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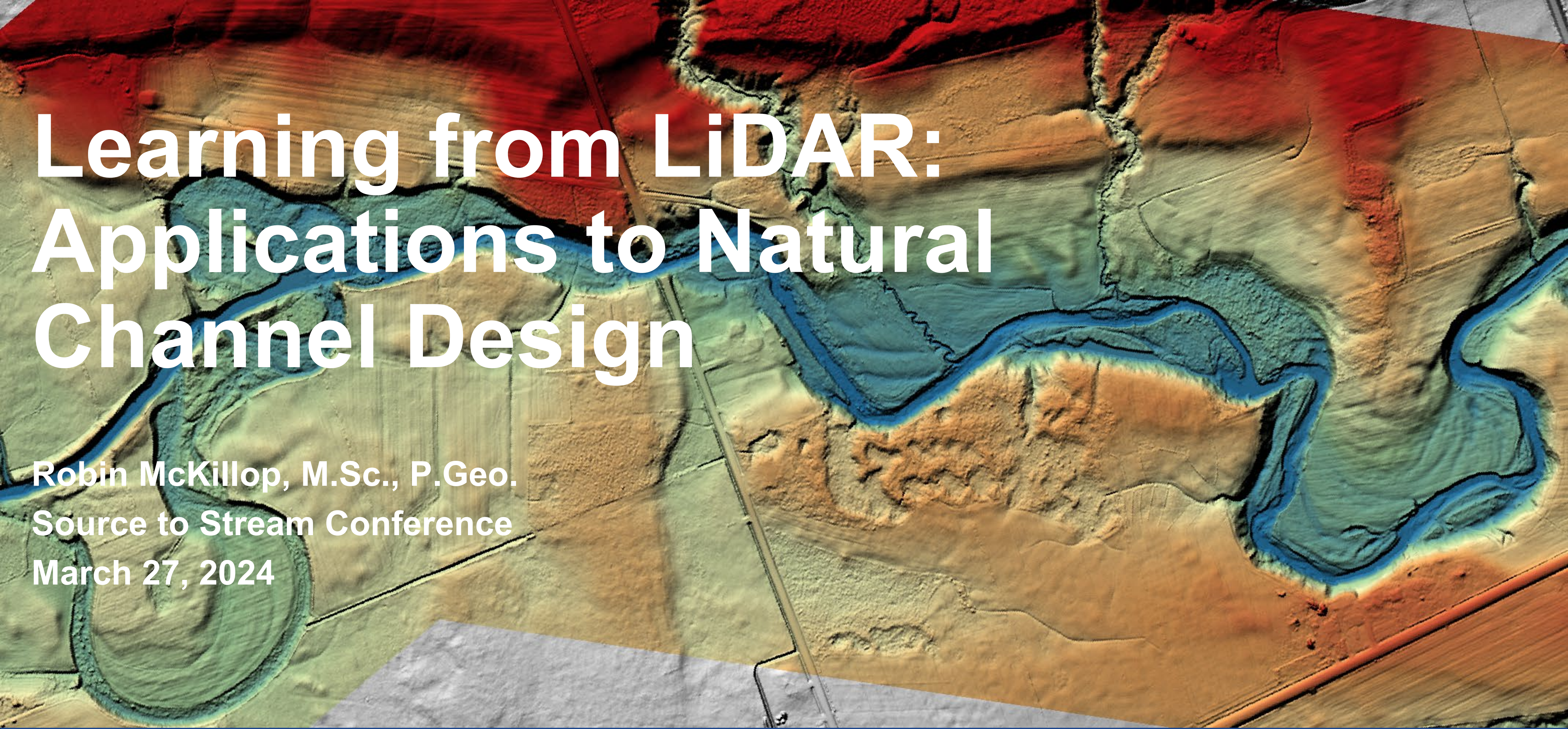

Learning from LiDAR: Applications to Natural Channel Design

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Source to Stream Conference

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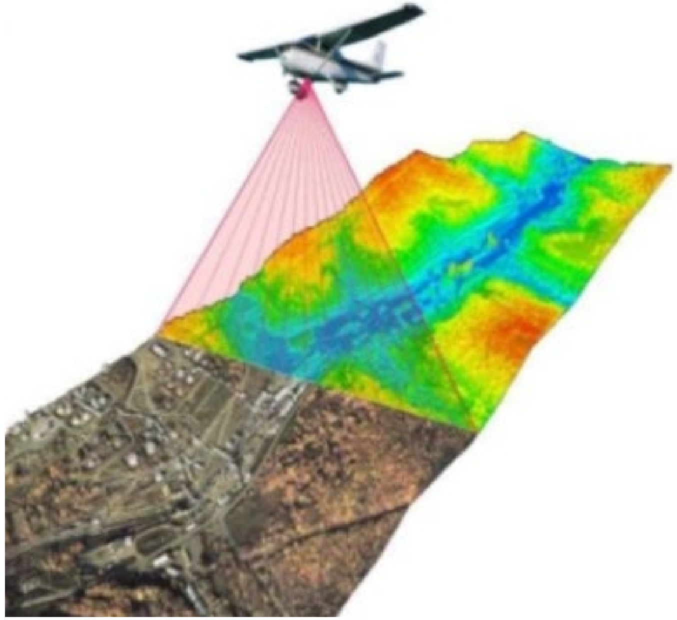
Outline

