



SnowEx17 Boise State University 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:

Glenn, N., L. Spaete, Z. Uhlmann, C. Merriman, A. Raymondi, and C. Tennant. 2019. *SnowEx17 Boise State University 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/IWGD4WFMCQNW>. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX17_TLS_PC_BSU



National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains lidar point cloud data from a Terrestrial Laser Scanner (TLS). 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, range = 0 to 65,535
ReturnNumber	Integer number of the point in a sequence of multiple returns from a given outgoing pulse: 1 = first return n = NumberOfReturns
NumberOfReturns	Total number of returns from a given outgoing pulse
ScanDirectionFlag	Scanner mirror direction of motion during the outgoing pulse: 0 = right to left 1 = left to right
EdgeofFlightLine	Flag denoting that this point is at the edge of the flight line
Classification	Point class attribute: 1 = unclassified 2 = ground
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
GpsTime	Time of point acquisition (seconds of GPS week)

1.2 File Information

1.2.1 Format

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

One Microsoft Excel (.xlsx) file, containing GPS information, is available for each scan.

One Portable Document Format (.pdf) file, containing an Online Positioning User Service (OPUS) solution report, is also available for each scan.

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

1.2.2 LAZ File Contents

LAZ files consist of thousands of individual points, each of which contains the parameters and properties described in Table 1.

1.2.3 Microsoft Excel File Contents

Microsoft Excel files contain the corrected geolocation coordinates for each scan location, as well as the horizontal and vertical precision of these coordinates. File headers contain the project name, surveyor, comments, linear unit, projection, datum, and geoid. Within the file, GPS coordinates and accuracy are separated into two separate tables. The first table, Point Summary, includes the corrected geolocation coordinates for the common targets and base station used during the scan. Point Summary column headers include Name, Grid Northing (m), Grid Easting (m), and Elevation (m) (Figure 1). The second table, titled RTK Obs Quality, short for Real Time Kinematic Observation Quality, contains the horizontal (horz) and vertical (vert) Root Mean Square (RMS) of each corrected coordinate (Figure 1).

Point Summary			
Name	Grid Northing (m)	Grid Easting (m)	Elevation (m)
110	4322291.285	228420.619	3103.849
111	4322428.527	228482.28	3111.081
112	4322424.764	228515.182	3112.606
113	4322293.73	228459.92	3107.888
114	4322477.414	228456.504	3113.494
115	4322459.73	228374.224	3105.043
116	4322459.742	228374.227	3105.05
base2	4322474.108	228480.659	3114.323

RTK Obs Quality		
Name	Horz RMS	Vert RMS
base2-110	0.001	0.001
base2-111	0.001	0.001
base2-112	0.001	0.001
base2-113	0.001	0.001
base2-114	0.001	0.001
base2-115	0.001	0.001
base2-116	0.003	0.004

Figure 1. Sample of Point Summary and RTK Obs Quality tables included in the Microsoft Excel Files. The Point Summary table contains corrected coordinates for the common targets and base station used during each scan. The RTK Obs Quality table contains the horizontal and vertical error associated with these coordinates.

1.2.4 PDF File Contents

PDF files contain the [Online Position User Service](#) (OPUS) report, which was generated when GPS coordinates were corrected for each scan location. OPUS reports include the original GPS coordinates recorded by the temporary base station, the original and corrected GPS coordinate systems, and the names and locations of the permanent base stations used to make the corrections.

1.2.5 Naming Convention

LAZ data files are named according to the following convention and as described in Table 2.

