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Evaluation of Terrestrial Lidar as a Tool for Monitoring Geomorphic Change at Archaeological Sites in Grand Canyon National Park

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U.S. Department of the Interior
U.S. Geological Survey

Outline

- Terrestrial lidar
  - Background
- Project 1 – Comparison of total station to lidar data collection for gully thalweg
  - Results
- Project 2 – Whole site change detection using terrestrial lidar
  - Preliminary results
- Future directions

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Terrestrial Lidar

- A new technology
  - Used for documentation of existing conditions (including widespread use in archaeology)
  - Used for change detection of geomorphic landscapes (landslide, cliff erosion)
  - Not yet used for high resolution, small-scale change detection
- Capabilities
  - Collection of thousands of points per second
  - Accuracy of several millimeters to centimeters
  - Range of 2m to 1000m
  - Units can be made portable (USGS focus for difficult environmental conditions)
  - Issues with reflectivity, laser divergence, laser obliqueness, all affect data quality
- Summary
  - A high-resolution, highly accurate survey device for documenting and monitoring landscape surface change

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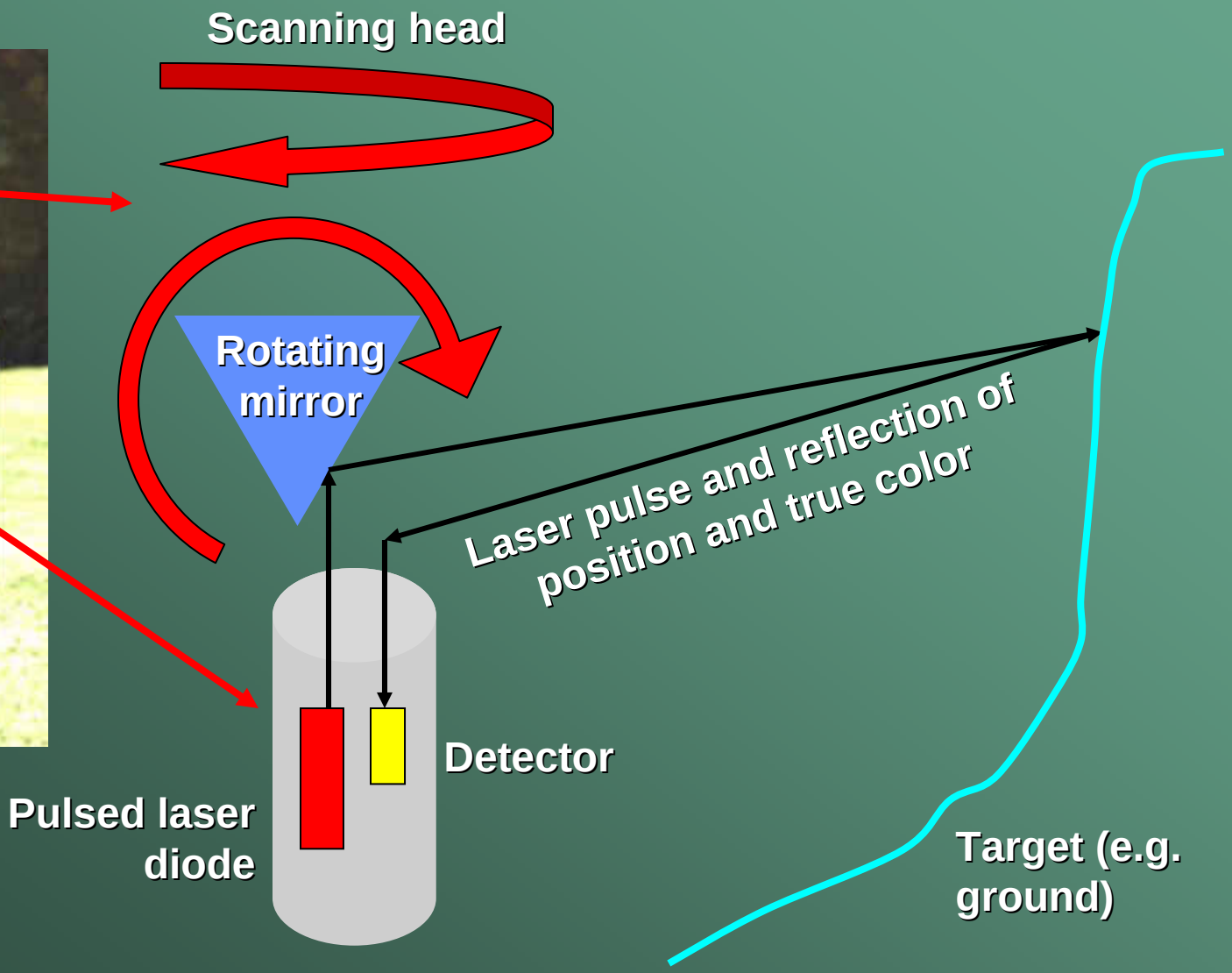
How does it work?

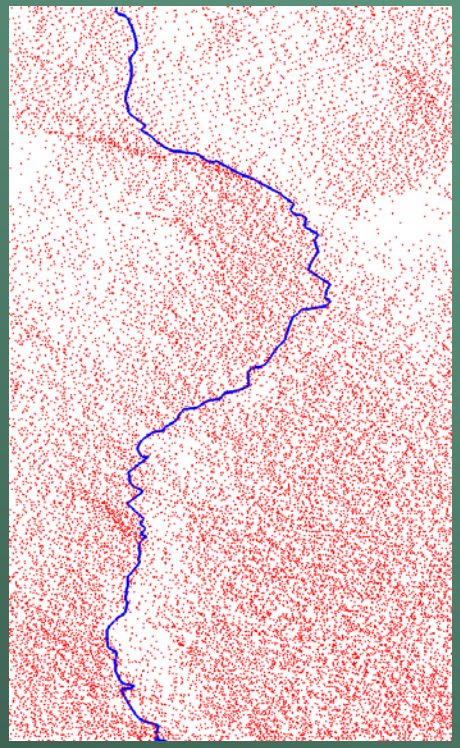


I-SiTE 3D Laser Imaging

How does it work?

