

Metadata Report

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Project Name: Virginia Tech StREAM Lab Summer 2024 Drone Lidar Survey

Summary

Two drone lidar flights were conducted on August 7, 2024, over the Virginia Tech StREAM Lab (https://www.bse.vt.edu/research/facilities/StREAM_Lab.html) during leaf-on conditions. The lidar data were collected using a Matrice 350 RTK drone (DJI, Shenzhen, Guangdong, China) with a Zenmuse L1 lidar unit (DJI, Shenzhen, Guangdong, China). From these two flights, a classified point cloud, a digital terrain model (DTM) with interpolated stream bathymetry (0.1 m resolution), and a canopy height model (CHM; 0.1 m resolution) were created. These data were collected to support ecohydrological modeling research. The drone lidar survey of the StREAM Lab was replicated in Spring 2017, Fall 2018, Winter 2021, Summer 2024, and Spring 2026. The point clouds and raster products from the Spring 2017 (<https://doi.org/10.5069/G95X275P>) and Winter 2021 surveys (<https://doi.org/10.5069/G9348HK3>) are also available on OpenTopography.

Personnel

- PI(s): W. Cully Hession
- Field staff: Laura Lehmann
- Additional team members: Yohtaro C. Kobayashi, Jonathan P. Resop

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-on at low flow
- Date/time spent at each site: Both flights were conducted on [August 7, 2024](#). The first flight was from the Foxridge foot-bridge (37.213753, -80.442172) to the concrete bridge (37.208597, -80.447194). The second flight was from the concrete bridge to bridge 3 (37.203908, -80.446327).

Survey Results

- Equipment used: Matrice 350 RTK drone (DJI, Shenzhen, Guangdong, China), Zenmuse L1 lidar unit (DJI, Shenzhen, Guangdong, China), lidar unit consists of a Livox Avia lidar module (LIVOX, Shenzhen, Guangdong, China) and a DJI D-RTK-2 GNSS system (DJI, Shenzhen, Guangdong, China). The drone includes a built-in 20 MP RGB mapping camera (DJI, Shenzhen, Guangdong, China).
- GPS solutions: Lidar data were post-processed using DJI Terra Pro (DJI, Shenzhen, Guangdong, China).
- Errors: Comments on lidar data noise, artifacts, and misclassifications can be found in (Resop et al., 2019) and below in the data processing methods.
- Alignments: Comments on misalignments and aligning the point cloud to the Winter 2021 dataset ([Hession et al., 2023](#)) can be found in (Resop et al., 2024) and below in the data processing methods.
- Collection methods: The DJI Pilot 2 on the DJI RC Plus controller (DJI, Shenzhen, Guangdong, China) was used to plan and conduct the drone flights. The lidar unit can record three returns per pulse and uses a wavelength of 905 nm. The first flight was flown at a 57 m altitude, at 10 kph, with 53% overlap, and the second flight was flown at a 50 m altitude, at 15 kph, with 40% overlap, which were calculated by the DJI Pilot 2 software to optimize point spacing and density.

Products

- Date of dataset collection: [August 7, 2024](#)
- Coordinate system of datasets: NAD83(2011) / UTM zone 17N
- Spatial resolution:
 - Lidar point cloud: 1,360 pts/m²
 - Digital terrain model (DTM): 0.1 m
 - Canopy height model (CHM): 0.1 m
- Point cloud accuracy (numbers provided by DJI and LIVOX):
 - Angular resolution: Horizontal: 0.03 degrees; Vertical: 0.28 degrees
 - Ranging accuracy: 3 cm @ 100 m
 - Absolute accuracy: Horizontal: 10 cm @ 50 m; Vertical: 5 cm @ 50 m
- Data formats:
 - Lidar point cloud: laz
 - Digital terrain model (DTM): tif
 - Canopy height model (CHM): tif

- Data processing methods:

After the lidar data from the two flights were collected and georeferenced, the resulting LAS files representing the different flightlines were merged into a single LAS file and converted to LAZ file format using LAStools (Rapidlasso, Gilching, Germany). The point cloud had 341,895,074 points with a density of 1,360 points/m². The dataset went through an initial inspection, and no obvious outliers were observed in the point cloud.

