Using LiDAR to study environmental processes & change

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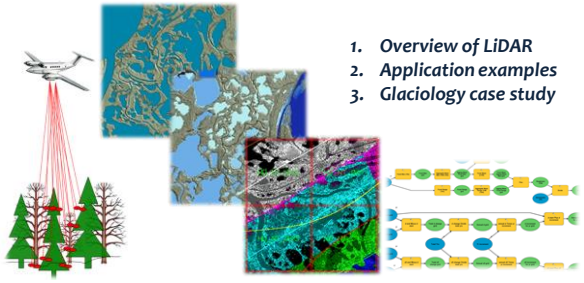
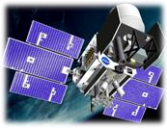


1. *Overview of LiDAR*
2. *Application examples*
3. *Glaciology case study*

LiDAR Technology

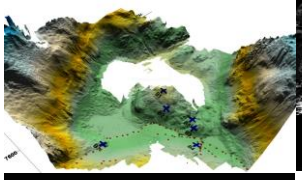
Common LiDAR sensor configurations:

- Satellite profiler (ICESat GLAS)
- Airborne scanners (discrete, waveform)
- Terrestrial static (frame, hemispheric)



Terrestrial LiDAR Technology

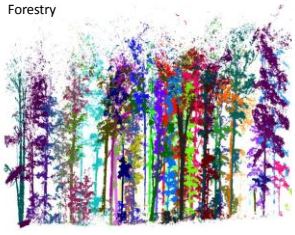
DEMs



Architecture / heritage

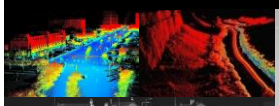
Reverse engineering

Forestry



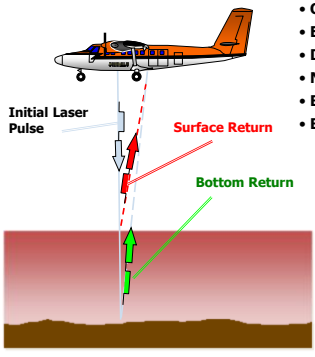
Mobile LiDAR system example

Optech Lynx can be mounted on multiple mobile platforms
Multiple scanners & GPS for rapid high res terrestrial scanning

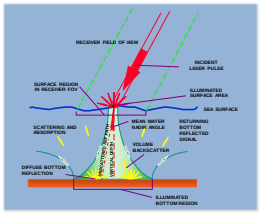


Mobile laser scanning – overcoming occlusion

Bathymetric LiDAR

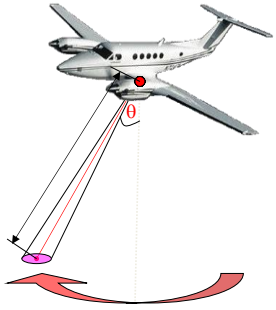


- Operates in shallow water regions
- Extends survey onto land
- Digital camera
- NIR laser for water surface
- Blue / Green laser for water depth
- Beam spreads beneath surface



Airborne LiDAR Technology

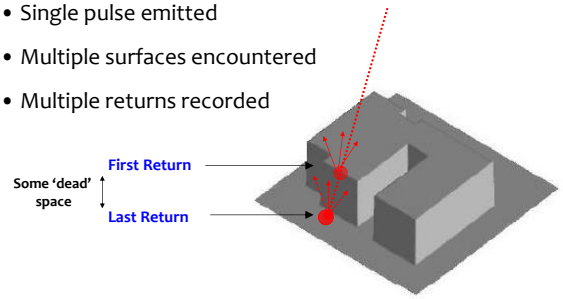
Decimetre accuracy 3D point cloud up to 500 km² per hour

