# SnowEx20 Grand Mesa Autumn 2019 Gravimetric Soil Moisture, Version 1

## USER GUIDE

**How to Cite These Data**

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

Brucker, L., A. White, M. Lewis, M. Cosh and K. Elder. 2021. *SnowEx20 Grand Mesa Autumn 2019 Gravimetric Soil Moisture, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/WFY6K8NKREIV. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_A19_GSM

National Snow and Ice Data Center

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# 1 DATA DESCRIPTION

## 1.1 Parameters

Gravimetric soil moisture is a direct measurements of soil water content in %. It is determined by weighing a soil sample before and after oven drying at 105°C for 24-48 h.

## 1.2 File Information

### 1.2.1 Format

Data are provided in a single comma-separated values (.csv) file.

### 1.2.2 File Contents

The file starts with a header indicating the location Grand Mesa, Colorado as study site and the UTM Zone 12. The header is followed by 11 columns of data. Column names are described in Table 1.

Table 1. Data Parameters

| Variable | Description | Units/Format |
|---|---|---|
| Date | Date of data acquisition in Coordinated Universal Time. | YYYYMMDD |
| Site | Sample site location short name. See Appendix A for details on sample site names. | N/A |
| Easting | UTM Easting | m |
| Northing | UTM Northing | m |
| Soil Moisture | Gravimetric soil moisture is the relative measure of mass water per mass of dry soil. | % |
| Sample | Sample name used on sample bag. Name depends on site type and is provided only for archival purposes. | N/A |
| Tin Number | Indicates the used tin for a given soil sample. | N/A |
| Tare Mass | Mass of the empty tin. | g |
| Wet + Tare Mass | Mass of tin with fresh soil sample. | g |
| Dry + Tare Mass | Mass of tin with dried soil sample. | g |

| Variable | Description | Units/Format |
|---|---|---|
| Notes | Optional, describes the quality of soil samples (grass, roots, etc.) | N/A |

### 1.2.3 Naming Convention

For this product, there is a single file named: `SNEX20_A19_GSM_v01.csv`. Table 2 describes the file naming convention.

Table 2. File Naming Convention

| Variable | Description |
|---|---|
| SNEX20_A19_GSM | SnowEx20 Grand Mesa Autumn 2019 Gravimetric Soil Moisture |
| v01 | Data set version |
| .csv | File extension |

## 1.3 Spatial Information

### 1.3.1 Coverage

Northernmost Latitude: 39.032624 ºN
Southernmost Latitude: 39.005715 ºN
Easternmost Longitude: 108.153539 ºW
Westernmost Longitude: 108.216254 ºW

### 1.3.2 Resolution

Point measurement

### 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** | WGS 84 / UTM Zone 12 North |
| **Longitude of true origin** | -111 |
| **Latitude of true origin** | 0 |
| **Scale factor at longitude of true origin** | 0.9996 |
| **Datum** | WGS 1984 |
| **Ellipsoid/spheroid** | WGS 84 |
| **Units** | meters |
| **False easting** | 500000 |
| **False northing** | 0 |
| **EPSG code** | 32612 |
| **PROJ4 string** | +proj=utm +zone=12 +datum=WGS84 +units=m +no_Defs |
| **Reference** | https://epsg.io/32612 |

## 1.4 Temporal Information

### 1.4.1 Coverage

Start Date: 04 November 2019

End Date: 06 November 2019

### 1.4.2 Resolution

Point measurement

# 2 DATA ACQUISITION AND PROCESSING

## 2.1 Background

Gravimetric soil moisture was obtained from soil samples collected in autumn (04-06 November 2019) as part of the NASA SnowEx 2020 campaign in Grand Mesa, CO. A total of 77 soil samples were taken at snow pit locations, soil moisture stations, and other areas where both the mobile and stationary cosmic-ray Soil Moisture Observing Systems (COSMOS) operated. Soil samples were processed at the Fraser Experimental Forest laboratory.

## 2.2 Acquisition

Soil was sampled close to the surface and bagged. The samples were then shipped to the Fraser Experimental Forest laboratory where they were weighed, dried at 105 °C for 24 h, and weighed again.

