OpenTopography: Open Access and Processing of Statewide Lidar Topography

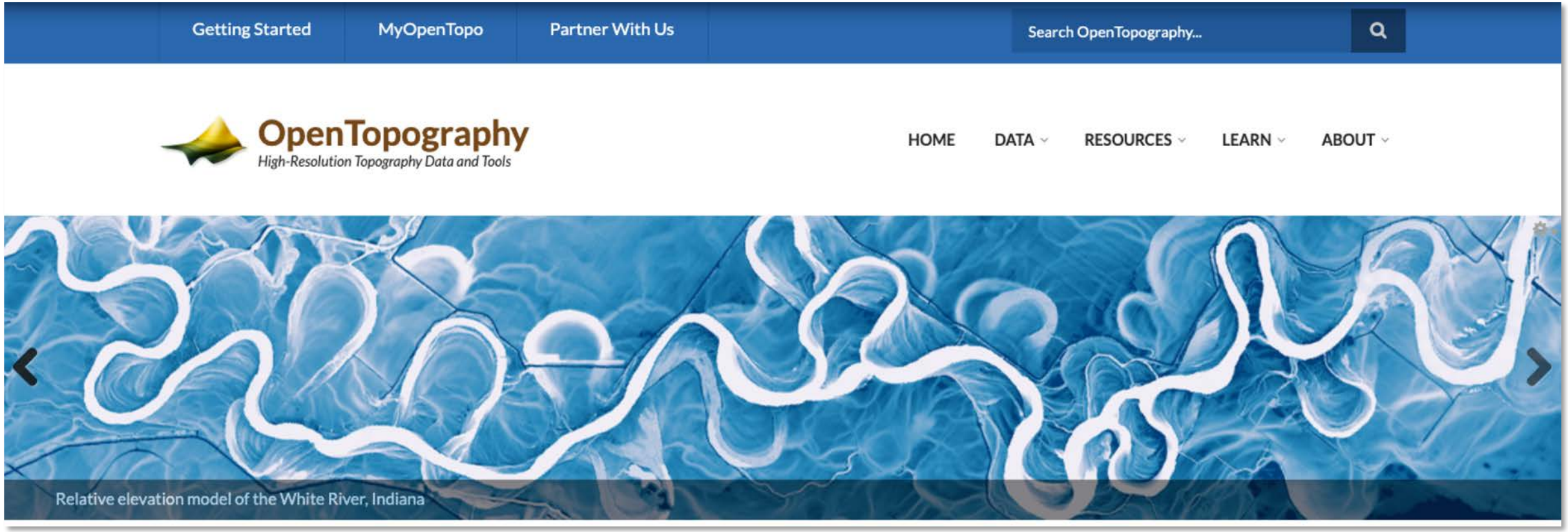
Christopher Crosby, Chelsea Scott, & the OT Team

2022 IGIC Webinar

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

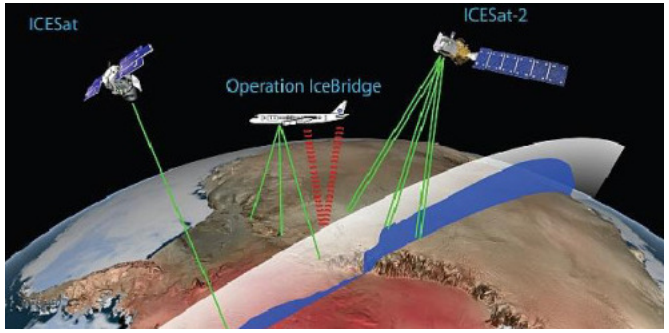
Democratize online access to *high-resolution* topography

- Lidar, photogrammetry, satellite data sources
- Tiered access to data – from raw point cloud to easy to use derived products. Co-location of data & processing tools.



TOPOGRAPHIC DATA COLLECTION PLATFORMS

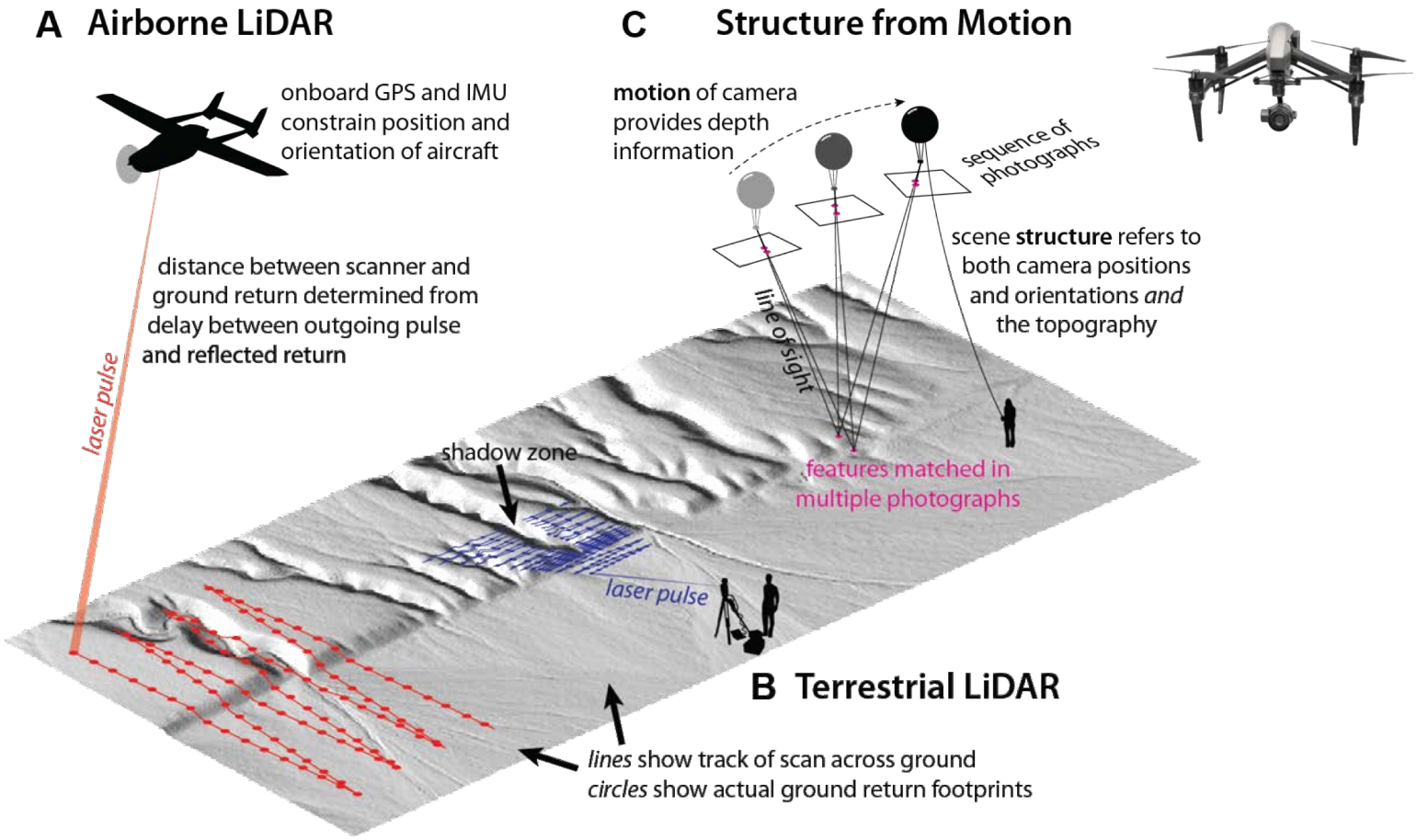
D. Space Based



planet.

MAXAR

Meters to centimeters spatial sampling



Source: Johnson et al., Geosphere, 2014

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
- Looking to expand access beyond US academics

Education and training in use of high resolution topography:

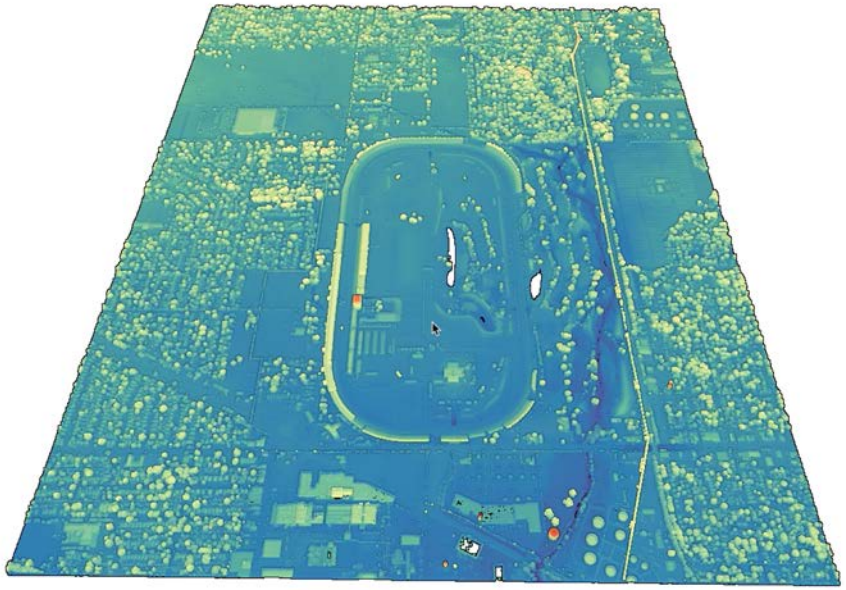
- Online or in-person short courses. Focus on methods and best practices, not specific software.

Past and current partners:

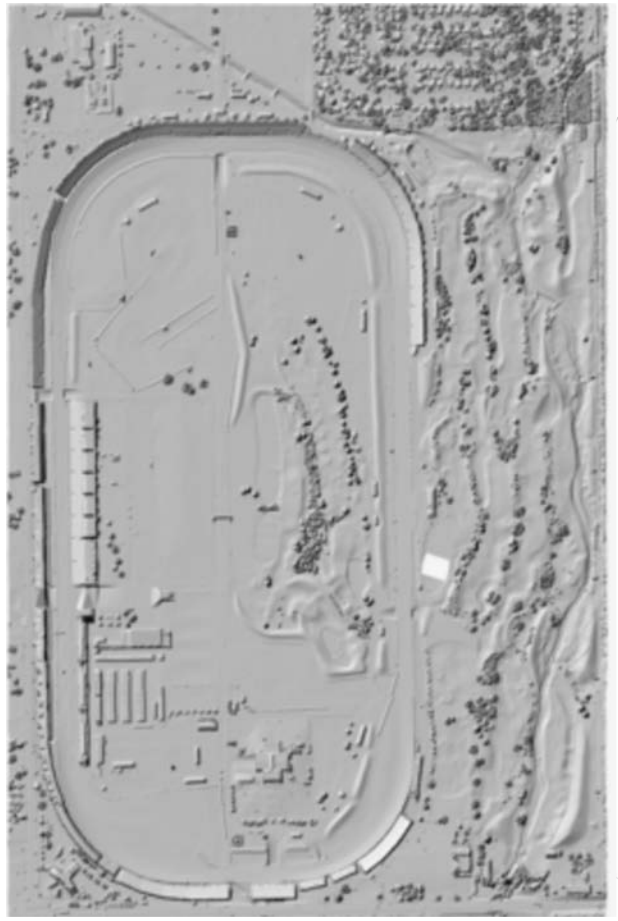
Land Information New Zealand, State of Indiana, State of Utah, California Geological Survey, Yurok Tribe, PG&E, USGS…

TOPOGRAPHIC DATA & DERIVATIVES

Indianapolis Motor Speedway



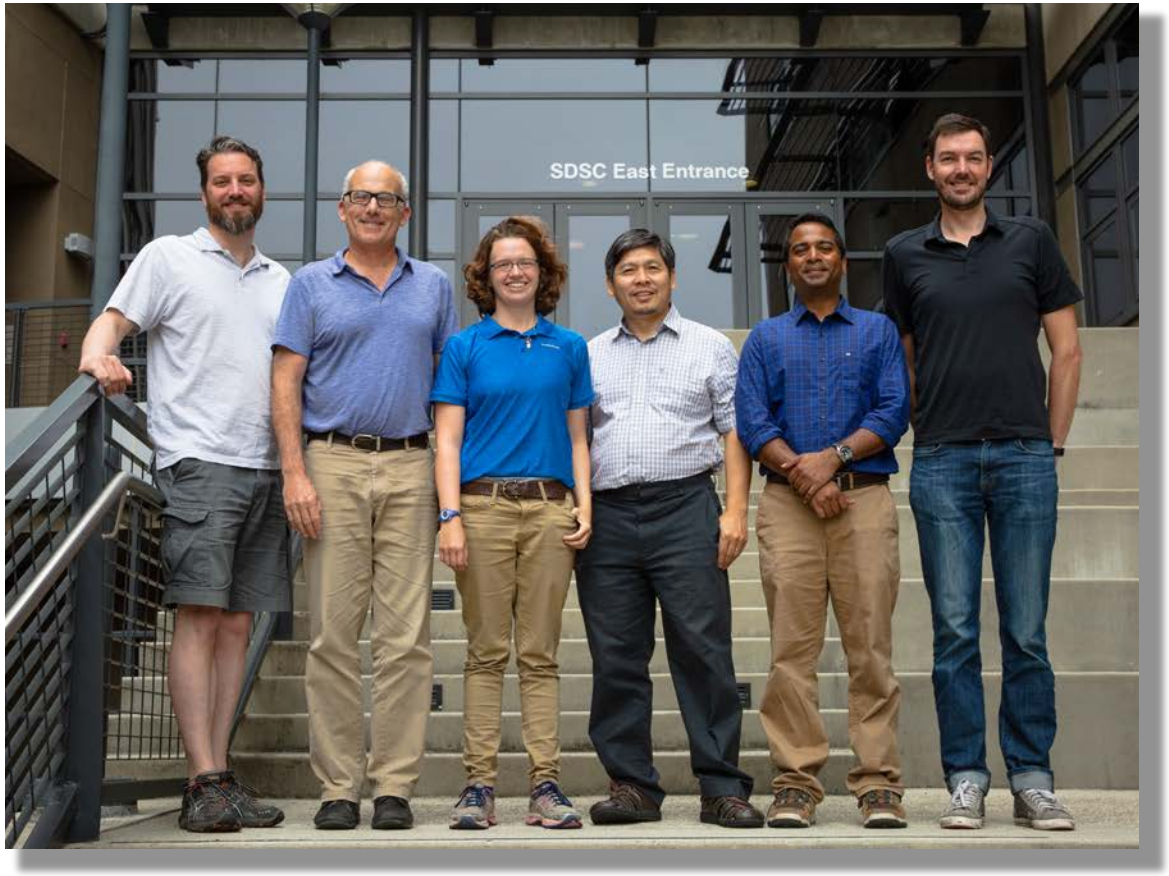
Point cloud *(LAS, LAZ, EPT, COPC)*



Raster: DEMs, hillshade, slope (*GTIFF, IMG, etc.)*

Vector: contours

WHO WE ARE



SDSC
SAN DIEGO SUPERCOMPUTER CENTER

UNAVCO

ASU
ARIZONA STATE UNIVERSITY

Founded in 2009

Supported by US National Science Foundation
(*EAR GEO/GLD Award No. 1948997, 1948994 & 1948857*)

