SnowEx20 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., A. Hojatimalekshah, J. Graham, J. Enterkine, A. B. Gelvin. 2021. *SnowEx20 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. https://doi.org/10.5067/F0M99WK7JW4X. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_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 comma-separated values (.csv) file, containing GPS information, is available for each scan location.

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

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 CSV File Contents

Comma-separated vales (.csv) 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 GPS Observations, contains the easting (dE), northing (dN) and height (dHt) distance between the base station and rover as well as 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)
BASE1?V1	4324033.018	225183.4	3089.052
POT1	4324025.583	225173.337	3091.117
POT2	4324008.918	225150.588	3088.977
POT3	4323992.865	225152.502	3087.764
POT4	4323979.419	225163.076	3087.108
POT5	4323975.846	225190.69	3088.151
POT6	4323982.839	225209.805	3089.755
POT7	4324000.112	225215.187	3090.972
POT8	4324023.655	225208.051	3092.262

GPS Observations

Name	dN (m)	dE (m)	dHt (m)	Horz RMS	Vert RMS
BASE1-V1?POT1	-7.435	-10.063	-0.496	0.001	0.001
BASE1-V1?POT2	-24.1	-32.812	-2.637	0.001	0.001
BASE1-V1?POT3	-40.154	-30.899	-3.85	0	0
BASE1-V1?POT4	-53.599	-20.325	-4.505	0.002	0.002
BASE1-V1?POT5	-57.173	7.29	-3.461	0.001	0.001
BASE1-V1?POT6	-50.179	26.405	-1.857	0.003	0.003
BASE1-V1?POT7	-32.907	31.787	-0.639	0.002	0.002
BASE1-V1?POT8	-9.363	24.65	0.65	0.001	0.001

Figure 1. Sample of Point Summary and GPS Observations tables included in the .csv files. The Point Summary table contains corrected coordinates for the common targets and base station used during each scan. The GPS Observations 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. In a few locations a Leica GPS instrument was used instead of the Topcon GPS instrument, as the work flow differs there is no OPUS files available for those sites.

1.2.5 Naming Convention

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

`SnowEx20_TLS_PC_BSU_[site]_[mm]_[dd]_[yyyy]_<file type>.[ext]`

Table 2. File Naming Convention

Variable	Description
`SnowEx20_TLS_PC_BSU`	Short name for SnowEx20 Boise State University Terrestrial Laser Scanner (TLS) Point Cloud data
`[site]`	Location of scan (e.g. SiteFL2B)
`[mm]`	Month of scan
`[dd]`	Day of scan
`[yyyy]`	Year of scan
`<file type>`	Naming convention that describes the file contents. “_Snow” indicates that the ground was snow covered, “_Vegetation” indicates that the ground is vegetation covered and “_Ground” indicates that there was no snow and no vegetation covering the ground. “OPUS_solution” refers to the .pdf file described in section 1.2.4 and “GPS_NAD83” to the .csv file described in section 1.2.3.
`[ext]`	File extension (e.g. laz, csv, pdf)

Examples:

```
SnowEx20_TLS_PC_BSU_SiteFL1B_01_30_2020_Snow.laz
SnowEx20_TLS_PC_BSU_SiteFL1B_01_30_2020_GPS_NAD83.csv
SnowEx20_TLS_PC_BSU_SiteFL1B_01_30_2020_OPUS_Solution.pdf
```

1.2.6 File Size

LAZ data files range in size from approximately 120 MB to 4 GB.

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 39.041° N
Southernmost Latitude: 39.000° N
Easternmost Longitude: 108.025° W
Westernmost Longitude: 108.146° W

1.3.2 Resolution

The horizontal and vertical resolution are both 2 cm.

1.3.3 Geolocation

The data set coordinates are in NAD83, UTM Zone 13 North Geoid 16b, Table 3 provides more information for geolocating this data set.

Table 3. Geolocation Details

Geographic coordinate system	NAD83
Projected coordinate system	NAD83 / UTM zone 13N
Longitude of true origin	-105
Latitude of true origin	0
Scale factor at longitude of true origin	0.9996
Datum	North_American_Datum_1983
Ellipsoid/spheroid	GRS 1980
Units	meters
False easting	500000
False northing	0
EPSG code	26913
PROJ4 string	+proj=utm +zone=13 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs
Reference	https://epsg.io/26913

1.4 Temporal Information

1.4.1 Coverage

Scans were conducted between 23 September 2019 and 02 February 2020.

1.4.2 Resolution

Most locations were scanned twice, once in September and once the following January/February. See Table 4 for more details.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Terrestrial laser scan surveys were performed at numerous locations in Grand Mesa, Colorado. Surveys were conducted under both snow-off (September 2019) and snow-on (January/February 2020) 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 2019)		**Snow-On Conditions (Winter 2020)**	
Location	**Survey Dates**	**Location**	**Survey Dates**
Site FL1A	not surveyed in fall	Site FL1A	29 Jan. 2020
Site FL1B	24 Sept. 2019	Site FL1B	30 Jan. 2020
Site FL2B	26 Sept. 2019 and 27 Sept. 2019	Site FL2B	28 Jan. 2020 and 02 Feb. 2020
Site FL2C	23 Sept. 2019 and 25 Sept. 2019	Site FL2C	01 Feb. 2020
Site FL3B	24 Sept. 2019	Site FL3B	31 Jan. 2020

2.2 Acquisition

At each survey location, a minimum of three scans/scan positions (Table 5) were conducted using a RIEGL VZ-1000 (1550 nm) 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.

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.

Table 5. Number of Scans Positions

Location	Survey Date	Number of Scan Positions
Site FL1A	29 Jan. 2020	4
Site FL1B	24 Sept. 2019	8
Site FL1B	30 Jan. 2020	5
Site FL2B	26 Sept. 2019	9
Site FL2B	27 Sept. 2019	8
Site FL2B	28 Jan. 2020	6
Site FL2B	02 Feb. 2020	9
Site FL2C	23 Sept. 2019	3
Site FL2C	25 Sept. 2019	10
Site FL2C	01 Feb. 2020	9
Site FL3B	24 Sept. 2019	8
Site FL3B	31 Jan. 2020	10

2.3 Processing

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 CloudCompare, open-source software for analyzing, visualizing, and processing lidar point cloud data. More details can be found on the CloudCompare website.

The following describes the detailed RTK and TLS processing steps.

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 NAD83 UTM Zone 13, GEOID16b.
5. The updated and reprojected base station coordinates were then exported as a Mircosoft 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, SnowEx20 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 (NAD83 UTM Zone 13, GEOID16b) 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 LAS files.
8. Scans were imported into CloudCompare.
9. Points were classified into ground and non-ground using a CSF filter.
10. Data were exported from CloudCompare.

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 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
1	25 Jan 2021	Initial release

4 RELATED DATA SETS

SnowEx at NSIDC | Data Sets
SnowEx20 Boise State University Terrestrial Laser Scanner (TLS) Point Cloud Raw
SnowEx17 Boise State University Terrestrial Laser Scanner (TLS) Point Cloud

5 RELATED WEBSITES

SnowEx at NSIDC | Overview
SnowEx at NASA

6 CONTACTS AND ACKNOWLEDGMENTS

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7 DOCUMENT INFORMATION

7.1 Publication Date

25 January 2021

7.2 Date Last Updated

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