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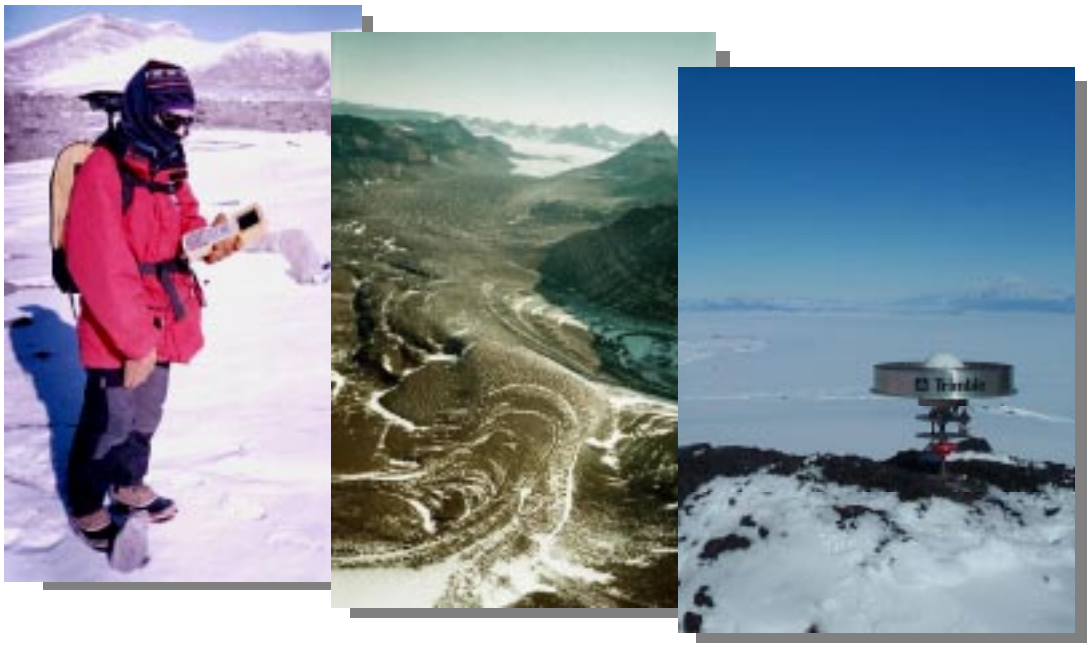
GPS Support to the National Science Foundation Office of Polar Programs



1999-2000 Season Report

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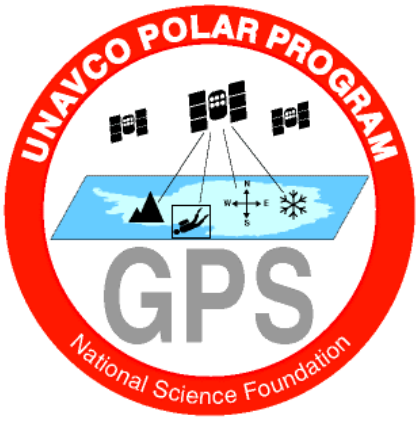

1999-2000 Season Report

May 12, 2000

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Cover photos:

1. Taylor Valley – kinematic GPS control for ground penetrating radar surveys (G-063 Prentice)
2. Beacon Valley flow lines (G-053 Hallet)
3. Mount Erebus deformation survey (G-081 Kyle)

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Summary

UNAVCO provides year round support for scientific applications of the Global Positioning System (GPS) to the National Science Foundation's Office of Polar Programs (NSF/OPP) Antarctic Program. This support includes pre-season planning, field support, and post-season follow-up, as well as development work for supporting new applications. UNAVCO maintains a "satellite" facility at McMurdo Station during the austral summer research season, providing a full range of support services including GPS equipment, training, project planning, field support, technical consultation, data processing, and data archiving. A total of 24 projects, encompassing a range of applications, were supported throughout the 1999-2000 field season.

22 projects received UNAVCO support as requested prior to the field season, and two additional projects, including the RADARSAT Ground Control survey, were added during the field season. Table 1 summarizes projects using UNAVCO support, while Appendix A provides a more detailed discussion of individual project support.

The UNAVCO Polar web site (www.unavco.ucar.edu/polar) was redone to better reflect the services and equipment available from UNAVCO, provide graphical interface to project meta-data and geodetic data, and provide technical and maintenance documentation for the McMurdo differential GPS system. Examples from the web site are included as examples in relevant sections throughout this report.

