Earth Science Lidar Topography Applications

Chris Crosby
San Diego Supercomputer Center @ UCSD

Featuring work from colleagues:
J Ramón Arrowsmith (ASU); David Phillips (UNAVCO); Mike Oskin (UC Davis), Kurt Frankel (GA Tech)

ASU Arizona State University

OpenTopography

SDSC San Diego Supercomputer Center

Introduction:

- Landscape development a combination of many processes:
  - Tectonic
  - Hillslope
  - Fluvial
  - Biologic
  - Anthropogenic
- High-resolution representation of landscape is central to qualitative and quantitative study of process.
- Aerial photography traditional tool for geomorphic studies
- 2D representation
- Qualitative tool

Crosby, 2006

Introduction:

- Digital topography provides 2.5D representation of landscape
- Widely avail. digital topography (digital elevation models - DEMs) are too coarse to provide representation of small geomorphic features / process.
- USGS 30 m DEM = best available national coverage

Crosby, 2006

Introduction:

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- USGS 10 m DEM

Crosby, 2006

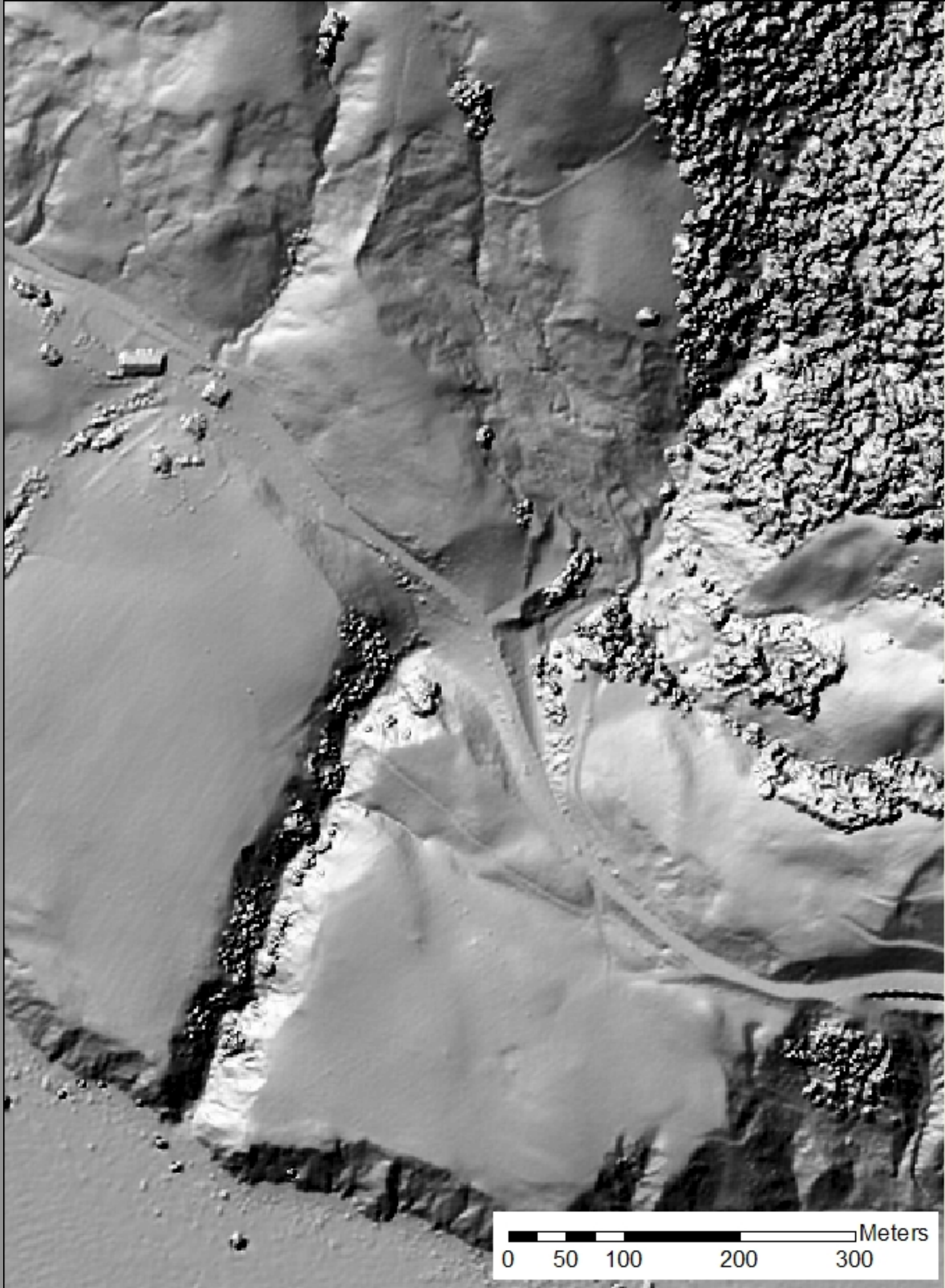
Introduction:

- LiDAR / ALSM data

- DEMs at resolutions not previously possible.
  - sub-meter resolution
  - Measure features at the appropriate scale

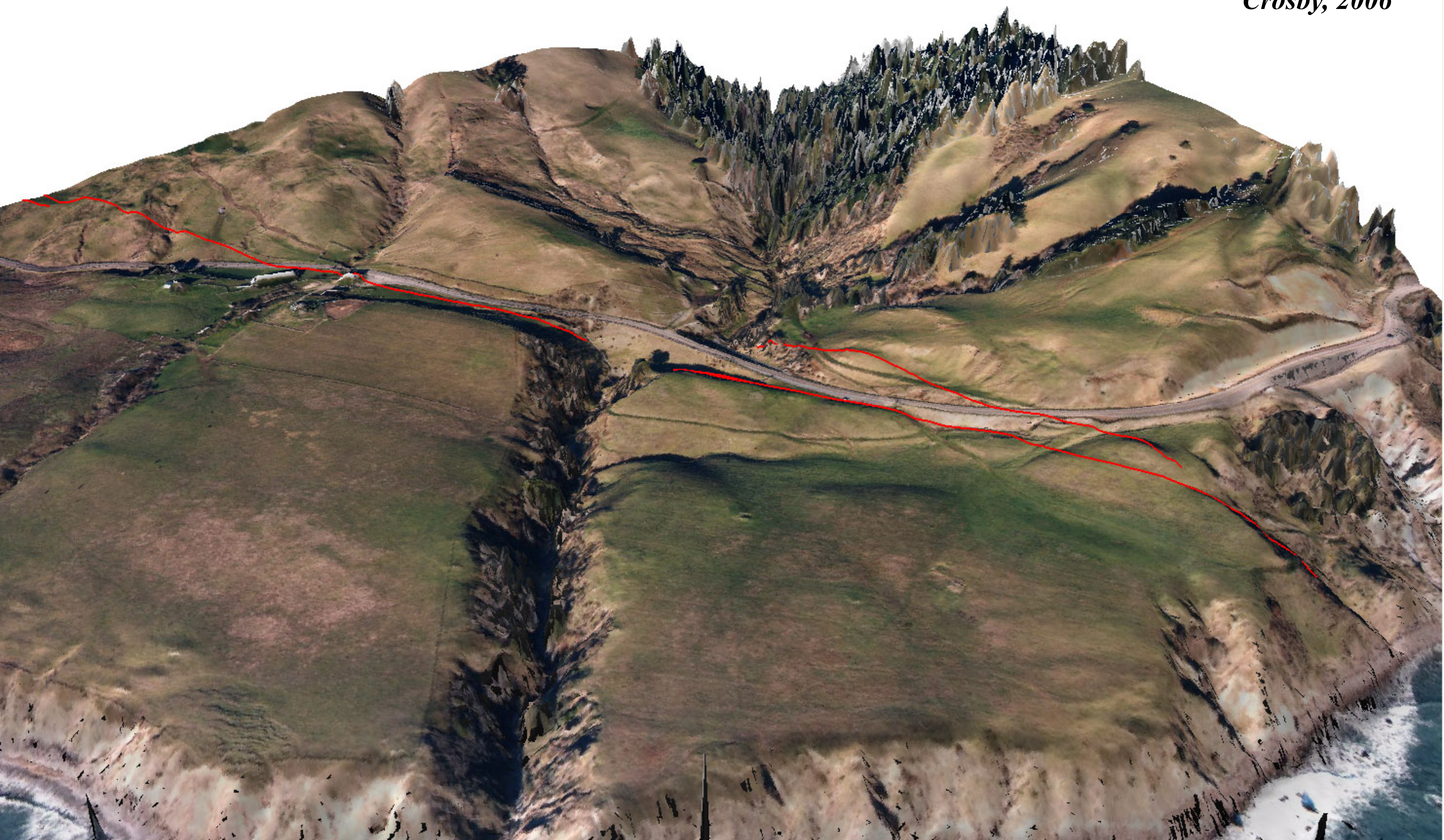
- Applicable to:
  - Geomorphology
  - Landslide & flood hazards
  - Forestry/Ecology
  - Civil Engineering
  - Urban planning
  - Volcanology

- One of the hottest tools in the Geosciences



3D visualization: DEM + air photo fusion

Crosby, 2006

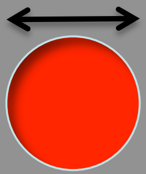


Airborne Lidar 101

lidar = **li**ght **d**etection **a**nd **r**anging (*aka* airborne laser swath mapping)

