# Topographic Change at the Statewide Scale: An Indiana Case-Study Powered by OpenTopography

Christopher Crosby, Chelsea Scott, & the OT Team

*2021 NSGIC Annual Conference, Dallas, TX*

OpenTopography is supported by the National Science Foundation under Award Numbers 1948997, 1948994 & 1948857

# What do we do?

Data hosting and distribution:

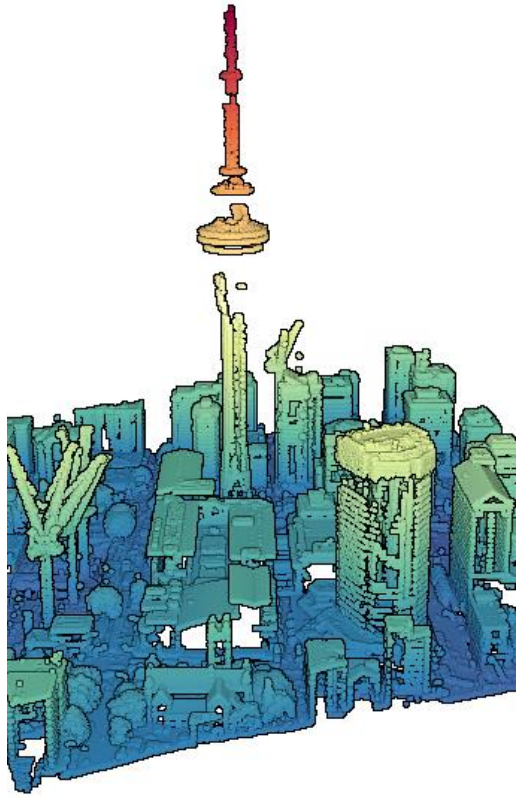
- Online distribution of point cloud, raster (DTM, DSM, orthoimagery, etc), and other derivative products.

Direct access to USGS 3DEP datasets:

- Easy on-demand access and processing for all 3DEP data.

Education and training in use of high resolution topography:

- Online or in-person short courses. Focus on methods and best practices, not specific software.



***Past and current partners:***

Land Information New Zealand, State of Indiana, State of Utah, California Geological Survey, Yurok Tribe, PG&E, USGS…

# DATA SERVICES

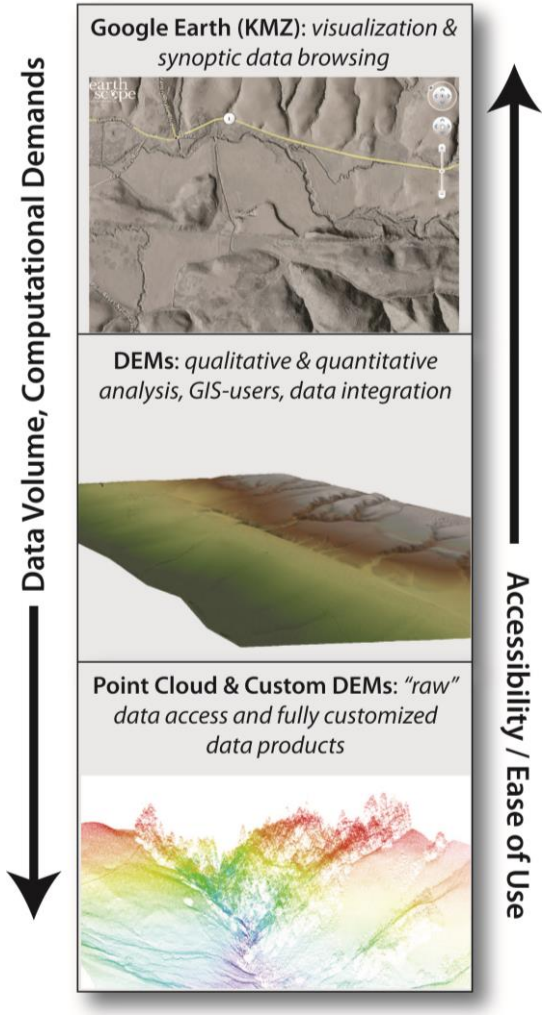
Topography data products and access mechanisms for a diverse user community

Range of available data products:

- Easy to access products for browsing and education.
  - Browse images, Google Earth, 3D visualization
- Majority of users want a standard gridded product.
  - GIS products (e.g. DTM, DSM, etc.)
- “raw” point cloud data for modeling or analysis

Multiple Access Pathways

- Web Portal interfaces, APIs and web services, Bulk Downloads (Cloud Optimized GeoTIFFs - COGs)



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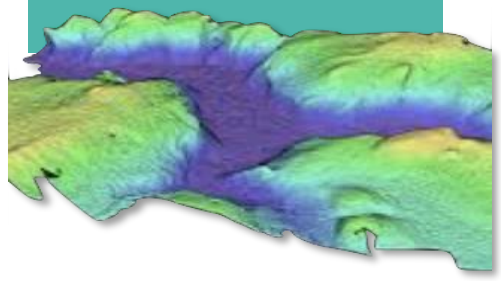
# DATA SERVICES

TOPOGRAPHY DATA

PC Data Filtering & Subsetting

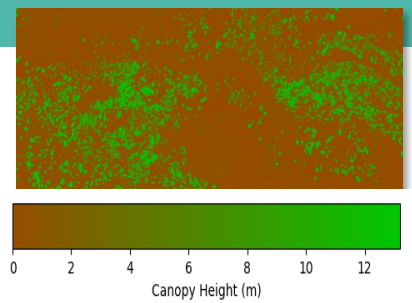
Raster Data Subsetting

3D Visualization

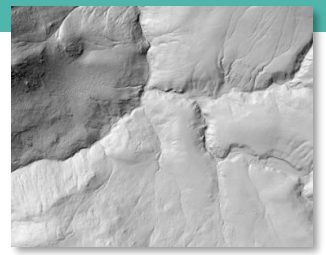


Digital Elevation Models
TIN / Local Gridding

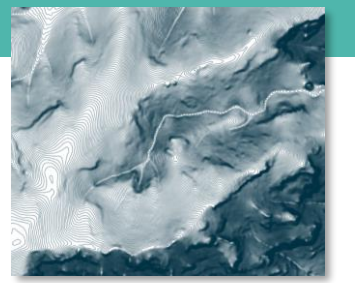
Canopy Height Model




Topographic Hillshades

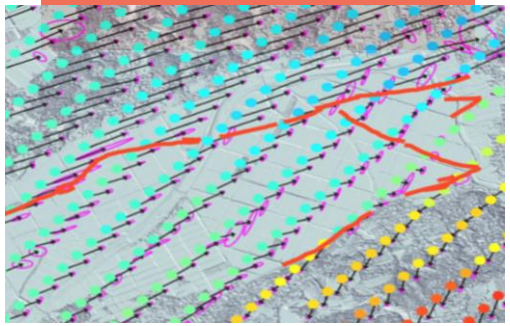


Contour Lines

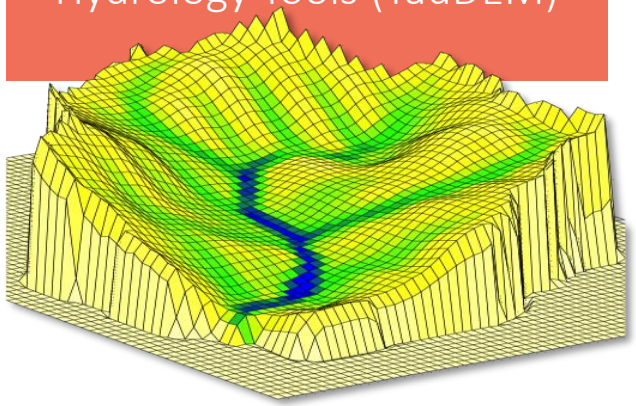


Vertical Differencing

3D Differencing

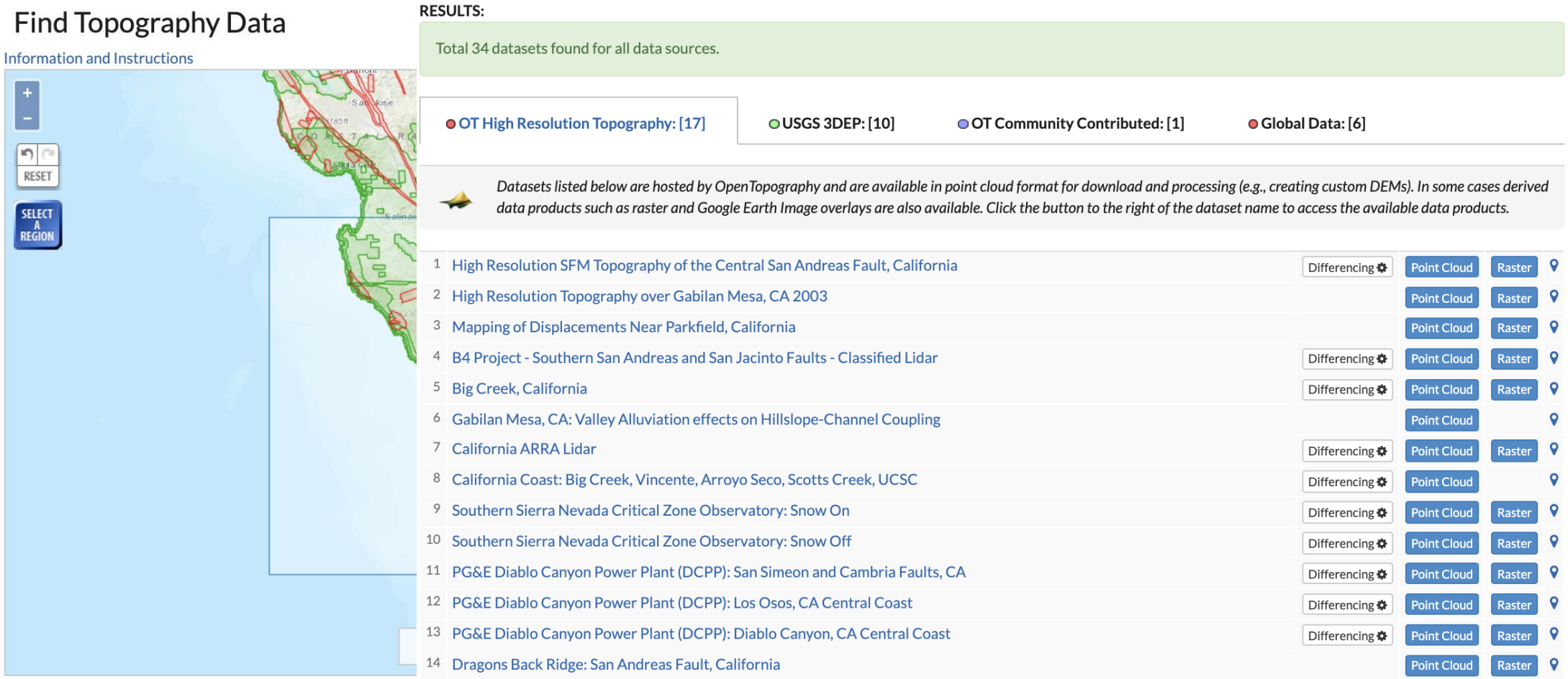


Hydrology Tools (TauDEM)

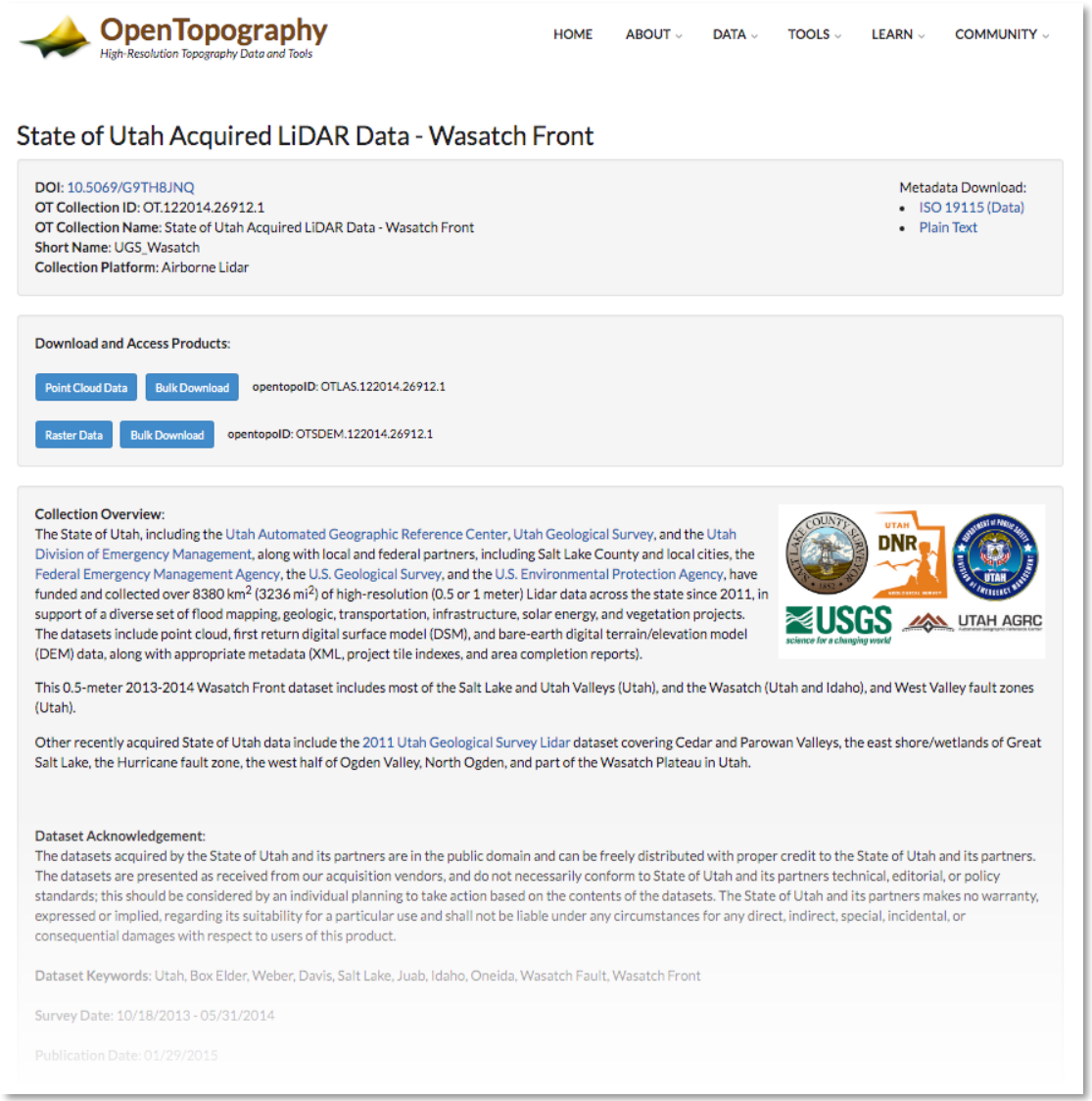


# Portal Interfaces

## AOI selection on Map



# PORTAL INTERFACES




Each OT Dataset contains:

- Landing page with metadata
- Logos & information on funders, partners, collectors.
- Citable DOI – persistent URL
- Options to download via web-map or “bulk” download

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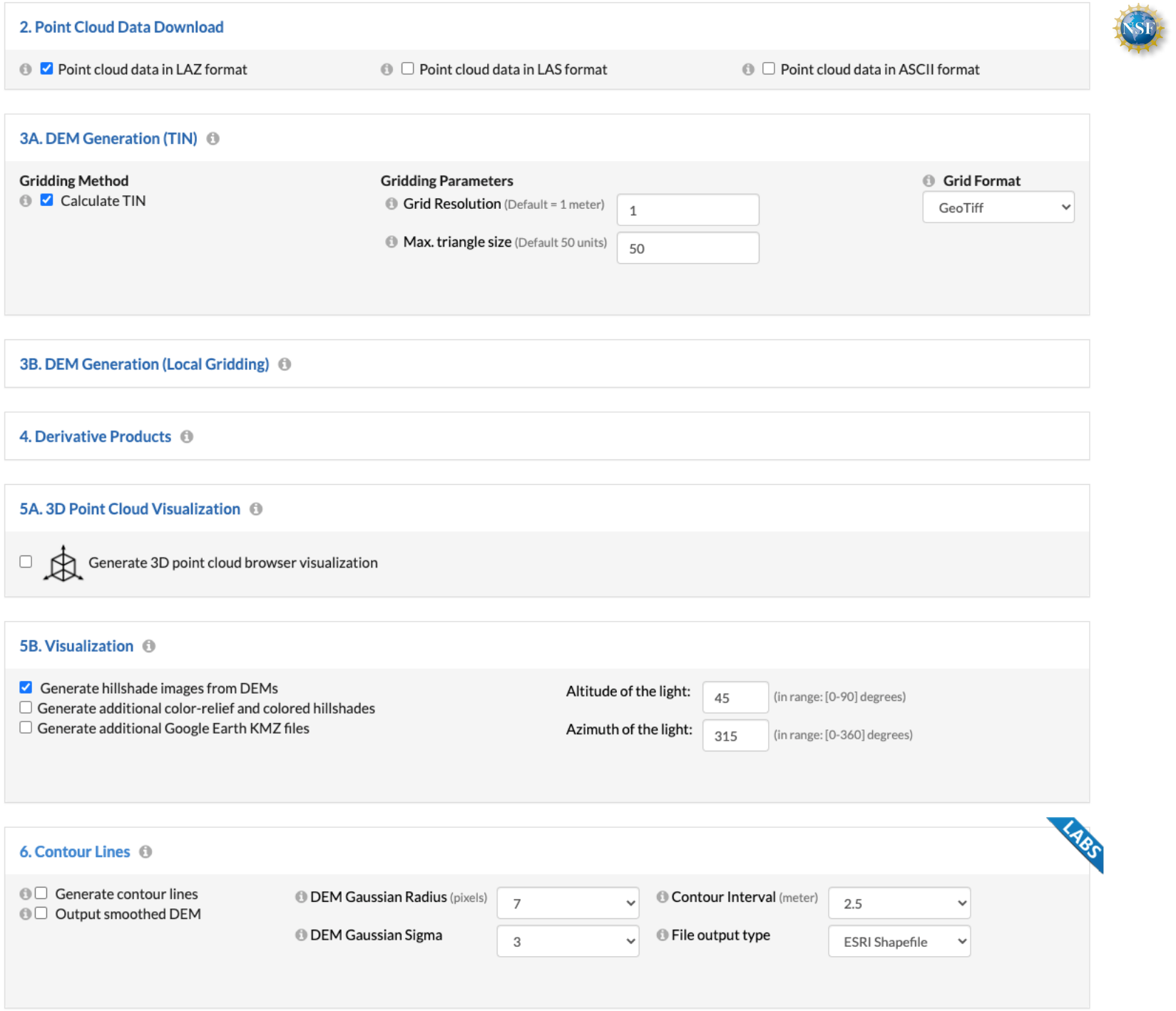
# PORTAL INTERFACES

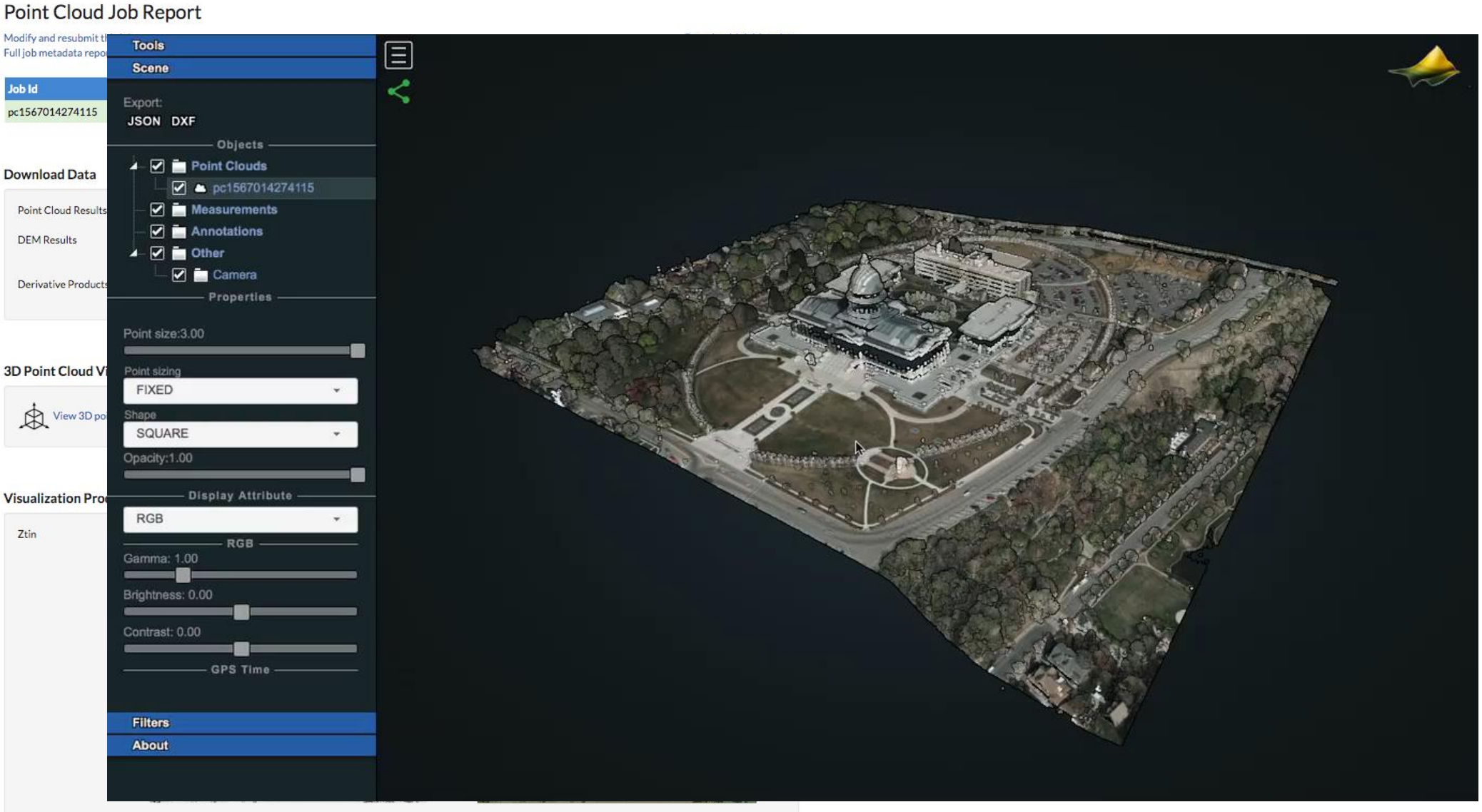
Job Customizations

- Output formats
- Parameters in algorithms

Jobs run on-demand



# PORTAL INTERFACES

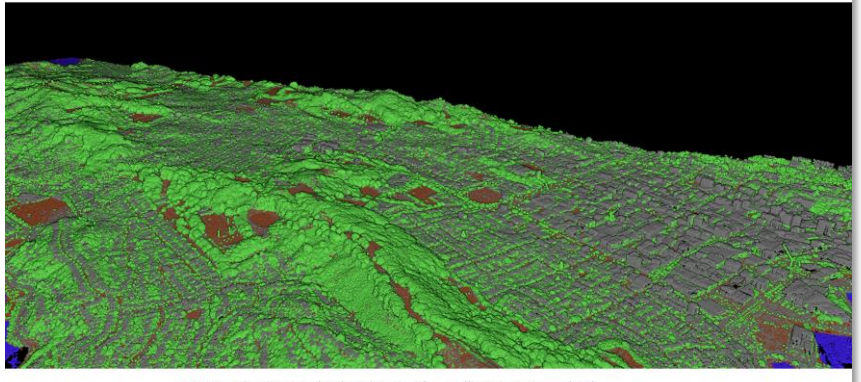


# New Zealand National Lidar Program

44 lidar point cloud datasets in OpenTopography covering 61,716 sq km

LINZ Follow
We make sure NZ has accurate information about where people and places are, people have confidence in property rights and Crown property is well managed.
Oct 16 · 5 min read

**Creating point cloud visualisations with OpenTopography**



Stripping down point clouds to bare earth—Wellington, New Zealand

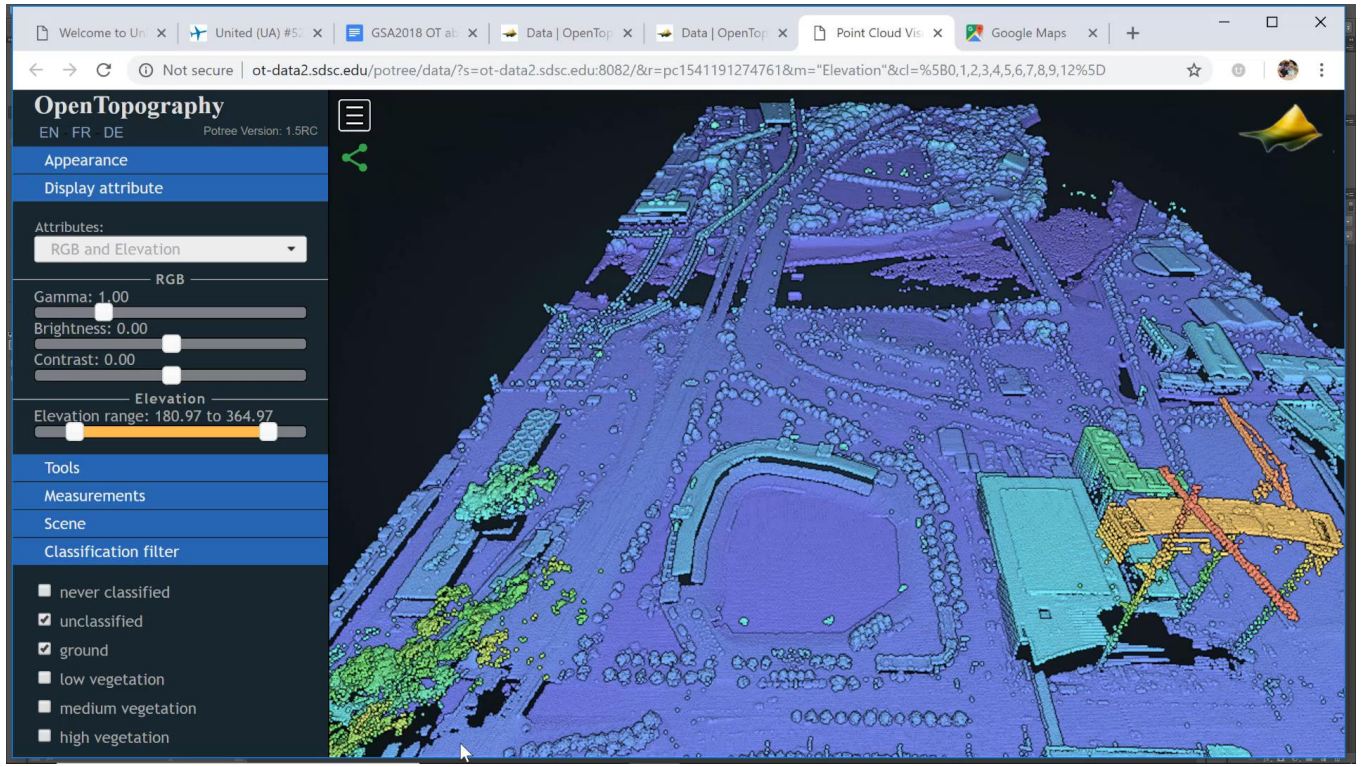
**LINZ Data Service**
@LINZLDS

New #LiDAR available! DEM/DSM of Westport data.linz.govt.nz/layer/105446. Point clouds @OpenTopography doi.org/10.5069/G9Z31W…. Check out this image of the Buller River showing land features not easily seen in aerial imagery alone #opendata

# 2011-2013 Indiana Statewide Lidar Collection

- Supported by Indiana Agencies
- >41,000 point cloud jobs run by 5,532 users
- Diverse use beyond academia
  - State / City Government
  - Engineering/Surveying
  - Agricultural
  - Water Management
  - Geospatial Consultants
  - Energy Utilities

INDIANA
Indiana Statewide Imagery and LiDAR Program
INDIANA OFFICE OF TECHNOLOGY
Indiana Geographic Information Office



# 2011-2013 Indiana Statewide Lidar Collection

*Honestly (OpenTopography) made the difference between success and failure of the use of the data because it made it so readily available, and really broke down the barriers to having the normal mom and pop engineering firms and surveyors get access to the data in a form they can use.*

