LiDAR = **Light Detection And Ranging** ...also known as LASER altimetry

An increasingly common form of **active** remote sensing

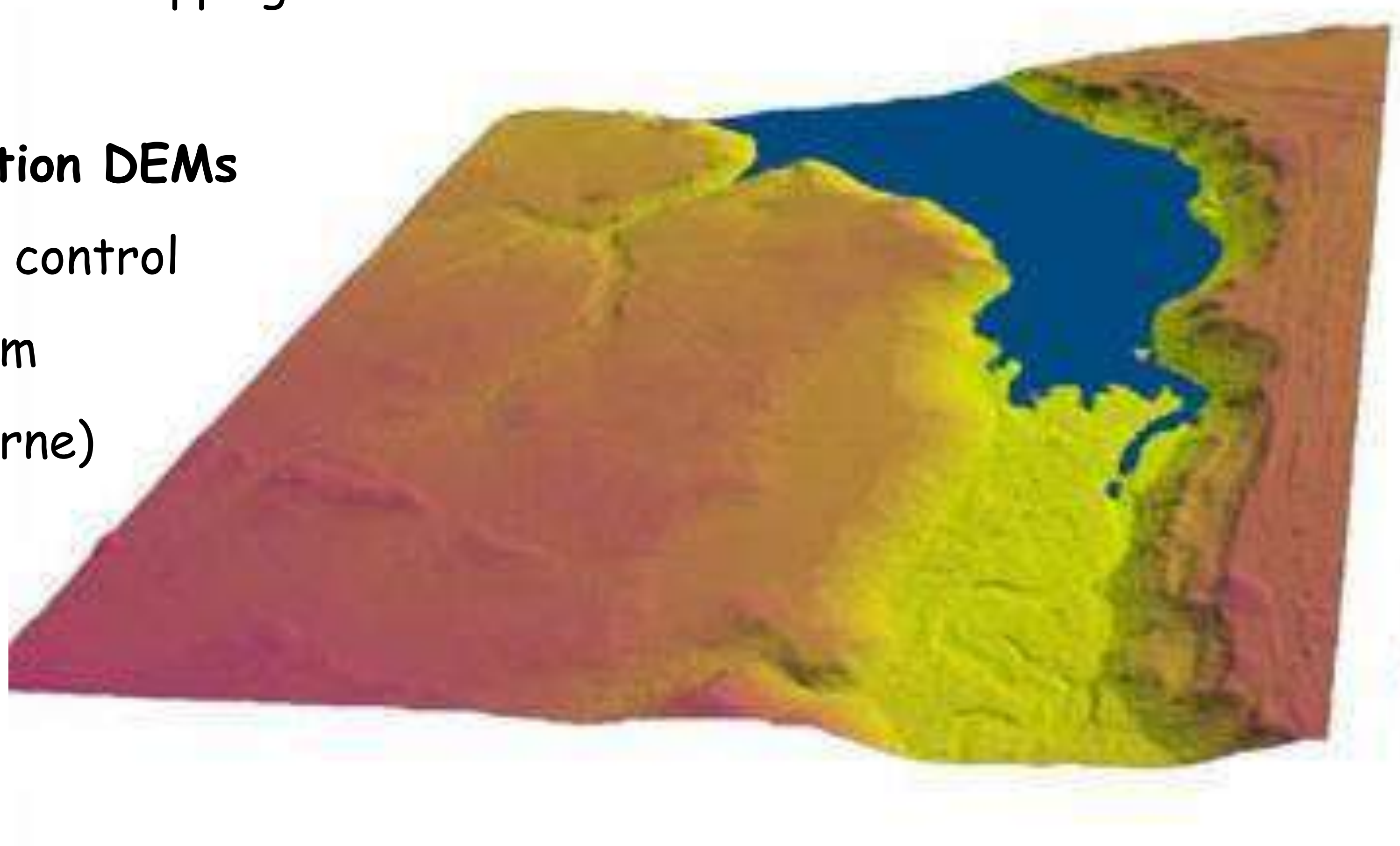
Objects reflect more in UV/visible/NIR (than radar microwaves) = higher resolution mapping

- **high resolution DEMs**

e.g. for flood control

~1 foot or <1 m

(mostly airborne)



What is LiDAR ?

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

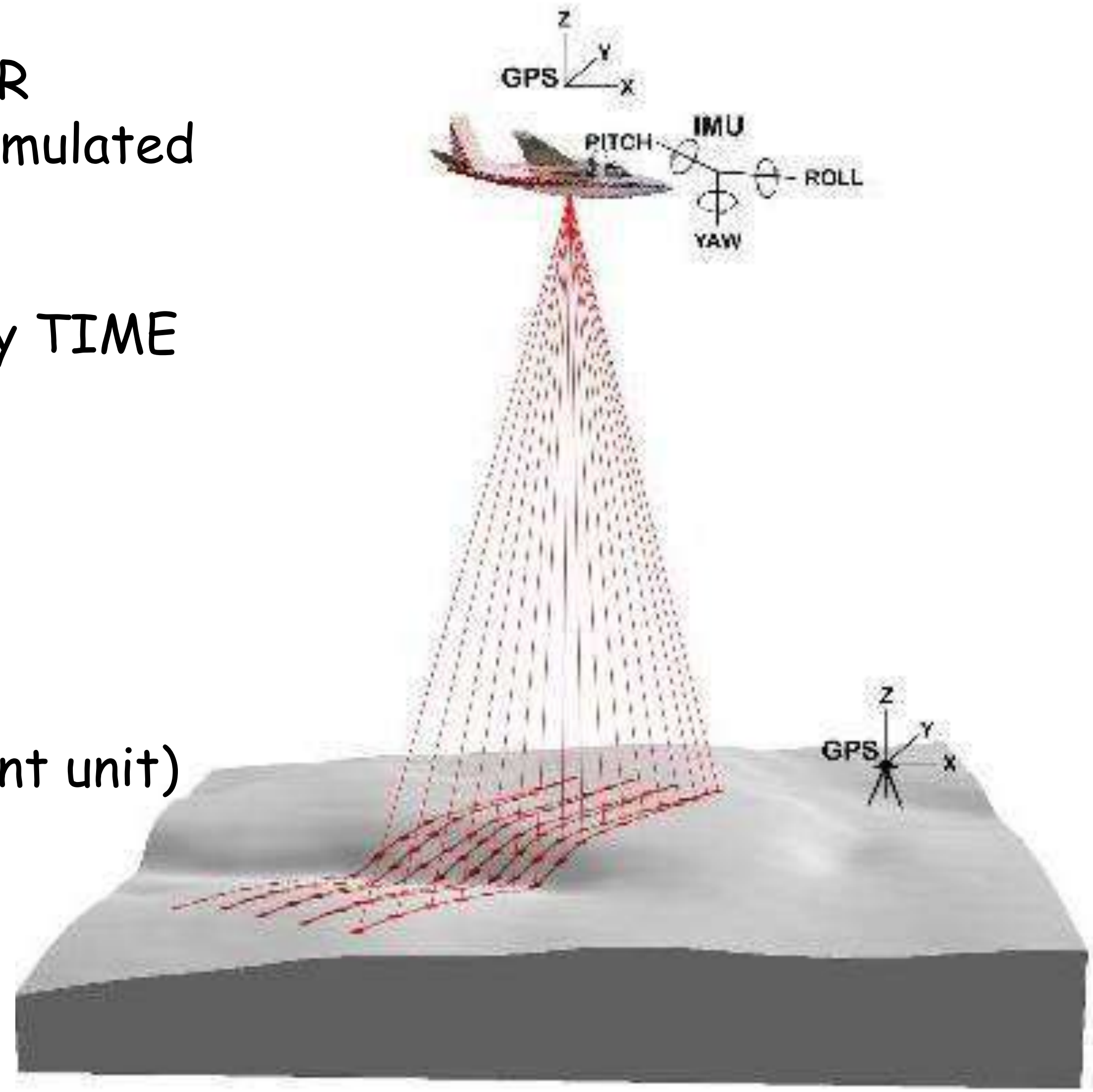
Distance to object given by TIME

-**requires 3 units:**

-laser emitter/receiver,

-GPS,

-IMU (Inertial measurement unit)



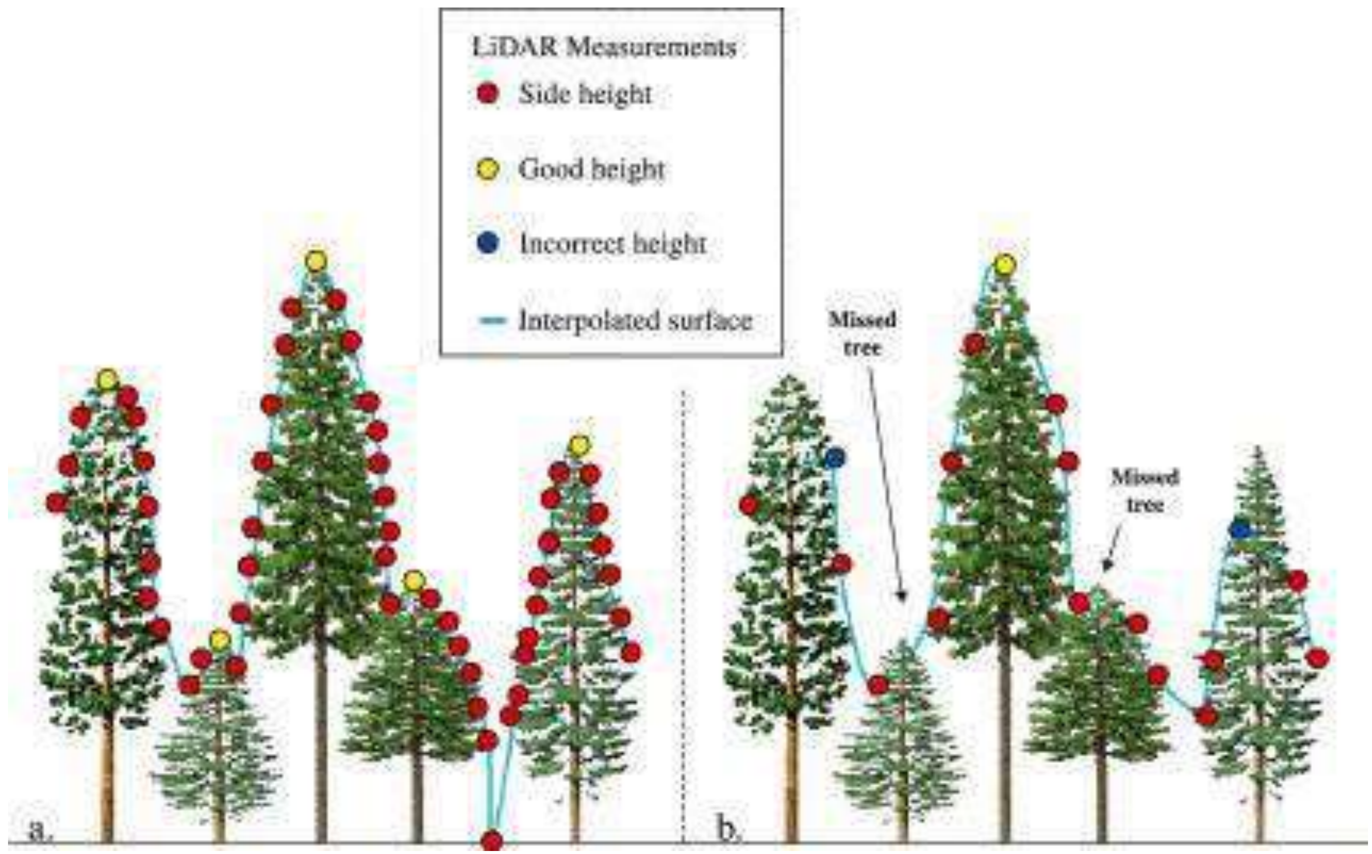
Laser pulses at up to 50,000 - 200,000 / second

