Science motivations and introductory remarks

SGTF 2018

J Ramón Arrowsmith
School of Earth and Space Exploration
Arizona State University

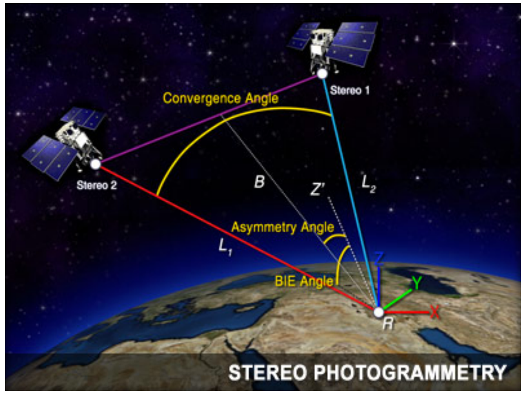
Ed Nissen, University of Victoria

Christopher J. Crosby
UNAVCO

OpenTopography
High-Resolution Topography Data and Tools

3D IMAGING WITH CAMERAS & LASERS

Space-based

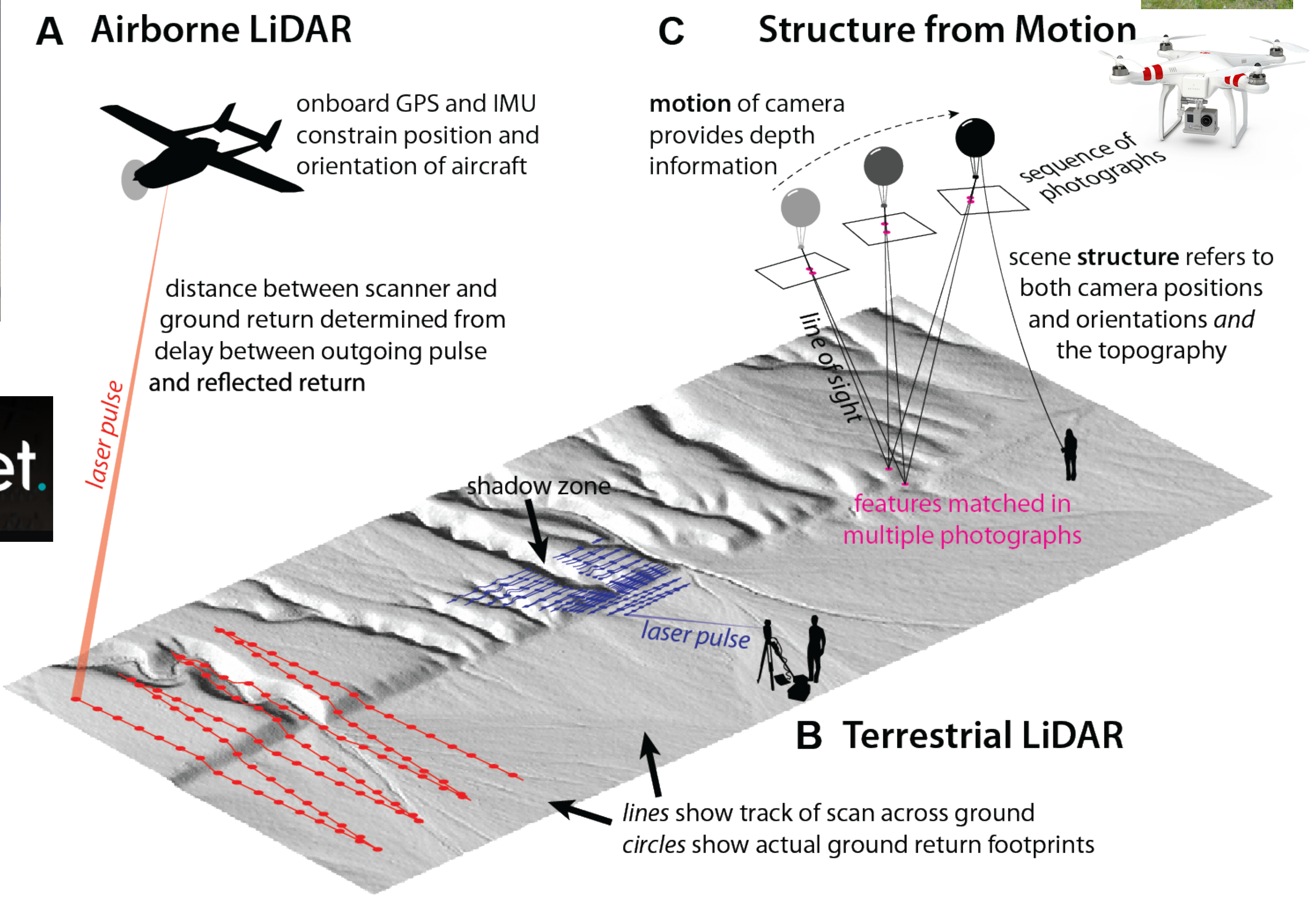


DigitalGlobe

planet.

