



OpenTopography

DATA & RESOURCES

CHRISTOPHER CROSBY, UNAVCO

Teaching SfM and GNSS Methods to Undergraduates in the Field

GSA 2022, BOULDER, CO

SDSC

UNAVCO

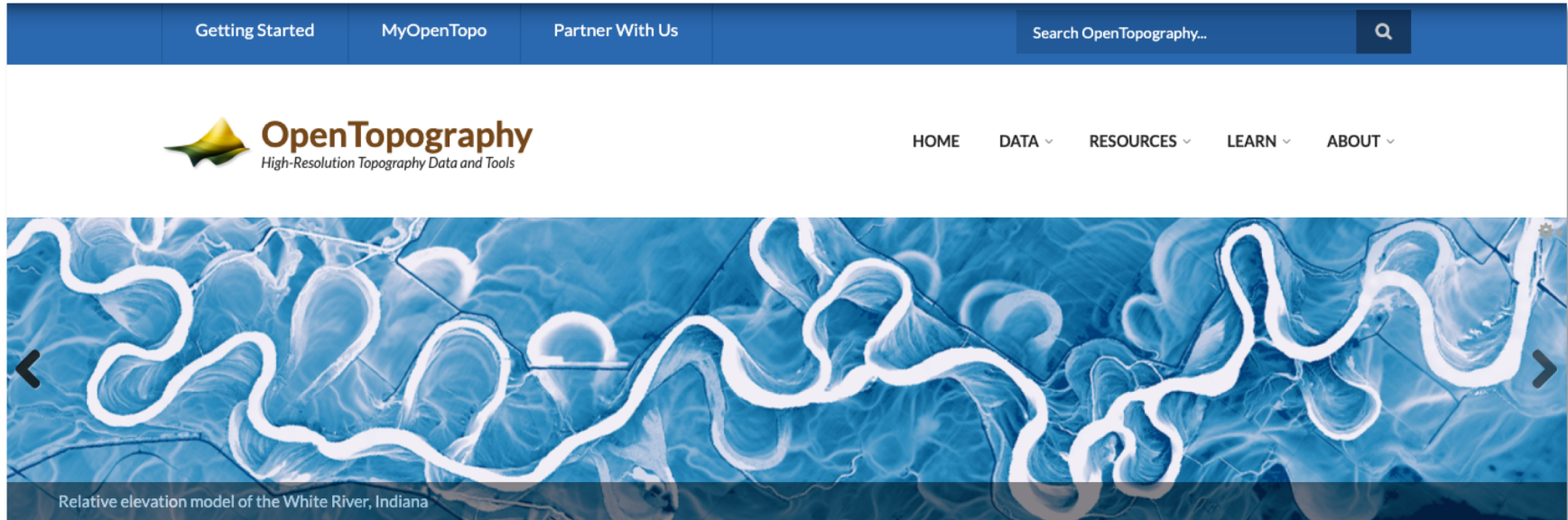
ASU

Supported by the US National Science Foundation (EAR/IF No 1948997, 1948994 & 1948857)



***Democratize* online access to high-resolution topography**

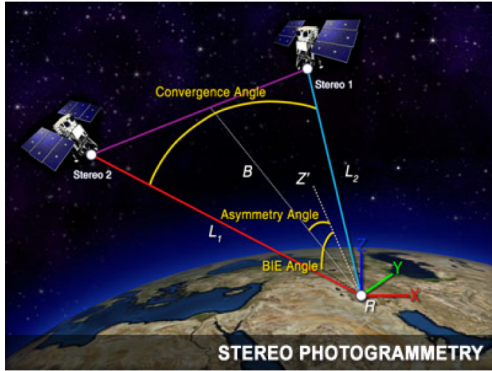
- Lidar, photogrammetry, & satellite derived topographic data
- Access to data – from raw point cloud to easy to use derived products. Co-location of data with processing



The screenshot shows the OpenTopography website interface. At the top, there is a dark blue navigation bar with the following elements: "Getting Started", "MyOpenTopo", "Partner With Us", a search bar labeled "Search OpenTopography..." with a magnifying glass icon, and a search button. Below the navigation bar, the OpenTopography logo is displayed on the left, featuring a stylized yellow and green mountain peak and the text "OpenTopography High-Resolution Topography Data and Tools". To the right of the logo is a horizontal menu with the following items: "HOME", "DATA" with a dropdown arrow, "RESOURCES" with a dropdown arrow, "LEARN" with a dropdown arrow, and "ABOUT" with a dropdown arrow. The main content area features a large, high-resolution topographic map of the White River in Indiana, rendered in shades of blue and white. The map shows the winding path of the river and the surrounding terrain. Navigation arrows are visible on the left and right sides of the map. At the bottom left of the map, there is a caption: "Relative elevation model of the White River, Indiana".

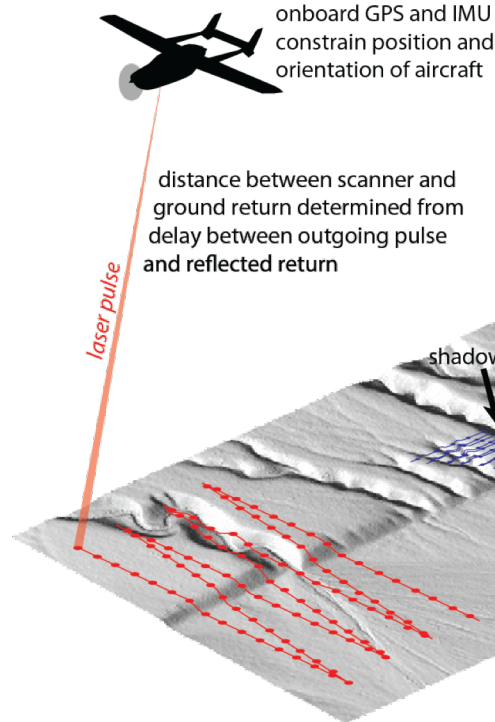
3D IMAGING WITH CAMERAS & LASERS

D. Space-based

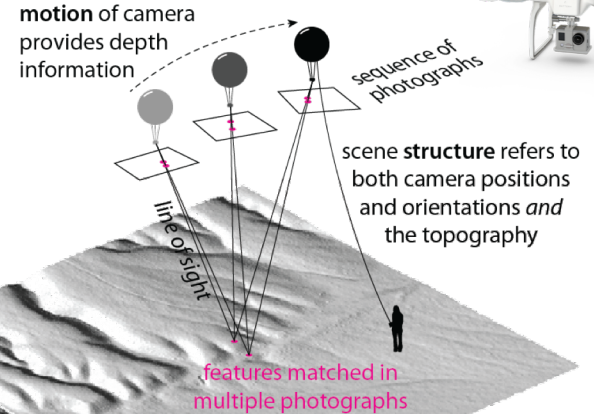


Meters to centimeters spatial sampling

A Airborne LiDAR



C Structure from Motion



B Terrestrial LiDAR

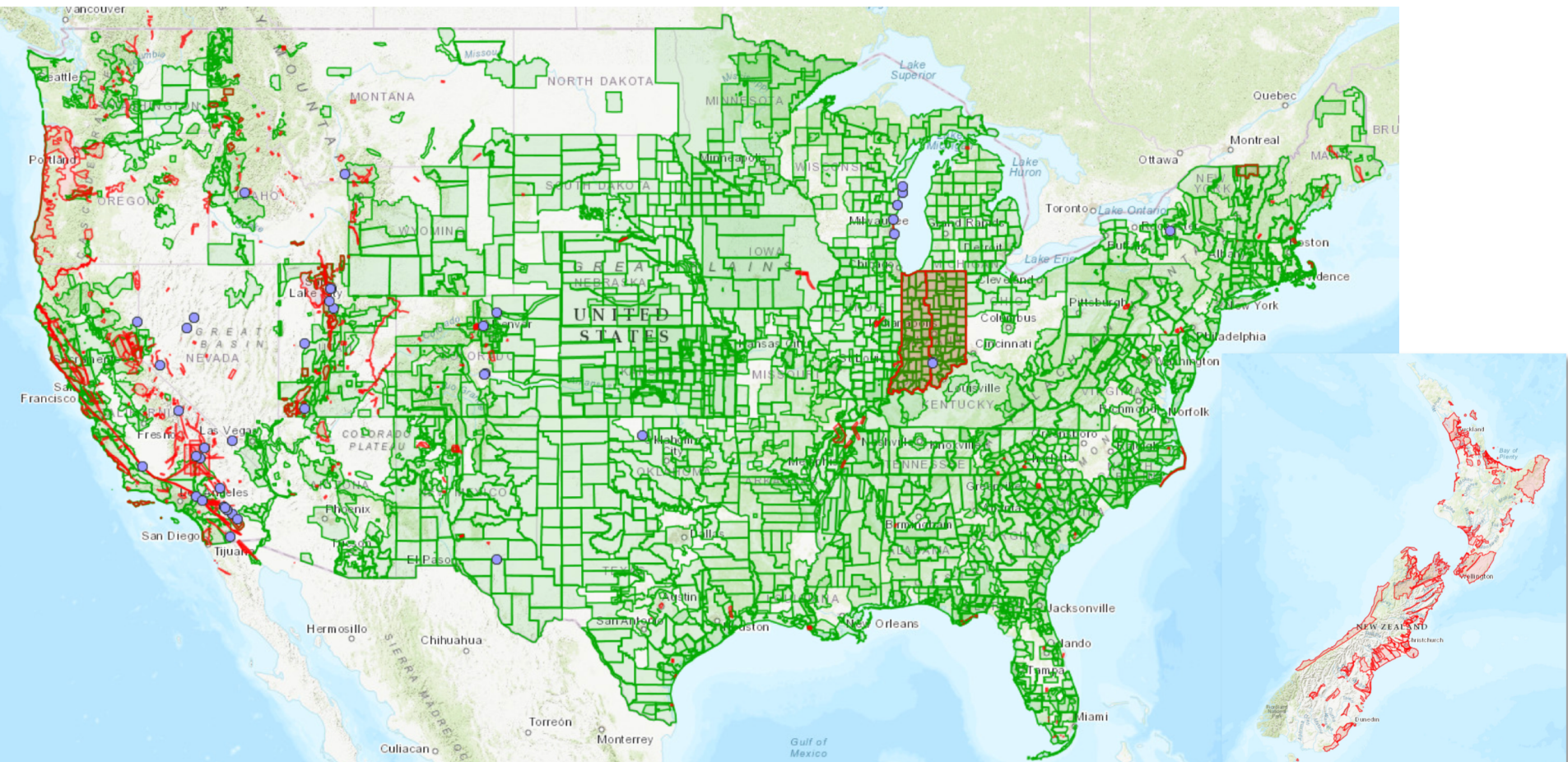
lines show track of scan across ground
circles show actual ground return footprints