DATA SERVICES

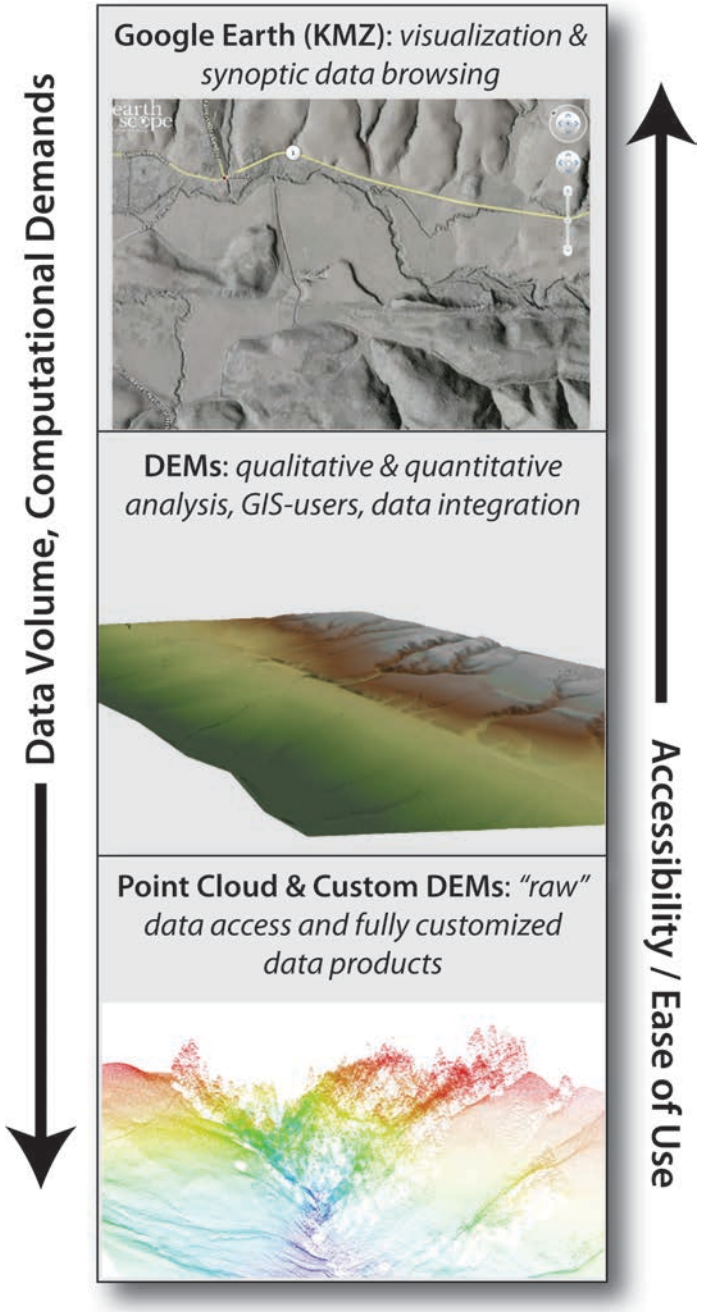
Topography data products and access mechanisms for a diverse user community

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)



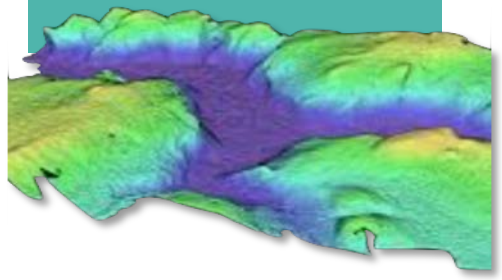
DATA SERVICES

TOPOGRAPHY DATA

PC Data Filtering & Subsetting

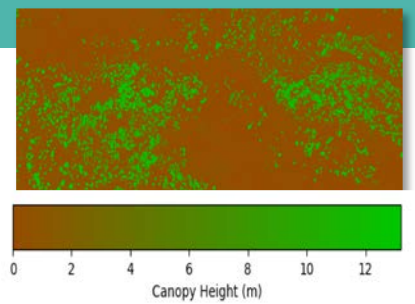
Raster Data Subsetting

3D Visualization

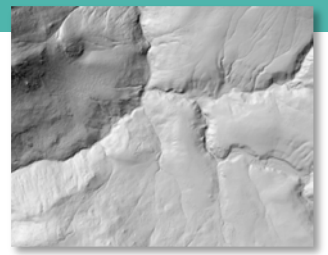


Digital Elevation Models
TIN / Local Gridding

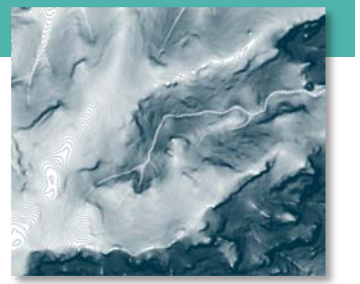
Canopy Height Model



Topographic Hillshades

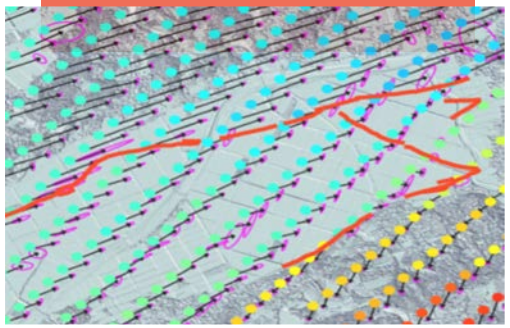


Contour Lines

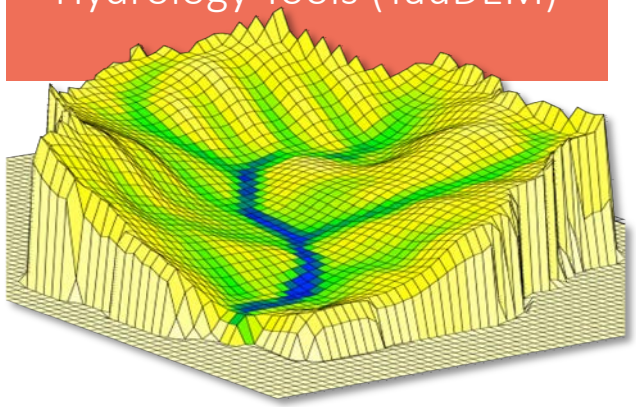


Vertical Differencing

3D Differencing



Hydrology Tools (TauDEM)



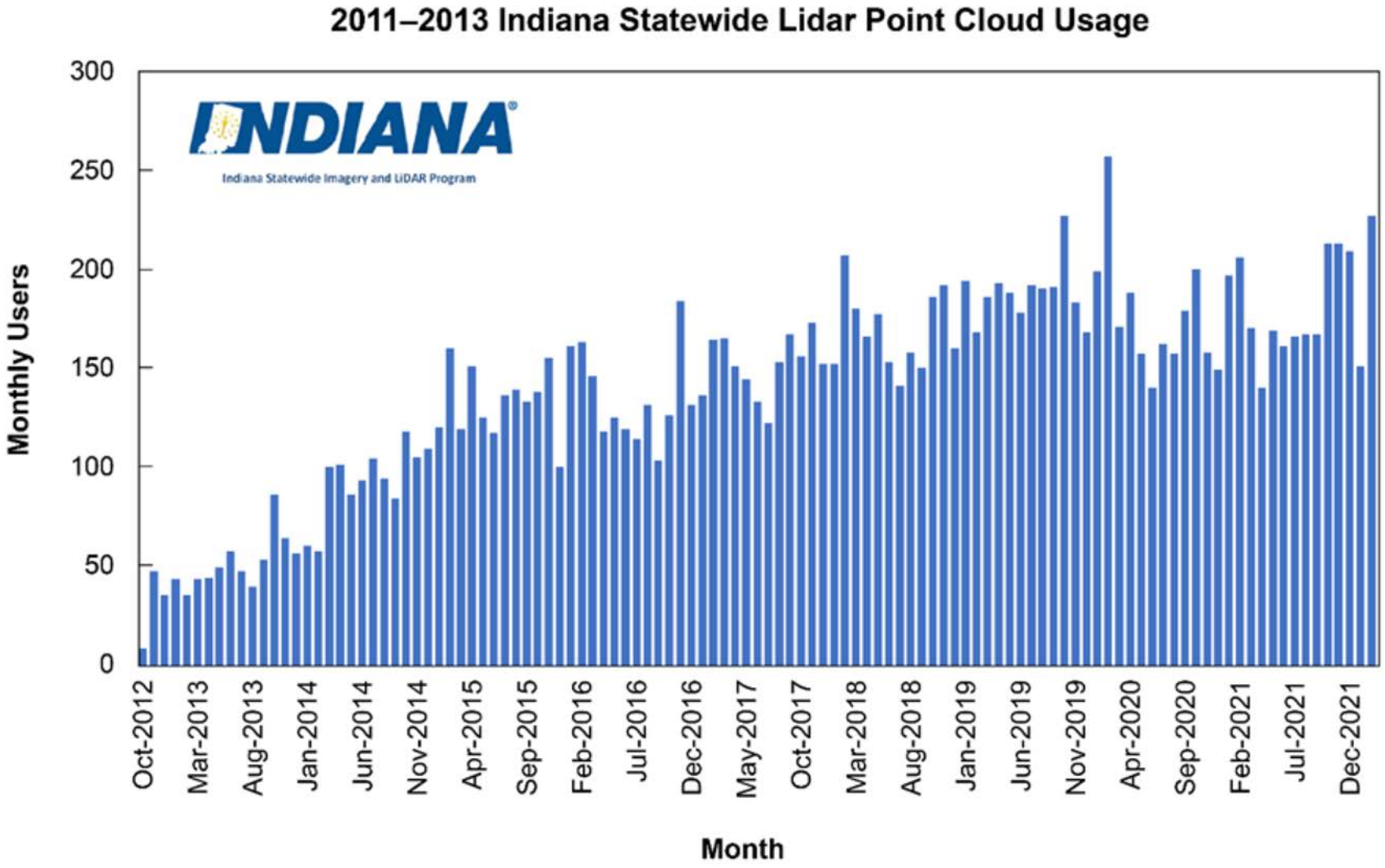
Case Study: Indiana

Indiana's Statewide Lidar:

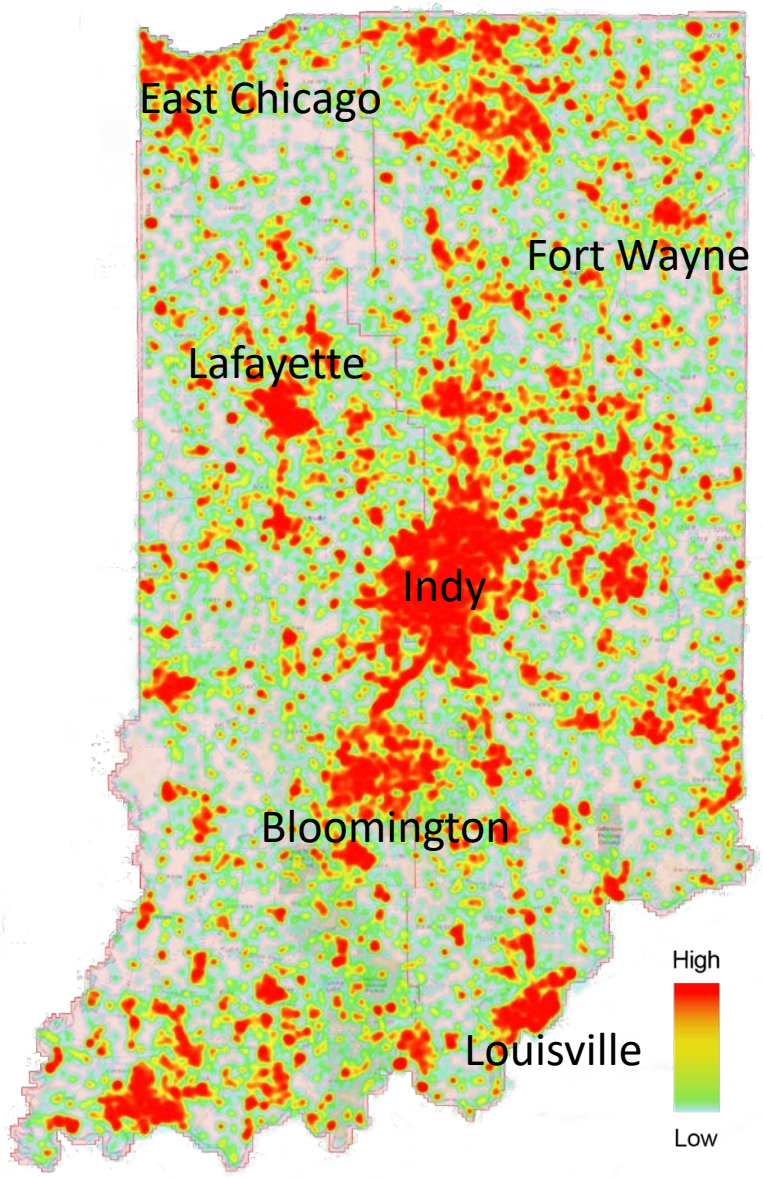
- Data collected from 2011 – 2013
- Covering all 92 Indiana Counties: >36,000 mi^2
- Multiple funding sources
- Impact: ~45,000 point cloud jobs run by ~6,000 users. 492 billion pts processed.