Laser

Filtering



Points

Surface building

Gully thalweg, ~22m in length

Surfaces

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Project 1 – Survey Method Comparison

- Purpose: compare site impacts and gully thalweg data collected between total station (TS) and terrestrial lidar (LIDAR)

- Topographic data collection
  - Focus only on gully thalwegs
  - Point accuracy
  - Data density
  - Feature detection

- Site impacts
  - Total survey time
  - Time in sensitive area
  - Footstep count

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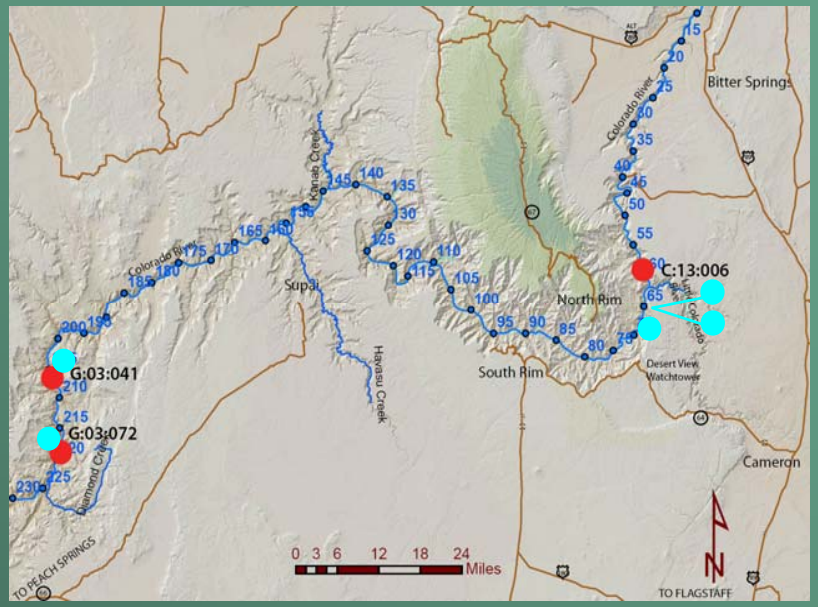
Project 1 – Data Collection

- May 2006 survey effort
  - May 2007 impact data also used
- Eight sites
  - 8 compared for impacts
  - 3 compared for topographic data
- Results available soon (USGS Open File Report – May 2008, 82p.)



Blue = impact evaluation sites
Red = topographic data and impact eval. sites

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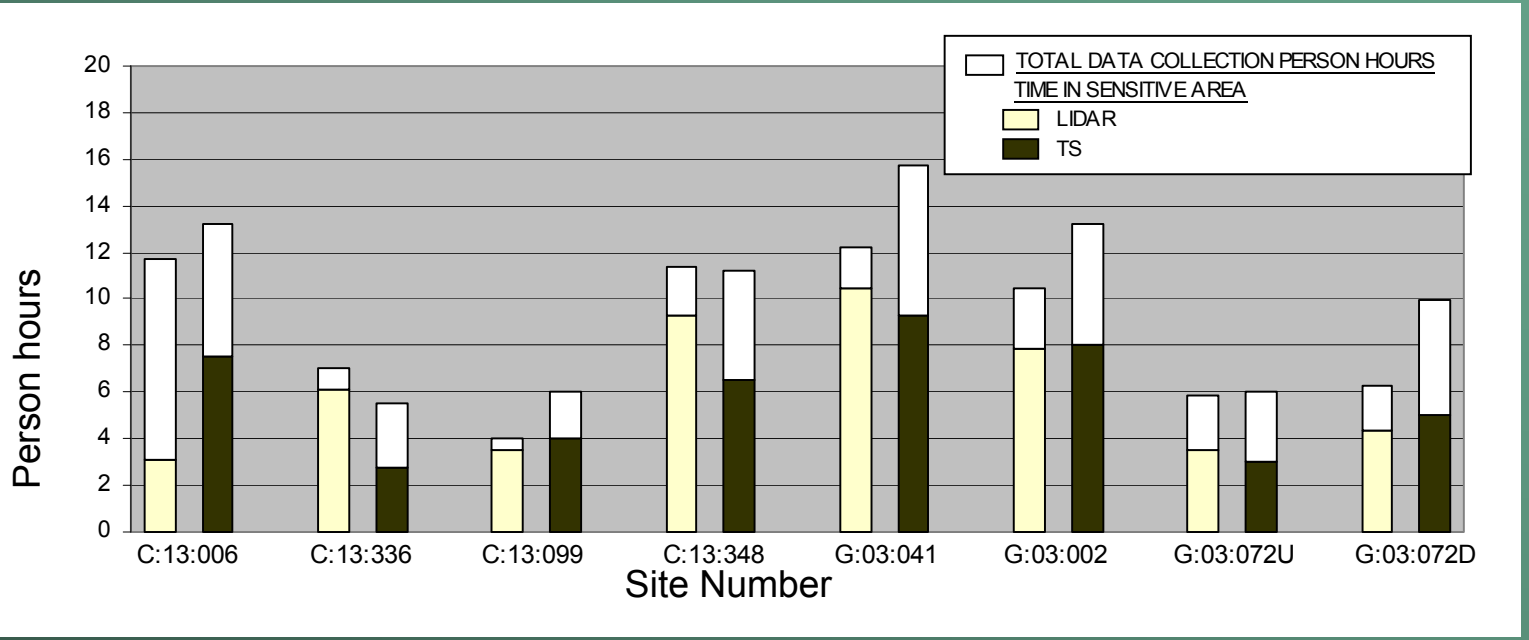
Results: Site Impacts



- Total time in sensitive area is similar between methods
- For TS, time is concentrated in the gullies
- For LIDAR, time is concentrated at the instrument, outside the gullies