## 2.3 Processing

Gravimetric soil moisture in % was calculated as a ratio of soil masses:

$\frac{M_{wet}-M_{dry}}{M_{dry}} * 100$ where $M_{wet}$ and $M_{dry}$ refer to wet and dry sample soil mass, respectively.

## 2.4 Quality, Errors, and Limitations

Uncertainty of the gravimetric measure is ±0.01 g. The accuracy of the GSM is usually on the order of ±0.03 g/g. Notes on the quality of the soil samples are available in the data column 'Notes'. During the campaign, the soil was mainly frozen in the morning, which made it challenging to collect clean soil samples.

GPS systems of various accuracies were used to geolocate the measurements. These handheld GPS devices are assumed to have errors of ~3-15 m in accuracy depending on canopy conditions.

## 2.5 Instrumentation

In situ soil sampler

# 3 SOFTWARE AND TOOLS

CSV files can be accessed using software that reads ASCII text.

# 4 VERSION HISTORY

Table 2. Version History Summary

| Version | Release Date | Description of Changes |
|---|---|---|
| V1 | 03 June 2021 | Initial Release |

# 5 RELATED DATA SETS

SnowEx at NSIDC| Data Sets
SnowEx20 Grand Mesa Autumn 2019 Snow Water Equivalent
SnowEx20 Grand Mesa Autumn 2019 Snow Depth (not yet published)
SnowEx20 Grand Mesa Autumn 2019 Snow Pits (not yet published)

# 6 RELATED WEBSITES

SnowEx at NSIDC | Overview
NASA SnowEx

# 7 CONTACTS AND ACKNOWLEDGMENTS

**Ludovic Brucker**

NASA GSFC / USRA

**Alex White**

USDA Hydrology and Remote Sensing Laboratory

**Michael Lewis**

US Army Corps of Engineers, Geospatial Research Laboratory

**Michael Cosh**

USDA Hydrology and Remote Sensing Laboratory

**Kelly Elder**

U.S. Forest Service

# 8 DOCUMENT INFORMATION

## 8.1 Publication Date

03 June 2021

## 8.2 Date Last Updated

03 June 2021

# APPENDIX A – SNOWEX GRAND MESA IOP SNOW PIT NAMING CONVENTION DESCRIPTION

The SnowEx Grand Mesa Intensive Observation Period (IOP) 2020 snow pits were used to validate snow remote sensing on Grand Mesa. Snow pits were selected to cover the full range of conditions found on Grand Mesa, from meadows to dense forests, and from shallow snow depths to deep snowpack.

Potential Grand Mesa snow conditions were evaluated based on SnowEx 2017 airborne lidar and optical imagery (Figure A1). Specifically, the Airborne Snow Observatory's 08 February 2017 lidar-derived snow depths (ASO L4 Lidar Snow Depth 3m UTM Grid, Version 1) were binned into three classes: shallow (<90 cm), intermediate (90-122 cm), and deep (>122 cm). A tree density map created from November 2010 WorldView-2 imagery was also binned into three classes based on the percentage of tree-class pixels within a 50-m radius: treeless (0%), sparse (1-30%), and dense (31-100%). The two factors were combined to form a nine-point snow and tree matrix (Figure A1). Within this matrix, values 1-3, 4-6, and 7-9 represent treeless, sparse, and dense tree areas, respectively. These three ranges can be further subdivided into three categories of snow depth classification: shallow (lowest number in a range, e.g. 1), intermediate, and deep (highest number in a range, e.g. 3). Treeless areas were not split into shrub or meadow cover types. Water bodies and missing lidar data remain unclassified (grey areas in Figure A1).

