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Buying lidar data

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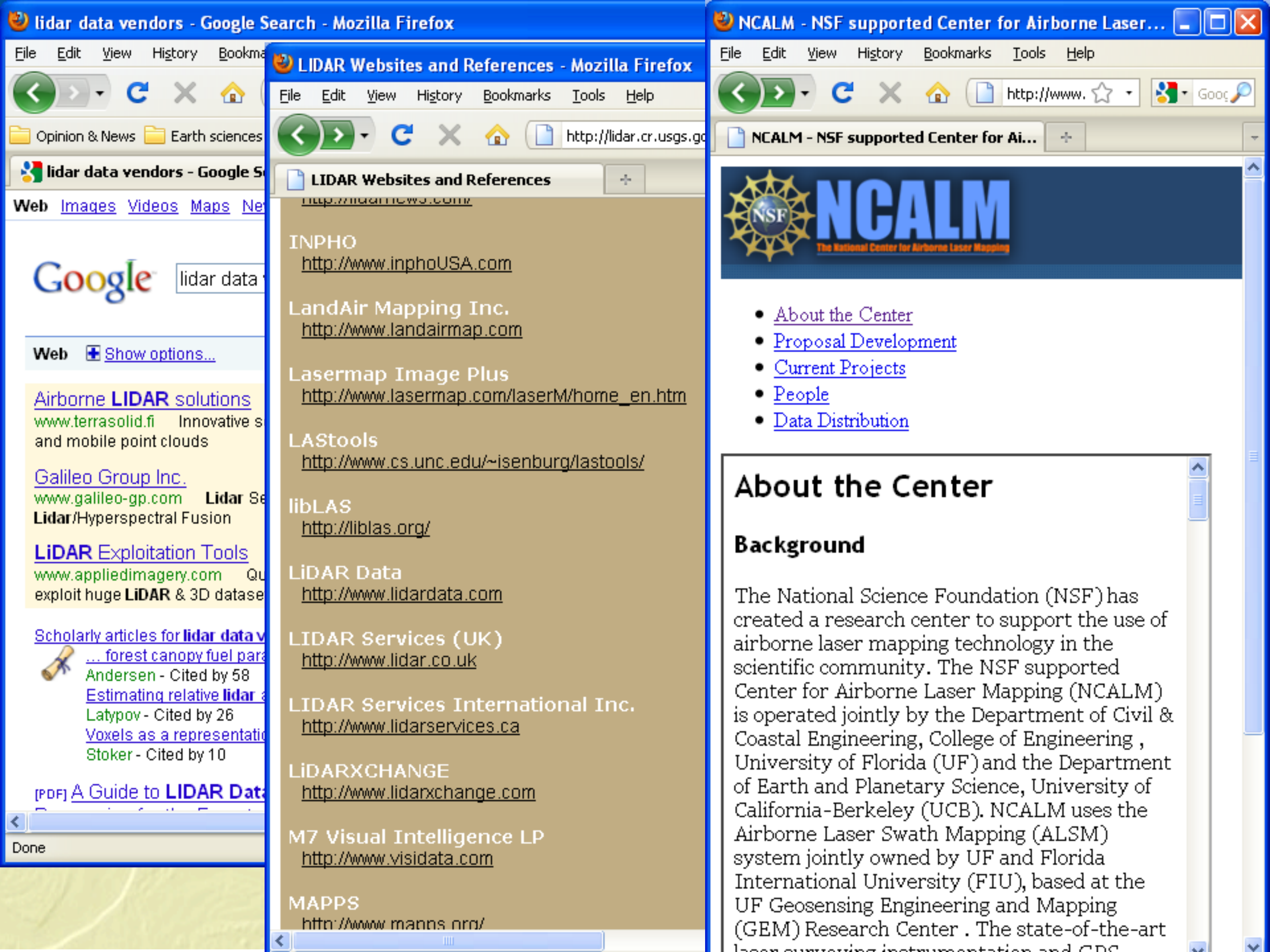
How to buy lidar data

- You know somebody…
  - A known quantity. Easiest
- Advertise for bids
  - Maybe you don't know as much as you think
- NCALM (http://www.ncalm.org/)
  - NSF sponsored, partly subsidized, limited capacity
- Participate in a consortium
  - Economies of scale, in-place contracting structure, community of experience
  - Geographically limited
- Start your own consortium
  - Advertise for bids
  - …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Lidar/Hyperspectral Fusion
LiDAR Exploitation Tools
www.appliedimagery.com Qu
exploit huge LiDAR & 3D datase
Scholarly articles for lidar data v
... forest canopy fuel para
Andersen - Cited by 58
Estimating relative lidar a
Latypov - Cited by 26
Voxels as a representatio
Stoker - Cited by 10
[PDF] A Guide to LIDAR Data
Done
LIDAR Websites and References - Mozilla Firefox
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http://lidar.cr.usgs.go
LIDAR Websites and References
INPHO
http://www.inphoUSA.com
LandAir Mapping Inc.
http://www.landairmap.com
Lasermap Image Plus
http://www.lasermap.com/laserM/home_en.htm
LAStools
http://www.cs.unc.edu/~isenburg/lastools/
libLAS
http://liblas.org/
LiDAR Data
http://www.lidardata.com
LIDAR Services (UK)
http://www.lidar.co.uk
LIDAR Services International Inc.
http://www.lidarservices.ca
LiDARXCHANGE
http://www.lidarxchange.com
M7 Visual Intelligence LP
http://www.visidata.com
MAPPS
NCALM - NSF supported Center for Airborne Laser...
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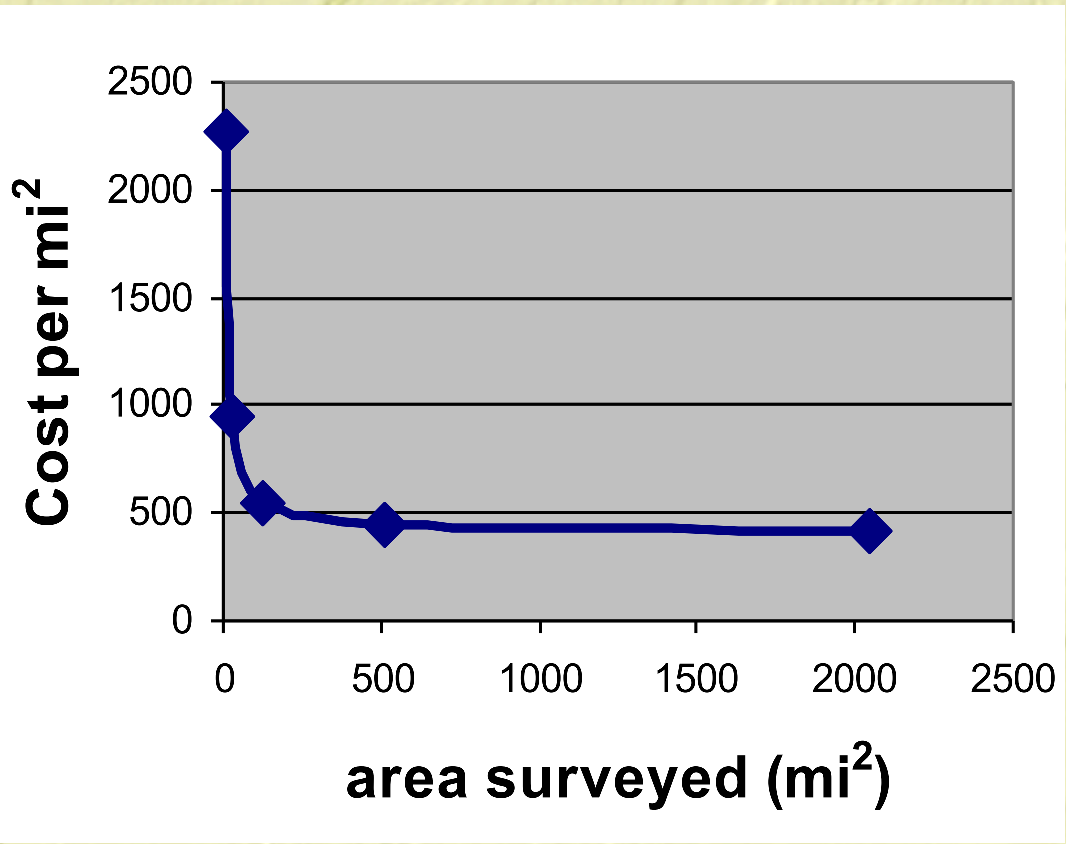
NCALM - NSF supported Center for Ai...
NSF
NCALM
The National Center for Airborne Laser Mapping
About the Center
Proposal Development
Current Projects
People
Data Distribution
About the Center
Background
The National Science Foundation (NSF) has created a research center to support the use of airborne laser mapping technology in the scientific community. The NSF supported Center for Airborne Laser Mapping (NCALM) is operated jointly by the Department of Civil & Coastal Engineering, College of Engineering , University of Florida (UF) and the Department of Earth and Planetary Science, University of California-Berkeley (UCB). NCALM uses the Airborne Laser Swath Mapping (ALSM) system jointly owned by UF and Florida International University (FIU), based at the UF Geosensing Engineering and Mapping (GEM) Research Center . The state-of-the-art

