SnowEx23 Mar23 IOP CSU 1 GHz 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., McGrath, D., Detre, A., and Holland-Goon, K. 2025. *SnowEx23 Mar23 IOP CSU 1 GHz 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/10.5067/3X5Q3X7Y87U3. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX23_CSU_GPR

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

This data set contains the results of 1 GHz ground-penetrating radar surveys conducted as part of the NASA SnowEx23 field campaign in Alaska, USA. Surveys were conducted at three different field sites between 07 March 2023 and 16 March 2023: 1) Farmers Loop/Creamers Field (FLCF), 2) the Bonanza Creek Experimental Forest (BCEF), and 3) the Caribou/Poker Creek Research Watershed (CPCW). Parameters in this data set include: two-way travel (TWT) time, snow density, calculated snow depth, and calculated snow water equivalent (SWE).

1.2 File Information

1.2.1 Format

The data is organized into 3 comma-separated value (.csv) files. Each file represents a separate study area.

1.2.2 File Contents

Each .csv file contains the following 12 columns.

Table 1. Data Parameters

Column	**Description**
Date[mmddyy]	Date of data acquisition, formatted as 2-digit month, 2-digit day, and 2-digt year
Time[HHMM]	Time of data acquisition, unavailable for this data set (NaN). Column is maintained to retain formatting used in other GPR data sets
Longitude[DD]	WGS 84 longitude in decimal degrees
Latitude[DD]	WGS 84 latitude in decimal degrees
ElevationWGS84[mae]	WGS84 ellipsoid elevation in meters above ellipsoid (mae)
Easting[m]	WGS84/UTM Zone 6N northing in meters
Northing[m]	WGS84/UTM Zone 6N easting in meters
UTM_Zone	WGS84/UTM Zone number
TWT[ns]	Semi-automatically picked two-way travel times of the radar wave through the snowpack in nansoseconds
Depth[cm]	Calculated snow depth in cm
SWE[mm]	Calculated snow water equivalent in millimeters

Column	Description
Density[kg m-3]	Bulk snow density each snow pit associated with the GPR survey, measured in kilograms per cubic meter
Notes	Snow pit ID

1.2.3 Naming Convention

The data files are named according to the following conventions, and as described below.

```
SNEX23_CSU_GPR_BCEF_20230310_20230310_v01.0.csv
SNEX23_CSU_GPR_CPCRW_20230308_20230315_v01.0.csv
SNEX23_CSU_GPR_FLCF_20230307_20230316_v01.0.csv
```

`SNEX23` refers to the SnowEx 2023 field campaign. `CSU` refers to Colorado State University. `GPR` refers to ground penetrating radar data. `BCEF`, `CPCRW`, and `FLCF` refers to the field site (Bonanza Creek Experimental Forest, Caribou/Poker Creek Research Watershed, and Farmers Loop/Creamers Field, respectively). The numbers are formatted as `MMDDYYYY` and represent the start and end of the temporal coverage.

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 68.6400° N
Southernmost Latitude: 68.5257° N
Easternmost Longitude: 149.2186° W
Westernmost Longitude: 149.5680° W

1.3.2 Resolution

Point measurements

1.3.3 Geolocation

This data set provides coordinates formatted as both latitude/longitude, which conform the WGS 84 coordinate reference system (EPSG 4326) and as easting/northing, which conform to the WGS 84 coordinate reference system / UTM zone 6N (EPSG 32606).

1.4 Temporal Information

1.4.1 Coverage

07 March 2023 to 16 March 2023

1.4.2 Resolution

Data was collected once per sampling site.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set was collected with a Sensors & Software 1GHz ground penetrating radar (GPR) as part of the SnowEx 2020 Intensive Observation Period (IOP) at Grand Mesa, Colorado between 07 March 2023 and 16 March 2023.

