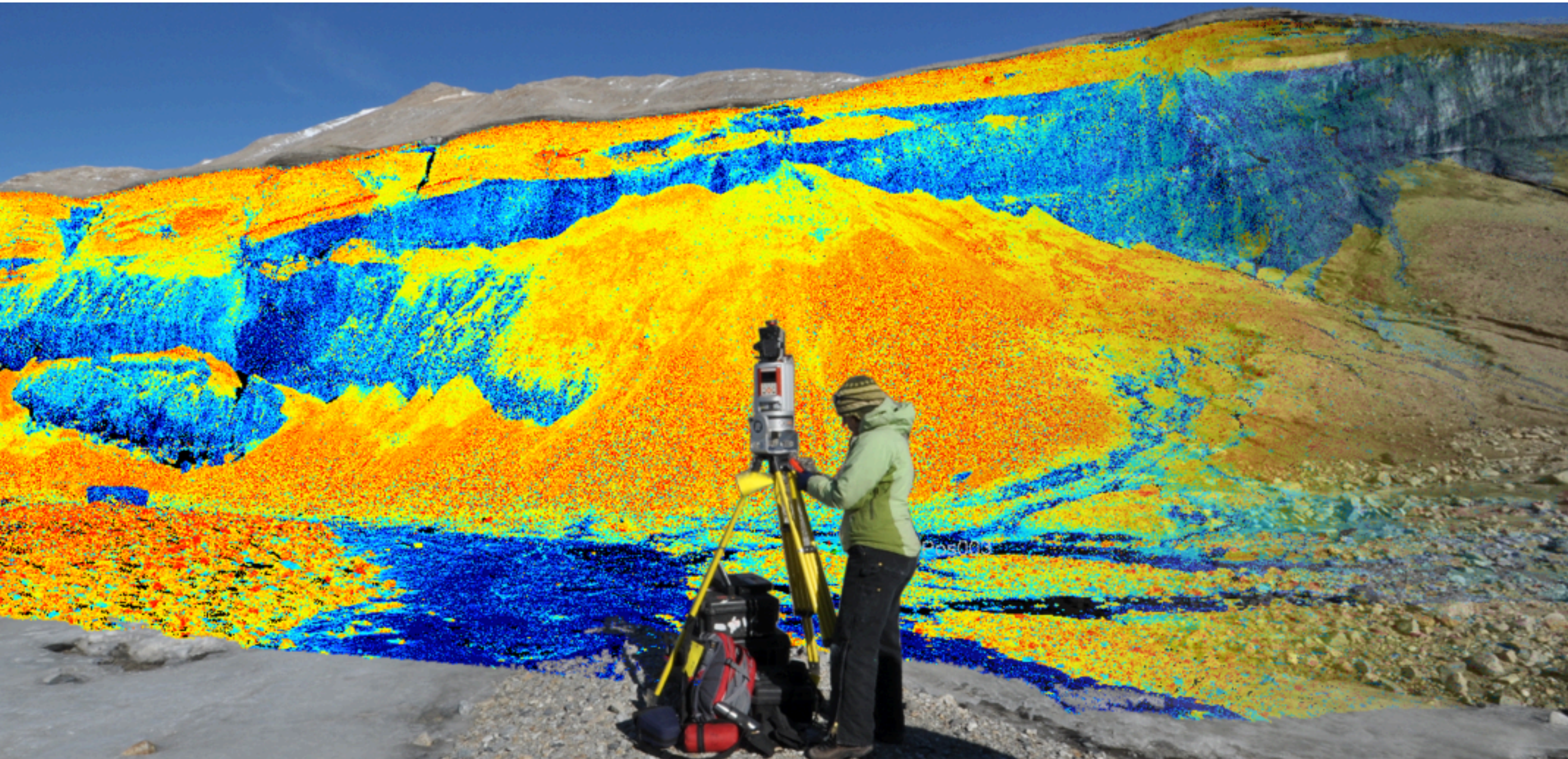
TLS Data Products & Analysis

C. Crosby, UNAVCO



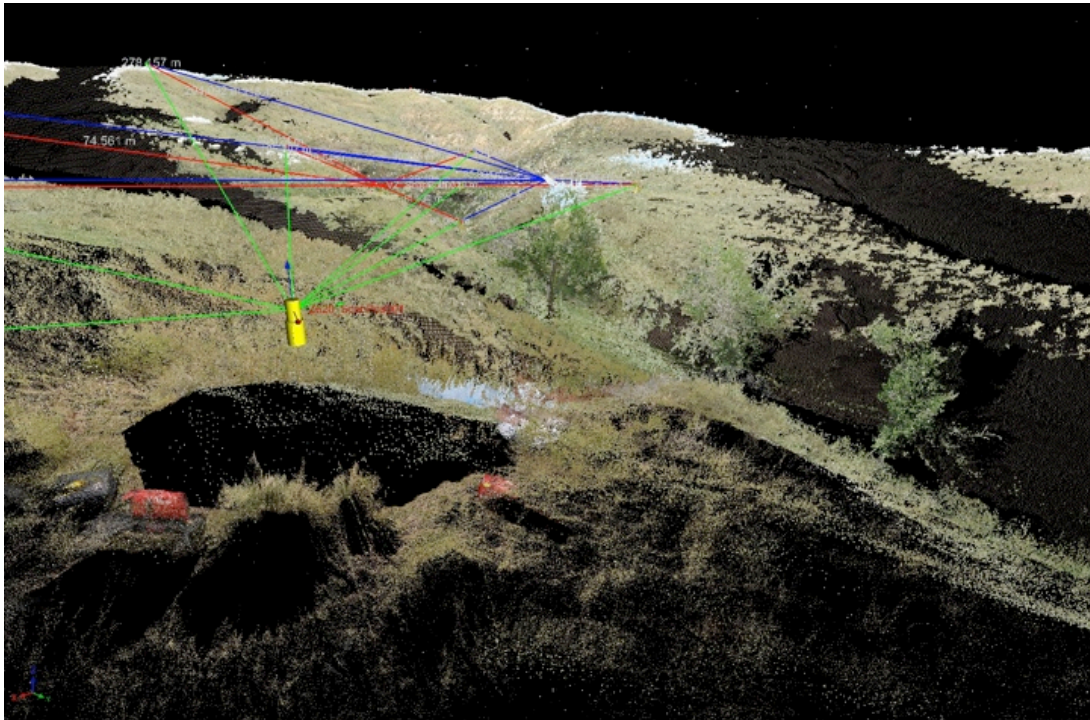
The problem…

Data volume – multi-GB per day of scanning

Scanner technology far outpaces most software available for data processing, management, and analysis.

Complex, multi-software workflows

Commercial ($$) software



How do you get from 10s or 100s of millions of X,Y,Z points to science?