Specifications

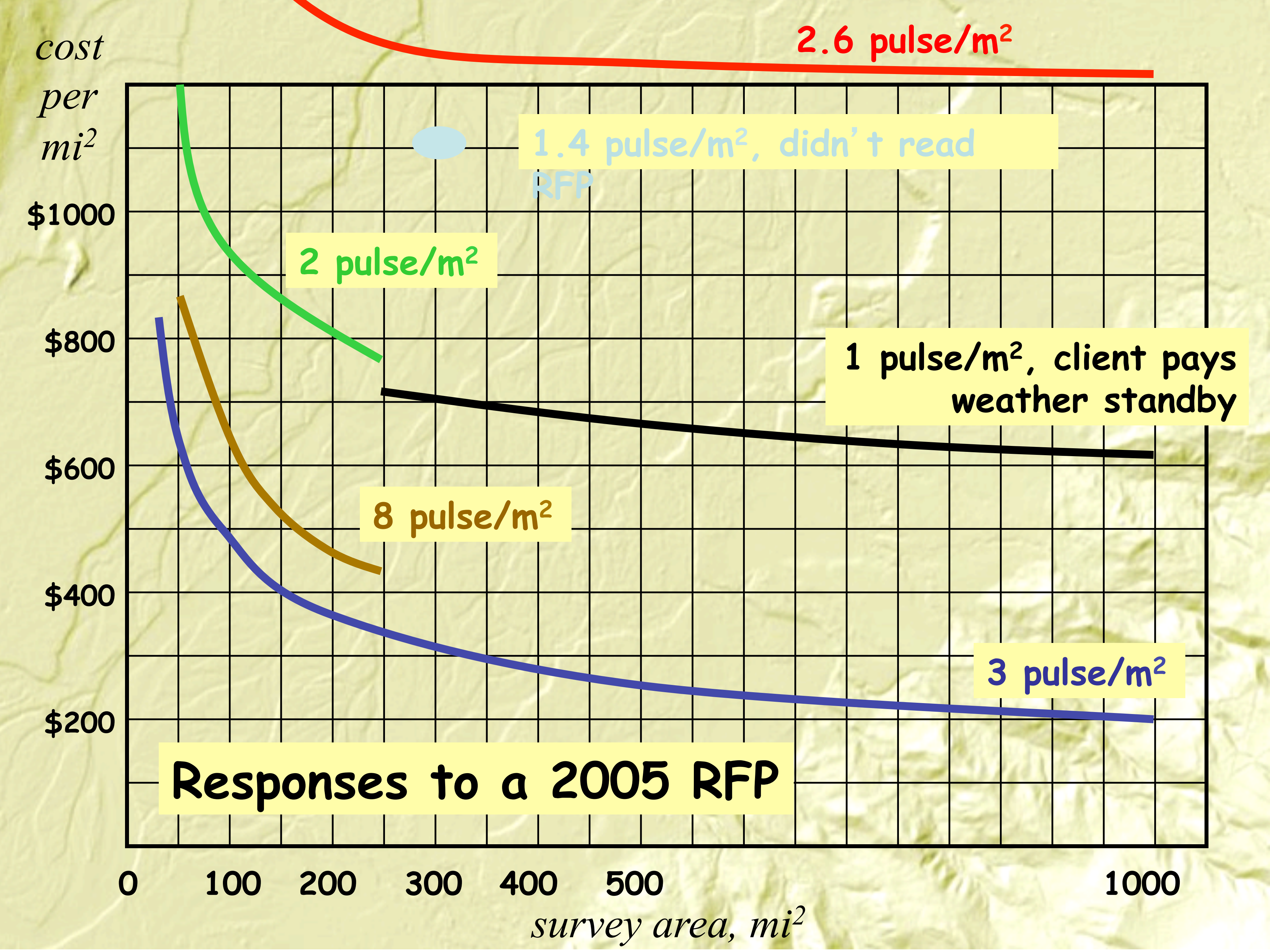
- Where
- When (acquisition, lag to delivery)
- Spatial reference framework
- Ground control (procedures, #, quality)
- Instrument
- Data density and completeness
- Accuracy
- Data products to be delivered (kind, file formats, file naming)
- Acquisition conditions
  - Sky: PDOP, # satellites in view, solar flares, airport operations
  - Ground: leaves, standing water, snow cover, tides
- Data ownership

see ***A proposed specification for lidar surveys in the Pacific Northwest***, in the course materials



- **\$21K mobilization**
- **\$400/mi² raw cost**
- **Half-swath selvedge**
- **2:1 rectangles**

Costs for an ideal survey


cost
per
mi²
$1000
$800
$600
$400
$200
2.6 pulse/m²
1.4 pulse/m², didn't read RFP
2 pulse/m²
1 pulse/m², client pays weather standby
8 pulse/m²
3 pulse/m²
Responses to a 2005 RFP
0
100
200
300
400
500
1000
survey area, mi²

Recent PSLC contract with Watershed Sciences

• 50-100 sq mi^2:	$943/$mi^2$	*$420/$km^2$*
• 100-150 mi^2:	$704/$mi^2$	
• 150-200 mi^2:	$592/$mi^2$	
• 200-250 mi^2:	$521/$mi^2$	
• > 250 mi^2:	$472/$mi^2$	*$210/$km^2$*

no mobilization fee

includes 5% to Kitsap County

5% to Regional Council

Data quality

a Puget Sound Lidar Consortium perspective

Outline

- Usability, Completeness, Accuracy
- A QA protocol: 3 analyses
  - Test against ground control
  - Examine images of bare-earth surface model
  - Evaluate internal consistency
- What accuracy do we need? Effects of correlated errors

Usability

- Report of Survey is complete and correct
- Formal metadata are complete and correct
- Consistent, correct, and correctly labeled spatial reference framework
- Consistent file names and file formats
- Usable tiling scheme

  can calculate names of adjoining tiles

Usability, continued

- Fully populated data attributes

  GPS week OR *Posix time*

- Consistent calibration
- Consistency between data layers
- No unnecessary artifacts in surface models

Completeness

- **Complete coverage**

  Filling gaps requires remobilization, thus is very expensive

- Adequate data density
- Adequate swath overlap

These are what we pay for

Accuracy *is complicated*

- Accuracy of point measurements
  - *What the vendor can be held responsible for*
  - *Evaluation requires abundant, expensive GCPs*
- Accuracy of DEM
  - *What we care about*
  - *Evaluation requires abundant, expensive GCPs*

DEM error

To make bare-earth DEM:

1) Measure XYZ of points
2) Classify points as ground or not-ground
3) Interpolate ground points to continuous surface