In addition to the science project support, the differential GPS system at McMurdo and Taylor Valley was also upgraded for improved performance, and UNAVCO installed two single frequency continuous GPS systems on Mount Erebus for technology demonstration and evaluation. The details of both the DGPS improvements and the continuous GPS systems are in the Equipment section.

Table 1 – 1999-2000 Projects Using UNAVCO Support

Event	Point of Contact	Support Effort	Preseason Request
G-052	Hothem	9	Yes
G-081	Kyle	9	Yes
I-153	Mayewski/Hamilton	9	Yes
I-151	Dunbar	8	Yes
G-063	Prentice	6	Yes
G-058	Harvey	5	Yes
I-169	Whillans	5	Yes
B-042-F	Fountain	4	Yes
B-044	Adams	4	Yes
G-053	Hallet	4	Yes
G-054	Marchant	4	Yes
RADARSAT	Jezek/Onstott	4	No
B-017	Davis	3	Yes
B-042-D	Doran	3	Yes
B-043	Bowser	3	Yes
G-084	Whillans	3	Yes
Italian Geodetic Survey/USGS	Capra/Hothem	3	Yes
I-166	Csatho	3	Yes
I-171	Clow	3	Yes
O-283	Stearns	3	Yes
E-318	Kennicutt	2	Yes
B-042-W	Parsons	1	Yes
G-098	Blankenship	1	Yes
B-005	DeVries	1	No

Science Support

Training

UNAVCO offers flexible options for field team training, including training before deployment to the field, training in the field, and direct field engineering support during the project. The level of training is tailored to the experience of each group. For the 1999-2000 season, all science team training was provided at McMurdo Station or in the field. Training was provided to G-058, G-063, G-081, I-151, I-171, and O-283.

Field Support

A field engineer[1] was present at McMurdo Station throughout the mainbody season. The primary responsibilities of the field engineer is managing the large equipment pool and providing technical support to field projects. Direct field support was provided to B-017, B-042-D, B-042-F, B-043, B-044, G-053, G-054, G-063, G-081, E-318, and RADARSAT. In addition, several projects in the McMurdo area took advantage of the differential GPS system to obtain meter-level accuracy in real-time (B-005, B-042-F, B-043, B-044, and E-318).

Data Processing

Post-processing of differential GPS data is necessary (unless the McMurdo DGPS RTK broadcast is used) to achieve the centimeter level precision required for most projects. UNAVCO supports data processing in the field using Trimble GPSurvey software. As in previous seasons, an effort was made to ensure that most data processing was completed before field teams (that do not have their own data processing resources) left McMurdo. UNAVCO also continues to provide post-season data processing support, using GPSurvey software, the NASA - Jet Propulsion Laboratory (JPL) Auto-GIPSY on-line data processing service, and advanced post-processing techniques for problem data sets. Data processing support was provided in the field to B-017, B-042-D, B-042-F, B-043, B-044, G-053, G-054, G-063, G-098, and O-283. Post-season support was also provided to B-042-F, B-044, G-058, G-081, I-151, and O-283.

Data Archiving

All GPS data handled by UNAVCO are archived, both locally at McMurdo Station and at the UNAVCO Facility archive, to ensure data safeguarding and future accessibility. The data are sorted by project event number and by Antarctic field season. UNAVCO archiving services are available to all NSF sponsored geodetic GPS projects – not just those directly supported by UNAVCO. For example, UNAVCO is also the data archive for the Ohio State University (OSU)/United States Geological Survey (USGS) Transantarctic Mountain Deformation Monitoring (TAMDEF) survey.

[1] Bjorn Johns and Spencer Reeder

The **Geodetic Data** section (Figure 1) of the UNAVCO Polar Program web page provides user friendly graphical access to geodetic data from UNAVCO supported Antarctic projects. This page is the central access point to UNAVCO's database of Antarctic benchmarks, raw data, and project meta-data, and provides links for continuous GPS stations throughout Antarctica.

Figure 1 – Geodetic data graphical interface
(www.unavco.ucar.edu/polar/geodetic_main/geo_main.html)

Data collected to geodetic standards are archived by site name, and precise site coordinates and site descriptions are readily available on-line (Figure 2). As this database of precise GPS coordinates continues to grow, future projects benefit by having pre-established geodetic control in their field study areas. This season GPS control points were added to the database from sites at Cape Royds, Mount Erebus, Mount Moulton, and New Harbor.

