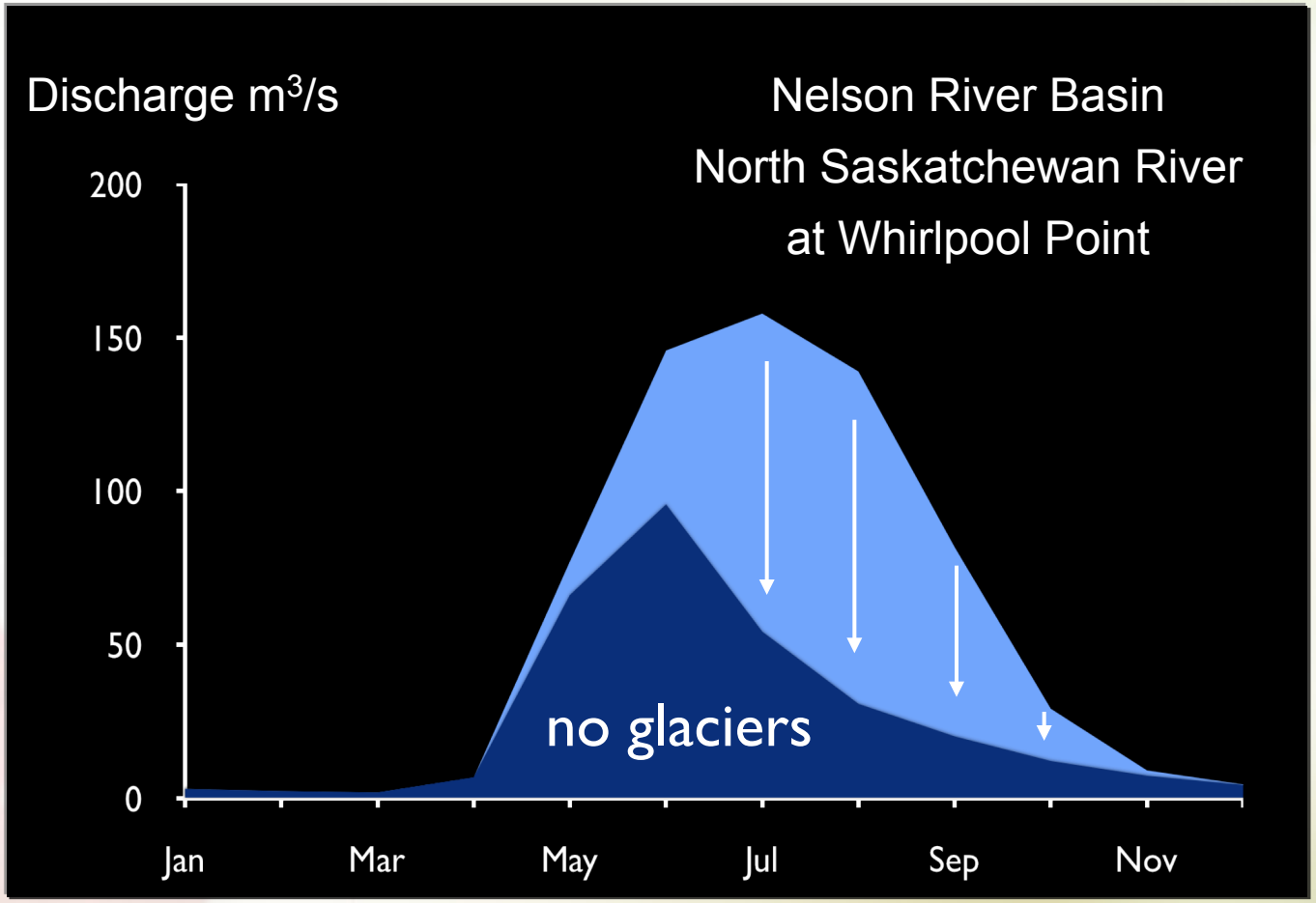
- Glaciers are fast approaching configurations not in evidence for several millennia
- Little Ice Age “Bonus Water” is gone
- Generally increasing rates of specific mass loss are being offset by drastic, long-term area-wise reductions
- The evolution of debris-covered ice, terminal lakes and fragmentation is confounding glacier-climate interpretation
- The melt contribution of expanding debris-covered ice and ice-cored peri-glacial features is poorly known

