SnowEx17 Time Series Sonic Snow Depth Measurement Array, Version 1

USER GUIDE

How to Cite These Data

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

Jennings, K. S., T. B. Barnhart, and N. P. Molotch. 2018. *SnowEx17 Time Series Sonic Snow Depth Measurement Array, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/5YJEYNLS1YK4. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX17_SSD

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

Snow depth.

1.2 File Information

1.2.1 Format

Snow depth data are provided in Comma-Separated Values (.csv) format.

Multiple images (.jpg) of each sensor location are included. One text file (.txt) describing the contents of each image is also available.

The CSV file, JPG images, and text file are available as a single ZIP file.

An associated Extensible Markup Language (.xml) file contains relevant metadata.

1.2.2 File Contents

Snow depth time series data are presented in a single CSV file. This file contains four levels of data - raw, quality controlled, infilled, and smoothed. Quality control (QC) and infill flags describe how the raw data was manipulated.

QC flags:
NA = Data passed all QC checks
1 = Observation removed because of vegetation effects
2a = Observation failed maximum / minimum threshold
2b = Observation failed rate of change threshold

Infill flags:
NA = No infilling performed
3a = Missing observation filled using linear interpolation (gap ≤ 24 h)
3b = Missing observation filled using spline interpolation (gap > 24 h)
4 = Observation failed visual inspection, was removed manually and infilled with linear interpolation
5a = Filled from beginning of snow season (2017-11-18 10:30 MST) to date of first usable observation using linear interpolation
5b = Filled from beginning of snow season (2017-11-18 10:30 MST) to date of first usable observation using average depth values from nearby working sensors, scaled to the first usable observation.

The CSV file header includes the campaign, location, names of researchers, missing data code, QC and infill flag codes, post-processed differential GPS coordinates for the 17 snow depth sensor locations, and notes.

Starting with row 40, data are presented in columns A through H. Columns include the date & time (MST) of measurement, sensor number, raw snow depth (cm), quality-controlled snow depth (cm), QC flag, infilled snow depth (cm), infill flag, and smoothed snow depth (cm). Column titles and ten rows of sample data are presented in Figure 1.

#datetime_MST	sensor_num	depth_raw_cm	depth_qc_cm	depth_qc_flag	depth_fill_cm	depth_fill_flag	depth_smooth_cm
10/12/16 23:30	SXK1	16.3	NA	1	0	NA	0
10/12/16 23:45	SXK1	24.5	NA	1	0	NA	0
10/13/16 0:00	SXK1	21.6	NA	1	0	NA	0
10/13/16 0:15	SXK1	18.6	NA	1	0	NA	0
10/13/16 0:30	SXK1	23.7	NA	1	0	NA	0
10/13/16 0:45	SXK1	14.9	NA	1	0	NA	0
10/13/16 1:00	SXK1	23.5	NA	1	0	NA	0
10/13/16 1:15	SXK1	23.5	NA	1	0	NA	0
10/13/16 1:30	SXK1	16.8	NA	1	0	NA	0
10/13/16 1:45	SXK1	17.9	NA	1	0	NA	0
10/13/16 2:00	SXK1	24.8	NA	1	0	NA	0

Figure 1. Sample data from file SnowEx17_snowdepth_15min_V2.csv.

1.2.3 Naming Convention

Image files utilize the following naming convention:

```
sx??_N_xxxx.JPG
```

Table 1. File Naming Convention

Variable	Description
sx??	sensor ID number: sxk? = sensor in the TLS-K footprint on the west mesa sxn? = sensor in the TLS-N footprint on the east mesa
N	number of image (four images associated with each sensor site)
xxxx	description of image: map = hand-drawn site map (not to scale) with pencil pointing to sensor location / number site = wide-angle shot of sensor down = sensor footprint up = sky view taken from beneath sensor

Examples:
sxn9_1_map.JPG
sxn9_2_site.JPG
sxn9_3_down.JPG
sxn9_4_up.JPG

1.2.4 File Size and Volume

The CSV file is approximately 24 MB.

JPG files range between approximately 1 MB and 7.5 MB.

The text file is approximately 1 KB.

The total data set is approximately 326 MB.

