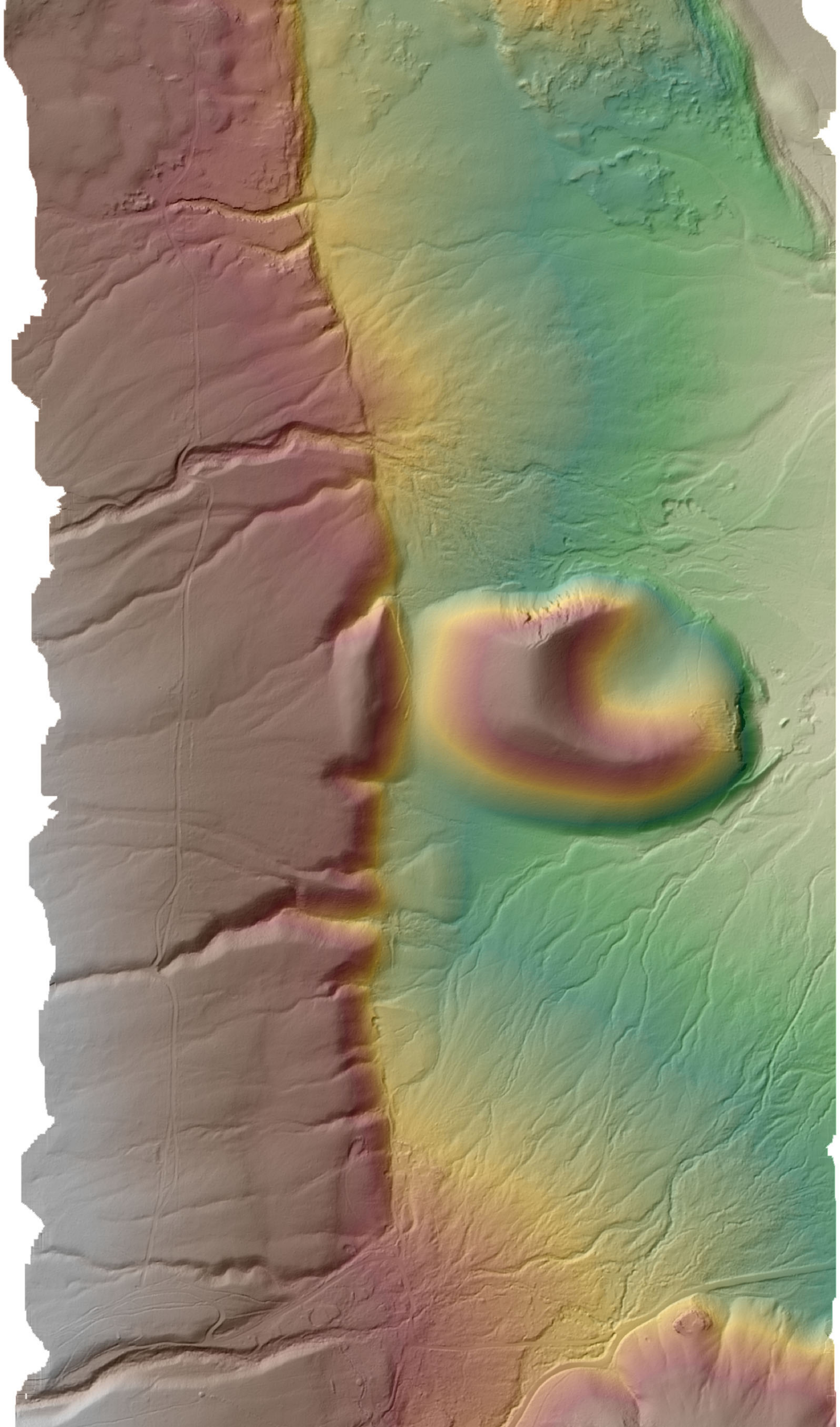


Lidar quality, artifacts, issues to keep in mind

Christopher Crosby

UNAVCO / OpenTopography

(with content adapted from Ralph Hagerud & Ken Hudnut (USGS); Ian Madin, DOGAMI; Quantum Spatial)

2016 OpenTopography / UNAVCO Short Course:

Imaging & Analyzing Active Faults with High Resolution Topography

April 18-19, 2016

UNAVCO, Boulder, CO

Lidar Data Quality

Not all lidar is created equal – huge range in quality, resolution, accuracy of data publicly available.

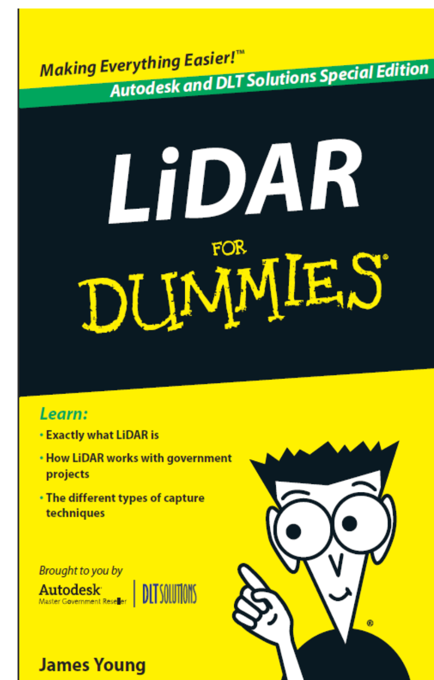
Typical metric is pulse density / shot ("post") spacing:

- Describes sampling density of data and potential grid resolution.
- Shot density highly heterogeneous.
- Ground point density typically far lower than total pulse density

Evaluate lidar data quality by:

- Testing against ground control
- Looking at big images
- Quantifying swath to swath reproducibility

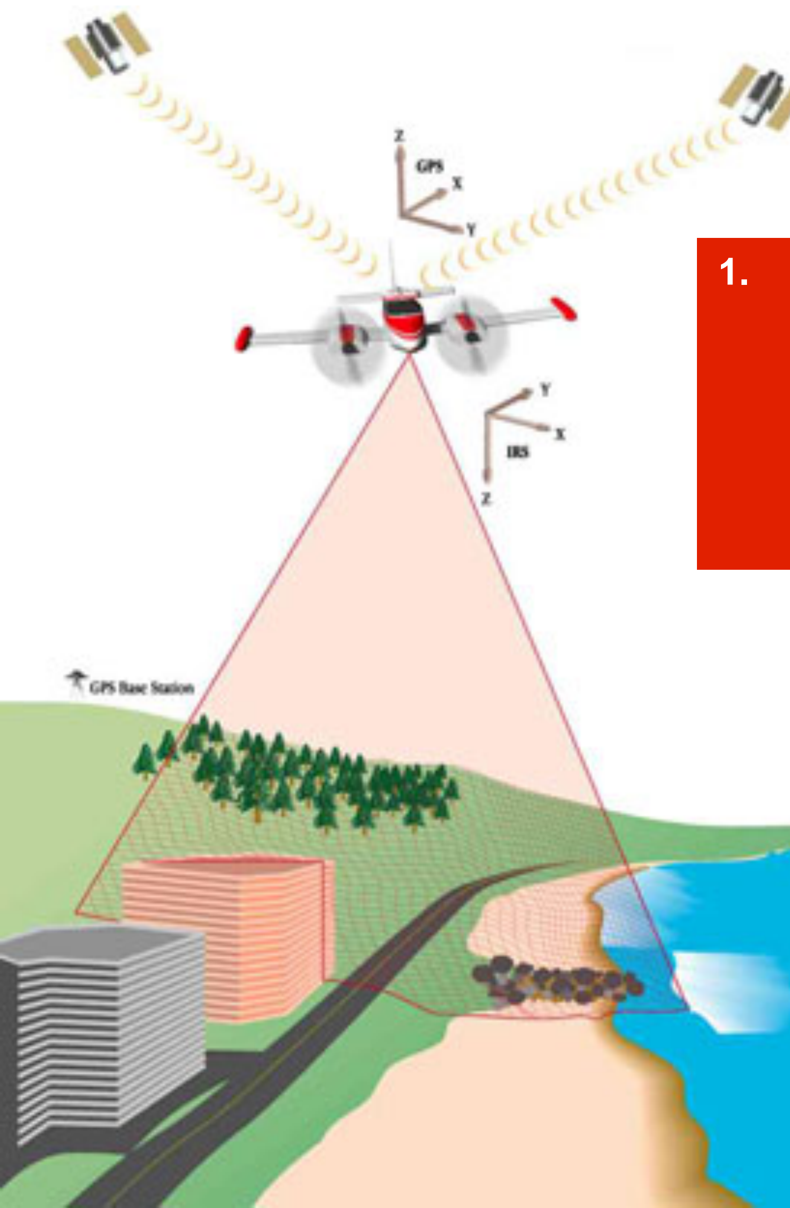
Read the metadata & survey report



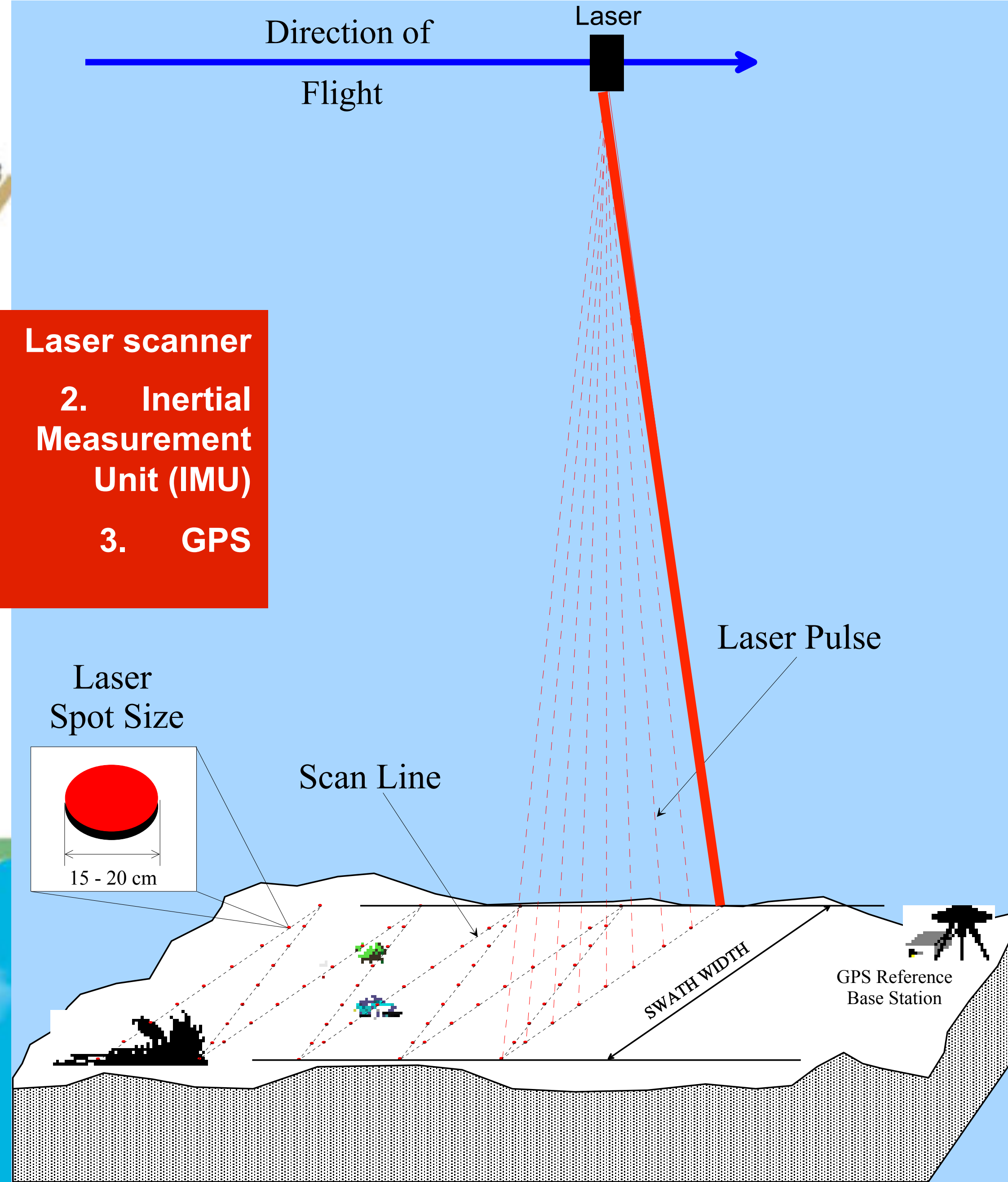
Modified from R. Hagerud, USGS

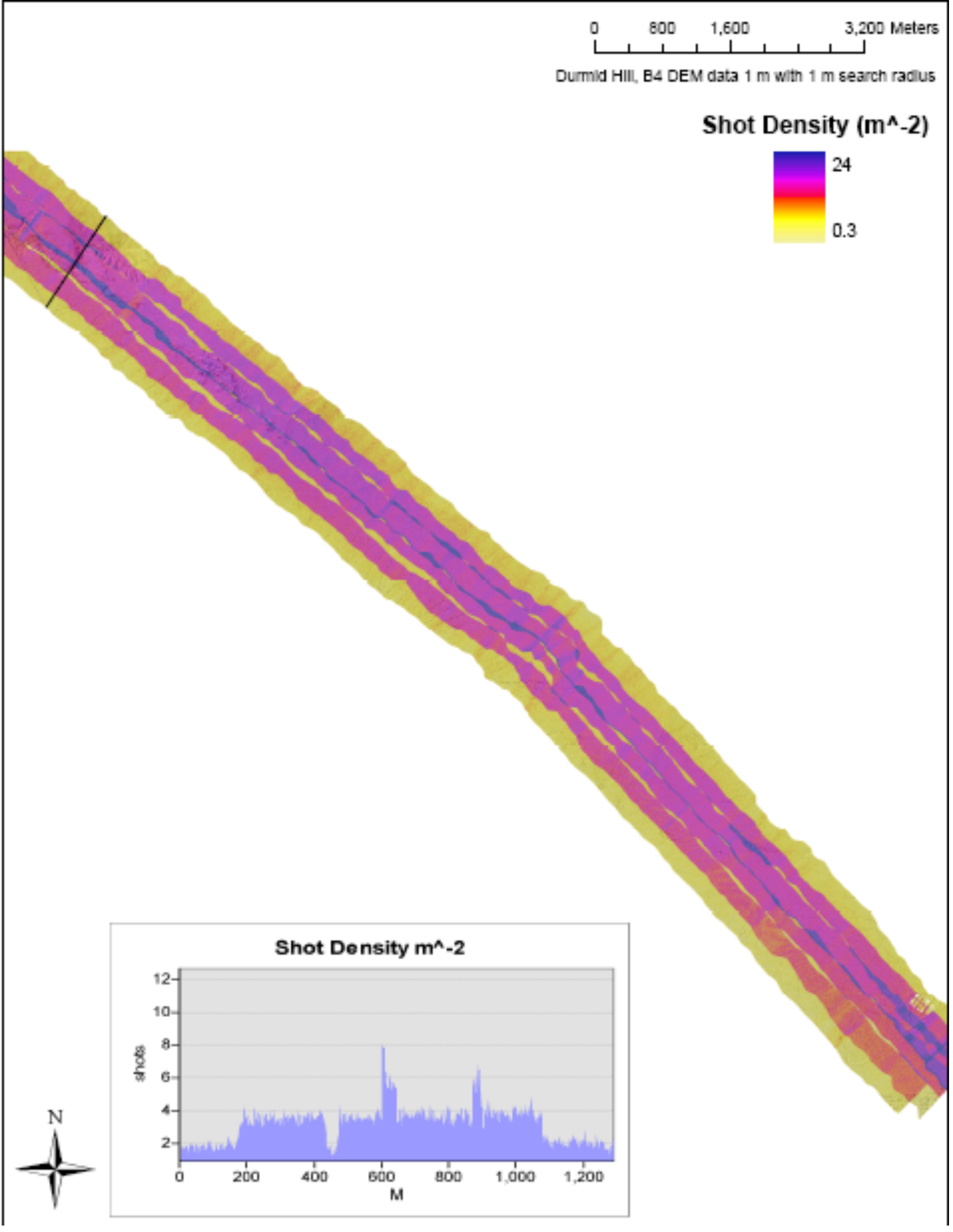
NCALM
The National Center for Airborne Laser Mapping