polar geospatial center

Meters to centimeters spatial sampling



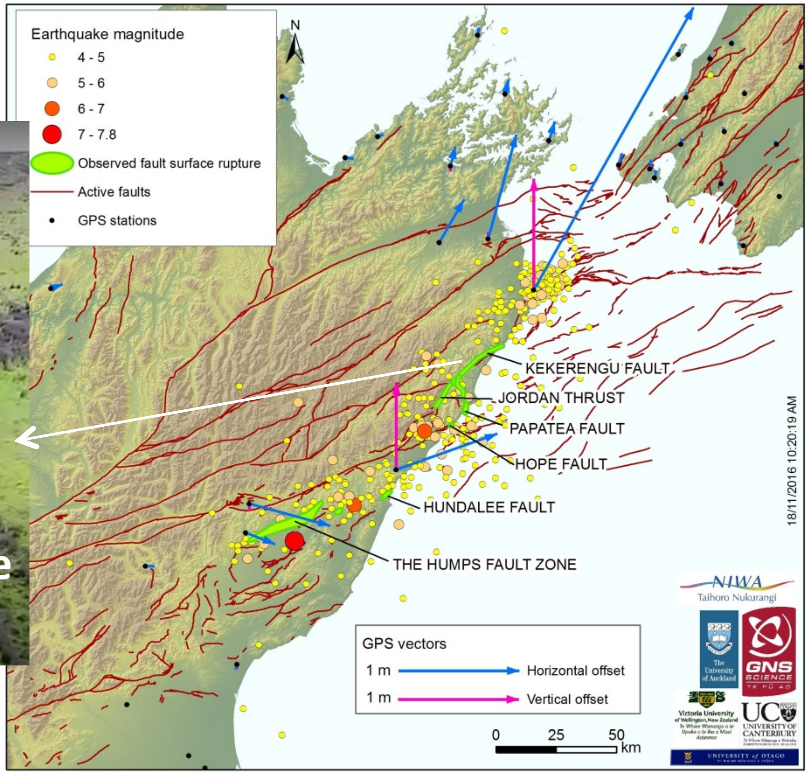
Johnson et al., Geosphere, 2014

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

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

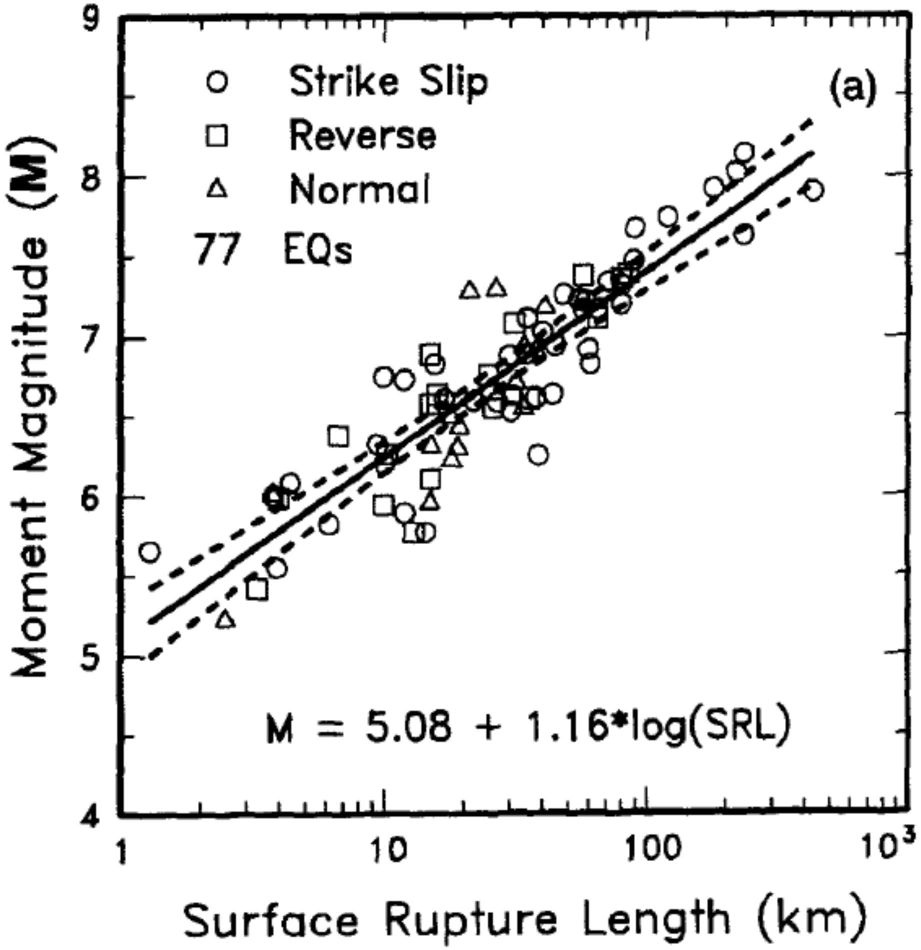
