

DEM Generation from the Antarctic LIDAR Data

SITE REPORT

Toni Schenk¹, Bea Csathó², Yushin Ahn^{1,2}, Taehun Yoon^{1,2}, Sung Woong Shin^{1,2}, Kyung In Huh²

¹Department of Civil and Environmental Engineering, The Ohio State University
2090 Neil Ave., Columbus, OH 43210

²Byrd Polar Research Center, The Ohio State University
1090 Carmack Rd., Columbus, OH 43210

Sep 2004

Table of content:

Introduction	3
Check point comparison	3
Appendix A: Site summary	6
Appendix B: Inlier and outlier file format.....	6
Appendix C: Descriptions of DEM labels.....	7
1 Odell Glacier	8
2 Barwick Valley	9
3. Victoria and Barwick Valleys	11
4a Mount Doorly Ridge, West – Victoria, Greenwood, Clark and Wright Valleys.....	14
4b Mount Doorly Ridge, East – Greenwood and Wright Valleys.....	16
5 McKelvey and Balham Valleys.....	18
6 Bull Pass and Victoria Valley	20
7 Wright Valley	22
8 Beacon Valley	24
9 Arena Valley	26
10a Taylor Valley, West and Pearse Valley.....	27
10b Taylor Valley, East.....	30
11 Radian Glacier - Portal	33
12 Denton Hills	34
13 Mount Discovery.....	36
14 Mount Morning	38
15 Cape Royds Rockery	40
16 Mount Erebus	42
17 Hut Point Peninsula and Erebus Ice Tongue	45
18 White Island	48

Introduction

This report provides detailed information about the DEM generation of the individual sites. General information as it pertains to all sites can be found in *Antarctic DEM Generation*. The DEMs were generated from data obtained by NASA's Airborne Topographic Mapper (ATM) laser altimetry system during an extensive survey in December, 2001.

Figure 1 provides an overview of the 18 sites located around McMurdo Sound. Five sites have a 4 m grid spacing while all other sites have a DEM resolution of 2 m x 2 m. The map also shows the trajectories of the aircraft, color-coded by the date of the mission. Table 1 below the site map lists the site names. Clicking a particular site brings you directly to the site.

Appendix A contains a summary of the sites in tabular form, including the coordinates of the corners of the enclosing rectangle of the site and the number of rows and columns. Details about the Lambert Conformal Conic projection used for all sites can also be found in Appendix A.

The individual site descriptions follow the same format. The site information displays the rectangle and the actual DEM coverage. Compared to the enclosing rectangle, the area with elevations is usually much smaller. After this figure a table is added that summarizes the most important data pertinent to a site. In order to provide a pictorial view of the site we include a Landsat TM image for the entire rectangle. If available, check points are shown with names on both, the site information and the Landsat image. The results of the check point comparison are listed in a second table. Additional documentation of the GPS check points, for example pictures, is added to the site report. This is quite useful as it provides insight to the particular GPS location. Unfortunately, only a few GPS locations have been documented carefully, including details about the exact location of the antenna.

In addition to the DEMs, so-called *label files* were generated. They contain information about the accuracy and reliability of the interpolated elevations of the DEM grid posts. The DEMs and label files are in geotiff format. The laser points are divided into inliers and outliers and the files are in ASCII format. Appendix B contains detailed information about the content and format of the ASCII point files and Appendix C explains the content of the label files.

Check point comparison

We verified the accuracy of the DEMs by using independent GPS points. The comparison was performed by interpolating an elevation from the DEM at the position of a GPS point and by determining the difference between interpolated elevation and GPS elevation. The following subsections describe the sources that provide GPS points and the interpolation method.

Sources of GPS points

1. USGS_Glover: the USGS geodetic field team collected geodetic data with the sole purpose of accuracy testing of NASA's ATM. The report by Bob Glover, USGS (rglover@usgs.gov, 703-648-5056) documents the field campaign, contains detailed information about the location of the GPS antenna, and provides accuracy measures for the GPS points. The vertical accuracy ranges from 0.05 to 0.20 meters. The GPS solutions are referenced to ITRF 1996 (Epoch 2000) with GRS 1980 reference ellipsoid. GPS surveys were performed in December 2001 and January 2002.
2. Bartel_Hallam: this data set was provided by Cheryl Hallam, USGS, November 29, 2002. Beth Bartel originally provided the coordinates. An accuracy of 0.01 to 0.1 meter was stated. No information was given about the reference system and the exact position of the GPS points relative to the topographic surface. Several GPS points are also listed under TAMDEF and UNAVCO. The position of these duplicate sites are almost identical, however, elevations differ as much as 1.5 meters (e.g., ELHT, Erebus Lower Hut over Mount Erebus). These rather large differences indicate erroneous data or references to different surfaces. Due to this uncertainty and

the lack of information about the reference system we could not include these check points for the assessing the DEM accuracy.

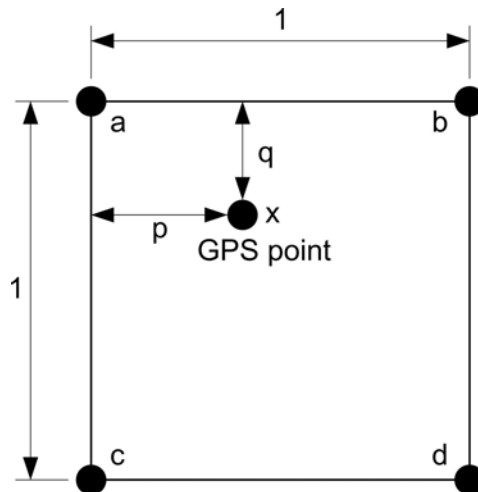
3. TAMDEF GPS positions were provided by Prof. Terry Wilson and Mike Willis (OSU): <http://www.geology.ohio-state.edu/~willis/stations-2.html>. The goal of the TAMDEF project is to investigate the crustal movement due to tectonics and changes in glacial loading by using repeat GPS surveys. Each site has geodetic style permanent pins installed in exposed bedrock. Most stations are installed on local bedrock highs to provide unobstructed sky view for continuous GPS observations. Only the elevation of the marker is noted and no information is given about its height over the topographic surface. The sites were surveyed in 1996-2001 and the GRS 1980 reference ellipsoid was used.
4. UNAVCO sites, posted on http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/geodetic.html were used as additional check points.

Bilinear interpolation from the DEMs

In order to derive an elevation from the DEM at the x,y position of a GPS check points, a bilinear interpolation was used in the following fashion. Let x be point within a DEM cell. The interpolated elevation from the four corner points a,b,c,d is obtained

$$x = a \cdot (1 - p) \cdot (1 - q) + b \cdot p \cdot (1 - q) + c \cdot (1 - p) \cdot q + d \cdot p \cdot q$$

with p and q the distances from the grid post as indicated in the figure below.

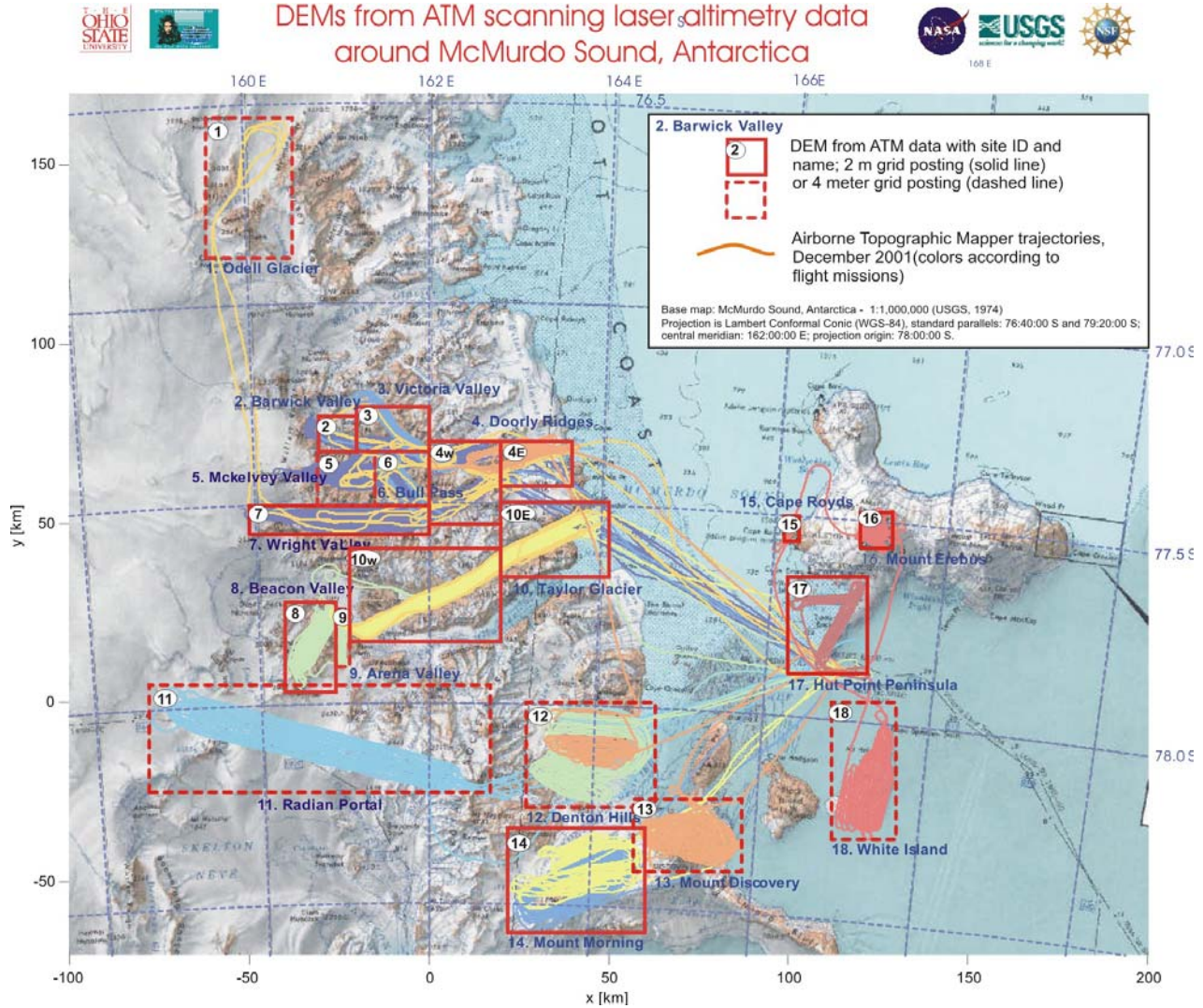


The elevation difference between GPS and interpolated DEM is defined by

$$\Delta h = \text{GPS elevation} - \text{interpolated DEM elevation}$$

Note that positive value of Δh means that the GPS point is above the interpolated DEM elevation and vice versa.

Figure 1 Flight trajectories with sites overlain on 1:1,000,000 topographic map



Appendix A: Site summary

ID	Site	Upper left corner		Lower right corner		Cell Size	# rows	#cols
		Longitude E	Latitude N	Longitude E	Latitude N			
1	Odell Glacier	159.615738	-76.528181	160.499980	-76.884597	4 x 4	6004	9754
2	Barwick Valley	160.752936	-77.280256	161.180569	-77.371554	2 x 2	5328	5003
3	Victoria Valley	161.187592	-77.259539	162.000000	-77.372807	2 x 2	10003	6253
4a	Doorly Valley S1	162.000000	-77.345894	162.831141	-77.550740	2 x 2	10003	11504
4b	Doorly Valley S2	162.817713	-77.344643	163.649698	-77.453786	2 x 2	10003	6304
5	Mckelvey Valley	160.729881	-77.369777	161.378954	-77.506502	2 x 2	8004	7503
6	Bull Pass	161.385389	-77.372084	162.000000	-77.507215	2 x 2	7502	7503
7	Wright Valley	159.930387	-77.499262	162.000000	-77.578907	2 x 2	25004	4004
8	Beacon Valley	160.311887	-77.743953	160.882529	-77.970918	2 x 2	7003	12503
9	Arena Valley	160.900993	-77.764852	161.059247	-77.908841	2 x 2	2002	8003
10a	Taylor Valley S1	161.081214	-77.613163	162.850978	-77.846388	2 x 2	21004	13003
10b	Taylor Valley S2	162.827452	-77.496972	164.099277	-77.678390	2 x 2	15004	10503
11	Radian Protal	158.655576	-77.935209	162.746213	-78.223083	4 x 4	23753	7504
12	Denton Hills	163.162826	-77.997599	164.771285	-78.246498	4 x 4	9003	7252
13	Mount Discovery	164.503591	-78.230985	165.876664	-78.395348	4 x 4	7503	5003
14	Mount Morning	162.972617	-78.311937	164.710536	-78.560976	2 x 2	19002	14503
15	Cape Royds	166.101397	-77.503058	166.287882	-77.563064	2 x 2	2003	3502
16	Mount Erebus	166.964106	-77.479595	167.372491	-77.561784	2 x 2	4504	5004
17	Hut Point Peninsula	166.192852	-77.654372	167.211727	-77.879747	2 x 2	11005	13504
18	White Island	166.813909	-77.958813	167.745490	-78.287899	4 x 4	4504	9628

Projection is Lambert Conformal Conic

Projection parameters:

Reference ellipsoid: WGS-84

Latitude of 1st standard parallel: 76:40:00 S

Latitude of 2nd standard parallel: 79:20:00 S

Longitude of central meridian: 162:00:00 E

Latitude of origin of projection: 78:00:00 S

False easting and northing at central meridian: 0 0 [m]

No data value: -9999

Appendix B: Inlier and outlier file format

Field	Content
1	UTC time packed (example: 153320100 = 15h 33m 20s 100ms)
2	Laser spot latitude [degree] (decimal degree, north latitude is positive, example: -77.809224)
3	Laser spot longitude [degree] (decimal degree, east longitude is positive, example: 160.986005)
4	Elevation [meter]
4	Laser spot x-coordinate, Lambert Conformal Conic projection [meter]
5	Laser spot y-coordinate, Lambert Conformal Conic projection [meter]
6	Start pulse signal strength (relative, non calibrated)
7	Reflected laser signal strength (relative, non calibrated)
8	Passive signal (relative, non calibrated)

Appendix C: Descriptions of DEM labels

Label 0

The elevation of the grid post is determined by a plane that is fitted through neighboring laser points. The laser points occur at least in 3 quadrants and the residuals of the fitting process are smaller than 10 cm.

Label 1

Same as Label 0 except the residuals are between 10 cm and 30 cm.

Label 2

Same as Label 0 except blunders in the laser points are detected and removed before fitting a plane. After removing blunders, the residuals are smaller than 10 cm.

Label 3

Same as Label 2, except the residuals are between 10 cm and 30 cm.

Label 4

Same as Label 2, except at least one residual exceeds 30 cm.

Label 5

The elevation of the grid post is computed by nearest neighbor interpolation. The distance between the grid post and its nearest laser point is smaller than 1/3 of the cell size. Nearest neighbor interpolation is used if fewer than 7 laser points are available or of their distribution is asymmetric, e.g. points in one or two quadrants only.

Label 6

Same as Label 5 except the nearest laser point is farther from the grid post than 1/3 cell size.

Label 7

No elevation was computed because there are no laser points inside the DEM cell.

Label 8

The elevation of the grid post is computed by nearest neighbor interpolation because the plane fitting process failed, either because the adjustment was singular or the residuals exceed a predefined threshold value.

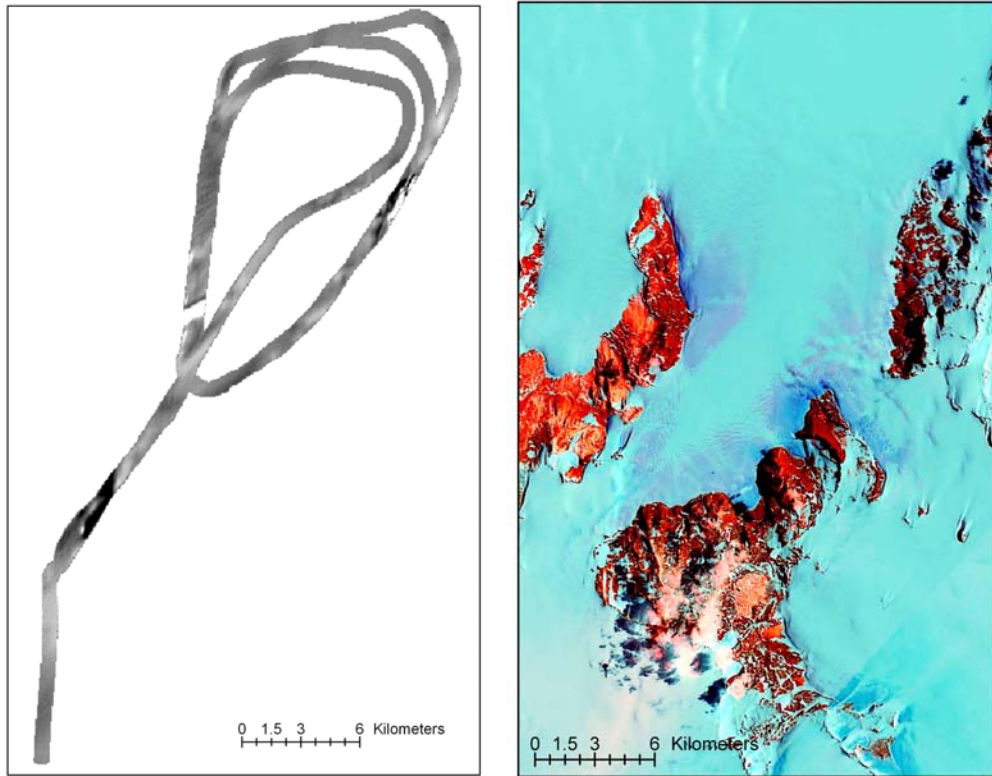
Label 9

This label is assigned to a grid post that was identified as a blunder during the post-processing phase.

