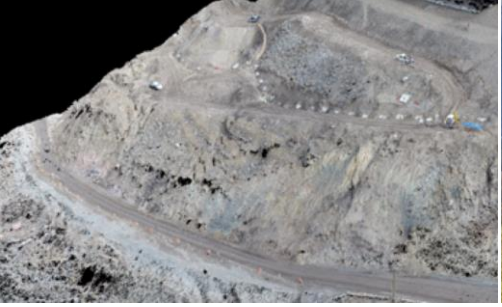
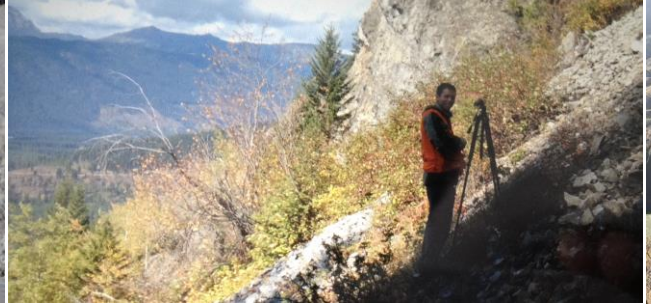

Movement Monitoring Technologies: case studies - University of Alberta

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Industrial Professor
School of Engineering Safety and Risk Management, University of Alberta

Geotechnical Engineer
Klohn Crippen Berger

Content

- Overview of the technologies being used at the UofA
- Applications illustrated through Case studies:
  - 10-mile Slide
  - Checkerboard Creek rock slope
  - Ripley Slide and the Thompson River Valley Landslides
  - Tornado Mountain and Block 739

Monitoring technologies

List of (new) technologies being used at the UofA in the last 5 years

<u>Remote:</u>

- Radar Interferometry (satellite and ground-based)
- LiDAR and change detection (ALS and TLS)
- Photogrammetry (ground-based and UAV)

<u>In ground:</u>

- SAA and geocube systems
- Waveguide system
- continuous ERT monitoring (not displacement)

Monitoring technologies

Equipment and capacity at the UofA

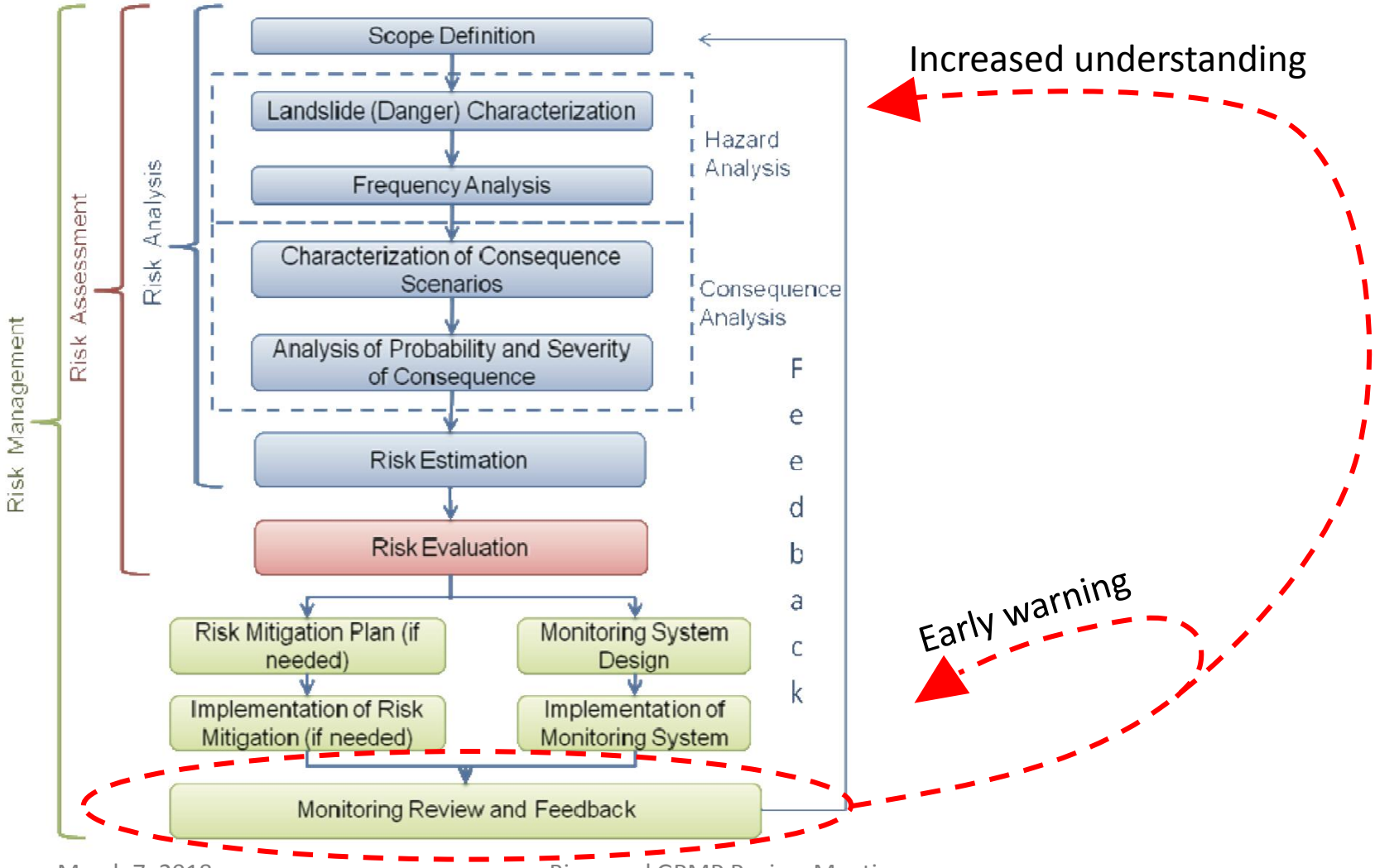
Remote:

- Radar Interferometry (satellite) – Partnership with TRE and UniFi
- **Radar Interferometry (ground-based) – UofA system and AGS system**
- **LiDAR and change detection (UofA - Optech 3km range**). ALS would need to buy the images
- **Photogrammetry (ground-based with DSLR and UAV with a small Phantom 4)**

In ground:

- **SAA – Have the expertise and we have a couple of systems (I think)**
- **Geocube system – have the knowhow, requires purchase**
- Waveguide system – new technology for early warning (out of UK)
- continuous ERT monitoring (not displacement) - new technology for early warning (out of UK)