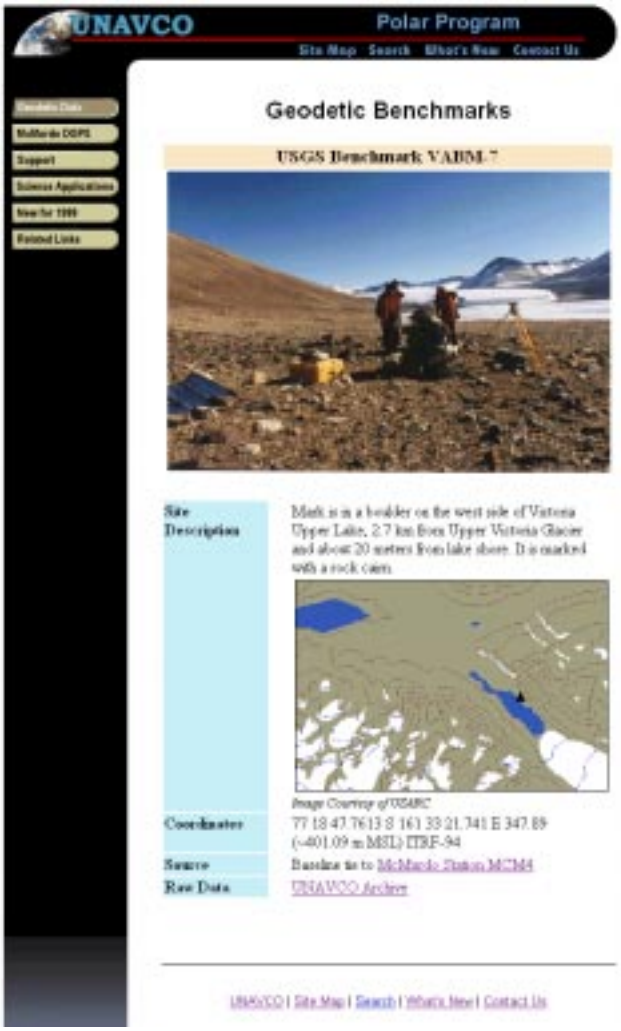

Figure 2 - Sample on-line benchmark description

Meta-data from all UNAVCO supported projects can be accessed on-line (Figure 3) by field season, project event number, or geographic location. The meta-data format is compatible with broader GIS initiatives, both within the United States Antarctic Program (USAP) and the Scientific Committee for Antarctic Research (SCAR). UNAVCO supported GPS project meta-data is also submitted to the National Snow and Ice Data Center (NSIDC) Antarctic Data Coordination Center.

Figure 3 – Sample on-line meta-data description

Equipment

Science Pool

UNAVCO provides complete GPS equipment for both geodetic surveying and mapping applications. 23 geodetic quality dual-frequency receivers from the UNAVCO pool (17 Trimble 4000 SSE/SSi receivers, four Trimble 4700 receivers, and two Trimble 4800 receivers) were provided for support throughout the field season. Prior to the field season, all Trimble receivers were updated with the most recent firmware. All necessary ancillary equipment (such as data processing software, solar panels, batteries, chargers, tribrachs, tripods, and cables) was also provided. Since nearly every science group now brings their own laptop computers to the field, UNAVCO encourages and supports the use of these computers for GPS data processing.

An assessment of current demand versus resources available indicated a need to provide more USAP-owned receivers to the UNAVCO pool (Figure 4). To ensure the ability to meet predicted demand, UNAVCO purchased two new Trimble 4700 GPS receivers for the UNAVCO equipment pool. The 4700 receivers were new this season, and provide state-of-the-art geodetic quality data at less bulk and power consumption than the traditional style 4000 series receivers. This makes them well suited for backpack mounted kinematic surveys, such as those conducted by G-063 in the Dry Valleys, or by I-151 at Mount Moulton. This new receiver purchase brought the number of USAP owned geodetic receivers in the UNAVCO pool up to 11. Recommendations for similar equipment purchases will continue in future seasons if necessary after re-assessing equipment pool resources and demand.

