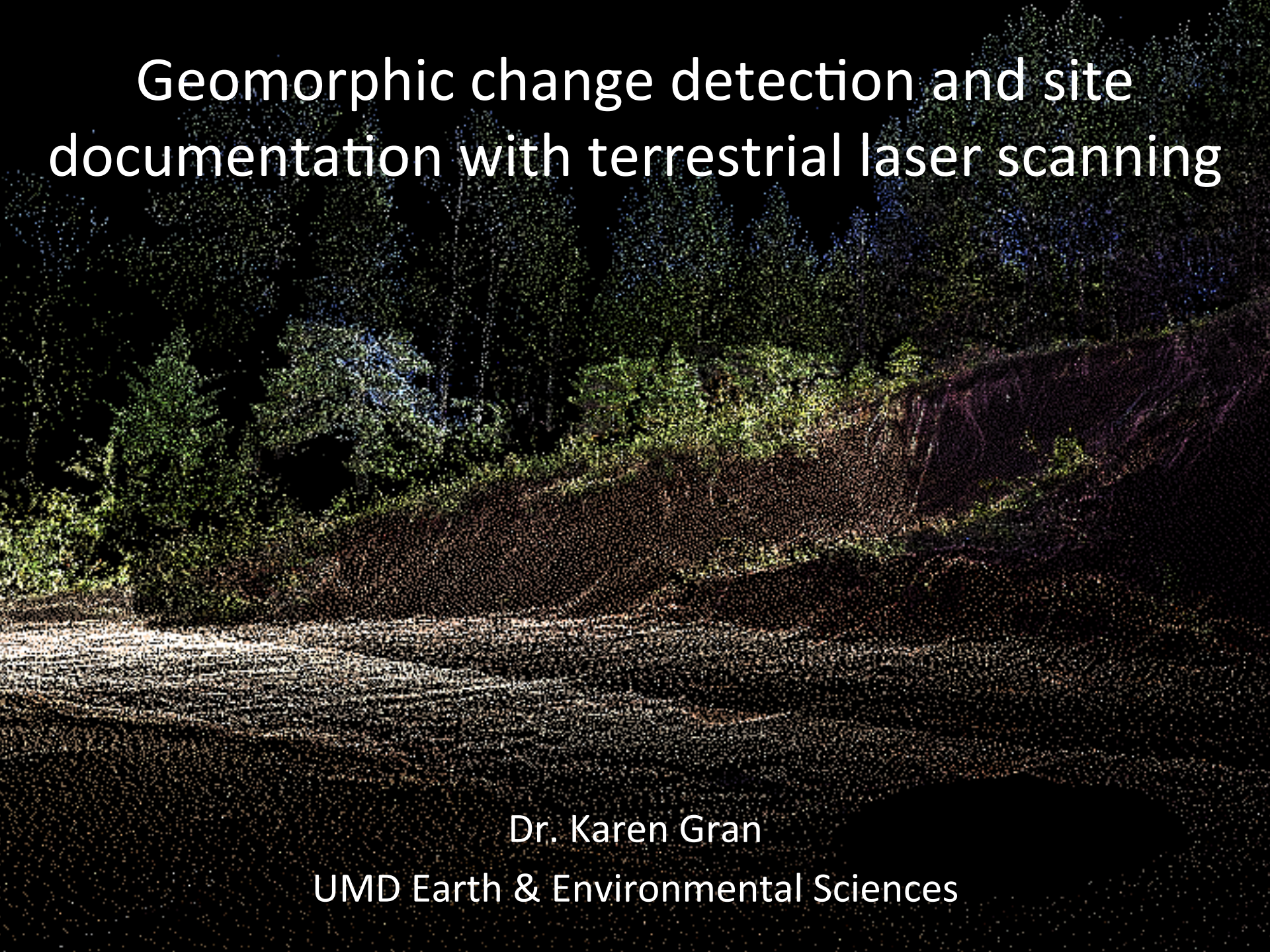


# Geomorphic change detection and site documentation with terrestrial laser scanning

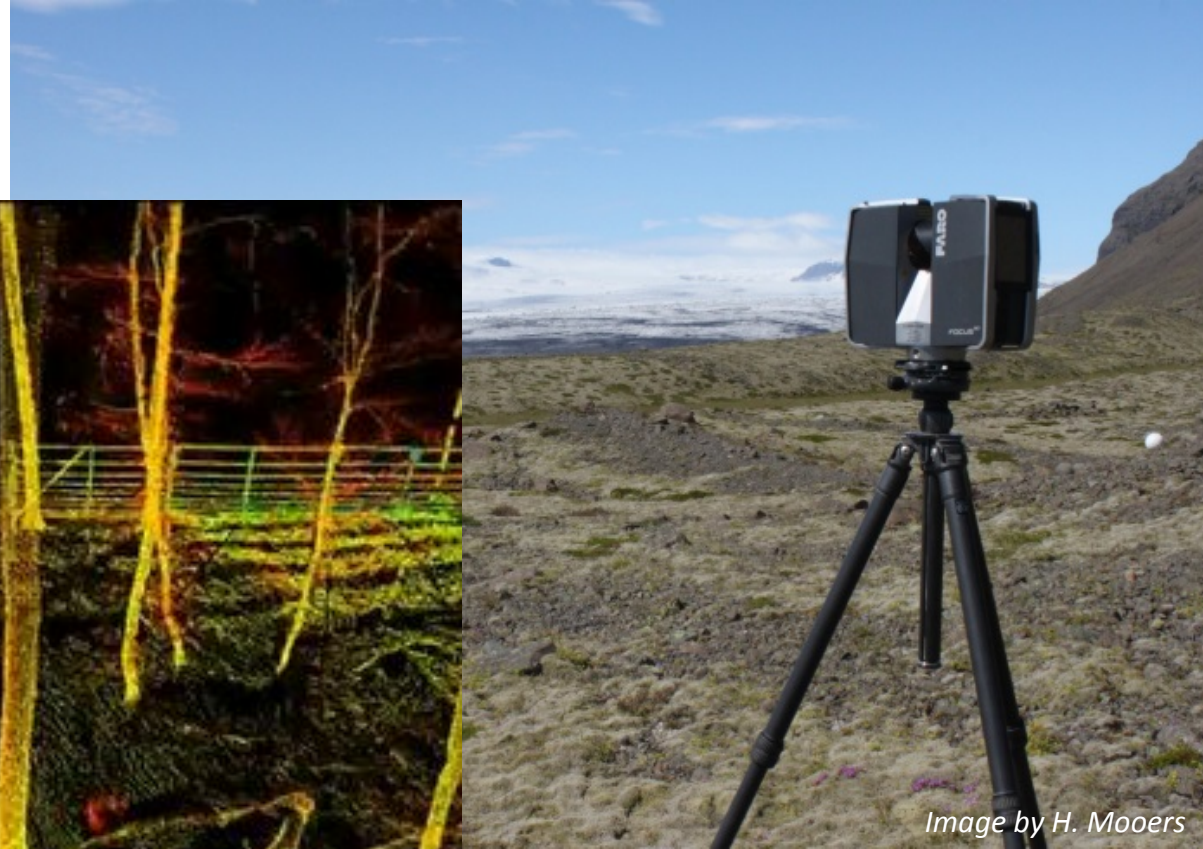
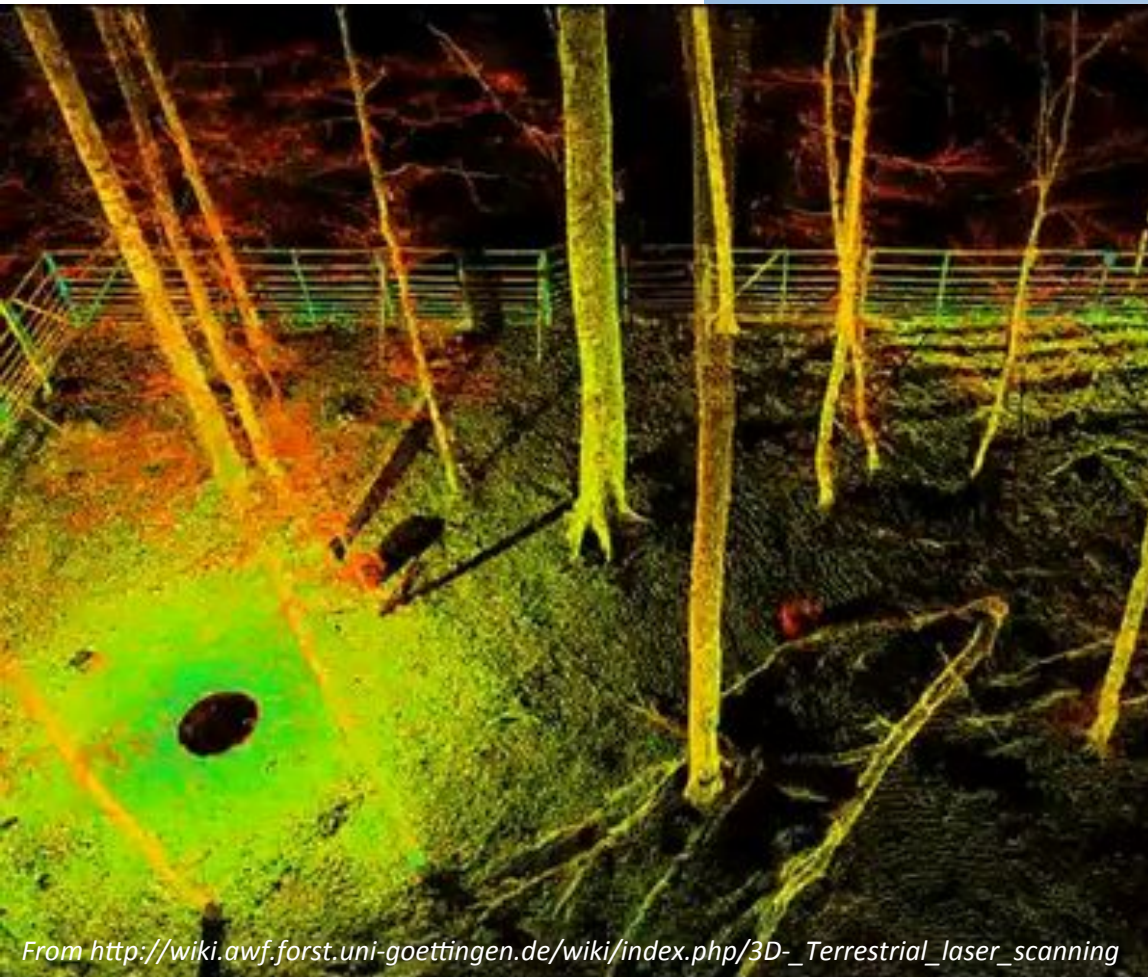


Dr. Karen Gran