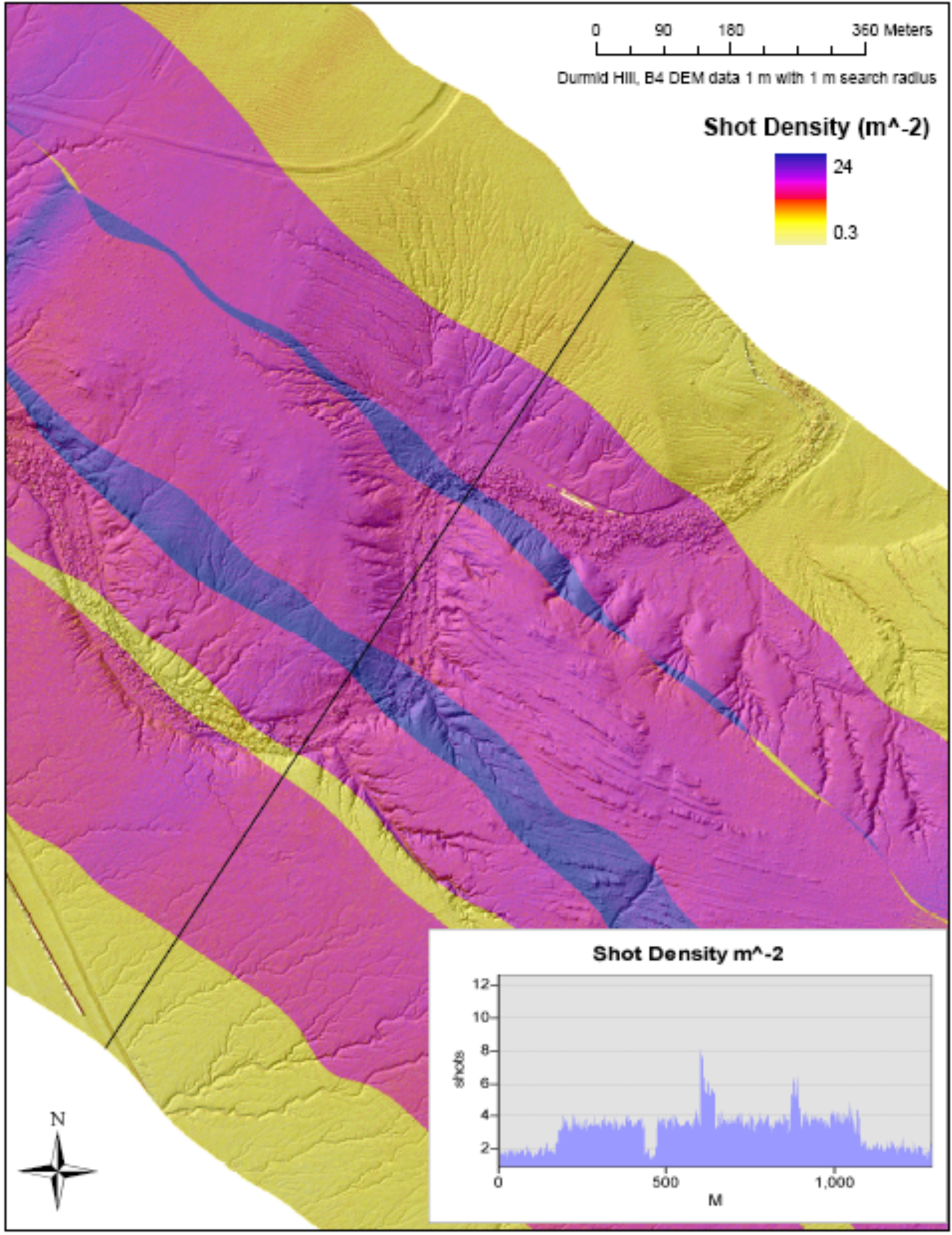
Lidar data collection



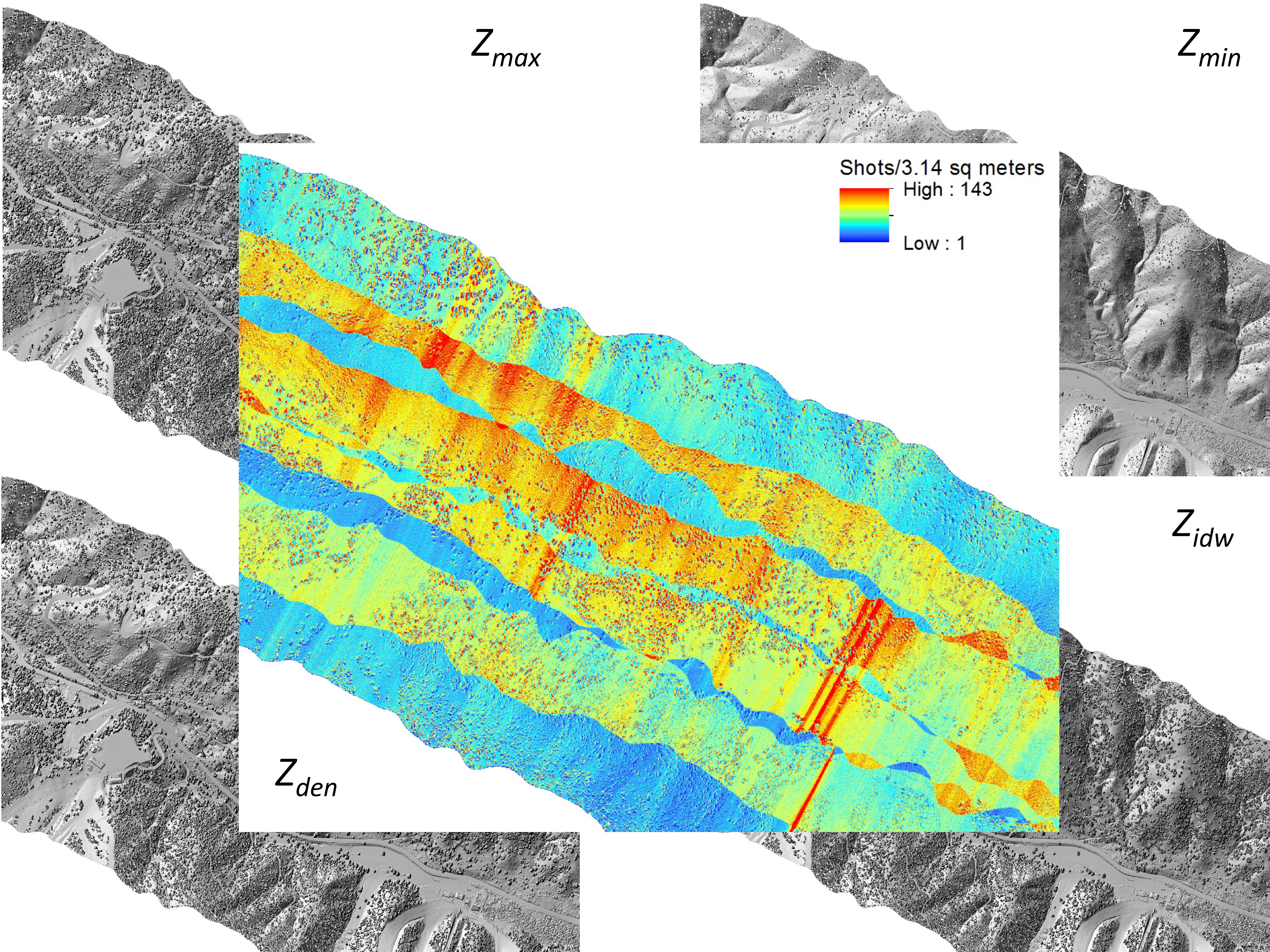
1. Laser scanner
2. Inertial Measurement Unit (IMU)
3. GPS







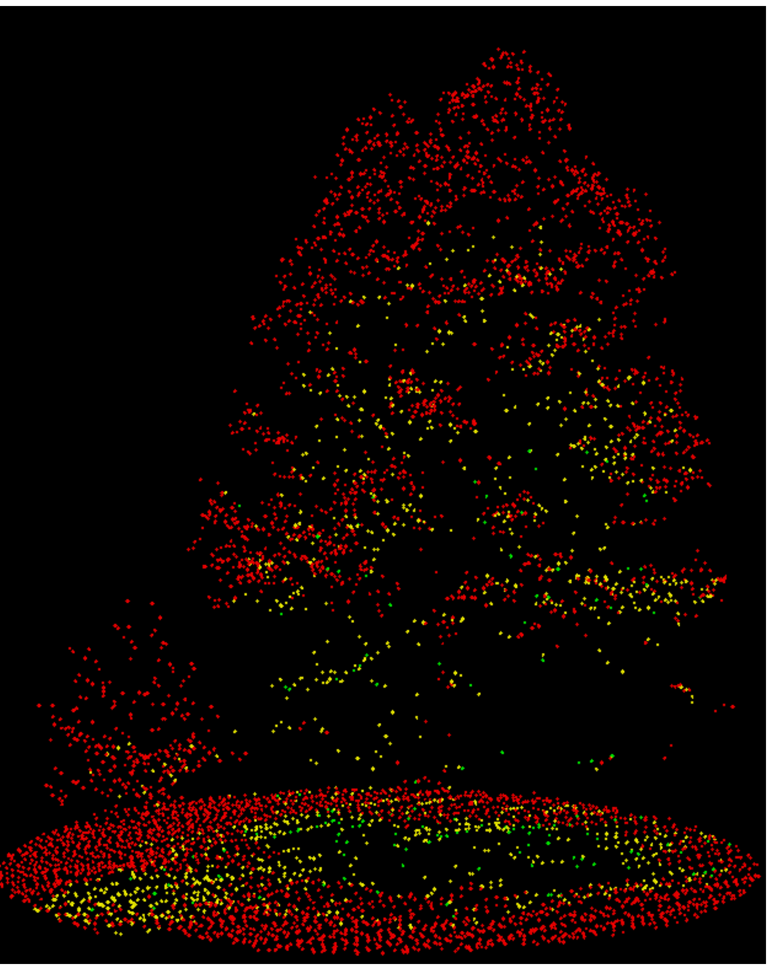
Heterogeneity of surface sampling: B4 shot density maps and profiles



Z_{max}
Z_{min}
Shots/3.14 sq meters
High : 143
Low : 1
Z_{idw}
Z_{den}

Each laser pulse can produce multiple consecutive measurements from reflections off several surfaces in its path

