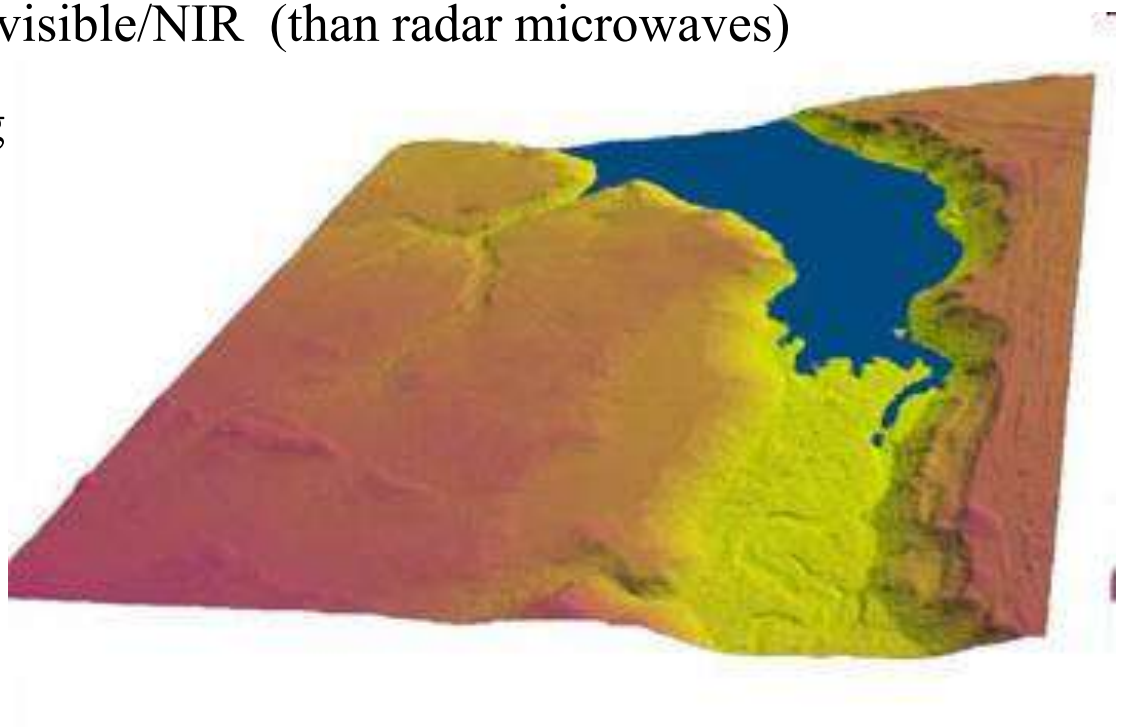
LiDAR = **Li**ght **D**etection And Ranging ...also known as LASER altimetry

An increasingly common form of **active** remote sensing since ~2000

- contrasts with Radio Detection and Ranging (RADAR) in the microwave

Objects reflect more in UV/visible/NIR (than radar microwaves)

= higher resolution mapping



- high resolution DEMs

e.g. for flood control

~1 foot or <1 m

(mostly airborne)

http://www.ags.gov.ab.ca/geohazards/turtle_mountain/lidar.html

Turtle Mountain, AB (Frank slide, 1903)

LiDAR DEM

What is LiDAR ?

Controlled bursts of LASER =
(Light Amplification by Stimulated Emission of Radiation)

Distance to object is given by TIME

-requires 3 units:

-laser emitter/receiver

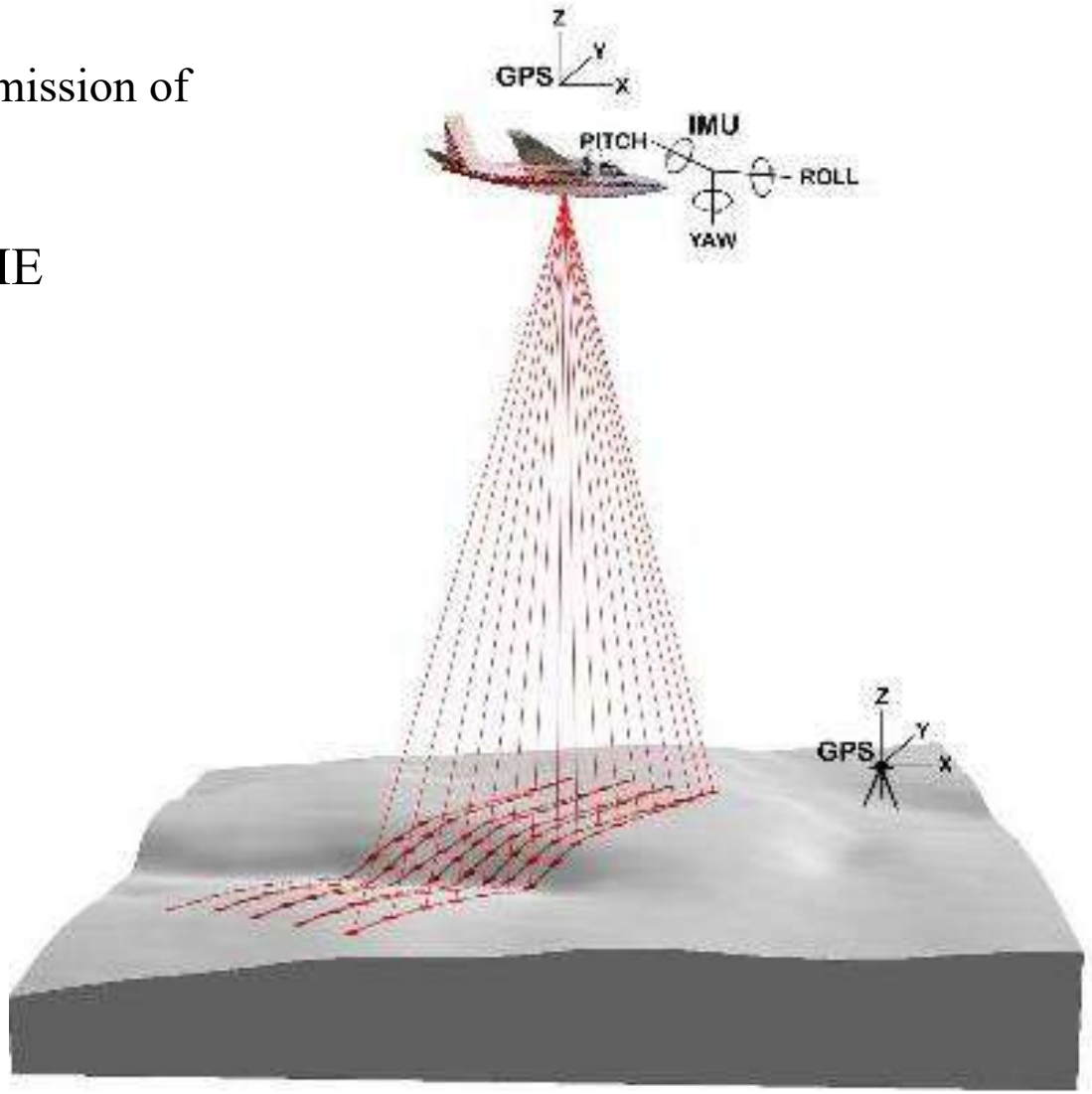
-GPS

-IMU (Inertial measurement unit)

First developed in 1960s but needed GPS technology for detailed mapping –1980s

Expansion since 2000s,

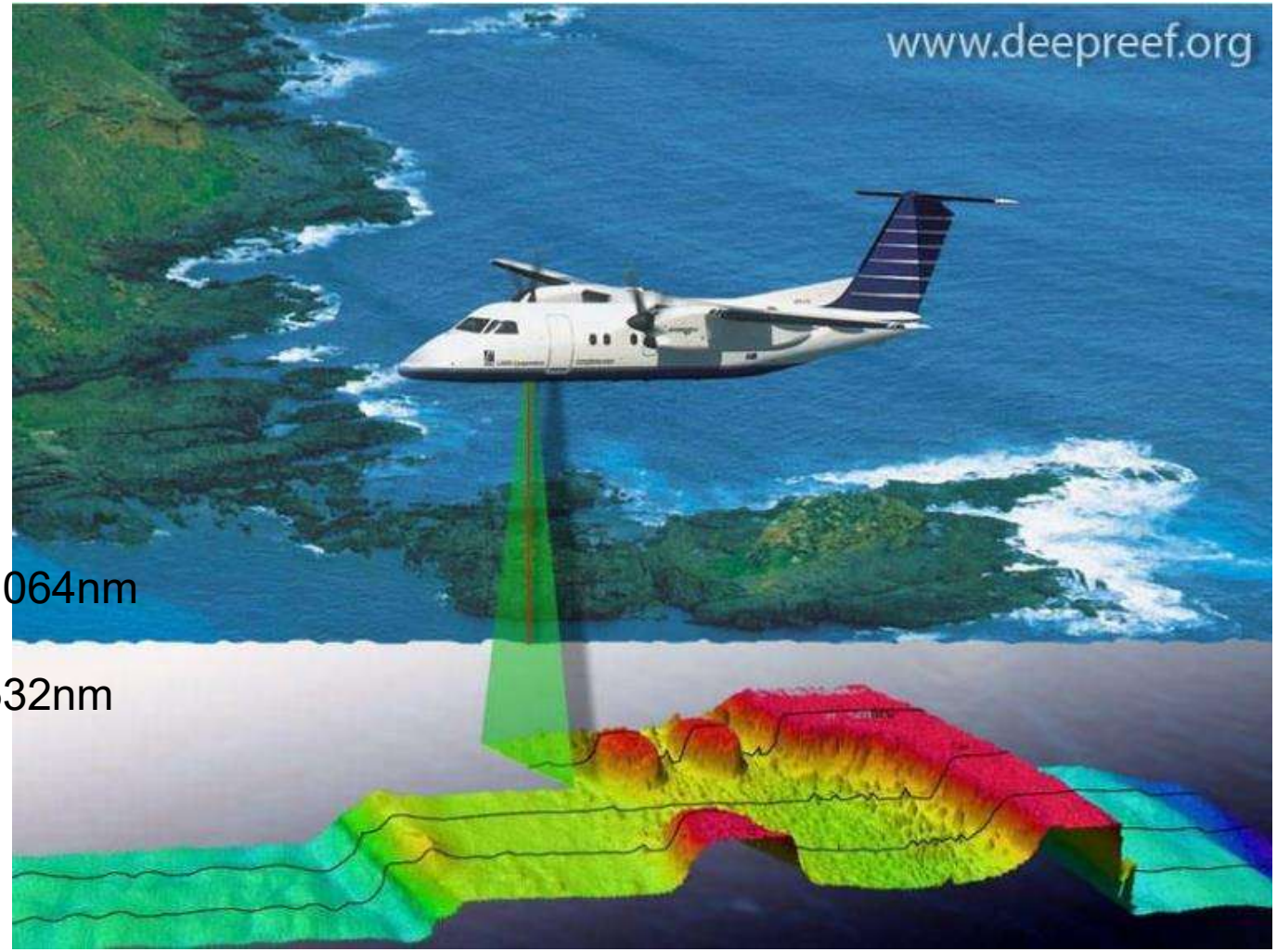
Drones 2015, iPhones 2020



Related technologies:

SONAR: SOund NAvigation and Ranging : sound propagation for communication/navigation
SODAR: SOnic Detection And Ranging : sound propagation upwards (atmospheric) for wind speeds

Laser Airborne Depth Sounder (LADS): Bathymetry



http://www.navy.gov.au/laser-airborne-depth-sounder-lads

Range finding LiDAR for topographic mapping

Unaffected by clouds **above** (unlike air photos) .. *why?*

Laser bursts are emitted usually at one of these wavelengths:

- 355 nm (UV): wind, water vapour
- 532 nm (green): bathymetry
- 1064 nm (Near IR): surface mapping

….. (why these ??? *) This was not solved by googling or LiDAR vendors

* I asked this every class and offered a 6-pack to who could solve this

Trivia: taser guns are at 650 nm; phasers (Star Trek) at 350nm

LiDAR – 1064 nm, 532nm, 355nm - why those wavelengths?