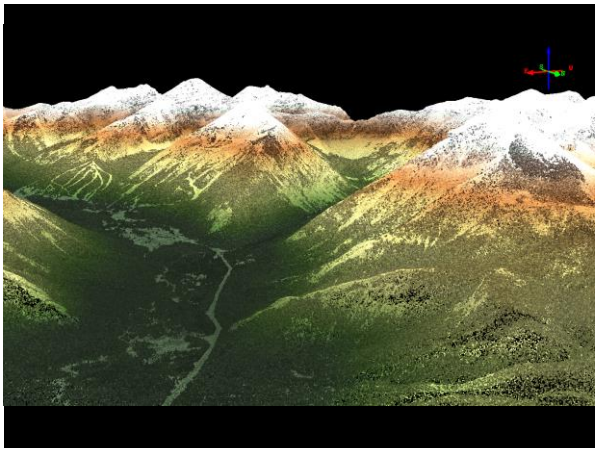


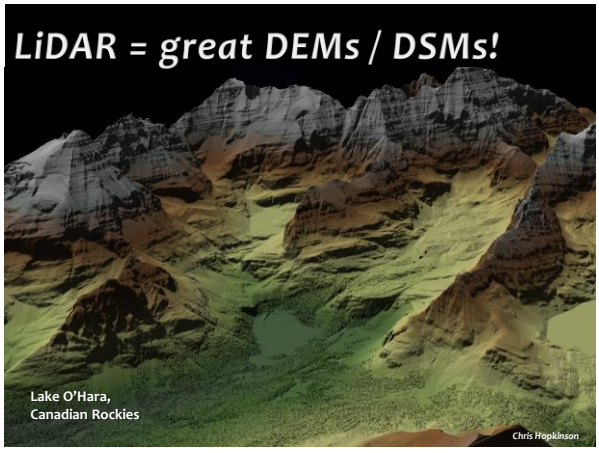
1 - Differential GPS
2 - Inertial Measurement Unit
3 - Electro-optical lidar system
4 - Scanner
5 - Aircraft platform & offsets
6 - Computer processing system

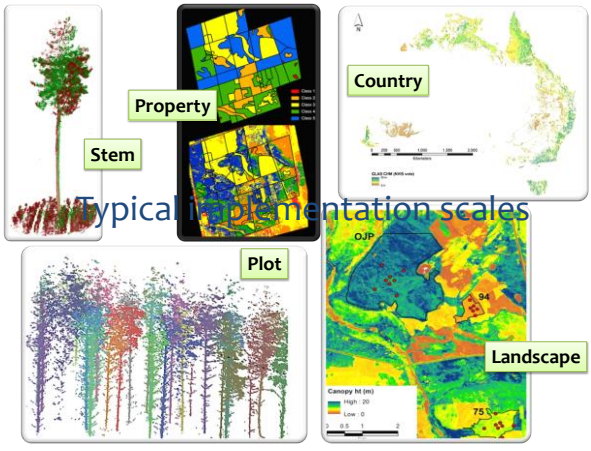
Multiple return capability

- Single pulse emitted
- Multiple surfaces encountered
- Multiple returns recorded