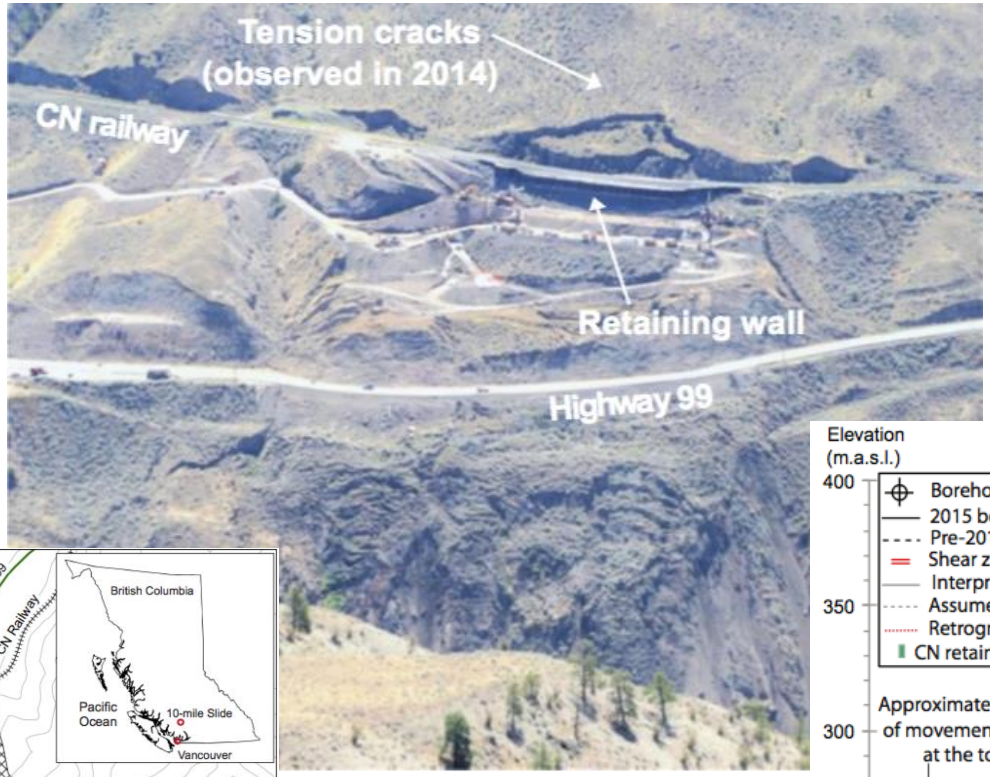
Monitoring technologies for GRM



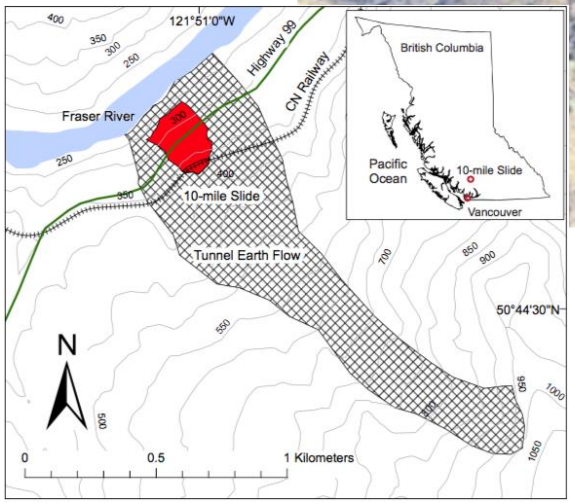
Case Studies: 10-mile Slide

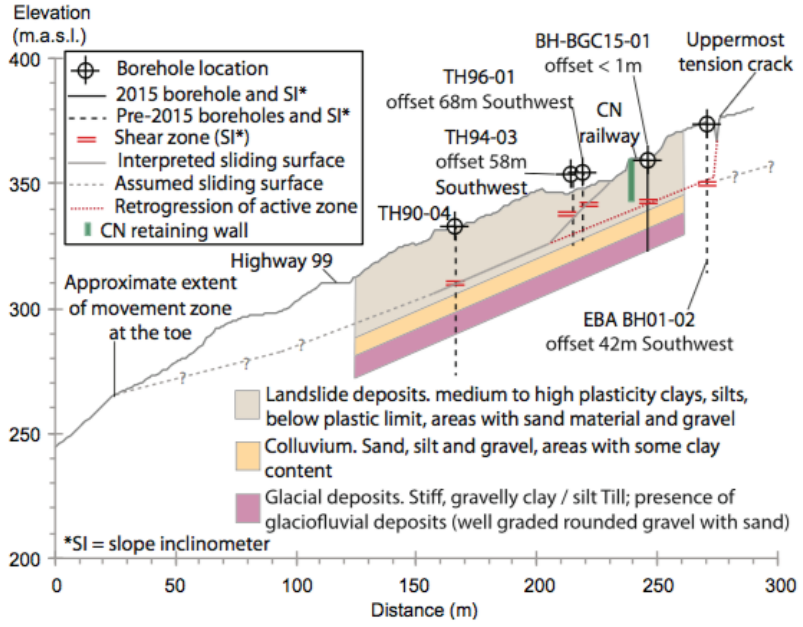
10-mile Slide

Case Studies: 10-mile Slide



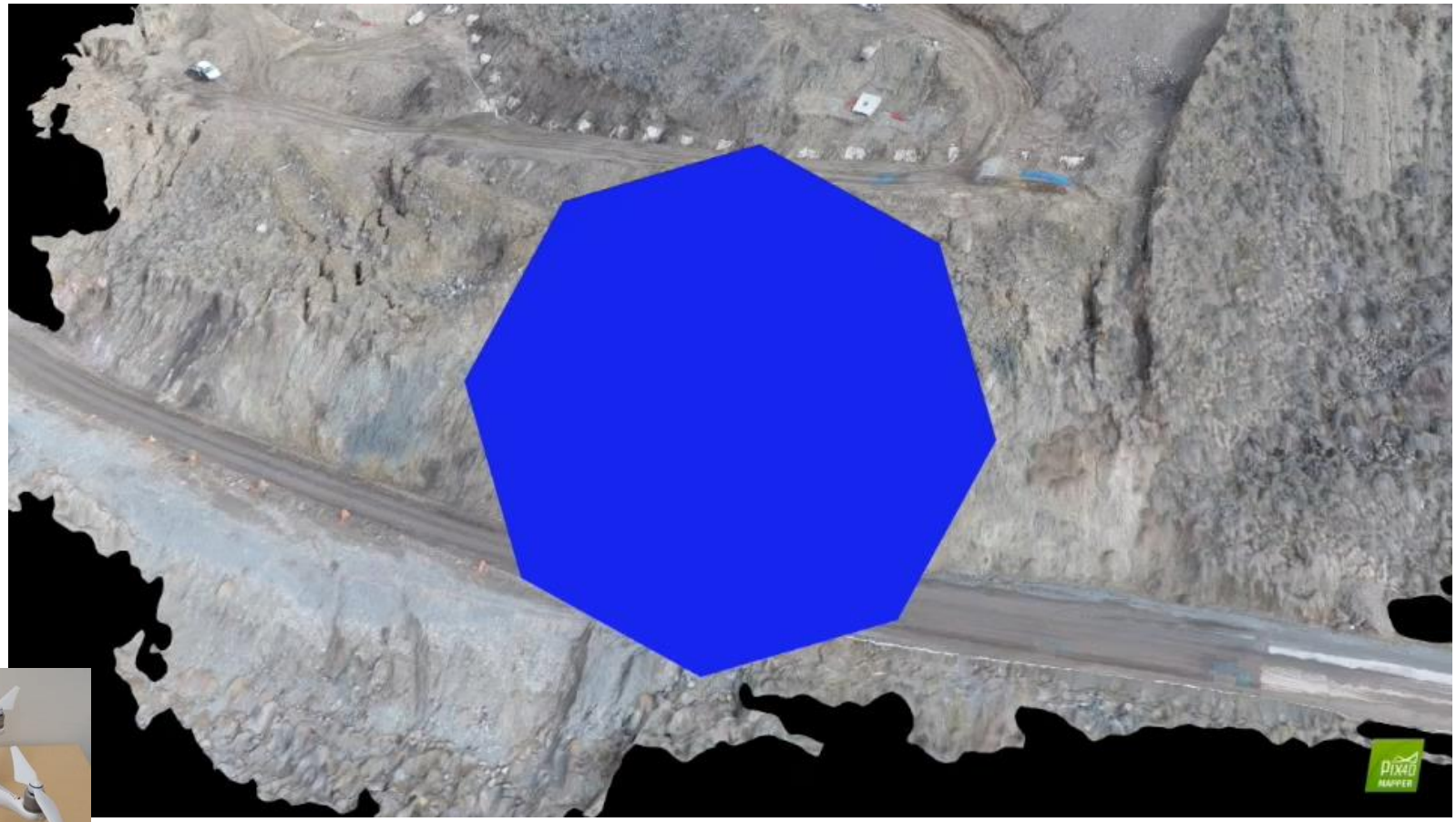
Location





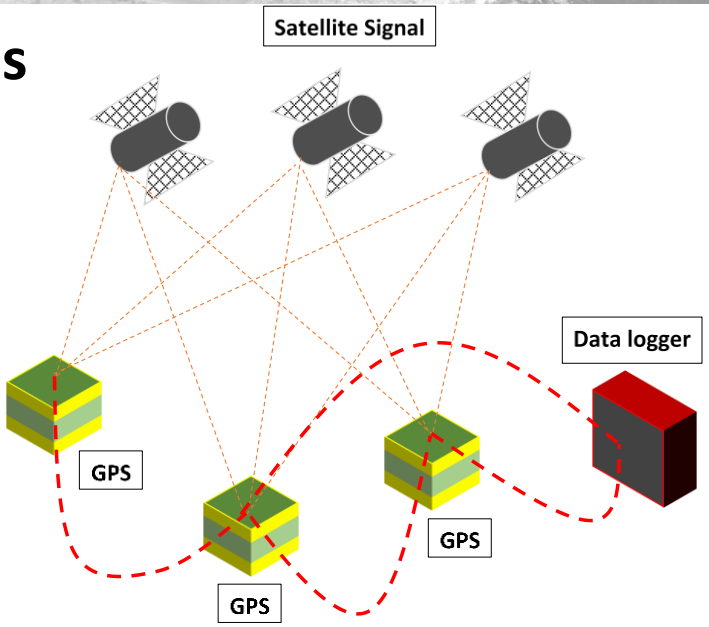
Case Studies: 10-mile Slide

UAV model



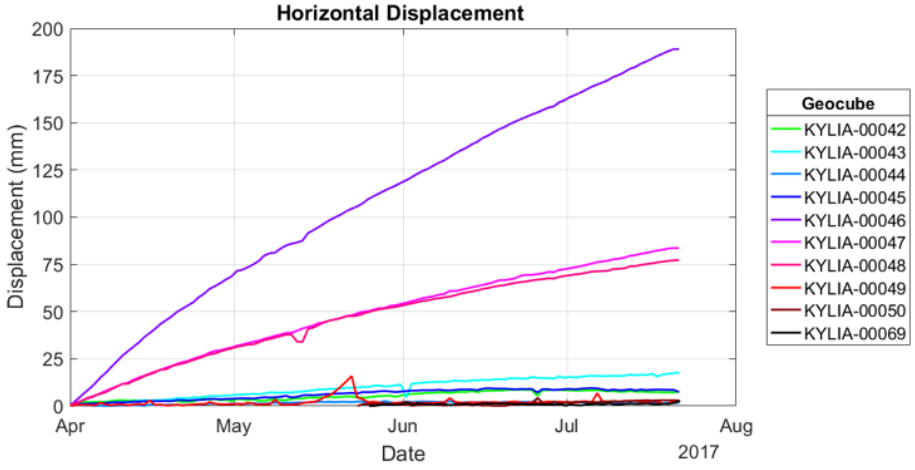
Case Studies: 10-mile Slide

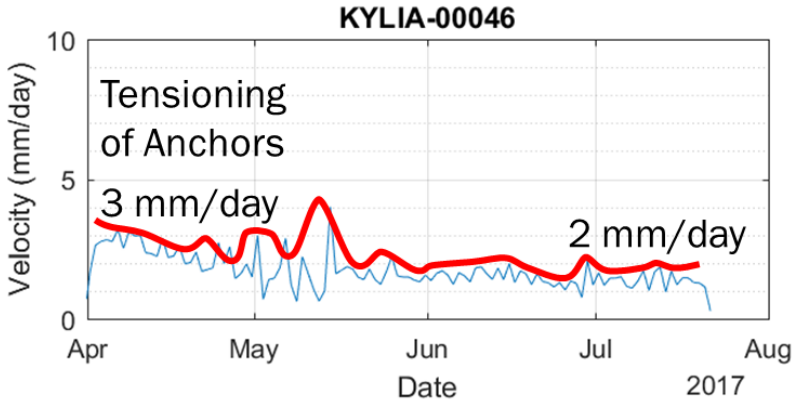