Lasers produce light the same way as a neon sign – a substance is stimulated to an excited state, causing the release of extra energy as a photon of light.

Nd:YAG (*neodymium-doped yttrium aluminium garnet*) is a crystal that is used as a lasing medium for solid-state lasers. It emits at a wavelength of 1064 nm.

According to the Planck-Einstein equation:

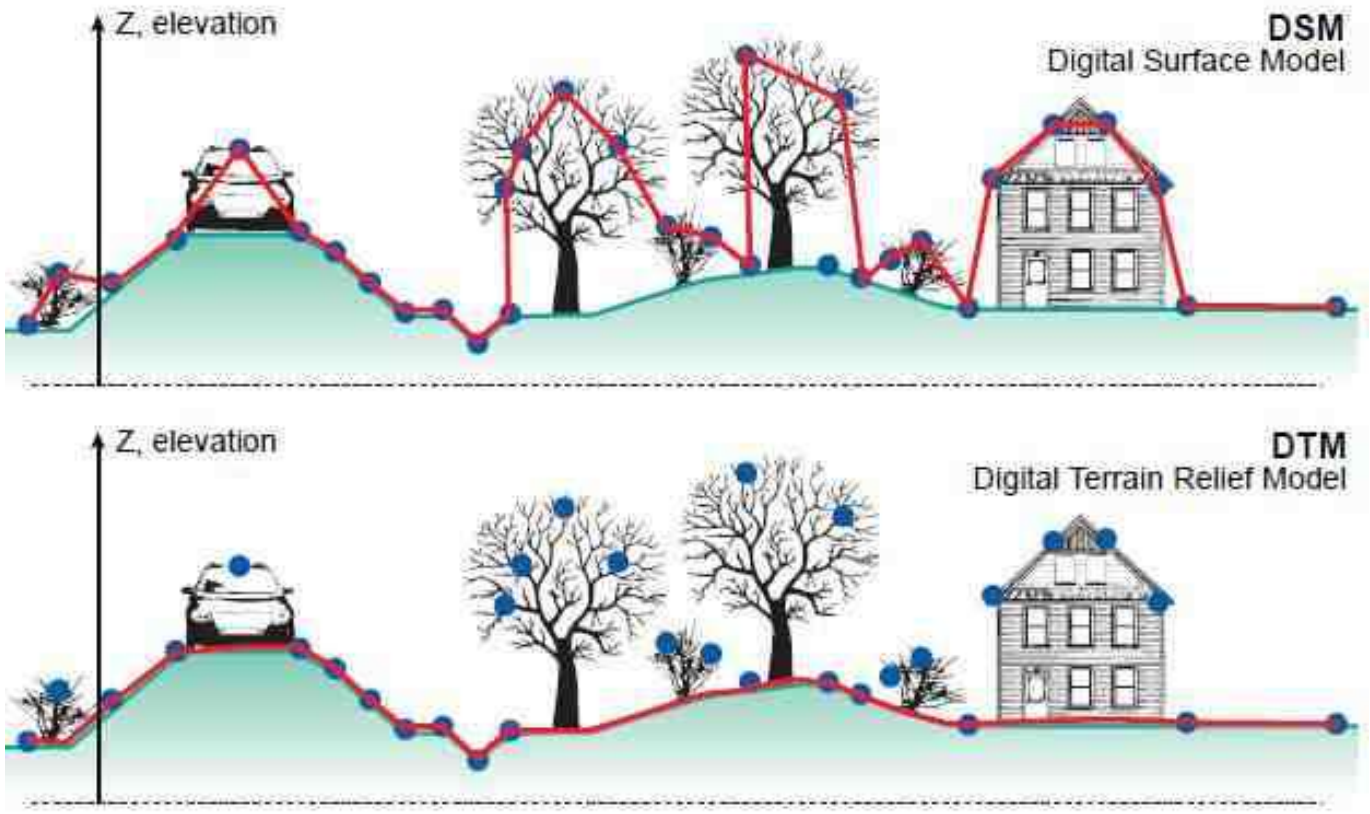
Where h= Planck's constant, and c = the speed of light; $E = \frac{hc}{\lambda}$.

halving the wavelength, has the effect of doubling the energy released, and one-third the wavelength (355) triples the energy (= the second and third harmonics)

Solved by Patrick Daley, (Fall 2009) – won a 6-pack of Guinness

** More recently, LiDAR seems to have switched to 905 and **1550 nm** for UAVs*

DEMs: DTM and DSM



Digital Surface Models

Spaceborne / LiDAR

Digital Terrain Models

Photogrammetric / LiDAR

'Bare Earth'

LiDAR is the only remote sensing system that can do both - and thus give a measure of tree heights (and buildings)

http://www.satimagingcorp.com/svc/dem.html

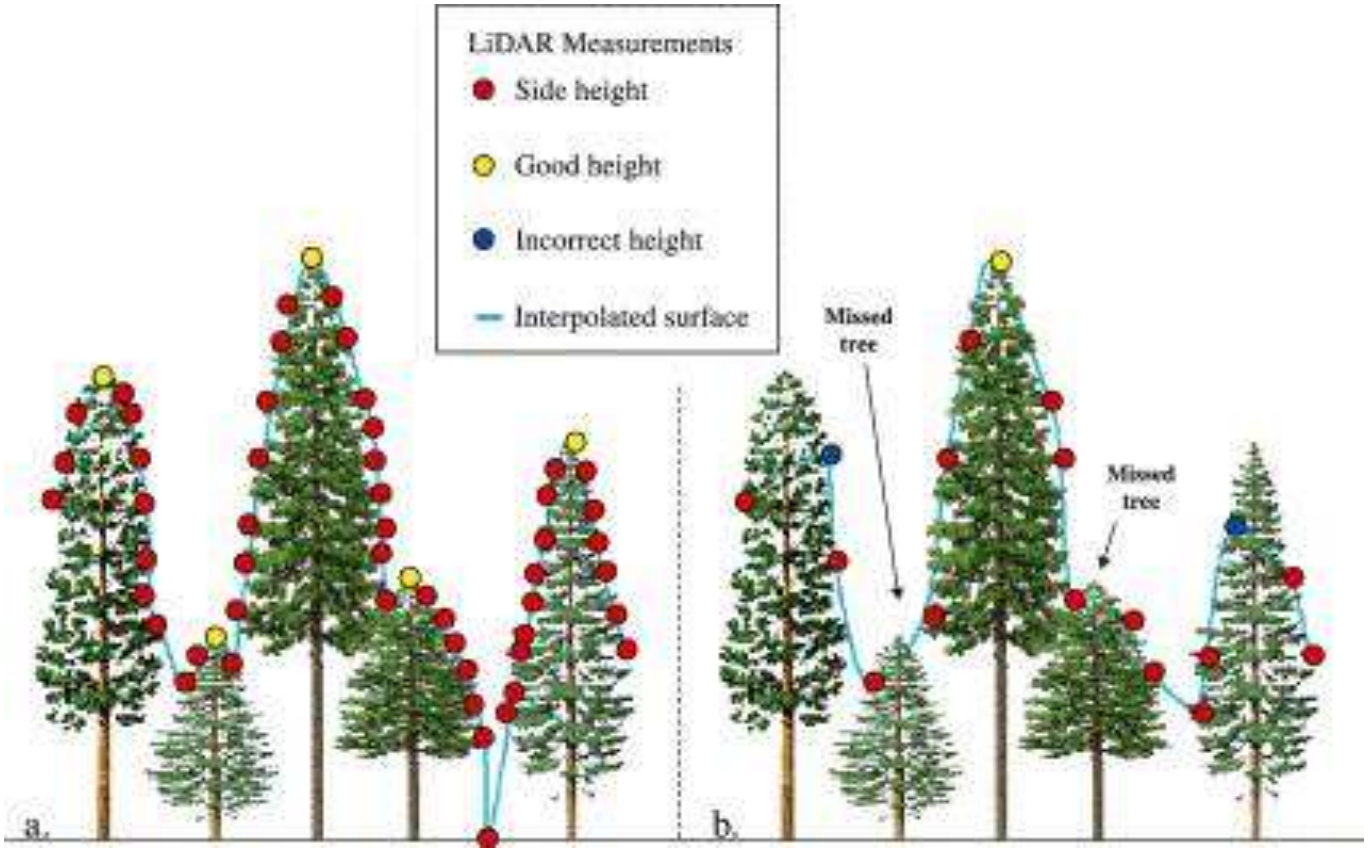
Laser pulses at up to 50,000 - 200,000 / second

Resulting cloud of points: up to 20 points / square metre

~10/m^2 needed for forestry 1/m^2 for glaciers (no trees)

Horizontal accuracy 50cm - 1m, vertical ~20cm

Cloud of points is converted to raster grid ~1 metre ….. 'LAS tools'



Vegetation: Tree Canopy Height

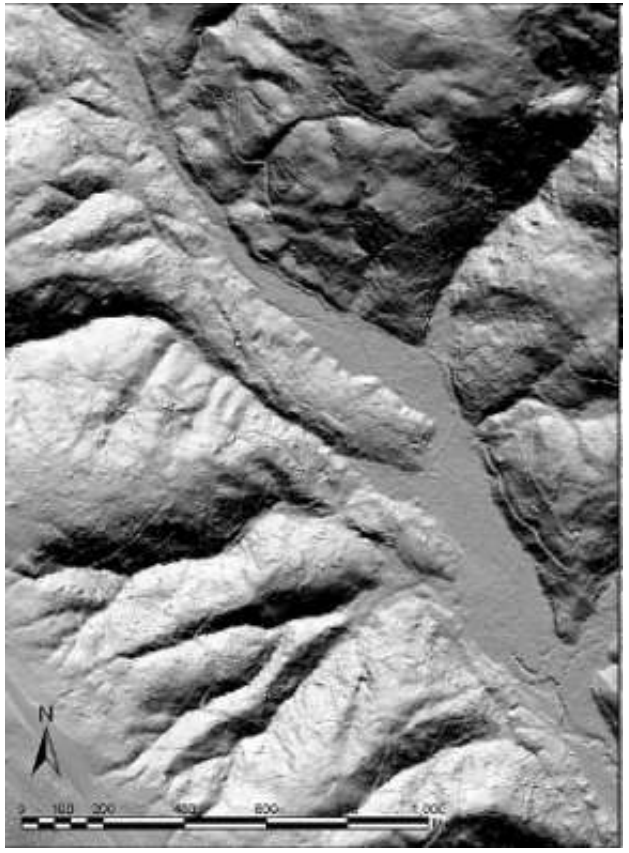
http://quake.wr.usgs.gov/research/geology/lidar/example2.html

