DEM Generation from the Antarctic LIDAR Data

SITE REPORT

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**Table of content:**

**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](mailto: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.
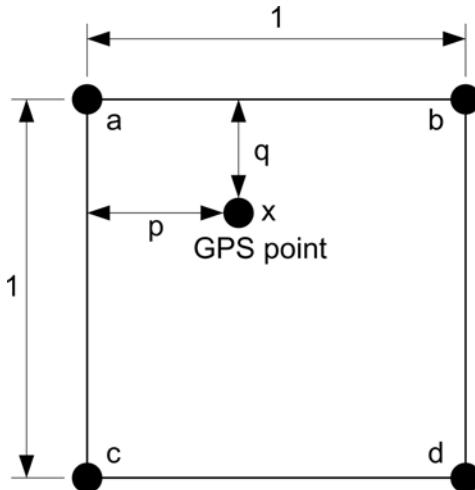


The elevation difference between GPS and interpolated DEM is defined by

Δh = GPS elevation – 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
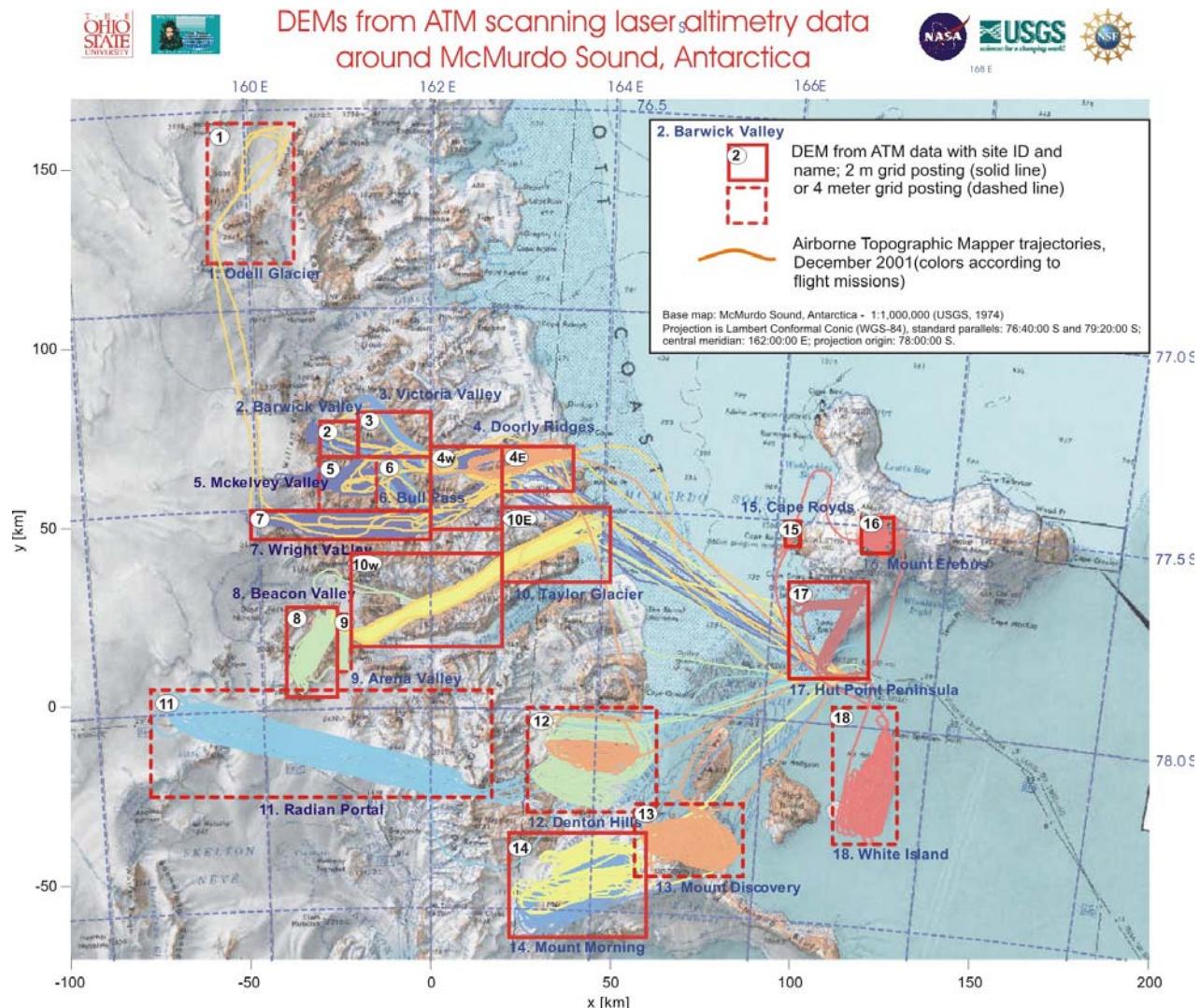


Table 1. List of sites linked to detailed site reports

| | DEM site 2m grid | | DEM site 4m grid |
|---|---|---|---|
| 2 | Barwick Valley | 1 | Odell Glacier |
| 3 | Victoria and Barwick Valleys | 11 | Radian Glacier  - Portal |
| 4 W, E | Mount Doorly Ridge<br>Victoria, Greenwood, Clark and Wright Valleys | 12 | Denton Hills |
| 5 | McKelvey and Balham Valleys | 13 | Mount Discovery |
| 6 | Bull Pass and Victoria Valley | 18 | White Island |
| 7 | Wright Valley | | |
| 8 | Beacon Valley | | |
| 9 | Arena Valley | | |
| 10 W, E | Taylor and Pearse Valleys | | |
| 14 | Mount Morning | | |
| 15 | Cape Royds Rockery | | |
| 16 | Mount Erebus | | |
| 17 | Hut Point Peninsula and Erebus Ice Tongue | | |

**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

## 1.1 Site information and Landsat TM imagery
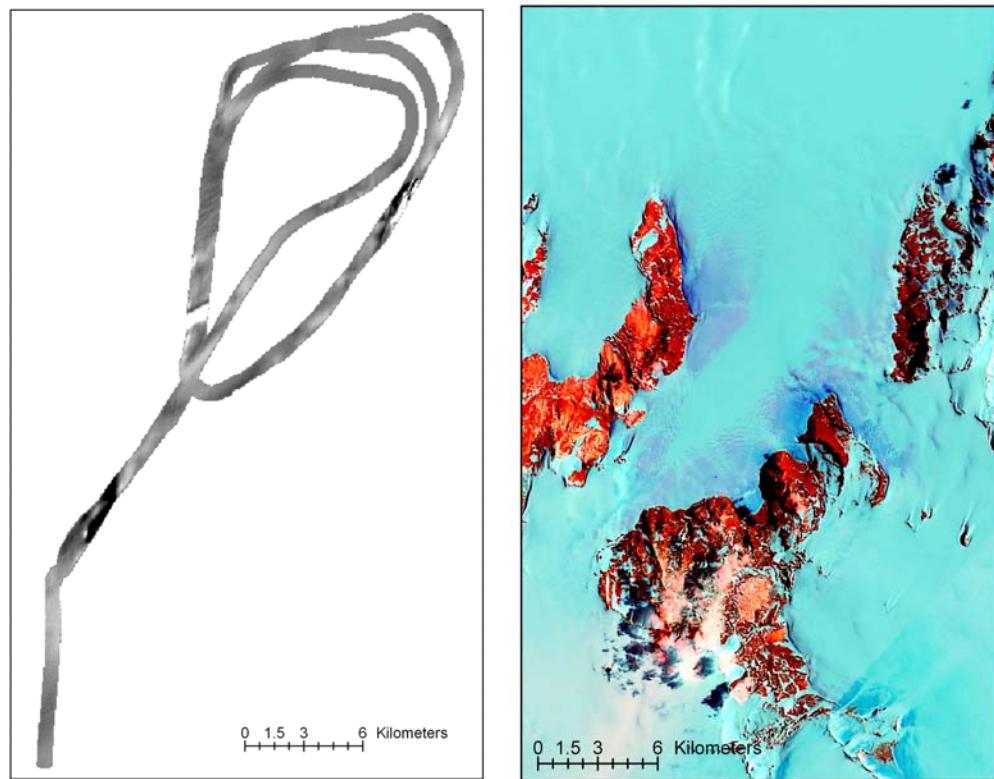


## 1.2 DEM information

| | | |
|---|---|---|
| File names | | Odell_atm_2001_dem_v5.tif<br>Odell _atm_2001_dem_v5.tfw<br>Inlier_odell_v5.zip<br>Outlier_odell_v5.zip<br>Odell _atm_2001_label_v5.tif<br>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**

2.1 Site information
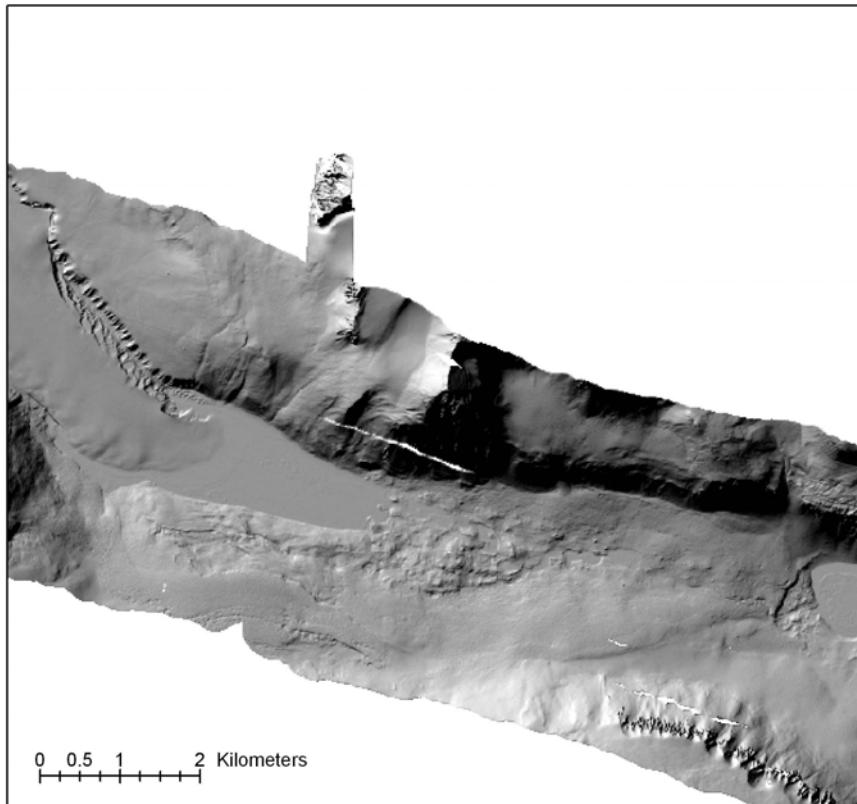


2.2 DEM information

| | | |
|---|---|---|
| File names | | barwick_atm_2001_dem_v5.tif<br>barwick_atm_2001_dem_v5.tfw<br>Inlier_barwick_v5.zip<br>Outlier_barwick_v5.zip<br>barwick_ATM_2001_Label_v5.tif<br>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 |