Hydrology Context





Pietroniro and Demuth for Alberta Environment

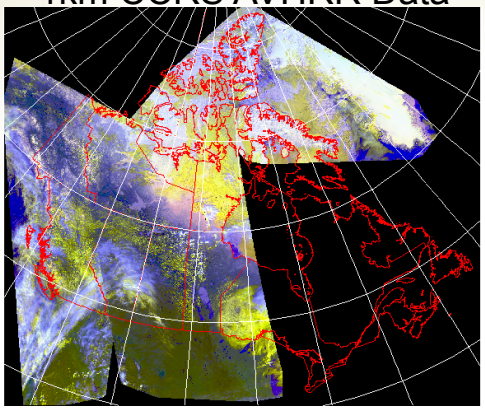


Snow Cover Activities

- Technology for continuous regional snow cover mapping using widely available data (AVHRR, MODIS).
- Systematic climate data records for snow cover over North America.
- Application of records for climate trend analysis and validation of climate models.

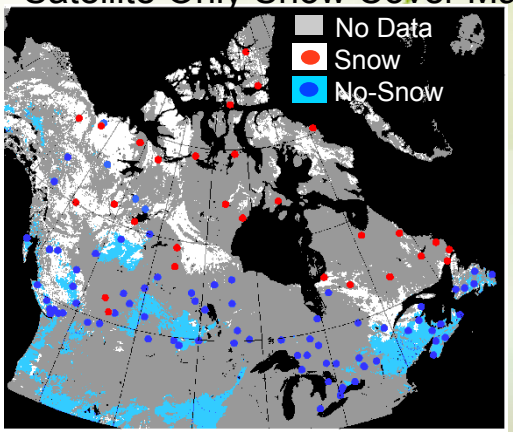
CCRS Data Assimilation System

1km CCRS AVHRR Data

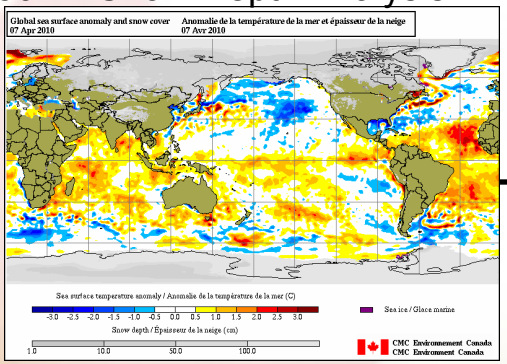


Daily Compositing of Satellite Images

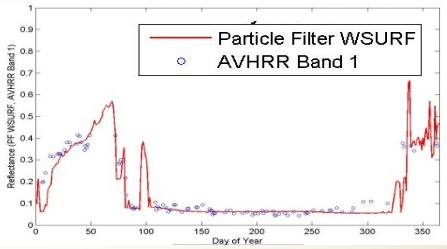
Satellite Only Snow Cover Map



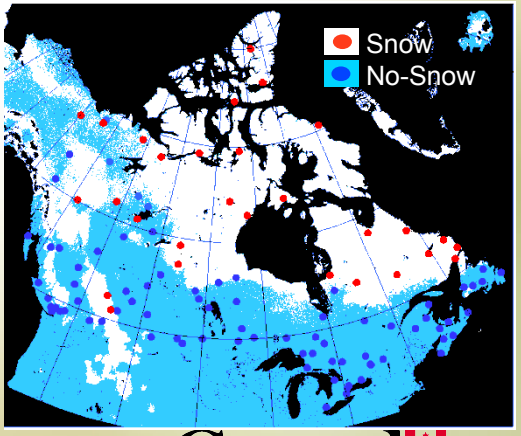
Canadian Meteorological Centre 30km Snow Depth Analysis



Data Assimilation into Land Surface Model



Continuous Daily Snow Cover Map



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Zhao, H., and R. Fernandes (2009), Daily snow cover estimation from Advanced Very High Resolution Radiometer Polar Pathfinder data over Northern Hemisphere land surfaces during 1982–2004, *J. Geophys. Res.*, 114, D05113, doi:10.1029/2008JD011272.