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

Case Study: Indiana - Analytics



Heat map of utilization



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

Case Study: Indiana

Diverse uses of data:

- State / City Government
- Individual Citizens
- Engineering/Surveying
- Agricultural
- Water Management
- Geospatial Consultants
- Energy Utilities
- Academic

Clark Farm Drainage *Schlatters, Inc.* *Peabody Energy* *HWC Engineering*

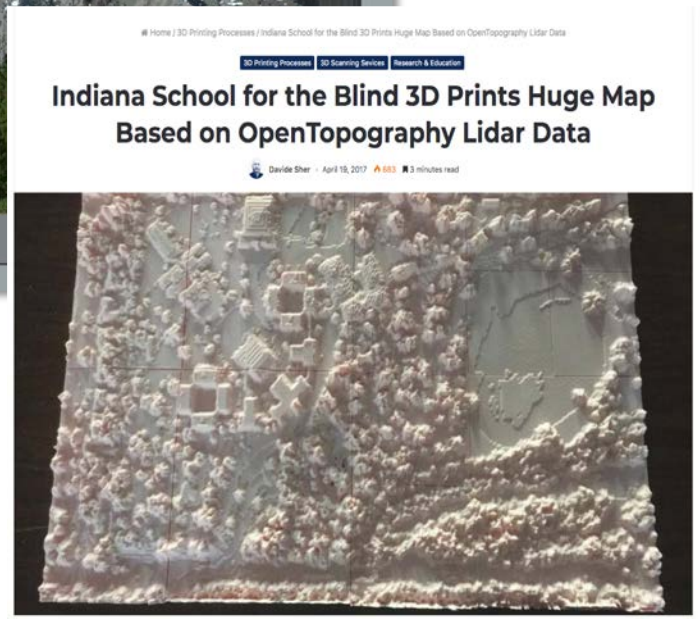
USI Consultants *Land Water Group* *Purdue University* *Department of Natural Resources*

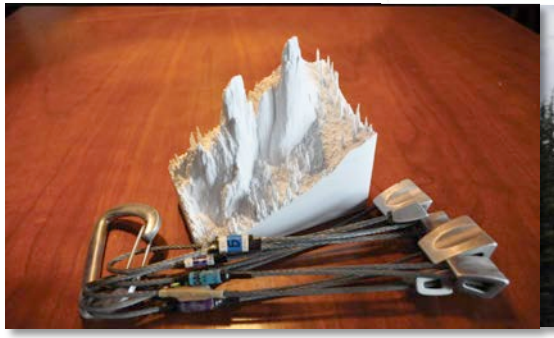
Parsons *Cash Waggner* *City of Fort Wayne* *American Electric Power*

Troxel Equipment *Indiana School of the Blind* *Indiana University* *Tbird Design*

Diverse Use Cases

- *"…developing a video game and want to experiment with landscapes"*
- *"…make maps for the family ranch"*
- *"…providing training and instruction to land surveyors and engineers"*
- *"…development of Emergency Action Plans"*
- *"…better understand avalanche conditions"*
- *"…generate fault hazard maps for the state of CA"*
- *"…I use these data sets both for teaching and for research"*
- *"…to create orienteering map contours"*
- *"…estimating forest canopy height and density"*





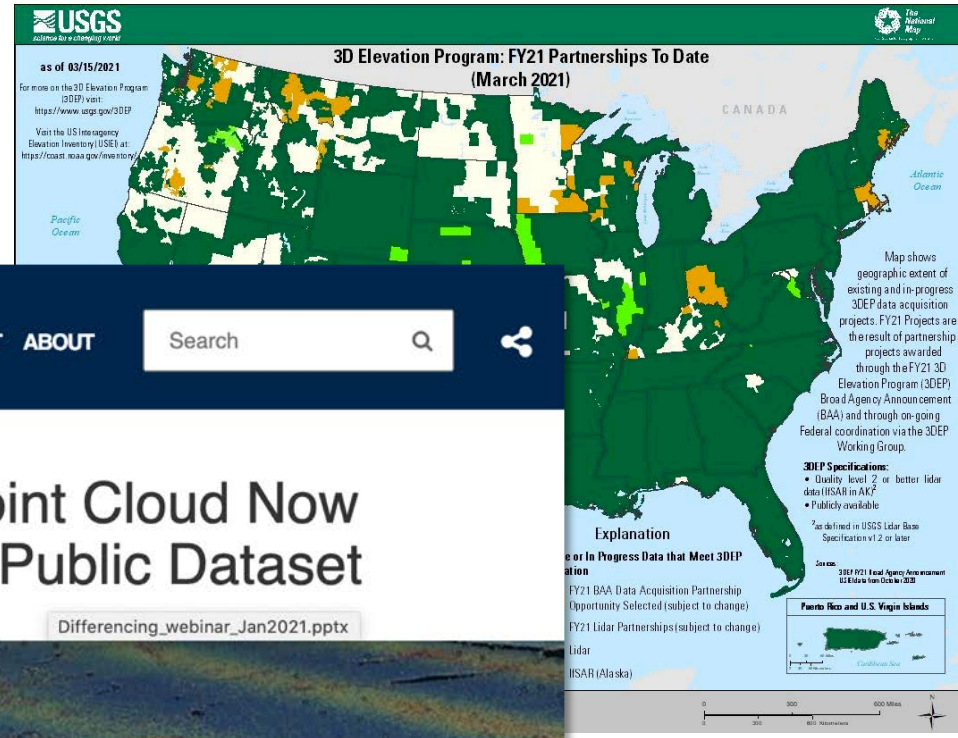
USGS 3DEP IN OPENTOPOGRAPHY

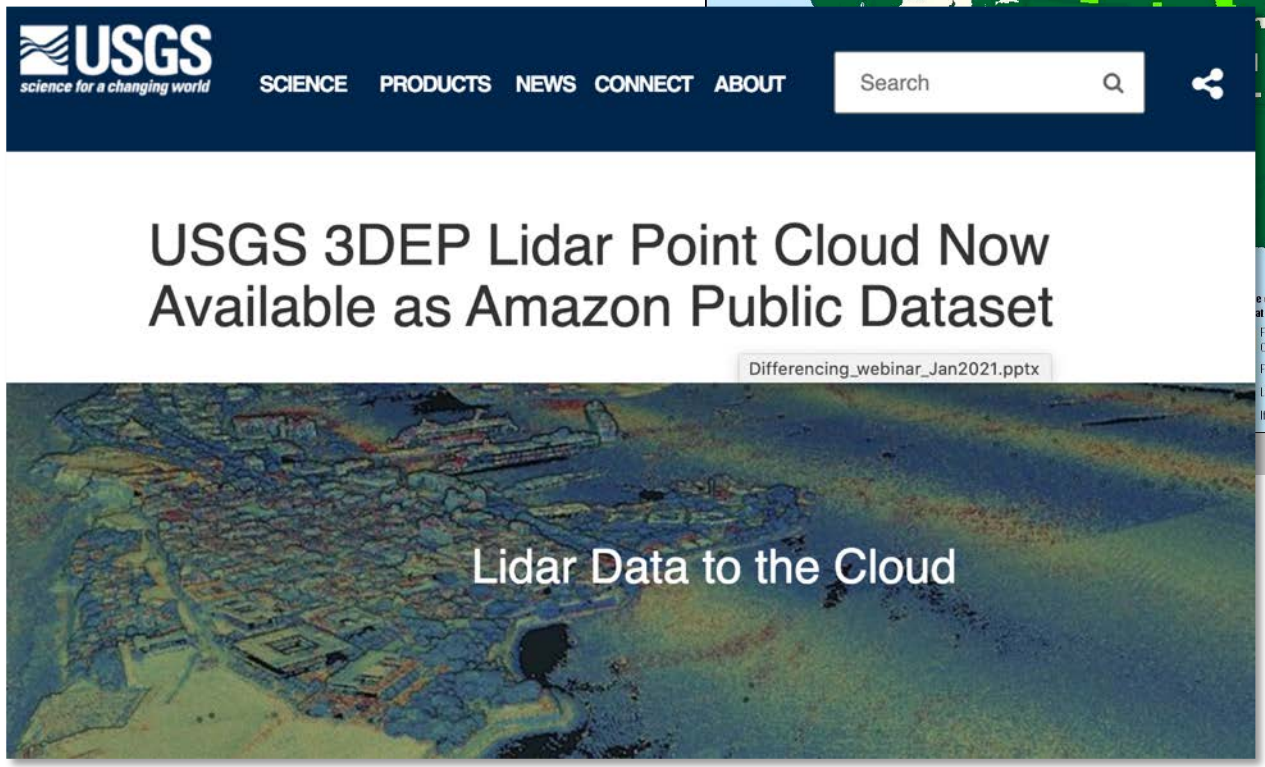
Easy discovery & derivative product generation

Leverage current OT functionality

Increase impact of investment in data

Access limited to academics & educators due to funding constraints





amazon S3

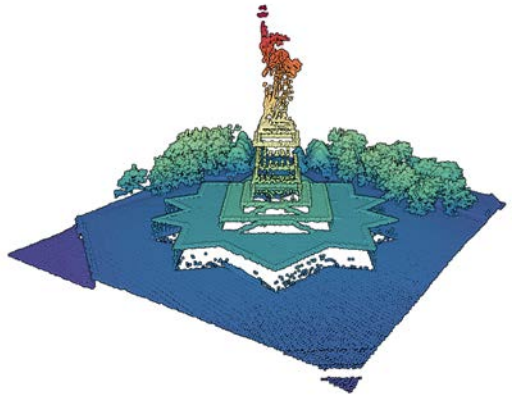
LAZ
Requestor Pays Bucket

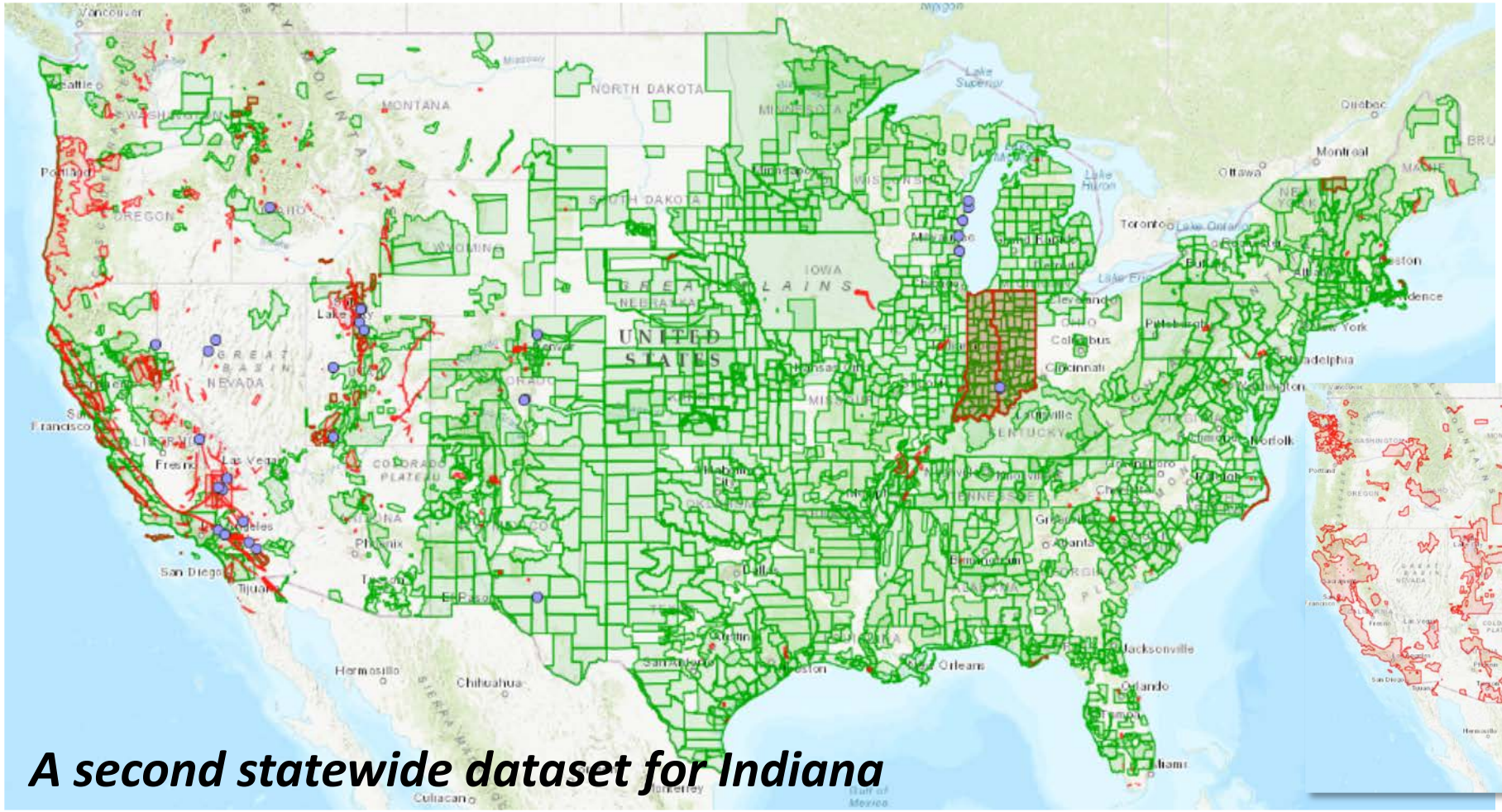
entwine
AWS Public Dataset

hobu

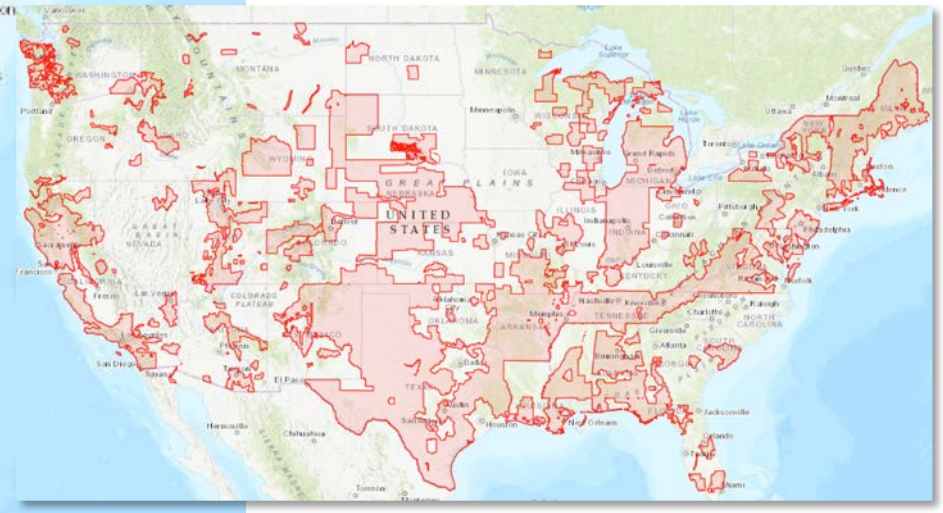
USGS 3DEP in OpenTopography

1,746 USGS 3DEP datasets currently available
40 trillion lidar returns covering 6.6 million km^2





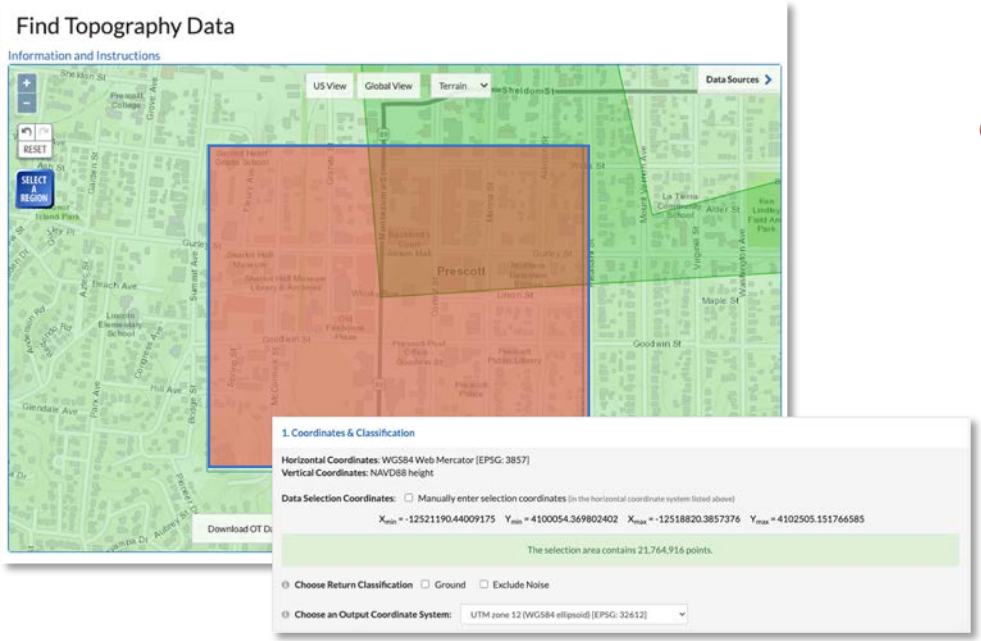
A second statewide dataset for Indiana



Recently added! 3DEP raster datasets:

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

USGS 3DEP IN OPENTOPOGRAPHY



SDSC

USGS science for a changing world

amazon web services S3

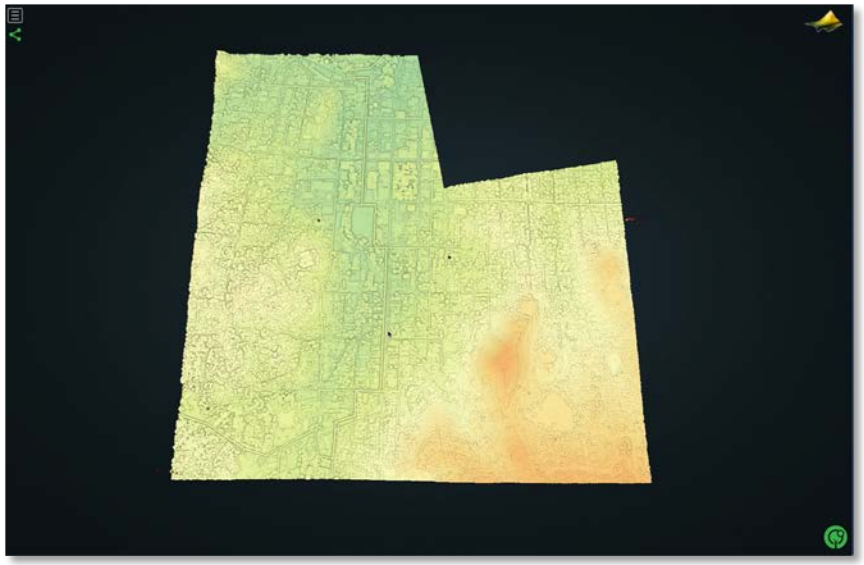
entwine

Output formats: LAS, LAZ

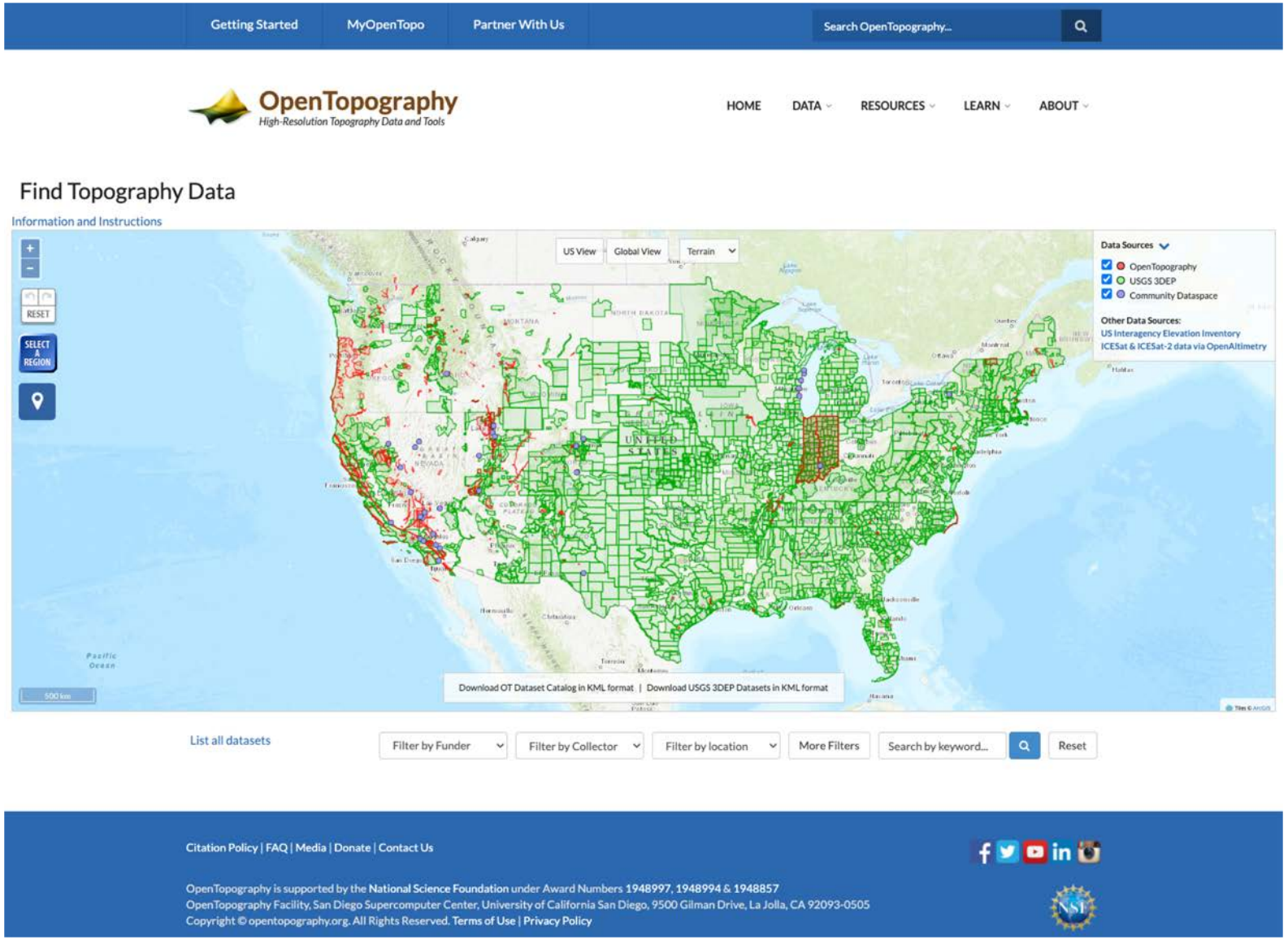
Dynamically created DEMs using TIN or local gridding algorithms

Output DEMs in GeoTIFF, IMG, or ESRI Arc GRID format

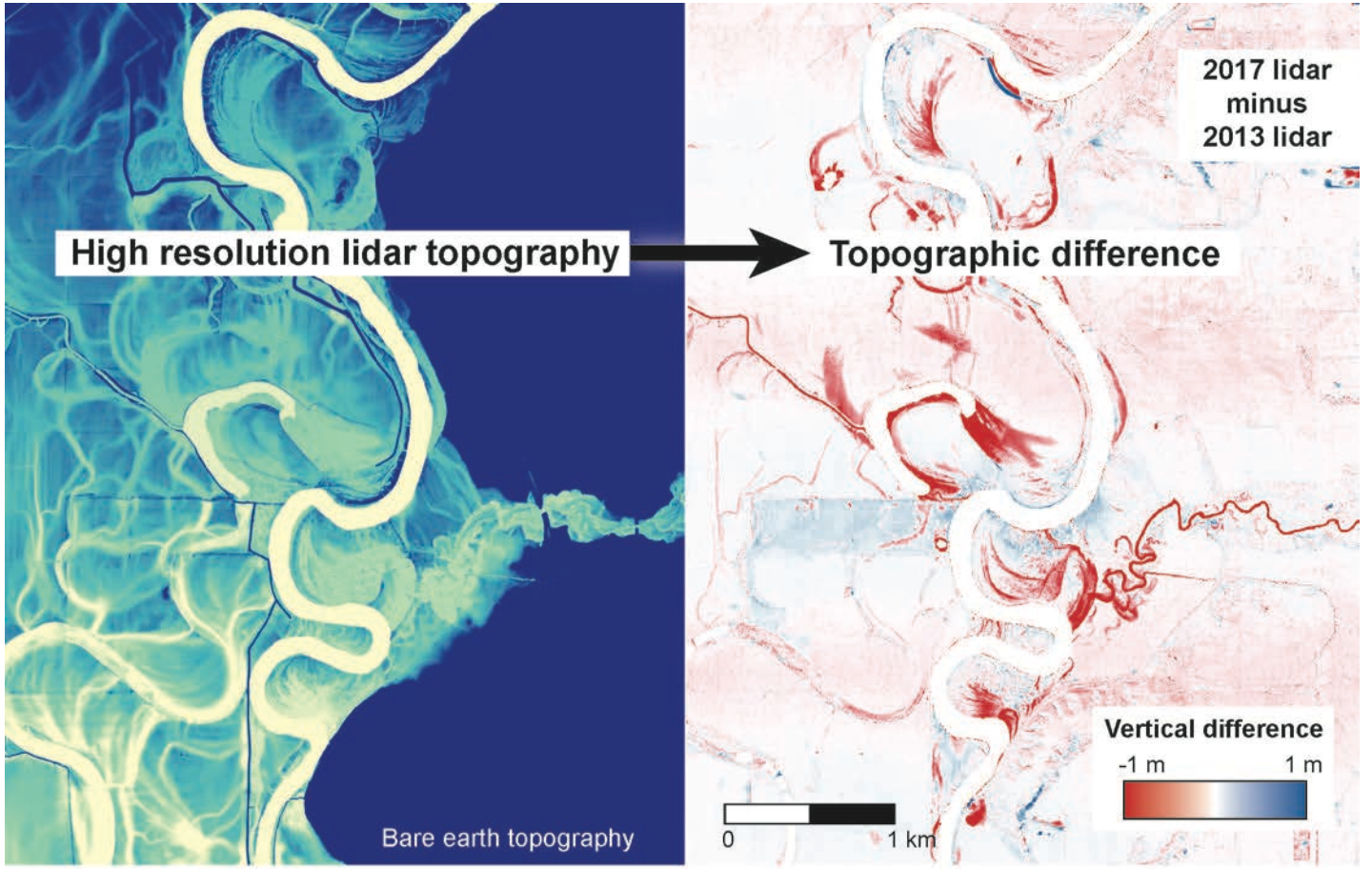
Visualizations (raster and point cloud)

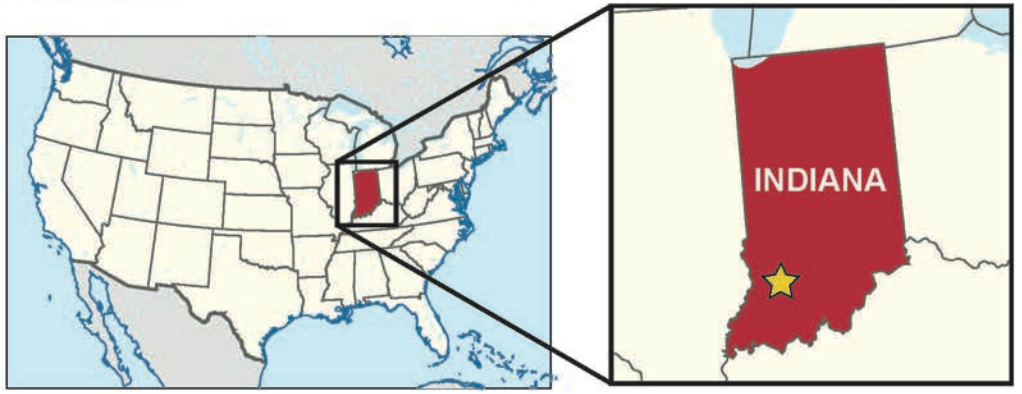


DEMO: https://opentopography.org/



Statewide Topographic Differencing of Indiana





Scott, C. P., Beckley, M., Phan, M., Zawacki, E., Crosby, C., Nandigam, V., & Arrowsmith, R. (2022). Statewide USGS 3DEP Lidar Topographic Differencing Applied to Indiana, USA. *Remote Sensing*, *14*(4). https://doi.org/10.3390/rs14040847

Statewide Topographic Differencing of Indiana

Motivation:

Large-scale processing of USGS 3DEP topography

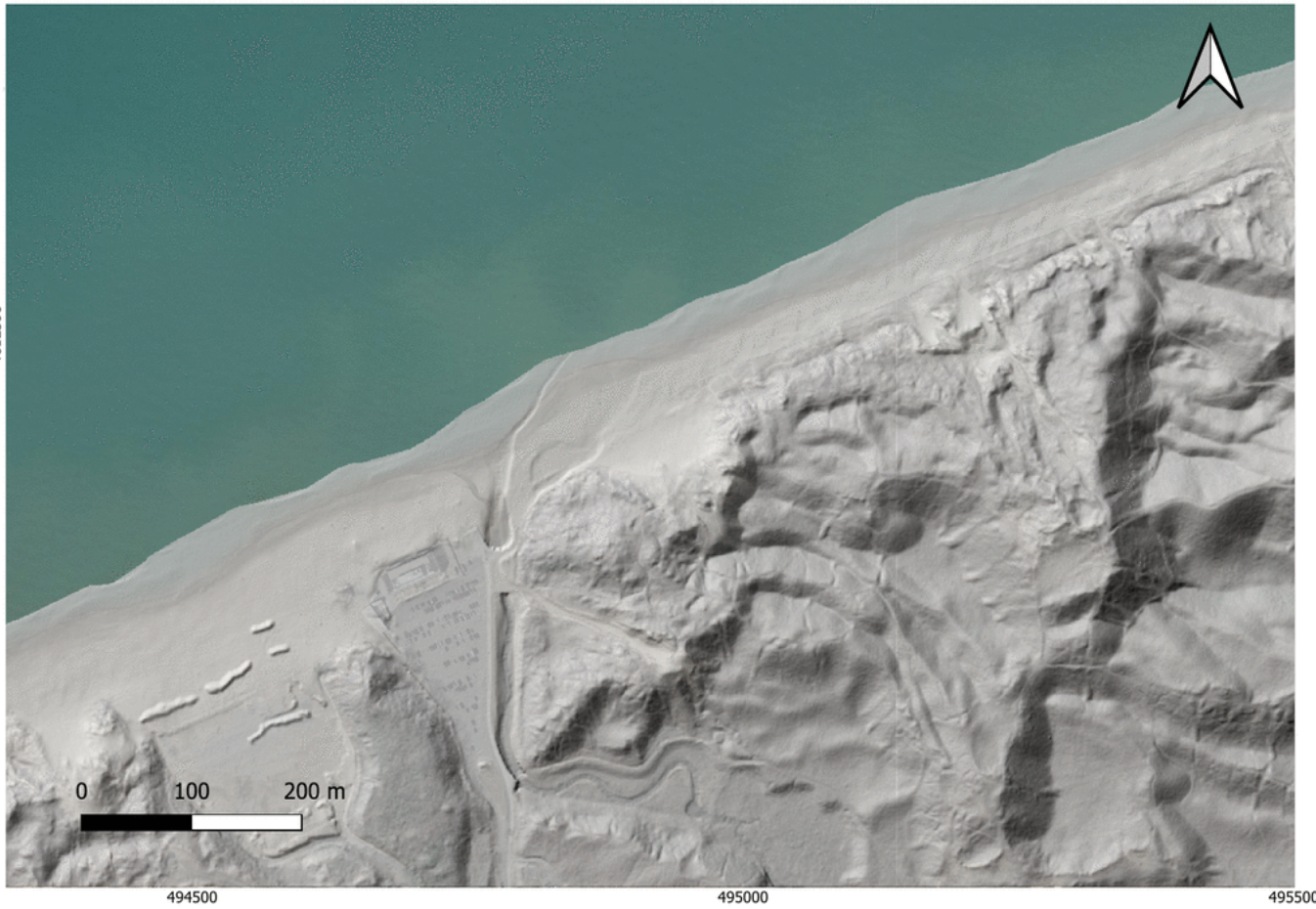
What does a decade of change look like?