DEM error ≈

$$[\ (\text{measurement error})^2 + (\text{classification error})^2 + (\text{interpolation error})^2\ ]^{1/2}$$

small, ≤10 cm

large in forested terrain

ditto

Rule of thumb:

internal DEM reproducibility

= 1.5–2 x Z measurement reproducibility

Accuracy *is complicated*

- Accuracy of point measurements
  - *What the vendor can be held responsible for*
  - *Evaluation requires abundant, expensive GCPs*
- Accuracy of DEM
  - *What we care about*
  - *Evaluation requires abundant, expensive GCPs*
- Reproducibility (consistency) of point positions
  - *Can be cheaply evaluated from swath overlaps*
  - *Provides lower bound on measurement accuracy*
- Reproducibility (consistency) of DEM
  - *Can be cheaply estimated from swath overlaps*
  - *Provides lower bound on surface model accuracy*

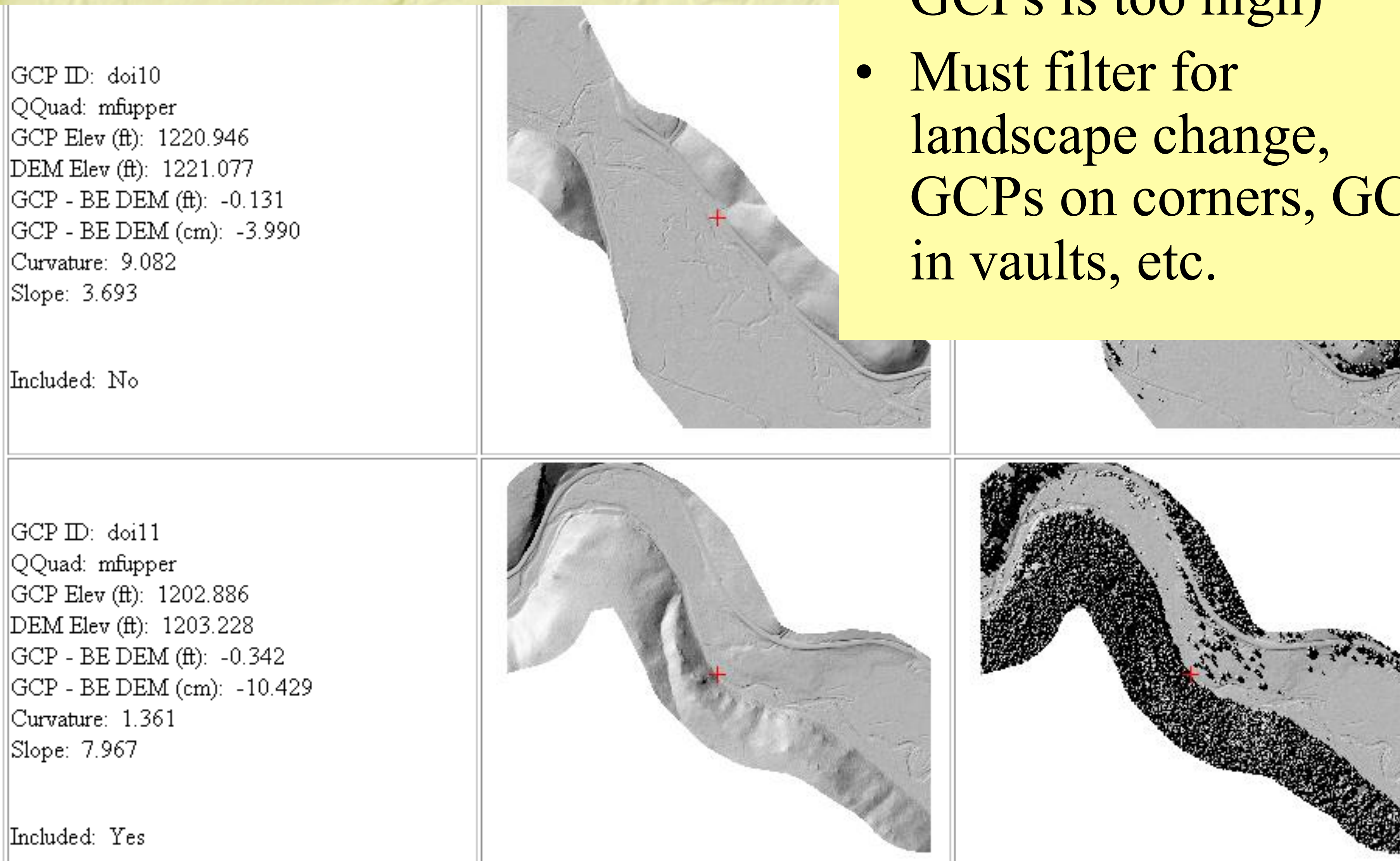
PSLC QA protocol: 3 analyses

1. Test against ground control points (GCPs)
2. Look at large-scale shaded-relief images
3. CONSISTENCY analysis of swath to swath reproducibility, with completeness inventory

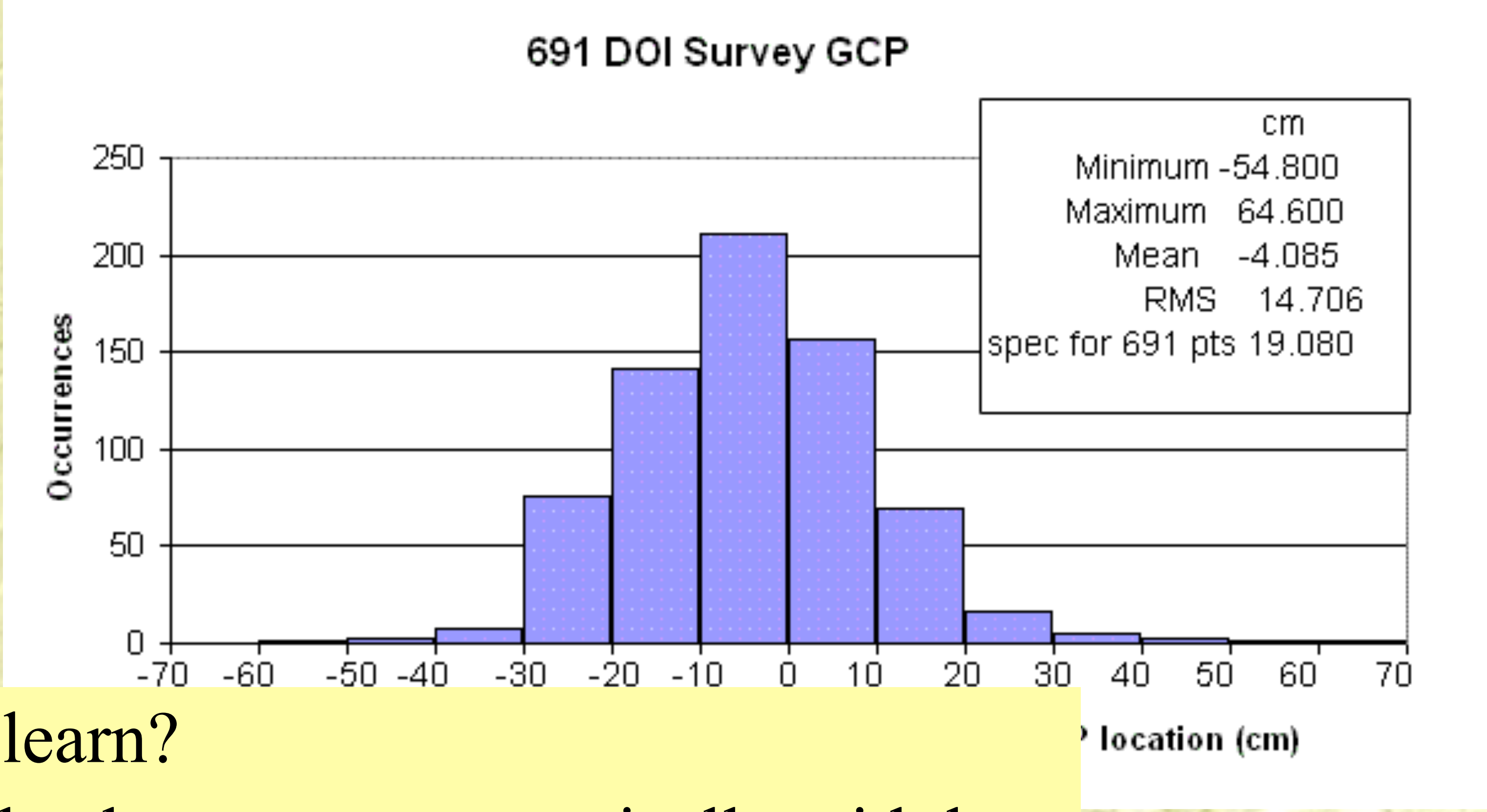
Extensive automated processing effectively tests for consistent file formats and file naming

Test against C

- We use existing GCPs (cost / benefit for new GCPs is too high)
- Must filter for landscape change, GCPs on corners, GCPs in vaults, etc.