## 2.3 Landsat TM imagery
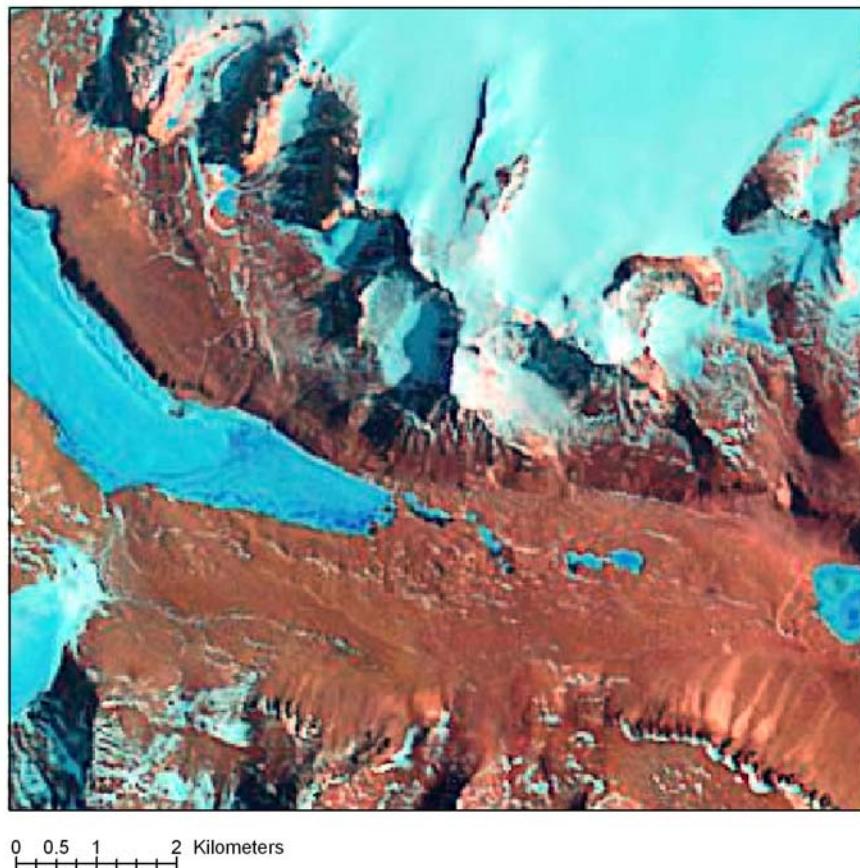


0   0.5   1          2   Kilometers

## 3. Victoria and Barwick Valleys

3.1 Site information



3.2 DEM information

| | | |
|---|---|---|
| File names | | victoria_atm_2001_dem_v5.tif<br>victoria_atm_2001_dem_v5.tfw<br>Inlier_victoria_v5.zip<br>Outlier_victoria_v5.zip<br>victoria_atm_2001_label_v5.tif<br>victoria_atm_2001_label_v5.tfw |
| Project size [rows × columns] | | $10,003 \times 6,253$ |
| 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 |

## 3.3 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

### 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

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

4a.1 Site information
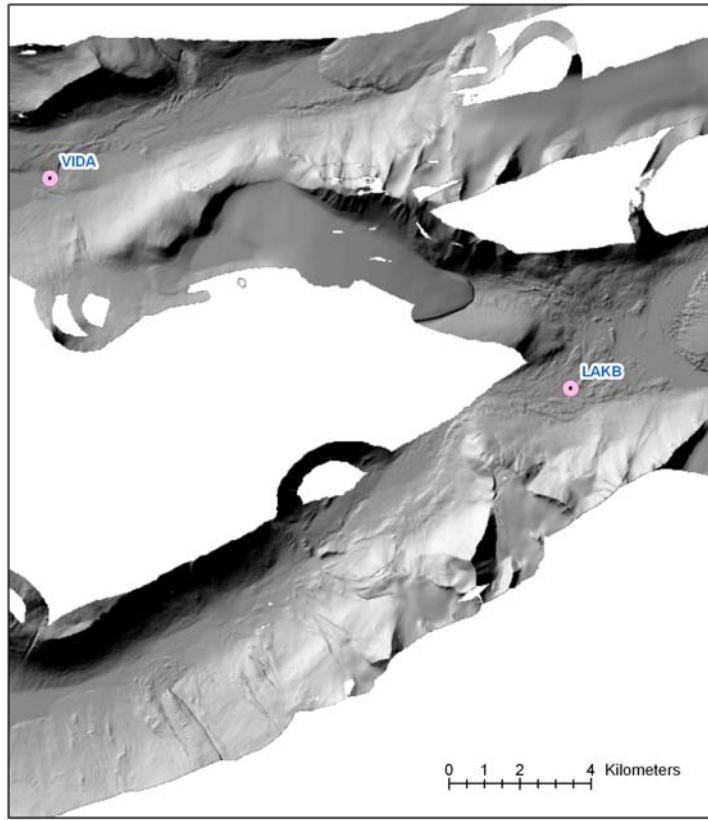


4a.2 DEM information

| | | |
|---|---|---|
| File names | Doorly_west_atm_2001_dem_v5.tif<br>Doorly_west _atm_2001_dem_v5.tfw<br>Inlier_doorly_west_v5.zip<br>Outlier_doorly_west_v5.zip<br>Doorly_west _atm_2001_label_v5.tif<br>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 |

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
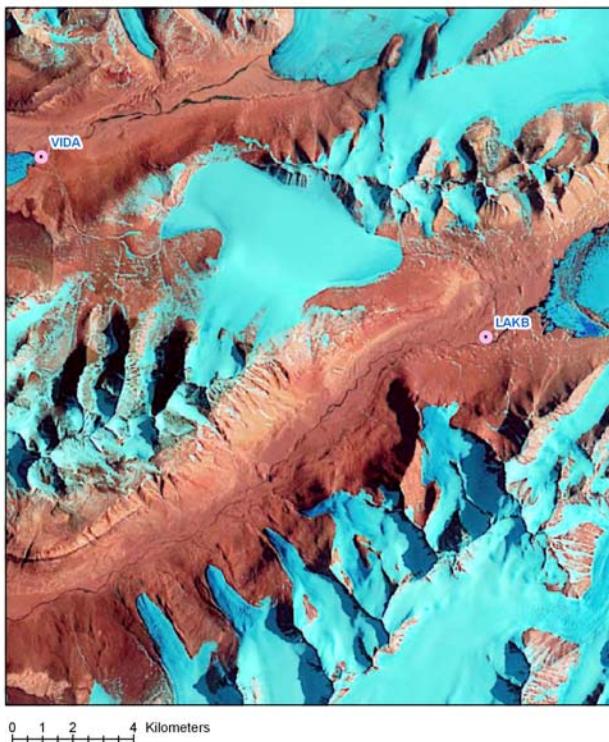


4a.3.3 GPS site documentation
LAKB_USGS_Glover, Lake Brownsworth Hut, true north corner, site sketch
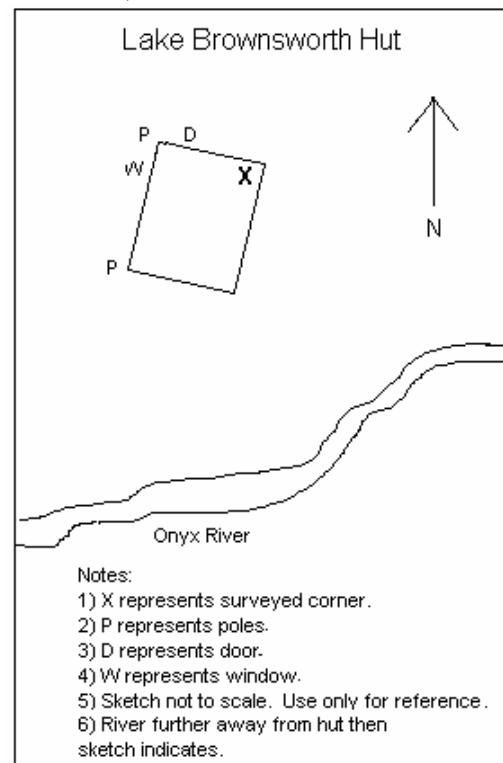
**4b Mount Doorly Ridge, East – Greenwood and Wright Valleys**

4b.1 Site information
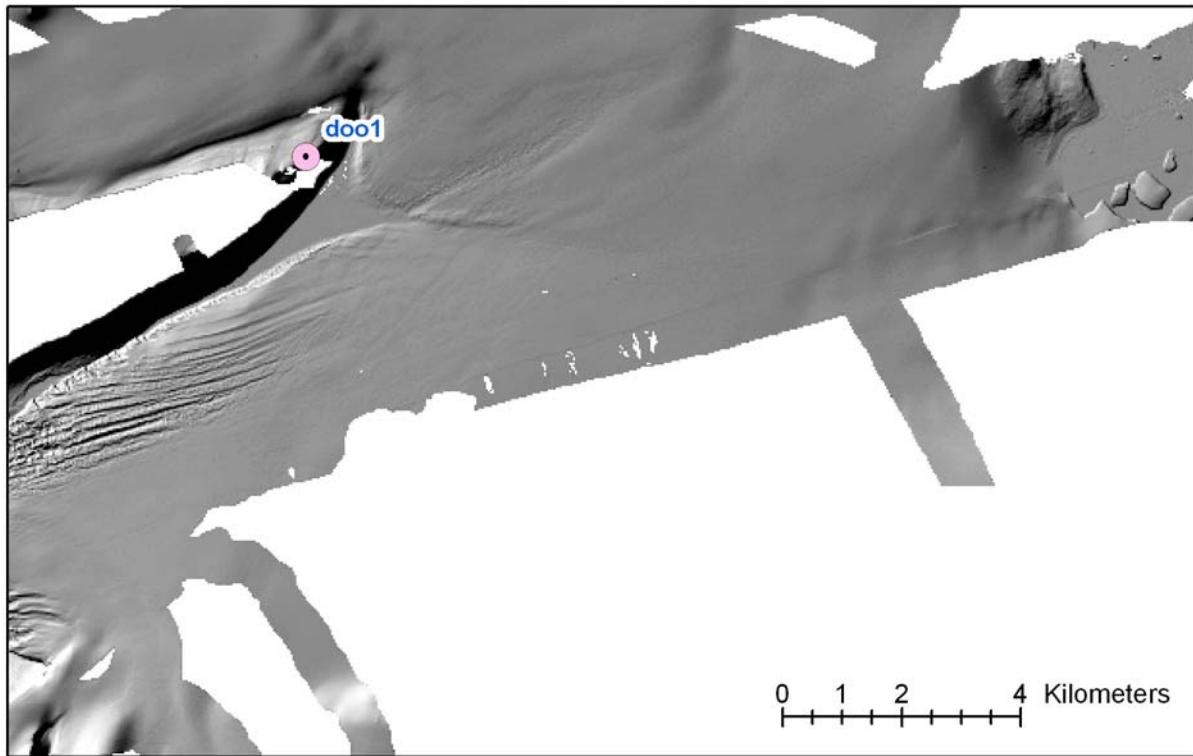


4b.2 DEM information

| | | |
|---|---|---|
| File names | Doorly_east_atm_2001_dem_v5.tif<br>Doorly_east _atm_2001_dem_v5.tfw<br>Inlier_doorly_east_v5.zip<br>Outlier_doorly_east_v5.zip<br>Doorly_east _atm_2001_label_v5.tif<br>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 |

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 | |

Δh = *GPS elevation – interpolated DEM elevation*

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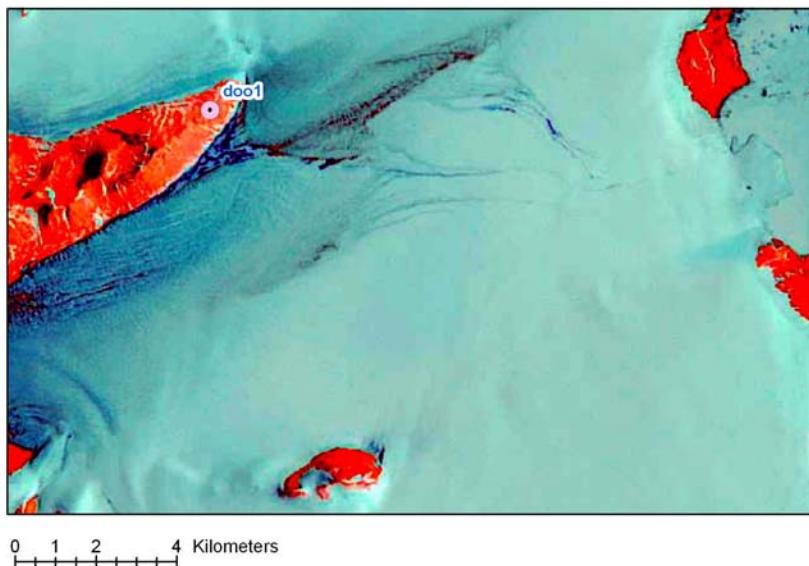