1 Odell Glacier

1 Odell Glacier

1.1 Site information and Landsat TM imagery



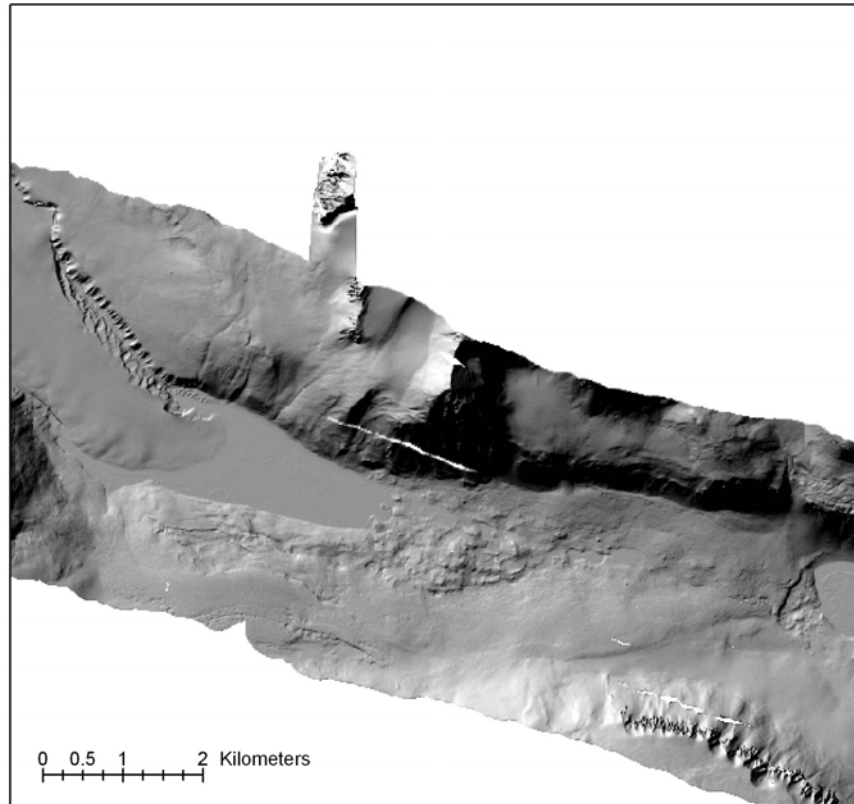
1.2 DEM information

File names		Odell_atm_2001_dem_v5.tif Odell_atm_2001_dem_v5.tfw Inlier_odell_v5.zip Outlier_odell_v5.zip Odell_atm_2001_label_v5.tif Odell_atm_2001_label_v5.tfw
Project size [rows × columns]		6,004 × 9,754
DEM resolution [meter]		4 by 4
Total number of laser points		12,267,277
Number of laser outliers		101,115
Number of valid laser points		12,166,162
Number of valid grid points		4,927,500
Point density [points/m ²]		0.15
DEM Corner points	Upper left X and Y [meter]	-62,016 163,024
	Lower right X and Y [meter]	-38,004 124,012
	Upper left Lat(S), Long(E) [degree]	76.528180 159.615738
	Lower right Lat(S), Long(E) [degree]	76.884597 160.499980
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	76:31:41.448 159:36:56.657
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	76:53:04.549 160:29:59.928

2 Barwick Valley

2 Barwick Valley

2.1 Site information

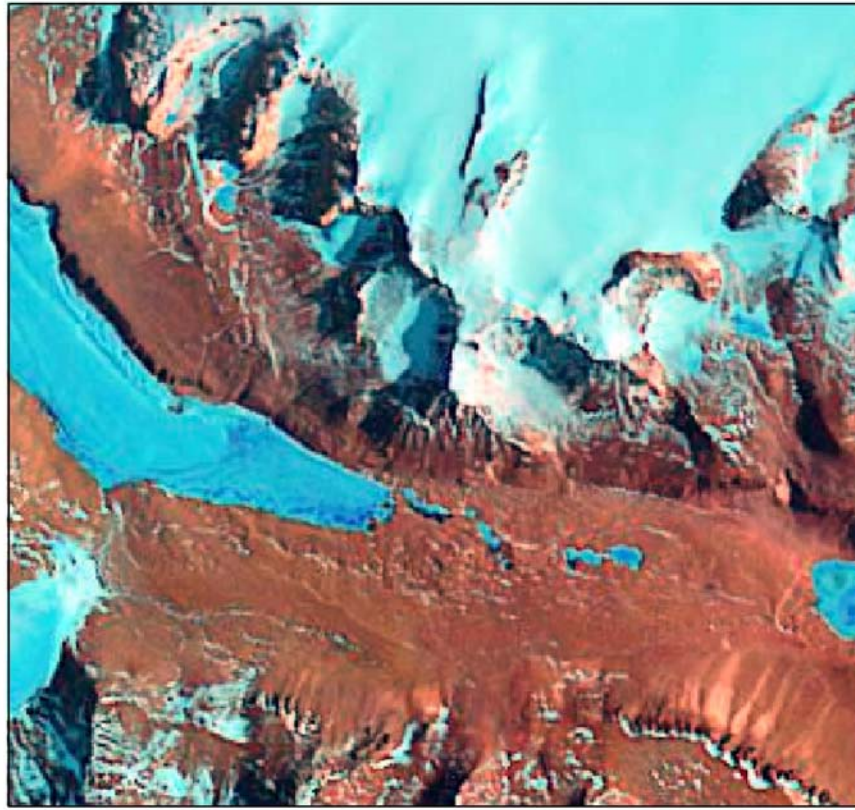


2.2 DEM information

File names		barwick_atm_2001_dem_v5.tif barwick_atm_2001_dem_v5.tfw Inlier_barwick_v5.zip Outlier_barwick_v5.zip barwick_ATM_2001_Label_v5.tif barwick_ATM_2001_Label_v5.tfw
Project size [rows × columns]		5,328 × 5,003
DEM resolution [meter]		2 by 2
Total number of laser points		12,247,109
Number of laser outliers		64,125
Number of valid laser points		12,182,984
Number of valid grid points		13,041,126
Point density [points/m ²]		0.23
DEM Corner points	Upper left X and Y [meter]	-30,656 163,024
	Lower right X and Y [meter]	-20,002 70,004
	Upper left Lat(S), Long(E) [degree]	77.280236 160.752853
	Lower right Lat(S), Long(E) [degree]	77.371534 161.180485
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:16:48.850 160:45:10.271
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:22:17.522 161:10:49.746

2 Barwick Valley

2.3 Landsat TM imagery

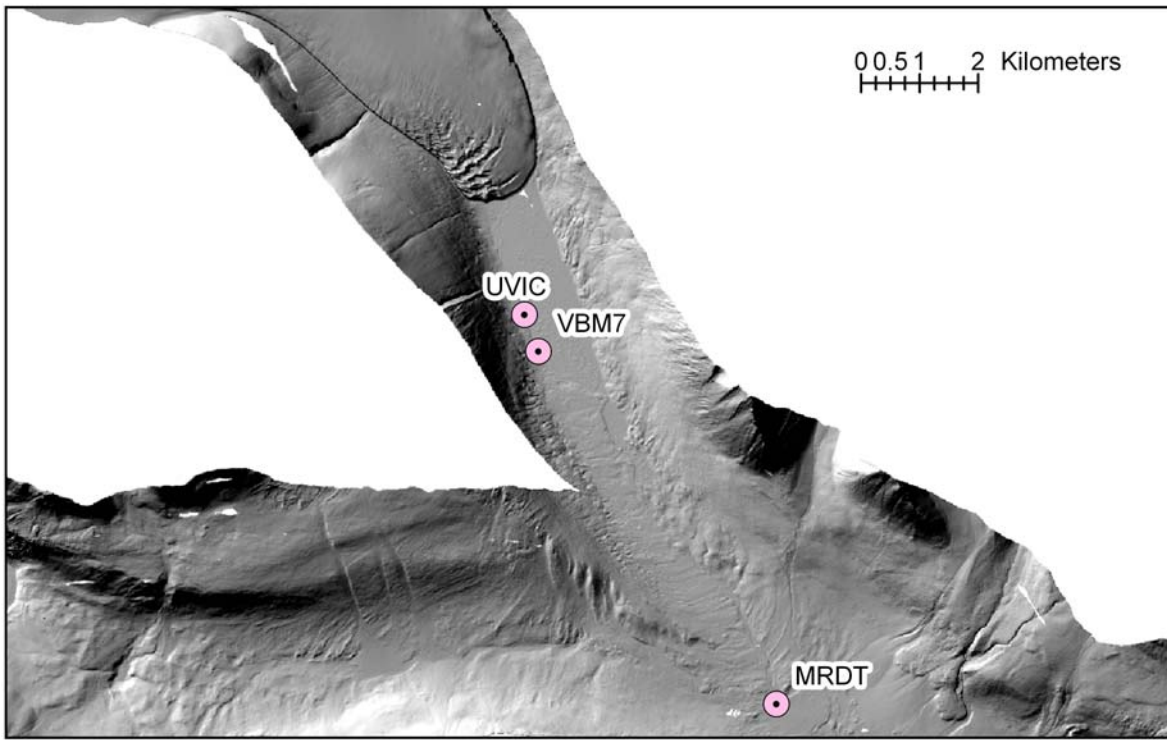


0 0.5 1 2 Kilometers

3 Victoria and Barwick Valleys

3. Victoria and Barwick Valleys

3.1 Site information



3.2 DEM information

File names	victoria_atm_2001_dem_v5.tif victoria_atm_2001_dem_v5.tfw Inlier_victoria_v5.zip Outlier_victoria_v5.zip victoria_atm_2001_label_v5.tif victoria_atm_2001_label_v5.tfw	
Project size [rows × columns]	10,003 × 6,253	
DEM resolution [meter]	2 by 2	
Total number of laser points	38,757,284	
Number of laser outliers	769,550	
Number of valid laser points	37,987,734	
Number of valid grid points	29,617,233	
Point density [points/m ²]	0.32	
DEM Corner points	Upper left X and Y [meter]	-20,004 82,508
	Lower right X and Y [meter]	0 70,004
	Upper left Lat(S), Long(E) [degree]	77.259520 161.187509
	Lower right Lat(S), Long(E) [degree]	77.372788 161.999915
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:15:34.272 161:11:15.037
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:22:22.037 161:59:59.694

3 Victoria and Barwick Valleys

3.3 Accuracy measured with GPS check points

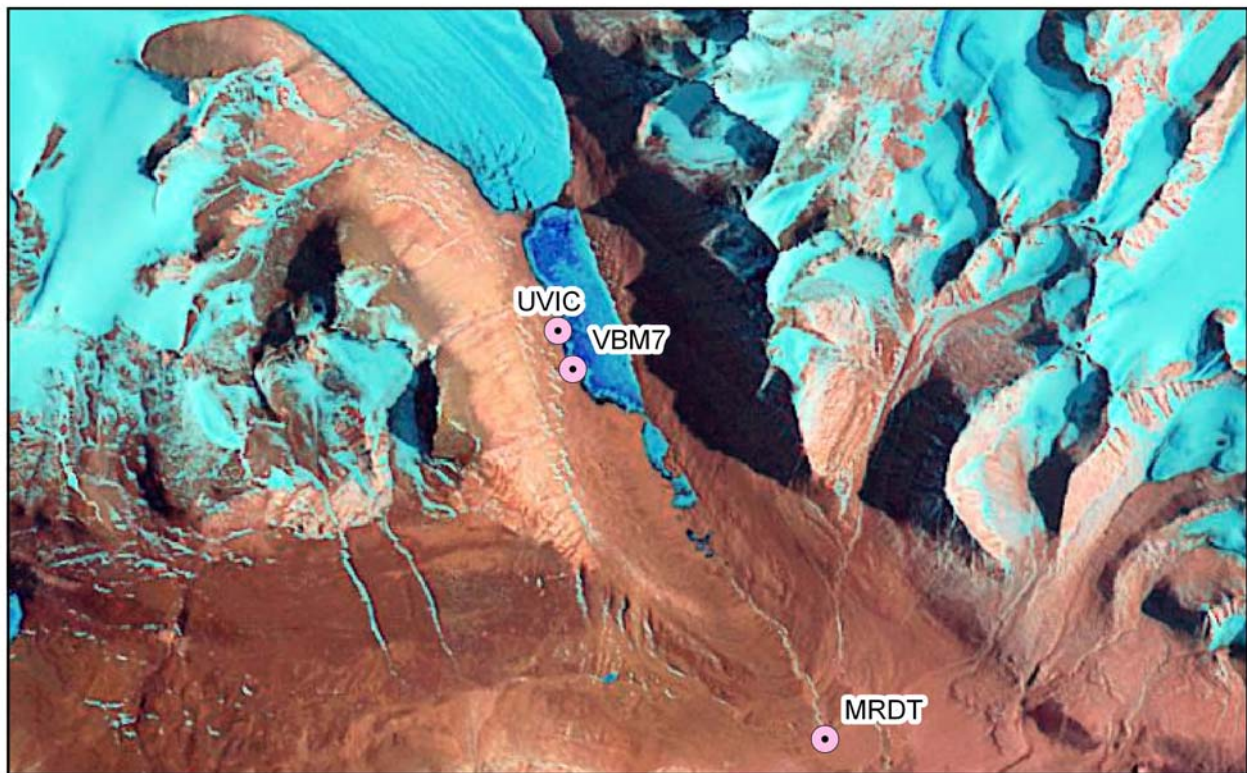
3.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
UVIC	USGS_Glover	-11,126.1	77,235.6	77.307632 S	161.546466 E	347.71	0.09	Victoria Valley, [1]
MRDT	UNAVCO	-6,816.6	70,579.3	77.367508 S	161.720837 E	316.86	0.35	
VBM7	UNAVCO	-10,886.5	76,608.5	77.313267 S	161.556039 E	347.89	0.10	

Δh = GPS elevation – interpolated DEM elevation

[1] Accuracy better than or equal to 5 cm with 95% confidence

3.3.2 Landsat TM imagery with locations of GPS sites



0 0.5 1 2 Kilometers

3 Victoria and Barwick Valleys

3.3.3 GPS Site documentation

MRDT_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/mrdt.html



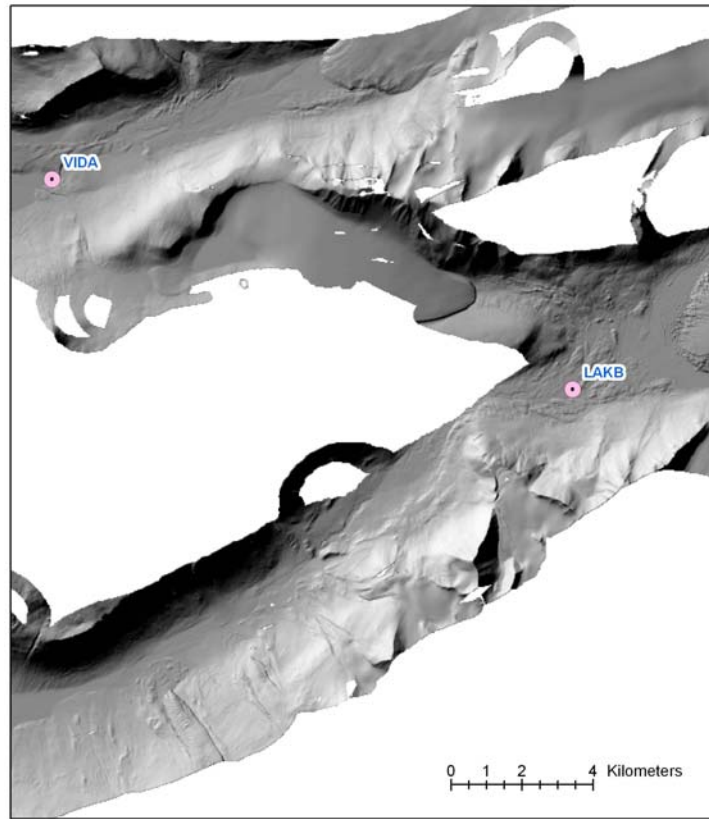
VBM7_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/vbm7.html