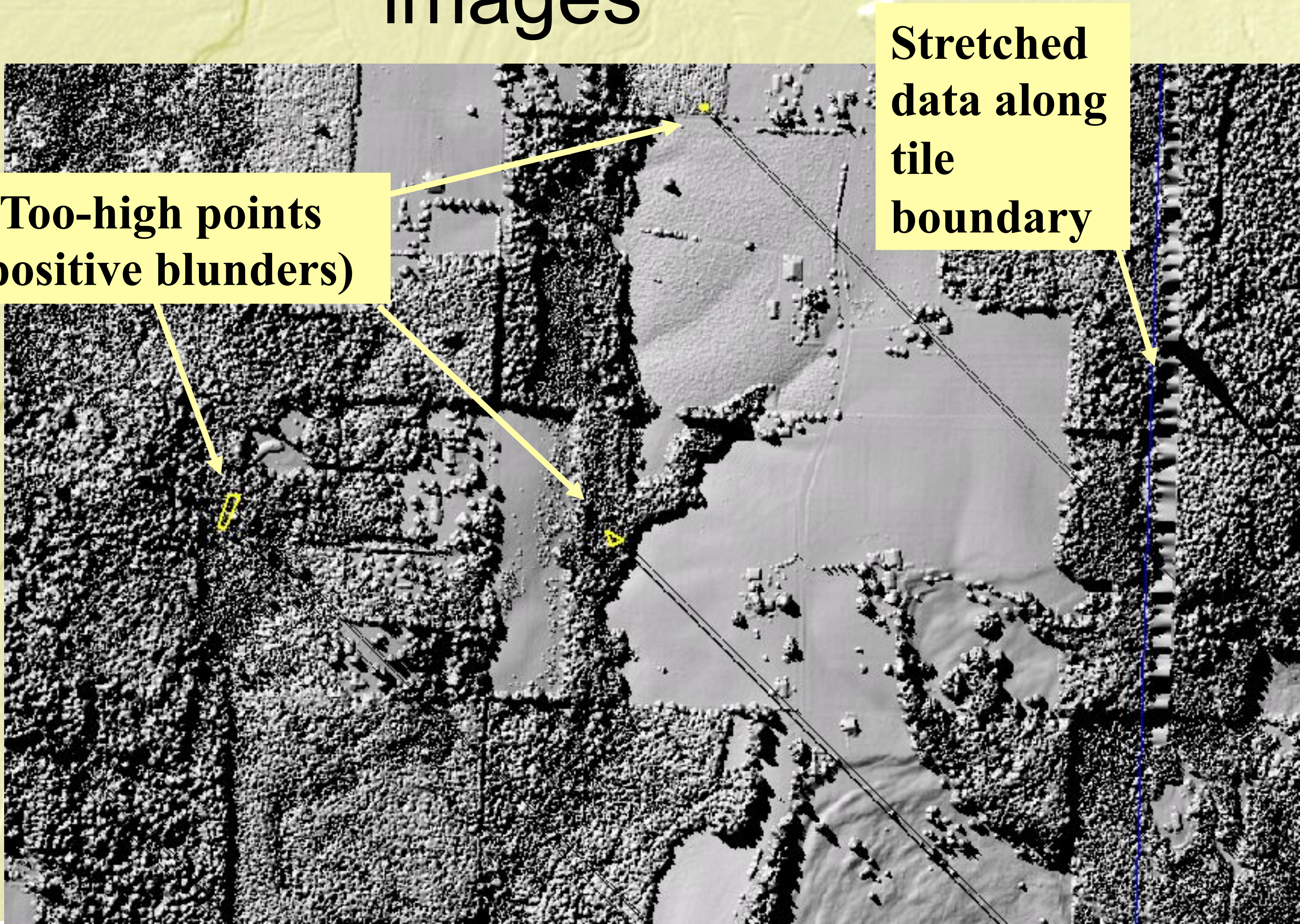
Test against GCPs

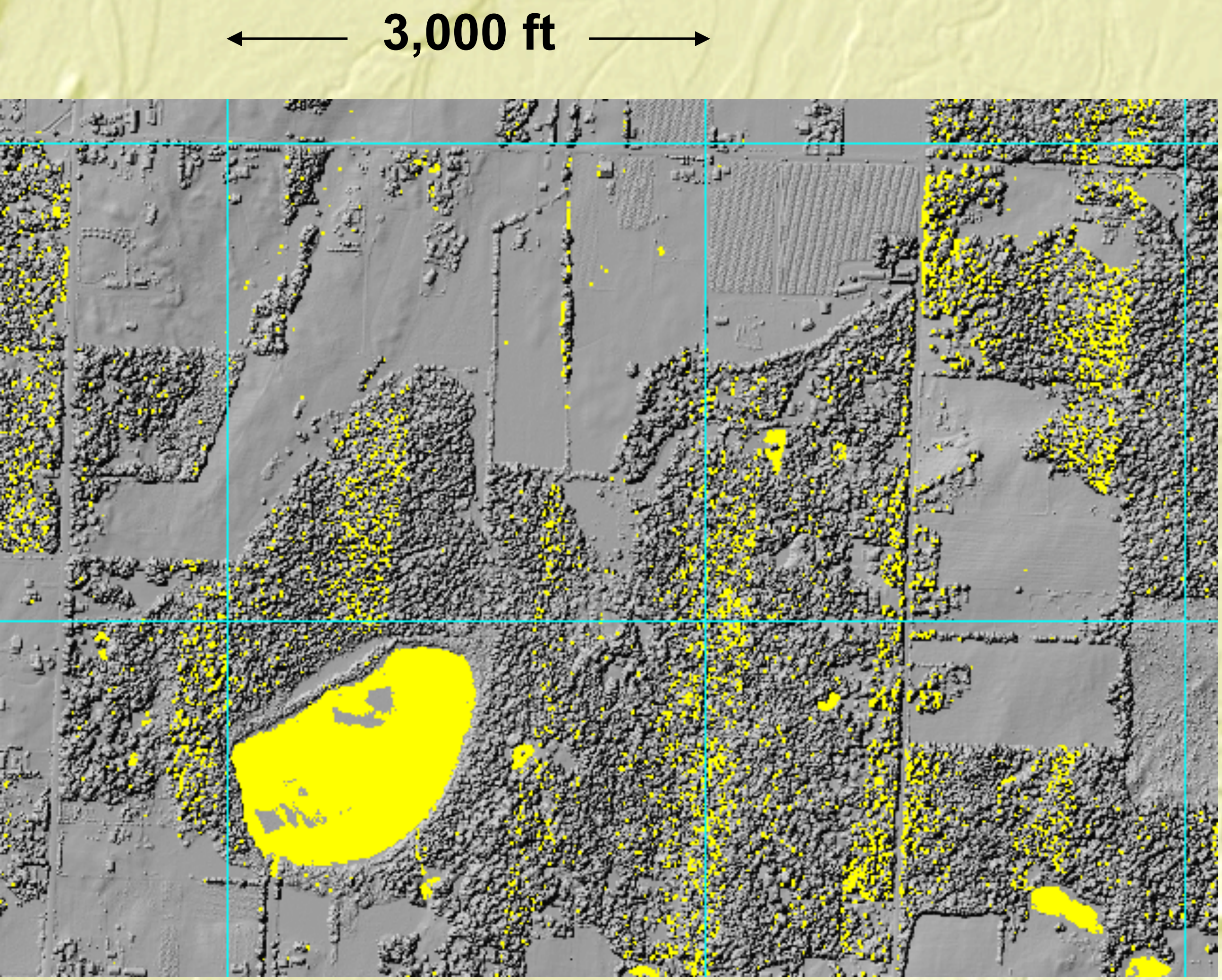


What do we learn?