Air photo

Vegetation surface DSM

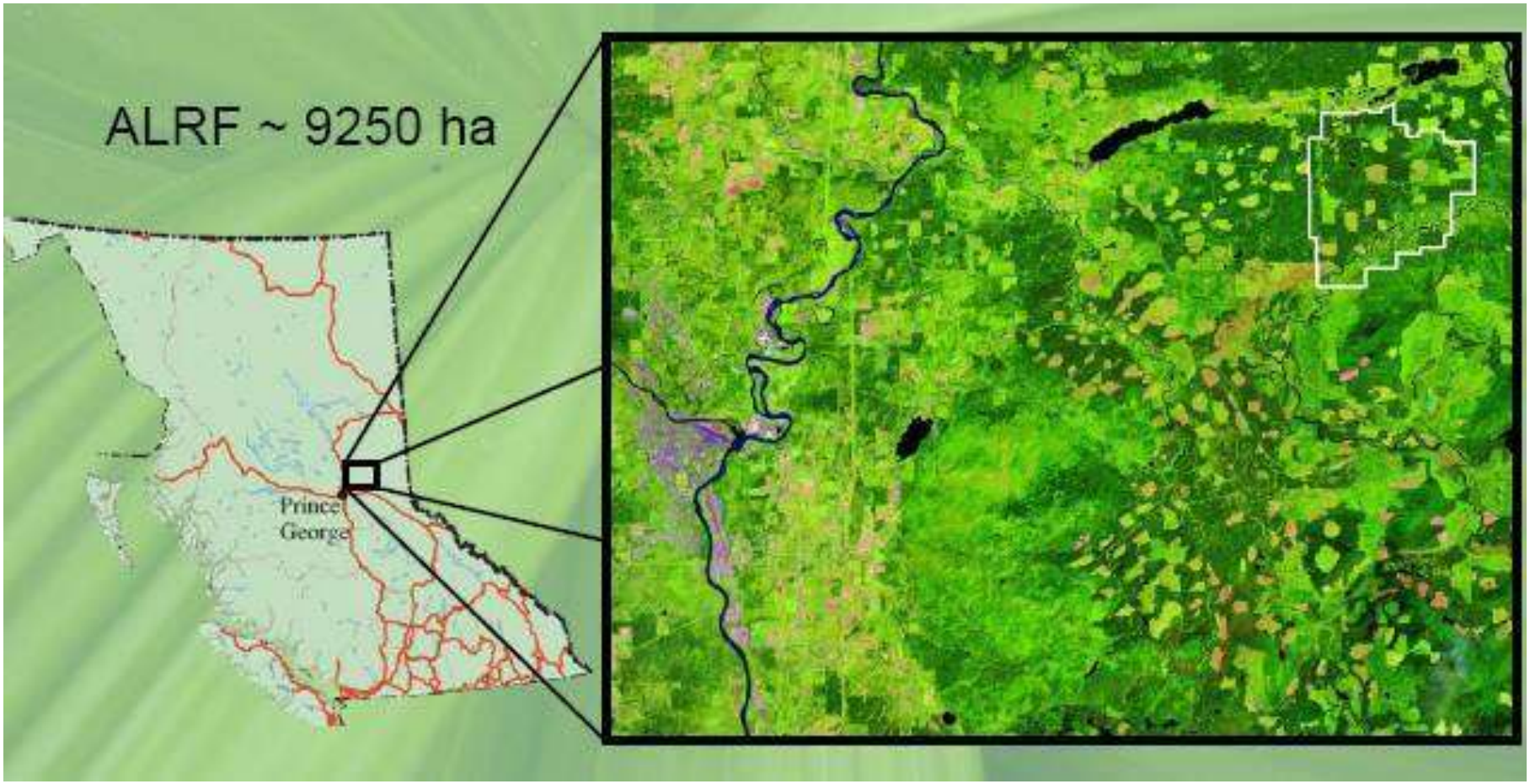
Bald Earth Model (BEM/BEDEM)

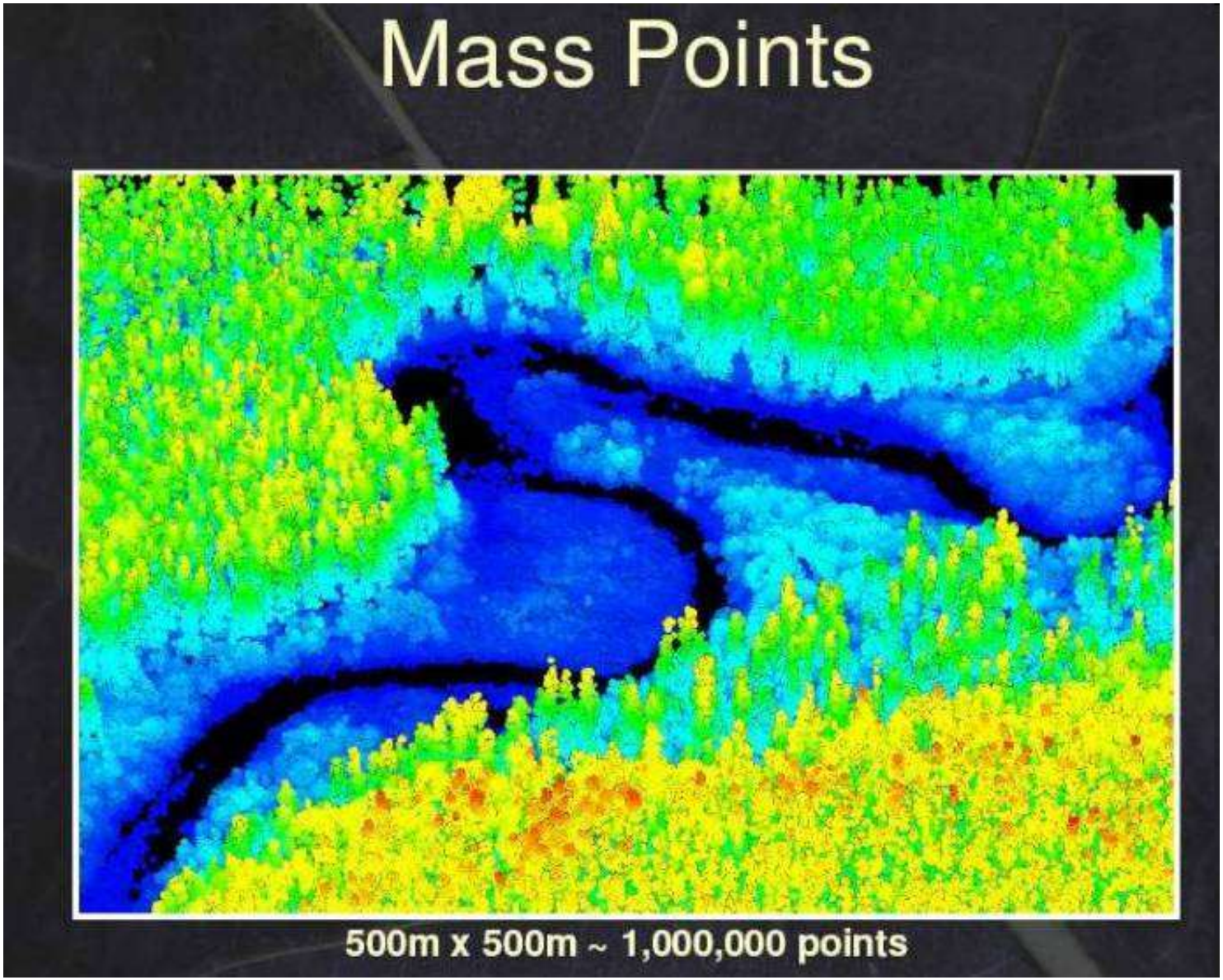
Vegetation height = DSM minus BEM



Aleza Lake Research Forest (ALRF)

Oldest research forest in BC, jointly operated by UBC and UNBC
60km north-east of Prince George, LiDAR mission 2005

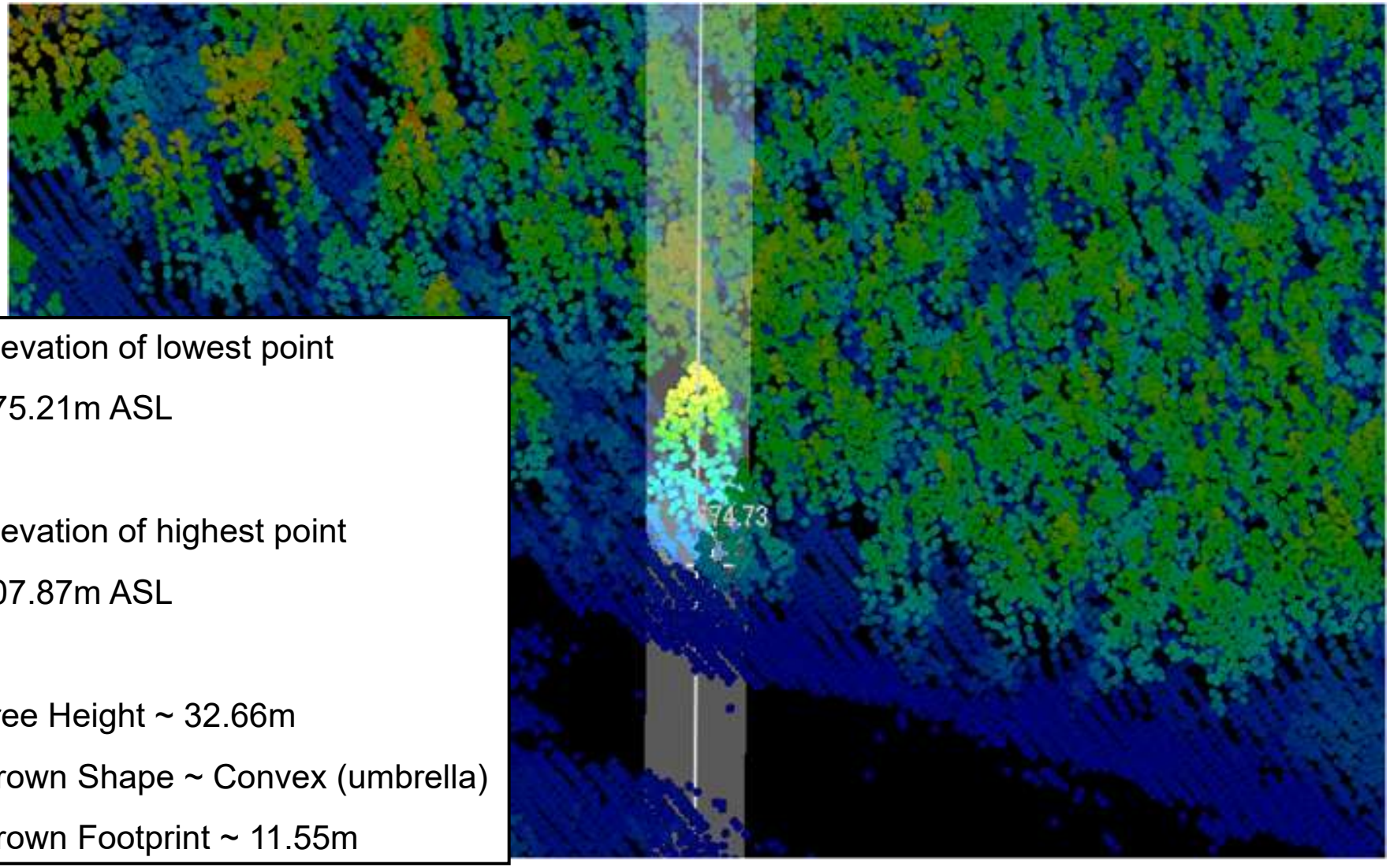




Cloud of points, colour coded by elevation, Bowron R. southern edge of ALRF

LiDAR reveals both ‘bare earth’ (ground) and canopy height

… and multiple vegetation layers – shrub layer, sub-canopy etc..



