LAS PROCESSING TO CREATE A PIT FILLED, HYDRO-FLATTENED, BARE EARTH LAYER

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Lidar technology can produce high-resolution models of ground elevation (e.g., 1-meter spatial resolution) with a vertical accuracy of +/-10 centimeters (0.1 meters). Aerial lidar data is collected as a point cloud using aircraft mounted with a laser scanner, an Inertial Navigation System (INS), and a Global Navigation Satellite System (GNSS) receiver. The laser scanner transmits pulses of light to the ground surface which are then reflected back to the active sensor. The travel time between the transmission and reflection of pulses is used to calculate distance between the laser scanner and the ground and ultimately represents the elevation of the surface. The resulting point cloud is comprised of pulse returns for the first return, last return, and all returns in between. Numerous classes are used to classify point returns such as highest hit (top of canopy or top of structure), sub-canopy returns, or ground returns. Raster bare earth models are created using the final returns representing the ground surface.

Nominal point spacing (NPS) refers to the “average” distance between laser point returns across the project area and helps determine the project’s quality level by quantifying the final lidar point returns per square meter. Idaho lidar standards require a minimum point density of 4 pulses/m^2 where at least 90% of the cells in a 1-m^2 raster grid contain 4 lidar points (Idaho Elevation Technical Working Group, 2021). Using lidar point cloud data (stored in LAS file format) the Create LAS Dataset geoprocessing tool in ArcGIS Pro reads the input LAS files. If available, breaklines are also incorporated into the LAS Dataset. Breaklines are vector line and polygon feature classes that define abrupt changes in elevation and contain known elevation values at those “break” lines. Breaklines are essential for creating hydro-flattened bare earth layers and a necessary precursor to developing a hydro-enforced flow model.

After creating the LAS dataset, ground returns are reviewed to determine if reprocessing is necessary. Oftentimes, the percent of ground point returns falls below 30%. If the ground point return for the LAS dataset does not reach a minimum of 30%, the dataset is reprocessed to increase the number of ground return points and the overall quality of the derived surface products. This is done using the Automated Ground Classification geoprocessing tool in ArcGIS

Pro and is an important step to ensure a sufficient number of ground returns will be used to generate the raster bare earth layer at the desired spatial resolution. For example, if a processed bare earth layer at 1-meter spatial resolution (i.e., the raster file contains 1 m x 1 m pixels) is desired, but the LAS point cloud provides only 4 pulses per meter^2 and a 10% ground classification rate, this suggests many output pixel values will not be derived from an actual lidar ground return but instead, from values interpolated from adjacent pixels. In this case, to ensure each pixel in the processed bare earth layer was derived from actual lidar ground return data requires increasing the pixel size to 2 meters resulting in an average of 1.6 ground returns per pixel (**Figure 1**). However, when the percent ground return rate is increased to 25%, a more reliable processed bare earth layer could be rendered using 1-meter pixels.

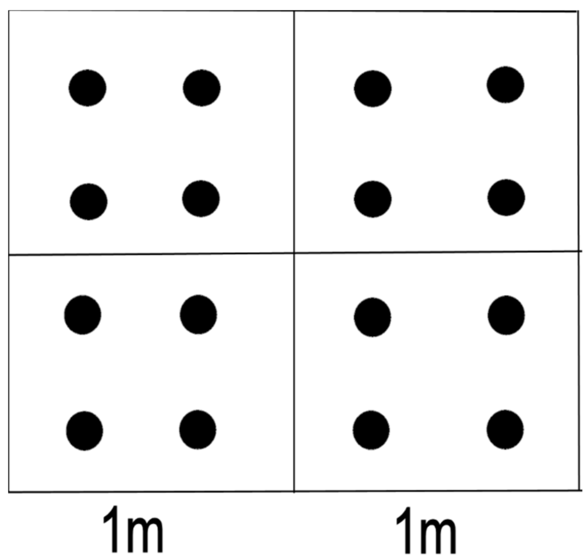

Figure 1: Lidar point returns in four 1-m x 1-m cells with four pulses per meter^2. A minimum of 25% ground classification rate is required to create a 1-m spatial resolution bare earth model. If the ground classification rate falls below 25%, increasing the spatial resolution to 2 m will provide a sufficient number of observations to derive a reliable model.

First, to satisfy the concern described above, a threshold value of 30% is used by Idaho State University's GIS Training and Research Center and second, since pulse density and point spacing is reported as a nominal value, increasing the minimum percent ground returns from 25 to 30% is reasonable to accommodate variability across large project areas. Last, the threshold value of 30% is used as it is a relatively easy threshold to achieve with most QL1 or QL2 lidar projects.

Once the lidar LAS dataset has been successfully created with a sufficient rate of classified ground returns, a series of geoprocessing tools are run using a python script that defines the areas where lidar data actually exists. In many instances a sparse number of lidar pulses are found near the edge of a project's area of interest and these areas need to be removed from the final bare earth layer. Particular attention is given to analyzing the boundary lines created from the script to ensure the resulting raster layer will be representative of the actual ground surface. Anomalies in the raster caused by "no data" areas are removed by clipping the raster to the boundary defined by the script using the Clip Raster geoprocessing tool.

All processed bare earth raster TIFF layers are created using 1-meter cell size (pixel size) and pyramids built using bilinear interpolation with LZW compression. Once anomalies and no data areas are removed, the layer is pit-filled to remove any sinks (**Figure 2**). A sink is a pixel with an undefined drainage direction and is frequently assigned a zero or negative elevation value. Sinks or pits are very difficult to detect visually but easily identified by calculating a flow direction and flow accumulation model. Most standard bare earth layers contain pits. Thus, applying the Fill geoprocessing tool is a necessary step to provide users with a high-quality bare earth layer.

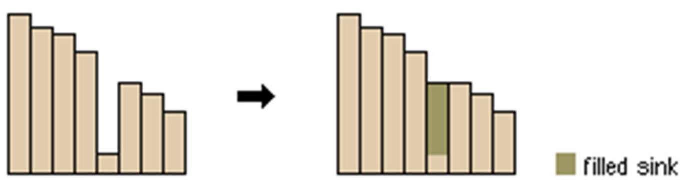

Figure 2: The Fill geoprocessing tool fills sinks in a bare earth layer (source from pro.arcgis.com).

Before lidar data are made available, the final products are reviewed to ensure that: (1) the data have been correctly projected with a defined spatial reference system, (2) the spatial resolution is 1.0 meters (or better resolved), (3) all units (X, Y, and Z) are expressed in meters, (4) the vertical datum has been correctly applied, and (5) all processed raster data are stored in TIFF file format with LZW compression and bilinear interpolation was used to generate the pyramids. This protocol for processing bare earth lidar products at ISU GIS TReC ensures that only the highest quality (Q1 or Q2) bare earth models are produced and made available for use.

REFERENCES

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