1. LiDAR 101

2. What can we learn from LiDAR?
   – Planform
   – Profile
   – Cross-section

3. Calls to Action!



1. LiDAR 101

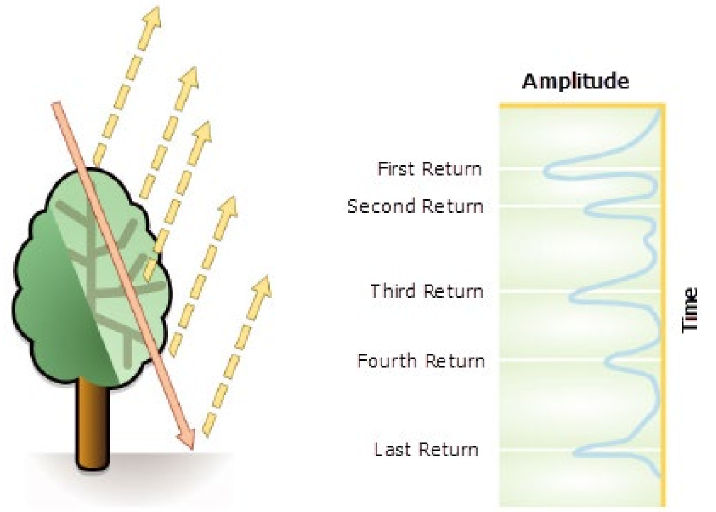
What is LiDAR?

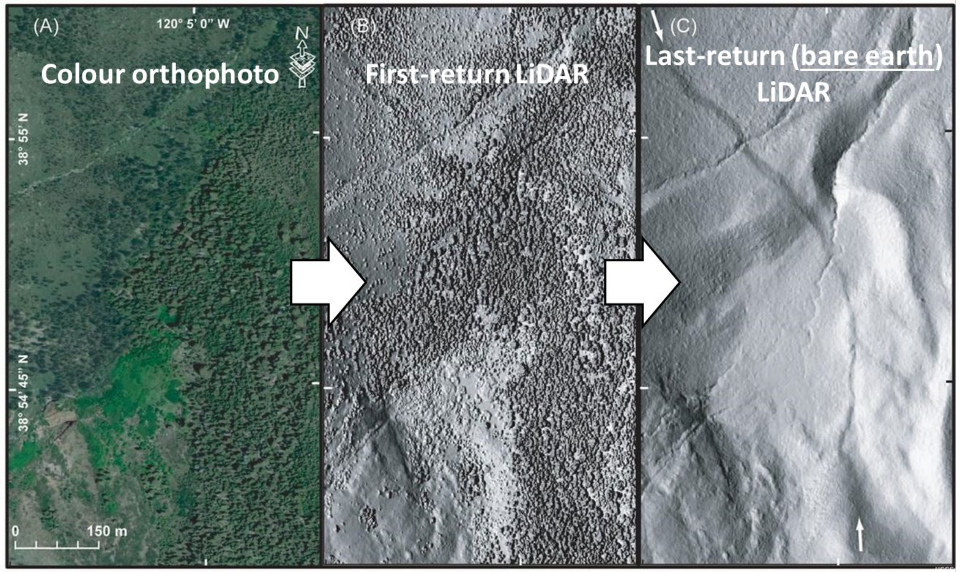
- **Li**ght **D**etection **A**nd **R**anging

- Remote sensing method that uses light – reflections from a pulsed laser – to measure distances to targets

- Duration and intensity of return important

- Point density (points/m^2)

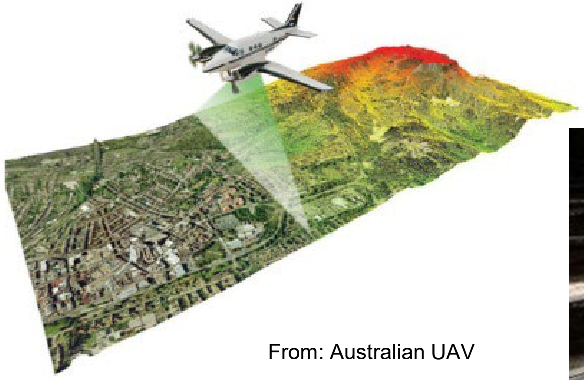




From: J. Howle (USGS)

Sources and Forms of LiDAR data

- Airborne
  - Airplane or UAV
- Terrestrial
  - Tripod-mounted scanner or **iPhone**!
    - Pro models since iPhone 12 Pro
- Full-feature (1st returns) vs. **bare earth**
- **Hillshade** rendering – try varying the “sun angle” to reveal more details!
- **Change detection**
  - Elevation gain (~deposition)
  - Elevation loss (~erosion)

