SnowEx20 Grand Mesa Time-Lapse Imagery, Version 1

USER GUIDE

How to Cite These Data

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

Breen, C. M., C. Lumbrazo, C. Hiemstra, C. Vuyovich, M. S. Raleigh, and H.P. Marshall. 2022. *SnowEx20 Grand Mesa Time-Lapse Imagery, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/P3D1QRH7O8X5. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_TLI

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains sub-daily time-lapse images collected by cameras placed around Grand Mesa, CO at 29 sites coincident with other SnowEx 2020 measurements. The field view of all cameras includes a 3.049 m, (10 ft) vertical pole that was painted red with a yellow top to serve as a reference for quantifying snow depth. Snow depth data derived from these time-lapse images will be published separately at NSIDC.

1.2 File Information

1.2.1 Format

All images for an individual camera location are collected within a tar.gz compressed file. Images are available as Joint Photographic Experts Group (.jpg) files.

1.2.2 Naming Convention

The packaged data files utilize the following naming convention:

`SnowEx20_TLI_[camera_name].tar.gz`

Table 1. File Naming Convention

Variable	Description
SnowEx20_TLI	Short name for SnowEx20 Time-Lapse Imagery
camera_name	All camera names are listed together with their location information in Table 2. Except for the TLS site, the camera names use a 3-digit naming convention, [XMR], where: X = East(E) or West (W) area on the Grand Mesa study site (see Figure 2) M = Matrix class for vegetation and snow (see Table 5) R = Replicate of matrix classes (Options A-E, see Section 2.1) Example: Camera E9B is located in the East area on Grand Mesa in matrix class 9 and the second replicate of the combination of the first two categories.
.tar.gz	File name ending referring to compression type.

Within each camera's tar.gz file, individual image files are named as follows:

`[camera_name]_[default_memory_card_#].jpg.`

An example for a sample tar.gz file is shown below:

`SNEX20_TLI_E9E.tar.gz`

And an image file therein is named `E9A_WSCT0010.jpg`.

1.3 Spatial Information

1.3.1 Coverage

This data set has the following spatial bounds:

Northernmost Latitude: 39.055° N
Southernmost Latitude: 39.007° N
Easternmost Longitude: 107.934° W
Westernmost Longitude: 108.216° W

Table 2 below lists the individual location coordinates for each camera and associated pole.

Table 2. Camera and pole names and location.

Camera Name	Latitude [°]	Longitude [°]	Northing [m]	Easting [m]
E3A CAM	39.108011	-107.881267	4333394.94	769672.96
E3A POLE	39.107937	-107.881191	4333386.95	769679.82
E6A CAM	39.097489	-107.862526	4332282.79	771334.19
E6A POLE	39.097464	-107.862476	4332280.17	771338.61
E6B CAM	39.048970	-107.913070	4326746.99	767145.25
E6B POLE	39.048982	-107.913198	4326747.94	767134.13
E8A CAM	39.097379	-107.887580	4332195.97	769167.45
E8A POLE	39.097329	-107.887477	4332190.72	769176.55
E9A CAM	39.103473	-107.880787	4332892.61	769731.79
E9A POLE	39.103561	-107.880742	4332902.52	769735.35
E9B CAM	39.100560	-107.900539	4332510.72	768034.45
E9B POLE	39.100639	-107.900614	4332519.27	768027.66
E9C CAM	39.098843	-107.893792	4332340.07	768624.56
E9C POLE	39.098962	-107.893702	4332353.55	768631.89
E9D CAM	39.073889	-107.877764	4329617.58	770106.20
E9D POLE	39.074028	-107.877689	4329629.90	770109.70
E9E CAM	39.059785	-107.876640	4328055.29	770257.30