4b.3.3 GPS site documentation

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





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## 5 McKelvey and Balham Valleys

5.1 Site information
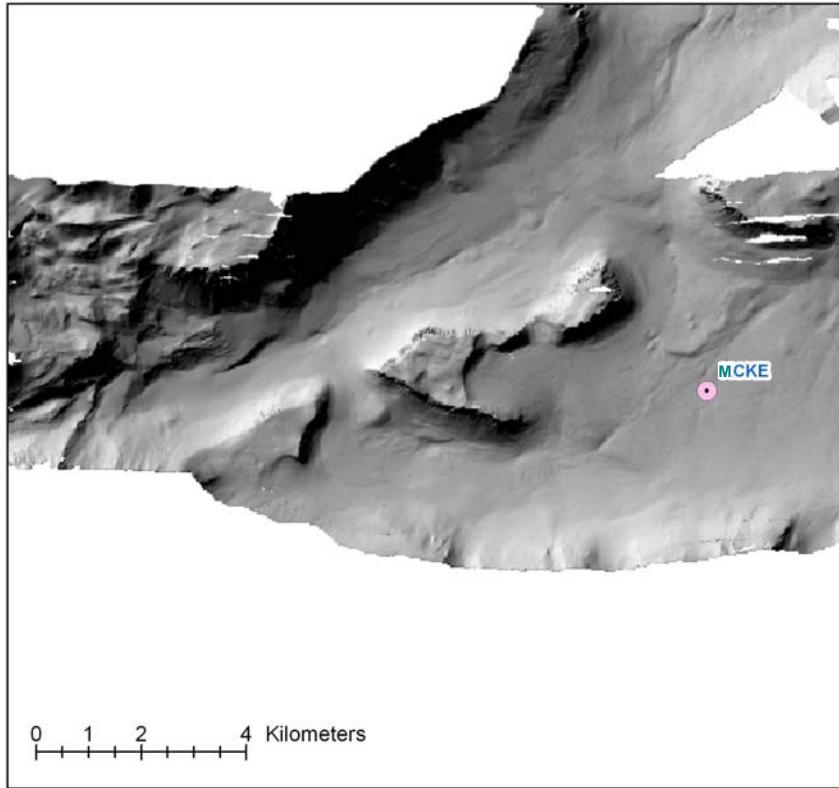


5.2 DEM information

| | | |
|---|---|---|
| File names | mckelvey_atm_2001_dem_v5.tif<br>mckelvey _atm_2001_dem_v5.tfw<br>Inlier_mckelvey_v5.zip<br>Outlier_mckelvey_v5.zip<br>mckelvey _atm_2001_label_v5.tif<br>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 |

## 5.3 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] |

Δh = *GPS elevation – 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
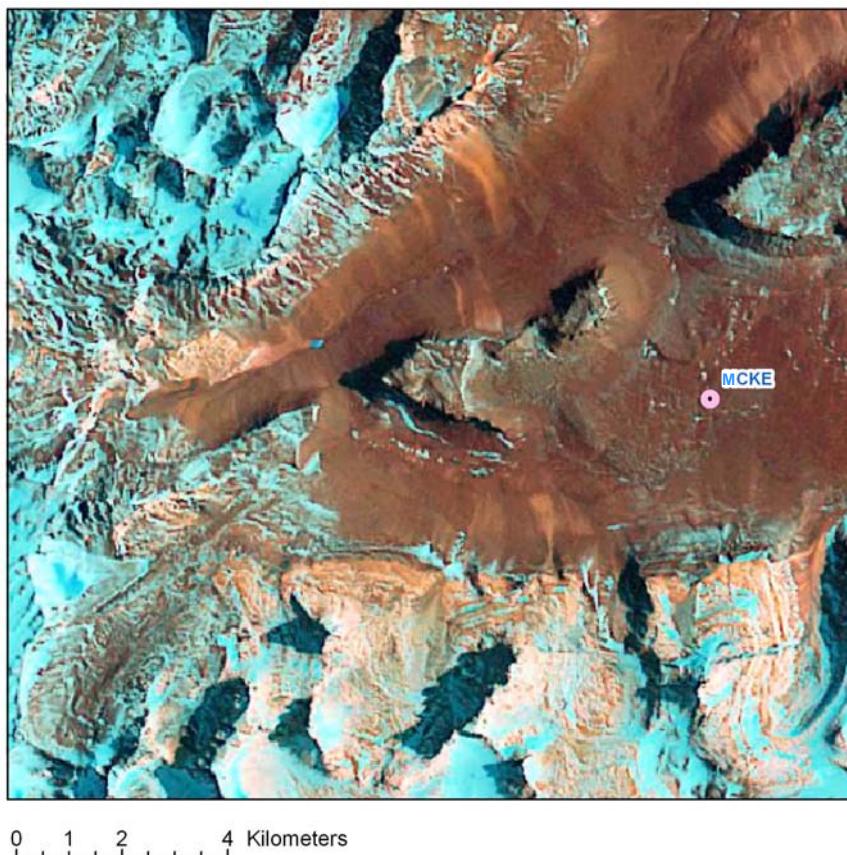
# 6 Bull Pass and Victoria Valley

6.1 Site information
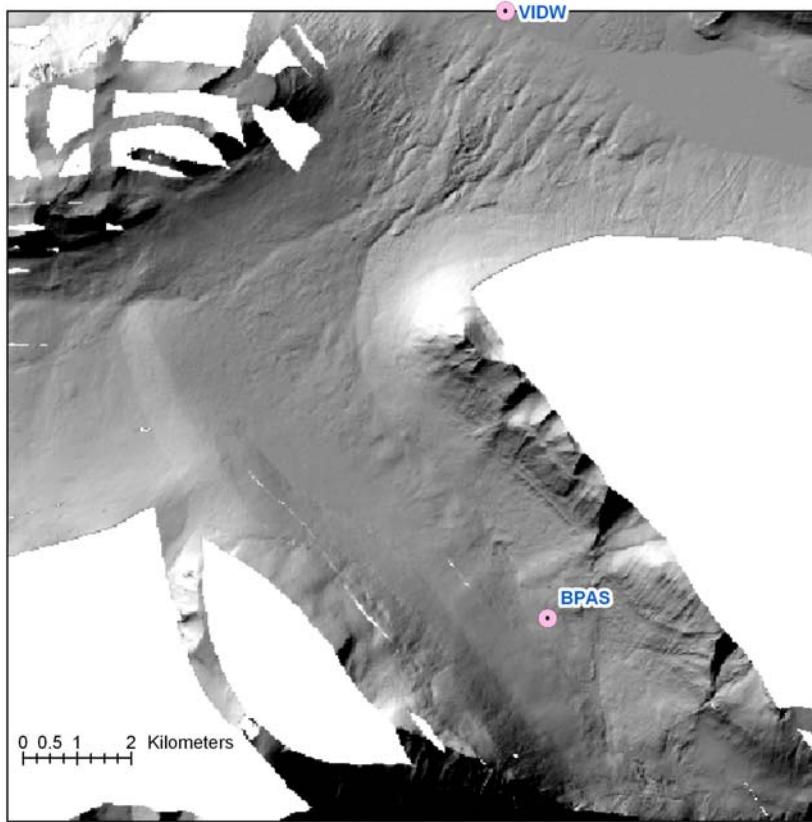


6.2 DEM information

| | | |
|---|---|---|
| File names | | bull_atm_2001_dem_v5.tif<br>bull _atm_2001_dem_v5.tfw<br>Inlier_bull_v5.zip<br>Outlier_bull_v5.zip<br>bull _atm_2001_label_v5.tif<br>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 |

## 6.3 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] |

Δh = *GPS elevation – 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
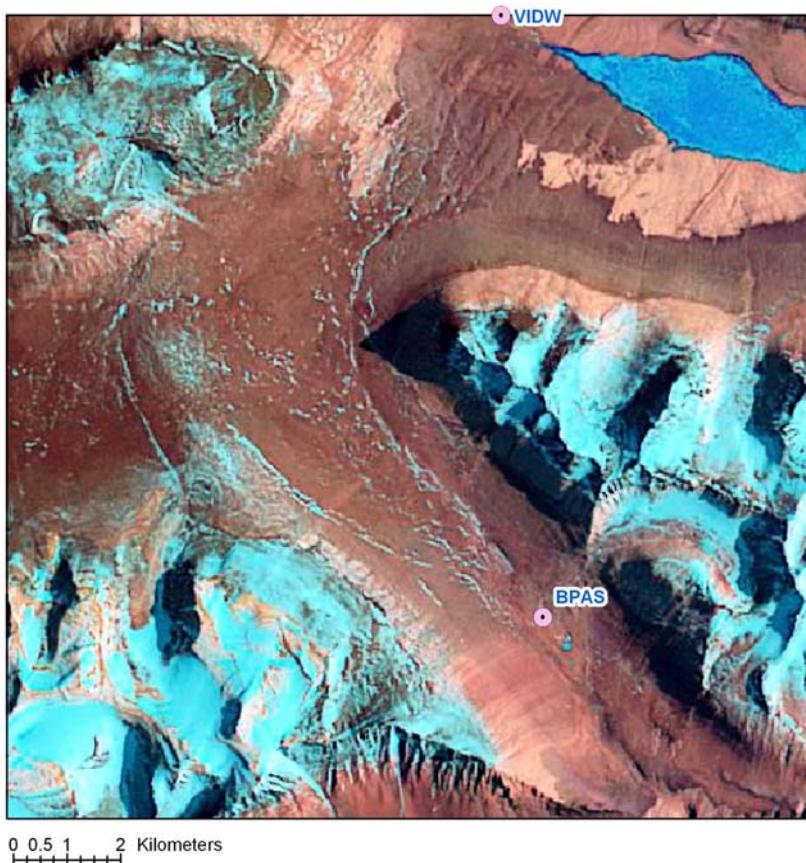
# 7 Wright Valley

## 7.1 Site information



0   2   4      8 Kilometers
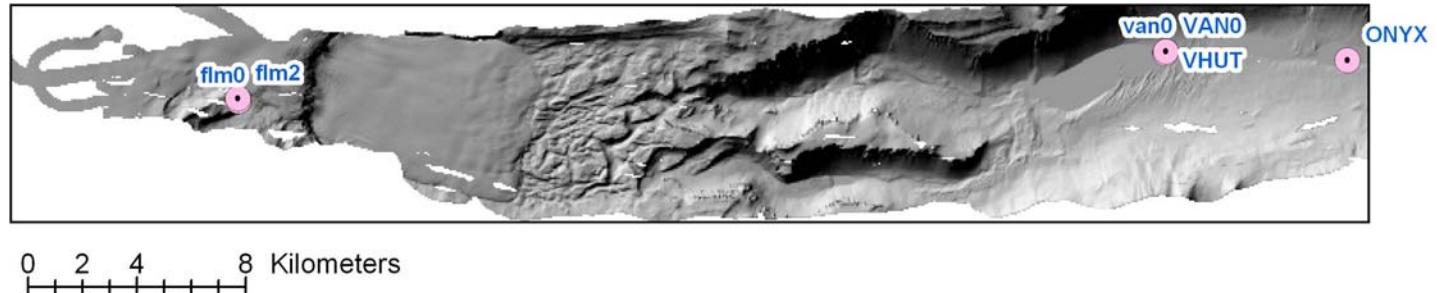
## 7.2 DEM information

| | | |
|---|---|---|
| File names | | wright_atm_2001_dem_v5.tif<br>wright _atm_2001_dem_v5.tfw<br>Inlier_wright_v5.zip<br>Outlier_wright_v5.zip<br>wright _atm_2001_label_v5.tif<br>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 |