Ian Madin, DOGAMI

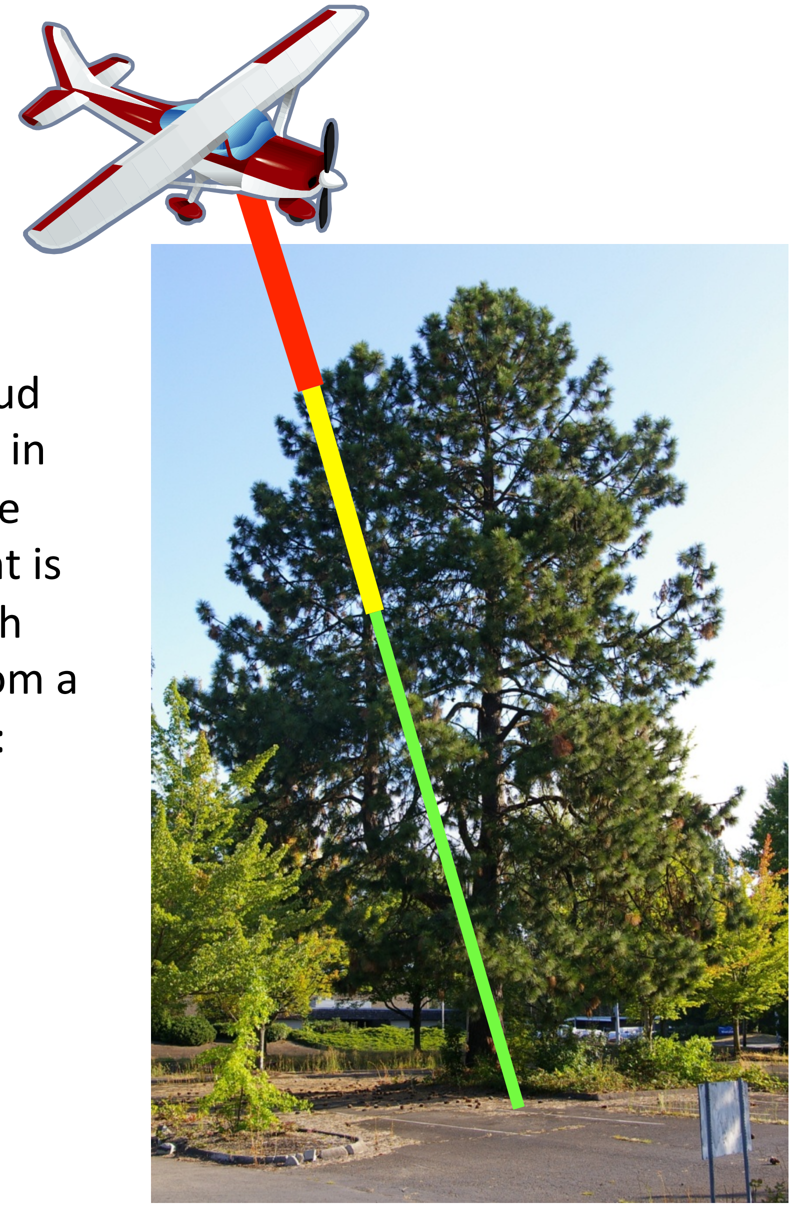


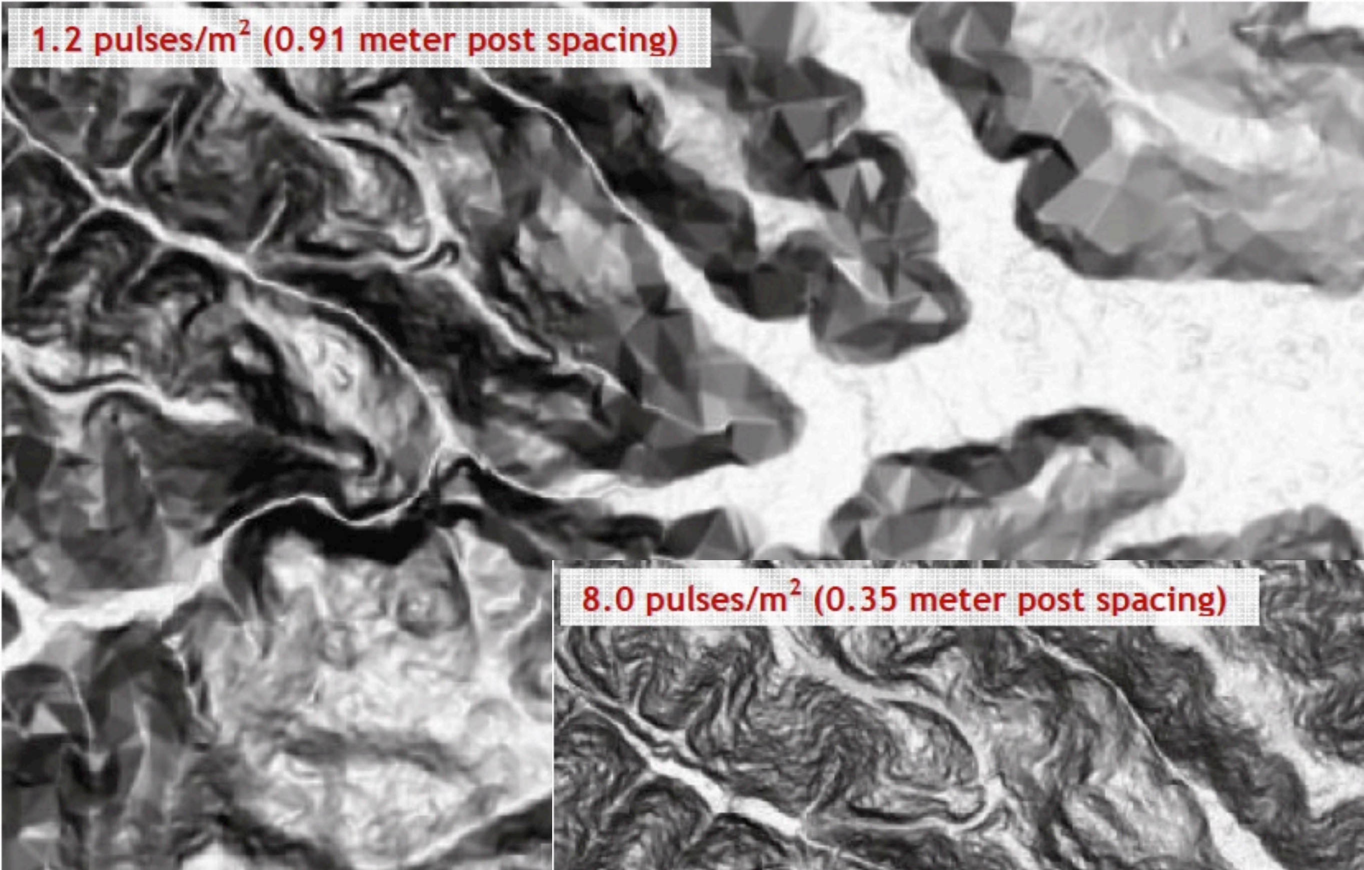
Left = point cloud view of the tree in the photo on the right. Each point is colored by which return it was from a particular pulse:

Red= 1^{st}

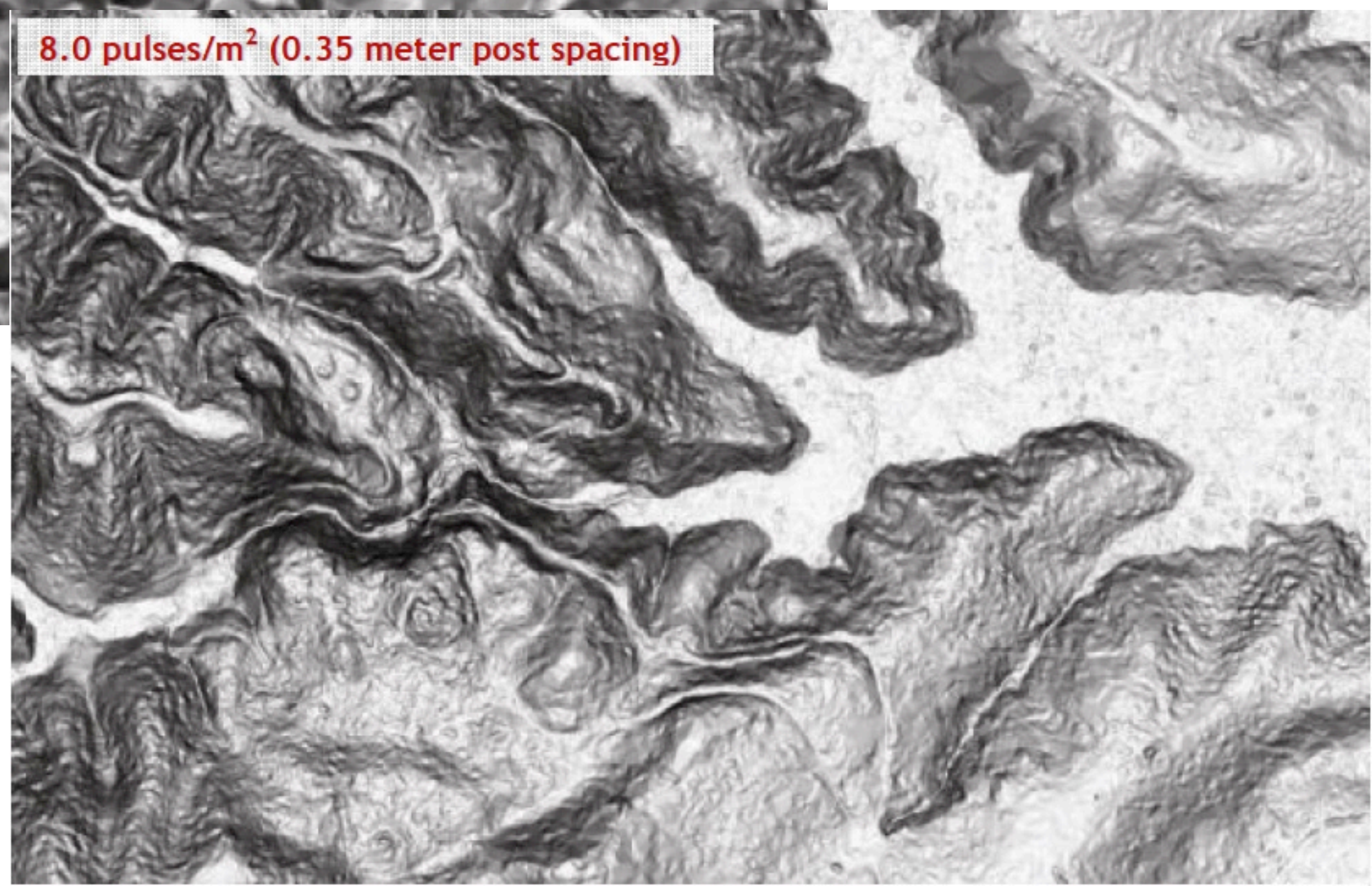
Yellow = 2^{nd}

Green = 3^{rd}



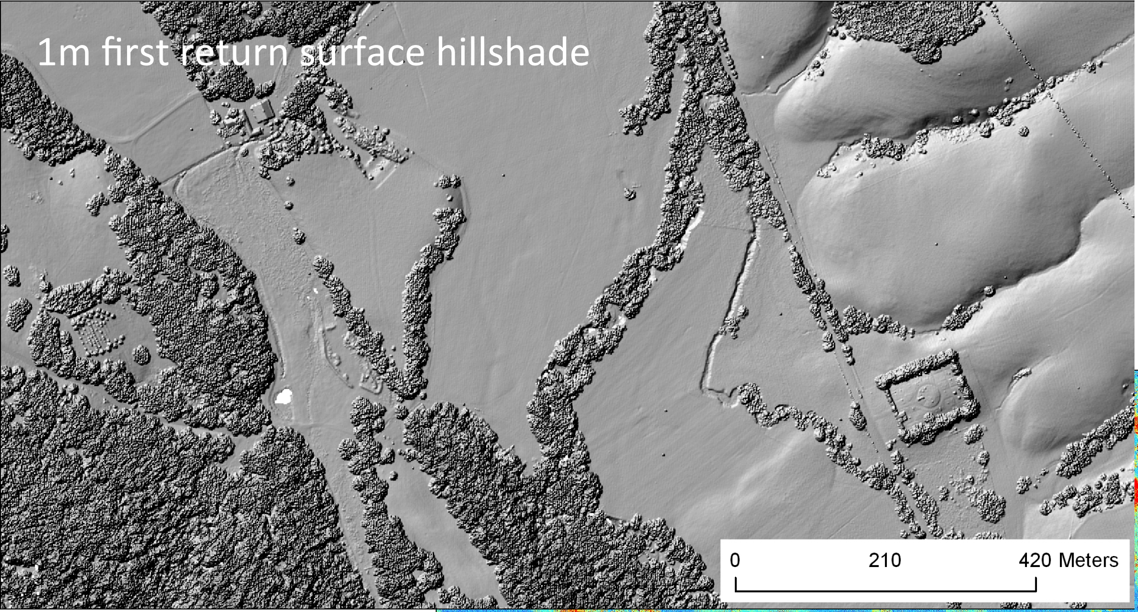


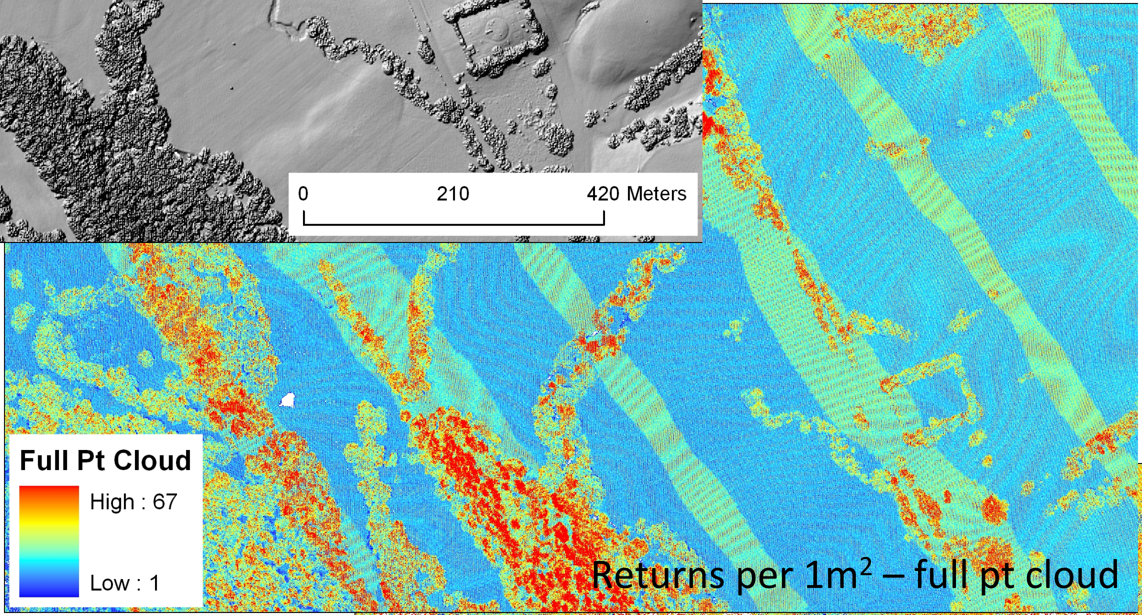
In the PNW:
14% of points classified as ground



Minimum LiDAR Considerations in the Pacific Northwest
Watershed Sciences, Inc.
http://www.oregongeology.org/sub/projects/olc/minimum-lidar-data-density.pdf