https://www.youtube.com/watch?v=U3H8wlzXGYE&feature=youtu.be

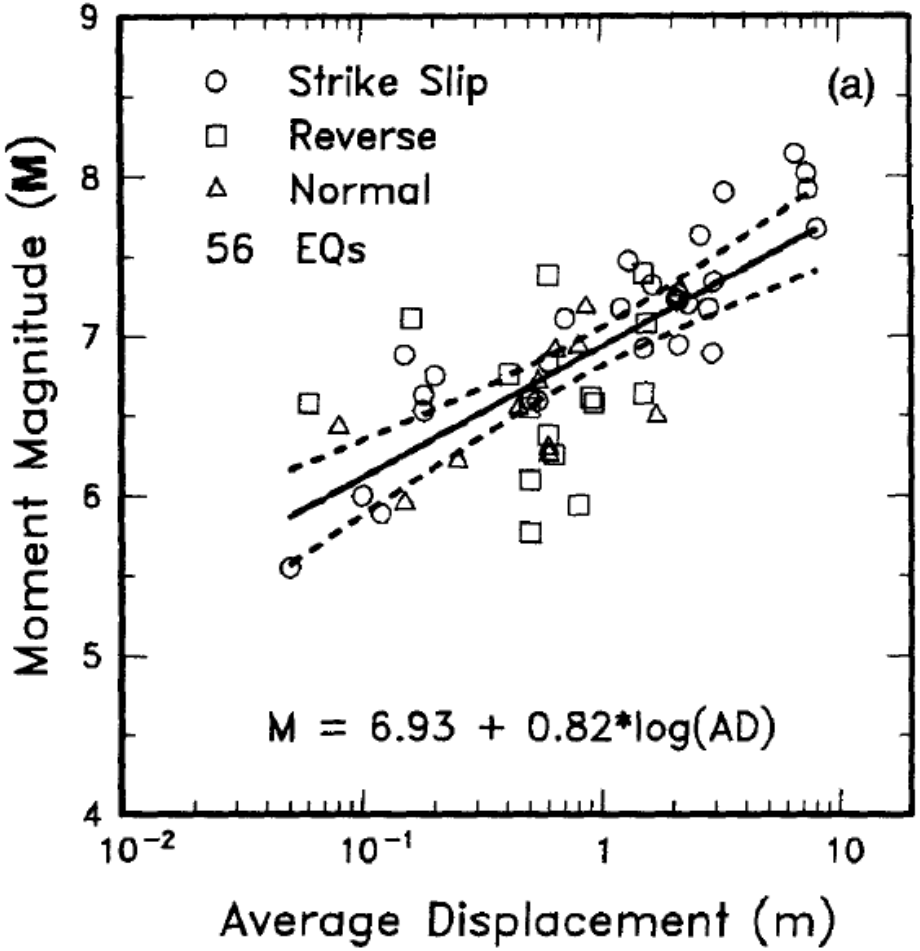


Kekerengu alone is 30+ km of this intricate ground rupture

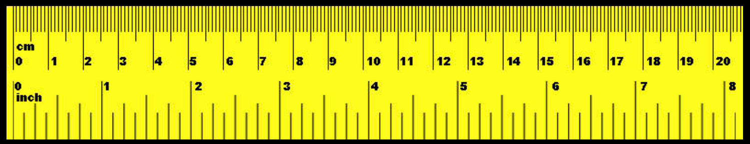
Length scales >10^5m and <1 m

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.