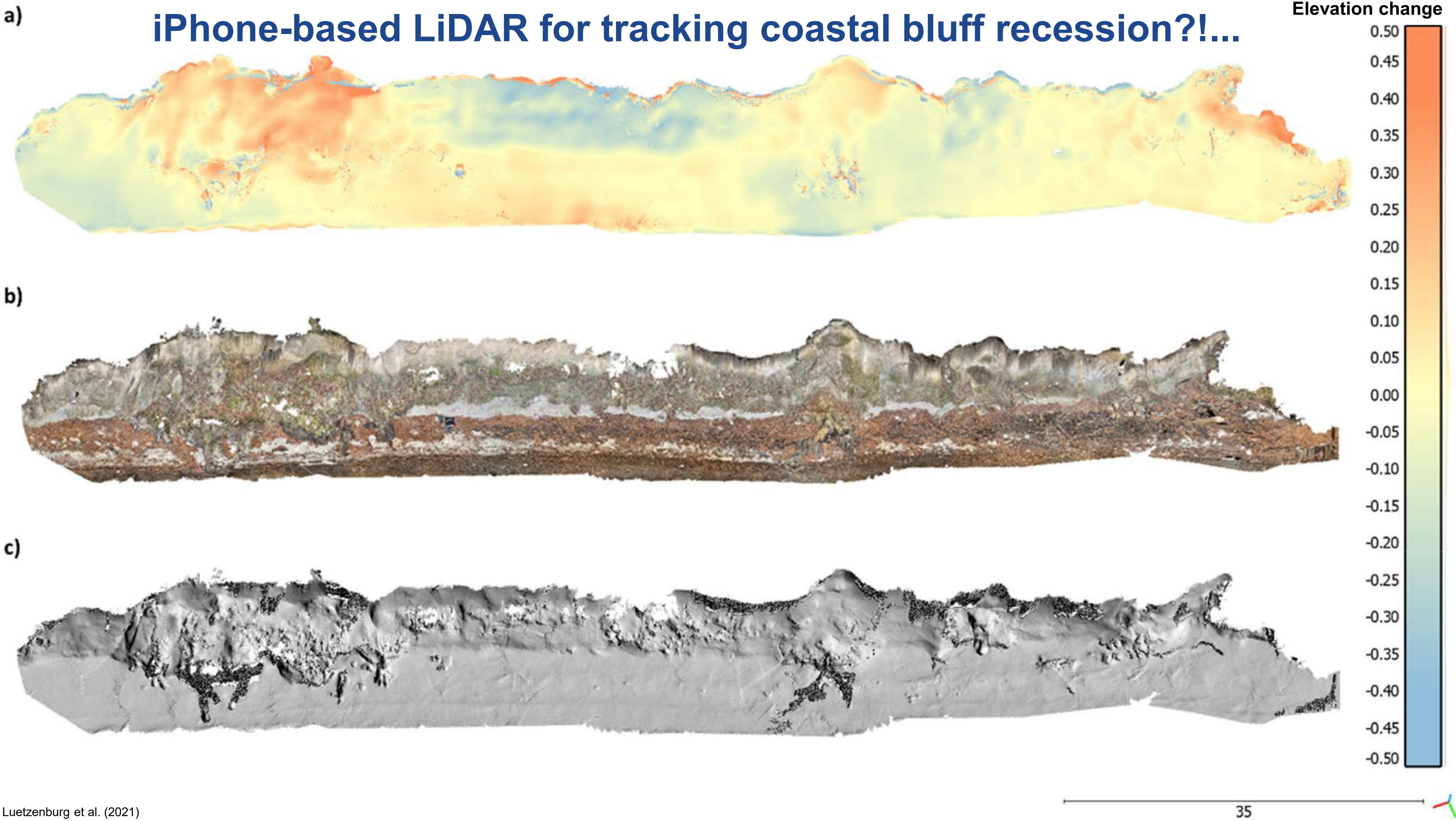


From: Australian UAV

LiDAR sensor

Luetzenburg et al. (2021)

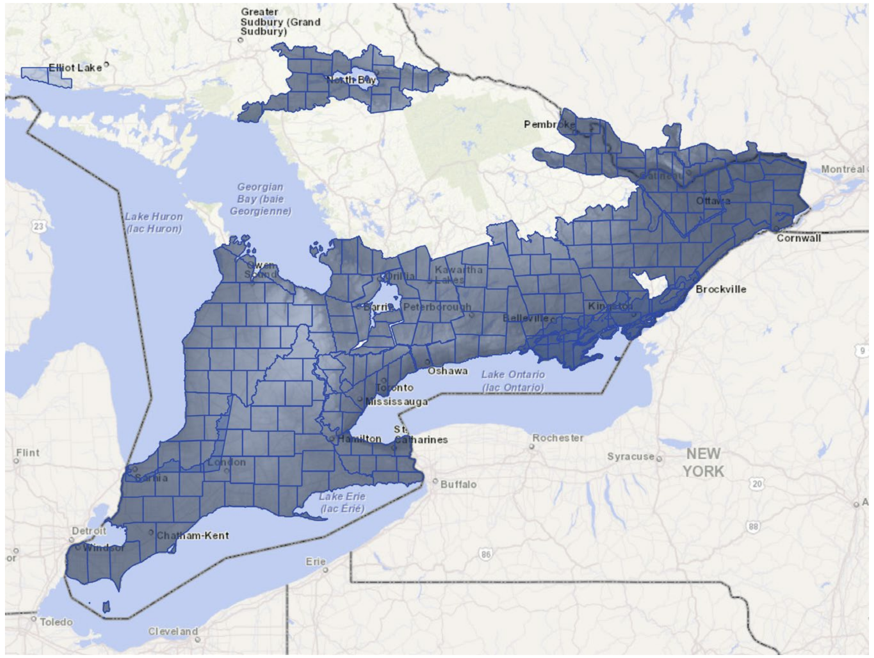
iPhone-based LiDAR for tracking coastal bluff recession?!...