Camera Name	Latitude [°]	Longitude [°]	Northing [m]	Easting [m]
E9E POLE	39.059881	-107.876662	4328065.88	770255.03
E9F CAM	39.047249	-107.923515	4326525.28	766247.62
E9F POLE	39.047323	-107.923406	4326533.40	766256.40
E9G CAM	39.038187	-107.935015	4325485.71	765286.11
E9G POLE	39.038270	-107.935097	4325494.69	765278.70
TLSK20 CAM	39.033764	-108.054196	4324653.57	754984.52
TLSK20 POLE	39.033806	-108.053996	4324658.79	755001.67
W1A CAM	39.017118	-108.184854	4322447.43	743730.22
W1A POLE	39.017236	-108.184880	4322460.46	743727.57
W1B CAM	39.007931	-108.184663	4321428.19	743778.33
W1B POLE	39.008078	-108.184794	4321444.16	743766.48
W2A CAM	39.013720	-108.208580	4322006.92	741687.30
W2A POLE	39.013823	-108.208536	4322018.47	741690.76
W2B CAM	39.029056	-108.200016	4323732.00	742376.50
W2B POLE	39.029174	-108.199952	4323745.27	742381.64
W3A CAM	39.013114	-108.186933	4321997.42	743563.94
W3A POLE	39.013208	-108.186994	4322007.69	743558.34
W5A CAM	39.017686	-108.165745	4322561.88	745382.96
W5A POST	39.017744	-108.165836	4322568.07	745374.88
W6A CAM	39.012471	-108.185758	4321929.19	743667.90
W6A POLE	39.012546	-108.185686	4321937.71	743673.88
W6B CAM	39.016241	-108.169723	4322390.40	745043.70
W6B POLE	39.016342	-108.169688	4322402.06	745046.17
W6C CAM	39.012711	-108.174204	4321986.86	744667.64
W6C POLE	39.012837	-108.174167	4322001.00	744670.00
W8A CAM	39.050536	-108.051602	4326522.59	755148.70
W8A POLE	39.050599	-108.051624	4326529.52	755146.57
W8B CAM	39.012307	-108.179372	4321928.12	744221.49
W8B POLE	39.012356	-108.179477	4321933.28	744212.23
W8C CAM	39.012731	-108.095955	4322202.55	751443.85
W8C POLE	39.012585	-108.095973	4322186.29	751442.80
W9A CAM	39.036252	-108.161794	4324633.37	745660.75
W9A POLE	39.036208	-108.161851	4324628.34	745655.97
W9B CAM	39.012294	-108.175999	4321935.74	744513.63
W9B POLE	39.012393	-108.176150	4321946.32	744500.21

Camera Name	Latitude [°]	Longitude [°]	Northing [m]	Easting [m]
W9C CAM	39.024344	-108.171138	4323286.37	744892.98
W9C POLE	39.024416	-108.171069	4323294.54	744898.70
W9D CAM	39.036556	-108.155603	4324683.87	746195.65
W9D POLE	39.036476	-108.155686	4324674.77	746188.74
W9E CAM	39.033624	-108.160760	4324344.46	745759.38
W9E POLE	39.033751	-108.160689	4324358.00	745766.00
W9G CAM	39.031286	-108.180180	4324032.61	744086.18
W9G POLE	39.031366	-108.180167	4324041.52	744087.03

1.3.2 Resolution

The spatial resolution varies across each image, from sub-centimeter resolution for objects close to the camera to many meters for objects far from the camera.

1.3.3 Geolocation

All camera location coordinates lie within UTM Zone 12N. The following table provides information for geolocating this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	UTM zone 12N
Longitude of true origin	-111
Latitude of true origin	0
Scale factor at longitude of true origin	0.9996
Datum	WGS 84
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 and Resolution

The temporal coverage for this data set is 21 September 2019 through 18 August 2020.

Images were taken two or three times a day at 11AM and 12PM or at 11AM, 12PM and 1PM.

The following table lists the installation and removal dates for all cameras as well as the daily sampling rate and the total amount of images per camera.

Table 4. Installation and Removal Dates, Daily Readings and Total Number of Images per Camera

Camera Name	Start Date	End Date	Readings per Day	Total number of images
E3A	22 September 2019	14 August 2020	3	984
E6A	22 September 2019	7 June 2020	3	780
E6B	21 September 2019	7 June 2020	3	979
E8A	21 September 2019	7 June 2020	3	781
E9A	22 September 2019	14 August 2020	3	984
E9B	22 September 2019	7 June 2020	3	780
E9C	22 September 2019	7 June 2020	3	780
E9D	22 September 2019	7 June 2020	3	780
E9E	23 September 2019	7 June 2020	3	777
E9F	22 September 2019	30 November 2019	3	207
E9G	23 September 2019	8 June 2020	2	519
W1A	24 September 2019	18 August 2020	2	659
W1B	28 September 2019	7 June 2020	2	509
W2A	29 September 2019	18 August 2020	2	650
W2B	25 September 2019	18 August 2020	2	659
W3A	28 September 2019	7 June 2020	2	507
W5A	24 September 2019	18 August 2020	2	660
W6A	28 September 2019	28 November 2019	2	118
W6B	24 September 2019	18 August 2020	2	660
W6C	23 September 2019	18 August 2020	2	661
TLSK20	29 September 2019	5 June 2020	2	502
W8A	29 September 2019	19 August 2020	2	652
W8C	28 September 2019	24 February 2020	2	302
W9A	25 September 2019	17 August 2020	2	656

Camera Name	Start Date	End Date	Readings per Day	Total number of images
W9B	29 September 2019	5 June 2020	2	515
W9C	4 October 2019	28 August 2020	2	659
W9D	24 September 2019	21 August 2020	2	665
W9E	25 September 2019	14 July 2020	2	587
W9G	24 September 2019	17 August 2020	2	657

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The SnowEx 2020 Grand Mesa study area was classified into nine matrix classes by combining snow depth data from the SnowEx 2017 airborne lidar and optical imagery (Figure 1 top-left) were combined with a tree density map (Figure 1 bottom-left). 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). Similarly, the tree density map created from November 2010 WorldView-2 imagery was 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 1 right). 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 classes of snow depth: shallow (lowest number in a range, e.g. 1), intermediate, and deep (highest number in a range, e.g. 3). Treeless areas include those characterized as shrub and meadow types. Water bodies and areas where lidar data is missing remain unclassified (grey areas in Figure 1).