Geocubes

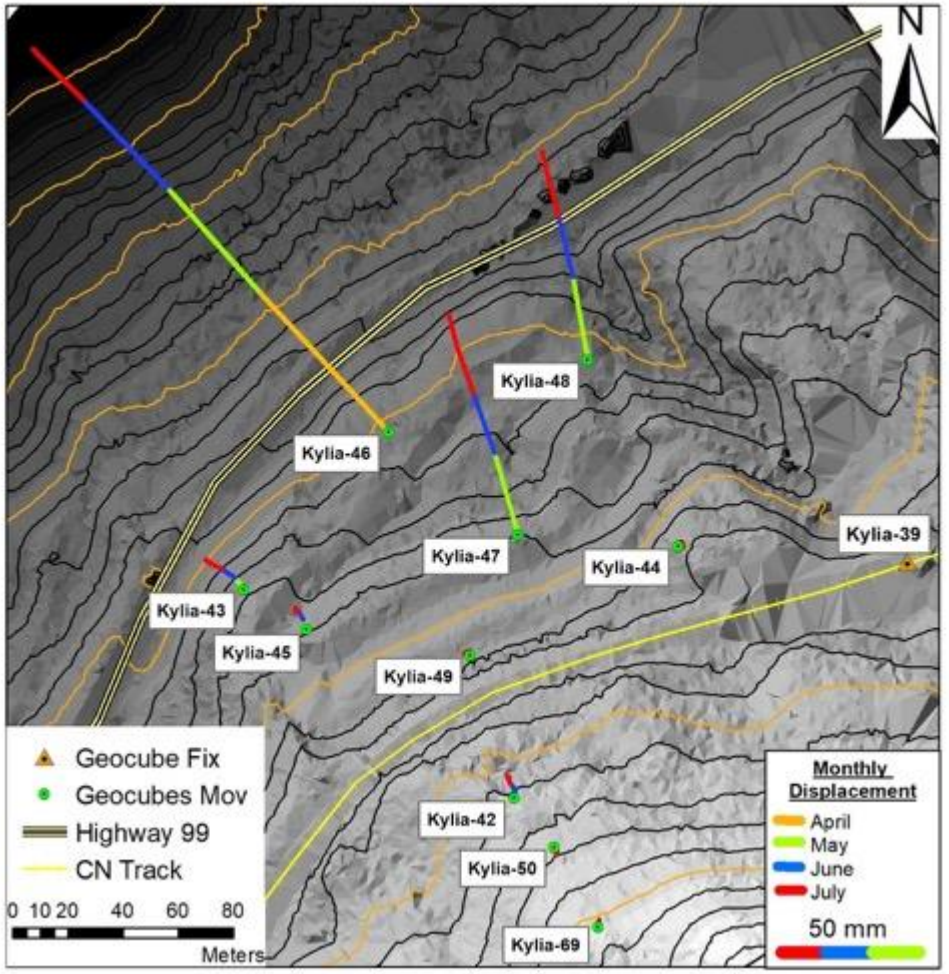


Case Studies: 10-mile Slide

Geocubes

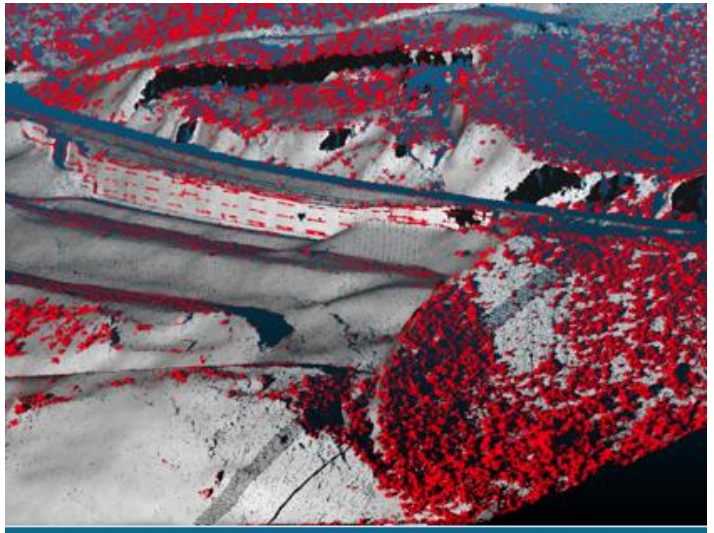


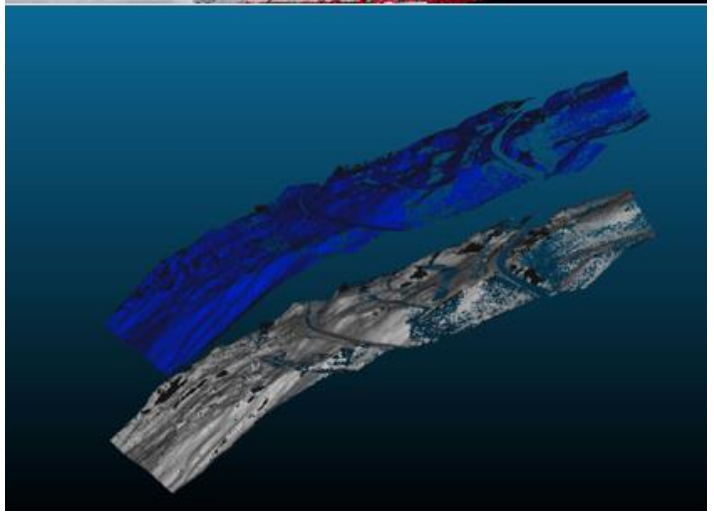




Case Studies: 10-mile Slide

TLS – Change detection



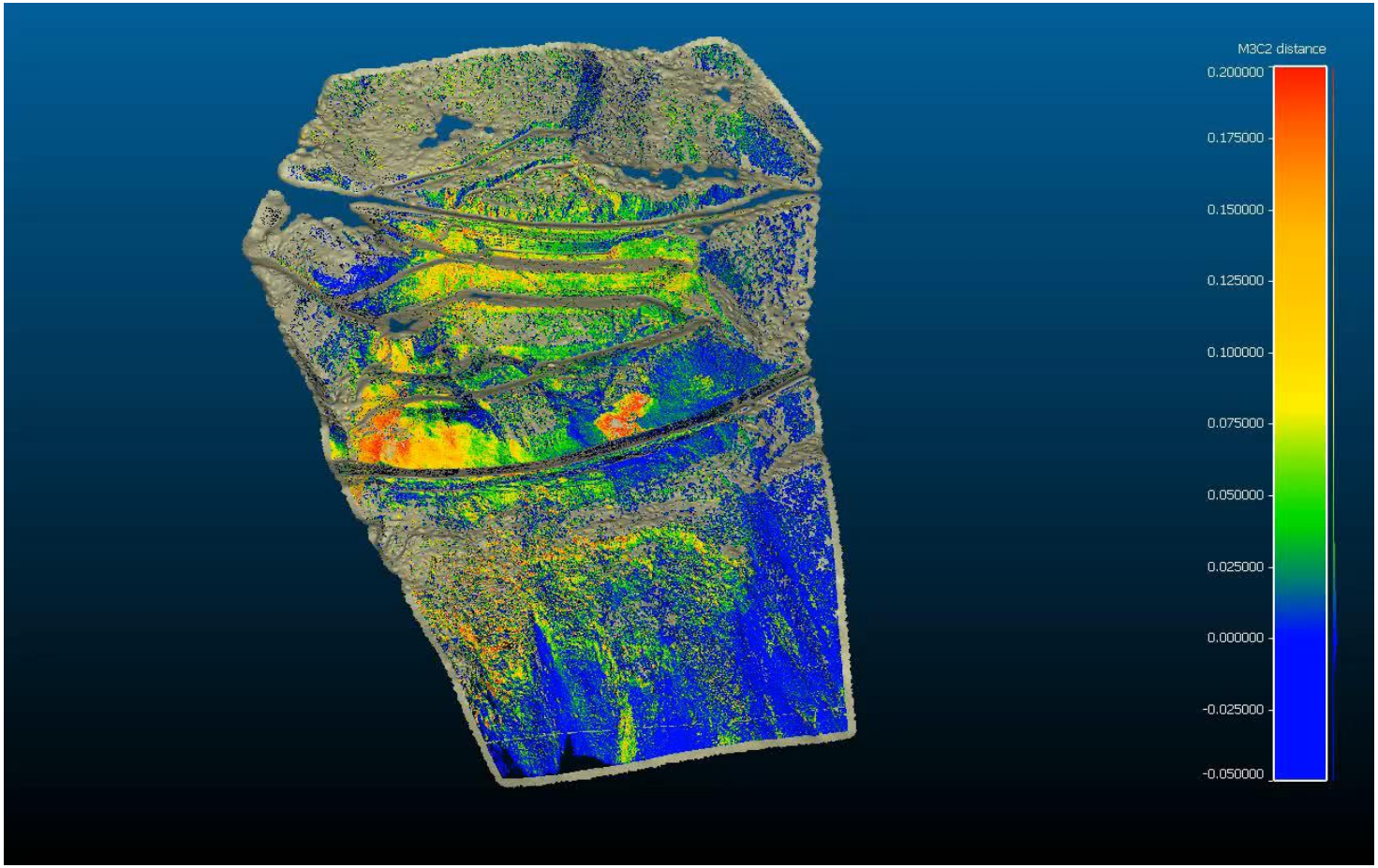


- Weather (Rain, Sunlight, dust, temperature)
- Vegetation, snow, external objects
- Distance
- Rate of movement
- Stable areas or Shot coordinates
- Batteries/Generator
- Shadows