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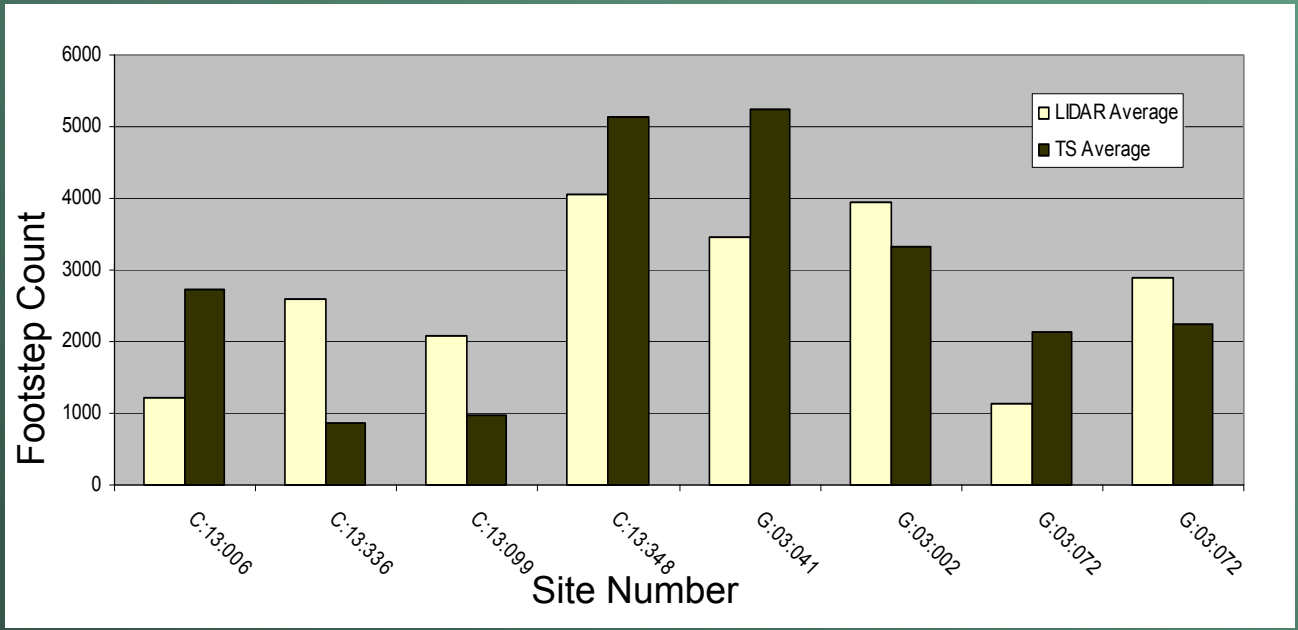
Results: Site Impacts

- Footstep impact is similar between LIDAR and TS methods
- Footstep locations are concentrated differently
- LIDAR utilizes two people outside the gullies, TS uses one person, in the gullies.



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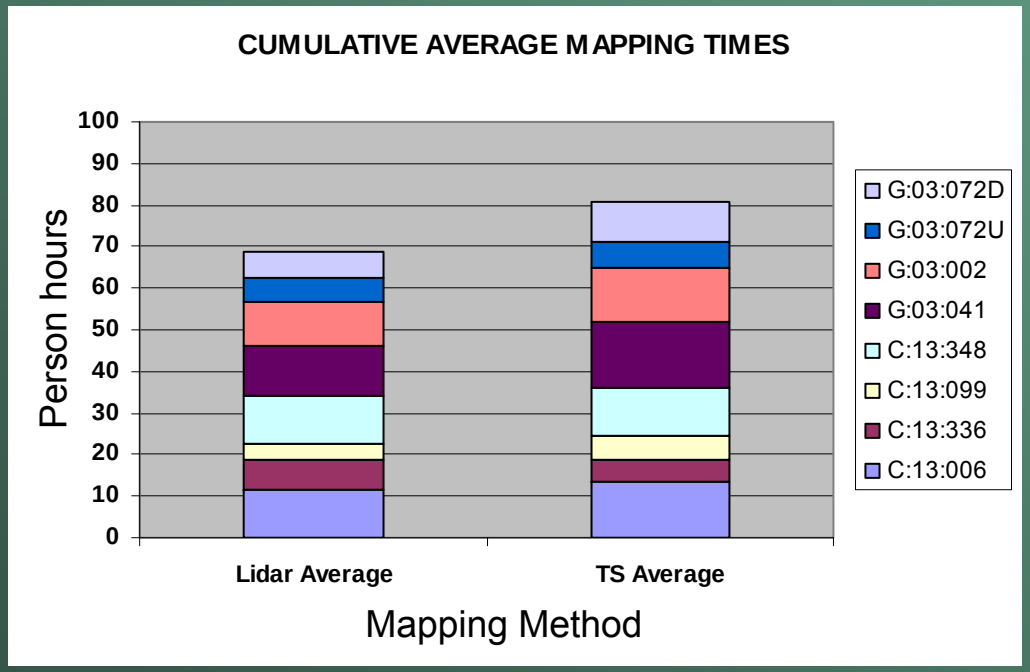
Results: Site Impacts



- Total mapping time is ~15% less for LIDAR
- Time savings is lost in post-processing
- Value is in the number of points collected (millions vs. hundreds)