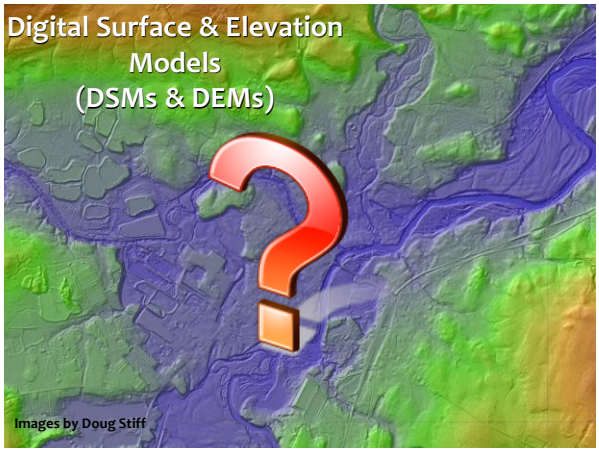


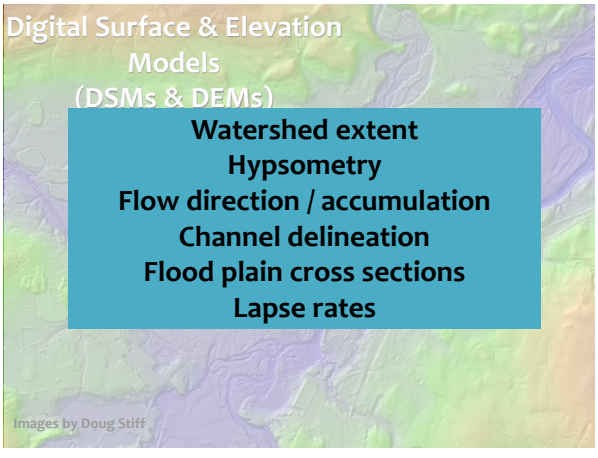






Typical implementation scales



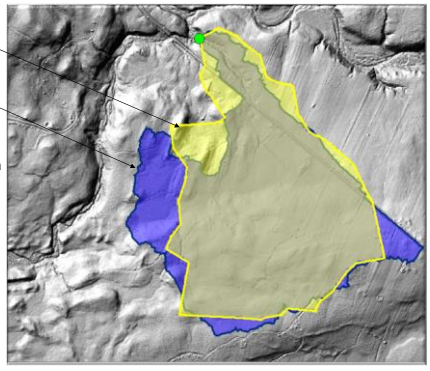


LiDAR watershed vs photogrammetric

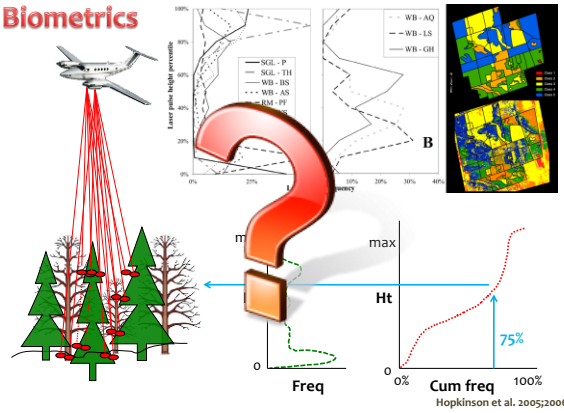
Photo-based

LiDAR-based

Improved:
- Watershed area
- Flow pathways
- Channel delineation
- Hypsometry

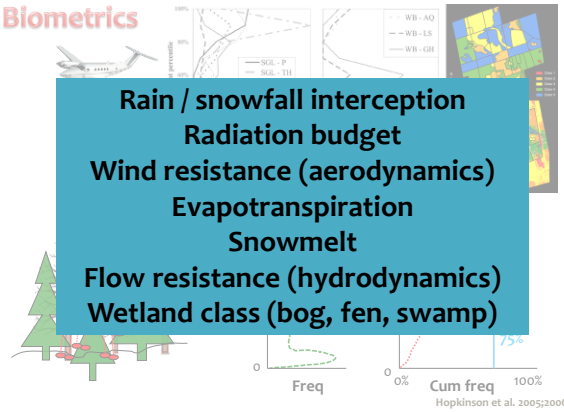


Biometrics



Hopkinson et al. 2005;2006

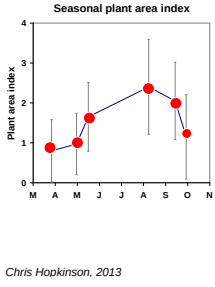
Biometrics

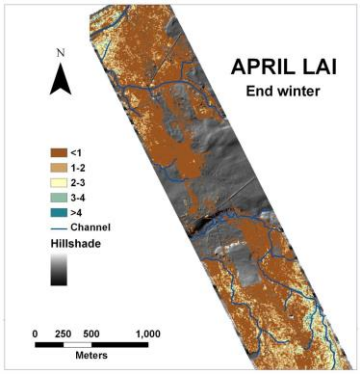


Rain / snowfall interception
Radiation budget
Wind resistance (aerodynamics)
Evapotranspiration
Snowmelt
Flow resistance (hydrodynamics)
Wetland class (bog, fen, swamp)

