SnowEx20 Laser Snow Microstructure Specific Surface Area Data, Version 1

USER GUIDE

How to Cite These Data

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

Durand, M., C. Vuyovich, J. Lemmetyinen, C. Vargel, K. Hale, and K. Yang. 2020. *SnowEx20 Laser Integrating Sphere Snow Microstructure Specific Surface Area, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SNMM6NGGKWIT. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_SSA

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This data set reports vertical profiles of snow reflectance, specific surface area (SSA), and spherical equivalent diameter at Grand Mesa, CO, USA, a snow-covered, forested study site about 40 miles east of the city of Grand Junction, CO. Reflectance was measured in situ using a 1310 nm integrating sphere laser device and converted to SSA and spherical equivalent diameter.

WARNING: Special morphological features of sampled snow are included in the “Comments” column of the data files. One feature observed regularly in the field was a layer of graupel; this is sometimes noted in the SSA comments, but not always. As not all SSA observers recorded the presence of graupel, the absence of a comment on “graupel” should NOT be treated as an indication that no graupel was present in the measured samples.

1.1 Parameters

This data set characterizes snow microstructure, including sample signal in mV, reflectance in %, specific surface area (SSA) in m^2/kg, sample top height in cm, spheric equivalent diameter (deq) in mm. The data files also include a column for comments.

NOTE: ‘Sample top height’ is the vertical measure from ground surface to the snow top and is equivalent to the ‘top depth’ measure in the 2017 SSA data set (SNEX17_SSA). The name was changed to better represent the physical measured property.

NOTE: ‘Spherical equivalent diameter (deq)’ is the equivalent measure to the 2017 SSA ‘optical equivalent parameter (DO)’ but describes the measurement more correctly, as it reflects the equivalent diameter a sphere would have at a specific measured SSA.

1.2 File Information

1.2.1 Format

Data files are provided in Comma Separated Values (.csv) format. Quick-look (browse) images are also available in PNG format that show side-by-side depth profiles of reflectance, SSA, and spherical equivalent diameter (deq) of snow grains.

1.2.2 File Contents

Data files begin with a 14-row header that specifies the date and time of acquisition, snowpit ID and location (in UTM), instrument, operator, notes, timing, and total snow depth. For example, data file `SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.csv` contains the following header:

# Location	Grand Mesa				
# Site	8N25				
# PitID	COGM8N25_20200128				
# Date/Time	2020-01-28-15:20				
# UTM Zone	12N				
# Easting [m]	743619				
# Northing [m]	4324416				
# Instrument	IS3-SP-11-01F				
# Profile ID	N/A				
# Operator	Juha Lemmetyinen				
# Timing	N/A				
# Notes	N/A				
# Total snow depth (cm)	100				
#					

Figure 1. Sample header from file `SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.csv`

Starting with row 15, the data are stored in columns A through E, with Column F reserved for operator comments (see Figure 2):

	A	B	C	D	E	F	G
15	# Sample signal (mV)	Reflectance (%)	Specific surface area (m^2/kg)	Sample Top Height (cm)	Deq (mm)	Comments	
16	413.5	47.85	42.1	100	0.1554		
17	379.6	44.5	35.1	95	0.1864		
18	385	45.04	36.1	90	0.1812		
19	331.4	39.45	26.6	85	0.246		
20	341.1	40.49	28.2	80	0.232		
21	347.3	41.15	29.2	75	0.2241		
22	250.7	30.18	16.2	70	0.4039		
23	242.4	29.16	15.4	65	0.4249		
24	236	28.36	14.7	60	0.4451		
25	242.8	29.21	15.4	55	0.4249		
26	206	24.53	12	50	0.5453		
27	198.9	23.6	11.4	45	0.574		
28	203.5	24.2	11.8	40	0.5545		
29	225.4	27.03	13.7	35	0.4776		
30	208.4	24.84	12.2	30	0.5363		
31	203.2	24.16	11.8	25	0.5545		
32	192.2	22.7	10.8	20	0.6058		
33	193.5	22.88	10.9	15	0.6003		
34	193.4	22.86	10.9	10	0.6003		
35	194.8	23.05	11.1	5	0.5895	grass around sample	

Figure 2. Column headers and sample data from file `SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.csv`

Quick look (browse) images show side-by-side depth profiles of reflectance, SSA, and equivalent optical diameter, as shown in Figure 3.