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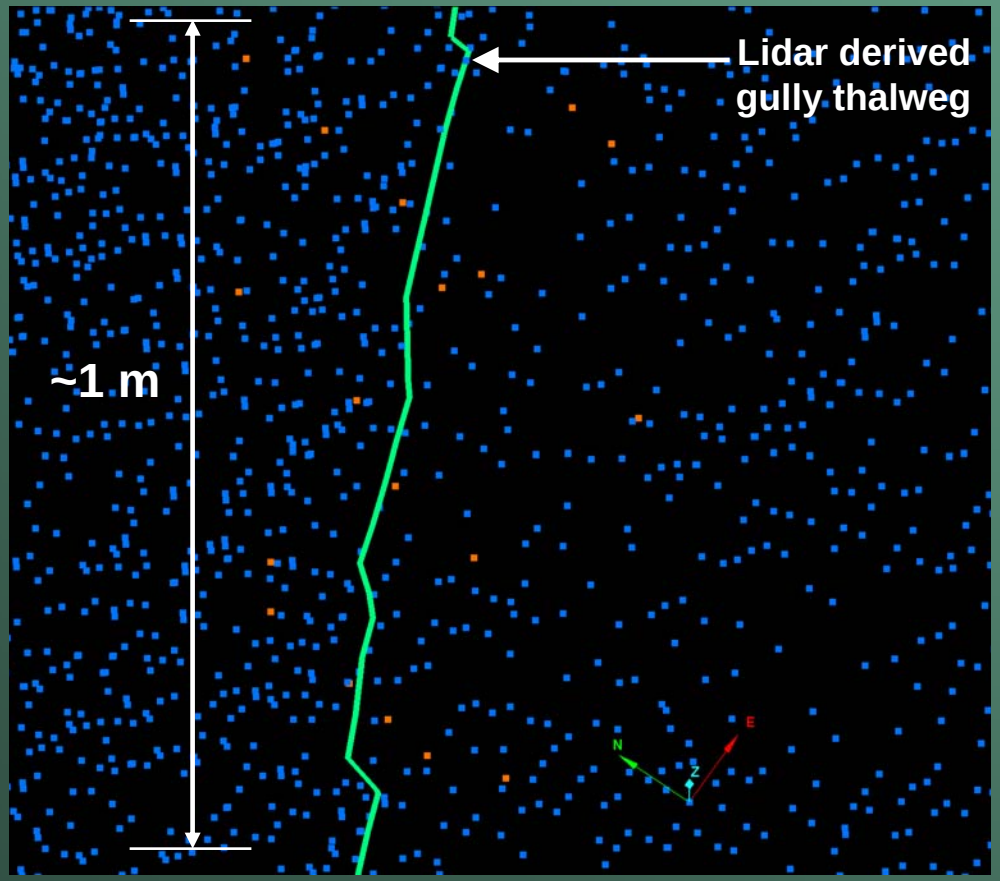
Results: Data Density



Orange = Total Station
Blue = Lidar

Site Number	Terrestrial LIDAR - # of ground points surveyed	Total station - # of ground points surveyed
AZ:C:13:006	1323471	953
AZ:G:03:041	1564445	656
AZ:G:03:072	455684	799

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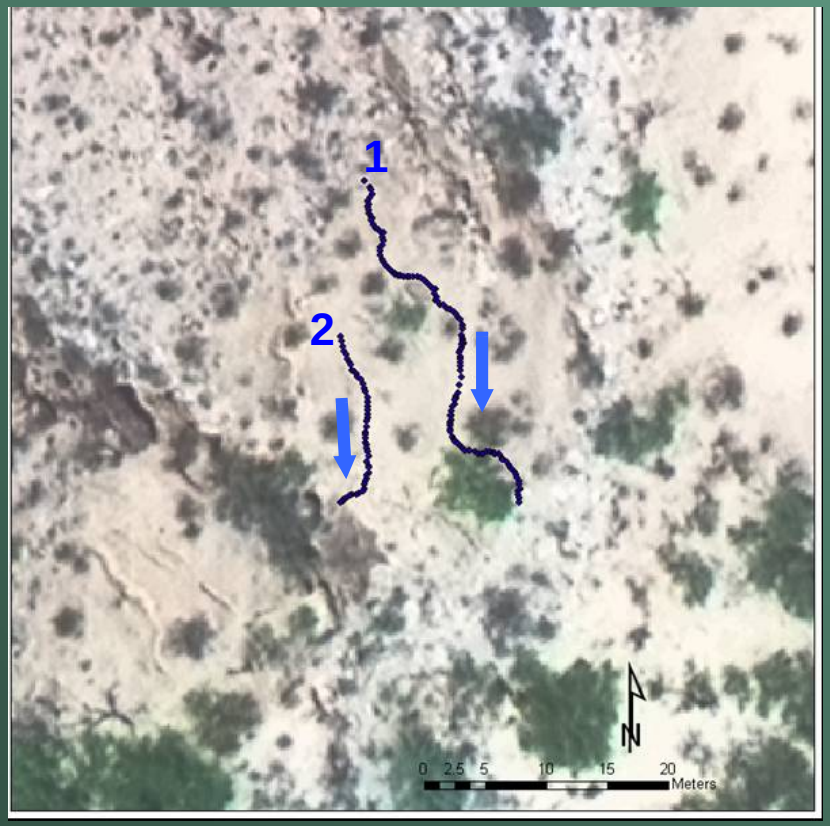
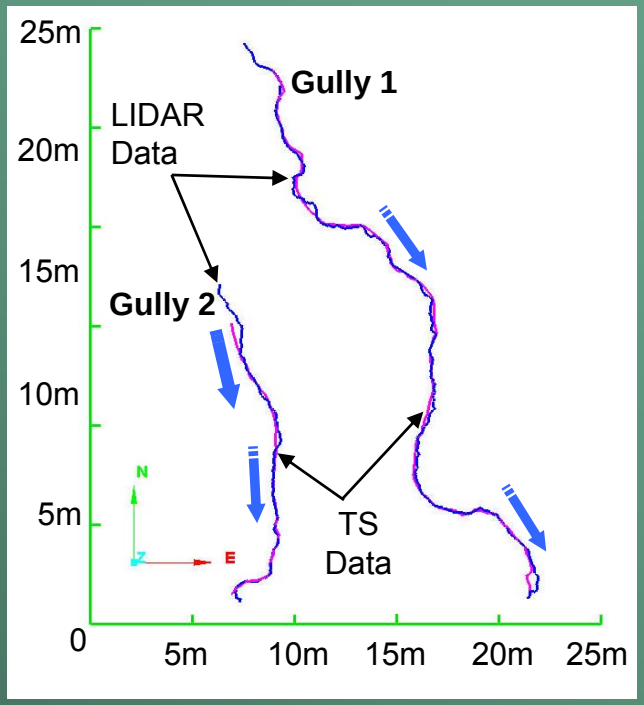
Results: Thalweg Location