The remaining points were classified using automated and manual tools in ArcGIS Pro (ESRI, Redlands, CA, USA) using a workflow detailed by Resop et al. (2019). First, ground points (LAS class code 2) were classified with the "Classify LAS Ground" tool using the standard ground detection algorithm. Then, the "Classify LAS by Height" tool was used to classify the non-ground points into two classes based on the height of each point above ground: unassigned (LAS class code 1) for points with a height between 0 m and 0.1 m and vegetation (LAS class code 5) for points with a height between 0.1 m and 25 m. The unassigned class represented the uncertainty of low points between ground and vegetation that were within the margin of precision of the lidar scanner. Manual inspection and classification were performed to classify human-built structures (e.g., bridges, cars, power lines, etc.) as building points (LAS class code 6). The final count for each class code in the dataset, after automated and manual classifications, is summarized in Table 1 and an example shown in Figure 1.

Table 1. Lidar point classifications in the dataset and their point counts.

Point Classification (Class Code)	Point Count
Unassigned (1)	120,069,384
Ground (2)	86,190,197
Vegetation (5)	135,207,046
Building (6)	428,447
Total	341,895,074

During the classification of ground and vegetation points for the Spring 2017 drone lidar survey, Resop et al. (2019) observed two common misclassifications along the streambanks over the entire stream reach. First, points that should have been classified as "ground" on the streambank would be misclassified as "vegetation" due to the sharp change in gradient. Second, points that should have been classified as "vegetation" hanging over the stream would be misclassified as "ground" due to the lack of points below due to the stream surface. These potential misclassifications have not been verified or corrected in the Summer 2024 drone lidar survey.

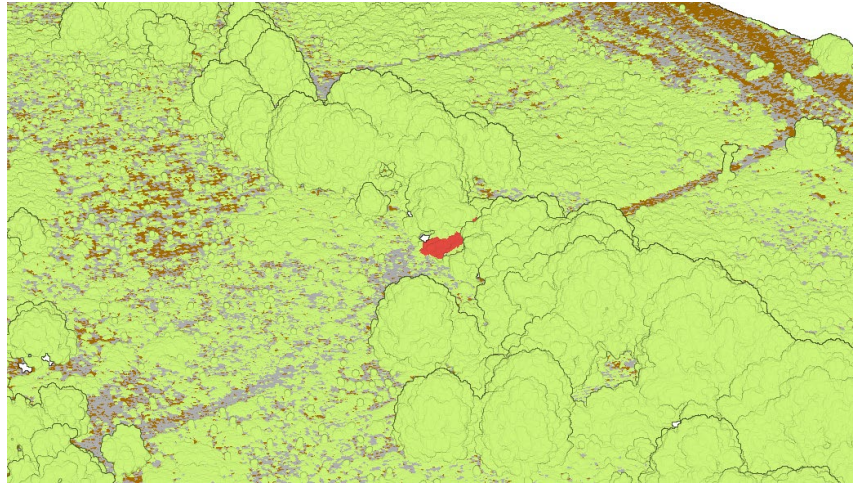


Figure 1. A section of the classified point cloud shown in ArcGIS Pro centered on one of the wooden bridges. Grey points are unassigned, brown points are ground, green points are vegetation, and red points are building.

Comparing the Summer 2024 and Winter 2021 drone lidar surveys, a misalignment was observed between the datasets. To correct the misalignment, CloudCompare (<https://www.danielgm.net/cc/>) was used, based on a similar workflow as developed by Resop et al. (2021) and Hession et al. (2023). First, the stationary structures (i.e., the three wooden bridges) were isolated from each dataset (Figure 2). The "Iterative Closest Point" tool was used to minimize the difference between the Summer 2024 and the Winter 2021 point clouds using the bridges as controls. This generated a transformation matrix, which was used to transform the entire Summer 2024 point cloud. Finally, the spatial projection of the Summer 2024 dataset was defined as the same coordinate system as the Winter 2021 dataset (NAD 1983 UTM Zone 17N).