4 Mount Doorly Ridge - Victoria, Greenwood, Clark and Wright Valleys

4a Mount Doorly Ridge, West – Victoria, Greenwood, Clark and Wright Valleys

4a.1 Site information



4a.2 DEM information

File names		Doorly_west_atm_2001_dem_v5.tif Doorly_west_atm_2001_dem_v5.tfw Inlier_doorly_west_v5.zip Outlier_doorly_west_v5.zip Doorly_west_atm_2001_label_v5.tif Doorly_west_atm_2001_label_v5.tfw
Project size [rows × columns]		10,003 × 11,504
DEM resolution [meter]		2 by 2
Total number of laser points		84,443,453
Number of laser outliers		4,734,785
Number of valid laser points		79,708,668
Number of valid grid points		61,513,083
Point density [points/m ²]		0.32
DEM Corner points	Upper left X and Y [meter]	0 73,008
	Lower right X and Y [meter]	20,004 50,002
	Upper left Lat(S), Long(E) [degree]	77.345894 160.000000
	Lower right Lat(S), Long(E) [degree]	77.550739 162.831140
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:20:45.218 160:00:00.000
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:33:02.660 162:49:52.104

4 Mount Doorly Ridge – Victoria, Greenwood, Clark and Wright Valleys

4a.3 Accuracy assignment with GPS points

4a.3.1 Check point comparison

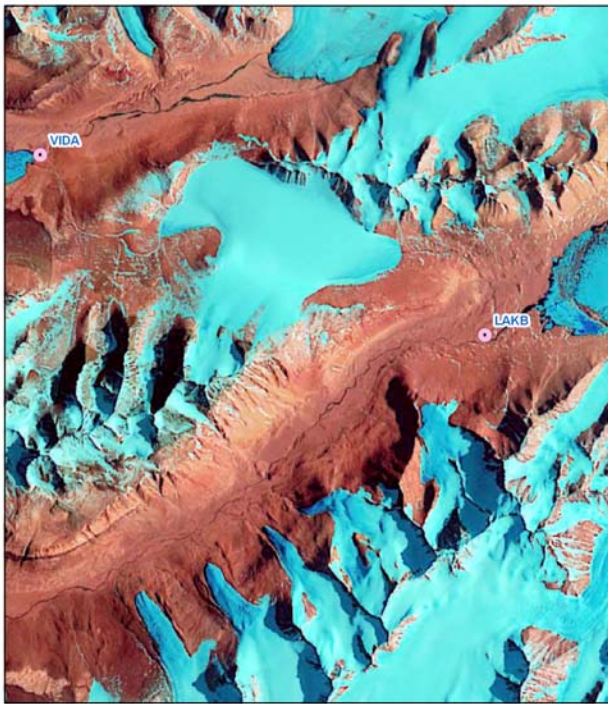
GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
LAKB	USGS_Glover	15,821.3	62,140.9	77.442466 S	162.651758 E	223.47	(2.72)	Lake Brownsworth Hut, true N corner, [1]
VIDA	USGS_Glover	1172.0	68,089.8	77.389953 S	162.048082 E	298.64	0.01	Lake Vida, [1]

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

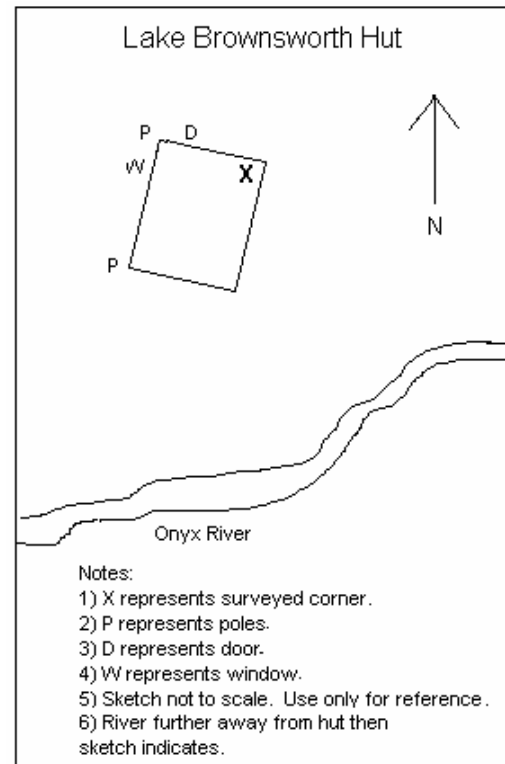
[1] Accuracy better than or equal to 5 cm with 95% confidence

4a.3.2 Landsat TM imagery with locations of GPS sites



4a.3.3 GPS site documentation

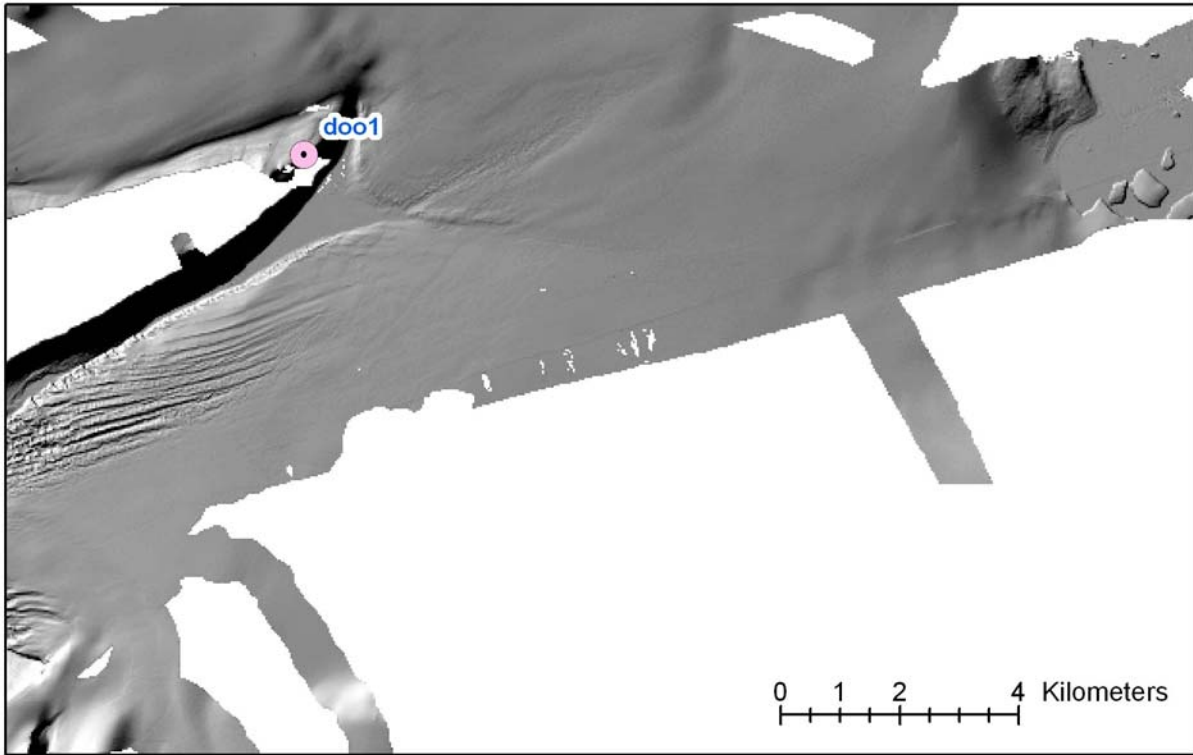
LAKB_USGS_Glover, Lake Brownsworth Hut, true north corner, site sketch



4 Mount Doorly Ridge – Victoria, Greenwood, Clark and Wright Valleys

4b Mount Doorly Ridge, East – Greenwood and Wright Valleys

4b.1 Site information



4b.2 DEM information

File names		Doorly_east_atm_2001_dem_v5.tif Doorly_east_atm_2001_dem_v5.tfw Inlier_doorly_east_v5.zip Outlier_doorly_east_v5.zip Doorly_east_atm_2001_label_v5.tif Doorly_east_atm_2001_label_v5.tfw
Project size [rows × columns]		10,003 × 6,304
DEM resolution [meter]		2 by 2
Total number of laser points		26,978,993
Number of laser outliers		1,054,640
Number of valid laser points		25,924,353
Number of valid grid points		32,148,076
Point density [points/m ²]		0.20
DEM Corner points	Upper left X and Y [meter]	20,002 73,008
	Lower right X and Y [meter]	40,006 60,402
	Upper left Lat(S), Long(E) [degree]	77.344643 162.817713
	Lower right Lat(S), Long(E) [degree]	77.453786 163.649698
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:20:40.715 162:49:03.767
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:27:13.630 163:38:58.913

4 Mount Doorly Ridge – Victoria, Greenwood, Clark and Wright Valleys

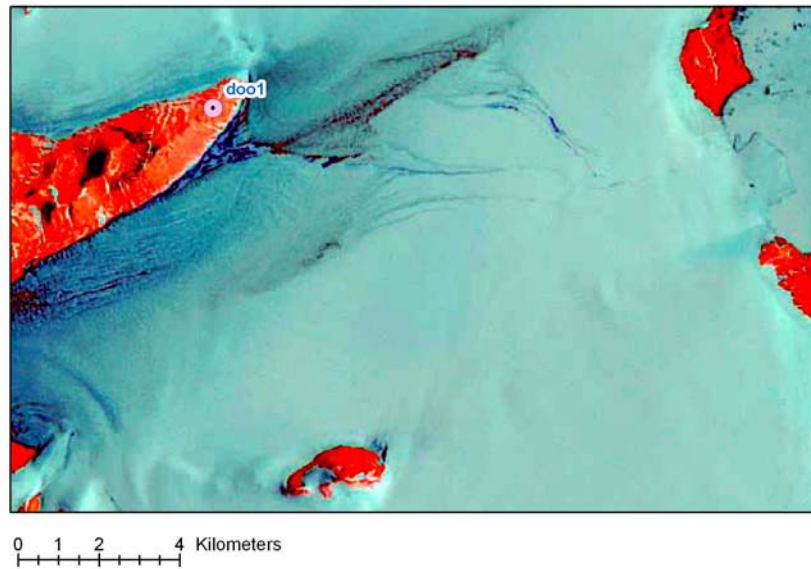
4b.3 Accuracy measured with GPS check points

4b.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
doo1	TAMDEF	25,014.2	70,476.2	77.366617 S	163.024393 E	460.90	0.85	

$\Delta h = \text{GPS elevation} - \text{interpolated DEM elevation}$

4b.3.2 Landsat TM imagery with location of GPS site



4b.3.3 GPS site documentation

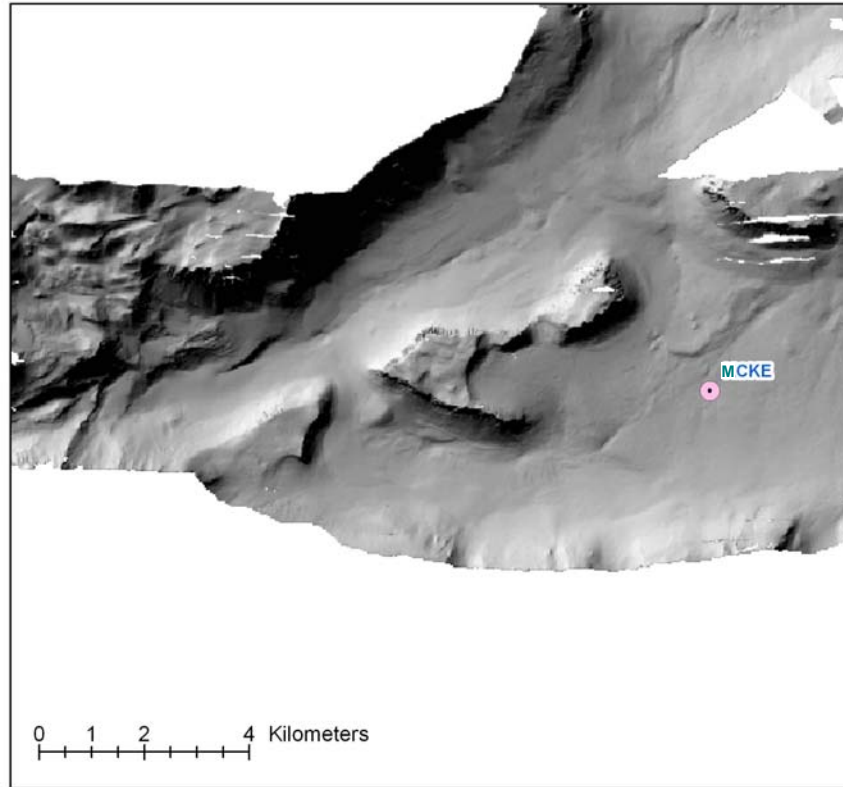
doo1_TAMDEF http://www.geology.ohio-state.edu/~willis/tamnotes/mount-doorly_notes.html



5 McKelvey and Balham Valleys

5 McKelvey and Balham Valleys

5.1 Site information



5.2 DEM information

File names		mckelvey_atm_2001_dem_v5.tif mckelvey_atm_2001_dem_v5.tfw Inlier_mckelvey_v5.zip Outlier_mckelvey_v5.zip mckelvey_atm_2001_label_v5.tif mckelvey_atm_2001_label_v5.tfw
Project size [rows × columns]		8,004 × 7,503
DEM resolution [meter]		2 by 2
Total number of laser points		32,120,918
Number of laser outliers		357,319
Number of valid laser points		31,763,599
Number of valid grid points		31,172,445
Point density [points/m ²]		0.25
DEM Corner points	Upper left X and Y [meter]	-31,006 70,006
	Lower right X and Y [meter]	-15,000 55,002
	Upper left Lat(S), Long(E) [degree]	77.369777 160.729881
	Lower right Lat(S), Long(E) [degree]	77.506502 161.378954
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:22:11.197 160:43:47.572
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:30:23.407 161:22:44.234

5 McKelvey and Balham Valleys

5.3 Accuracy measured with GPS check point

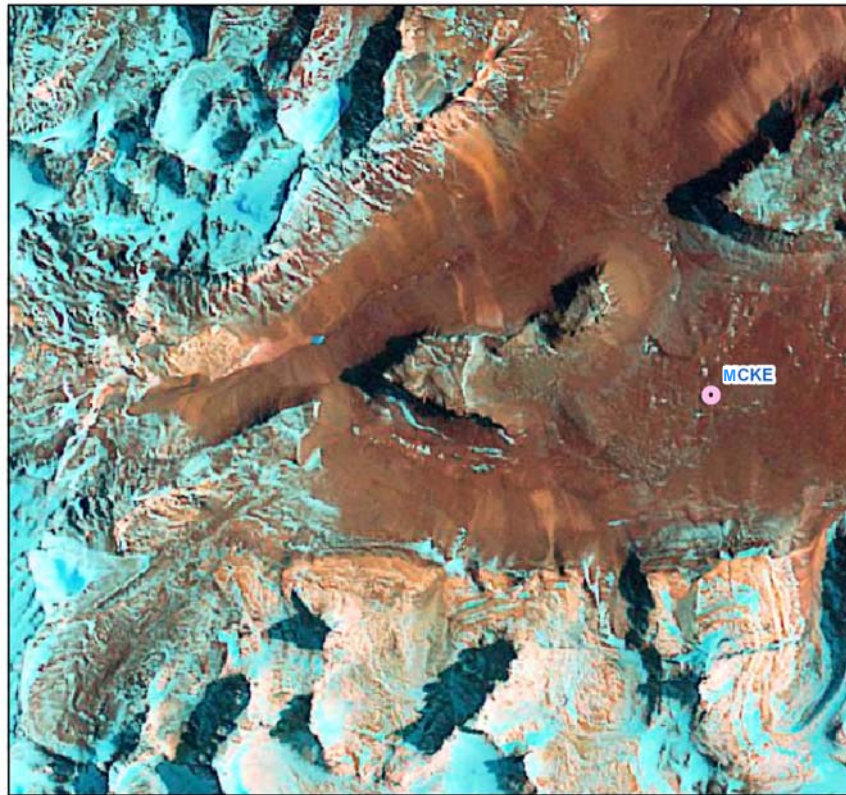
5.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
MCKE	USGS_Glover	-17,694.1	62,602.9	77.43813 S	161.271336 E	797.79	-0.04	McKelvey Valley, [1]