SURVEY Plan
- Location
- Time
- Frequency of Scan

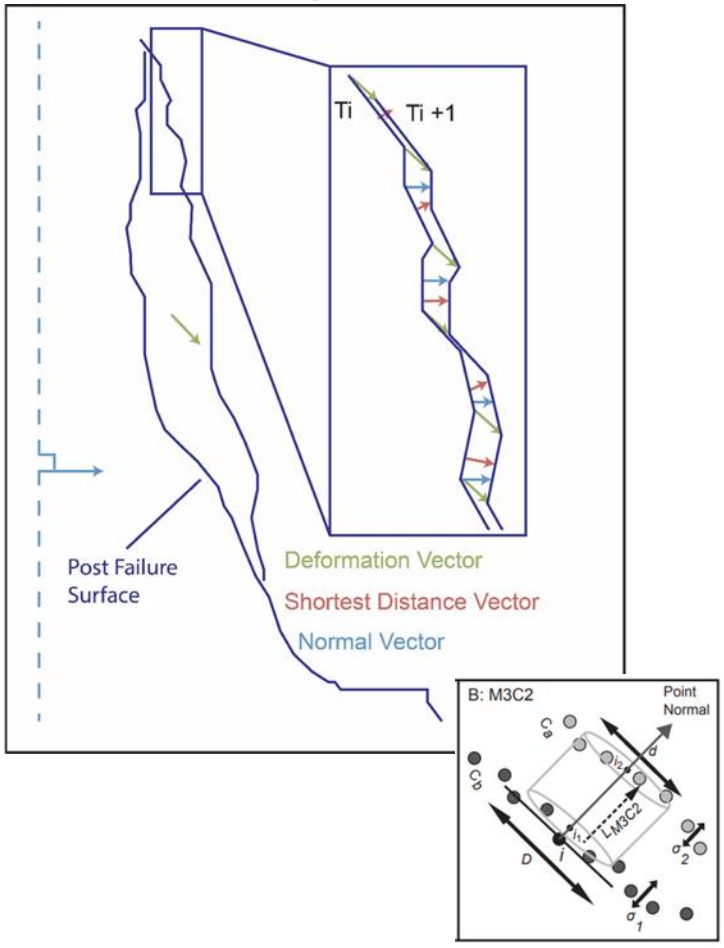
Case Studies: 10-mile Slide

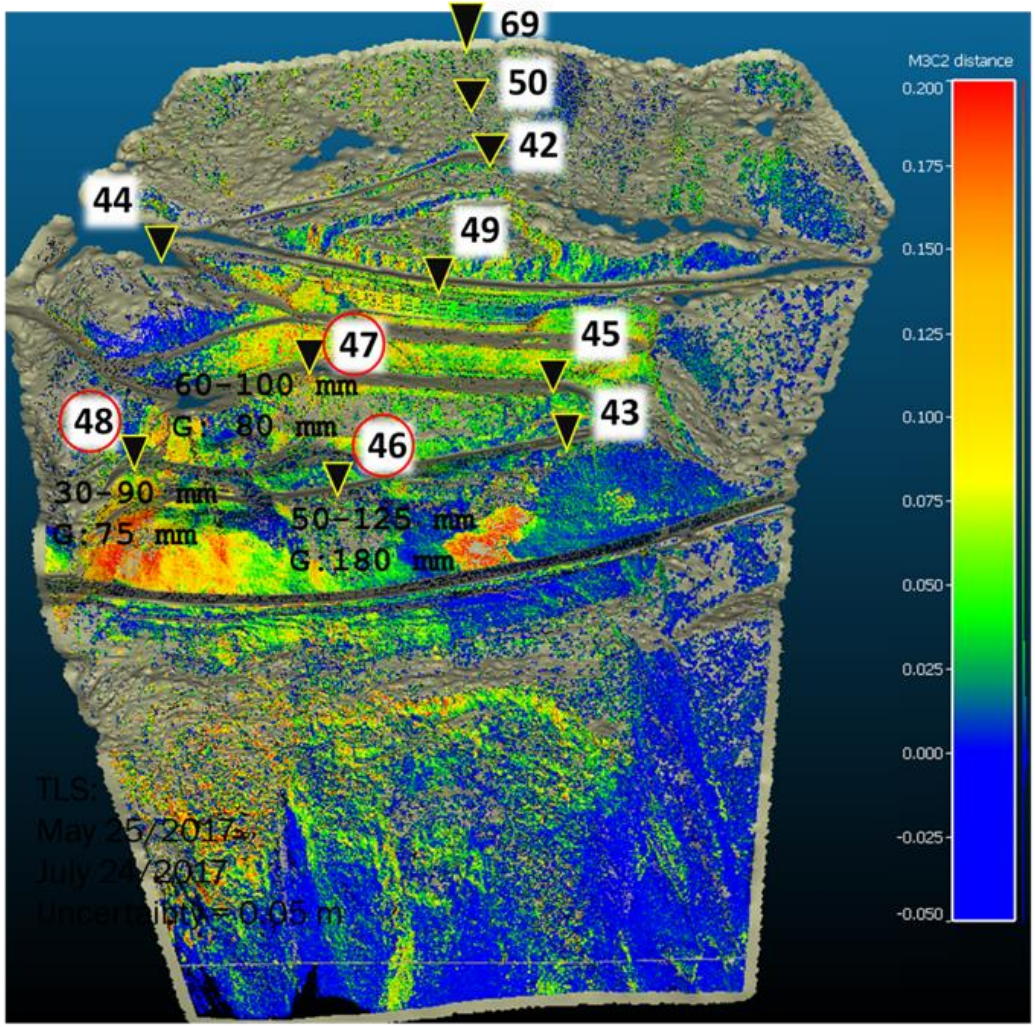
TLS – Change detection



Case Studies: 10-mile Slide

TLS – Change detection

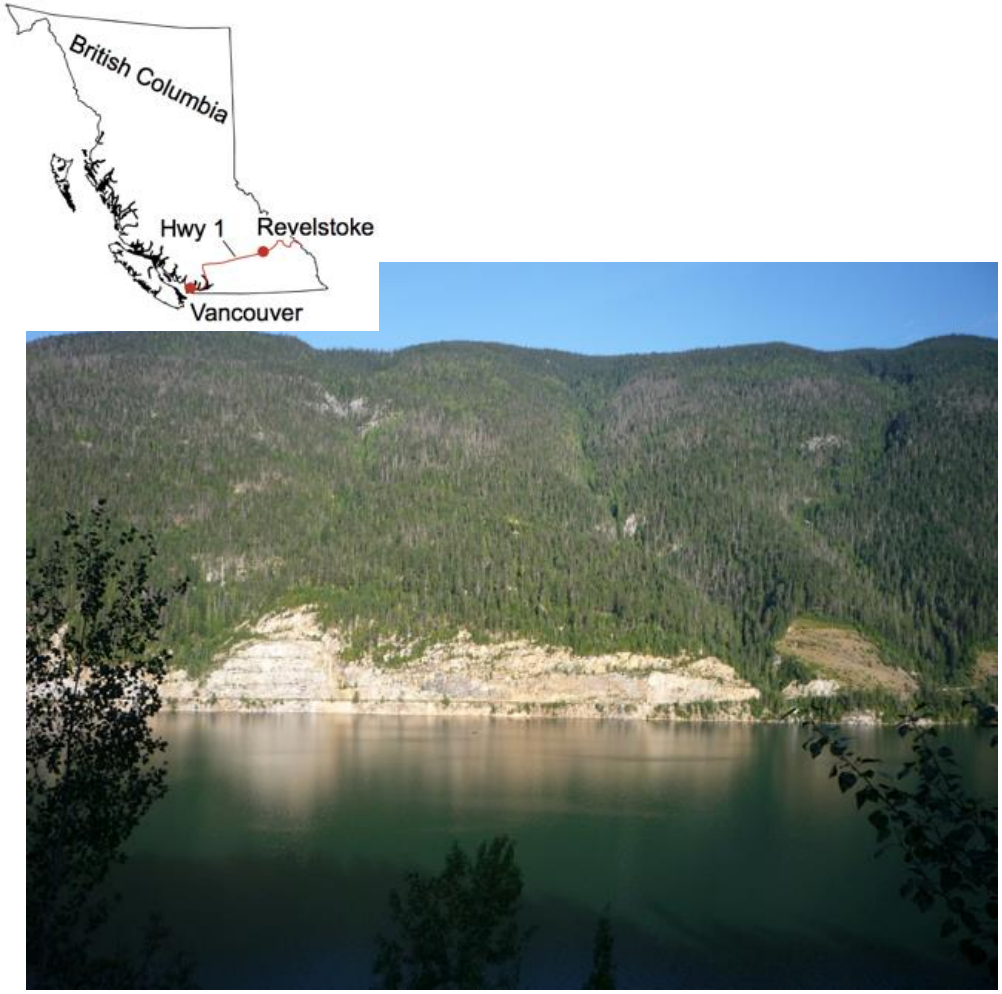




Case Studies: Checkerboard Creek

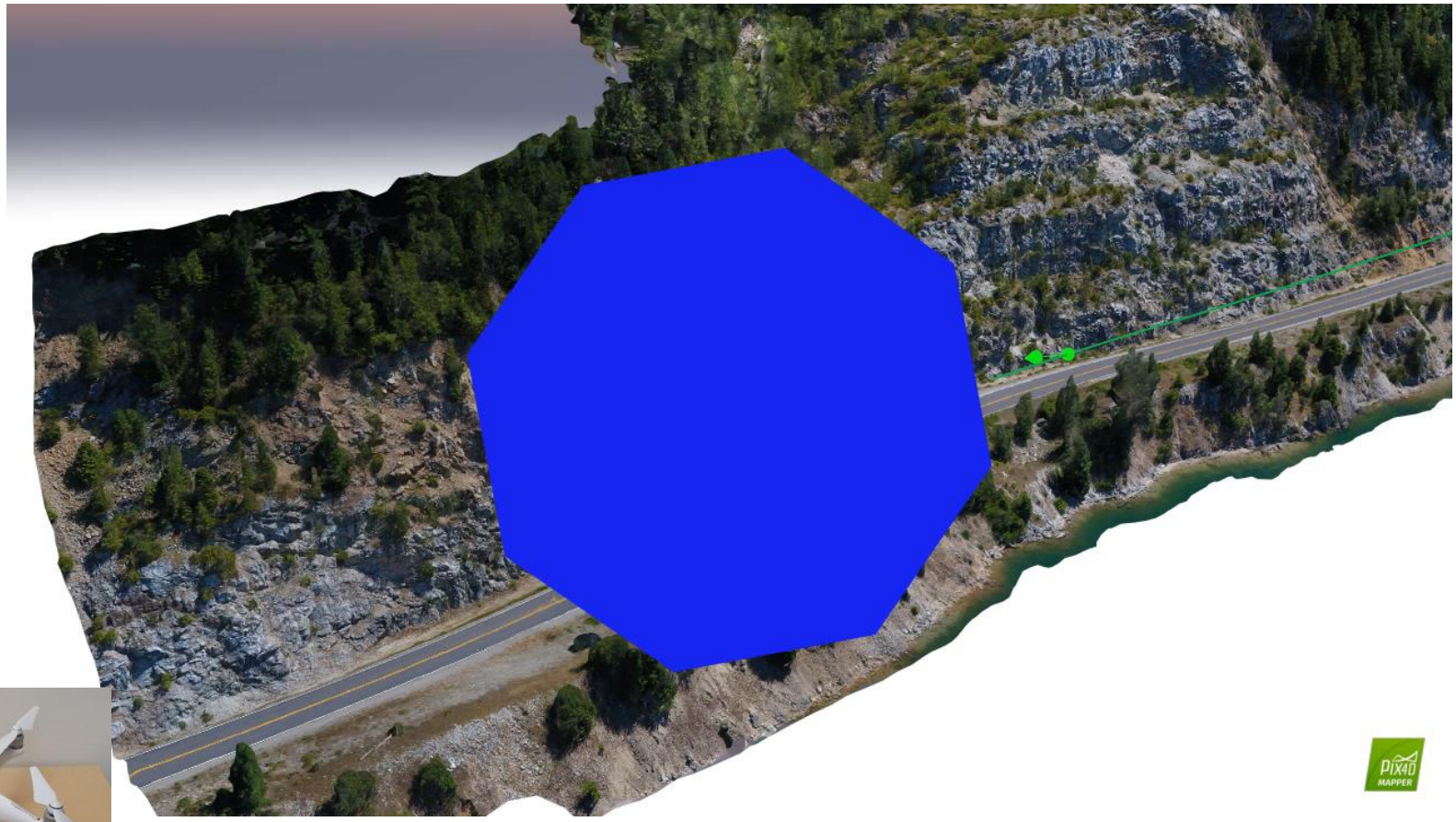
Checkerboard Creek

Case Studies: Checkerboard Creek



Case Studies: Checkerboard Creek

UAV model



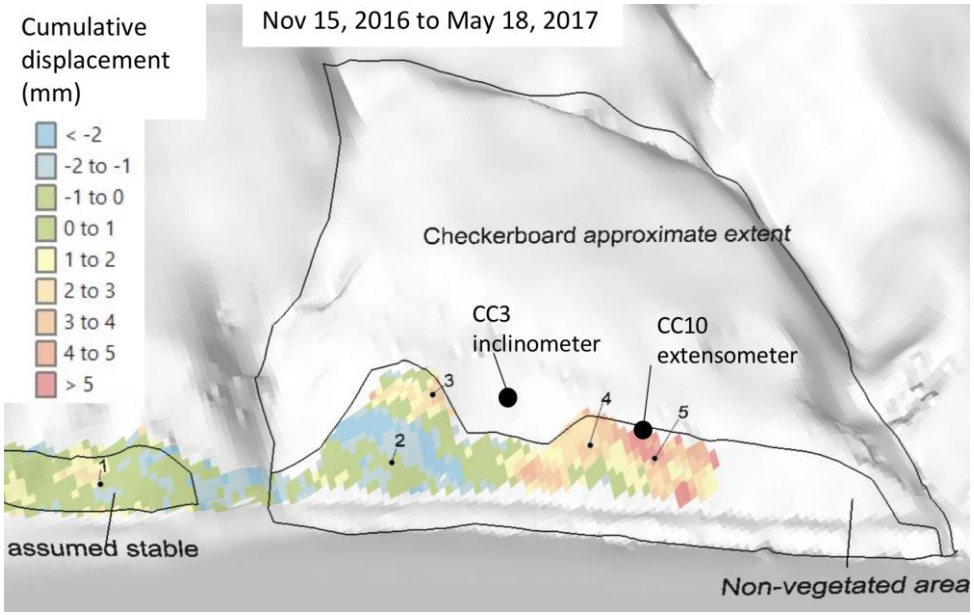
Case Studies: Checkerboard Creek