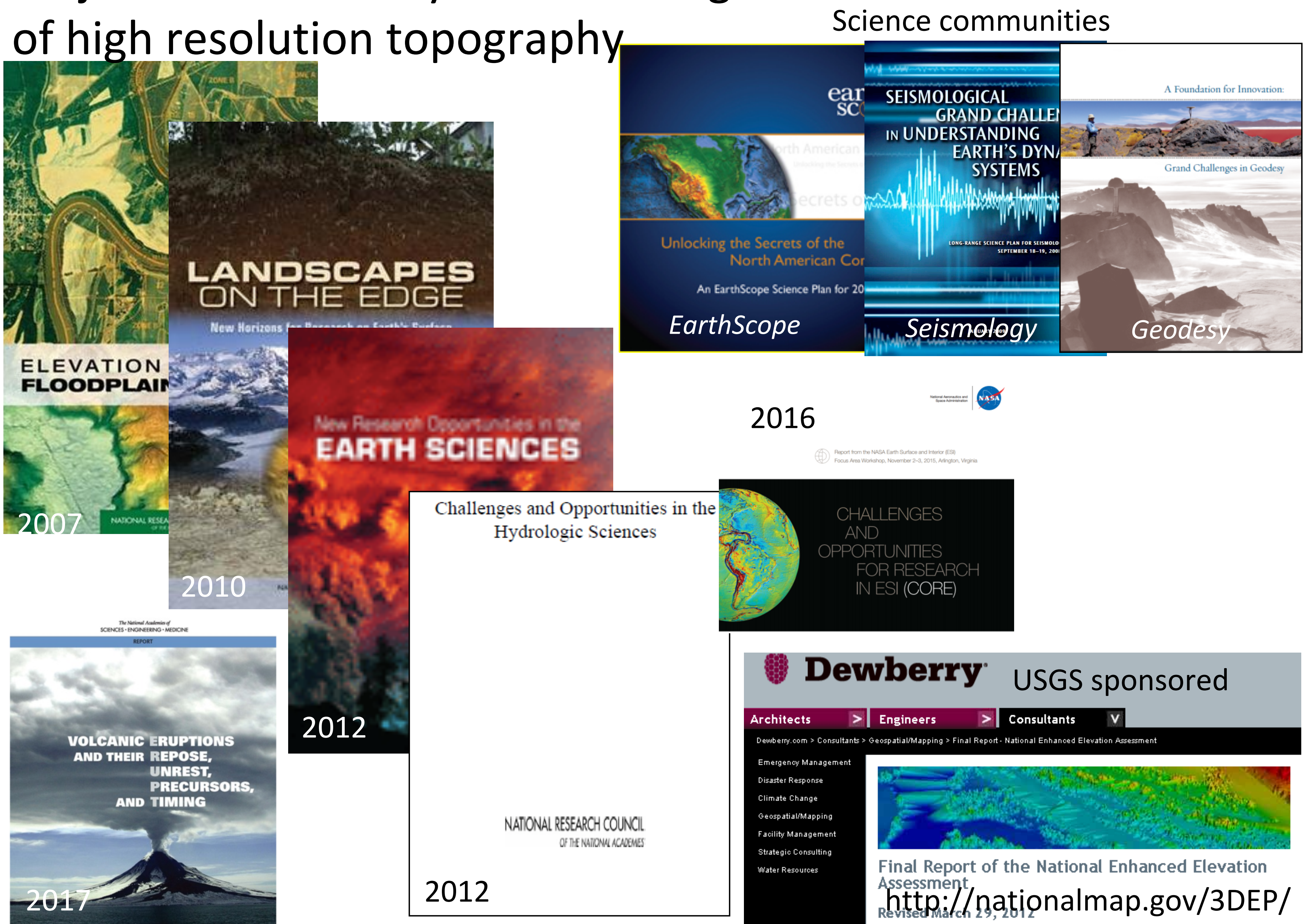
Applies in particular to statistical self similarity