TLS Processing Workflow – Software

9. What software do you use to process and/or analyze TLS data? Choose all that apply.

	Response Percent	Response Count
PolyWorks	29.9%	23
Cyclone	19.5%	15
Riscan	35.1%	27
TerraSolid	13.0%	10
Arc/GIS	**61.0%**	**47**
QT Modeler	18.2%	14
Matlab	32.5%	25
Other (specify)	28.6%	22
	Other (please specify)	32

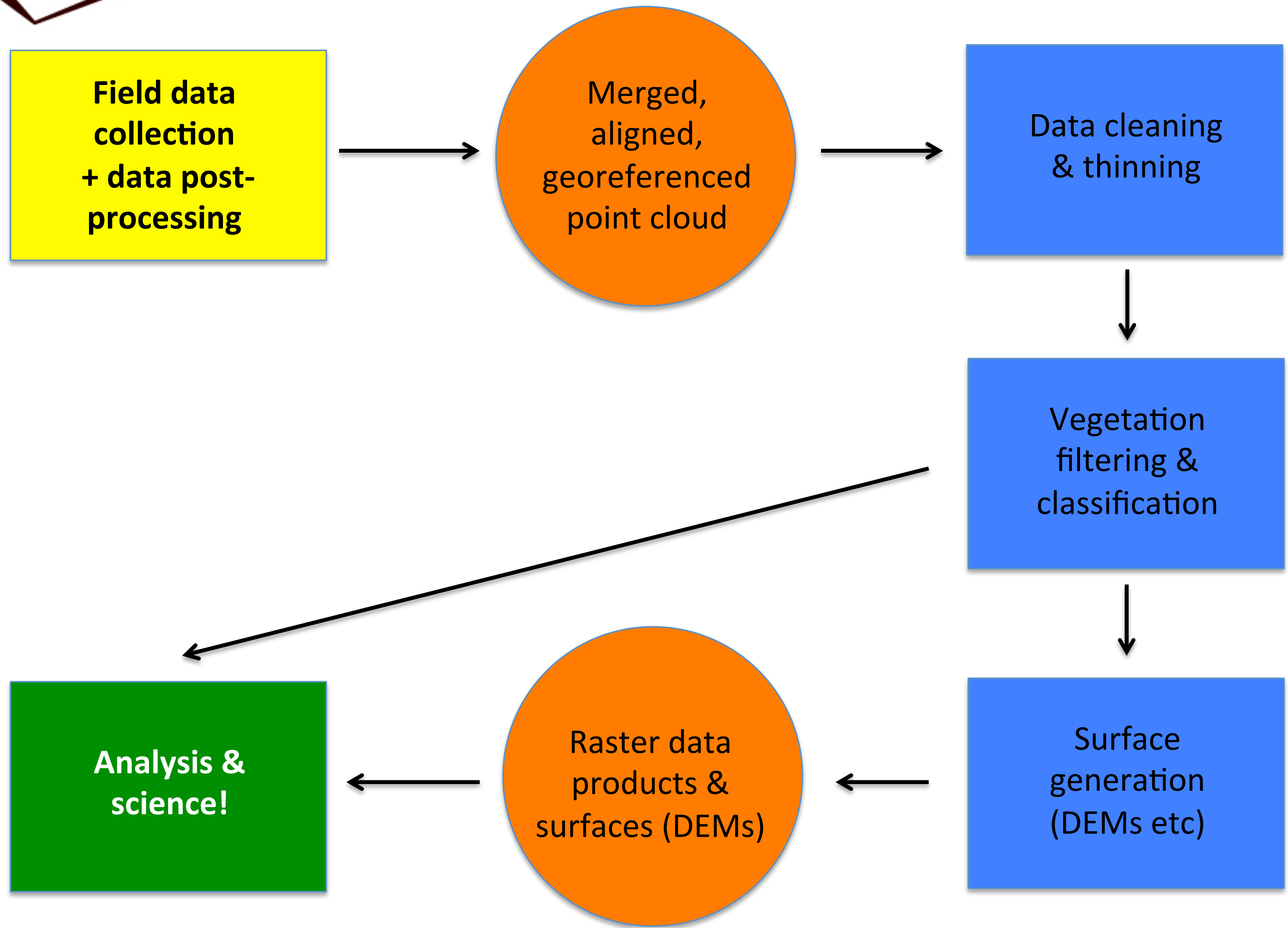
Other:

- 3D Studio
- 3dReshaper
- AutoCad
- BCAL LiDAR Tools
- Blender
- CloudWorx
- Crusta
- ENVI
- FARO Scene
- GDAL
- GeoAnalysis Tools
- Geovisionary
- Global Mapper
- GMT
- GRASS
- IDL
- Kingdom Suite
- LASTools
- libLAS
- MapScenes
- MapTek I-SiTE Studio
- Meshlab
- MicroCad
- MicroStation
- MicroSurveyCAD
- OpenTopography DEM generator
- OpenVC
- Point Cloud Library (PCL)
- Points2Grid
- PointTools
- Python modules and custom tools
- RealityLinx
- Split-FX
- Surfer
- TerraModeler
- Trimble RealWorks
- UC Davis tools
- (LidarViewer, Crusta)
- “home grown software”

Point Cloud

- 3D "point cloud" of discrete locations derived from range and orientation of scanner for each laser pulse.
- XYZ position in cartesian coordinates plus associated point attributes: intensity, RGB, etc.
- 3D point clouds are the basis for subsequent analysis and used to create CAD or GIS models
- Typically ***ASCII XYZ*** + attributes or ***LAS***
  - E57 = New standard under development, minimal adoption
- UNAVCO ***standard deliverable*** = merged, aligned, georeferenced point cloud in ASCII or LAS format.

TLS Processing Workflow – Overview



TLS Processing Workflow – Digital Elevation Models

- Digital representation of topography / terrain
  - "Raster" format – a grid of squares or "pixels"
  - Continuous surface where Z (elevation) is estimated on a regular X,Y grid
  - "2.5D"

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
0	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	0
0	50	100	150	150	150	150	150	150	150	150	150	150	150	100	50	0
0	50	100	150	200	200	200	200	200	200	200	200	200	150	100	50	0
0	50	100	150	200	250	250	250	250	250	250	250	200	150	100	50	0
0	50	100	150	200	250	300	300	300	300	300	250	200	150	100	50	0
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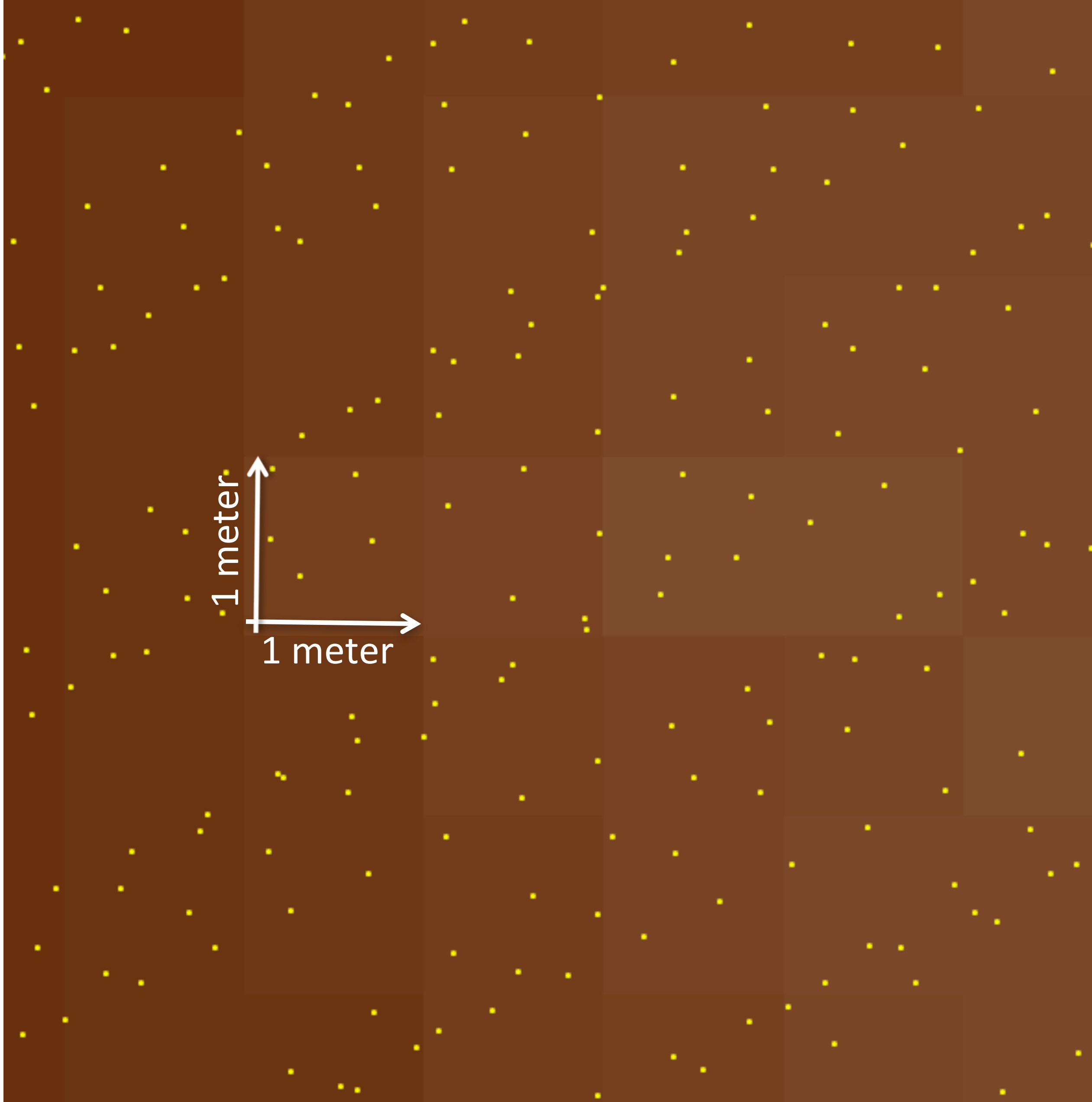
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: http://www.ncgia.ucsb.edu/giscc/extra/e001/e001.html