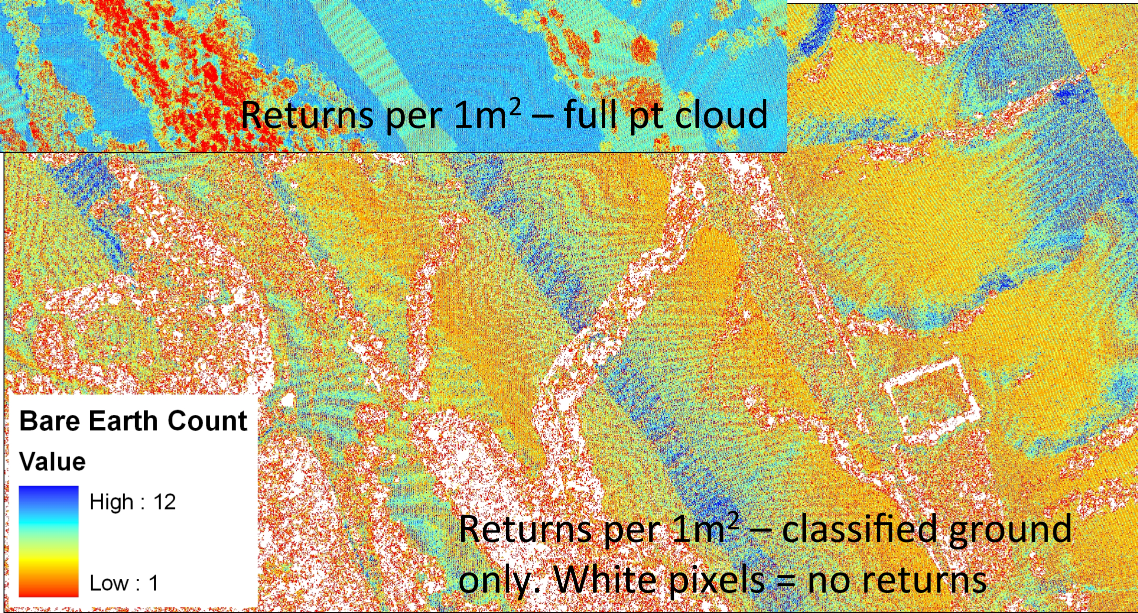
Ground return density = DEM resolution

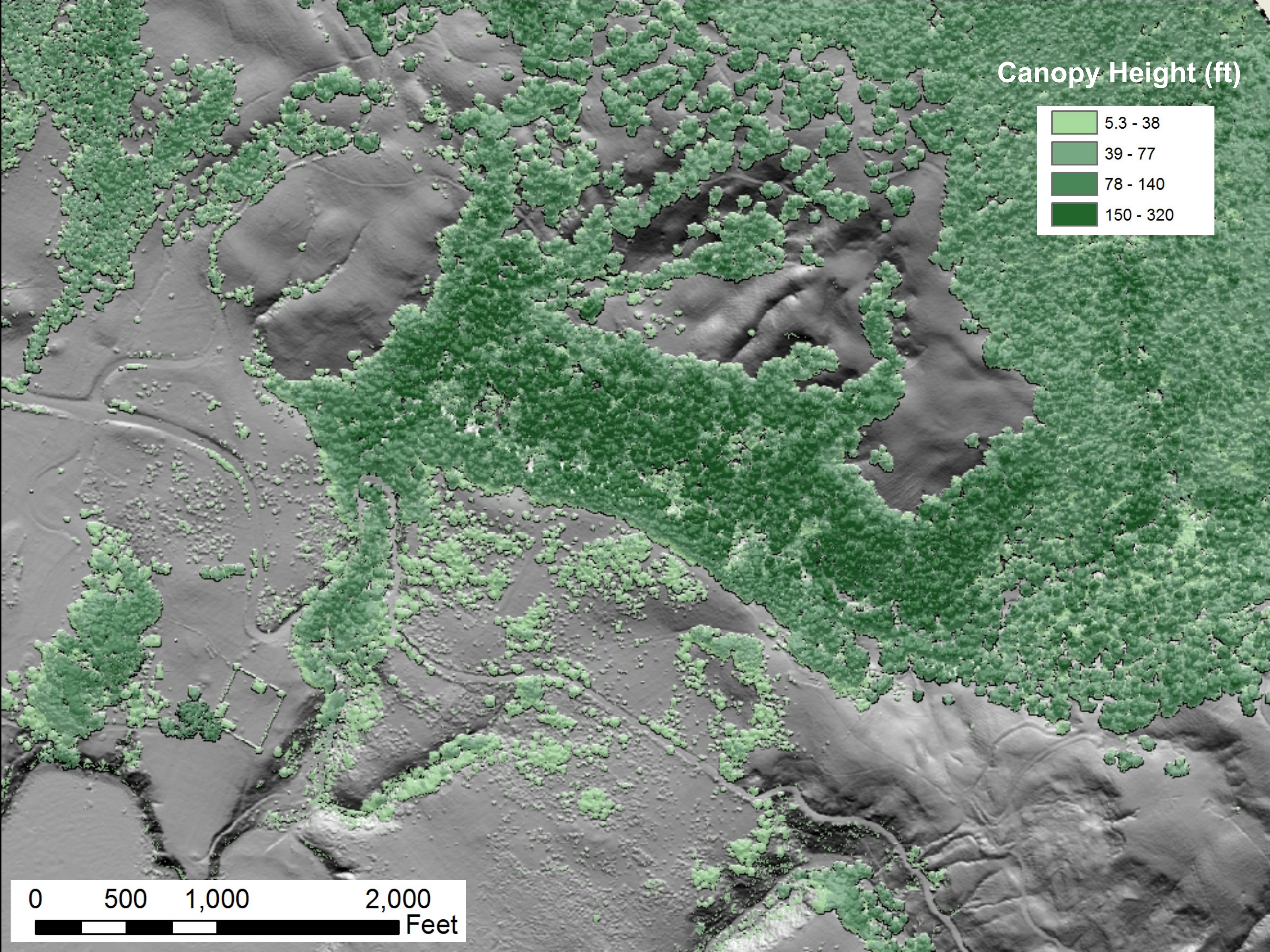




.

TIN or other non-local interpolator necessary in areas of sparse ground returns (right).




Canopy Height (ft)
5.3 - 38
39 - 77
78 - 140
150 - 320
0
500
1,000
2,000
Feet

Lidar data deliverables

- Classified point cloud
  - Ground, vegetation, buildings, water, blunders etc.
  - Intensity, return number & number of returns, GPS time, RGB…
  - Tiled LAS, ASCII

- Raster data derivatives
  - DTM (“bare earth”), DSM (“highest hit”)
  - Hillshades of DTM, DSM; intensity; RGB
  - Tiled GeoTIFF, IMG, Arc Binary

- Metadata & survey report


asprs
THE IMAGING & GEOSPATIAL INFORMATION SOCIETY

LAS SPECIFICATION

VERSION 1.3 – R10

Approved: JULY 14, 2009

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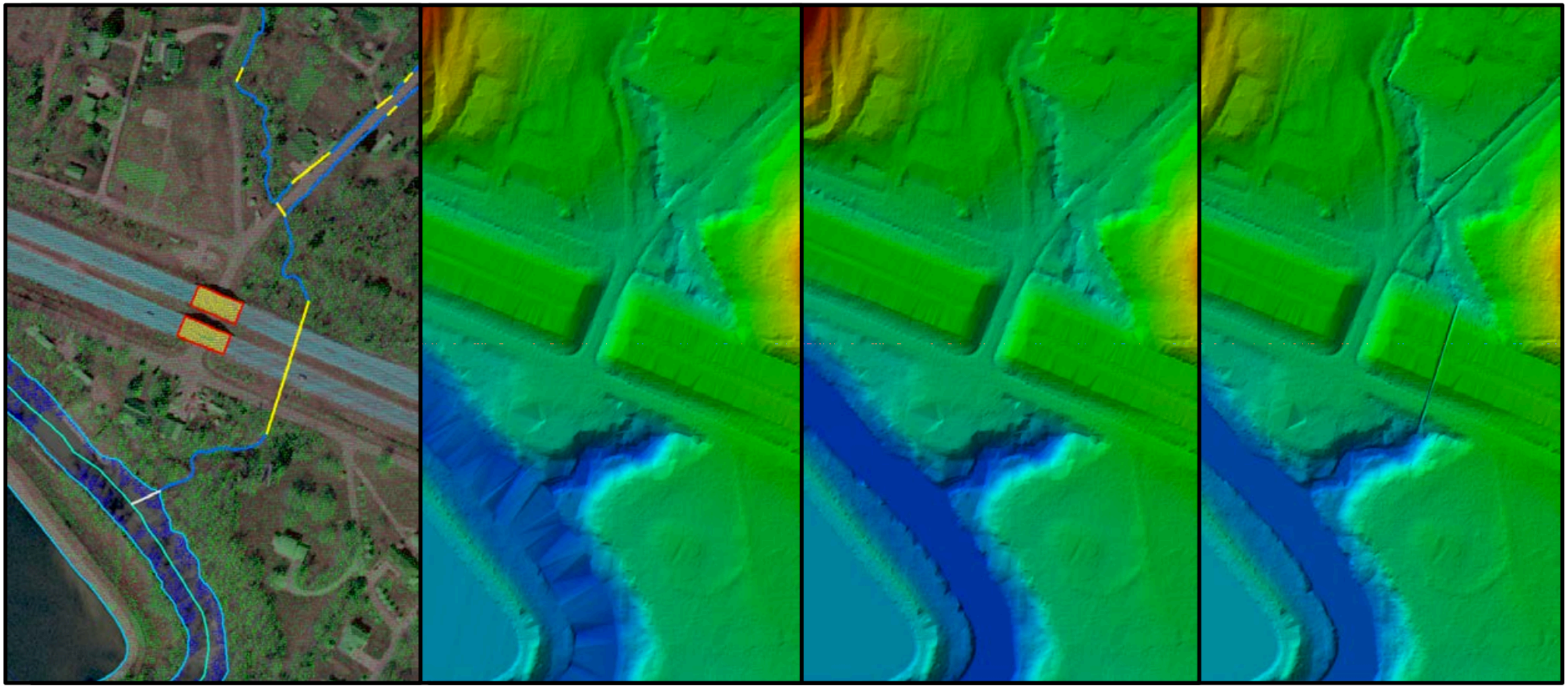
Bethesda, Maryland 20814-2160
Voice: 301-493-0290
Fax: 301-493-0208
Web: www.asprs.org

Lidar data deliverables



LPC and Breaklines | Pure lidar DEM | Hydro flattened DEM | Hydro enforced DEM

J. Stoker, USGS

Lidar ground modeling

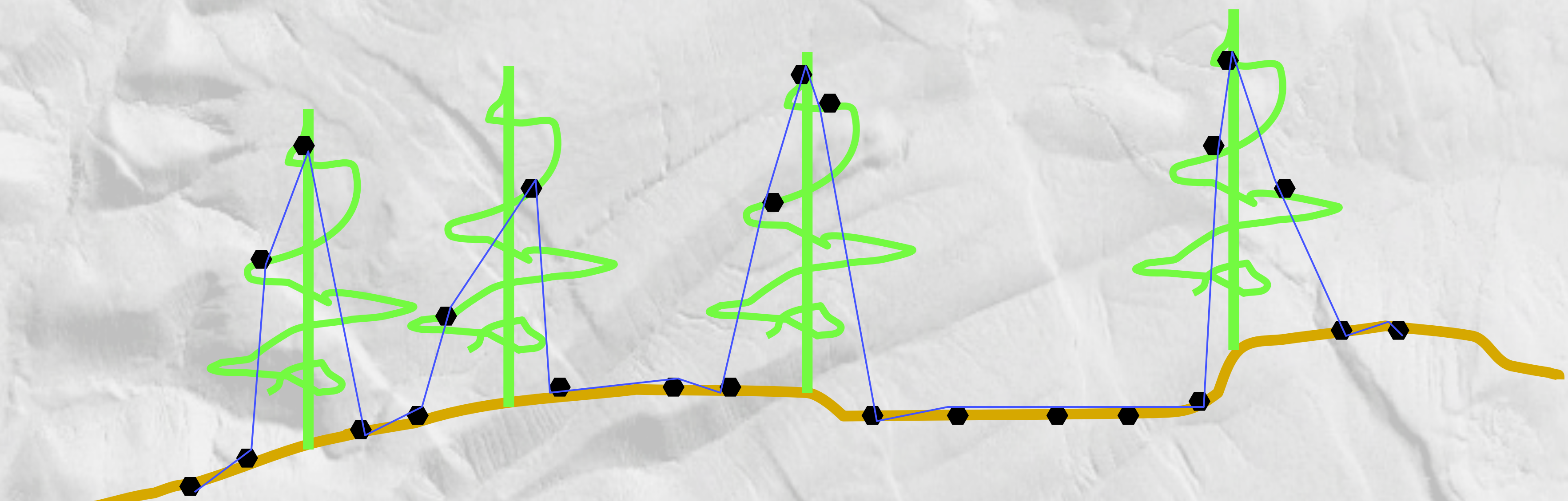
…simplified…

Three assumptions:

1. Ground is smooth
   - Assumption: high curvature is not a point on the ground
2. Ground is continuous (single-valued)
3. Ground is lowest surface in vicinity

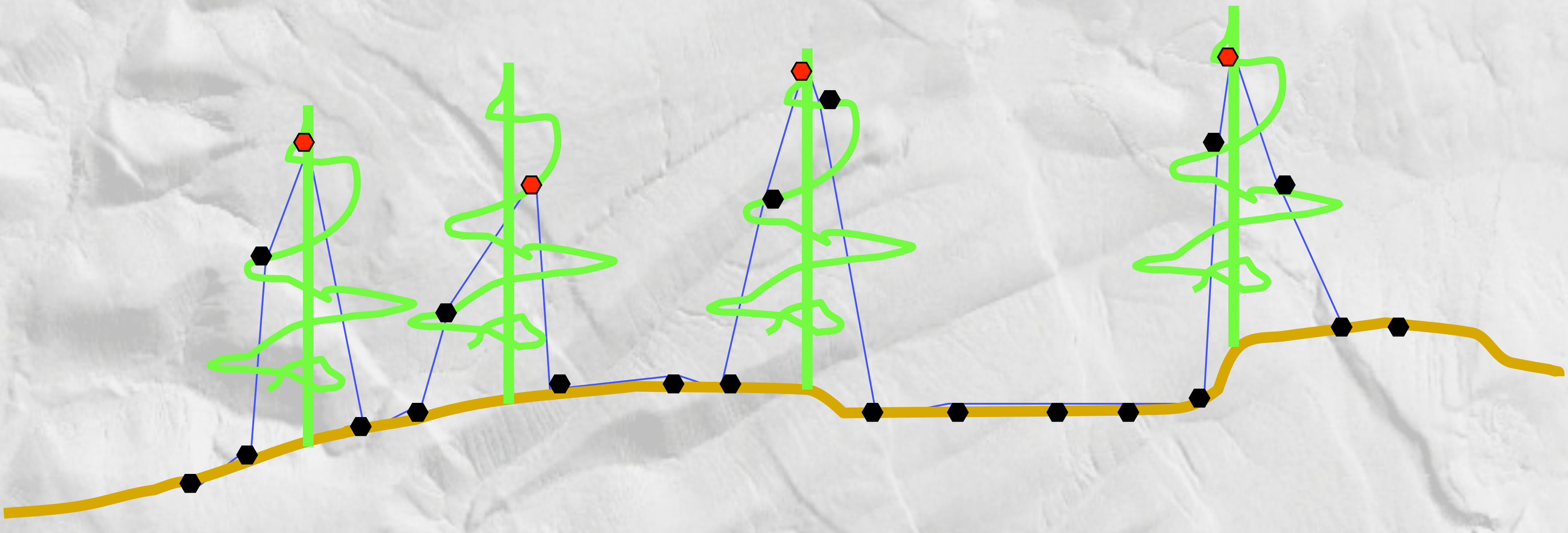
Modified from: R. Hagerud, USGS

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



R. Hagerud, USGS

Flag points that define spikes (strong convexities)

