OpenTopography

Metadata Report

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Project Name: Virginia Tech StREAM Lab Winter 2021 Drone Lidar Survey

Summary

Two drone lidar flights were conducted on November 11, 2021 and December 13, 2021 over the Virginia Tech StREAM Lab (https://www.bse.vt.edu/research/facilities/StREAM_Lab.html) during leaf-off conditions. The lidar data were collected using a Vapor35 (AeroVironment, Simi Valley, CA, USA) with a YellowScan Surveyor Core lidar unit (Monfeerier-sur-Lez, France). More information about the drone lidar system can be found in (Prior et al., 2021). From these two flights, a classified point cloud, a ground point density raster (1 m^2 resolution), a digital elevation model (DEM) with surveyed stream bathymetry (0.1 m^2 resolution), and a canopy height model (CHM; 0.1 m^2 resolution) were created.

Personnel

- PI(s): W. Cully Hession
- Field staff: Laura Lehmann
- Additional team members: Elizabeth M. Prior, Yohtaro C. Kobayashi, Nicholas D. Christensen, Jonathan P. Resop, Thomas J. Pingel, Jonathan A. Czuba

Site Information

- Site description: Between 2009 and 2010, approximately 1.5 km of Stroubles Creek was restored downstream of Virginia Tech (Wynn et al., 2010). This area is now the Stream Research, Education and Management (StREAM) Lab at Virginia Tech, where interdisciplinary research is conducted to better understand the interactions between natural and human systems.
- Site objective: The overall objective of the stream restoration was to reduce sediment loads to Stroubles Creek since it was listed as impaired in 1996 (US EPA's 303(d) report) due to failed benthic macroinvertebrates bioassessments. The overall StREAM Lab objective is to maintain a unique, real-world research and education laboratory anchored by long-term, shared data (hydrologic, water quality, biological, and spatial) and interdisciplinary experiences (Thompson et al., 2012).
- Site location (GPS cords and/or map): 37.207506, -80.447095
- Site conditions: Leaf-off at low flow
- Date/time spent at each site: The first flight was conducted on November 11, 2021 from the Foxridge foot-bridge (37.213753, -80.442172) to the concrete bridge (37.208597, -80.447194). The second flight was conducted on December 13, 2021 from the concrete bridge to bridge 3 (37.203908, -80.446327).

Survey Results

- Equipment used: Vapor35 (AeroVironment, Simi Valley, CA, USA), YellowScan Surveyor Core lidar unit (Monfeerier-sur-Lez, France), lidar unit consists of a Velodyne VLP-16 laser scanner (Velodyne, San Jose, CA, USA) and a GNSS-inertial Trimble APPLANIX APX-15 (Trimble, Richmond Hill, ON, Canada)
- GPS solutions: Lidar data was corrected using a local airport CORS base station via OPUS.
- Errors and Alignments: Comments on misalignments and how these were fixed can be found in (Prior et al., 2022) and below in the data processing methods.
- Collection methods: The wePilot1000 flight control system and the weGCS ground control system software (weControl SA, Courtelary, Switzerland) were used to plan and conduct the drone flights. The lidar unit can record two returns per pulse and uses a wavelength of 905 nm. The lidar flights were flown at a 30 m altitude, with 20 m flight-line spacing, which was recommended by YellowScan staff for optimum point spacing and density.

Products

- Date of dataset collection: November 11, 2021 and December 13, 2021
- Coordinate system of datasets: NAD83(2011) / NAD83(2011) / UTM zone 17N
- Spatial resolution
  - Lidar point cloud: 501 points/m^2 (median value from Ground point density raster)
  - DEM: 0.1 m^2
  - CHM: 0.1 m^2
  - Ground point density raster: 1 m^2
- Point cloud accuracy (numbers provided by YellowScan):
  - Angular resolution: 0.125 degrees
  - Precision: 3 cm
  - Absolute accuracy: 5 cm
- Data formats
  - Lidar point cloud: laz
  - DEM: tif
  - CHM: tif
  - Ground point density raster: tif
- Data processing methods