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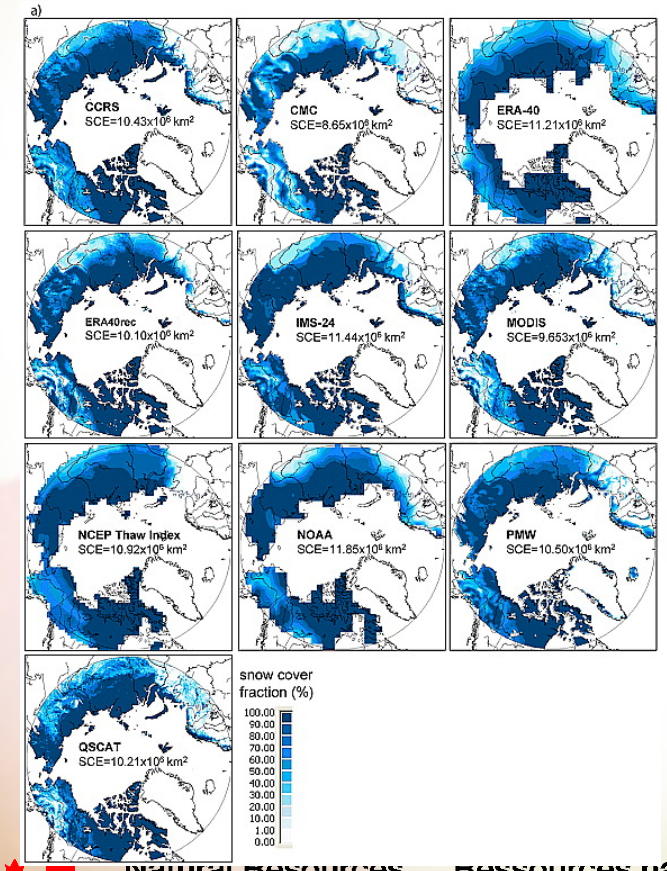
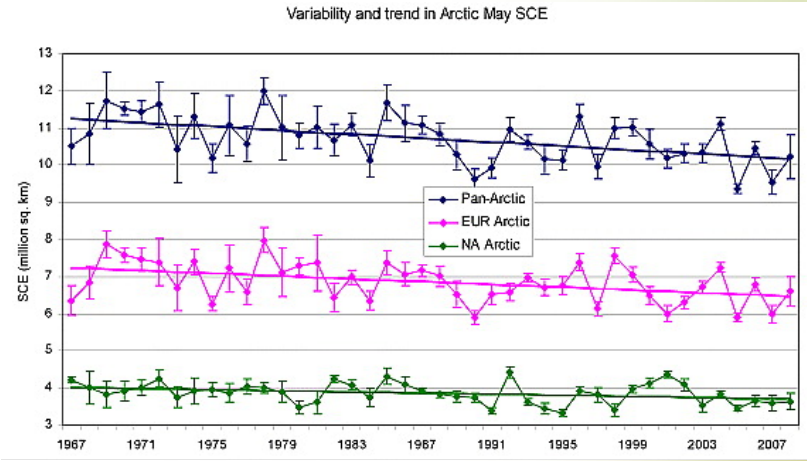
Snow Cover Trends

Multi-Data Set Snow Cover
Standardized with CCRS AVHRR



Trends in Arctic Snow Cover Extent
Using Standardized Data



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Brown, R., C. Derksen, and L. Wang (2010), A multi-data set analysis of variability and change in Arctic spring snow cover extent, 1967–2008, *J. Geophys. Res.*, 115, D16111, doi:10.1029/2010JD013975.

