Lidar quality, artifacts, issues to keep in mind

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

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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
Lidar data collection

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

15 - 20 cm
Heterogeneity of surface sampling: B4 shot density maps and profiles
Each laser pulse can produce multiple consecutive measurements from reflections off several surfaces in its path.

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\textsuperscript{st}
Yellow = 2\textsuperscript{nd}
Green = 3\textsuperscript{rd}

Ian Madin, DOGAMI
In the PNW:
14% of points classified as ground

Minimum LiDAR Considerations in the Pacific Northwest
Watershed Sciences, Inc.
TIN or other non-local interpolator necessary in areas of sparse ground returns (right).
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**
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
Flag points that define spikes (strong convexities)
Rebuild TIN

R. Hagerud, USGS
Flag points that define spikes
(strong convexities)
Rebuild TIN
Flag points that define spikes (strong convexities)
Rebuild TIN
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

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

Cross-section of highway cut

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
Tile-boundary artifacts

points scalped off corners

swath-boundary fault

points scalped off bluff corners

corduroy

Poor veg penetration, swath mismatch, bad point classification

R. Hagerud, USGS
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)
Corduroy & Scan Edge Artifacts

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

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.
Clark Lake is flat - it is a dry lake or ‘playa’ surface.
Corduroy & Scan Edge Artifacts

0.5 m DEM from NCALM
Ante Perez, CGS

“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)
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
Scan artifact - at scan edge on dry lake one sees a pattern of up-down consistently; as mirror flips, height reads differently.
One scan (aircraft pass) is consistently lower than the other scan; this is a different source of ‘corduroy’, related to aircraft trajectory/positioning.