## 7.3 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 assessment – 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
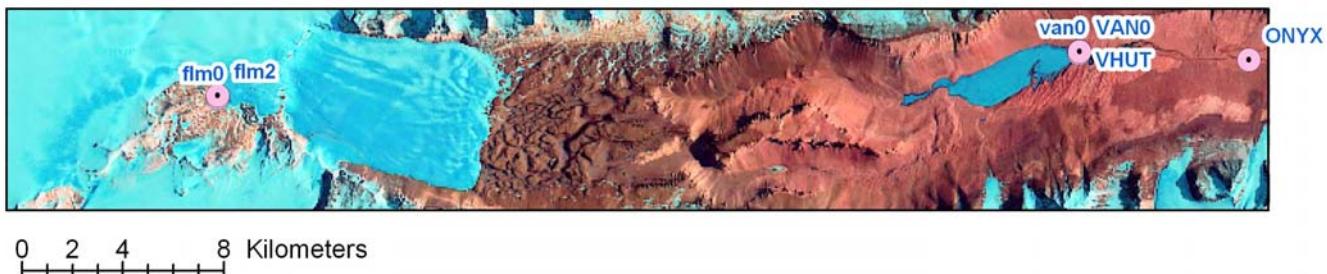


### 7.3.3 GPS site documentation

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
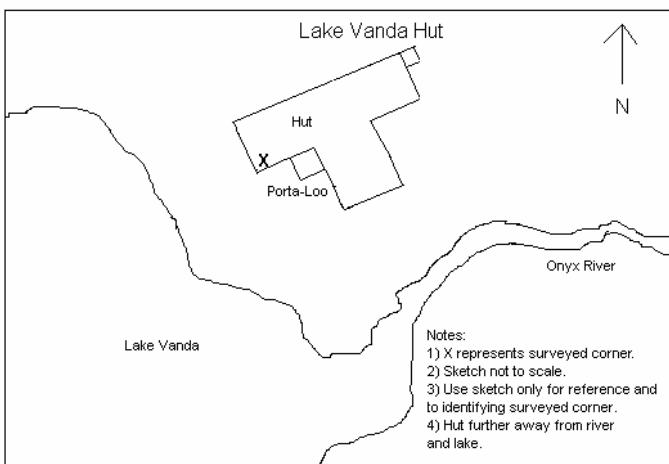
## 8 Beacon Valley

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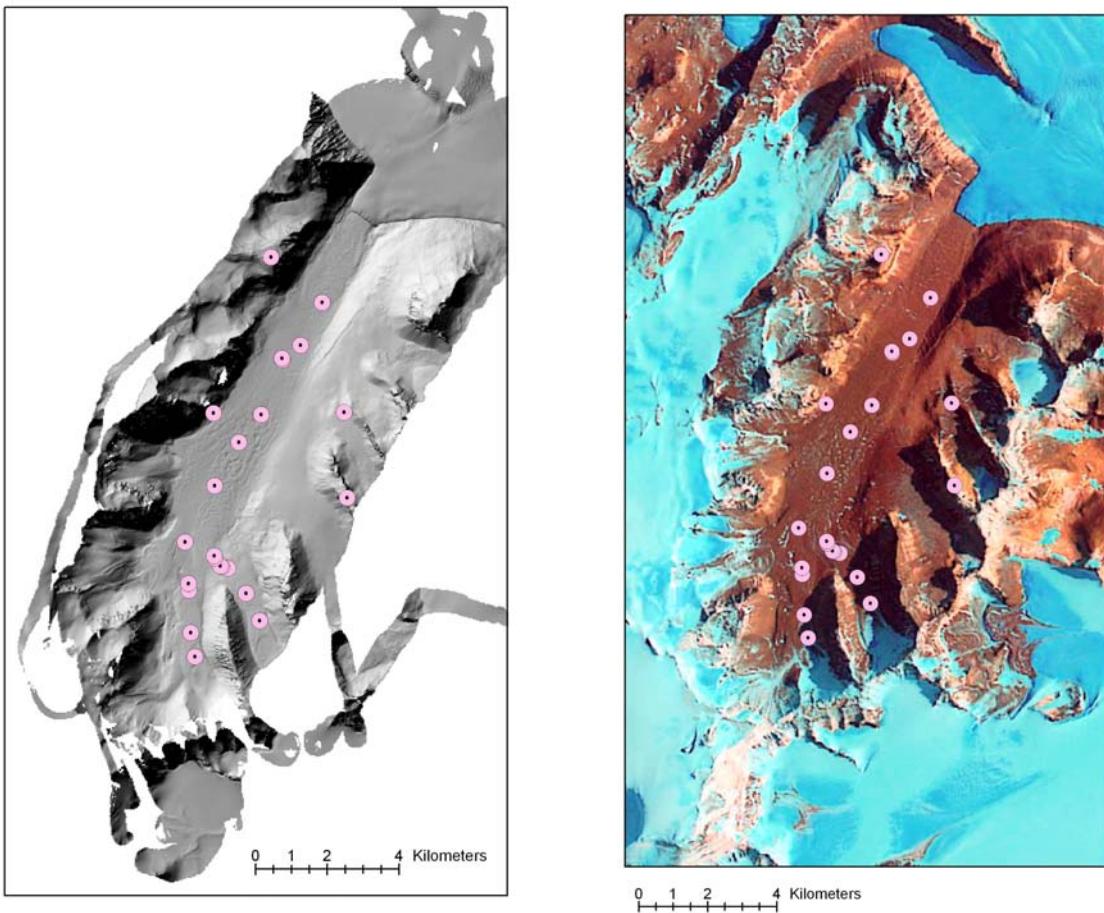


8.2 DEM information

| | | |
|---|---|---|
| File names | | beacon_atm_2001_dem_v5.tif<br>beacon _atm_2001_dem_v5.tfw<br>Inlier_beacon_v5.zip<br>Outlier_beacon_v5.zip<br>beacon _atm_2001_label_v5.tif<br>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 |

## 8.3 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

9.1 Site information and Landsat TM imagery
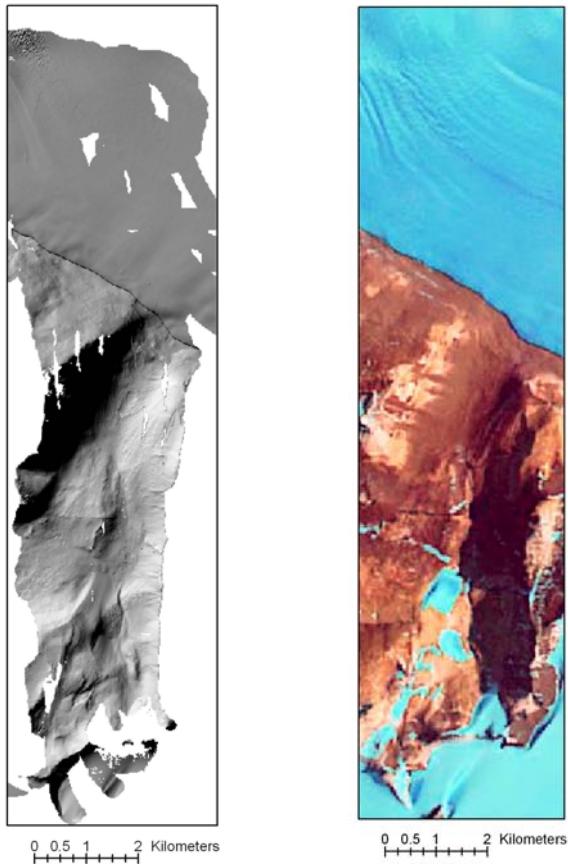


9.2 DEM information

| | | |
|---|---|---|
| | File names | arena_atm_2001_dem_v5.tif<br>arena _atm_2001_dem_v5.tfw<br>Inlier_arena_v5.zip<br>Outlier_arena_v5.zip<br>arena_atm_2001_label_v5.tif<br>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 |

## 10a Taylor Valley, West and Pearse Valley

10a.1 Site information
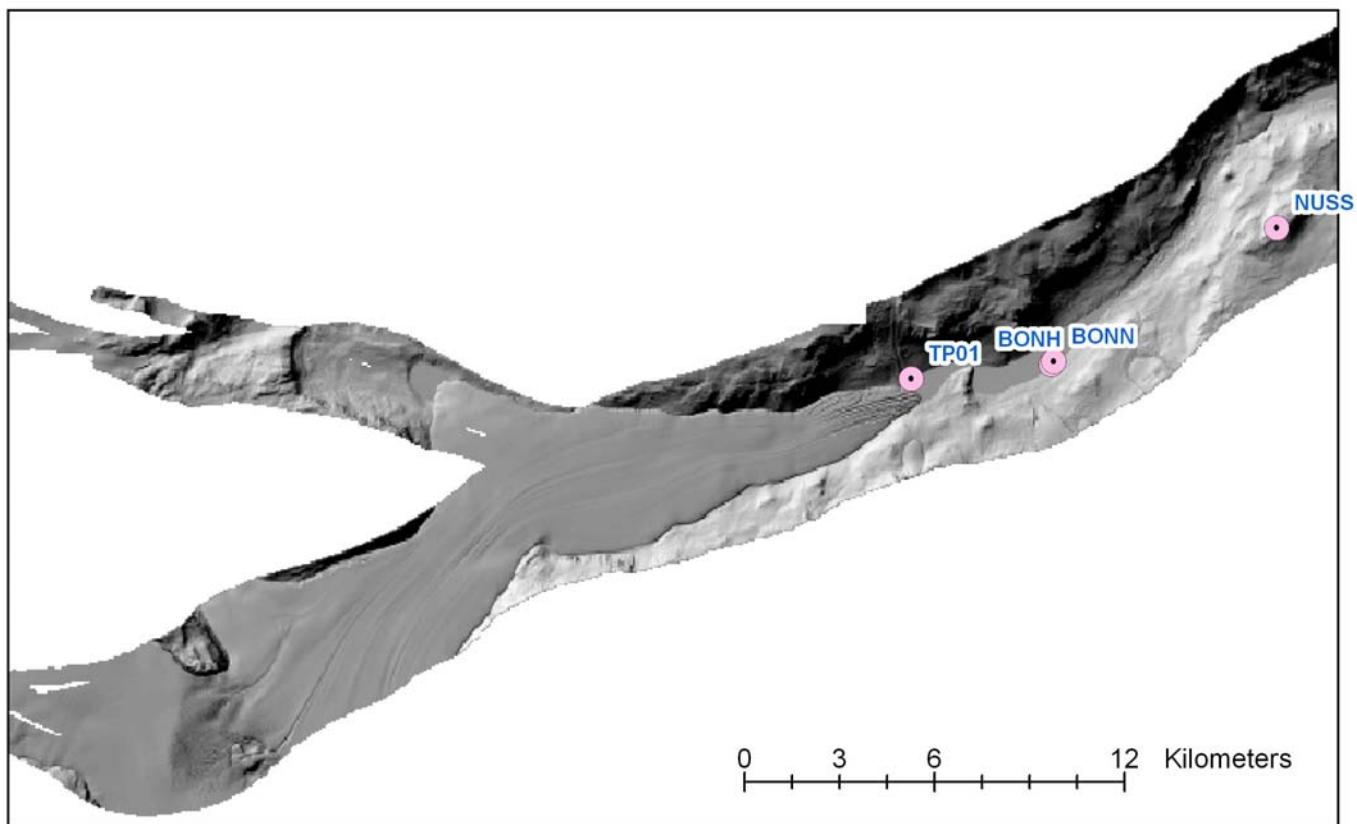


10a.2 DEM information

| | | |
|---|---|---|
| File names | taylor_west_atm_2001_dem_v5.tif<br>taylor_west_atm_2001_dem_v5.tfw<br>Inlier_taylor_west_v5.zip<br>Outlier_taylor_west_v5.zip<br>taylor_west_atm_2001_label_v5.tif<br>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 |