- Confirm absolute accuracy, typically with low confidence
- Identify undocumented and misdocumented spatial reference frameworks

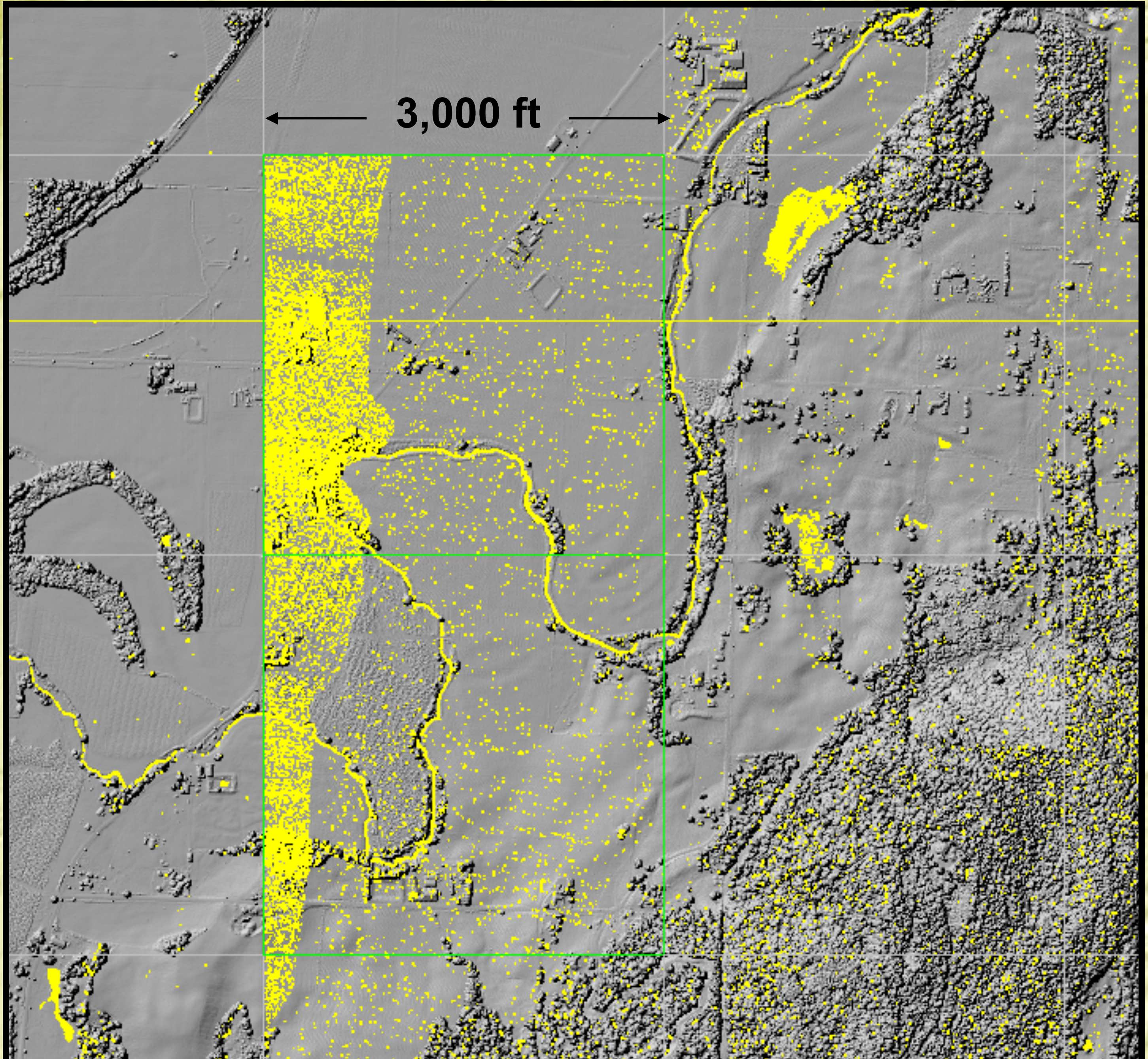
Look at large-scale shaded-relief images





- Highest-hit surface, voids = NoData.
- 6-ft raster
- Voids for open water (specular reflection) and in forest (off-nadir shadowing by canopy)

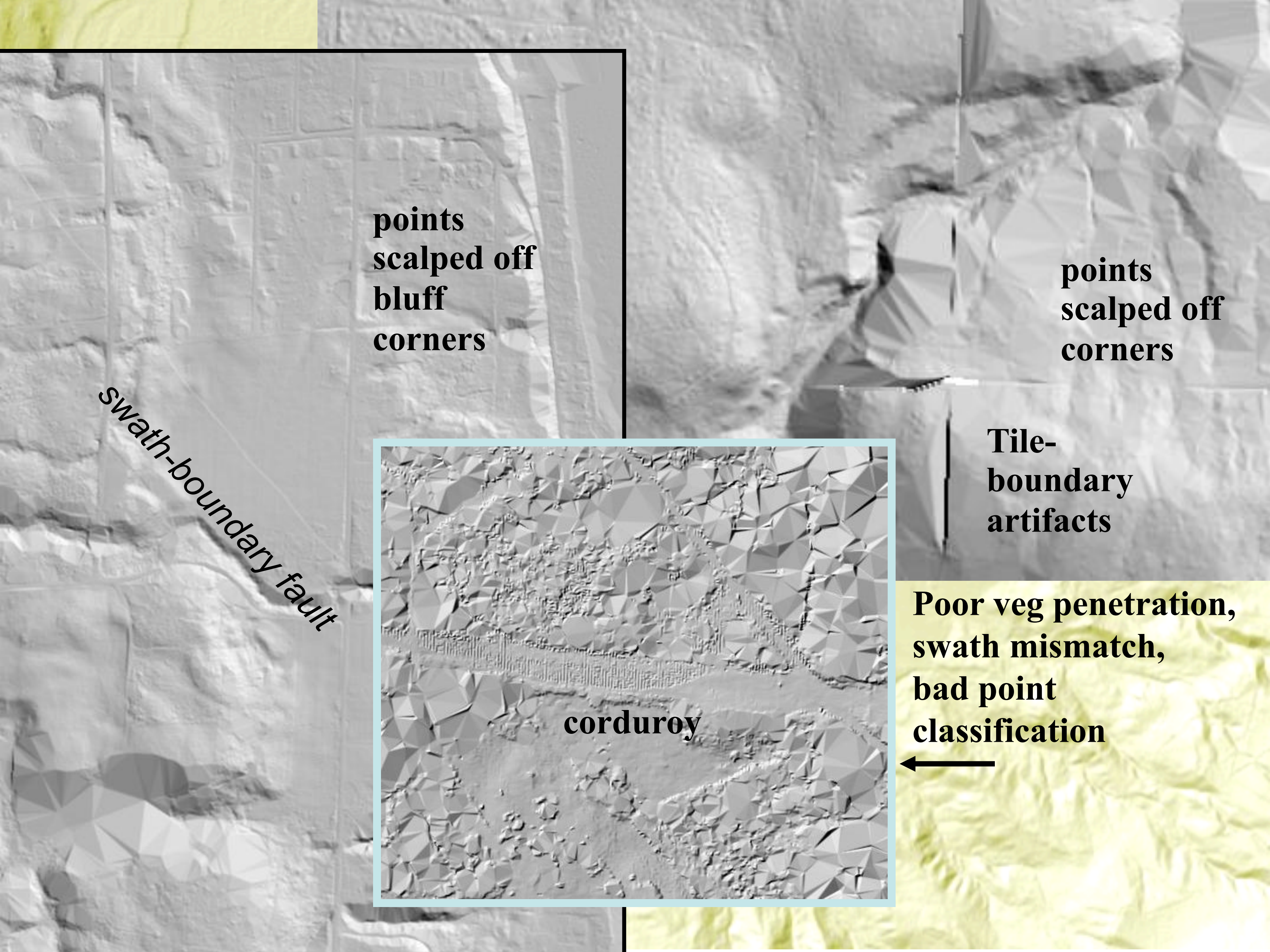
GOOD



Observation: Voids end at tile boundaries, not only at swath margin.

