SnowEx20 SnowMicroPen (SMP) Penetration Force Profiles, Version 1

USER GUIDE

How to Cite These Data

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

Mason, M., H.P. Marshall, and I. Merkouriadi. 2020. *SnowEx20 SnowMicroPen (SMP) Penetration Force Profiles, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ZYW6IHFRYDSE. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_SMP

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

Table 1. Parameters

Parameter	Description	Units
Depth	Depth of snow measurement	Millimeters (mm)
Force	Force required to drive a motorized probe into the snow at a constant measurement speed of 20 mm/s	Newtons (N)

1.2 File Information

1.2.1 Format

Data containing field observations for each SnowMicroPen (SMP) profile are both provided as space-delimited comma-separated values (.csv) files. Raw output files from the SMP instrument (.pnt) are also provided.

Browse images (.png) and Extensible Markup Language (.xml) files with associated metadata are also available.

1.2.2 File Contents

Figures 1 and 2 contain sample of data from snow pit 2N4 collected on 28 January 2020.

# Date: 2020-01-28	
# Time (UTC): 18:56:11	
# Lat: 39.03627014160156	
# Lon: -108.2181396484375	
# SMP Serial Number: 6	
# Total Samples: 153720	
Depth (mm)	Force (N)
0	0.064933002
0.003968254	0.097399503
0.007936508	0.097399503
0.011904763	0.103892803
0.015873017	0.097399503
0.019841271	0.097399503

Figure 1. The header and first six rows of data from file SNEX20_SMP_S06M0603_2N4_20200128.csv.

