Regional-scale landslide and erosion monitoring utilizing airborne LiDAR change detection analysis

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Andrew Mitchell, Matt Lato, Scott McDougall, Mike Porter, Stephanie Bale, Andrew Watson

Motivation

- Variety of projects exposed to landslide and erosion risks over large spatial extents
  - Transportation corridors
  - Electrical infrastructure
  - Pipelines
- Areas of instability and erosion can be located and delineated using field mapping
  - Very rich source of information
  - Labour intensive to collect
- Remote sensing techniques can be used for rapid detection of areas requiring greater scrutiny

Photo: M. Porter

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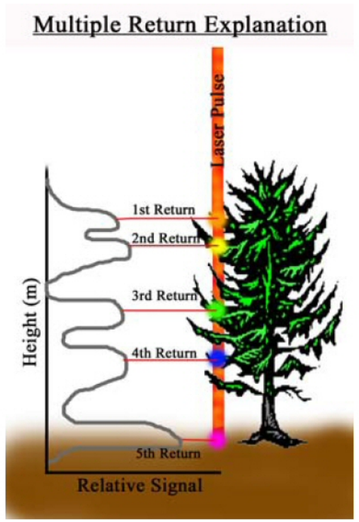
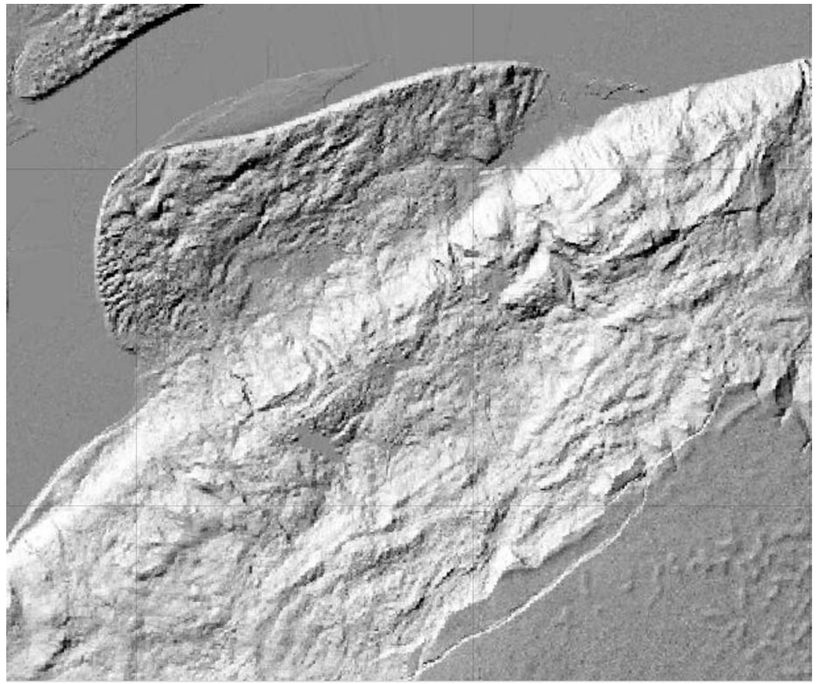
ALS for Geohazards Monitoring

- Airborne LiDAR Scanning (ALS) has become common for many engineering and geology applications
- Bare earth data gives an improved perspective on geohazards for vegetated slopes



Fancher 2012



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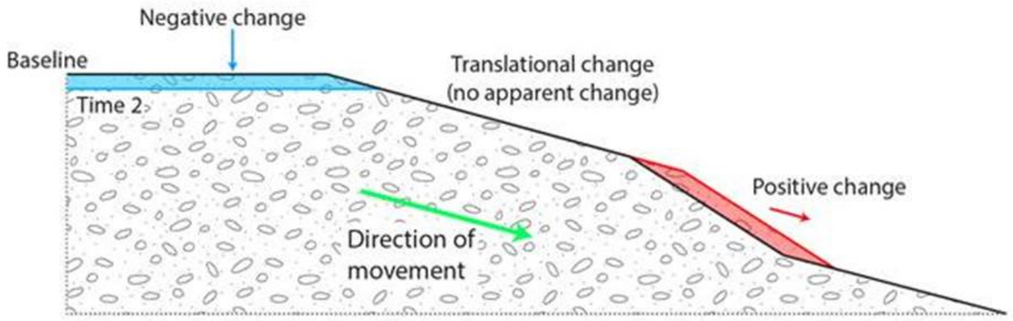
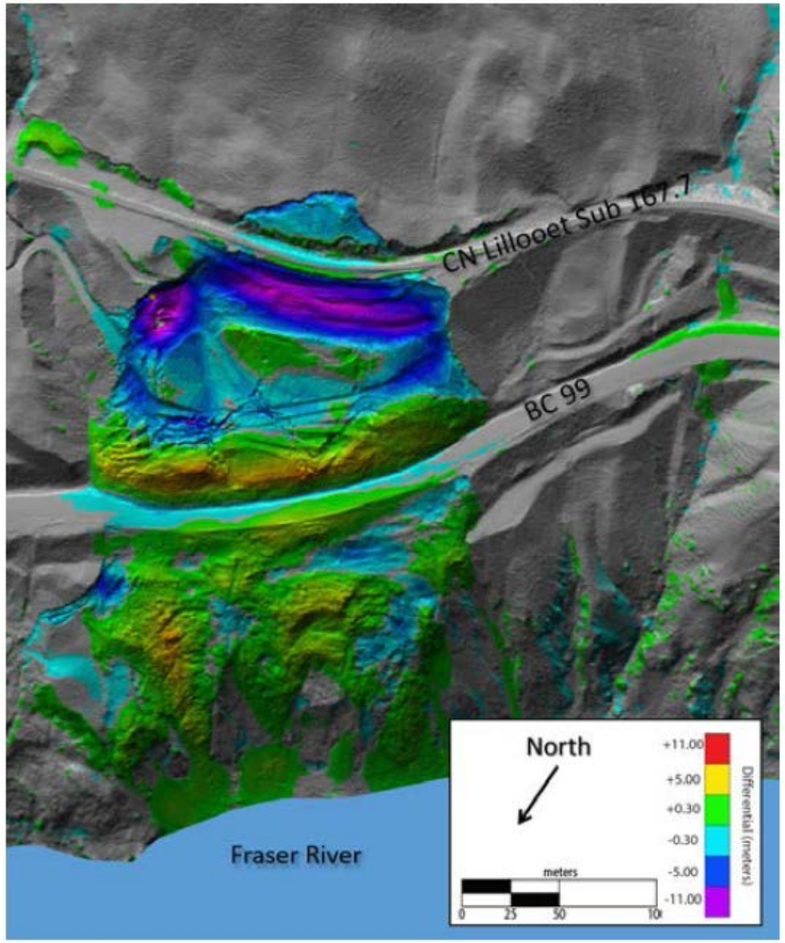
Change Detection Analysis