Plan View

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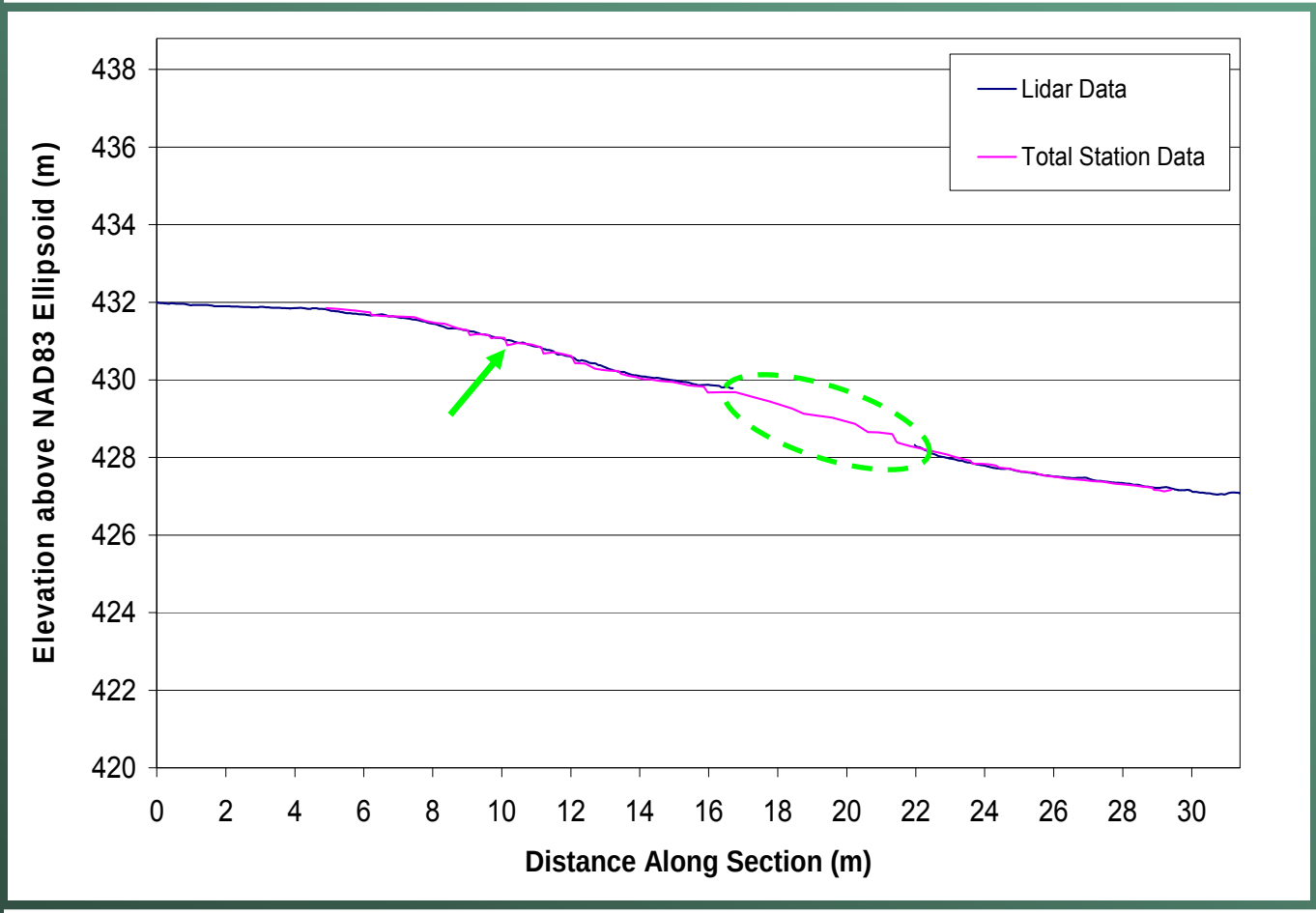
Results: Long Profile Comparison



- Very good comparison
- Vegetation blocking
- Knick point identification

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Project 2 – Change Detection Evaluation

- Purpose: determine if terrestrial lidar is capable of change detection at the centimeter/decimeter scale
- Focus on both gully erosion and whole site geomorphic change
- Investigate ability to monitor entire archaeologic sites for short- and long-term change

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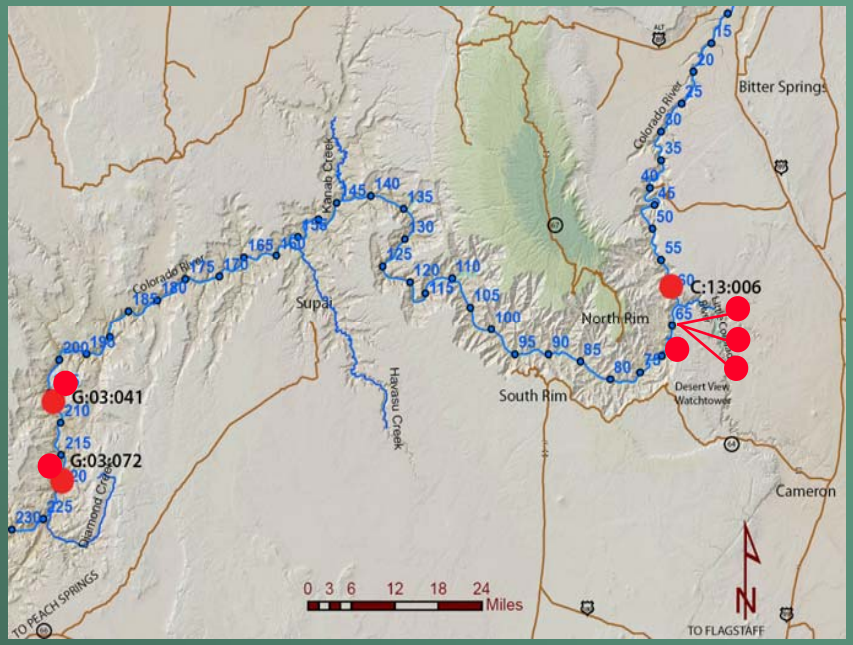
Project 2 – Data Collection