SnowEx17_TLS_PC_BSU_[site]_[mm]_[dd]_[yyyy]_<file type>.[ext]

Table 2. Naming Convention of .laz Files

Variable	Description
SnowEx17_TLS_PC_BSU	Short name for SnowEx17 Boise State University Terrestrial Laser Scanner (TLS) Point Cloud data
[site]	Location of scan (e.g. SiteF)
[mm]	Month of scan
[dd]	Day of scan
[yyyy]	Year of scan
<file type>	Optional naming convention that describes the file contents (e.g. GPS observations or OPUS Solution)
[ext]	File extension (e.g. laz, xlsx)

Examples:

SnowEx17_TLS_PC_BSU_SiteL_2_10_2017.laz

SnowEx17_TLS_PC_BSU_SiteL_2_10_2017_GPS.xlsx

SnowEx17_TLS_PC_BSU_SiteL_2_10_2017_OPUS_Solution.pdf

1.2.6 File Size

PDF files range in size from approximately 85 MB to 92 MB.

Microsoft Excel files range in size from approximately 12 MB to 13 MB.

LAZ data files range in size from approximately 226 MB to 3.50 GB.

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 39.04° N

Southernmost Latitude: 39.00° N

Easternmost Longitude: 108.03° W

Westernmost Longitude: 108.15° W

1.3.2 Resolution

The horizontal and vertical resolution are both 2 cm.

1.3.3 Geolocation

Table 3 provides information for geolocating this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	WGS 84/UTM Zone 13 North
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

1.4 Temporal Information

1.4.1 Coverage

Scans were conducted between 26 September 2016 and 25 February 2017.

1.4.2 Resolution

Scans were conducted once in September and once in February.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Terrestrial lidar surveys were performed at numerous locations in Grand Mesa, Colorado. Surveys were conducted under both snow-off (September) and snow-on (February) conditions, at both open and forested locations, as detailed in Table 4. The resulting TLS data can be used to measure snow depth and look at the interactions between snow and nearby vegetation.

Table 4. Survey Location and Dates

Snow-Off Conditions (Fall 2016)		Snow-On Conditions (Winter 2017)	
Location	Survey Dates	Location	Survey Dates
Site F	27 Sept. 2016	Site F	21 Feb. 2017
Site K	26 Sept. 2016	Site K	08 Feb. 2017 and 22 Feb. 2017
Site O	28 Sept. 2016	Site O	25 Feb. 2017
Site P	28 Sept. 2016	Site P	9 Feb. 2017
		Site L	10 Feb. 2017
		Site J	24 Feb. 2017
		Local Scale Observation Site (LSOS) Cabin	23 Feb. 2017

2.2 Acquisition

At each survey location, a minimum of four scans (Table 5) were conducted using a RIEGL VZ-1000 terrestrial laser scanner (TLS). The TLS was positioned to maximize the overlap between scans at the same site. Once combined, the overlapped scans created an area of continuous coverage. All scans were completed at a vertical and horizontal resolution of 0.03 degrees.

During each scan, common targets were distributed throughout the scan area. These targets serve as tie points for georeferencing the scans to real-world coordinates. A minimum of three common targets were visible in each scan (Table 5).

Table 5. Number of Scans and Common Targets

Location	Survey Date	Number of Scan Positions	Number of Common Targets
Site F	27 Sept. 2016	13	10
Site F	21 Feb. 2017	9	11
Site J	24 Feb. 2017	8	9
Site K	26 Sept. 2016	11	12
Site K	8 Feb. 2017	9	6
Site K	22 Feb. 2017	10	10
Site L	10 Feb. 2017	7	5
Site O	28 Sept. 2016	7	5
Site O	25 Feb. 2017	4	6

Location	Survey Date	Number of Scan Positions	Number of Common Targets
Site P	28 Sept. 2017	5	4
Site P	9 Feb. 2017	5	6
LSOS Cabin	23 Feb. 2017	4	7

In addition to a RIEGL VZ-1000 TLS, a Topcon HiperV GPS base station was used at each site. The base station ran for the duration of each survey, collecting internal GPS data to use in post-processing. A Topcon HiperV rover was also deployed to conduct a Real-Time Kinematic (RTK) survey of the common targets. The base station broadcasted correction data to the rovers, allowing for real-time corrections of atmospheric conditions and multi-path errors.