- Grid resolution is defined by the size in the horizontal dimension of the pixel
  - 1 meter DEM has pixels 1 m x 1m assigned a single elevation value.

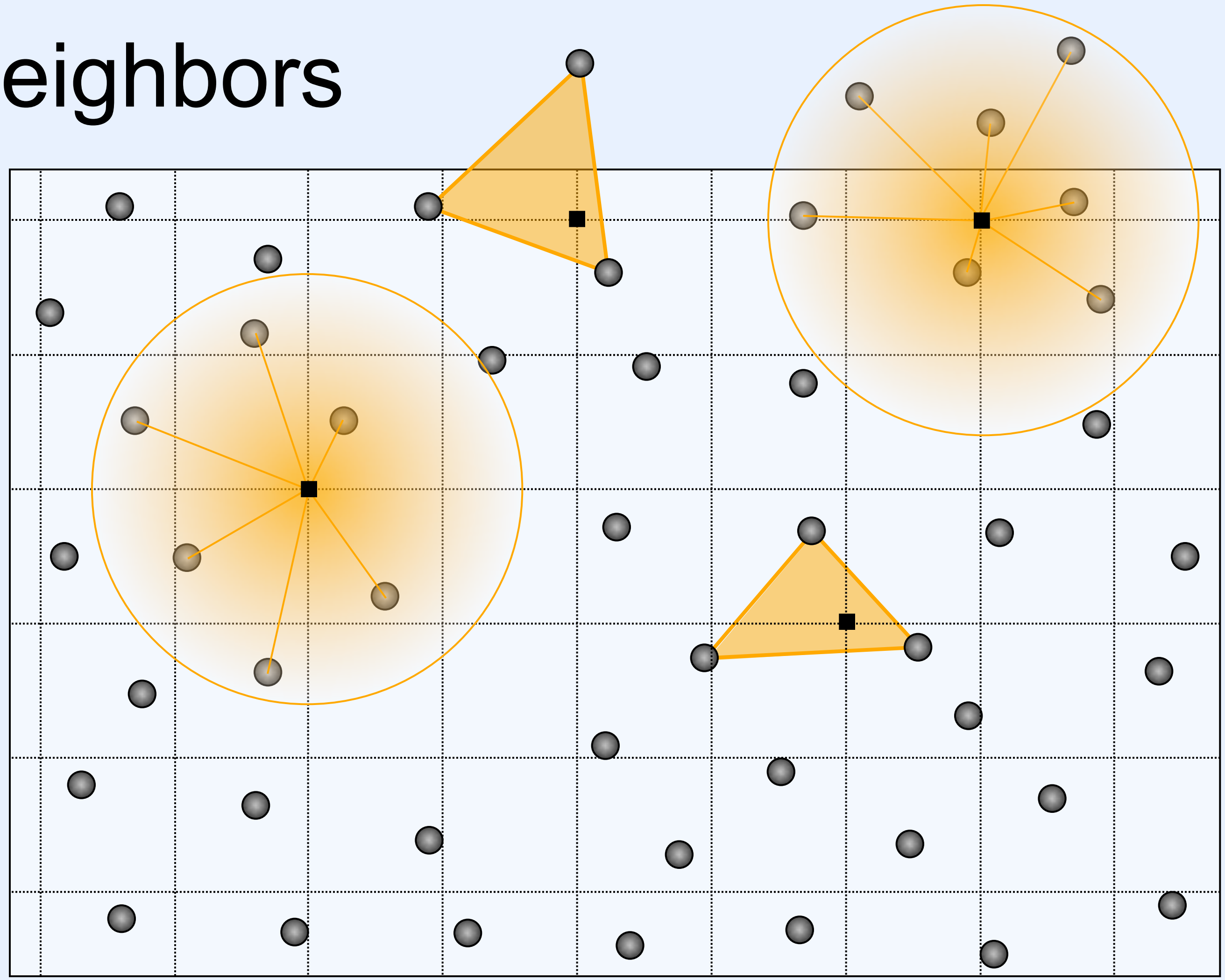
Generating DEMs from LIDAR

- EarthScope lidar data
- Example from flat area with little or no vegetation. Ground sampled 5+ times per square meter
- How do we best fit a continuous surface to these points?
- Ultimately wish to represent irregularly sampled data on a regularized grid.