- collected at 10s to 100s of kHz

- Vertical accuracy ~15 cm



- Beam diameter 15-20 cm

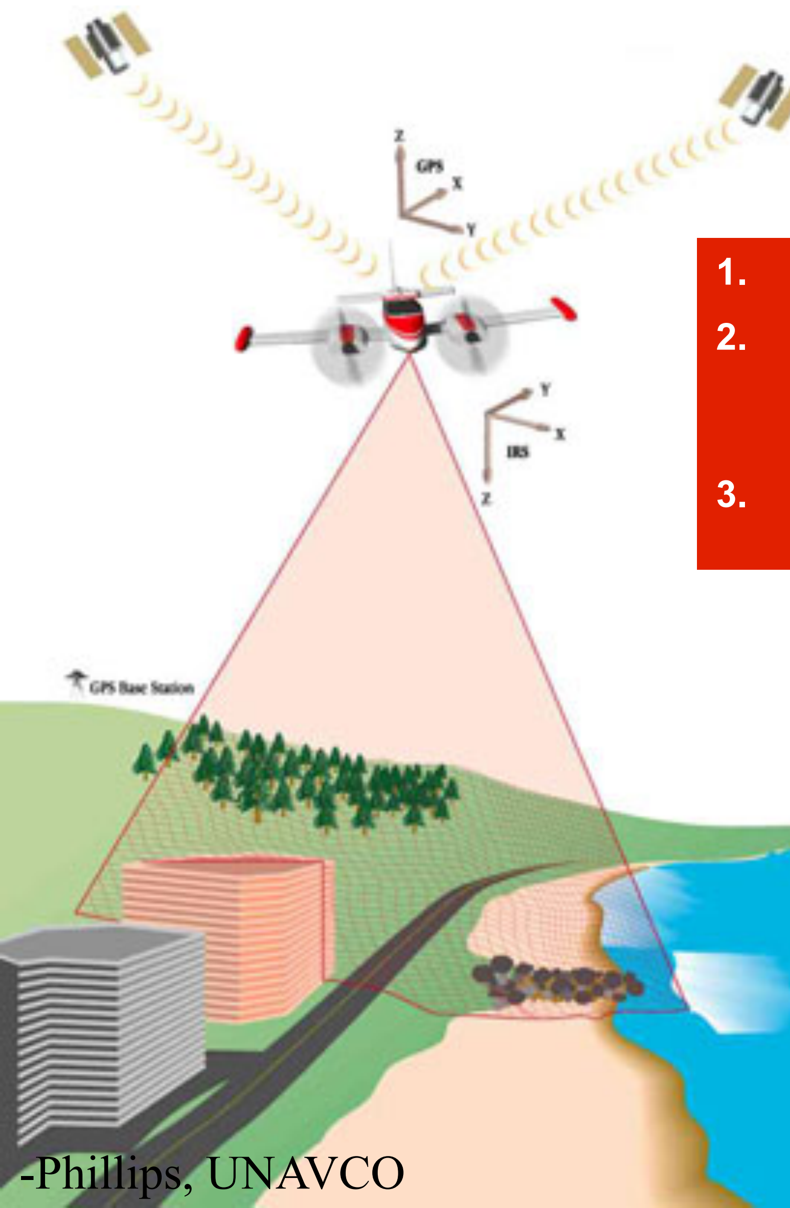
- 10^6 to 10^9 measurements of ground, vegetation, structures
  - *Point cloud (x,y,z* coordinates) = fundamental lidar data product

- Earth's surface > 8 times per meter^2

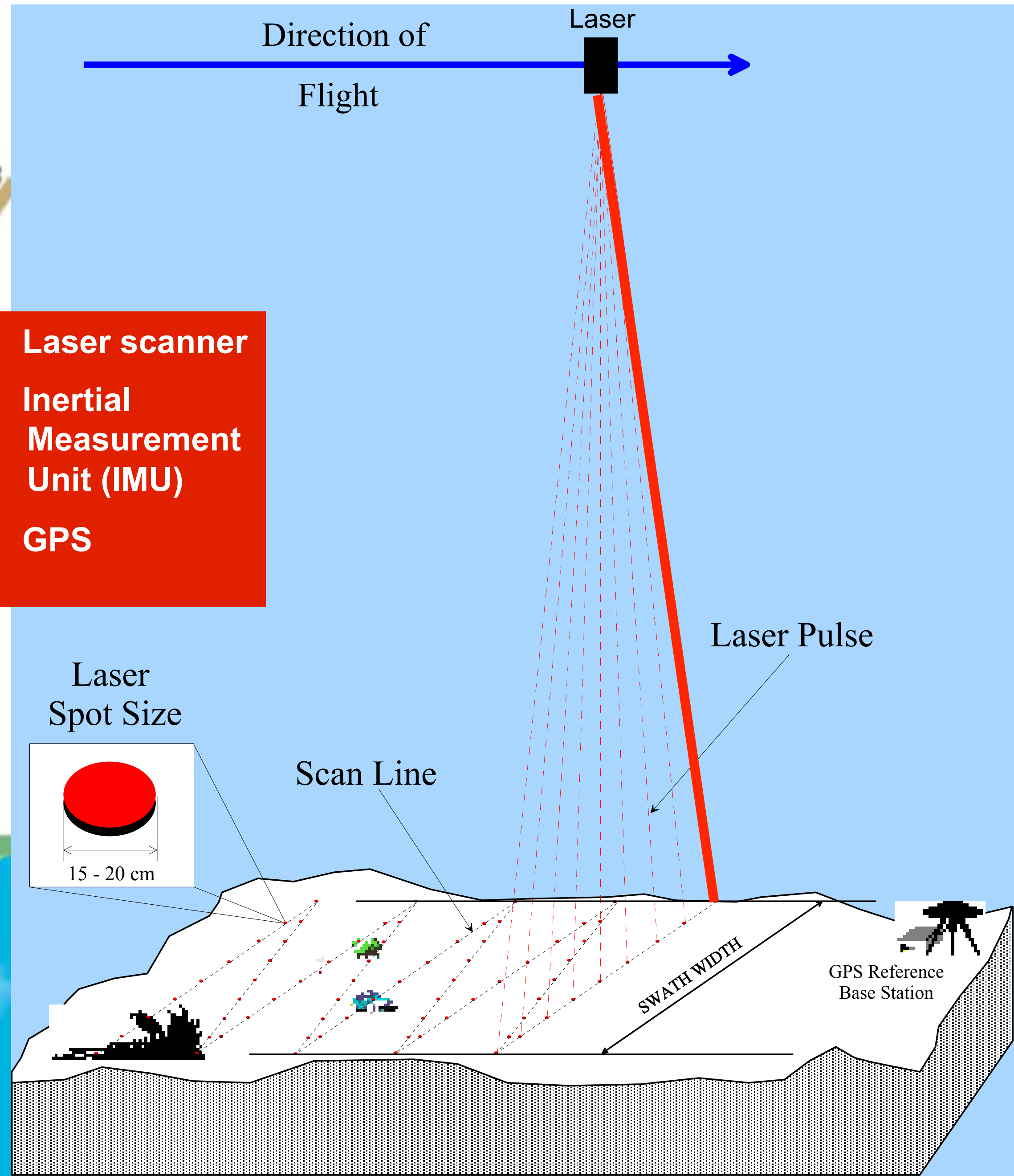
Crosby, 2010

NCALM
The National Center for Airborne Laser Mapping

Airborne Laser Swath Mapping (ALSM)