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

B. B. Mandelbrot

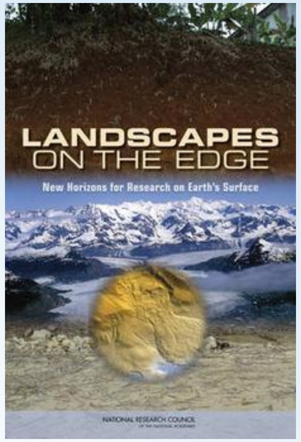
http://en.wikipedia.org/wiki/How_Long_Is_the_Coast_of_Britain%3F_Statistical_Self-Similarity_and_Fractional_Dimension

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

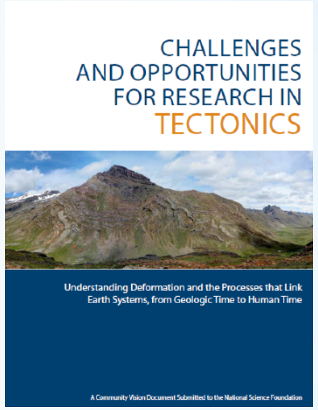


Example scientific motivations

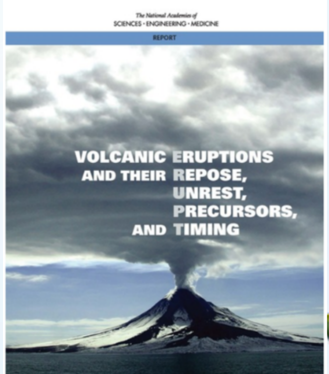
- How do geopatterns on the Earth's surface arise and what do they tell us about processes?
- How do landscapes influence and record climate and tectonics?
- What are the transport laws that govern the evolution of the Earth's surface?



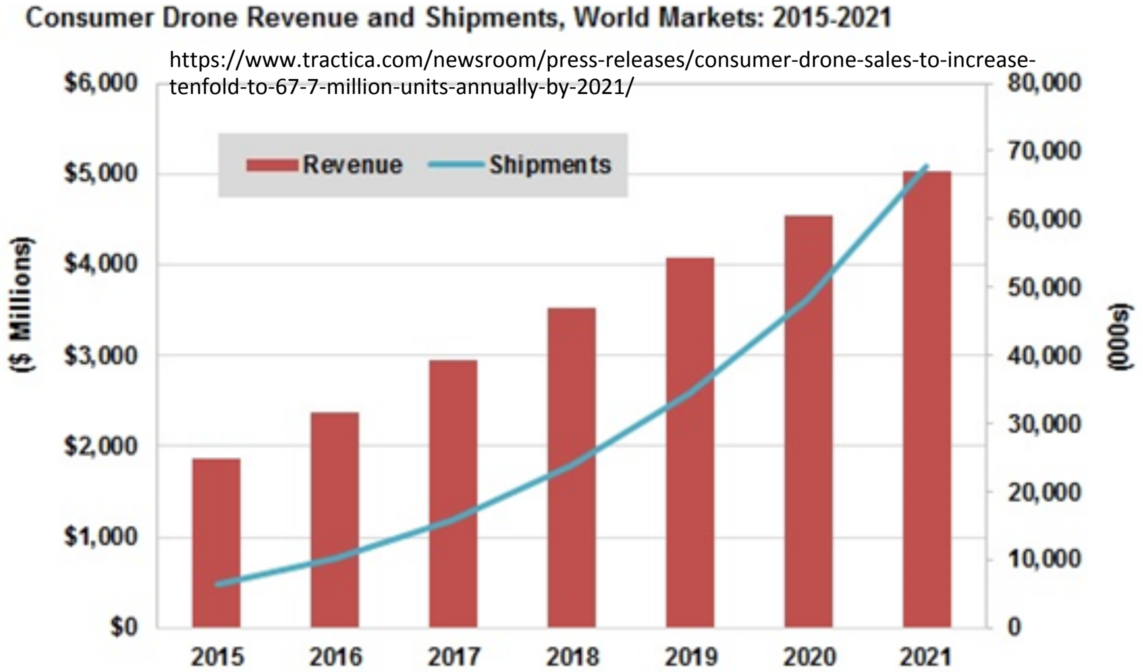
- How do faults rupture and slip throughout multiple earthquake cycles and what are the implications for earthquake hazard?