**-Phill Worrel, IGIC**

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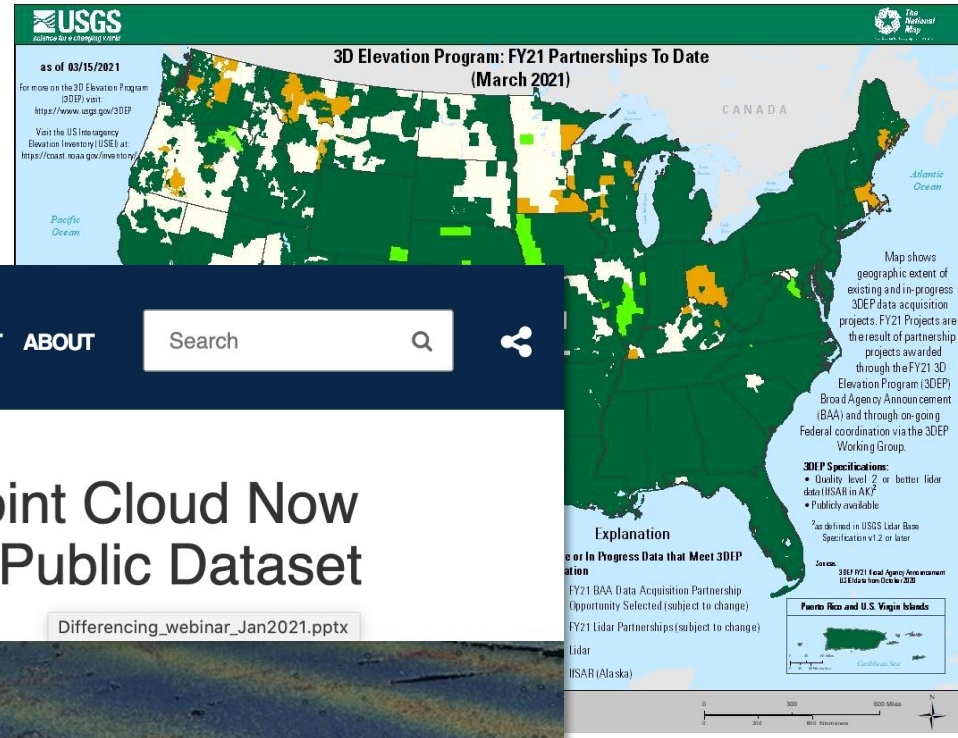
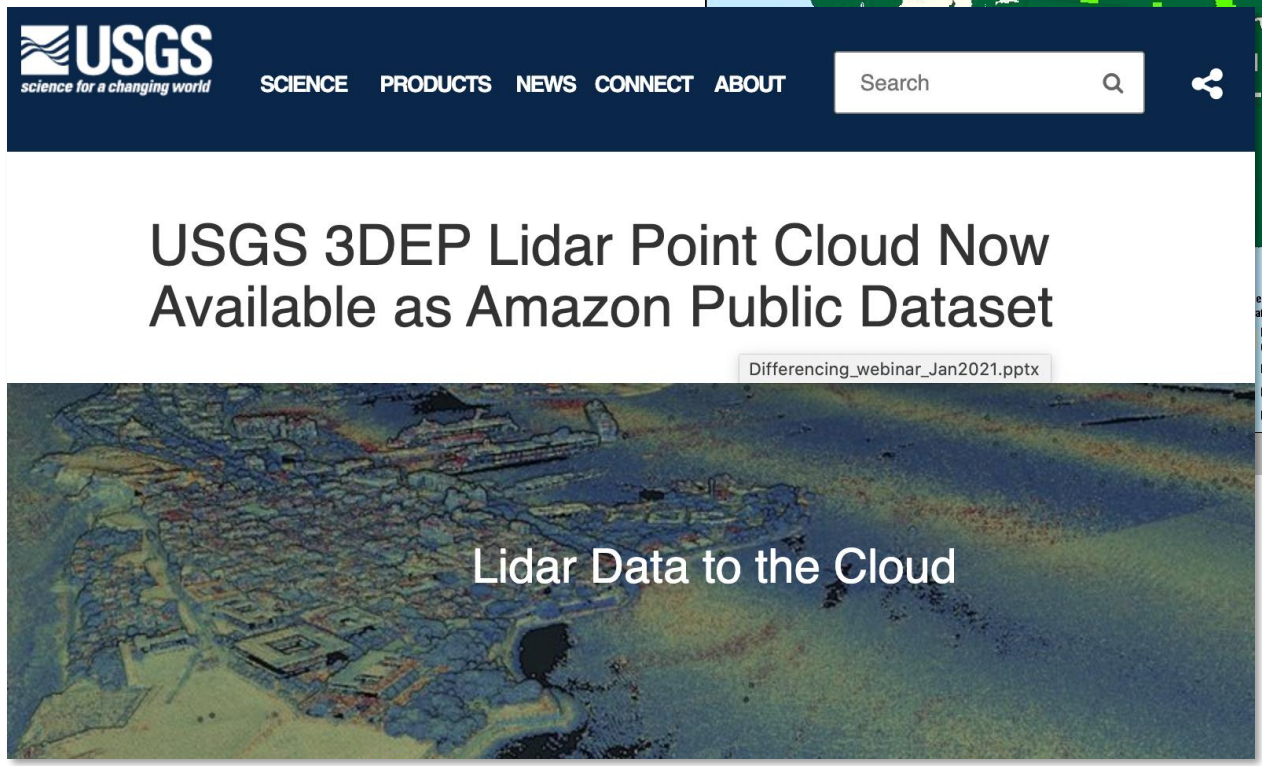
# USGS 3DEP IN OPENTOPOGRAPHY

- Leverage 3DEP in the cloud to offer OT users seamless access.
- Easy discovery & derivative products
- OT current functionality = 3DEP value added service
- Increase impact of investment in data



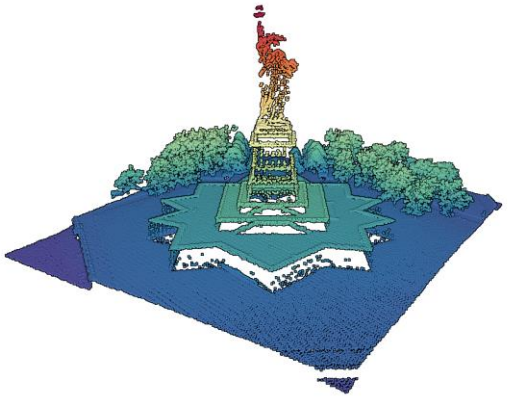

amazon S3

LAZ
Requestor Pays Bucket

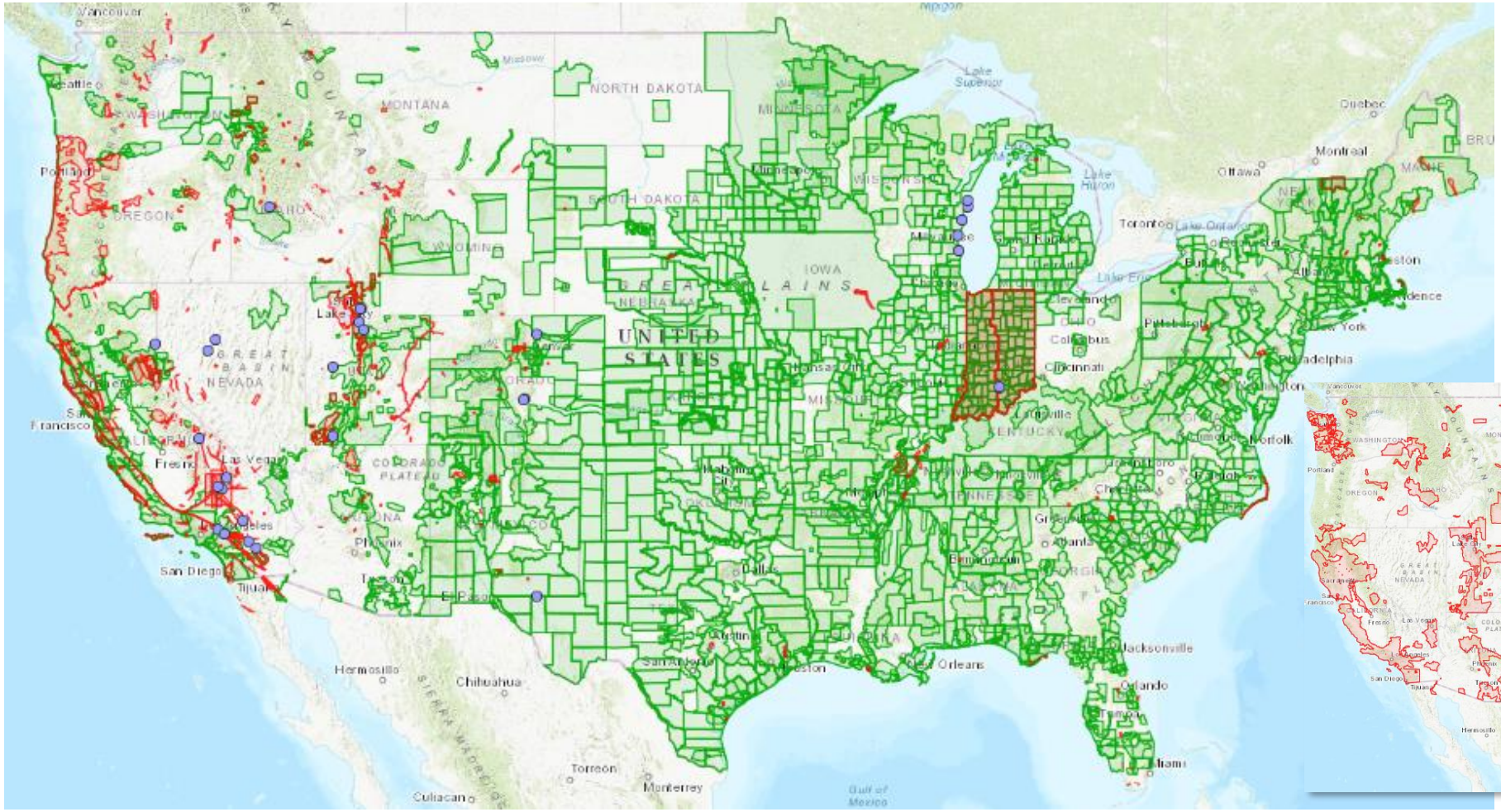
entwine
AWS Public Dataset
hobu

OpenTopography

# USGS 3DEP IN OPENTOPOGRAPHY

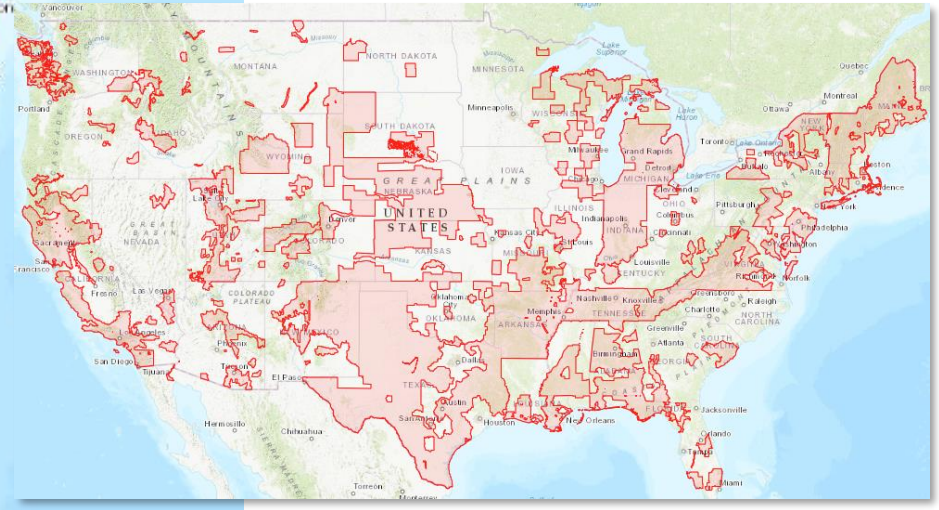


1,588 USGS 3DEP datasets currently available
31 trillion lidar returns covering 5.8 million km$^2$



