# SnowEx21 Prairie Station Digital Surface Models from UAV-LiDAR, Version 1

## USER GUIDE

### How to Cite These Data

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

Sproles, E, R. Palomaki, A. Mullen, J. Rizza, and M. Beck. 2024. *SnowEx21 Prairie Station Digital Surface Models from UAV-LiDAR, Version 1* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/2JA2F0NF99TF. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX21_PS_DSM

NSIDC National Snow and Ice Data Center

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# 1 DATA DESCRIPTION

## 1.1 Parameters

This dataset consists of Digital Surface Models (DSMs) derived from UAV-LiDAR acquired during the SnowEx 2021 field campaign at the Central Agricultural Research Center in central Montana (USA). The DSMs are at 0.3 m resolution and consist of one snow-off and seven snow-on flights.

## 1.2 File Information

### 1.2.1 Format

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

### 1.2.2 File Contents

Each GeoTIFF file contains embedded georeferenced data representing surface elevation (DSM). Seven of the files represent snow-on surface elevation, and one file represents snow-off surface elevation.

### 1.2.3 Naming Convention

The single snow-off data file is named: `SNEX21_PS_DSM_CASC_snowoff_V01.0.tif`

The seven snow-on data files are named according to the following convention:

`SNEX21_PS_DSM_CASC_[YYYYMMDD]_V01.0.tif`

In both naming conventions, `SNEX21_PS` refers to the SnowEx 2021 Prairie Station Field Campaign, `DSM` refers to digital surface model, `CASC` refers to the Central Agricultural Research Station study site, `V01.0` refers to the data set version number, and `tif` refers to the file type. In the snow-on data files `YYYYMMD` represents the date of acquisition formatted as four-digit year, two-digit month, and two-digit day.

## 1.3 Spatial Information

### 1.3.1 Coverage

Northernmost latitude: 47.0655 ºN

Southernmost latitude: 47.0562 ºN

Easternmost longitude: 109.9461 ºW

Westernmost longitude: 109.9593 ºW

### 1.3.2 Resolution

0.3 meters

### 1.3.3 Geolocation

The following tables provide information for geolocating this data set:

Table 1. Geolocation Details

| | |
|---|---|
| **Geographic coordinate system** | NAD83 |
| **Projected coordinate system** | NAD83 / UTM zone 12N" |
| **Longitude of true origin** | -111 |
| **Latitude of true origin** | 0 |
| **Scale factor at longitude of true origin** | 0.9996 |
| **Datum** | North American Datum 1983 |
| **Ellipsoid/spheroid** | GRS 1980 |
| **Units** | degrees |
| **False easting** | 500000 |
| **False northing** | 0 |
| **EPSG code** | 26912 |
| **PROJ4 string** | +proj=utm +zone=12 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs +type=crs |
| **Reference** | https://epsg.io/26912 |

## 1.4 Temporal Information

### 1.4.1 Coverage

15 January 2021 to 04 March 2021

### 1.4.2 Resolution

The study site was scanned eight times, with each scan occurring over the span of a single day.

# 2 DATA ACQUISITION AND PROCESSING

## 2.1 Background

Airborne lidar data collection was performed as part of the NASA SnowEx 2021 Prairie Snow field campaign at the Central Agricultural Research Center in Moccasin, Montana. The study site consisted of an ~1 $km^2$ region of farmland, primarily used for growing cereals, pulses, and forage crops. Data acquisition overlapped temporally with SnowEx21 Prairie Station Hourly Meteorological Data, Version 1 and SnowEx21 Prairie Station In Situ Dielectric Soil Moisture and Soil Temperature, Version 1 data sets, also available at the NASA NSIDC DAAC.