Why Indiana:

-Two statewide differencing datasets

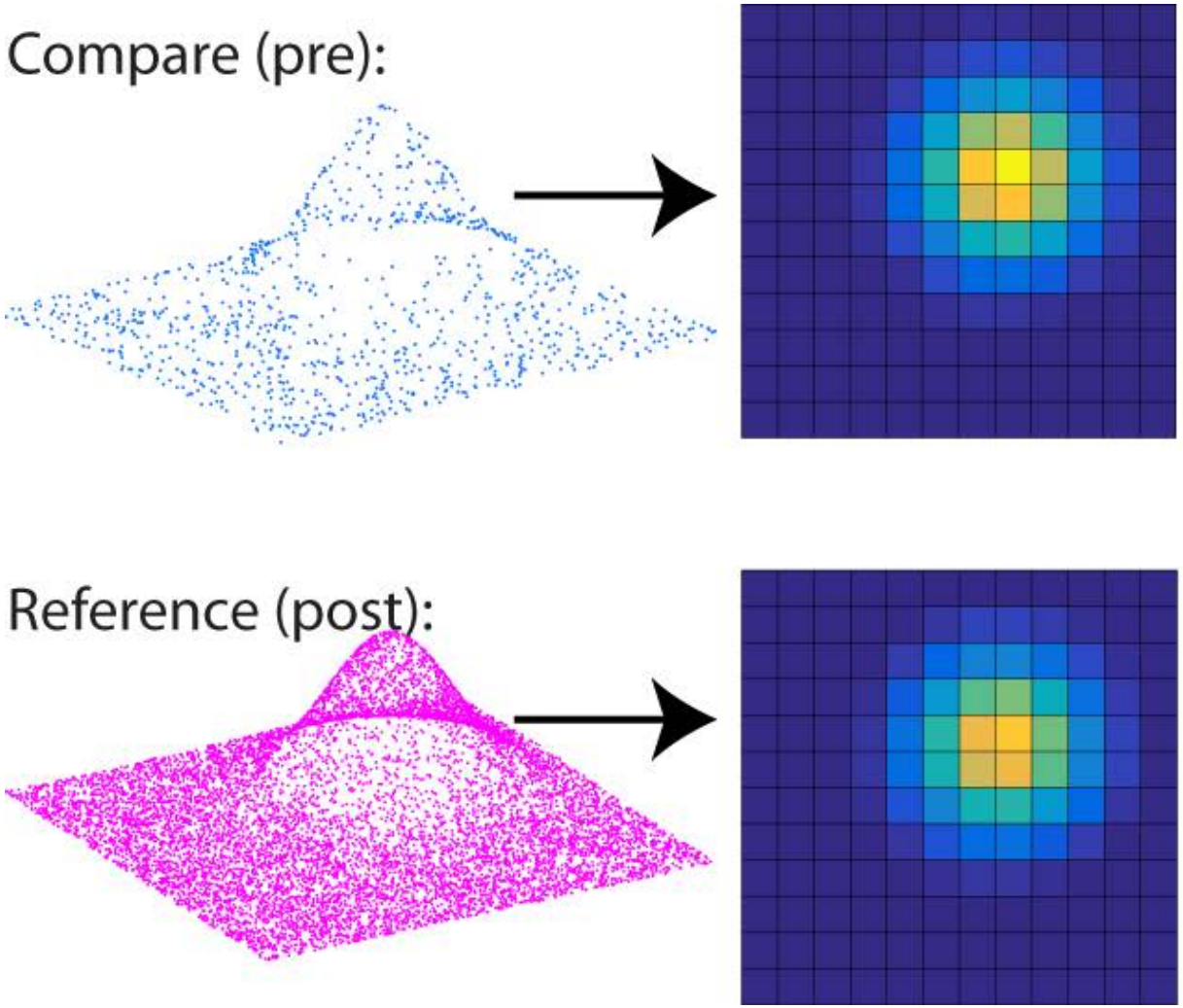
- Anticipated interesting change

- Data-hosting partnership between OT and Indiana



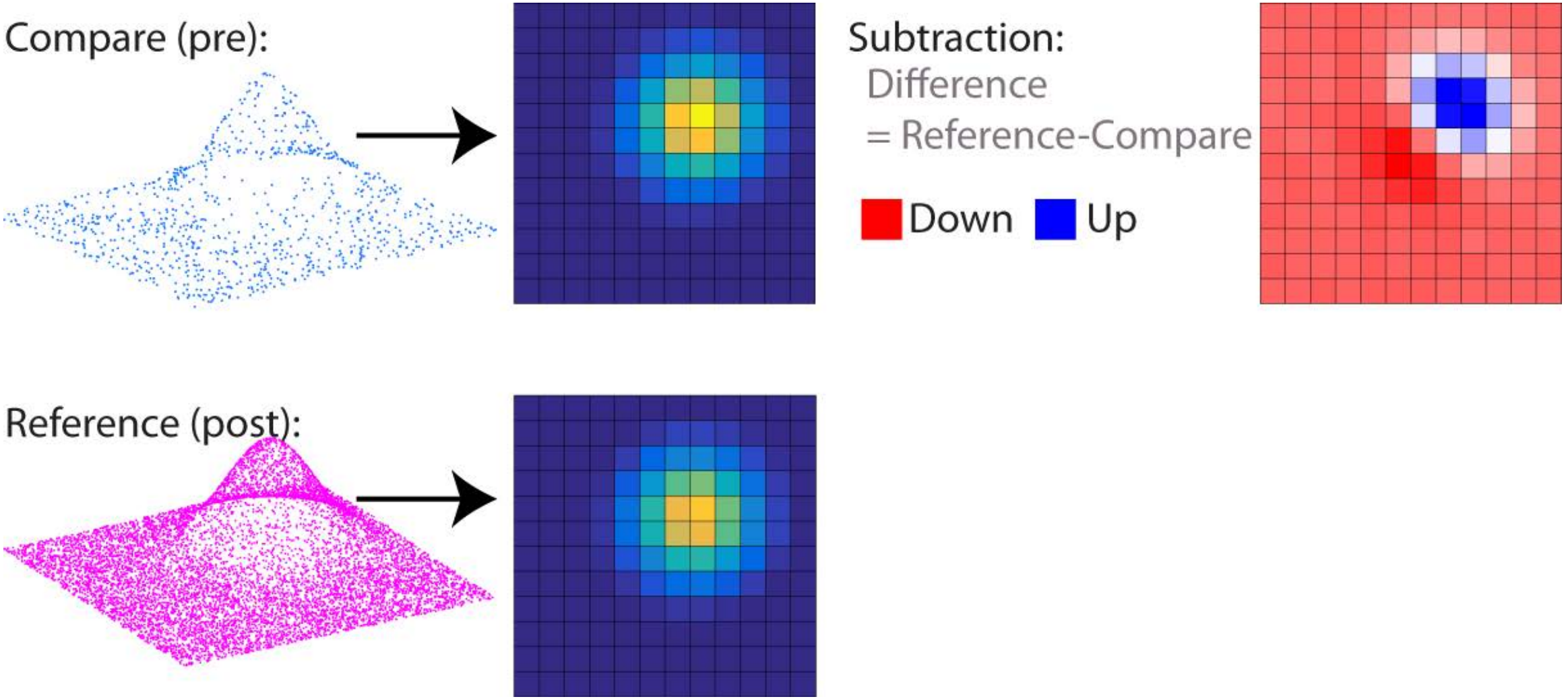
Indiana Dunes National Park

Vertical topographic differencing



Identical grid for pre and post event topography

Vertical topographic differencing



Raster subtraction

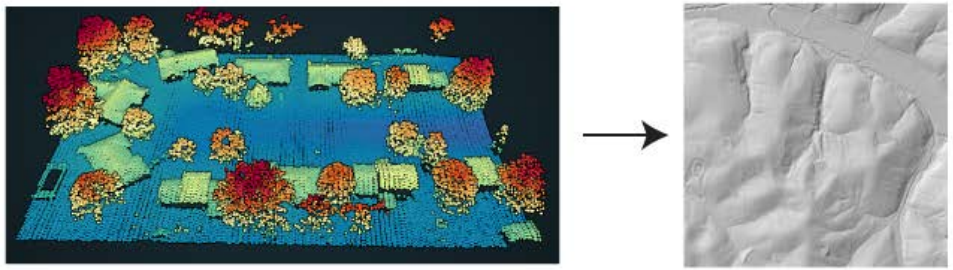
Indiana Statewide Topographic Differencing Workflow

Indiana: Repeat for 92 counties over ~94,000km^2 with 2011-2013 (IndianaMap) and 2016-2020 (USGS 3DEP) Datasets

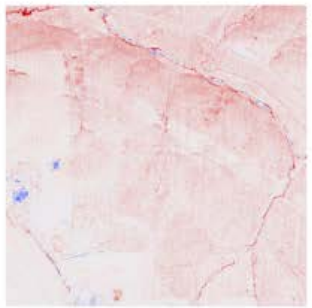
Data Access: Download lidar topography from AWS (Python and PDAL)

SDSC ↔ USGS, amazon web services S3, entwine

Processing: Tile, extract ground points, transform the CRS, generate DEMs (LAStools & GDAL)

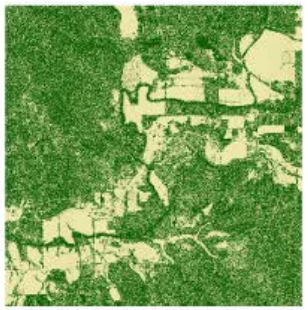


Differencing: Produce differenced DSMs & DTMs and Canopy Height Models (GDAL)



Topographic change

Canopy Height Model



Visualization: Create a Web Mapping Service (Geos

Scott et al., (2022)

Challenges:

Indiana is 94,000 km^2: ~10^2-10^5 x larger than other differencing studies

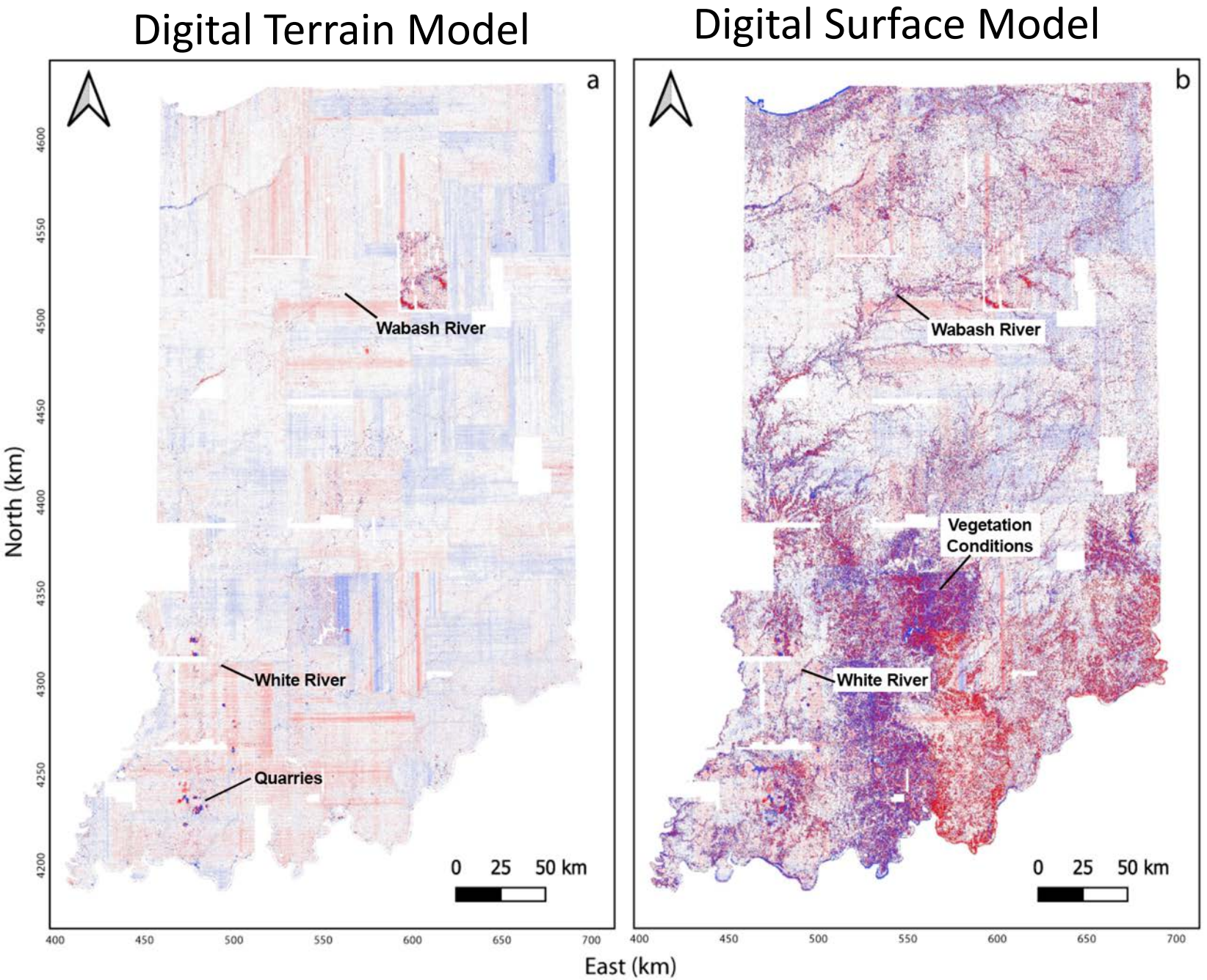
Final products are ~4 TB

Need high performance computing (HPC) resources: Processing would take 1 year to complete on a workstation

Ensure sufficient memory for intermediate calculations

What are the sources of noise? Should we correct the noise at the state-scale?

Visualize the results?