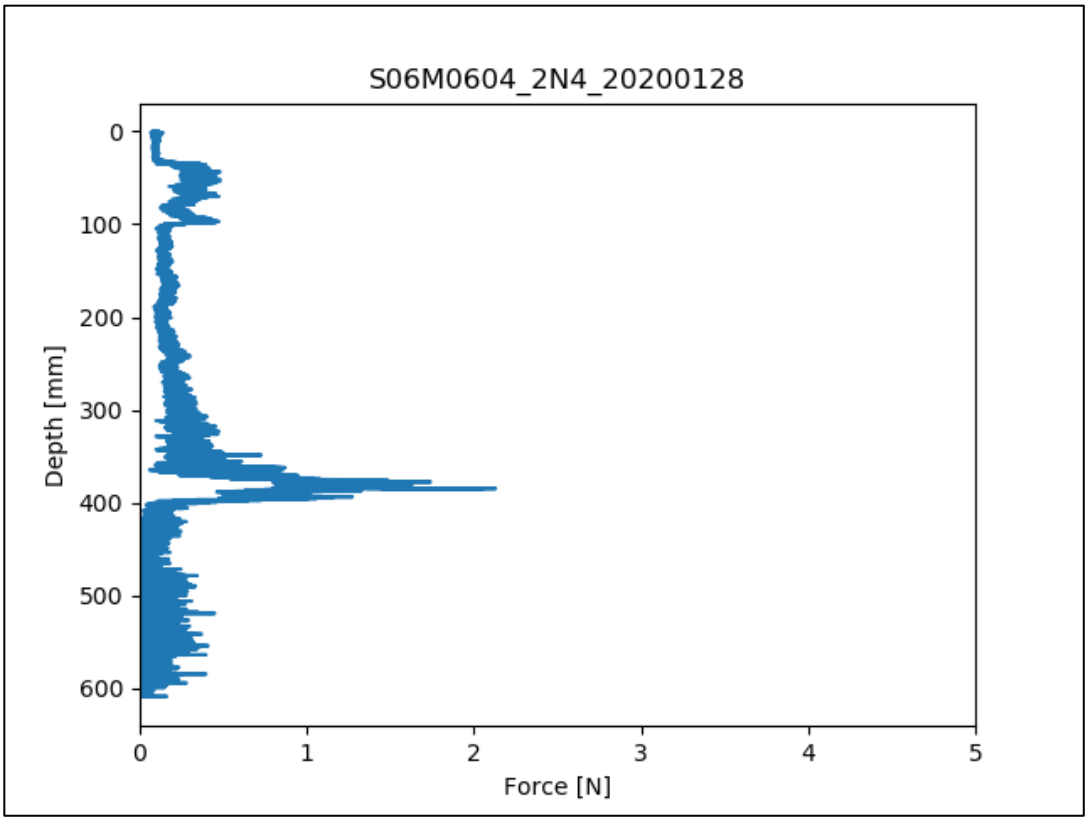

Figure 2. Sample browse image and force profile from file SNEX20_SMP_S06M0603_2N4_20200128.png.

1.2.3 Naming Convention

Data files are named according to the following convention and as described in Table 2:

`SNEX20_SMP_S??M????_<pitID>_yyyymmdd.ext`

Table 2. File Naming Convention

Variable	Description
SNEX20_SMP	Indicates that this file is part of the SnowEx20 SnowMicroPen (SMP) Raw Penetration Force Profiles data set
S??	Identifies the instrument used to collect measurements: S06 or S19
M????	4-digit measurement number
<pitID>	Snow pit ID (see Section 9. Appendix for more details).
yyyymmdd	Date of measurement in year-month-day format
.ext	File extension indicating the data type • .csv = comma-separated value data file • .pnt = binary data file • .png = browse image

Example file names:

```
SNEX20_SMP_S06M0604_2N4_20200128.csv
SNEX20_SMP_S06M0604_2N4_20200128.pnt
SNEX20_SMP_S06M0604_2N4_20200128.png
```

1.3 Spatial Information

1.3.1 Coverage

Southernmost Lat: 39.0139 N
Northernmost Lat: 39.0541 N
Westernmost Lon: 108.2201 W
Eastern Most Lon: 108.0030 W

1.3.2 Resolution

SMP profiles were acquired at a single point, with a vertical resolution of 4 μm.

1.3.3 Geolocation

These data use the WGS 1984 geographic coordinate system (EPGS:4326).

1.4 Temporal Information

1.4.1 Coverage

28 Jan 2020 through 12 Feb 2020

1.4.2 Resolution

Data were collected daily at different snow pits; snow pits were not revisited during the campaign.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Spatial variability in snow microstructure was one of many ground observations taken during the SnowEx 2020 Intensive Observation Period (IOP) in Grand Mesa, Colorado. During the Grand Mesa IOP, 4 to 18 snow pits were visited each day by one to five ground observation teams. Snow microstructure was measured at a random selection of Grand Mesa IOP snow pits (Figure 3).