## 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
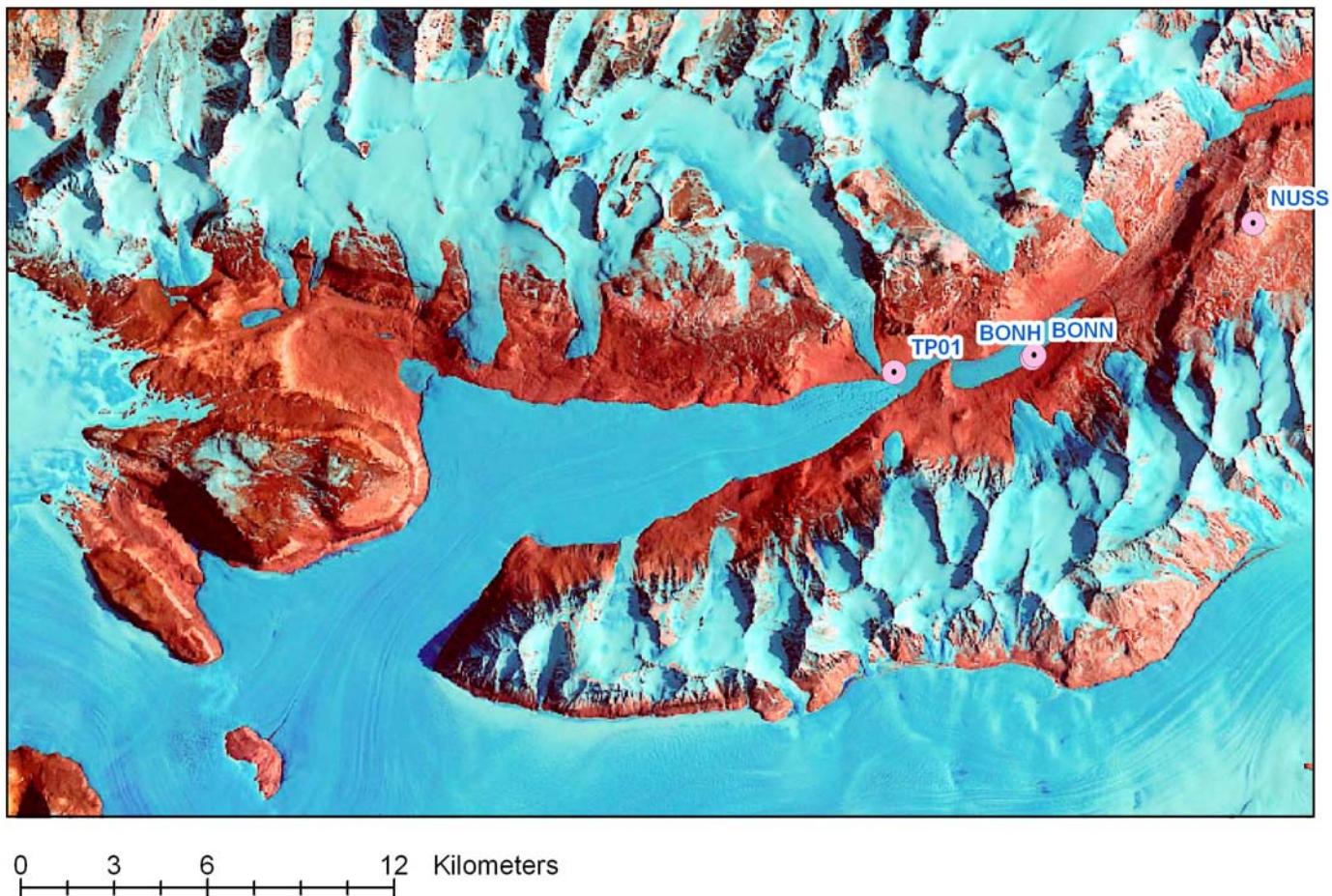
10a.3.3 GPS site documentation

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
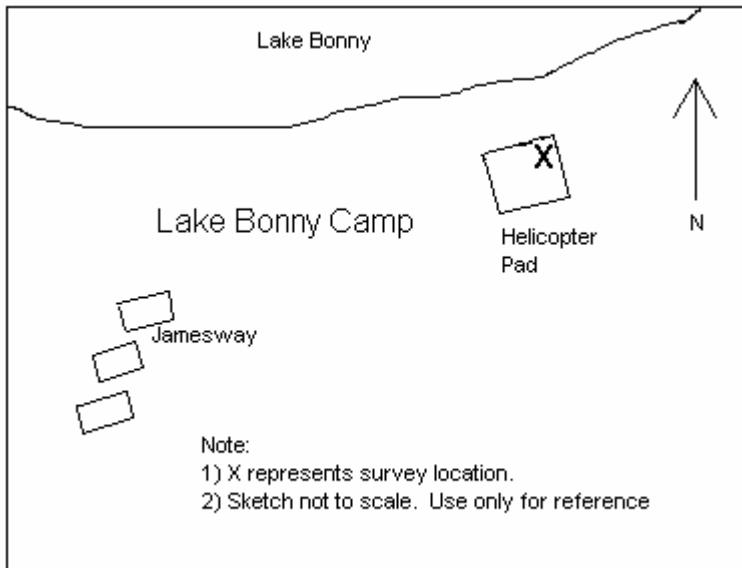
**10b Taylor Valley, East**

10b.1 Site information
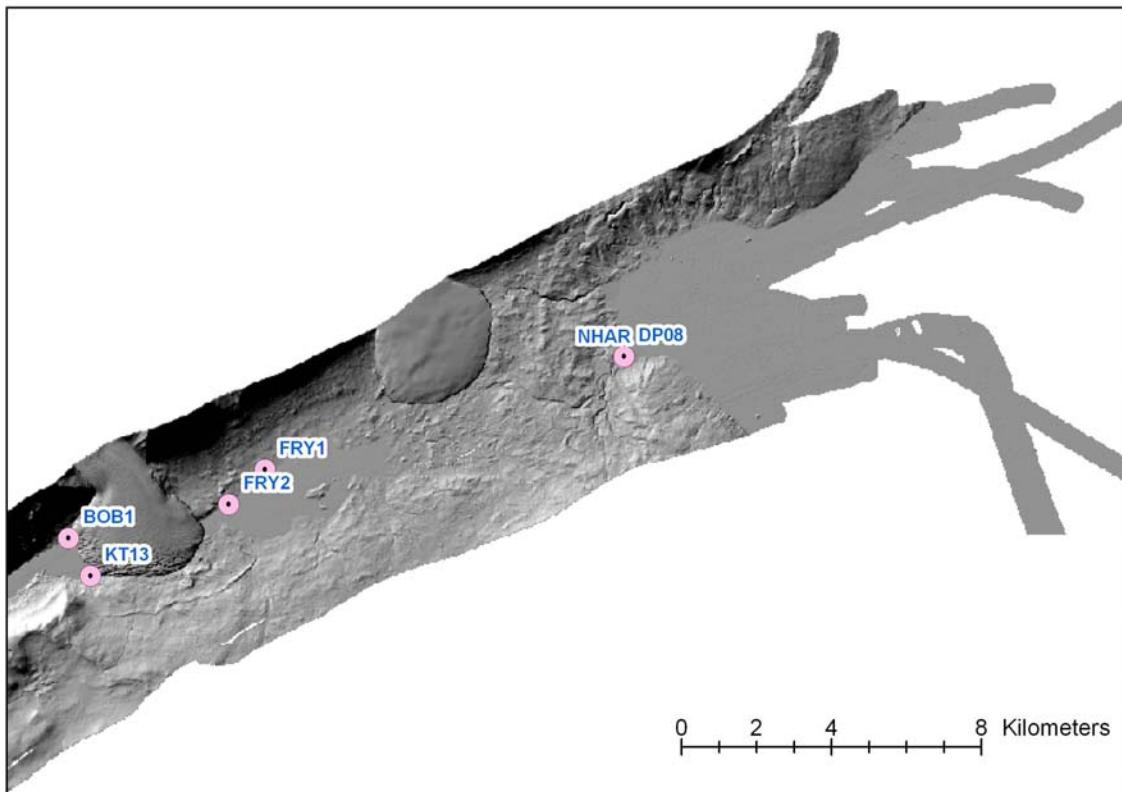


10b.2 DEM information

| | | |
|---|---|---|
| File names | | taylor_east_atm_2001_dem_v5.tif<br>taylor_east_atm_2001_dem_v5.tfw<br>Inlier_taylor_east_v5.zip<br>Outlier_taylor_east_v5.zip<br>taylor_east_atm_2001_label_v5.tif<br>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 |

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
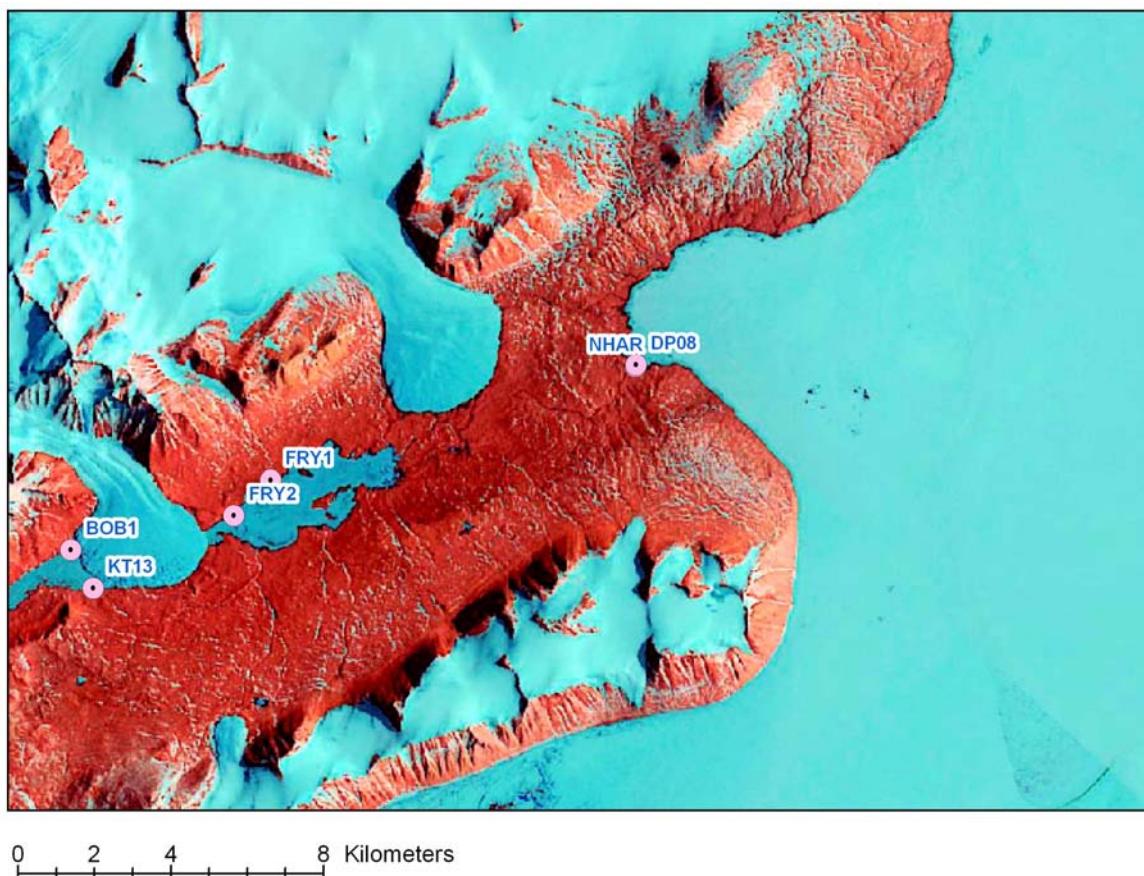
10b.3.3 GPS site documentation

