SnowEx17 CRREL Differential GNSS Survey, Version 1

USER GUIDE

How to Cite These Data

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

Hiemstra, C. and A. B. Gelvin. 2018. *SnowEx17 CRREL Differential GNSS Survey, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/I0HTB2UVNSEF. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX17_DGNSS1

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains coordinates from a Differential Global National Satellite System (DGNSS) Real-Time-Kinematic (RTK) survey.

1.2 File Information

1.2.1 Format

Data files are provided in Comma-Separated Values (.csv) format.

Each data file is paired with an associated Extensible Markup Language (.xml) file that contains additional metadata.

1.2.2 File Contents

Each data file begins with a header that specifies the campaign, location, surveyor(s), items surveyed, coordinate zone, date of survey, and any relevant notes. For example, the data file `SnowEx17_DGNSS1_July_UTMZ13N_snow_survey_stakes.csv` contains the following header:

```
# SnowEx July 2017 post-campaign summer survey
# Location: Grand Mesa
# Surveyor: Chris Hiemstra and Art Gelvin
# T-post and white PVC stake locations used to mark 88 of the 101 Grand Mesa
transects
# All coordinates are reported in UTM Zone 13N, WGS84, using Geoid 12B (CONUS)
# RTKsurvey was conducted 18-23 July 2017 on Grand Mesa
# horizontal and vertical precision reported in meters
# Missing data value: -9999
#
```

All data files contain IDs for the items surveyed (e.g. transect number), easting & northing coordinates, elevation, horizontal & vertical precision, and the date and time (MDT) of each reading, along with any relevant notes (e.g. height of measurement).

Sample Data

Figure 1 shows 10 lines of data from the file:

`SnowEx17_DGNSS1_July_UTMZ13N_snow_survey_stakes.csv`.

Name	Easting	Northing	Elevation (m)	H_Prec_Obs (m)	V_Prec_Obs (m)	Date	Time (MDT)	T-post Y/N	PVC Y/N	UTM E Initial	UTM N Initial	Notes
1.1	221596.77	4325175.45	3038.47	0.01	0.02	7/18/17	1:46:57 PM	Y	N	221597	4325177	
1.7	221294.19	4325175.84	3033.34	0.01	0.01	7/18/17	1:34:27 PM	Y	N	221297	4325177	
2.1	221338.92	4325319.27	3028.71	0.01	0.02	7/18/17	1:40:21 PM	Y	Y	221339	4325308	
2.6	221590.96	4325304.51	3033.3	0.01	0.02	7/18/17	1:51:59 PM	Y	Y	221589	4325308	Stake mislabeled "2.7"
2.12	221839.81	4325307.47	3033.88	1.58	2.8	7/18/17	2:30:15 PM	Y	Y	221839	4325308	
3.1	222319.07	4325397.59	3035.48	0.02	0.03	7/18/17	1:53:11 PM	Y	N	222323	4325402	
3.3	222221.92	4325398.57	3040.68	0.02	0.04	7/18/17	1:56:45 PM	Y	Y	222223	4325402	
3.7	222015.89	4325393.88	3033.14	0.17	0.26	7/18/17	2:19:13 PM	Y	Y	222023	4325402	
4.1	222192.77	4322920.59	3021.97	0.03	0.03	7/20/17	10:14:21 AM	Y	N	222191	4322921	
4.7	222492.22	4322911.4	3025.24	0.03	0.03	7/20/17	10:19:48 AM	Y	N	222491	4322921	

Figure 1. Sample Data Image

1.3 Directory Structure

1.3.1 Naming Convention

Data files utilize the following naming convention:

`SnowEx17_DGNSS1_[month]_UTMZ##N_[items_surveyed].csv`

Table 1. File Naming Convention

Variable	Description
SnowEx17_DGNSS1	Short name for SnowEx Cold Regions Research and Engineer Lab (CRREL) Differential GNSS Survey
month	Acquisition month
##N	Universal Transverse Mercator (UTM) Zone number in the Northern Hemisphere
items surveyed	Can vary in length and include underscores

Sample file names:

`SnowEx17_DGNSS1_July_UTMZ13N_base_stations.csv`

`SnowEx17_DGNSS1_July_UTMZ13N_found_red_pit_stakes.csv`

`SnowEx17_DGNSS1_July_UTMZ13N_snow_survey_stakes.csv`

1.3.2 File Size and Volume

CSV files range in size between 1 KB and 22.5 KB.