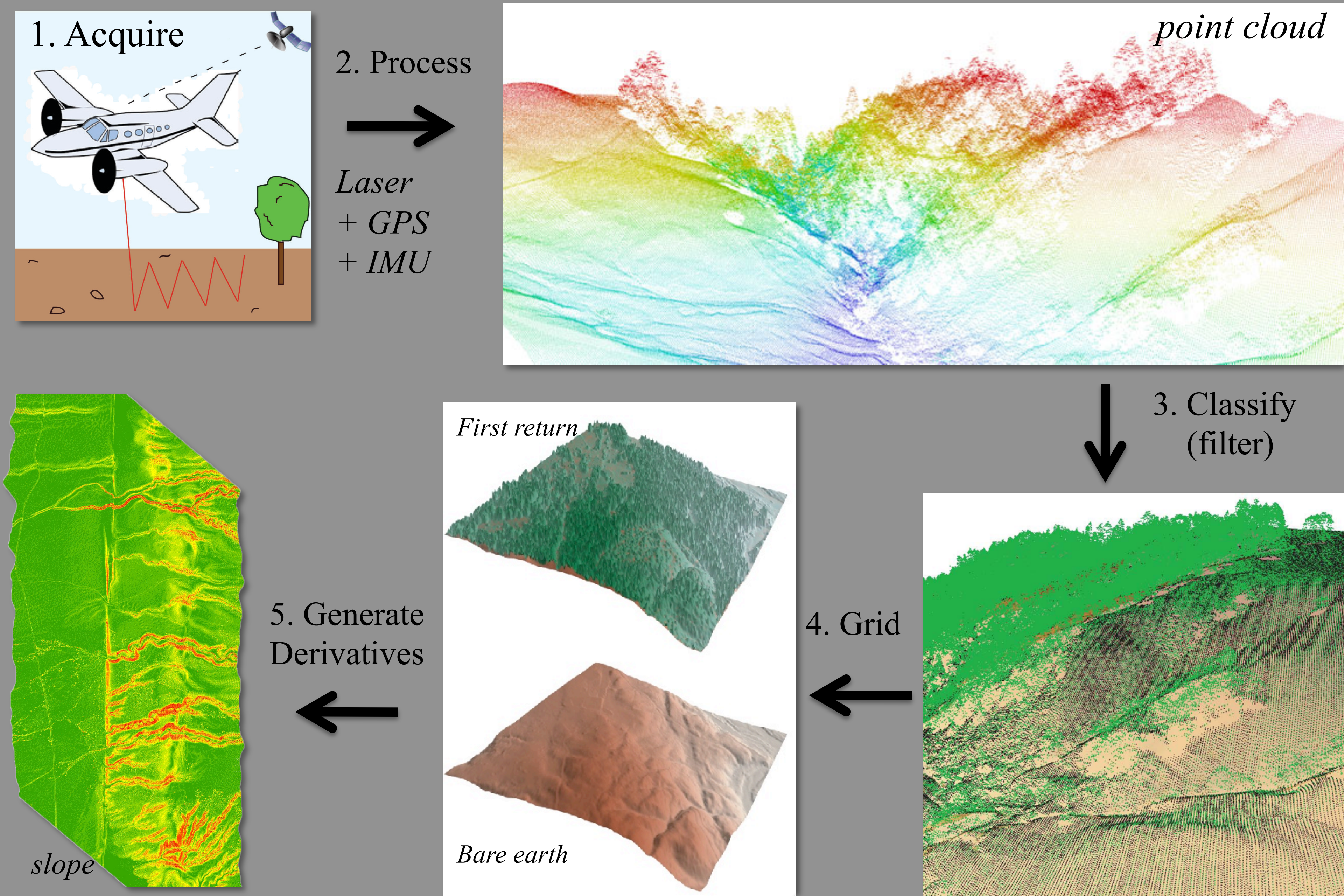


1. **Laser scanner**
2. **Inertial Measurement Unit (IMU)**
3. **GPS**

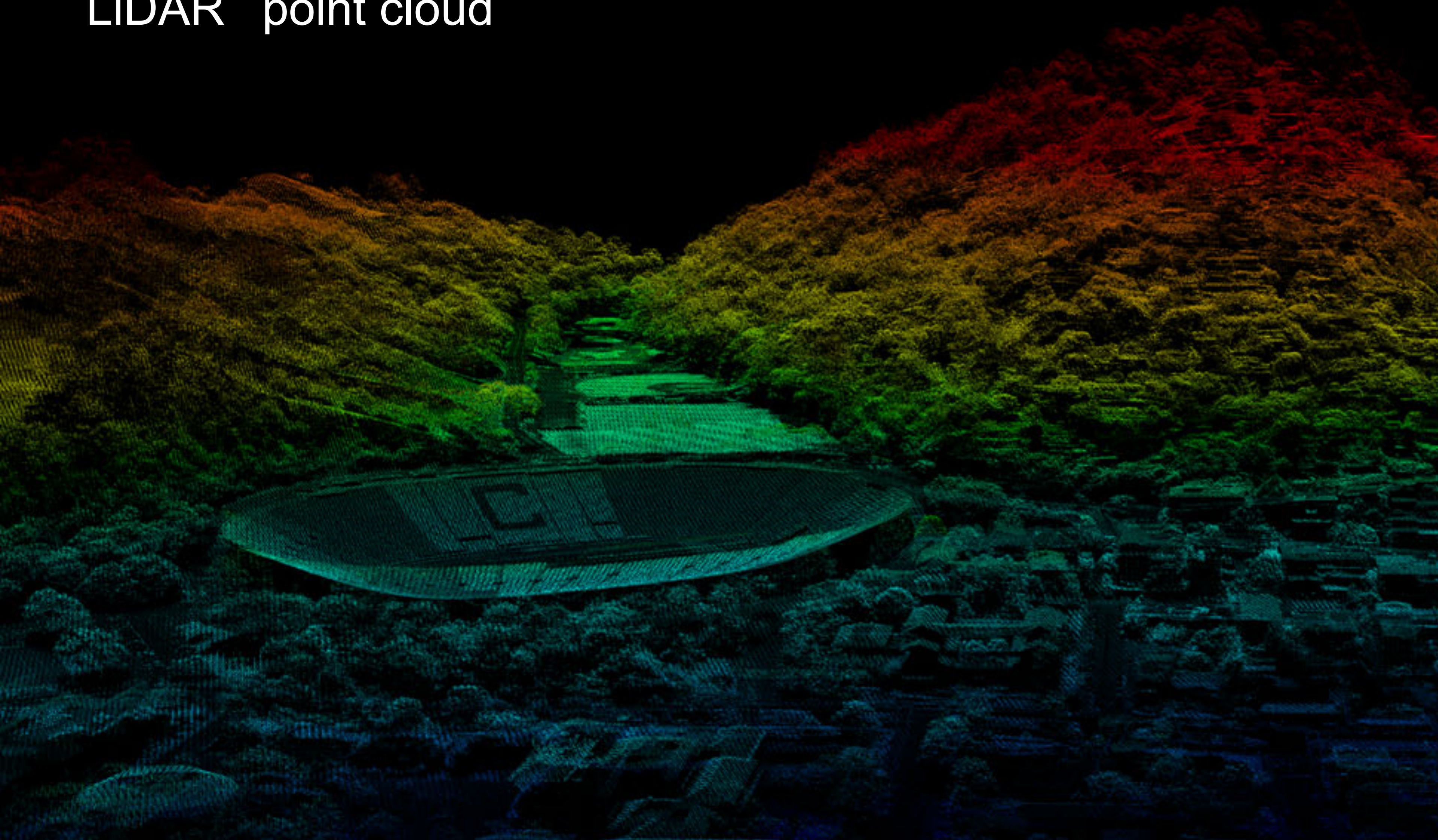


Crosby, 2010

Airborne Lidar Workflow



LiDAR “point cloud”



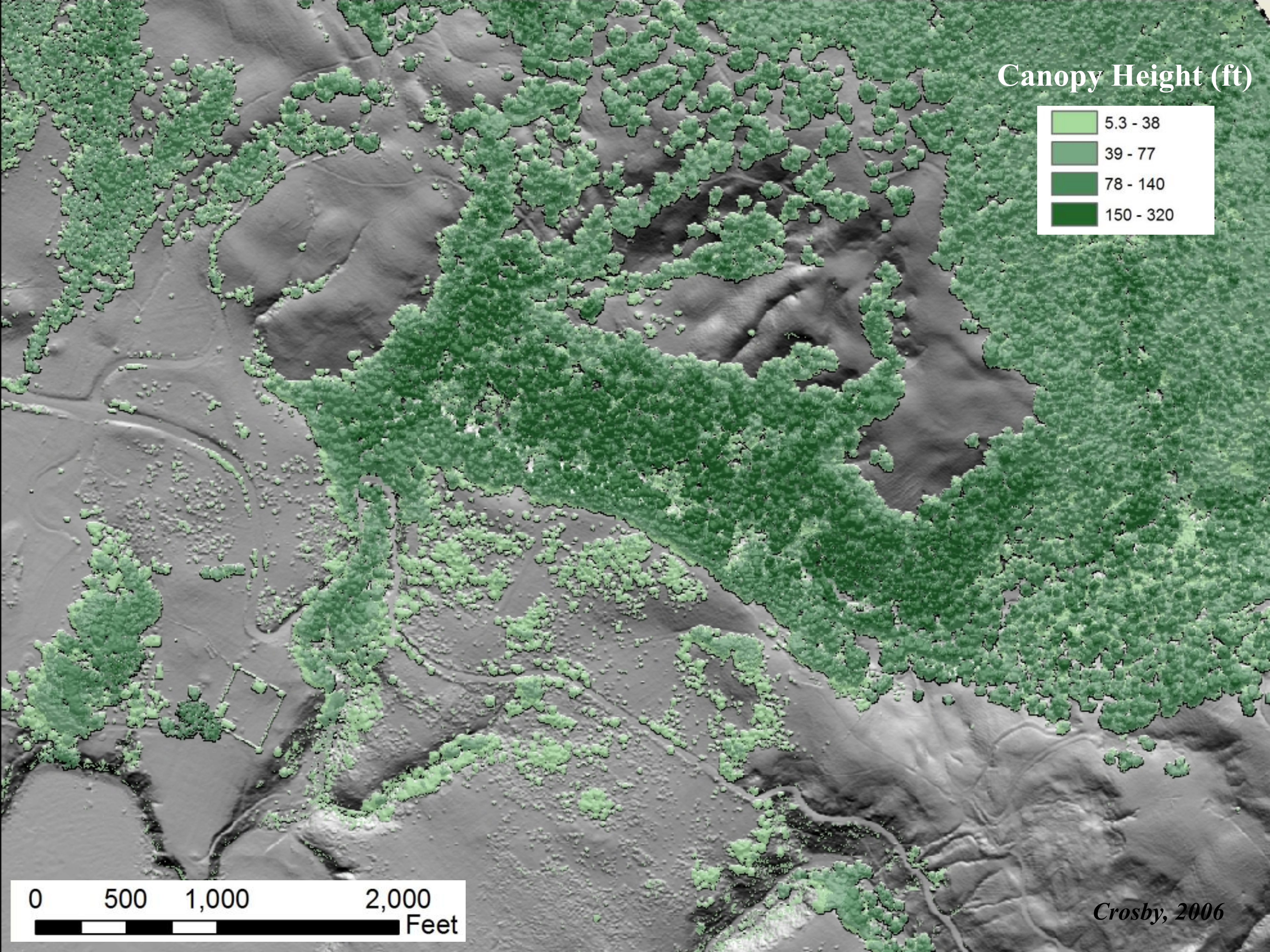
- *x,y,z* + attributes
- Filtering algorithms allow classification by return type:
  - Ground, vegetation, building …

Comparisons of Techniques for measuring surfaces and detecting changes in surfaces*

	GPS	InSAR	ALSM	TLS
Sample Density	1 site/10 km^2	10,000 pixels/ km^2	1- >14 hits/ m^2	1000 hits/ m^2
Position Precision	1-20 mm	2-3 m	5-15 cm	0.6-5 cm
Change Detection	1 mm	1-2 cm	10 cm	1 cm
Scale	Global	100 km	10-100 Km	1 km

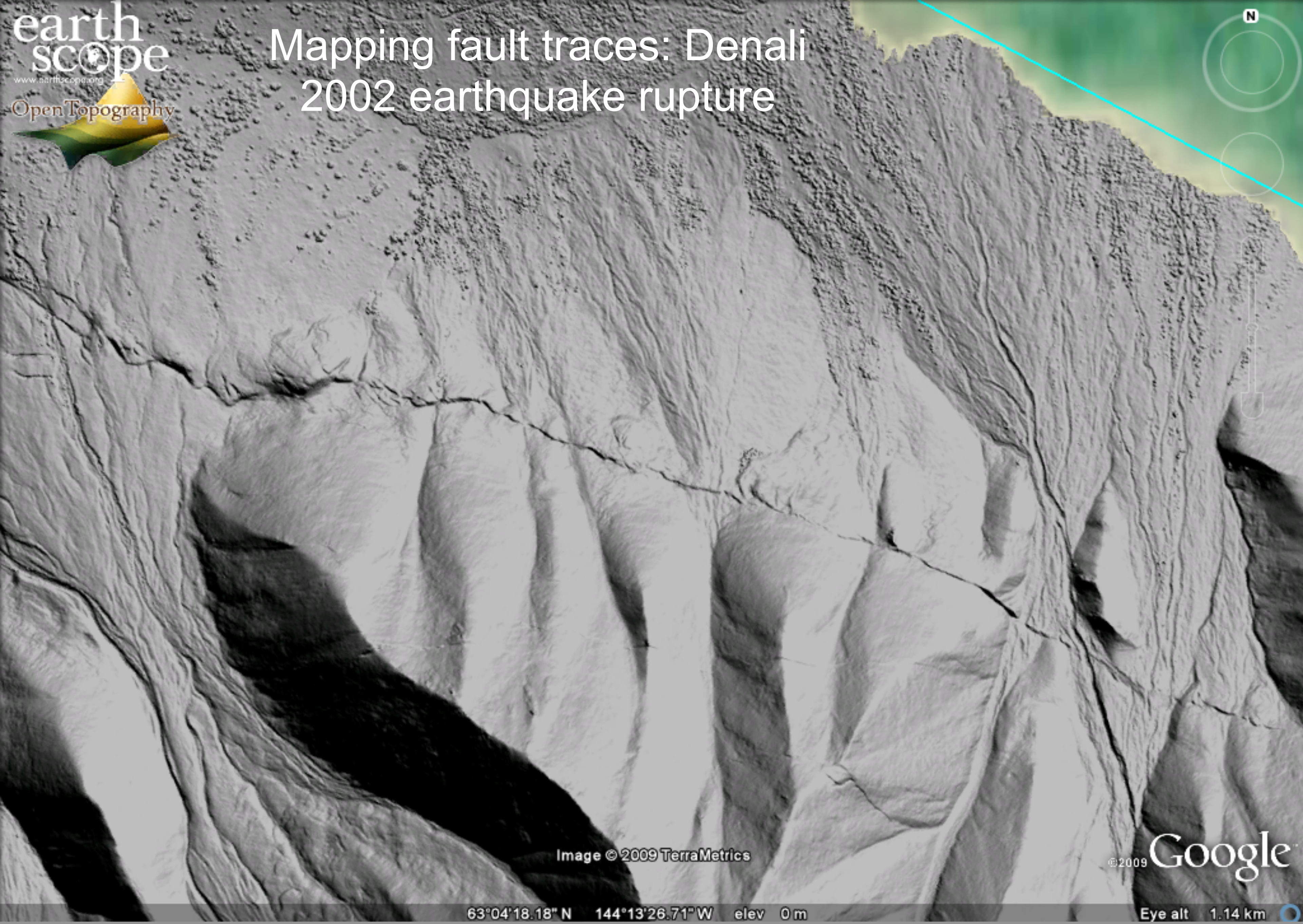
* Ball park numbers for typical applications