UMD Earth & Environmental Sciences

# What is Terrestrial Laser Scanning (TLS)?

## Tripod-mounted ground-based lidar



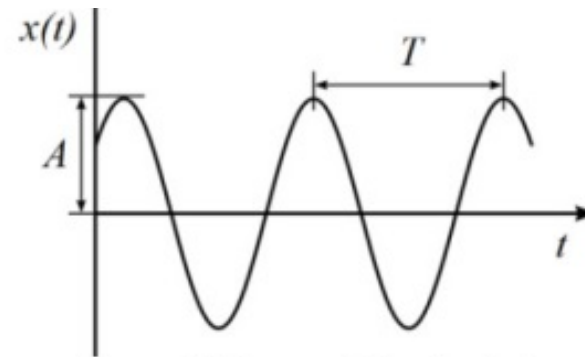
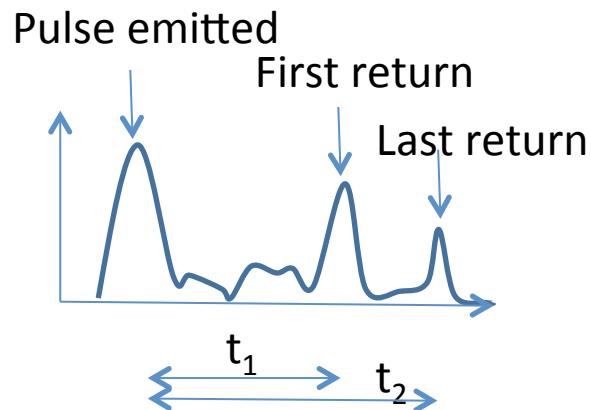
*Image by H. Mooers*