Inference: Data omitted on tile-by-tile basis

BAD

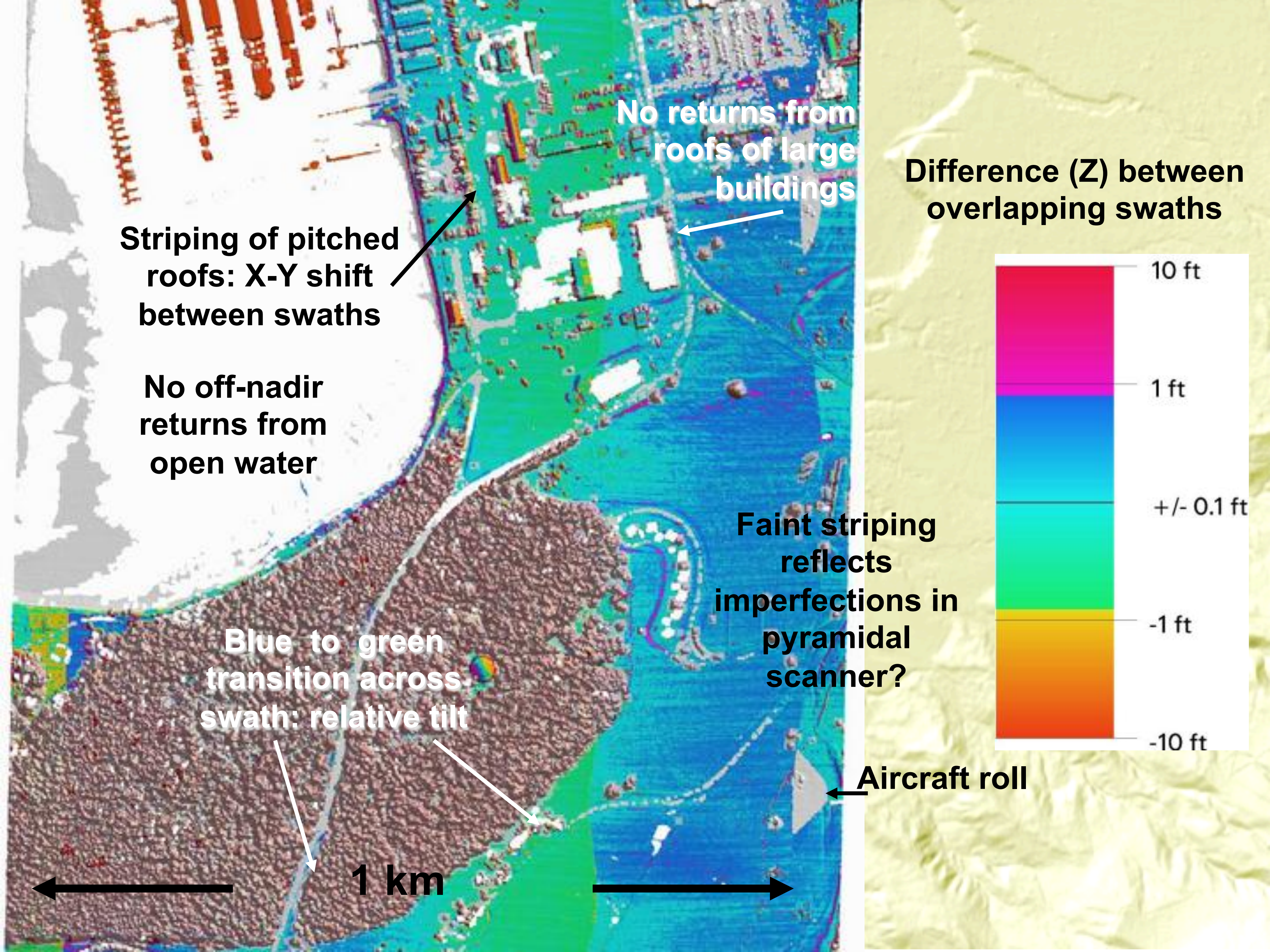

points
scalped off
bluff
corners
points
scalped off
corners
Tile-
boundary
artifacts
swath-boundary fault
corduroy
Poor veg penetration,
swath mismatch,
bad point
classification

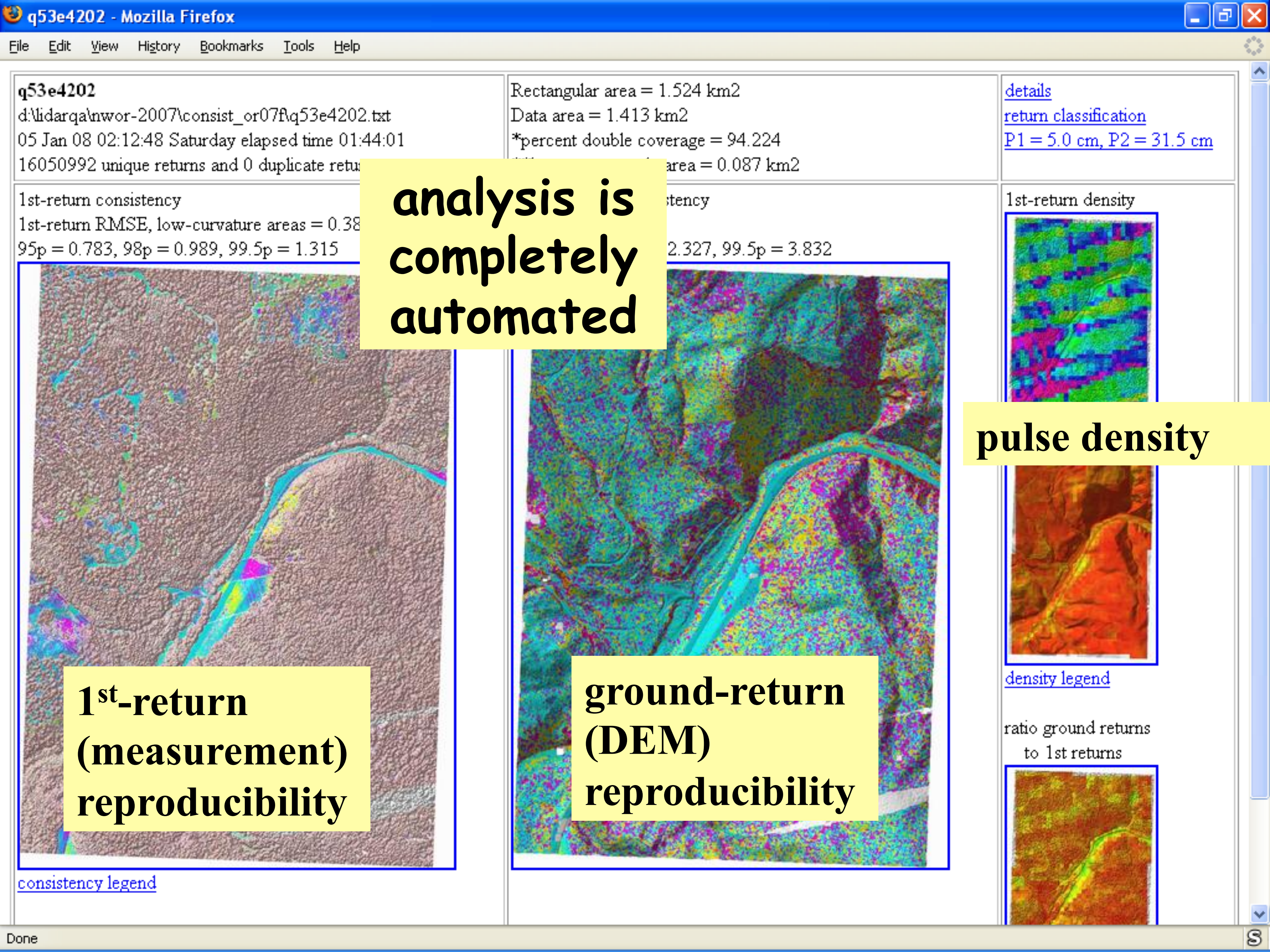
Observation: 3 ft step in freeway at tile boundary