Luetzenburg et al. (2021)

Publicly Accessible LiDAR

- NRCan HRDEM – **online viewer**, web server & data download
  - https://datacube.services.geo.ca/en/viewer/elevation/index.html
  - https://datacube.services.geo.ca/ows/elevation
- LIO GeoHub – web server & data download
  - https://geohub.lio.gov.on.ca/maps/mnrf::ontario-digital-surface-model-lidar-derived/explore?location=44.120184%2C-78.650842%2C7.12
  - https://ws.geoservices.lrc.gov.on.ca/arcgis5/rest/services/Elevation
- Provincial government
- Municipalities
- Conservation authorities
- Private industry



Ontario GeoHub

How is LiDAR relevant to Natural Channel Design (NCD)?

- **Topographic base**
  - Overbank, floodplain and valley wall areas
  - Parts of channel – mainly riffles (grade control), especially during low flow
- Critical information on **site context and history**
  - Geomorphic “persistence time” (Guthrie & Evans, 2007)
  - High-resolution spatial information ➔ temporal information!

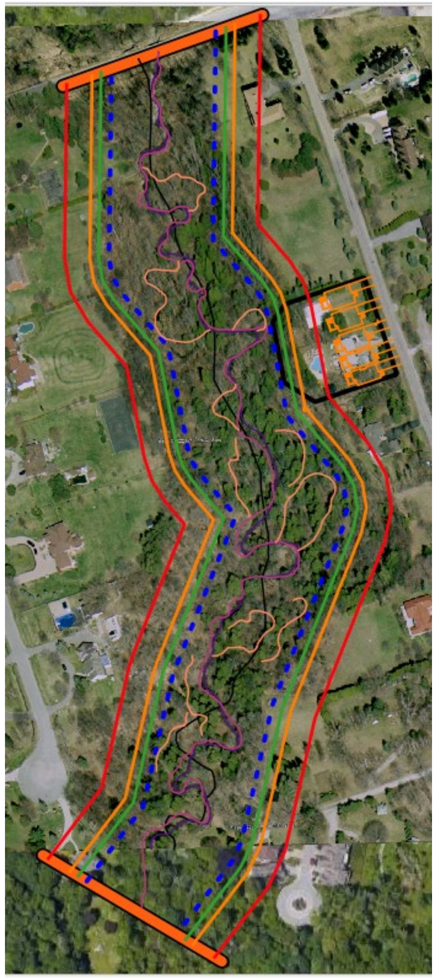
2. What can we learn from LiDAR?

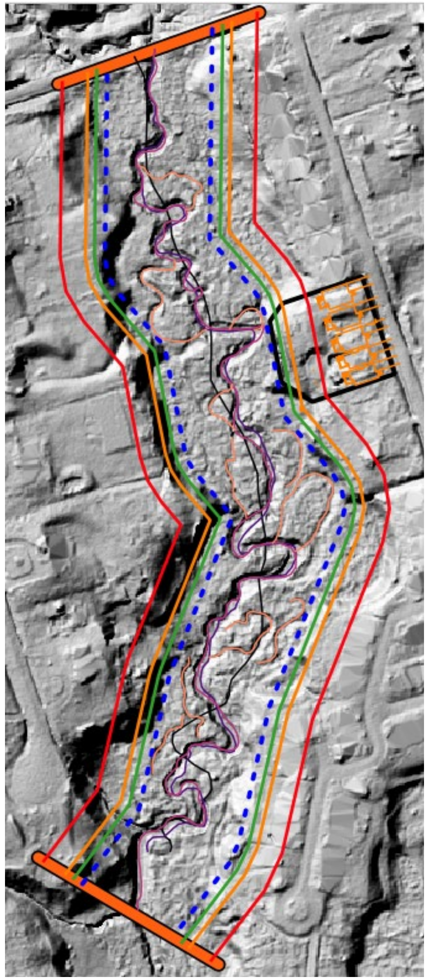
Planform

- LiDAR doesn't lie (like air photos can!)
  - We see things in LiDAR that are commonly undetectable in air photos
    - Aids differentiation of headwater drainage features (HDFs) and watercourses

- Improved detection of oxbows/meander scars
  - Historical channel dynamics (avulsion history or anthropogenic straightening)
  - More precise delineation of meander belts (input to NCD)