- May 2007 and September 2007 survey efforts
- Nine sites
  - All compared for topographic data
  - Cross-sections
  - Surface change maps
- Results available ~August 2008



Red = topographic data evaluation sites

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Preliminary Results: Site with No Change

- 60 Mile Site
- Area of stabilized cryptogamic soil with incipient gullying
- Archaeological site exists over entire area
- Three gullies traverse site and discharge to an arroyo that discharges to the Colorado River

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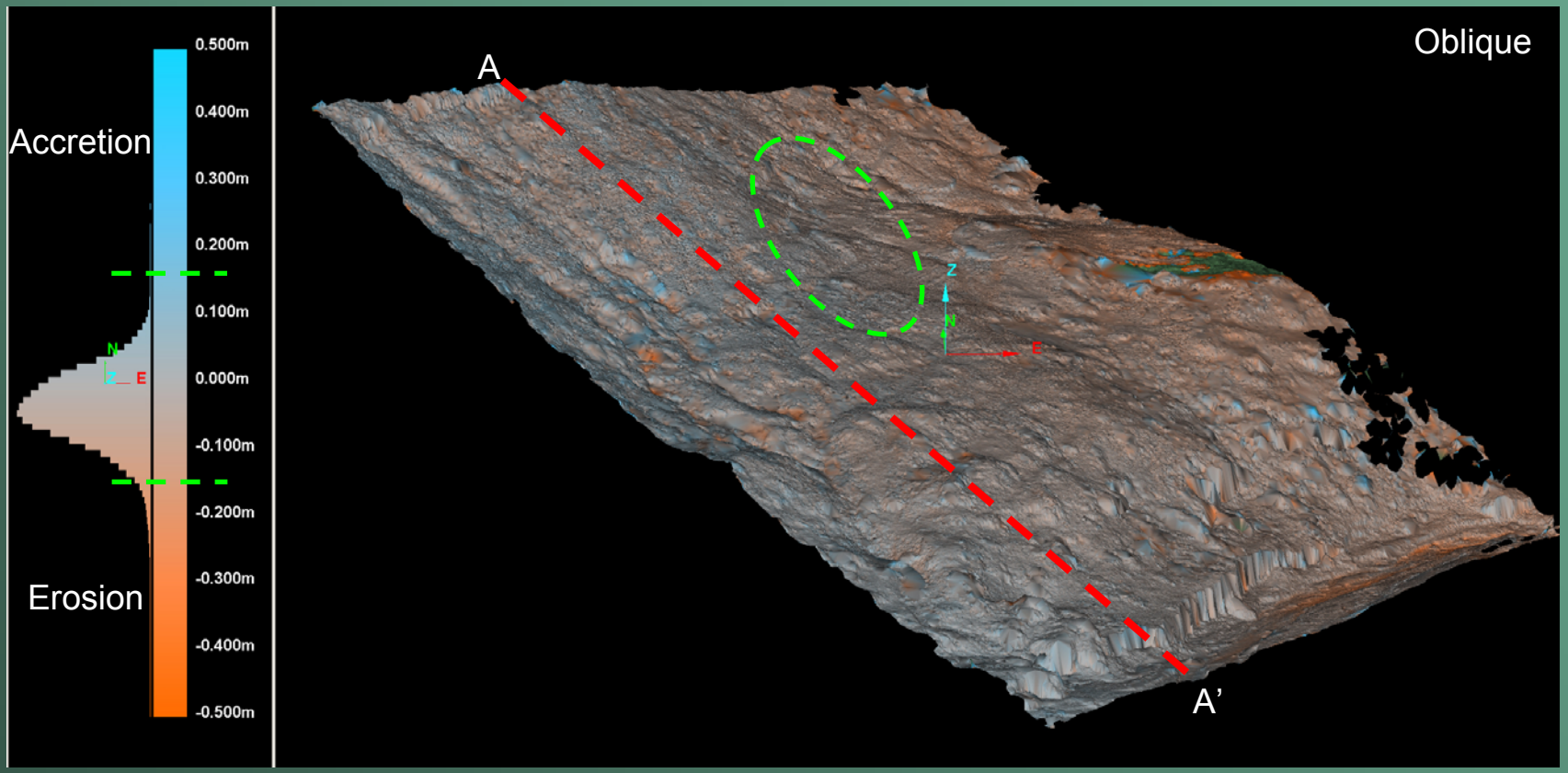
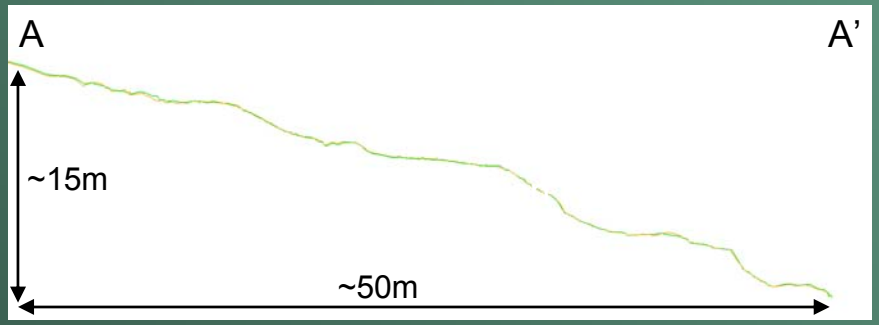
Preliminary Results: Surface Change Detection



May 2007 to September 2007 Surface Change Map at 60 Mile Site



Cross-section through site

Preliminary Results: Site with Change

- 223 Mile Upstream Site
- Area of aeolian deposition with pronounced gullying
- Archaeological sites are immediately adjacent to gullies
- Three gullies traverse site and discharge directly into Colorado River