2.3 Processing

RTK GPS survey data processing steps:

1. The internal file from the base station was sent to the [Online Position User Service](#) (OPUS), which is operated by the NOAA National Geodetic Survey (NGS).
2. OPUS automatically corrected the coordinates of the base station using the National Spatial Reference System. These corrections were provided in an OPUS report. Corrected coordinates and accuracies are available in the OPUS reports and GPS excel files.
3. The updated base station location was uploaded into MAGNET Office Tools.
4. Within MAGNET Office Tools, the coordinates of the base station were reprojected into WGS84 UTM Zone 13, GEOID12b.
5. The updated and reprojected base station coordinates were then exported as a Microsoft Excel (.xls) file from MAGNET Office Tools.
6. All header information was stripped from the XLS file, which was then converted to a Comma-Separated Value (.csv) file.

TLS data processing steps:

1. All raw TLS data files (point cloud data, images, etc.) were opened as a new project in RiSCAN PRO; the raw files are archived separately at NSIDC, SnowEx17 Boise State University Raw Terrestrial Laser Scanner (TLS) Point Cloud.
2. Scans were coarsely registered together using common targets and a project-centric coordinate system was established.
3. Registered scans were adjusted to increase accuracy by matching the closest points between overlapping scans (multi-station adjustment).
4. GPS coordinates for the base station were imported.
5. Scans were re-registered from a project-centric coordinate system into a global coordinate system (WGS84 UTM Zone 13, GEOID12b) using the imported GPS file.
6. A noise filter was applied to each scan in RiSCAN PRO. Any points with a deviation greater than 30 were removed.
7. Filtered scans were exported as LAZ files.
8. Scans were imported into Terrasolid.
9. Scans were tiled into smaller, more manageable rectangular pieces.

10. Small point clusters, those with less than 10 points, sitting more than 3 m distant from the main cloud were deleted using the Terrasolid isolated point filter.
11. Points were classified into ground and non-ground using an iterative height filter.
12. Data were exported from Terrasolid.
13. Tiled data were imported into Boise Calibration Aerospace Laboratory (BCAL) Lidar Tools (is there a specific tool that was used?).
14. Within BCAL, tiles were recombined into a single file per site, which was then exported as a LAZ.

2.4 Quality, Errors, and Limitations

The error range for this data set is 1 to 5 cm.

2.5 Instrumentation

2.5.1 Description

The Lidar survey was conducted using a RIEGL VZ-1000 TLS. More details about this instrument can be found on the RIEGL website.

The RTK survey was conducted using Topcon HiperV units. More details about these instruments can be found on the Topcon Product website.

3 SOFTWARE AND TOOLS

The RTK GPS data was processed in the Online Positioning User Service (OPUS). OPUS is an online tool run by NOAA that corrects GPS coordinates so they are accurate and consistent with the National Spatial Reference System. More details can be found on the OPUS website.

MAGNET Office Tools was also used to process GPS coordinates. MAGNET Office Tools is a TOPCON software which enables customized processing and adjustment of GPS coordinates. More details can be found on the TOPCON Products website.

TLS data were processed in RiSCAN Pro, a proprietary RIEGL software. RiSCAN PRO is the companion software for all RIEGL TLS systems. It is used to register scans together and to transform the data into a common coordinate system. More details about this software can be found on the RIEGL Software Packages website.

TLS data were also processed using TerraScan, the main Terrasolid software for processing lidar point cloud data. More details can be found on the Terrasolid website.

Boise Calibration Aerospace Laboratory (BCAL) Lidar Tools were also used to process TLS data. BCAL Lidar Tools, developed at Boise State University (BSU), are open-source tools for processing, analyzing, and visualizing lidar data. More details about these products can found on the BCAL website.

4 RELATED DATA SETS

[SnowEx Data | Overview](#)

5 RELATED WEBSITES

[SnowEx NASA](#)

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7 DOCUMENT INFORMATION

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