

Classify Ground Points by Terrain Following

A major application of LIDAR point clouds is the accurate delineation of the terrain surface. However, LIDAR data may also include point returns from vegetation and man-made objects such as buildings, towers, and wires. Creating a bare-earth terrain surface requires that these above-ground returns be excluded. The Lidar Classification process in TNTmips (see the Technical Guide entitled *LIDAR: Automatically Classify LAS Point Clouds*) includes several classifiers that you can use to automatically identify likely ground points. The Ground - Terrain Following method uses a fast, slope-based approach to identify ground points.

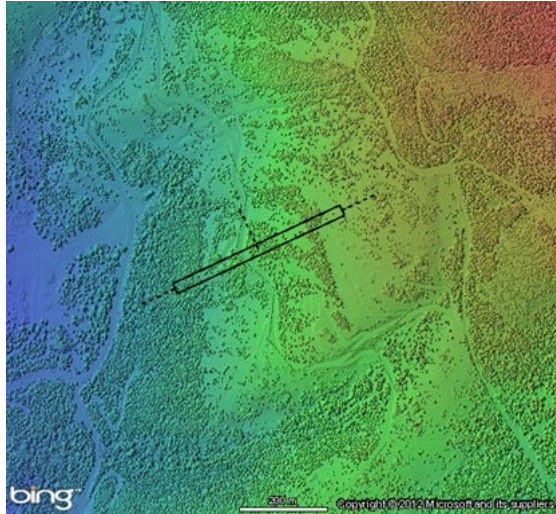
Terrain Following Strategy

The Terrain Following classifier begins by considering only points that are single returns or the last of multiple returns, as earlier returns are almost certainly from vegetation. Some last returns are also rejected as likely vegetation if their elevations are significantly higher than nearby last-of-multiple returns. A square grid of designated cell size is then used to select an initial sampling of potential ground points, with each grid cell represented by the lowest point near the center of the cell.

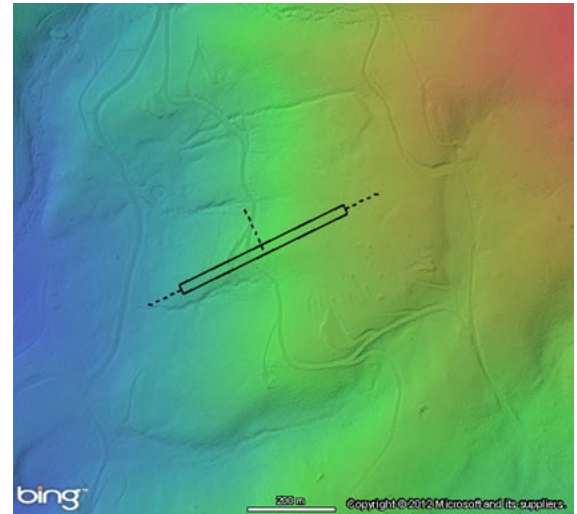
The point grid is subdivided into square *seed areas*, which should be large enough to include at least several actual ground points. Within each seed area, the lowest grid point is identified as ground and is used to begin an *upslope* search for additional ground points using three slope constraints.

These constraints are based on the concept that the edges of point clusters representing trees, bushes, and buildings are marked by abrupt increases in point-to-point slope from ground to off-ground points. For each identified ground point, sample points in the eight neighboring grid cells are also classified as ground if the slope to that point is less than an *initial slope* value. In addition, neighboring points are classified as ground if the slope from the existing ground point to the neighbor is less than a *maximum slope* threshold and the change in slope is also less than the designated *slope increment* value. Using these criteria, ground points are progressively added to the identified set in the seed area, typically moving in one or more upslope directions.