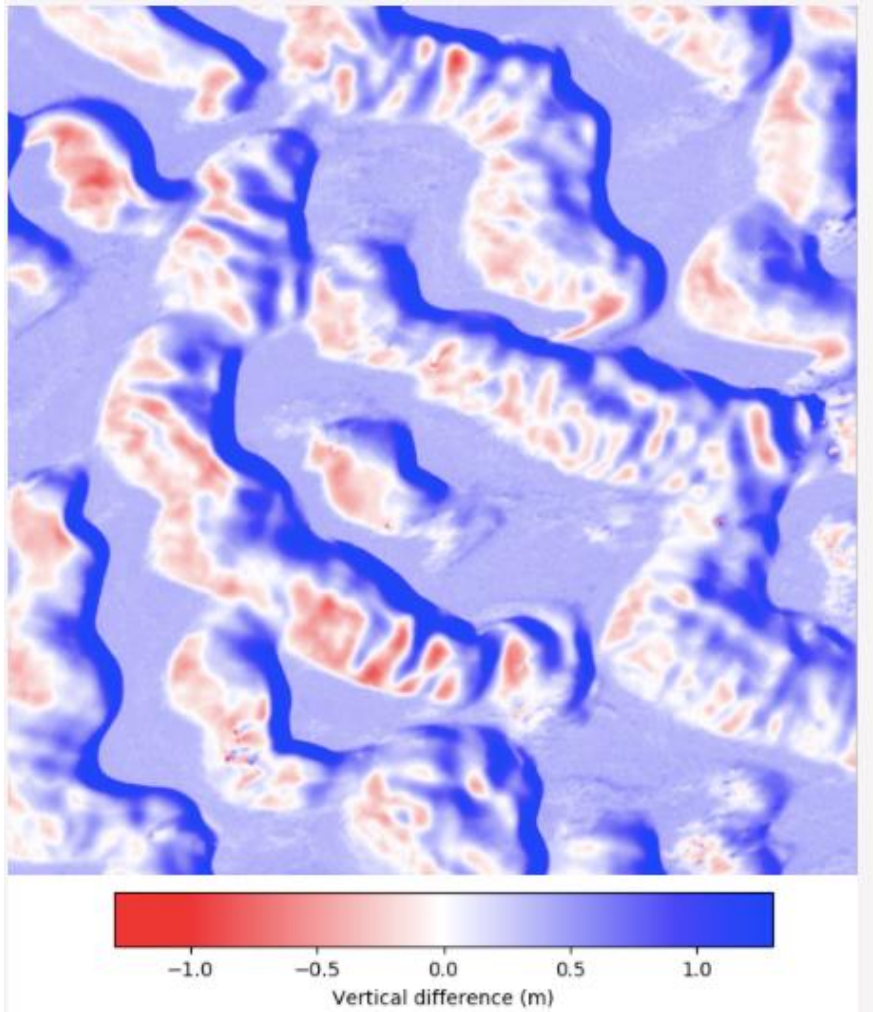

***Just added! 3DEP raster datasets:***

- ***1 m***
- ***10 m***
- ***30 m***

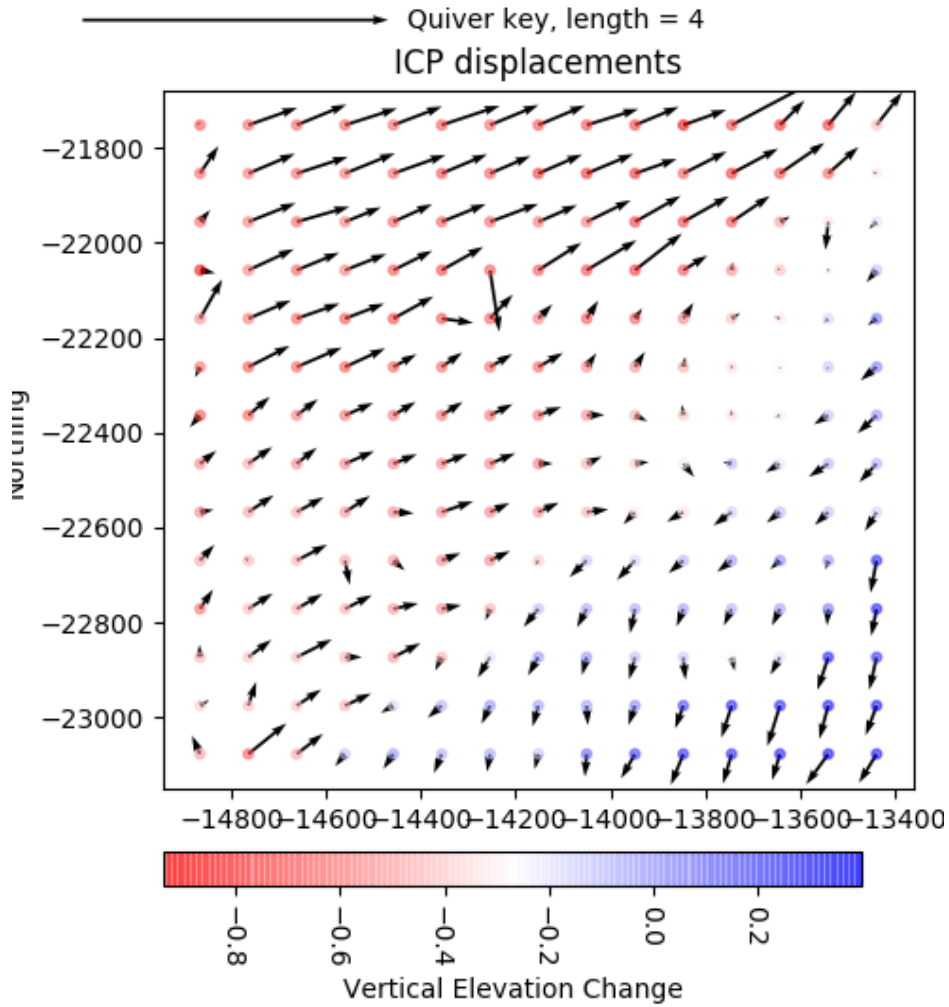


# Topographic Differencing

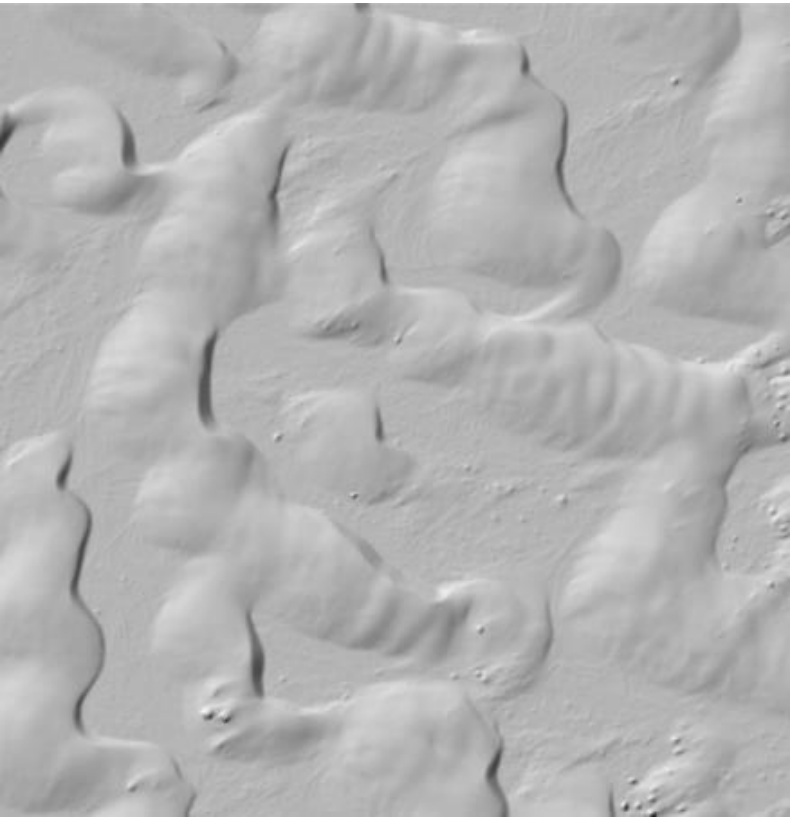
**Vertical Differencing:**
Sand dune migration, NM



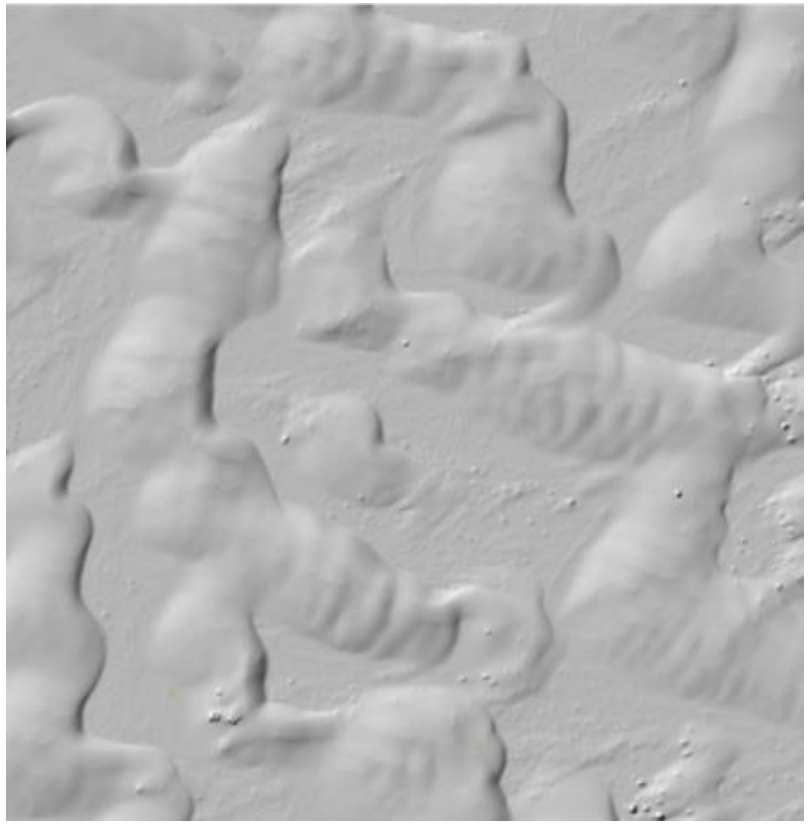

**3D differencing:**
Earthquake, Japan



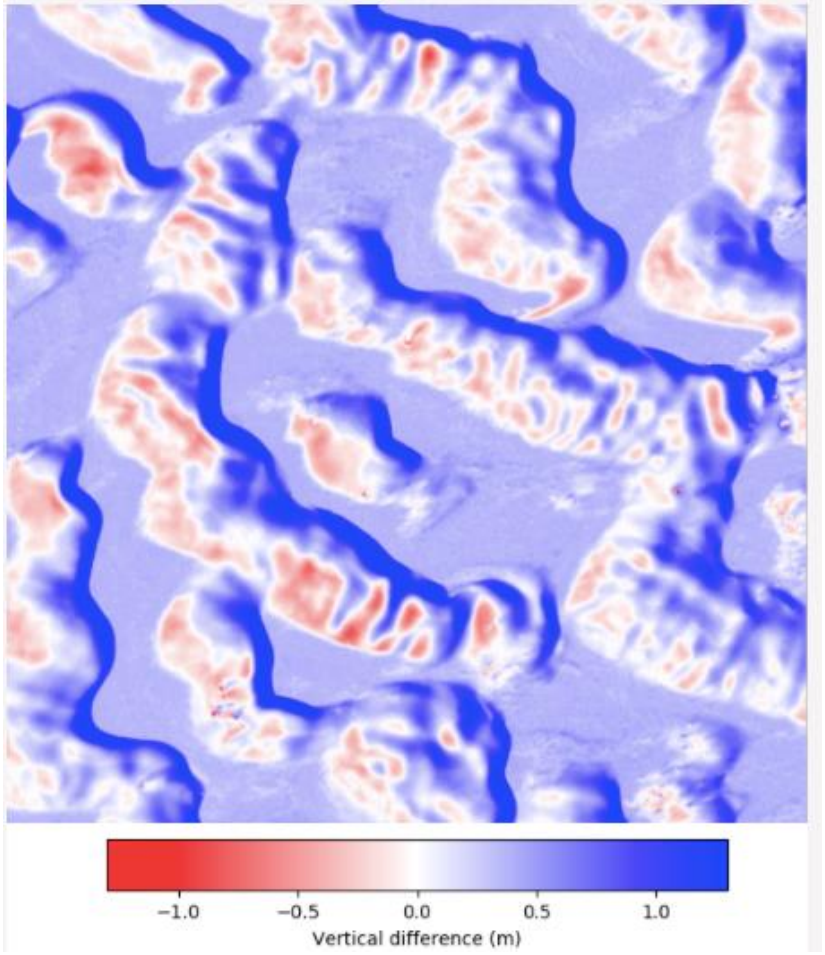
# Vertical Differencing: Sand Dune Migration, White Sands National Monument, New Mexico



Compare: 1st dataset
Sept 2009



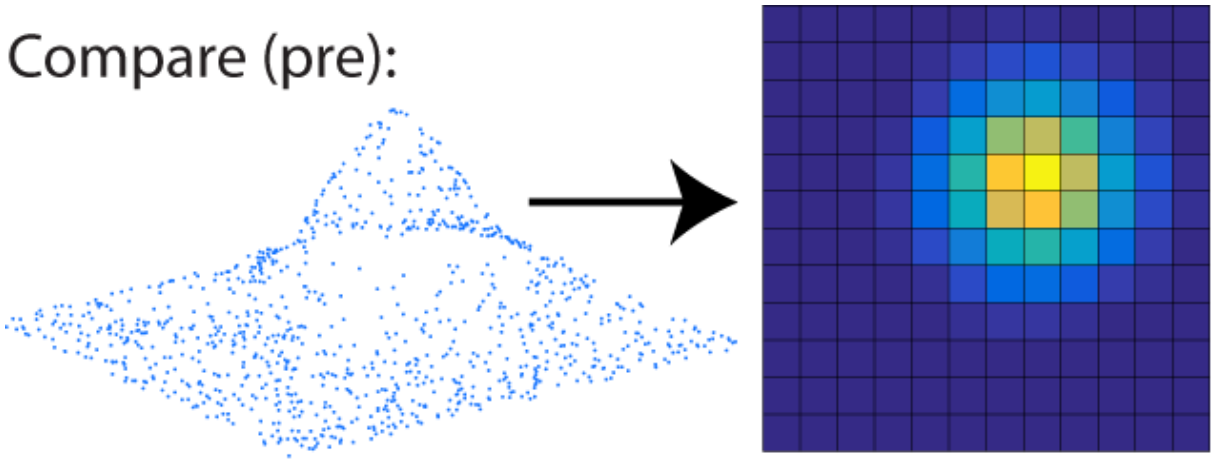
Reference: 2nd dataset
June 2010



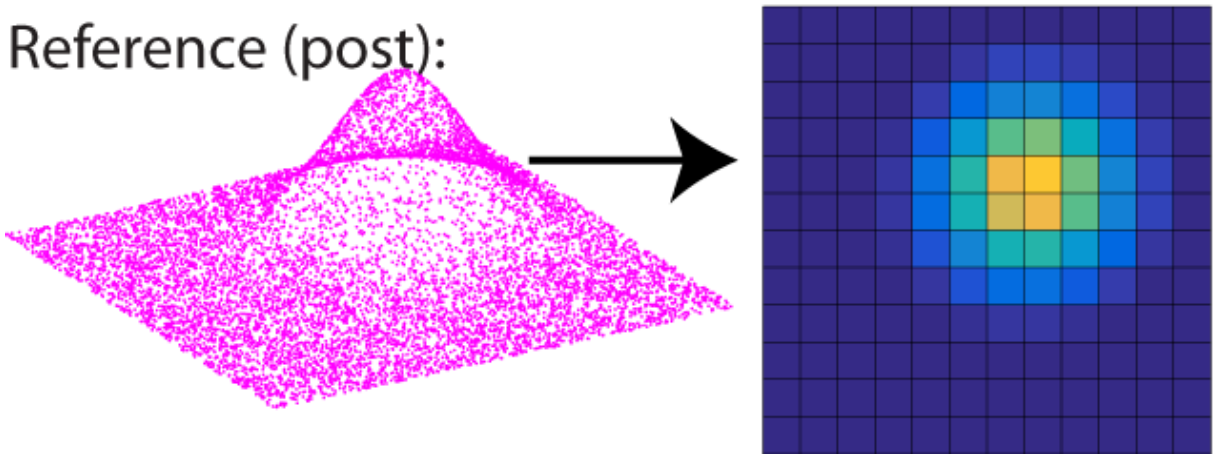

Vertical difference

# VERTICAL TOPOGRAPHIC DIFFERENCING

Compare (pre):



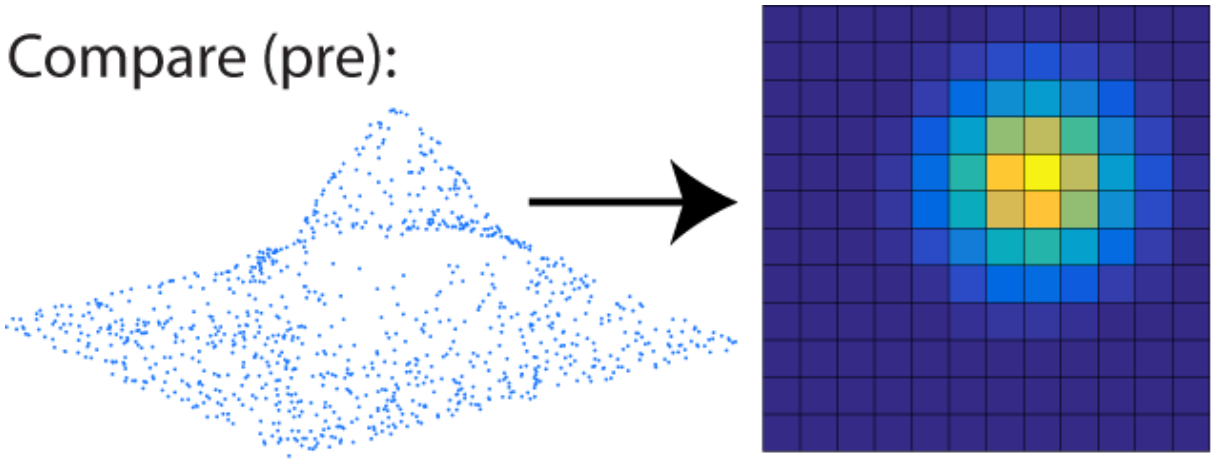
Reference (post):