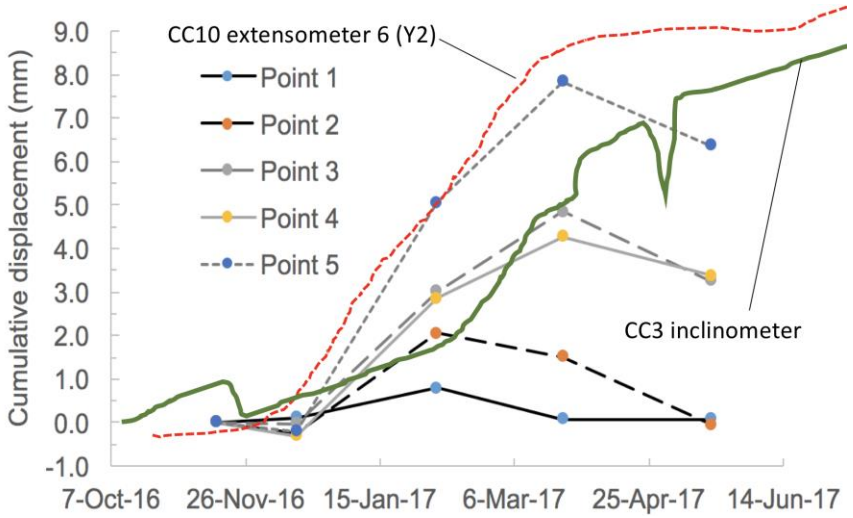
GB-InSAR

Three (parallel) double battery (series) packs for 300a 24v
Two 260 watt solar panels
System consumes 2.2 – 4.4 ah …
However there's no sunlight!

Case Studies: Checkerboard Creek

GB-InSAR

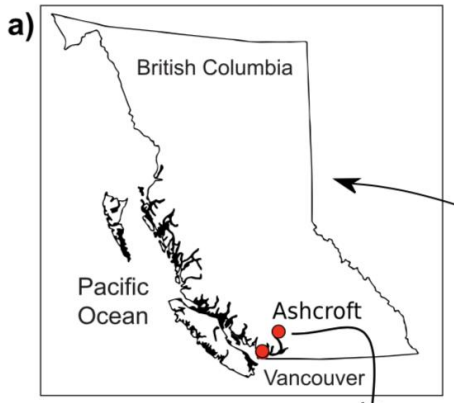


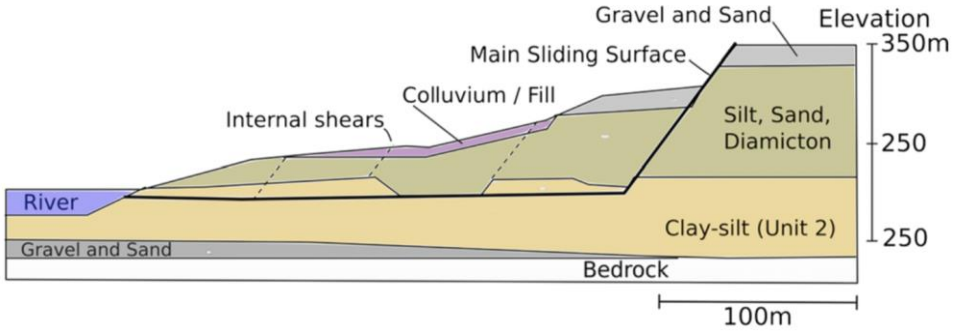


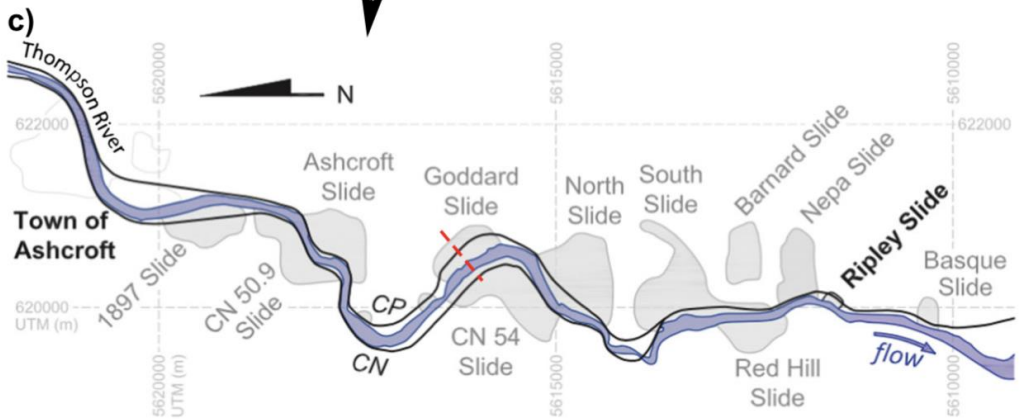
Case Studies: Ripley Slide and Thompson River Valley Landslides

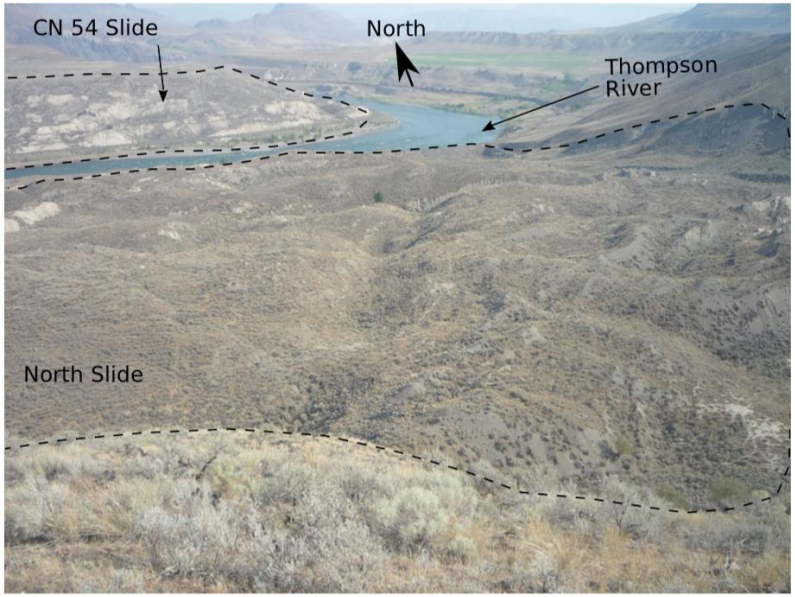
Ripley Slide and Thompson River Valley Landslides

