SnowEx20-21 QSI Lidar 0.5m UTM Grid, Version 1: DEM, Snow Depth, and Vegetation Height

USER GUIDE

How to Cite These Data

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

Adebisi, N., H.P. Marshall, S. O'Neel, C. Vuyovich, C. Hiemstra, K. Elder. 2022. *SnowEx20-21 QSI Lidar DEM 0.5m UTM Grid, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/YO583L7ZOLOO. [Date Accessed].

Adebisi, N., H.P. Marshall, C. Vuyovich, K. Elder, C. Hiemstra, M. Durand. 2022. *SnowEx20-21 QSI Lidar Snow Depth 0.5m UTM Grid, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/VBUN16K365DG. [Date Accessed].

Adebisi, N., H.P. Marshall, C. Vuyovich, K. Elder, C. Hiemstra, M. Durand. 2022. *SnowEx20-21 QSI Lidar Vegetation Height 0.5m UTM Grid, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/8RBIUIPEUJ7Z. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_QSI_DEM, https://nsidc.org/data/SNEX20_QSI_SD, and https://nsidc.org/data/SNEX20_QSI_VH

National Snow and Ice Data Center

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> **This user guide applies to the following data sets:**
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> SnowEx20-21 QSI Lidar DEM 0.5m UTM Grid, Version 1 (SNEX20_QSI_DEM)
> SnowEx20-21 QSI Lidar Snow Depth 0.5m UTM Grid, Version 1 (SNEX20_QSI_SD)
> SnowEx20-21 QSI Lidar Vegetation Height 0.5m UTM Grid, Version 1 (SNEX20_QSI_VH)

1   DATA DESCRIPTION

1.1 Parameters

The data sets described here provide digital elevation models, snow depth, and vegetation height, acquired by a scanning lidar system and derived from Point Cloud Digital Terrain Models (PCDTMs). Data were acquired over multiple areas in Colorado, Idaho, and Utah during February 2020, March 2021, and September 2021 as part of the SnowEx 2020 and SnowEx 2021 campaigns.

1.2 File Information

1.2.1   Format

The data are available as Geographic Tagged Image (GeoTIFF, 32-bit) files.

1.2.2   File Contents

Each GeoTIFF file contains embedded georeferenced data representing bare earth surface elevation (DEM), snow depth (SD), or vegetation height (VH).

1.2.3   Naming Convention

This section explains the GeoTIFF naming conventions with examples. The data are named according to the following convention and as described in Table 1.

SNEX20_QSI_[file type]_[0.5M]_[country][state][site]_[yyyymmdd_yyyymmdd].[tif]

Table 1. File Naming Convention

Variable	Values	Description
SNEX20_QSI		Short name for SnowEx2020 QSI Lidar data
[file type]	DEM, SD, VH	Naming convention that describes the file contents. DEM indicates bare earth surface elevation data. SD indicates snow depth measurements. VH refers to vegetation height measurements.

Variable	Values	Description
[0.5M]		Spatial resolution: 0.5 meters for all data
[country]	US	Two-digit country code: United States for all data
[state]	CO, ID, UT	Two-digit state code: CO (Colorado), ID (Idaho), UT (Utah)
[site]	CP, FR, GM, BS, DC, MC, RC, LC	Two-digit site code: CP (Cameron Pass), FR (Fraser), GM (Grand Mesa), BS (Banner Summit), DC (Dry Creek), MC (Mores Creek), RC (Reynolds Creek), LC (Little Cottonwood Canyon)
[yyyymmdd_yyyymmdd]		Basin survey start and end dates: 4-digit year, 2-digit month, 2-digit day

1.3 Spatial Information

1.3.1 Coverage

These data are provided in three different regions, as defined by the bounding boxes in Table 2 below.

Table 2. Spatial Coverage

Spatial Extent	Colorado	Idaho	Utah
Northernmost Latitude	40.5841° N	44.3658° N	40.6041° N
Southernmost Latitude	38.9681° N	43.0343° N	40.5161° N
Easternmost Longitude	105.7432° W	114.8547° W	111.5989° W
Westernmost Longitude	108.3384° W	117.0661° W	111.7319° W

1.3.2 Resolution

The horizontal spatial resolution is 0.5 m.