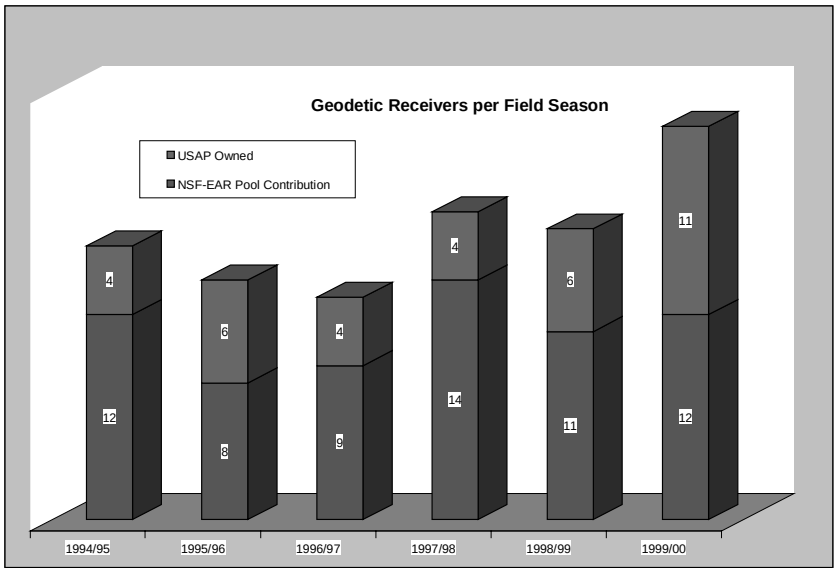

Figure 4 – Geodetic receivers per Antarctic field season

During the field season, a bug was discovered in Trimble 4000 series receivers using the most up-to-date version 7.29 firmware. The symptoms were corrupted data files that occurred when the receiver tracked more satellites than it had channels to accommodate. While the problem was difficult to duplicate, the UNAVCO Facility received reports of trouble from both high-latitude and tropical field sites – areas that have the most number of satellites visible. In Antarctica, only a few TAMDEF surveys with Trimble receivers were effected – a result of the TAMDEF surveys using a very low elevation cutoff angle to maximize the amount of satellite data recorded. Unfortunately, a field solution was not available to fix the bug. Trimble has verified the problem after reports from UNAVCO and other users, and replacement firmware (version 7.19a) is currently available to all 4000 series users.

Mount Erebus Continuous GPS Stations

In December 1999, two single frequency (L1) systems were installed on Mount Erebus to operate through the Antarctic winter as a technology demonstration and evaluation project (Figure 5). Use of L1 GPS provides a cost-effective deformation monitoring system for dense networks with short baselines, such as volcano monitoring networks. UNAVCO has developed an L1 monitoring system that integrates a Canadian Marconi AllStar OEM GPS card, FreeWave spread spectrum radio telemetry, and a Time Domain Multiple Access (TDMA) communications protocol. This system is currently used in volcano monitoring networks on Kilauea and Mauna Loa in Hawaii, Popocatepetl in Mexico, and Taal in the Philippines.