Case Studies: Ripley Slide and Thompson River Valley Landslides

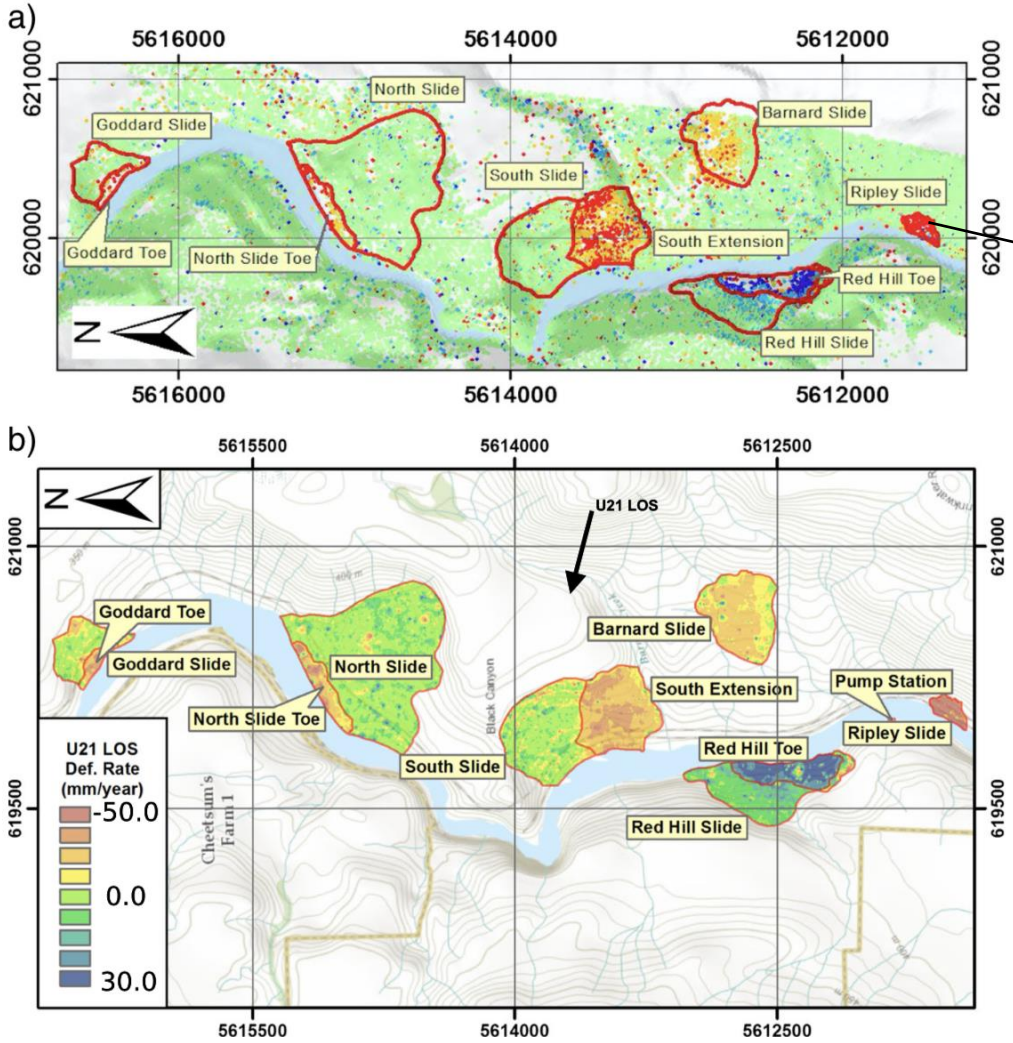




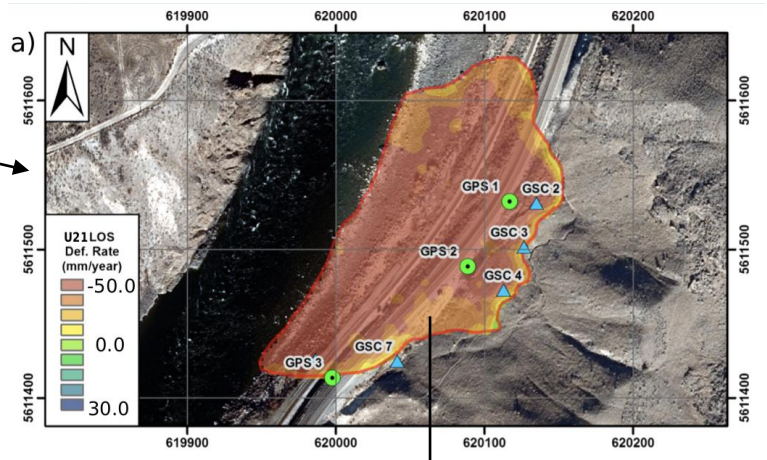


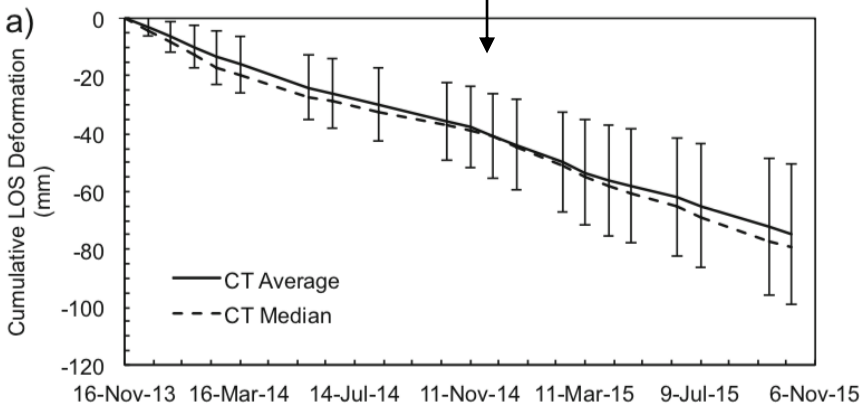


Case Studies: Ripley Slide and Thompson River Valley Landslides



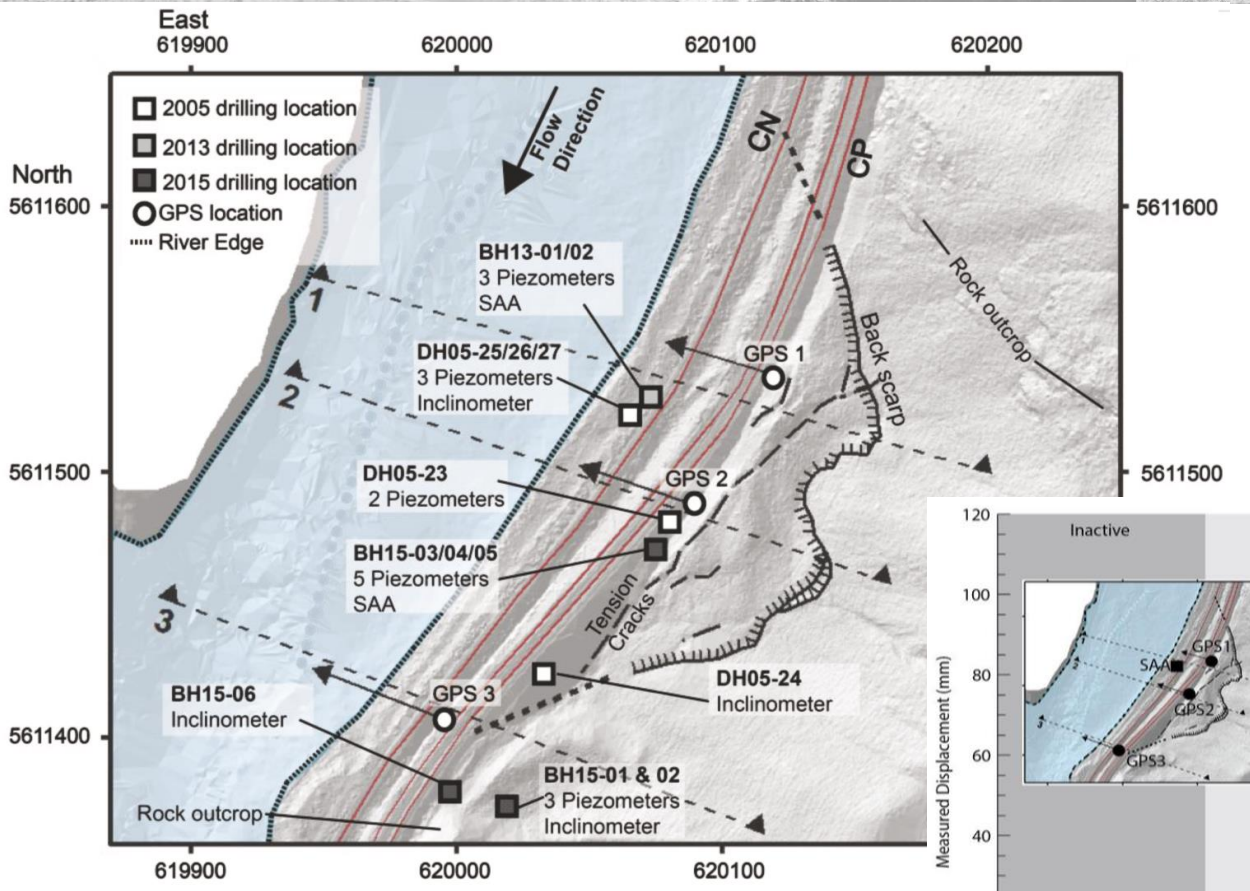
Satellite InSAR



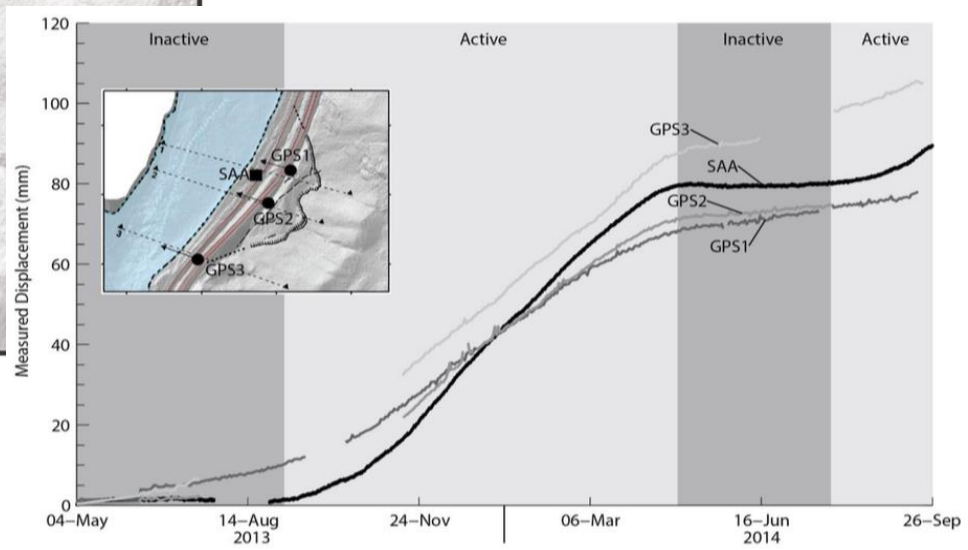


Case Studies: Ripley Slide and Thompson River Valley Landslides

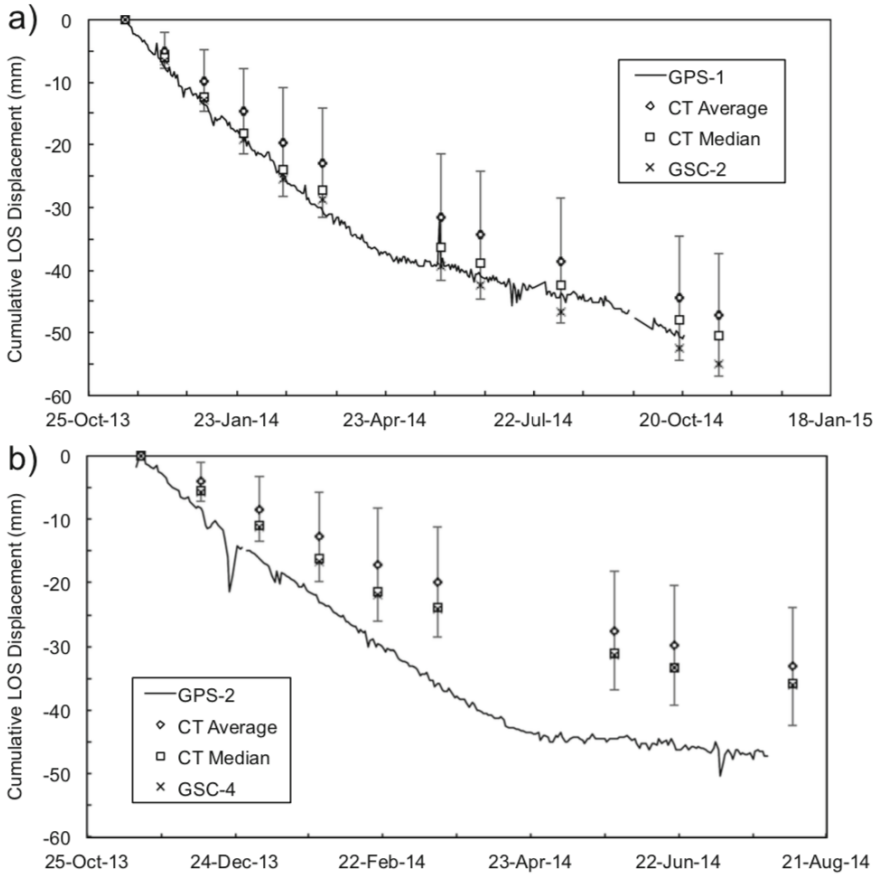