AGENDA

1. Community Dataspace
2. Data available to you: ~47 trillion pts!
3. Topographic differencing

2019 Little Cottonwood Canyon, Tanners Gulch Debris Flow, Utah
(<https://doi.org/10.5069/G9FX77KF>)





STRUCTURE FROM MOTION PHOTOGRAMMETRY

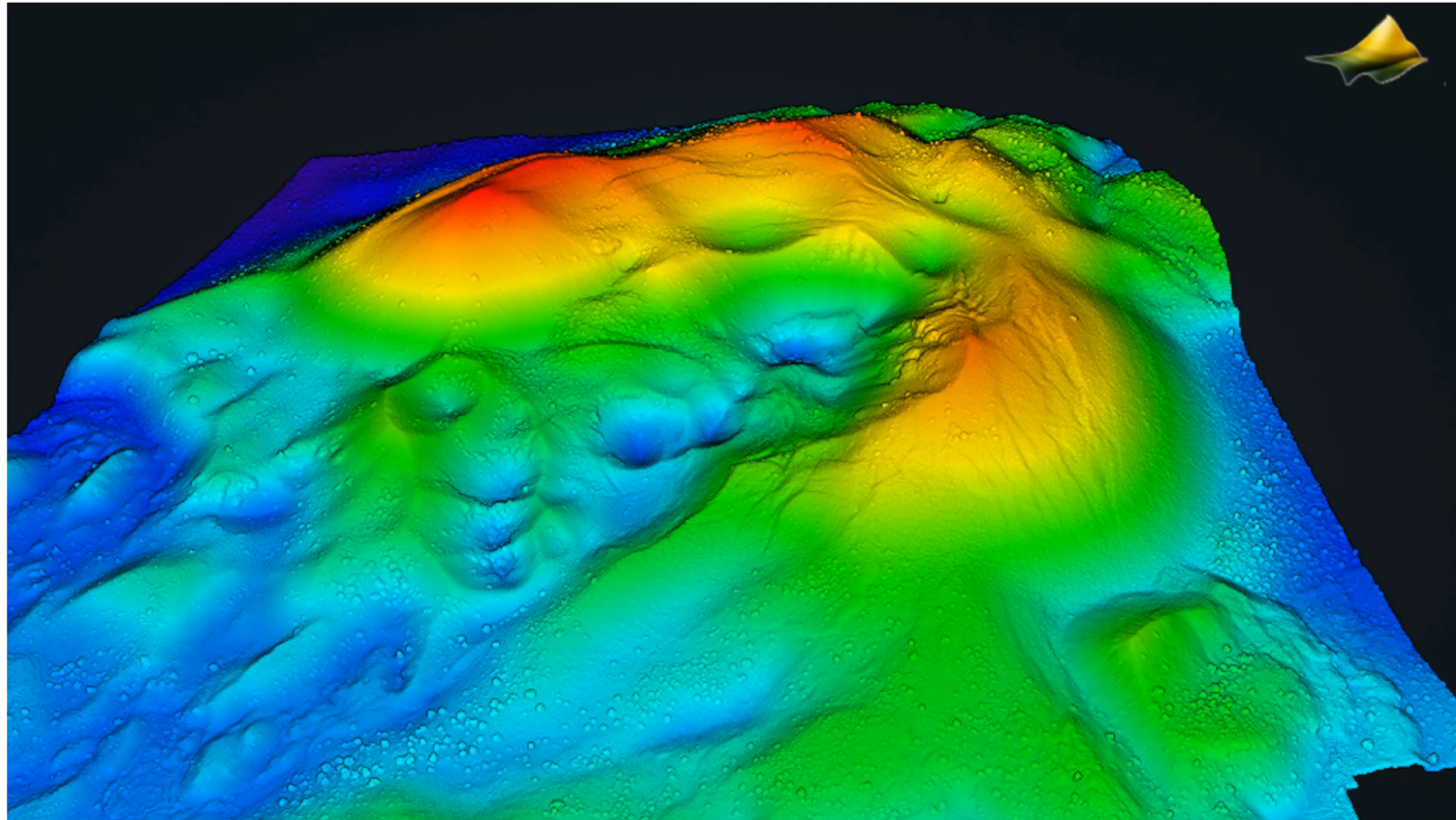
Photogrammetric
model of the
Tecolote Volcano,
Sonora, Mexico.

<https://doi.org/10.5069/G9028PFR>

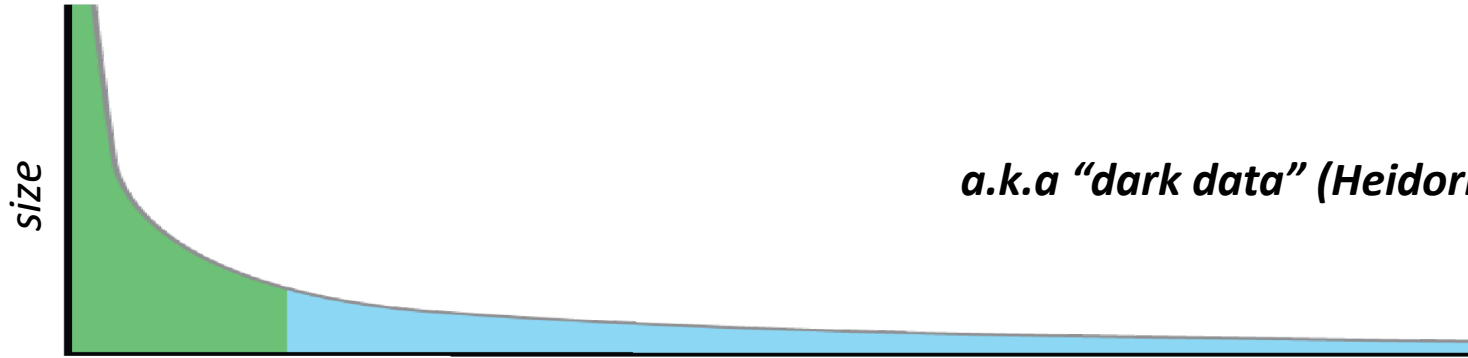
~2k images =
563 million pts

309 pt/m²

8 cm gridded
resolution



LONG TAIL TOPOGRAPHIC DATA



a.k.a "dark data" (Heidorn, 2008)

HEAD

number

LONG TAIL



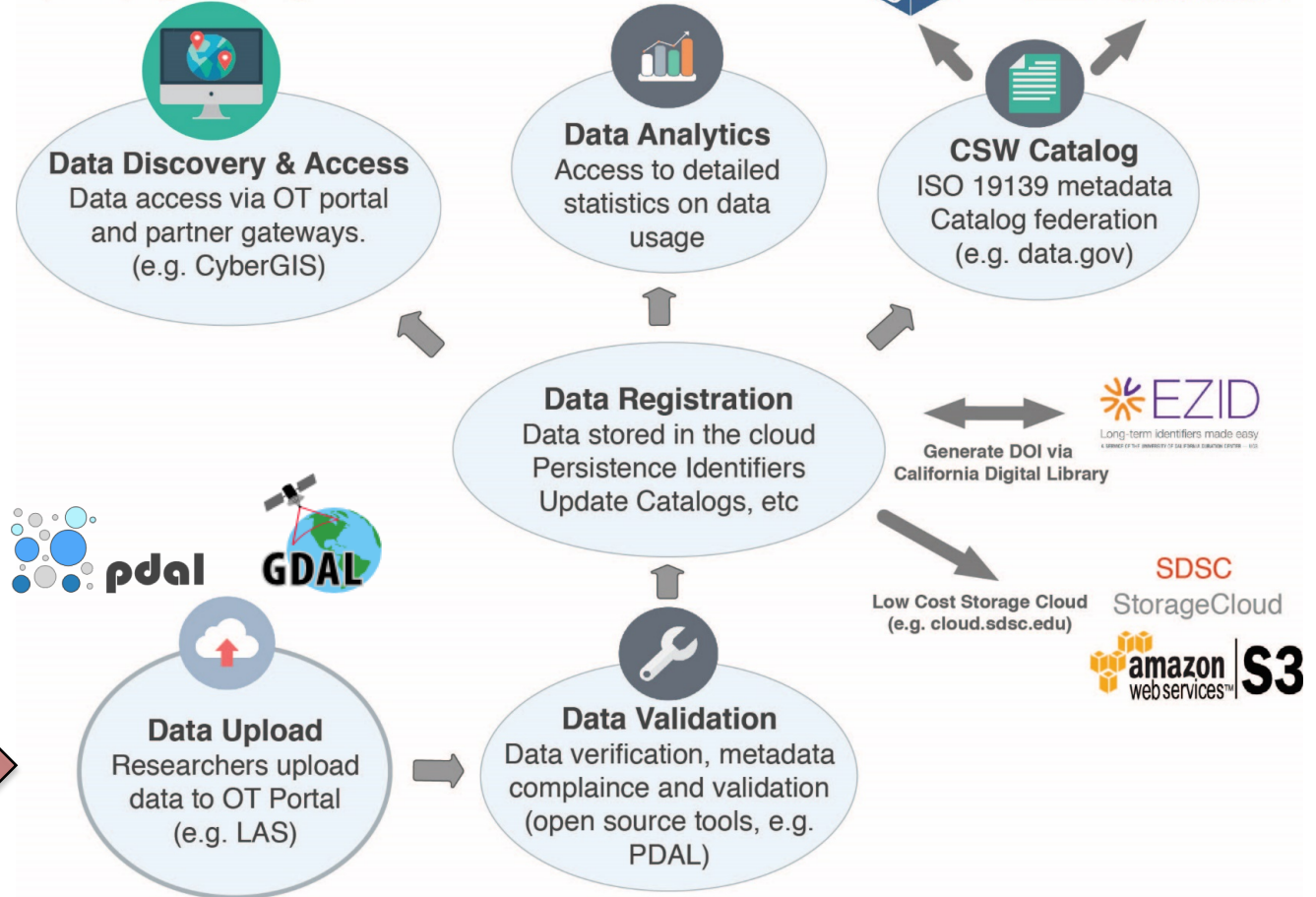
- Acquired by individual investigators or small teams
- Modest size but great value



OT COMMUNITY DATASPACE

EARTHCUBE CINERGI

opentopography.org/data



DEMO: [HTTPS://OPENTOPOGRAPHY.ORG/](https://opentopography.org/)



HOME DATA ▾ RESOURCES ▾ LEARN ▾ ABOUT ▾

Find Topography Data

Information and Instructions

List all datasets

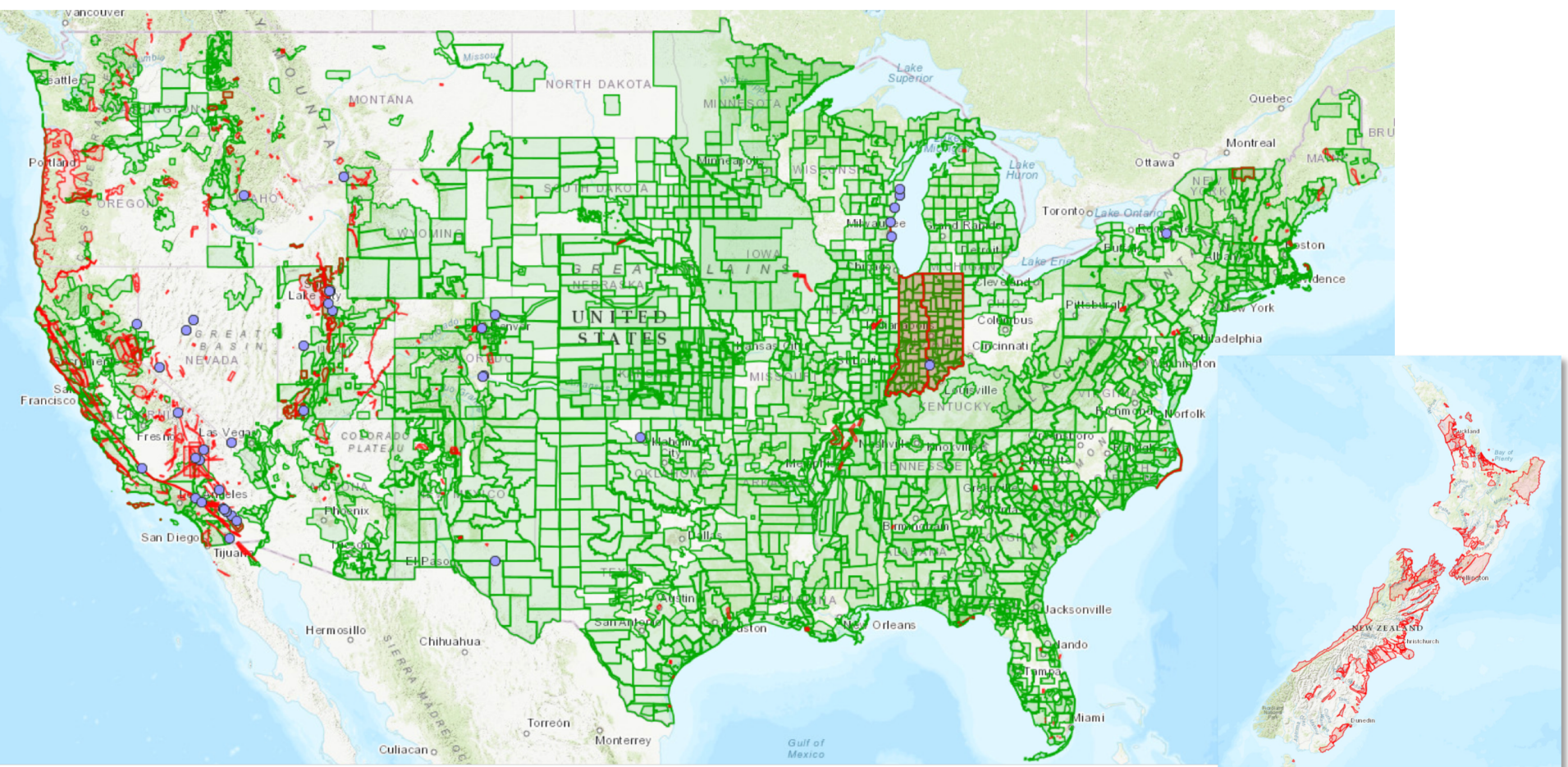
Filter by Funder ▾ Filter by Collector ▾ Filter by location ▾ More Filters Search by keyword...