# Time-of-flight vs. Phase Shift



$$\text{Distance} = \text{Speed of Light} * \text{TOF}/2$$

$$\text{TOF} = \text{Phase Shift} / (2\pi * \text{Frequency})$$



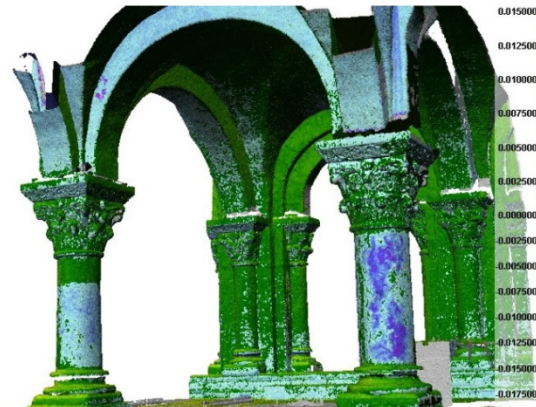
# Time-of-flight vs. Phase Shift



**Farther Range (up to few km)**  
**Not good up at close range**  
**Slower (10k-100k pps)**



**Close Range (generally < 100m)**  
**Signal deteriorates at far range**  
**Fast! (million points/s)**



# Example work flow, TOF at Pinatubo

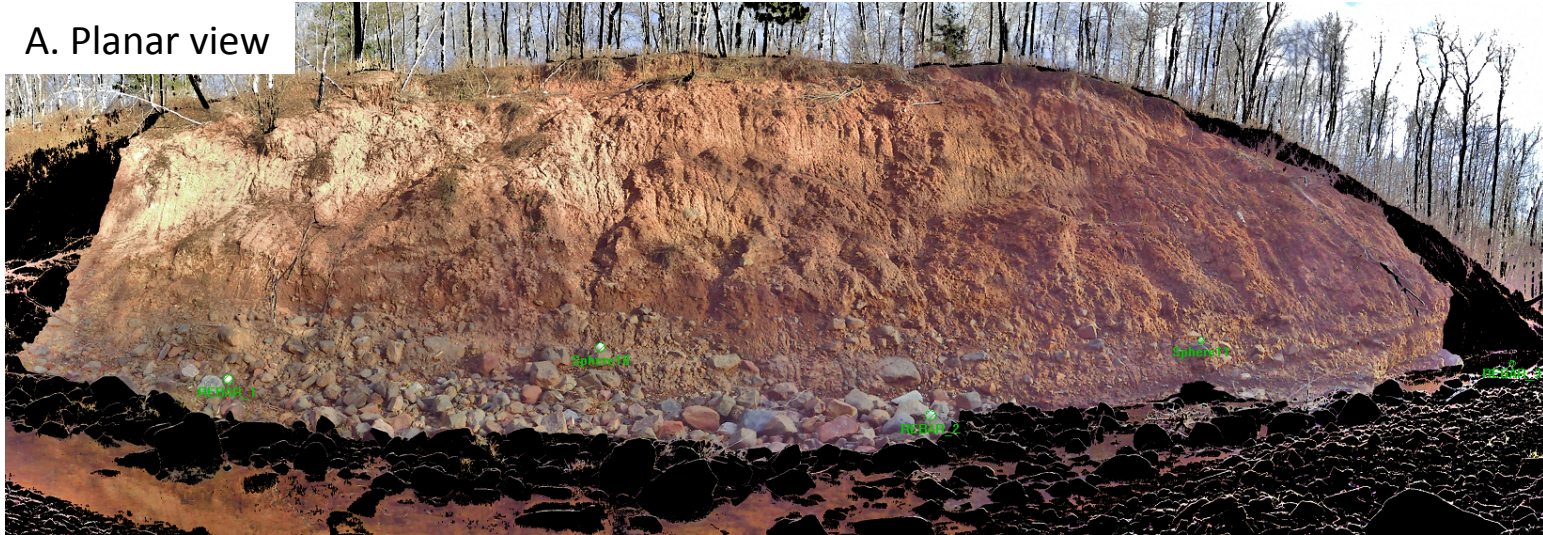
Riegl Z620



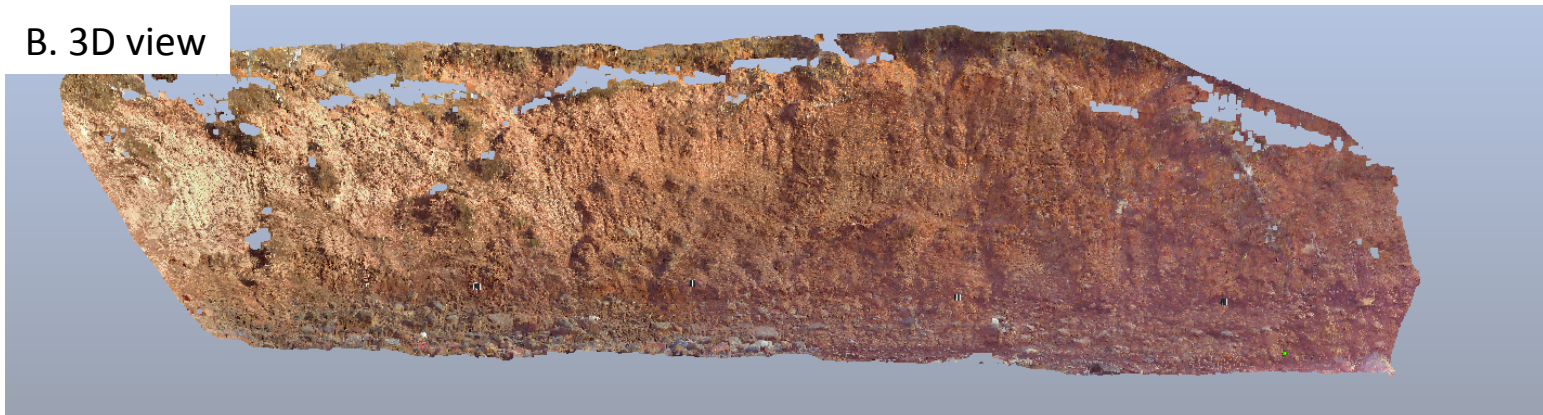
Google Earth

# Example work flow, PS in Duluth

A. Planar view



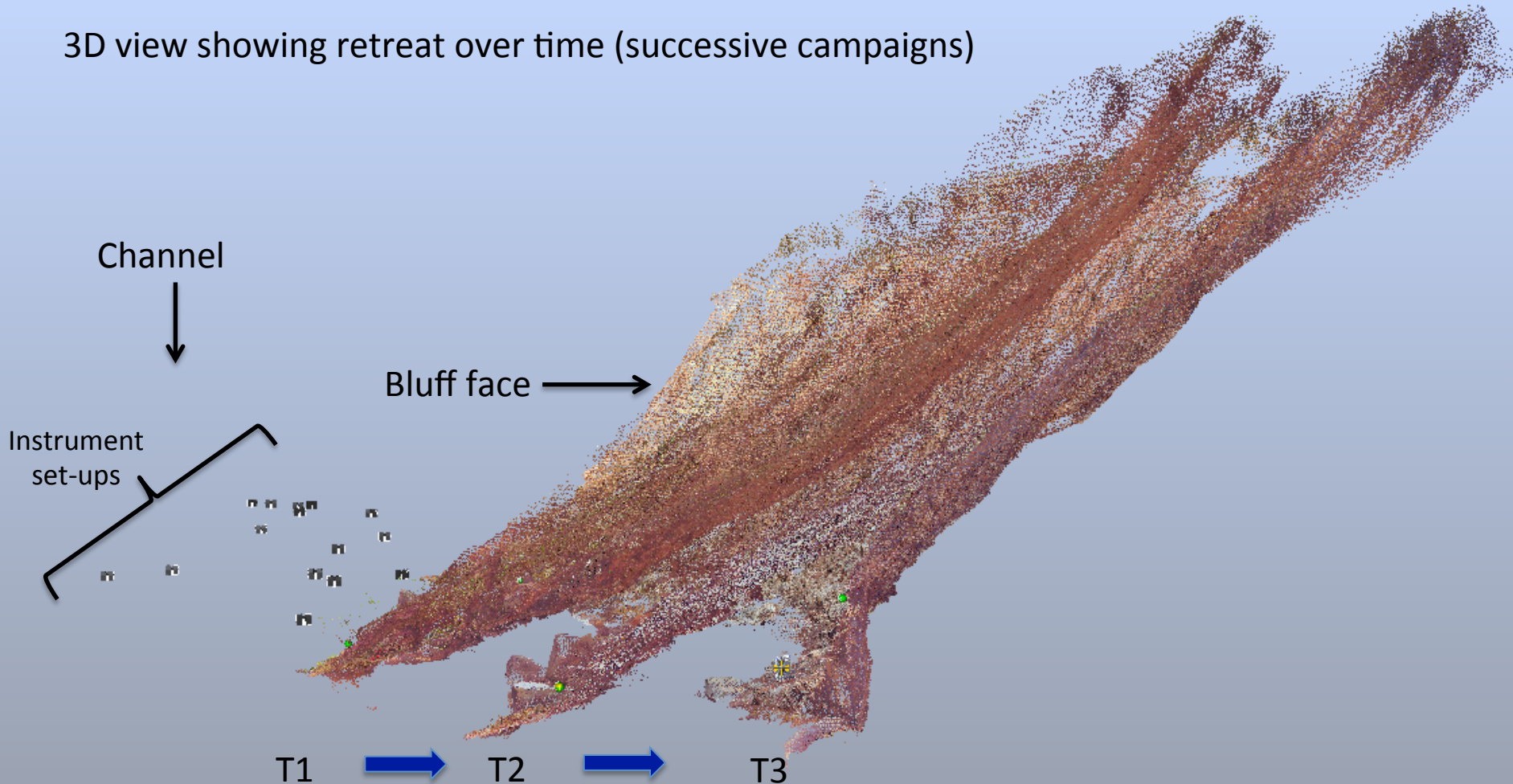
B. 3D view



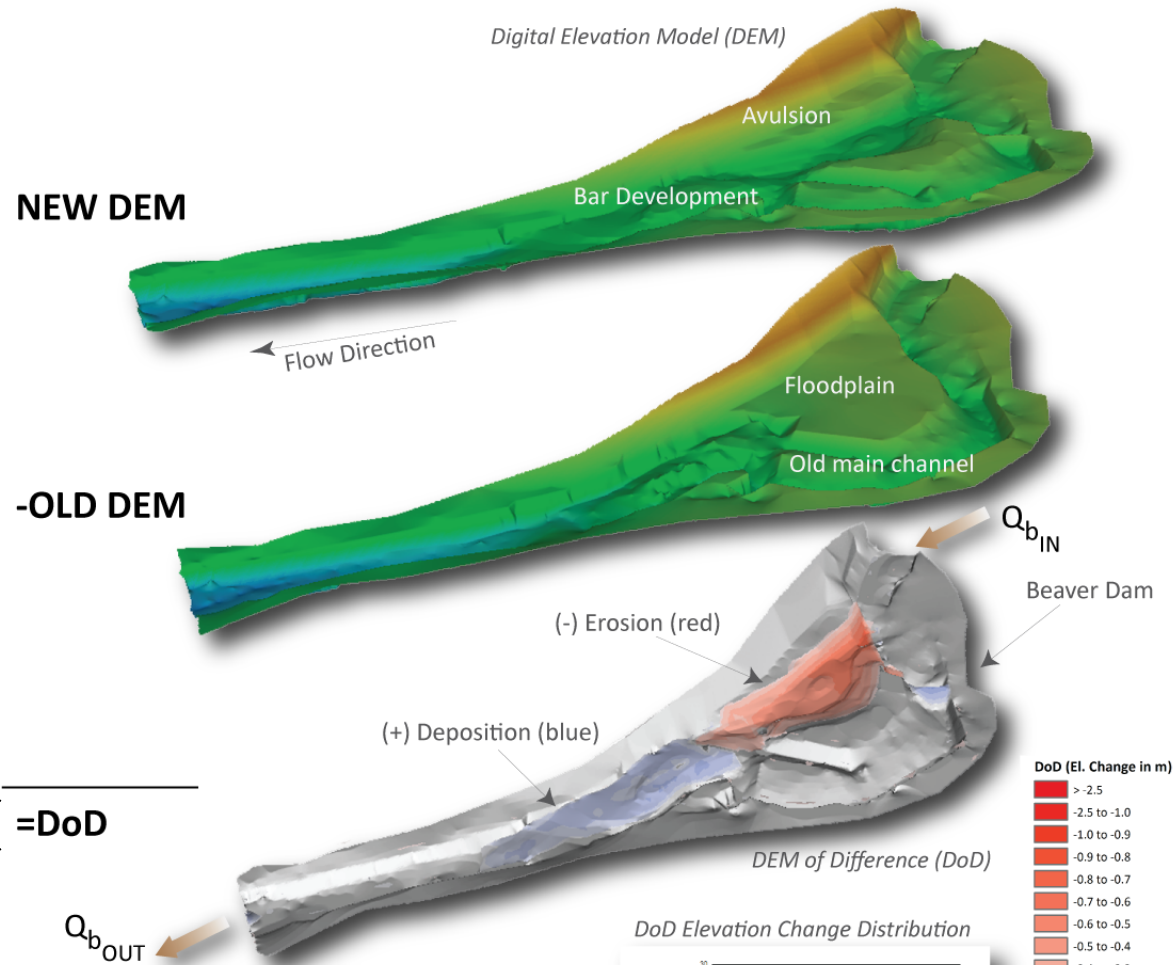
[Example Data Set](#)

