Science motivations and introductory remarks

GSA 2019

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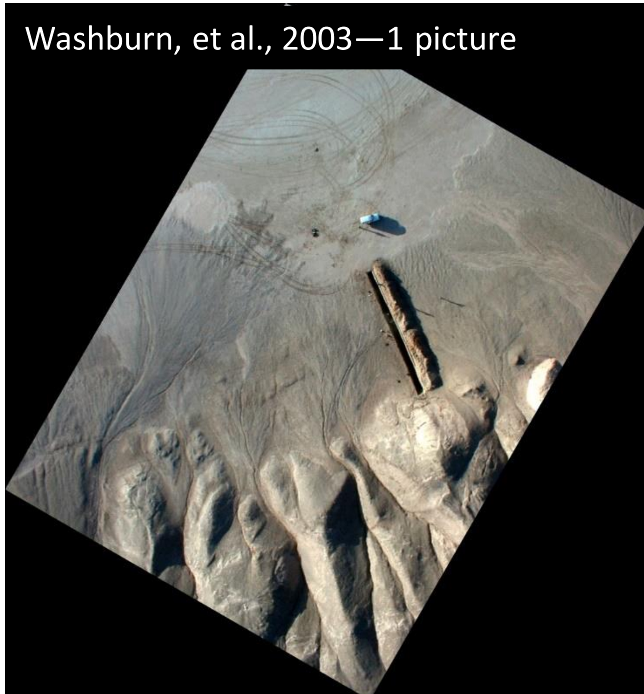
OpenTopography
High-Resolution Topography Data and Tools

Trying to get at least a few pictures along the Altyn Tagh Fault, western China (1998)

-16 and 32 sq. ft. Flowform kites

-1280x960 pixels from radio triggered Olympus 340 digital camera

-geometry not appropriate for traditional photogrammetry; we needed structure from motion