Scott et al., (2022)

Vertical Difference (m): -1 0 1

IN topographic differencing

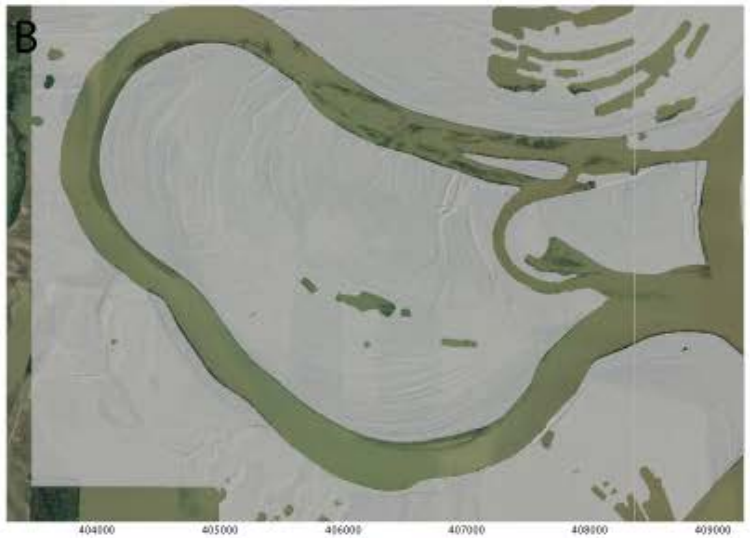
Fluvial and riparian

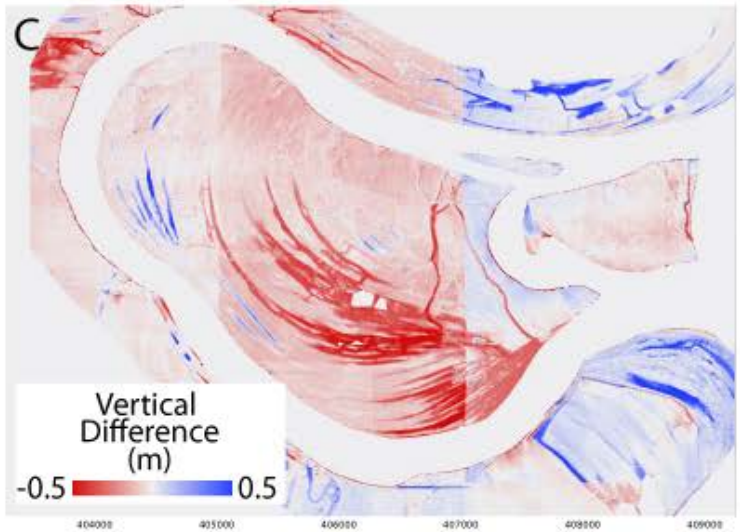
Vegetation (correlations with season of data acquisition)

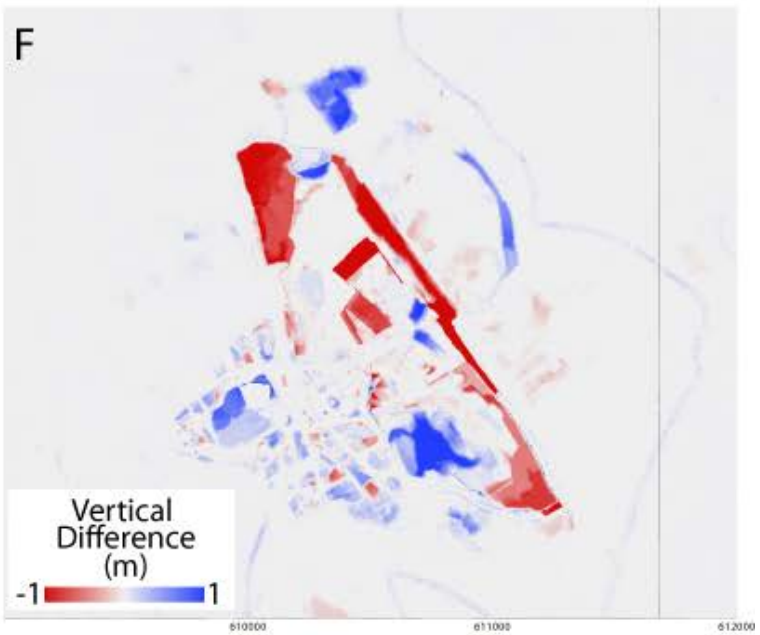
Quarries and mining

Flight alignment errors

Fluvial processes and quarry

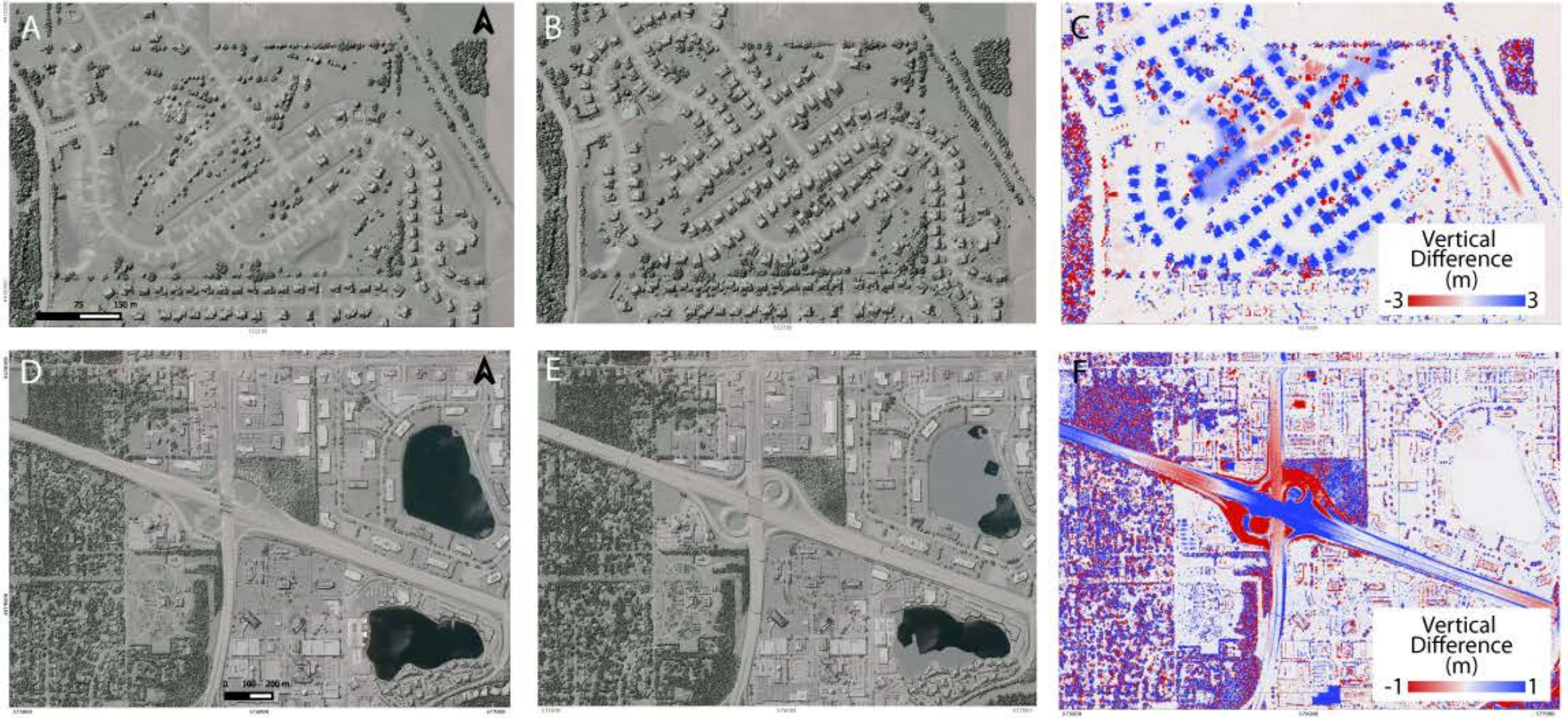






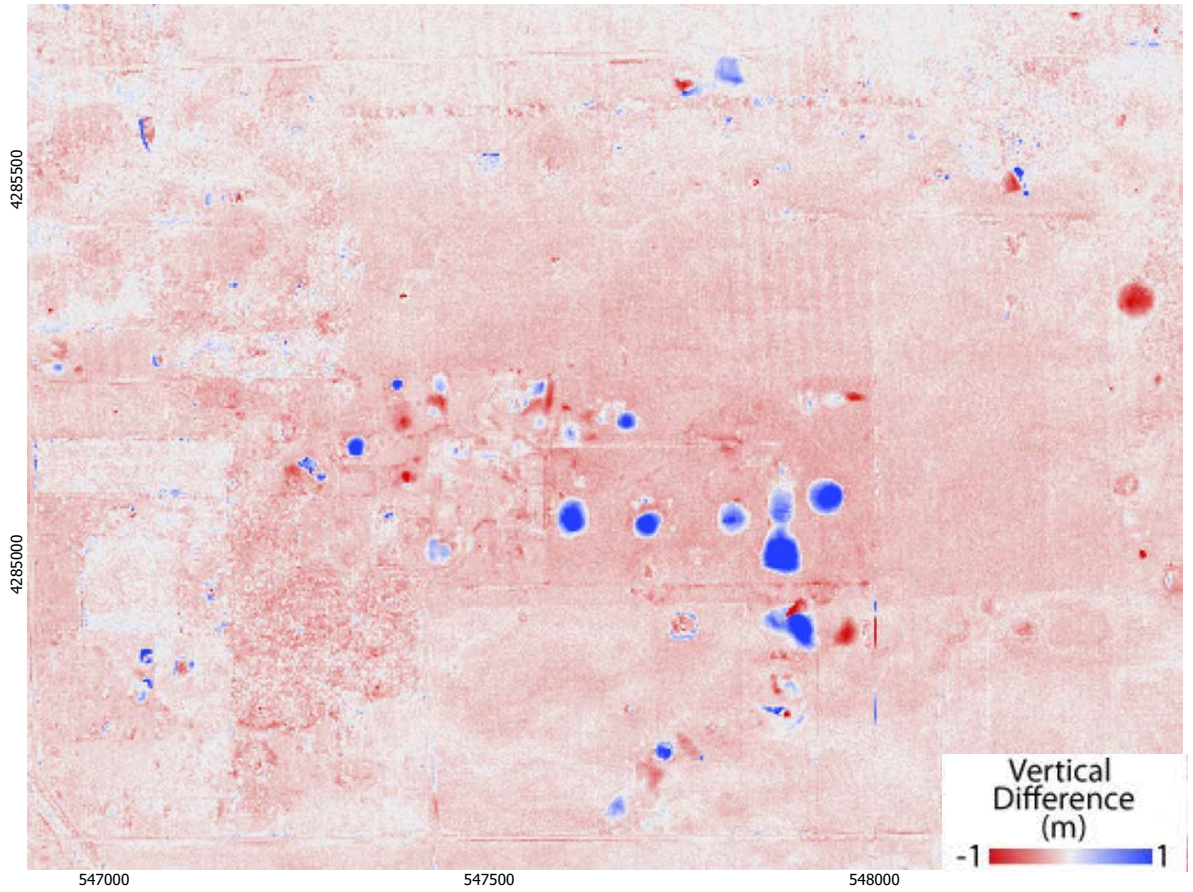
Scott et al., (2022)

Construction in Indianapolis



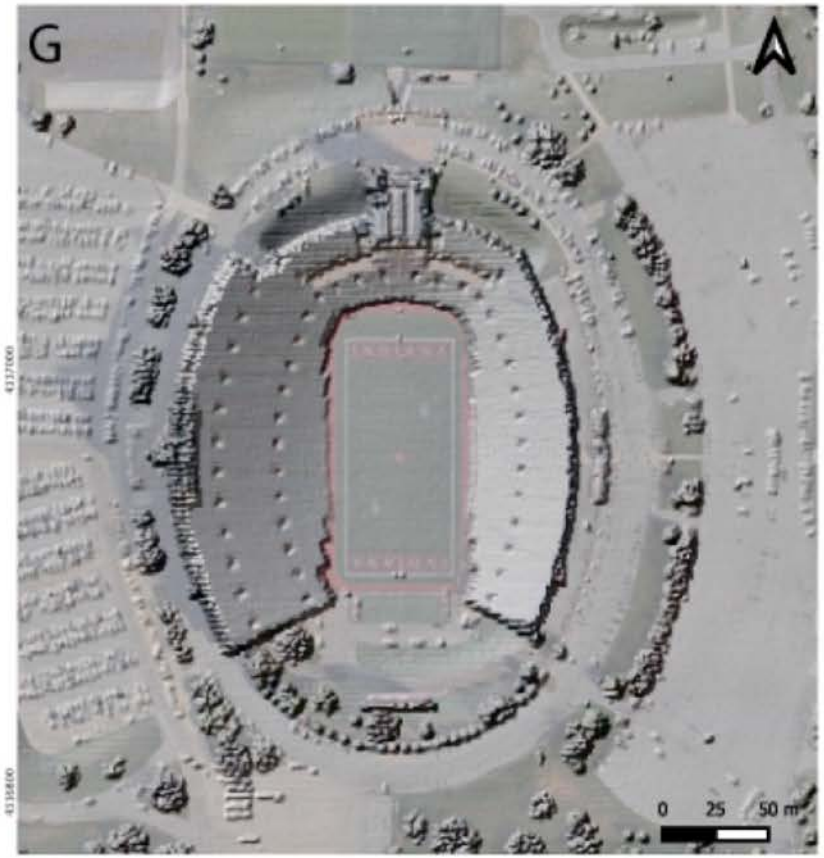
Scott et al., (2022)