$\Delta h = \text{GPS elevation} - \text{interpolated DEM elevation}$

[1] Accuracy better than or equal to 5 cm with 95% confidence

5.3.2 Landsat TM imagery with location of GPS site

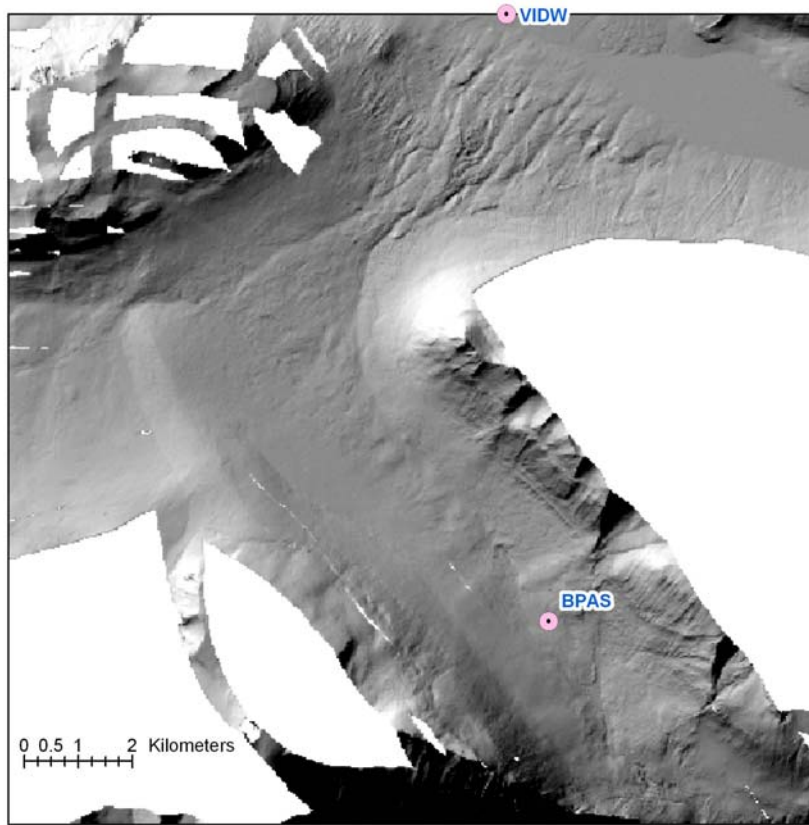


0 1 2 4 Kilometers

6 Bull Pass and Victoria Valley

6 Bull Pass and Victoria Valley

6.1 Site information



6.2 DEM information

File names		bull_atm_2001_dem_v5.tif bull_atm_2001_dem_v5.tfw Inlier_bull_v5.zip Outlier_bull_v5.zip bull_atm_2001_label_v5.tif bull_atm_2001_label_v5.tfw
Project size [rows × columns]		7,502 × 7,503
DEM resolution [meter]		2 by 2
Total number of laser points		52,267,443
Number of laser outliers		9,303,425
Number of valid laser points		42,964,018
Number of valid grid points		38,541,362
Point density [points/m ²]		0.28
DEM Corner points	Upper left X and Y [meter]	-15,002 70,006
	Lower right X and Y [meter]	0 55,002
	Upper left Lat(S), Long(E) [degree]	77.372084 161.385389
	Lower right Lat(S), Long(E) [degree]	77.507215 162.000000
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:22:19.502 161:23:07.400
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:30:25.974 162:00:00.000

6 Bull Pass and Victoria Valley

6.3 Accuracy measured with GPS check points

6.3.1 Check point comparison

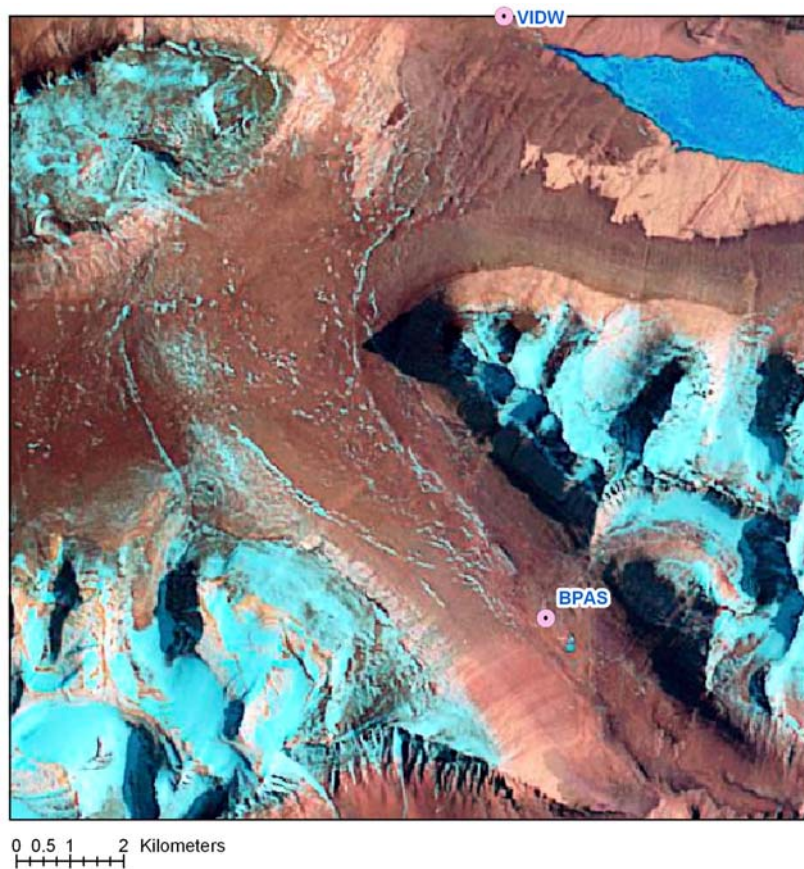
GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
BPAS	USGS_Glover	-5,011.5	58,767.3	77.473401 S	161.793051 E	595.49	0.12	Bull Pass, [1]
VIDW	USGS_Glover	-5,790.9	69,994.6	77.372787 S	161.762745 E	301.46	0.11	Lake Vida, [2]

$\Delta h = \text{GPS elevation} - \text{interpolated DEM elevation}$

[1] Accuracy better than or equal to 5 cm with 95% confidence

[2] Accuracy better than or equal to 8 cm with 95% confidence

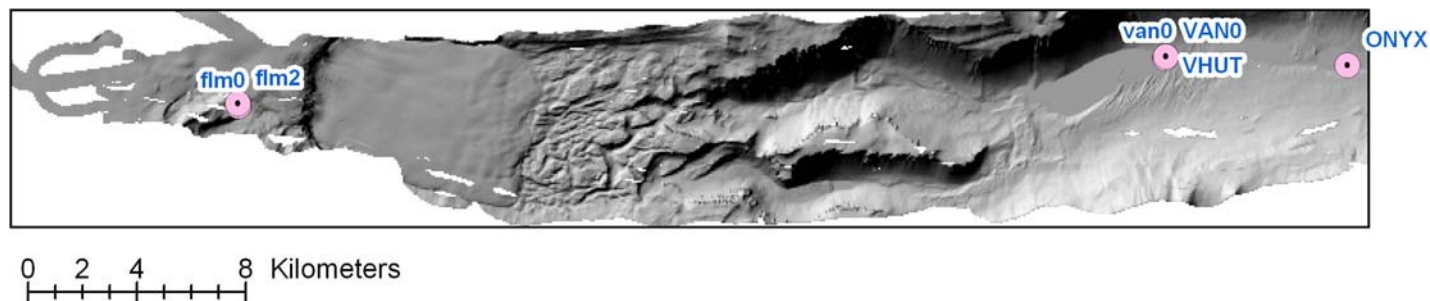
6.3.2 Landsat TM imagery with locations of GPS sites



7 Wright Valley

7 Wright Valley

7.1 Site information



7.2 DEM information

File names		wright_atm_2001_dem_v5.tif wright_atm_2001_dem_v5.tfw Inlier_wright_v5.zip Outlier_wright_v5.zip wright_atm_2001_label_v5.tif wright_atm_2001_label_v5.tfw
Project size [rows × columns]		25,004 × 4,004
DEM resolution [meter]		2 by 2
Total number of laser points		65,280,556
Number of laser outliers		2,111,154
Number of valid laser points		63,169,402
Number of valid grid points		69,414,413
Point density [points/m ²]		0.23
DEM Corner points	Upper left X and Y [meter]	-50,006 55,006
	Lower right X and Y [meter]	0 47,000
	Upper left Lat(S), Long(E) [degree]	77.499262 159.930387
	Lower right Lat(S), Long(E) [degree]	77.578907 162.000000
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:29:57.343 159:55:49.393
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:34:44.065 162:00:00.000

7 Wright Valley

7.3 Accuracy measured with GPS check points

7.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
ONYX	USGS_Glover	-778.0	52,956.1	77.525543 S	161.967741 E	99.77	0.17	Onyx river [3]
VHUT	USGS_Glover	-7,503.3	53,230.6	77.522907 S	161.688942 E	45.27	(2.49)	Lake Vanda Hut SW corner of long part, [1]
flm0	TAMDEF	-41,629.5	51,466.2	77.533392 S	160.272529 E	1,868.10	0.05	Mount Flemming
flm2	TAMDEF	-41,640.8	51,550.1	77.532638 S	160.272162 E	1,870.08	0.13	Mount Flemming
van0	TAMDEF	-7,481.2	53,290.6	77.52237 S	161.689873 E	41.78	(0.06)	Same site as VAN0_UNAVCO
VAN0	UNAVCO	-7,481.0	53,290.7	77.522369 S	161.689879 E	41.81	0.09	

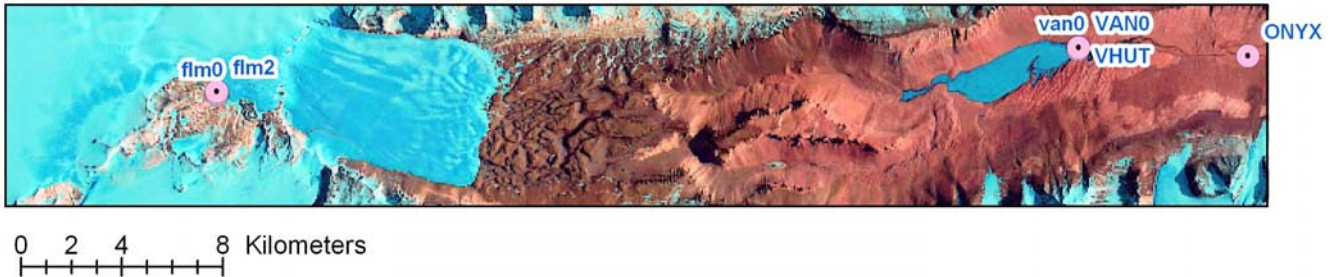
Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessments – see report for explanation

[1] Accuracy better than or equal to 5 cm with 95% confidence

[3] Accuracy better than or equal to 20 cm with 95% confidence

7.3.2 Landsat TM imagery with locations of GPS sites

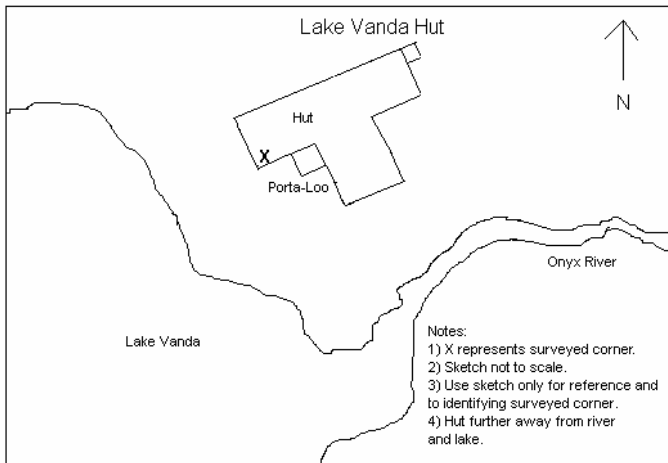


7.3.3 GPS site documentation

flm0, flm2_TAMDEF http://www.geology.ohio-state.edu/~willis/tamnotes/mount-flemming_notes.html

VAN0_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/van0.html

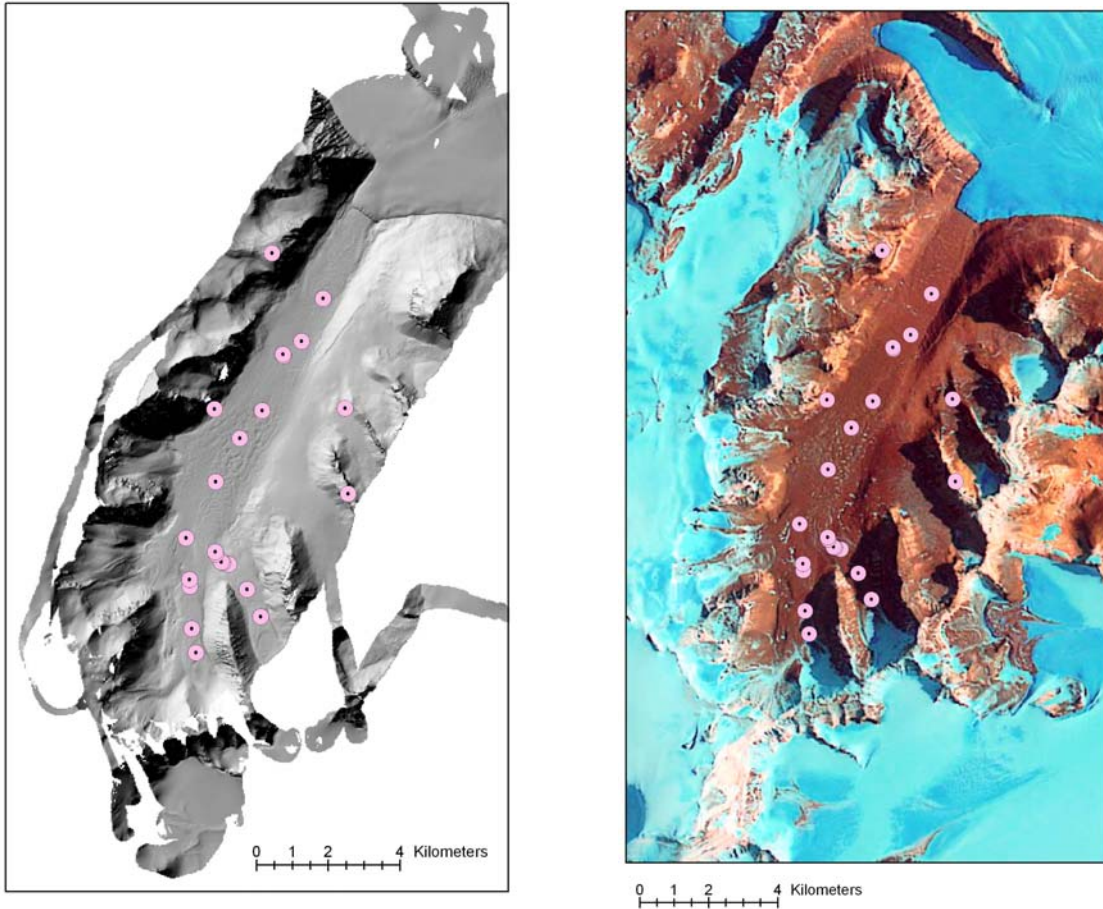
VHUT_USGS_Glover, Lake Vanda Hut, SW corner on the long rectangular section, site sketch



8 Beacon Valley

8 Beacon Valley

8.1 Site information and Landsat TM imagery with locations of GPS sites



8.2 DEM information

File names		beacon_atm_2001_dem_v5.tif beacon_atm_2001_dem_v5.tfw Inlier_beacon_v5.zip Outlier_beacon_v5.zip beacon_atm_2001_label_v5.tif beacon_atm_2001_label_v5.tfw
Project size [rows × columns]		7,003 × 12,503
DEM resolution [meters]		2 by 2
Total number of laser points		42,404,515
Number of outliers		882,366
Number of valid laser points		41,522,149
Number of valid grid points		36,693,016
Point density [points/m ²]		0.28
DEM Corner points	Upper left X and Y [meter]	-40,004 28,002
	Lower right X and Y [meter]	-26,000 2,998
	Upper left Lat(S) , Long(E) [degree]	77.743953 160.311886
	Lower right Lat(S) , Long(E) [degree]	77.970917 160.882529
	Upper left Lat(S) , Long(E) [dd:mm:ss.sss]	77:44:38.231 160:18:42.790
	Lower right Lat(S) , Long(E) [dd:mm:ss.sss]	77:58:15.301 160:52:57.104