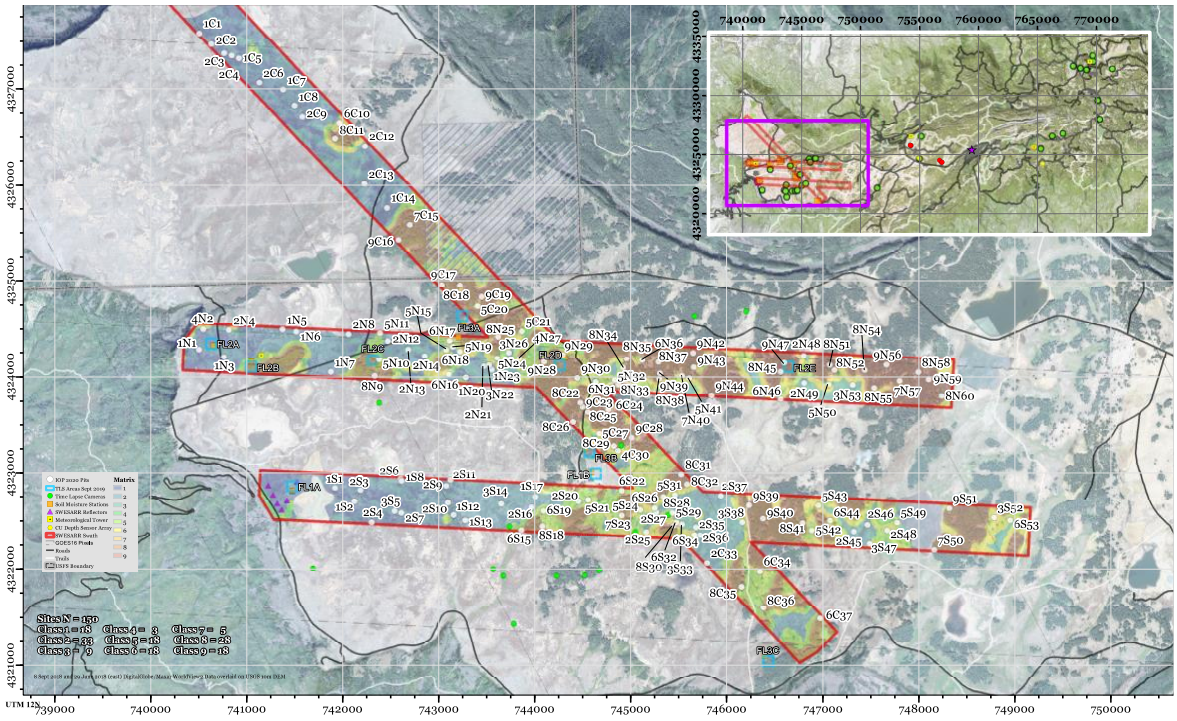

Figure 3. Location of the 2020 Grand Mesa IOP snow pits. Snow pits were randomly spaced along the North (upper horizontal line), South (lower horizontal line), and Cross (diagonal line) flight lines, along which airborne measurements and various ground observations were collected. See Section 9. Appendix for more details on how snow pit locations and names were chosen.

Snow microstructure was measured using the rapid sampling capabilities of the SMP. The SMP acquires high vertical-resolution (~250 measurements per mm) profiles of the force (measured in newtons, N) required to drive a motorized probe into the snow at a constant measurement speed (20 mm/s). Typical force measurements range from 0.01 N for soft snow to 40 N for very hard snow.

Snow microstructure parameters, such as density, layering, snow grain type, and snow grain specific surface area (SSA), can be derived from force measurements; but only the raw force profiles are provided in this data set. Users will need to apply algorithms to identify the air/snow and snow/ground interfaces, vertically smooth the raw data, and covert the force measurements to other snow microstructure parameters.

2.2 Acquisition

Multiple SMP profiles were taken at each snow pit site. Adjacent to the snow pit wall, profiles were spaced approximately 20 cm apart. Additional profiles were spaced every 10 or 20 meters along a 100 m by 100 m transect around the snow pit (See Figure 4 for more details). Occasionally, the probe reached the frozen ground (force values ~30-40N), otherwise measurements stopped just short of the ground surface.