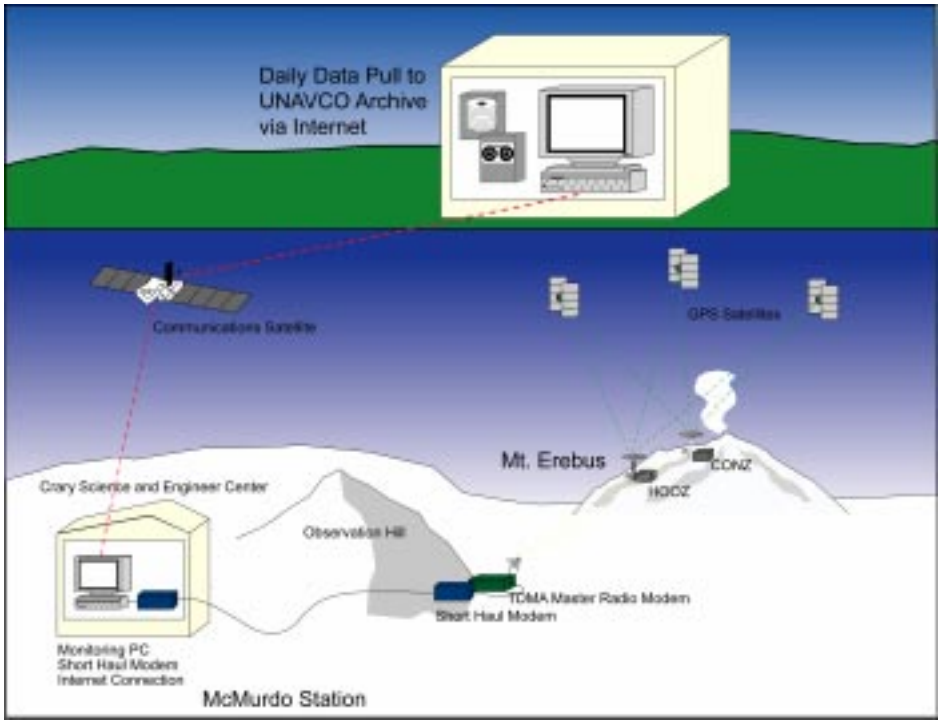

Figure 5 – Mount Erebus continuous GPS station diagram

The low power consumption of the systems will allow them to run well into winter darkness before the solar charged battery reserve is depleted. The batteries will begin to re-charge at the end of August, and the sites should begin transmitting in September barring environmental (extreme cold and wind) damage. A passive thermal design with R40 insulation provides a -30C to +30C operating temperature range when power is available. Since the electronics will be subjected to temperatures below their published specifications when the system shuts down after the battery reserve is depleted, assessing what damage (if any) occurs is a goal of this evaluation. The data files are retrieved daily by the UNAVCO Archive, and Figure 6 shows the data available into May 2000. Figure 7 is a time series of results from the four km long baseline, processed using Bernese software. As expected, there is no indication of relative motion between these points on the same side of the volcano.