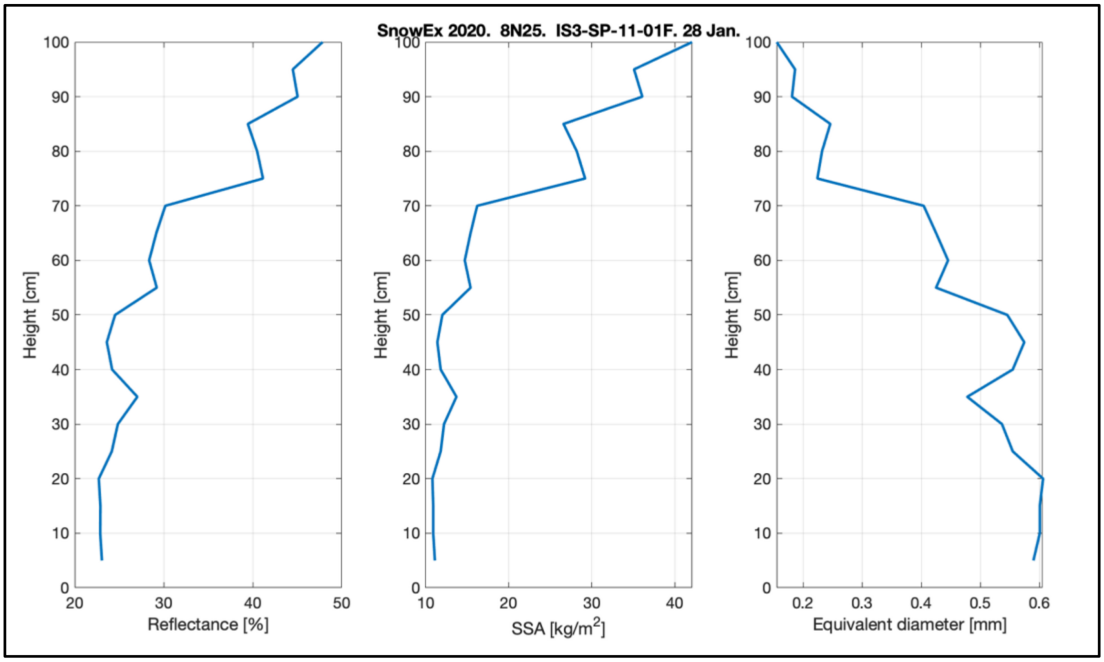

Figure 3. Quick look image for data file `SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.png`

1.2.3 File Naming Convention

Data files utilize the following naming convention which is described in Table 1:

`SnowEx20_SSA_[site]_[yyyymmdd]_[pitID]{_profileID}_[instrument]_v[nn].[ext]`

Table 1. File Naming Convention

Variable	Description
SnowEx20_SSA	SnowEx 2020 field campaign specific surface area (SSA) measurements
site	General measurement area; in 2020 this is set to GM for all files, as all measurements were taken at Grand Mesa.
yyyymmdd	Year, month, and day of data acquisition
pitID	See APPENDIX A for details on snow pit naming convention
profileID	This is optional and occurs only if multiple profiles were taken in the same snow pit.
instrument	Instrument code. Values are one of IRIS, IceCubeFMI, or IceCubeOSU. See section 2 for details.
nn	Version number
ext	File type: .csv (data file) or .png (quick look)

Example file names:

`SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.csv`

`SnowEx20_SSA_GM_20200128_8N25_IceCubeFMI_v01.png`

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 39.0642º N

Southernmost Latitude: 39.0050º N

Easternmost Longitude: 108.0046° W

Westernmost Longitude: 108.2203° W

1.3.2 Resolution

Vertical profiles were obtained at 115 locations within the Grand Mesa study site. The vertical distance between measurements is 3 cm or 5 cm depending on the instrument (See Section 2 for more details).

1.3.3 Geolocation

All data lie within the UTM Zone 12N. Refer to Table 2 for details.

Table 2. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	WGS 84 / UTM zone 12N
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

27 January 2020 to 12 February 2020

1.4.2 Resolution

Each snow pit was measured once during the campaign period.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Vertical profiles of reflectance to a 1310 nm laser were recorded in the field using one of two integrating sphere systems: IRIS (InfraRed Integrating Sphere) or IceCube. These devices utilize the same underlying principle—the relationship between the hemispherical infrared reflectance of snow and SSA—and differ only in their respective sphere sizes. One IRIS and two IceCube instruments were deployed in the field. The instrument used is denoted in data file names by IRIS, IceCubeOSU, or IceCubeFMI. The samples prepared for IRIS are 5 cm in height, whereas samples prepared for IceCube are 3 cm in height. This leads to a different vertical resolution for the two instrument types.