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

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

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

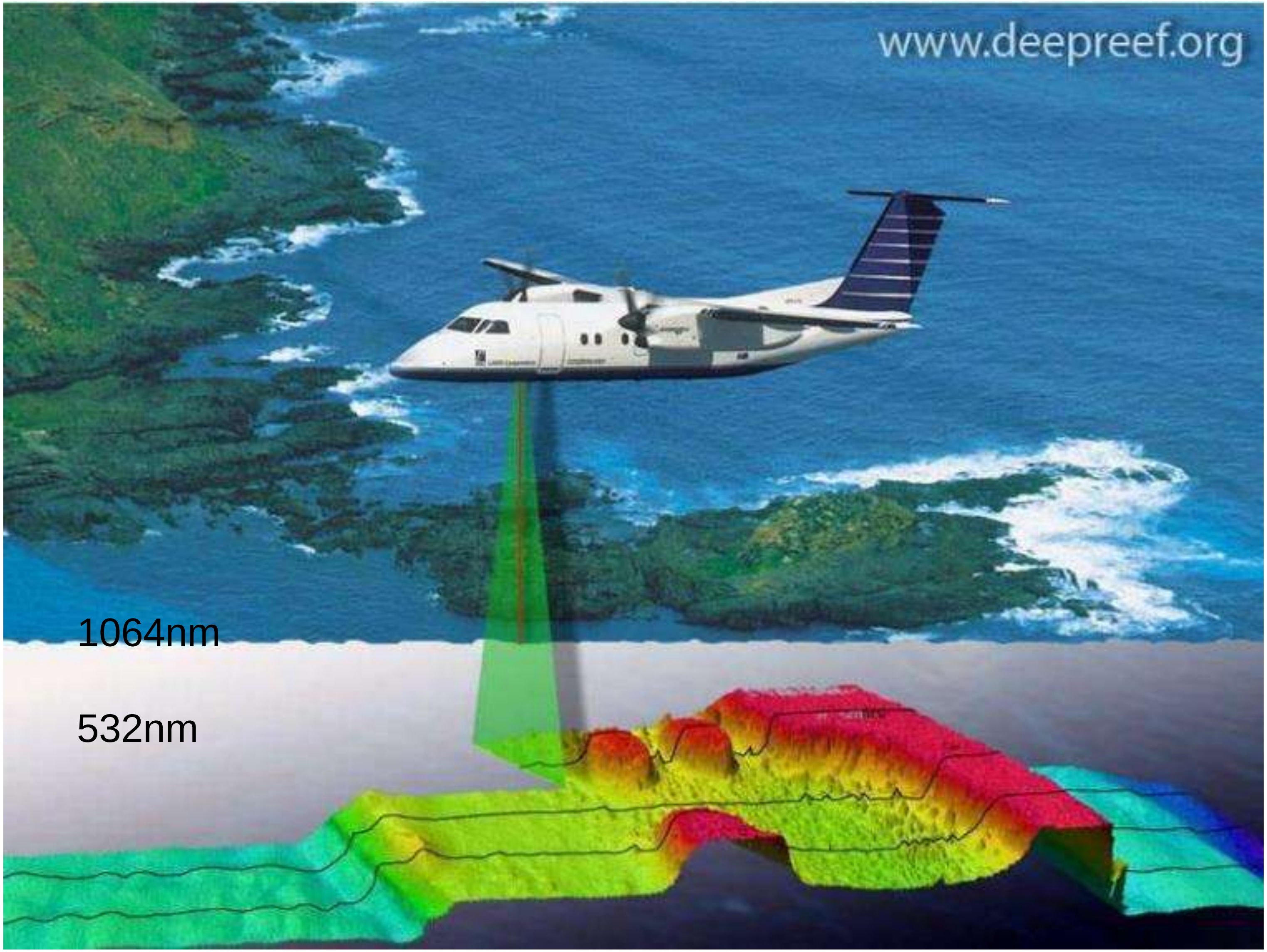
Cloud of points is converted to raster grid ~1metre



Related technologies:

SONAR: SOund NAvigation and Ranging : sound propagation for communication/ navigation

SODAR: SOnic Detection And Ranging : sound propagation upwards (atmospheric)



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

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.

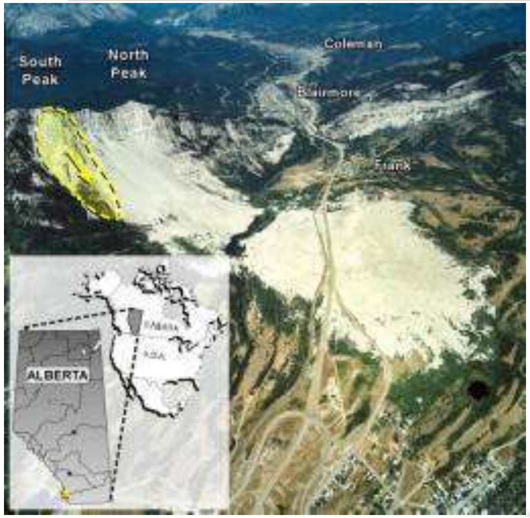
According to the Planck-Einstein equation:

$$E = \frac{hc}{\lambda}.$$

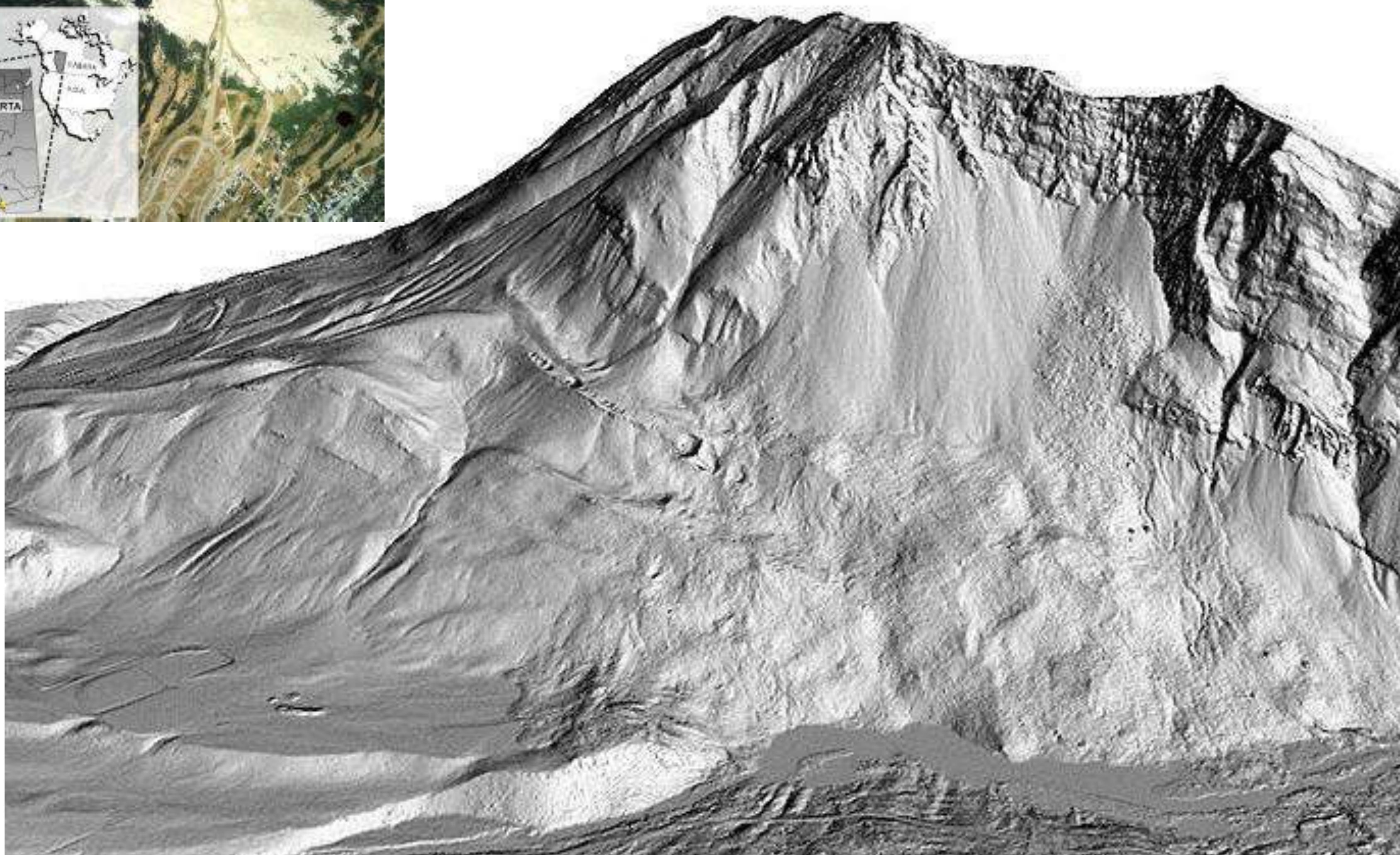
Where h= Planck's constant, and c = the speed of light;
halving the wavelength, has the effect of doubling the energy released, and one-third the wavelength (355) triples the energy (= the second and third harmonics)

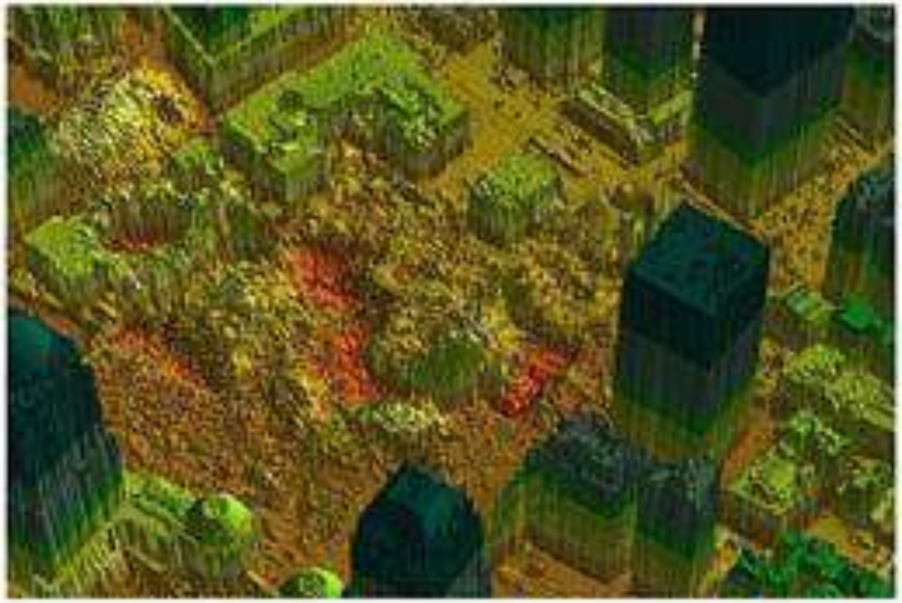
Solved by Patrick Daley, (Fall 2009) – wins a 6-pack of Guinness