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
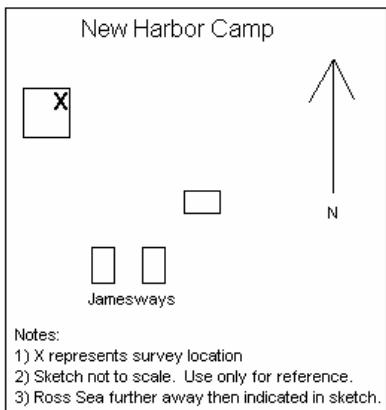
## 11 Radian Glacier - Portal

11.1 Site information
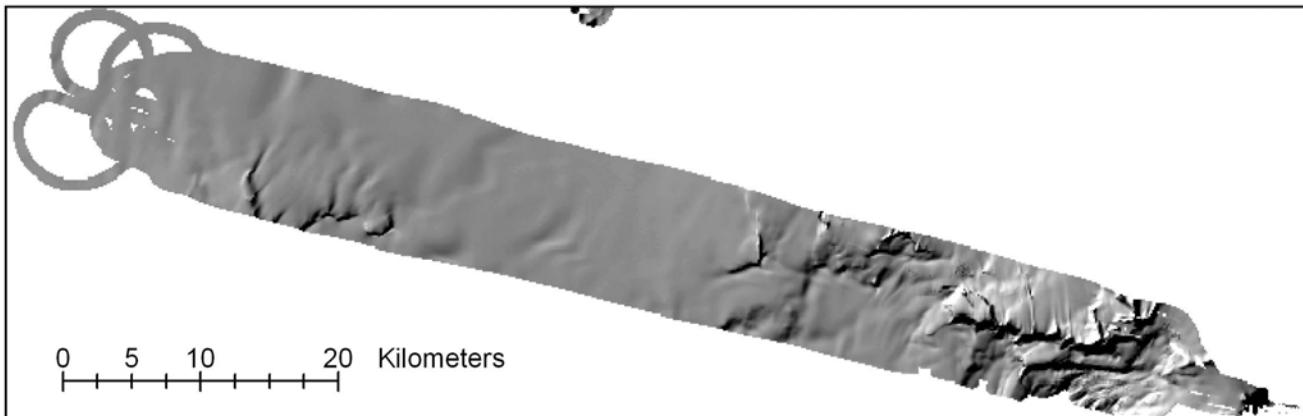


11.2 DEM information

| | | |
|---|---|---|
| File names | | radian_atm_2001_dem_v5.tif<br>radian_atm_2001_dem_v5.tfw<br>Inlier_radian_v5.zip<br>Outlier_radian_v5.zip<br>radian_atm_2001_label_v5.tif<br>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
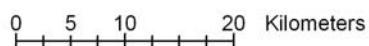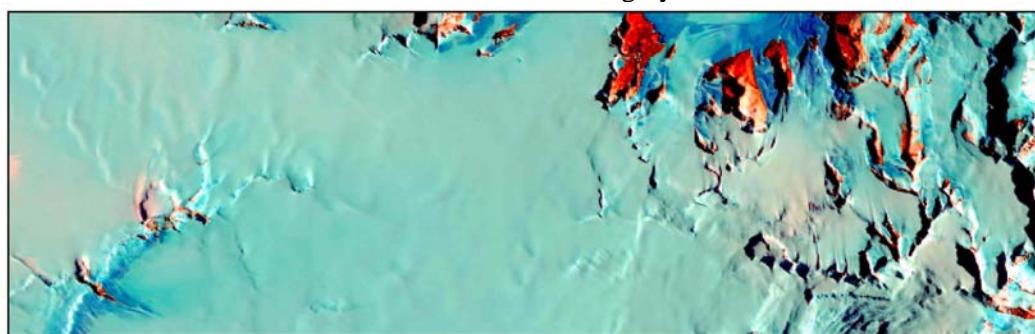
## 12 Denton Hills

12.1 Site information
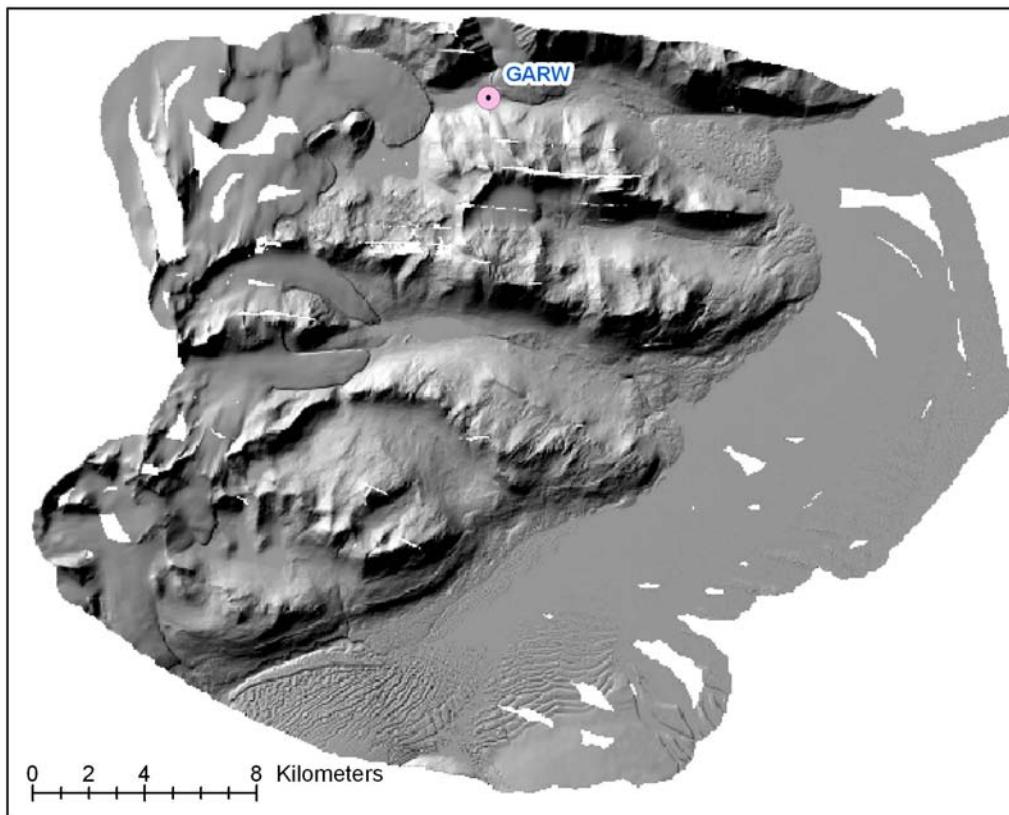


12.2 DEM information

| | | |
|---|---|---|
| File names | | dentont_atm_2001_dem_v5.tif<br>denton_atm_2001_dem_v5.tfw<br>Inlier_dental_v5.zip<br>Outlier_dental_v5.zip<br>denton_atm_2001_label_v5.tif<br>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 |

## 12.3 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
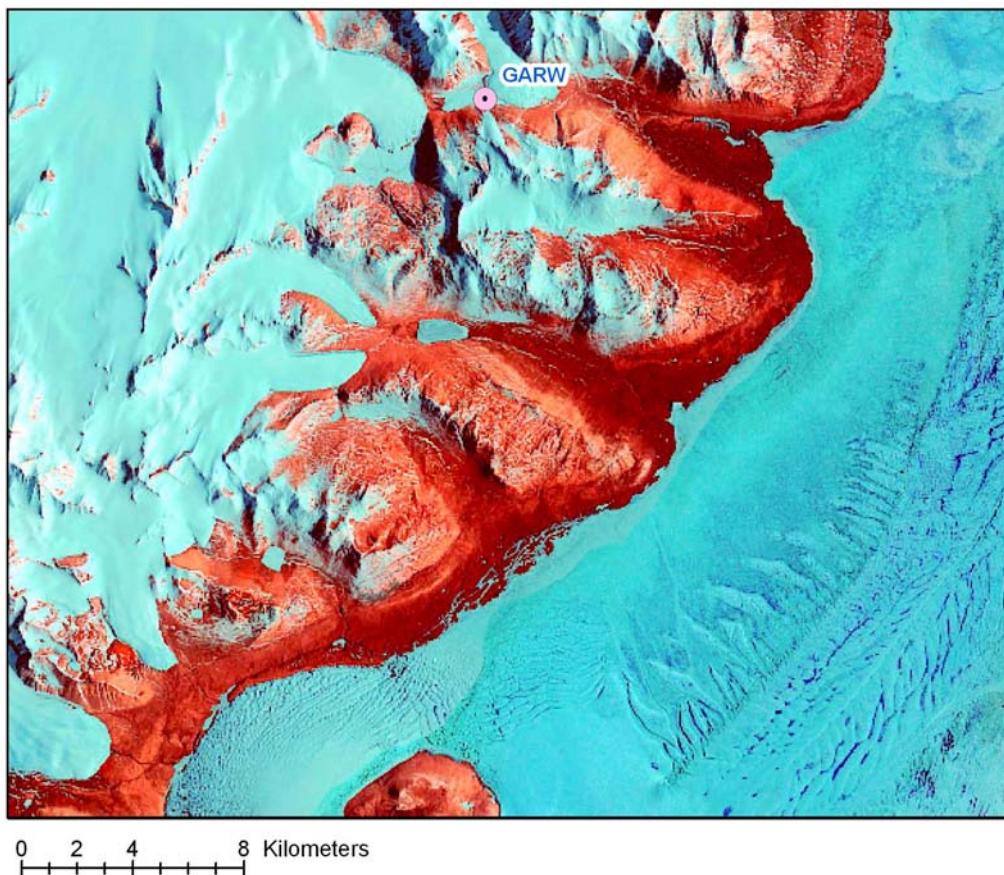
## 13 Mount Discovery