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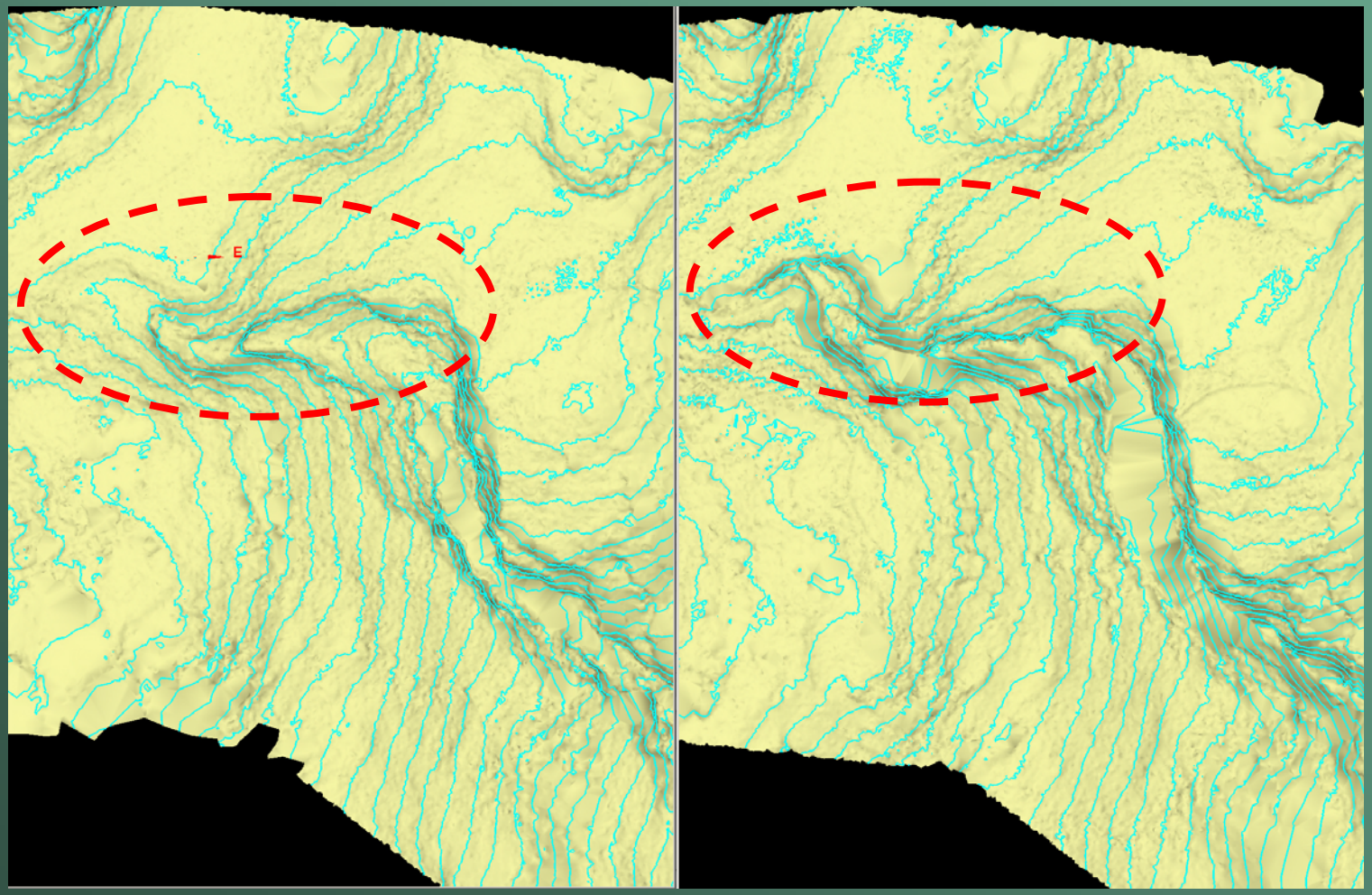
Preliminary Results: Surface Comparison