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



Turtle Mountain, AB (Frank slide, 1903)



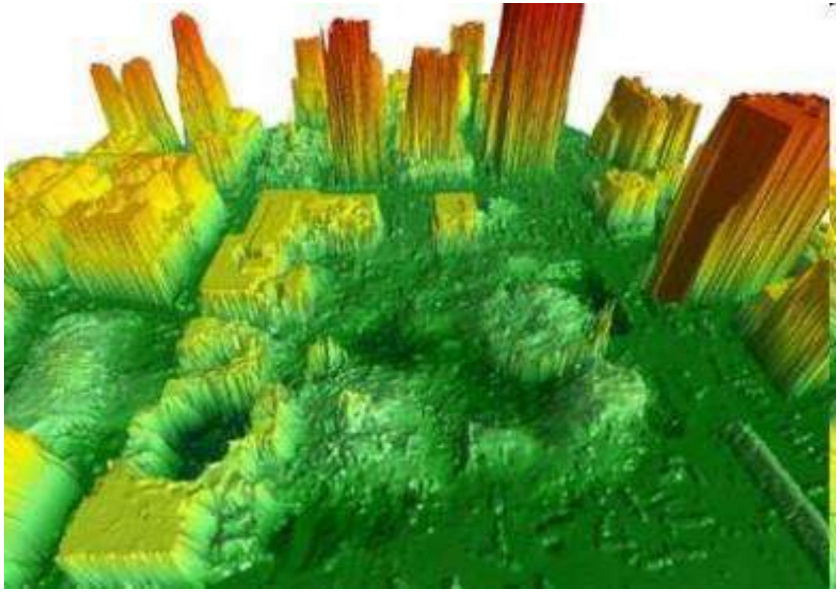


Volume estimation:

Ground Zero, World Trade Centre site, New York

Post September 2001

http://www.volker-goebel.de/Lidar.html

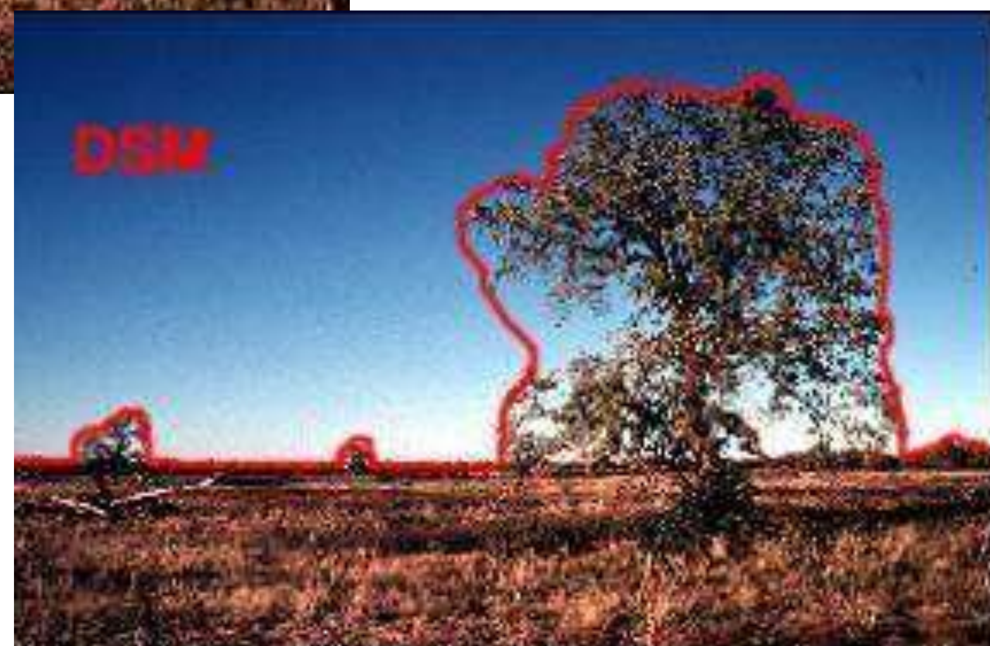


Repeat slide from DEMs

Digital Terrain Models

- Photogrammetric

  (and LiDAR)



Digital Surface Models

- Spaceborne

  (and LiDAR)

Vegetation: Tree Canopy Height

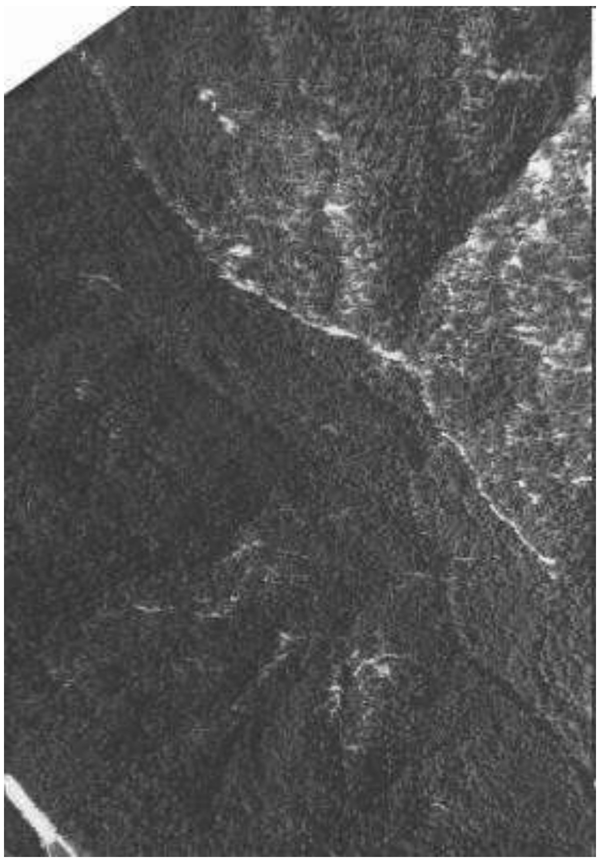
http://quake.wr.usgs.gov/research/geology/lidar/example2.html

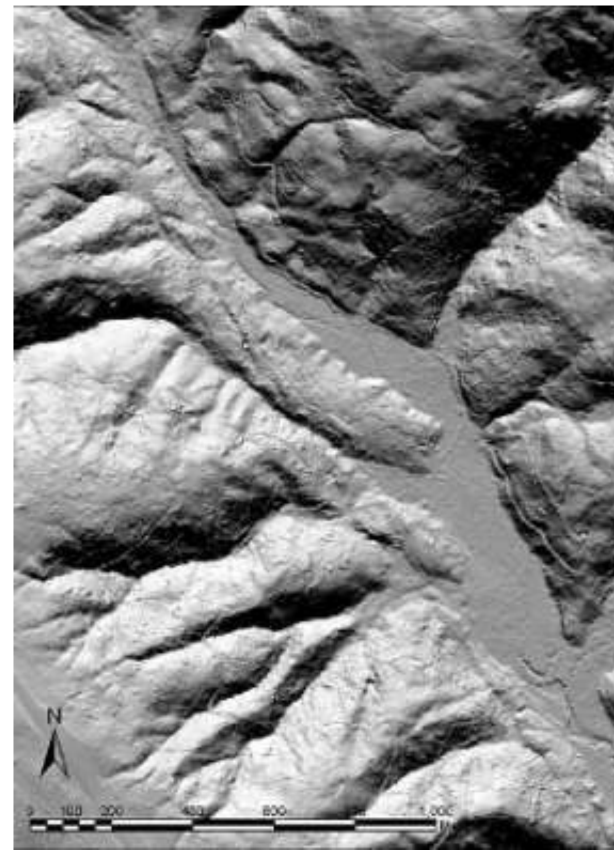
Air photo

Vegetation surface DSM

Bald Earth Model (BEM/ BEDEM)