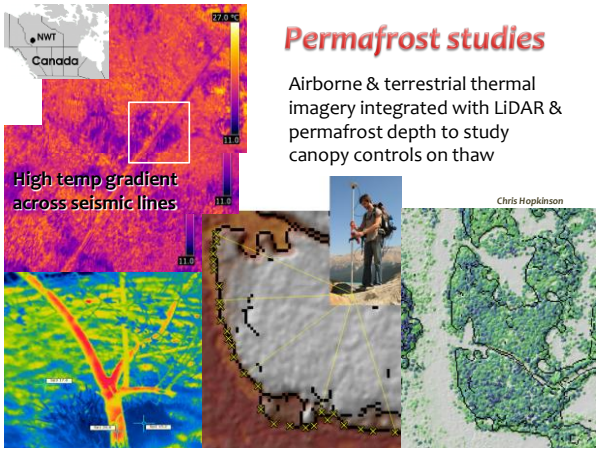
Hopkinson et al. 2005;2006

Radiative transfer & LAI modeling



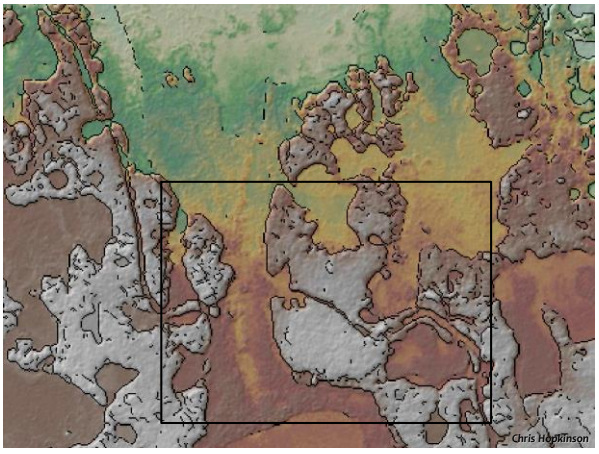


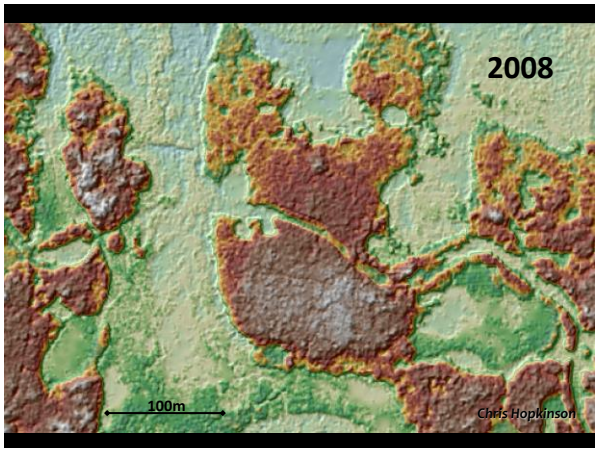
Chris Hopkinson, 2013

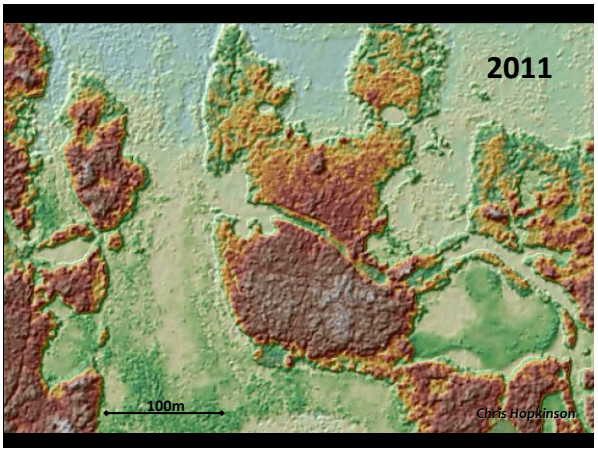


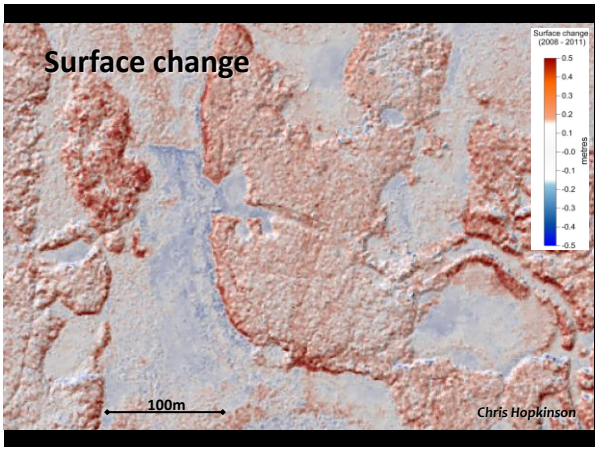
Permafrost studies

Airborne & terrestrial thermal imagery integrated with LiDAR & permafrost depth to study canopy controls on thaw