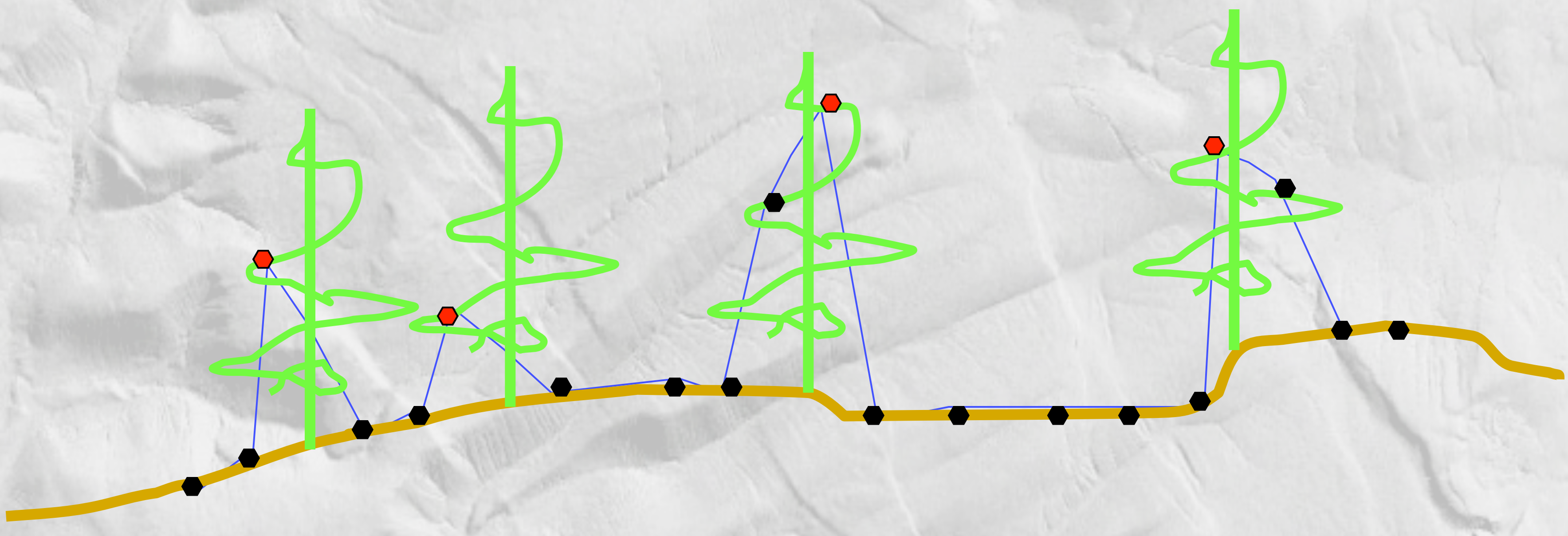


R. Hagerud, USGS

Rebuild TIN

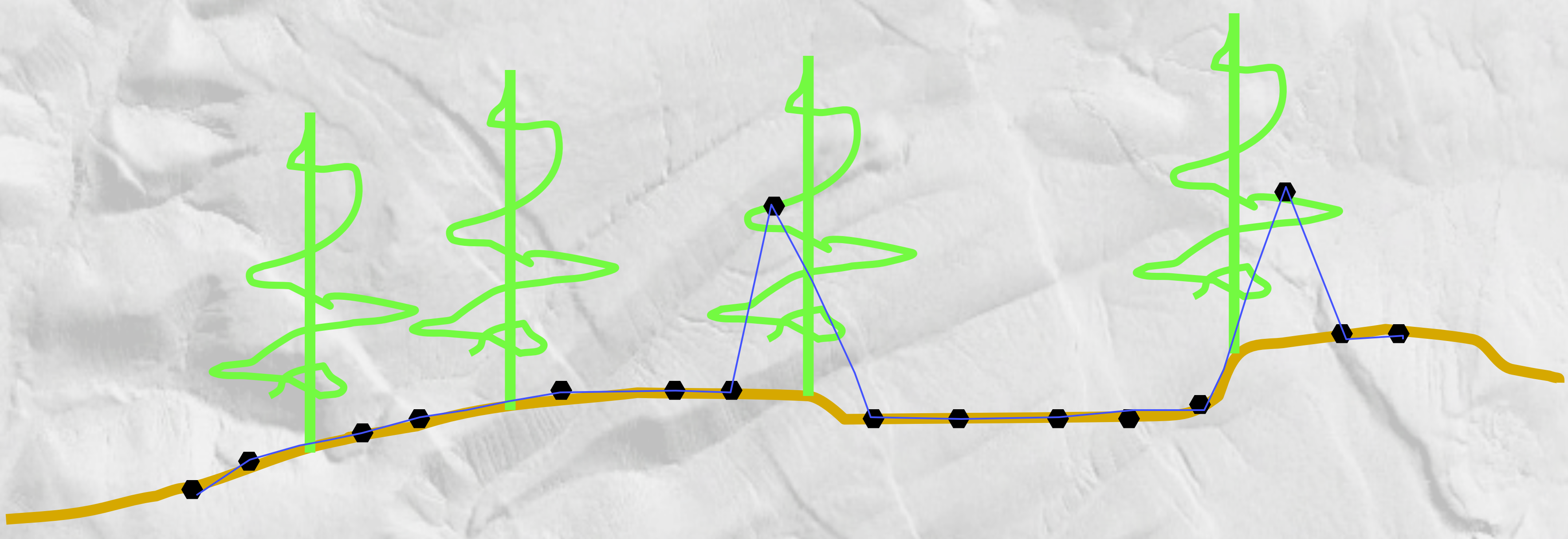
R. Hagerud, USGS

Flag points that define spikes (strong convexities)



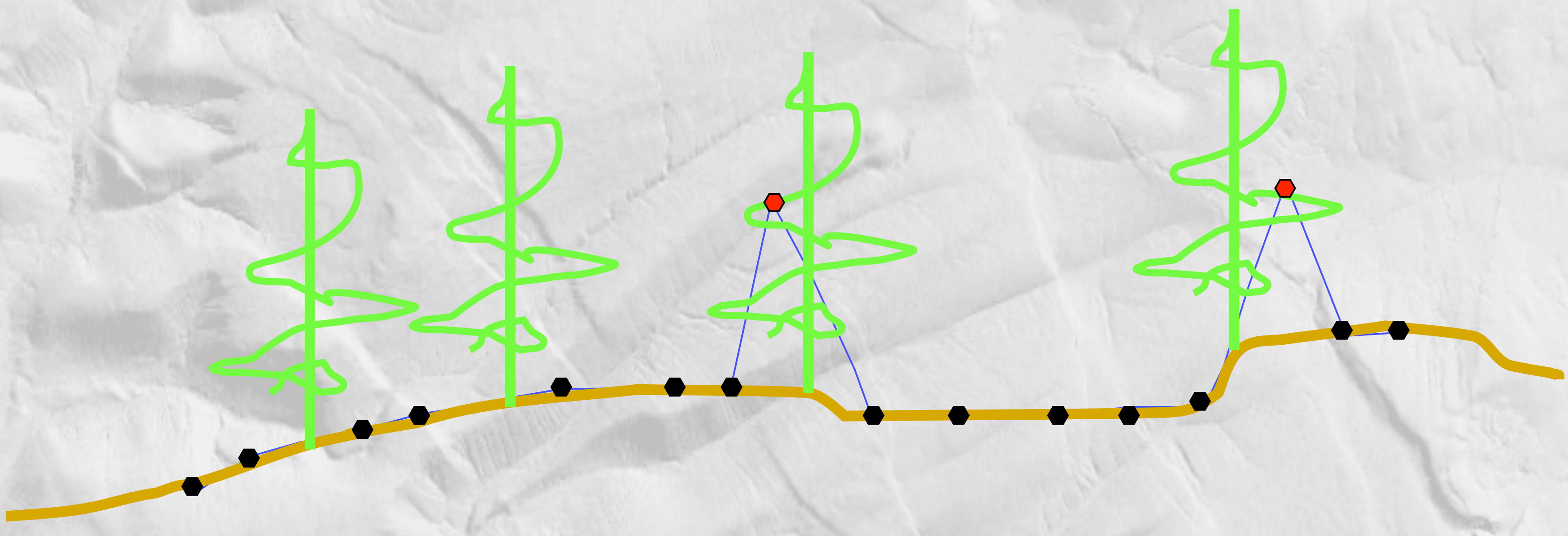
R. Hagerud, USGS

Rebuild TIN



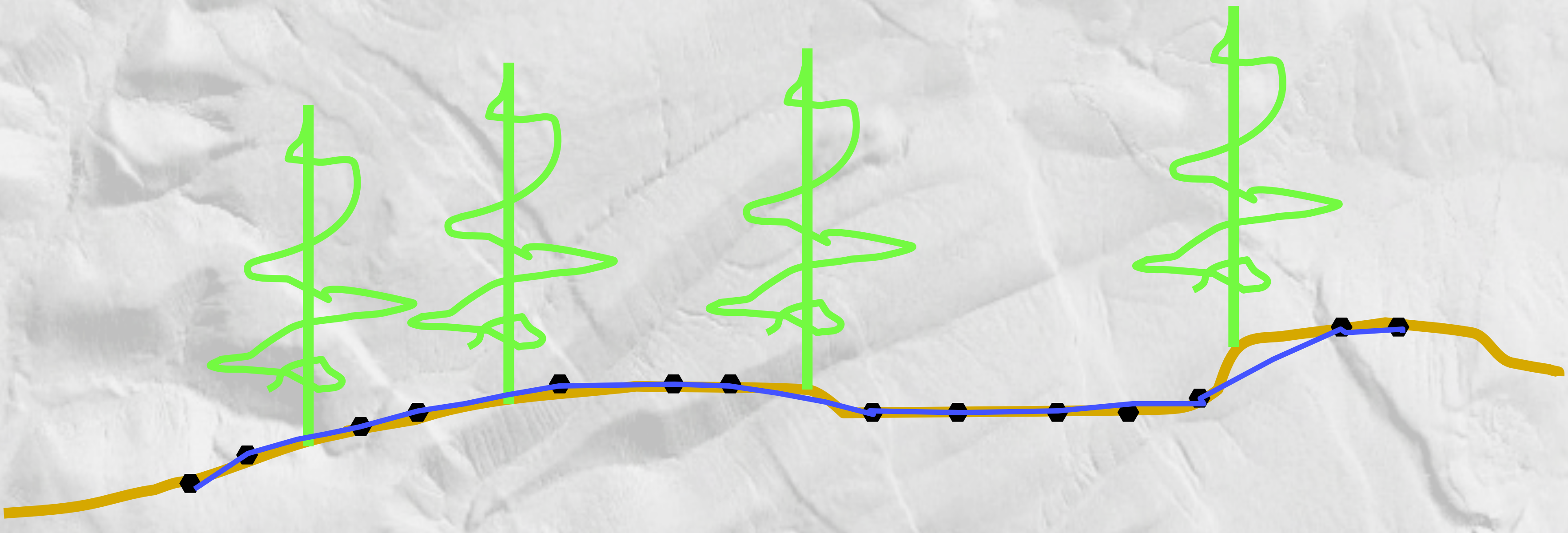
R. Hagerud, USGS

Flag points that define spikes (strong convexities)



R. Hagerud, USGS

Rebuild TIN



R. Hagerud, USGS

Despike algorithm

<u>Benefits</u>:

- It works

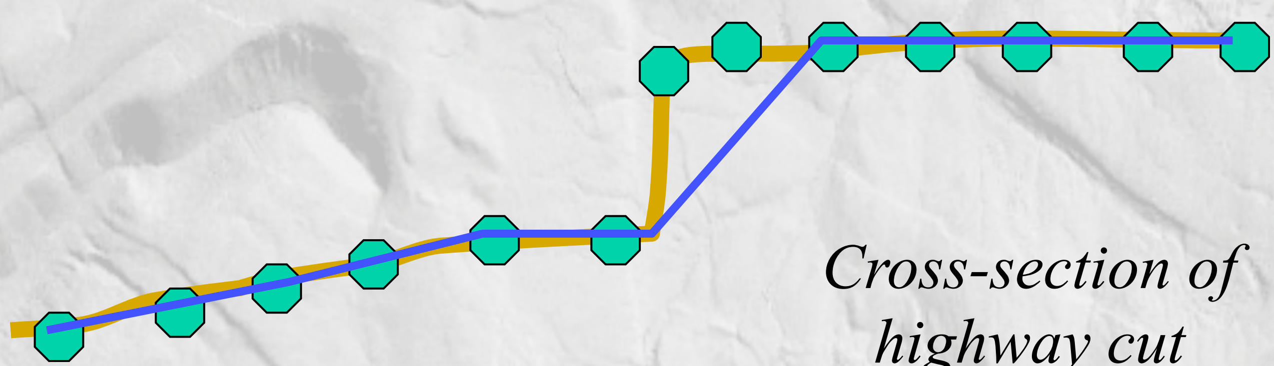
- It's automatic
  - Cheap
  - All assumptions explicit