Ground instrumentation



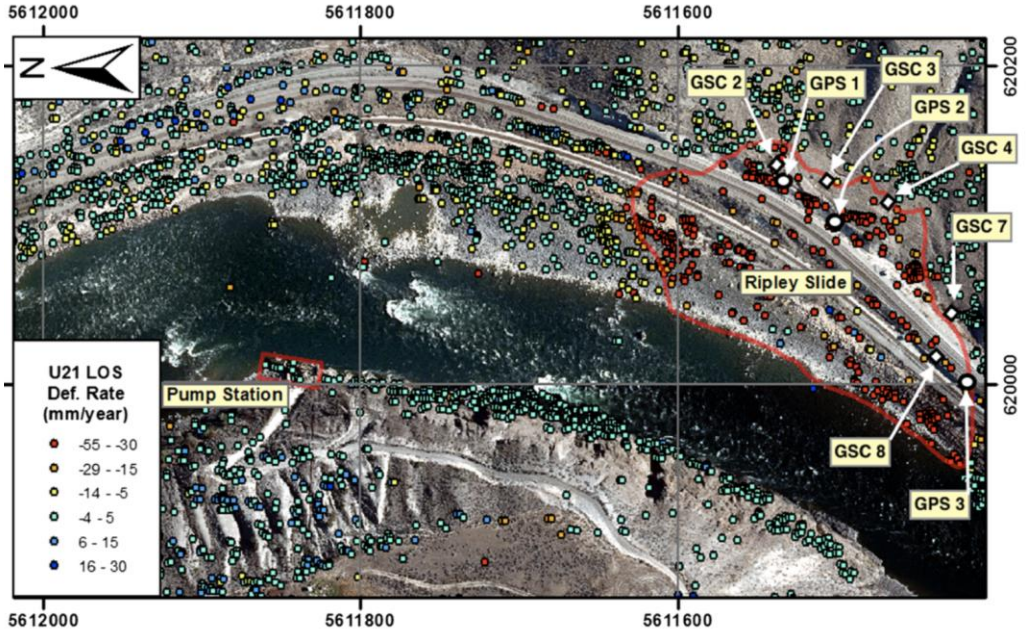
Base map = ALS



Case Studies: Ripley Slide and Thompson River Valley Landslides

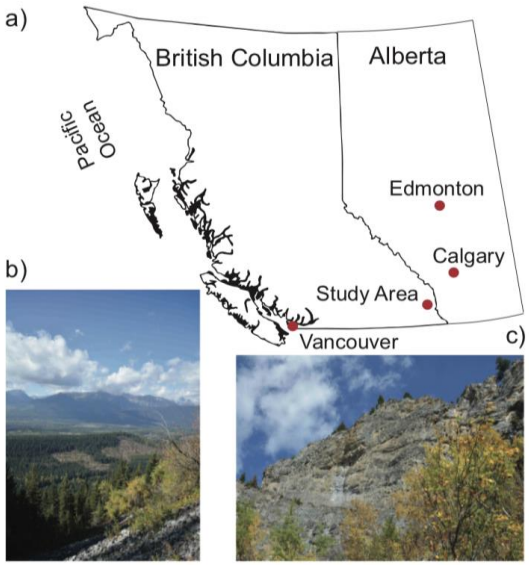


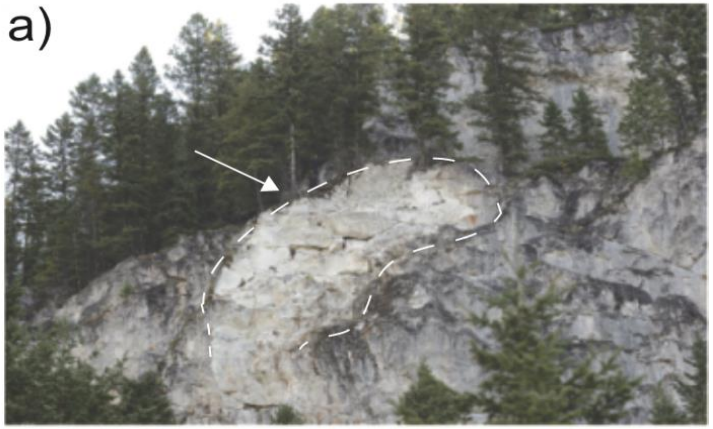
Ground instrumentation and InSAR

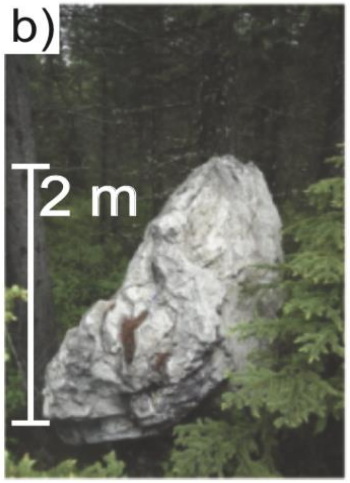


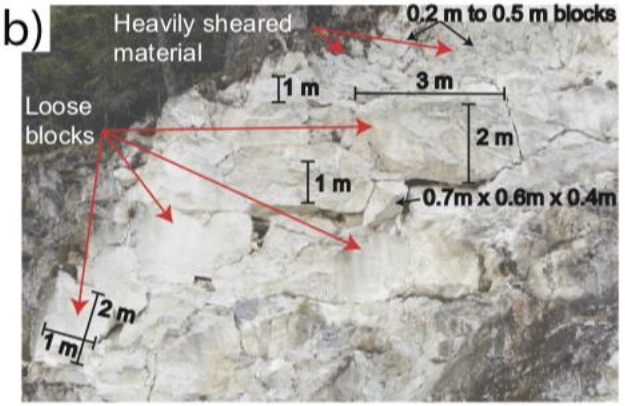
Photogrammetry for Structural Mapping

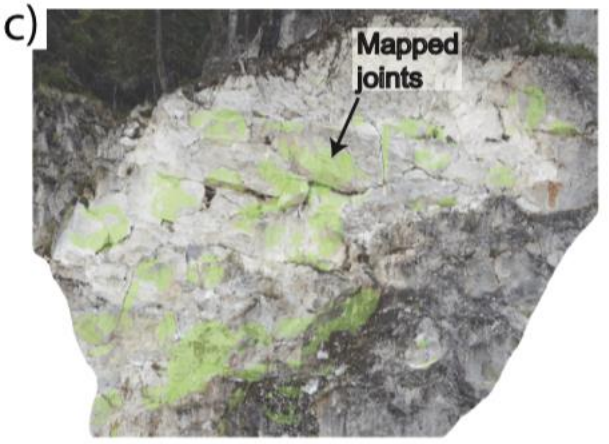
Photogrammetry for Structural Mapping – Tornado Mountain