1.3.3 Geolocation

These data are referenced to the NAD83 horizontal datum and the NAVD88 (Geoid 12b) vertical datum. Data are provided in the UTM projection; Table 3 provides information on the specific zones for each region.

Table 3. Geolocation Details

State/region	Idaho	Utah	Colorado
Projected coordinate system	NAD83 / UTM zone 11N	NAD83 / UTM zone 12N	NAD83 / UTM zone 13N
Longitude of true origin	-117	-111	-105
Latitude of true origin	0	0	0
Scale factor at longitude of true origin	0.9996	0.9996	0.9996
Datum	North_American_Datum_1983	North_American_Datum_1983	North_American_Datum_1983
Ellipsoid/spheroid	GRS 1980	GRS 1980	GRS 1980
Units	meters	meters	meters
False easting	500000	500000	500000
False northing	0	0	0
EPSG code	6340	6341	6342
PROJ4 string	+proj=utm +zone=11 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs +type=crs	+proj=utm +zone=12 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs +type=crs	+proj=utm +zone=13 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs +type=crs
Reference	https://epsg.io/6340	https://epsg.io/6341	https://epsg.io/6342

1.4 Temporal Information

1.4.1   Coverage

DEM data: 16-21 September, 2021

Snow Depth data: 9-19 February, 2020 and 15-20 March, 2021

Vegetation Height data: 2-19 February, 2020 and 15-20 March, 2021

1.4.2   Resolution

Most locations were scanned twice, once in September 2021, and once either in February 2020 or March 2021. Three sites (USCOFR, USIDBS, USIDMC) were scanned in both February 2020 and March 2021.

2   DATA ACQUISITION AND PROCESSING

2.1 Background

Lidar scanning and imaging spectroscopy was performed at several locations in Colorado, Idaho, and Utah during snow-off (September 2021), and snow-on conditions (March 2020, February 2021). A detailed report (Quantum Spatial, 2020) containing information about the 2020 snow-on Lidar data acquisition and data processing can be found here. The resulting data were used to create bare Earth DEM products and to derive snow depth and vegetation heights. See Table 4 for survey site locations, dates, snow conditions, and available data products.

Table 4. Data Product Details

Site	Scan Dates	Snow Conditions	Data Products
Cameron Pass, Colorado (USC0CP)	2021-03-19 to 2021-03-19	Snow on	SD, VH
	2021-09-18 to 2021-09-18	Snow off	DEM
Fraser, Colorado (USCOFR)	2020-02-11 to 2020-02-11	Snow on	VH
	2021-03-19 to 2021-03-20	Snow on	SD, VH
	2021-09-18 to 2021-09-21	Snow off	DEM
Grand Mesa, Colorado (USCOGM)	2020-02-01 to 2020-02-02	Snow on	VH
	2020-02-13 to 2020-02-13	Snow on	VH
Basin Summit, Idaho (USIDBS)	2020-02-08 to 2020-02-19	Snow on	VH
	2021-03-15 to 2021-03-15	Snow on	SD, VH
	2021-09-17 to 2021-09-17	Snow off	DEM
Dry Creek, Idaho (USIDDC)	2020-02-19 to 2020-02-19	Snow on	SD, VH
	2021-09-16 to 2021-09-16	Snow off	DEM
Mores Creek, Idaho (USIDDC)	2020-02-09 to 2020-02-09	Snow on	SD, VH
	2021-03-15 to 2021-03-15	Snow on	SD, VH
	2021-09-17 to 2021-09-17	Snow off	DEM
Reynolds Creek, ID (USIDRC)	2020-02-18 to 2020-02-20	Snow on	VH
Little Cottonwood Canyon, Utah (USUTLC)	2021-03-18 to 2021-03-18	Snow on	SD, VH
	2021-09-21 to 2021-09-21	Snow off	DEM

2.2 Acquisition

Lidar scanning and imaging spectroscopy were conducted by Quantum Spatial, Inc (QSI, an NV5 subsidiary), under contract from ATA Aerospace, NASA, and Boise State University.