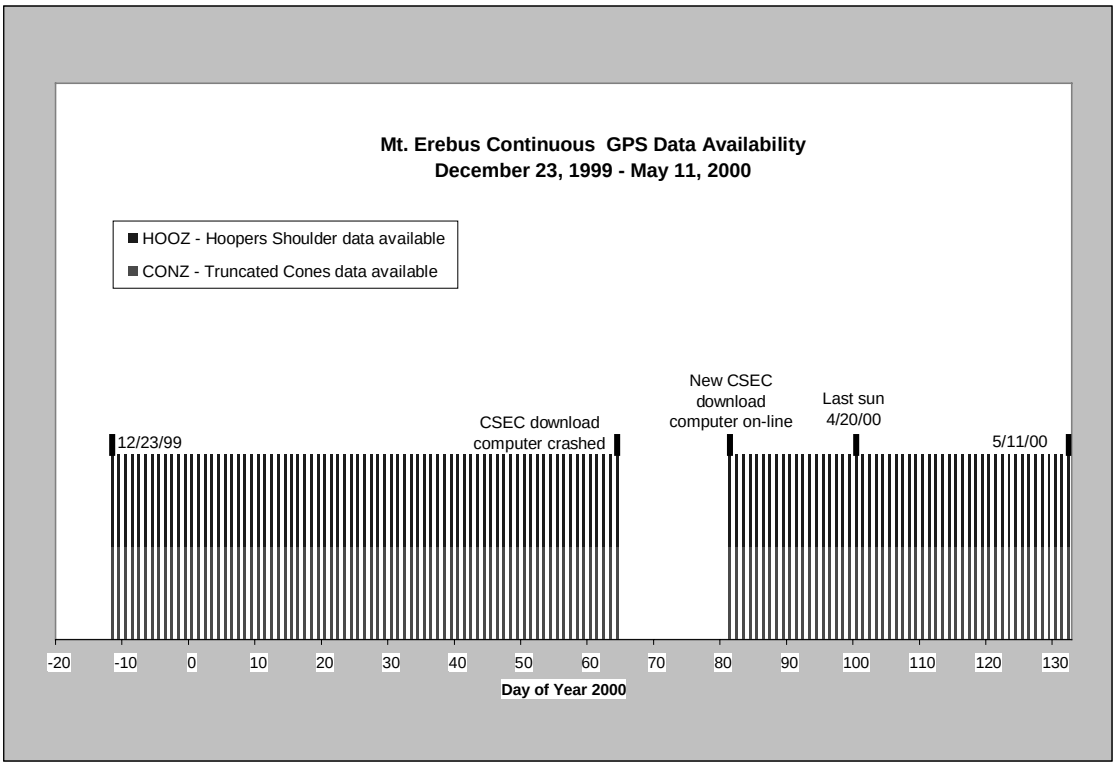

Figure 6 - Mount Erebus continuous GPS data availability

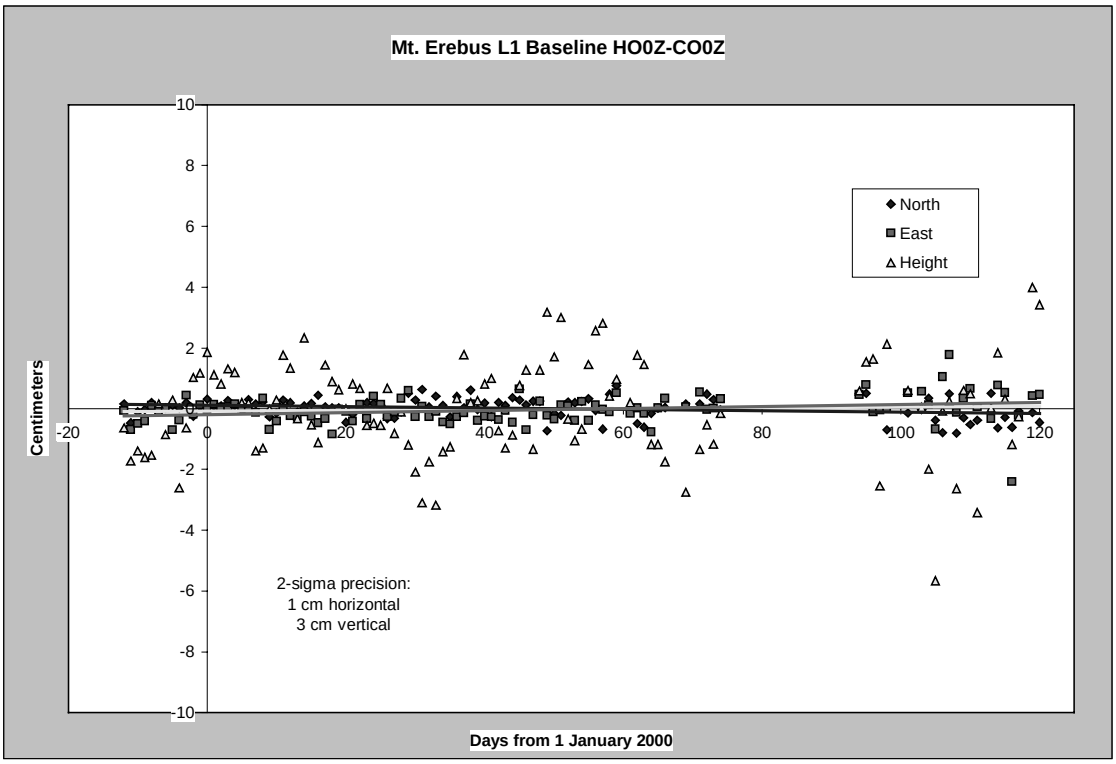

Figure 7 - Baseline time series

Differential GPS System

Note: On May 1, 2000, the intentional degradation of the GPS C/A code (selective availability or SA) was turned off as directed by the White House. As a result, handheld GPS receivers now achieve an accuracy better than 20 meters (www.igeb.gov), and often as good as five meters, without differential correction. This will likely make the DGPS system obsolete for certain applications, such as surveying fish and dive holes on McMurdo Sound, and rescue vehicle navigation. However, the differential corrections are still necessary for centimeter level (RTK surveying) and 1-2 meter level (GIS, mapping) applications. System applications will be evaluated during the 2000/01 season, with future recommendations after the field season. UNAVCO will conduct empirical testing at McMurdo at the start of the season to determine the typical accuracy of handheld GPS units without SA. Preliminary results in Colorado show better than five meter accuracy, but this may not be representative of results in Antarctica due to variations in the ionospheric disturbance, which is now the dominant inherent GPS error source.

Five real-time differential GPS (DGPS) receivers are available for use with the UNAVCO McMurdo DGPS base station (Figure 8) during the field season: three Garmin 12XL and two Trimble GeoExplorer II handheld receivers capable of providing meter level accuracy in real-time. This season, the UNAVCO DGPS equipment was used by B-005 in McMurdo Sound, B-042 in Taylor Valley, B-043 at New Harbor, B-044 at Lake Bonney, and E-318 at McMurdo Station. In addition, the ASA surveyors used the system with their own equipment for the annual ice runway layout and other survey jobs, and the search and rescue team uses the system for improved rescue vehicle navigation during poor visibility. Two Antarctica New Zealand researchers also took advantage of the available DGPS broadcast: Tim Haskell (K-131) purchased his own radio modem for use on the sea-ice, and Brent Sinclair (K-067) borrowed a UNAVCO radio modem for use with his own GPS equipment at Cape Bird.