[Citation Policy](#) | [FAQ](#) | [Media](#) | [Donate](#) | [Contact Us](#)

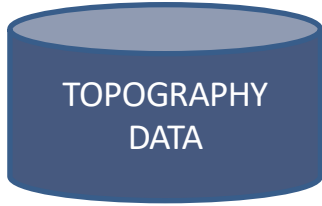


OpenTopography is supported by the National Science Foundation under Award Numbers 1948997, 1948994 & 1948857
OpenTopography Facility, San Diego Supercomputer Center, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0505
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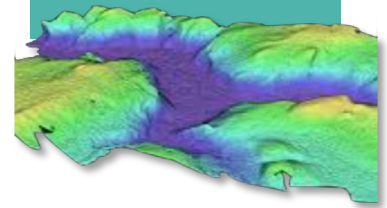
DATA SERVICES



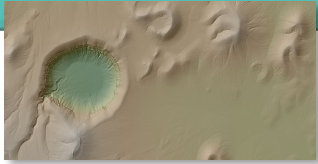
PC Data Filtering &
Subsetting

Raster Data
Subsetting

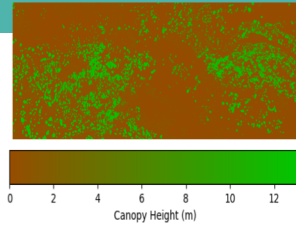
3D Visualization



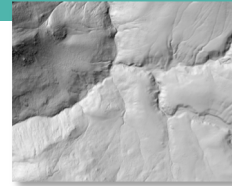
Digital Elevation Models
TIN / Local Gridding



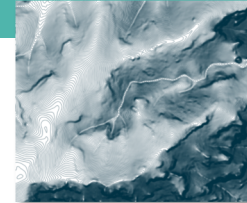
Canopy Height Model



Topographic
Hillshades



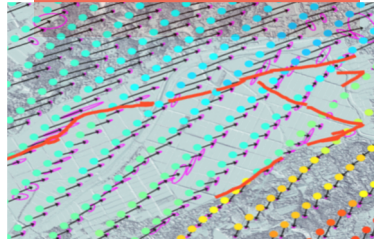
Contour Lines



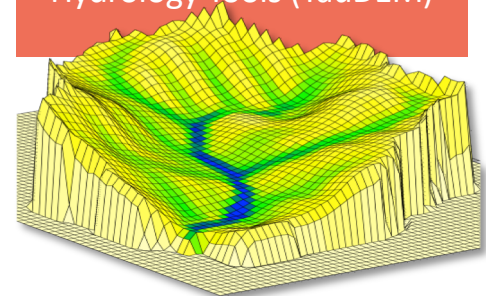
Vertical Differencing



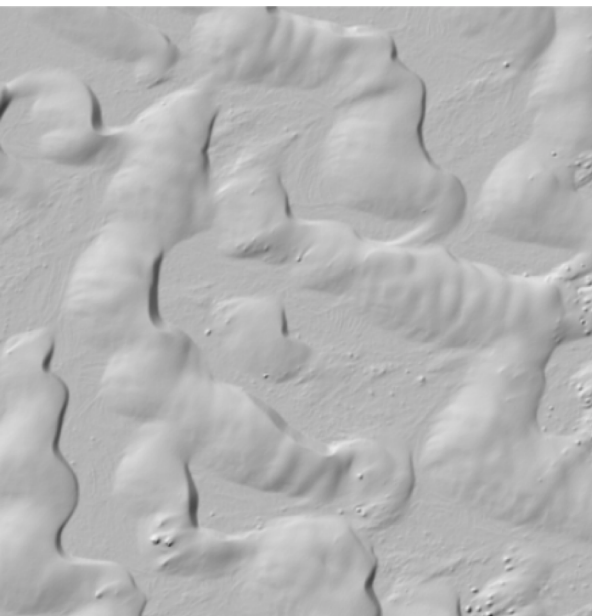
3D Differencing



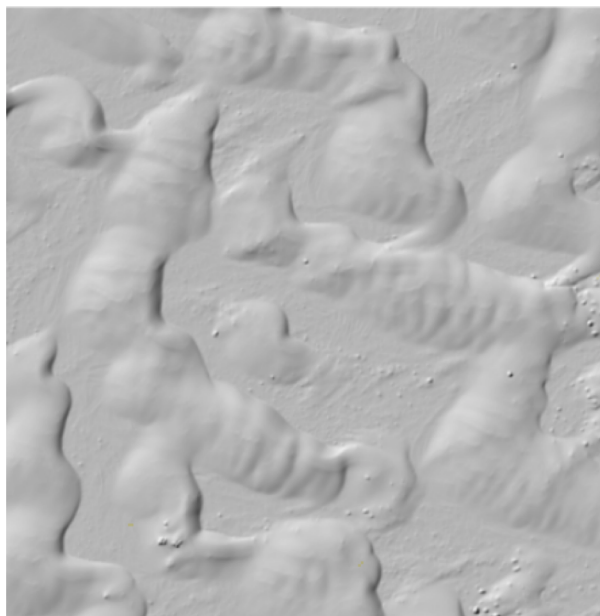
Hydrology Tools (TauDEM)



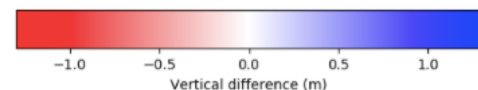
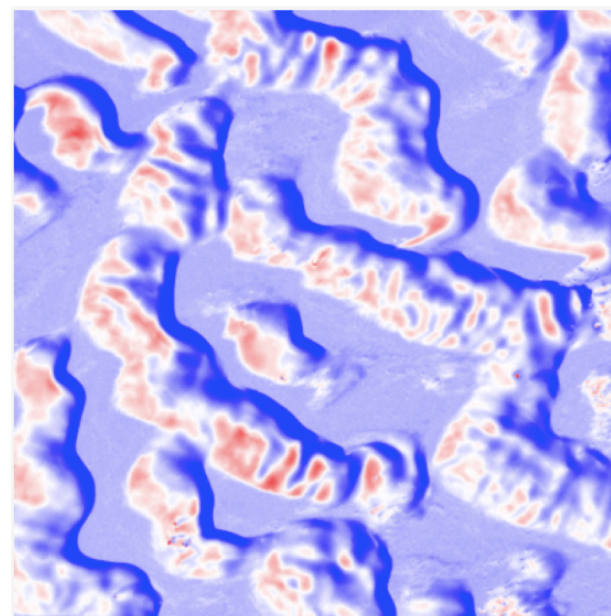
VERTICAL DIFFERENCING: SAND DUNE MIGRATION, WHITE SANDS NATIONAL MONUMENT, NEW MEXICO



Compare: 1st dataset
Sept 2009



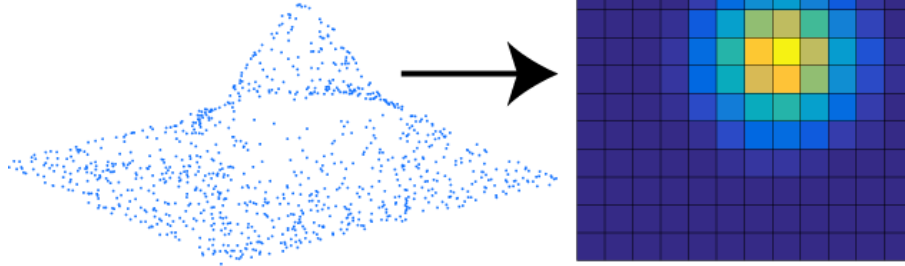
Reference: 2nd dataset
June 2010



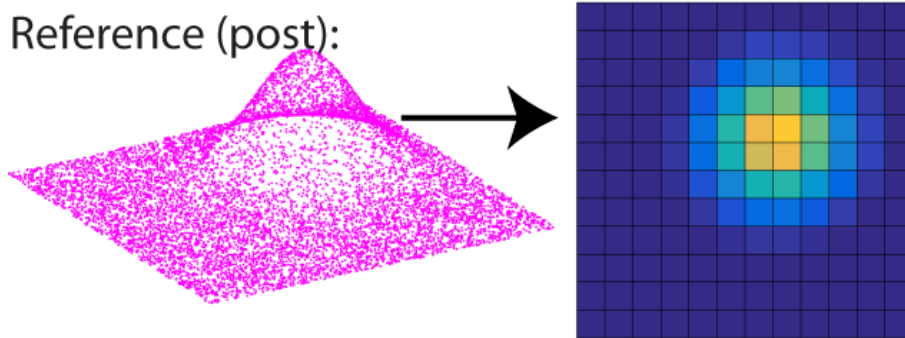
Vertical difference

VERTICAL TOPOGRAPHIC DIFFERENCING

Compare (pre):



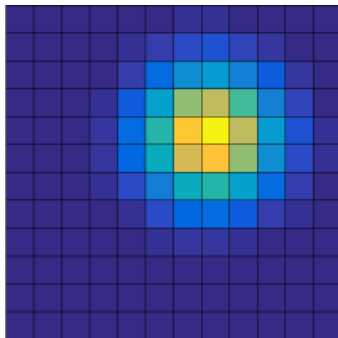
Reference (post):



Identical grid for pre and post event topography

VERTICAL TOPOGRAPHIC DIFFERENCING

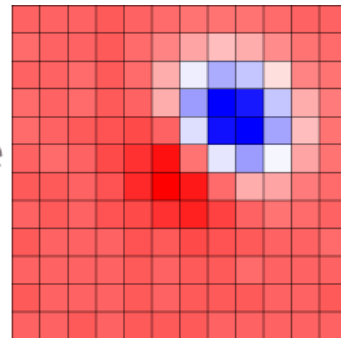
Compare (pre):



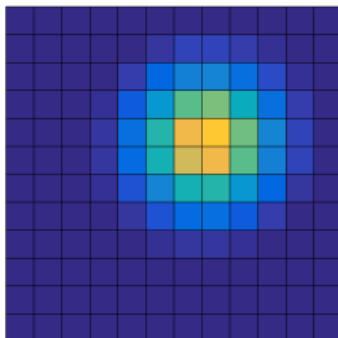
Subtraction:

Difference
= Reference-Compare

Red Down Blue Up



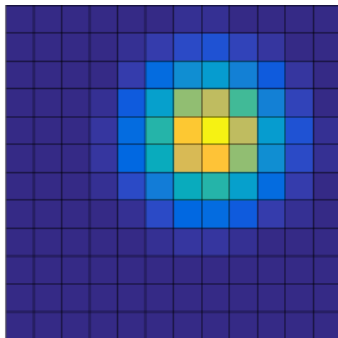
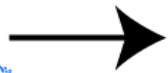
Reference (post):