- Requires at least two data collections separated in time
- Three main steps
  - Alignment of the active and reference data sets for areas not suspected of changing – requires an assumption of what is and is not moving
  - Calculate a limit of detection for non-moving areas – there will be variation in the point clouds in the non-moving areas, the limit of detection is between 2.5% and 97.5% of the cumulative distribution of errors.
  - Calculate the 3D shortest distance change between the points of the complete active dataset to the mesh of the reference dataset
- Typically done for local areas of interest





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Application to Regional Scale Data

- Reservoir area with numerous stakeholders potentially affected by landslides or erosion
- Baseline dataset collected in 2006
  - Approximately 1 pt/m^2 bare earth point density
- Second dataset collected in 2015
  - Approximately 5 pt/m^2 bare earth point density
- Total collection area is approximately 750 km^2
  - Large area required an efficient processing technique
  - Area was subdivided and alignment process was automated using Polyworks

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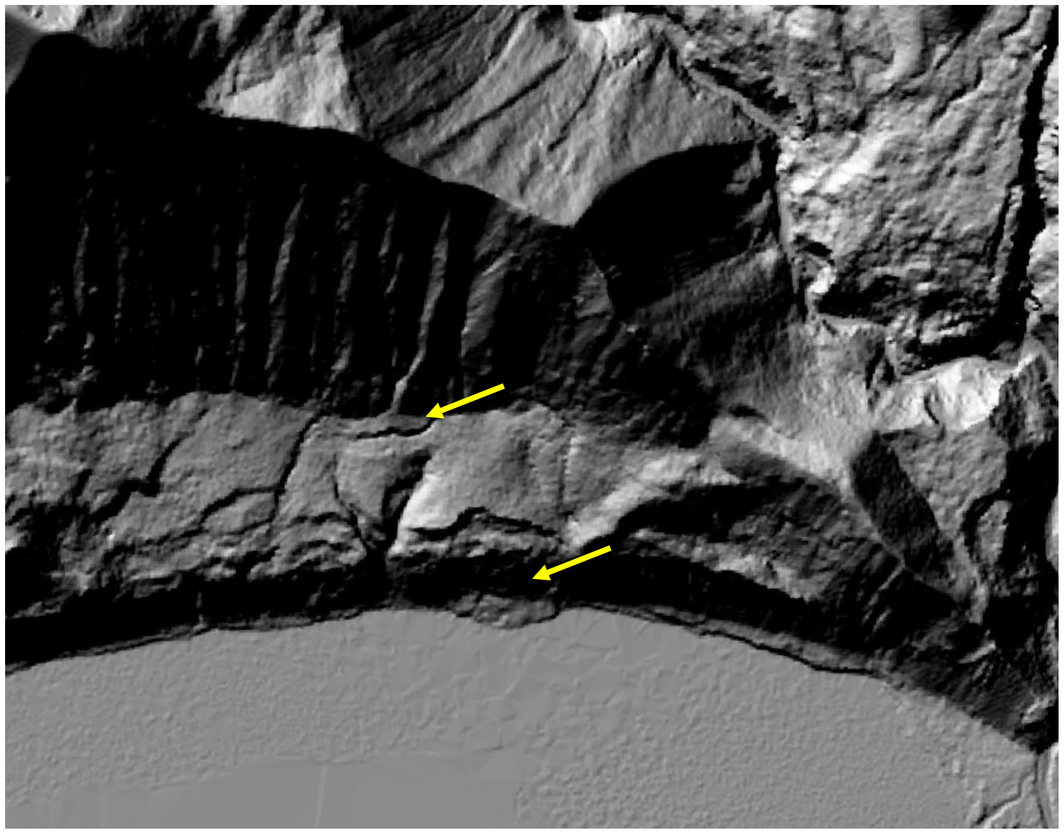
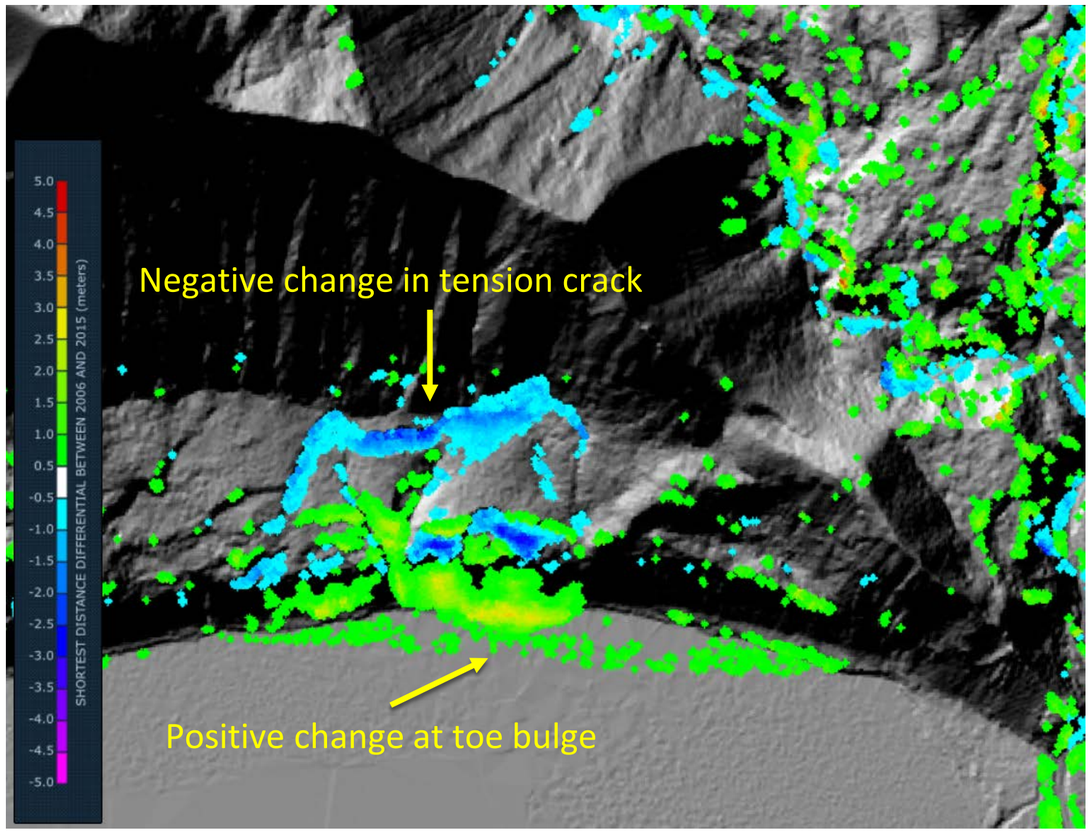
Detection of Landslide Areas

2015 ALS Data



2015 vs 2006 Change Detection



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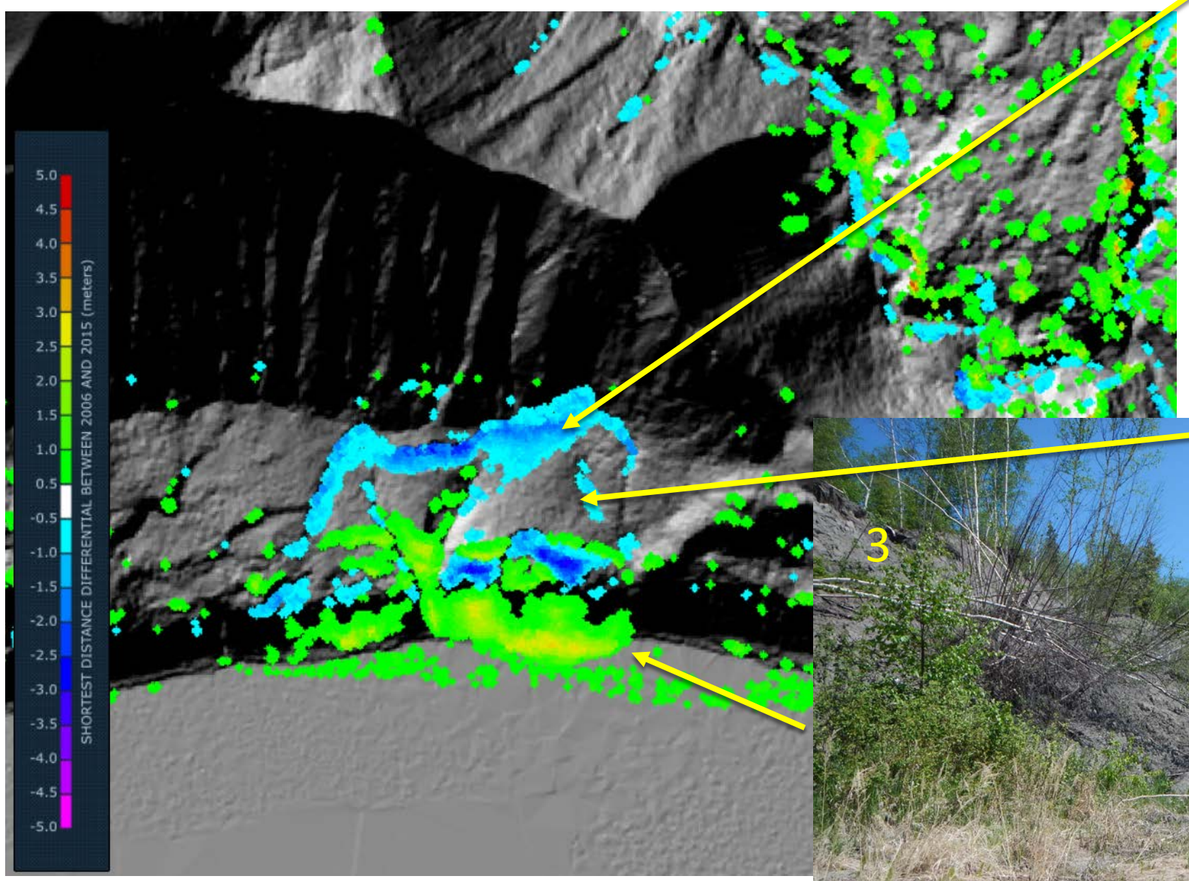
Field Verification