8 Beacon Valley

8.3 Accuracy measured with GPS check points

8.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
bea0	TAMDEF	-32,581.2	20,965.1	77.808721 S	160.617983 E	1,822.94	0.11	
beaa	TAMDEF	-30,464.5	14,196.3	77.869784 S	160.701373 E	2,010.15	0.14	
bv01	UNAVCO	-32,895.0	10,728.3	77.900344 S	160.594258 E	1,592.50	(0.78)	On boulder
bv02	UNAVCO	-33,272.1	11,506.5	77.893292 S	160.578956 E	1,538.60	(0.46)	On boulder
bv03	UNAVCO	-33,781.1	12,204.9	77.886925 S	160.557961 E	1,469.10	(0.70)	On boulder
bv04	UNAVCO	-33,954.1	12,256.2	77.886428 S	160.550633 E	1,449.20	(0.33)	On boulder
bv05	UNAVCO	-33,991.3	12,271.7	77.886281 S	160.549061 E	1,442.70	(1.08)	On boulder
bv06	UNAVCO	-34,137.8	12,499.1	77.884211 S	160.543053 E	1,410.30	(0.42)	On boulder
bv07	UNAVCO	-34,159.1	12,556.0	77.883697 S	160.542203 E	1,401.20	(0.65)	On boulder
bv09	UNAVCO	-32,857.1	16,534.1	77.848350 S	160.601800 E	1,273.20	(0.60)	On boulder
bv10	UNAVCO	-32,261.7	18,078.1	77.834647 S	160.628667 E	1,225.00	(1.06)	On boulder
bv11	UNAVCO	-32,275.0	18,116.2	77.834303 S	160.628139 E	1,220.60	(0.07)	On boulder
bv21	UNAVCO	-34,703.5	9,722.5	77.908953 S	160.515919 E	1,580.70	(0.88)	On boulder
bv22	UNAVCO	-34,815.9	10,399.1	77.902867 S	160.511847 E	1,535.50	(1.30)	On boulder
bv23	UNAVCO	-34,872.8	11,588.0	77.892206 S	160.510711 E	1,436.70	(0.29)	On boulder
bv24	UNAVCO	-34,883.4	11,781.0	77.890475 S	160.510467 E	1,409.40	(0.32)	On boulder
bv25	UNAVCO	-34,979.4	12,948.8	77.879994 S	160.507639 E	1,347.70	(0.24)	On boulder
bv26	UNAVCO	-34,149.9	14,528.4	77.866033 S	160.544689 E	1,299.30	(0.20)	On boulder
bv27	UNAVCO	-33,471.5	15,753.9	77.855206 S	160.574856 E	1,281.20	(0.47)	On boulder
bv28	UNAVCO	-34,179.9	16,572.9	77.847714 S	160.545572 E	1,282.80	(1.16)	On boulder
bv29	UNAVCO	-30,541.7	16,599.5	77.848242 S	160.700356 E	1,574.90	(1.44)	On boulder
bv30	UNAVCO	-31,753.6	18,480.3	77.831150 S	160.650647 E	1,182.00	(0.70)	On boulder
bv31	UNAVCO	-31,160.2	19,686.3	77.820469 S	160.677014 E	1,082.60	(0.37)	On boulder

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

8.3.3 GPS site documentation

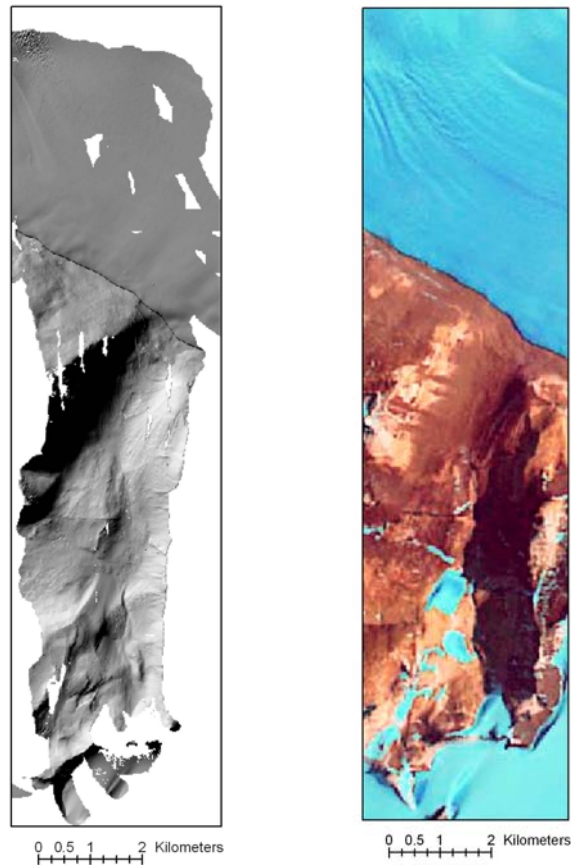
bv01-31_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/bv01-31.html



9 Arena Valley

9 Arena Valley

9.1 Site information and Landsat TM imagery



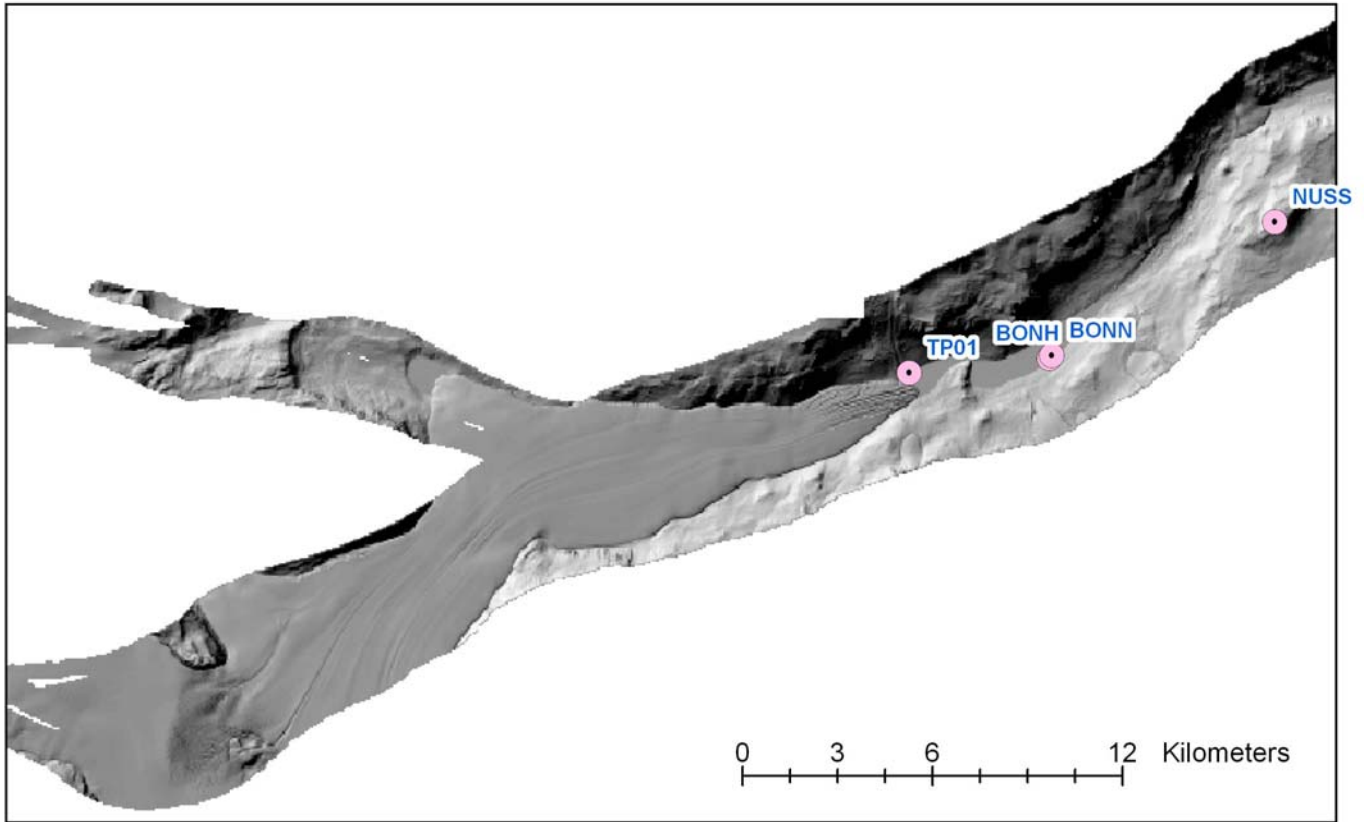
9.2 DEM information

File names		arena_atm_2001_dem_v5.tif arena_atm_2001_dem_v5.tfw Inlier_arena_v5.zip Outlier_arena_v5.zip arena_atm_2001_label_v5.tif arena_atm_2001_label_v5.tfw
Project size [rows × columns]		2,002 × 8,003
DEM resolution [meter]		2 by 2
Total number of laser points		11,908,295
Number of outliers		145,059
Number of valid laser points		11,763,236
Number of valid grid points		10,475,514
Point density [points/m ²]		0.28
DEM Corner points	Upper left X and Y [meter]	-26,002 26,002
	Lower right X and Y [meter]	-22,000 9,998
	Upper left Lat(S) , Long(E) [degree]	77.764852 160.900993
	Lower right Lat(S) , Long(E) [degree]	77.909941 161.059247
	Upper left Lat(S) , Long(E) [dd:mm:ss.sss]	77:45:53.467 160:54:03.575
	Lower right Lat(S) , Long(E) [dd:mm:ss.sss]	77:54:35.788 161:03:33.289

10 Taylor and Pearse Valleys

10a Taylor Valley, West and Pearse Valley

10a.1 Site information



10a.2 DEM information

File names		taylor_west_atm_2001_dem_v5.tif taylor_west_atm_2001_dem_v5.tfw Inlier_taylor_west_v5.zip Outlier_taylor_west_v5.zip taylor_west_atm_2001_label_v5.tif taylor_west_atm_2001_label_v5.tfw
Project size [rows × columns]		21,004 × 13,003
DEM resolution [meter]		2 by 2
Total number of laser points		91,537,158
Number of laser outliers		693,200
Number of valid laser points		90,843,958
Number of valid grid points		70,973,836
Point density [points/m ²]		0.32
DEM Corner points	Upper left X and Y [meter]	-22,004 43,004
	Lower right X and Y [meter]	20,002 17,000
	Upper left Lat(S), Long(E) [degree]	77.613163 161.081214
	Lower right Lat(S), Long(E) [degree]	77.846389 162.850978
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:36:47.387 161:04:52.370
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:50:47.000 162:51:03.521

10 Taylor and Pearse Valleys

10a.3 Accuracy measured with GPS check points

10a.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
BONH	USGS_Glover	10,941.4	31,740.1	77.715242 S	162.460588 E	11.36	0.14	Lake Bonney helo pad, NE corner, [2]
NUSS	USGS_Glover	18,064.5	36,080.9	77.675689 S	162.758050 E	784.85	0.05	Nussbaum Riegel, [2]
BONN	UNAVCO	11,026.9	31,828.6	77.714443 S	162.464161 E	10.43	0.08	
TP01	UNAVCO	6,517.2	31,283.7	77.719579 S	162.274440 E	18.39	(0.62)	large boulder

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

[2] Accuracy better than or equal to 8 cm with 95% confidence

10a.3.2 Landsat TM imagery with locations of GPS sites



0 3 6 12 Kilometers

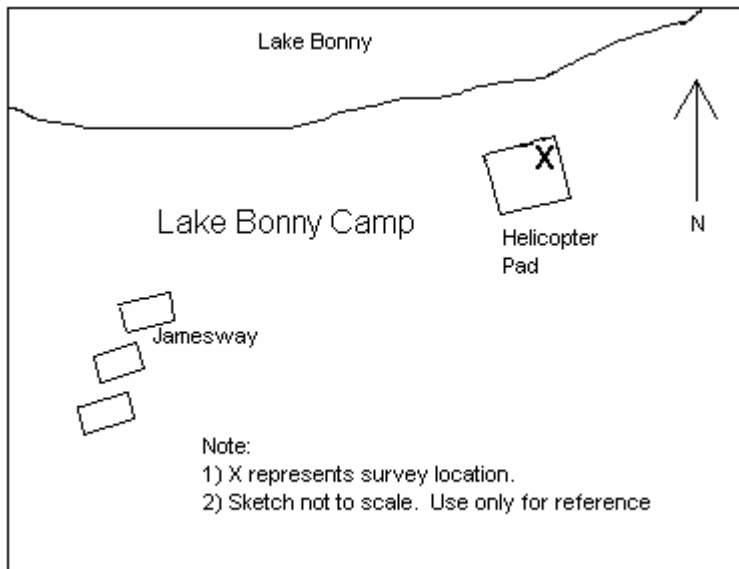
10 Taylor and Pearse Valleys

10a.3.3 GPS site documentation

BONN_UNAVCO (left) http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/bonn.html
TP01_UNAVCO (right) http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/tp01.html



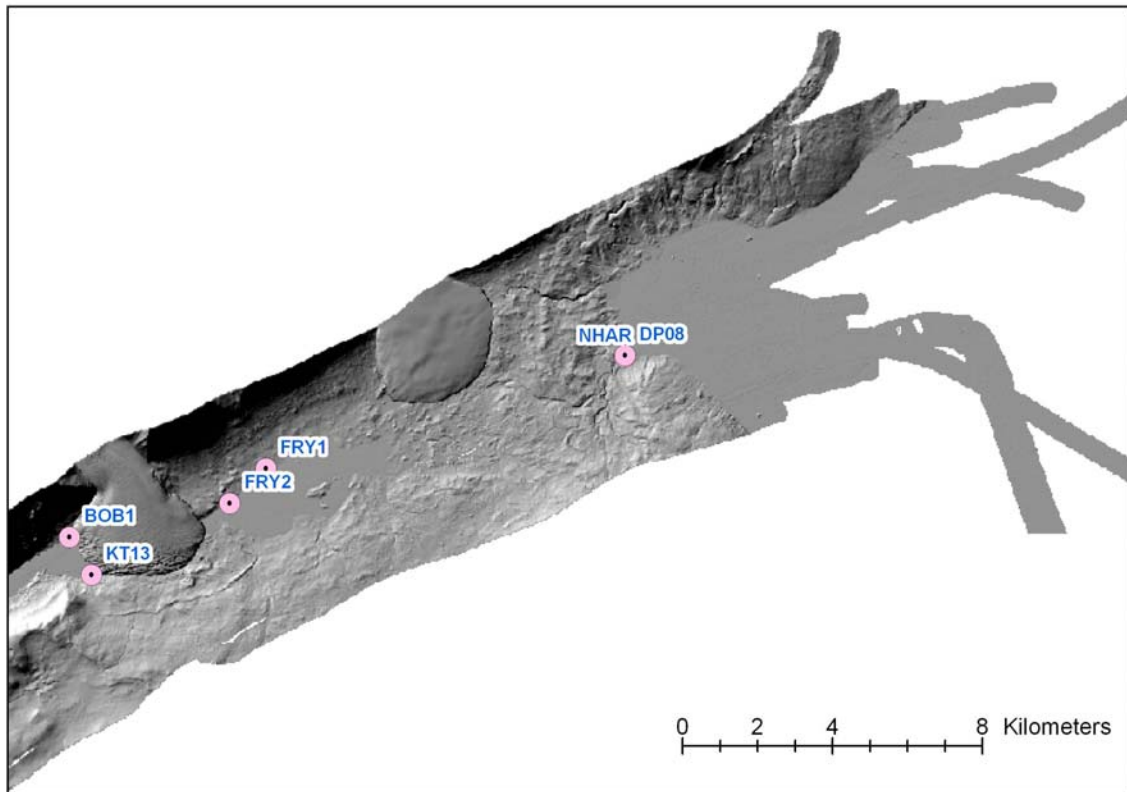
BONH_USGS_Glover, Lake Bonney Helo pad NE corner, site sketch



10 Taylor and Pearse Valleys

10b Taylor Valley, East

10b.1 Site information



10b.2 DEM information

File names		taylor_east_atm_2001_dem_v5.tif taylor_east_atm_2001_dem_v5.tfw Inlier_taylor_east_v5.zip Outlier_taylor_east_v5.zip taylor_east_atm_2001_label_v5.tif taylor_east_atm_2001_label_v5.tfw
Project size [rows × columns]		15,004 × 10,503
DEM resolution [meter]		2 by 2
Total number of laser points		55,255,897
Number of laser outliers		799,625
Number of valid laser points		54,456,272
Number of valid grid points		47,362,986
Point density [points/m ²]		0.29
DEM Corner points	Upper left X and Y [meter]	20,000 56,004
	Lower right X and Y [meter]	50,006 35,000
	Upper left Lat(S), Long(E) [degree]	77.496972 162.827452
	Lower right Lat(S), Long(E) [degree]	77.678390 164.099277
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:29:49.099 162:49:38.827
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:40:42.204 164:05:57.397