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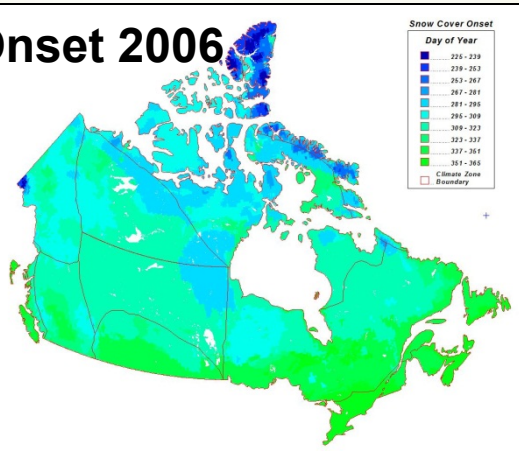
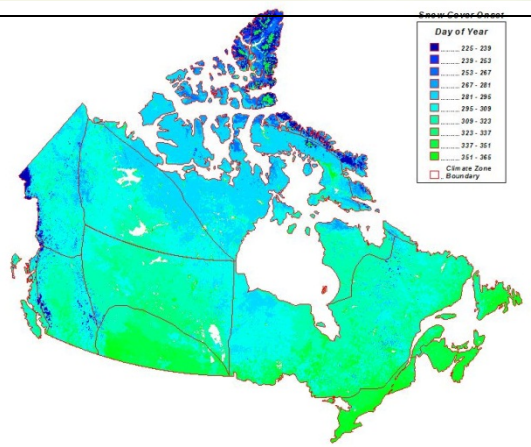
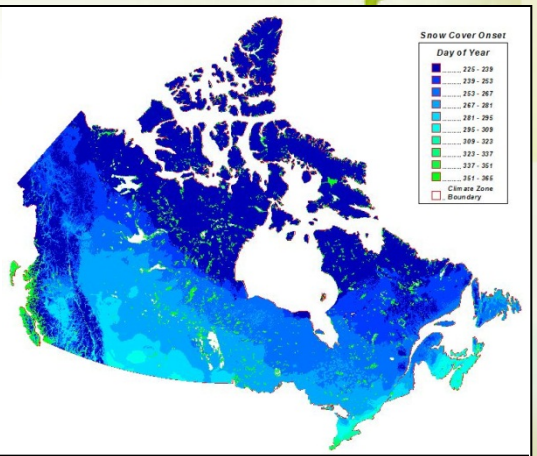
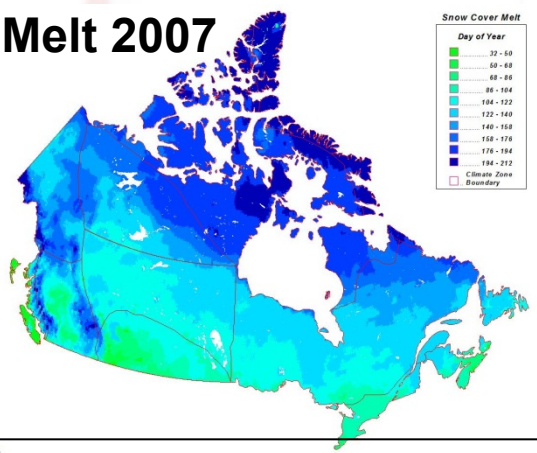
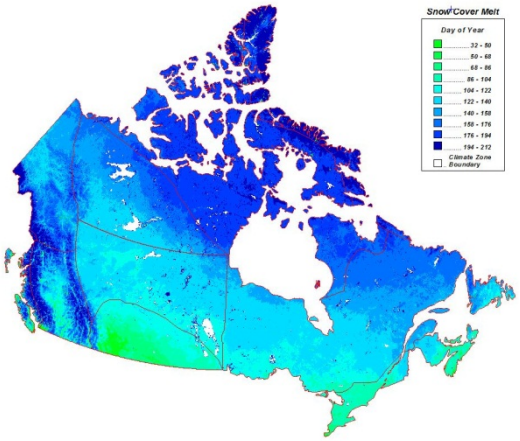
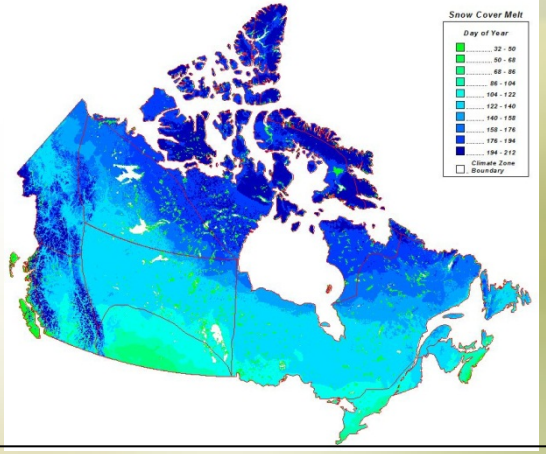
Snow Indicator Intercomparison

