SnowEx Meteorological Station Measurements from Grand Mesa, CO, Version 1

USER GUIDE

How to Cite These Data

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

Houser, P., W. Rudisill, J. Johnston, K. Elder, H.P. Marshall, C. Vuyovich, E. Kim, M. Mason. 2022. *SnowEx Meteorological Station Measurements from Grand Mesa, CO, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/497NQVJ0CBEX. [Date Accessed].

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

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

National Snow and Ice Data Center

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1   DATA DESCRIPTION

1.1 Parameters

This data set contains observations from five meteorological stations installed in Grand Mesa, Colorado as part of NASA SnowEx field campaigns. Measured data include: air temperature, relative humidity, wind speed and direction, long and shortwave solar radiation, barometric pressure, soil moisture and temperature, and derived snow depth (Table 1). Temporal coverage varies between each station, but spans October 2016 to August 2022 for the entire data set.

Table 1. Parameters

Parameter	Unit	Description
TIMESTAMP	hours	Time in UTC (MM/DD/YYYY HH:00)
RH_20ft	%	Relative humidity measured at 20 ft tower level
RH_10ft	%	Relative humidity measured at 10 ft tower level
BP_kPa_Avg[1]	kPa	Barometric pressure
AirTC_20ft_Avg	°C	Air temperature measured at 20 ft tower level
AirTC_10ft_Avg	°C	Air temperature measured at 10 ft tower level
WSms_20ft_S_WVT	m/s	Vector mean wind speed measured at 20 ft tower level
WSms_10ft_S_WVT	m/s	Vector mean wind speed measured at 10 ft tower level
WindDir_10ft_D1_WVT	°	Vector mean wind direction measured at 10 ft tower level
WindDir_20ft_D1_WVT	°	Vector mean wind direction measured at 20 ft tower level
SUp_Avg[2]	W/m^2	Shortwave radiation measured with upward-facing sensor
SDn_Avg[2]	W/m^2	Shortwave radiation measured with downward-facing sensor
LUpCo_Avg[2]	W/m^2	Longwave radiation measured with upward-facing sensor
LDnCo_Avg[2]	W/m^2	Longwave radiation measured with downward-facing sensor
SM_5cm_Avg	-	Soil moisture measured at 5 cm below the soil
SM_20cm_Avg	-	Soil moisture measured at 10 cm below the soil
SM_50cm_Avg	-	Soil moisture measured at 20 cm below the soil
TC_5cm_Avg	°C	Soil temperature measured at 5 cm below the soil
TC_20cm_Avg	°C	Soil temperature measured at 10 cm below the soil
TC_50cm_Avg	°C	Soil temperature measured at 20 cm below the soil
SnowDepthUnFiltered	m	Temperature corrected, derived snow surface height
SnowDepthFiltered	m	Temperature corrected, derived snow surface height

[1] Parameter not available for sites Mesa Middle and Mesa West
[2] Parameter not available for site Grand Mesa Study Plot

1.2 File Information

1.2.1 Format

The data are available as comma-separated value (CSV) files, with a corresponding browse image (PNG) for each data file. A single CSV and PNG file are available for each of the five weather stations.

1.2.2 File Contents

Each CSV file includes a 4-line header which provides the weather station site name, location (latitude and longitude), and data processing date (formatted as MM/DD/YYYY). The rest of the file consists of 22 columns of data, starting with a header row containing parameter names as listed in Table 1. Missing values are identified as -9999.

1.2.3 Naming Convention

The data files follow the naming convention `SNEX_Met_[STATION]_final_output.csv`. `SNEX` refers to the ongoing NASA SnowEx field campaigns. `[STATION]` refers to the location of each weather station, as seen in Table 2 below.

1.3 Spatial Information

1.3.1 Coverage

These data were collected from five separate fixed weather station locations in Grand Mesa, Colorado. See Table 2 below for individual station locations.

Table 2. Spatial Coverage

Station	Latitude	Longitude
Grand Mesa Study Plot (GMSP)	39.05084 N	108.06144 W
Local Scale Observation Site (LSOS)	39.05225 N	108.09792 W
Mesa East (ME)	39.10358 N	107.88383 W
Mesa Middle (MM)	39.03954 N	107.94174 W
Mesa West (MW	39.03388 N	108.21399 W

1.3.2 Resolution

Measurements were taken at various levels between 6.1 m above the ground and 50 cm below the ground, depending on the parameter.

1.3.3 Geolocation

Table 3 provides information for geolocating this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs +type=crs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

Collectively, temporal coverage for these data spans 9 October 2016 to 8 August 2022. The specific collection dates for each meteorological station can be found in Table 4.

Table 4. Temporal Coverage

Station	Start Date	End Date
Grand Mesa Study Plot (GMSP)	06-21-2017	03-10-2022
Local Scale Observation Site (LSOS)	10-09-2016	05-17-2017
Mesa East (ME)	10-10-2016	08-03-2022
Mesa Middle (MM)	10-10-2016	08-05-2022
Mesa West (MW	10-09-2016	08-30-2022

1.4.2 Resolution

Data are available as hourly averages.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

As part of the ongoing the NASA SnowEx mission, five meteorological stations were installed between 2016-2017 in Grand Mesa, Colorado to provide supporting data for SnowEx field campaigns and forcing data for modeling experiments. Each station collects a suite of meteorological data at a fixed geographic point, from varying heights above and below the surface elevation.