# Repeat scans over time

3D view showing retreat over time (successive campaigns)



# Geomorphic Change Detection



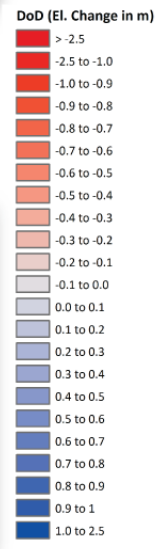
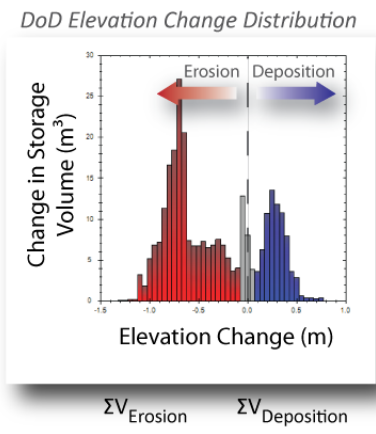
DEM of Difference =DoD

Morphological Sediment Budget:

$$Q_{b_{IN}} - Q_{b_{OUT}} = \frac{\Delta V_{DoD}}{\Delta t}$$

Bedload Flux Difference      Change in Storage

$$\Delta V_{DoD} = \Sigma V_{Deposition} - \Sigma V_{Erosion}$$

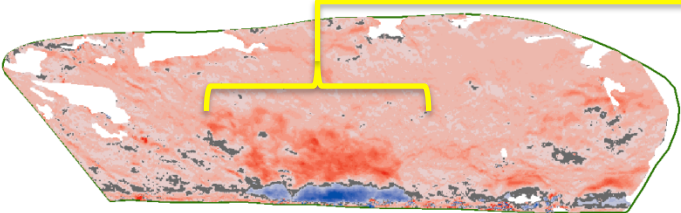




# Amity Creek, Duluth

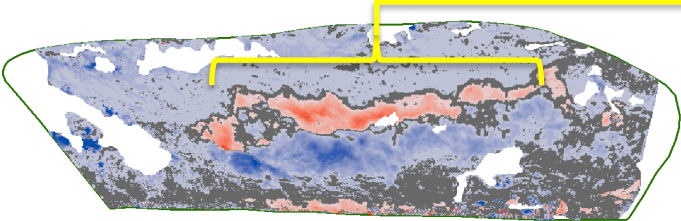


B9 Net Change: November 2011 to April 2012