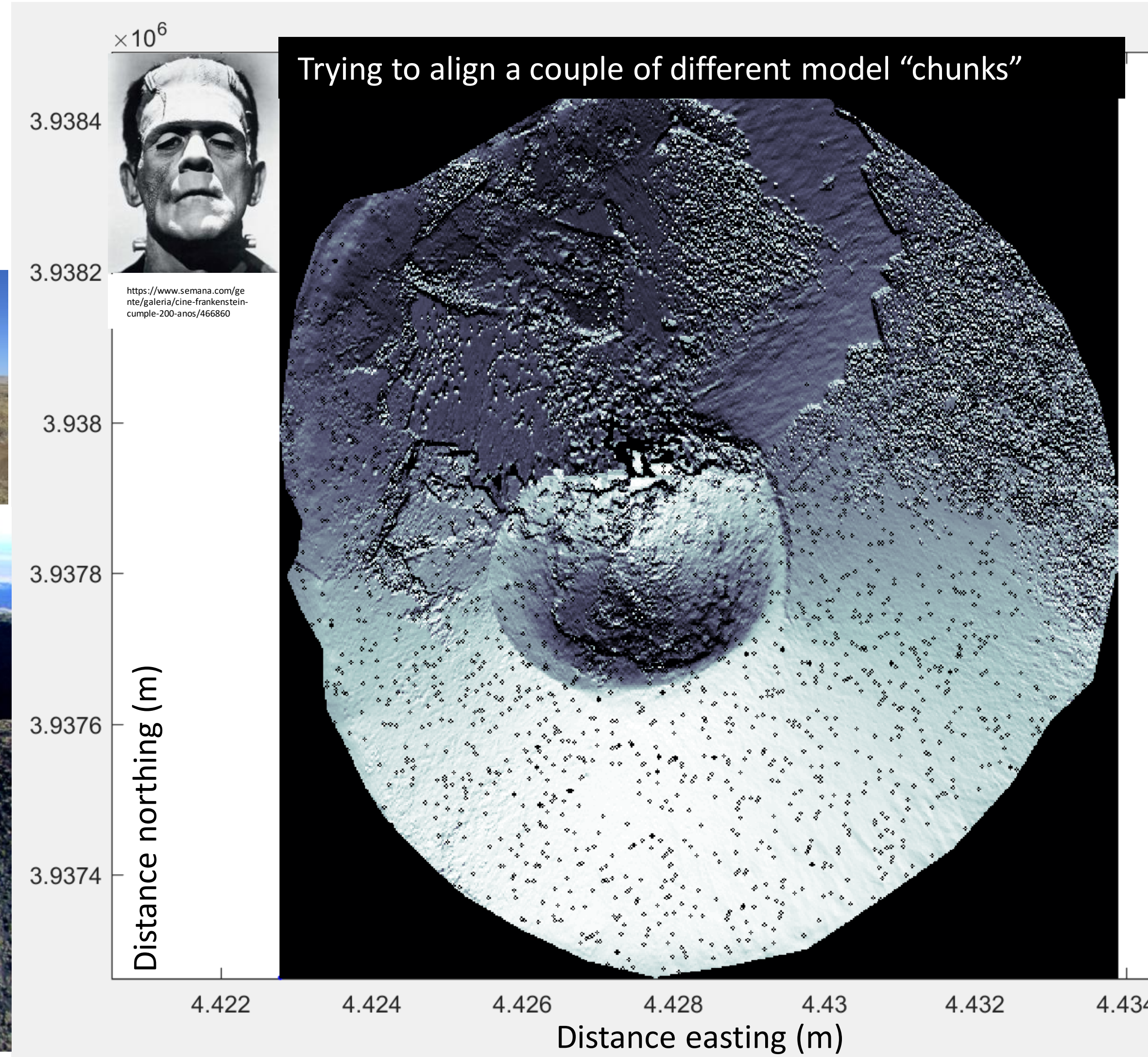


Washburn, et al., 2003—1 picture

Trying to build a complete model of SP Crater, Northern Arizona with REU students (2013)

-using balloon and auto kite mounted system

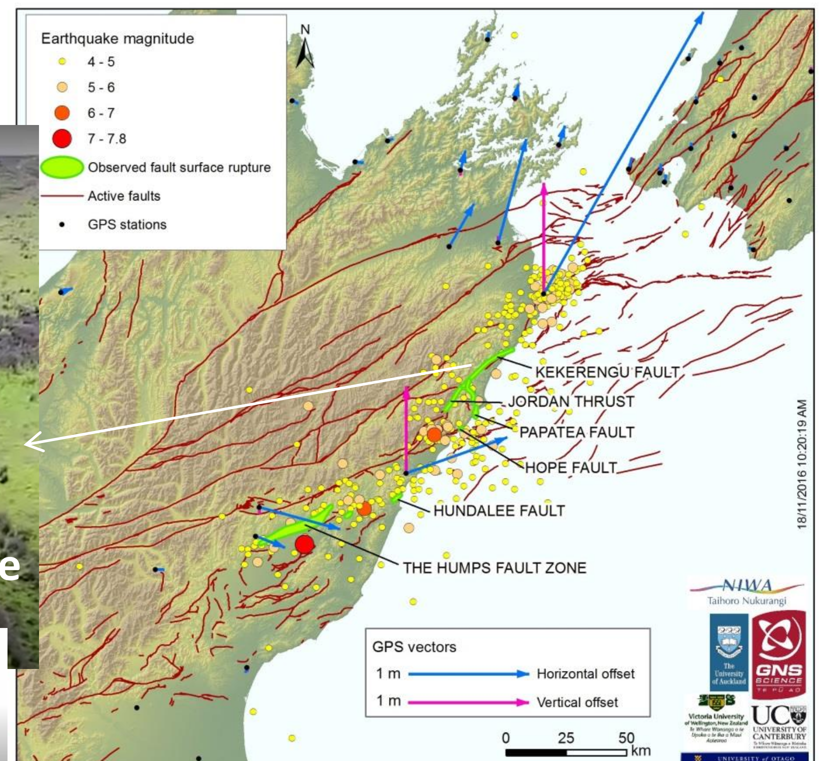
-different surveys, weak ground control, under powered processing machines



Science requirements

- Need topography data with sufficient spatial extent and resolution to capture phenomena of interest
- Need topography data with sufficient temporal repeat to capture changes of interest

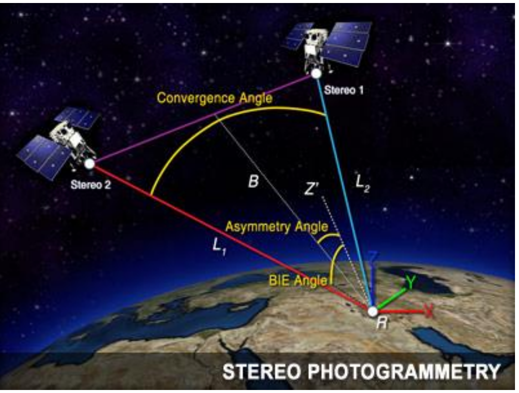
https://www.youtube.com/watch?v=U3H8wlzXGYE&feature=youtu.be