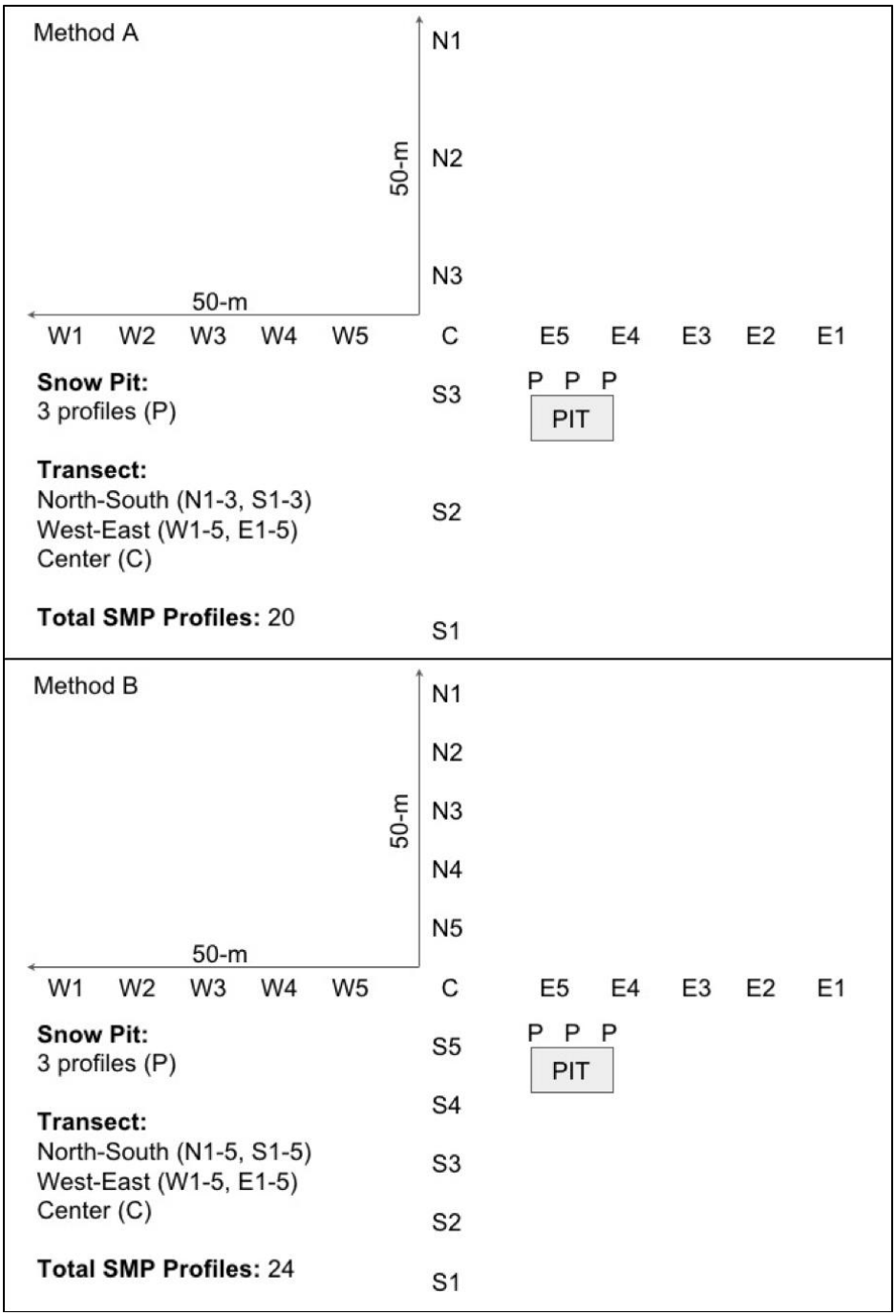

Figure 4. Diagram of the two collection methods (Method A (top) and Method B (bottom)) used to space SMP profiles around the snow pit. In both methods, the distance from W1 to E1 and S1 to N1 is 100 meters. In Method A, profiles were taken every 10 meters along the east-west transect (at W1, W2, W3, etc.) and every 20 meters along the north-south transect (at N1, N3, N3, etc.). In Method B, profiles were taken every 10 meters along both the east-west and north-south tracks (at N1, S1, E1, W1, etc.). In both Method A and Method B, three profiles, spaced 20 centimeters apart, were taken at the pit wall.

Field notes and additional details on each SMP acquisition are provided in a Master Log File (SNEX20_SMP_FieldNotes.xlsx), which is available as a technical reference. This master log file

(Figure 5) contains nine columns of data, described in Table 3. Abbreviations used to populate each column are explained in the header (first nine rows).