## 2.2 Acquisition

Lidar scanning was conducted using an unmanned aerial vehicle (UAV) operated by DJ&A, P.C., as contracted by Montana State University. For the initial snow-off data acquisition on 15 January, 2021, DJ&A used a Phoenix LiDAR Systems Ranger LR system, which features a 1500 nm Riegl VUX-1 LR sensor, a Northrup Grumman LN200C Fiber Optic Gyroscope (FOG) inertial measurement unit, a Novatel OEM 617 GNSS receiver, and a Novatel Pinwheel GNSS antenna. All snow-on data acquisitions were collected using a Phoenix LiDAR Systems miniRanger system, which features a 950 nm Riegl miniVUX-2 sensor, an Inertial Labs IMU-P inertial measurement unit, a Novatel OEM 7720 GNSS receiver, and Novatel Pinwheel GNSS antenna. Both lidar systems were mounted on a customized Freefly Systems ALTA X drone. Each of the UAV flight lines were spaced to create a 40% minimum overlap between lidar swaths at a 45º field of view half angle. Additional details about each flight can be found in the DJ&A project report.

## 2.3 Processing

Data from each lidar acquisition was processed using the Novatel Inertial Explorer software to compute a SBET (Smooth Best Estimate Trajectory) via a post-processing kinematic (PPK) method. The software also produced a file containing accuracy data for each trajectory (known as an SMRMSG file). Point clouds (formatted as LAS files) were created by combining the trajectory data with lidar returns using Phoenix LiDAR Systems Spatial Explorer software. Next, TerraSolid mapping software was used to rectify flight lines, manually remove noise from each point cloud, and create the ground/surface classifications required to produce the final snow-off and snow-on DSMs. The determination of the snow surface classification for each point cloud required more processing steps than usual for typical bare-earth ground surface classification. A detailed description of all data processing steps, including the challenges involved with determining the true snow surface location can be found within the DJ&A project report.

The presence of isolated snow patches (typically along windbreaks) during the 15 January lidar acquisition required additional processing of the data to create an accurate snow-off surface model. This was accomplished by collecting GNSS real-time kinematic data along the boundaries of each snow patch to delineate 2D polylines, which were then used to clip out data from the snow-off point cloud. The resulting snow-off DSM has no data within the bounds of these polylines.

## 2.4 Quality, Errors, and Limitations

Data quality statistics are available for each point cloud used to create the final snow-off and snow-on DSMs. See Table 2 below and the DJ&A project report for additional details.

Table 2. Lidar point cloud data quality statistics

| **Acquisition Date** | 1/15 | 1/21 | 1/22 | 1/29 | 2/17 | 2/18 | 2/24 | 3/4 |
|---|---|---|---|---|---|---|---|---|
| **Average Vertical Error (m)** | -0.003 | -0.059 | -0.067 | -0.066 | -0.071 | -0.088 | -0.055 | -0.009 |
| **Maximum (highest) Vertical Error (m)** | 0.075 | 0.012 | 0.020 | -0.005 | -0.006 | -0.030 | 0.003 | 0.107 |
| **Minimum (lowest) Vertical Error (m)** | -0.057 | -0.127 | -0.155 | -0.143 | -0.155 | -0.139 | -0.124 | -0.081 |
| **Average Magnitude Vertical Error (m)** | 0.024 | 0.060 | 0.068 | 0.066 | 0.071 | 0.088 | 0.055 | 0.031 |
| **Vertical Accuracy RMSE(z) (m)** | 0.031 | 0.068 | 0.077 | 0.076 | 0.079 | 0.092 | 0.063 | 0.039 |
| **Standard Deviation of Vertical Error** | 0.032 | 0.035 | 0.038 | 0.038 | 0.037 | 0.029 | 0.032 | 0.039 |
| **NSSDA Vertical Accuracy (95% CL)** | 0.062 | 0.133 | 0.150 | 0.149 | 0.156 | 0.181 | 0.124 | 0.077 |

# 3 VERSION HISTORY

Table 3. Version History Summary

| **Version** | **Date Implemented** | **Impacted Temporal Coverage** | **Description of Changes** |
|---|---|---|---|
| v01.0 | October 2024 | 15 January 2021 – 04 March 2021 | Initial release |

# 4 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

SnowEx21 Prairie Station Hourly Meteorological Data, Version 1

SnowEx21 Prairie Station In Situ Dielectric Soil Moisture and Soil Temperature, Version 1

# 5 RELATED WEBSITES

NASA SnowEx

NSIDC SnowEx | Overview

# 6 DOCUMENT INFORMATION

## 6.1 Publication Date

October 2024

## 6.2 Date Last Updated

October 2024