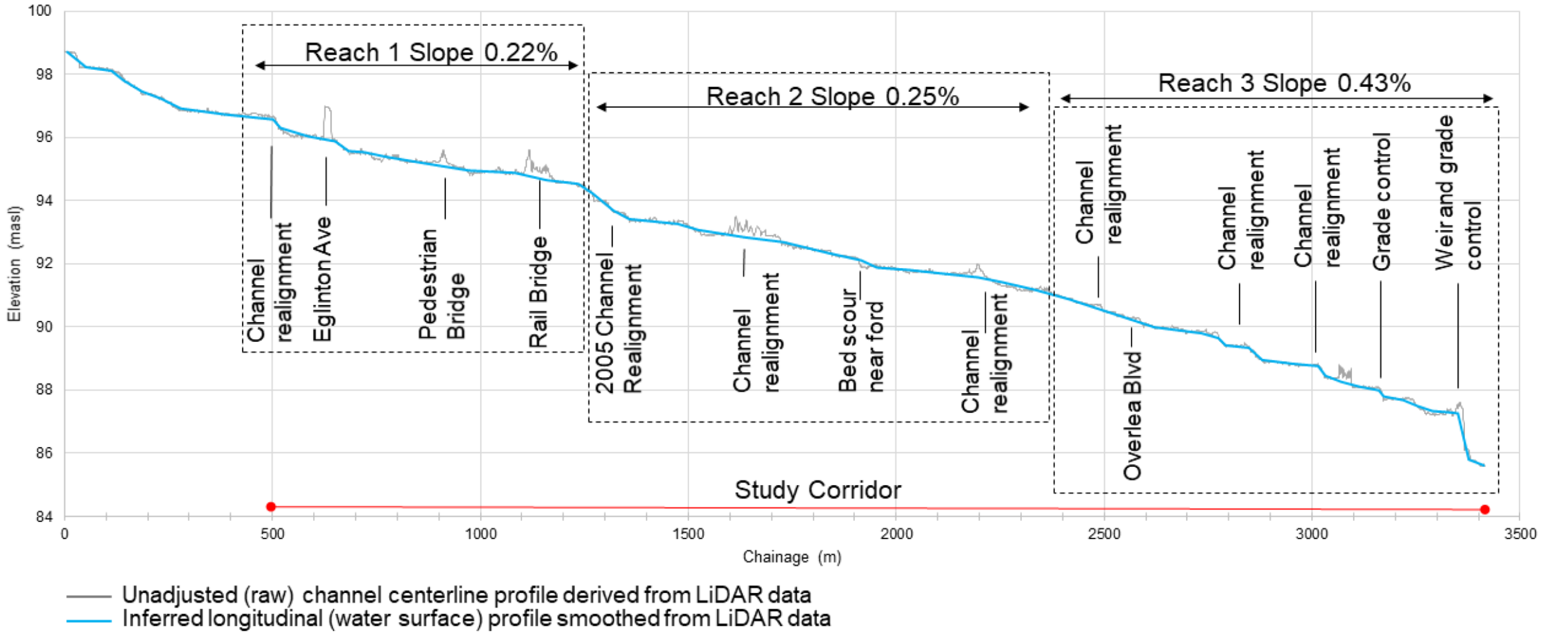
- Regulatory agencies should be requesting meander belts on LiDAR hillshades, instead of (or addition to) air photos!





Profile

- Water surface ≠ bed
  - Except roughly at riffles (hydraulic grade control), during most flow conditions
- Reach- to site-scale average longitudinal gradients
- Profile shape
  - Concavity vs. convexity ➔ trend in degradation or aggradation?
  - Knickpoints ➔ risk of undermining erosion control structures?