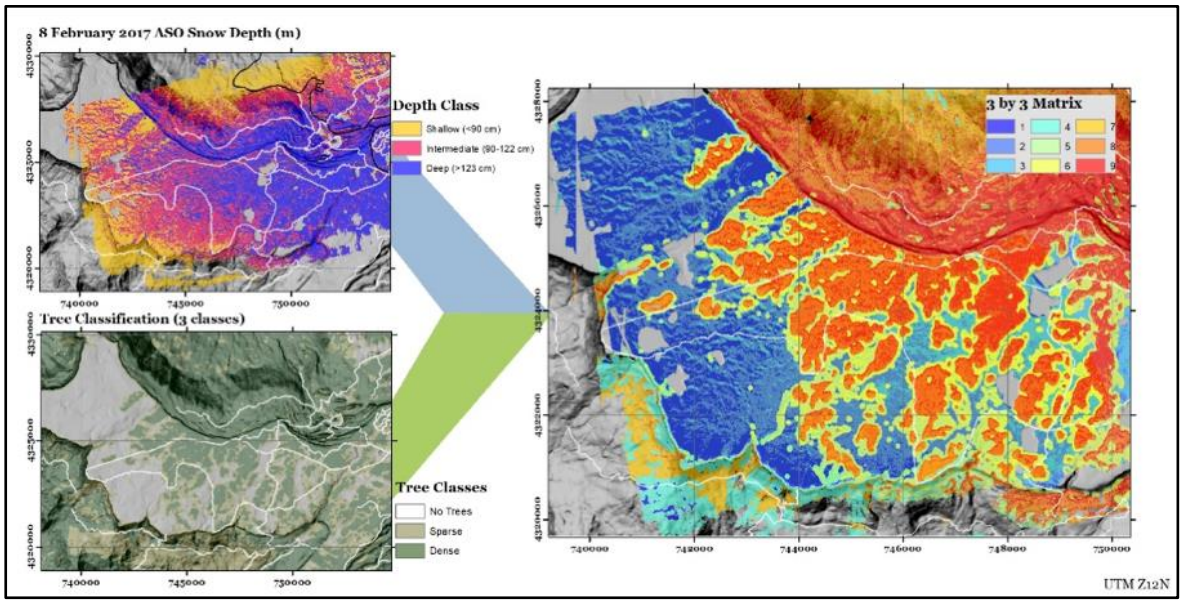

Figure 1. Separate vegetation and snow depth classifications for the Grand Mesa IOP study site are shown (left). These classifications were combined to form the final tree density and snow depth matrix used to describe snow pit and camera locations (right). In all images, gray areas represent undefined regions (e.g., water bodies).

The camera and pole pairs were split into 20 cameras on the western area and 10 cameras in the eastern area of the Grand Mesa study site (Figure 2). Within those two areas, cameras were distributed proportionally among the matrix classes based on matrix class area (Table 5). All sites were randomly located with the exception of the Terrestrial Laser Scanner (TLS) site. One camera went missing after deployment leading to a total of 29 camera locations.

Table 5. Matrix classes with in parenthesis numbers of cameras in that class.

Matrix class (number of cameras per class)	Shallow snow (<90 cm)	Intermediate snow (90-122 cm)	Dense snow (>122 cm)
Treeless	1 (n=2)	2 (n=2)	3 (n=2)
Sparse forest	4 (n=0)	5 (n=1)	6 (n=6)
Dense forest	7 (n=0)	8 (n=4)	9 (n=13)

With the exception of the TLS site (named TLSK20), camera names use the following 3-digit naming convention: [XMR], where:

X = East(E) or West (W) area on the Grand Mesa study site (Figure 2)
M = Matrix class value for vegetation and snow (See Table 5)
R = Replicate of the combination of X and M. (Options A-E)