Raster subtraction

VERTICAL TOPOGRAPHIC DIFFERENCING

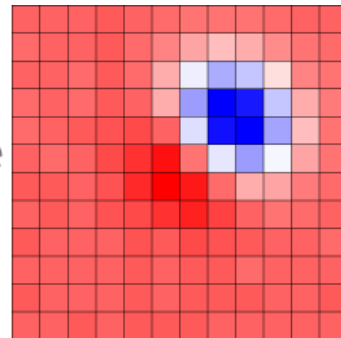
Compare (pre):



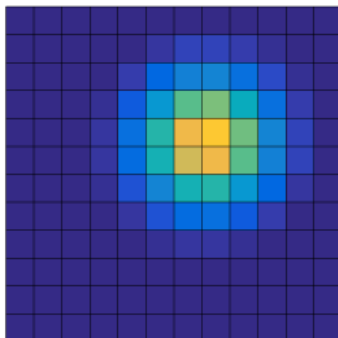
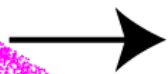
Subtraction:

Difference
= Reference-Compare

Red Down Blue Up



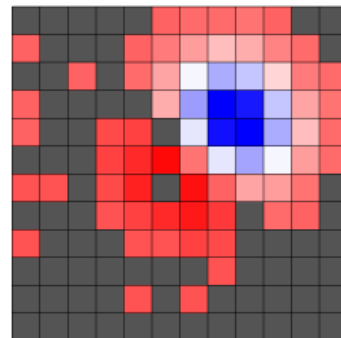
Reference (post):



Error:

Mask out differences
below the error
threshold

Grey Masked points



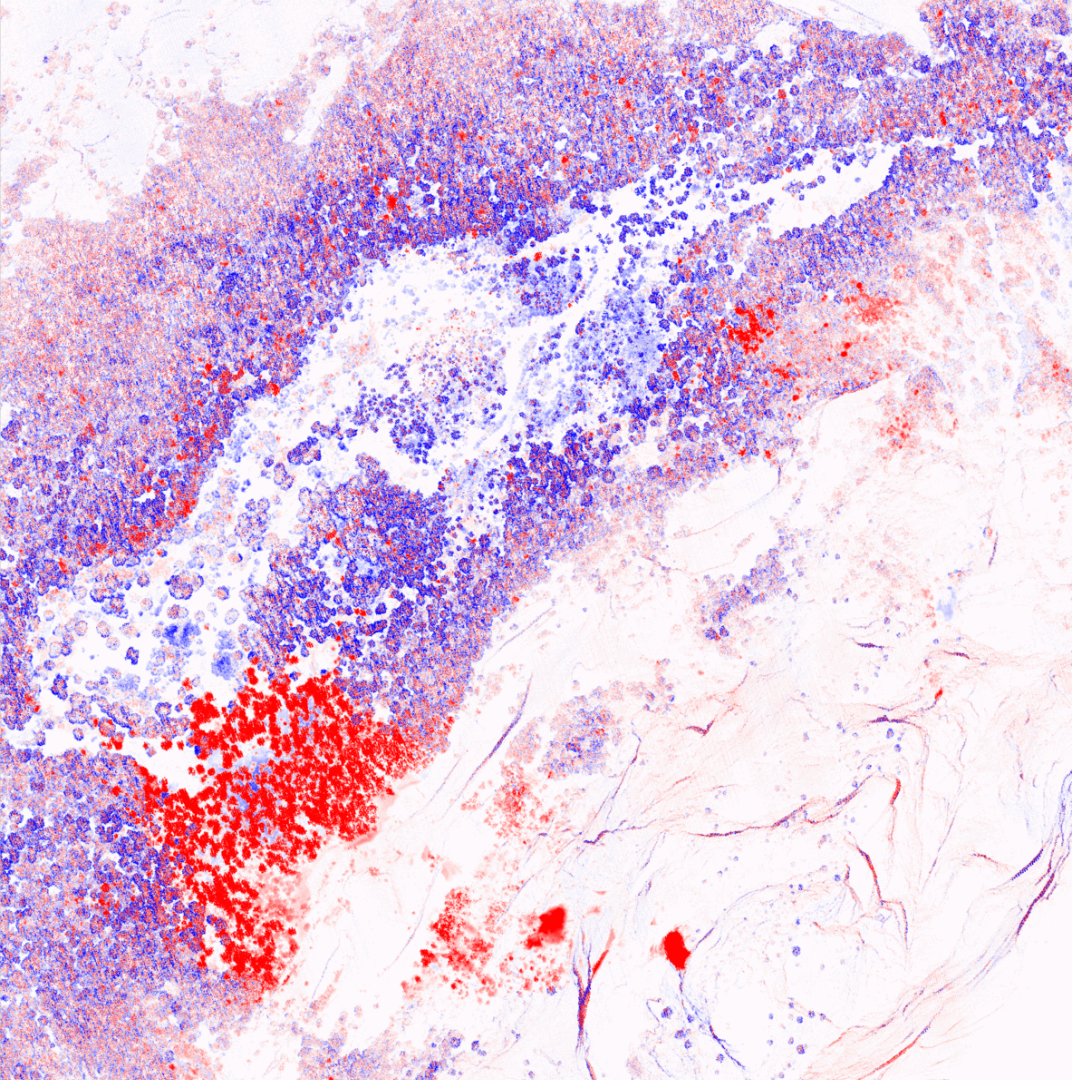
Option: mask differences below error threshold

TOPOGRAPHIC DIFFERENCING WORKFLOW

- Overlapping data
- Dataset must be on identical grids
 - Original raster and gridded point cloud data
 - Varying raster and point densities
- Raster subtraction
- User-defined error threshold
- Display difference maps and histogram of differences



Infrastructure damage following the 2016 M7 Kumamoto, Japan, earthquake.



Yosemite, CA

Differencing: 2011-2013



-15 0 15

Vertical Difference (m)

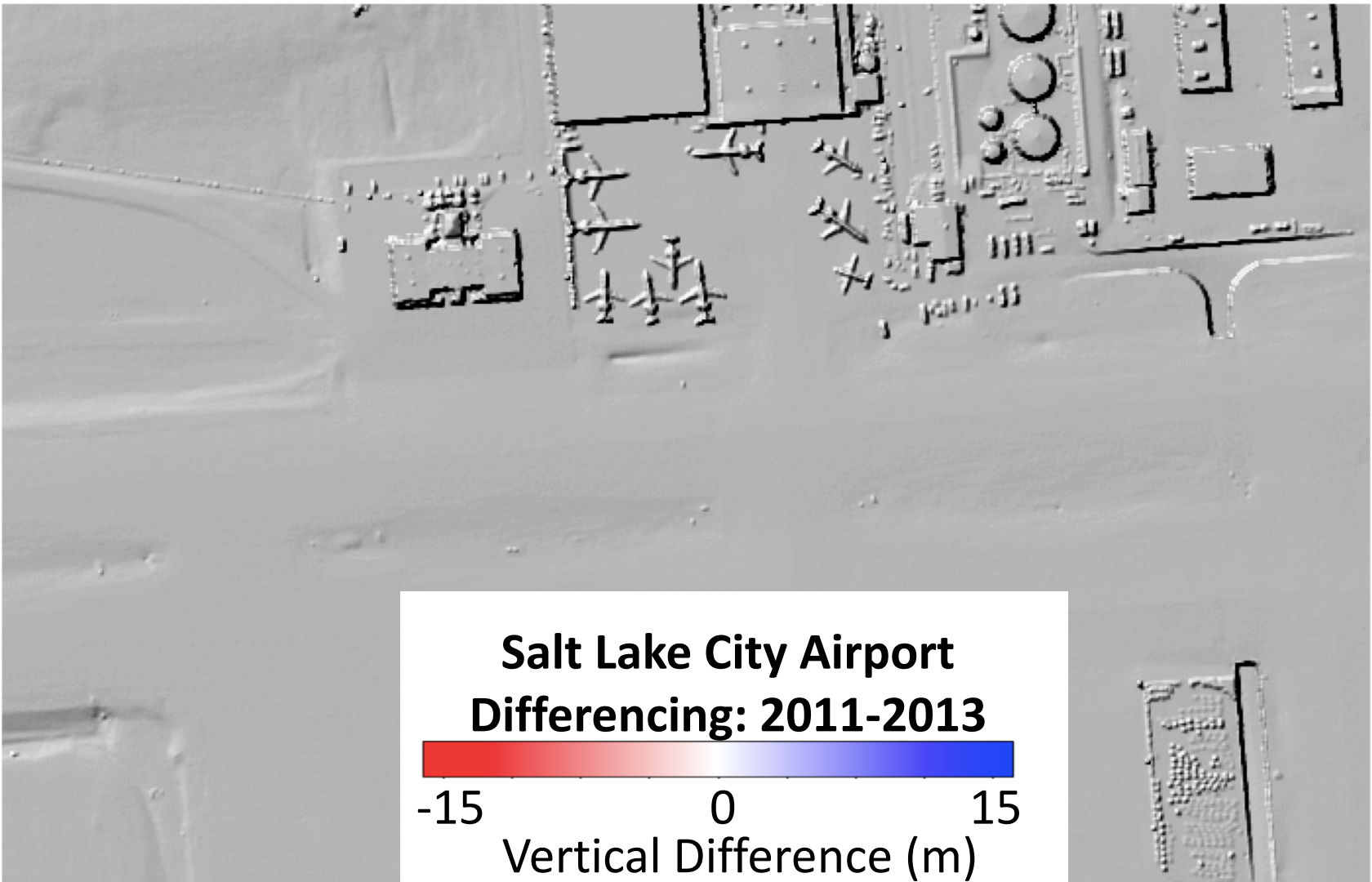


-8 0 8

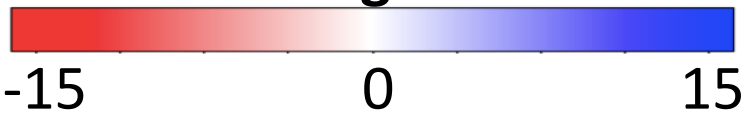
Iowa City, Iowa

Differencing: June 2008- August 2014

Vertical Difference (m)



**Salt Lake City Airport
Differencing: 2011-2013**



-15

0

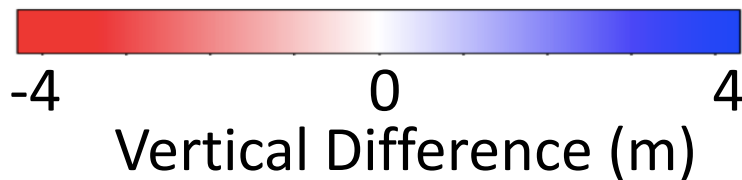
15

Vertical Difference (m)



Salt Lake City, Utah

Differencing: Oct 2015- Oct 2017



THANKS!