- It can preserve breaklines

- It appears to retain more ground points than other algorithms

R. Hagerud, USGS

Despike algorithm

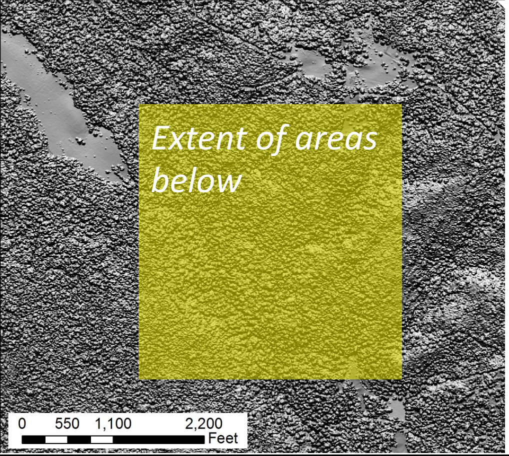


Cross-section of highway cut

Problems:

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

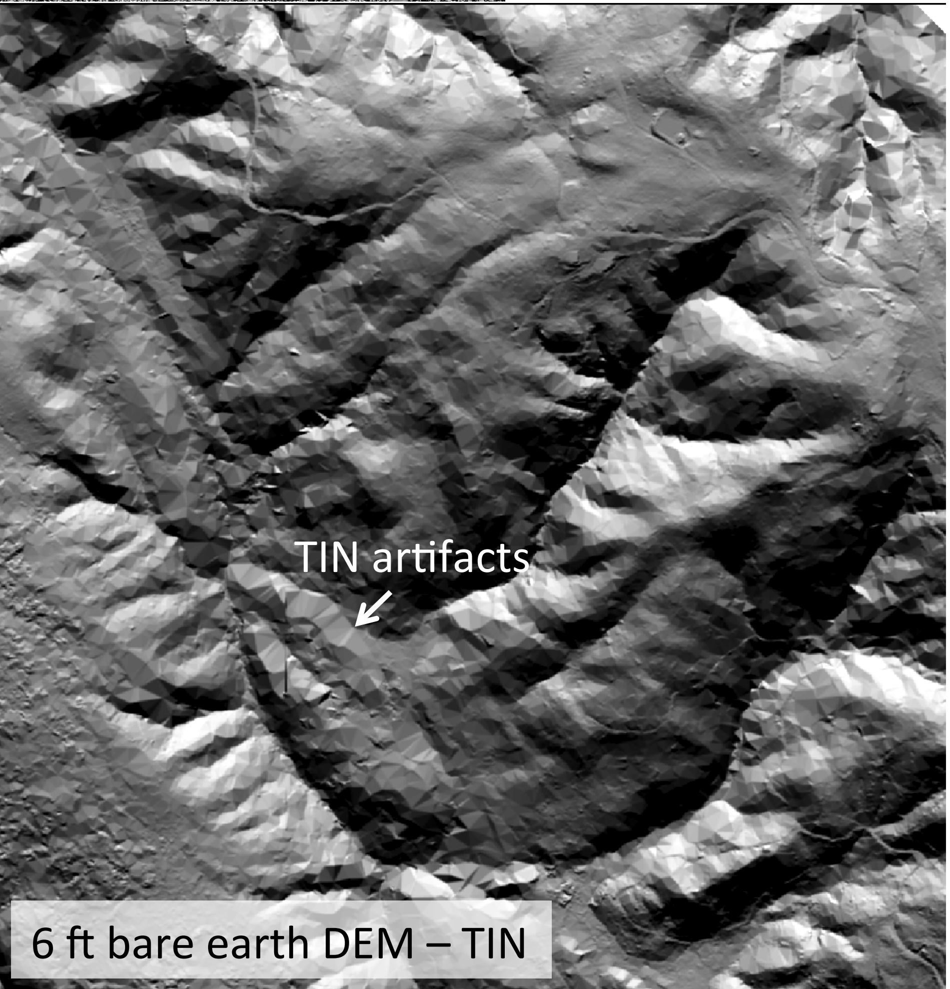
R. Hagerud, USGS

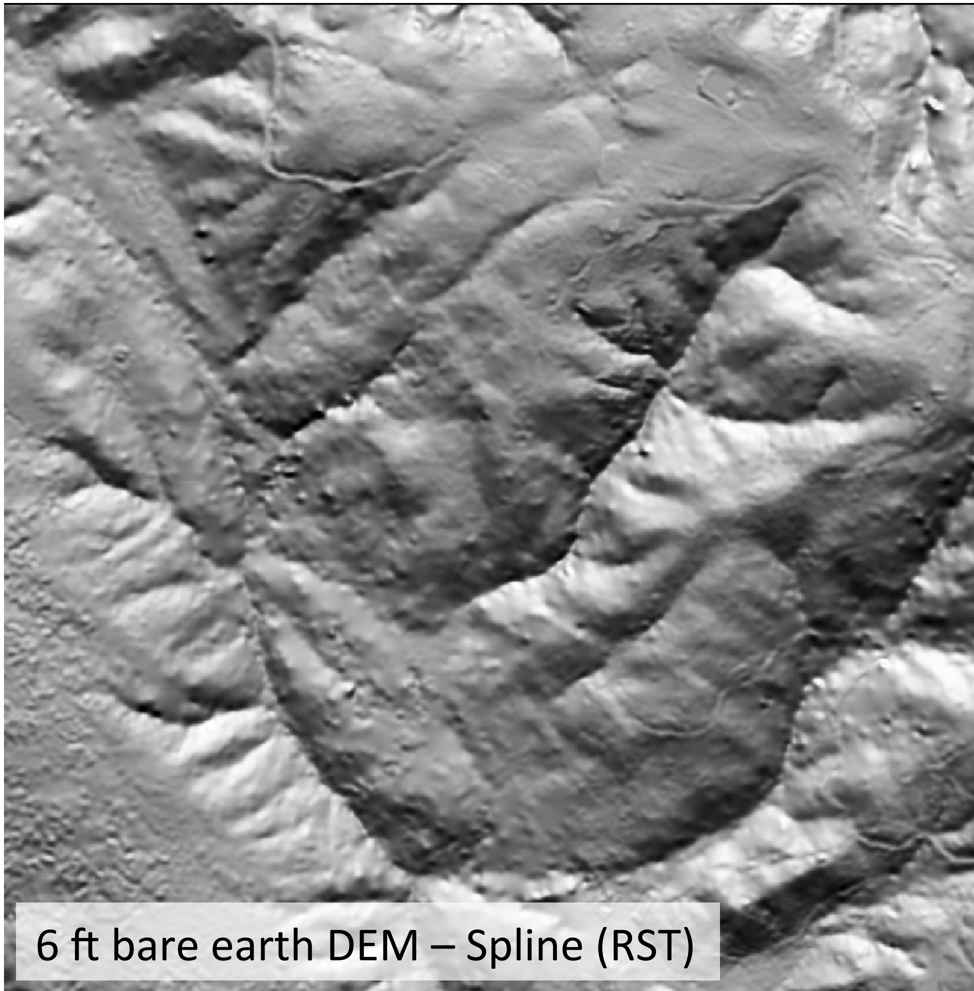


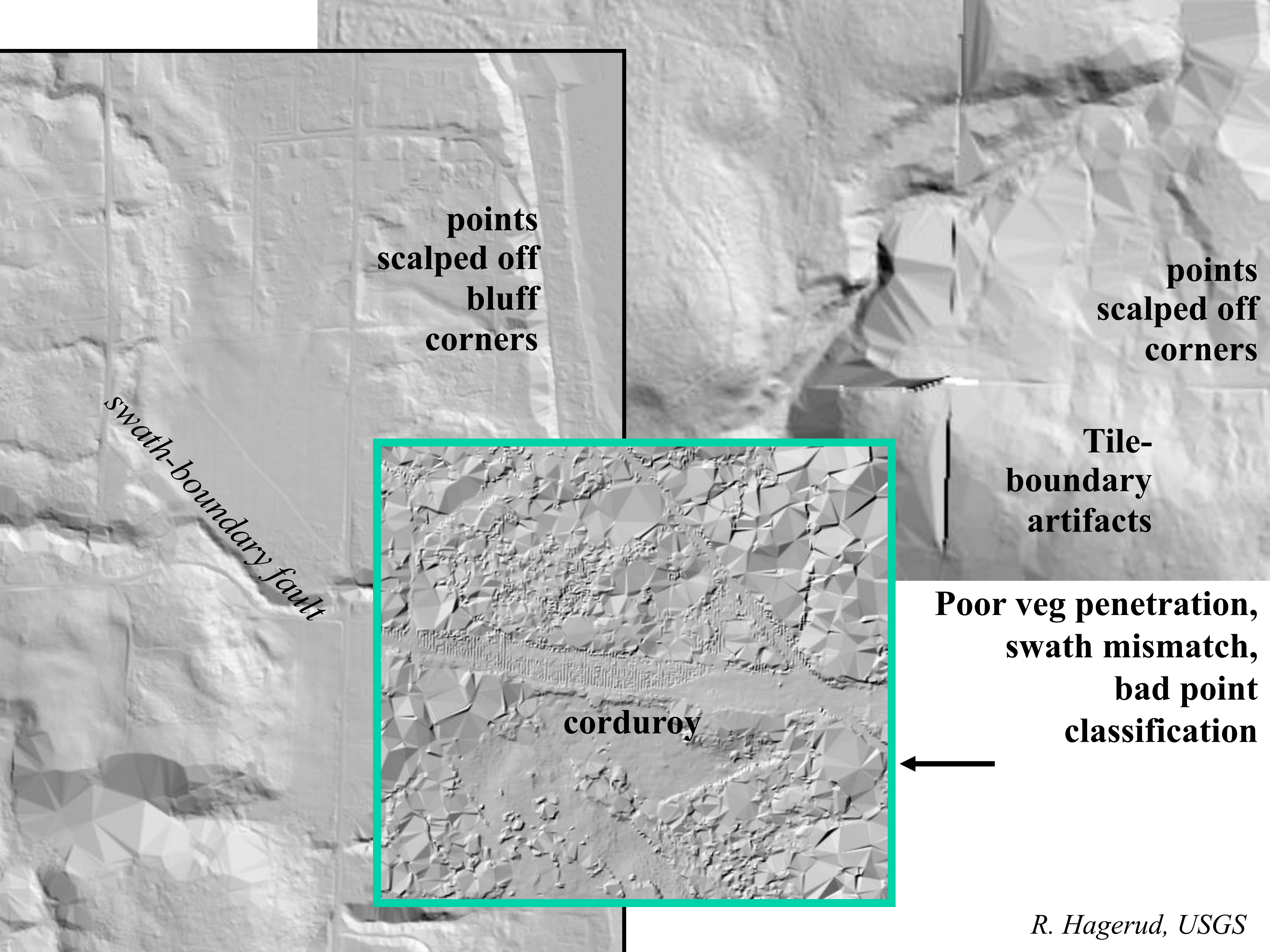
Role of gridding method in areas of low return density:

Do you prefer visible artifacts or smoothed regions where surface is less well constrained?

- Local methods can populate pixels without returns to null (swiss cheese surface – very honest representation of data)
- TIN artifacts in low ground return density
- Spline and Kriging = smoother surface…low return density less clear






points scalped off bluff corners
swath-boundary fault
points scalped off corners
Tile-boundary artifacts
corduroy
Poor veg penetration, swath mismatch, bad point classification
R. Hagerud, USGS

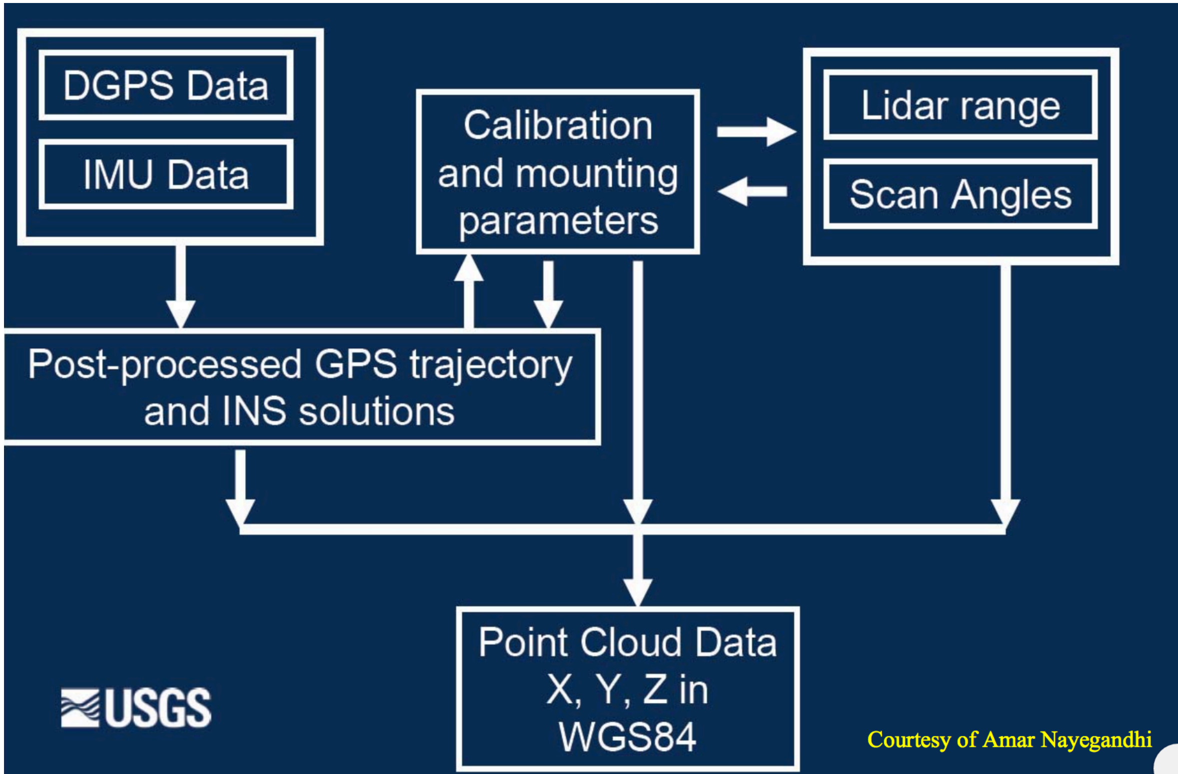

0
60
120
240 Meters

Lidar data error sources

- GPS Precision
- INS Precision
- Lidar System Noise (range error)
- Timing & Mechanical Tolerances (temperature, atmospheric pressure variations)
- Atmospheric Distortions (extreme ground temperature, haze)