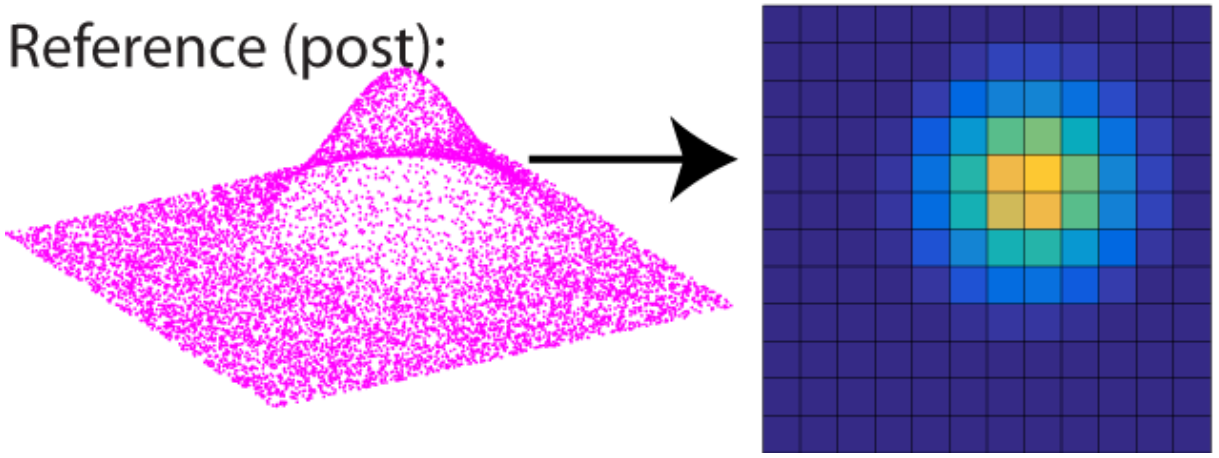
*Identical grid for pre and post event topography*

# VERTICAL TOPOGRAPHIC DIFFERENCING

Compare (pre):



Reference (post):

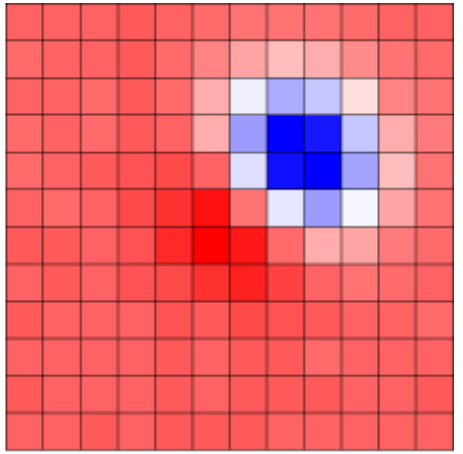


Subtraction:

Difference

= Reference-Compare

Down Up



*Raster subtraction*

# INDIANA STATE-WIDE TOPOGRAPHIC DIFFERENCING

*Why Indiana?*

- Repeat coverage (2011-13 and 2016-20) = ~decadal change
- Early OT partnership with IGIC

*Challenges:*

- Indiana is 36,000 miles$^2$: Differencing must be **automatic**
- Manage big data: Final products are **4 TB**; Intermediate products are much bigger
- **1 year of compute time** on average server
- Some empty datasets in AWS; Naming conventions change
- Coordinate system reference system choice

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## ACCESS DATA

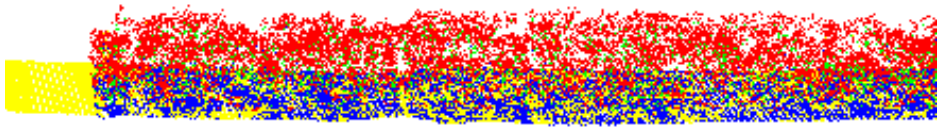
SDSC

USGS science for a changing world

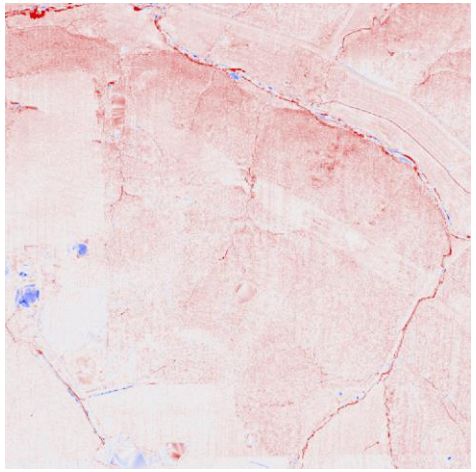
amazon web services™ S3

entwine

## POINT CLOUDS

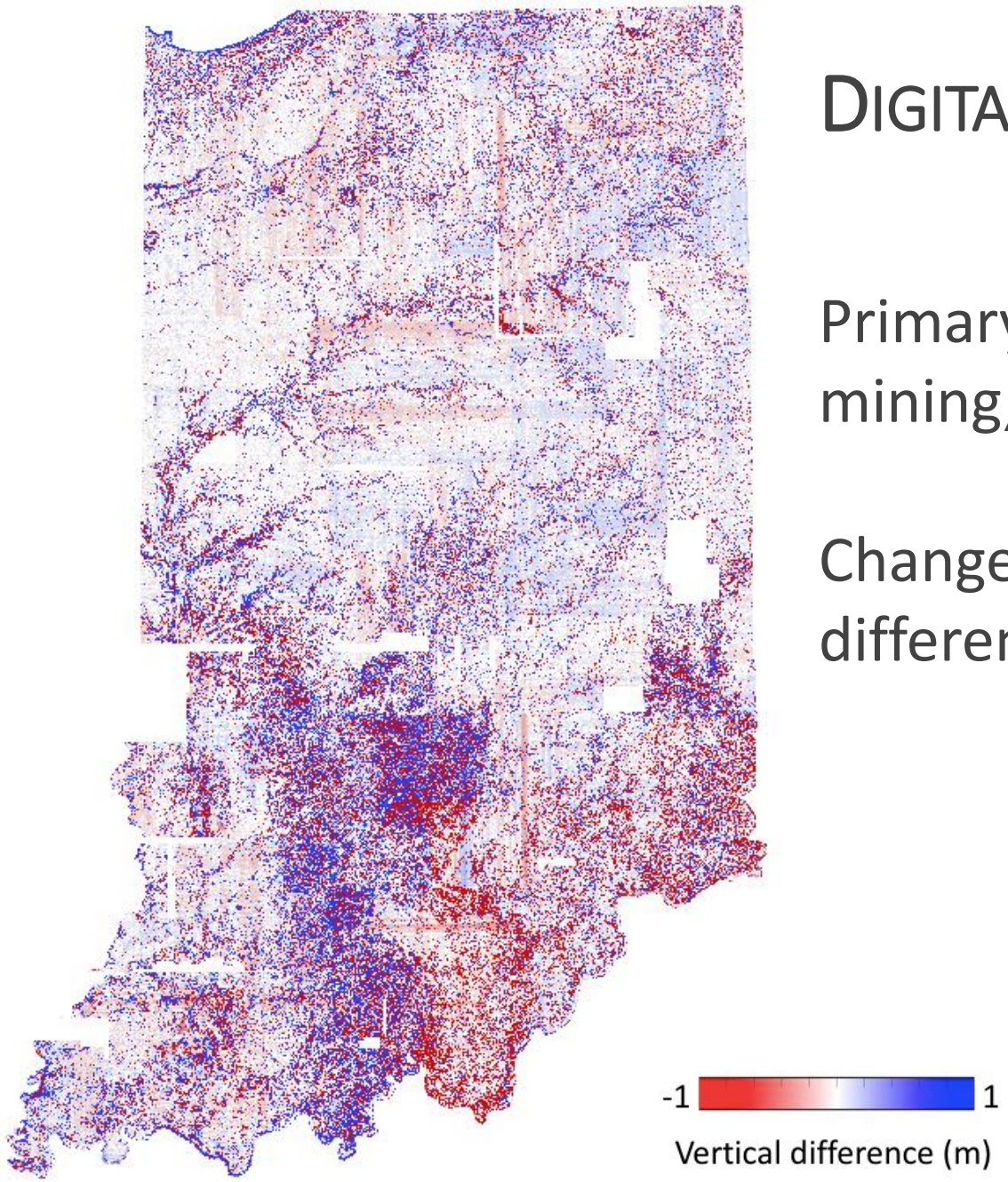


GENERATE DEM



TOPOGRAPHIC DIFFERENCING

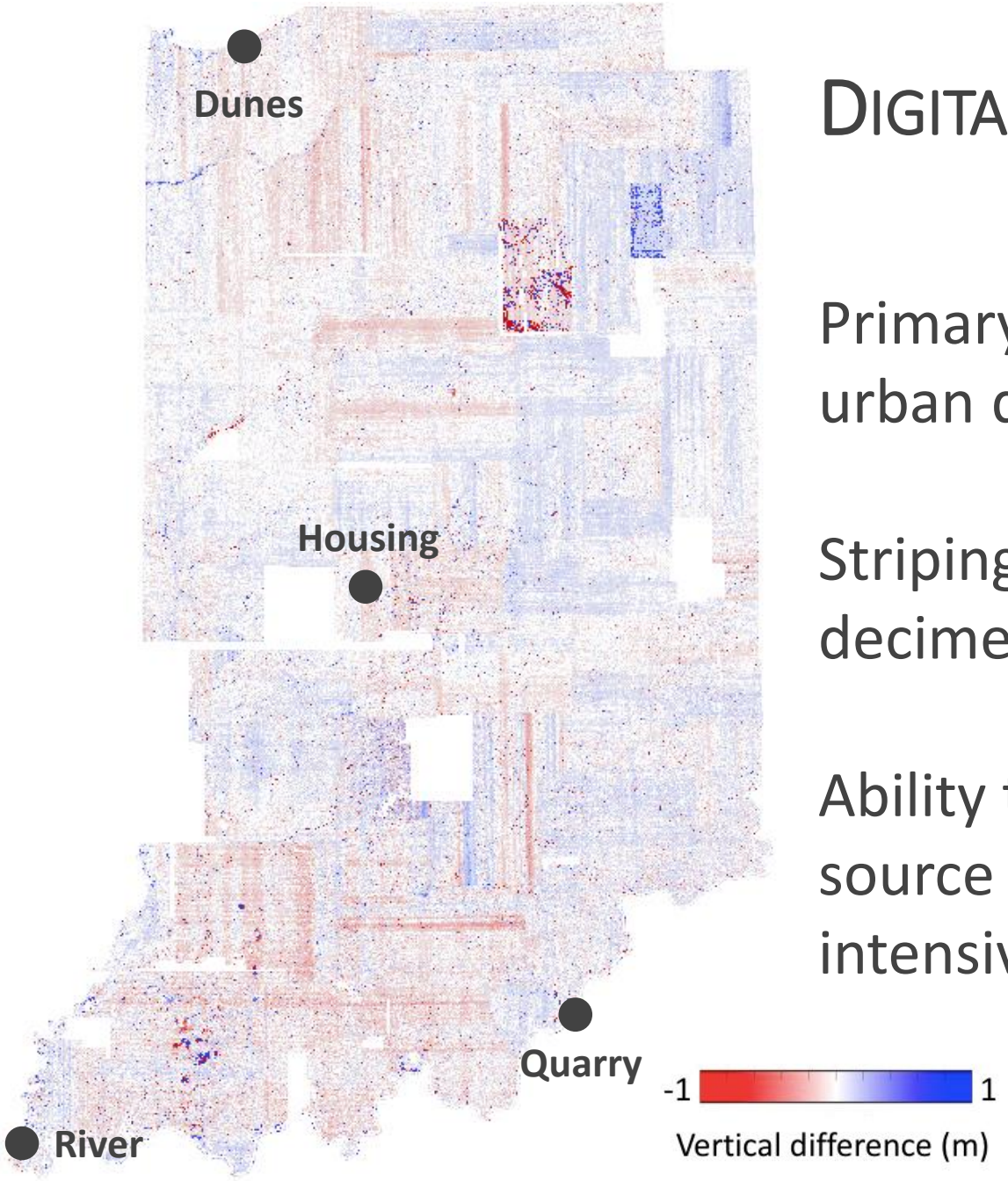
Challenge: 36,000 sq. miles of data to process




# Digital Surface Model Differencing

Primary change from agriculture, rivers, quarries, mining, and urban development

Changes in vegetation due to seasonal differences in when the data were acquired



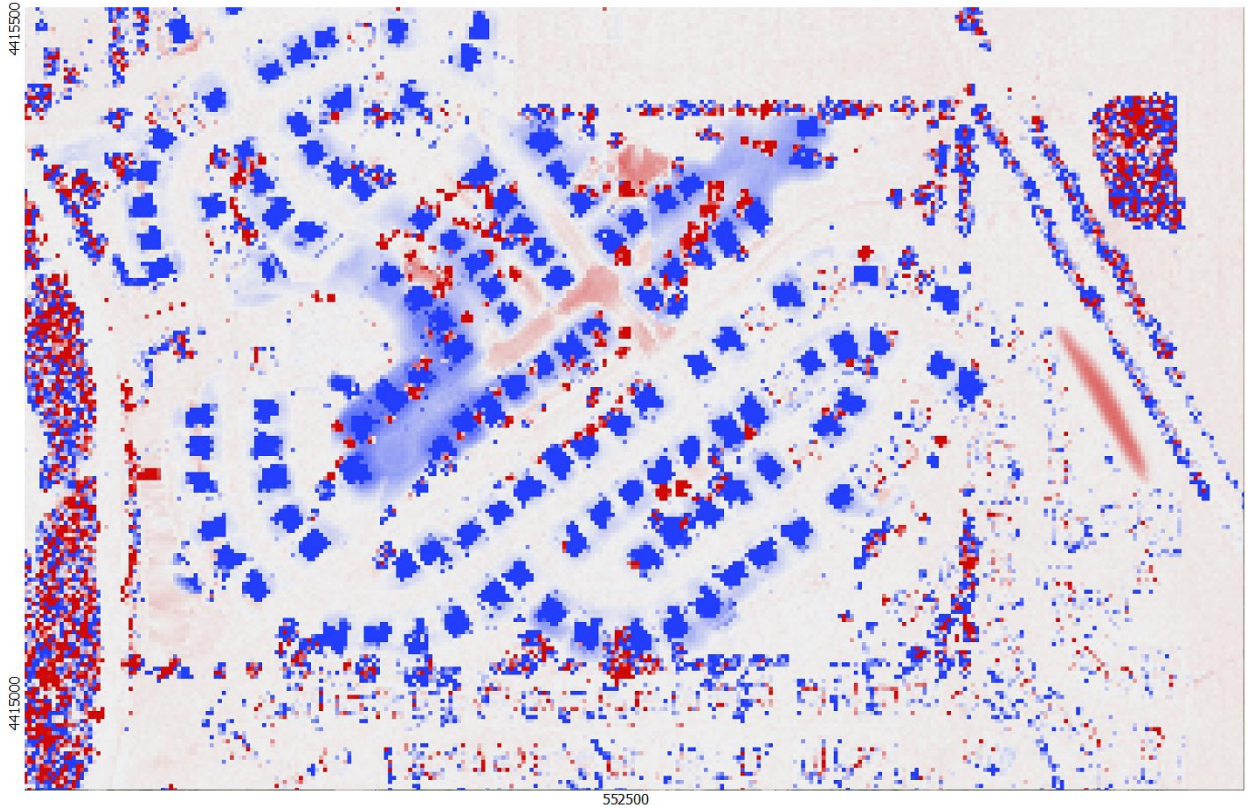

# Digital Terrain Model Differencing

Primary change from rivers, quarries, mining, and urban development

Striping reflects flight-line offset errors of several decimeters in many locations.