OpenTopography.org



@OpenTopography



Facebook.com/OpenTopography

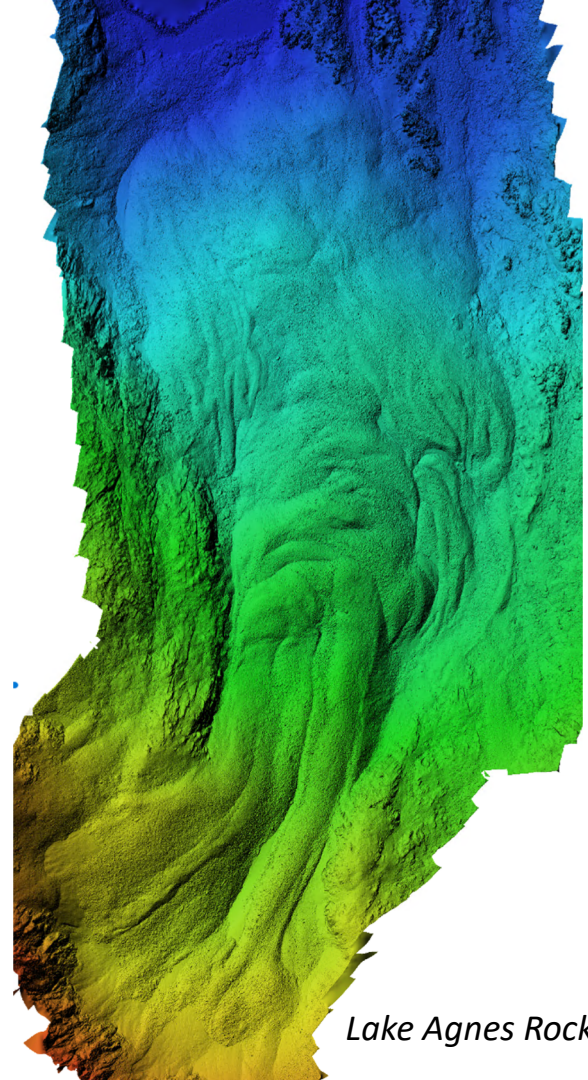


@OpenTopography



info@opentopography.org

crosby@unavco.org

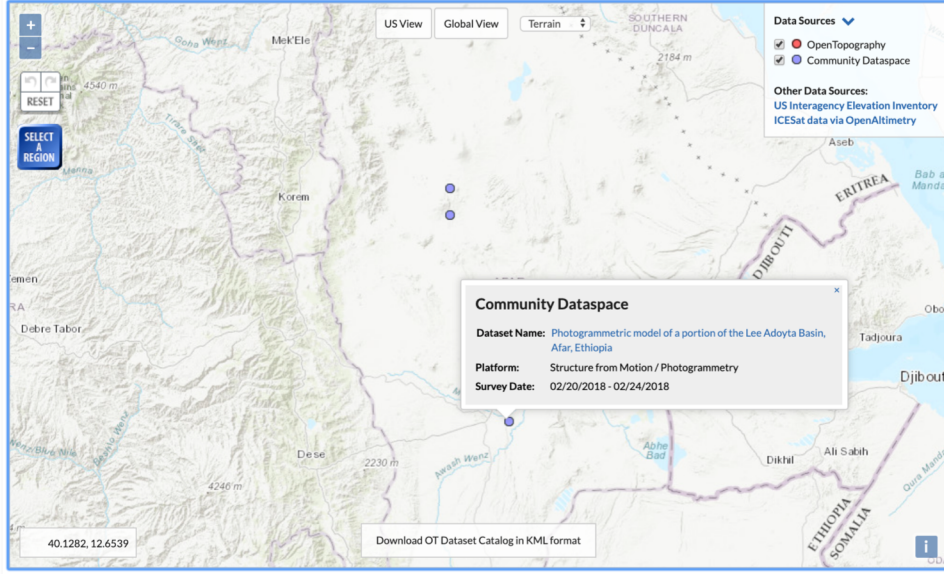


Lake Agnes Rock Glacier, CO

OT COMMUNITY DATASPACE

Find Topography Data

Information and Instructions



Publish, discover, download, cite

Arrowsmith, J R., DiMaggio, E. N., Garello, G. I., Villmoare, B. and LediGeraru Research Project (2018): Photogrammetric model of a portion of the Lee Adoyta Basin, Afar, Ethiopia. Distributed by OpenTopography. Accessed July 20, 2022. <https://doi.org/10.5069/G95X271W>



OpenTopography

OpenTopography facilitates community access to high-resolution, Earth science-oriented, topography data, and related tools and resources. OpenTopography is based at the San... read more

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Dataset extent

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Photogrammetric model of a portion of the Lee Adoyta Basin, Afar, Ethiopia

Metadata Updated: July 25, 2019

These data were collected in the Lee Adoyta basin of Ledi Geraru Research Project, Lower Awash Valley, Afar, Ethiopia. They were produced in support of paleontological research. The area comprises gently tilted 2.7 million year old rocks faulted against 3 million year old basalts. The area was described by DiMaggio, E. N., Campisano, C. J., Rowan, J., Dupont-Nivet, G., Deino, A. L., Bibi, F., Lewis, M. E., Souron, A., Garello, D., Werdelin, L., Reed, K. E., Arrowsmith, J. R., Late Pliocene Fossiliferous Sedimentary Record and the Environmental Context of early Homo from Afar, Ethiopia, Science, VOL 347 ISSUE 6228, 10.1126/science.aaa1415, 2015.

Collected with a DJI Mavic Air by Ramon Arrowsmith in coordination with Erin DiMaggio. Dominico Garello and Brian Villmoare assisted in ground control and planning.

Access & Use Information

Non-Federal: This dataset is covered by different Terms of Use than Data.gov.
License: No license information was provided.

Downloads & Resources

Download

Navigate directly to the URL for data access and download.

Visit page

OT COMMUNITY DATASPACE

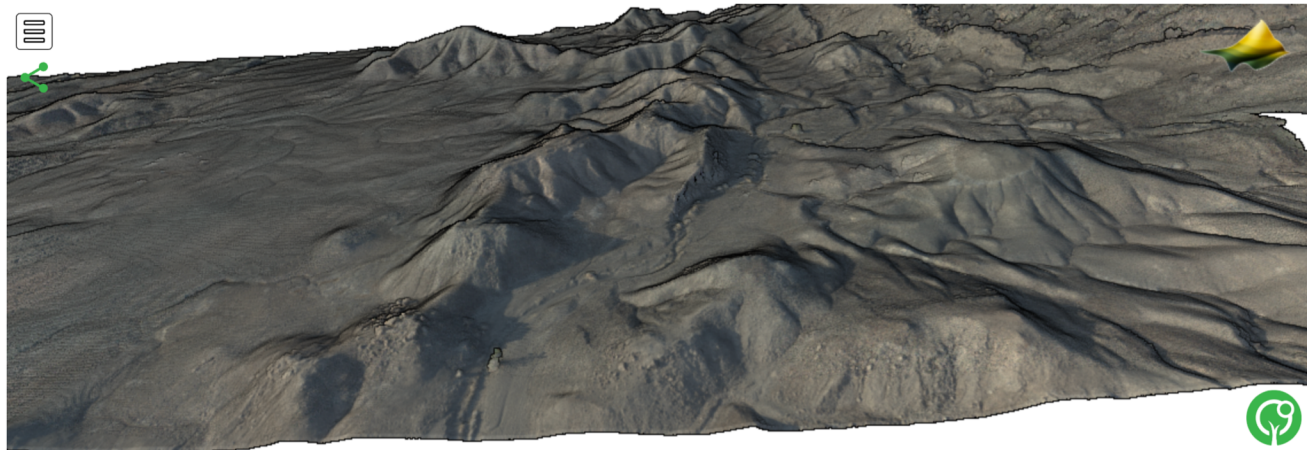
[Getting Started](#)[MyOpenTopo](#)[Partner With Us](#)[HOME](#)[DATA](#)[RESOURCES](#)[LEARN](#)[ABOUT](#)

Photogrammetric model of a portion of the Lee Adoyta Basin, Afar, Ethiopia

Welcome Christopher Crosby ([Sign Out](#))[OT Dataspace](#)

Dataset Information

These data were collected in the Lee Adoyta basin of Ledi Geraru Research Project, Lower Awash Valley, Afar, Ethiopia. They were produced in support of paleontological research. The area comprises gently tilted 2.7 million year old rocks faulted against 3 million year old basalts. The area was described by DiMaggio, E. N., Campisano, C. J., Rowan, J., Dupont-Nivet, G., Delno, A. L., Bibi, F., Lewis, M. E., Souron, A., Garello, D., Werdelin, L., Reed, K. E., Arrowsmith, J. R., Late Pliocene Fossiliferous Sedimentary Record and the Environmental Context of early Homo from Afar, Ethiopia, *Science*, VOL 347 ISSUE 6228, 10.1126/science.aaa1415, 2015. Collected with a DJI Mavic Air by Ramon Arrowsmith in coordination with Erin DiMaggio. Dominique Garello and Brian Villmoare assisted in ground control and planning.

opentopoID: OTDS.102018.32637.1**DOI:** <https://doi.org/10.5069/G95X271W>**Platform:** Structure from Motion / Photogrammetry**Data Format:** Point Cloud, Raster, Images**Dataset Acknowledgement:** Arrowsmith, J. R., DiMaggio, E. N., Garello, D. I., Villmoare, B. and the Ledi G Science Foundation and the Institute of Human Origins at Arizona State University. Collected in coordin State.**Dataset Citation:** Arrowsmith, R. (2018). Photogrammetric model of a portion of the Lee Adoyta Basin, <https://doi.org/10.5069/G95X271W>. Accessed: 2022-10-07**Survey Date:** 02/20/2018 - 02/24/2018**Survey Area:** 0.1 km²**Publication Date:** 10/24/2018

Show Data Files

Point Cloud Data

	File Name	Size	Points	Area (m ²)	Density	
1	LA6_hires_UTM37_cleaned.laz	856.02 MB	122,479,973	95,999	1,275.85	View Detail

Raster Data

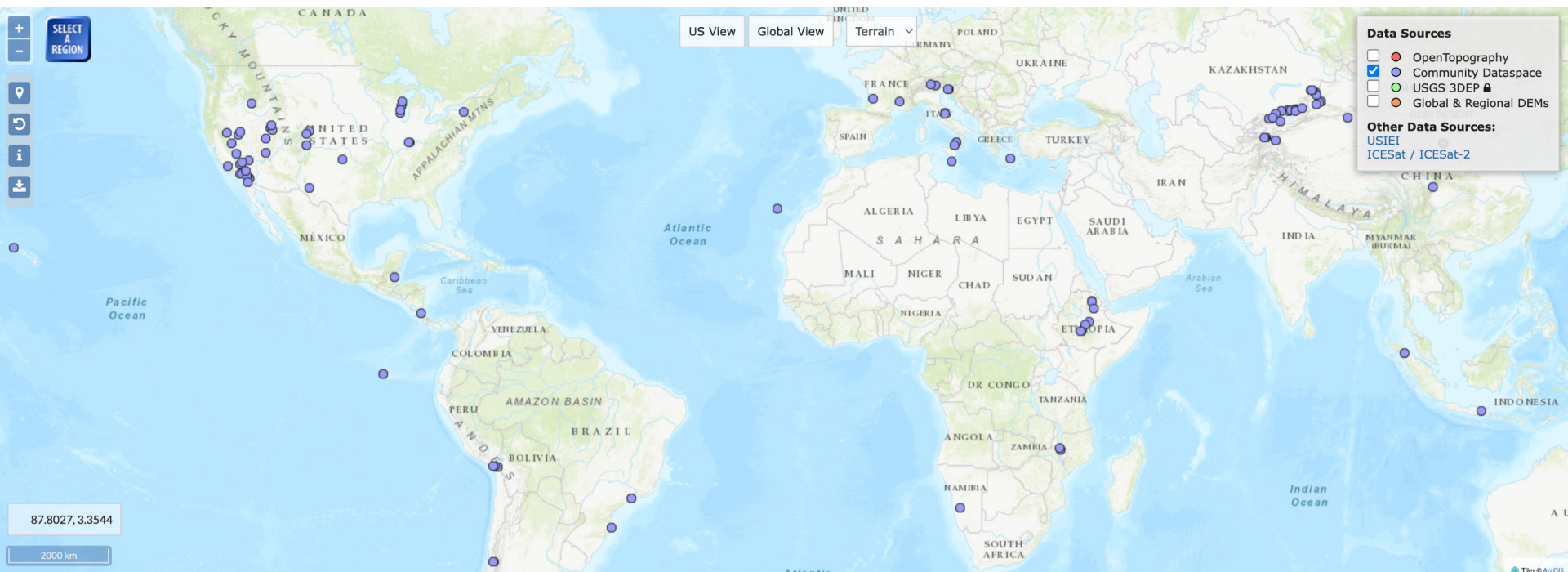
	File Name	Size	Resolution	Dimensions	Layer Type	
1	LA6_DEM_0.25mv2.tif	20.00 MB	0.25 meter	1943 x 1161		View Detail
2	LA6_hightrez_2cm_ortho_UTM37_trimmed.tif	301.87 MB	0.02 meter	22354 x 14550		View Detail
Summary		321.87 MB				