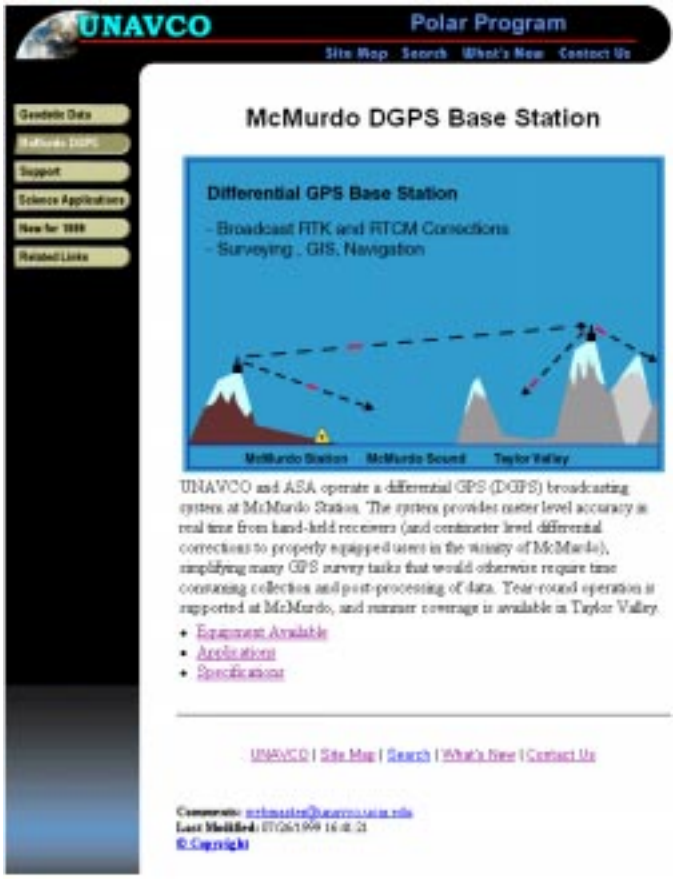

Figure 8 - DGPS system documentation
(www.unavco.ucar.edu/polar/mcmurdo/mcmurdo.html)

The DGPS system is now configured for year-round operation at McMurdo. During the 1999/2000 field season, several upgrades were made to provide more robust year-round operation:

- The Peak 1882 repeater site in Taylor Valley was configured for autonomous operation. Since the site is solar powered, it is expected to shut down in the winter and power up again shortly after the sun returns in late August. This autonomous operation is intended to eliminate the requirement to visit the site at the start of the season. As a result, the DGPS system will be available to Taylor Valley users during the early season before UNAVCO personnel arrive at McMurdo.

- The science technician, who has access to spare components and on-line system documentation, provides technical support and maintenance. The current science technician, Gary Miller, has one DGPS receiver that can now be used during the winter and spring before UNAVCO personnel arrive.

- An improved power supply and UPS protection was added to the Crater Hill transmitter site in response to power problems at the end of the 1998/99 field season.

- An integrity monitoring station was set up in the Crary Lab to provide instant warning if the DGPS signal is interrupted (summer only).

NASA International GPS Service (IGS) Base

UNAVCO provided maintenance support to the MCM4 GPS station, located at the NASA McMurdo Ground Station (MGS) facility, as part of UNAVCO's contractual support to the NASA GPS Global Network (GGN). The entire electronics suite was moved to a new rack in a location (within the same building) that better suits the needs of both the MGS Allied Signal contractors and technicians servicing the GPS equipment (Figure 9). An old Macintosh computer was replaced with a standard GGN Linux computer, and a rubidium oscillator was added to the site for external atomic frequency reference. The MCM4 GPS site remains an important IGS global network site for low earth orbit satellite missions requiring low-latency GPS data from robust ground stations.

Figure 9 - MCM4 GPS rack

Geographical Information Systems (GIS) Products

The increased popularity of GIS with USAP research projects has created a demand for geo-referenced coordinates of physical features. UNAVCO has assisted several projects obtain geo-referenced spatial data for several seasons. Examples include control points for aerial photography, boundary surveys, and digitized physical features for mapping and other applications (Figure 10). Many of these data sets are of potential interest to users other than the project team that originally collected the data. For example, last year UNAVCO received a request from the Synthetic Aperture Radar (SAR) facility at the University of Alaska, Fairbanks for the digitized shorelines of Dry Valley lakes. These data sets were to be used to geo-reference SAR data sets of the area. This past season, UNAVCO met a request to measure the vertical and horizontal motion of the McMurdo ice shelf as ground control for a RADARSAT ice velocity mapping project. To make such data sets of general interest readily available, a section for GIS Data Products will be added to the UNAVCO Polar web page. Data sets that will be added include:

- Taylor Valley lakes perimeters
- Lake Brownworth perimeter
- New Harbor shoreline
- McMurdo Ice Shelf one month tidal response
- Dellbridge Islands perimeters

Relevant future data sets will be added annually as they are collected.

