SnowEx21 Cameron Pass Ground Penetrating Radar, Version 1

USER GUIDE

How to Cite These Data

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

Bonnell, R., D. McGrath, L. Zeller, E. Bump, and A. Olen-Mikitowicz. 2022. *SnowEx21 Cameron Pass Ground Penetrating Radar, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SRWGLYCB6ZC4. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX21_COCP_GPR

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains the results of 1 GHz ground-penetrating radar surveys conducted at Cameron Pass, Colorado during the SnowEx21 campaign. Data include two-way travel time, pit-measured snow density, calculated snow depth, and calculated snow water equivalent.

1.2 File Information

1.2.1 Format

All data is collected in two comma-separated value (.csv) files.

1.2.2 File Contents

Each .csv file contains 12 columns with the parameters listed in Table 1.

Table 1. Data Parameters

Name	Description	Unit/Format
Date[mmddyy]	Date using six digits representing month, day and last two digits of year	[mmddyy]
Time[HHMM]	Four digits representing the hour and minute within the day.	[HHMM]
Longitude[DD]	Longitude	degree
Latitude[DD]	Latitude	degree
ElevationWGS84[mae]	Elevation	m
Easting[m]	Easting	m
Northing[m]	Northing	m
UTM_Zone	Universal Transverse Mercator zone	N/A
TWT[ns]	Two-way travel time	ns
Depth[cm]	Snow depth	cm
SWE[mm]	Snow water equivalent	mm
Density[kg m-3]	Snow density	kg/m^3

1.2.3 Naming Convention

The data files are named `SNEX21_COCPMR_GPR_01132021_05272021.csv` and `SNEX21_COCPCP_GPR_01132021_05202021.csv`. `SNEX21` refers to the SnowEx 2021 Time-Series Campaign. `COCPMR` refers to the Colorado, Cameron Pass, Michigan River Field site. `COCPCP` refers to the Colorado, Cameron Pass, Cameron Peak Field site. The numbers are formatted as `MMDDYYYY` and represent the start and end of the temporal coverage

1.3 Spatial Information

1.3.1 Coverage

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

Table 2. Spatial Coverage

Spatial Extent	Cameron Peak	Michigan River
Northernmost Latitude	40.566º N	40.520º N
Southernmost Latitude	40.563º N	40.517º N
Easternmost Longitude	105.867° W	105.890° W
Westernmost Longitude	105.873° W	105.893° W

1.3.2 Resolution

Point measurements. Data was collected along two pre-determined transects coinciding with NASA UAVSAR overflights.

1.3.3 Geolocation

The following table provides information for geolocating this data set.

Table 3. Geolocation Details

Geographic Coordinate System	WGS 84
Projected Coordinate System	N/A
Longitude of True Origin	0°
Latitude of True Origin	N/A
Scale factor at longitude of true origin	N/A
Datum	World Geodetic System 1984
Ellipsoid/spheroid	WGS 84
Units	degree
False Easting	N/A

False Northing	N/A
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

The data file also contains northing/easting in WGS 84 / UTM zone 13N (epsg.io/32613).

1.4 Temporal Information

1.4.1 Coverage

13 January 2021 to 27 May 2021

1.4.2 Resolution

Data collection was repeated weekly, biweekly, or monthly depending on month and field site. See Background section for details.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set contains the results of ground-penetrating radar surveys conducted at Cameron Pass, Colorado during the SnowEx20 field campaign. Data were collected between 13 January 2021 and 27 May 2021 along two pre-determined lines that were repeated weekly until late March, coinciding with NASA UAVSAR overflights. From April to May, surveys were repeated biweekly at the COCPCP site, while only one survey was performed in May for the COCPMR site.

2.2 Acquisition

Ground-penetrating radar (GPR) surveys were conducted using a Sensors and Software PulseEKKO PRO radar system and a shielded 1000 MHz antenna. The control unit and antenna were pulled in a plastic sled behind the operators, who were on snowshoes. Individual GPR traces were geolocated using a Emlid RS2 (L1/L2) GPS receiver that was mounted on the sled.

2.3 Processing

Raw data files were processed using Matlab and ReflexW software. The following steps were applied to process the data:

- Time-zero correction
- Dewow filter
- Trace resampling to equidistant spacing of 0.10 m
- Background 2D noise removal

The traces had a sample rate of 0.1 ns. The base of the snowpack was manually picked following a consistent positive phase at the snow-ground interface.

GPS measurements were made with an Emlid RS2 receiver operated in post-processed kinematic (PPK) mode. The rover was post-processed in RTKlib using observations from an Emlid RS2 receiver base station at the field site.

Measured two-way travel times were converted to snow depth and snow water equivalent using pit-measured snow densities and an empirically derived radar velocity (Kovacs et al., 1995). Snow density was measured in two pits at different locations within the study area for each survey date. The snow density/velocity from the nearest pit was applied to the corresponding radar measurements.

2.4 Quality, Errors, and Limitations

The uncertainty of the snow depth is ±3.5 to 4.0 cm, based on the bulk range of the densities observed in the field (see Figure 3 in McGrath et al., 200) and the standard deviation of the two-way time travel (calculated at ±0.31 ns, McGrath et al., 2022). During time periods when liquid water may have been present in the snowpack (April and May), the Kovacs et al. (1995) equation used to calculate snow depths from two-way travel times may introduce greater uncertainty in the resulting snow depth and SWE values.

2.5 Instrumentation

Data were collected using a Sensors & Software pulseEKKO PRO ground penetrating radar (GPR) system and a 1 GHz antenna.

3 VERSION HISTORY

Table 4. Version History Summary

Version	Release Date	Description of Changes
V1	December 2022	Initial release

4 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

SnowEx20 Cameron Pass Ground Penetrating Radar

SnowEx20 Cameron Pass Ground Penetrating Radar Raw

SnowEx21 Cameron Pass Ground Penetrating Radar Raw

5 RELATED WEBSITES

SnowEx at NSIDC | Overview
SnowEx at NASA

6 REFERENCES

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McGrath, D., R. Bonnell, L. Zeller, A. Olsen-Mikitowicz, E. Bump, R. Webb, & H.P. Marshall. (2022). A Time Series of Snow Density and Snow Water Equivalent Observations Derived from the Integration of GPR and UAV SfM Observations. Frontiers in Remote Sensing, 47, https://doi.org/10.3389/frsen.2022.886747

McGrath, D., R. Webb, D. Shean, R. Bonnell, H. P. Marshall, T. H. Painter, et al. (2019). Spatially extensive ground penetrating radar snow depth observations during NASA's 2017 SnowEx campaign: Comparison with in situ, airborne, and satellite observations. Water Resources Research, 55, https://doi.org/10.1029/2019WR024907.

7 DOCUMENT INFORMATION

7.1 Publication Date

December 2022

7.2 Date Last Updated

December 2022