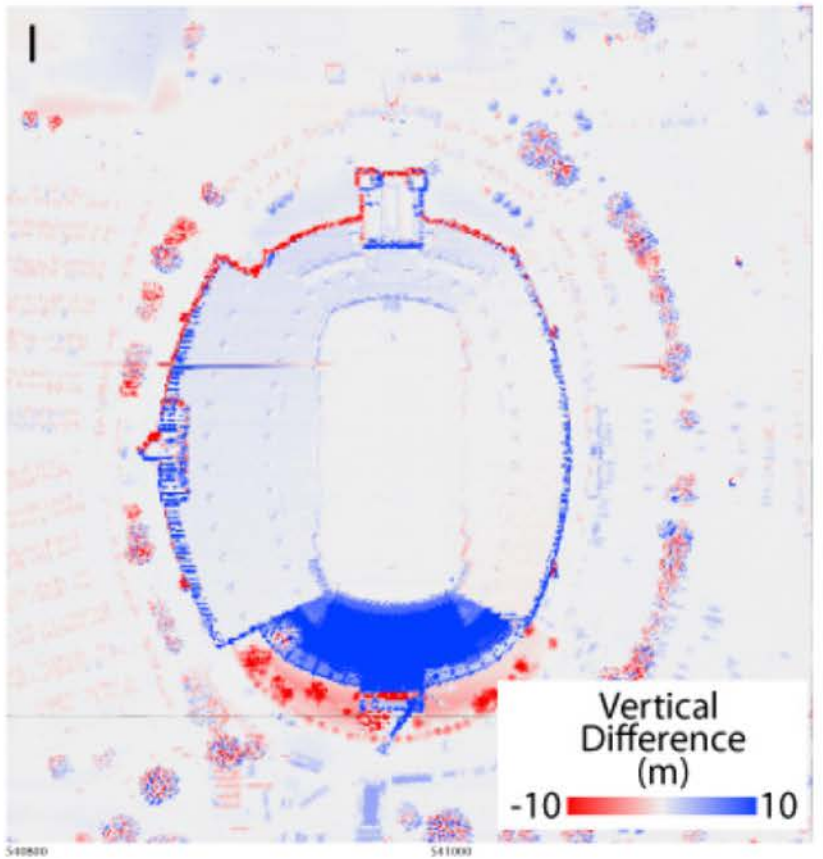
Sinkholes



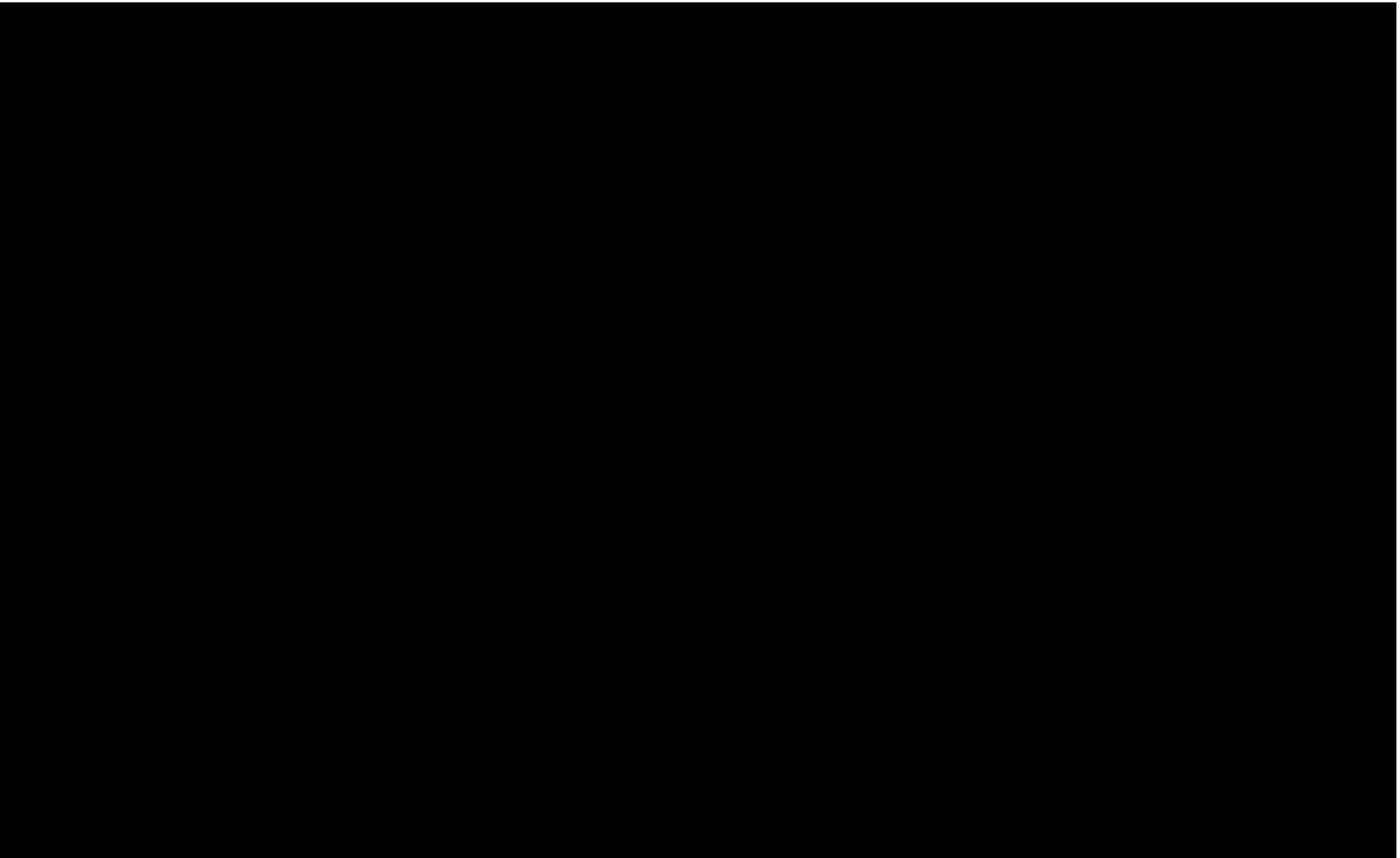
Scott et al., (2022)

Construction of the Indiana University Stadium





Visualize: https://portal.opentopography.org/indiana



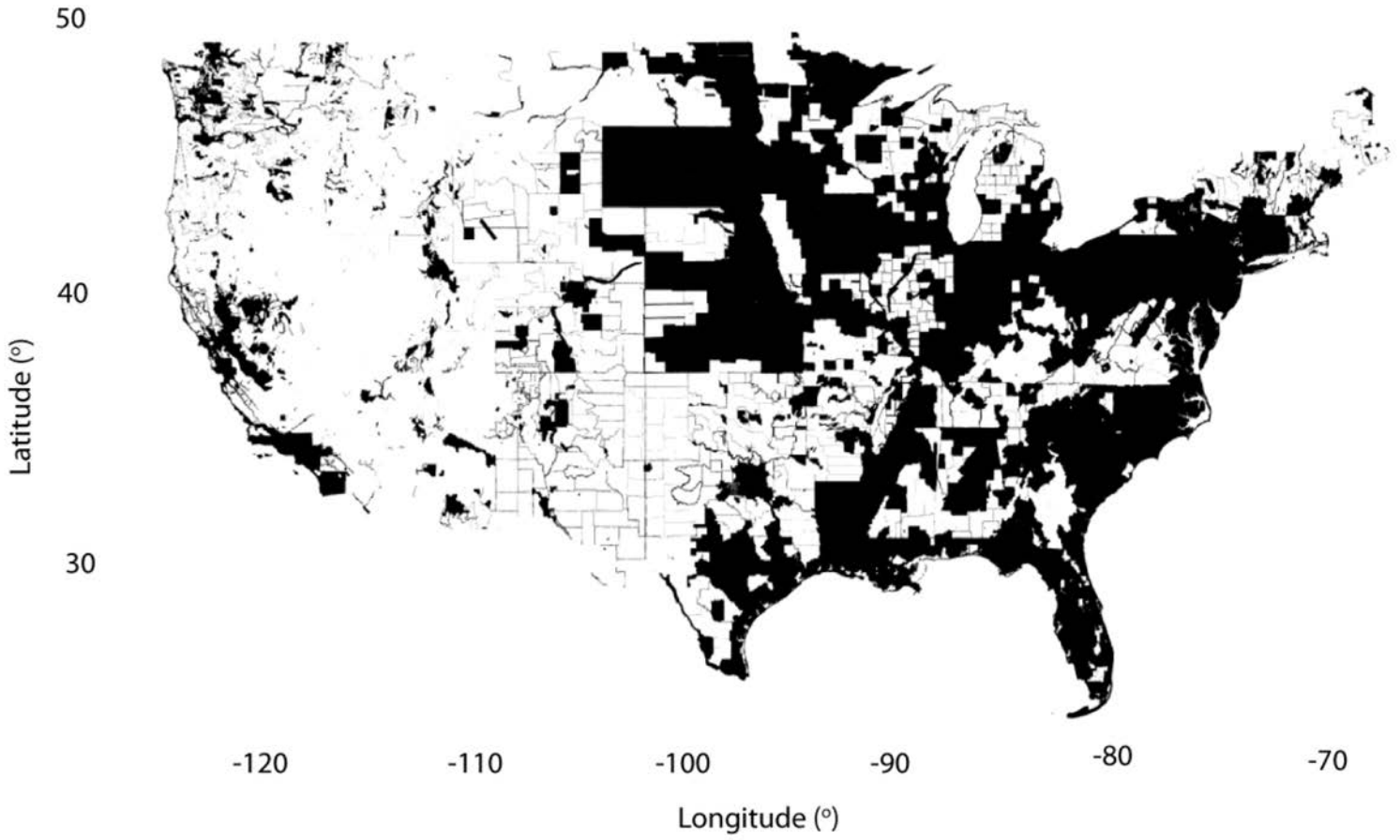
Looking forward

~1/3 of the lower 48 is covered by repeat lidar data

Enormous opportunity to characterize change to anthropogenic and natural landscape.

Applications: Biomass change, coastal change, hazards (flooding, landslides, sinkholes), urban development

Challenge: Manually analyzing large datasets becomes prohibitively time-intensive. Need an approach like Machine Learning.



LESSON LEARNED?

Ease of Use:

Easy to find and use data provides maximum ROI. Stakeholders have diverse geospatial skills and variable needs.

User Support, Training, Durability:

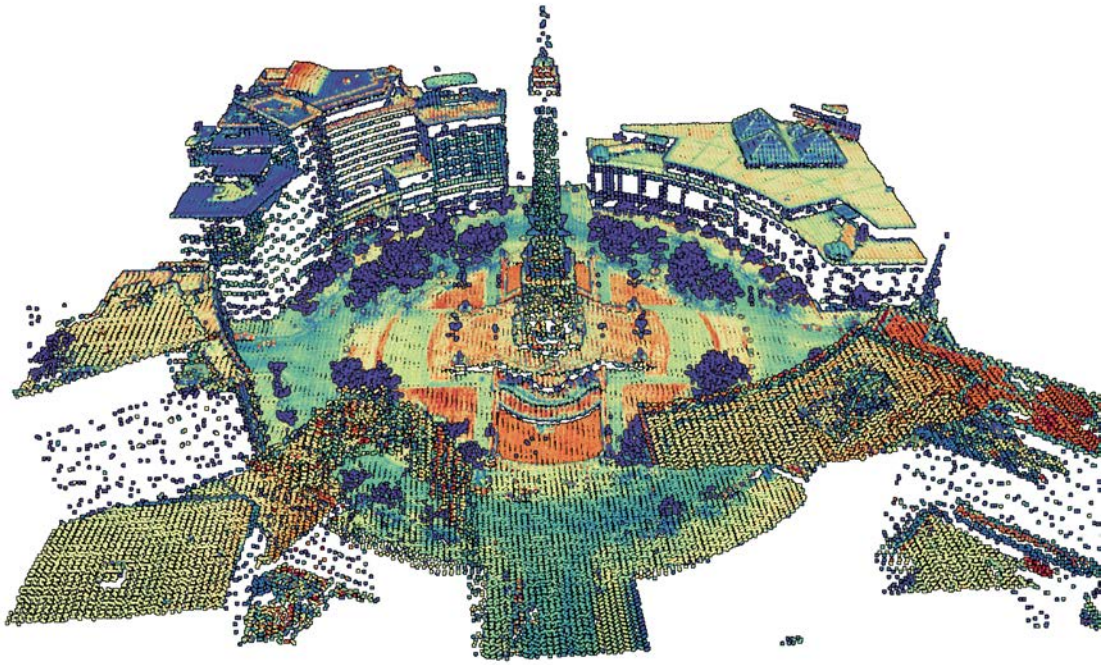
Responsive answers to user inquiries, active training and outreach programs. High service availability & scalability: <1% job failure rate.

Analytics:

Real world metrics: types of users, types of jobs, spatial and temporal utilization. Provides justification for investment in the data collection

Lidar as Big Data:

State and National scale dataset present massive opportunities for advance processing and analysis. Requires modern approaches with high performance computing and cloud to fully realize potential.



Soldiers and Sailors Monument, Indianapolis, IN

Thanks!

OpenTopography.org

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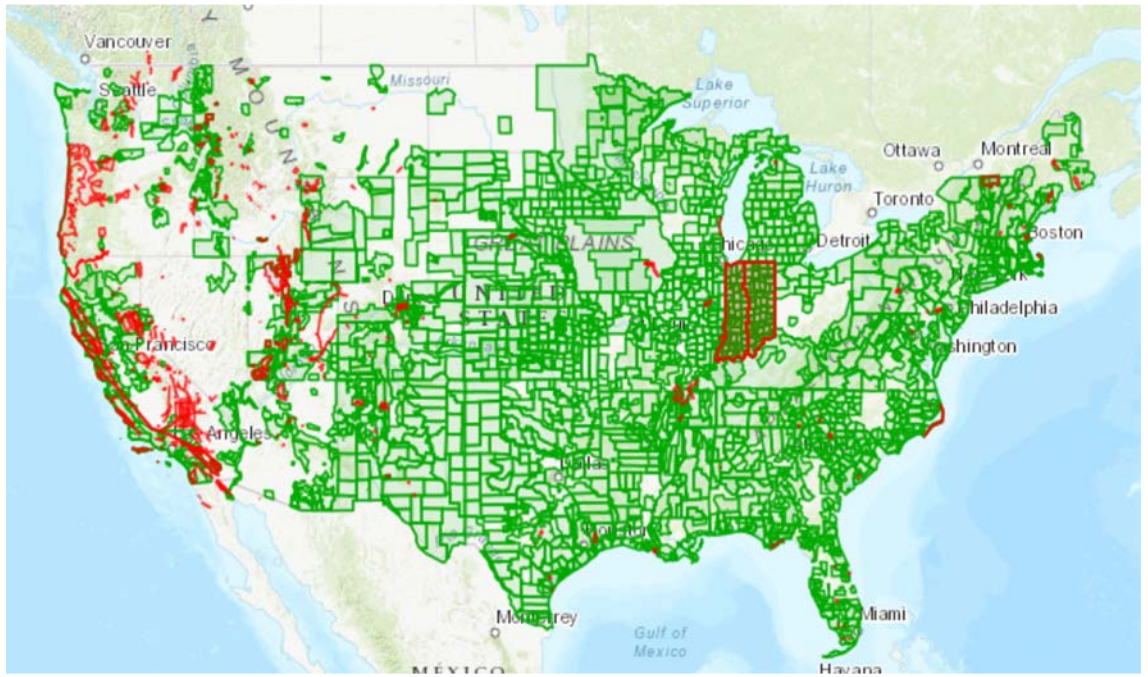
cpscott1@asu.edu