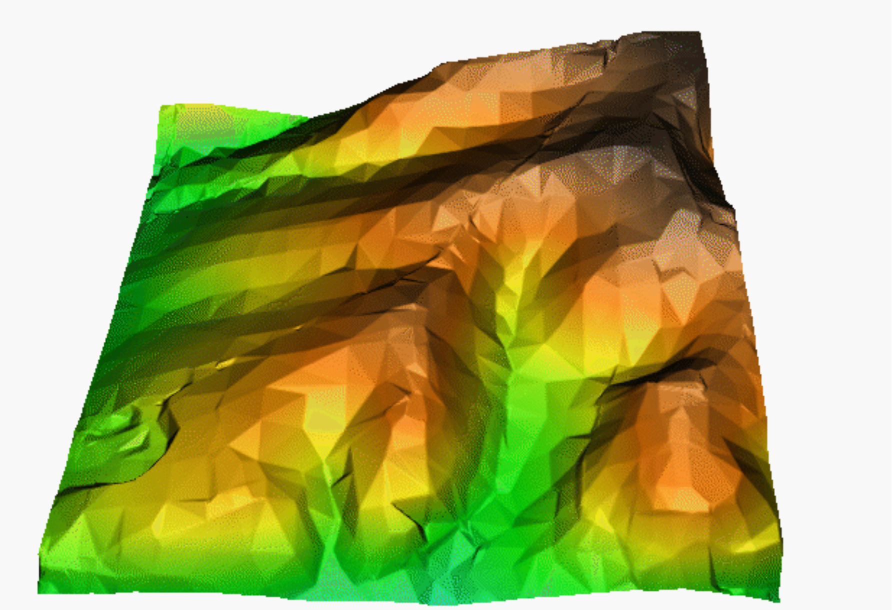


Interpolation Methods

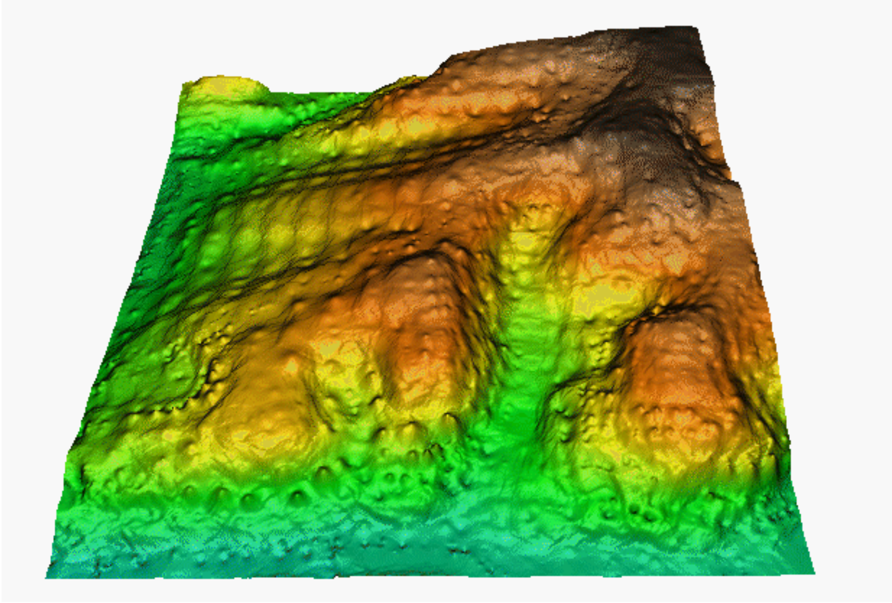
- Inverse Distance Weighting (IDW)
- Natural Neighbors
- Kriging
- Splines
- TIN
  - linear
  - quintic
- …



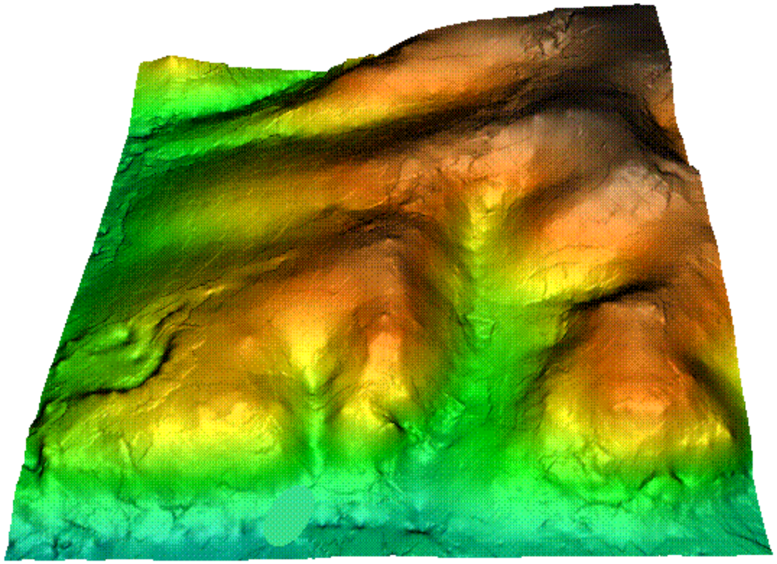
Isenburg, et al., 2006



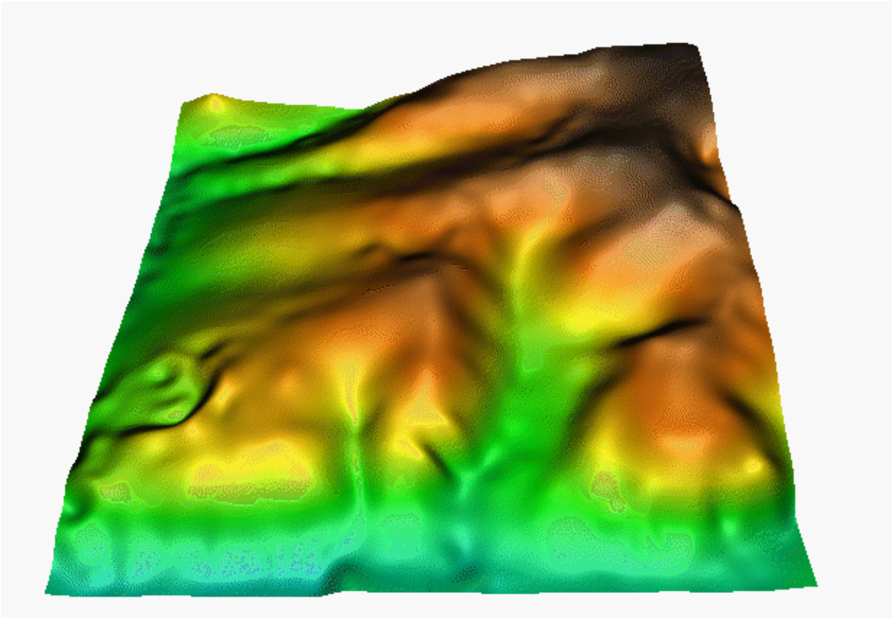
Triangulated Irregular Network (TIN)



Inverse Distance Weighted (IDW)



Kriging

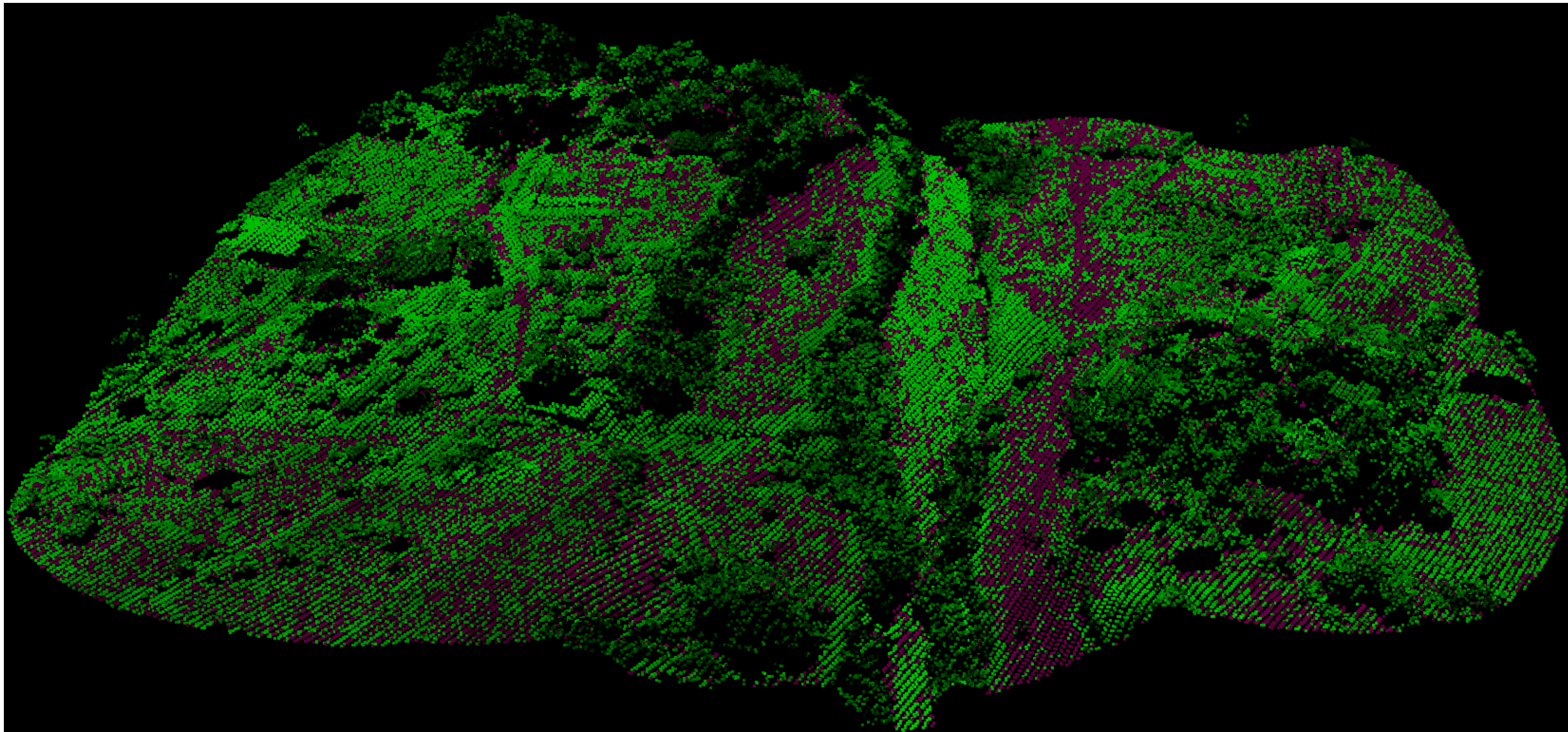


Regularized Spline with Tension and smoothing (RST)