Ability to detect change is only as good as the source data. Swath re-alignment is labor intensive but could greatly reduce errors.

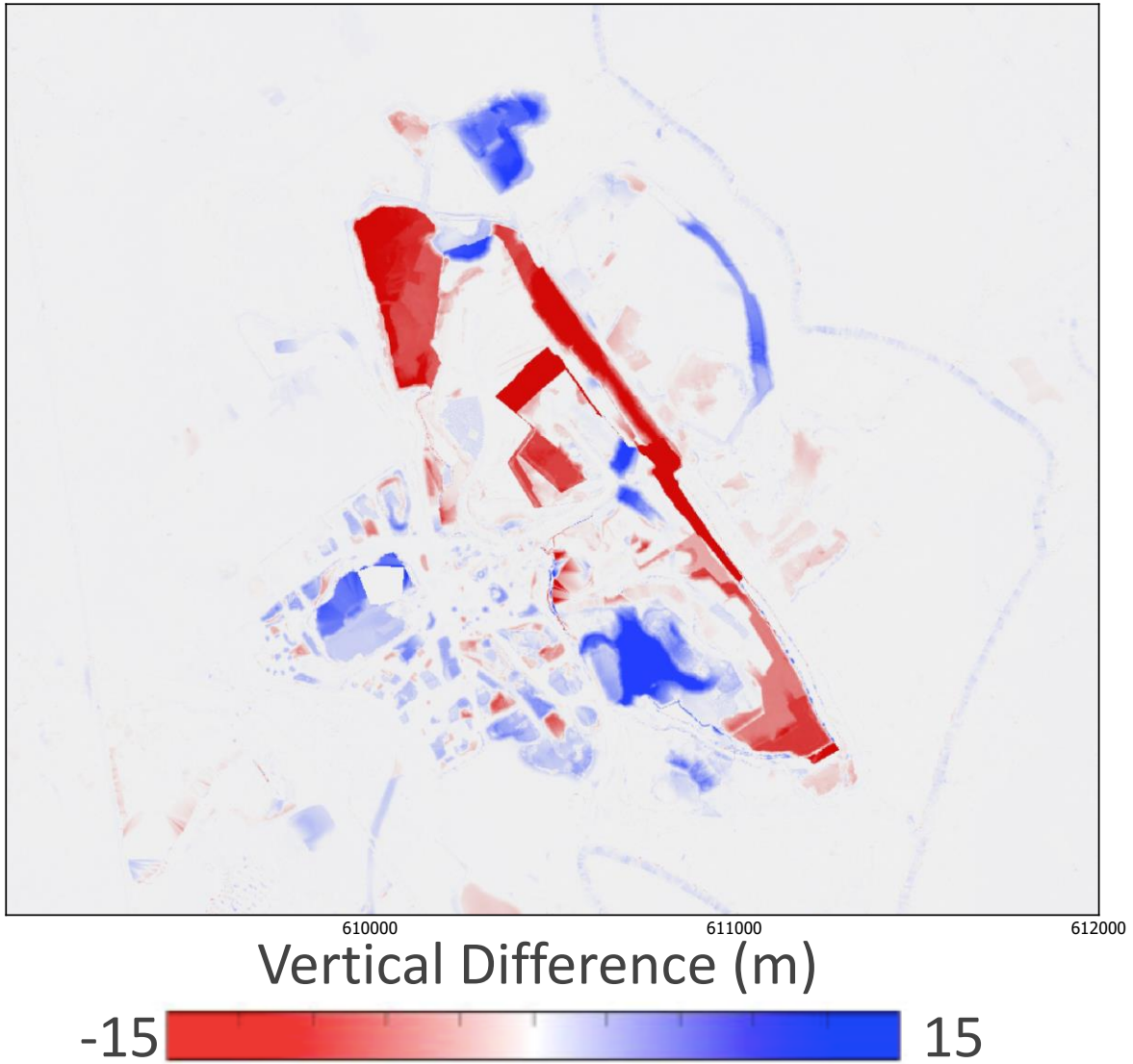
# HOUSING CONSTRUCTION NEAR INDIANAPOLIS



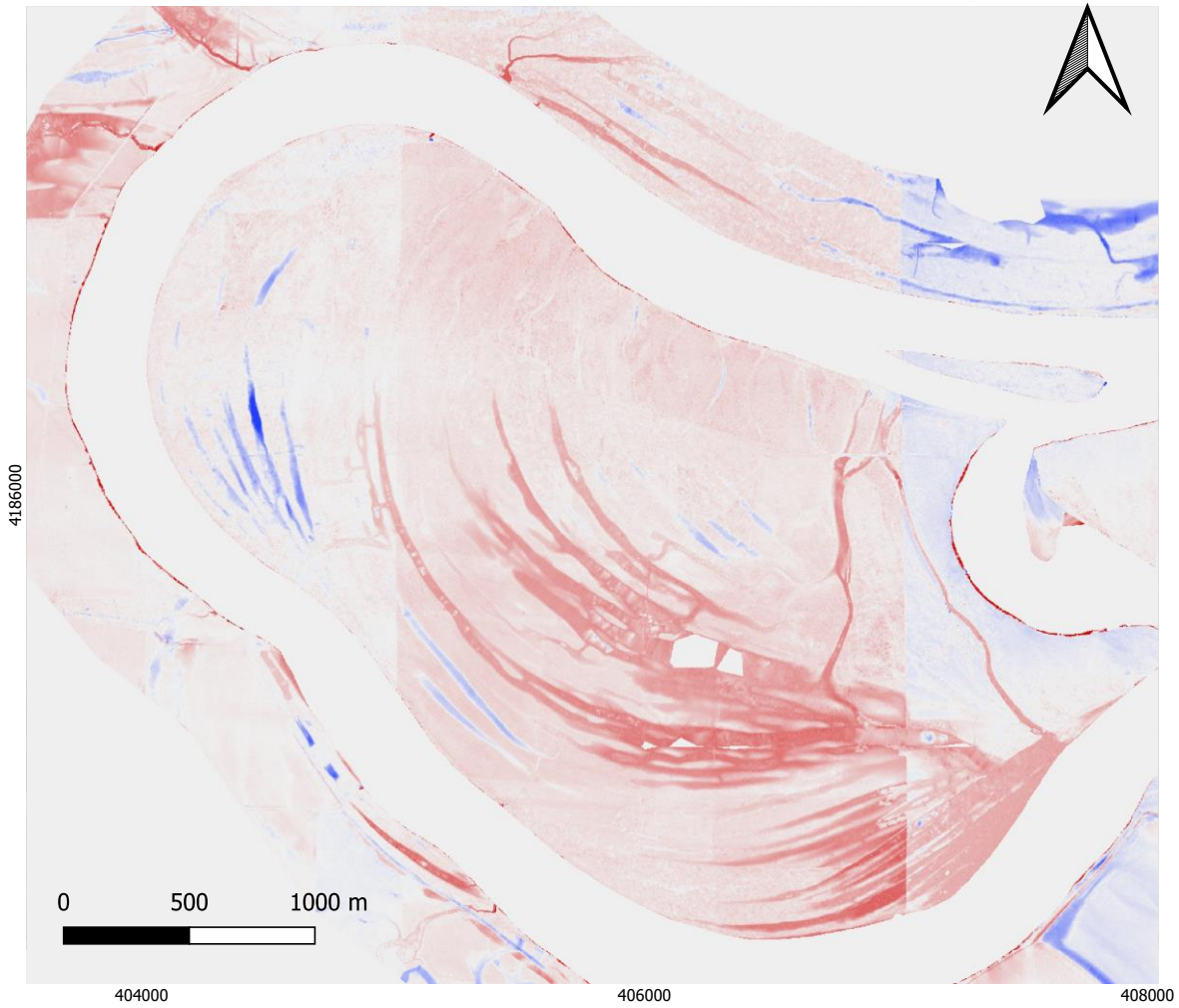

Vertical Difference (m)

-3 3

# Limestone Quarry near Louisville



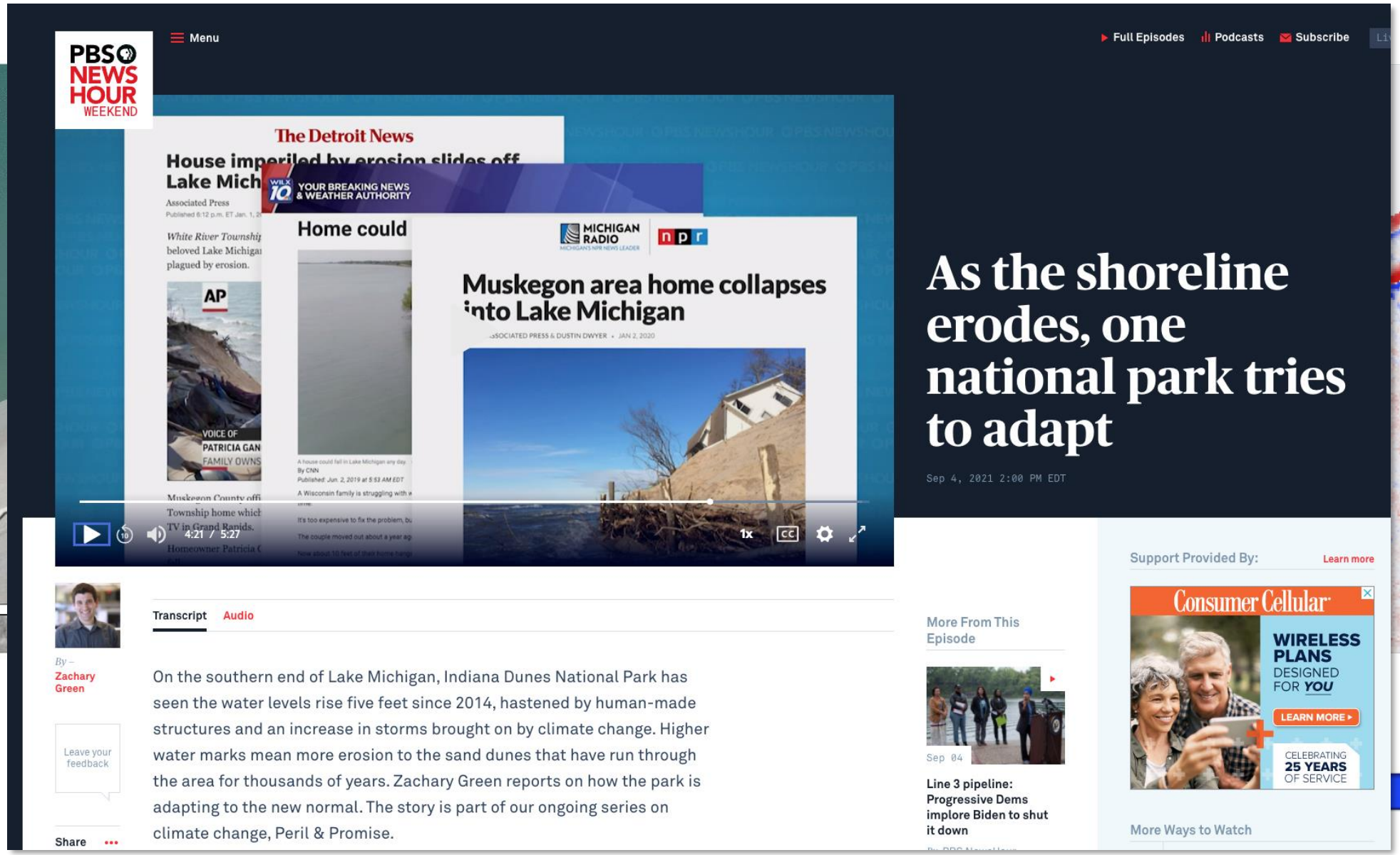
# Wabash River

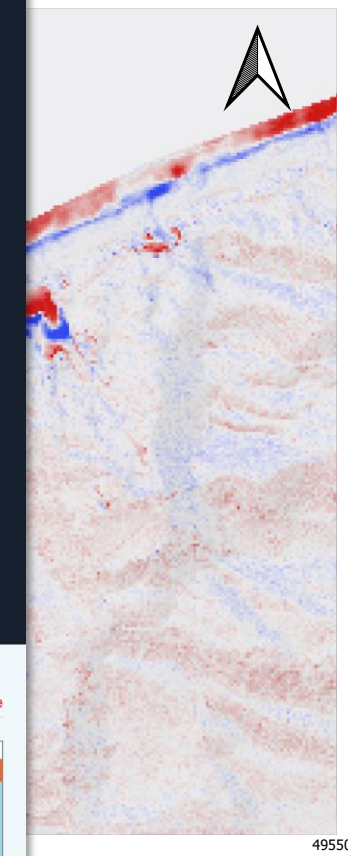



Vertical Difference (m)

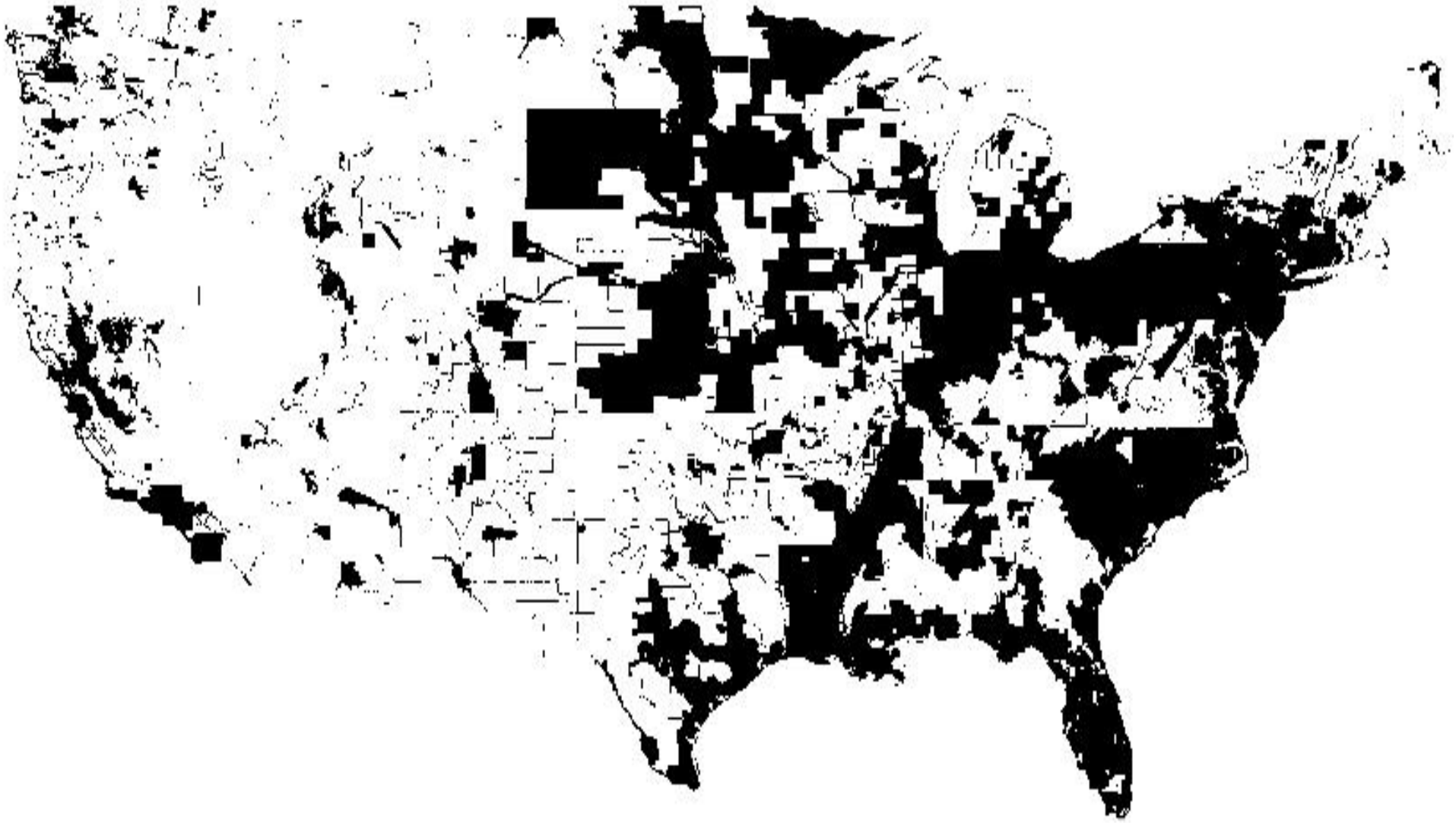
-2 2

# Indiana Dunes National Park along Lake Michigan



# WHERE ELSE IS THERE REPEAT LIDAR?



Black:
Areas of overlapping datasets within 3DEP and/or USIEI.