2.2 Acquisition and Processing

In the field, a snow sample is illuminated with the instrument's laser. An InGaAs photodiode converts the reflected light to current, and the voltages are converted to reflectance using certified standards. SSA is calculated from reflectance during post-processing, using custom calibration algorithms for each IRIS or IceCube instrument. Finally, equivalent optical diameter is computed from SSA.

2.3 Quality, Errors, and Limitations

Quality control was performed by visually inspecting graphs of each reflectance, SSA, and equivalent diameter profile. To assess consistency of SSA observations among instruments, instruments were compared at four different snow pits. The three instruments produce excellent consistency, with most of the differences in the ±10% range. The largest differences are ±25% and occur in fresh snow near the snow-air interface.

3 SOFTWARE AND TOOLS

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

4 VERSION HISTORY

Initial release

5 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

SnowEx 2017 Specific Surface Area

6 RELATED WEBSITES

SnowEx at NSIDC | Overview

SnowEx at NASA

7 CONTACTS AND ACKNOWLEDGMENTS

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8 REFERENCES

Gallet, J.-C., F. Domine, C. S. Zender, and G. Picard. 2009. Measurement of the specific surface area of snow using infrared reflectance in an integrating sphere at 1310 and 1550 nm, *The Cryosphere* 3:167-182. doi:10.5194/tc-3-167-2009, 2009.

9 DOCUMENT INFORMATION

9.1 Publication Date

02 December 2020

9.2 Date Last Updated

11 December 2020

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).

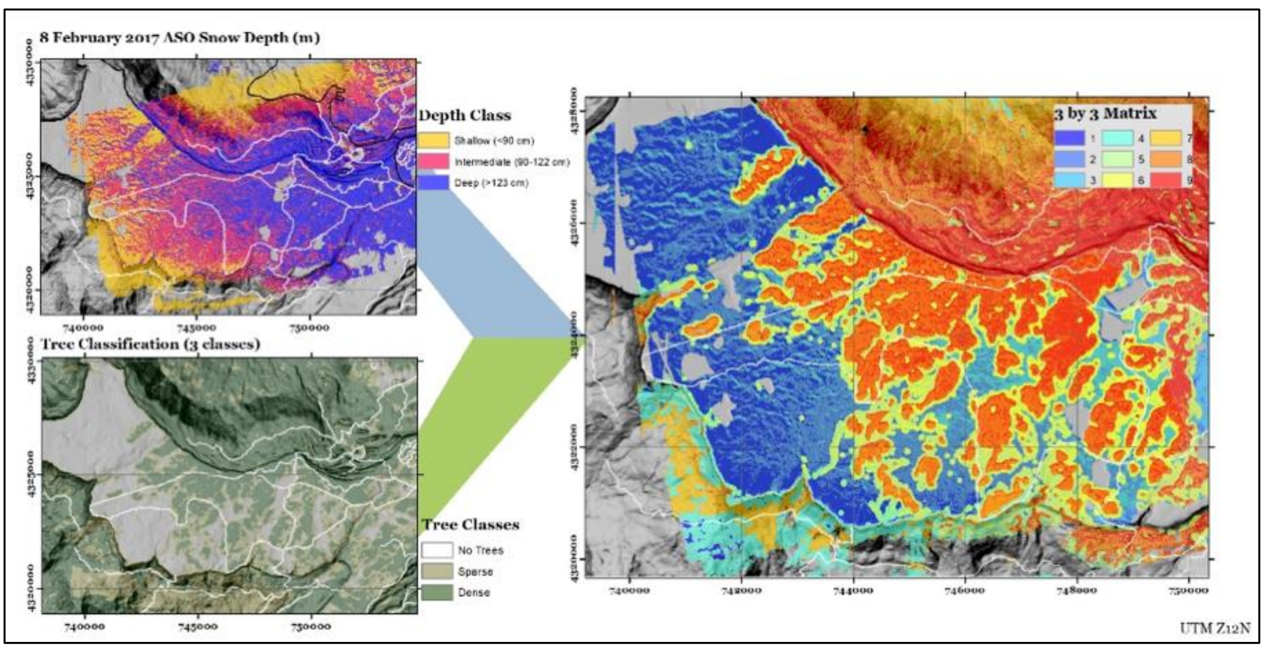

Figure A1. Separate vegetation and snow depth classifications for the Grand Mesa IOP study site are shown (left). These classifications were combined to form the final tree density and snow depth matrix used to describe snow pit locations (right). In all images, gray areas represent undefined regions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