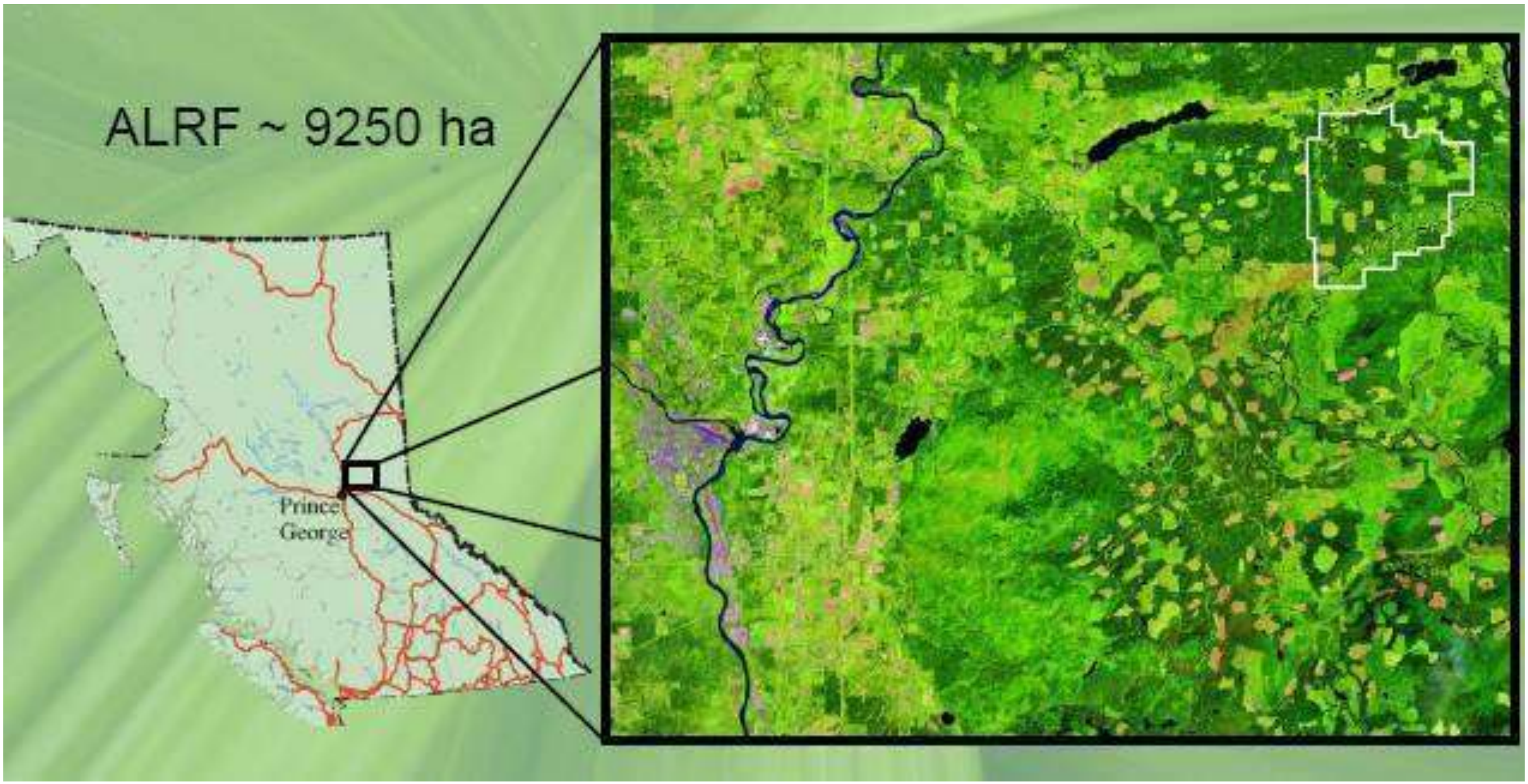
Vegetation height = DSM minus BEM



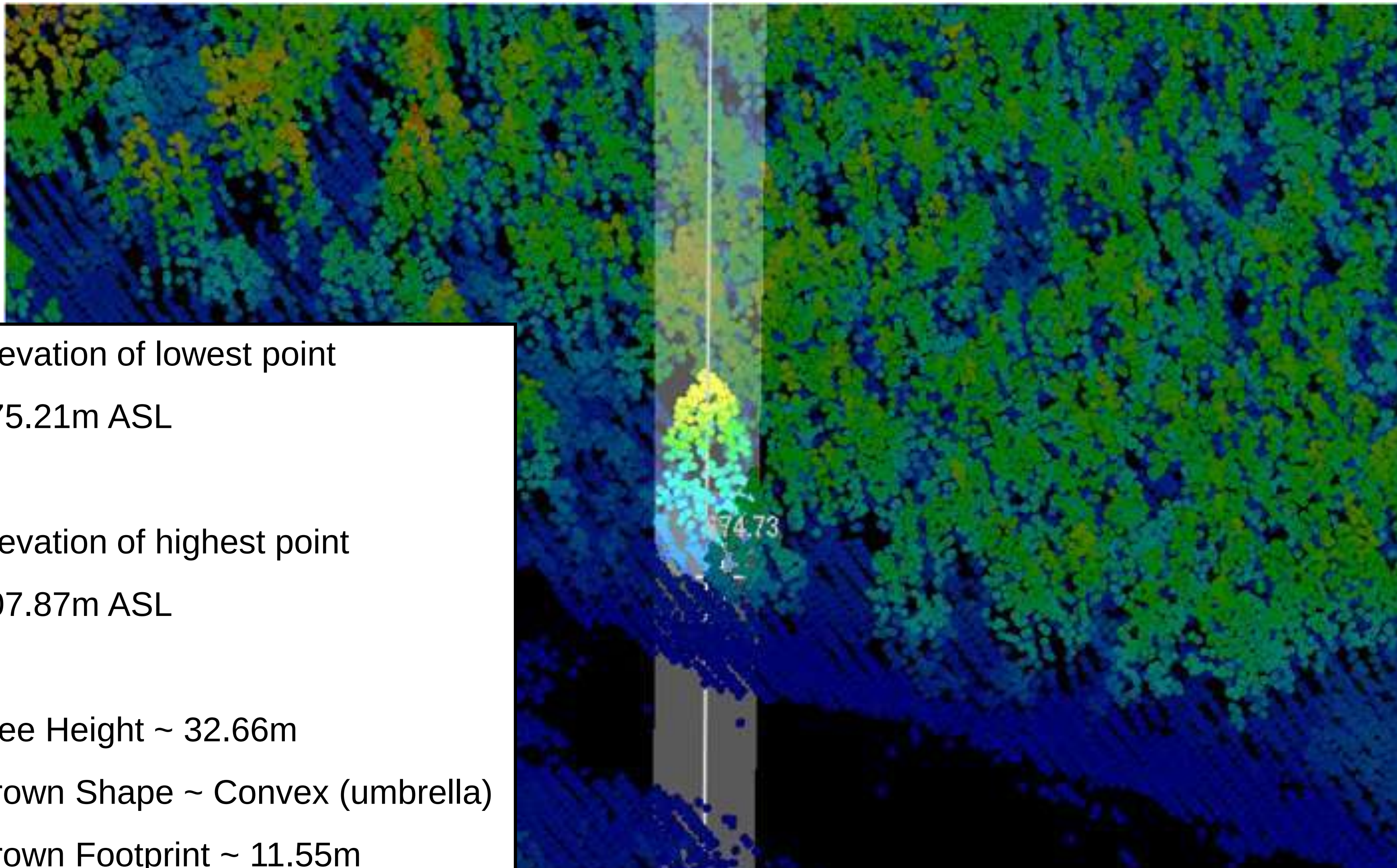


Aleza Lake Research Forest

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



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



Elevation of lowest point

675.21m ASL

Elevation of highest point

707.87m ASL

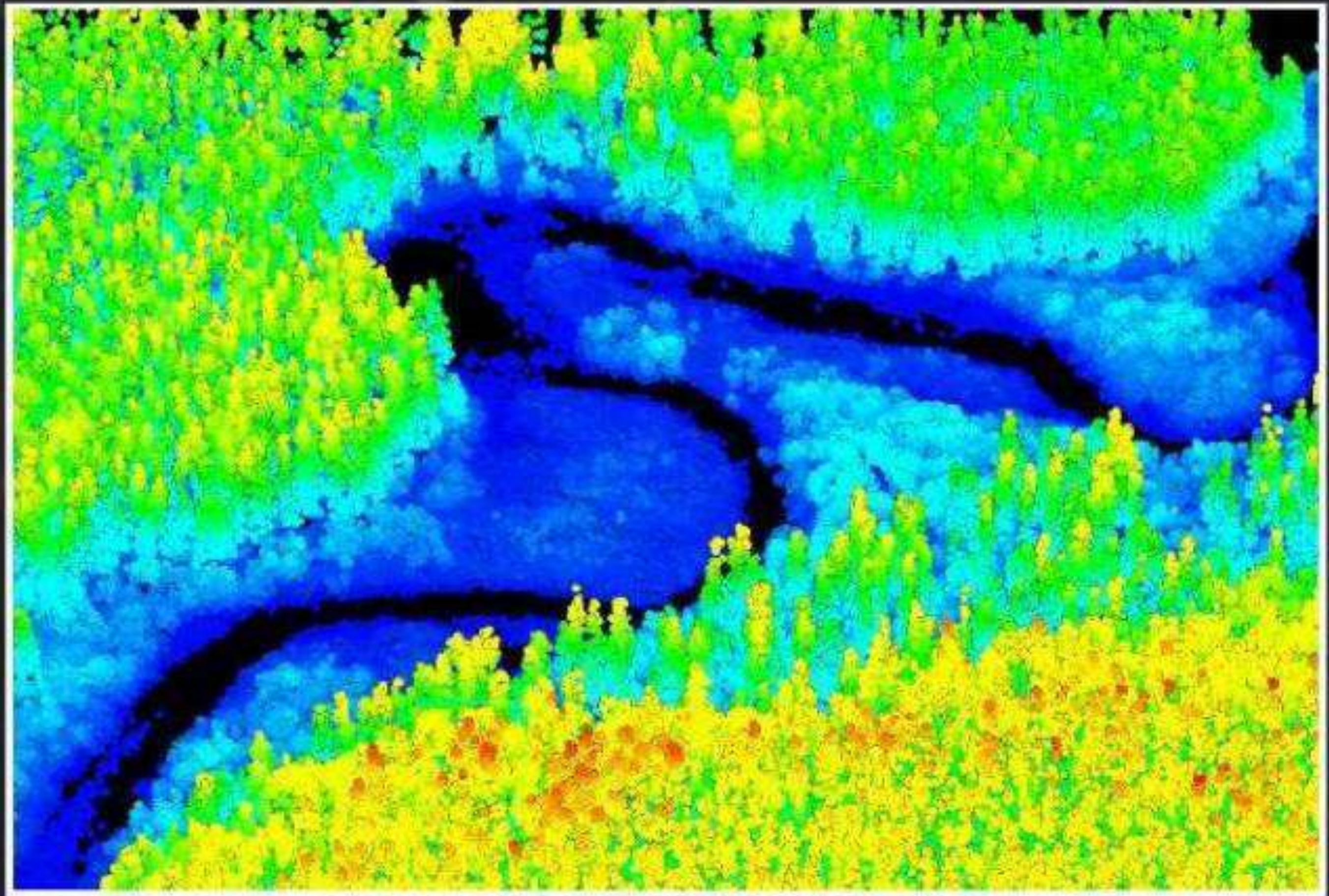
Tree Height ~ 32.66m

Crown Shape ~ Convex (umbrella)

Crown Footprint ~ 11.55m

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

Mass Points



500m x 500m ~ 1,000,000 points

LiDAR Data Products

Mass points detailing elevation can be converted into:

- Bare Earth Model (BEM)
- Slope, Aspect, and Hillshade models
- Canopy Surface Model

Numerical models can be built to estimate:

- Species, volume, dbh, biomass

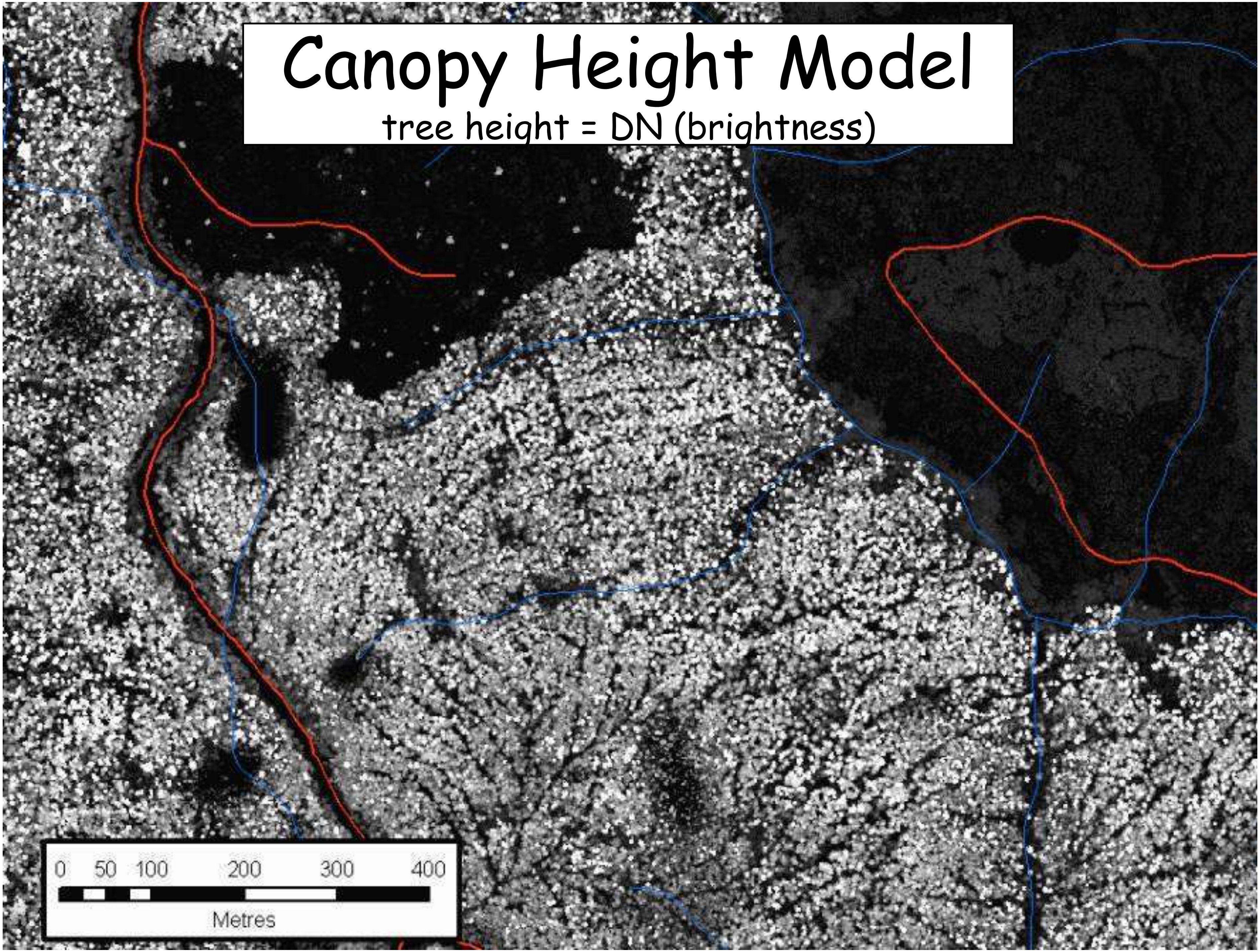
Canopy Surface Model

shaded relief draped on DEM

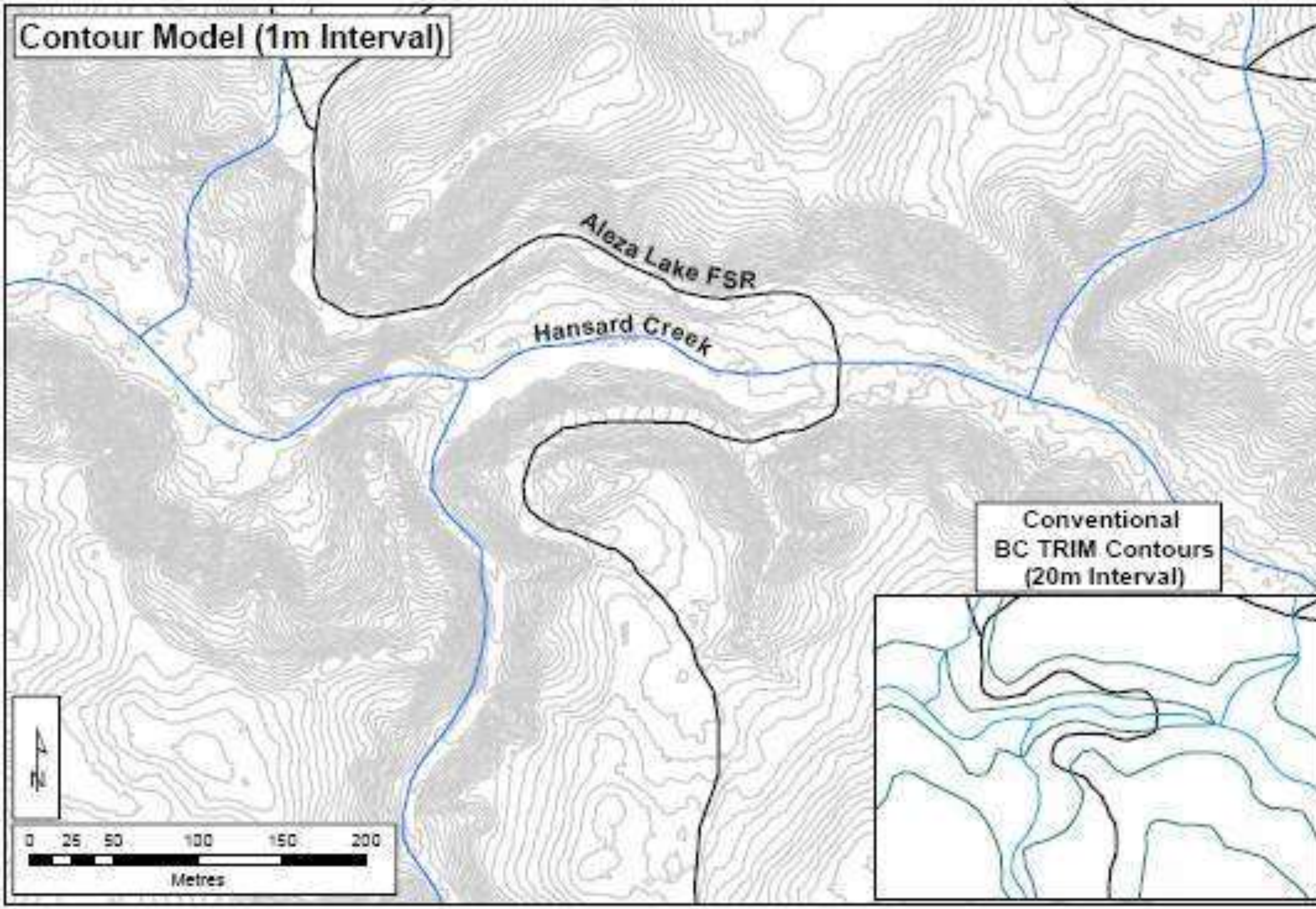
Canopy Height = Canopy Surface – Bare Earth

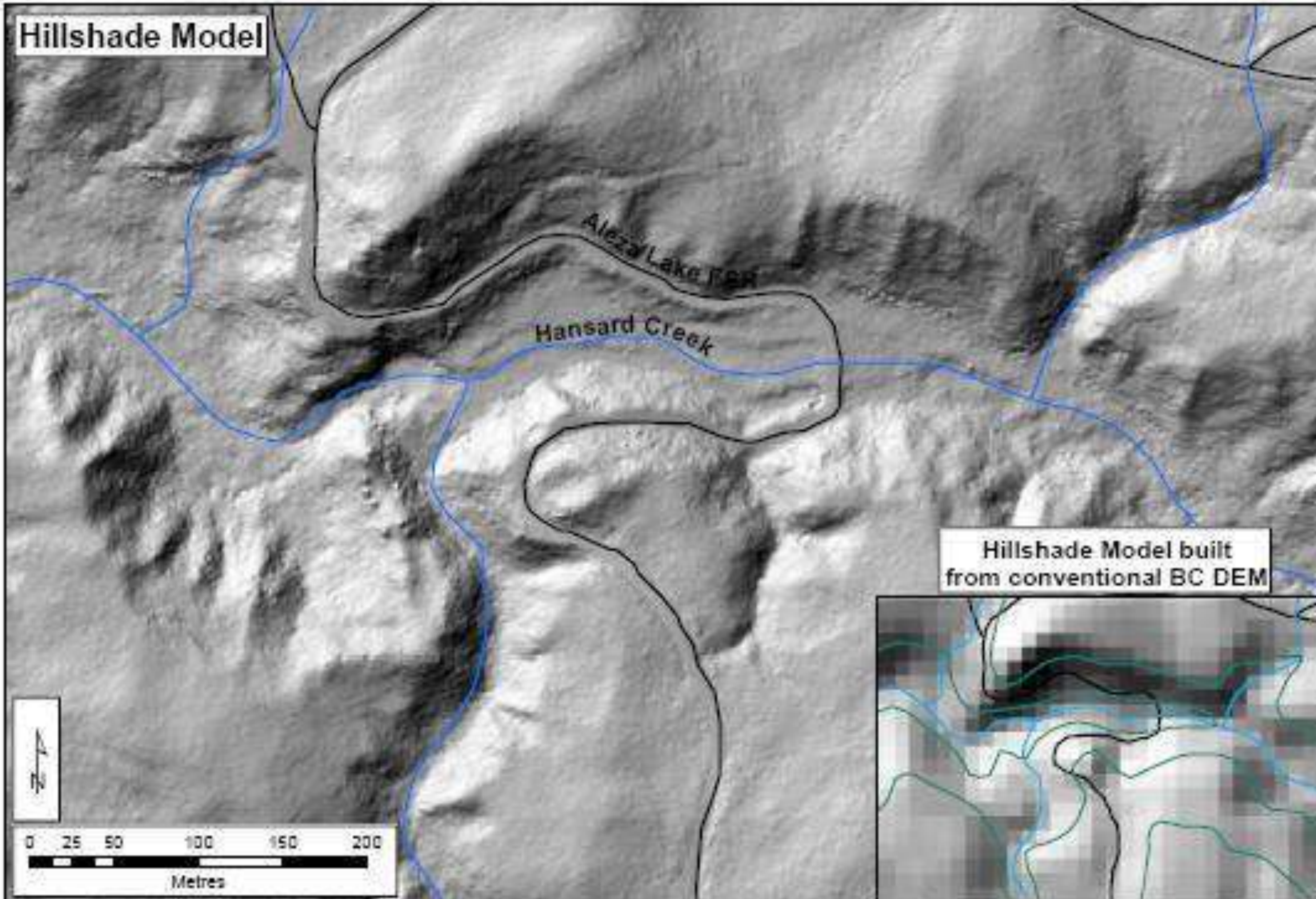
Canopy Height Model

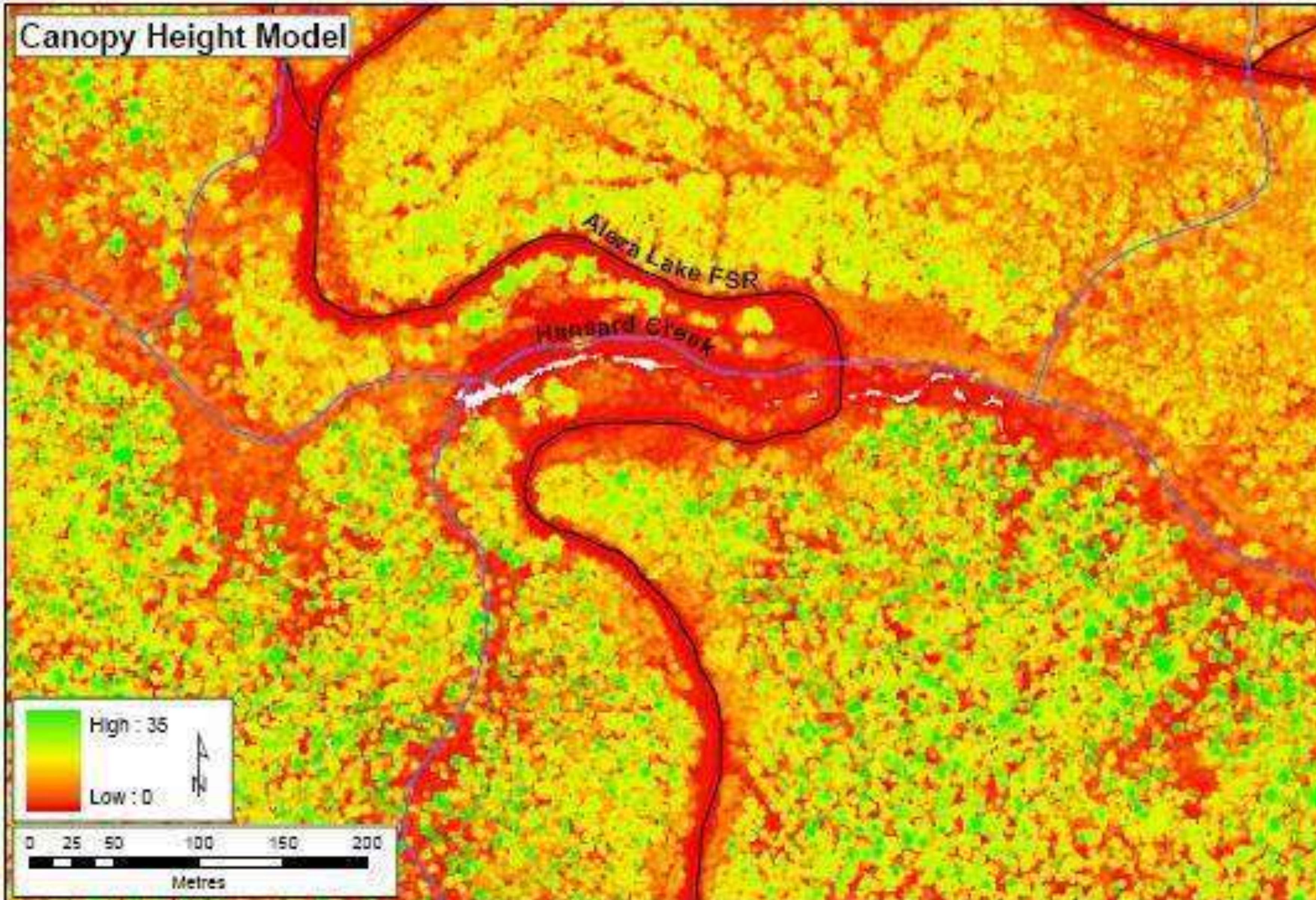
tree height = DN (brightness)