Elevation of lowest point

675.21m ASL

Elevation of highest point

707.87m ASL

Tree Height ~ 32.66m

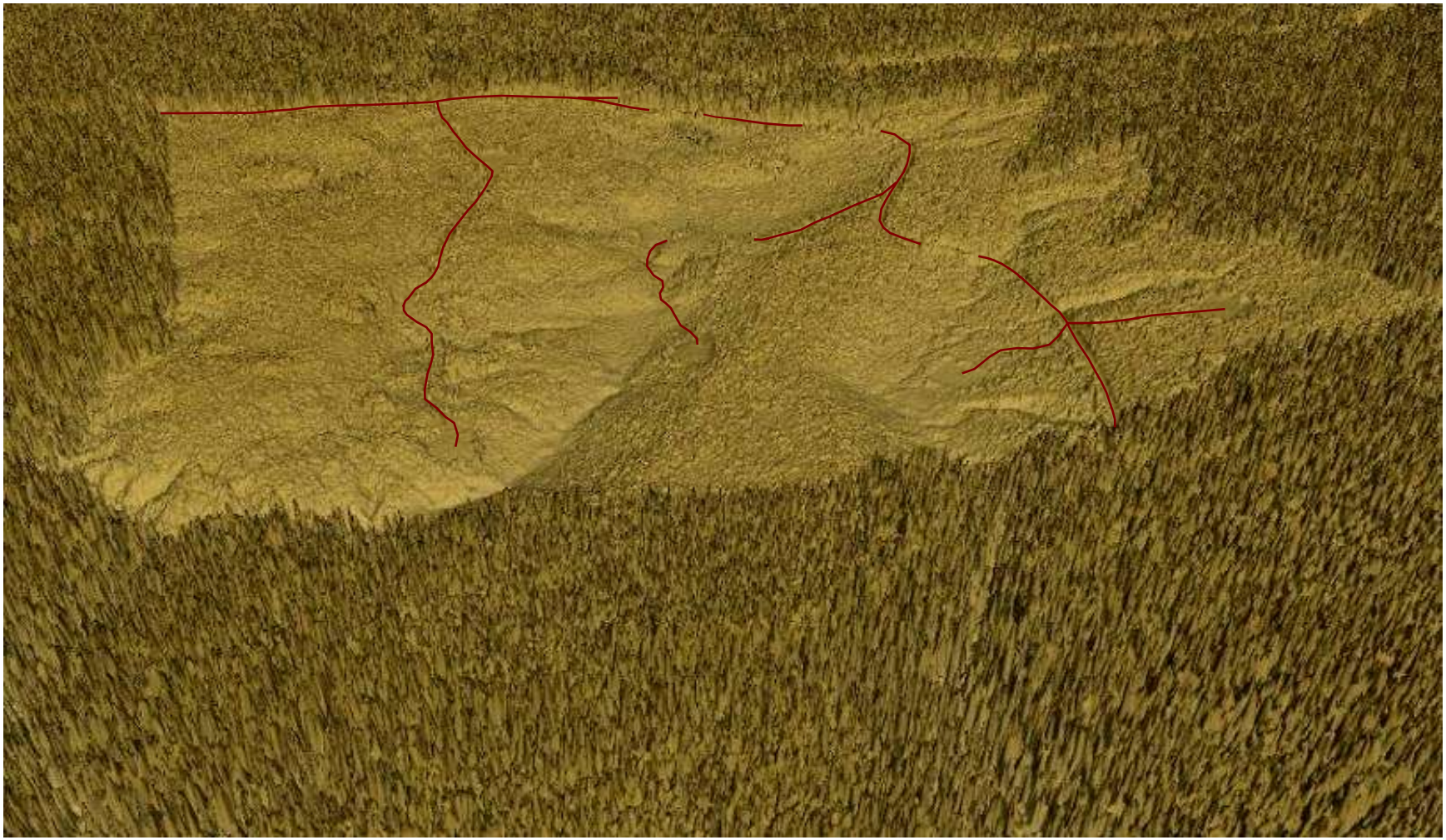
Crown Shape ~ Convex (umbrella)

Crown Footprint ~ 11.55m

UNBC LiDAR datasets include UNBC campus, Aleza Lake RF, JPRF, Ancient Forest

Canopy Surface Model

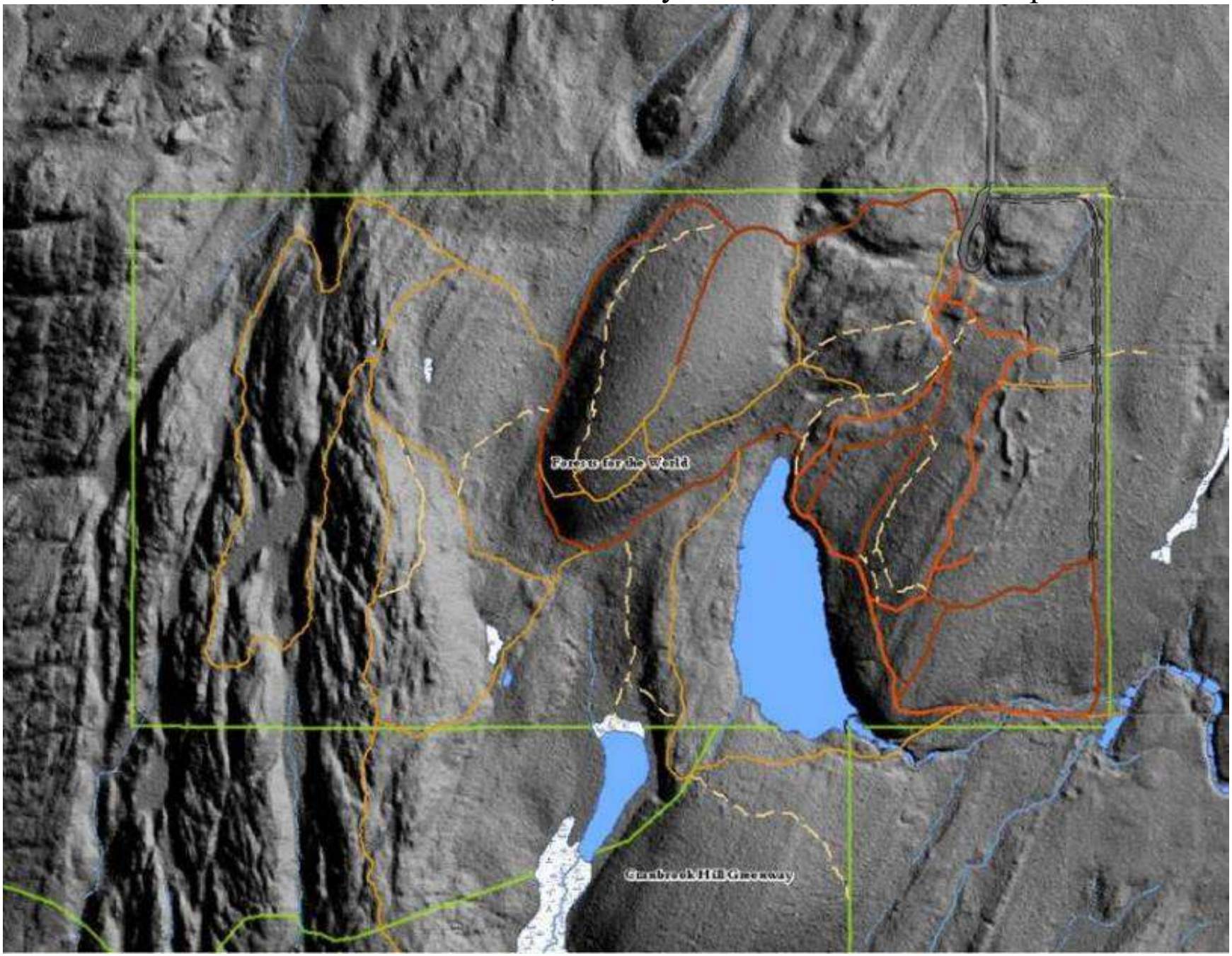
shaded relief draped on DEM, ALRF



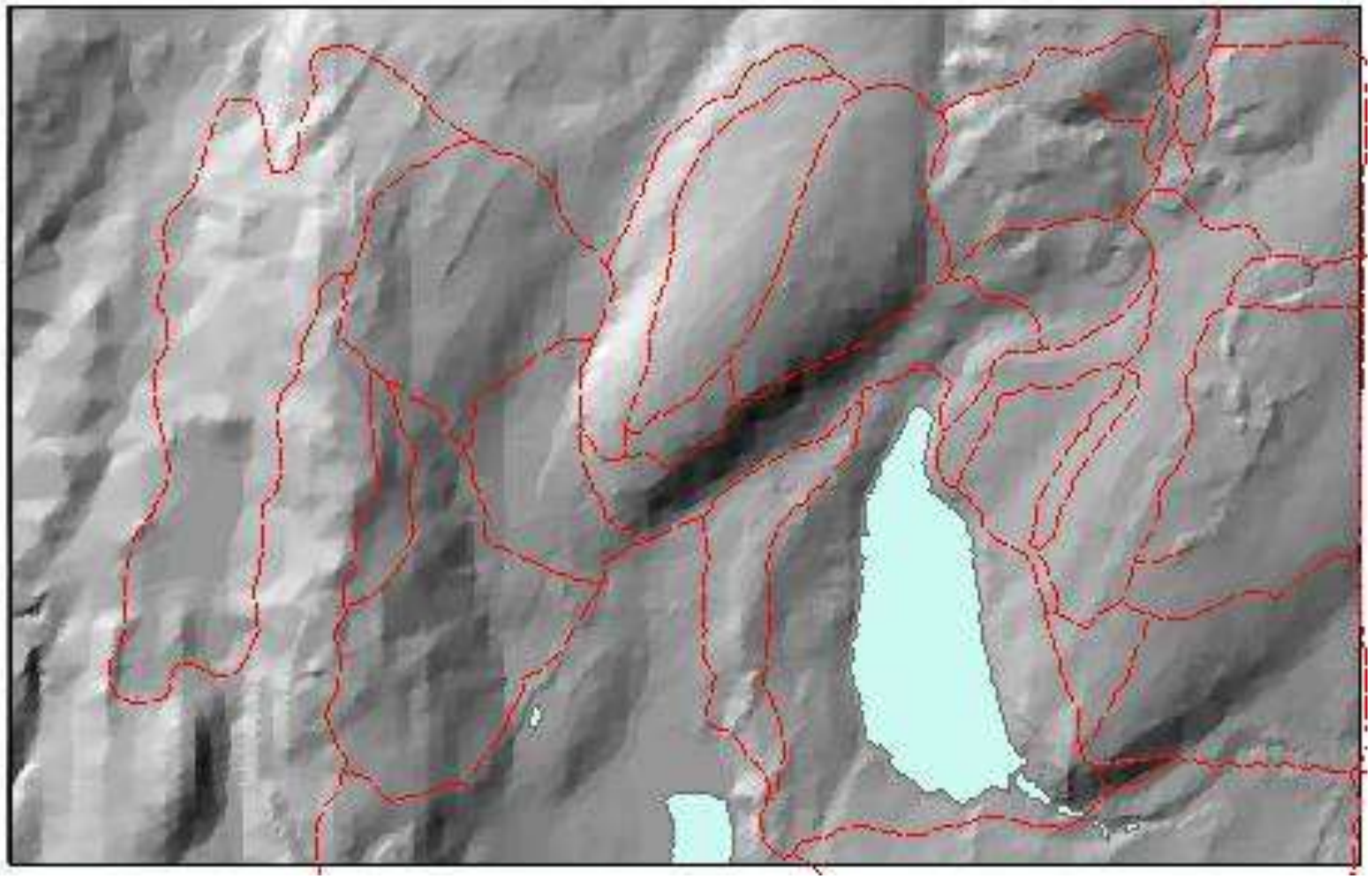
Canopy Height = Canopy Surface – Bare Earth