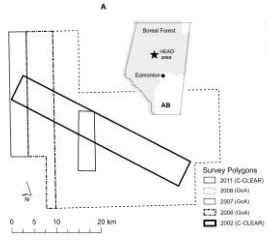


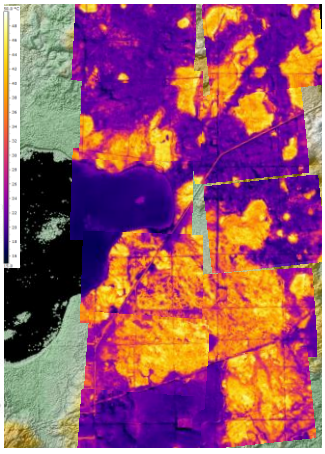




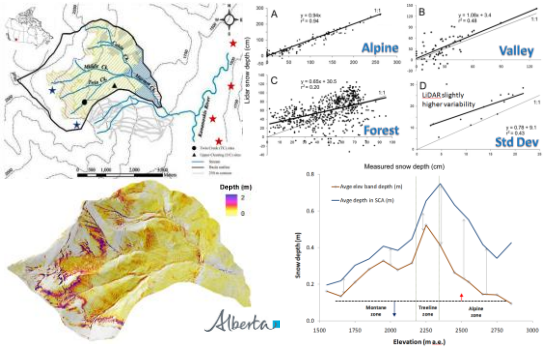
Biomass loss due to Alberta wildfire

Thermal & temporal LiDAR integrated to map volume of canopy & peatland loss





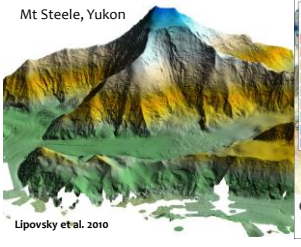
Snow depth mapping



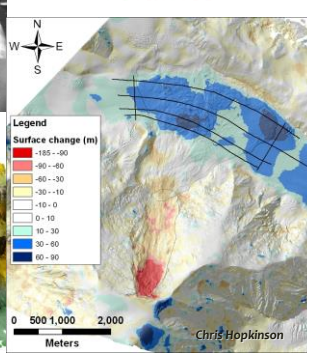
Hopkinson et al. 2012a; 2012b

Landslide/avalanche volumes

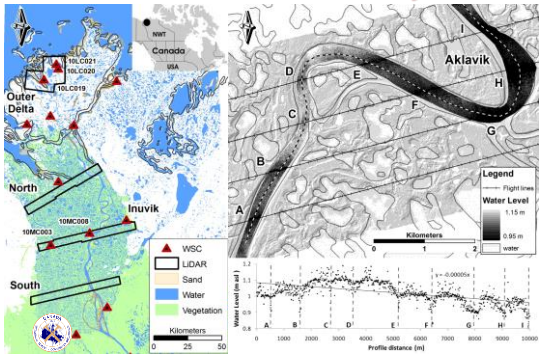
Mt Steele, Yukon



Lipovsky et al. 2010



River channel water levels & hydraulics



Hopkinson et al. 2011

Channel & lake water levels

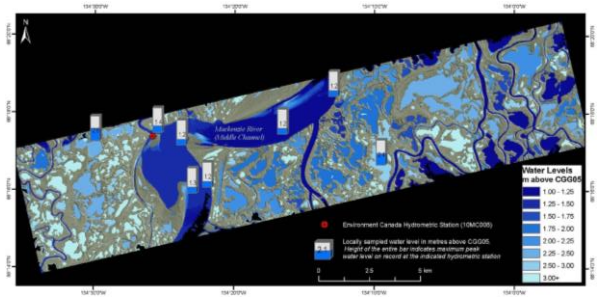


Image courtesy of Neville Crasto, M.Sc

Floodplain storage calculation

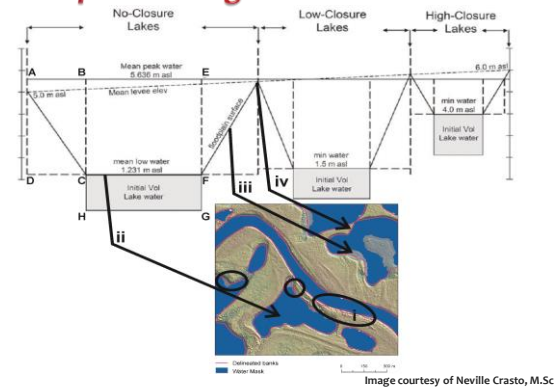


Image courtesy of Neville Crasto, M.Sc

Channel hydraulic model set up

Traditional approach:
- A few cross-sections from a few highly accurate survey points
- LUT friction parameters

LiDAR approach:
- Infinite cross sections from thousands of points
- Modeled friction from point cloud roughness elements

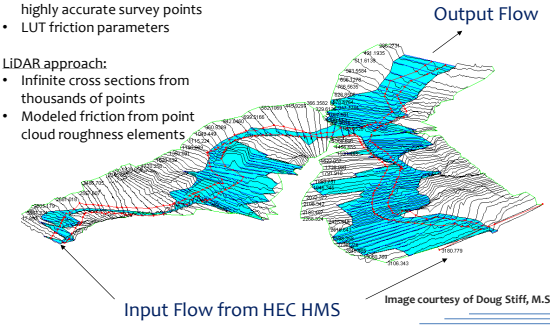
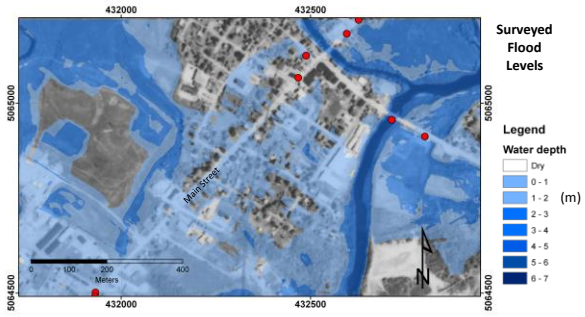