13.1 Site information
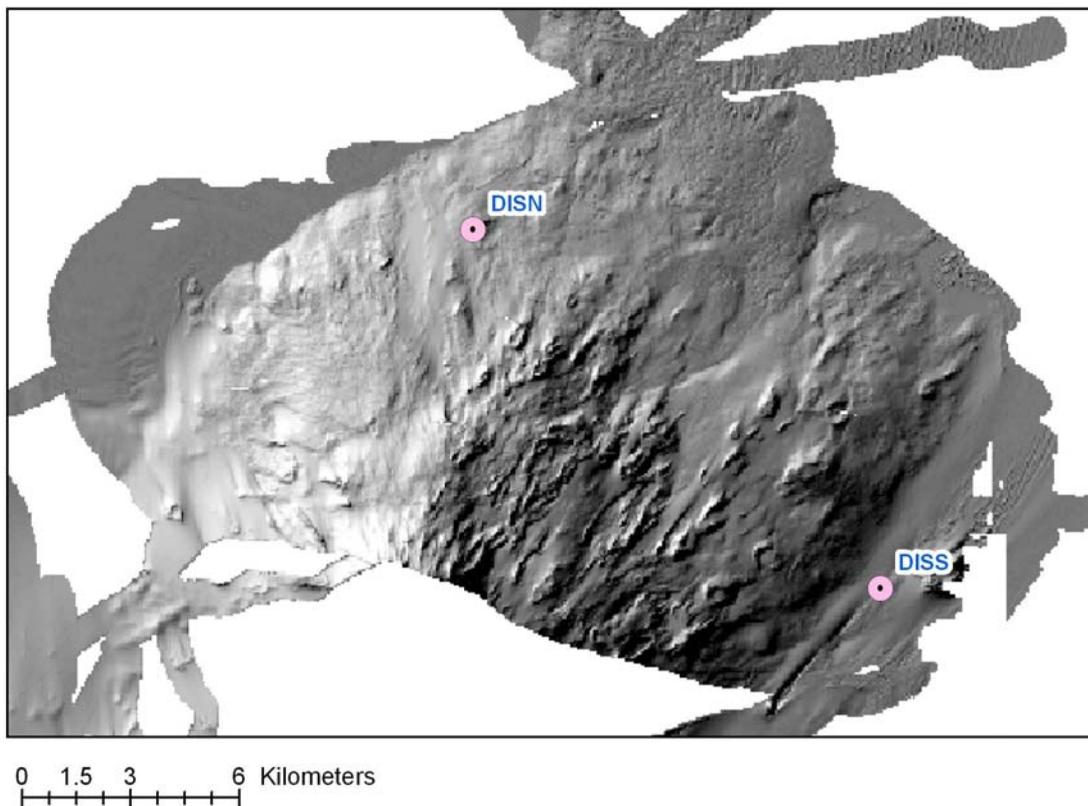


13.2 DEM information

| | | |
|---|---|---|
| File names | | discovery_atm_2001_dem_v5.tif<br>discovery_atm_2001_dem_v5.tfw<br>Inlier_discovery_v5.zip<br>Outlier_discovery_v5.zip<br>discovery_atm_2001_label_v5.tif<br>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 |

## 13.3 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
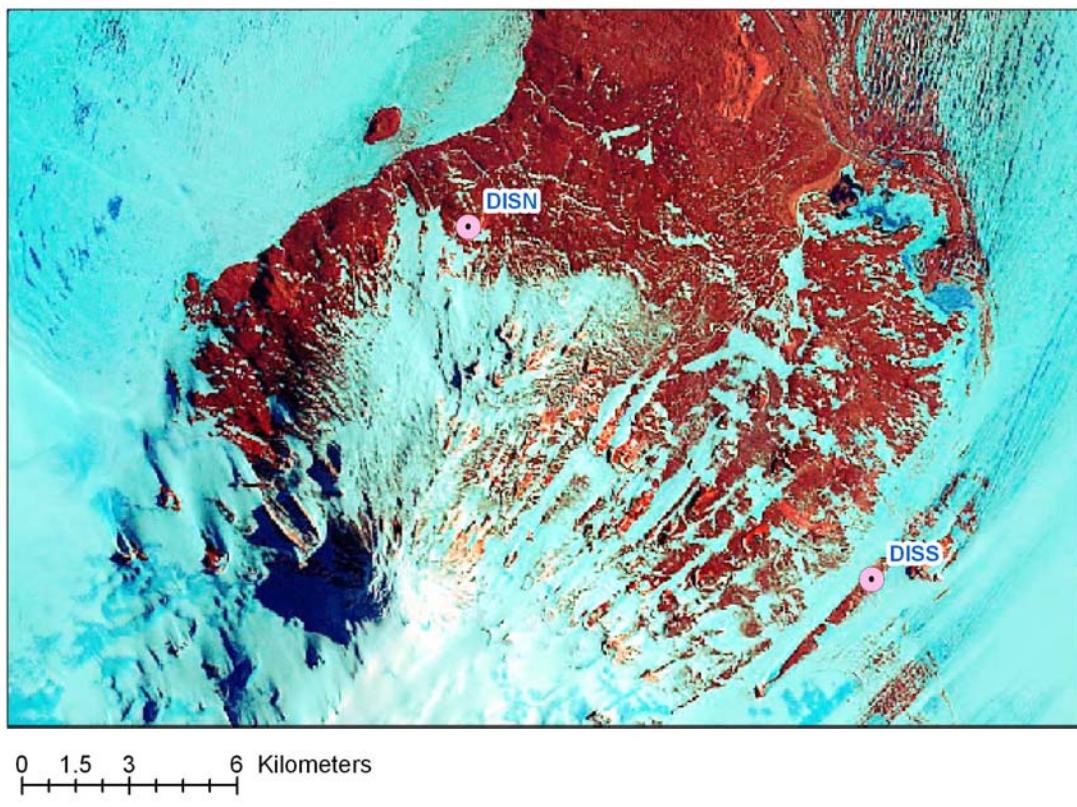
# 14 Mount Morning

14.1 Site information
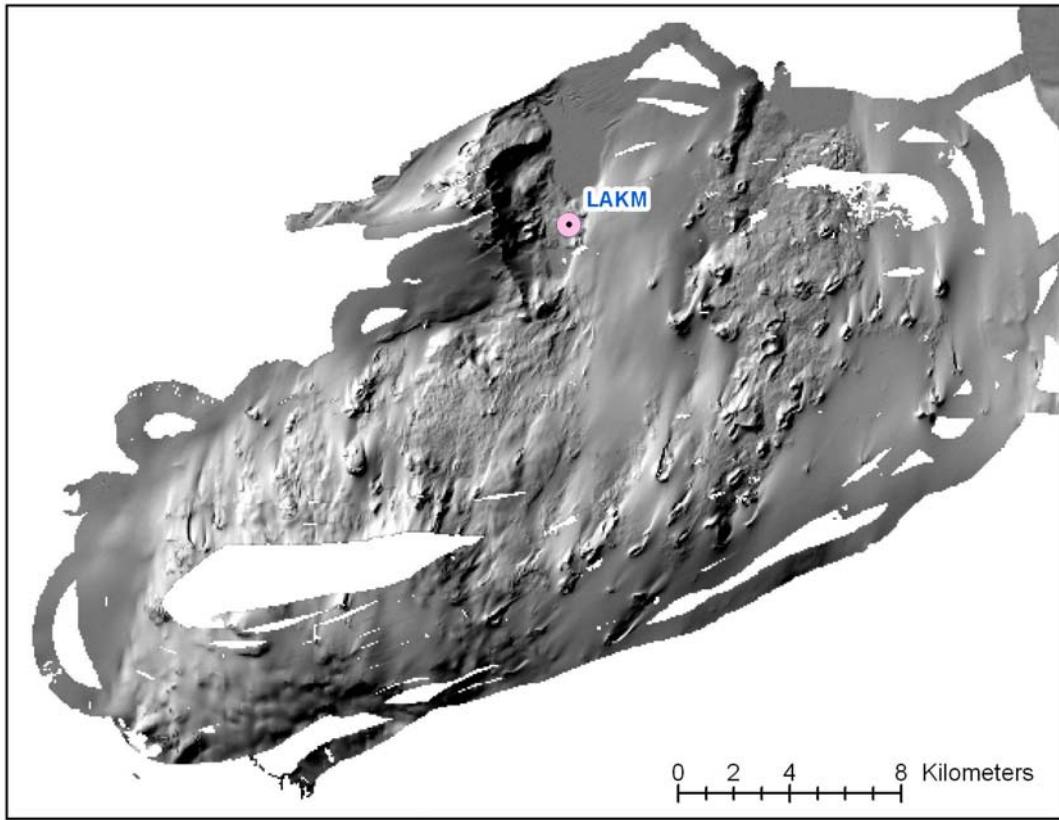


14.2 DEM information

| | | morning_atm_2001_dem_v5.tif |
|---|---|---|
| | File names | morning_atm_2001_dem_v5.tfw<br>Inlier_morning_v5.zip<br>Outlier_morning_v5.zip<br>morning_atm_2001_label_v5.tif<br>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 |

## 14.3 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
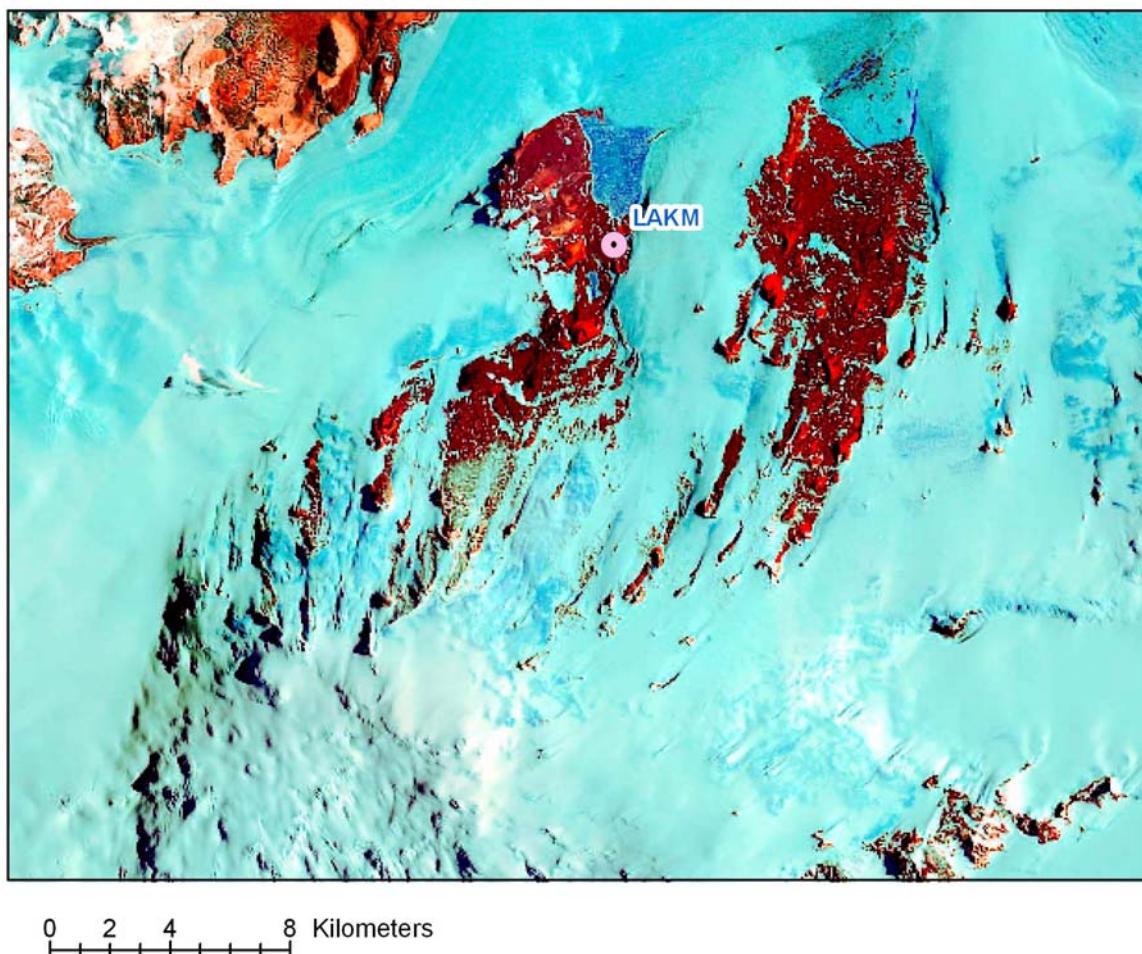
## 15 Cape Royds Rockery