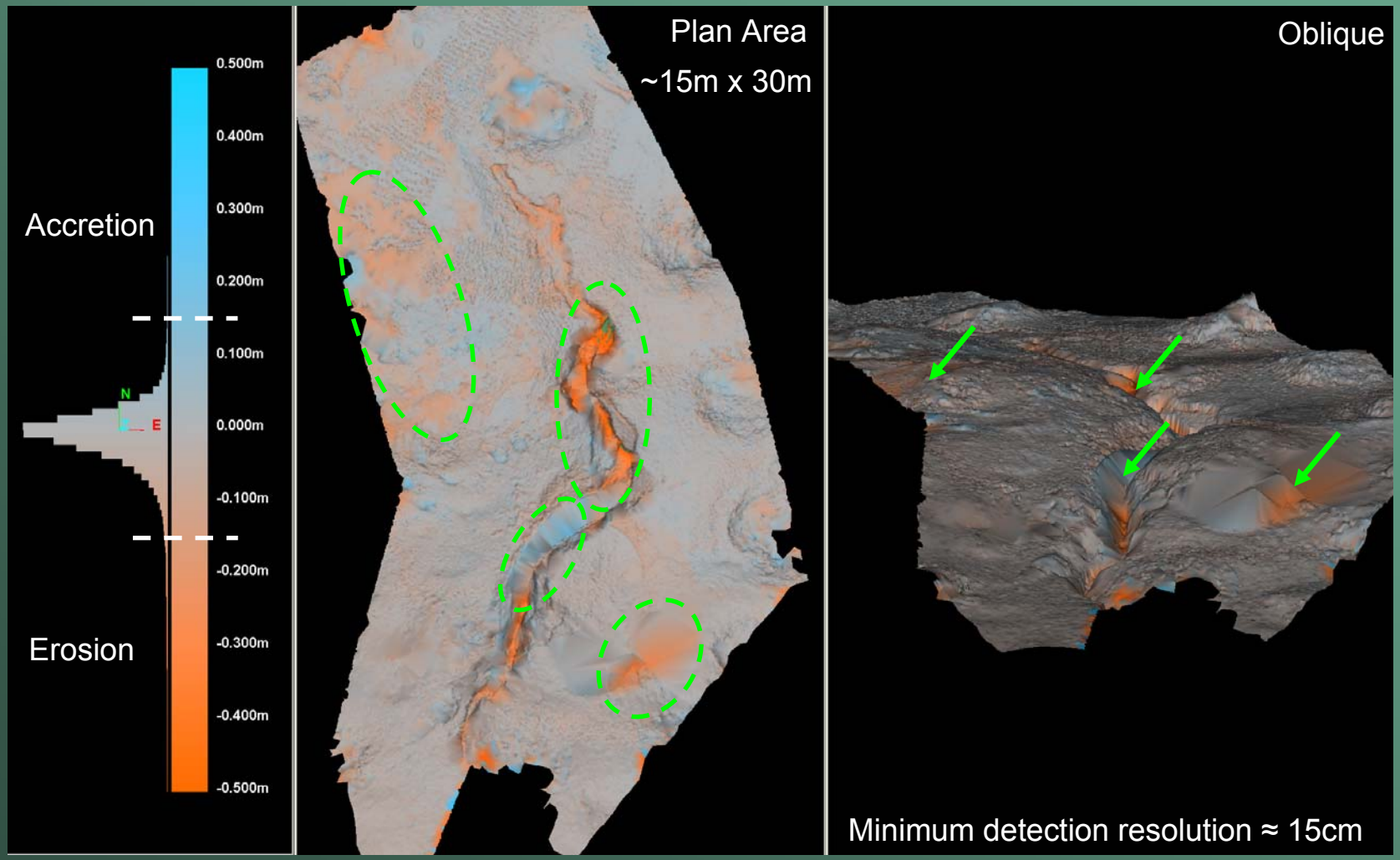


May 2007

September 2007

10cm Contour Maps of 223 Mile-US Site – Gully 3 Area

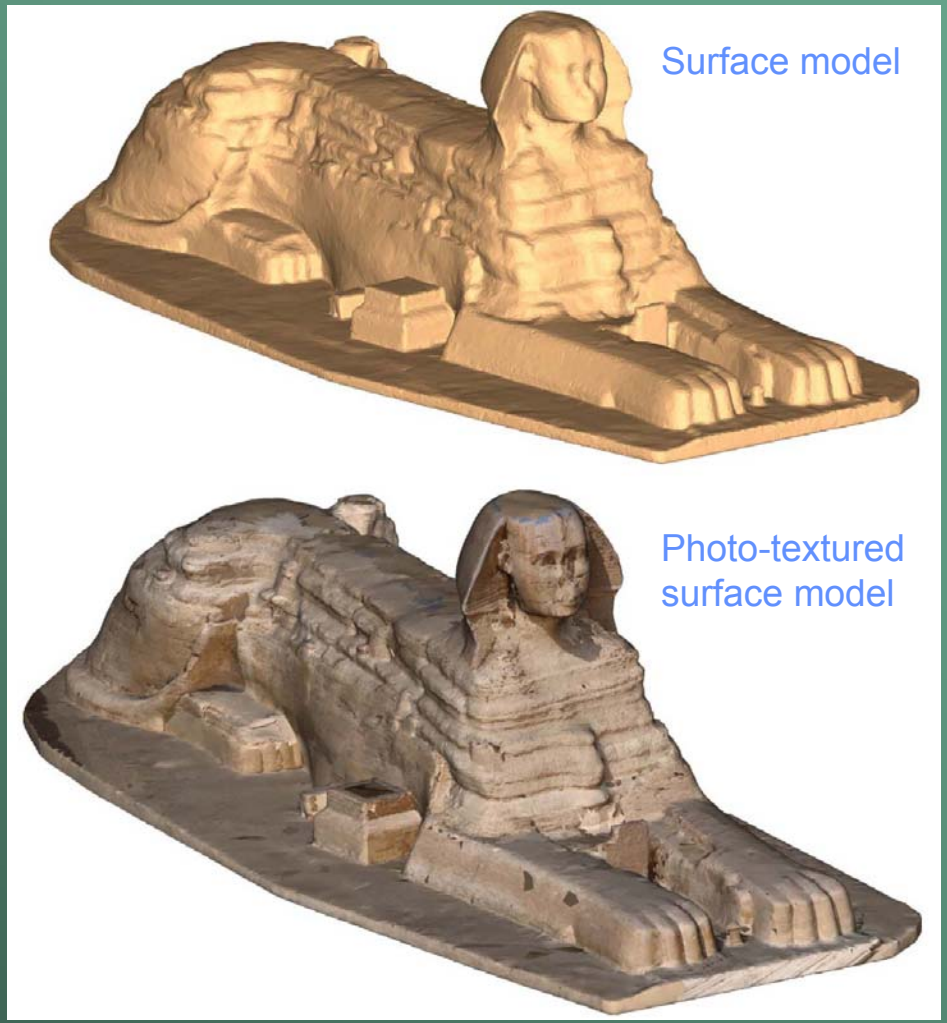
Preliminary Results: Surface Change Detection



May 2007 to September 2007 Surface Change Map at 223 Mile-US Site

Future Directions

- Rapidly changing technology
- Higher accuracy – reduce model error from ~ 7cm to < 1cm.
- Longer range – lower site impact?
- Digital photo draping – feature identification and monitoring



Courtesy: RieglUSA, Source: Neubauer et al., Combined High Resolution Laser Scanning and Photogrammetrical Documentation of the Pyramids at Giza

Conclusions and Future Directions

- Project 1 - complete
  - Viable data collection method
  - Saves time in the field
  - Does not reduce site impact appreciably
  - Provides superior data coverage and ability to perform whole site monitoring
- Project 2 – nearing completion
  - Change detection is achievable – 10 to 15 cm scale
  - Excellent potential for identifying areas of incipient change
- Technology is new – and changing
  - Newest generation of lasers addressed existing limitations
  - Feature and site monitoring via photo draping

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Thank you.