# SnowEx17 CRREL Terrestrial Laser Scanner (TLS) Point Cloud, Version 1

## USER GUIDE

**How to Cite These Data**

As a condition of using these data, you must include a citation:

Hiemstra, C. and A. B. Gelvin. 2019. *SnowEx17 CRREL Terrestrial Laser Scanner (TLS) Point Cloud, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/YOIPYEWCZOD5. [Date Accessed].

National Snow and Ice Data Center

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# 1 DATA DESCRIPTION

## 1.1 Parameters

This data set contains unprocessed lidar point cloud data. Available parameters are shown in Table 1.

Table 1. Parameters

| Parameter | Description |
|---|---|
| X | X coordinate / Easting (meters) |
| Y | Y coordinate / Northing (meters) |
| Z | Elevation above sea level (meters) |
| Intensity | Pulse return magnitude |
| ReturnNumber | Integer number of the point in a sequence of multiple returns from a given outgoing pulse, values range from 1 to $n$<br>1 = first return<br>$n$ = NumberOfReturns |
| NumberOfReturns | Total number of returns from a given outgoing pulse |
| ScanDirectionFlag | Direction of motion during the outgoing pulse:<br>0 = right to left<br>1 = left to right |
| EdgeofFlightLine | Flag denoting that this point is at the edge of the flight line |
| Classification | Point class attribute:<br>0/1 = unclassified<br>2 = ground<br>3 = low vegetation<br>4 = medium vegetation<br>5 = high vegetation<br>9 = water |
| ScanAngleRank | Angle (-90° to +90°) at which the outgoing pulse was emitted from the TLS (0 = nadir) |
| UserData | N/A for this data set |
| PointSourceID | N/A for this data set |
| *Red** | *Percentage of red color in the image, scaled 0 to 255* |
| *Blue** | *Percentage of blue color in the image, scaled 0 to 255* |
| *Green** | *Percentage of green color in the image, scaled 0 to 255* |
| *\*Red, Blue, and Green (R, G, B) color data derived from coincident color photographs. Under snow-on conditions, light conditions were not suitable for color photographs so no color data is available.* | |

## 1.2 File Information

### 1.2.1 Format

TLS data are provided in Lidar Data Exchange zipped (.laz) files.

Extensible Markup Language (.xml) files with associated metadata are also provided.

### 1.2.2 File Contents

The LAZ files consist of thousands of individual points, each of which contains the parameters and properties described in Table 1. Figure 1 contains a sample of these point values, as presented in a text file.

| X | Y | Z | Intensity | ReturnNumber | NumberOfReturns | ScanDirectionFlag | EdgeOfFlightLine | Classification | ScanAngleRank | UserData | PointSourceId | Red | Green | Blue |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 232277.855 | 4327408.85 | 2975.8 | 470 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 212 | 251 | 228 |
| 232127.338 | 4327423 | 2975.902 | 414 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 37 | 35 |
| 232149.879 | 4327288.26 | 2991.474 | 382 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 55 | 43 |
| 232132.695 | 4327207.73 | 2987.959 | 446 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 100 | 82 |
| 232136.753 | 4327228.45 | 2988.038 | 493 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 42 | 37 |
| 232138.411 | 4327230.65 | 2987.773 | 508 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 56 | 45 |
| 232133.117 | 4327231.92 | 2998.792 | 344 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 94 | 105 | 88 |
| 232137.556 | 4327218.4 | 2999.672 | 421 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 135 | 125 | 89 |
| 232189.819 | 4327205.25 | 3007.157 | 370 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 253 | 254 |

Figure 1. Sample of SNEX17_TLS_PC_CRREL_09262016_Site1.laz contents presented in a text file.

### 1.2.3 Naming Convention

The data files are named according to the following convention and as described to Table 2:

SNEX17_TLS_PC_CRREL_[MMDDYYYY]_[location].laz

Example:

SNEX17_TLS_PC_CRREL_10022016_SiteB.las

Table 2. Naming Convention

| Variable | Description |
|---|---|
| SNEX17_TLS_PC_CRREL | Short name for SnowEx17 CRREL Terrestrial Laser Scanner |
| MMDDYYYY | Date in MMDDYYYY format |
| location | Location of scan |

### 1.2.4 File Size

The .laz files range from approximately 52 to 644 MB. The total file volume is approximately 4 GB.