Error budget =

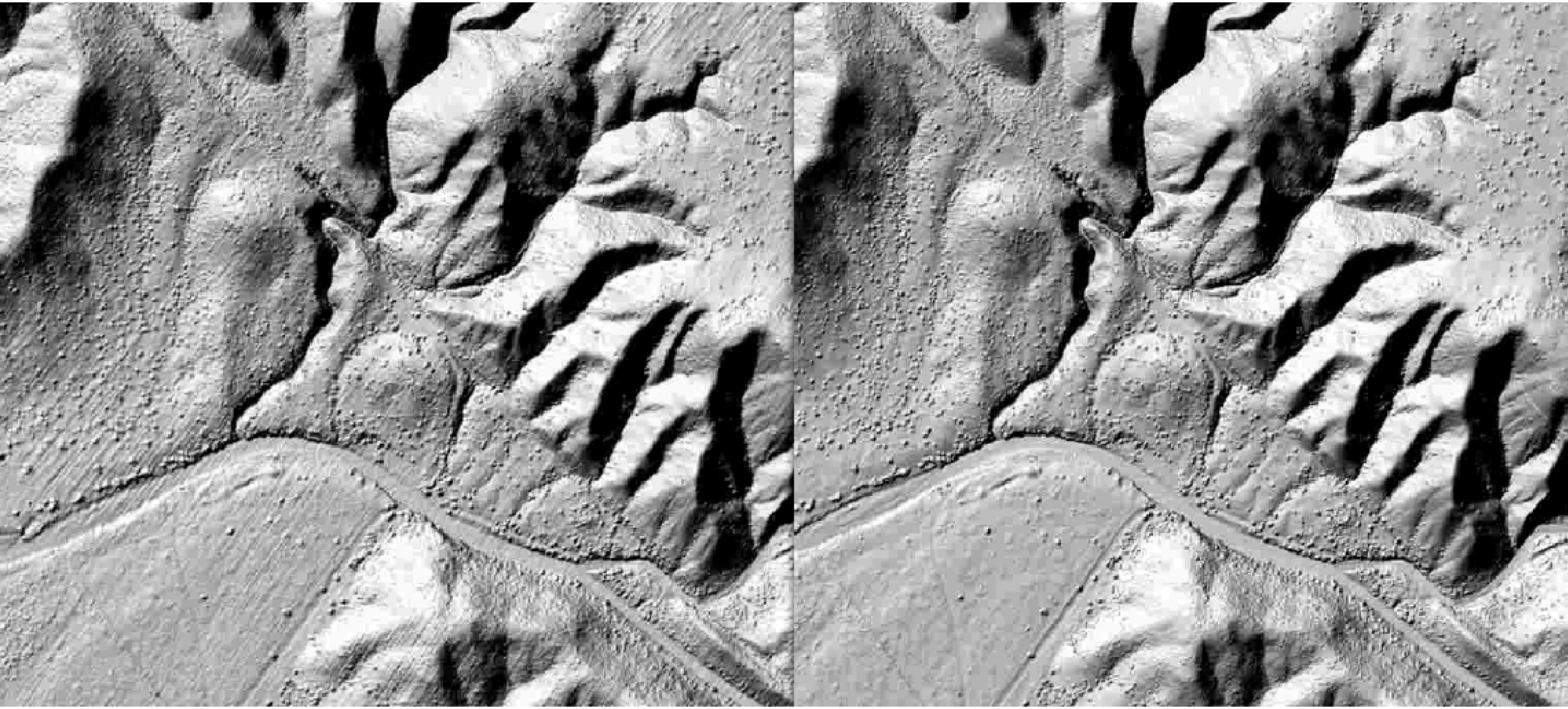
+/- 5 to 15 cm
(vertical)



Modified from K. Hudnut, USGS

Corduroy & Scan Edge Artifacts

The B4 survey was supported by the loan of a 5100 unit from Optech to NCALM.



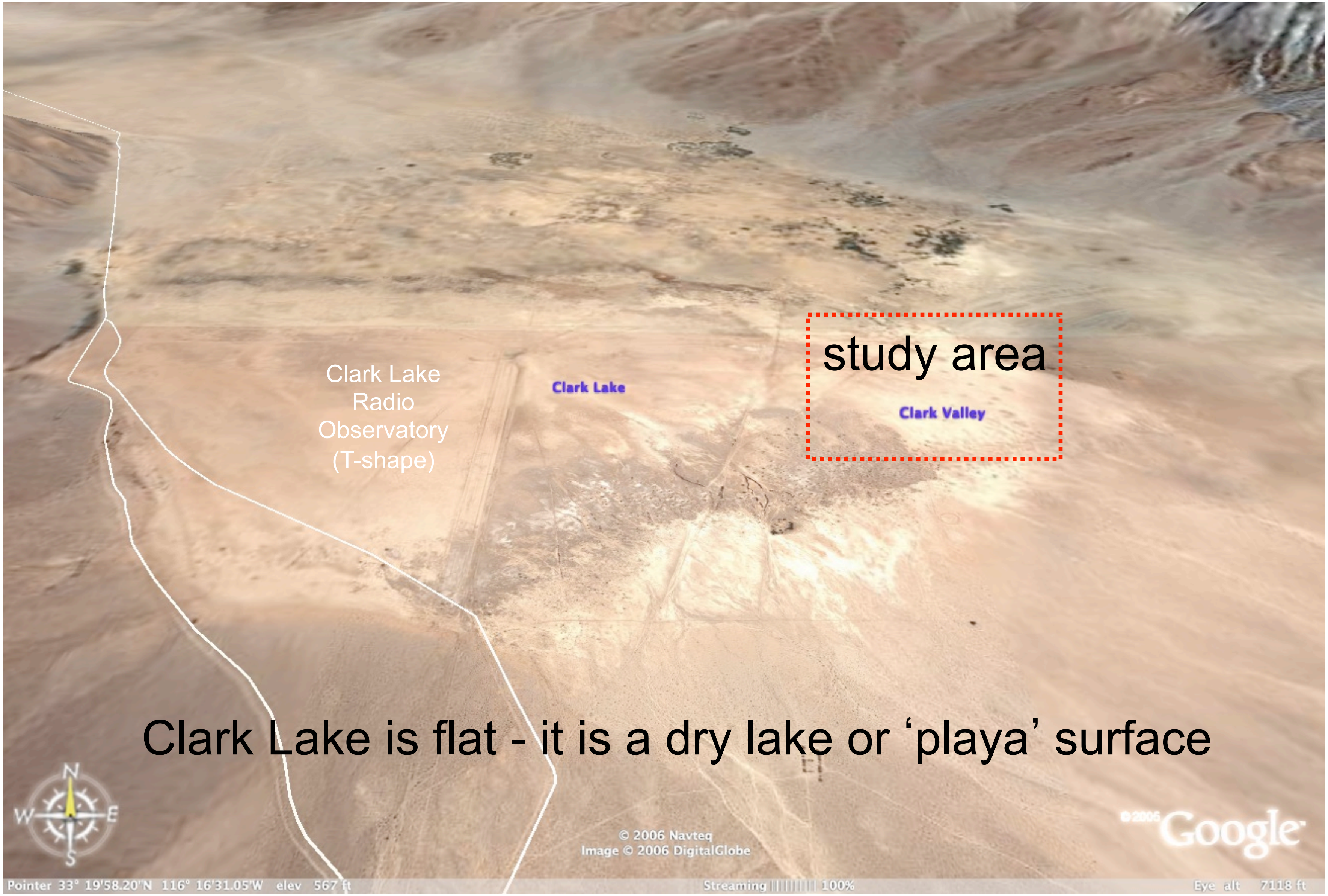
1233 5100

Carizzo Plain

Both models were used over the first few days of the May campaign. In general corduroy, though still present, is more subdued in the 5100 data, as illustrated in these DEM patches.