Hansard Creek Digital Aerial Photography
1:2,500
N

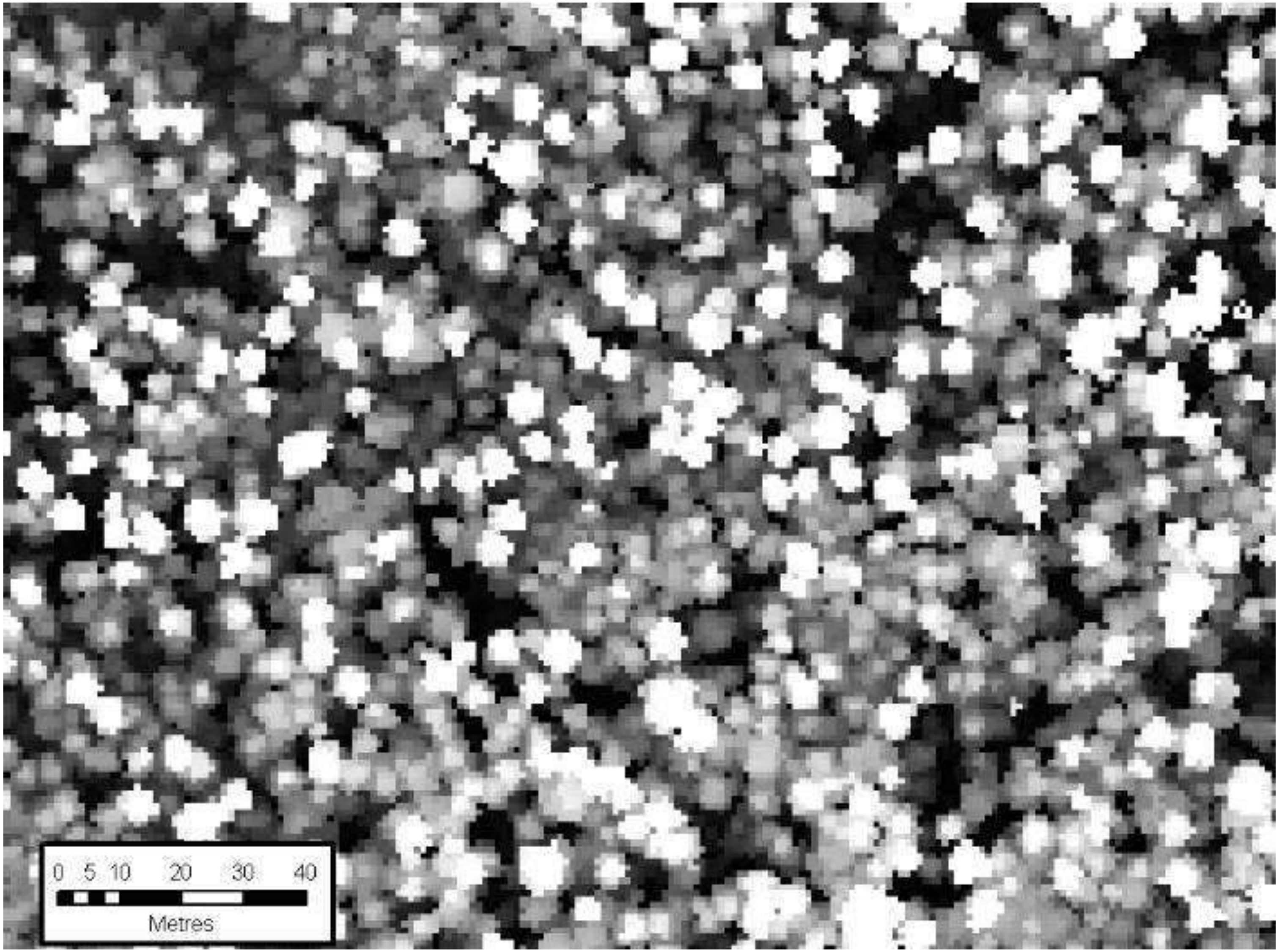

Contour Model (1m Interval)
Aleza Lake FSR
Hansard Creek
Conventional
BC TRIM Contours
(20m Interval)
0 25 50 100 150 200
Metres


Hillshade Model
Aleza Lake FSR
Hansard Creek
Hillshade Model built
from conventional BC DEM
0 25 50 100 150 200
Metres

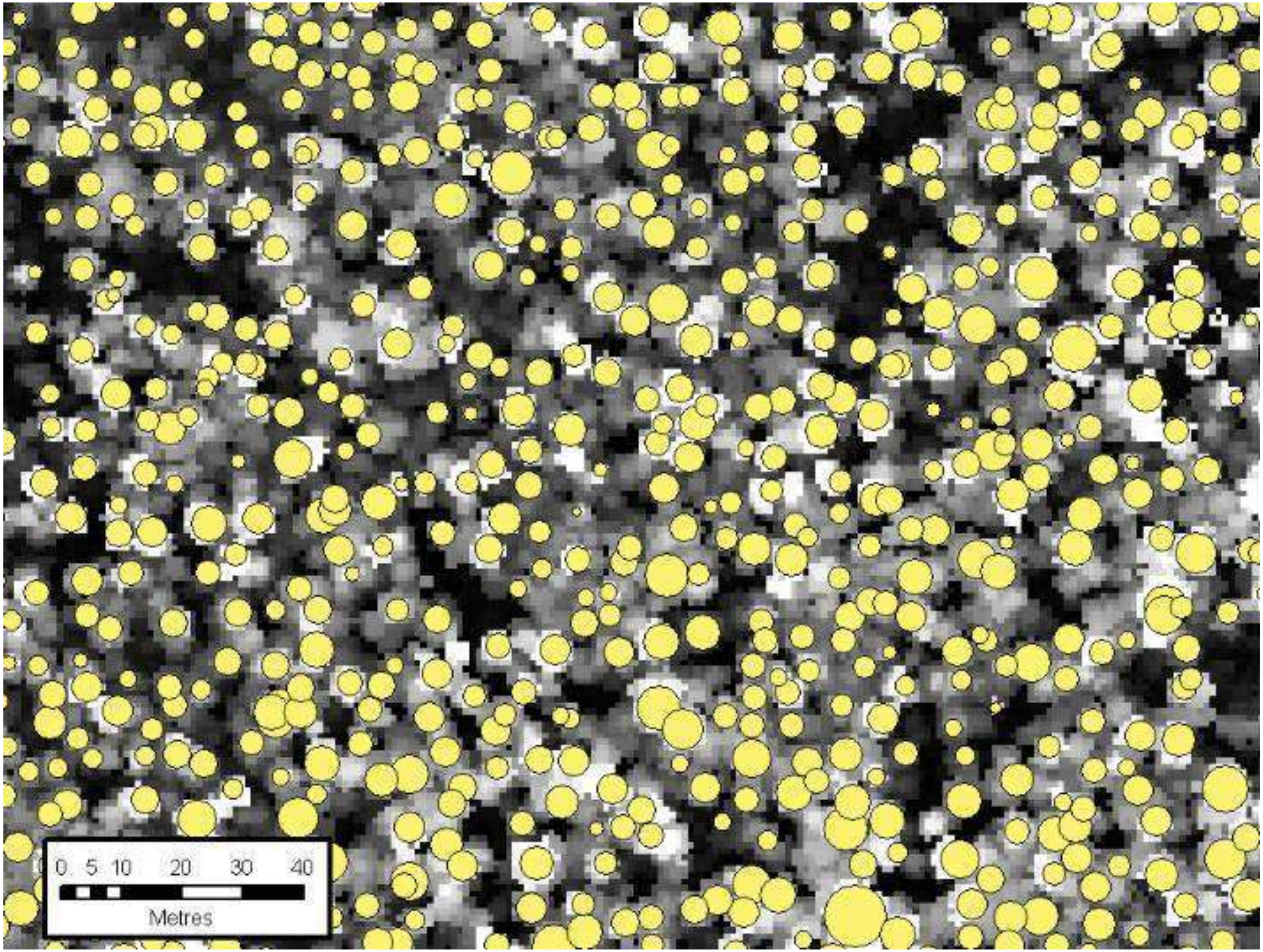

Canopy Height Model
Alera Lake FSR
Hansard Creek
High : 35
Low : 0
N
0 25 50 100 150 200
Metres

Tree Stem Maps

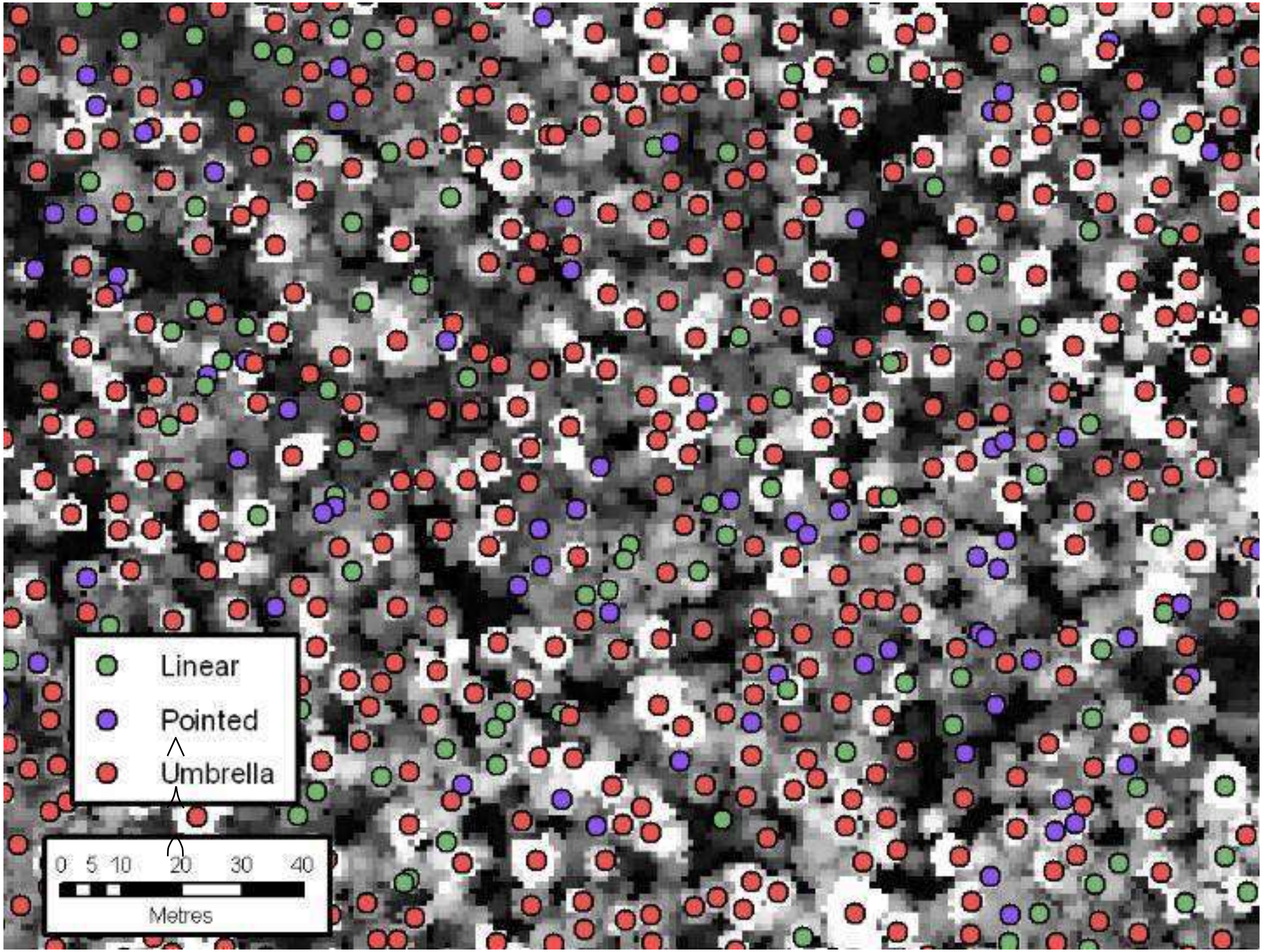
Individual tree crowns are discernable from the Canopy Height Model so we developed a tree finding algorithm to identify tree stem locations