1.3 Spatial Information

1.3.1 Coverage

Overall spatial coverage:

Northernmost Latitude: 39.03430447° N
Southernmost Latitude: 39.02755193° N
Easternmost Longitude: 107.9335668° W
Westernmost Longitude: 108.0545976° W

1.3.2 Resolution

1 cm

1.4 Temporal Information

1.4.1 Coverage

Data from the TLS-K footprint (SXK sensors) were collected between 12 October 2016 and 02 July 2017.

Data from the TLS-N footprint (SXN sensors) were collected between 12 October 2016 and 06 June 2017.

1.4.2 Resolution

Depth sensors recorded snow depth observations every 15 minutes.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Data can be used for model forcing, calibration, and validation; evaluation of airborne and satellite remote sensing products; and an analysis of vegetation's effects on snow accumulation and ablation, among other purposes.

2.2 Acquisition

Data were measured at two locations on Grand Mesa, Colorado: the TLS-K footprint (in the west mesa study site) and the TLS-N footprint (in the east mesa study site). Ten sensors recorded usable data from TLS-K; seven sensors recorded usable data from TLS-N. Sensors were positioned within each study site to capture three vegetation conditions: open-canopy, canopy-edge, and closed-canopy.

Snow depth was recorded using Judd Communications Ultrasonic Depth Sensors. Every 15 minutes, the sensors directed an ultrasonic pulse at the ground and recorded the two-way travel time. The instrument then calculated snow depth by dividing the air-temperature-corrected speed of sound by 1/2 the two-way travel time. Snow depth sensors have a 22° beam width and a range of 0.5 to 10 meters.

Snow depth records were stored on Campbell Scientific CR1000 data loggers.

2.3 Processing

Raw data were subjected to quality control (processing steps one through four), infilling (processing steps five through eight), and smoothing (processing step nine).

Quality Control:

1. Data was visually inspected. Observations tainted by vegetation influences (e.g. grass growth in the sensor footprint) were removed.
2. Observations were removed if they exceeded the maximum / minimum threshold.
3. Data points with a change in depth greater than ±5 cm per 15 minutes were removed.

4. Sensor offsets were corrected to correspond to 0 cm during snow-free periods. All sensors, except SXK6, SXN3, SXN6, had their offsets adjusted so that depth = 0 cm when there was no snow on the ground. Offset corrections were less than 15 cm in all cases.

Infilling:

5. Data gaps less than 24 hours were infilled using linear interpolation between the preceding and following observations.

6. Data gaps greater than 24 hours were infilled using spline interpolation between the preceding and following observations.

7. Data were again visually inspected. Any questionable data points that passed the previous QC inspection were removed and infilled using linear interpolation.

8. For those sensors whose observations were affected by vegetation during the snow-free season, depth was reconstructed by averaging values from nearby, non-affected sensors and then scaling these observations to match the first usable observation of the vegetation-affected sensor.

Smoothing:

9. Depth values were smoothed using a 6-hour moving average filter, where each observation in the 3-hour window before and after the data point was given equal weight. Other smoothing approaches are available to users and can be performed on the infilled data (column F, depth_fill_cm).

2.4 Quality, Errors, and Limitations

Sensors SXN2, SXN5, and SXN7 were installed but recorded no usable data. No data from these sensors were retained for the final product.

The percentage of infill required varied by sensor, ranging between 1.7% and 64.0%. All sensors except SXK5 and SXN3 had fewer than 18.6% infill. The mean rate of infill was 14.5%; the median rate of infill was 9.0%.

JPG images are meant to illustrate site conditions only. Cameras were not leveled or precisely located, so no attempts should be made to quantify vegetation height, leaf area index, or other parameters from the images.

2.5 Instrumentation

2.5.1 Description

Snow depth was measured by Judd Communications Ultrasonic Depth Sensors. See the manufacturers website for specifications.

Snow depth data were stored on Campbell Scientific CR1000 data loggers. See the manufacturers website for more details.

3 RELATED DATA SETS

Other SnowEx Data Sets

4 RELATED WEBSITES

NASA SnowEx Campaign

CU Mountain Hydrology Group

5 CONTACTS AND ACKNOWLEDGMENTS

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6 REFERENCES

Molotch, N. P., P. D. Brooks, S. P. Burns, M. Litvak, R. K. Monson, J. R. McConnell, and K. Musselman. 2009. Ecohydrological controls on snowmelt partitioning in mixed conifer sub-alpine forests. *Ecohydrology* 2(2): 129-142.

7 DOCUMENT INFORMATION

7.1 Publication Date

09 July 2018

7.2 Date Last Updated

02 October 2018