Kekerengu alone is 30+ km of this intricate ground rupture

3D IMAGING WITH CAMERAS & LASERS

Space-based

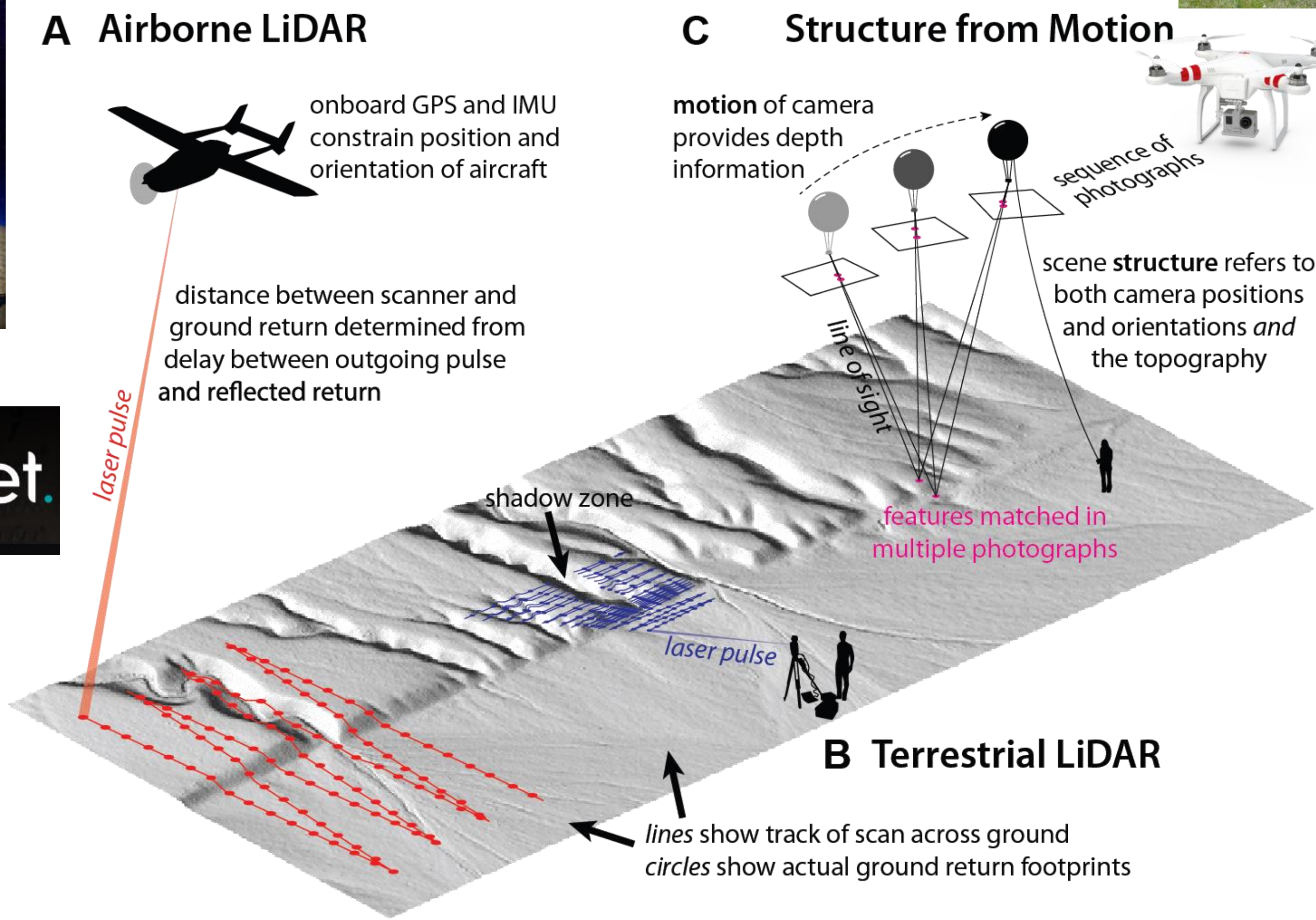


DigitalGlobe

planet.