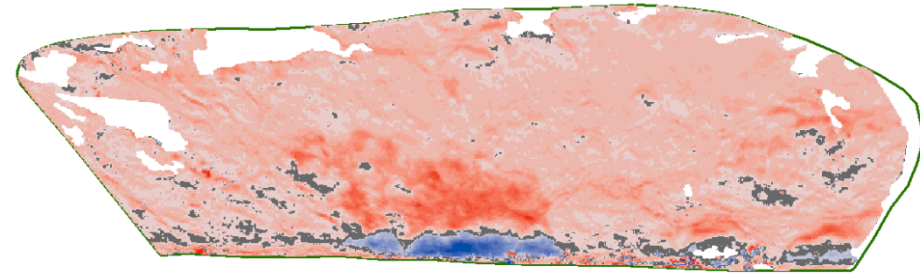


Same rock...channel centerline moved ~4-5 m post-flood

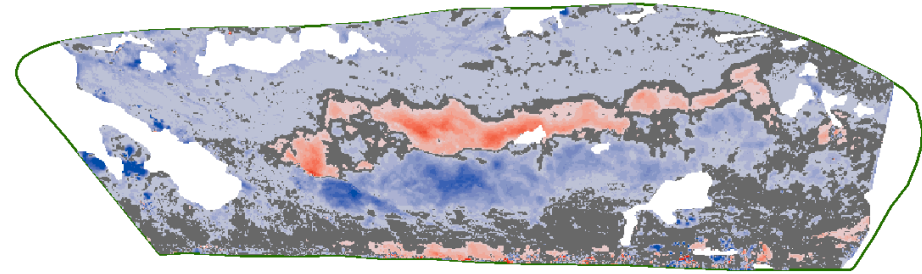
B9 Net Change: April to May 2012



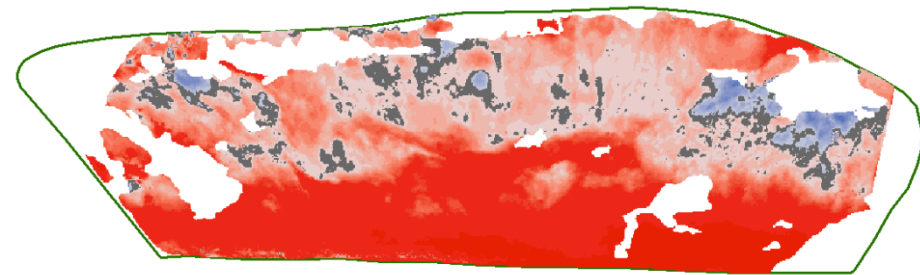
A. B9: November 2011 to April 2012



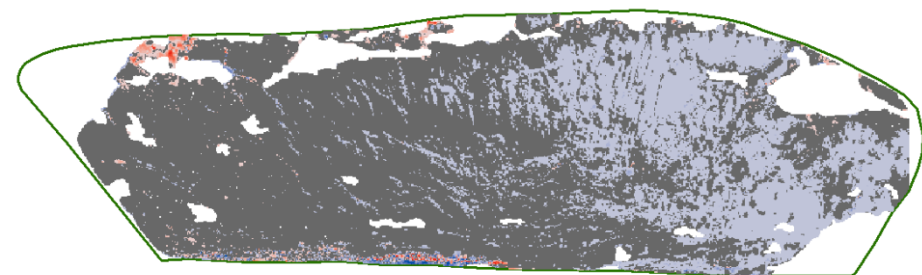
B. B9: April to May 2012



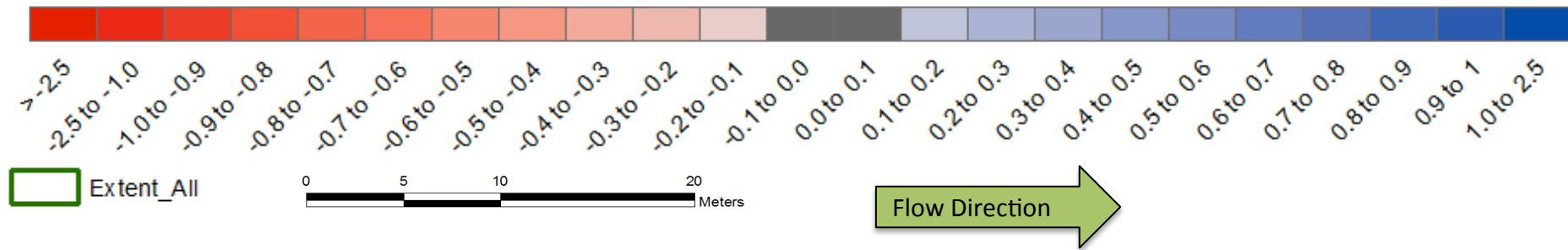
C. B9: May to June 2012



D. B9: June to November 2012



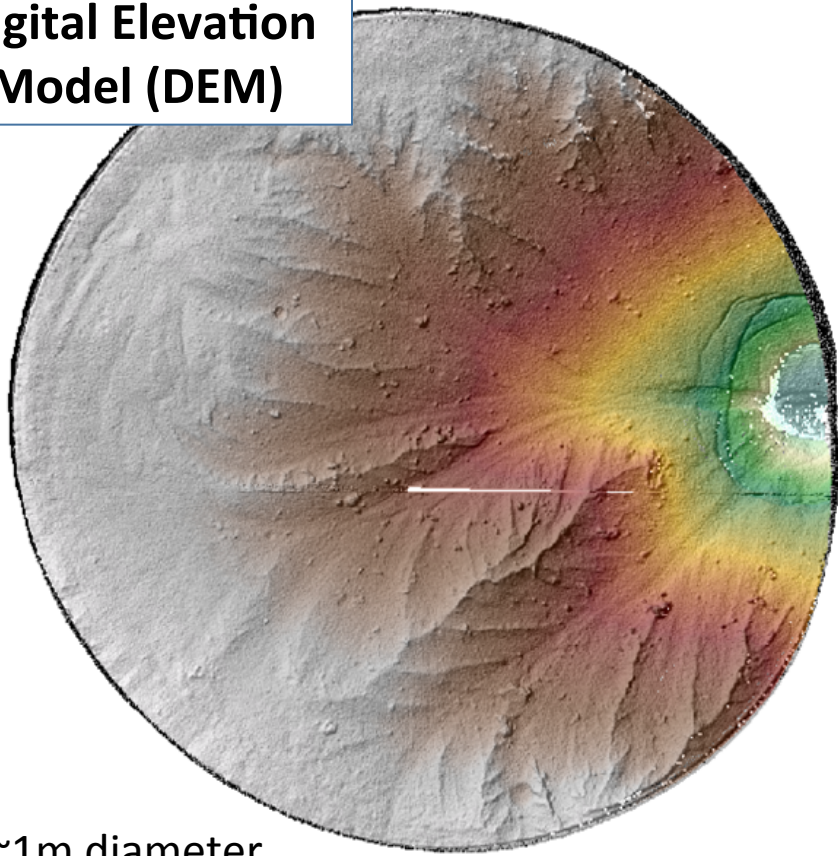
### Erosion and Deposition (m)



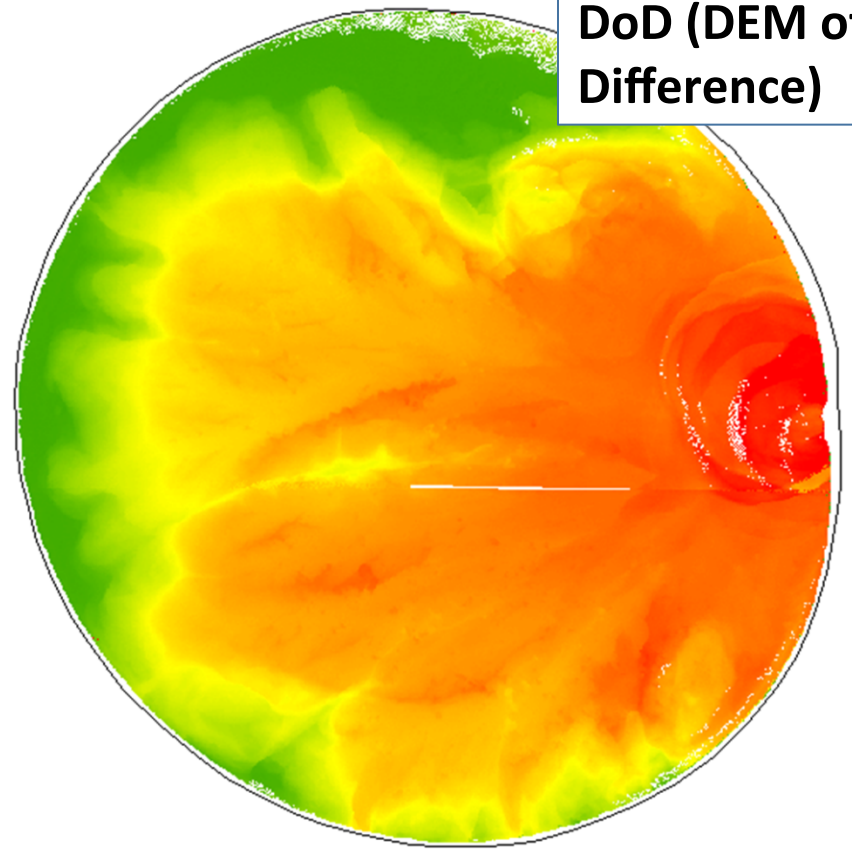
# Near-range scanning in experimental settings