-Phillips, Meertens, and Jackson, UNAVCO



Canopy Height (ft)
5.3 - 38
39 - 77
78 - 140
150 - 320
0
500
1,000
2,000
Feet
Crosby, 2006

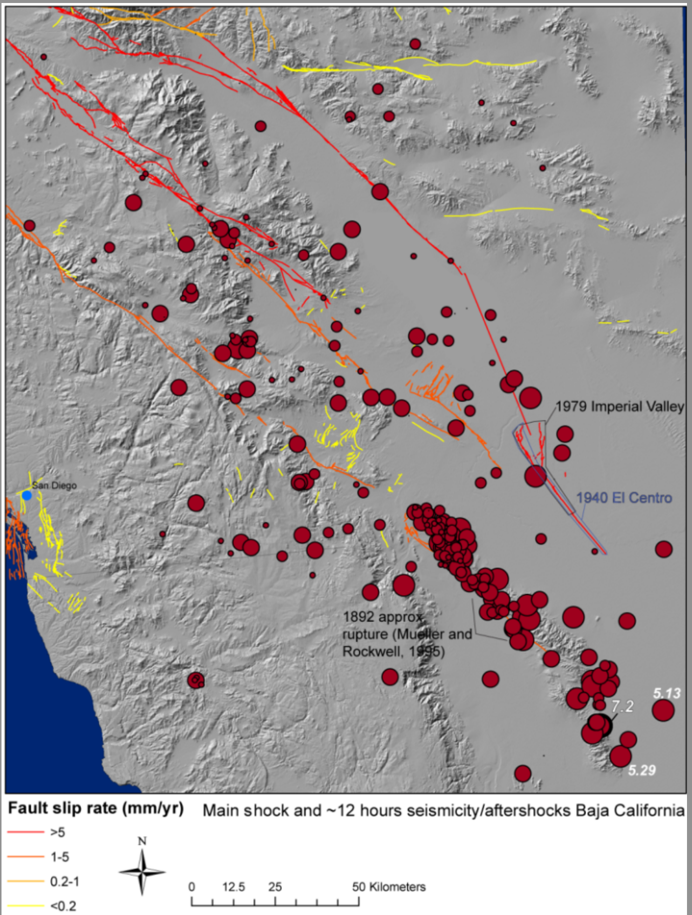
Mapping fault traces: Denali 2002 earthquake rupture

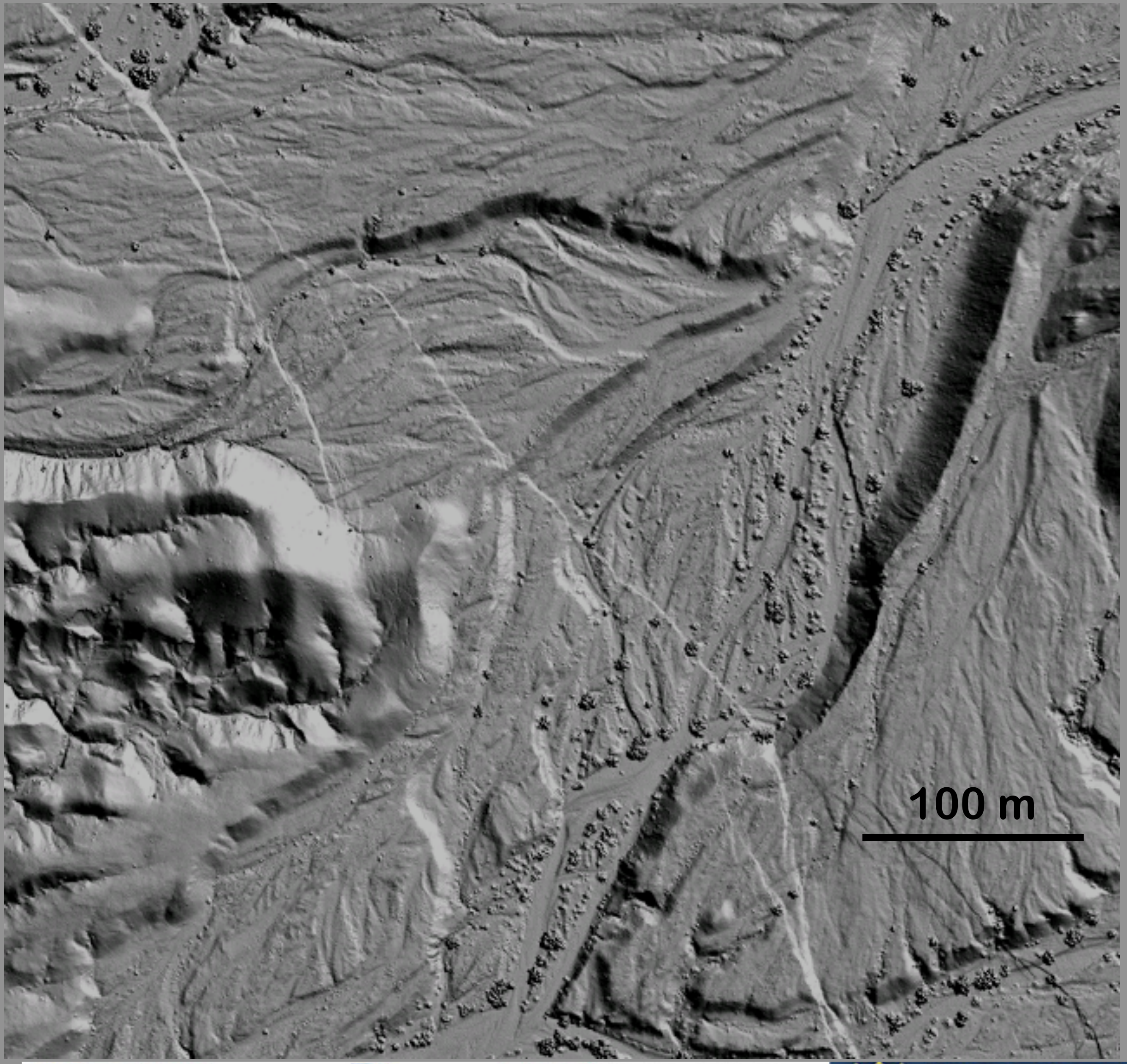


Post earthquake laser scanning and repetition (B4, Hector Mine, Denali)

Post El Mayor-Cucupah EQ Scan

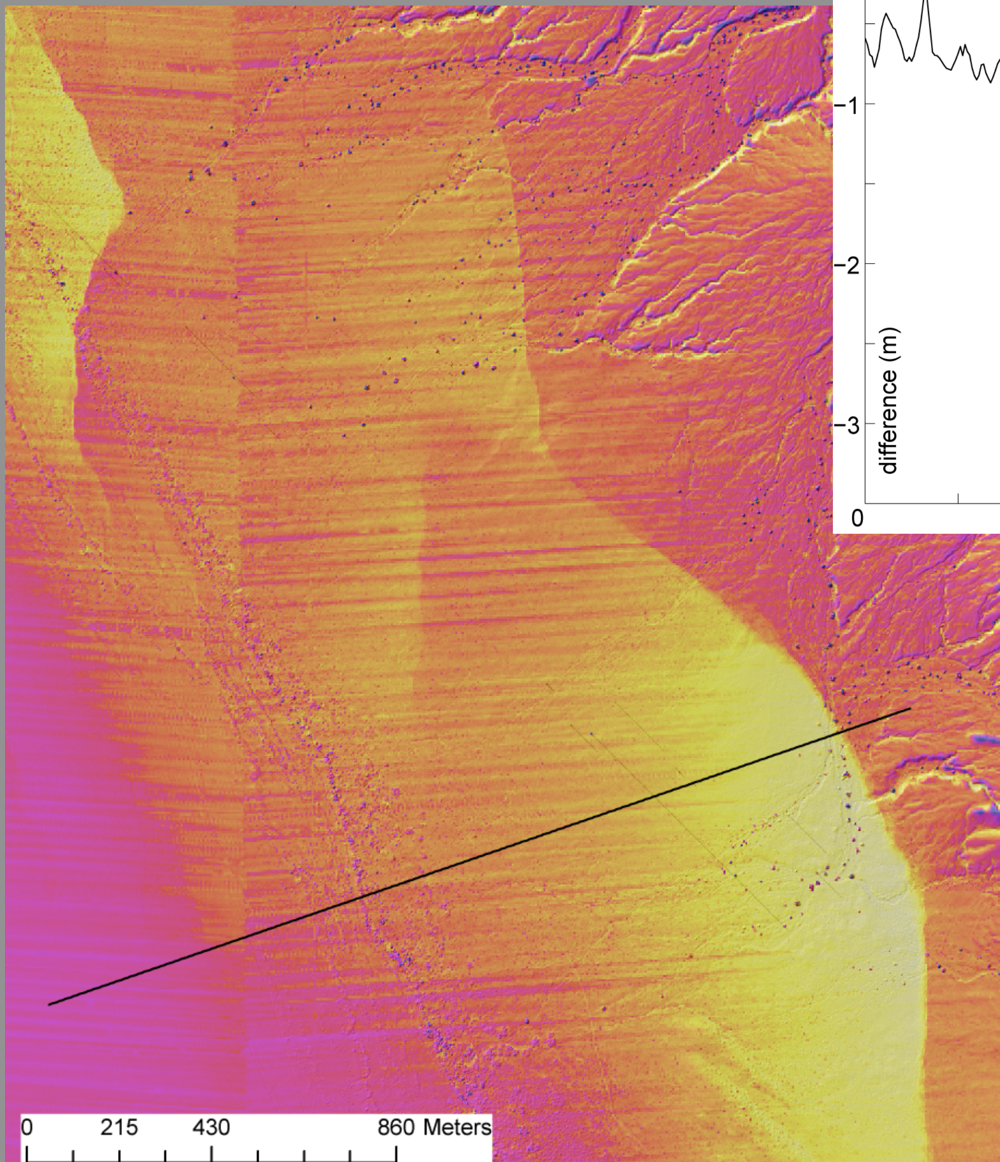
- Oskin, Arrowsmith, Hinojosa, Fletcher (NSF Rapid + SCEC); collected by NCALM