Table 3. Master log file column descriptions

Column Header	Description
Date	Date the SMP profile was collected, in Month/Day/Year format
Pit ID	Snow pit ID (see Section 9. Appendix for more details)
SMP Instrument #	SMP instrument # (see Table 4 for more details)
Fname suffix	File name suffix (equates to M???? in Table 3)
Orientation	Location of SMP profile along the transect (see Figure 4)
Snow depth	Recorded depth at the pit wall, N/A for most measurements
Flag	Quality flag
Observer	Initials of the SMP operator
Comments	Field notes

#SNOWEX IOP GRAND MESA								
#SMP MEASUREMENTS								
#Level_1=omitted files removed from level_0								
#OBSERVER:	Megan Mason (MM), HP Marshall (HP), Ioanna Merkouriadi (IM)							
#P=pitwall measurement, P_top=top portion of pit, P_mid=mid portion, P_bot=bottom portion								
#SMP instrument number:	06=SMP06 (short), 19=SMP19 (1.75m, longest), 19b=SMP19re-born (parts harvested from SMP06)							
#Orientation:	ex, N5,N4,N3,N2,N1=10,20,30,40,50m, C=Center (transect crossing point)							
#CK=check when plotting, something doesn't align with notes								
#NA=measurement not taken or not applicable								
Date	Pit ID	SMP instrument #	Fname sufix	Orientation	Snow depth	Flag	Observer	Comments
1/28/20	6N18	19	689	N1	NA		MM	
1/28/20	6N18	19	690	N2	NA		MM	
1/28/20	6N18	19	691	N3	NA		MM	
1/28/20	6N18	19	692	N4	NA		MM	
1/28/20	6N18	19	693	N5	NA		MM	
1/28/20	6N18	19	694	N6	NA		MM	
1/28/20	6N18	19	695	C	NA		MM	transect cross (tx)
1/28/20	6N18	19	696	S6	NA		MM	
1/28/20	6N18	19	697	S5	NA		MM	
1/28/20	6N18	19	698	S4	NA		MM	
1/28/20	6N18	19	699	S3	NA		MM	

Figure 5. Header and first ten rows of data from the master log file.

2.3 Processing

These data contain raw force profile measurements taken directly from the SMP instrument. The data have not been processed in any way, but the following changes were made to improve the usability of this data set:

1. Erroneous SMP measurements were removed based on field notes of bad data. Bad data include when a profile was acquired accidentally, when a profile needed to be re-run due to hard snow slab, when the SMP instrument reported an SD card error, etc.
2. The PitID was appended to each file name.
3. The correct date was appended to each file name (the raw SMP output incorrectly recorded the year as 2000).

2.4 Quality, Errors, and Limitations

Beyond omitting erroneous measurements, these data have not been processed further or validated. Likely errors include profiles with negative force values, which can occur when there is ice on the instrument tip. Other areas of uncertainty include the probe not entering the snowpack orthogonally to the surface or minor instrument movement during measurements due to snowpack settling.

2.5 Instrumentation

2.5.1 Description

Two SMP devices were brought to the field, SMP-06 and SMP-19. Both devices had a vertical sampling velocity of 20 mm/s and a vertical sampling resolution of 4 μm. Each experienced instrument failure at some point. A brief description and history of each instrument is included in Table 4.

Table 4. Instrument Descriptions and Histories

Instrument	Description	Period of Use
SMP-06	Original SMP instrument with a maximum sampling depth of 0.70 m.	28 Jan 2020 to 31 Jan 2020
SMP-19	Original SMP instrument with a maximum sampling depth of 1.72 m.	28 Jan 2020 to 30 Jan 2020
SMP-19b	A hybrid instrument made primarily from SMP-19, with some replacement parts from SMP-06 and a maximum sampling depth of 1.72 m. Abbreviated as “S19” in file names for all measurements after 01 Feb 2020.	01 Feb 2020 to 12 Feb 2020

3 SOFTWARE AND TOOLS

CSV files can be read with any text editor or word processing program capable of reading ASCII text files.

XML files can be read with any Web browser.

Python code for vertically smoothing the raw SMP profiles, and converting force to snow microstructure parameters, is available on GitHub: https://github.com/m9brady/SMP_to_CSV.