## 1.3 Spatial Information

### 1.3.1 Coverage

Northernmost Latitude: 39.05° N

Southernmost Latitude: 39.00° N

Easternmost Longitude: 107.93° W

Westernmost Longitude: 108.22° W

### 1.3.2 Resolution

Spatial resolution is 4 mm at close range, but expands to 1-10 cm at distances greater than 100 m from the scanner.

### 1.3.3 Geolocation (XY Coordinates)

All data has been projected into the WGS 84/UTM Zone 13 North coordinate system, a detailed description of which is provided in Table 3.

Table 3. Geolocation Details

| Geographic coordinate system | WGS 84 |
|---|---|
| Projected coordinate system | WGS 84/UTM Zone 13N |
| Longitude of true origin | -105 |
| Latitude of true origin | 0 |
| Scale factor at longitude of true origin | 0.9996 |
| Datum | WGS 1984 |
| Ellipsoid/spheroid | WGS 84 |
| Units | Meter |
| False easting | 500000 |
| False northing | 0 |
| EPSG code | 32613 |
| PROJ4 string | +proj=utm +zone=13 +datum=WGS84 +units=m +no_defs |
| Reference | https://epsg.io/32613 |

### 1.3.4 Vertical Projection (Z Coordinates)

The elevation (Z coordinate) of each point is reported as the orthometric height, calculated based on the NAVD88 vertical datum and GEOID12B model. This value is different than the geodetic height associated with the WGS 84/UTM Zone 13N projection described in Table 3.

## 1.4 Temporal Information

### 1.4.1 Coverage

26 September 2016 to 17 February 2017.

### 1.4.2 Resolution

Scans were completed once in the fall (September and October) and once in the winter (February).

# 2   DATA ACQUISITION AND PROCESSING

## 2.1 Background

A terrestrial lidar survey (conducted with a terrestrial laser scanner) was performed at a number of sites around Grand Mesa, Colorado. The goal was to cover as much ground as possible, to scan into the trees as much as possible, and to produce a high-resolution bare-earth and snow-surface data set. To this end, surveys were conducted under both snow-off (September and October) and snow-on (February) conditions at both open and forested sites. Table 4 contains more information about survey locations and dates.

Table 4. Survey Locations and Dates

| Snow-Off Conditions (Fall 2016) | | Snow-On Conditions (Winter 2017) | |
|---|---|---|---|
| **Location** | **Survey Dates** | **Location** | **Survey Dates** |
| Site A | 28 Sept. 2016 | Site A | 08 Feb. 2017 |
| Site B | 02 Oct. 2016 | Site B | 16 Feb. 2017 |
| Site I | 26 Sept. 2016 | Site D | 08 Feb. 2017 and 16 Feb. 2017 |
| Site M | 01 Oct. 2016 | Site M | 14 Feb. 2017 |
| Site N | 27 Sept. 2016 | Site N | 15 Feb. 2017 |
| Ranger Station | 01 Oct. 2016 | Ranger Station | 17 Feb. 2017 |
| Local Scale Observation Site (LSOS) | 02 Oct. 2016 | Local Scale Observation Site (LSOS) | 13 Feb. 2017 |
| | | County Line Parking Lot | 17 Feb. 2017 |

## 2.2 Acquisition

At each survey location, 4-15 scans were conducted using a Leica ScanStation C10 terrestrial laser scanner (TLS). The TLS was positioned to maximize the overlap between scans at the same site. Once combined, the overlapped scans create an area of continuous coverage.

Each scan utilized a 360° horizontal- and a 270° vertical-arc sweep, collecting points from multiple surfaces and, when light conditions permitted, collecting (RGB) color images of the scanned area. Scans were completed at an intermediate resolution, meaning that at 100 m from the scanner, there was a 10 cm gap between adjacent points.