polar geospatial center

Meters to centimeters spatial sampling

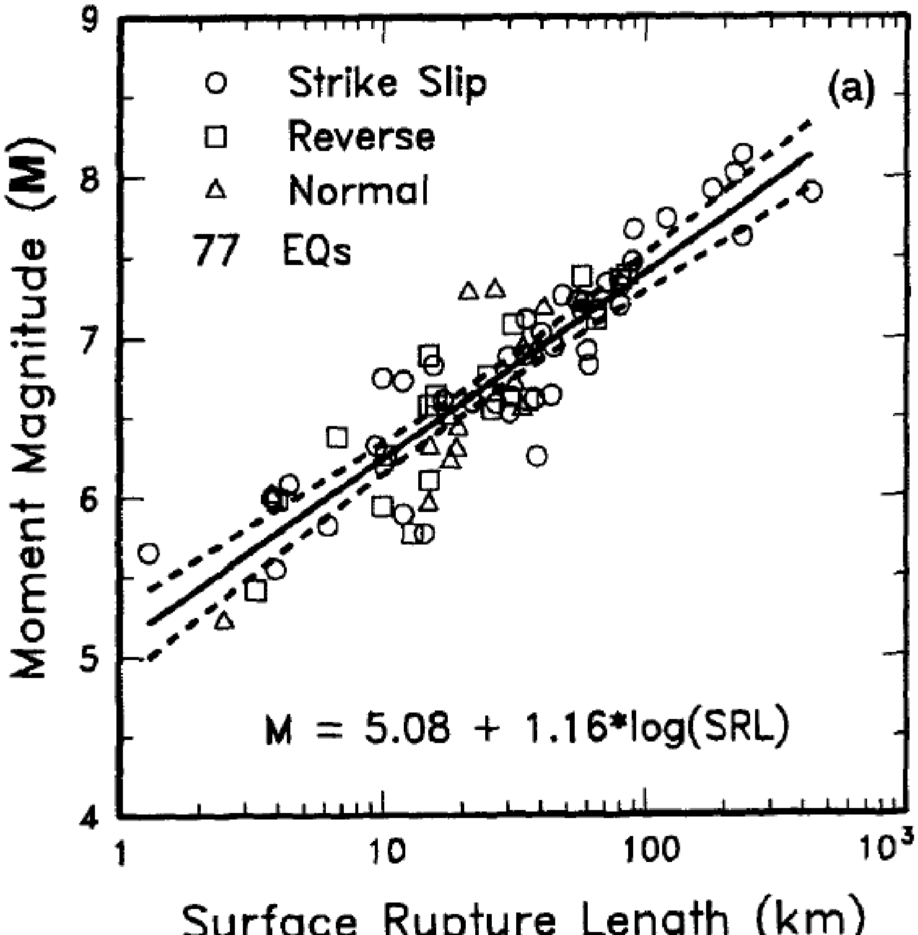


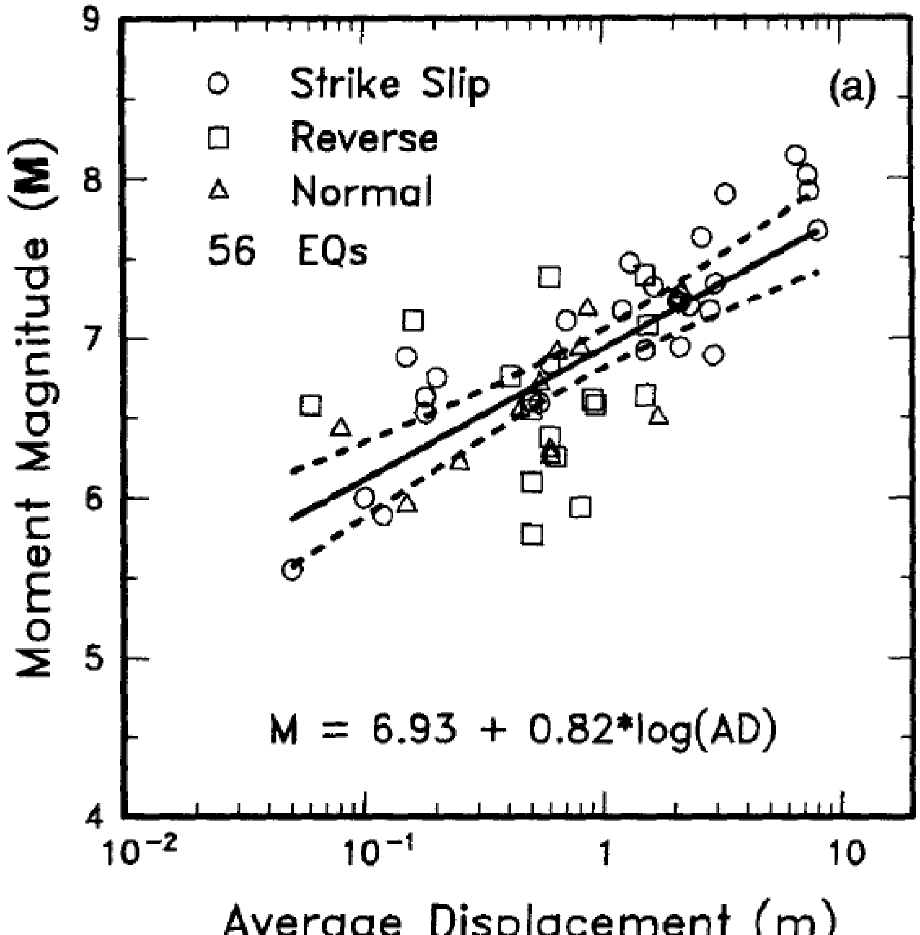
Johnson et al., Geosphere, 2014

Need ~<meter-scale sampling to cover critical scale breaks and temporal repeat to address log(t) response of some phenomena