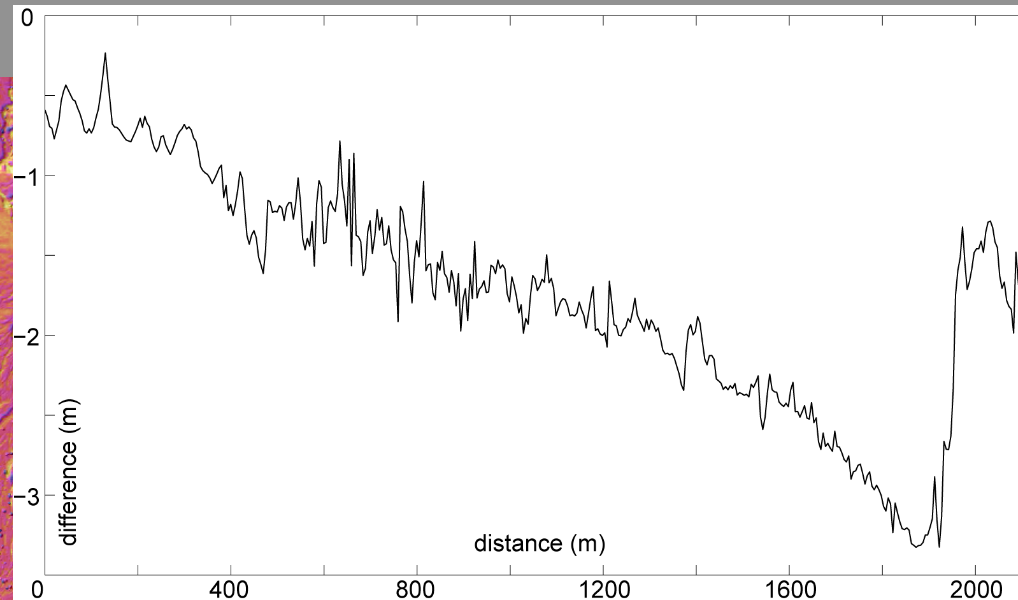




UCDAVIS DEPARTMENT of GEOLOGY | CICESE | ASU School of Earth & Space Exploration ARIZONA STATE UNIVERSITY | NSF | NCALM

Change Detection with LiDAR Data

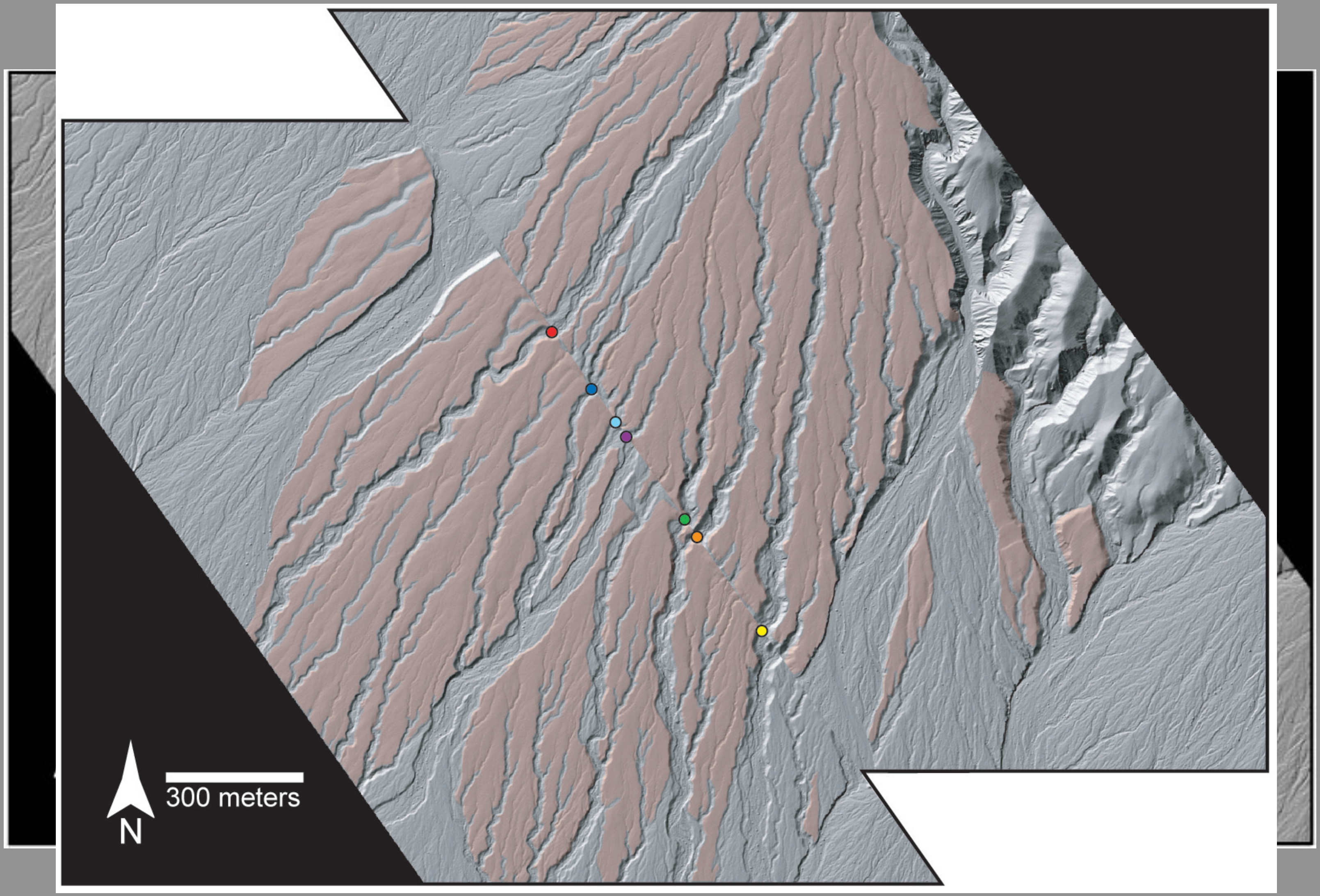




- vertical different pre- and post-El Mayor- Cucupah earthquake
- subtract 5 m pre-earthquake INGEGI DEM from 5 m post-earthquake DEM