	CCRS	NASA/MODIS	NOAA
Onset 2006			
Melt 2007			

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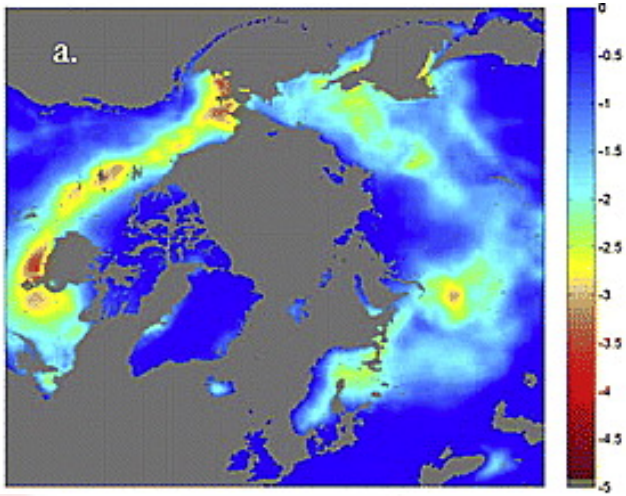
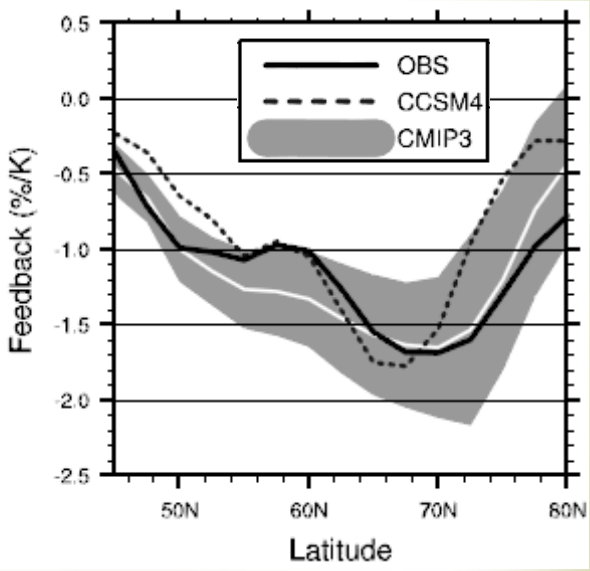
Snow Albedo Feedback

Observed Snow Albedo Feedback (1982-1999)



Observed vs. Modelled Snow Albedo Feedback



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Fletcher, C. Zhao, H. Kushner, P. and Fernandes, R. (2012), Using models and satellite observations to evaluate the strength 2 of snow albedo feedback, Journal of Geophysical Research, VOL. 117, doi:10.1029/2012JD017724, 2012

Area of Collaboration

- 30 year 4km resolution times series of snow cover over North America available
- Global map of snow albedo feedback should be produced. This would require snow and albedo data south of 45N (e.g Tibet, Andes, Murray-Darling basin).
- We are open to sharing our data assimilation system (it is being ported to a PC GPU platform).

Thank you

Columbia Icefield Water for Life

Mackenzie

Columbia

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