During each scan, 4-6 Leica six-inch High Definition Surveying (HDS) targets were distributed throughout the scan area. These targets serve as tie points for georeferencing the scans to real-world coordinates. Whenever HDS targets became hidden from scanner view, they were renamed and redeployed in a leapfrog fashion. A minimum of four reflectors were visible for each scan.

In addition to Leica ScanStation C10 TLS, a Trimble R8 GNSS base station was used at each site. The base station ran for the duration of each survey (for a minimum of two hours), collecting internal GPS data to use in post-processing. A Trimble R8 rover was also deployed to conduct a real-time kinematic (RTK) survey of the HDS targets. The base station broadcast correction data to the rovers, allowing for real-time corrections of atmospheric conditions and multi-path errors.

## 2.3 Processing

RTK survey data processing steps:

1. RTK survey data underwent post-processing in Trimble Business Center.

2. The internal file from the base station was sent to the Online Position User Service (OPUS), which is operated by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS).

3. OPUS automatically corrected the data from the Trimble R8 rovers with the internal GPS file collected by the base station. Corrected GPS coordinates were accurate to within a few centimeters.

TLS data processing steps:

1. A new database was created in Leica's Cyclone software.

2. TLS data files, including point cloud data, images, HDS target scans, and any data associated with scanner placement, were imported into Leica's Cyclone software directly

from the TLS. The aggregate files from each scan were stored in a folder called *ScanWorld*.

3. Within each ScanWorld, a scanner-centric coordinate system was established.

4. During registration, multiple ScanWorlds were integrated into a single coordinate system using overlapping HDS targets, resulting in a project-centric coordinate system.

5. The Registration Mean Absolute Error (RMAE) was calculated for each constraint in the project-centric coordinate system.

6. If RMAE was too high (>11 mm), the registration process was repeated to generate a new project-centric coordinate system, after which the RMAE was recalculated. This step was repeated until an acceptably low RMAE (typically between 2 and 11 mm) was obtained.

7. The registration process was repeated once more using the corrected RTK survey data for the HDS targets to convert the point cloud data into a real-world global coordinate system.

8. Minor edits were made to the point cloud data, including removing extraneous points caused by scanning the sun, the top handle on the scanner, or objects in mid-air.

9. The point cloud data was exported from Leica's Cyclone into one of three file formats, .pts, .ptx, or .txt.

10. PointZip, a third-party software, was then used to export the point cloud data into the Lidar Data Exchange (.las) file format.

11. Data were compressed into Lidar Data Exchange zipper (.laz) files.

## 2.4 Quality, Errors, and Limitations

The error range for this data set is 6 to 15 mm.

## 2.5 Instrumentation

### 2.5.1 Description

Surveys were conducted using a Leica ScanStation C10 terrestrial laser scanner. Under clear line-of-sight conditions, the C10 TLS has a range of approximately 100 m. For more information about this instrument, please see the Leica Geosystems website.

A Trimble DGPS R8 rover and base unit were used to collect position data for each HDS target. More information about these instruments can be found on the Trimble Products and Solutions website.

# 3   SOFTWARE AND TOOLS

TLS data were processed using Leica's Cyclone software. Cyclone is a composite of different software that can be mixed and matched to meet user needs. The two basic modules are Cyclone-REGISTER, which aligns point clouds captured from different scanning positions, and Cyclone-Survey, which provides measurement tools to analyze laser scan data.

PointZip was used to export TLS data to the Lidar Data Exchange file format.

Trimble Business Center software was used to correct the RTK survey data.

# 4   VERSION HISTORY

Table 5. Version History Summary

| Version | Release Date | Description of Changes |
|---|---|---|
| 1.1 | 08 September 2020 | Updated 11 files that had incorrect geolocation information and added 4 new files with additional sites / dates. |
| 1 | 24 July 2018 | Initial release |

# 5   RELATED DATA SETS

Other SnowEx Data Sets

# 6   RELATED WEBSITES

NASA SnowEx

# 7   CONTACTS AND ACKNOWLEDGMENTS

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# 8   DOCUMENT INFORMATION

## 8.1 Publication Date

24 July 2018


## 8.2 Date Last Updated

16 June 2020