On initial inspection of the lidar data, misalignment in both the vertical (z) and horizontal (xy) directions were apparent when comparing scanlines from each flight (Figure 1b and 1c). Each flight consists of four to six scans that were then merged together to create the final point cloud. These misalignments were most apparent when inspecting sampling bridges, but were also present at other human-made objects in the floodplain, such as fence posts, gates, the weather station, and cars.
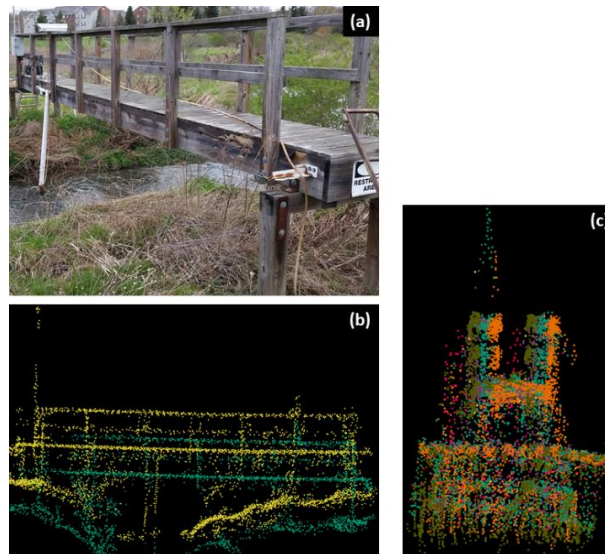
Figure 1. Lidar misalignment demonstrated at two sample bridges with the different color point clouds representing different scanlines within one flight. (a) image of the first sampling bridge, (b) vertical misalignment occurring at the first sampling bridge between two scans, (c) horizontal misalignment occurring at the second sampling bridge between four scans.

To correct these misalignments, the CloudCompare software (https://www.danielgm.net/cc/) was used to align data sets to 2018 Virginia Geographic Information Network (VGIN) lidar and surveyed bridge points. First, a minimum filter was applied to our data and to the VGIN lidar. Once both the minimum filtered points were produced, iterative closest point (ICP) was used to minimize the difference between the two clouds of points. This produces a transformation matrix, which was then applied to our original point cloud. This shifted the point cloud to be more aligned with the VGIN lidar data. Manual adjustment was then done to better align with the surveyed bridge points. This was then done for each scan, until all scans were aligned and merged (Figure 2a).

Next, the point cloud was passed through a Python code that utilized the Simple Morphological Filter (SMRF) to classify ground points (Pingel et al., 2013). SMRF was modified to better account for the high density of points, along with the local topography (window size = 2, slope threshold = 0.15, elevation threshold = 0.1, elevation scaler = 1.25 and cell size = 0.5). Along with classifying ground, vegetation was classified as low, medium and high by utilizing the above ground height that was previously calculated by SMRF (low vegetation < 1 m, medium vegetation between 1 m and 3 m, high vegetation > 3 m). These vegetation height thresholds can easily be changed in the future. A portion of the classified point cloud can be seen in Figure 2b. The points were then used to create a DEM.
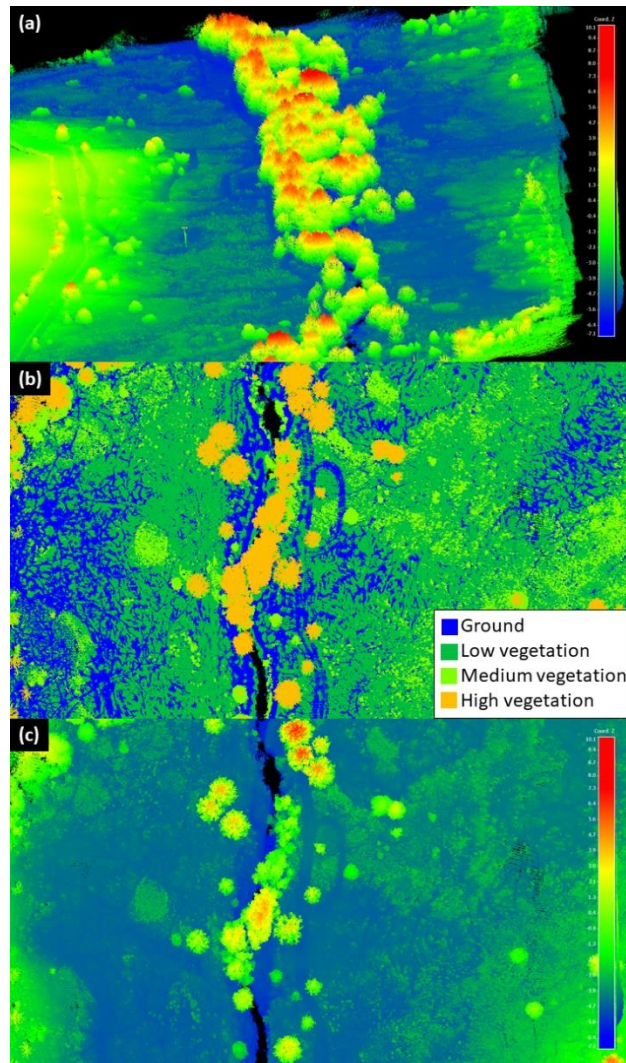
Figure 2. Final point cloud colored by Z coordinate value (a and c), and classification (b).