Field verification of areas of change

1. Headscarp
2. Central zone, translational movement
3. Toe bulge

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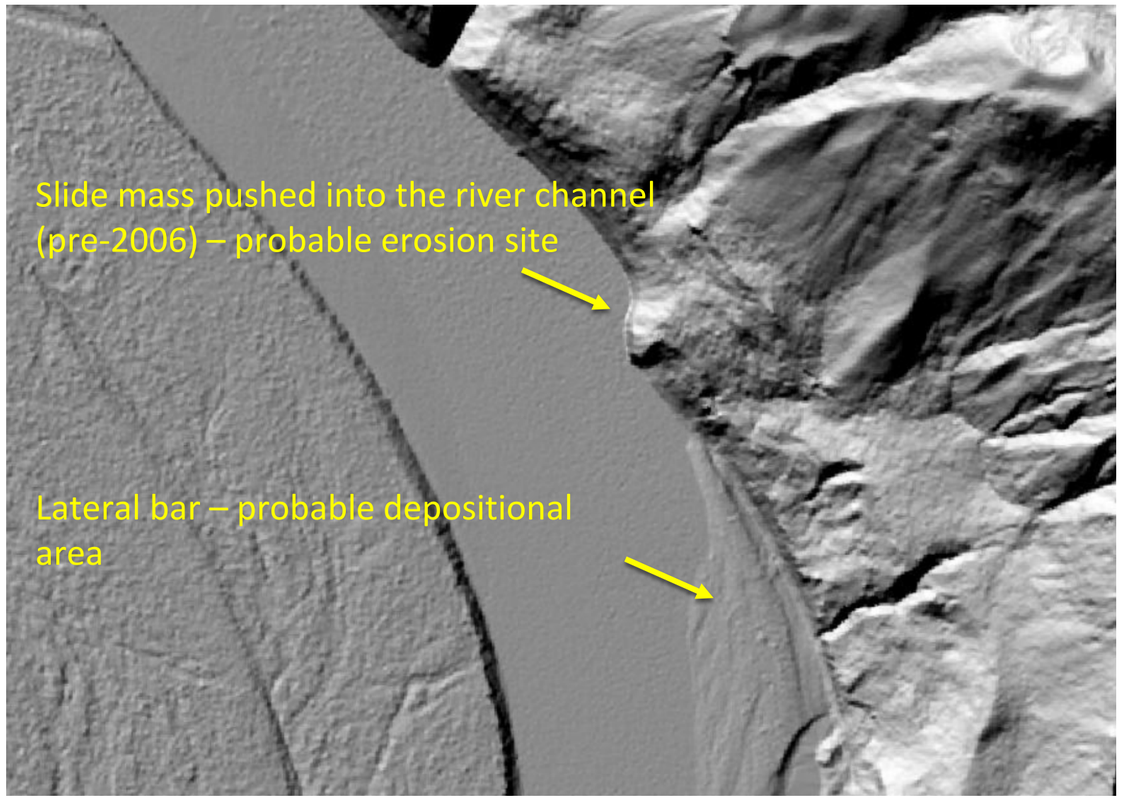
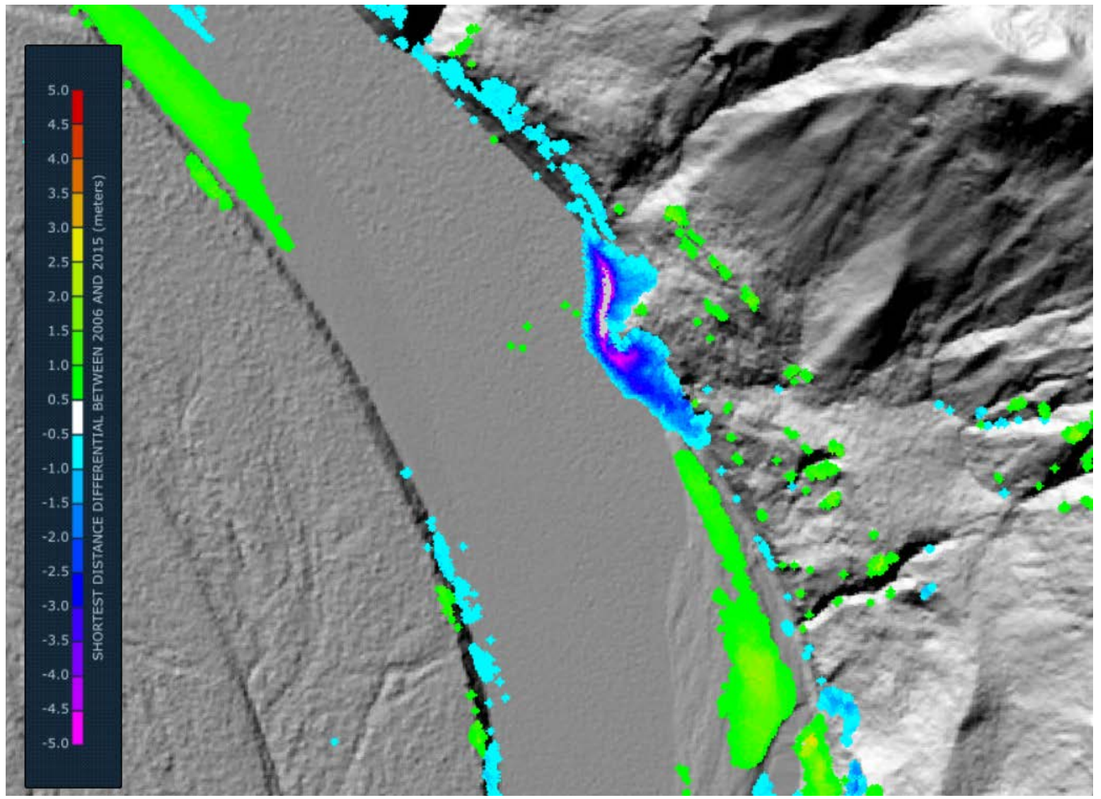
Detection of Erosion Areas