Image courtesy of Doug Stiff, M.Sc

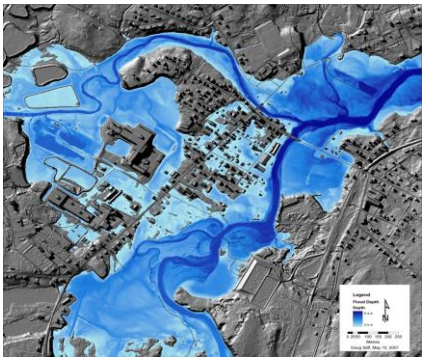
Flood extent validation



Black and white airphoto with estimated water depth based on surveyed points

Image courtesy of Doug Stiff, M.Sc

Flood extent & inundation mapping



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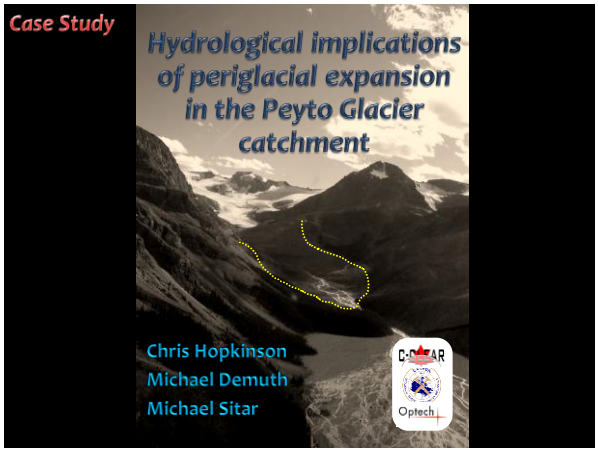
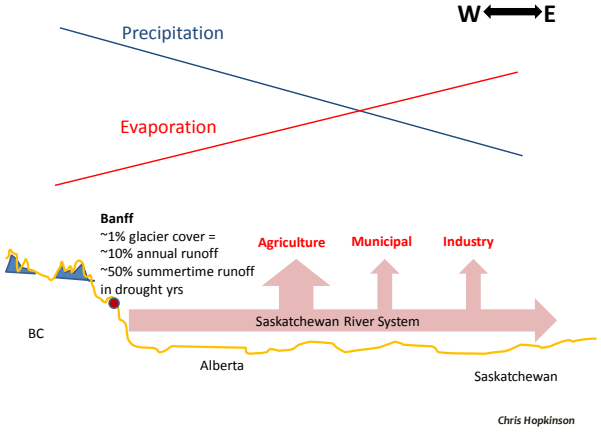
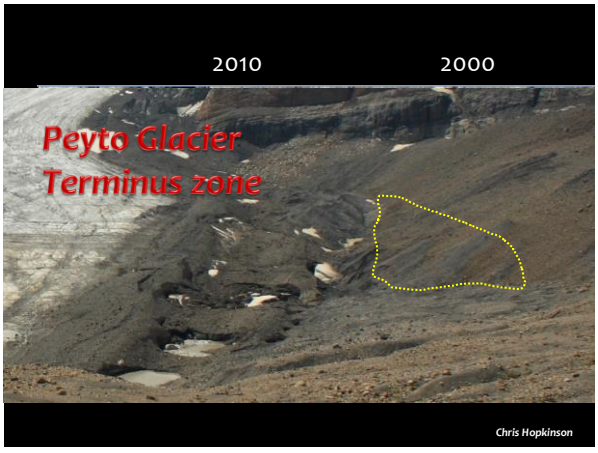






Long term glacier changes

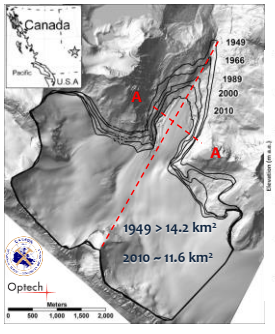
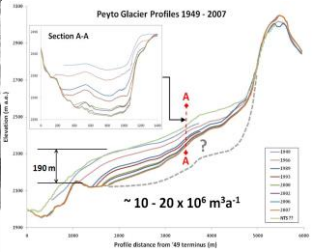
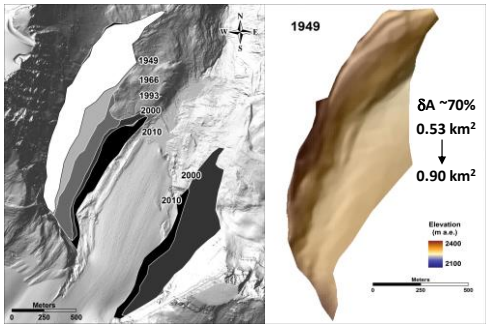