- What are the shapes of structures?
- Volcano form and process
- Changes in volume of domes, edifice, flows



UAS platforms for mapping & mapping will continue to grow as part of our toolkit

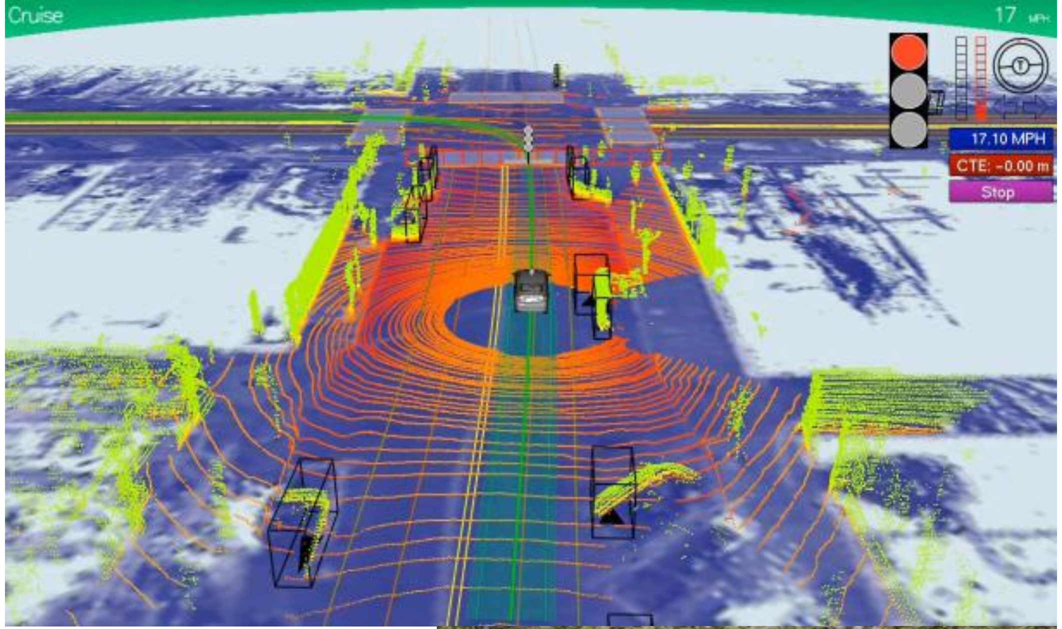


https://www.tractica.com/newsroom/press-releases/consumer-drone-sales-to-increase-tenfold-to-67-7-million-units-annually-by-2021/

THE OPPORTUNITY AHEAD

Between now and 2020, we forecast a $100 billion market opportunity for drones—helped by growing demand from the commercial and civil government sectors.

http://www.goldmansachs.com/our-thinking/technology-driving-innovation/drones/



Google car: Gb/ sec high accuracy navigation data

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

Opportunities in Research and Teaching!

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

GEOSPHERE

GEOSPHERE, v. 13, no. 6

doi:10.1130/GES01236.1

5 figures; 3 tables; 1 supplemental file

CORRESPONDENCE: serobins@asu.edu

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Applications of high-resolution topography in Earth science education

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Sarah E. Robinson[1], Wendy Bohon[1], Emily J. Kleber[1], J Ramón Arrowsmith[1], and Christopher J. Crosby[2]
[1]School of Earth and Space Exploration, Arizona State University, Tempe, Arizona 85287, USA
[2]UNAVCO, Boulder, Colorado 80301, USA