Arrowsmith, Oskin, Fletcher, Hudnut, in submitted

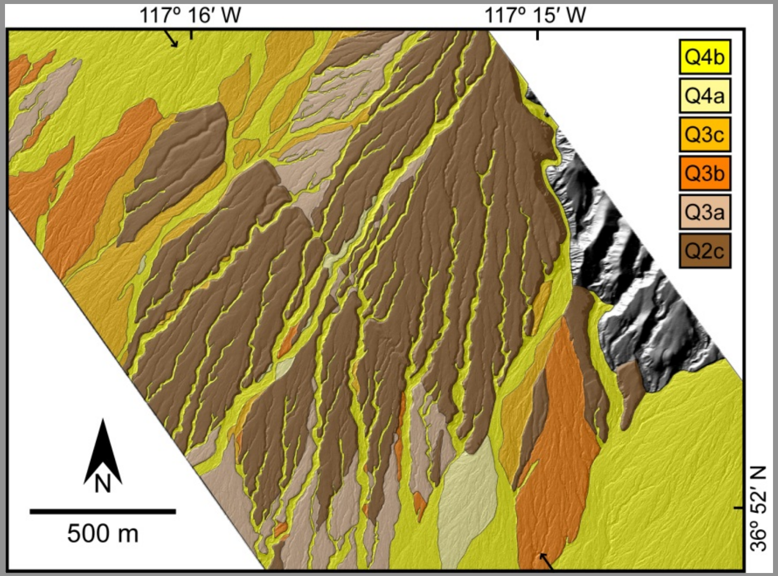
Red Wall Canyon Offset



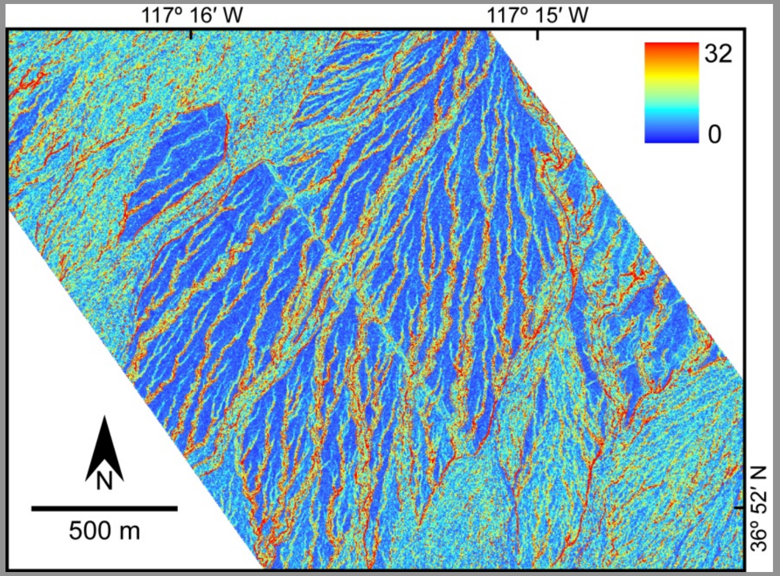
- total displacement = 297 ± 9 meters

Frankel et al., 2007, *JGR - Solid Earth*

Objective Mapping with Roughness

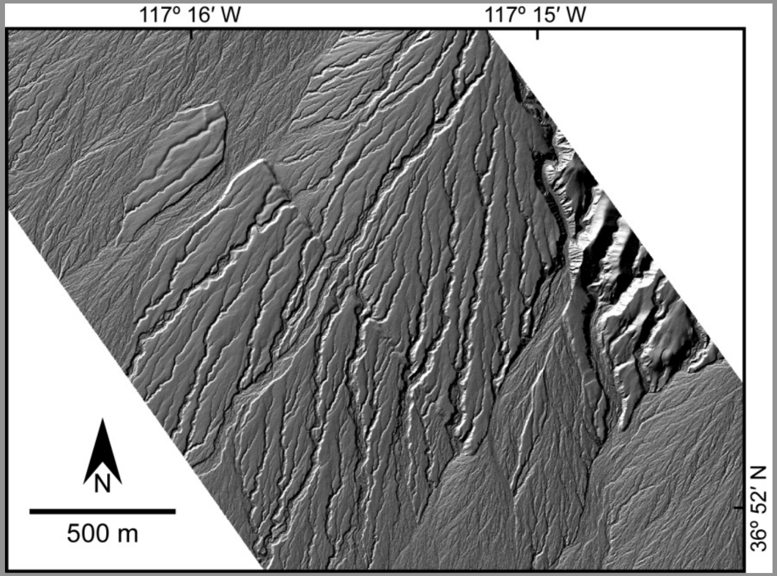


• surficial geologic map

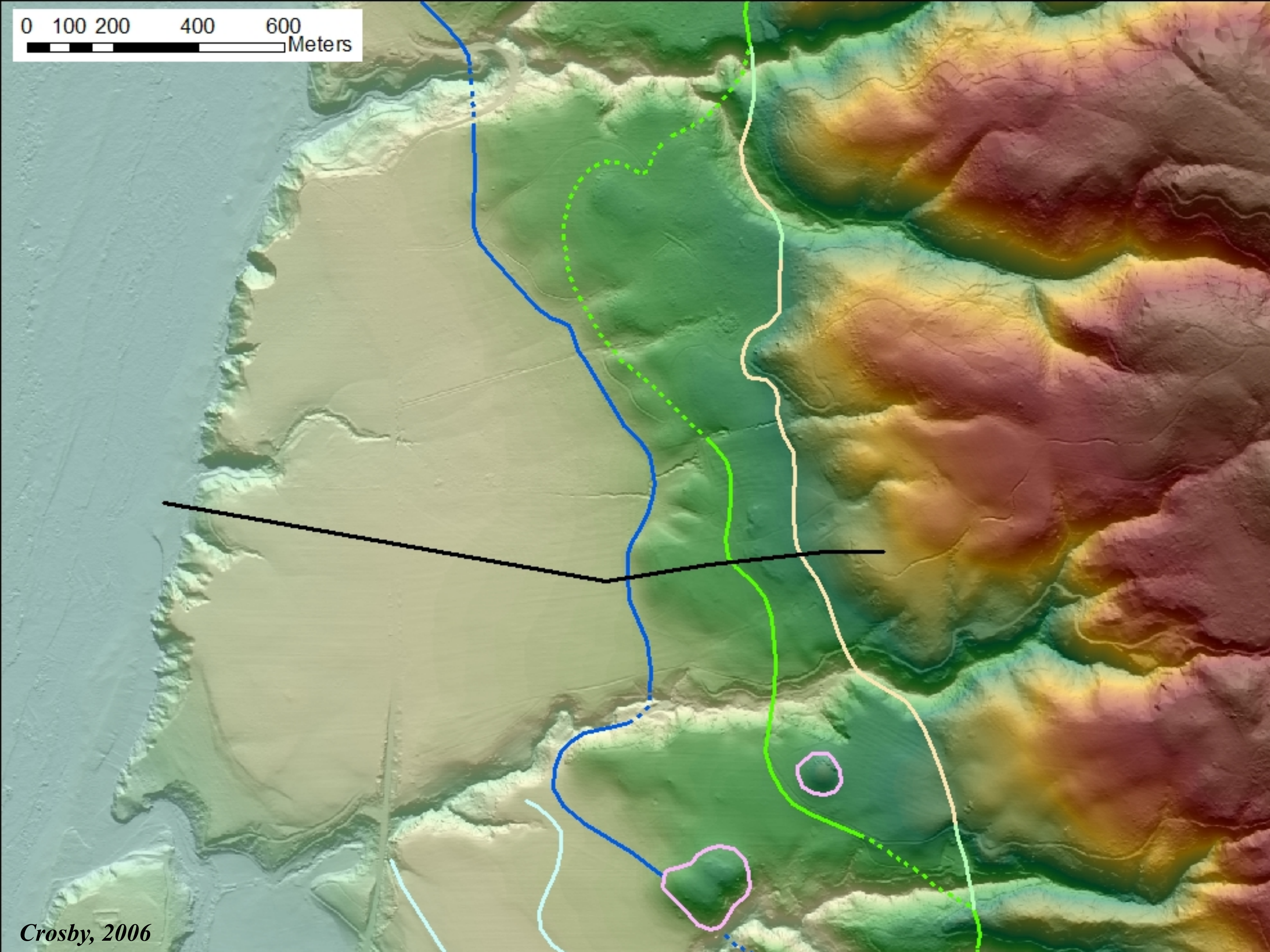


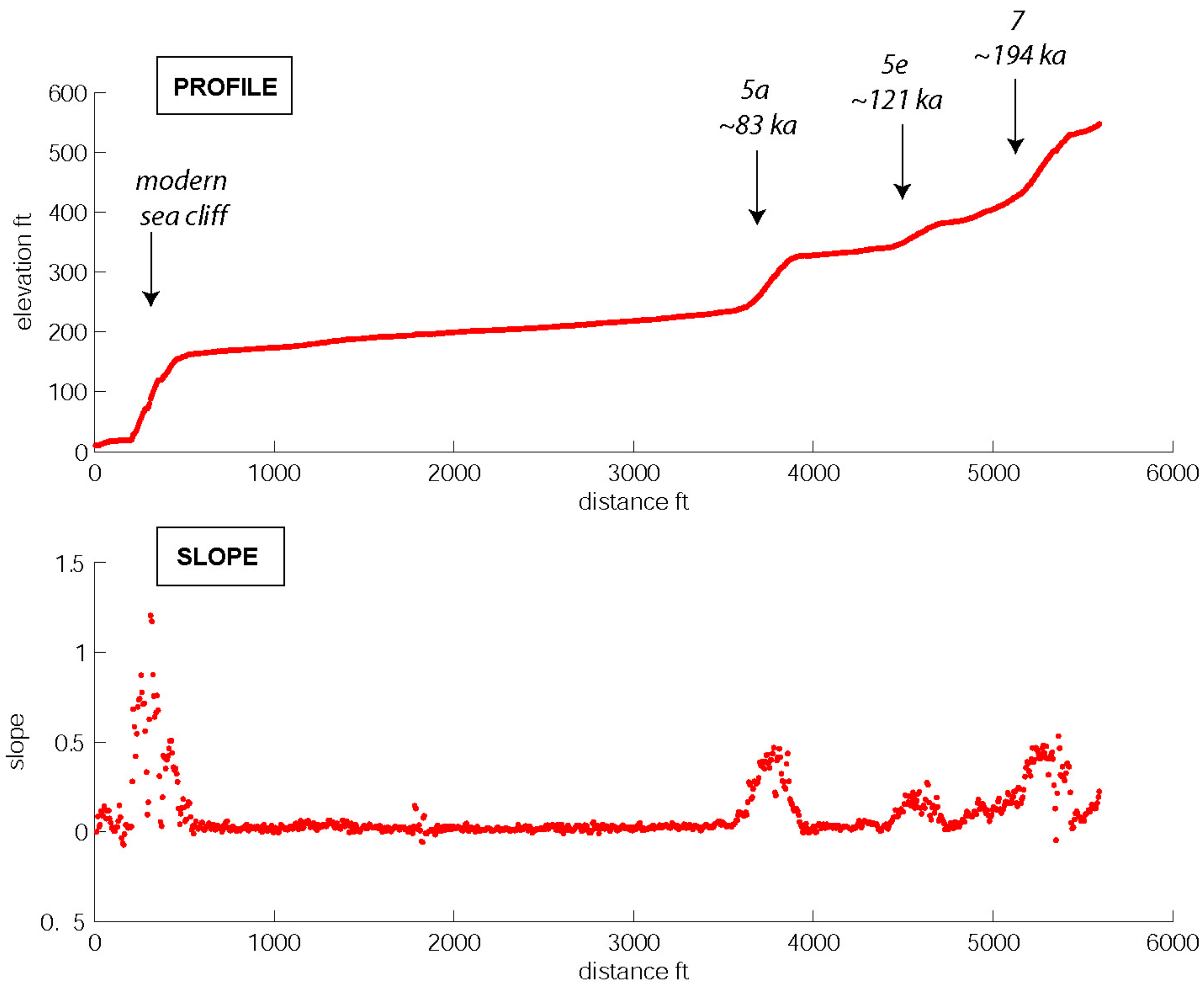
• surface roughness map

• bare-earth DEM (1 m)



Frankel and Dolan, 2007, *JGR - Earth Surface*

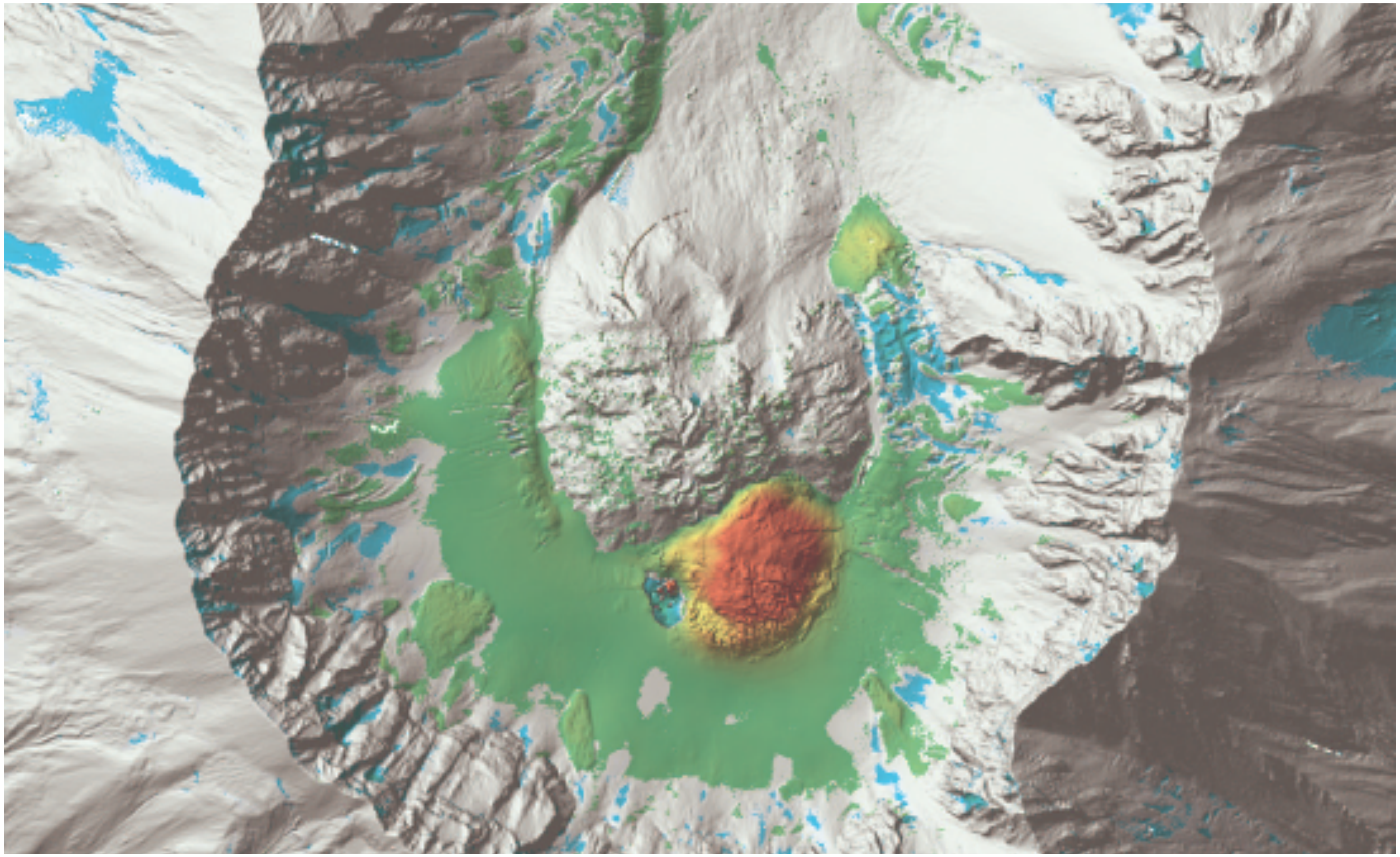

0 100 200 400 600
Meters
Crosby, 2006


PROFILE
modern
sea cliff
5a
~83 ka
5e
~121 ka
7
~194 ka
elevation ft
0
100
200
300
400
500
600
0
1000
2000
3000
4000
5000
6000
distance ft
SLOPE
slope
1.5
1
0.5
0
0. 5
0
1000
2000
3000
4000
5000
6000
distance ft