PG LiDAR: Forests for the World orthophoto

LiDAR Forests for the World, PG city DEM 2009 – see PGMap

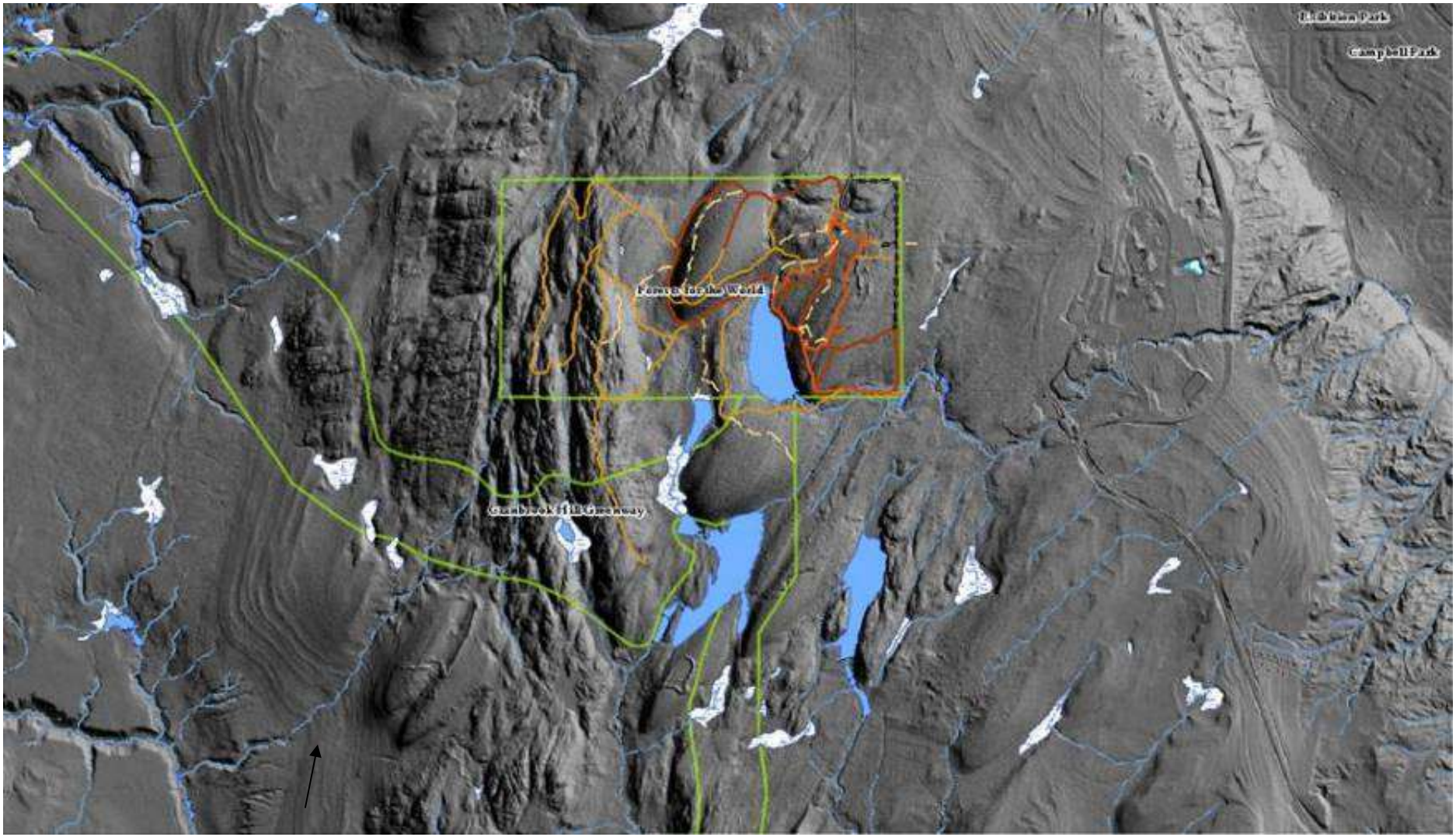


City pre-LiDAR 1 metre DEM (from 1m contours) 2000s



UNBC / Cranbrook Hill LiDAR 2009

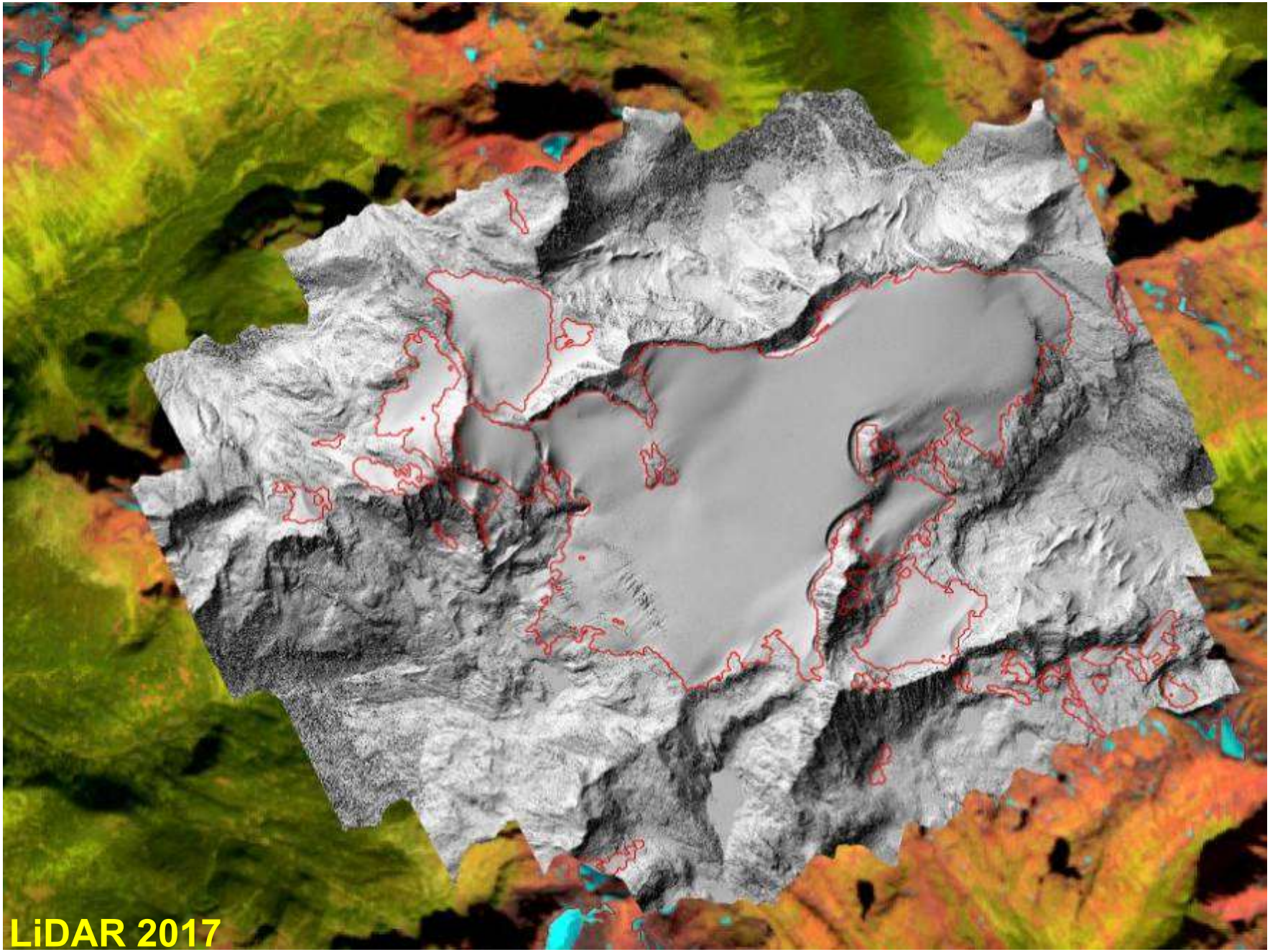
Glacier Lake Fraser
Ice-dammed lake ~10,000BC
Up to 760m= UNBC agora



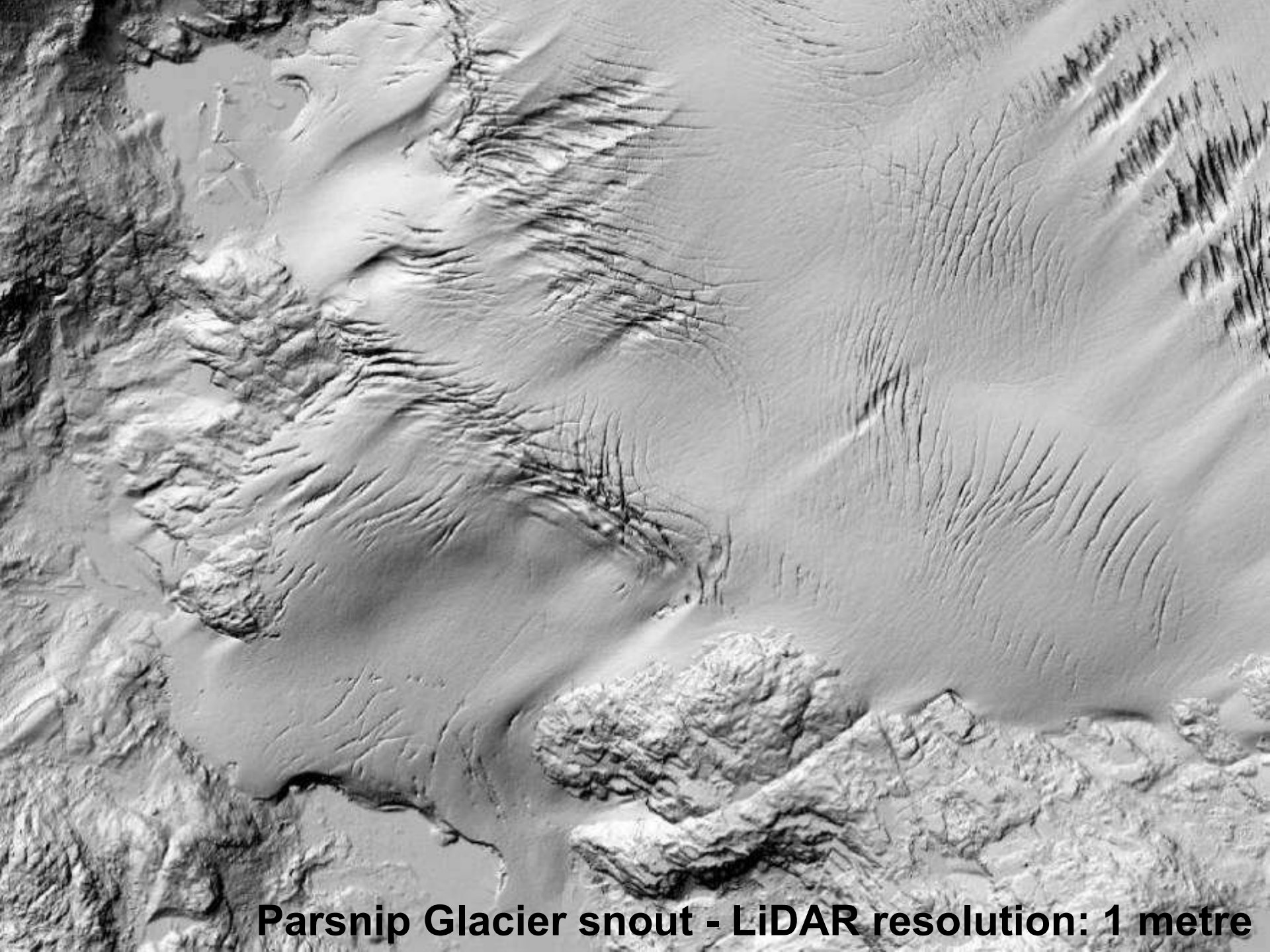
https://pgmap.princegeorge.ca/Html5Viewer/index.html?viewer=PGMap

50cm beach lines

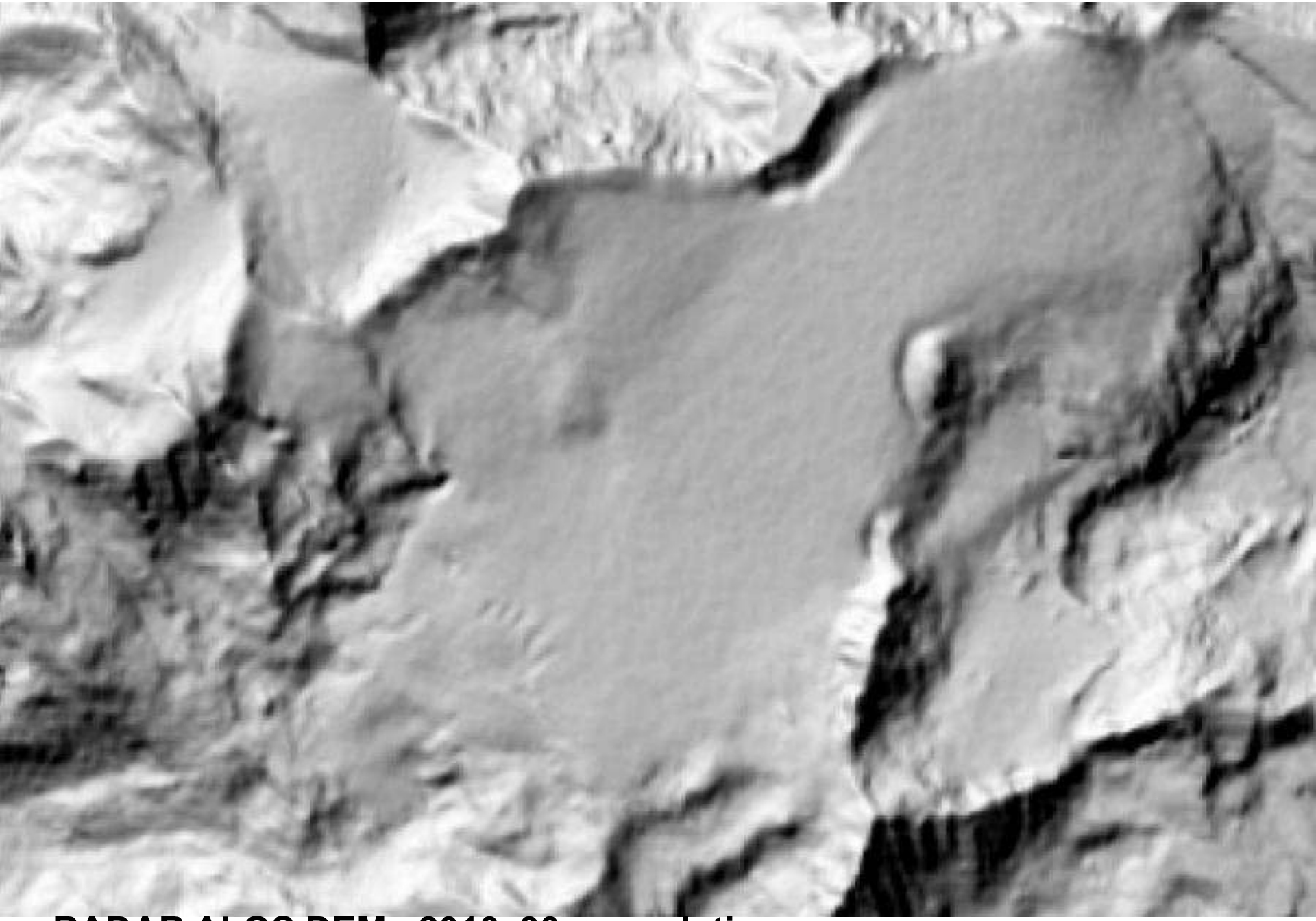
Monkman provincial park: Parsnip Glacier….the closest glacier to PG