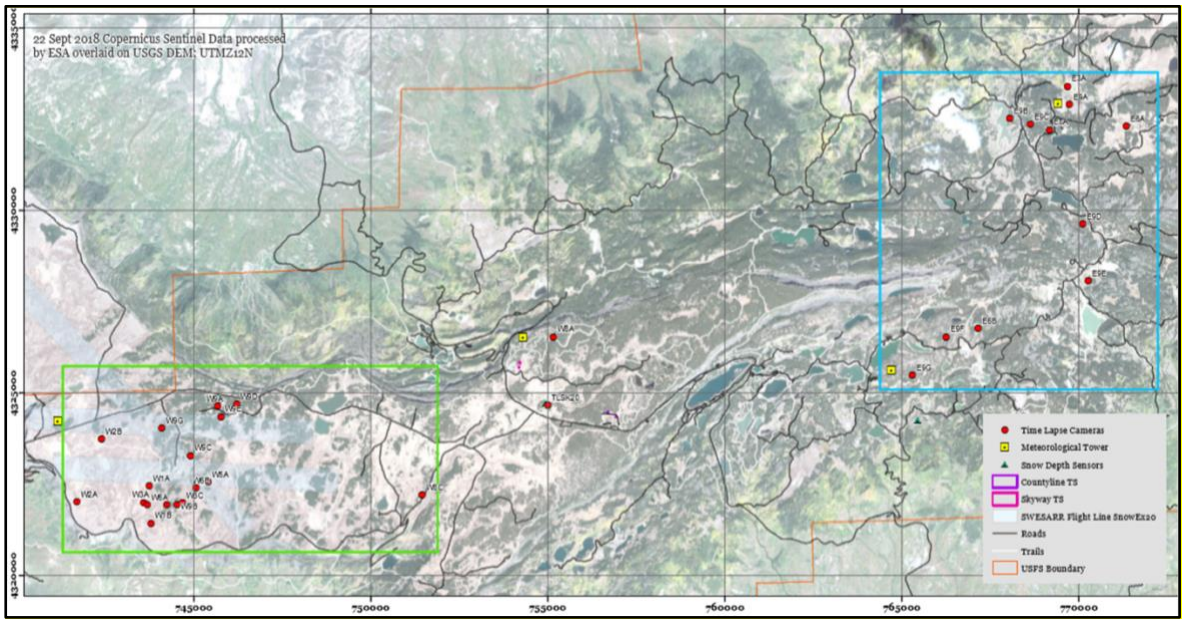

Figure 2. Camera Locations along with Weather Stations, Snow Depth Sensors and Land Boundaries during the SnowEx2020 Campaign on Grand Mesa, CO.

These data have been used to evaluate remote sensing data and models. Snow depth data (SnowEx20 Grand Mesa Snow Depth from Snow Pole Time-Lapse Imagery, Version 1) were derived from this data set and will be published separately at NSIDC. Time-lapse cameras have also been used to extract other information about snow properties such as snow-covered area and snow presence/absence in the forest canopy (Lumbrazo et al. 2021; Dickerson-Lange et al. 2015; Raleigh et al. 2013).

2.2 Instrumentation

The time-lapse camera network was composed of Wingscapes brand trail/game cameras. The deployed model was WCT-00126 TimeLapseCam Pro. The focal length of this camera is 3 mm and image dimensions are 6080 x 3402 pixels.

Most cameras were mounted on t-posts approximately 2 m above the ground.

The field view of all cameras included a 3.049 m, (10 ft) vertical pole that was painted red with a yellow top to serve as a reference for quantifying snow depth. A time series of snow pole derived snow depth measurements will be published separately at NSIDC.

2.3 Acquisition

Cameras were placed around Grand Mesa, CO at 29 sites coincident with other SnowEx 2020 measurements. The cameras were installed in late September 2019 or early October 2019. Cameras were removed between June and August of 2020. Cameras E9F and W6A stopped

working in November 2019 and camera W8C stopped operating in February 2020 Once installed, cameras took a test image and then either three images daily (11AM, 12 PM, 1PM) or twice daily (11AM and 12PM). See details on camera operation and image frequency in Table 4.

2.4 Processing

This data set contains raw images; no data processing was performed. A full protocol on how cameras and snow poles were installed can be found on the data set landing page.

2.5 Quality, Errors, and Limitations

The raw time-lapse photos are provided in this data set. Image quality may be variable depending on local light and weather conditions at the time of each image acquisition. Some photos may be blurry or obscured by falling snow. Temperature readings on images are not calibrated and likely have large error due to solar radiation variation.

3 SOFTWARE AND TOOLS

The SnowEx Hackweek 2021 included a tutorial for accessing time-lapse camera data and describes possible data applications.

4 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
001	16 February 2022	Initial release

5 RELATED DATA SETS

SnowEx at NSIDC | Data Sets
SnowEx17 Time Lapse Imagery
SnowEx20 Grand Mesa Snow Depth from Snow Pole Time-Lapse Imagery (not yet published)

6 RELATED WEBSITES

SnowEx at NSIDC | Overview
NASA SnowEx

7 CONTACTS AND ACKNOWLEDGMENTS

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8 REFERENCES

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9 DOCUMENT INFORMATION

9.1 Publication Date

16 February 2022

9.2 Date Last Updated

04 March 2022