4 VERSION HISTORY

Initial release.

5 RELATED DATA SETS

SnowEx17 SnowMicroPen (SMP) Raw Penetration Force Profiles at Grand Mesa, CO

SnowEx17 Senator Beck SnowMicroPen (SMP) Raw Penetration Force Profiles

SnowEx Data | Overview

6 RELATED WEBSITES

SnowEx Project at NASA

SnowMicroPen

7 CONTACTS AND ACKNOWLEDGMENTS

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8 DOCUMENT INFORMATION

8.1 Publication Date

August 2020

8.2 Date Last Updated

August 2020

9 APPENDIX – ABOUT THE SNOWEX 2020 GRAND MESA IOP SNOW PITS

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 8 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).

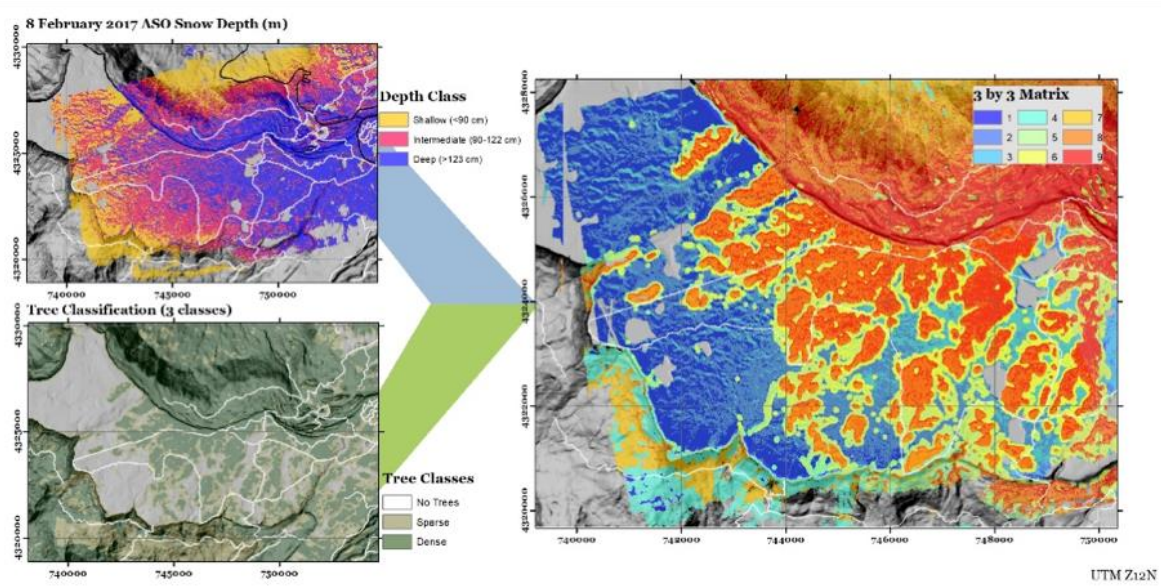

Figure A1. Separate vegetation and snow depth classifications for the Grand Mesa IOP study site are shown (left). These classifications were combined to form the final tree density and snow depth matrix used to describe snow pit locations (right). In all images, gray areas represent undefined regions (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: • 1/2/3 = treeless (0% tree cover) • 4/5/6 = sparse (1-30% tree cover) • 7/8/9 = dense (31-100% tree cover) and the relative, expected snow pit depth: • 1/4/7= shallow snowpack • 2/5/8= medium snowpack • 3/6/9= deep snowpack

Variable	Description
[FlightLine]	Indicates on which flight line the snow pit resided: • N = North • S = South • 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 40th 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 14th pit along the Cross line from Northwest to Southeast.