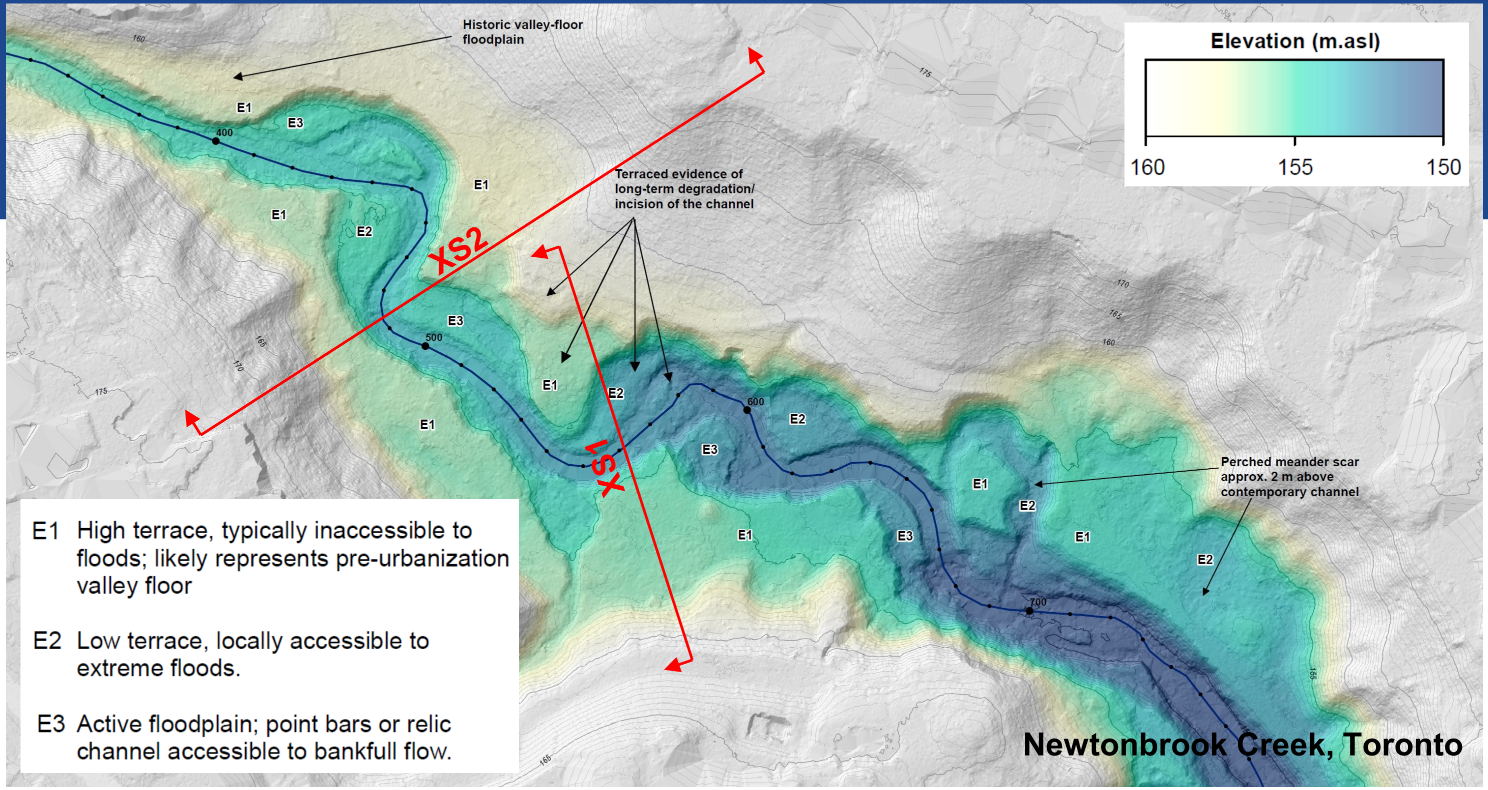


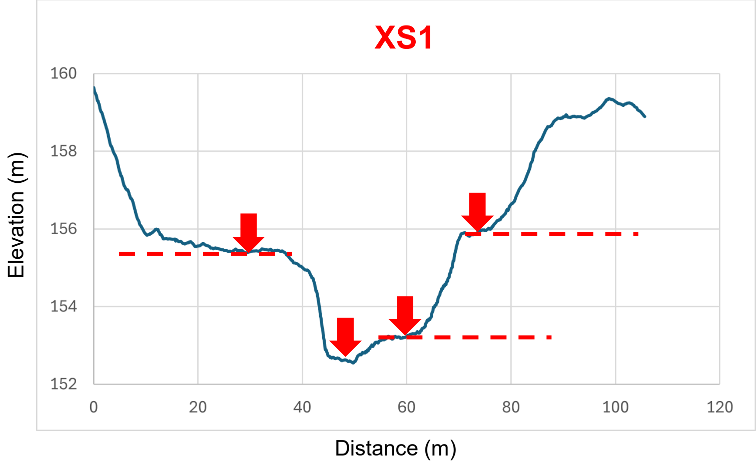
West Don River at E.T. Seton Park, Toronto

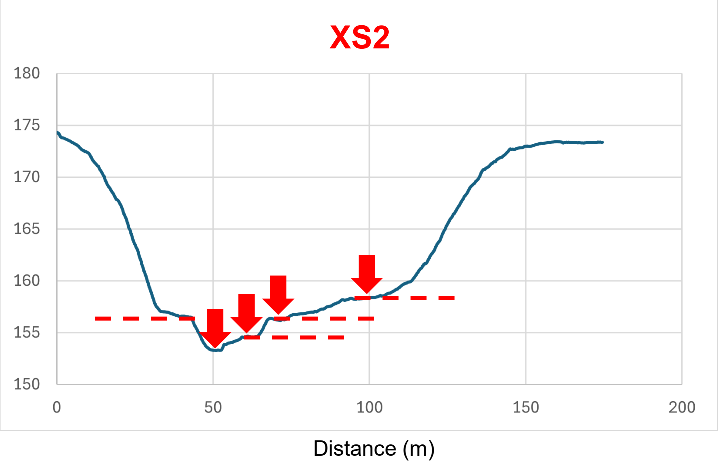
Cross-section

- Valley to channel scale
- Assessment of confinement (**confined** vs. **unconfined**)
- History of down-cutting (terracing) and entrenchment

- Approx. channel width and depth (subject to water surface limitations)
  - More accurate for wide channels
  - Enables more representative measurements
- Natural vs. unnatural (fill) slopes
- Channel boundary materials