2015 ALS Data



2006 vs 2015 Change Detection



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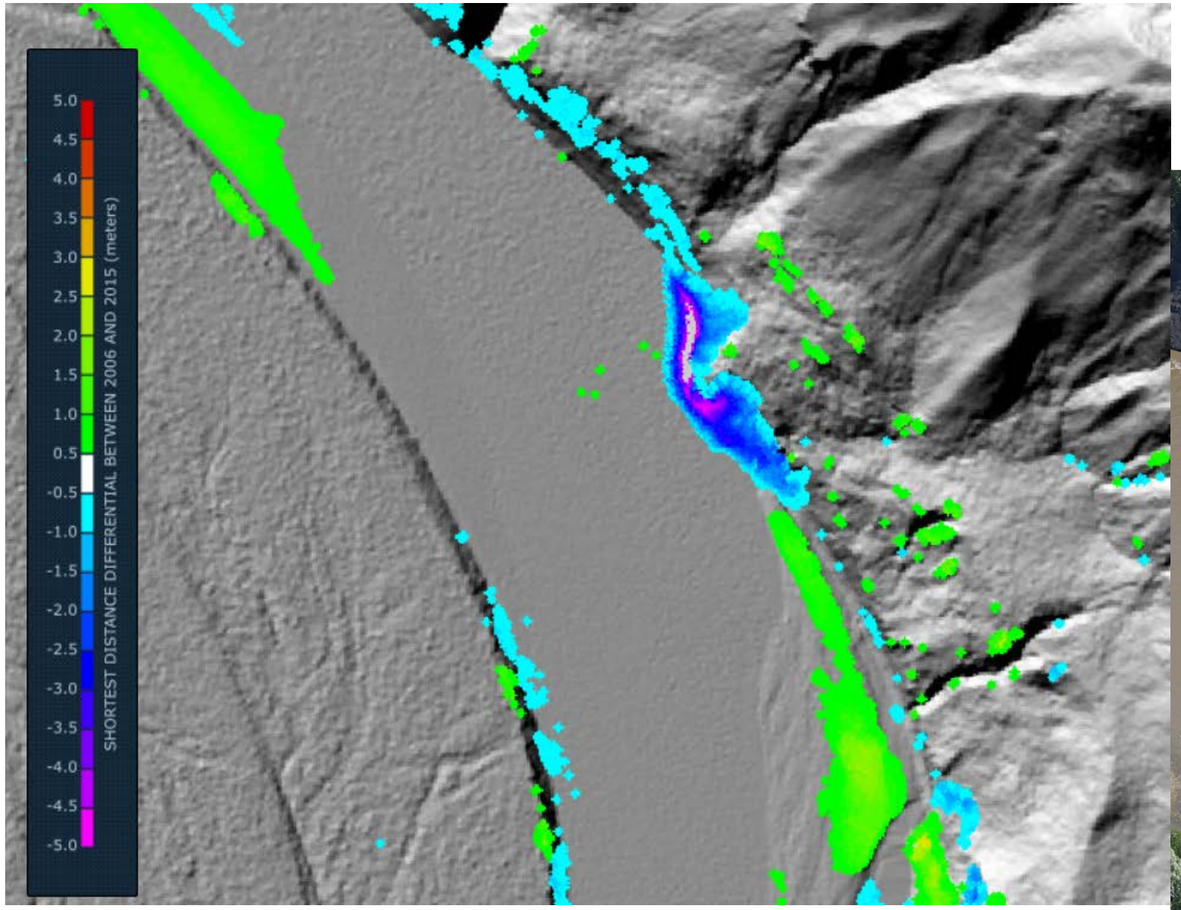
Field Verification