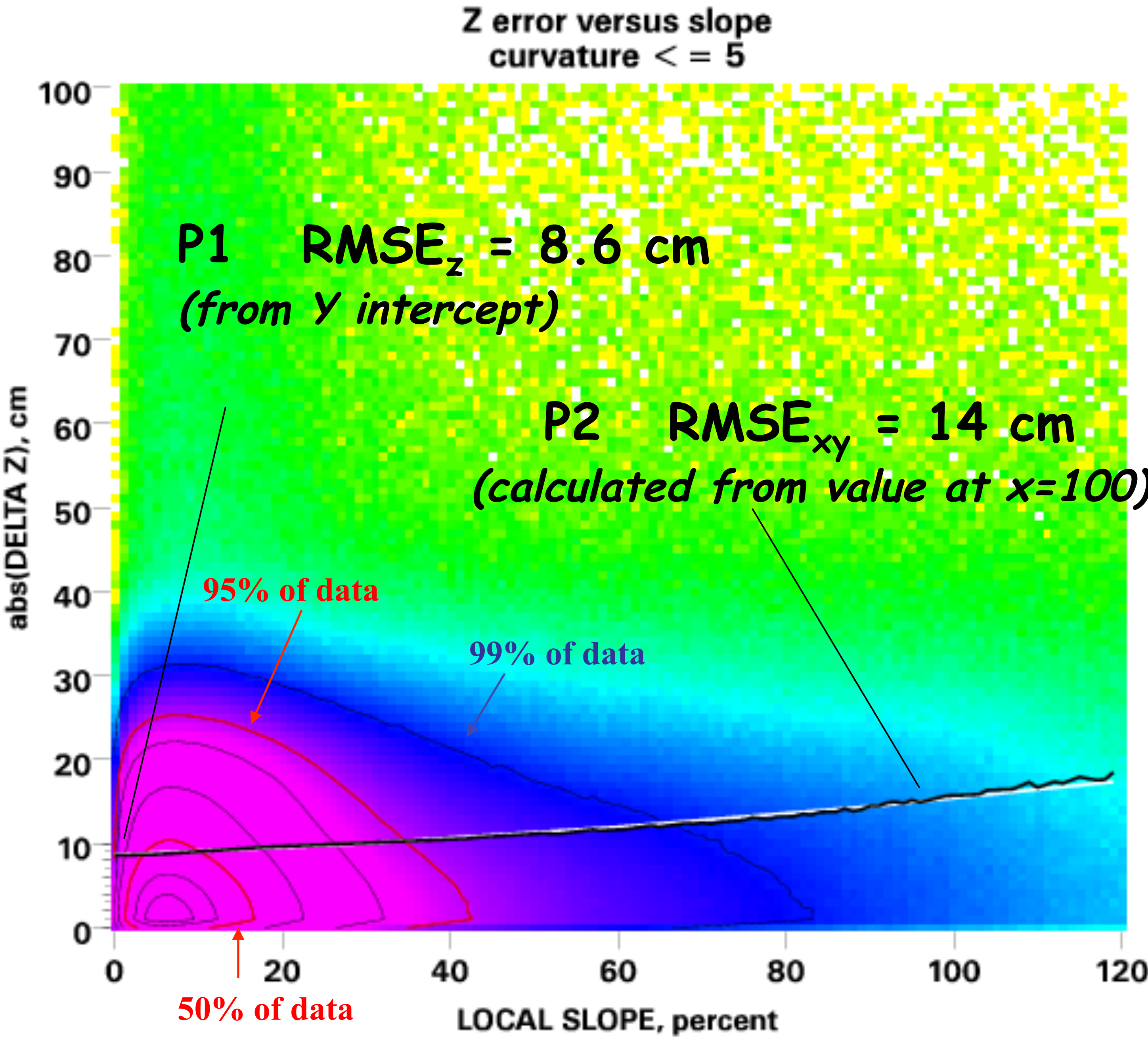
Inferred cause: tile to tile variation in inclusion of data, “calibration”, and/or range-walk correction

CONSISTENCY analysis

- Start with tile of multiple-swath data
- Sort on time. Split into swaths at time breaks. For each swath
  - Identify data areas
  - Build surface (1st-return points → TIN → lattice)
- Subtract swath surfaces, spatially merge results
- Calculate curvature to identify smooth areas where interpolation is valid
- Make image
  - Saturated color = smooth area with overlap
  - Unsaturated color = rough area with overlap
  - Gray = no overlap
  - White = no returns


No returns from roofs of large buildings
Difference (Z) between overlapping swaths
10 ft
1 ft
+/- 0.1 ft
-1 ft
-10 ft
Striping of pitched roofs: X-Y shift between swaths
No off-nadir returns from open water
Faint striping reflects imperfections in pyramidal scanner?
Blue to green transition across swath: relative tilt
Aircraft roll
1 km


q53e4202 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
q53e4202
d:\lidarqa\nwor-2007\consist_or07f\q53e4202.txt
05 Jan 08 02:12:48 Saturday elapsed time 01:44:01
16050992 unique returns and 0 duplicate retu
Rectangular area = 1.524 km2
Data area = 1.413 km2
*percent double coverage = 94.224
area = 0.087 km2
details
return classification
P1 = 5.0 cm, P2 = 31.5 cm
1st-return consistency
1st-return RMSE, low-curvature areas = 0.38
95p = 0.783, 98p = 0.989, 99.5p = 1.315
stency
2.327, 99.5p = 3.832
1st-return density
density legend
ratio ground returns
to 1st returns
consistency legend
Done
analysis is completely automated
pulse density
1st-return (measurement) reproducibility
ground-return (DEM) reproducibility