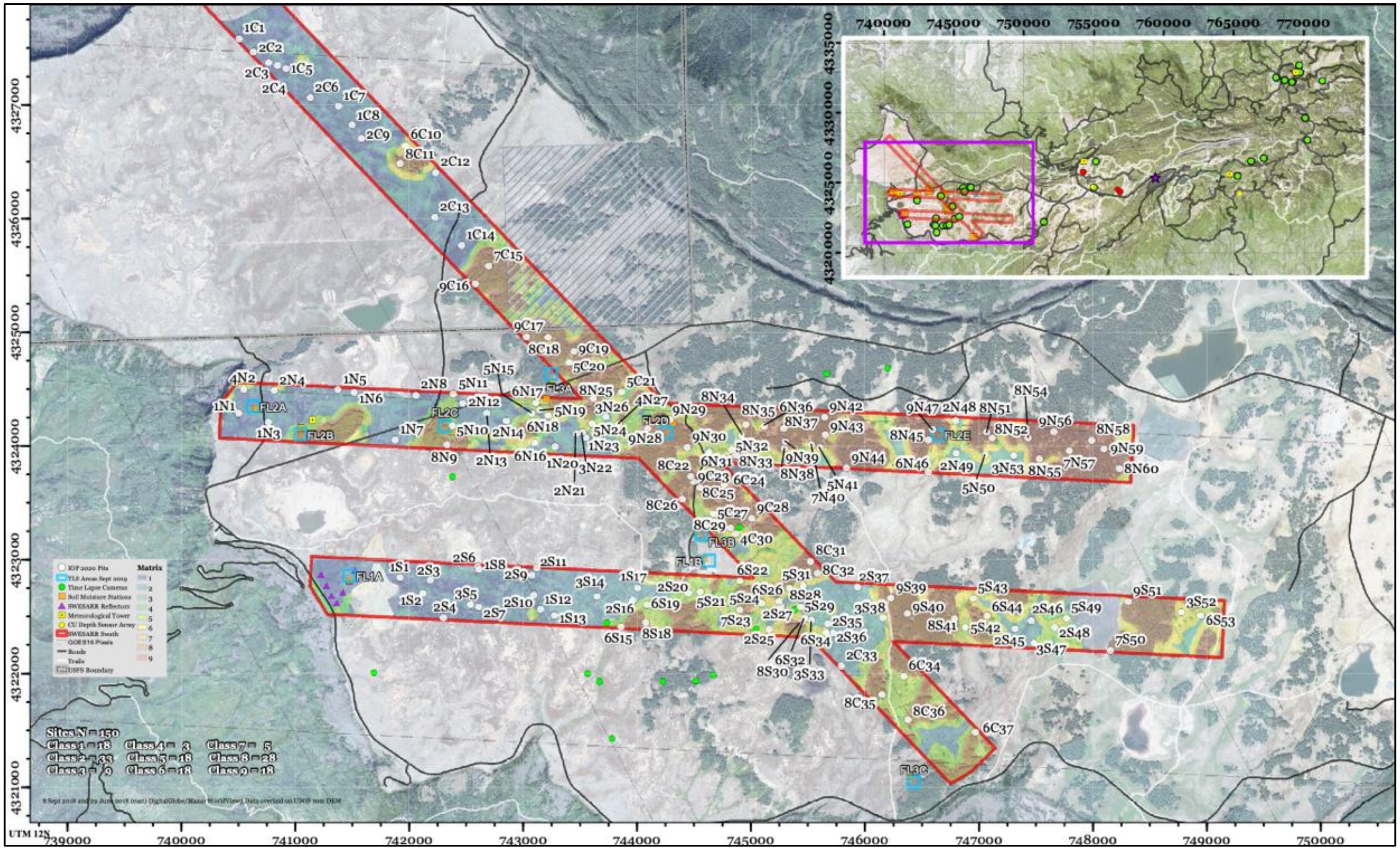

Figure A2. Location of the 150 Grand Mesa IOP snow pits. Snow pits were randomly spaced along the North (upper horizontal line), South (lower horizontal line), and Cross (diagonal line) flight lines, along which airborne measurements were collected. Snow pit naming conventions are described in Table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