The upslope search for ground points in a seed area may be blocked locally by vegetation or steep ground slopes, so that viable ground points behind

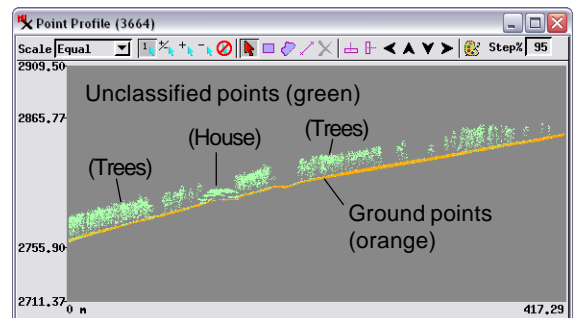


Virtual Terrain Display from All Points



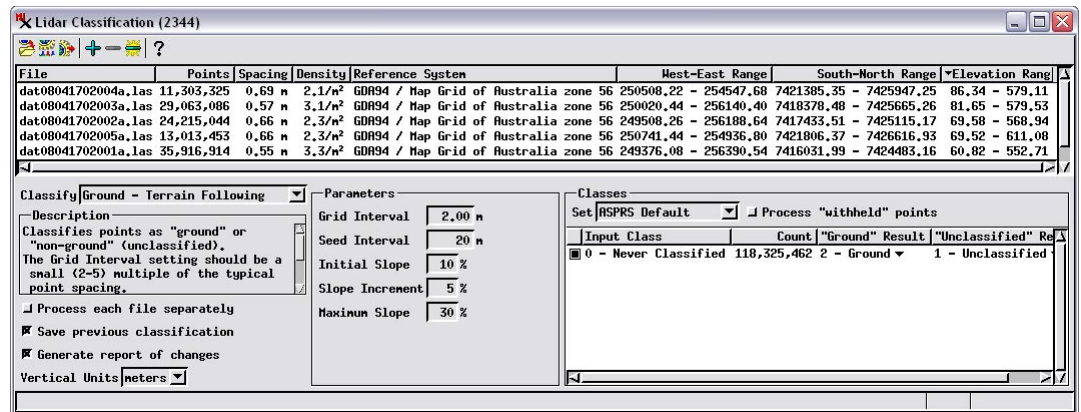
Virtual Terrain Display using Ground Points from Terrain Following method

Result from ground classification by the Terrain Following method for an area with moderate relief and a mix of forest and open areas. A Bing Maps image of the area is shown to the left; the scale bar length is 200 meters. Above, color shaded-relief virtual terrain displays of Lidar points covering the area with nominal point spacing of 0.56 meter. Blue color indicates lower elevations and red the higher elevations; total relief in the scene is about 250 meters. The virtual terrain on the left uses all point classes, so the surface includes trees and scattered houses. The virtual terrain on the right is based only on ground points classified (from all input points) by the Terrain Following method in the Lidar Classification process in TNTmips. Trees and houses were effectively excluded from the ground class, yet the classification produced a sufficient density of ground points to produce a detail terrain visualization even in the forested areas. The black box in the terrain illustrations (red in the image illustration) outlines the location of the point profile shown below. The vertical and horizontal scales in the profile are equal, so it shows the true slope of the terrain.



(over)

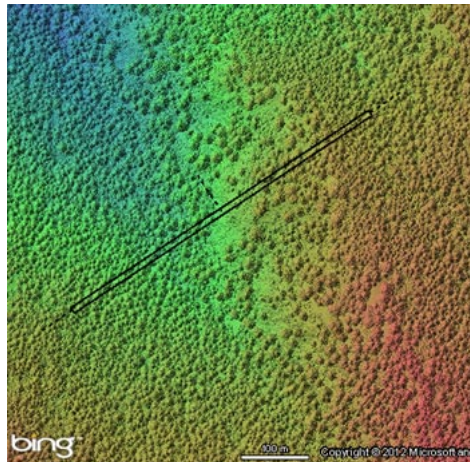
these barriers may not be identified initially. Therefore the ground points identified in the upslope search are used to initiate a *downslope* search for additional ground points using similar slope constraints. Finally, points not included in the gridded sample set are processed and classified as ground if their elevations are below the surface defined by the ground points identified in the gridded sample.