Differencing possible over at least one-third of lower 48.

# TAKE HOMES:

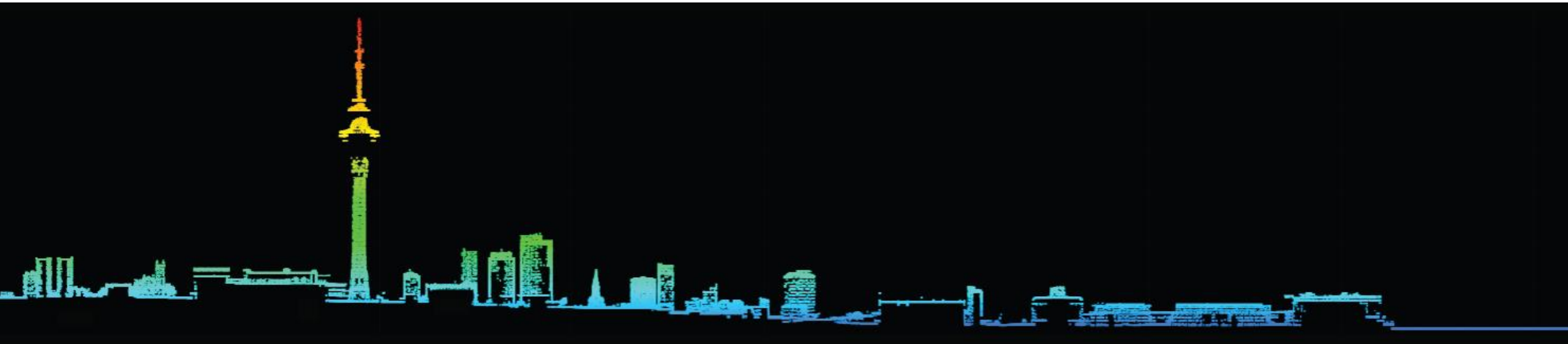
Demonstration of topographic differencing at scale

- Automated workflow that leverage remote data resources
- Approach will become increasingly feasible as multi-temporal high resolution topography becomes available

Seeking partnerships to facilitate access to state and regional/local/national scale lidar data via OT.

Differencing is an example of opportunities to leverage OT to enhance impact of these data, and improve ROI.

**Goal**: build a consortium around OT as a shared platform for data management and distribution.



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Thank you!

*Questions? Want to talk about making data available in OT?*

***info@opentopography.org***

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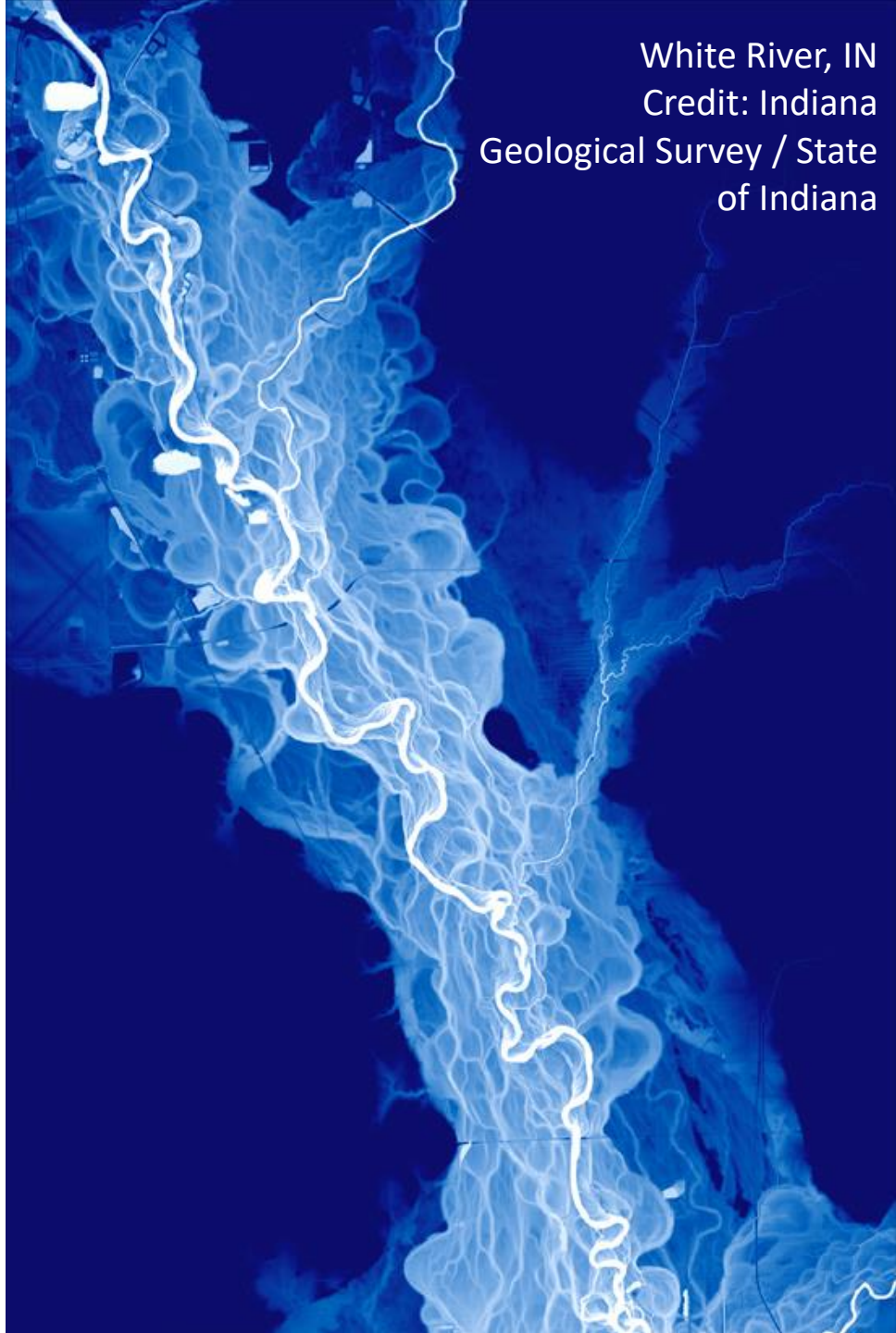
Facebook.com/OpenTopography

@OpenTopography

*OpenTopography is supported by the National Science Foundation under Award Numbers 1948997, 1948994 & 1948857*



White River, IN
Credit: Indiana Geological Survey / State of Indiana

I ♥ LIDAR
WWW.OPENTOPOGRAPHY.ORG

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# COMMUNITY DATASPACE

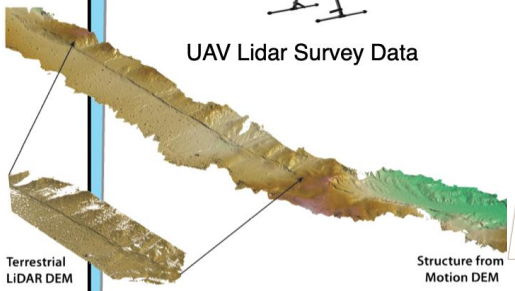
HEAD

NCALM NSF NASA USGS science for a changing world

Partnerships
MOUs
Service Agreements

LONG TAIL

UAV Lidar Survey Data




opentopography.org/data

DATA.GOV Google Dataset Search

**Data Discovery & Access**
Data access via OT portal and partner gateways.

**Data Analytics**
Access to detailed statistics on data usage

**CSW Catalog**
**schema.org**
ISO 19139 metadata
Catalog federation

**Data Registration**
Data stored in the cloud
Persistence Identifiers
Update Catalogs, etc

EZID
Long-term identifiers made easy

EZID DOI service via California Digital Library

Low Cost Storage Cloud (Qumulo)

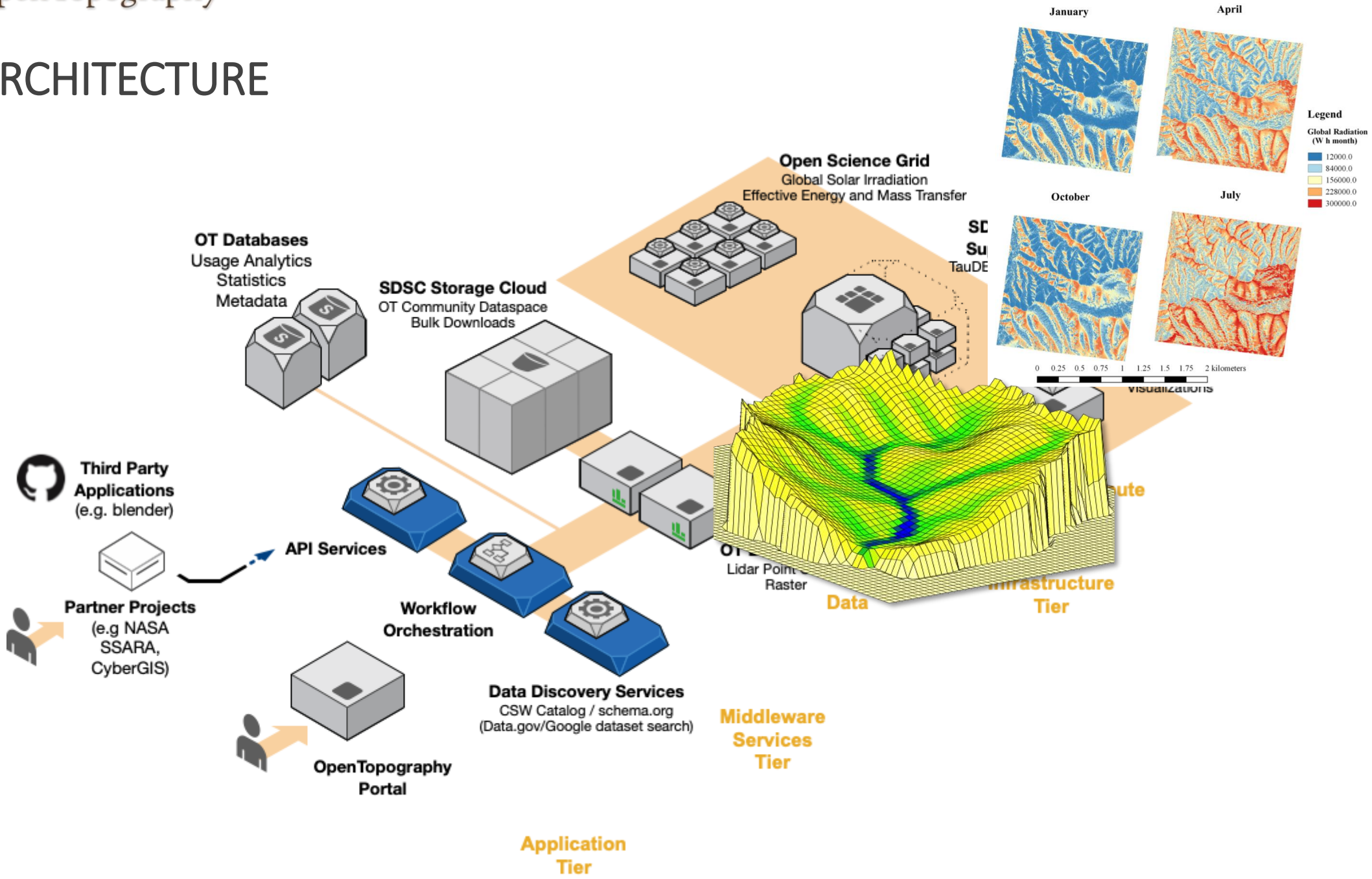
S3

**Data Upload**
Researchers upload data to OT Portal (e.g. LAS)

**Data Validation**
Data verification, metadata complaince and validation (open source tools, e.g. PDAL)

COMMUNITY DATASPACE

# ARCHITECTURE



OpenTopography

# API / Bulk Access

OpenT

/apidocs/openapi.json

**Public**

GET /globaldem Access glo (Global Ba COP90 an

Parameters

| Name | Description |
|---|---|
| **demtype** * required<br>string<br>*(query)* | Available global r<br>• SRTMGL3 (S<br>• SRTMGL1 (S<br>• SRTMGL1_E<br>• AW3D30 (A<br>• AW3D30_E<br>• SRTM15Plu<br>• NASADEM (<br>• COP30 (Cop<br>• COP90 (Cop<br>* require API key<br>SRTMGL3 |
| **south** * required<br>number<br>*(query)* | WGS 84 boundin<br>36.738884 |
| **north** * required<br>number | WGS 84 boundin |

STAC Index Catalogs Collection Search Ecosystem + Contact Privacy Po

OpenTopography / Clearwater NF, ID: Effects of Watershed Restoration on Hillslope Stability

## Clearwater NF, ID: Effects of Watershed Restoration on Hillslope Stability (OT.012012.26911.1)

https://portal.opentopography.org/stac/ID09_Lloyd_catalog.json

NCALM Seed Project PI: Rebecca Lloyd, University of Arizona. The survey area is two experimental watersheds, Shotgun Creek and Twin Creek located in the Clearwater National Forest of Northern Idaho. These areas are roughly 70 km southwest of Missoula, MT. The survey polygon for Shotgun Creek is approximately 15.8 square kilometers and for Twin Creek is 26.34 square kilometers. The data were collected to study the effects of watershed restoration on hillslope stability and ecohydrological functions.