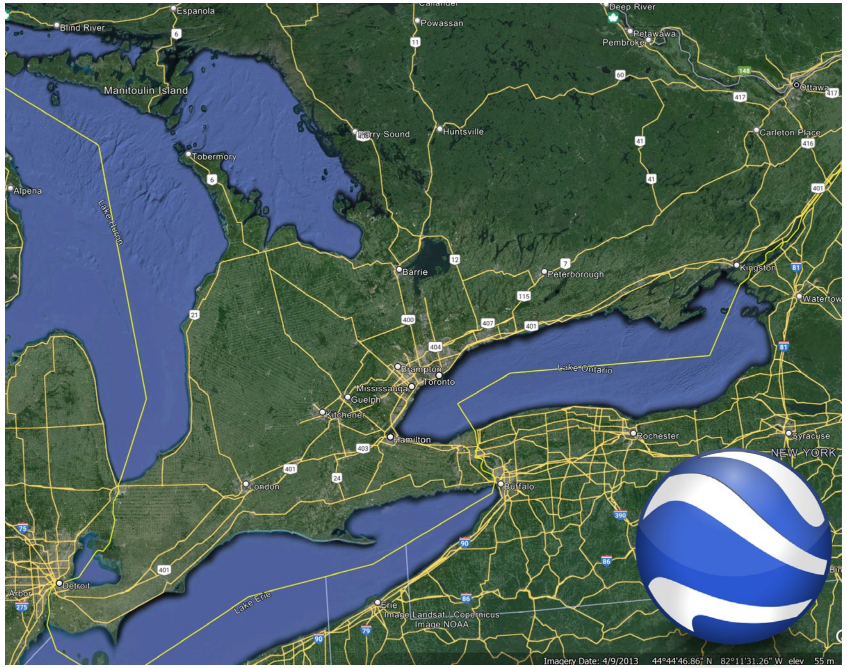


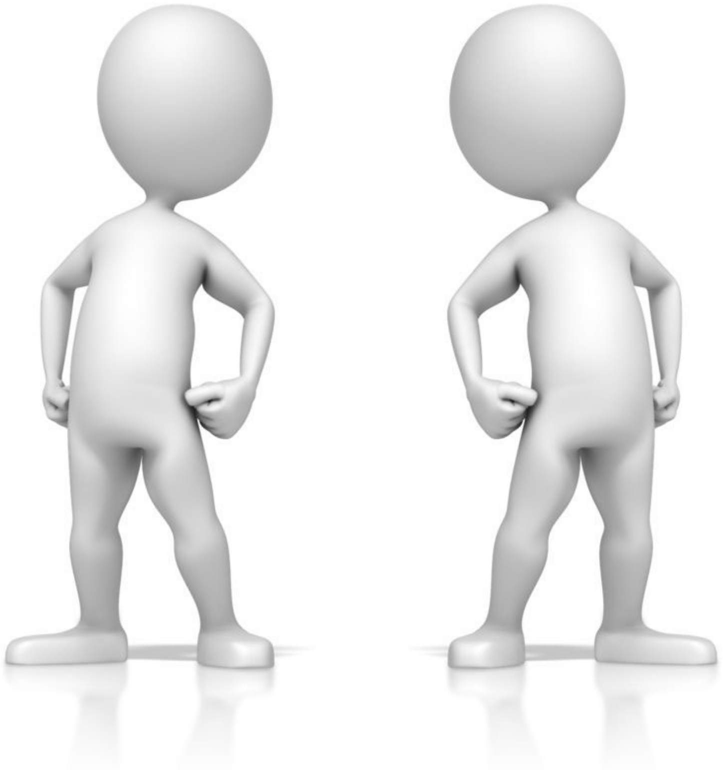
3. Calls to Action!

Action 1: LiDAR viewers for site screening

- LiDAR viewers should become default site screening tool, just like Google Earth
  - Online viewers – *no need to actually download data!*

Google Earth





NRCan's HRDEM

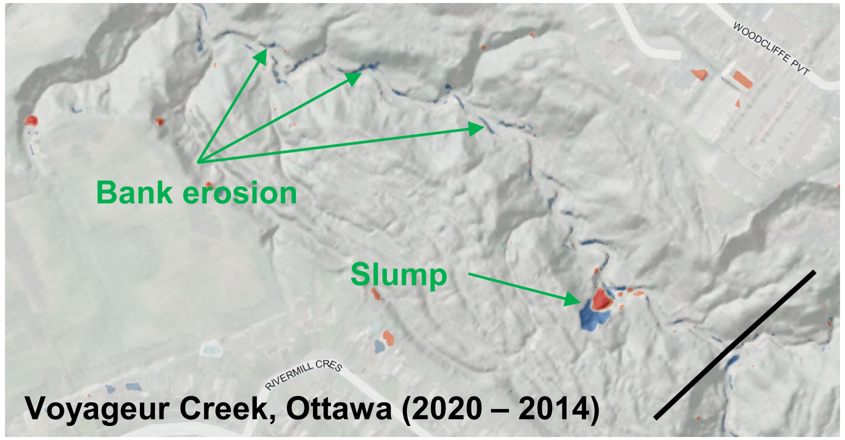
https://datacube.services.geo.ca/en/viewer/elevation/index.html

Action 2: LiDAR data to be publicly accessible

- Purchasers of LiDAR data are encouraged to make their datasets publicly accessible (subject to licensing restrictions)

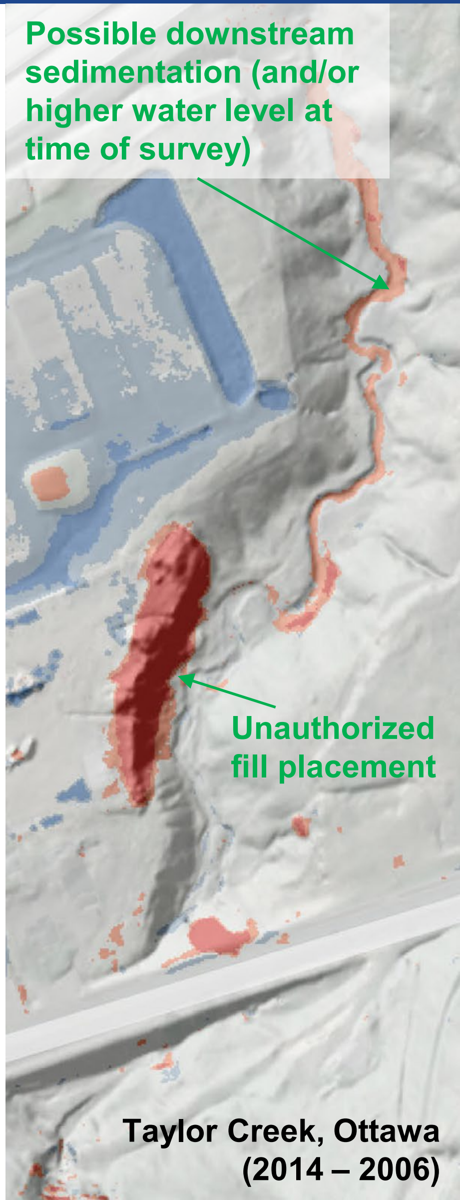
- Ideally contribute the datasets to online viewer/download compilations
  - Improve spatial and temporal resolution!