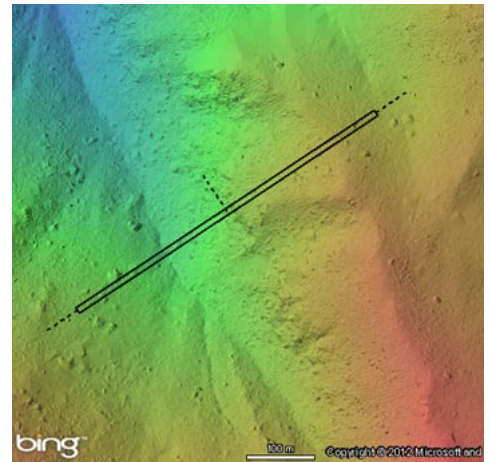
Terrain Following ground classifier set to process six unclassified LAS files as a group. Classifier settings can be modified in the Parameters panel as described in the text.



Forested Area with Steep Terrain

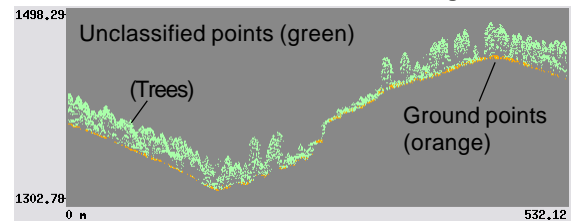


Virtual Terrain Display from All Points



Virtual Terrain Display using Ground Points from Terrain Following method

Result from ground classification by the Terrain Following method for an area of coniferous forest in steep terrain. A Bing Maps image of the area is on the left; the length of the scale bar is 100 meters. Center and right, color shaded-relief virtual terrain displays of Lidar points covering the area with nominal point spacing of 0.3 meter. Blue color indicates lower elevations and red the higher elevations; total relief in the scene is about 370 meters. The virtual terrain in the center uses all point classes, so much of the surface is dominated by trees. The virtual terrain on the right is based only on ground points classified (from all input points) by the Terrain Following method in the Lidar Classification process in TNTmips. The red box in the image illustration (black in the terrain illustrations) outlines the location of the point profile shown above. The vertical and horizontal scales in the profile are equal, so true ground slopes are shown. Most trees were excluded from the ground point class by the Terrain Following classifier, but the ground virtual terrain shows scattered "bumps" where some tree returns were misclassified as ground. In order to classify points on bare patches on steep slopes (e.g., center of area illustrated) as ground, a Maximum Slope setting of 50 degrees was used, but in areas with lower slopes this setting failed to exclude all vegetation points from the ground class. Such isolated points can be reclassified manually (see the TechGuide entitled *LIDAR: Interactive Editing of Point Classes*).



Parameters for Terrain Following

Controls for setting the parameters that guide the Terrain Following ground classifier are on the Parameters pane of the Lidar Classification window. The Grid Interval value sets the cell size of the sampling grid; this value should be a small (2 to 5) multiple of the typical point spacing (shown in the Spacing column in the input file list for each LAS file). The Seed Interval value sets the size of the square seed areas. As discussed previously, the seed area size should be large enough to ensure that at least several valid ground points are present in each seed area. In practice, this means that seed areas should be larger than typical tree crowns in forested areas and larger than the largest buildings (otherwise the lowest point in the seed area may be in vegetation or on a building roof). On the other hand,

if seed areas are too large, they may include too many terrain irregularities and vegetation barriers, so that the upslope and downslope ground point searches may be blocked from reaching all parts of the seed area. Thus seed areas should be no larger than necessary to ensure identification of true ground seed points.

The Initial Slope, Slope Increment, and Maximum Slope values are explained in the previous discussion. Setting suitable values for the Slope Increment and Maximum Slope parameters requires consideration of the terrain slopes and amount of local topographic relief in the data area. In areas with steep terrain slopes higher values for the latter parameters will be required in order to avoid excluding valid ground points on steeper slopes and areas of rough ground.