Figure from Helena Mitasova (NCSU): http://skagit.meas.ncsu.edu/~helena/gmslab/index.html

Vegetation is a headache is geoscientists

- *Our noise is someone else's signal*
- How to get good ground model? - Automated vs manual?



Dumay Slip-Rate Site, Enriquillo Fault, Haiti

P. Gold, UCD

Typical approach ⇒ despike algorithm

Approach:

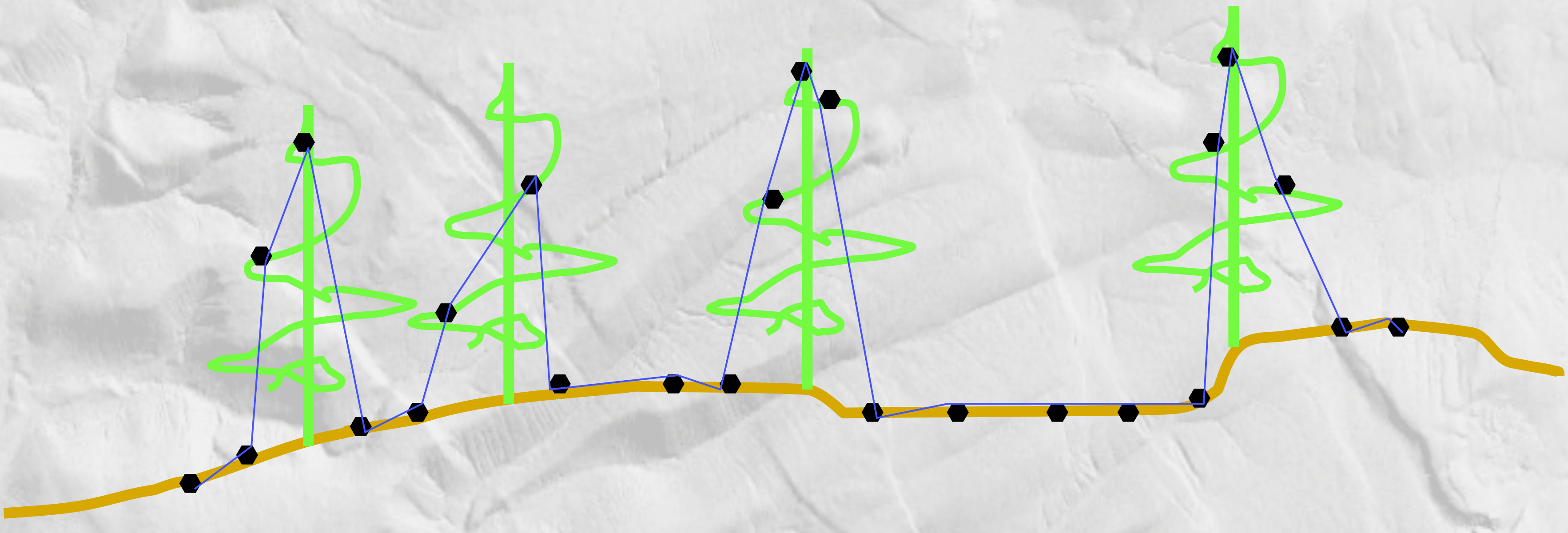
1. flag all points as ground

2. repeat:
   - build TIN (triangulated irregular network) of ground points
   - identify points that define strong positive curvatures
   - flag identified points as not-ground

