SnowEx20 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:

Gelvin, A B., K. Liddle Broberg, and C. A. Hiemstra. 2021. *SnowEx20 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. https://doi.org/10.5067/NJ3FFEESXVYE. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_TLS_PC_CRREL

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. The most important parameters are X, Y, Z and intensity. All available parameters are listed 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* 1 = first return *n* = NumberOfReturns
NumberOfReturns	Total number of returns from a given outgoing pulse
ScanDirectionFlag	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: This data set is entirely unclassified (value set to 0) due to the nature of the used scanner type that does now allow for classification.
Synthetic	N/A for this data set
KeyPoint	N/A for this data set
Withheld	N/A for this data set
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	N/A for this data set

1.2 File Information

1.2.1 Format

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

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.

1.2.3 Naming Convention

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

`SNEX20_TLS_PC_CRREL_[MMDDYYYY]_[FLXX].laz`

Table 2. Naming Convention

Variable	Description
SNEX20	Field campaign for SnowEx 2020
TLS	Terrestrial Lidar Scan
PC	Point Cloud
CRREL	Agency that collected the data
MMDDYYYY	data collection date in MMDDYYYY format
FLXX	Flight line TLS scan location

Example file name:

`SNEX20_TLS_PC_CRREL_01312020_FL2D.laz`

1.3 Spatial Information

1.3.1 Coverage

All data were collected from Grand Mesa, Colorado, the boundaries of which are described below:

Northernmost Latitude: 39.07° N
Southernmost Latitude: 39.00° N
Easternmost Longitude: 107.997° W
Westernmost Longitude: 108.228° W

1.3.2 Resolution

Data are point observations with 1 cm depth resolution.

1.3.3 Geolocation

All data have been projected into the WGS 84/UTM Zone 12 North coordinate system. See Table 3 for a detailed description.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	WGS 84 / UTM zone 12N
Longitude of true origin	-111
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	32612
PROJ4 string	+proj=utm +zone=12 +datum=WGS84 +units=m +no_defs

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 differs from the geodetic height associated with the WGS 84/UTM Zone 12N projection described in Table 3.

1.4 Temporal Information

1.4.1 Coverage

23 September 2019 to 01 February 2020

1.4.2 Resolution

Scans at each location were completed once in the fall (September) and once in the winter (January/February). See Table for more information.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The team surveyed a number of sites around Grand Mesa, Colorado to produce a high-resolution, bare-earth and snow-surface data set covering as much ground as possible including under tree cover. TLS sites were selected to represent a variety of canopy types and to span transitions from open meadows or shrublands into forests. Snow-off conditions were surveyed in September 2019 and snow-on conditions in January/February 2020. Table summarizes survey locations and dates.

Table 4. Survey Locations and Dates

Snow-Off Conditions (Fall 2019)		**Snow-On Conditions (Winter 2020)**	
Location	**Survey Dates**	**Location**	**Survey Dates**
FL1A	26 Sept. 2019	FL1A	29 Jan. 2020
FL2A	25 Sept. 2019	FL2A	28 Jan. 2020
FL2D	23 Sept. 2019	FL2D	31 Jan. 2020
FL3A	24 Sept. 2019	FL3A	30 Jan. 2020
FL3C	27 Sept. 2019	FL3C	01 Feb. 2020

2.2 Acquisition

A Leica C10 ScanStation laser scanner was used to collect point and color photo data. Multiple scans were required to cover the large areas.

High Definition Surveying (HDS) targets were deployed as tie points to allow multiple scan positions to be registered together. A Trimble DGPS R8 rover and base unit were used to collect position data for each HDS target, to allow for high accuracy cloud registration to the global coordinate system. The Trimble R8 base station ran for the duration of the survey, to collect an internal GPS data file for post-processing of the survey data.

At each survey location, 4-15 scans were conducted using a Leica ScanStation C10 terrestrial laser scanner (TLS). The TLS has a range of approximately 100 m in clear line-of-sight conditions. 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.

Each scan performed a 360° horizontal- and 270° vertical-arc sweep, collecting point returns from multiple surfaces and, if light conditions permitted, RGB[1] 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, four to six Leica six-inch HDS targets were distributed throughout the scan area. These targets served as tie points to georeference the scans to real-world coordinates. Whenever HDS targets became hidden from scanner view, they were renamed and redeployed in a leapfrog fashion so that a minimum of four reflectors were visible for each scan.

2.3 Processing

Real-time kinematic (RTK) survey data processing steps:

1. RTK survey data were post-processed using 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 folder, a scanner-centric coordinate system was established.
4. During registration, multiple ScanWorld folders 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.

[1] Due to low image quality, only intensity values (no RGB values) are reported in this data set. Color photos were taken and conserved in the raw data files.

6. If RMAE was too high (>6 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. The quality of the survey of the HDS targets will affects the overall RMAE of the project; in this dataset, the RMAE ranges between .006 to .085 m.

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

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

10. PointZip, a third-party application, 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 3 to 85 mm.

2.5 Instrumentation

2.5.1 Description

Surveys were conducted using a Leica ScanStation C10 terrestrial laser scanner (TLS). For more information about this instrument, please see the Leica Geosystems website.

A Trimble R8 rover and Global Navigation Satellite System 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 modules 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 1. Version History Summary

Version	Release Date	Description of Changes
1	13 January 2021	Initial release

5 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

6 RELATED WEBSITES

NASA SnowEx Project

SnowEx at NSIDC | Overview

7 CONTACTS AND ACKNOWLEDGMENTS

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8 DOCUMENT INFORMATION

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