Digital Elevation Model (DEM)



DoD (DEM of Difference)



~1m diameter

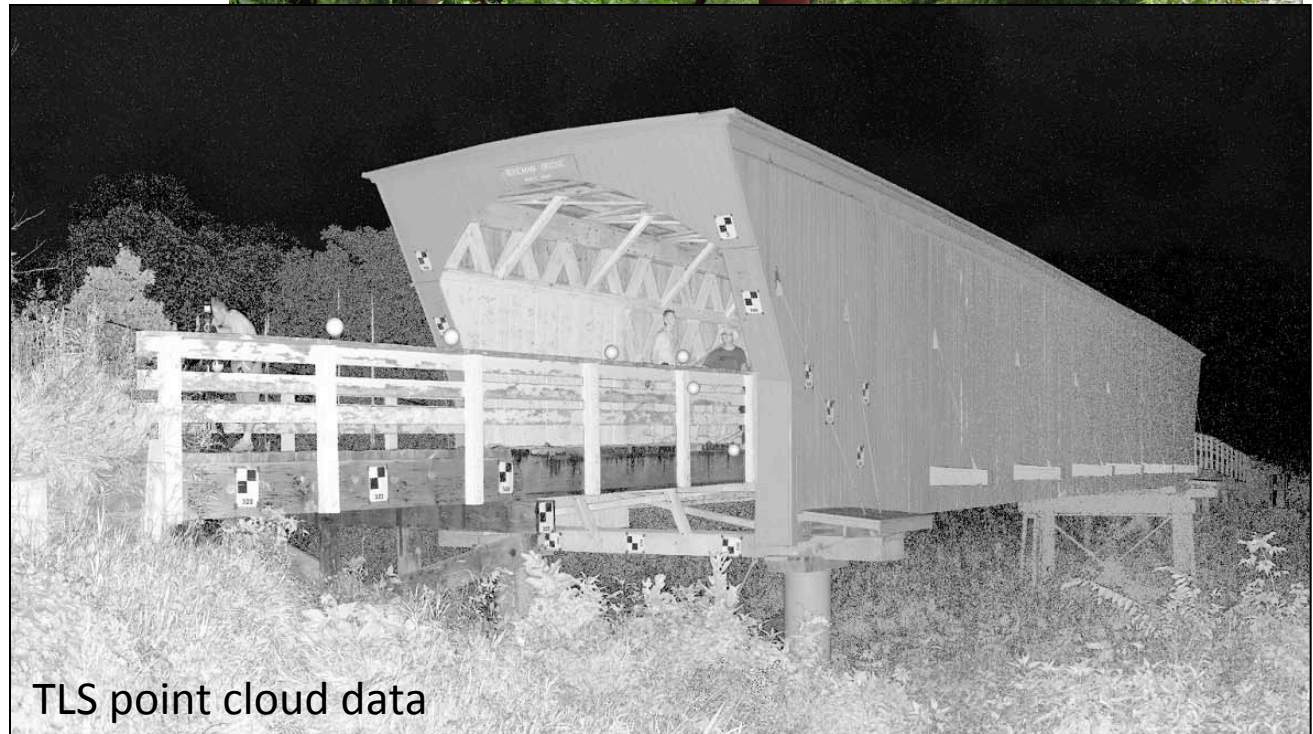


# Potential Applications

## Historic Documentation



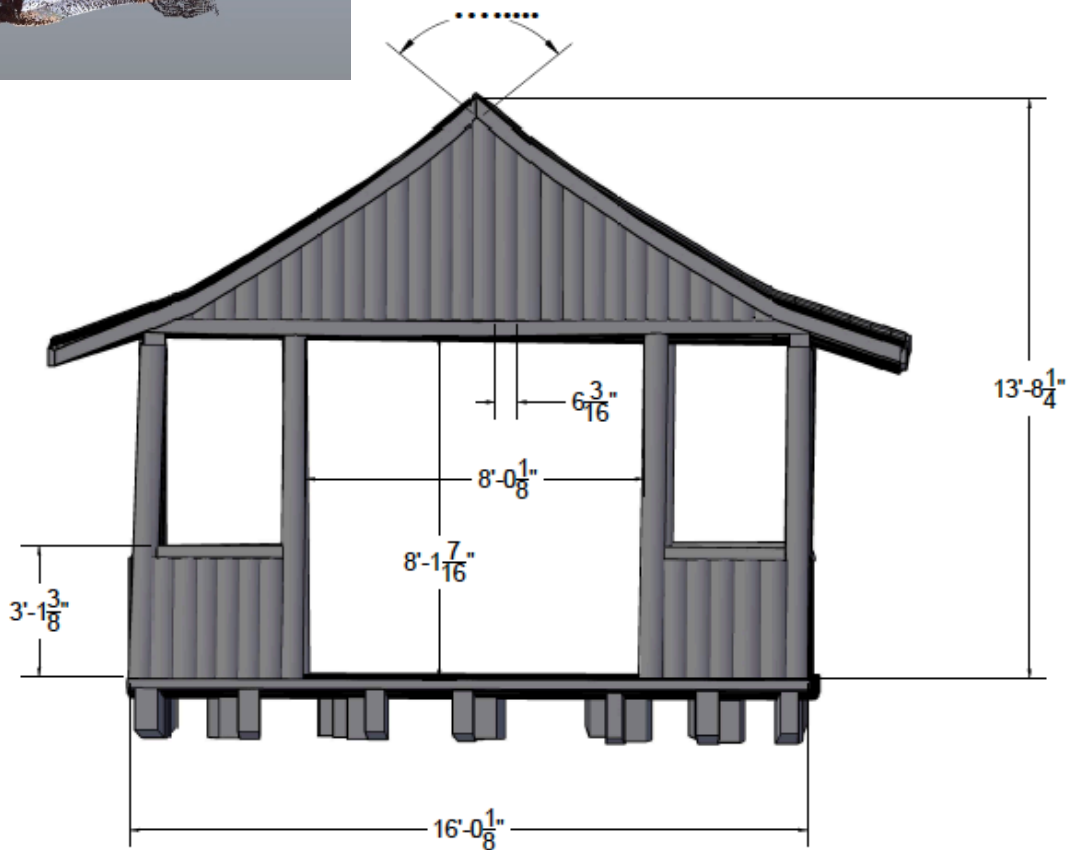
Roseman Bridge,  
Madison County, Iowa



TLS point cloud data



Construct "As-built" documentation  
In AutoCAD from TLS data



# Potential Applications

## Cultural Preservation

Moai, Easter Island



*Kersten et al. 2010*

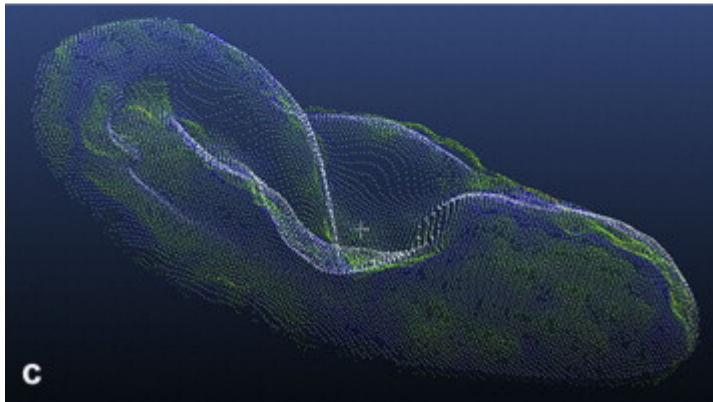
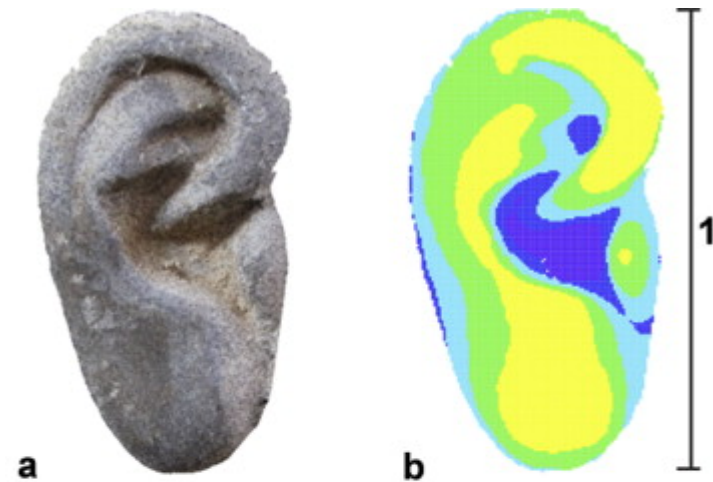


*Getty images*

Terracotta Warriors, China

# Potential Applications

Cultural Preservation  
& Forensics



*Bevan et al., 2014*