3. Iterate until no or few points are flagged

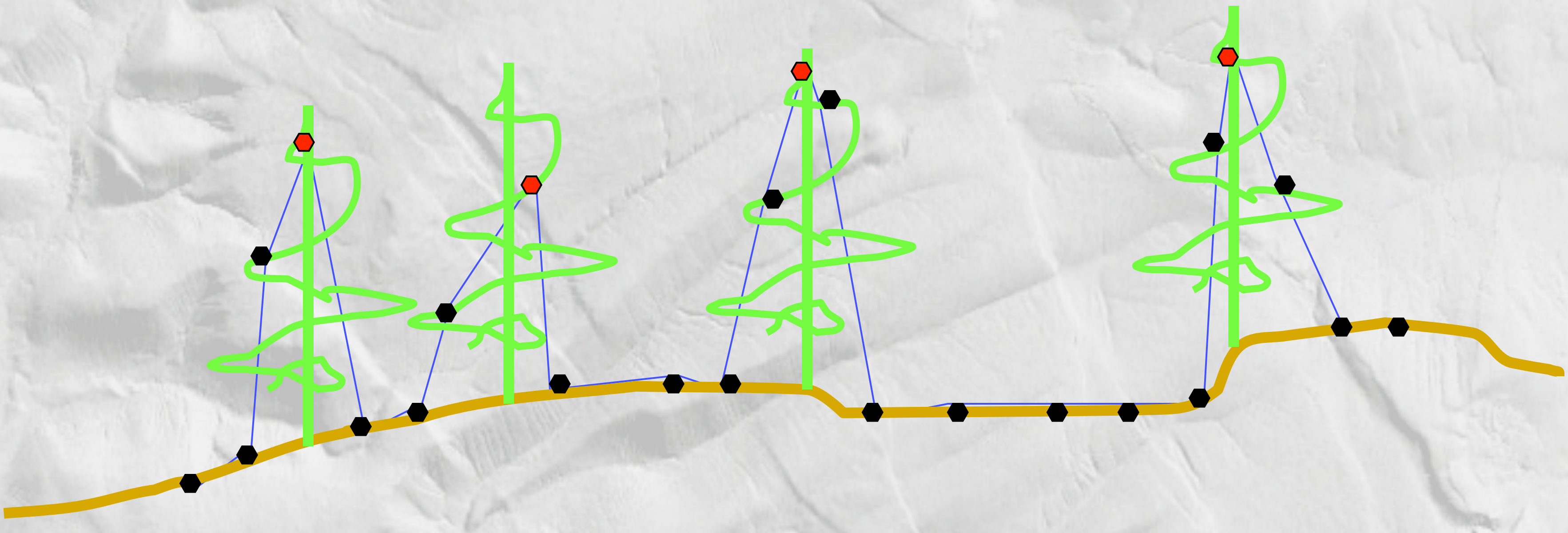
Modified from: R. Hagerud, USGS

Start with mixed ground and canopy returns (e.g. last-return data), build TIN



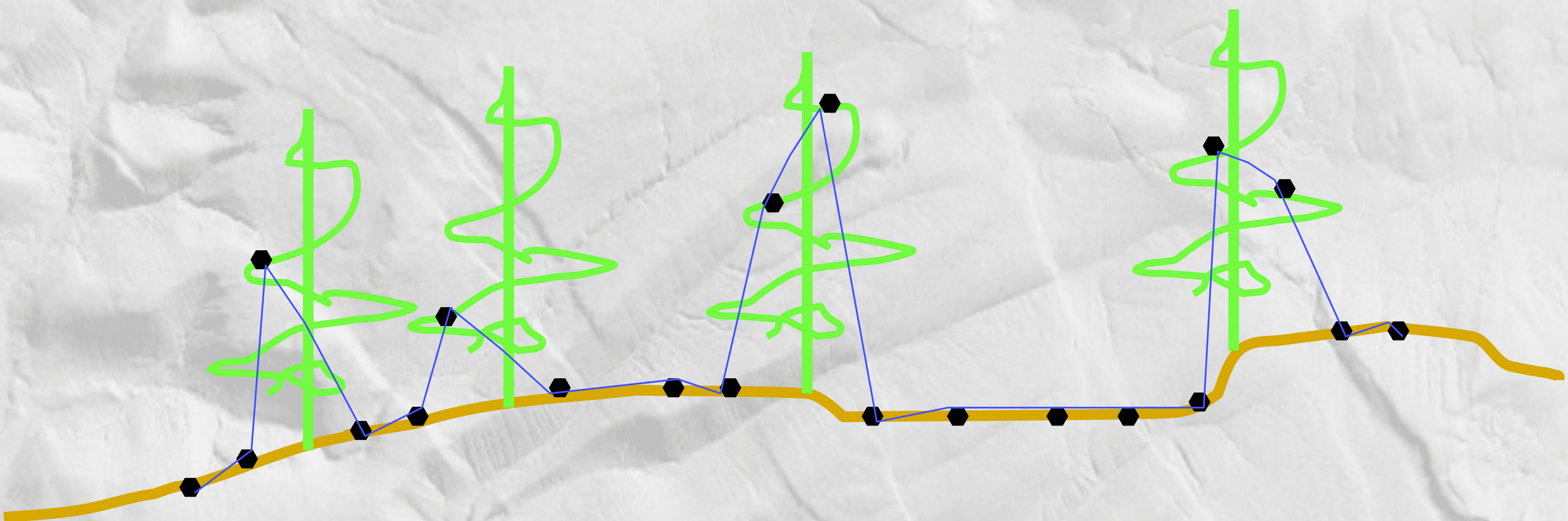
R. Hagerud, USGS

Flag points that define spikes (strong convexities)



R. Hagerud, USGS

Rebuild TIN



R. Hagerud, USGS

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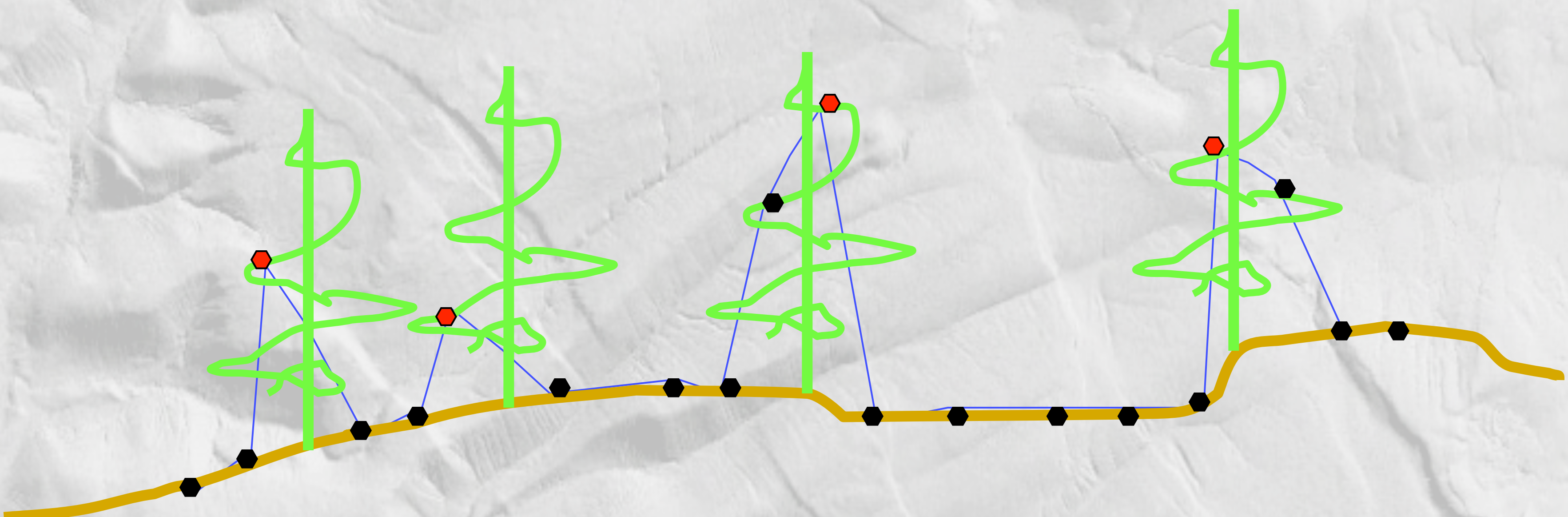
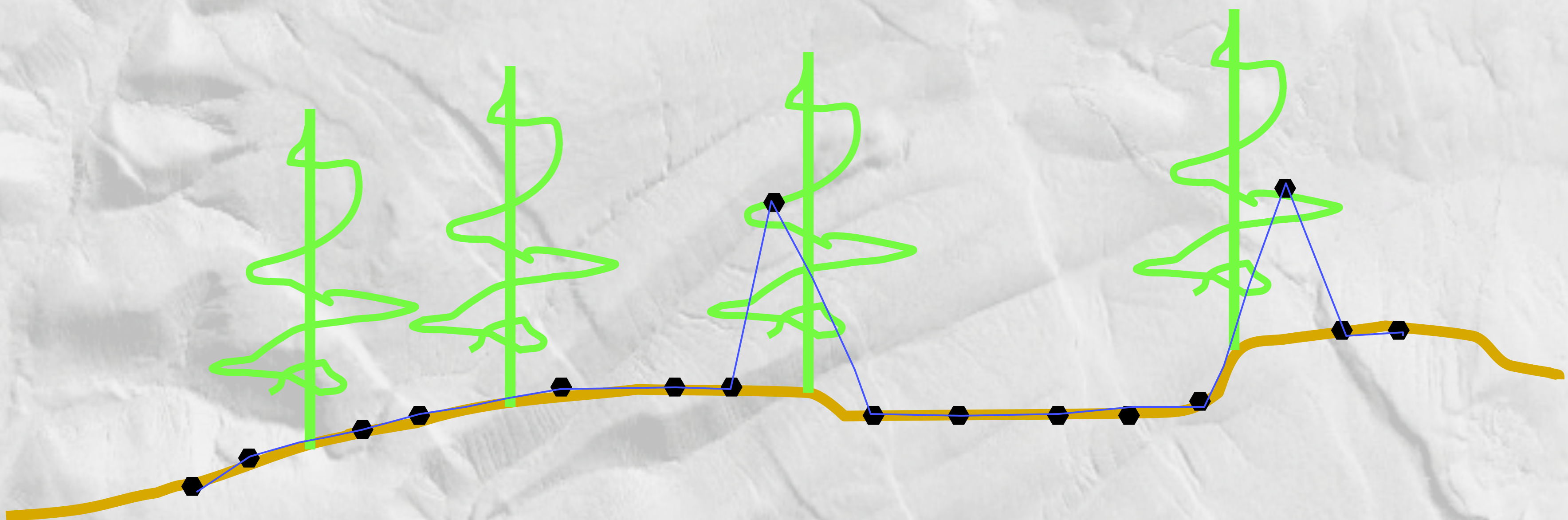