Images Files

	File Name	Size	Dimensions	
1	DJI_0451.JPG	6.88 MB	4056 x 3040	
2	DJI_0452.JPG	6.78 MB	4056 x 3040	
3	DJI_0453.JPG	6.70 MB	4056 x 3040	
4	DJI_0454.JPG	6.52 MB	4056 x 3040	
5	DJI_0455.JPG	6.76 MB	4056 x 3040	

STATUS

- 155 datasets (vast majority UAS SfM)
- Datasets from all over the globe. International contributors.
- Functionality: Data discovery & download; 3D visualization; *full processing coming soon...*



OT COMMUNITY DATASPACE

- Platform for publication of long tail topographic data to increase impact, enable reuse
- Point clouds, raster-derivatives, “raw” data/source imagery

Features:

- Automated ingest via browser-based workflow.
- Standardized & user friendly
- Aligned with **FAIR** best practices for data preservation, curation, publication & citation



Show Data Files

Point Cloud Data

	File Name	Size	Points	Area (m ²)	Density	
1	LA6_hires_UTM37_cleaned.laz	856.02 MB	122,479,973	95,999	1,275.85	View Detail

SpatialReference:

```
COMPDS["unknown",PROJCS["WGS 84 / UTM zone 37N",GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS 84",6378137,298.257223563,AUTHORITY["EPSG":"7030"]],TOWGS84[0,0,0,0,0,0],AUTHORITY["EPSG":"6326"],PRIMEM["Greenwich",0],UNIT["degree",0.0174532925199433],AUTHORITY["EPSG":"4326"]],PROJECTION["Transverse_Mercator"],PARAMETER["latitude_of_origin",0],PARAMETER["central_meridian",39],PARAMETER["scale_factor",0.9996],PARAMETER["false_easting",500000],PARAMETER["false_northing",0],UNIT["metre",1],AUTHORITY["EPSG":"9001"]],AUTHORITY["EPSG":"32637"]],VERT_CS["unknown",VERT_DATUM["unknown",2005],UNIT["metre",1.0,AUTHORITY["EPSG":"9001"]],AXIS["Up",UP]]]
```

Lat/Lon/Elevation Boundary:

```
North-East (lat,lon,elev): [11.36167694, 40.86388512, 498.9730007]  
South-West (lat,lon,elev): [11.35902683, 40.85942062, 442.3320007]
```

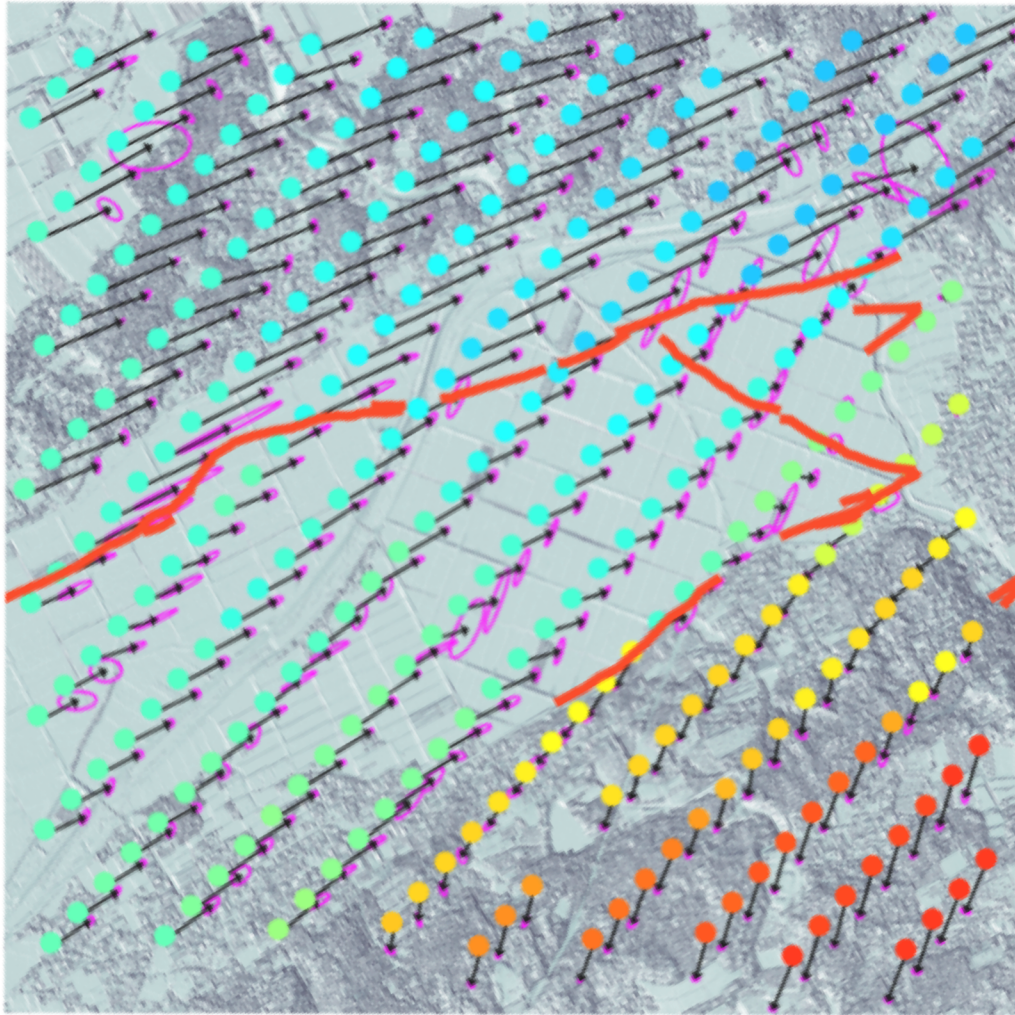
Coordinates Boundary:

```
North-East (X,Y): 703399.045, 1256619.52]  
South-West (X,Y): 702913.526, 1256329.442]
```

Classifications:

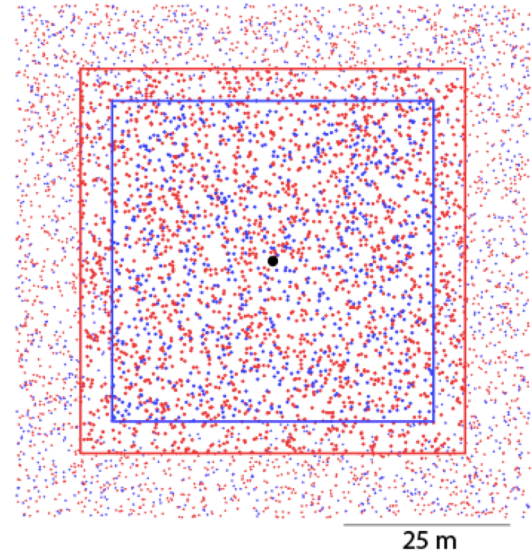
```
Class 0 (Created, never classified): 122,479,973
```

3D TOPOGRAPHIC DIFFERENCING

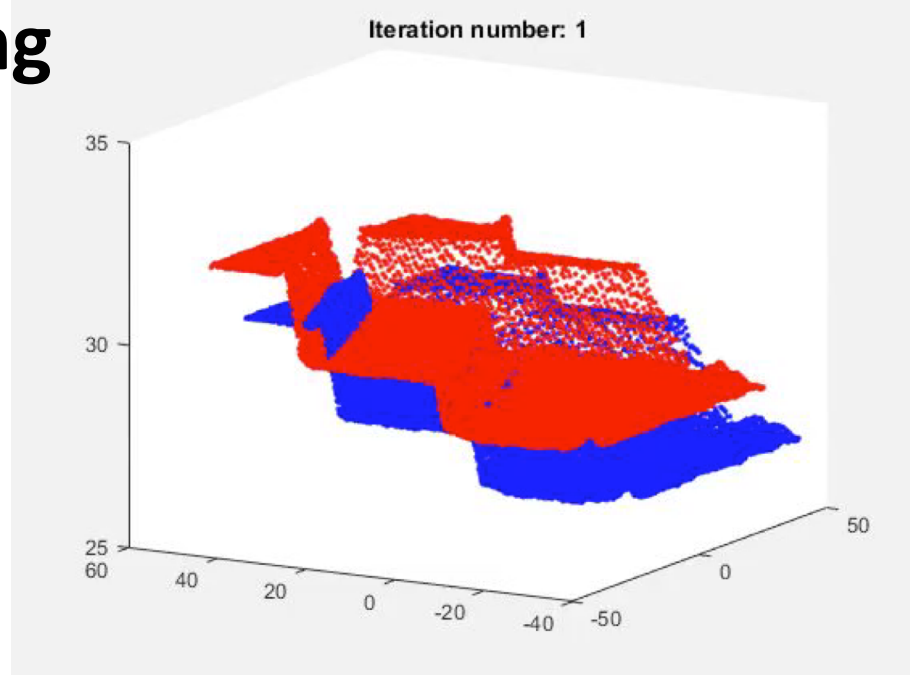


3D coseismic
displacements from the
M7 Kumamoto Earthquake
Scott et al. (2018)

3D Topographic differencing Iterative Closest Point



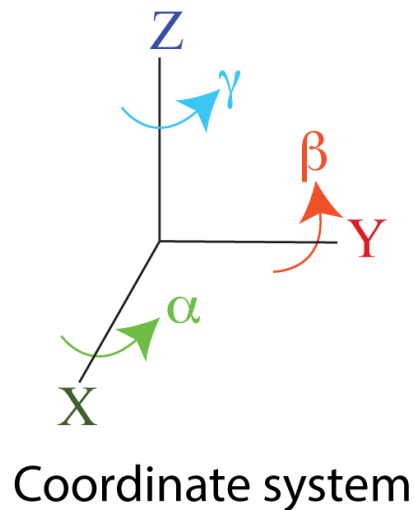
- Compare (pre)
- Reference (post)

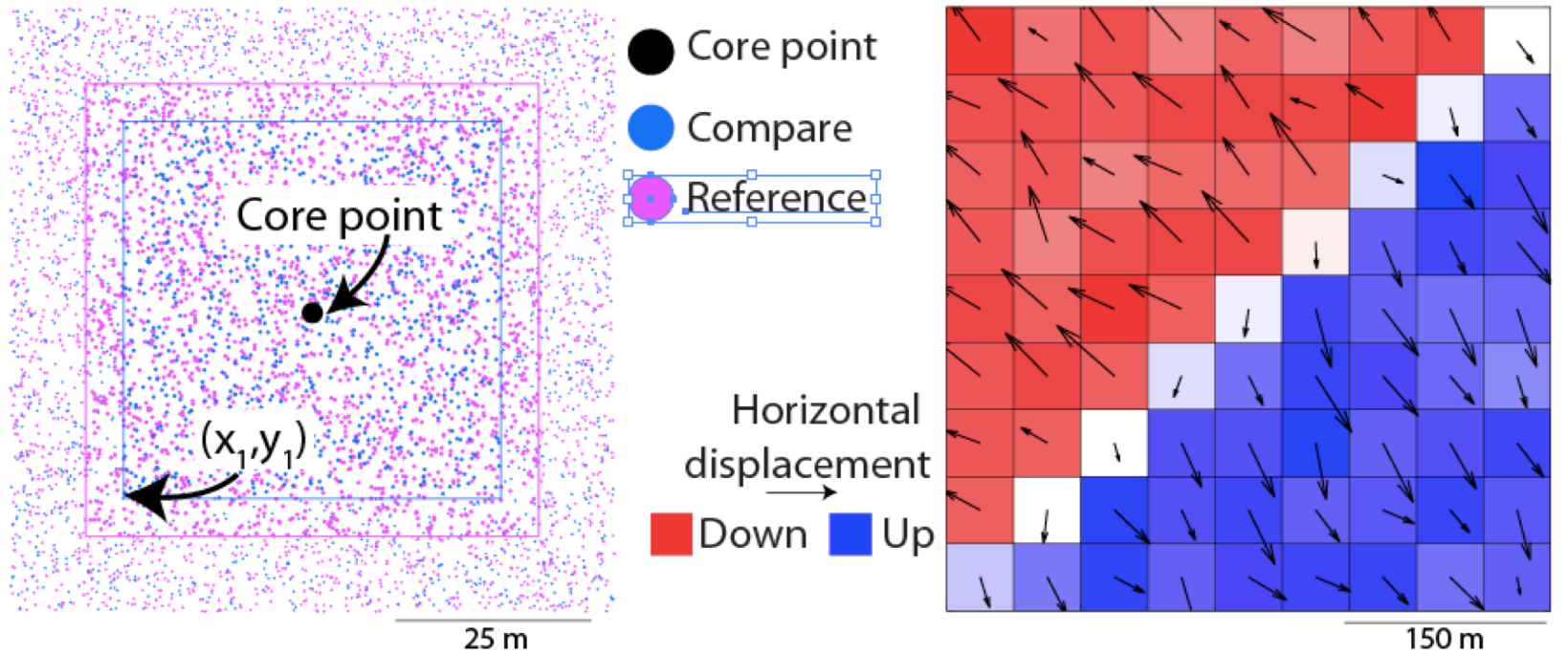


Align **pre-** and **post-** event
point clouds

$$\text{Deformed point cloud} = \begin{bmatrix} 1 & -\gamma & \beta \\ \gamma & 1 & -\alpha \\ -\beta & \alpha & 1 \end{bmatrix} \begin{bmatrix} \text{Undeformed} \\ \text{point cloud} \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix}$$