10 Taylor and Pearse Valleys

10b.3 Accuracy measured with GPS check points

10b.3.1 Check point comparison

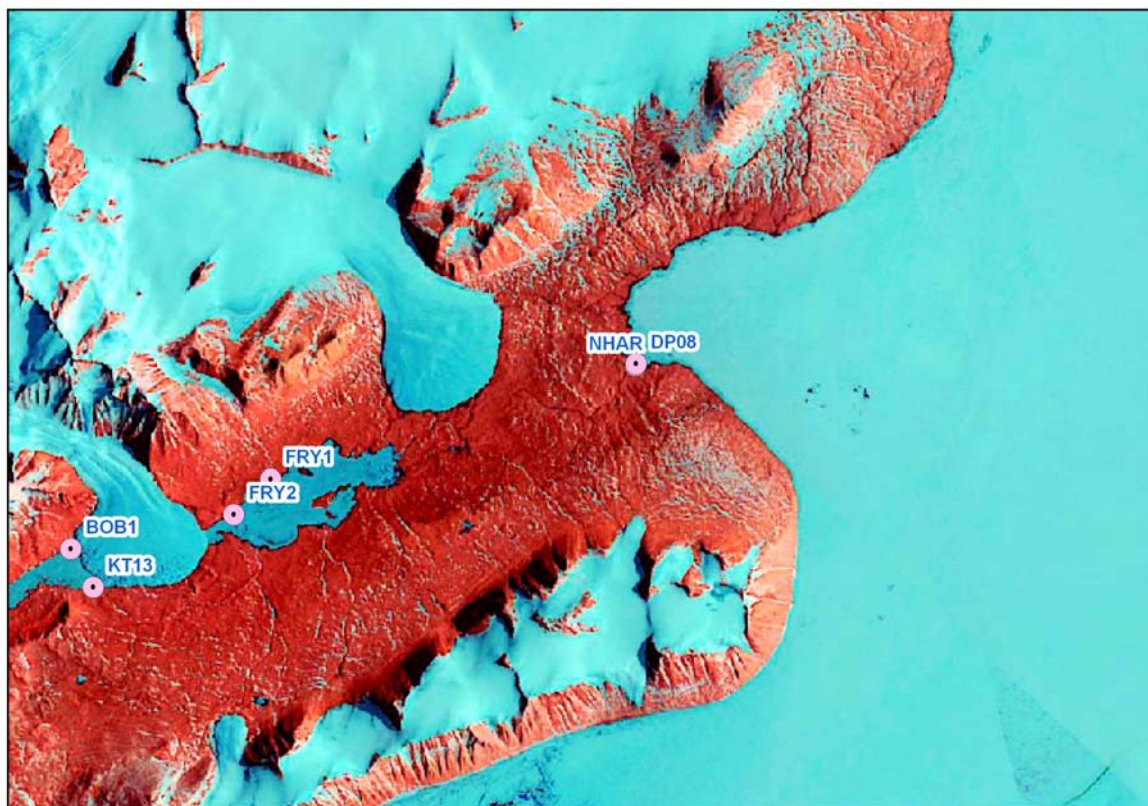
GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
NHAR	USGS_Glover	36,457.2	46,653.6	77.577778 S	163.518118 E	-47.71	(2.56)	New Harbor Hut NE corner of N building, [2]
BOB1	UNAVCO	21,653.2	41,849.5	77.623554 S	162.904883 E	20.12	0.04	
DP08	UNAVCO	36,460.5	46,701.5	77.577348 S	163.518203 E	-51.80	(0.47)	drill stem
FRY1	UNAVCO	26,883.6	43,678.7	77.606357 S	163.12195 E	-36.73	0.33	
FRY2	UNAVCO	25,918.6	42,747.1	77.614865 S	163.082405 E	-35.51	0.03	
KT13	UNAVCO	22,231.6	40,844.5	77.632476 S	162.929719 E	27.33	(-0.07)	large boulder

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation.

[2] Accuracy better than or equal to 8 cm with 95% confidence

10b.3.2 Landsat TM imagery with locations of GPS sites



0 2 4 8 Kilometers

10 Taylor and Pearse Valleys

10b.3.3 GPS site documentation

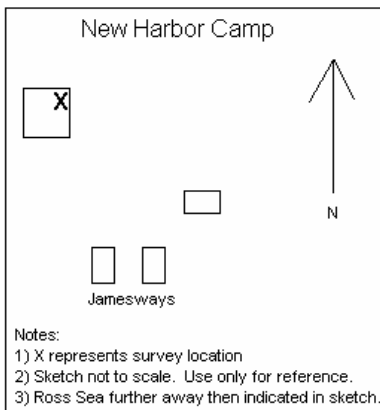
BOB1_UNAVCO (left): http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/bob1.html
DP08_UNAVCO (right): http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/dp08.html



KT13_UNAVCO: http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/kt13.html



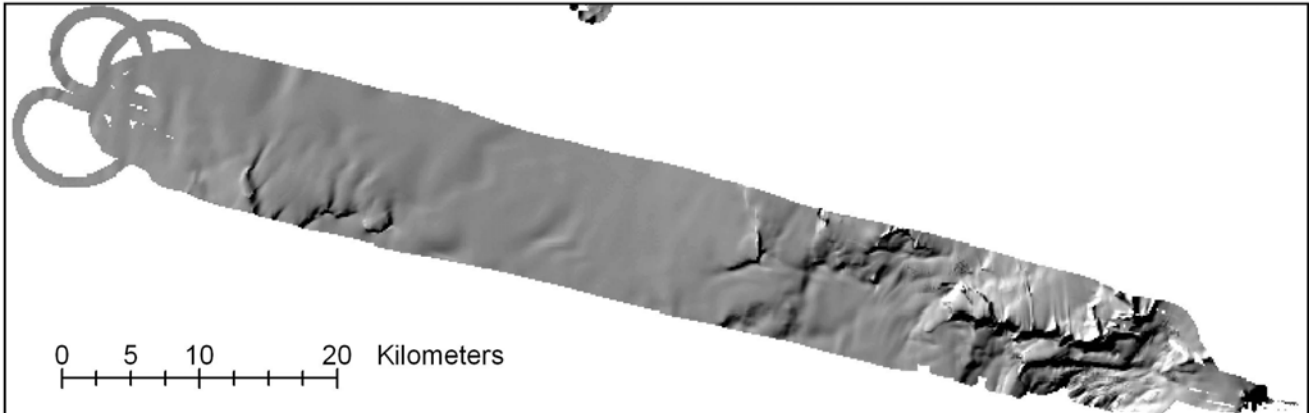
NHAR_USGS_Glover, New Harbor Hut, NE corner of northernmost building, site sketch



11 Radian Glacier - Portal

11 Radian Glacier - Portal

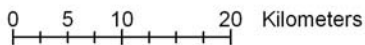
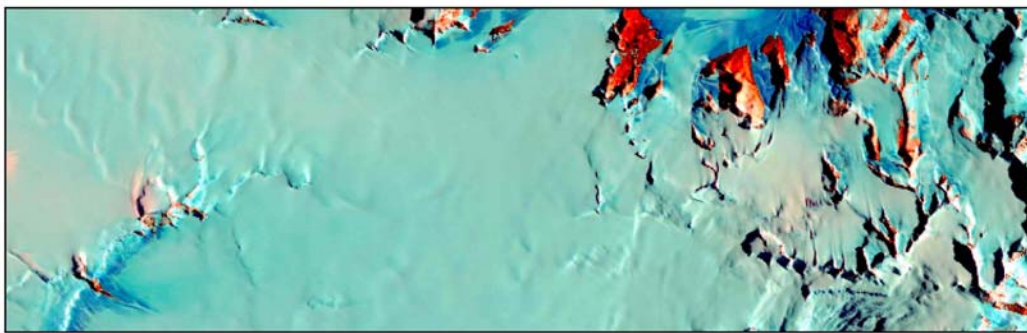
11.1 Site information



11.2 DEM information

File names		radian_atm_2001_dem_v5.tif radian_atm_2001_dem_v5.tfw Inlier_radian_v5.zip Outlier_radian_v5.zip radian_atm_2001_label_v5.tif radian_atm_2001_label_v5.tfw
Project size [rows × columns]		23,753 × 7,504
DEM resolution [meter]		4 by 4
Total number of laser points		91,720,026
Number of laser outliers		1,452,734
Number of valid laser points		90,267,292
Number of valid grid points		52,190,574
Point density [points/m ²]		0.11
DEM Corner points	Upper left X and Y [meter]	-78,004 5,004
	Lower right X and Y [meter]	17,004 -25,008
	Upper left Lat(S), Long(E) [degree]	77.935209 158.655576
	Lower right Lat(S), Long(E) [degree]	77.223083 162.746213
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:56:06.752 158:39:20.074
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:13:23.099 162:44:46.367

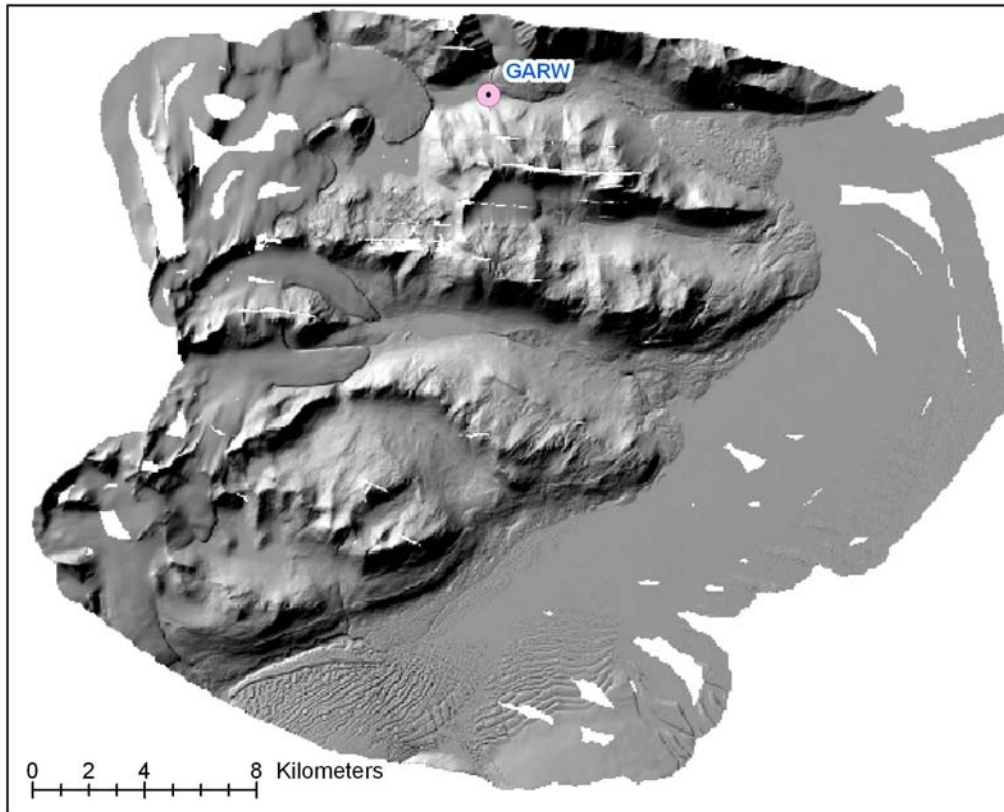
11.3 Landsat TM imagery



12 Denton Hills

12 Denton Hills

12.1 Site information



12.2 DEM information

File names		dentont_atm_2001_dem_v5.tif denton_atm_2001_dem_v5.tfw Inlier_dental_v5.zip Outlier_dental_v5.zip denton_atm_2001_label_v5.tif denton_atm_2001_label_v5.tfw
Project size [rows × columns]		9,003 × 7,252
DEM resolution [meter]		4 by 4
Total number of laser points		93,194,326
Number of laser outliers		1,205,898
Number of valid laser points		91,988,428
Number of valid grid points		41,922,072
Point density [points/m ²]		0.14
DEM Corner points	Upper left X and Y [meter]	26,996 0
	Lower right X and Y [meter]	63,004 -29,004
	Upper left Lat(S), Long(E) [degree]	77.997599 153.162826
	Lower right Lat(S), Long(E) [degree]	78.246498 164.771284
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:59:51.356 153:09:46.174
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	78:14:47.393 164:46:16.622

12 Denton Hills

12.3 Accuracy measured with GPS check points

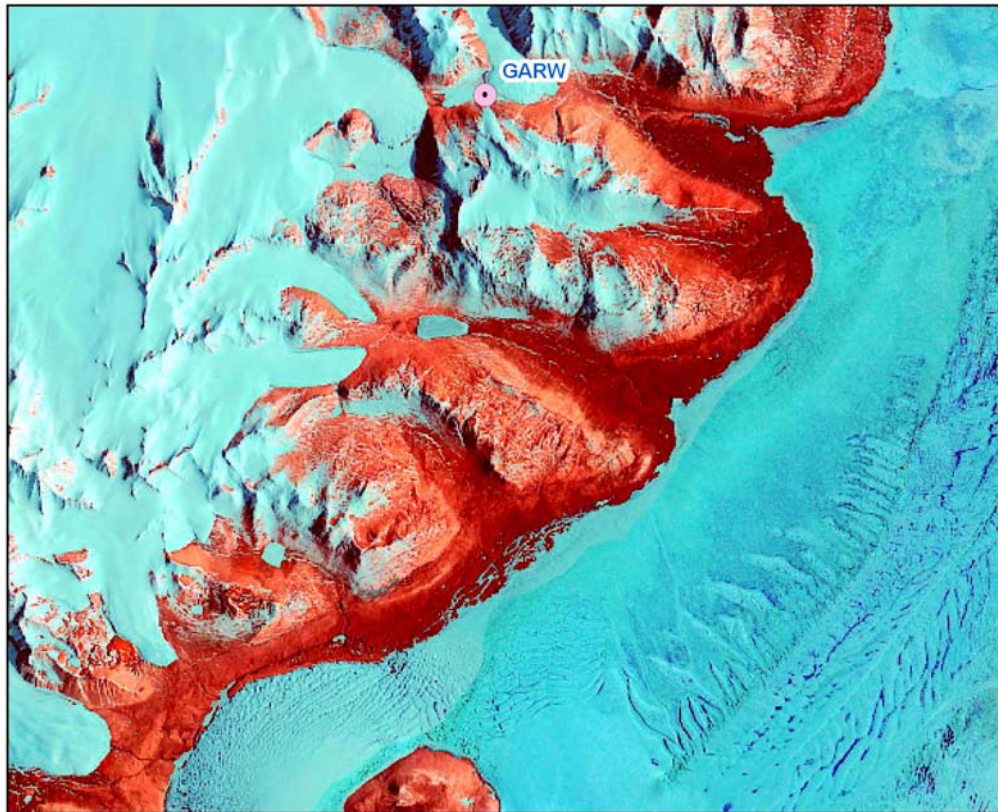
12.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
GARW	USGS_Glover	44,187.7	-3,214.6	78.022354 S	163.907427 E	299.92	0.21	Garwood Valley, [2]