Exposed, steep slope indicating active erosion

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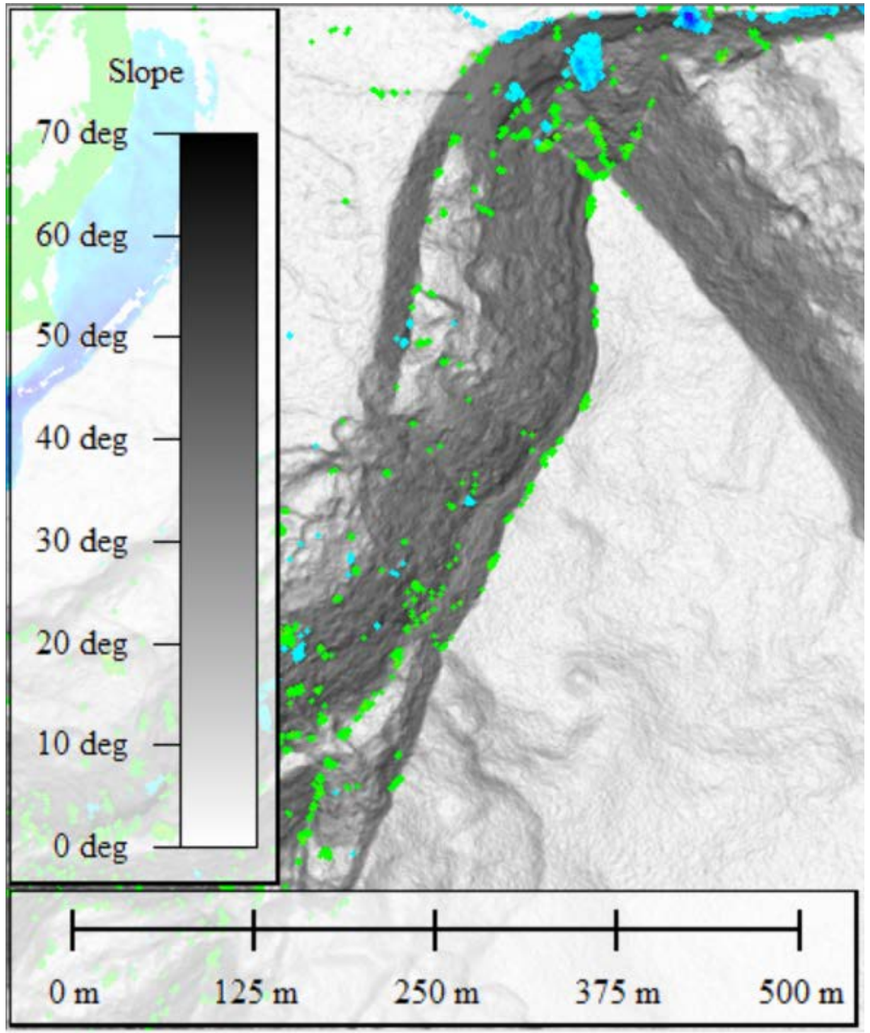
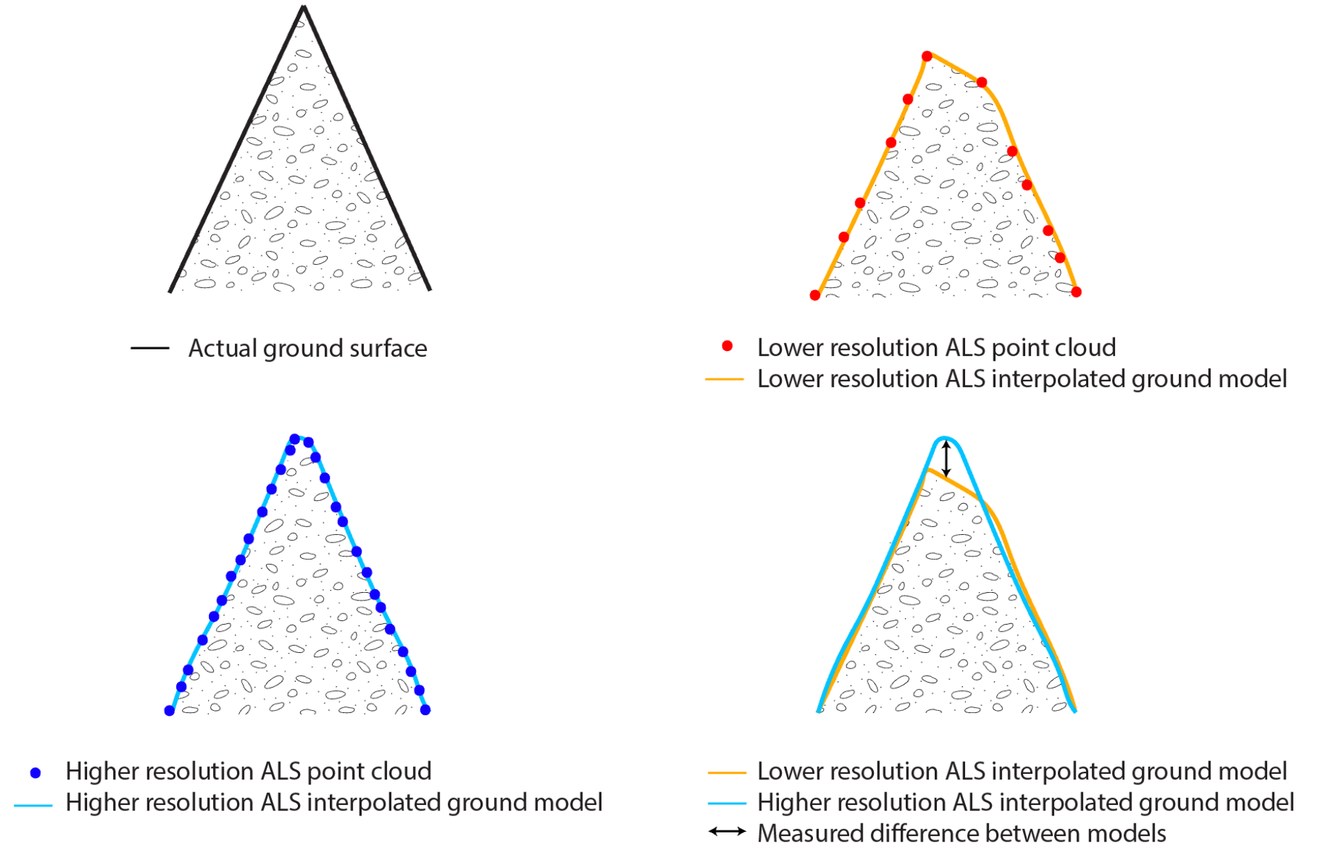
Spurious Change Detection Results