2.2 Acquisition

The GPR surveys were conducted using a Sensors & Software control unit and a shielded 1 GHz antenna. The control unit and antenna were pulled in a plastic sled behind an operator, who used snowshoes. Individual GPR traces were geolocated using an Emlid RS2 (L1/L2) GPS receiver. A detailed description of the data collection procedures can be found in Holland-Goon et al. (2025).

2.3 Processing

Data was processed following methods outlined in McGrath et al. (2019), as described in detail in Holland-Goon et al. (2025). GPR traces primarily had a spacing of 0.1 m, with the exception of a few BCEF traces, which were processed at 0.5 m spacing. The GPR traces had a sample rate of 0.1 ns. TWT times were manually selected, then used to calculate snow depth and snow water equivalent using the bulk snow density measurement from the nearest adjacent snow pit to each transect and the empirically derived radar velocity derived using the equation from Kovacs et al. (1995).

GPS measurements were made with an Emlid RS2 receiver operated in post-processed kinematic (PPK) mode. The measurements were post-processed in RTKlib, an open-source program package for global navigation satellite system (GNSS) positioning, using observations from an Emlid RS2 receiver base station at the field site.

2.4 Quality, Errors, and Limitations

Sources of uncertainty in this data set include the accuracy of GPS measurements and potential over/under-estimation of GPR-derived snow depth measurements. Horizontal accuracy of the GPS measurements in the boreal forest environment where the study sites were located can range between ±0.5–3 m. Underestimations of snow depth can occur to compaction of the snowpack caused by the weight of the instrument sled or due to the presence of thick vegetation layers obscuring the true depth of the snowpack. Overestimation of snow depth may be caused by the presence of void spaces with the snowpack, or the lack of strong radar reflection at the snow/ground interface due to the presence of frozen soil. The GPR-calculated snow depths in this data set were found to have a slightly positive bias toward overestimation of snowpack depth (+0.06 m) when compared to physical snow depth measurements collected at adjacent snow pits, likely due to the presence void spaces caused by the abundant vegetation in boreal forests. A detailed discussion of data quality can be found in Holland-Goon et al. (2025).

3 VERSION HISTORY

Table 2. Version History

Version	Date Implemented	Impacted Temporal Coverage	Description of Changes
v01.0	September 2025	07 March 2023 to 16 March 2023	Initial release

4 RELATED DATA SETS

SnowEx23 Colorado State University Ground Penetrating Radar Raw, Version 1
SnowEx23 CRREL Ground Penetrating Radar, Version 1
SnowEx23 CRREL Ground Penetrating Radar Raw, Version 1
SnowEx23 University of Wyoming Ground Penetrating Radar, Version 1

5 RELATED WEBSITES

NASA SnowEx
NSIDC SnowEx | Overview

6 ACKNOWLEDGMENTS

We thank the SnowEx leadership team for planning and executing the SnowEx 2023 campaign. We thank the SnowEx 2023 participants for providing snow pit observations and measurements. In particular, we thank Wyatt Reis, Megan Mason, and Dragos Vas for their assistance with GPR surveys in the field.

7 REFERENCES

Holland-Goon, K., Bonnell, R., McGrath, D., Baxter, W. B., Meehan, T., Webb, R., Larsen, C., Marshall, H.-P., Mason, M., and Vuyovich, C. (2025). Brief Communication: Evaluating Snow Depth Measurements from Ground-Penetrating Radar and Airborne Lidar in Boreal Forest and Tundra Environments during the NASA SnowEx 2023 Campaign, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-2435,

Kovacs, A., A. J. Gow & R. M. Morey. (1995). The in-situ dielectric constant of polar firn revisited. Cold Regions Science and Technology, 23(2), 245-256, https://doi.org/10.1016/0165-232X(94)00016-Q.

McGrath, D., Webb, R., Shean, D., Bonnell, R., Marshall, H.-P., Painter, T. H., 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, 10026–10036. https://doi.org/10.1029/2019WR024907

8 DOCUMENT INFORMATION

8.1 Publication Date

September 2025

8.2 Date Last Updated

September 2025