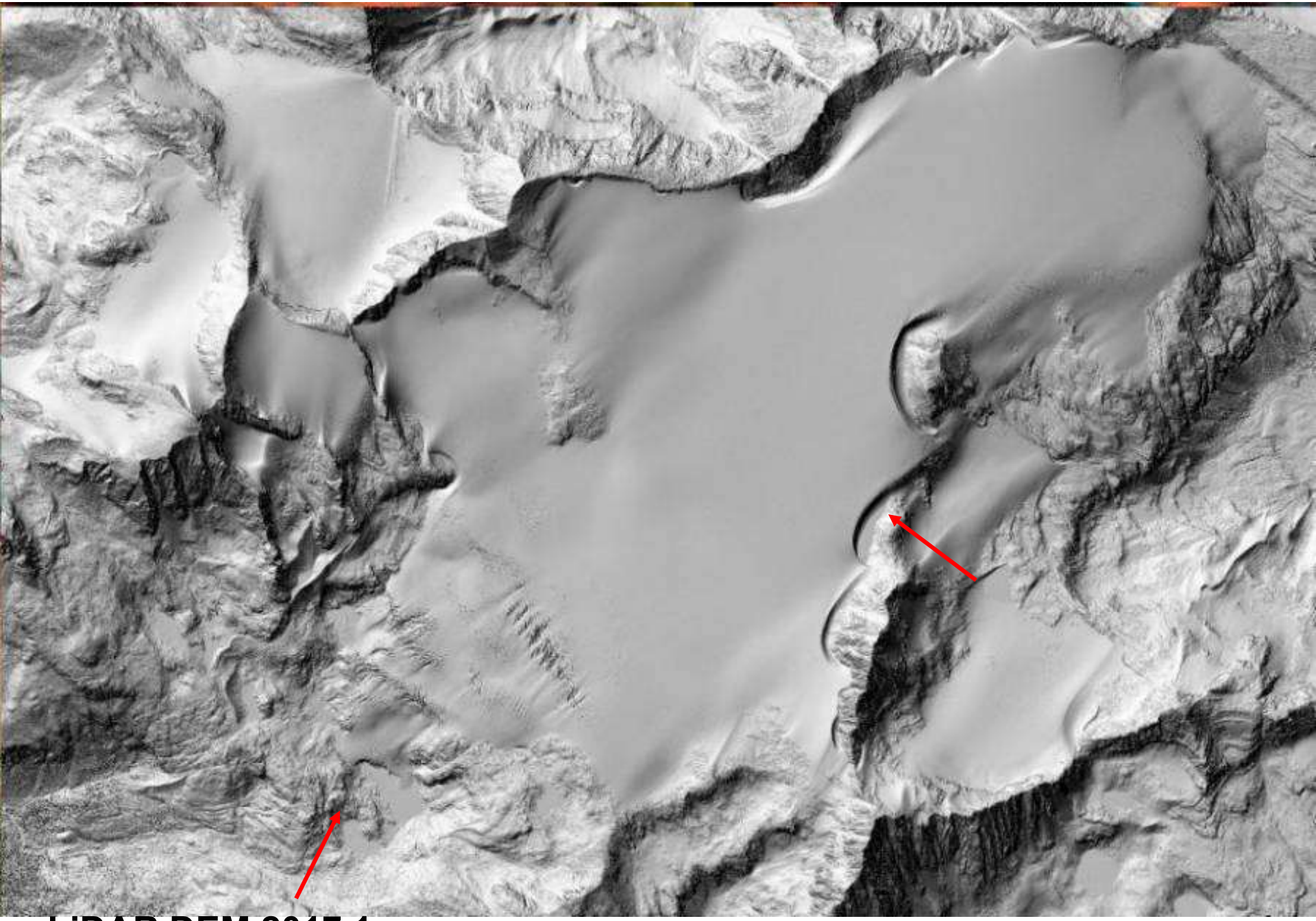
LiDAR data from Dr. Brian Menounos, UNBC



Parsnip Glacier snout - LiDAR resolution: 1 metre



RADAR ALOS DEM ~2010 30m resolution



LiDAR DEM 2017 1m

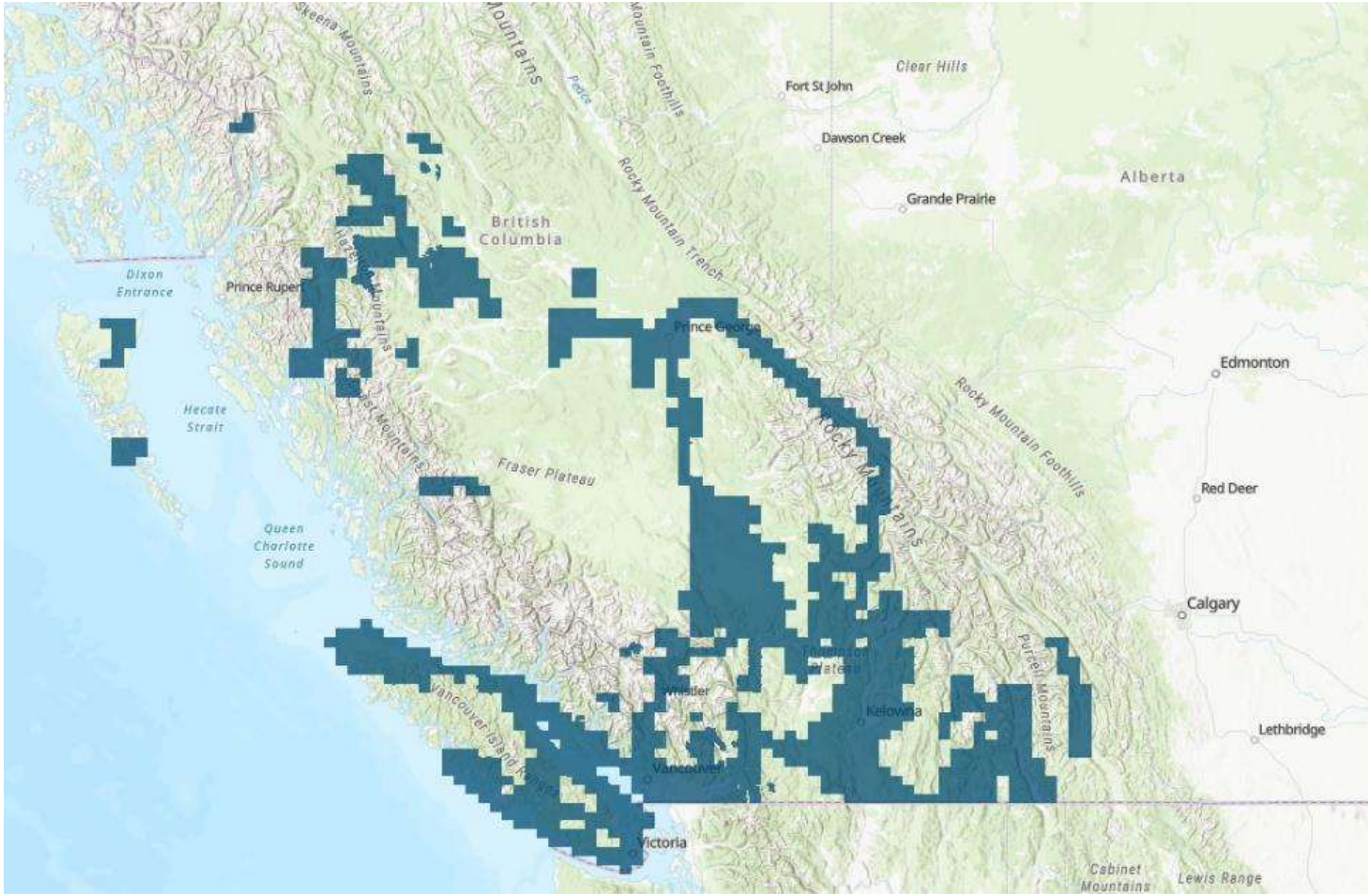
LiDAR summary

Previous drawbacks: (all reducing with technology increase)

- The relative high cost of collecting LiDAR
- High data volume - Terabytes
- Steep learning curve in research and understanding

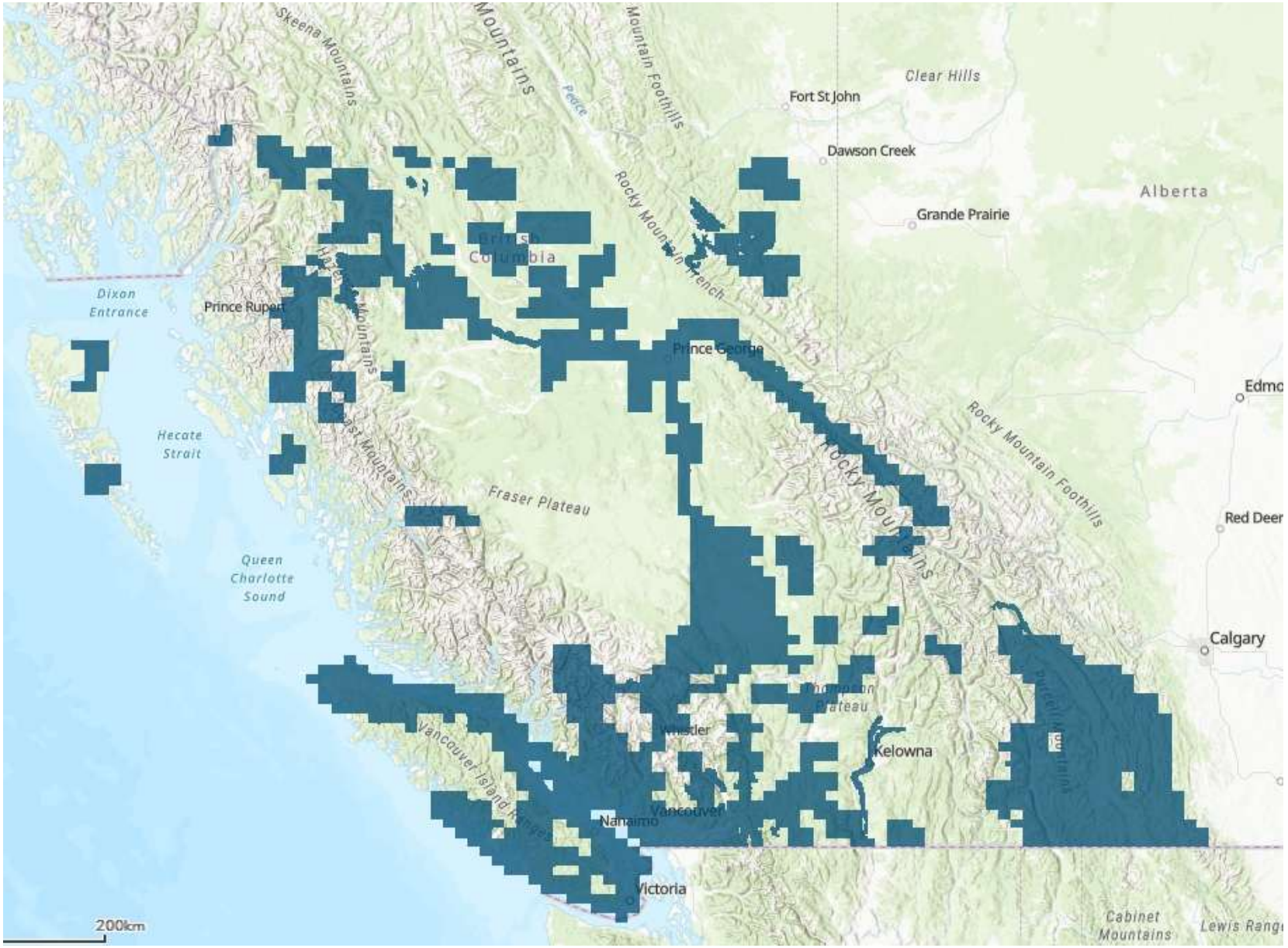
  (involving utilizing the entire point cloud)

LidarBC - Open LiDAR Data Portal - Web Map 2022 (free download)



https://www.arcgis.com/apps/mapviewer/index.html?webmap=c2967cee749b4bdbac5e7c62935ca167

BC LiDAR data portal, 2023



BC LiDAR data portal, 2025

LidarBC Data Availability

Click to filter the map by data availability

Available

Data available for download through the LidarBC data download portal.