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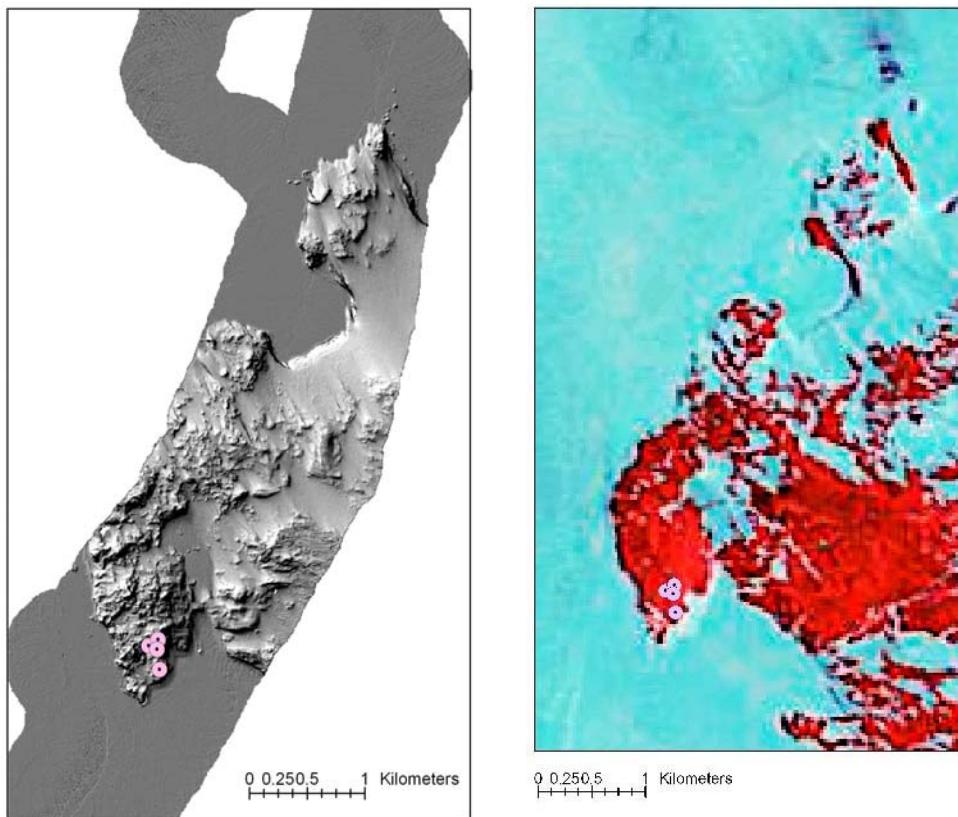


15.2 DEM information

| | | |
|---|---|---|
| File names | | royds_atm_2001_dem_v5.tif<br>royds_atm_2001_dem_v5.tfw<br>Inlier_royds_v5.zip<br>Outlier_royds_v5.zip<br>royds_atm_2001_label_v5.tif<br>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 |

## 15.3 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

16.1 Site information
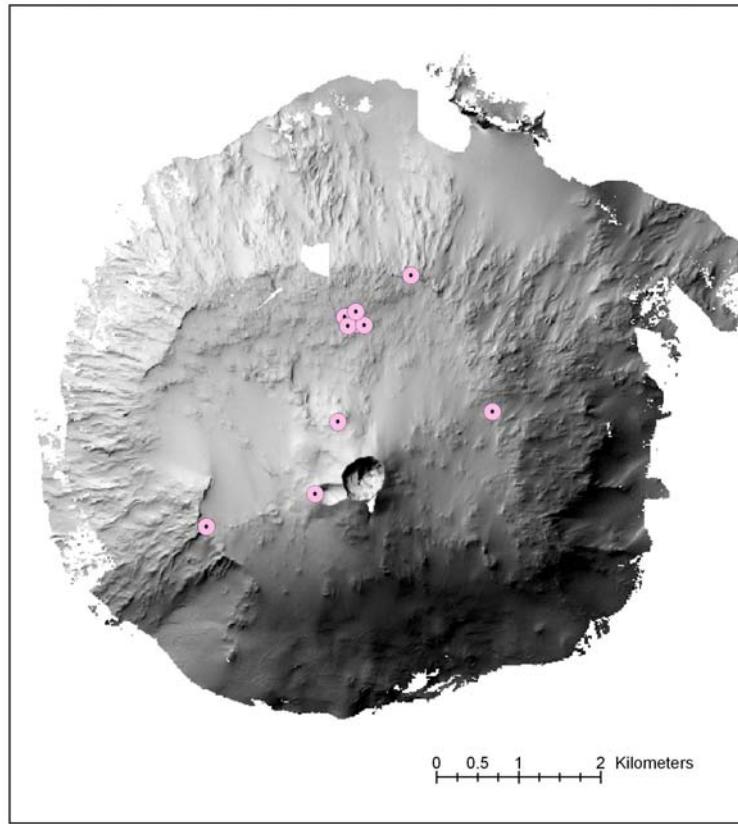


16.2 DEM information

| | | |
|---|---|---|
| File names | | erebus_atm_2001_dem_v5.tif<br>erebus_atm_2001_dem_v5.tfw<br>Inlier_erebus_v5.zip<br>Outlier_erebus_v5.zip<br>erebus_atm_2001_label_v5.tif<br>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/m²] | | 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 |

## 16.3 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*

## 16.3.2 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

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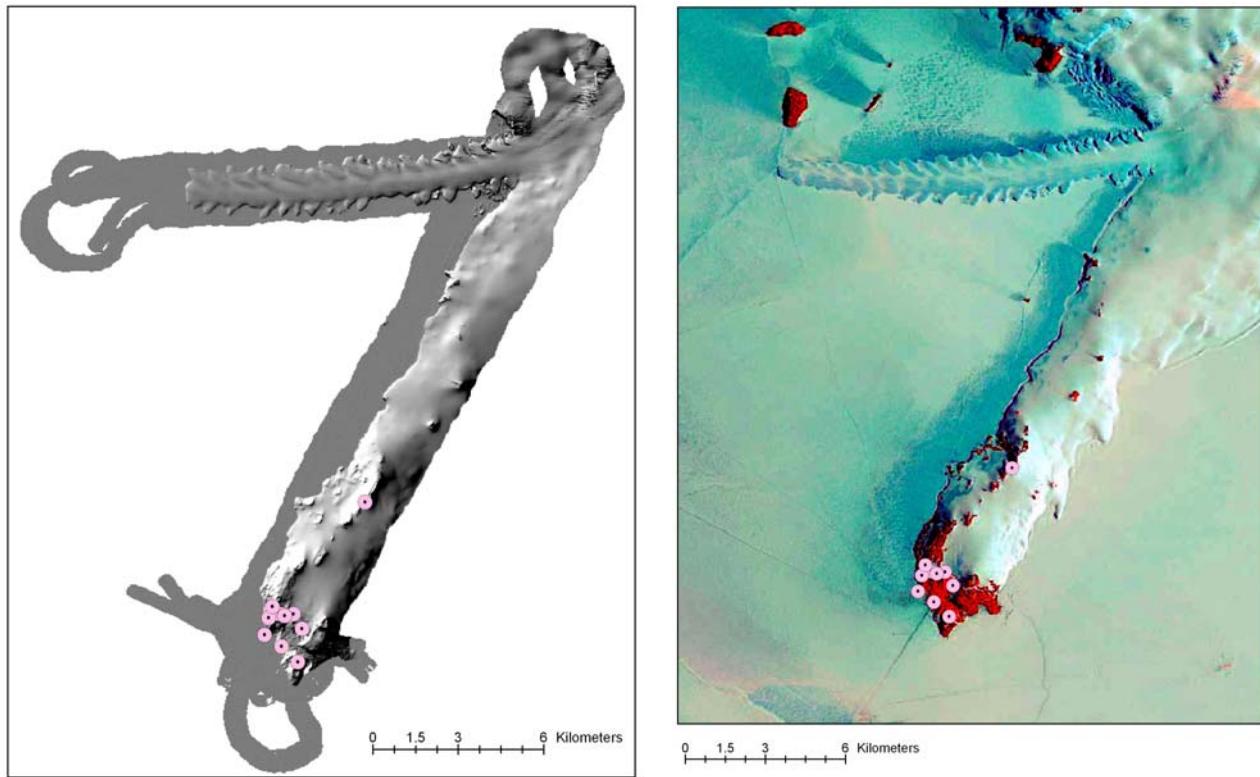


17.2 DEM information

| | | |
|---|---|---|
| File names | | hutpoint_atm_2001_dem_v5.tif<br>hutpoint_atm_2001_dem_v5.tfw<br>Inlier_hutpoint_v5.zip<br>Outlier_hutpoint_v5.zip<br>hutpoint_atm_2001_label_v5.tif<br>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<br>Corner<br>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 |

## 17.3 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

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

## 18 White Island

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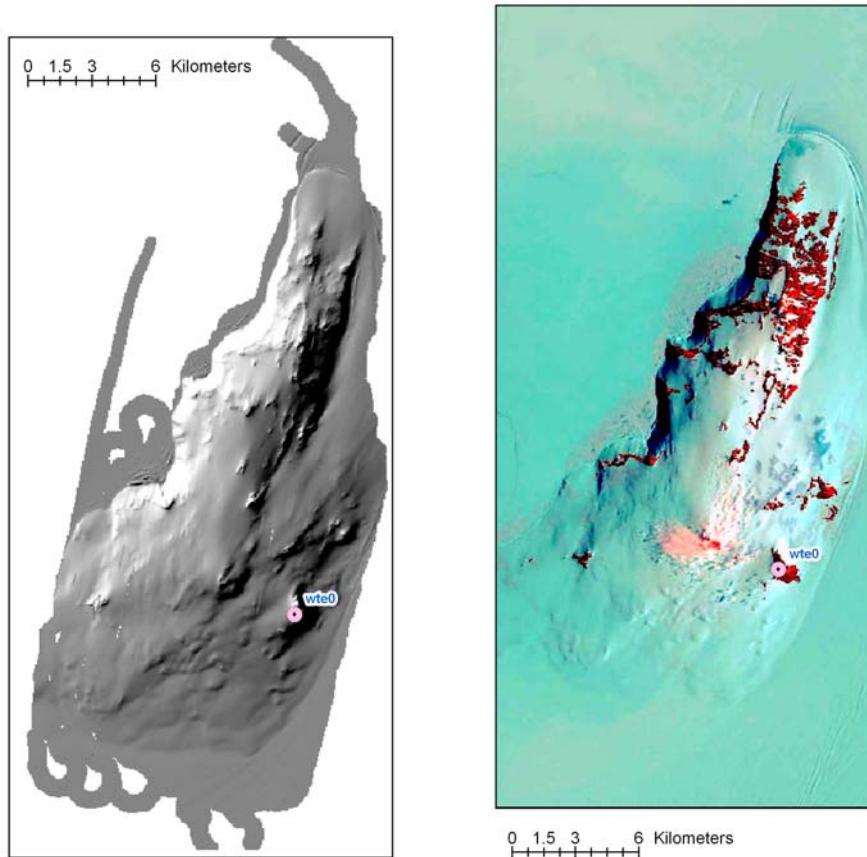


18.2 DEM information

| | | |
|---|---|---|
| File names | white_atm_2001_dem_v5.tif<br>white_atm_2001_dem_v5.tfw<br>Inlier_white_v5.zip<br>Outlier_white_v5.zip<br>white_atm_2001_label_v5.tif<br>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 |

| | | |
|---|---|---|
| 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 |

*Δh = GPS elevation – interpolated DEM elevation*

### 18.3.3 GPS site documentation

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