2.2 Acquisition

Air temperature, relative humidity, and mean wind speed and direction data were measured at elevations of 3.0 m (10ft) and 6.1 m (20 ft) above the ground surface. Soil moisture (measured in water fraction by volume) and soil temperature where measured at depths of 5 cm, 20 cm, and 50 cm below the ground surface. Barometric pressure readings and solar radiation data (both longwave and shortwave), were measured at 3.0 m (10 ft) above the ground surface. Longwave and shortwave radiation were each measured using a radiometer containing two pyranometer and pyrgeometer pairs. Each pair contains an upward-facing sensor to measure atmospheric radiation, and a downward-facing sensor to measures radiation being reflected/emitted by the ground surface. The radiometer also contains built-in temperature sensors which are used to correct the infrared readings for the temperature of the instrument housing (see link to instrument specifications in Table 6). Sonic depth measurements (sensor-to-ground distance) were also taken from a fixed height of 3.0 m (10 ft) and used to derive snow depth.

2.3 Processing

Raw data sampling occurred in 10-minute intervals. Subsequent processing removed data with duplicated time stamps, replaced missing data points with missing data value (-9999) and resampled the data into hourly averages. If there was less than a three-hour time gap between missing data points, the missing data was calculated using a linear interpolation. All scripts used during data processing are available via GitHub.

For longwave radiation data from the Mesa Middle (MM) site, an additional data correction was applied to account for a period of unexpectedly high values interspersed between expected values. More details about this correction can be found on the Github page linked above.

Additional data processing was used to derive snow depth from the sonic depth measurements. The sensor calculates distance-to-ground using ultrasonic wave reflection. A Python script was used to apply temperature corrections to the measured distances (as per the sensor manufacturer's specifications, see link in section 2.5) using the measured air temperature readings. The script also removed measurements with a high standard deviation (to account for potential errant returns due to factors such as blowing snow). Two snow depth data products are available. Filtered snow depth (SnowDepthFiltered) has been corrected using a rules-based method which combines the date of data acquisition with the measured temperature to identify likely snow-free periods. The unfiltered data (SnowDepthUnFiltered) has not been corrected, and therefore the data may represent vegetation growth or surface elevation rebound during periods when snow is absent.

2.4 Quality, Errors, and Limitations

Error in air temperature, relative humidity, wind speed, barometric pressure, soil moisture, and soil temperature measurements are dependent on instrument accuracy. See Table 5 below for reported accuracy. Links to specifications for each instrument are available in Table 6 in Section 2.5.

Table 5. Instrument Accuracy

Parameter	Instrument Accuracy
AirTC, RH	±0.1° C (at 23 °C)
WS	±0.3 m/s (0.6 mph)
BP	±0.3 mb (at 20 °C)
	±0.6 mb (at 0 to 40 °C)
	±1 mb (at -20 to 45 °C)
	±1.5 mb (at -40 to 60 °C)
SM	±0.01 to 0.03 water fraction by volume (m^3/m^3)
TC	±0.3°C (at -30-60°C)

Errors in solar radiation measurements are calculated as percent uncertainty in daily totals measured at the 95% confidence interval, which are <5% for shortwave radiation (SUp, SDn) data and <10% for longwave radiation (LUp, LDn data).

Errors in snow depth measurements are not provided, but are dependent on two factors: the accuracy of the Campbell Scientific SR50A sonic ranging sensor, from which snow depth data is derived, and the accuracy of the temperature data used to correct the SR50A measurements. Temperature accuracy is the same as AirTC, listed in Table 5 above.

2.5 Instrumentation

Each meteorological weather station is equipped with multiple instruments for collecting data. Table 6 lists each instrument and its specifications.

Table 6. Instrumentation Details

Instrument	Measured Parameters	Description
Campbell Scientific HC2S3	Air temperature, relative humidity	Probe which measures temperature using a 100 Ω platinum resistant thermometer, and relative humidity using a Rotronic IN1 capacitive sensor. Specifications
R.M. Young 05103	Vector mean wind speed, vector mean wind direction	Wind monitor featuring a 4-blade helicoid propeller and precision potentiometer. Specifications
Campbell Scientific CS106	Barometric pressure	Sensor capable of measuring barometric pressure between 500 to 1100 mb. Specifications
Kipp and Zonnen CNR4	Shortwave radiation, longwave radiation	Net radiometer which measures incoming and outgoing/surface-reflected shortwave and longwave Far Infrared (FIR) radiation. Specifications
Stevens Water Hydraprobe II	Soil moisture, soil temperature	Soil sensor which measures moisture, temperature and soil conductivity. Specifications.
Campbell Scientific SR50A	Target-to-sensor distance (snow depth)	Sonic ranging sensor which uses a 50 kHz (Ultrasonic) electrostatic transducer calculate distance between a target and the sensor. Specifications.

3   SOFTWARE AND TOOLS

Python scripts used to process and correct data are available on Github.

4   VERSION HISTORY

Table 7. Version History Summary

Version	Release Date	Description of Changes
1	December 2022	Initial release

5   RELATED DATA SETS

SnowEx at NSIDC | Data Sets

SnowEx Meteorological Station Measurements from Grand Mesa, CO Raw, Version 1

6   RELATED WEBSITES

Snow Ex at NSIDC | Overview

Snow Ex at NASA

7 ACKNOWLEDGMENTS

This data set would not have been possible without the effort taken by participants of the NASA SnowEx campaigns to install and maintain the stations.

8 DOCUMENT INFORMATION

8.1 Publication Date

December 2022

8.2 Date Last Updated

December 2022