- Data collected 2023 onwards
- Data collected prior to 2023

Being Processed

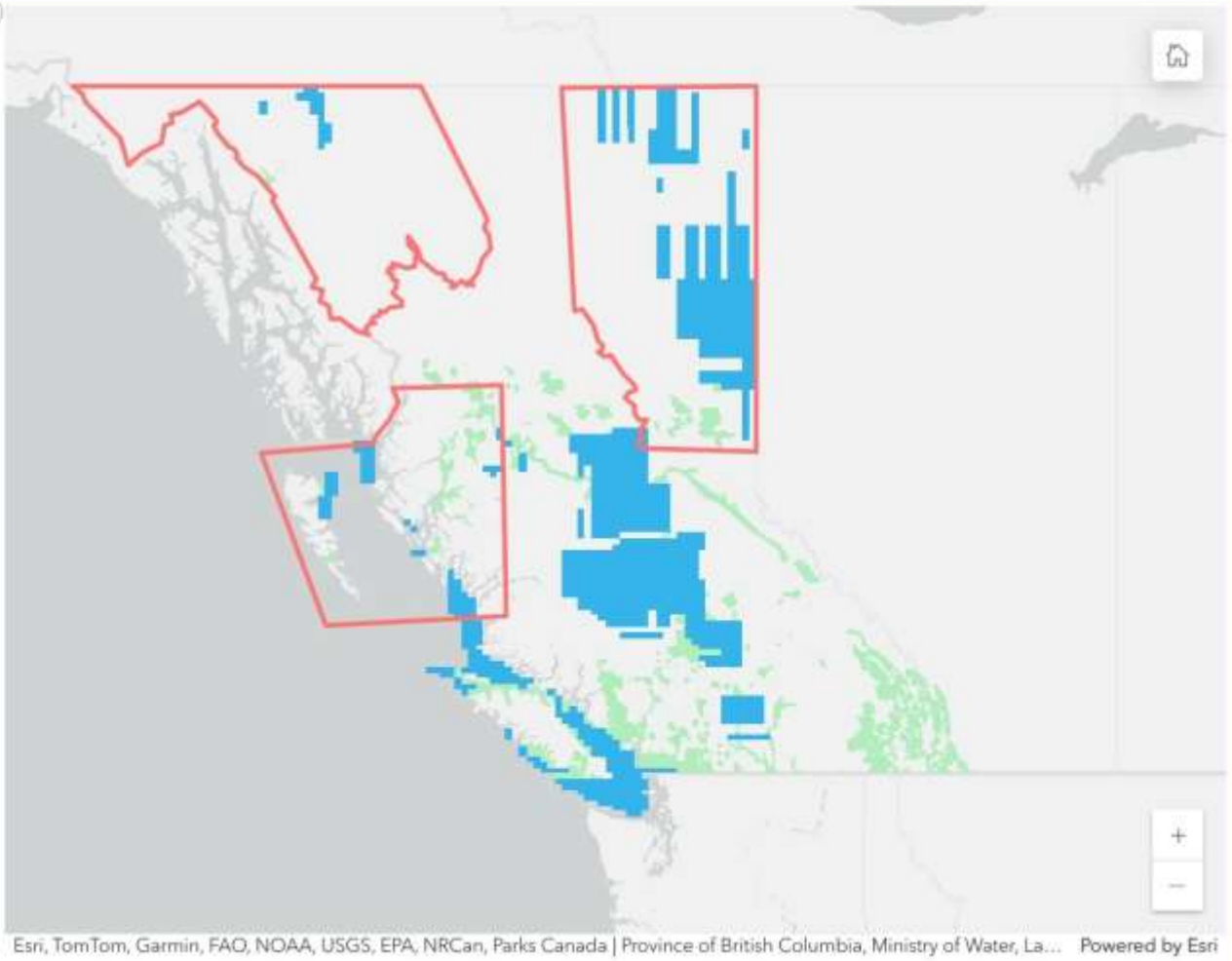
Data being processed for publication.

Actual Acquisition

Data flown and acquired.

Planned Acquisition

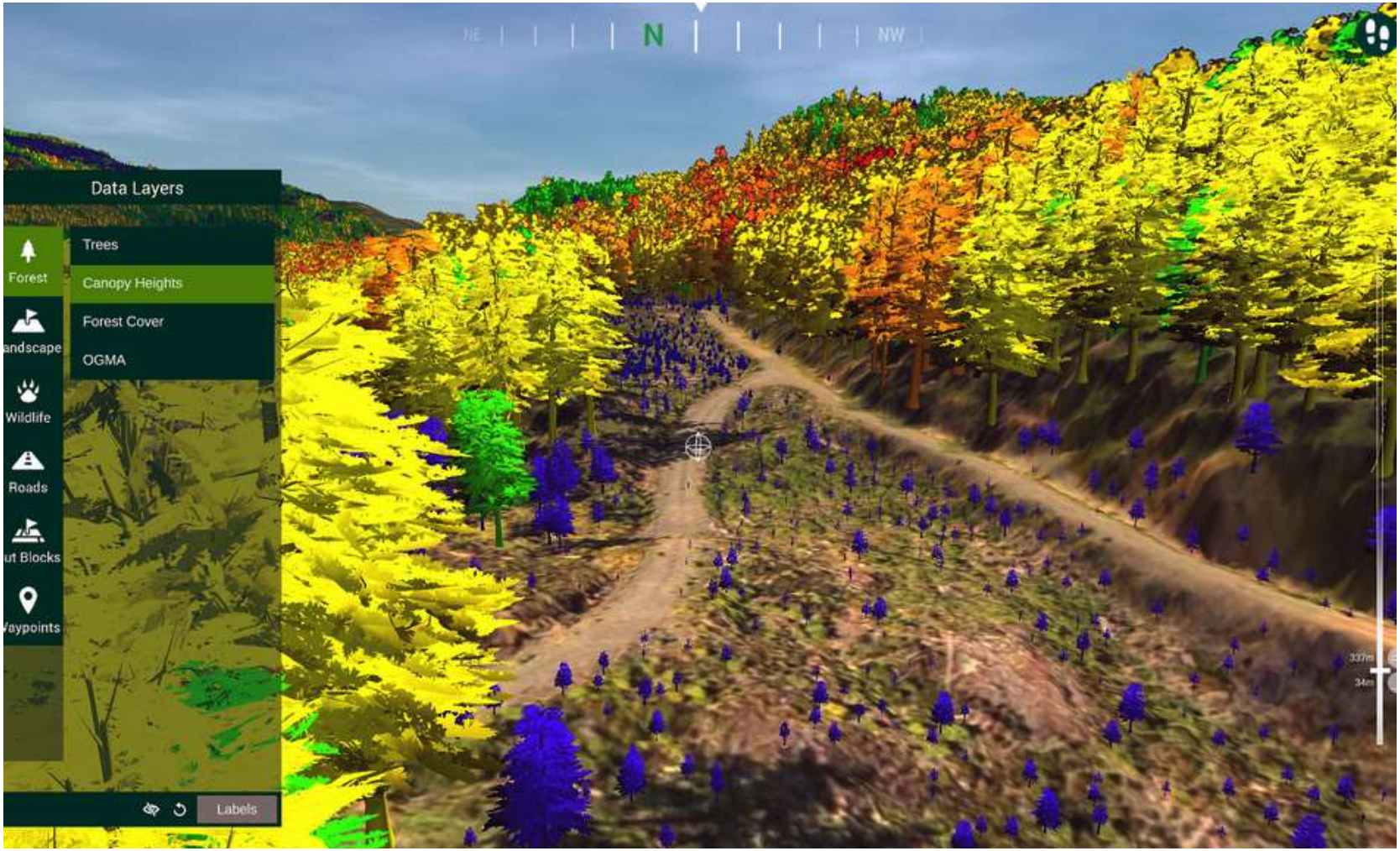
Planned data acquisition areas for 2024.



B.C. announces $38 million aerial mapping project

Entire province will be eventually be surveyed using Light Detection and Ranging (LiDAR) technology - complete by 2030

Ted Clarke Apr 14, 2023 7:07 AM

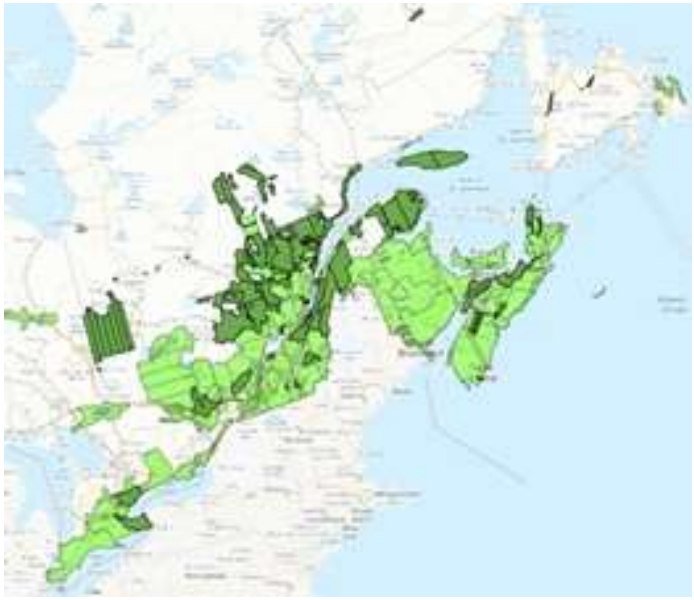


https://www.princegeorgecitizen.com/local-news/bc-announces-38-million-aerial-mapping-project-6853531

Alberta – LiDAR all done, not free

Fish Creek Park, Calgary, DSM -Above
BEM(DTM)- below

Eastern Canada: free download



Ontario
https://geohub.lio.gov.on.ca/pages/ontario-elevation-mapping-program

All provinces
https://canadiangis.com/free-canada-lidar-data.php

LiDAR summary

Advantages:

- ✓ Very high resolution DEM for many applications
- ✓ All urban areas with flooding potential
- ✓ Multi-layer data for forestry and ecosystems
- ✓ Increasing data supply – some free download e.g. PEI, NS, NB, BC
- ✓ Increasing conference content in GIS/RS/Cartography/Forestry
- ✓ Many online resources

LiDAR Platforms

Airborne since 1970s e.g. Optech (Ottawa) NorthWest Geo (Calgary)