Δh = GPS elevation – interpolated DEM elevation

[2] Accuracy better than or equal to 8 cm with 95% confidence

12.3.2 Landsat TM imagery with location of GPS site

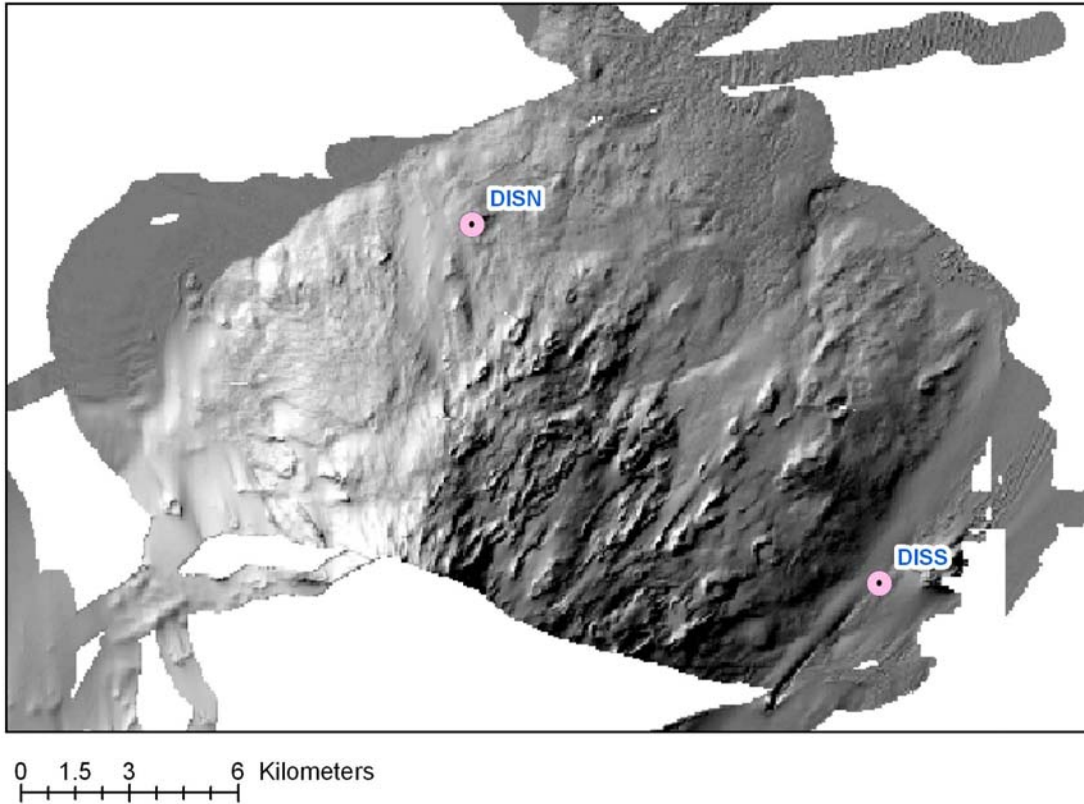


0 2 4 8 Kilometers

13 Mount Discovery

13 Mount Discovery

13.1 Site information



13.2 DEM information

File names		discovery_atm_2001_dem_v5.tif discovery_atm_2001_dem_v5.tfw Inlier_discovery_v5.zip Outlier_discovery_v5.zip discovery_atm_2001_label_v5.tif discovery_atm_2001_label_v5.tfw
Project size [rows × columns]		7,503 × 5,003
DEM resolution [meter]		4 by 4
Total number of laser points		60,835,733
Number of laser outliers		2,793,793
Number of valid laser points		58,041,940
Number of valid grid points		23,267,718
Point density [points/m ²]		0.16
DEM Corner points	Upper left X and Y [meter]	56,997 -27,000
	Lower right X and Y [meter]	87,004 -47,008
	Upper left Lat(S), Long(E) [degree]	78.230985 164.503591
	Lower right Lat(S), Long(E) [degree]	78.395348 165.876664
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	78:13:51.546 164:30:12.928
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	78:23:43.253 165:52:35.990

13 Mount Discovery

13.3 Accuracy measured with GPS check points

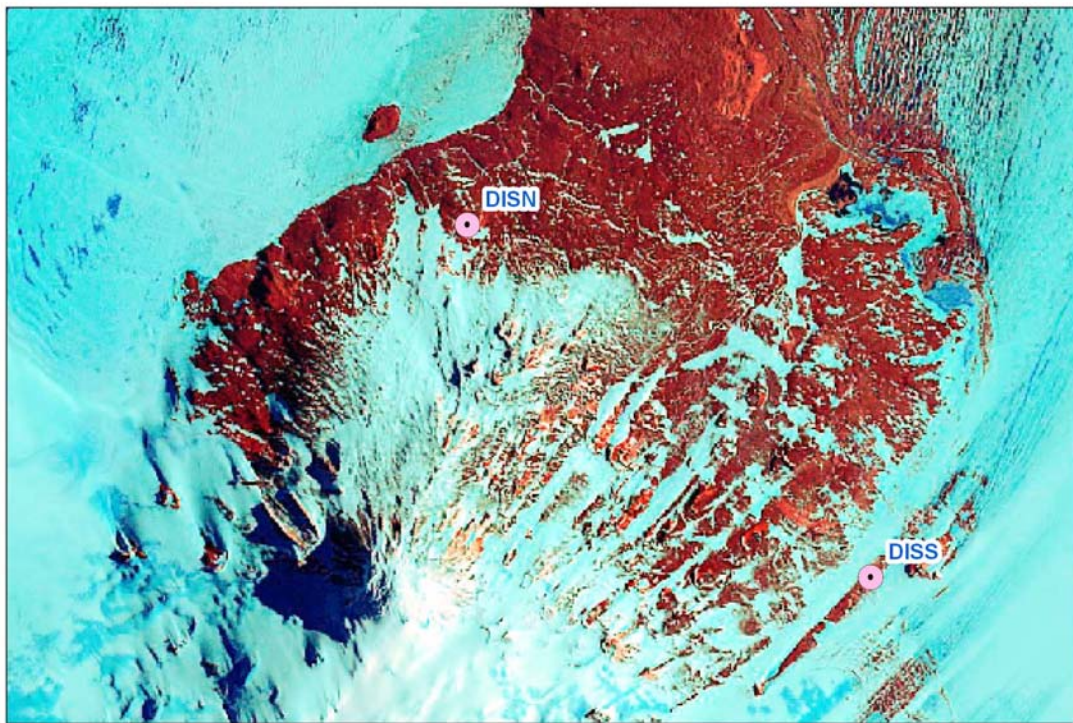
13.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
DISN	USGS_Glover	69,874.6	-33,059.8	78.279715 S	165.082347 E	354.31	-0.33	[2]
DISS	USGS_Glover	81,131.8	-42,911.0	78.362075 S	165.60448 E	-3.78	-0.34	[2]

Δh = GPS elevation – interpolated DEM elevation

[2] Accuracy better than or equal to 8 cm with 95% confidence

13.3.2 Landsat TM imagery with locations of GPS sites

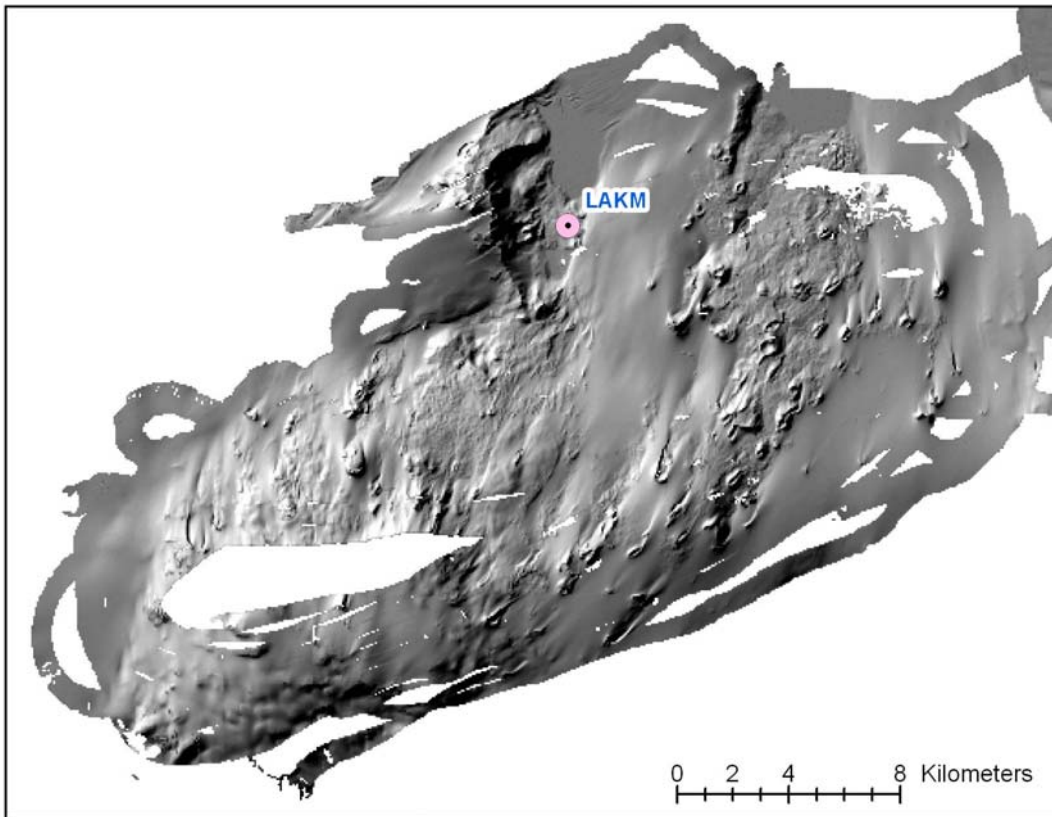


0 1.5 3 6 Kilometers

14 Mount Morning

14 Mount Morning

14.1 Site information



14.2 DEM information

File names		morning_atm_2001_dem_v5.tif morning_atm_2001_dem_v5.tfw Inlier_morning_v5.zip Outlier_morning_v5.zip morning_atm_2001_label_v5.tif morning_atm_2001_label_v5.tfw
Project size [rows × columns]		19,002 × 14,503
DEM resolution [meter]		2 by 2
Total number of laser points		98,738,082
Number of laser outliers		6,314,320
Number of valid laser points		92,423,762
Number of valid grid points		125,803,866
Point density [points/m ²]		0.18
DEM Corner points	Upper left X and Y [meter]	21,998 -35,000
	Lower right X and Y [meter]	60,000 -64,004
	Upper left Lat(S), Long(E) [degree]	78.311937 162.972617
	Lower right Lat(S), Long(E) [degree]	78.560976 164.710536
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	78:18:42.973 162:58:21.421
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	78:33:39.514 164:42:37.930

14 Mount Morning

14.3 Accuracy measured with GPS check points

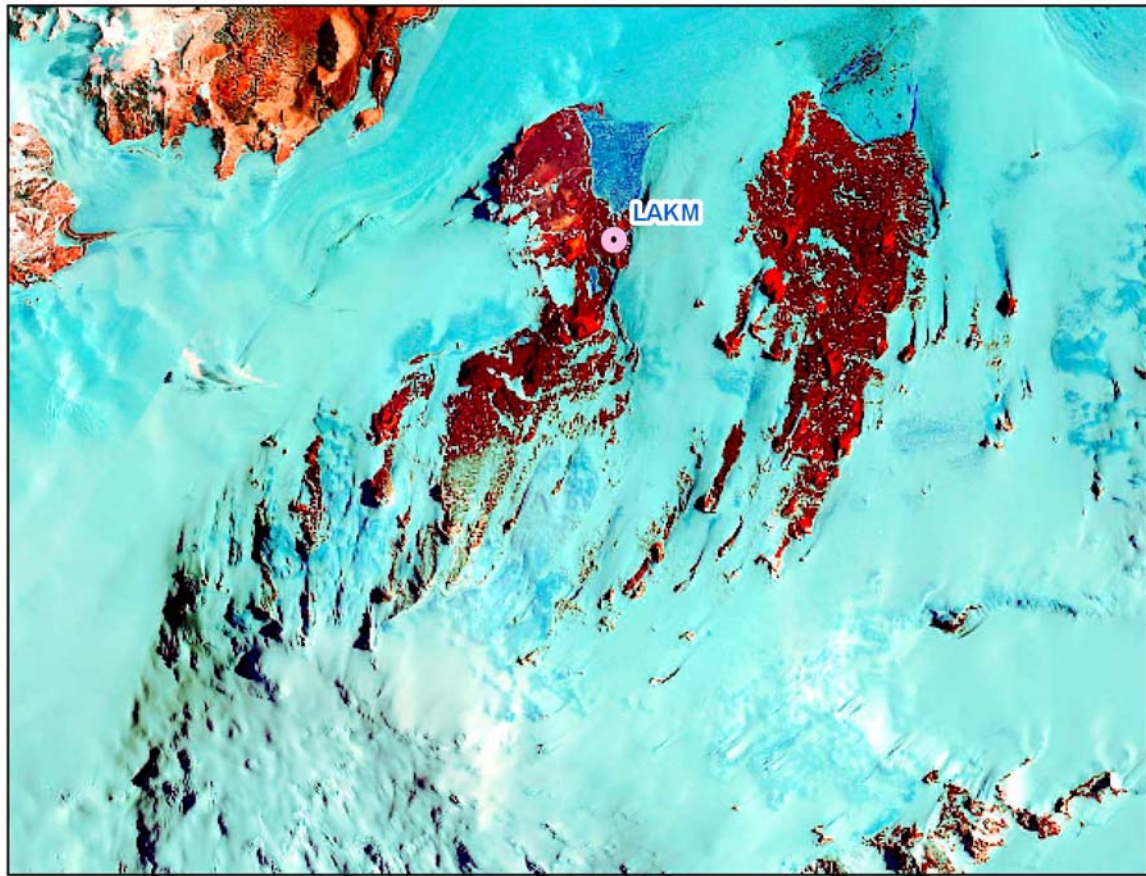
14.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
LAKM	USGS_Glover	42,200.7	-42,813.9	78.377521 S	163.876462 E	464.80	-0.35	Lake Morning, [3]

Δh = GPS elevation – interpolated DEM elevation

[3] Accuracy better than or equal to 20 cm with 95% confidence

14.3.2 Landsat TM imagery with locations of GPS sites

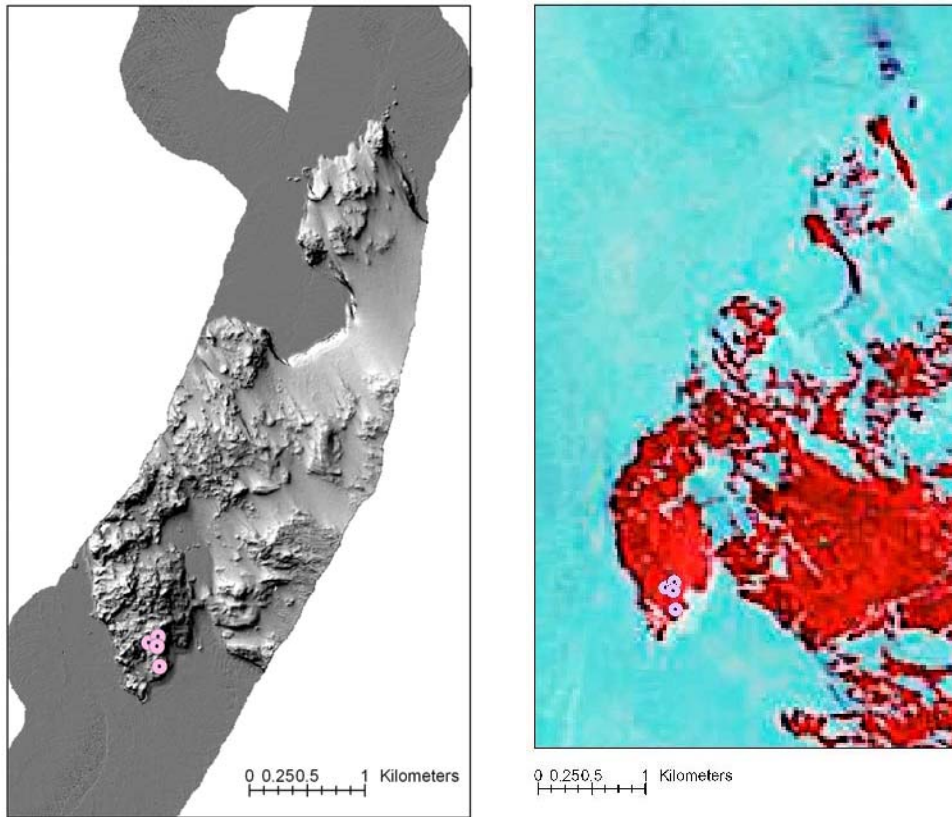


0 2 4 8 Kilometers

15 Cape Royds Rockery

15 Cape Royds Rockery

15.1 Site information and Landsat TM imagery with locations of GPS sites



15.2 DEM information

File names		royds_atm_2001_dem_v5.tif royds_atm_2001_dem_v5.tfw Inlier_royds_v5.zip Outlier_royds_v5.zip royds_atm_2001_label_v5.tif royds_atm_2001_label_v5.tfw
Project size [rows × columns]		2,003 × 3,502
DEM resolution [meter]		2 by 2
Total number of laser points		1,606,060
Number of laser outliers		4,349
Number of valid laser points		1,601,711
Number of valid grid points		3,523,294
Point density [points/m ²]		0.11
DEM Corner points	Upper left X and Y [meter]	99,008 51,998
	Lower right X and Y [meter]	103,012 44,996
	Upper left Lat(S), Long(E) [degree]	77.503058 166.101397
	Lower right Lat(S), Long(E) [degree]	77.563064 166.287882
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:30:11.009 166:06:05.029
Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:33:47.030 166:17:16.375	