The point cloud file was then imported into ArcGIS Pro (ESRI, Redlands, CA, USA, version 2.9.2). It was filtered to just include the points classified as ground (Figure 4b). The ground points were then used to create a DEM raster by using the "LAS Dataset to Raster" tool, where the interpolation type was set to binning, cell assignment was set to nearest and void fill method was set to natural neighbor. Raster size was set to 10 cm.

Next, bathymetric cross-sections surveyed with a Trimble R12 GNSS System (Trimble, Sunnyvale, CA, USA) were completed all along the stream channel since the near infrared light used by the lidar system is absorbed by water, thus no bathymetry data were recorded. Bathymetry data were collected at the top and toe of banks and at least one point in the deepest part of channel at streamwise spacings of roughly one channel width apart. These surveyed points were then used to create a raster of stream bathymetry

using the "Topo to Raster." The bathymetry raster and the DEM raster were then combined using the "Mosaic to New Raster" tool (Figure 3d).
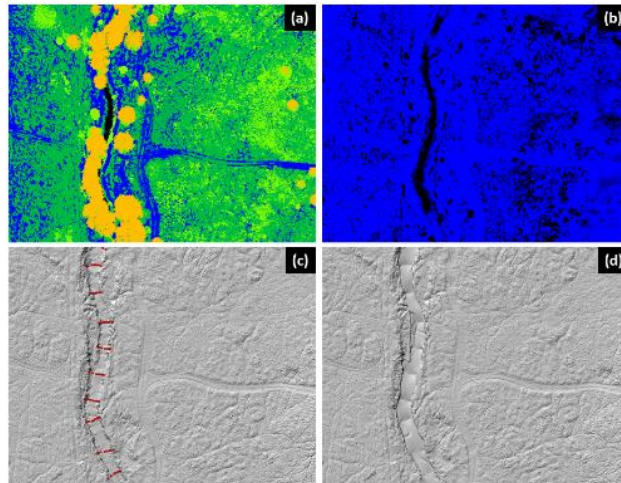

Figure 3. Process of going from a classified point cloud (a) to the final DEM (d) by isolating just the ground points (b), creating a surface from the ground points and utilizing surveyed cross-sections of bathymetry (c), thus resulting in a DEM with bathymetry (d).

The CHM was created by subtracting a digital surface model (DSM) from the DEM using the ArcGIS Pro tool "Raster Calculator". The DSM was created in ArcGIS Pro using the "LAS Dataset to Raster" tool with all points selected. The interpolation type was set to binning, cell assignment was set to nearest and void fill method was set to natural neighbor. Raster size was set to 10 cm. Some negative values were present in the CHM. These values were changed to zero using the ArcGIS Pro tool "Con".

The ground point density raster was created using the ArcGIS Pro tool "LAS Point Statistics As Raster" with only ground points selected. The method type was set to point count, sampling type was set to cell size, and sampling value was set to 1.

Misc Notes
Funding acknowledgements

References

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