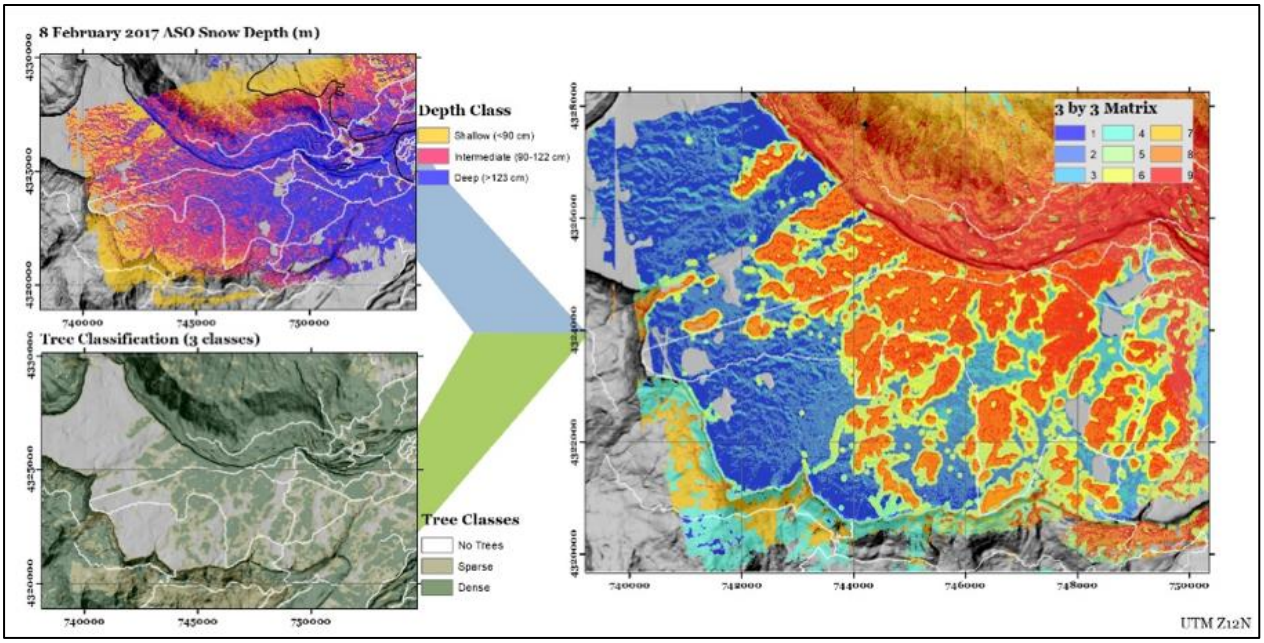


Figure A1. Separate vegetation and snow depth classifications for the Grand Mesa IOP study site are shown (left). These classifications are combined to form the final tree density and snow depth matrix used to describe snow pit locations (right). In all images, gray areas represent undefined regions (e.g., water bodies).

Finally, the Grand Mesa IOP study site was clipped into three flight lines (north, N; south, S; and cross, C) (Figure A2). These flight lines correspond to the scheduled IOP airborne observations.

Within the flight lines, 150 snow pit locations (approximately three weeks of work) were proportionally divided by the nine matrix classes, then randomly distributed amongst the three flight lines for each matrix class (Figure A2). Matrix classes were not evenly represented and varied in frequency; for example, there are 3 class 4 snow pits and 33 class 2 snow pits. Snow pit names use the following convention, as described in Table A1:

`<matrix>[FlightLine]##`

Table A1. Snow Pit Naming Convention Description

| Variable | Description |
|---|---|
| Matrix | Number describing the measurement site conditions. Each number contains information about the amount of vegetation around the snow pit:<br>• 1/2/3 = treeless (0% tree cover)<br>• 4/5/6 = sparse (1-30% tree cover)<br>• 7/8/9 = dense (31-100% tree cover)<br>and the relative, expected snow pit depth:<br>• 1/4/7 = shallow snowpack<br>• 2/5/8 = medium snowpack<br>• 3/6/9 = deep snowpack |
| [FlightLine] | Indicates on which flight line the snow pit resided:<br>• N = North<br>• S = South<br>• C = Crossline |
| ## | Pit ID number. Numbers are lowest in the West and North and increase incrementally by whole numbers as you move further East or South along a particular flight line. |

For example, Pit “9S40” denotes matrix class 9 (deep snow and dense trees), South flight line, and the 40$^{th}$ total pit on the South line from west to east. Similarly, Pit “1C14” denotes matrix class 1 (shallow snow and no trees), Cross line, and the 14$^{th}$ pit along the Cross line from Northwest to Southeast.