Collections | Catalogs | Items | Links

| Title |
|---|
| https://portal.opentopography.org/stac/ID09_Lloyd/pc_catalog.json |
| https://portal.opentopography.org/stac/ID09_Lloyd/raster_catalog.json |

**METADATA**

| | |
|---|---|
| STAC Version | 1.0.0-beta.2 |
| Keywords | lidar |
| License | Not-Provided |
| Temporal Extent | 8/30/2009, 5:00:00 PM - 8/30/2009, 5:00:00 PM |

**PROVIDERS**

1. OpenTopography (*host*)

odified

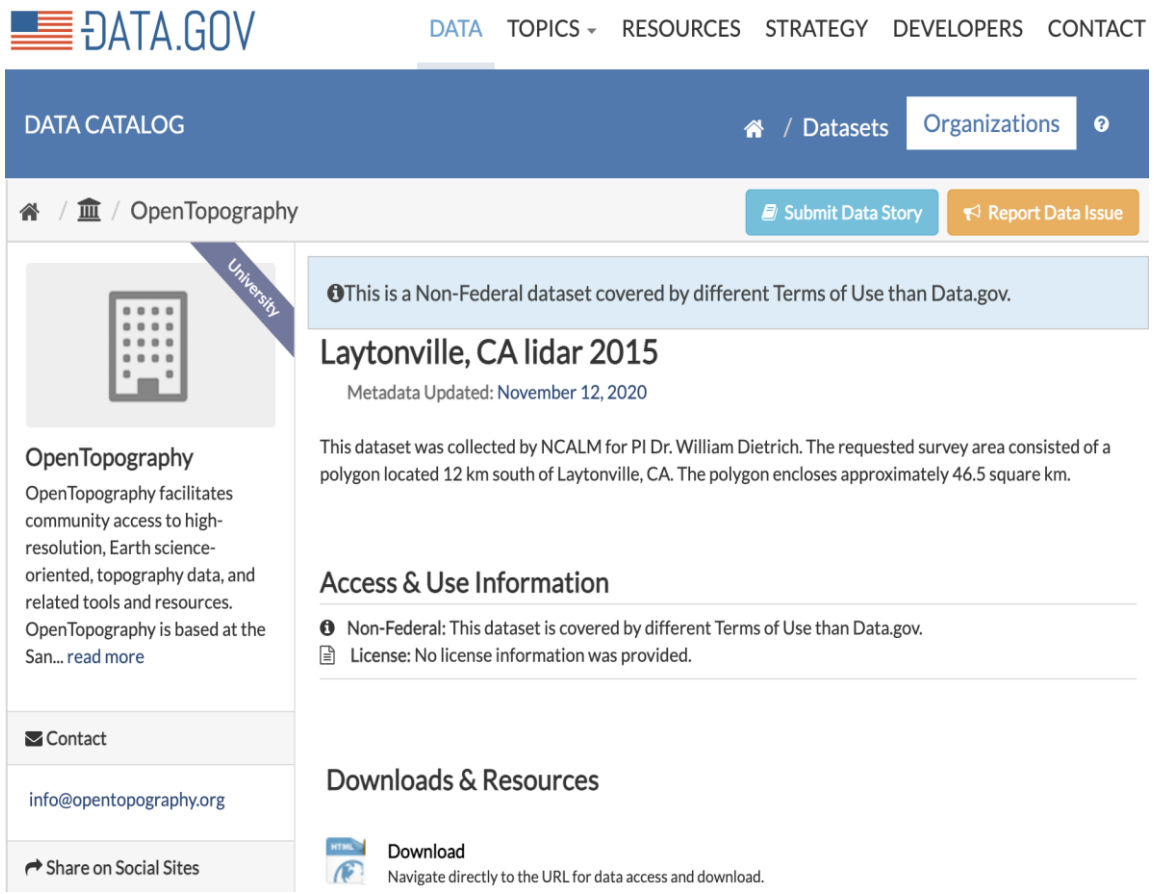
, 2021 3:35 PM
, 2021 3:35 PM
, 2021 3:35 PM
, 2021 3:35 PM
, 2021 3:35 PM
, 2021 3:34 PM

Cloud
G)

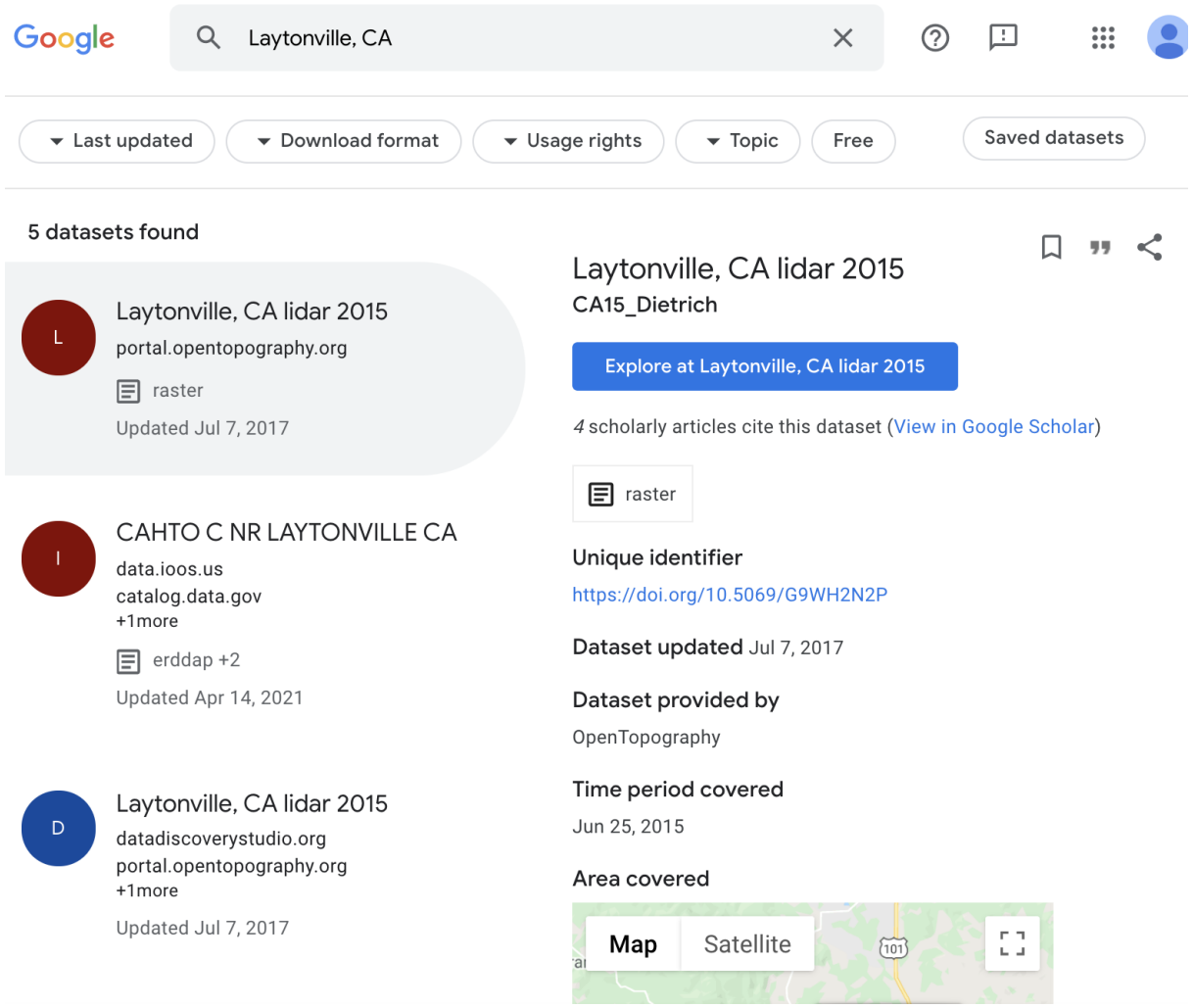
https://stacindex.org/catalogs/opentopography#

# Data Discovery and Federation

## OGC CSW catalog

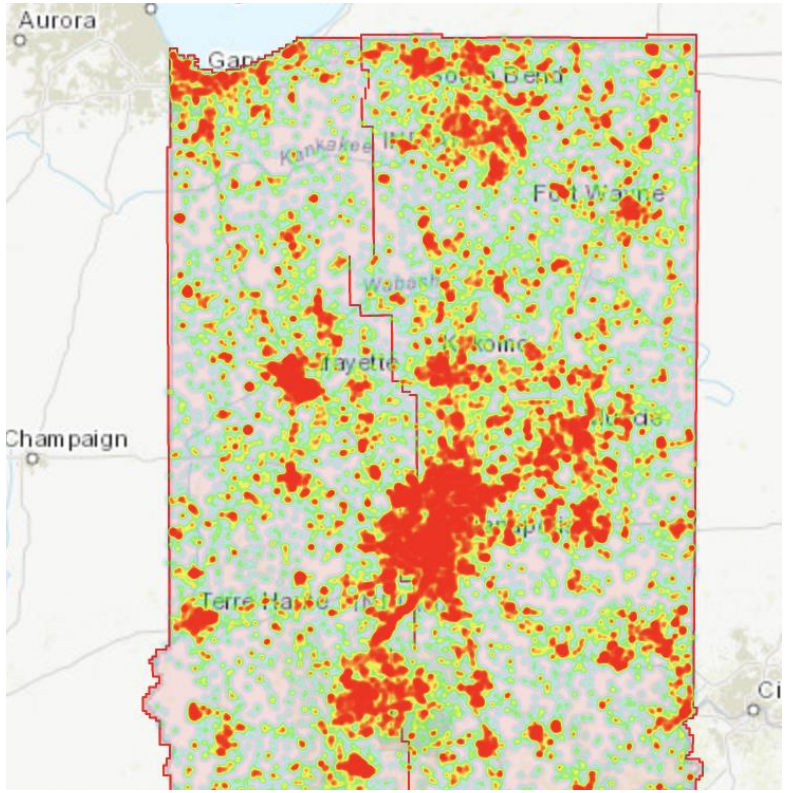



## Schema.org

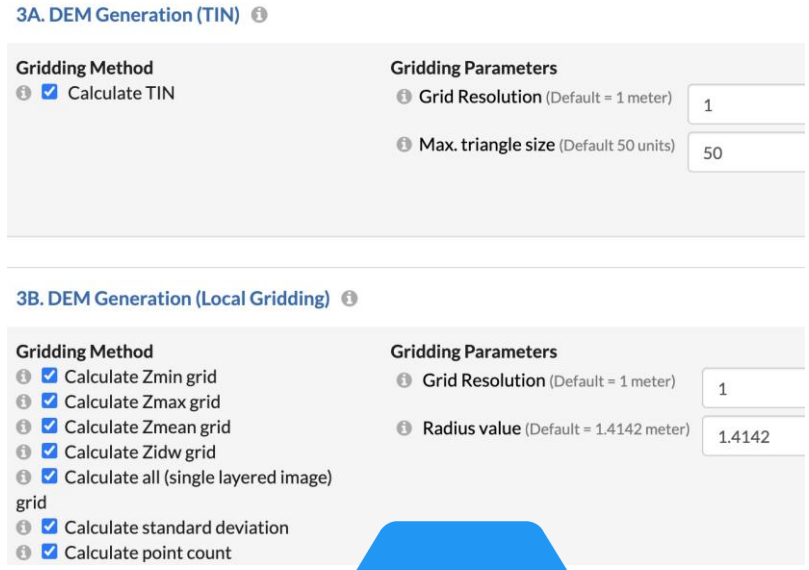


# Access Patterns

## Indiana Usage



Storage based on data value



Pre-computed superset products
Recommendation systems

aws
spot instances

OpenTopography

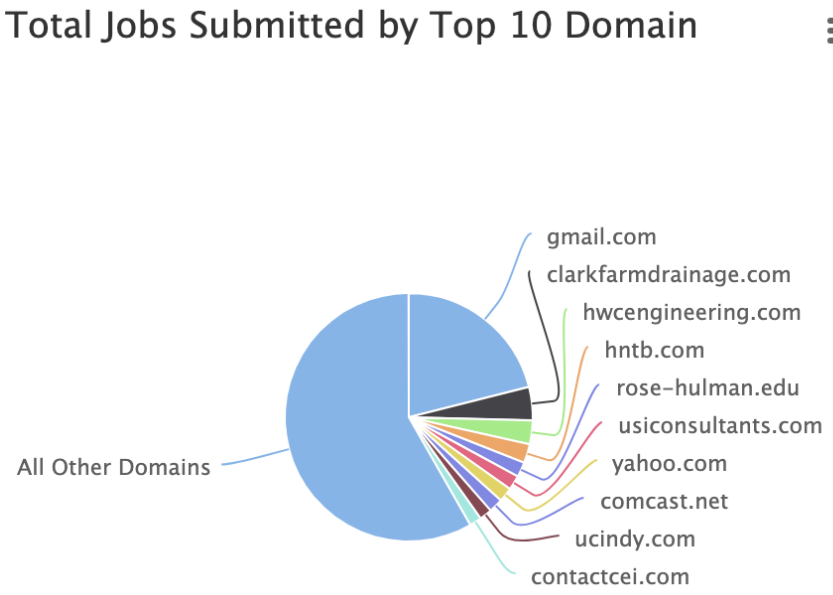
# Data Provider Dashboards

| | Dataset | No. of jobs ↓ | Total points processed | No. of unique users |
|---|---|---|---|---|
| 1 | 2011 - 2013 Indiana Statewide Lidar | 39,941 | 448,728,874,172 | 5,393 |

## C. Point Cloud Jobs Statistics by User Domain Addresses

Expand to Top 100 Domains

| | OT User Domain | # of Jobs ↓ |
|---|---|---|
| 1 | gmail.com | 8,417 |
| 2 | clarkfarmdrainage.com | 1,732 |
| 3 | hwcengineering.com | 1,234 |
| 4 | hntb.com | 989 |
| 5 | rose-hulman.edu | 774 |
| 6 | usiconsultants.com | 755 |
| 7 | yahoo.com | 753 |
| 8 | comcast.net | 733 |
| 9 | ucindy.com | 657 |
| 10 | contactcei.com | 622 |




## D. Average RunTime for Opal Services by Datasets

(*) This statistics only cover the OpenTopography hosted datasets

| | Dataset ↓ | Avg Points per Job | Avg Runtime per Job (second) |
|---|---|---|---|
| 1 | 2011 - 2013 Indiana Statewide Lidar | 11,279,129 | 123 |

# EDUCATION & TRAINING

- Online Resources

- Workforce Development

- In person short courses