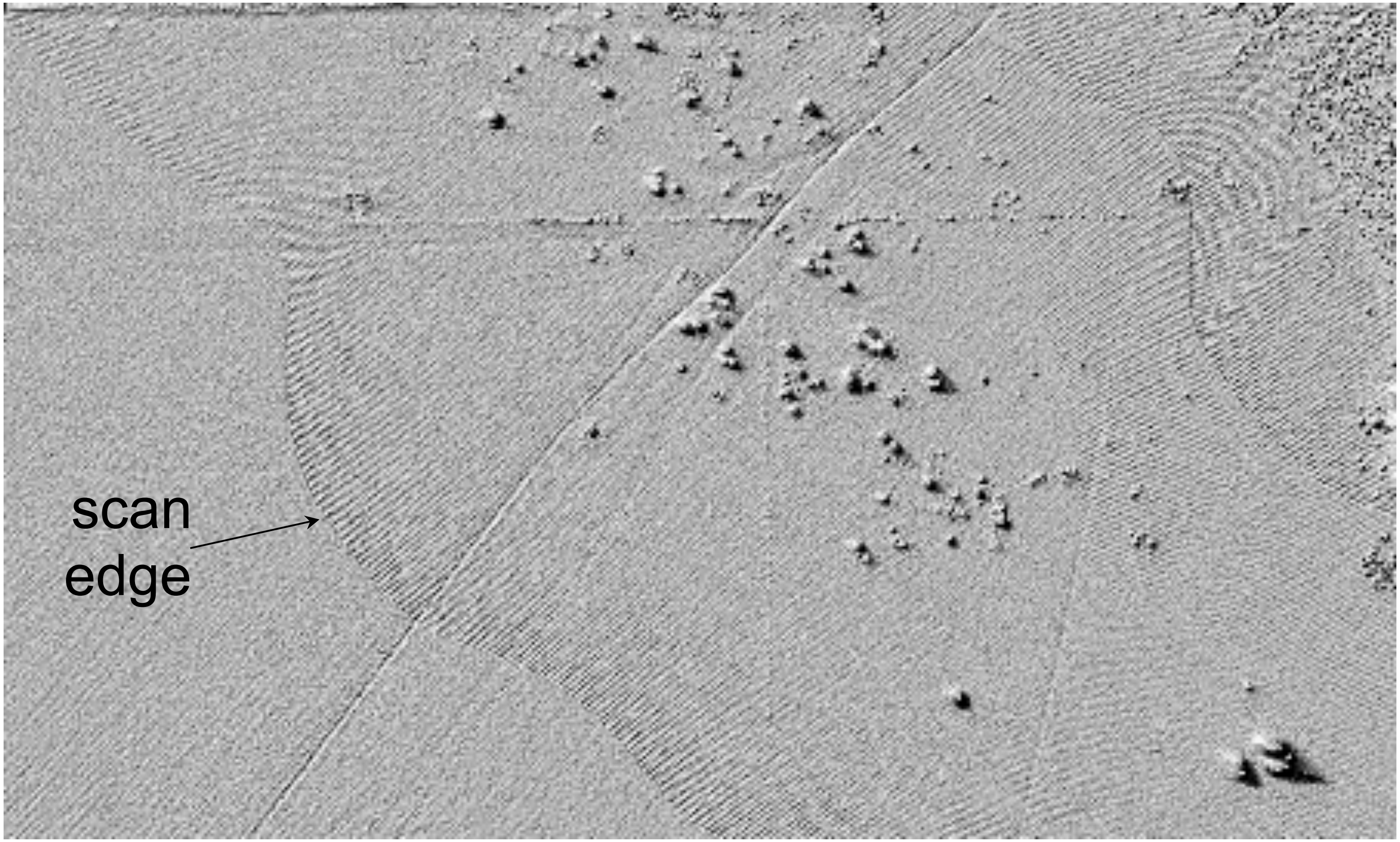
Modified from K. Hudnut, USGS

Corduroy & Scan Edge Artifacts

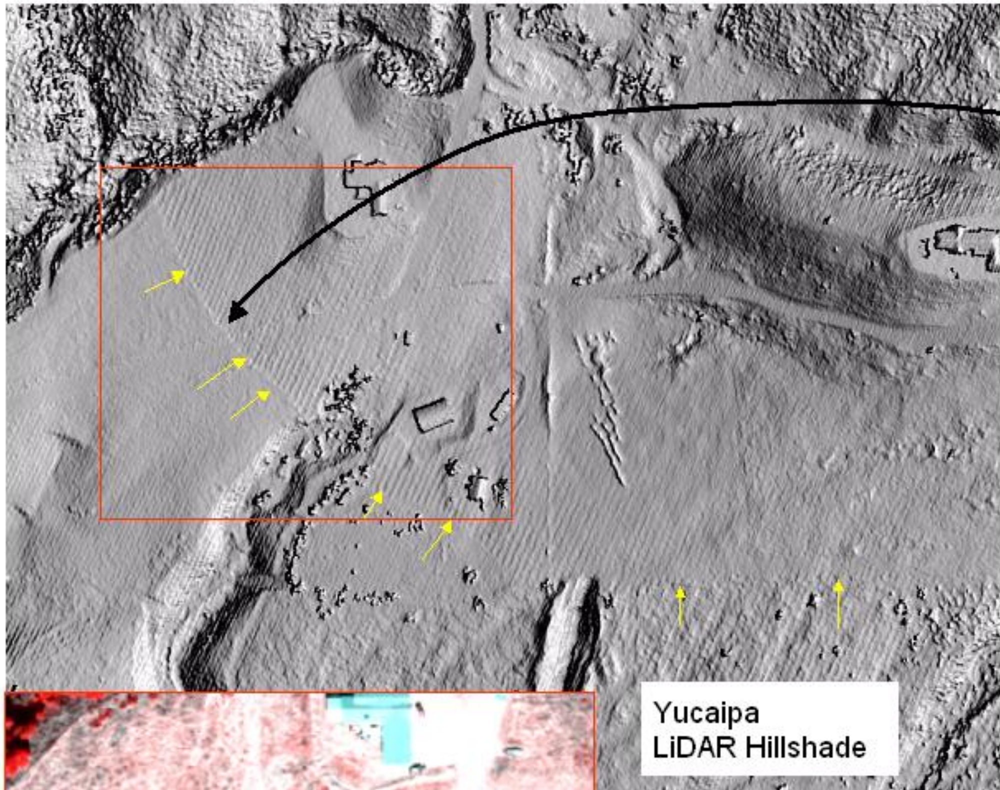


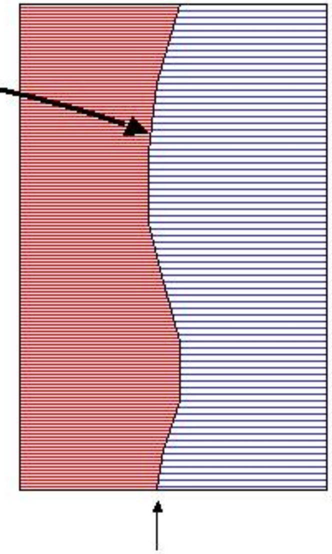
Modified from K. Hudnut, USGS

Corduroy & Scan Edge Artifacts

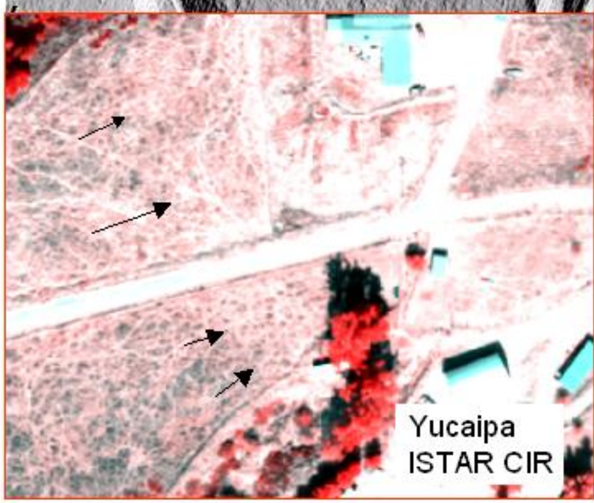


0.5 m DEM from NCALM



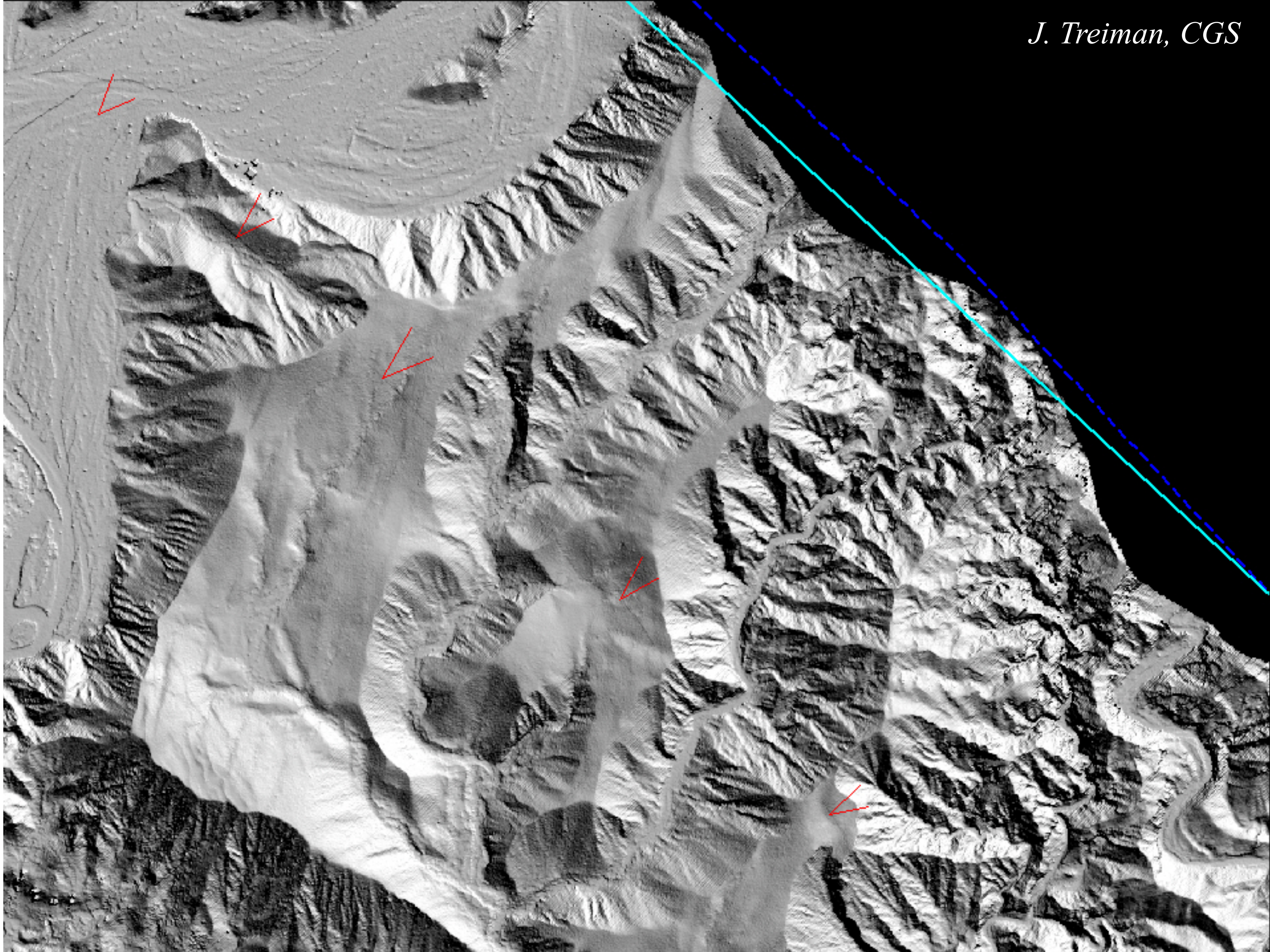


“Seam line” between swaths where the corduroy artifacts will not line up due to Vertical Swath Offset.



Red Arrows – features *attributed* to artifacts   Green Arrows – "natural" features (aligned drainages, scarplets)

Ante Perez, CGS


J. Treiman, CGS

Modified from K. Hudnut, USGS

Corduroy

There are *two* types of 'corduroy' in B4 data

type 1 - 'scan angle artifact' (*INS / bore-sight error &/ or scanner error*)

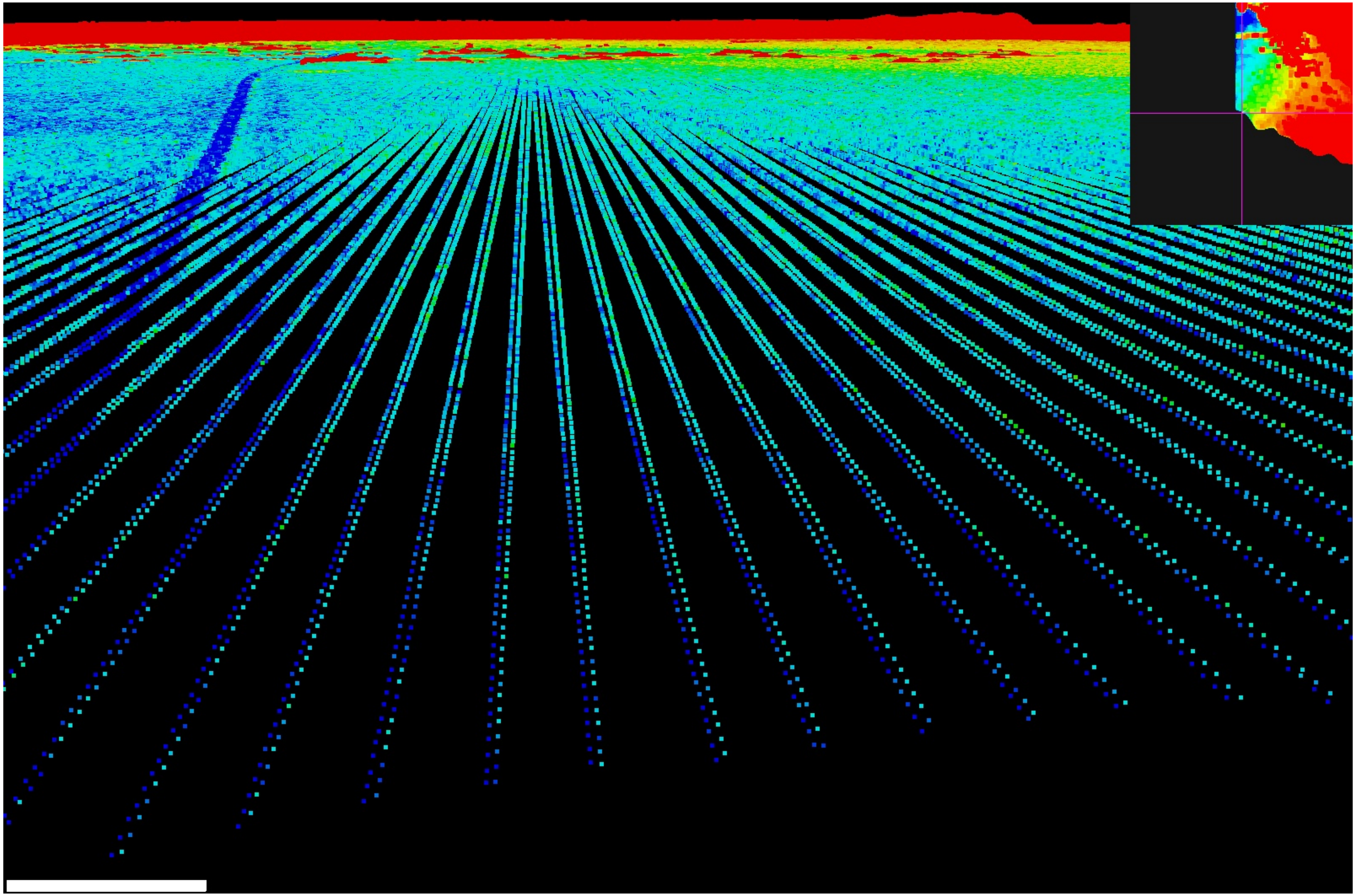
scanner reads higher going one direction than it does in the other

type 2 - 'vertical swath offset' (*GPS error*)

aircraft first pass is vertically mis-aligned with second pass within a given area

Modified from K. Hudnut, USGS

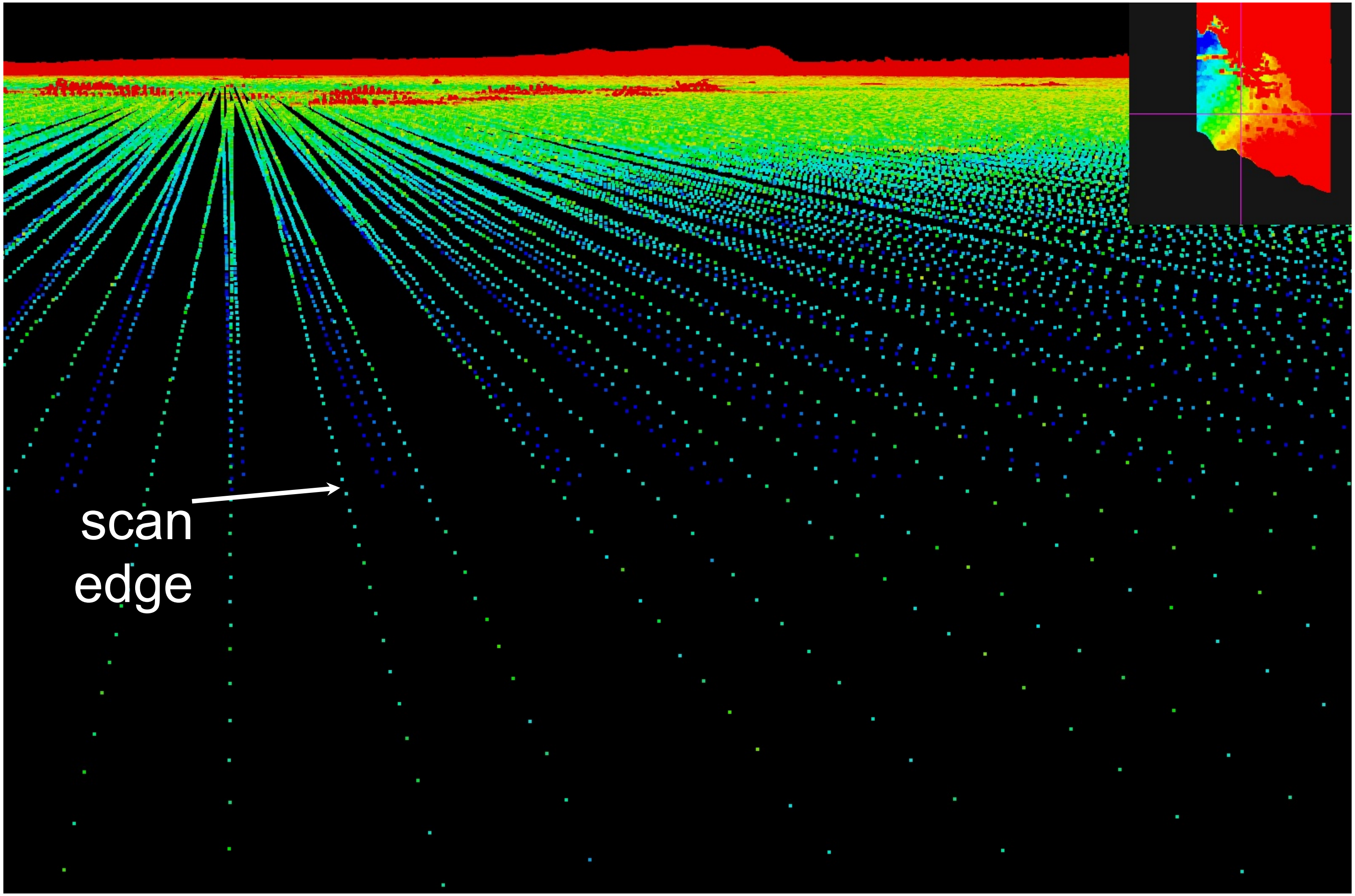
Corduroy & Scan Edge Artifacts – type 1



Scan artifact - at scan edge on dry lake one sees a pattern of up-down consistently; as mirror flips, height reads differently

Modified from K. Hudnut, USGS

Corduroy & Scan Edge Artifacts – type 2



One scan (aircraft pass) is consistently lower than the other scan;
this is a different source of 'corduroy', related to aircraft trajectory/positioning.