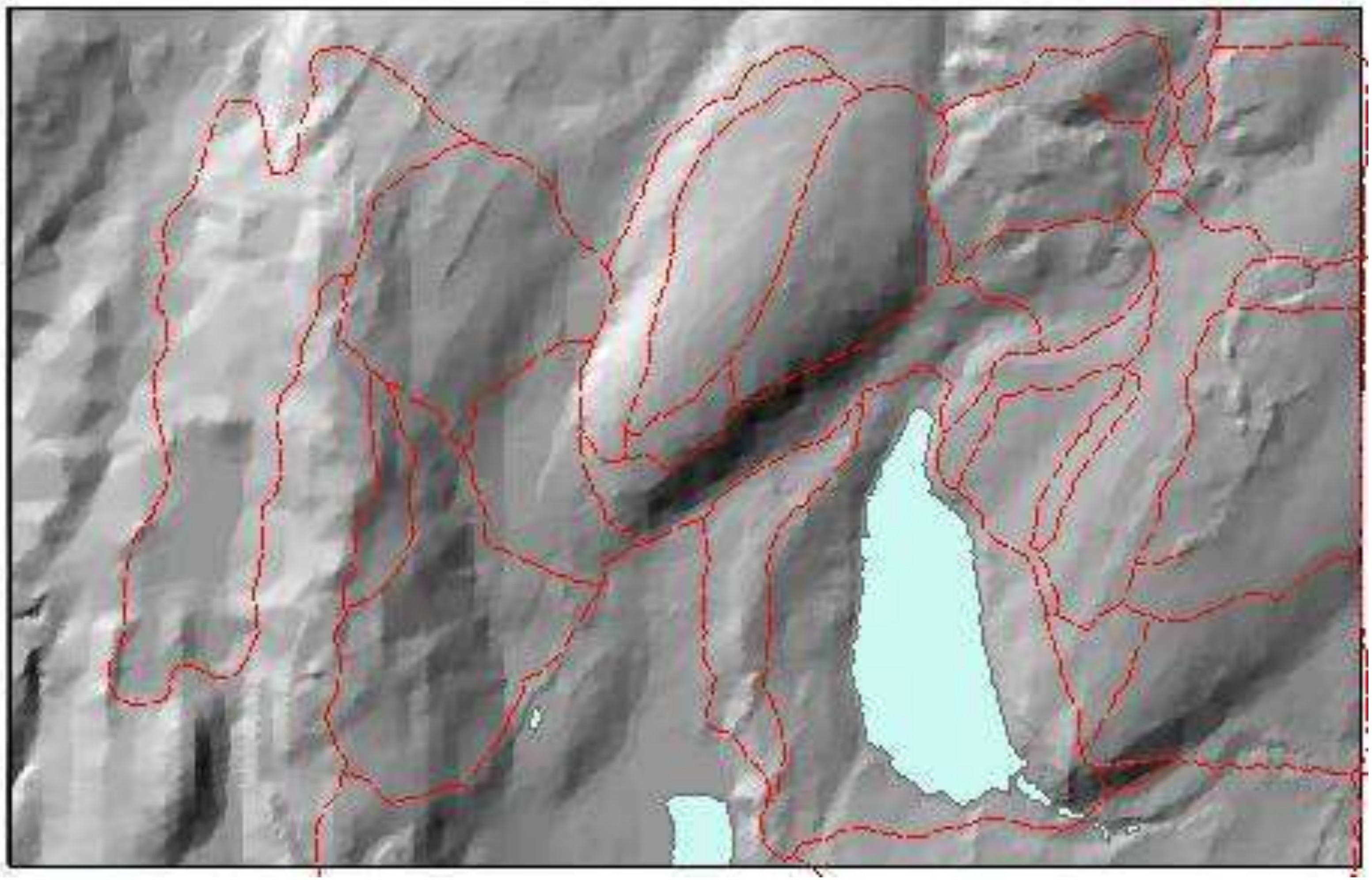
LiDAR Data – tree stems



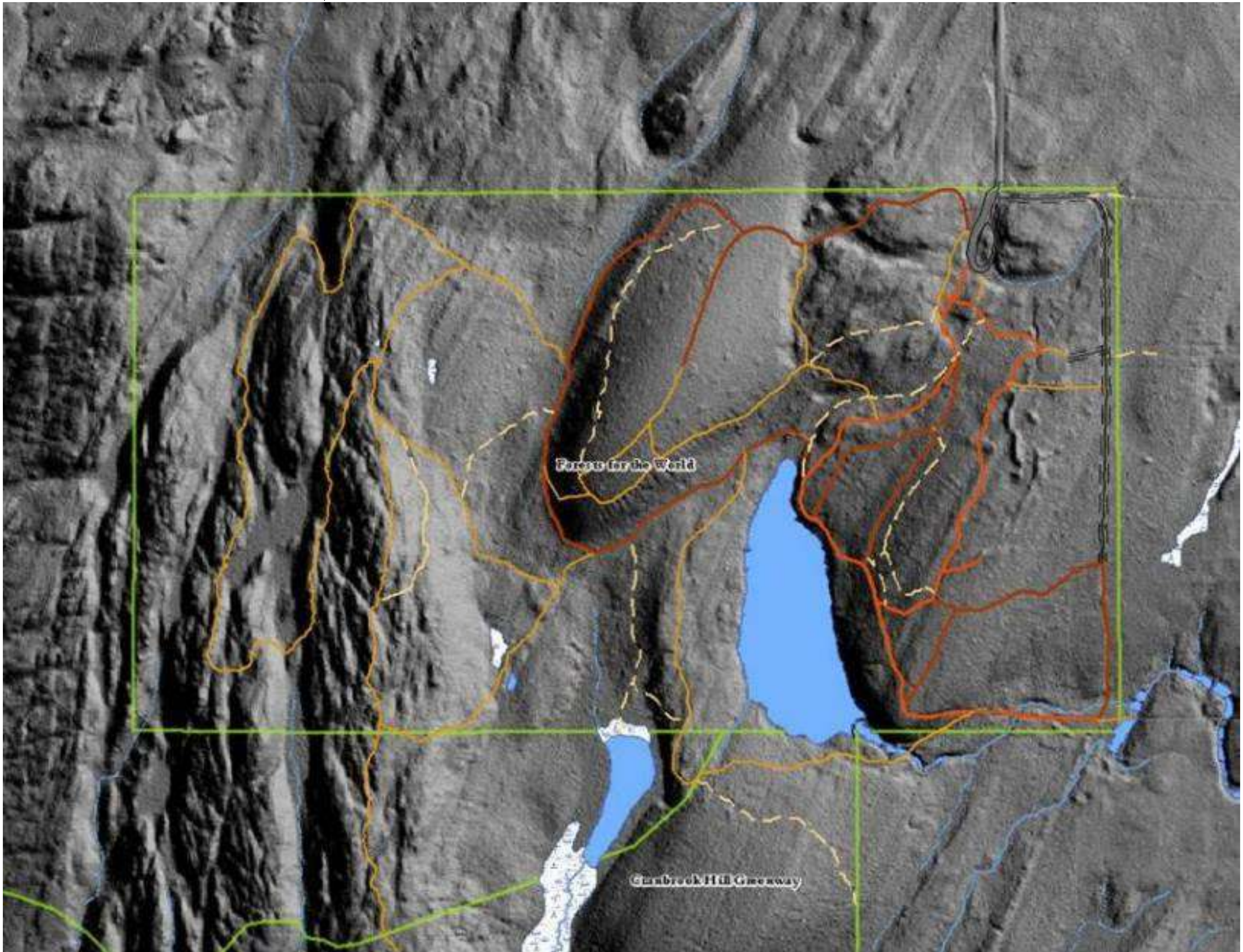
Tree Stems *(displayed by crown shape)*



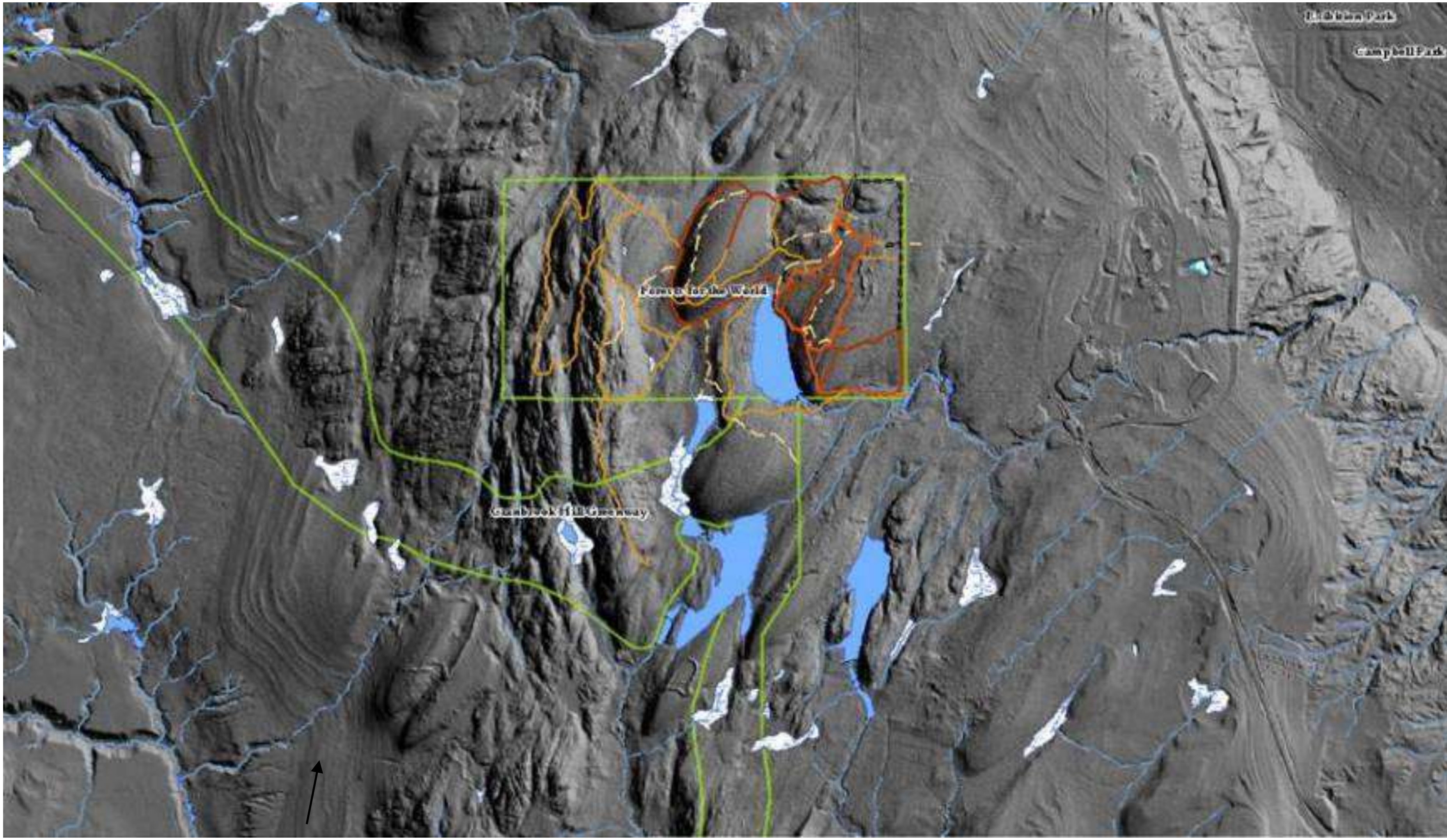
Forests for the World
City 1 metre DEM (from 1m contours) 2000s