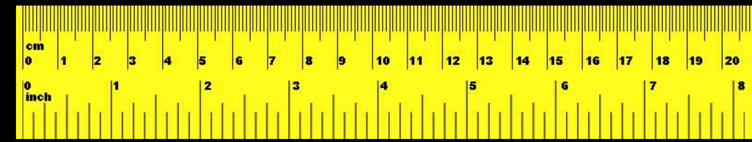
Length scales >10^5m and <1 m

Wells and Coppersmith, 1994





“Seeing” at the appropriate scale means measuring at the right scale



Surface processes act to change elevation through erosion and deposition while tectonic processes depress or elevate the surface directly—
their record is best characterized with the right fine scale.

Applies in particular to statistical self similarity

How long is the coast of Britain?
Statistical self-similarity and fractional dimension
Science: 156, 1967, 636-638

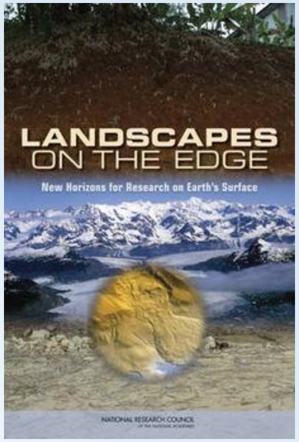
B. B. Mandelbrot

http://en.wikipedia.org/wiki/How_Long_Is_the_Coast_of_Britain%3F_Statistical_Self-Similarity_and_Fractional_Dimension

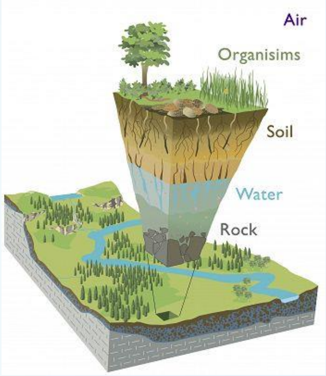
Major US community studies recognize the scientific value of high resolution topography

Science communities

Example scientific motivations

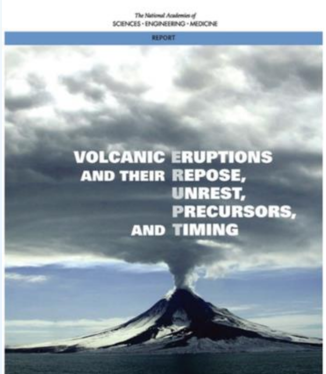


- How do geopatterns on the Earth's surface arise and what do they tell us about processes?
- How do landscapes influence and record climate and tectonics?
- What are the transport laws that govern the evolution of the Earth's surface?



- How do faults rupture and slip throughout multiple earthquake cycles and what are the implications for earthquake hazard?

- Landscape and ecosystem dynamics



- Volcano form and process
- Changes in volume of domes, edifice, flows

Advances in and decreasing costs for software (algorithms such as structure from motion), computational hardware (rapid computation of colored point clouds and textured 3D models), and unmanned aerial vehicles (UAVs) as semi-autonomous sensing platforms has absolutely changed the geoscientist's toolkit.

Proc. R. Soc. Lond. B. **203,** 405–426 (1979)
Printed in Great Britain

The interpretation of structure from motion

By S. Ullman
Artificial Intelligence Laboratory, Massachusetts Institute of Technology, 545 Technology Square (Room 808), Cambridge, Massachusetts 02139 U.S.A.

(*Communicated by S. Brenner, F.R.S. – Received 20 April 1978*)

The interpretation of structure from motion is examined from a computational point of view. The question addressed is how the three dimensional structure and motion of objects can be inferred from the two dimensional transformations of their projected images when no three dimensional information is conveyed by the individual projections.

Proc. of the International Conference on Computer Vision, Corfu (Sept. 1999)

Object Recognition from Local Scale-Invariant Features

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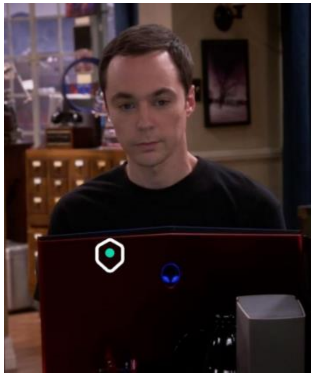
Abstract

An object recognition system has been developed that uses a new class of local image features. The features are invariant to image scaling, translation, and rotation, and partially invariant to illumination changes and affine or 3D projection.