Photo / LiDAR DEM comparison



Hopkinson et al. 2012c

Long term moraine changes



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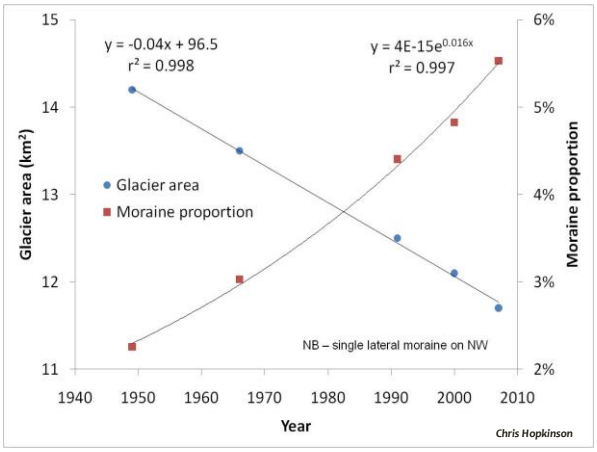

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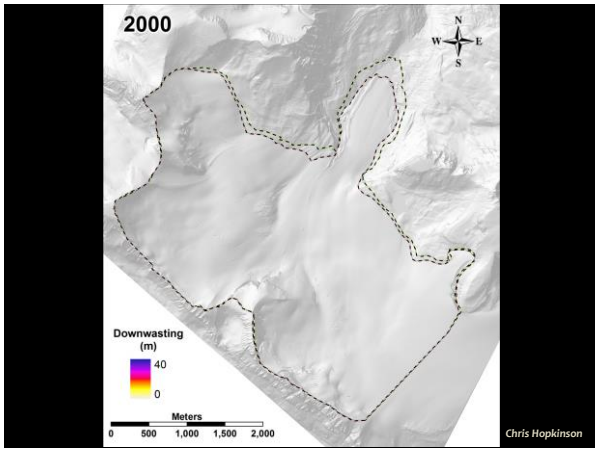

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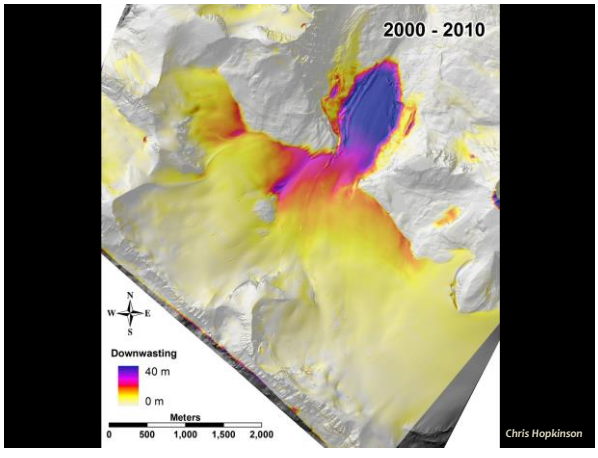

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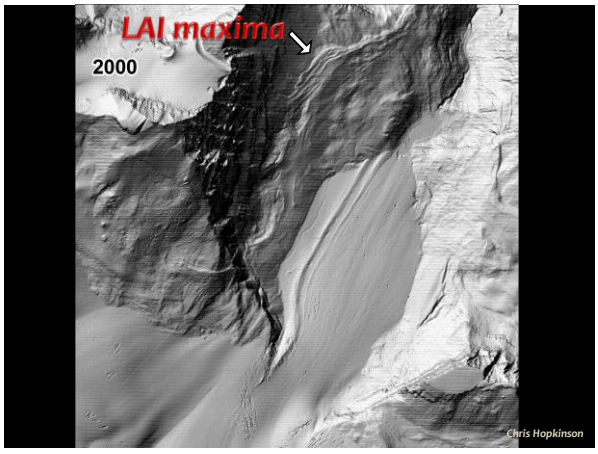

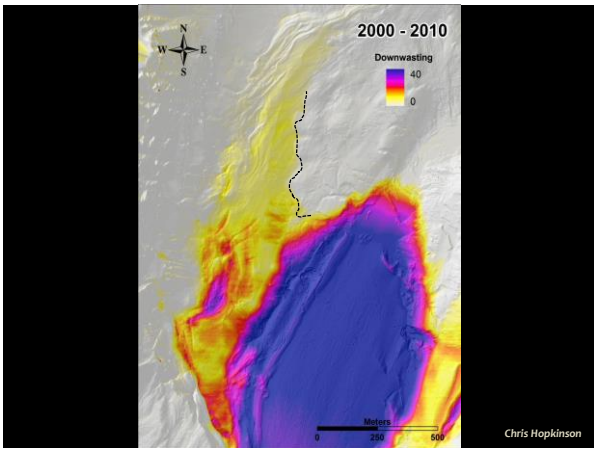

Periglacial elevation change

1. **Fluviochemical (-ve)**
   Sediment transport and dissolution
2. **Gravitational / Geomorphic (+ve)**
   Ice backwasting = slope debutressing = moraine/talus backfill
3. **Thermal (-ve)**
   Debris covered ice core ablation