LiDAR Forests for the World, 2009



UNBC / Cranbrook Hill LiDAR 2009



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

50cm beach lines

LiDAR Platforms

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

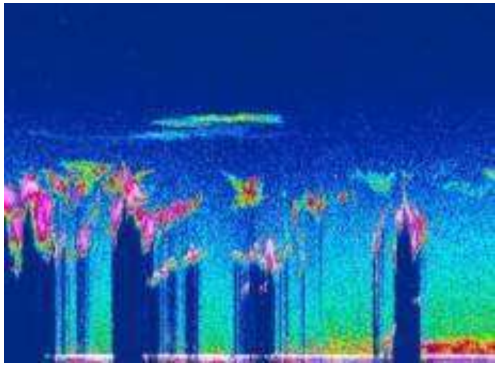
And many others … including UNBC (Brian Menounos)
- LiDAR is mostly airborne, while RADAR is mostly spaceborne

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

LiDAR summary

Present 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)

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
- ✓ Increasing conference content in GIS/RS/Cartography/Forestry
- ✓ Many online resources e.g. :

USGS: http://lidar.cr.usgs.gov/knowledge.php

BC CARMS: http://carms.geog.uvic.ca/carmslidarnew.html

Sentinel 2 - LiDAR mashup

Marcel Morin

‘Lost Art Cartography’

Annapolis Valley, NS

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

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

Ground based – 'terrestrial' Lidar

Lidar-based rock-fall hazard characterization of cliffs

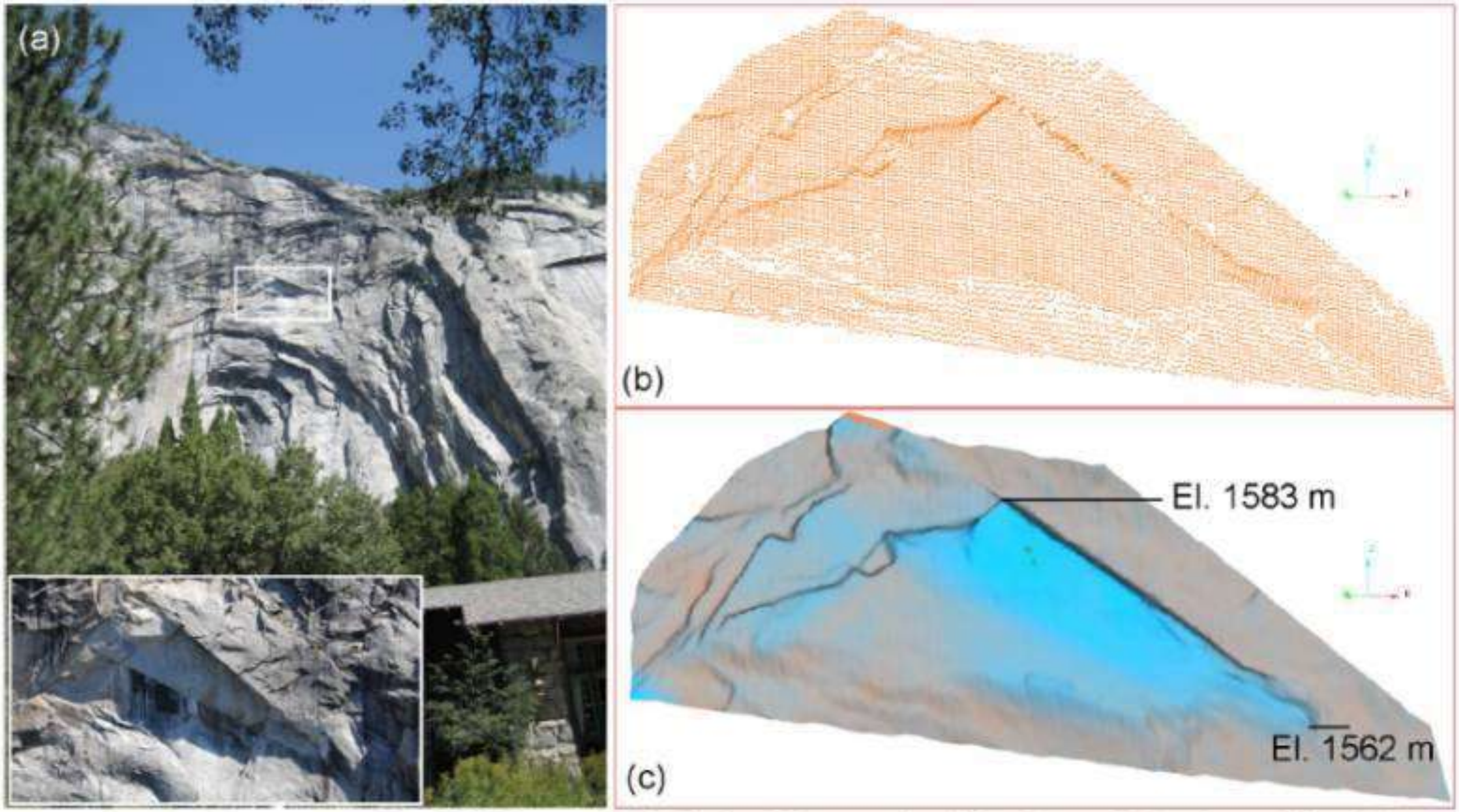


Figure 1. (a) Image of a 2009 rock-fall in Yosemite National Park with (b) point cloud and (c) surface model of the source area. Brightest-blue colored areas of surface model in (c) indicate areas of change following the rock fall.

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.

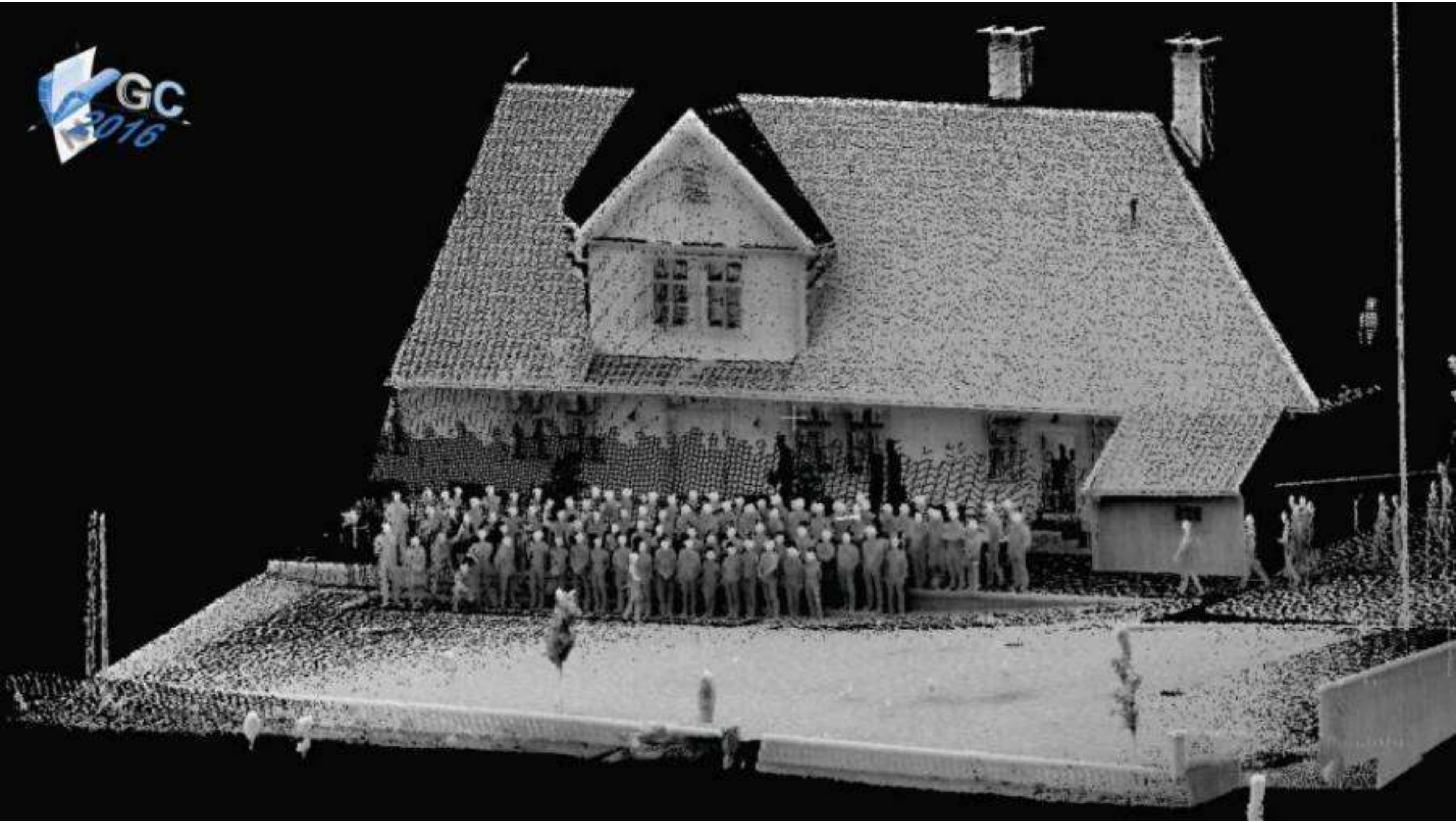
Fig. 2: Gaping Gill Main Chamber LIDAR survey 2003. Vertex cloud looking east.

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

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

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

Conference group photo (RW in red jacket, front centre)



The same Conference group LiDAR scan image