Software
Freely available
Bundler Photogrammetry Package[a,b]
SFMToolkit[a,b]
Python Photogrammetry Toolbox (PPT)[a,b]
VisualSFM[b]
3DF Samantha
Web sites and services
Photosynth
Arc3D
CMP SfM Web service[a]
Autodesk 123D Catch
Pix4D
My3DScanner
Commercial
PhotoScan
Acute3D
PhotoModeler
3DF Zephyr Pro

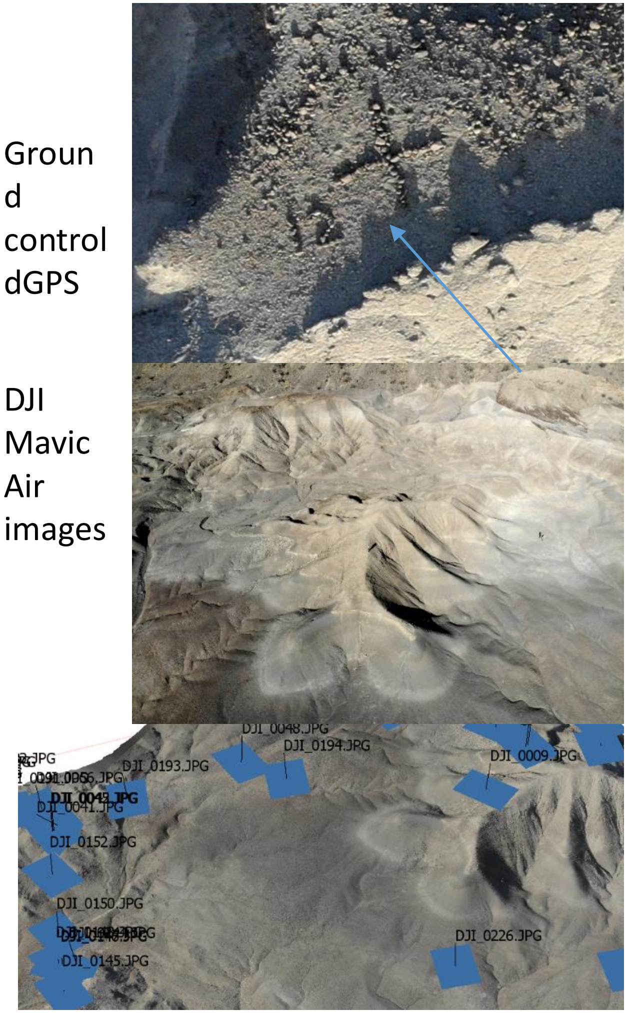
Bemis, et al., 2014

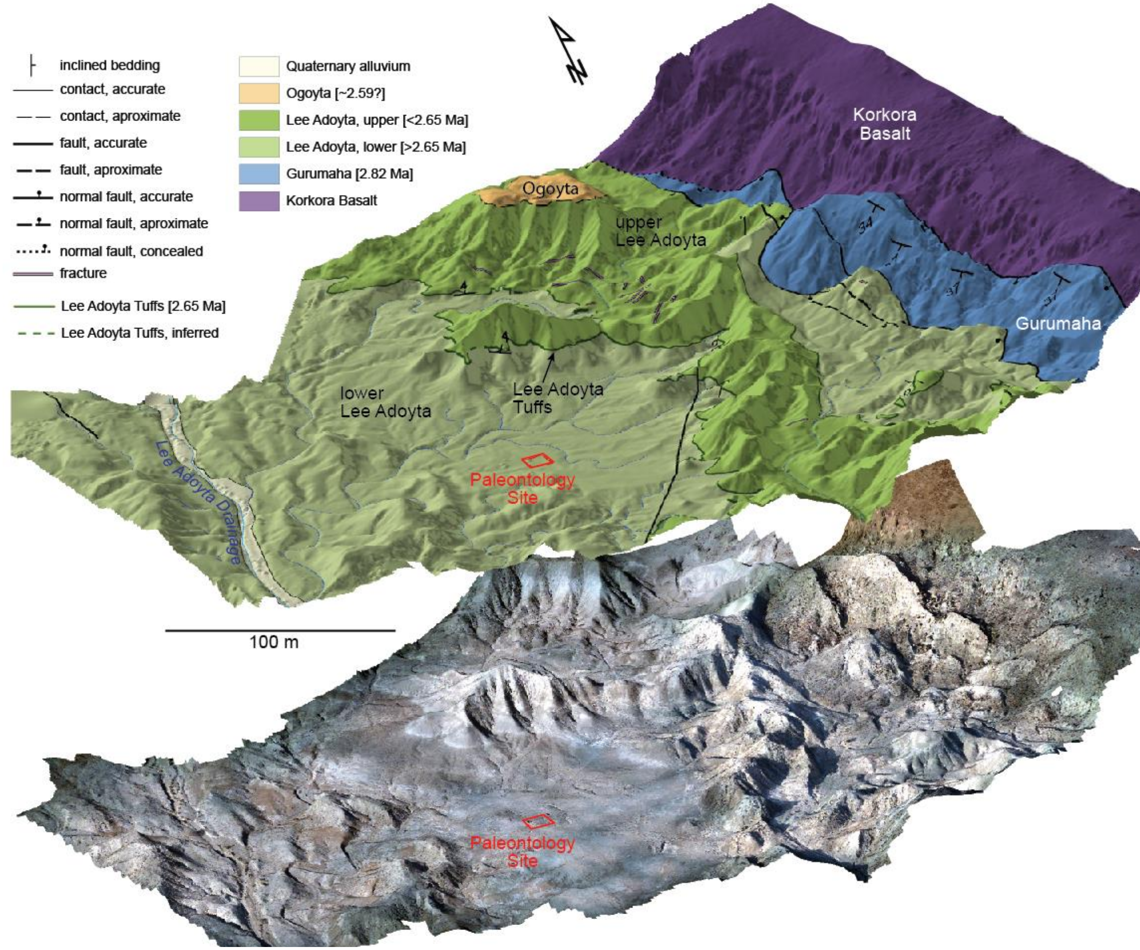
https://www.dell.com/en-us/gaming/alienware-desktops