15 Cape Royds

15.3 Accuracy measured with GPS check points

15.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
ROY0	TAMDEF	100,291.1	46,479.2	77.551569 S	166.170625 E	-28.03	0.67	
ROY1	TAMDEF	100,220.0	46,509.8	77.55134 S	166.167586 E	-24.73	0.74	
ROY2	TAMDEF	100,301.1	46,563.0	77.550813 S	166.170788 E	-20.59	1.35	
ROY3	TAMDEF	100,315.0	46,303.3	77.553125 S	166.172136 E	-29.69	1.22	
ROY0	USGS_C	100,290.9	46,479.4	77.551567 S	166.170616 E	-29.62	(-0.92)	Same as site ROY0_TAMDEF

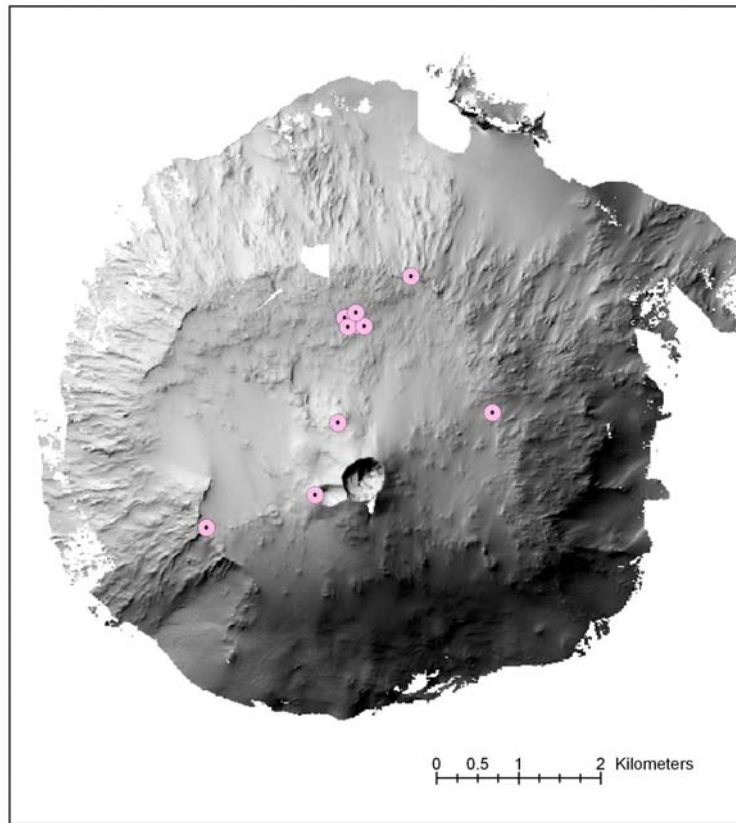
Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

16 Mount Erebus

16 Mount Erebus

16.1 Site information



16.2 DEM information

File names		erebus_atm_2001_dem_v5.tif erebus_atm_2001_dem_v5.tfw Inlier_erebus_v5.zip Outlier_erebus_v5.zip erebus_atm_2001_label_v5.tif erebus_atm_2001_label_v5.tfw
Project size [rows × columns]		4,504 × 5,004
DEM resolution [meter]		2 by 2
Total number of laser points		11,677,163
Number of laser outliers		565,465
Number of valid laser points		11,111,698
Number of valid grid points		10,967,004
Point density [1/m ²]		0.25
DEM Corner points	Upper left X and Y [meter]	120,010 52,996
	Lower right X and Y [meter]	129,016 42,990
	Upper left Lat(S), Long(E) [degree]	77.479595 166.964106
	Lower right Lat(S), Long(E) [degree]	77.561784 167.372491
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:28:46.542 166:57:50.782
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:33:42.422 167:22:20.968

16 Mount Erebus

16.3 Accuracy measured with GPS check points

16.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
conz	TAMDEF	122,404.5	46,629.1	77.534591 S	167.085474 E	3,402.85	0.07	
ere1	TAMDEF	124,131.7	49,076.3	77.511399 S	167.147949 E	3,361.37	1.11	
ere2	TAMDEF	124,330.8	49,084.6	77.511168 S	167.156134 E	3,355.62	0.46	
ere3	TAMDEF	124,230.8	49,251.6	77.509756 S	167.1514 E	3,348.68	1.67	
ELHT	UNAVCO	124,095.6	49,186.0	77.510448 S	167.146064 E	3,347.31	0.39	
CONZ	Bartel_Hallam	122,404.4	46,629.2	77.53459 S	167.085466 E	3,401.39	(-1.39)	same as site conz TAMDEF
E1GP	Bartel_Hallam	123,734.0	47,027.0	77.530001 S	167.13898 E	3,648.85	(-0.58)	
EAST	Bartel_Hallam	125,898.1	48,025.5	77.519377 S	167.224697 E	3,390.42	(-0.13)	
ELHT	Bartel_Hallam	124,095.4	49,186.0	77.510448 S	167.146055 E	3,345.80	(-1.10)	same as site ELHT UNAVCO
ERE0	Bartel_Hallam	124,266.8	49,094.4	77.511131 S	167.153458 E	3,355.30	(-0.93)	
ERE1	Bartel_Hallam	124,131.6	49,076.4	77.511398 S	167.147948 E	3,359.90	(-0.34)	same as site ere1 TAMDEF
ERE2	Bartel_Hallam	124,330.6	49,084.8	77.511166 S	167.156124 E	3,354.05	(-1.07)	same as site ere2 TAMDEF
ERE3	Bartel_Hallam	124,230.6	49,251.6	77.509756 S	167.151395 E	3,347.07	(0.11)	same as site ere3 TAMDEF
HELZ	Bartel_Hallam	124,903.9	49,696.8	77.505252 S	167.177541 E	3,299.90	(-1.13)	
NAUS	Bartel_Hallam	124,008.6	47,903.9	77.521959 S	167.147133 E	3,570.62	(-0.58)	

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

16 Mount Erebus

16.3.2 Landsat TM imagery with locations of GPS sites



16.3.3 GPS site documentation

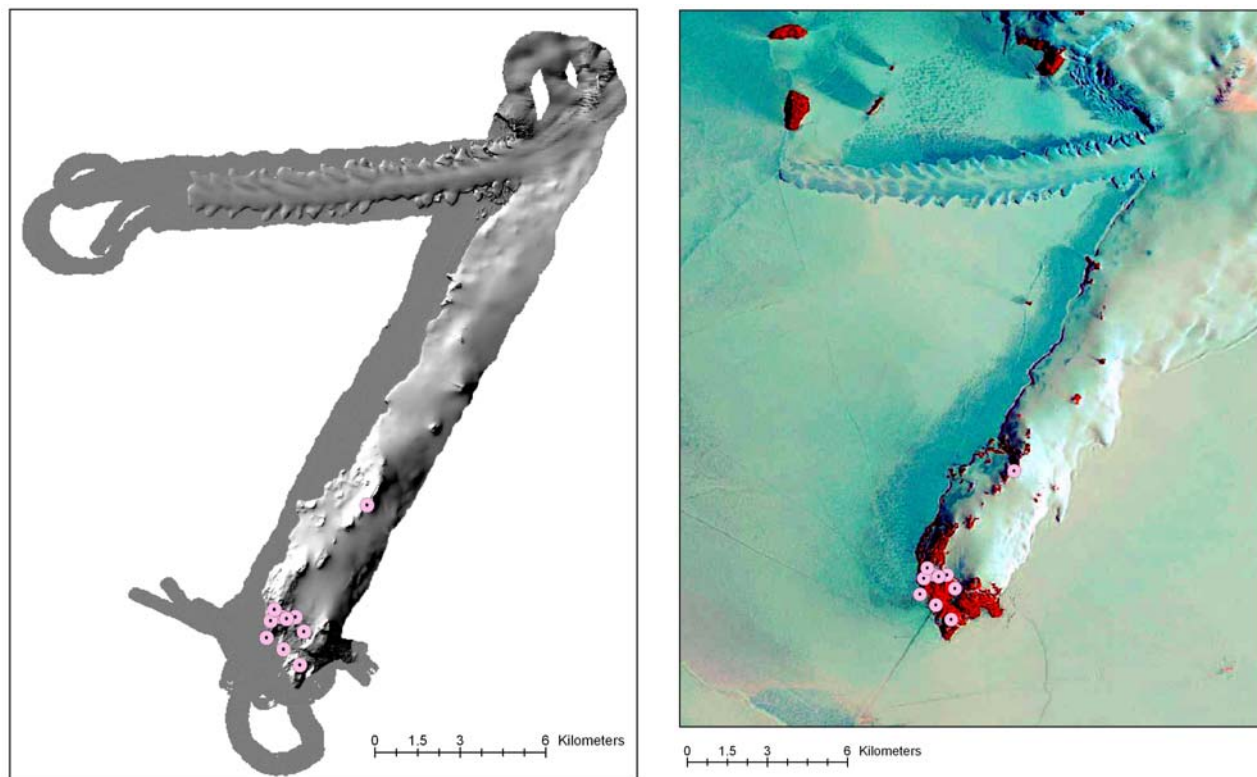
ELHT_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/elht.html



17 Hut Point Peninsula and Erebus Ice Tongue

17 Hut Point Peninsula and Erebus Ice Tongue

17.1 Site information and Landsat TM imagery with locations of GPS sites



17.2 DEM information

File names		hutpoint_atm_2001_dem_v5.tif hutpoint_atm_2001_dem_v5.tfw Inlier_hutpoint_v5.zip Outlier_hutpoint_v5.zip hutpoint_atm_2001_label_v5.tif hutpoint_atm_2001_label_v5.tfw
Project size [rows × columns]		11,005 × 13,504
DEM resolution [meter]		2 by 2
Total number of laser points		31,259,104
Number of laser outliers		2,312,206
Number of valid laser points		28,946,898
Number of valid grid points		36,384,084
Point density [points/m ²]		0.20
DEM Corner points	Upper left X and Y [meter]	100,004 34,996
	Lower right X and Y [meter]	122,012 7,990
	Upper left Lat(S), Long(E) [degree]	77.654372 166.192852
	Lower right Lat(S), Long(E) [degree]	77.879747 167.211728
	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:39:15.739 166:11:34.267
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:33:42.422 167:12:42.221

17 Hut Point Peninsula and Erebus Ice Tongue

17.3 Accuracy measured with GPS check points

17.3.1 Check point comparison

GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
		X[m]	Y[m]	Lat[°]	Long[°]			
arr0	TAMDEF	109,590.7	13,724.5	77.837922 S	166.664065 E	95.24	1.00	
arr1	TAMDEF	109,506.2	13,735.7	77.837882 S	166.660446 E	89.22	1.15	
arr2	TAMDEF	110,024.9	13,726.5	77.837594 S	166.682459 E	106.66	0.86	
arr3	TAMDEF	109,152.7	13,594.1	77.839398 S	166.645939 E	78.90	0.36	
arr4	TAMDEF	109,280.2	13,982.2	77.835841 S	166.650038 E	97.58	0.77	
arr5	TAMDEF	110,322.0	13,207.4	77.842017 S	166.696817 E	69.70	0.80	
arr6	TAMDEF	109,005.3	12,997.7	77.844829 S	166.641701 E	-35.26	(2.19) 0.39*	1.8 meter high concrete pier
arr7	TAMDEF	112,527.6	17,638.6	77.80085 S	166.774959 E	354.24	0.36	
arr8	TAMDEF	110,168.2	12,043.5	77.852522 S	166.694258 E	164.40	1.77	
CRAR	UNAVCO	109,598.7	12,590.7	77.848042 S	166.668242 E	-19.94	(6.61)	On appr. 3 meter tall mast above Crary laboratory, McMurdo
ARR6	Bartel_Hallam	109,005.1	12,997.9	77.844828 S	166.641692 E	-36.73	(0.74)	same as site arr6_TAMDEF
mcm4	TAMDEF	109,710.3	13,667.1	77.838349 S	166.669326 E	98.01	0.31	
MCM4	UNAVCO	109,710.3	13,667.1	77.838349 S	166.669326 E	97.96	(0.26)	Same as site mcm4_TAMDEF
MCM4	Bartel_Hallam	109,710.1	13,667.3	77.838348 S	166.669318 E	96.55	(-1.16)	Same as site mcm4_TAMDEF

Δh = GPS elevation – interpolated DEM elevation

Elevations in brackets are not used for accuracy assessment – see report for explanation

* corrected to obtain height of topographic surface

17.3.3 GPS site documentation

CRAR_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/crar.html



17 Hut Point Peninsula and Erebus Ice Tongue

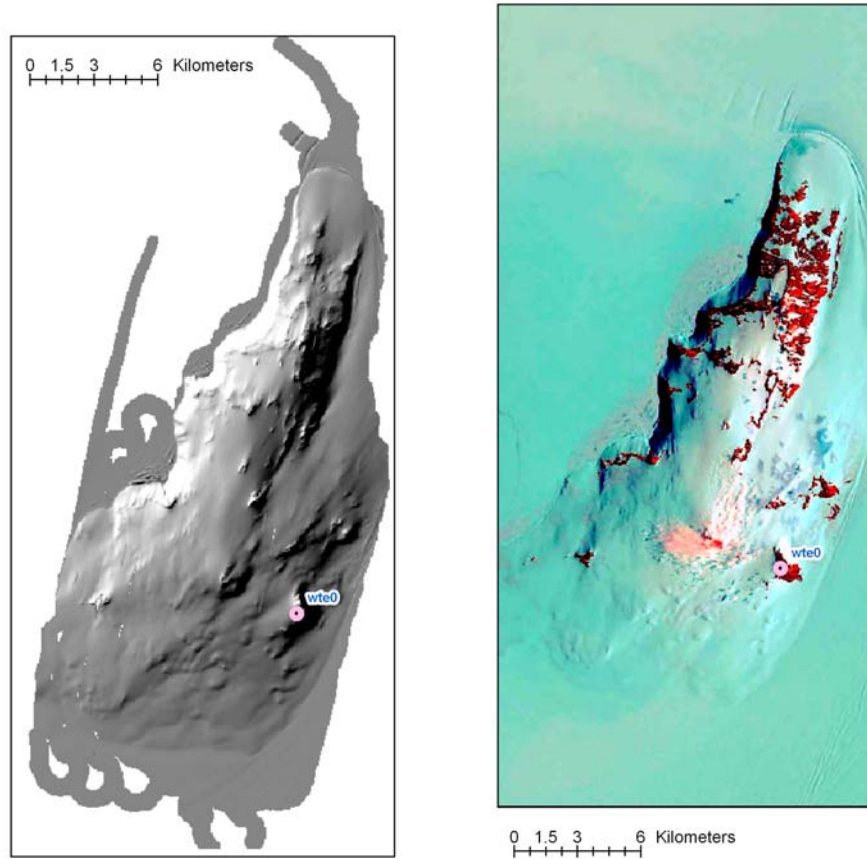
MCM4_UNAVCO http://www.unavco.org/facility/project_support/polar/geodetic_main/geodetic/sites/mcm4.html



18 White Island

18 White Island

18.1 Site information and Landsat TM imagery with locations of GPS sites



18.2 DEM information

File names		white_atm_2001_dem_v5.tif white_atm_2001_dem_v5.tfw Inlier_white_v5.zip Outlier_white_v5.zip white_atm_2001_label_v5.tif white_atm_2001_label_v5.tfw
Project size [rows × columns]		4,504 × 9,628
DEM resolution [meter]		4 by 4
Total number of laser points		42,512,886
Number of laser outliers		39,440
Number of valid laser points		42,473,446
Number of valid grid points		21,144,348
Point density [points/m ²]		0.13
DEM Corner points	Upper left X and Y [meter]	111,996 -8
	Lower right X and Y [meter]	130,008 -38,516
	Upper left Lat(S), Long(E) [degree]	77.958813 166.813909
	Lower right Lat(S), Long(E) [degree]	77.287899 167.745489

18 White Island

	Upper left Lat(S), Long(E) [dd:mm:ss.sss]	77:57:31.727	166:48:50.072
	Lower right Lat(S), Long(E) [dd:mm:ss.sss]	77:17:16.436	167:44:43.760

18.3 Accuracy measured with GPS check points

18.3.1 Check point comparison

	GPS Site Name	Source	LCC Projection		Geographic Coordinates		GCP Height [m]	Δh [m]	Comment
			X[m]	Y[m]	Lat[°]	Long[°]			
1	wte0	TAMDEF	125,404.0	-27,066.7	78.189747 S	167.495911 E	400.44	(1.09)	On boulder

$\Delta h = \text{GPS elevation} - \text{interpolated DEM elevation}$

18.3.3 GPS site documentation

wte0 <http://www.geology.ohio-state.edu/~willis/wteimages.htm>