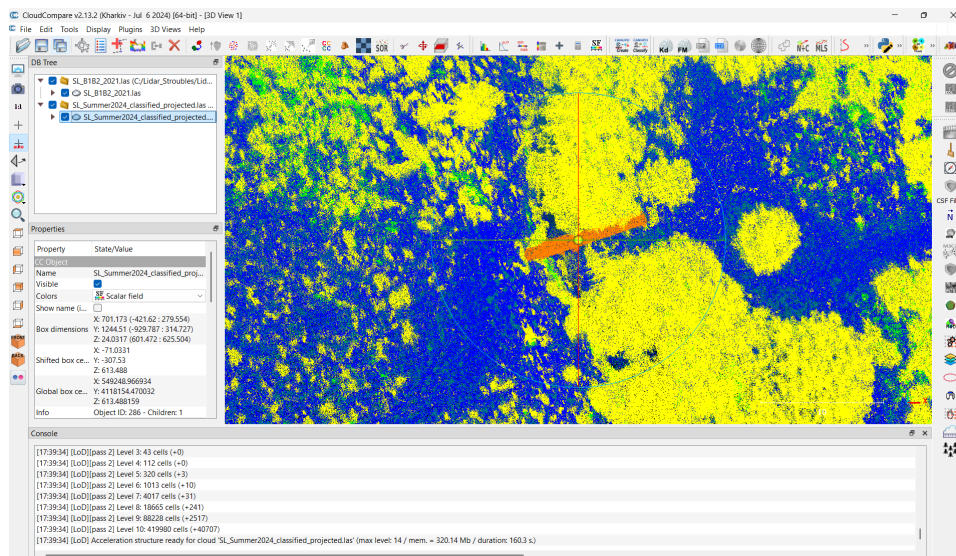


Figure 2. A section of the aligned point cloud shown in CloudCompare centered on one of the wooden bridges used to correct the alignment between the Summer 2024 and Winter 2021 surveys (Hession et al., 2023).

Two rasters were produced from the final classified and aligned point cloud: (1) a digital terrain model (DTM) representing the elevation of ground points and (2) a canopy height model (CHM) representing the height above ground of vegetation points. Both rasters were created using ArcGIS Pro at 0.1-m resolution using the workflow detailed by Resop et al. (2019). The DTM was created using the "LAS Dataset to Raster" tool after selecting only ground and unassigned points. The minimum point elevation was used for each cell and voids, such as shadows under dense tree canopy and the data gap produced by the stream surface, were filled using simple linear interpolation. This resulted in interpolated elevation for the area covered by the stream, instead of surveyed bathymetry; however, the lidar survey was performed at low flow, so elevation biases were minimal (Resop et al., 2024). The DTM was then clipped to the extent of the lidar scan (Figure 3a).

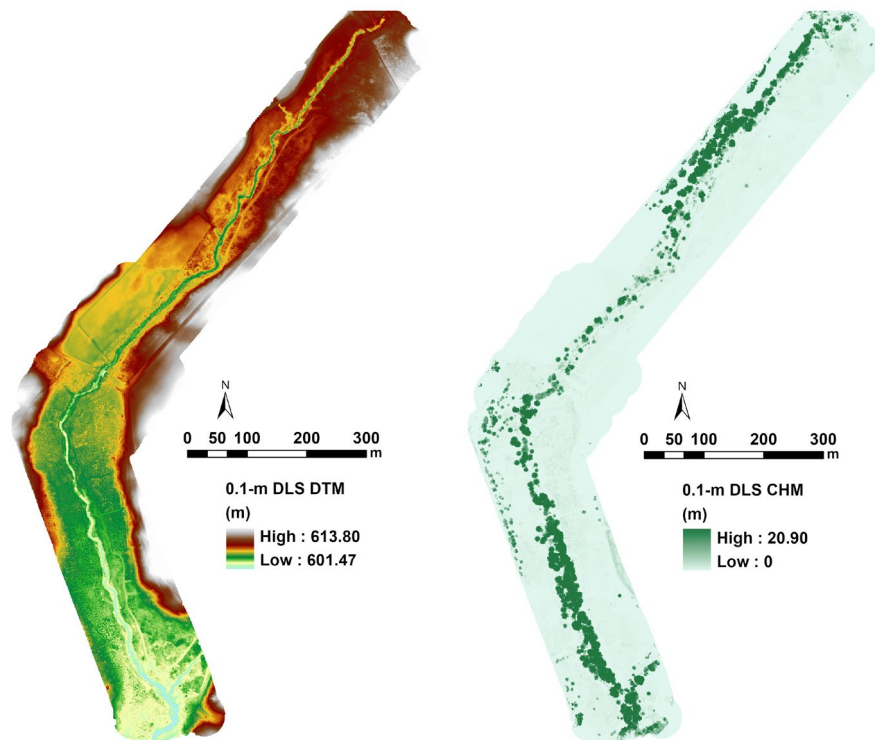


Figure 3. The 0.1-m rasters produced from the Summer 2024 drone lidar survey of the StREAM Lab: (a) the digital terrain model (DTM) and (b) the canopy height model (CHM).

To produce the CHM, a 0.1-m digital surface model (DSM) was created using the "LAS Dataset to Raster" tool after selecting only vegetation points. The maximum point elevation was used for each cell and voids were left as null values, resulting in a raster representing the elevation of the vegetation canopy. A normalized DSM (nDSM) was then calculated with map algebra as the DSM minus the DTM using Raster Calculator, resulting in raster cell values representing height above ground. The CHM was derived from the nDSM by converting cells with null values or height values less than 0.1 m to a zero value (i.e., representing no vegetation) (Figure 3b).

Misc Notes

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