R. Hagerud, USGS

Rebuild TIN



R. Hagerud, USGS

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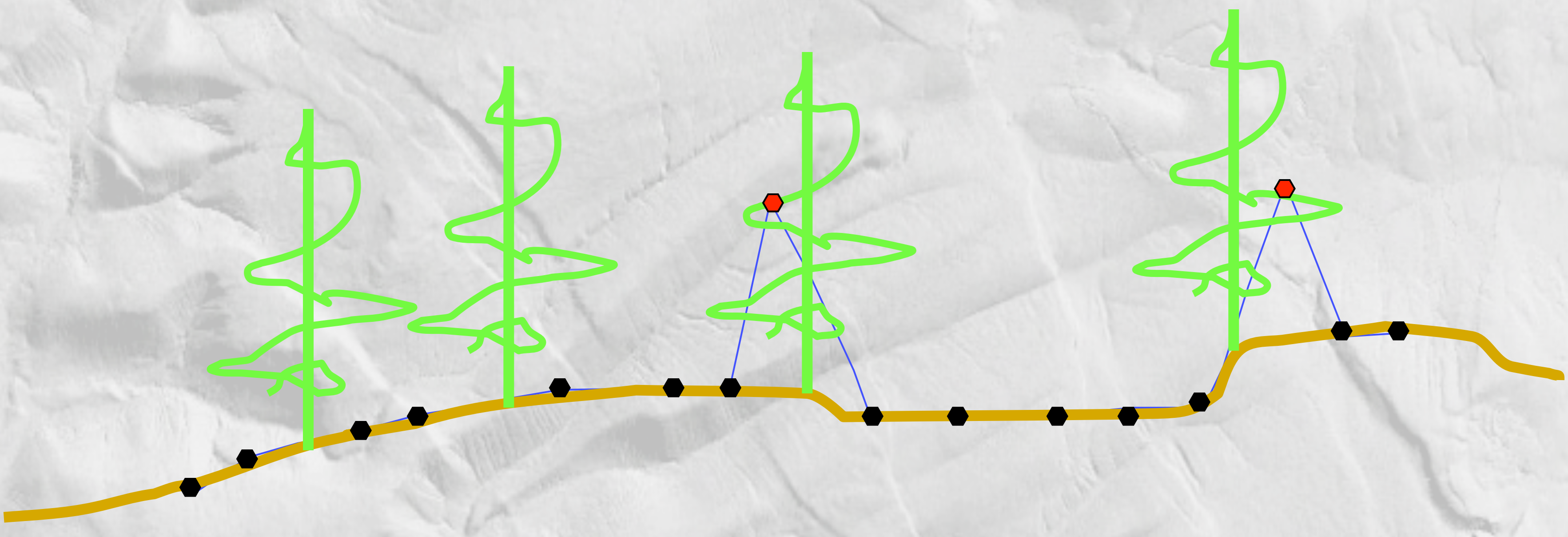
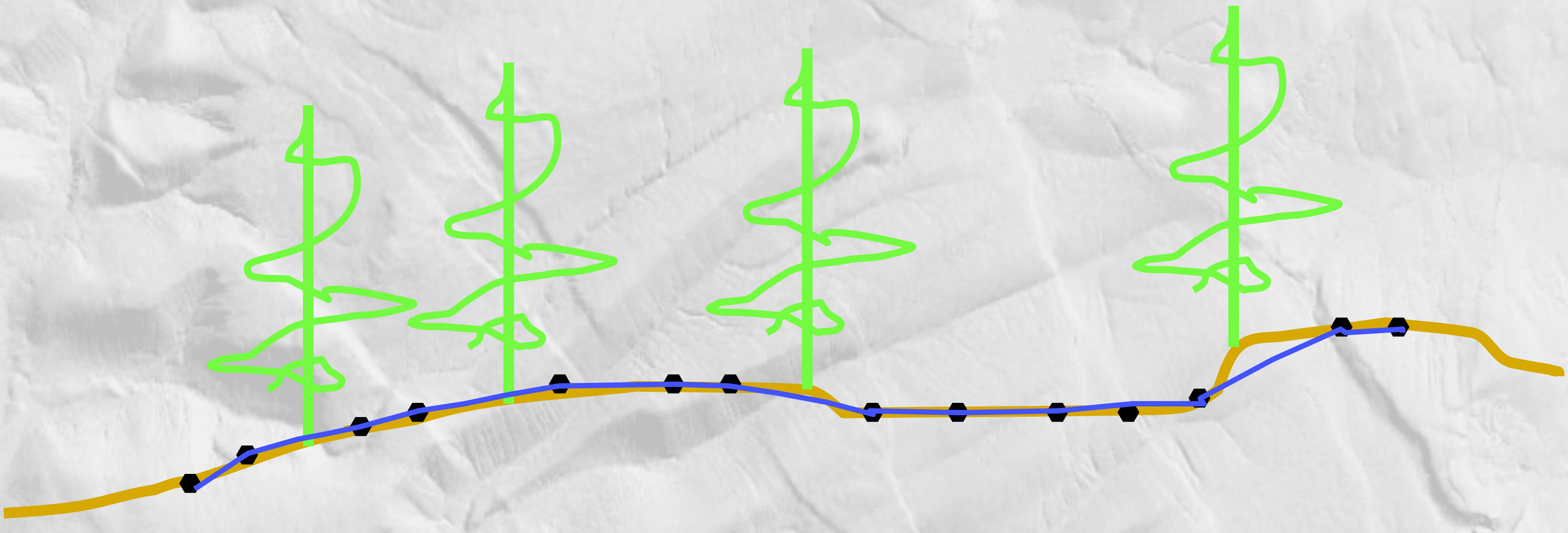


R. Hagerud, USGS

Rebuild TIN



R. Hagerud, USGS

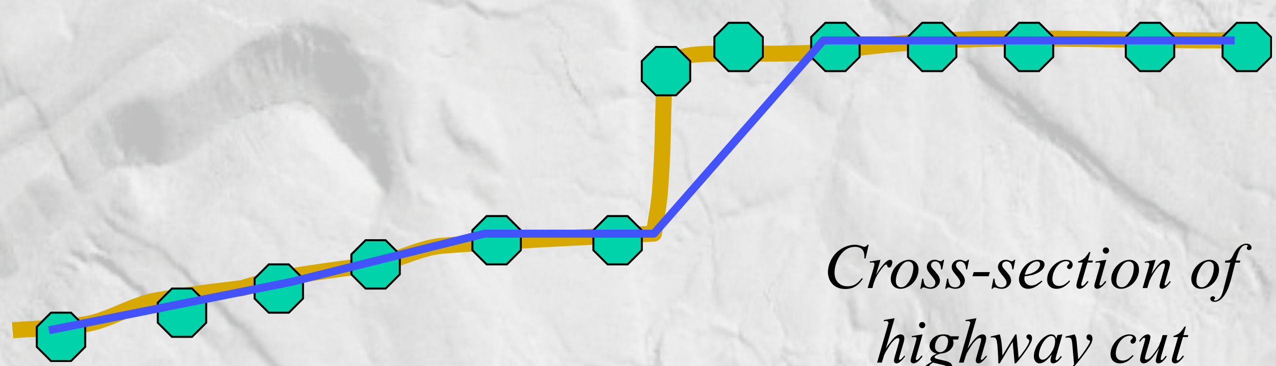
Despike algorithm

Benefits:

- It works
- It's automatic
  - Cheap(!)
  - All assumptions explicit
- It can preserve breaklines
- It appears to retain more ground points than other algorithms

R. Hagerud, USGS

Despike algorithm



Cross-section of highway cut

<u>Problems</u>:

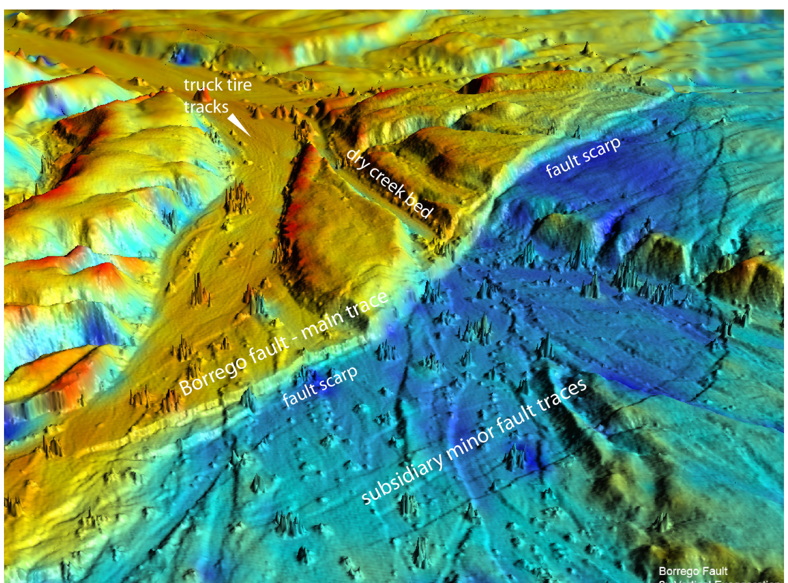
- Removes some corners
- Sensitive to negative blunders
- Computationally intensive
- Makes rough surfaces
  - Real? Measurement error? Misclassified vegetation?

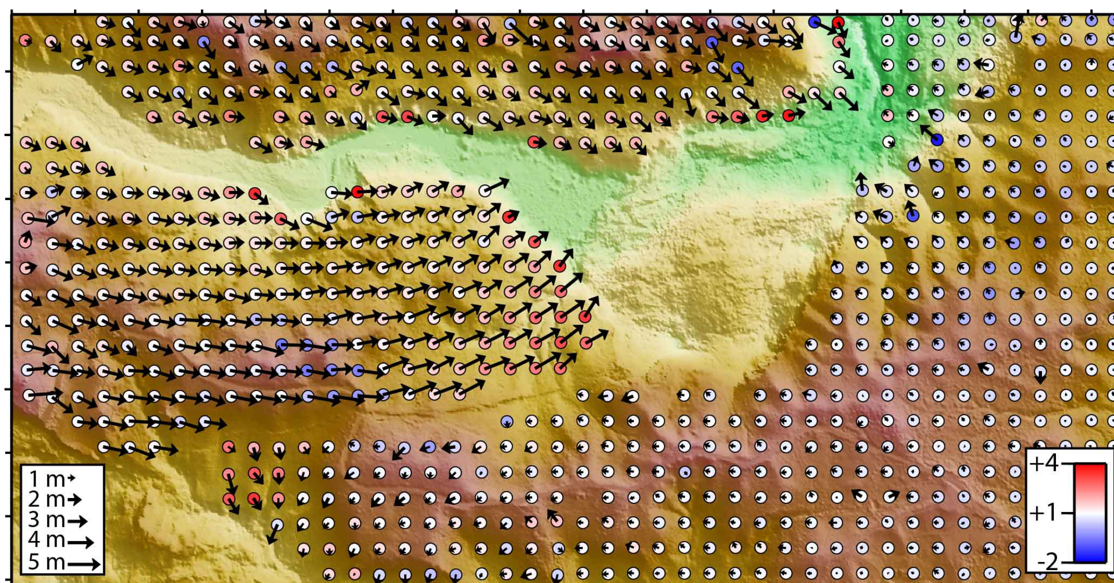
R. Hagerud, USGS

Change Detection

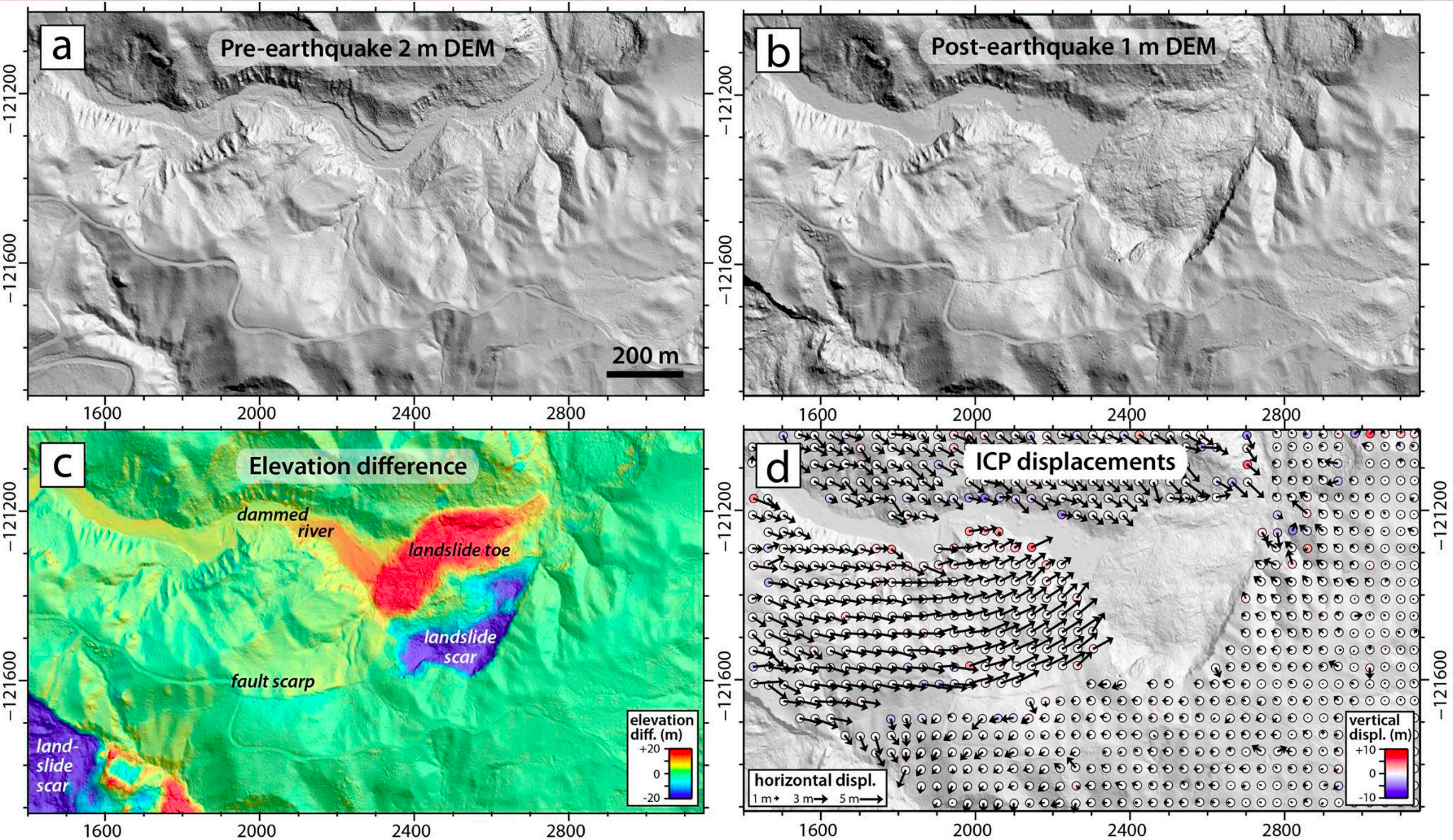
- Repeat TLS data (or TLS combined w/ ALS data) provide opportunity to explore topographic change and driving processes.

- Vertical change vs 3D displacements?
  - Depends on the geophysical process being studied.
  - Datasets must be well aligned – horizontal and vertical coordinates, datums, etc.
  - Signal must be larger than noise and error in datasets





Change Detection



Nissen et al., 2014, Coseismic fault zone deformation revealed with differential lidar: Examples from Japanese Mw ~7 intraplate earthquakes