Rotation
Translation





Pre-ICP alignment

ICP rigid alignment

● Compare post ICP alignment

Perform On-demand 3D differencing

Select region with overlapping datasets
Choose 3D change detection

Processing options

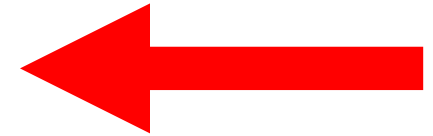
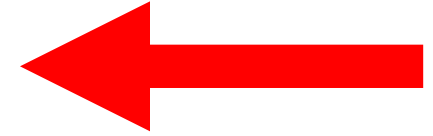
Window size: Suggestions based on point density
Point classification
Processing limit: Number of core points

Calculate 3D change

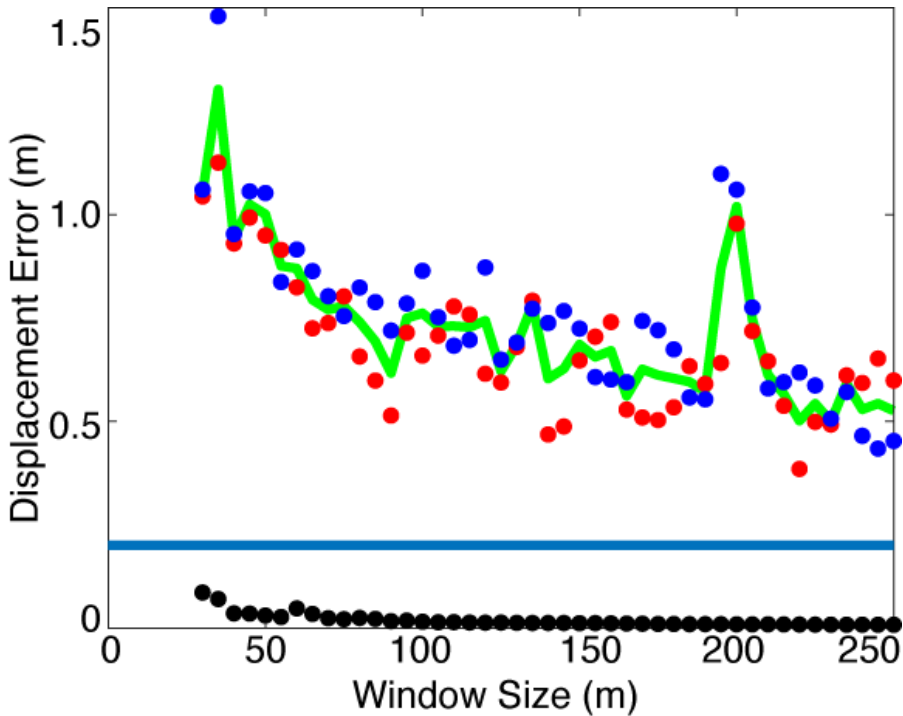
Window point cloud dataset
ICP algorithm: 3D displacements and rotations

Presentation of results

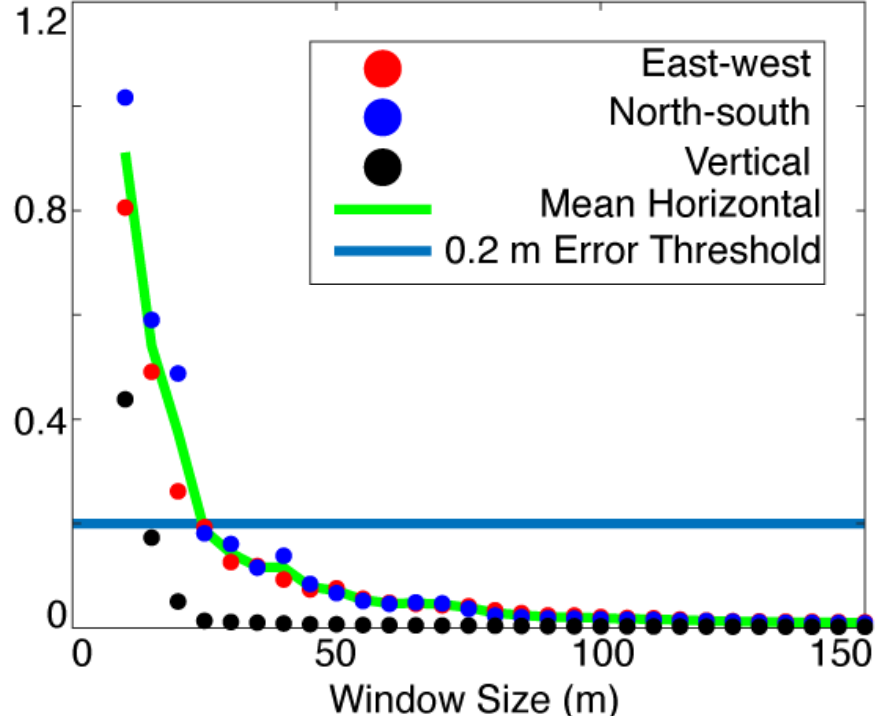
Geotiffs of the 3D displacements and rotations
Graphics of the 3D displacements and rotations