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

OT partnerships

OpenTopography



Land Information New Zealand
Toitū te whenua

UTAH DNR FORESTRY

NASA

University of Colorado Boulder

OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES 1937

IDAHO LiDAR Consortium

Caltech

OKLAHOMA STATE UNIVERSITY

THE UNIVERSITY OF IOWA

INDIANA

NSF

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

NATIONAL PARK SERVICE

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

USGS science for a changing world

UNIVERSITY OF MINNESOTA Driven to Discover

USDA

THE UNIVERSITY OF TEXAS AT AUSTIN JACKSON SCHOOL OF GEOSCIENCES

PG&E Pacific Gas and Electric Company

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

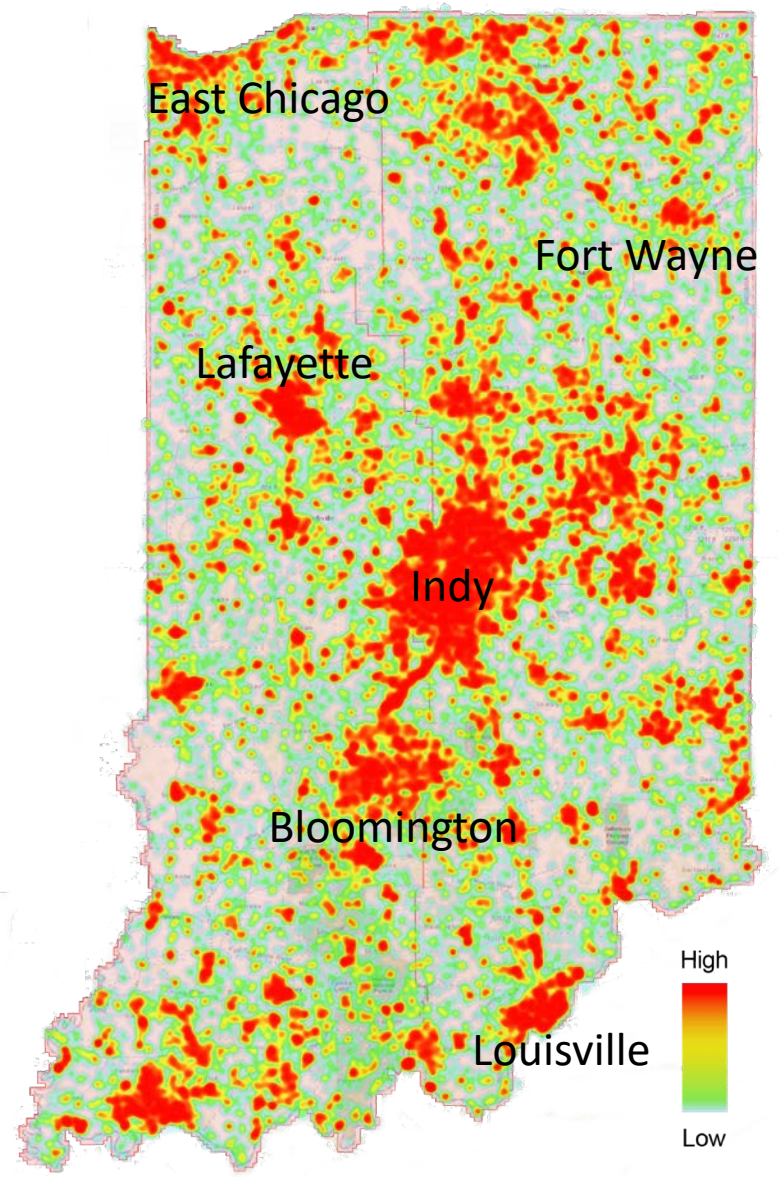
THE WORLD BANK

Case Study: Indiana - Analytics

Real-time user analytics:

- Heat Map Analysis
  - Identify high-value subsets of data
  - Prioritization of data recollection

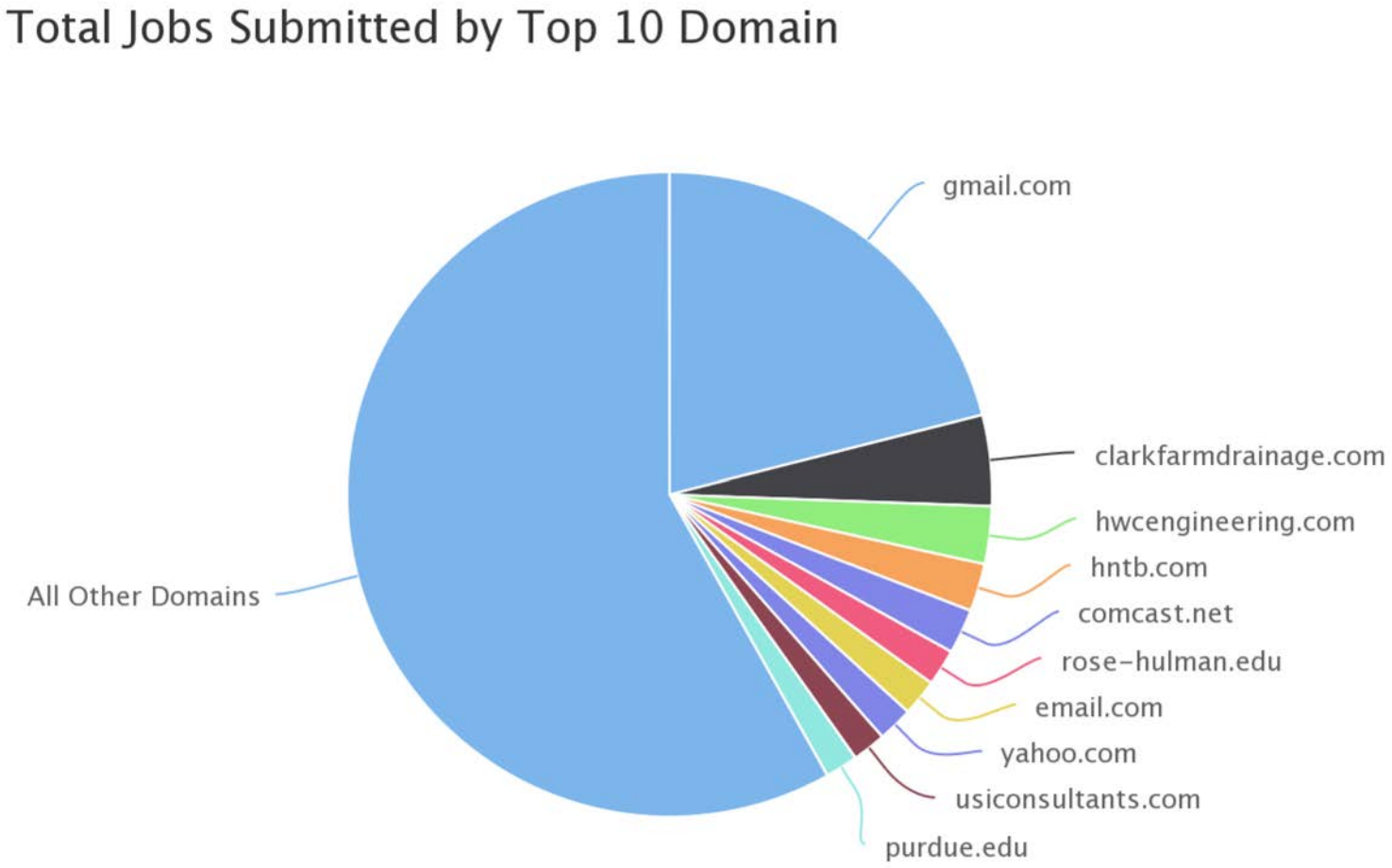
- Dynamic aggregation of all jobs run



Case Study: Indiana – Real time user Analytics

A. Point Cloud Jobs Statistics by Datasets

	Dataset	Total jobs ↓	Total points processed	Size (from 8/2021)	Unique users
1	2011 - 2013 Indiana Statewide Lidar	44,846	491,795,002,094	670.7 GB	5,979



	OT User ID	# of Jobs ↓
1	[Guest]@clarkfarmdrainage.com	880
2	[Guest]@gmail.com	634
3	[User]@comcast.net	603
4	[Guest]@gmail.com	591
5	[Guest]@email.com	546
6	[Guest]@gmail.com	454
7	[Guest]@gmail.com	387
8	[Guest]@gmail.com	260
9	[Guest]@clarkfarmdrainage.com	241
10	[Guest]@schlattersinc.com	206
11	[Guest]@msn.com	187
12	[Guest]@cashwaggner.com	169
13	[Guest]@guest.com	166
14	[Guest]@peabodyenergy.com	166
15	[Guest]@hwcengineering.com	164
16	[Guest]@contactcei.com	155
17	[Guest]@usiconsultants.com	145
18	[Guest]@hwcengineering.com	141
19	[Guest]@clarkfarmdrainage.com	140
20	[Guest]@landwatergroup.com	135
21	[Guest]@gmail.com	131
22	[Guest]@aol.com	122
23	[Guest]@fpbhonline.com	121
24	[Guest]@purdue.edu	107
25	[User]@dnr.in.gov	106
26	[Guest]@gmail.com	105
27	[Guest]@triadassoc.net	98
28	[Guest]@gmail.com	97
29	[Guest]@clarkfarmdrainage.com	97
30	[Guest]@weihe.net	95

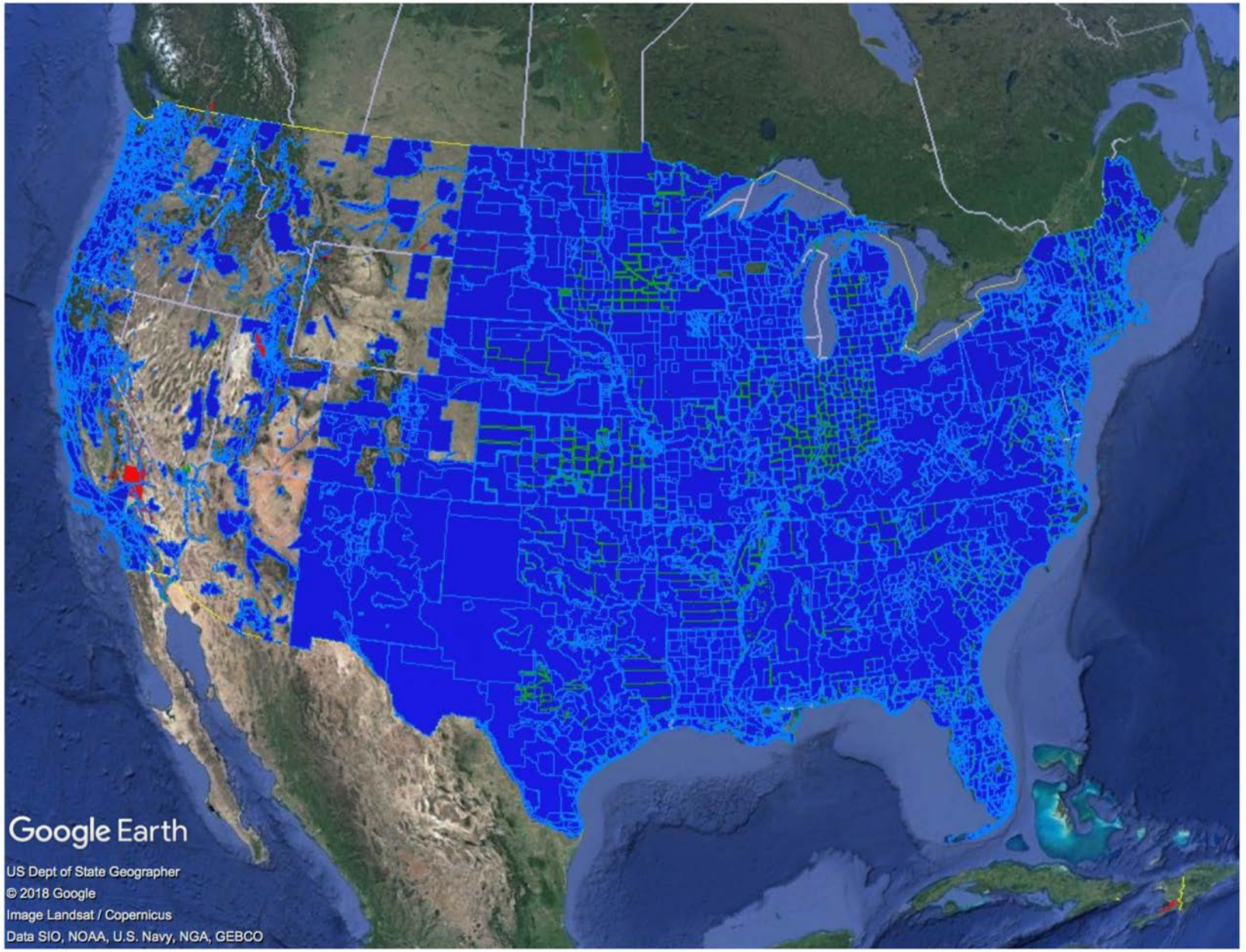
Case Study: Indiana - Analytics

Real-time user analytics:

- Easily break down usage per month

Jul 2020	441	2,308,155,741	161
Aug 2020	442	2,829,860,563	156
Sep 2020	589	3,246,243,268	178
Oct 2020	529	5,016,044,106	199
Nov 2020	441	3,321,228,509	157
Dec 2020	394	7,533,523,182	148
Jan 2021	518	2,413,006,644	196
Feb 2021	535	5,930,704,156	205
Mar 2021	488	2,283,718,184	169
Apr 2021	386	3,272,096,869	139
May 2021	424	3,231,191,226	168
Jun 2021	434	4,235,530,370	160
Jul 2021	432	2,262,926,071	165
Aug 2021	433	3,535,152,841	166
Sep 2021	513	6,598,760,588	183
Oct 2021	639	5,907,090,503	212
Nov 2021	522	3,191,915,124	212
Dec 2021	521	4,829,226,900	208
Jan 2022	462	8,664,440,345	150
Feb 2022	620	4,024,887,221	226
Mar 2022	486	2,299,568,333	173

Opportunities & Challenges



1. Proven a success as a platform for NSF-funded lidar and Geoscience

2. Expansion to host 3DEP data would benefit a broader community

3. USIEI illustrates considerable public domain data not in 3DEP.

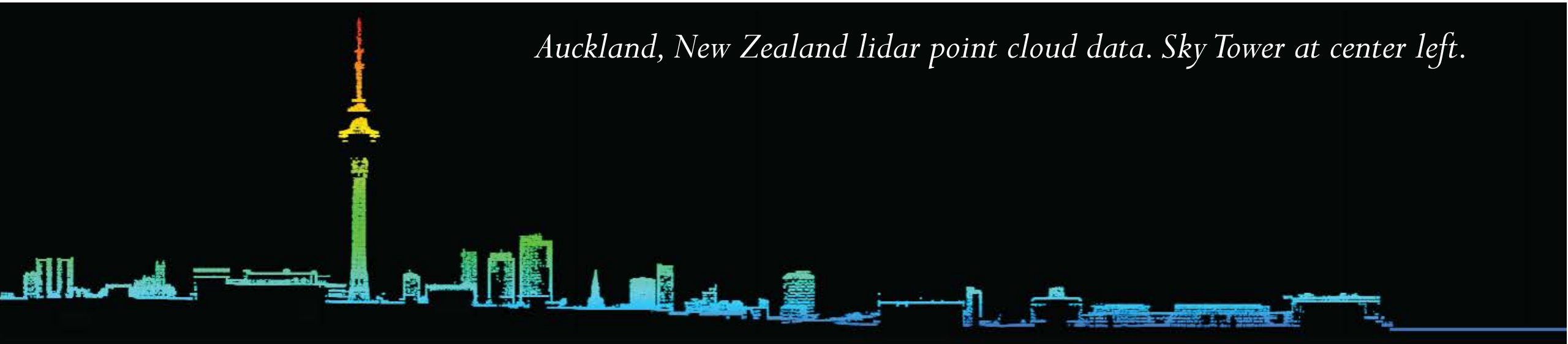
Looking Forward

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

Opportunities to leverage OT to enhance impact of these data, and improve ROI.

Pursuing creative solutions to funding / sustainability.

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



Auckland, New Zealand lidar point cloud data. Sky Tower at center left.