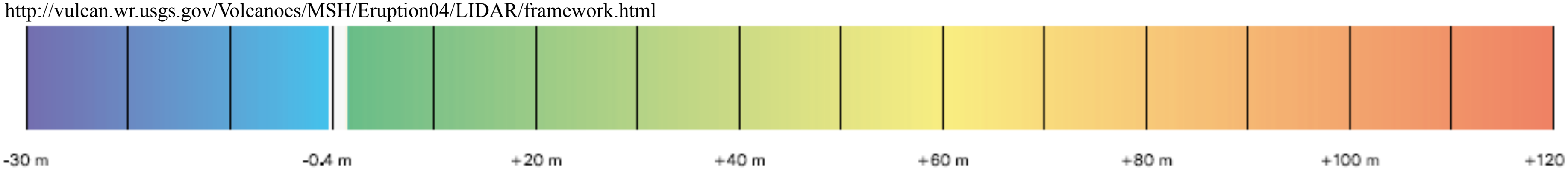
Crosby, 2006

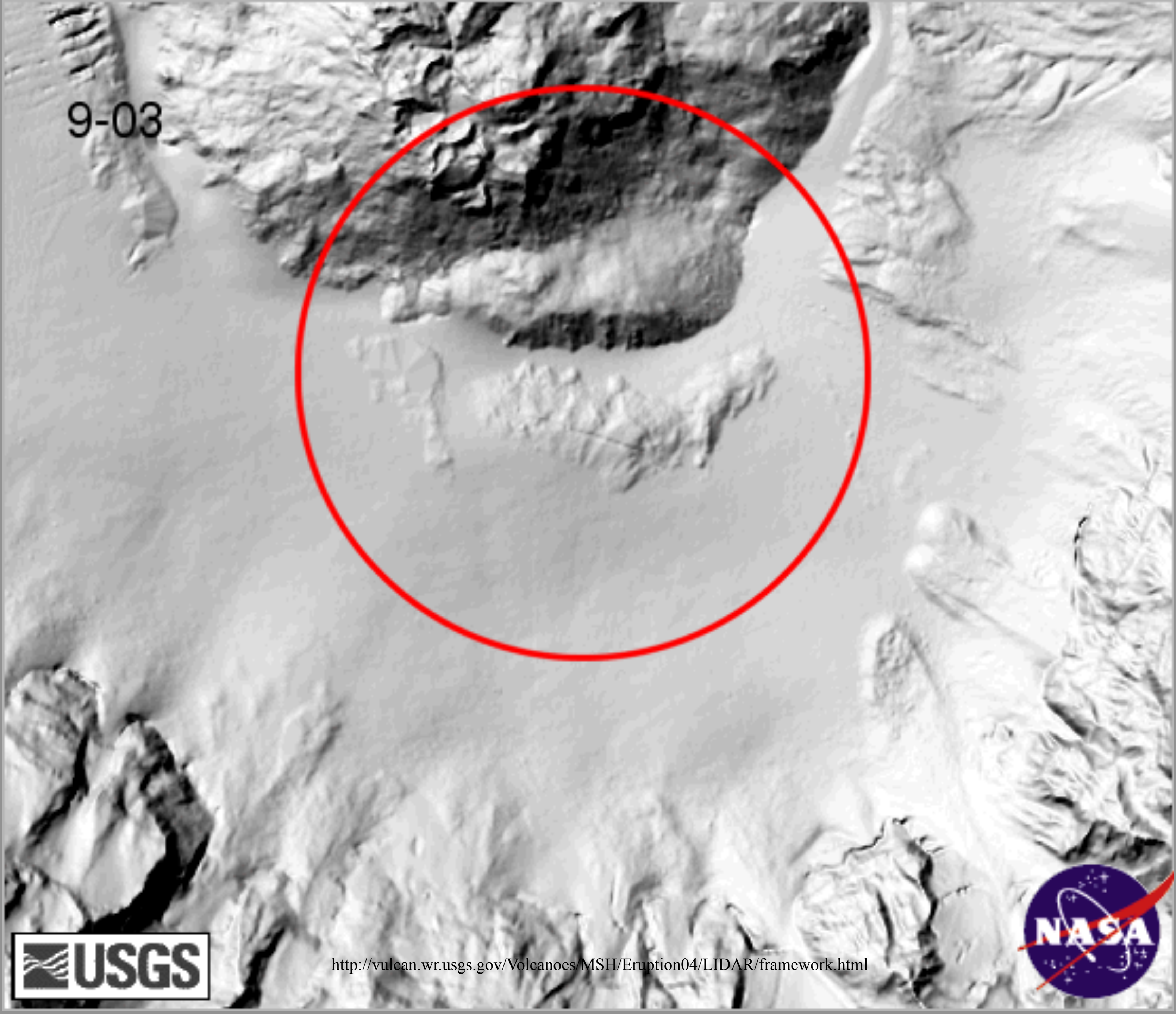
Elevation change at Mt St Helens, September 2003 to October 4-5, 2004

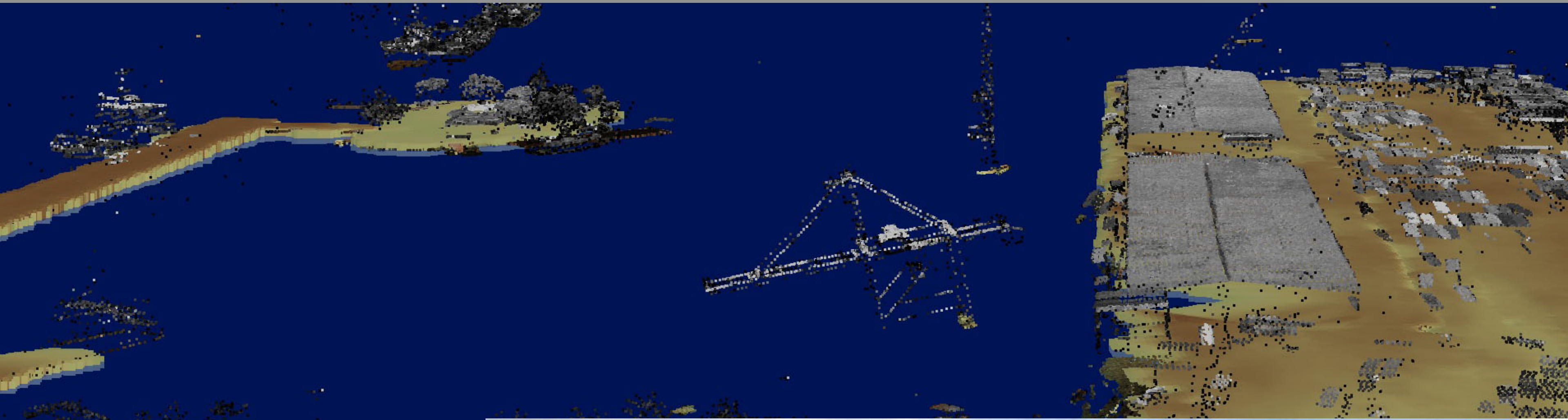
Ralph Haugerud (USGS), David Harding (NASA), Vivian Queija (USGS), Linda Mark (USGS)

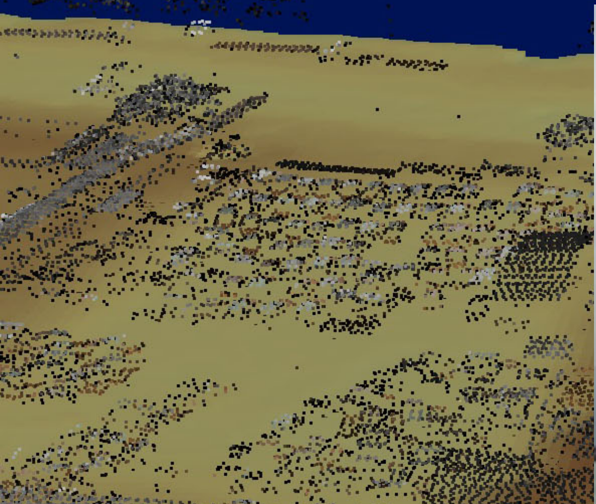


http://vulcan.wr.usgs.gov/Volcanoes/MSH/Eruption04/LIDAR/framework.html




9-03
USGS
NASA
http://vulcan.wr.usgs.gov/Volcanoes/MSH/Eruption04/LIDAR/framework.html