Ground control dGPS

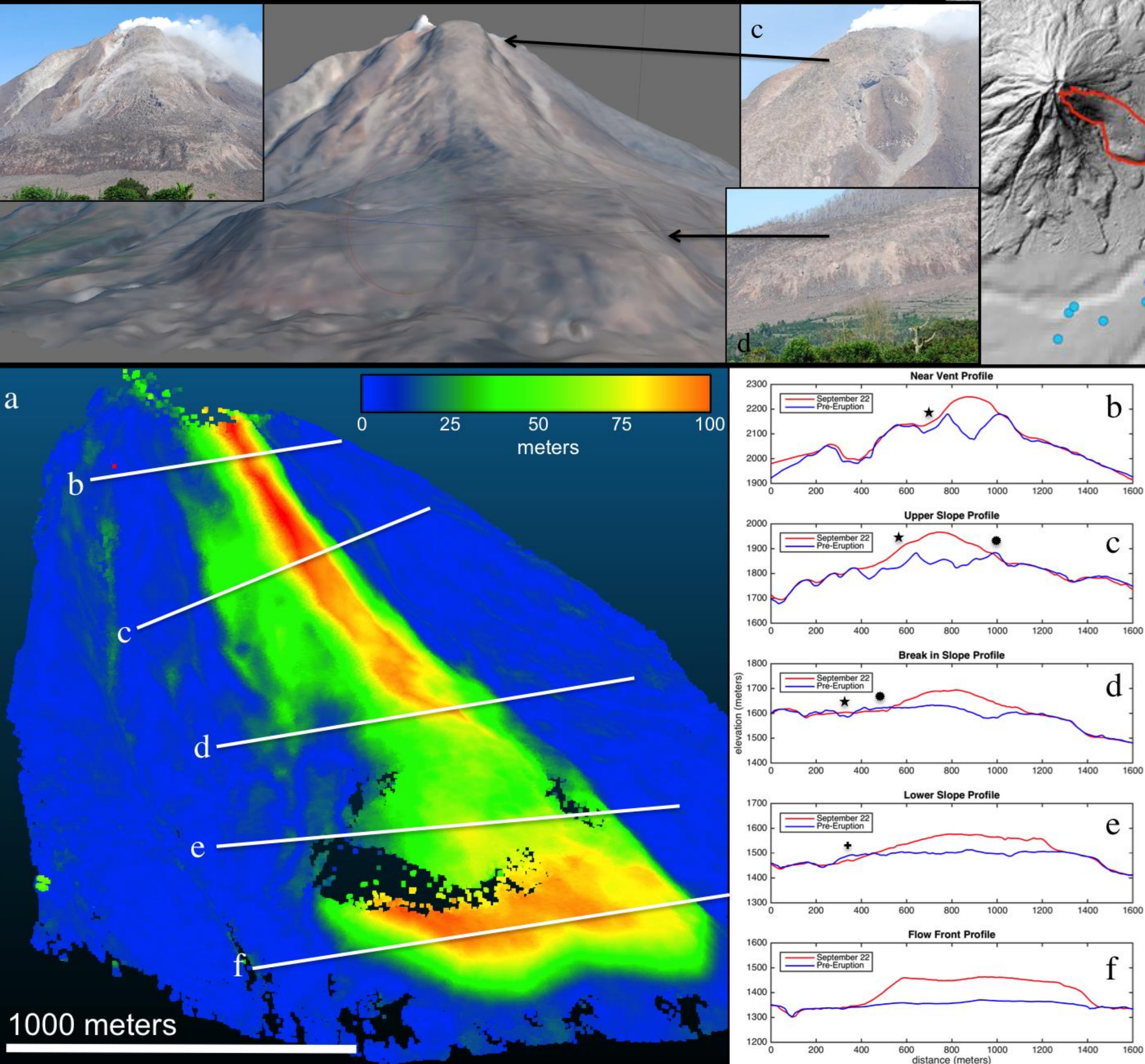
DJI Mavic Air images



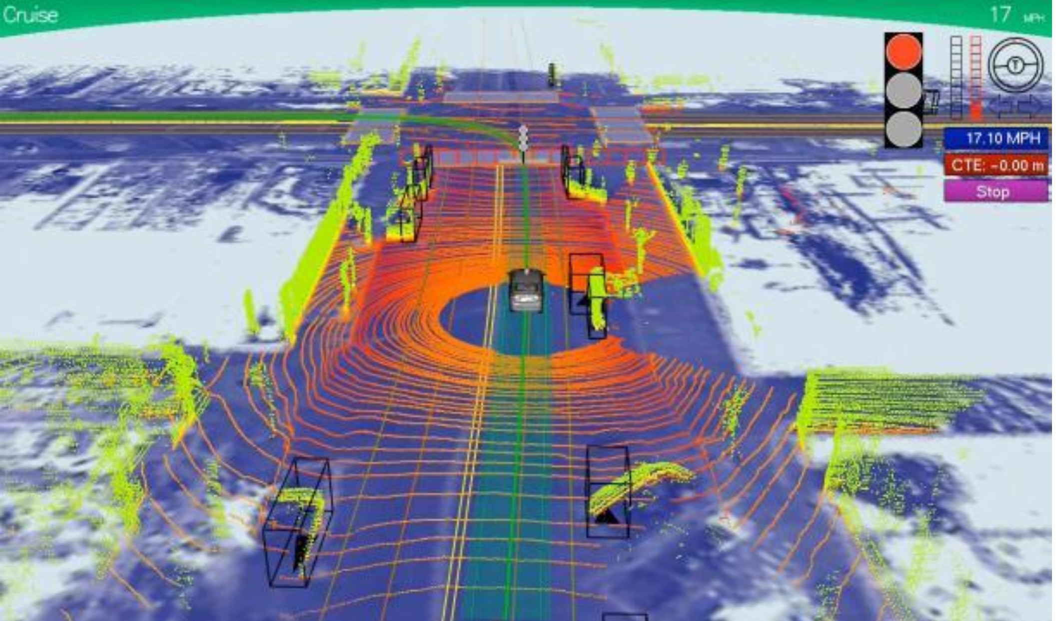


Detailed geology of Lee Adoyta, Ledi Geraru Research Project Afar Ethiopia:

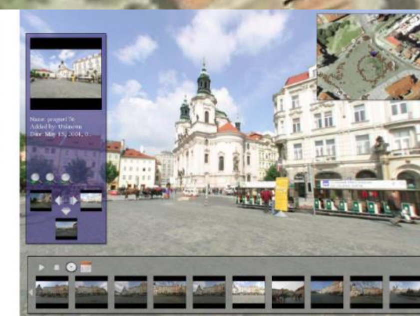
Rapid acquisition of imagery of deformed fossiliferous and tuff-bearing sedimentary rocks in the Afar region of Ethiopia provide 3D control for paleontological provenance and environmental reconstruction studies



The emplacement of the active lava flow at Sinabung Volcano, Sumatra, Indonesia, documented by structure-from-motion photogrammetry -Carr, et al., 2018. Pre-eruption 5 m DEM and post eruption SfM registered to unchanged areas



Google car: Gb/sec high accuracy navigation data



Modeling the World from Internet Photo Collections (Snavely, et al., Int J Comput Vis , 2007)

Ubiquitous point clouds + 3D models: **coordinated (mapping and monitoring) and haphazard (autonomous navigation, individual photo collections, etc.)**

-Need open access and cyberinfrastructure to support archive, and rapid query, data handling, preprocessing, and differencing