The entire data set is approximately 31 KB.

1.4 Spatial Information

1.4.1 Coverage

Coverage is limited to Grand Mesa, Colorado:
Northernmost Latitude: 39.1º N
Southernmost Latitude: 39.0º N
Easternmost Longitude: 107.8°
Westernmost Longitude: 108.2° W

Within Grand Mesa, the DGNSS surveys targeted specific items of interest, including transect stakes, snow pit stakes, time-lapse cameras, and reference poles used to estimate snow depth from camera images. Figures 2 through 4 display the locations of each surveyed item; Figure 5 shows the locations of the reference base stations.

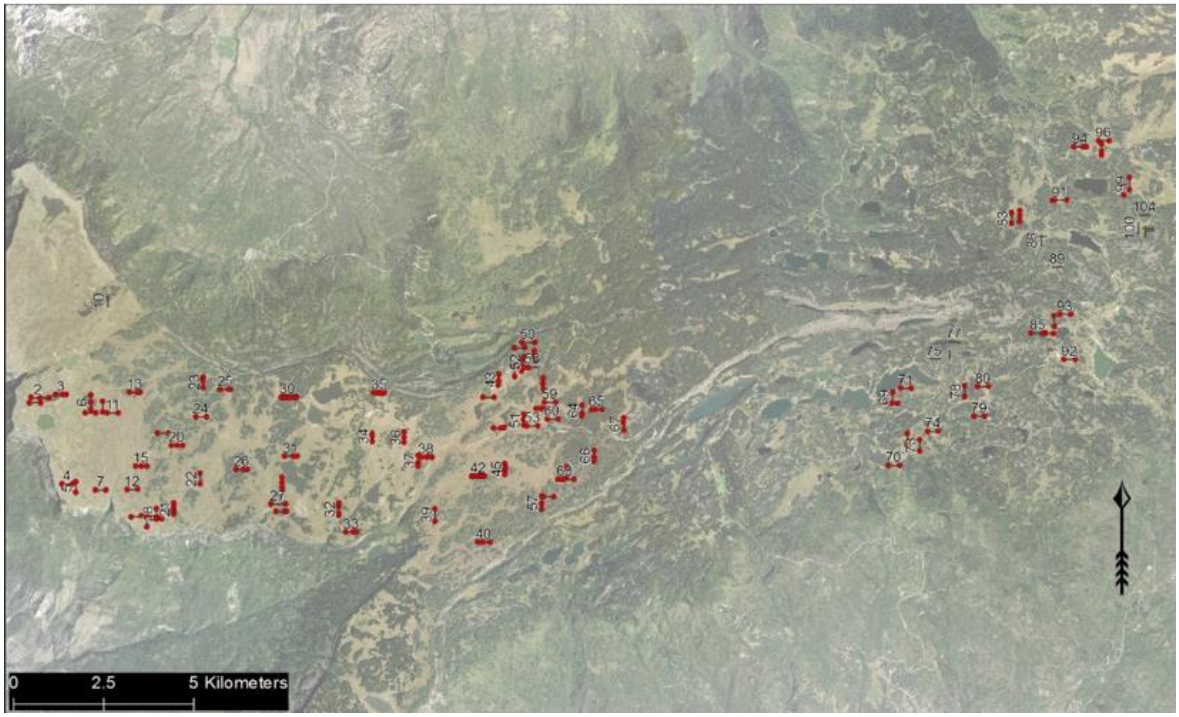

Figure 2. Transect stakes geolocated as part of the DGNSS surveys.