3D DIFFERENCING: WINDOW SIZE SYNTHETIC TESTING

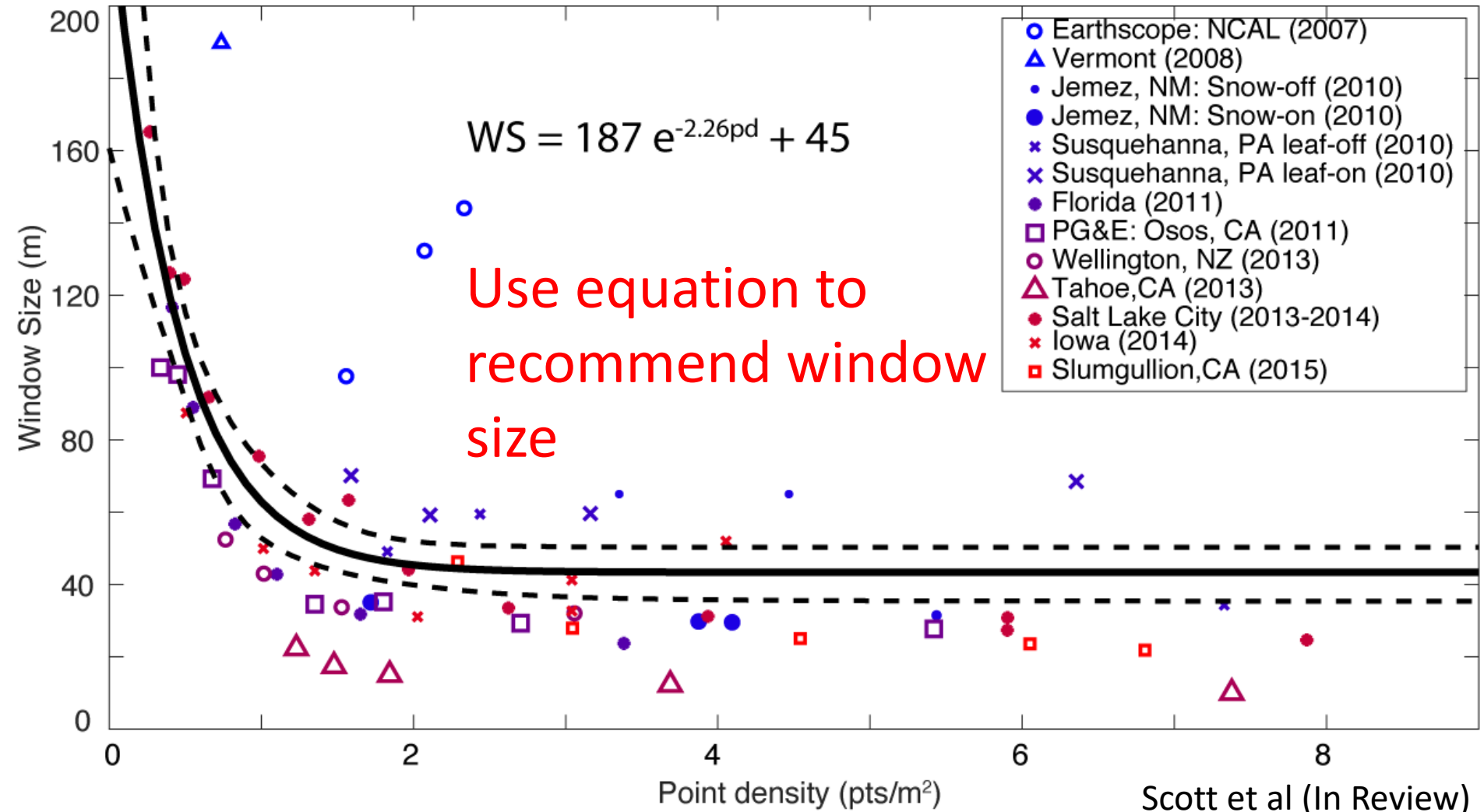


Indiana: 2012, density: 0.6 pts/m²

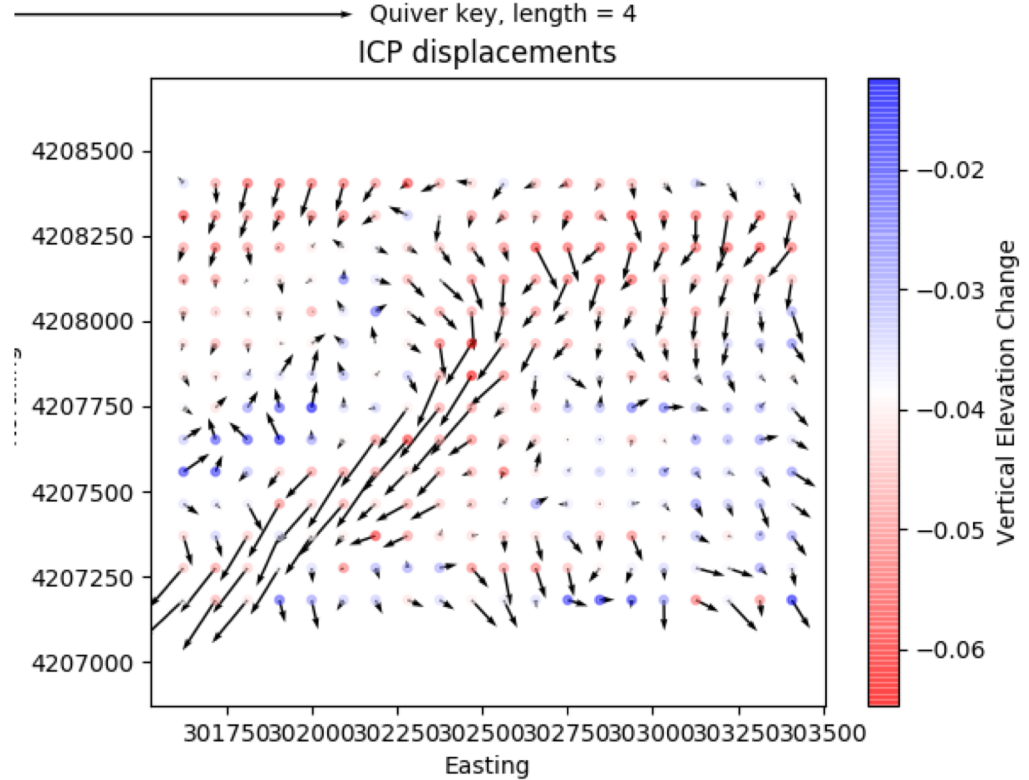
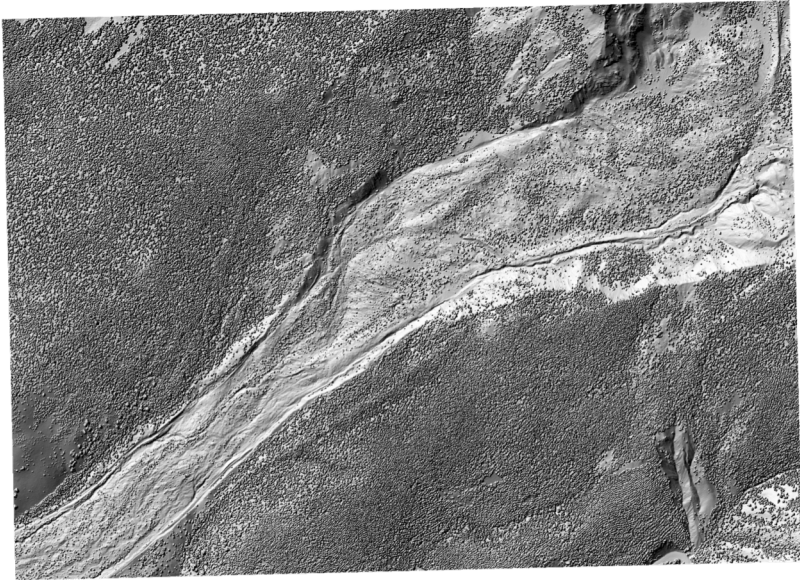


Utah: 2014, Density: 7.9 pts/m²

Data resolution and quality impact window size

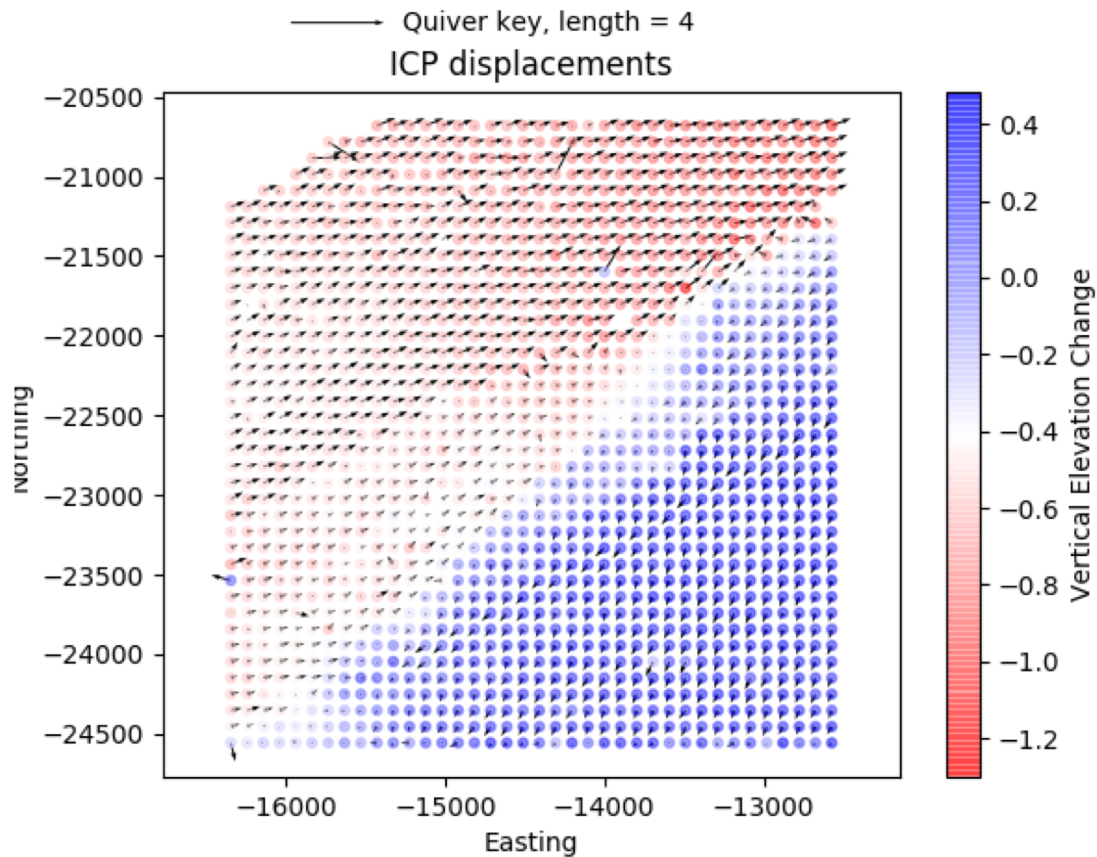
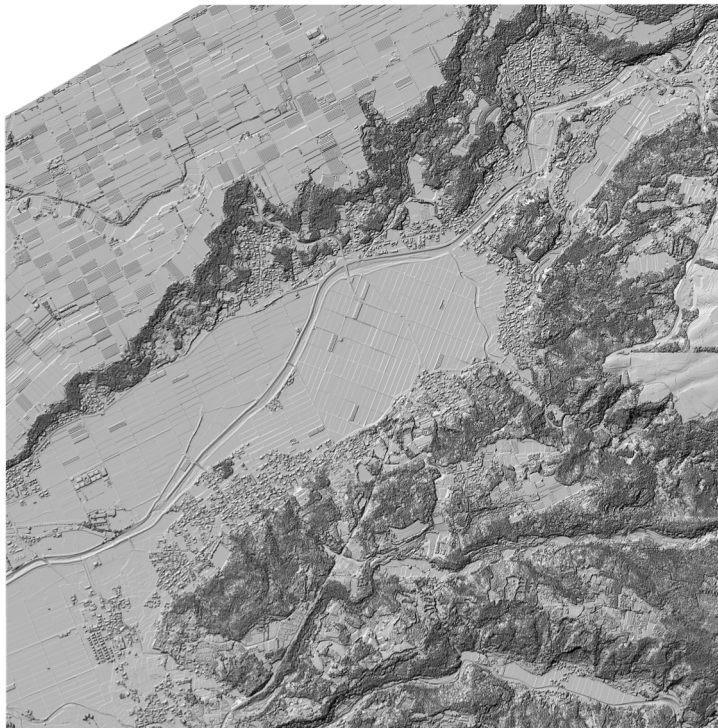


SLUMGULLION LANDSLIDE, COLORADO

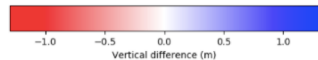
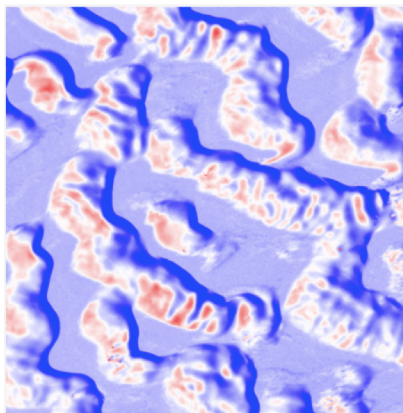
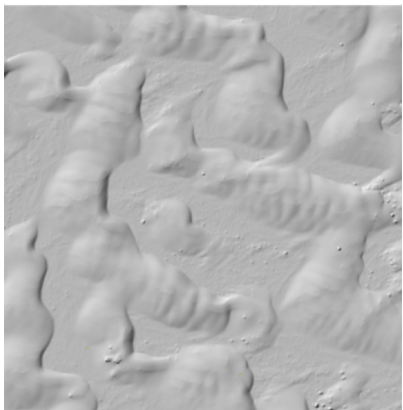


Landslide creep: July 3- July 10, 2015

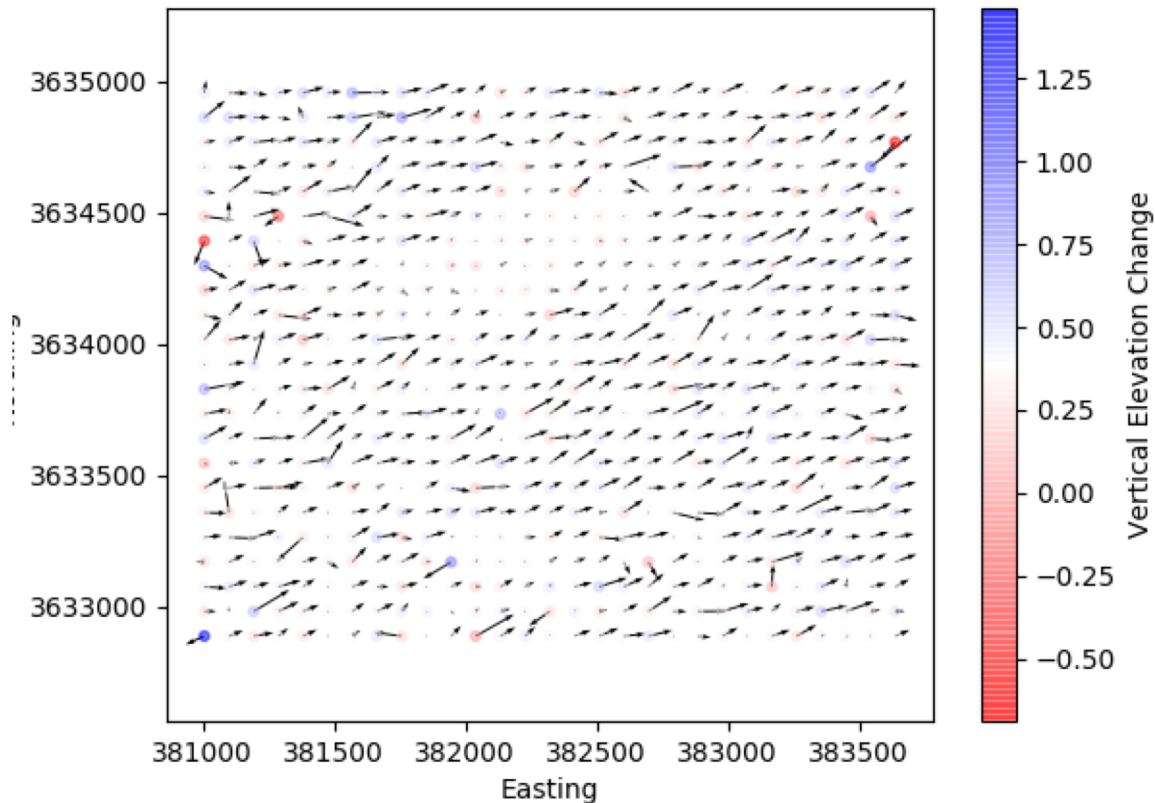
M7 KUMAMOTO EARTHQUAKE, JAPAN



SAND DUNE MIGRATION, WHITE SANDS, NM



→ Quiver key, length = 4
ICP displacements



OPPORTUNITIES & CHALLENGES

A revolution in 3 and 4D data collection and analysis – ubiquitous point clouds & 3D models

Challenges:

Community needs best practices, standards, documentation to fully enable dataset reuse.

Sustainability: Data collection is cheap & easy and drones are common (govt, academia, industry, personal/hobbyist).