ABSTRACT

High-resolution topography (HRT) provides Earth scientists the opportunity to measure landscapes at unprecedented meter to submeter resolutions. HRT also enables use of new quantitative tools that explore landscape structure and evolution. The wide applications for HRT products in research have motivated Earth science educators to evaluate their usefulness for teaching concepts such as plate tectonics, faulting, and landscape change. This study assesses the usefulness of HRT as an educational tool for teaching Earth science concepts. The application of HRT to Earth science education is motivated by concepts outlined in undergraduate geology textbooks, the U.S. Next Generation Science Standards, and the Earth Science Literacy Initiative. We developed three activities using HRT to assess its educational value. An exploratory study involving undergraduate students assesses their ability to evaluate and interpret the landscape in HRT shaded-relief image versus aerial photography. The hillshades allow novice learners to focus more directly on the landscape, enabling faster and more accurate interpretations of geologic features. In addition, an educational video on HRT and an exercise exploring the earthquake cycle with HRT were tested in undergraduate introductory geology classes. Students who used educational tools involving HRT increased their understanding of the earthquake cycle and HRT for studying earthquakes. Novice Earth science students who use HRT improve their ability to evaluate topography for geologic features and come to accurate conclusions about landscape evolution. These positive outcomes are possible because of the fine scale at which topography can be examined without visual distractors within HRT.

INTRODUCTION

High-resolution topography (HRT; commonly derived from terrestrial or airborne lidar) has become an indispensable tool for providing insights into geologic phenomena such as faulting, earthquake and landslide hazards, surface morphology, ice sheet dynamics, and coastline evolution (Haugerud et al., 2003; Cunningham et al., 2006; Carter et al., 2007; Chan et al., 2007; Hilley and Arrowsmith, 2008; Arrowsmith and Zielke, 2009; Zielke et al., 2010; Meigs, 2013; Passalacqua et al., 2015). The diverse research and educational applications of HRT (which samples the ground at least once per square meter) have motivated the collection of data sets with large spatial extents spanning numerous geologic features. One important resource for free access to HRT data is the U.S. National Science Foundation (NSF)–funded OpenTopography Facility (www.opentopography.org). This web portal provides online access to >213,066 (as of October 2017) square kilometers of HRT data gathered by various groups for multiple applications, processing tools to generate derivative products and visualizations of the data, and educational products and tools for educators (Crosby et al., 2011; Krishnan et al., 2011).

The spatial nature of HRT data and its active role in Earth science research complement education concepts such as visualization, Earth as a system, role of technology, place-based learning, inquiry-based teaching, and active learning. There is a recognized need within the science education community for curricula that encourage spatial thinking and use two-dimensional and three-dimensional (3-D) environments (Hegarty, 2014; Kopcha et al., 2015). Despite the obvious applications of this technology to Earth science education, little work has been done to formally assess the effectiveness of HRT as an education tool. This discussion of HRT as a teaching tool for Earth science education is further motivated by science education initiatives and the science education community calling for integration of research-level data into the classroom (Taber et al., 2012). HRT data have the potential to address many of the established science educational standards, including the "Big Ideas" of the community-driven Earth Science Literacy Initiative (National Science Foundation, 2009) and the Next Generation Science Standards (NGSS) (Table 1).

To examine the effectiveness of HRT as a teaching tool, we conducted a study at Arizona State University (Tempe, Arizona, USA) in 2010 that tested the cognitive ability of undergraduate students to recognize the topographic signature of faulting and earthquakes in HRT. Based on these preliminary results, two targeted Earth science education resources were developed that use HRT to teach Earth systems. The goal of these developed resources was to determine whether undergraduate students would understand HRT, and if the addition of HRT within undergraduate Earth science laboratories would aid in the understanding of the earthquake cycle. The first is an exercise using HRT at the San Andreas fault (California, USA) to teach about landscape evolution and the earthquake cycle, core concepts in understanding plate tectonics. The

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LiDAR data for the University of California, Berkeley fused with color aerial photography.

Overview Video | Find Data | Tools | Learn

Spotlight

New Video: *LiDAR - Illuminating Earthquake Hazards*

This educational video, produced by Sarah Robinson (ASU M.S. student) and Andrew Whitesides (USC undergraduate) in a collaboration between the Southern California Earthquake Center (SCEC) and OpenTopography, provides an introduction to both LiDAR technology as well as the earthquake science that is being done with the data.

Data Summary

Total Coverage: **13,479 km^2**

Total number of LiDAR returns: **46,234,163,717**

Latest LiDAR Datasets:

- El Mayor-Cucapah Earthquake (4 April 2010) Rupture Scan
- NOAA ISEMP Bridge Creek, Oregon Survey
- Granite Dells, AZ TLS
- LVIS 2008 Sierra Nevada, CA
- LVIS 2007 Greenland

More Metrics ...

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