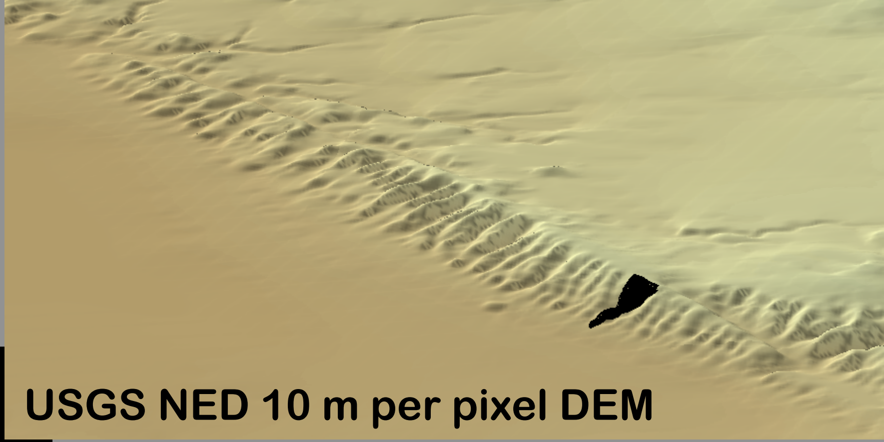


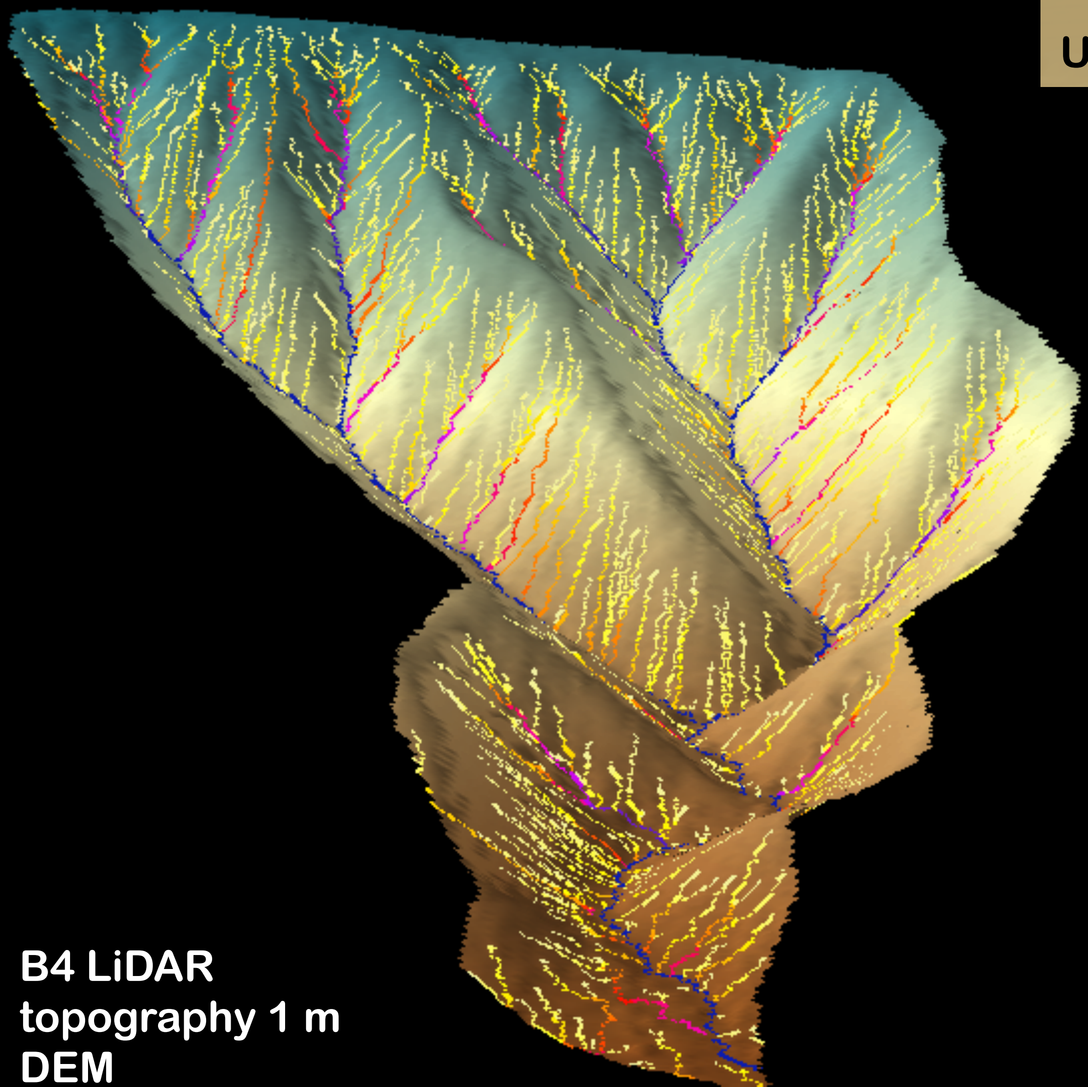


Port-au-Prince waterfront produced from lidar point cloud data.

Crosby, SDSC

Measuring Landscape Characteristics at the Appropriate Scale






Arrowsmith, ASU

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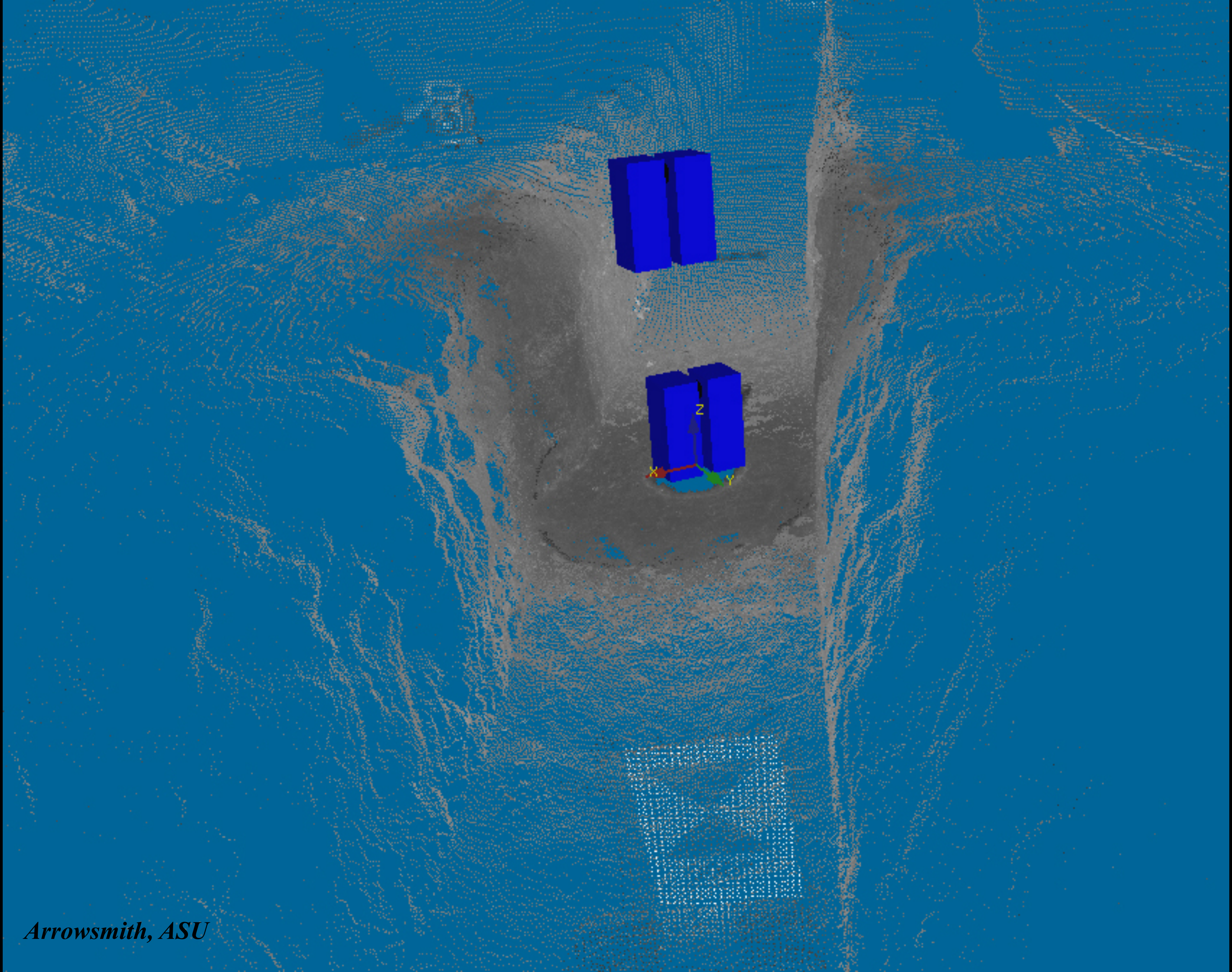

Arrowsmith, ASU

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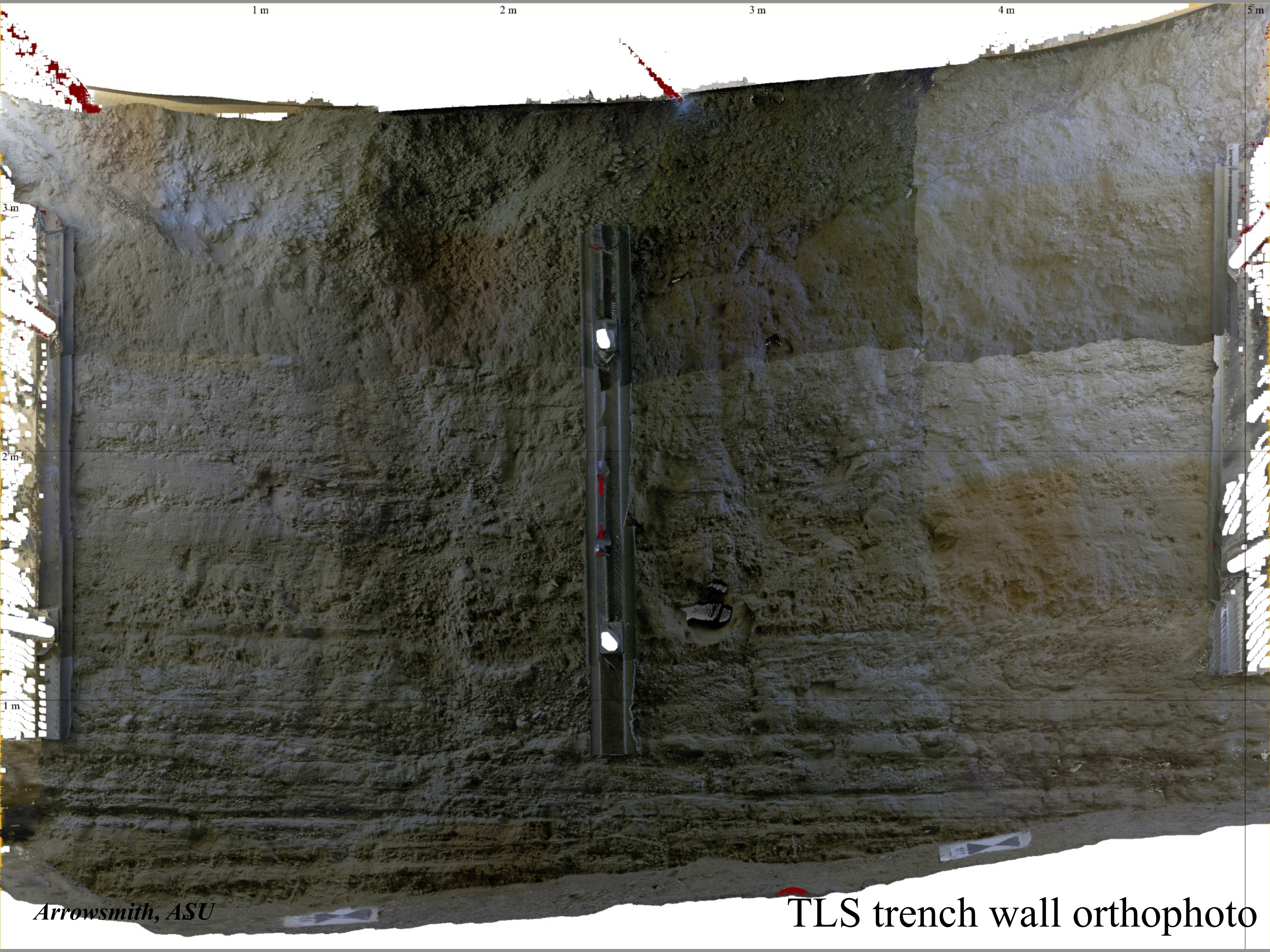
1 m
2 m
3 m
4 m
5 m
3 m
2 m
1 m
Arrowsmith, ASU
TLS trench wall orthophoto

Questions & Comments:

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