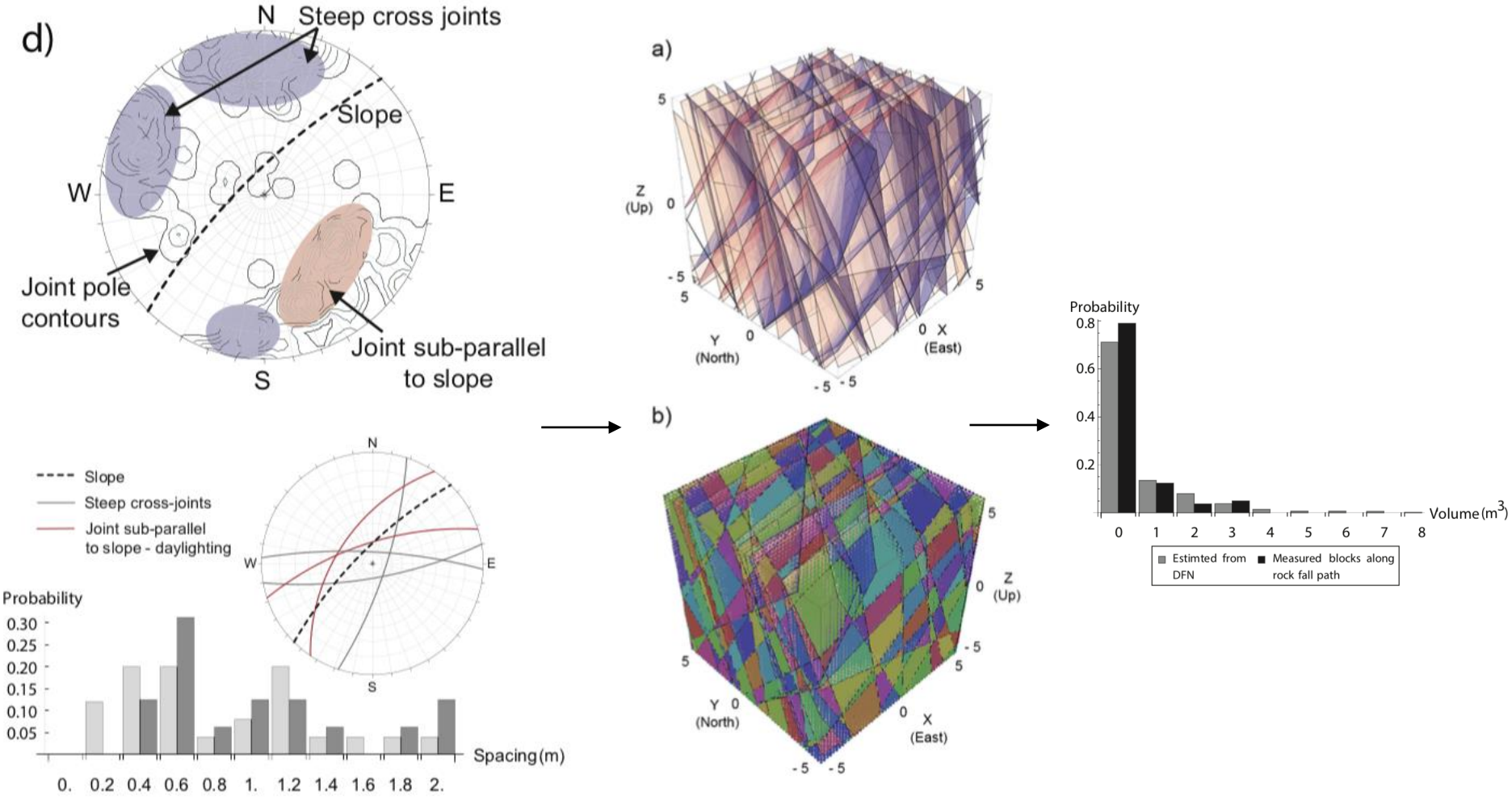




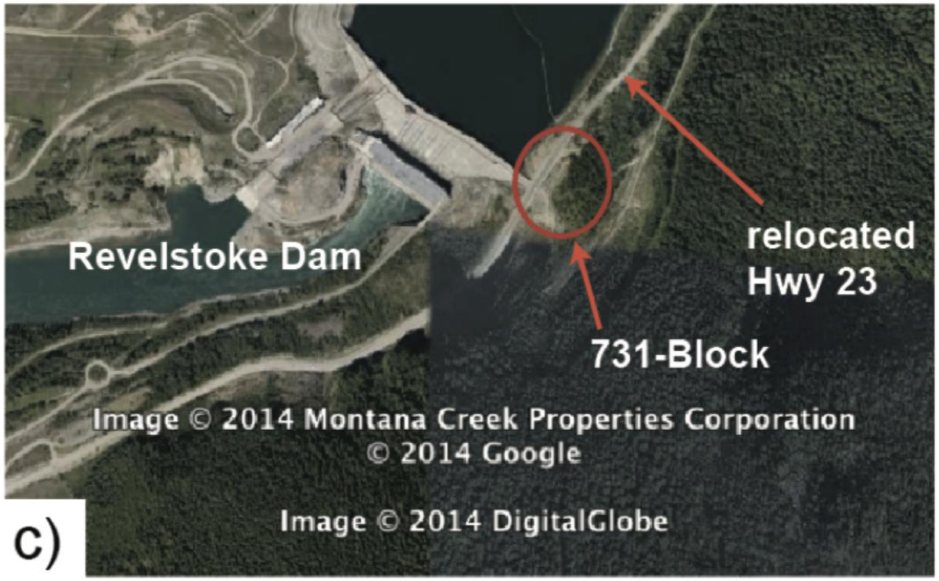


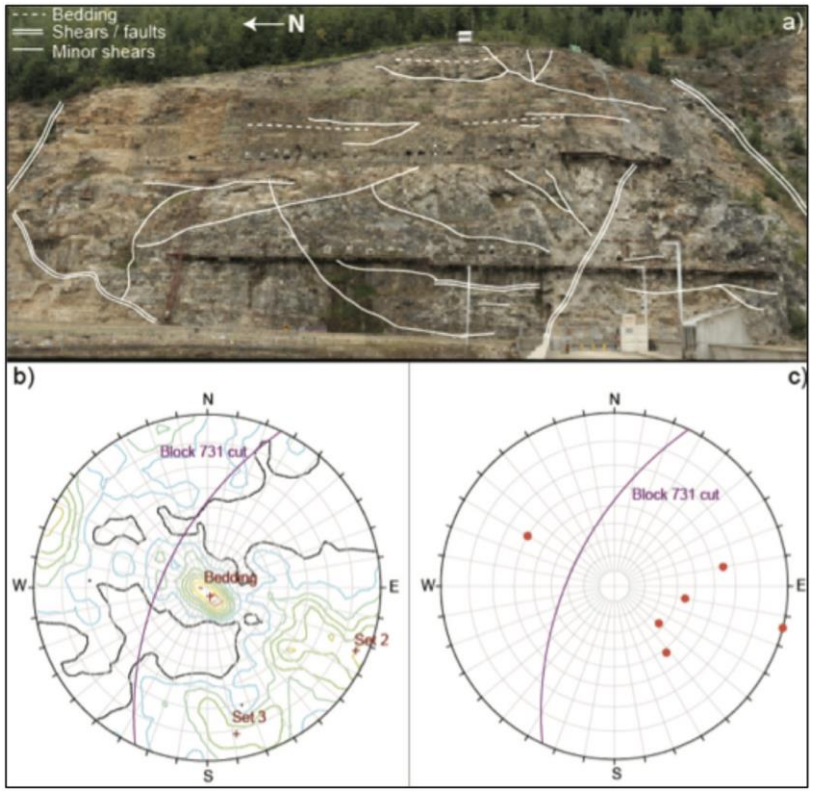


Photogrammetry for Structural Mapping – Tornado Mountain

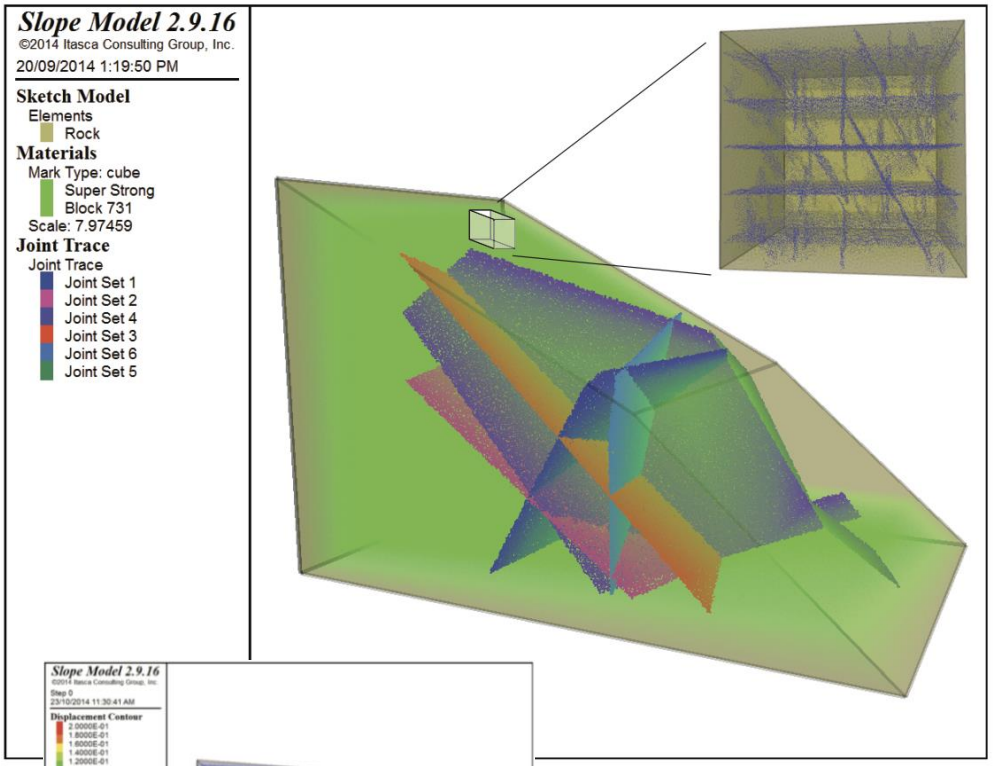


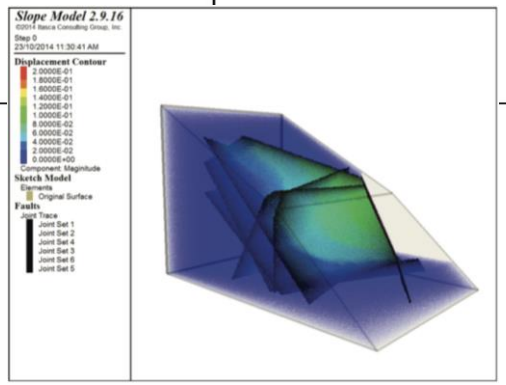
Photogrammetry for Structural Mapping – Block 731

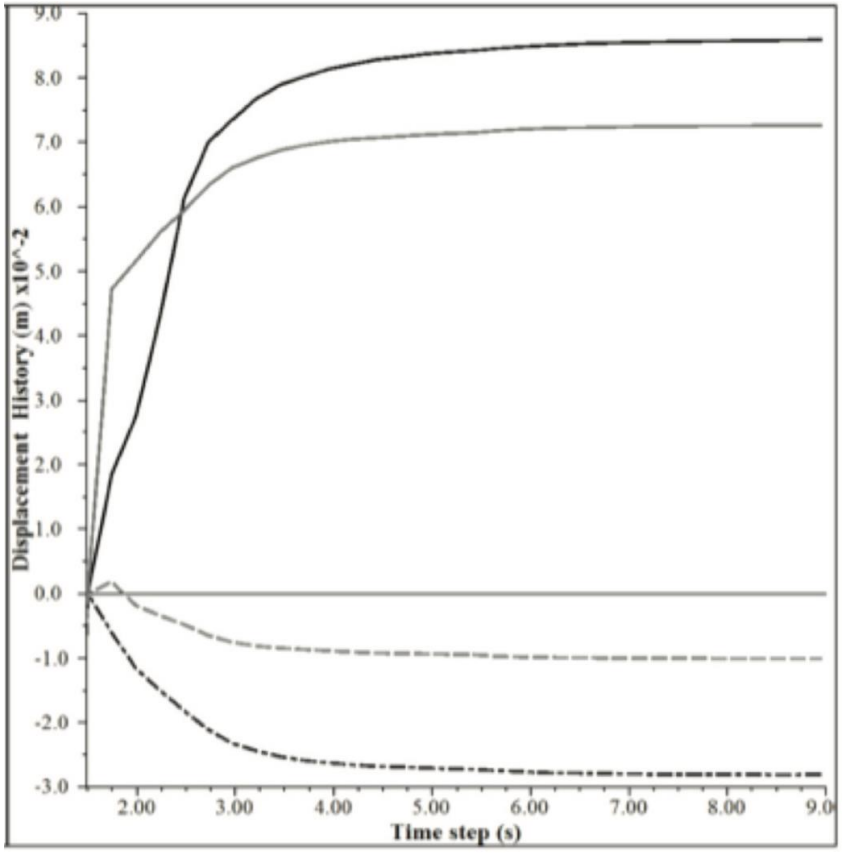




Photogrammetry for Structural Mapping – Block 731







Thank You

Journault, J., Macciotta, R., Hendry, M., Charbonneau, F., Huntley, D., Bobrowsky, P. 2017. Measuring displacements of the Thompson River valley landslides, south of Ashcroft, BC, Canada, using satellite InSAR. Landslides. Published online September 25, 2017. doi: 10.1007/s10346-017-0900-1

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Macciotta, R., Hendry, M., Martin, C.D. 2016. Developing an Early Warning System for a Very Slow Landslide Based on Displacement Monitoring. Natural Hazards 81: 887 doi:10.1007/s11069-015-2110-2

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Macciotta, R., Rodriguez, J.L., Hendry, M., Martin, C.D., Edwards, T., Evans, T. 2017. The 10-mile Slide north of Lillooet, British Columbia – history, characteristics and monitoring. In: Jerome V. De Graff and Abdul Shakoor (eds.) Landslides: Putting Experience, Knowledge and Emerging Technologies into Practice. Proceedings of the 3rd North American Symposium on Landslides. June 4-8, 2017, Roanoke, Virginia, USA. Association of Environmental and Engineering Geologists (AEG) Special Publication 27 pp:937-948

Macciotta, R., Carlà, T., Hendry, M., Evans, T., Edwards, T., Farina, P., Casagli, N. 2017. The 10-mile Slide and Response of a Retaining Wall to its Continuous Deformation. In: M. Mikoš et al. (eds.) Advancing Culture of Living with Landslides, Proceedings of the 4th World Landslide Forum, May 29th to June 2nd, 2017, Ljubljana, Slovenia

Huntley, D., Bobrowsky, P., Charbonneau, F., Journault, J., Macciotta, R., Hendry, M. 2017. Innovative Landslide Change Detection Monitoring: Application of Space-borne InSAR Techniques in the Thompson River Valley, British Columbia, Canada. In: M. Mikoš et al. (eds.) Advancing Culture of Living with Landslides, Proceedings of the 4th World Landslide Forum, May 29th to June 2nd, 2017, Ljubljana, Slovenia