Appendix C   Development of Digital Elevation Models

Digital elevation models (DEMs) of the slope were developed in RiSCAN Pro. Following registration and alignment, vegetation was removed from the point clouds by following the workflow outlined in Figure C 1.
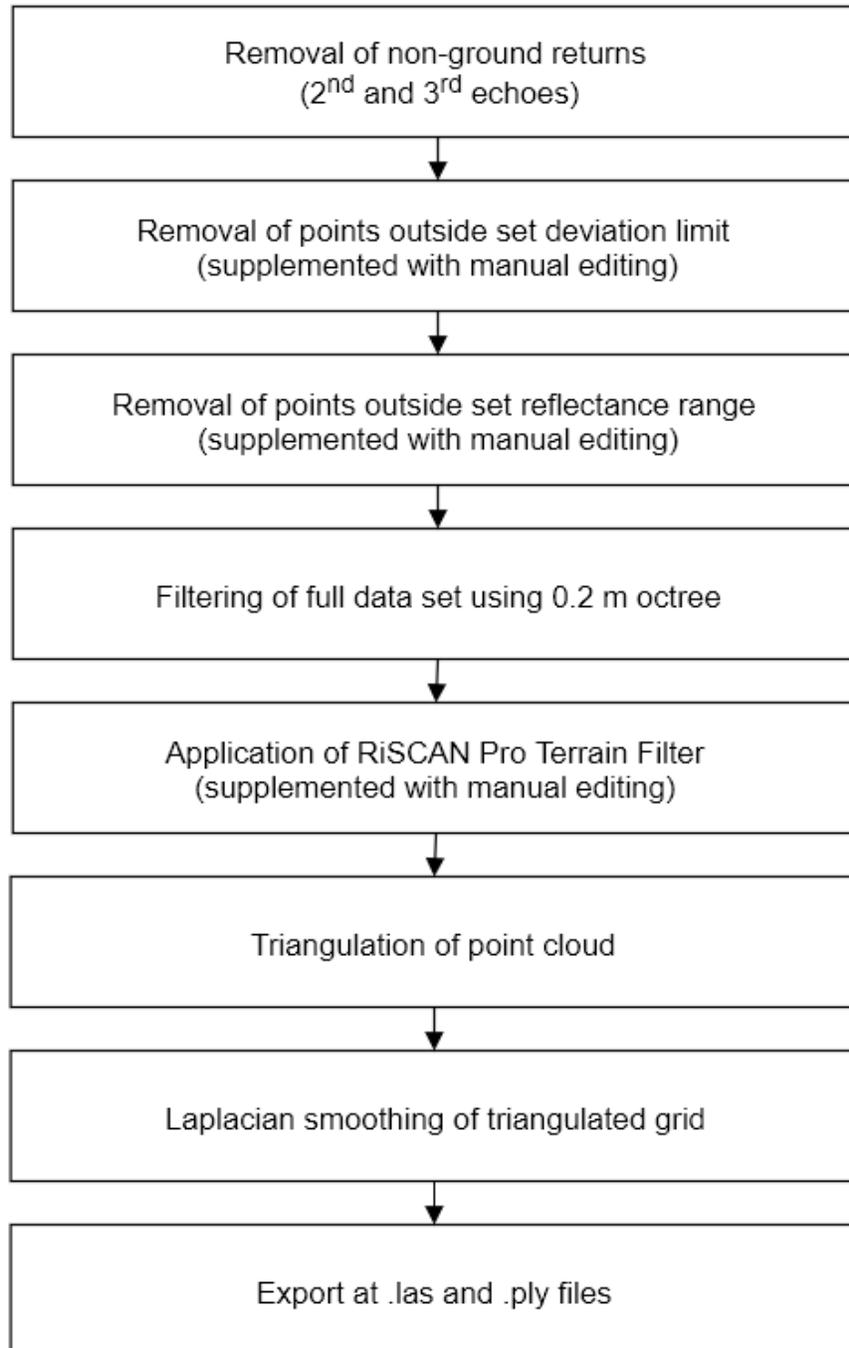
Figure C 1.   Workflow for creation of slope-scale DEMs in RiSCAN Pro using TLS data.

The point clouds were filtered using RiSCAN PRO deviation, reflectance range and terrain filters (RIEGL 2016). Deviation limits were selected through an iterative process to determine the most suitable range for the given dataset. For the 2016 and 2017 point clouds this was found to be 10 while filtering by deviation limit did not effectively pick up vegetation from the surrounding slope for the 2012 dataset and consequently was not used. All points outside the specified reflectance range (25 dB to 5 dB) were also removed prior to applying the RiSCAN PRO terrain filter. All filters required significant manual editing to ensure that rock outcrops, boulders, ridge lines, etc. were not mistakenly removed from the dataset in conjunction with the intended removal of vegetation and other extraneous points.

When complete, the bare earth datasets were triangulated (50 m maximum edge length) and smoothed using a Laplacian smoothing algorithm available in RiSCAN Pro. The resulting grids were imported to CloudCompare (Girardeau-Montaut 2017) and exported as slope-scale rasters (0.5 m resolution) for further analysis in ArcGIS (ESRI 2017).

At select locations, the DEMs were artificially rotated in CloudCompare to align with a primary axis (x, y, z) prior to rasterization (Figure C 2). In this manner, the outcrop could be analyzed along a line of sight that facilitates change detection into and out of the face. This was particularly useful on sub-vertical faces that would otherwise be adversely oriented along the Z-axis line of sight in ArcGIS prohibiting accurate change detection on those faces.
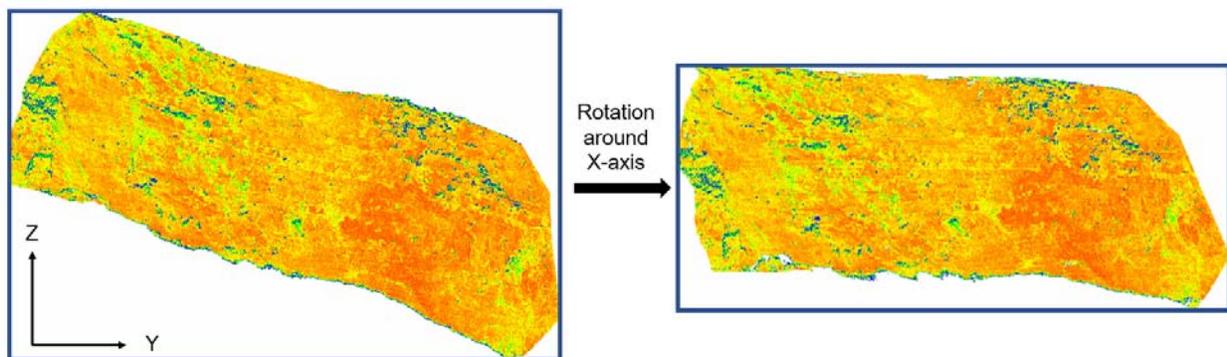
Figure C 2.   Rotation of TLS point cloud around X-axis to facilitate improved line of sight orientation for change detection.