2.3 Processing

QSI completed the initial processing of the lidar data, including: computing the aircraft trajectory, generating the initial point cloud, optimizing the data, adjusting the flight line, generating optimized LAS files, filtering noise, and segmenting and rasterizing the data. QSI provided the processed data to the science team as LAS v. 1.2 point cloud data, in addition to Esri Grid format (tiles) raster models.

Additional data processing was conducted by the science team to create the three data sets described in this document. The tiled raster models were mosaicked to create DEM raster images of each field site. The snow-off DEMs were subtracted from the snow-on DEMs for each site, and the resulting elevation difference was used to calculate snow depth. When necessary, the CRS, extent, and resolution of the two DEMs were reprojected. To calculate vegetation height, the bare Earth DEM for each site was subtracted from the corresponding DSM (Digital Surface Model, which includes above ground features such as vegetation). DEMs are available for September 2021, and snow depth and vegetation height data are available for February 2020 and March 2021. Snow-off DEM and DSM data were used to calculate vegetation height (Canopy Height Model), with the exception of data from 2020. More information about how the science team derived the canopy height model data and subsequent snow depth are described in the Lidar Remote Sensing tutorial in the SnowEx Hackweek 2022 Jupyter notebook, available here.

2.4 Quality, Errors, and Limitations

Absolute accuracy of initial lidar data was calculated by QSI using Non-vegetated Vertical Accuracy (NVA) specifications, which meet the Federal Geographic Data Committee (FGDC) National Standard for Spatial Data Accuracy guidelines. See Table 5 for a data quality assessment example.

Table 5. DEM Data Quality Assessment

Site	Grand Mesa, Colorado
Ground Control Points	29 points
95% Confidence (1.96*RMSE)	0.058 m
Average	-0.018 m
Median	-0.020 m
RMSE	0.029 m
Standard Deviation (1σ)	0.023 m

The science team evaluated snow depth data quality and error assessment by comparing snow depth measurements to available SNOTEL data. Uncertainty in horizontal accuracy was minimized

by calculating the mean and standard deviation of lidar pixels within a 3-meter buffer zone around each SNOTEL location. Calculated snow depth values were within an acceptable margin of error to SNOTEL values. See Table 6 for a snow depth data quality assessment example. Note, negative snow depth values appear in the data set when Lidar measurements occurred over bodies of water; these should be disregarded.

Table 6. Snow Depth Data Quality Assessment

Site	Snow Depth at SNOTEL (m)	Lidar derived Snow Depth (m)	Std Dev
Banner Summit	1.55	1.52	0.024
Cameron Pass	1.68	1.66	0.073
Fraser	1.51	1.54	0.071
Little Cottonwood Canyon	1.83	2.02	0.105
Mores Creek	1.88	1.89	0.038

The 2020 DEM and DMS data used to calculate vegetation height were acquired during snow-on conditions, which introduces potential bias from vegetation buried beneath snow.

2.5 Instrumentation

The lidar survey was conducted using a RIEGL VQ-1560i mounted on a twin-turboprop Beechcraft King Air aircraft. More details about this instrument can be found in the SnowEx 2020 Snow-On, Colorado and Idaho NIR Lidar Technical Data Report and on the RIEGL website.

3   VERSION HISTORY

Table 7. Version History Summary

Version	Release Date	Description of Changes
1	29 September 2022	Initial release

4   RELATED DATA SETS

SnowEx at NSIDC | Data Sets

5   RELATED WEBSITES

SnowEx at NSIDC | Overview

Snow Ex at NASA

6   REFERENCES

Quantum Spatial, Inc. (2020). SnowEx 2020 Snow-On, Colorado and Idaho NIR Lidar Technical Data Report. 1-74.

7   DOCUMENT INFORMATION

7.1 Publication Date

29 September 2022

7.2 Date Last Updated

29 September 2022