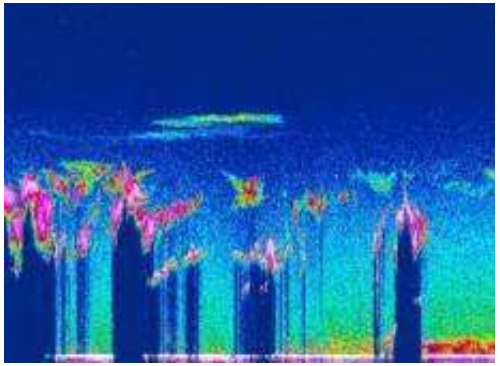
And many many others … including UNBC (Brian Menounos)
- LiDAR is mostly airborne, while RADAR is mostly spaceborne

Spaceborne

ICESat (Jan 2003->2009): Geoscience Laser Altimeter System (GLAS):

66m 'footprint' and 10cm vertical resolution, designed for polar icecaps

ICESat2 (Sept 2018): https://icesat-2.gsfc.nasa.gov



CALIPSO:
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
https://calipso.cnes.fr/en/CALIPSO/lidar.htm

Ground based – 'terrestrial' Lidar

Lidar-based rockfall hazard characterization of cliffs

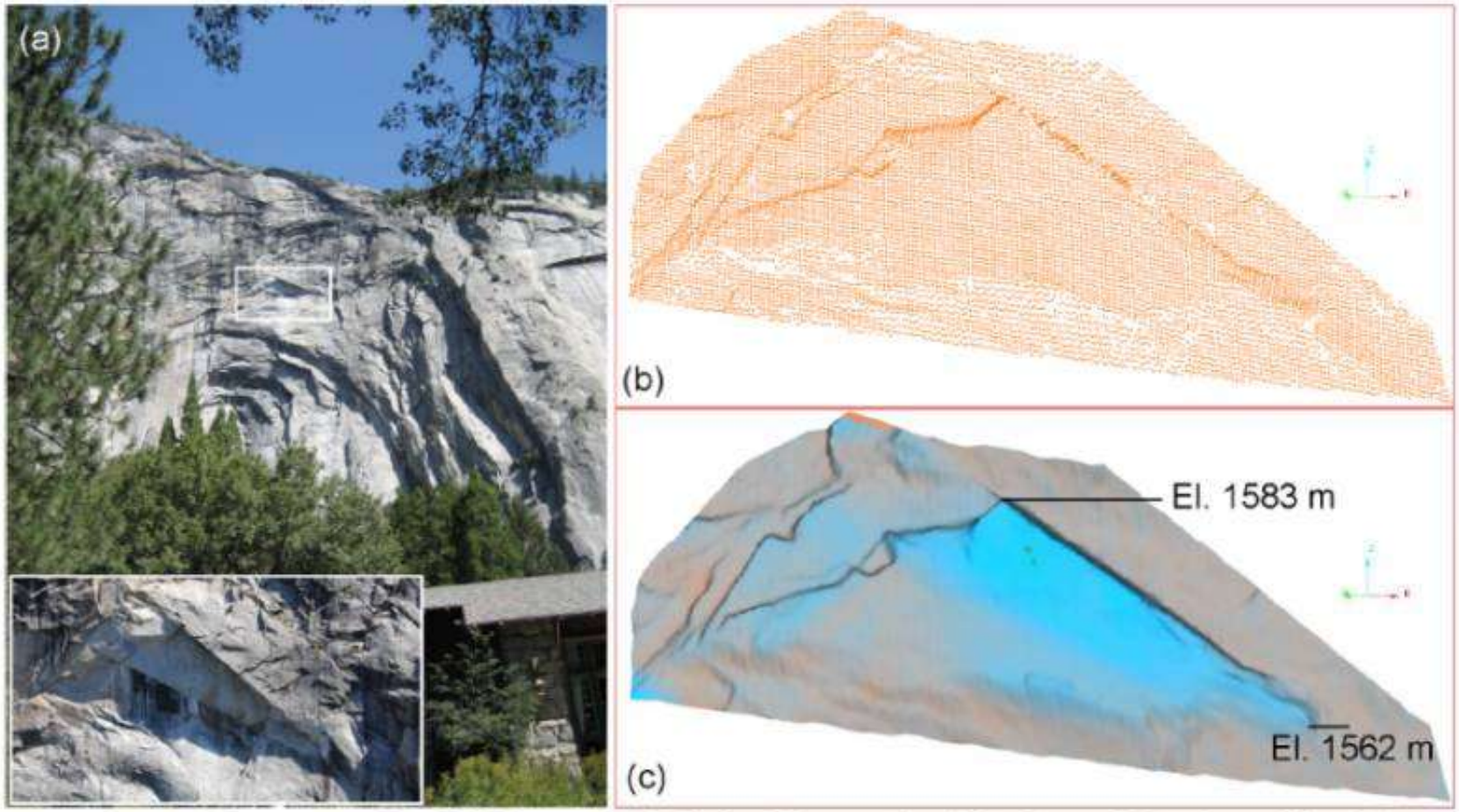


Figure 1. (a) Image of a 2009 rock-fall in Yosemite National Park with (b) point cloud and (c) surface model of the source area. Brightest-blue colored areas of surface model in (c) indicate areas of change following the rock fall.

http://www.nps.gov/yose/naturescience/upload/Collins-Stock-2012-ASCE.pdf

LiDAR imagery of Gaping Gill - Britain's largest cavern

http://www.eepublishers.co.za/images/upload/PositionIT-pages%2029-32.pdf

Fig. 1: Gaping Gill Main Chamber LIDAR survey 2003. Vertex cloud looking west.

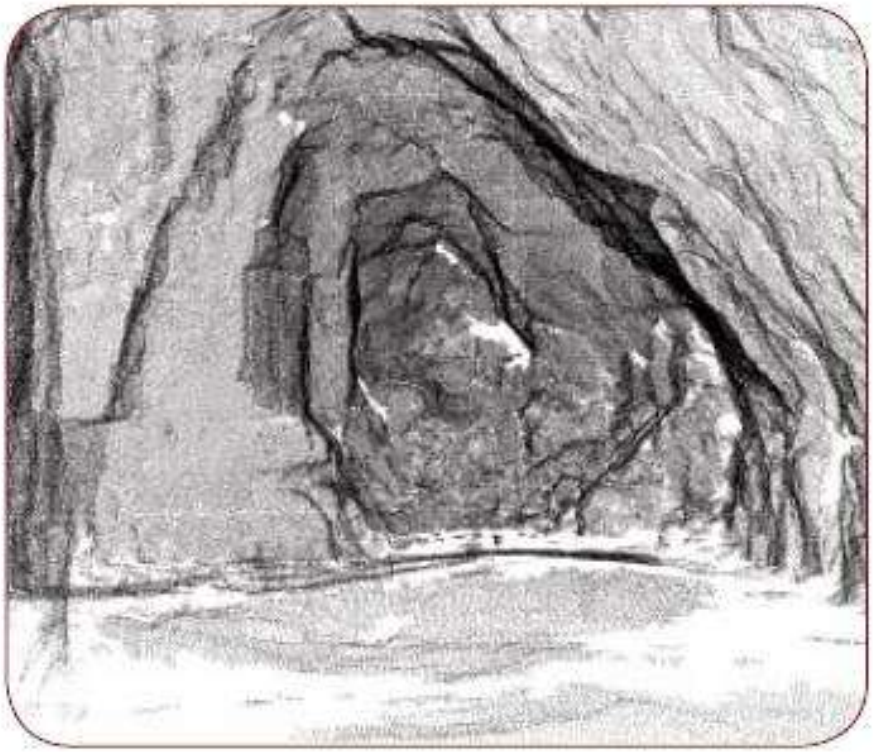


Fig. 2: Gaping Gill Main Chamber LIDAR survey 2003. Vertex cloud looking east.

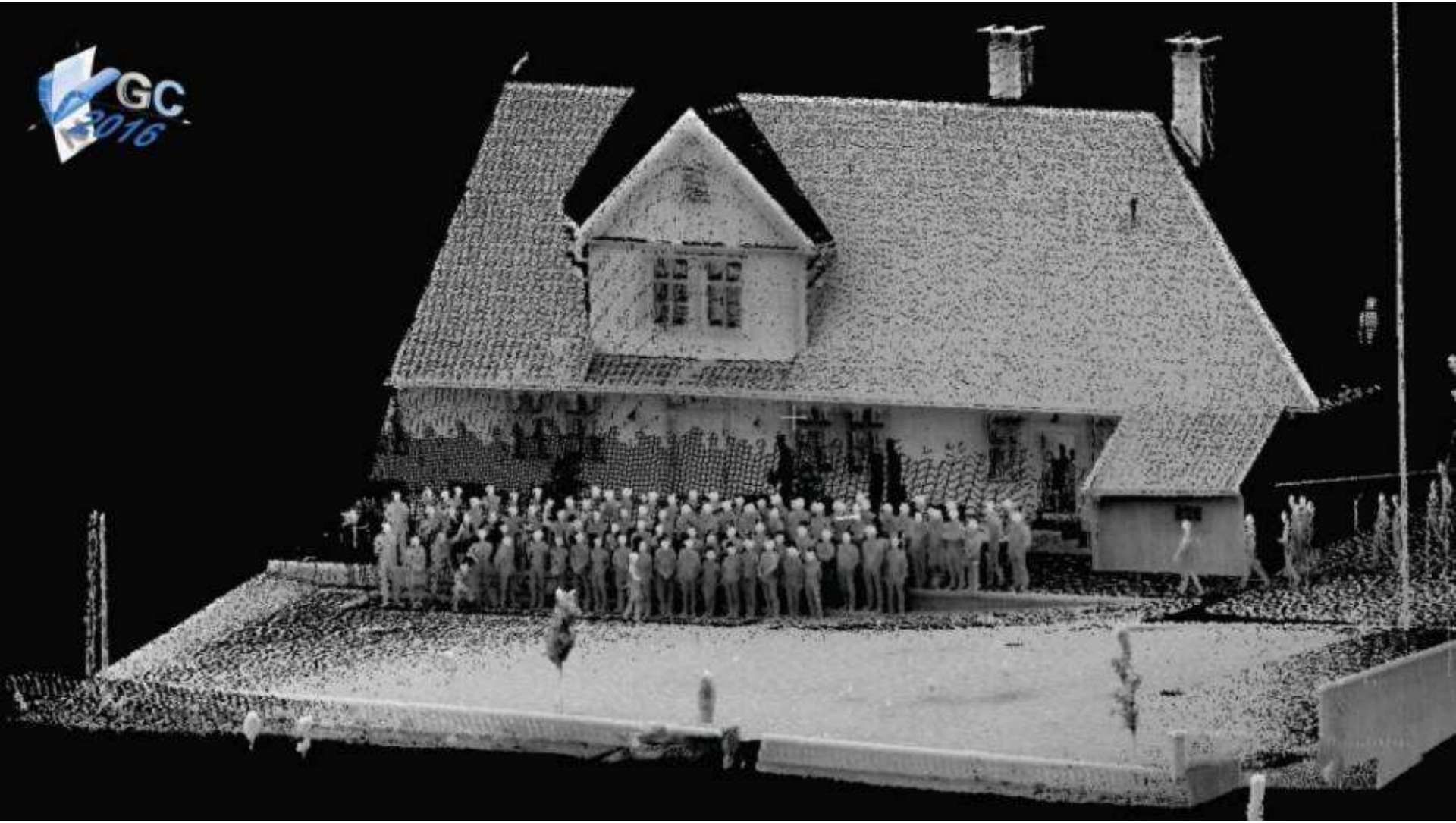
Video: http://www.youtube.com/watch?v=8HdgliagAds

Heritage building scanning: http://www.youtube.com/watch?v=4AGk01Ims5k

- **building information modeling (BIM)**

Conference group photo
(RW in red jacket, front centre)
LiDAR scanning unit ----→

The same Conference group LiDAR scan image -RW just in front of walking person



Stonehenge mapping: Archaeology LiDAR

Stonehenge map https://www.archiuk.com/cgi-bin/build_lidar_map.pl?map_location=Stonehenge&point_title=Neolithic%20site%20of%20Stonehenge%2C%20Wiltshire&ngr=&is_sub=&pwd=&point_lat=51.179420&point_long=-1.826809

Stonehenge3D: https://sketchfab.com/3d-models/stonehenge-lidar-archaeology-landscape-c15c247d4e6c462ca48b5276492c1b7c

Flight: https://www.wessexarch.co.uk/our-work/explore-stonehenge-landscape