Apparent positive change can be detected when datasets with different Resolutions are used at features like ridge lines or gullies

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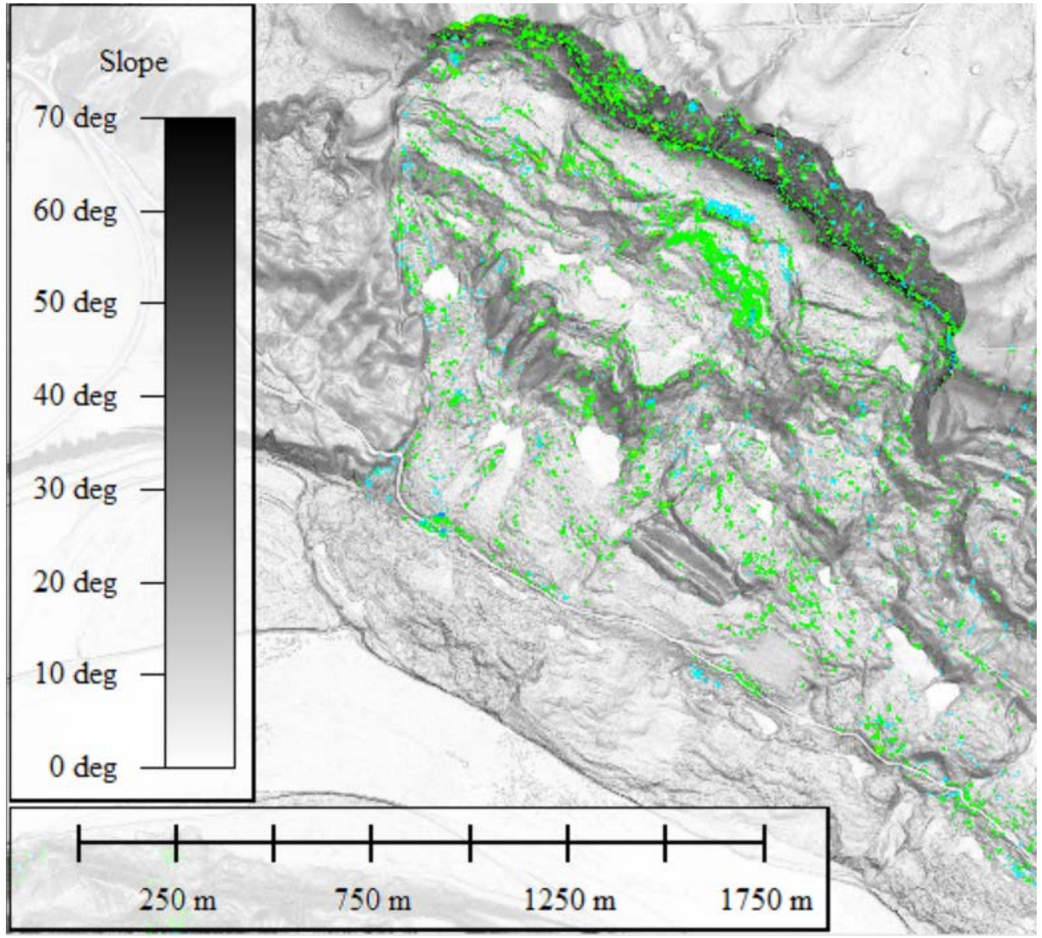
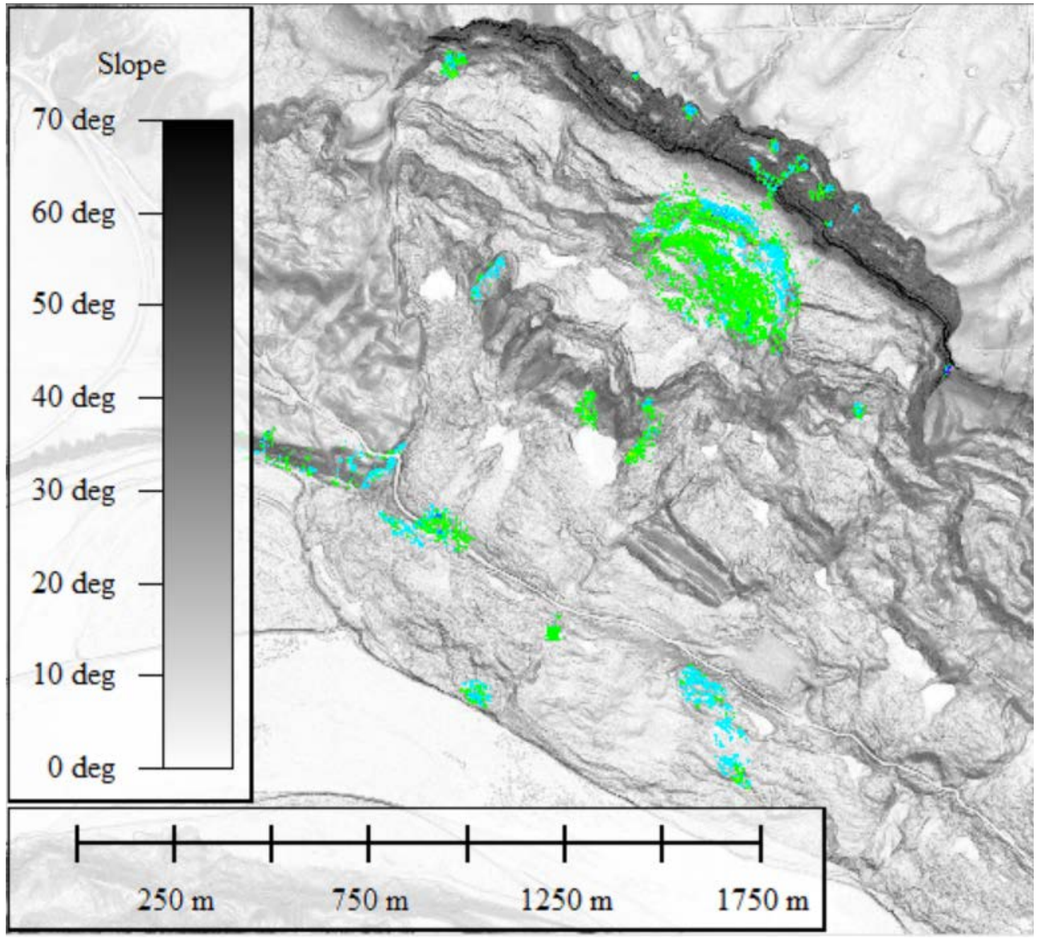
Refined Analysis