# Potential Applications

## Site Documentation



Tui Ofu well, American Samoa, *Photo by S. Day*



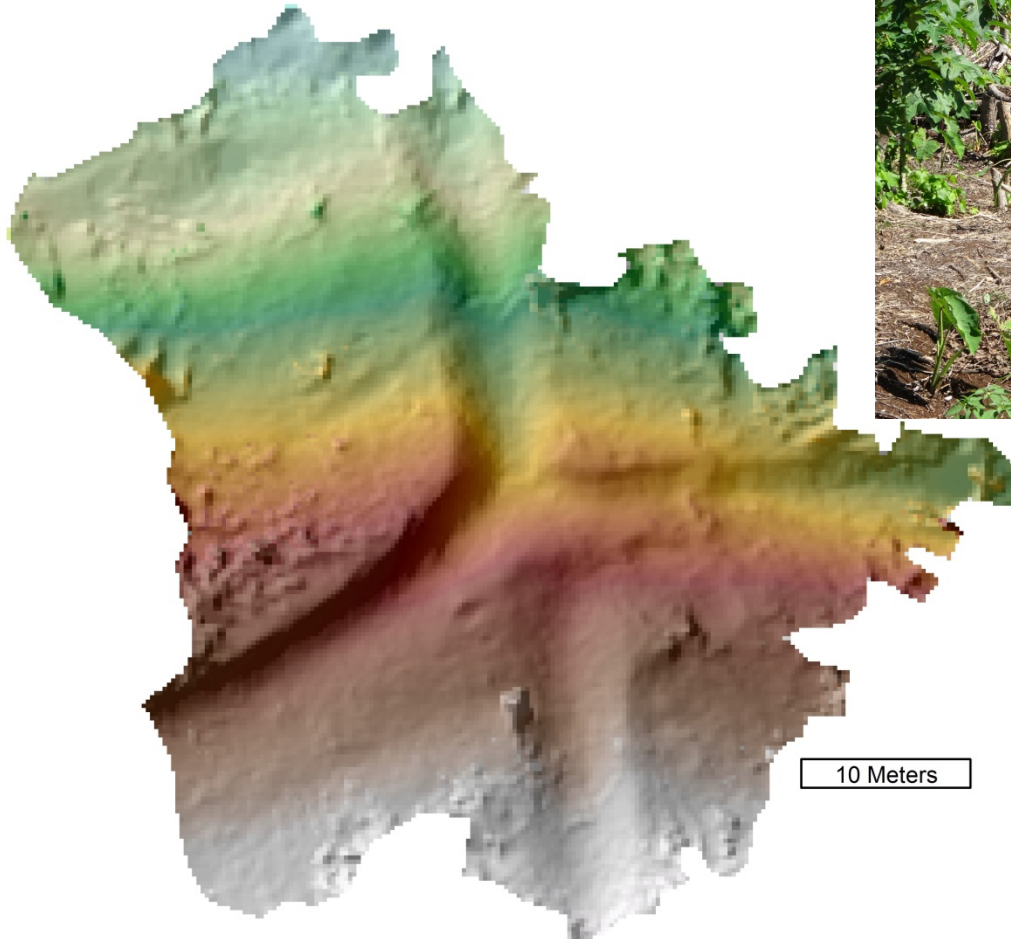
Easter Island, *Kersten et al. 2010*



Tui Ofu well, American Samoa

# Potential Applications

## Paleohydrology



American Samoa, ditch networks

# Challenges with using TLS

- Scan data files can be massive
- Processing time
- Proprietary software for initial processing
- Time-of-flight vs. Phase Shift
- Cost
- Data collection limitations
  - Vegetation (WYSIWYG)
  - Data holes/shadows
  - Water

# Next Step: Structure from Motion

St. Andrew's Church, East Sussex

AgiSoft Photoscan  
Bundler  
123D Catch  
Photosynth



Photograph



3D point cloud from 244 photos

Let's do it!