- Optimally re-acquire LiDAR data at least every 5 years in dynamic environments (and perform **change detection analysis**!)



Change in Elevation

- >1 m Gain
- 0.385–1 m Gain
- No significant change
- 0.385–1 m Loss
- >1 m Loss



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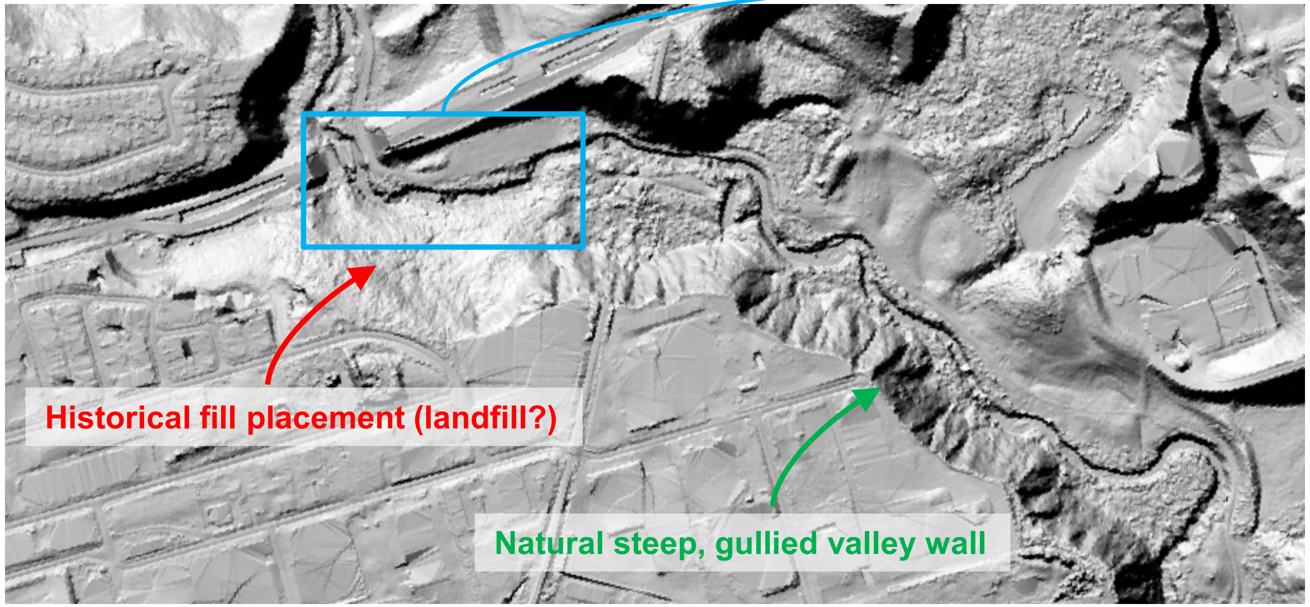
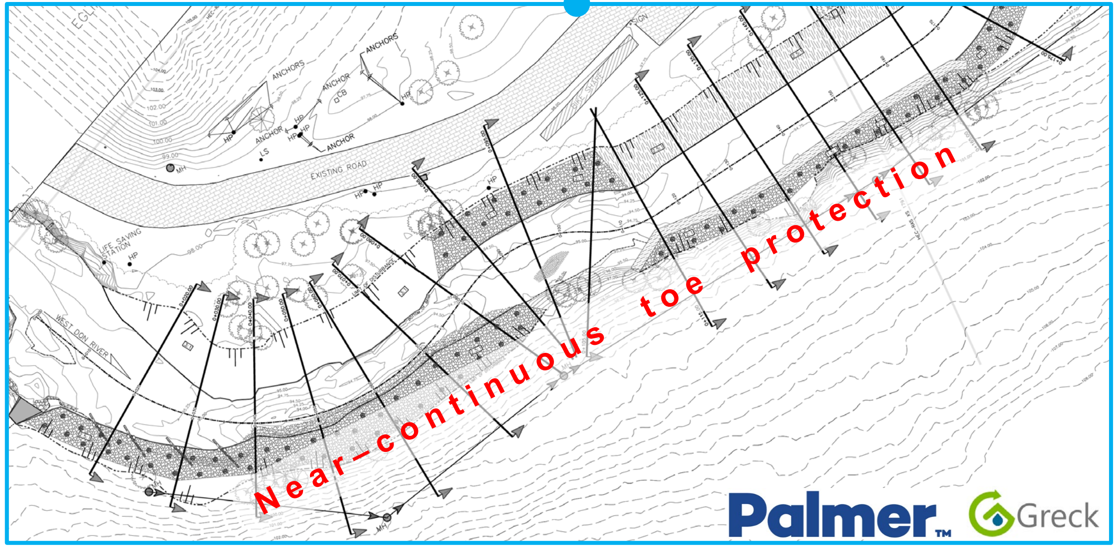
Action 3: LiDAR data implications for NCD

– Every NCD should, at a minimum, be informed by review of LiDAR data (where available)





– Regulatory agencies should look for highlights of LiDAR review on drawings or in design briefs; if they're not obvious, ask!

Key takeaways

– LiDAR data is available, commonly publicly, from a variety of sources and in a variety of formats

– LiDAR data, where available, should be reviewed, analyzed and/or interpreted in association with any NCD project

– LiDAR data viewers should become default site screening tools, just like Google Earth

– Get a Pro version of my next iPhone?... 😏

Thank you

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