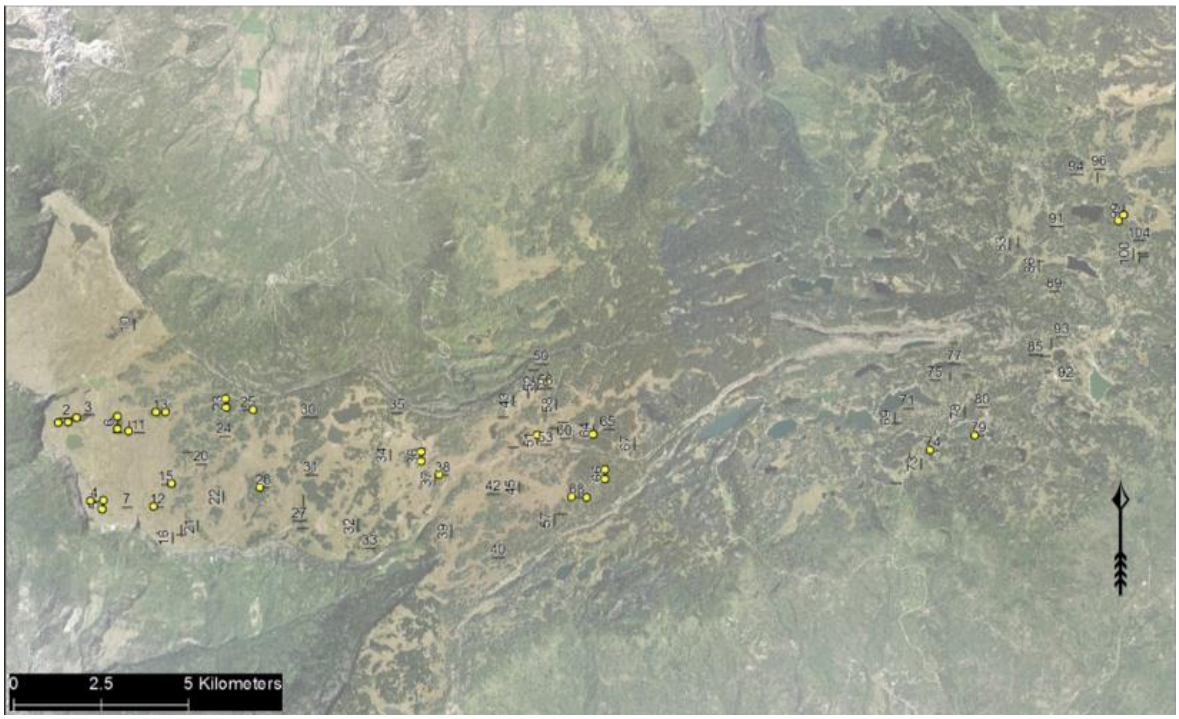

Figure 3. Winter snow pit snakes geolocated as part of the DGNSS surveys.