Downwasting glacial ice at margin: $\delta Z\downarrow_{PG} = \delta Z\downarrow_{T} + \delta Z_{G} - \delta Z_{FC}$

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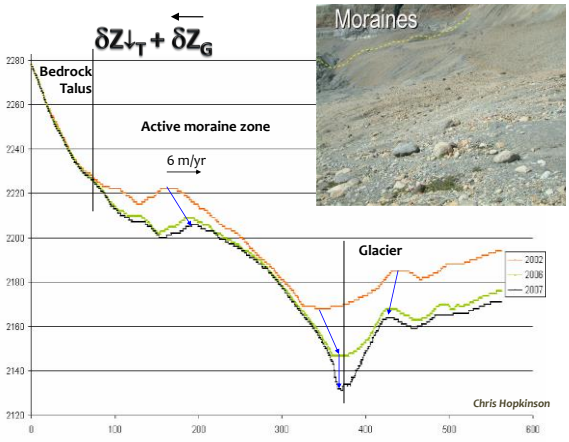
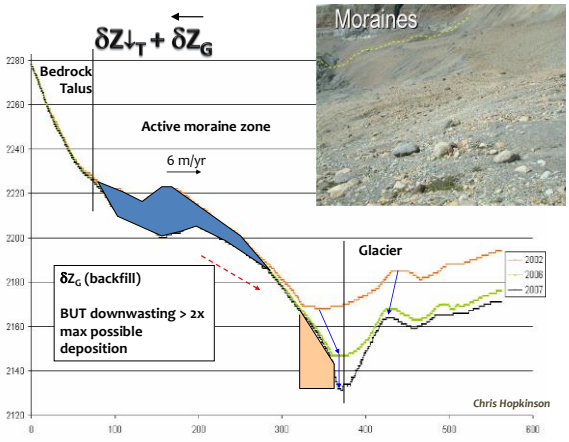
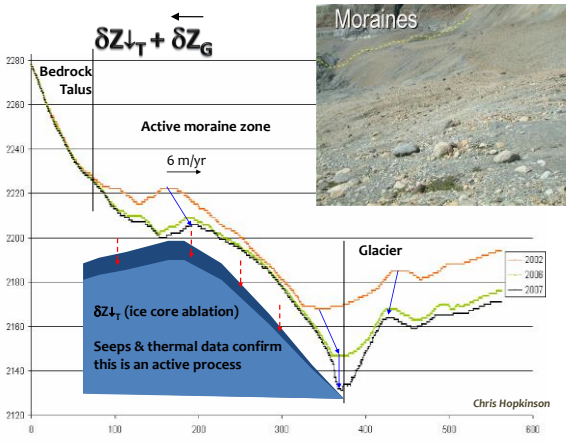
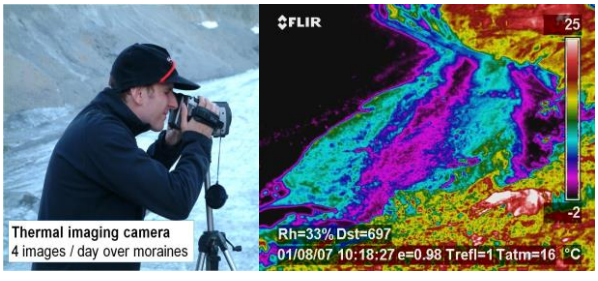






Thermal imagery

Heat scavenging to drive melt apparent in thermal signatures



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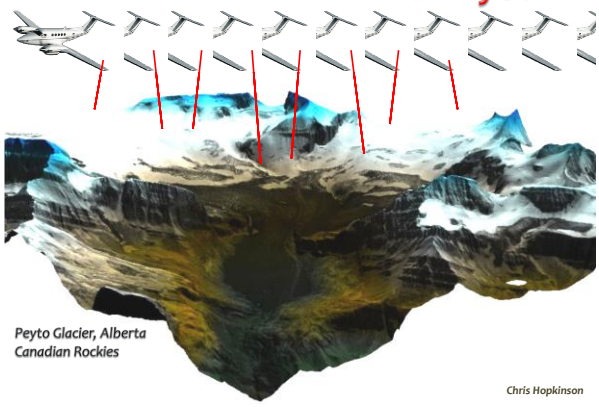
Thank you!



Peyto Glacier, Alberta
Canadian Rockies

Chris Hopkinson