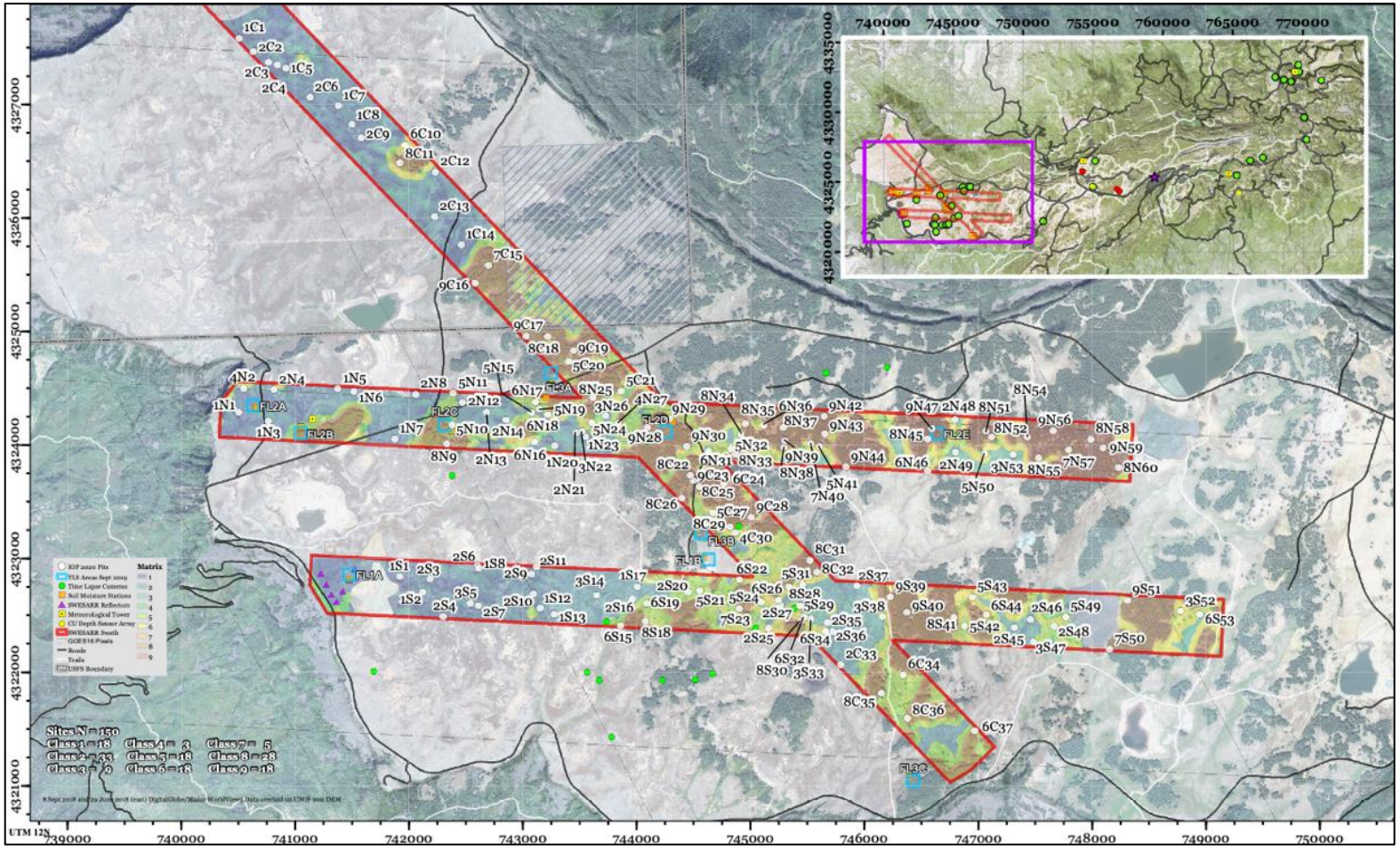


Figure A2. Location of the 150 Grand Mesa IOP snow pits. Snow pits were randomly spaced along the North (upper horizontal line), South (lower horizontal line), and Cross (diagonal line) flight lines, along which airborne measurements were collected. Snow pit naming conventions are described in Table A1. The inset in the top right shows the location of the IOP snow pits and flight lines relative to the rest of Grand Mesa and other SnowEx 2020 locations. Green dots show the location of time lapse cameras, red dots show the location of time series snow pits, yellow squares with black circles show the location of meteorological towers, and yellow circles show the location of snow depth sensors.