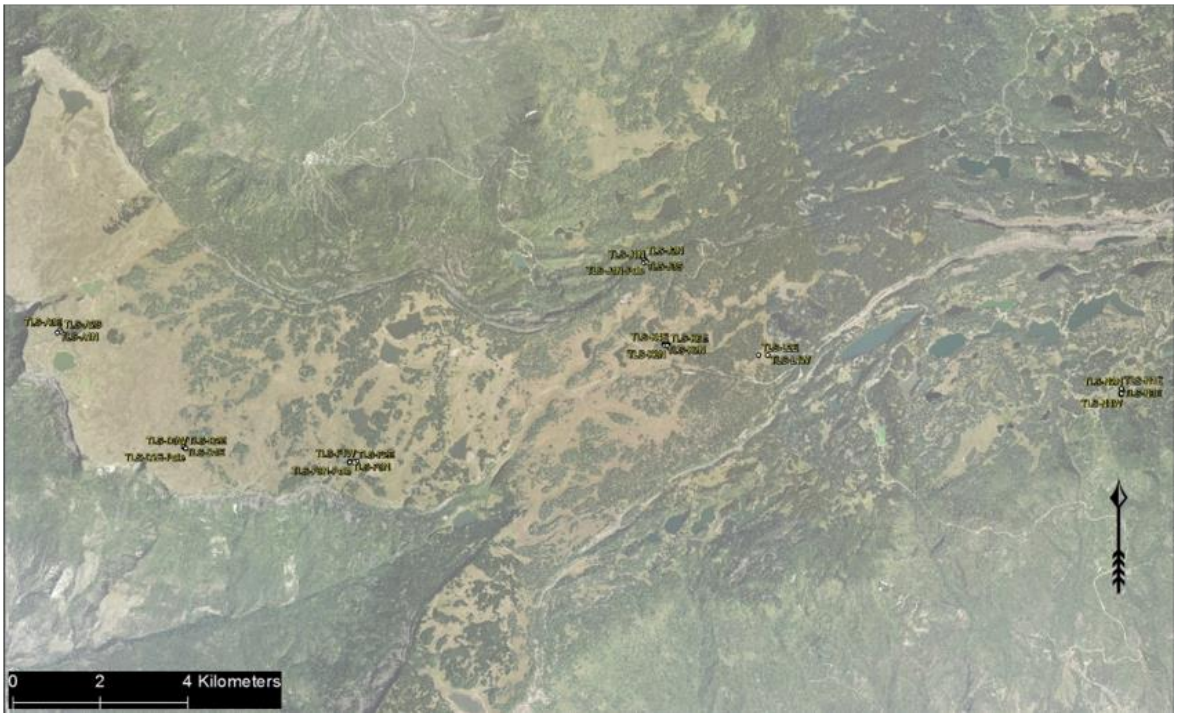

Figure 4. Time lapse cameras and reference poles geolocated as part of the DGNSS surveys.

Figure 5. Base stations used for the DGNSS surveys conducted around Grand Mesa.

1.4.2 Resolution

Surveys were conducted at 244 stakes along 88 transects, 31 snow pits, 24 time-lapse cameras, and 15 reference poles used to estimate snow depth from camera images.

Horizontal accuracies range from 0.01 m to 5.30 m.

Vertical accuracies range from 0.01 m to 4.96 m.

1.4.3 Geolocation

All reported coordinates lie within UTM Zone 13N. See Table 2 for details.

Table 2. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	WGS 84/UTM zone 13N
Longitude of true origin	-108
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	32613
PROJ4 string	+proj=utm +zone=13 +datum=WGS84 +units=m +no_defs
Reference	https://epsg.io/32613

1.5 Temporal Information

1.5.1 Coverage

Data were obtained between 18 July and 23 July 2017.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Prior to the start of the Winter 2017 SnowEx campaign, survey transects and snow pits were randomly distributed across Grand Mesa under various canopy conditions, ranging from treeless to dense forest. These distributions were determined in ArcGIS. Handheld Garmin GPSMAP 64st units were then used to implement this sampling scheme on the ground. Since each handheld instrument had an accuracy ranging between approximately 3m and 30m, this created inaccuracies between documented and realized transect/snow pit locations. Dense canopy coverage tended to exacerbate these inaccuracies.

Accurate geolocation records are necessary to compare in situ measurements, remote sensing, and modeled snow depths. This is especially true in heavily forested conditions, where handheld GPS errors are generally larger and the influences of trees more pervasive. Therefore, before all SnowEx infrastructure was permanently removed, a real-time-kinematic survey was performed in July 2017 to obtain more accurate location information.

RTK surveys enhance the precision of satellite-based position systems (in this case, GPS). This technique relies on a reference station to provide real-time corrections to mobile GPS units, providing centimeter-level accuracy.