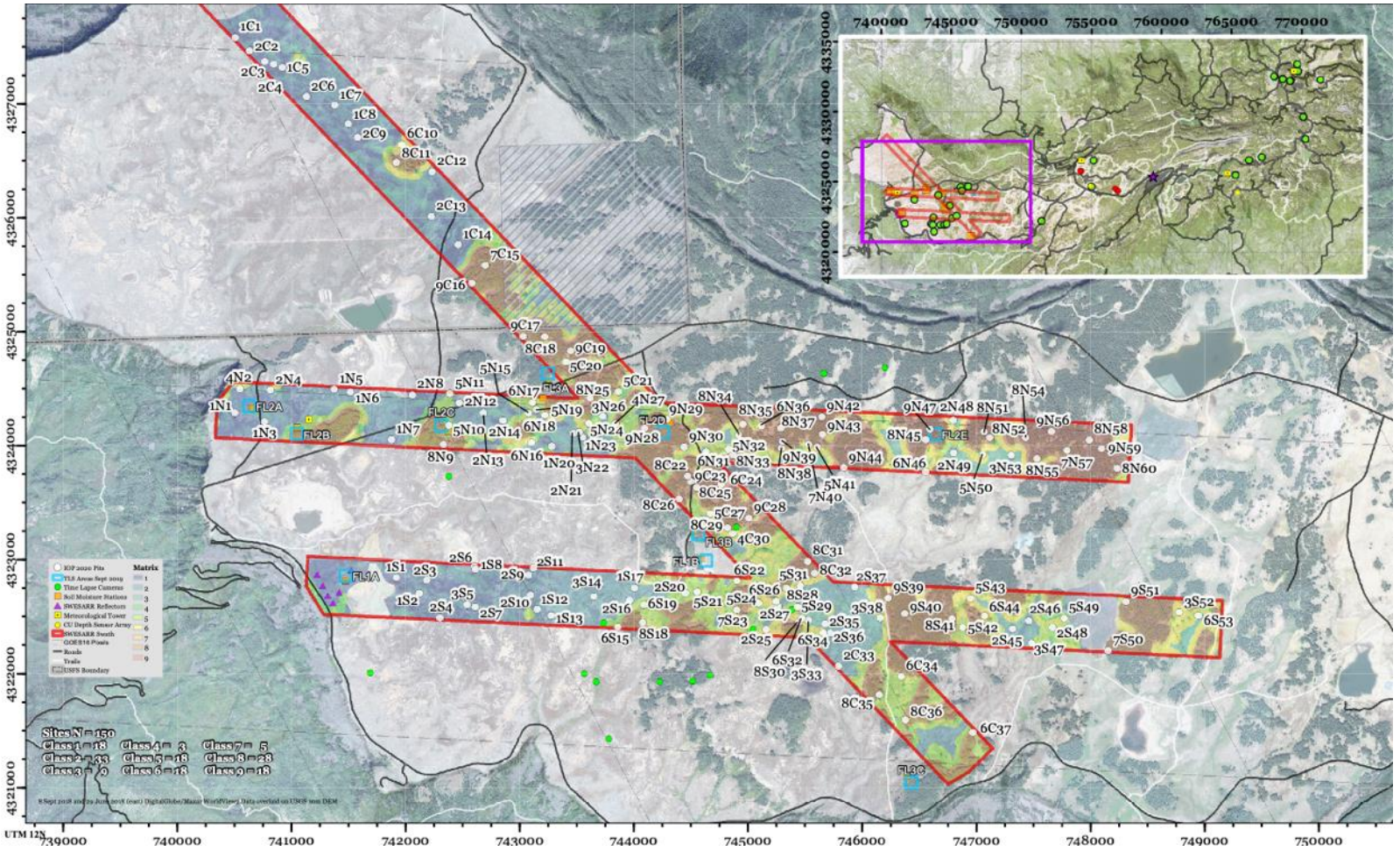

Figure A2. Location of the 150 Grand Mesa IOP snow pits. Snow pits were randomly spaced along the North (upper horizontal line), South (lower horizontal line), and Cross (diagonal line) flight lines, along which airborne measurements were collected. Snow pit naming conventions are described in Table 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.