Initial results



Refined analysis



Select areas were re-aligned focusing on smaller areas to reduce the effects of spurious change, and better define areas of movement.

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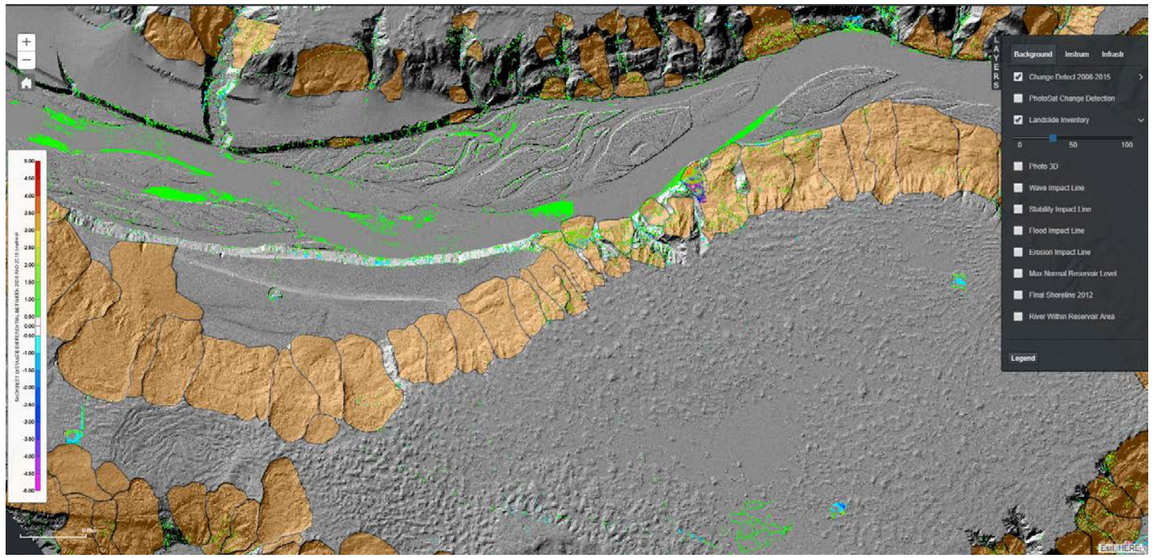
Web-based GIS data delivery

- This amount of spatial data needs an effective way to be communicated
  - Static maps can be used, but either a lot of maps need to be generated, or the results need to be down sampled
  - GIS software is effective, but not all end users have access to this

- Web-based GIS platform developed for this project
  - Project topographical and change detection results are stored on a secure server
  - Allows users without GIS software to view and interact with the data – a web browser, username and password are the only requirements
  - Other sources of data (other infrastructure, predicted project impacts, etc.) are also on the server and can be overlain on the data



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