2.2 Acquisition

Each day, a Trimble R8 GNSS receiver was placed and left operating for a minimum of two hours at each base station location to collect an internal GPS data file. A radio antenna was used to broadcast correction data from the base station to two rovers, deployed within approximately 6 km of said base station. The two rovers, a Trimble R8 and a Trimble R10, utilized GNSS antennae and radio antennae to receive corrections from the base station.

Snow transects were surveyed from West to East across Grand Mesa. The high-accuracy Trimble rovers were placed directly next to the transect stakes. Transects were walked in their entirety to avoid missing any undocumented stakes. At most positions, a single reading was collected over a five-second interval. However, in thicker canopy conditions a number of readings were collected, with occupying times extending for several minutes to achieve the most accurate results.

Snow pit stakes, time-lapse cameras, and reference poles were also surveyed. During the winter, red two-meter long stakes were inserted into the ground to mark snow pit locations. The stakes which were still in place in July were surveyed at the mid-point as part of the RTK survey. Time-lapse cameras and orange reference poles, used to estimate snow depth from the cameras, were stationed at TLS sites, including TLS-A, TLS-D, TLS-F, TLS-J, TLS-K, TLS-L, and TLS-N. The cameras were surveyed as close to the tree and camera as possible at ground elevation (i.e. not at camera height). Cameras and snow stakes adopted the TLS-site naming convention, with reference poles identified by the word "pole" (e.g. TLS-A1N-pole).

2.3 Processing

The internal GPS files collected at each base station were sent to Online Position User Service (OPUS), a geodetic operating tool run by the National Oceanic and Atmospheric Administration's (NOAA's) National Geodetic Survey (NGS). During post-processing, OPUS automatically processed the base station files and used them to provide additional corrections to the locations collected by the rovers, further refining the accuracy of the RTK surveys. After post-processing, all data points were verified in ArcGIS before finally being exported to CSV files.

In cases were multiple survey readings were collected at a single point, only the most accurate one was retained for the final product. The point with the highest accuracy was determined by horizontal and vertical error calculations.

2.4 Quality, Errors, and Limitations

Average, median, minimum, and maximum horizontal and vertical errors are shown in Tables 3 through 5. The maximum horizontal and vertical errors were associated with readings taken in the trees, where satellite signals were difficult to obtain and signal multi-pathing increased errors.

In all instances, locations represent a substantial leap in accuracy from the previously documented GP S coordinates.

Table 3. Errors for Snow Transect Stake DGNSS Coordinates

Error	Value
Average horizontal error	0.24 m
Average vertical error	0.28 m
Median horizontal error	0.03 m
Median vertical error	0.04 m
Minimum horizontal error	0.01 m
Minimum vertical error	0.01 m
Maximum horizontal error	5.36 m
Maximum vertical error	4.96 m

Table 4. Errors for Red Snow Pit Stake DGNSS Coordinates

Error	Value
Average horizontal error	0.26 m
Average vertical error	0.33 m
Median horizontal error	0.04 m
Median vertical error	0.04 m
Minimum horizontal error	0.01 m
Minimum vertical error	0.02 m
Maximum horizontal error	2.43 m
Maximum vertical error	2.56 m

Table 5. Errors for Time-Lapse Cameras and Reference Pole DGNSS Coordinates

Error	Value
Average horizontal error	0.53 m
Average vertical error	0.66 m
Median horizontal error	0.06 m
Median vertical error	0.06 m

2.5 Instrumentation

2.5.1 Description

This RTK survey was conducted using Trimble R8 (base station and one rover) and Trimble R10 (one rover) integrated GNSS systems. More details about the instruments can be found on the Trimble website.

3 SOFTWARE AND TOOLS

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

4 RELATED DATA SETS

Other SnowEx Data Sets

5 RELATED WEBSITES

NASA SnowEx

6 CONTACTS AND ACKNOWLEDGMENTS

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7 DOCUMENT INFORMATION

7.1 Publication Date

02 July 2018

7.2 Date Last Updated

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