$n \approx 25$ *million*

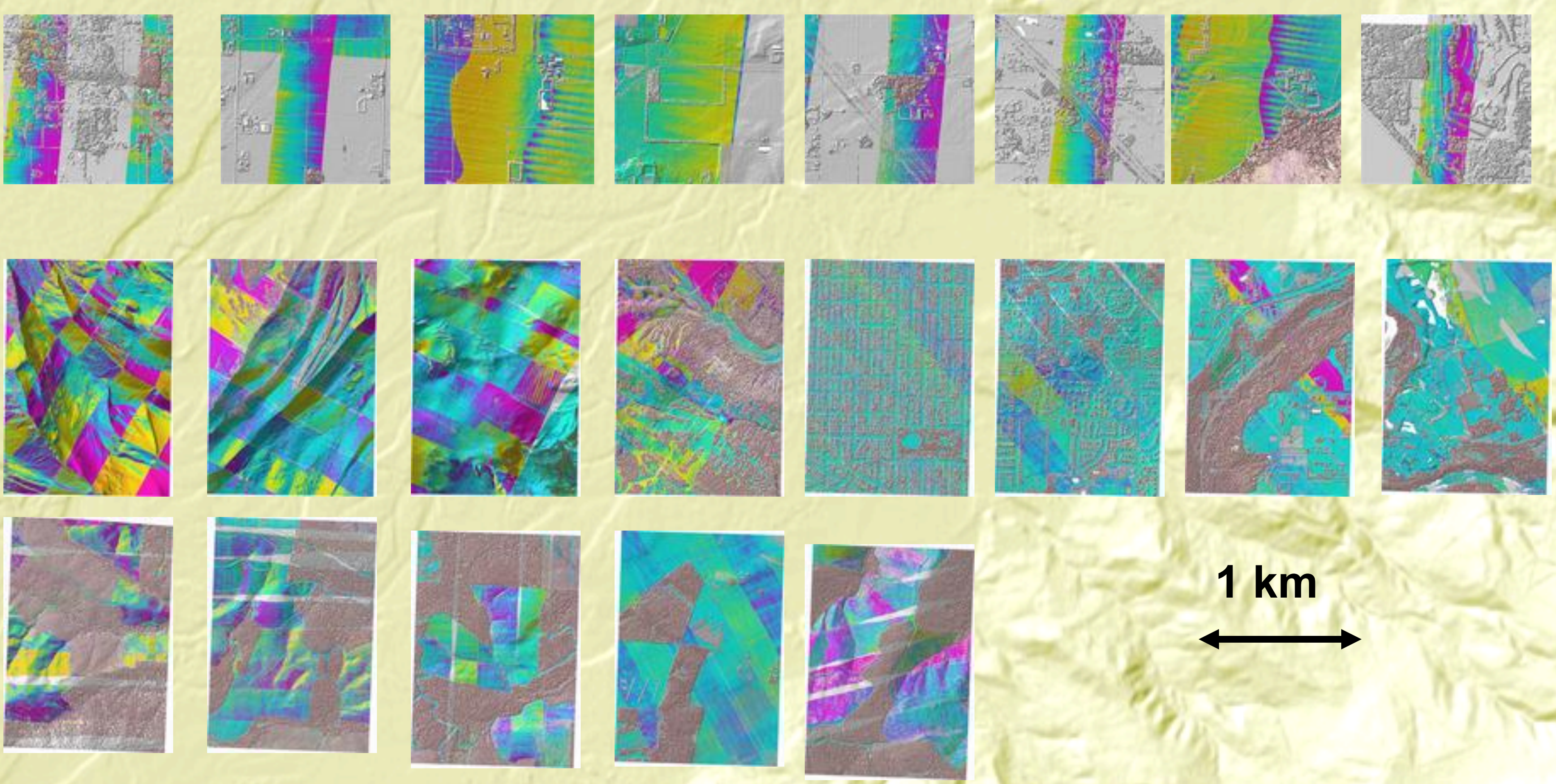
TerraPoint 2005 Lower Columbia survey

25% sample of two 7.5- minute quadrangles, 2 pulse/m^2

wiggly black line: RMS Y for each X

white line: least-squares best fit quadratic

Observation: errors in lidar measurements show strong spatial correlation

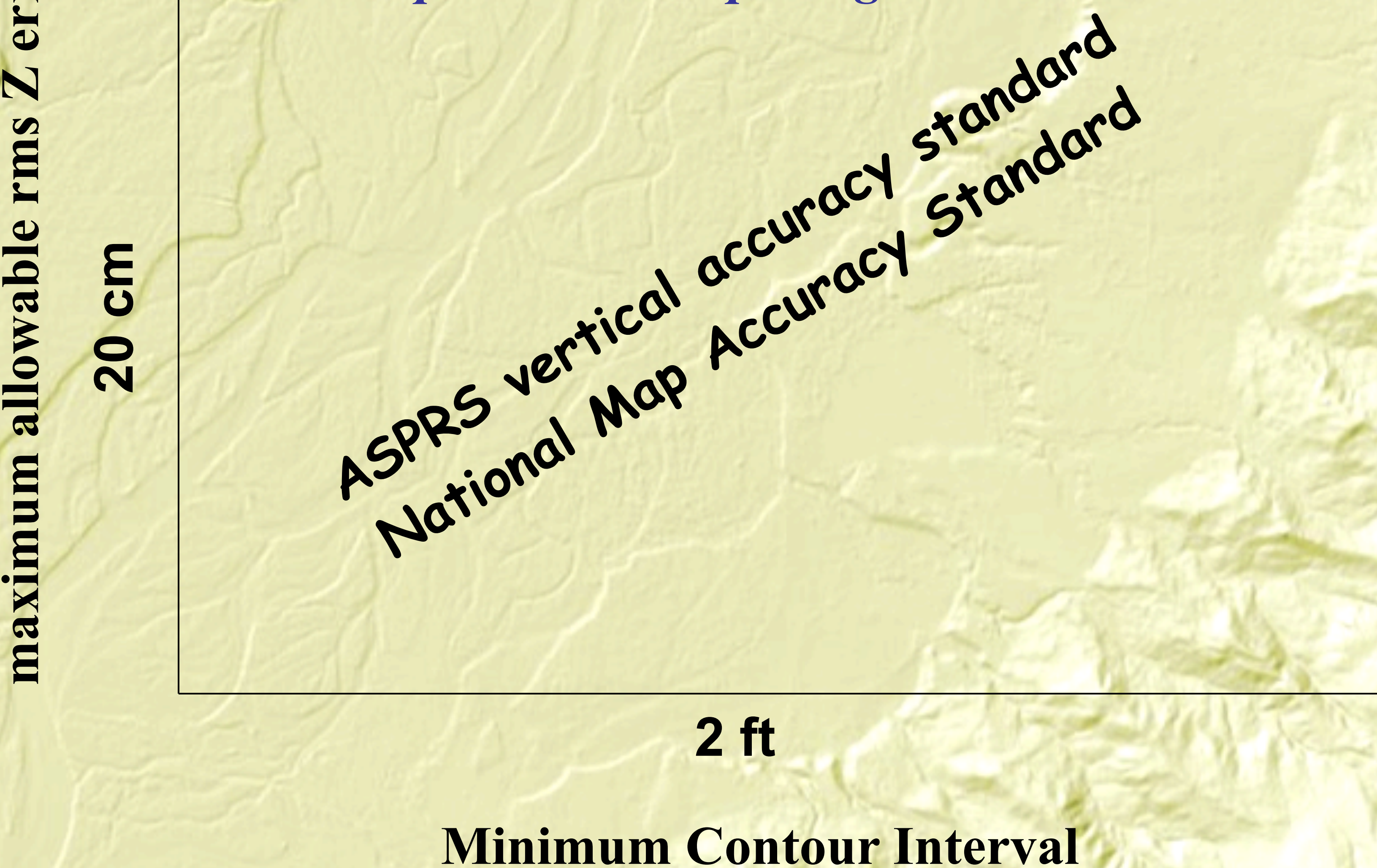


Hypothesis: errors in photogrammetric DEMs have little spatial correlation

Why?

- Aerotriangulation and image orientation done with greater care (and more redundancy) than identification of corresponding image points
- Largest source of error has no spatial correlation beyond that imposed by structure of target region

This relationship between measurement accuracy and intended use is (I hypothesize) empirical and based in experience with photogrammetric DEMs



- Uncorrelated errors disappear upon spatial averaging
- Drawing contours (and cut-and-fill calculations) involves spatial averaging
- Contouring minimizes errors in photogrammetric DEMs by averaging them away
- Contouring a lidar DEM, with its highly correlated errors, does NOT minimize errors by averaging

Lidar surveys for contouring (and other averaging operations) should be more accurate than suggested by ASPRS and NMAS standards

Lidar surveys for feature recognition (e.g., finding fault scarps, counting trees) can be significantly less accurate than experience might suggest, provided adequate XY resolution

- Lidar data quality has 3 dimensions
  - Usability
  - Completeness
  - Accuracy
- Evaluate lidar data quality by
  - Testing against ground control
  - Looking at big images
  - Quantifying swath to swath reproducibility and completeness
- Standards for required mean accuracy need revision
  - Inundation modeling requires better absolute accuracy than we expect
  - Geomorphic mapping (feature recognition) requires less absolute accuracy