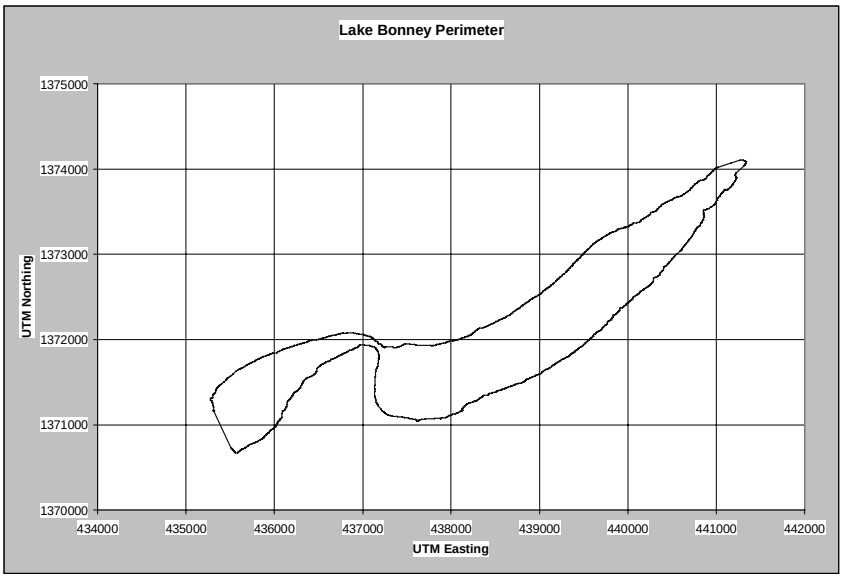

Figure10 - Geo-referenced and digitized Lake Bonney perimeter

B-005 (Art DeVries)

Teri McLain requested assistance to locate a large depression in the seafloor near Cape Armitage. This unique feature was shown on a bathymetic chart produced by Rikk Kvitek (S-320), and the research team wanted to deploy fish traps and take conductivity, temperature, and depth (CTD) readings in it as part of their research to better understand the role of antifreeze proteins in freezing avoidance of Antarctic fishes. A Garmin DGPS receiver was provided to obtain meter-level positioning.

B-017 (Randy Davis)

The B-017 research team requested a survey of their field site "Weddell World", where they study the underwater behavioral and energetic adaptations of a captive Weddell seal foraging in the Antarctic fast-ice environment. GPS was used to obtain sub-meter positions of seal dive holes, camp buildings, the nearby McMurdo Ice Shelf transition, and the road leading to Weddell World. UNAVCO provided field support, data processing, and data archiving for this project, which was performed with the new Trimble 4700 receiver system. These coordinates will be used for mapping purposes, and geo-reference the specific research sites so they can be recovered in future seasons.

B-042-D (Peter Doran)

Peter Doran requested support to survey floating boulders and ice ablation monitoring stakes on Lakes Fryxell, Hoare, and Bonney in Taylor Valley. The ice ablation monitoring stakes were new this season, and were surveyed with GPS to monitor the annual motion of the permanent lake ice. These stakes will provide hydrologic balance measurements for the McMurdo Dry Valleys Long Term Ecological Research (LTER) program. Due to project time constraints, this season's GPS work was limited to Lake Hoare, where UNAVCO provided field support for the surveys, performed with the new Trimble 4700 receiver. Data processing and archiving were provided after the field surveys.

B-042-F (Andrew Fountain)

Field support was provided to survey topographical transect endpoints on Taylor Glacier, radar reflector locations on Commonwealth Glacier, and a stream and lake system on Canada Glacier. This work helps to understand the melt water contribution of the Taylor Valley glaciers to the ecosystem, and is part of the McMurdo Dry Valleys LTER program. These surveys were performed with the new Trimble 4700 receiver system. Data processing and archiving were provided after the field surveys. A handheld Garmin DGPS receiver was also provided to field assistant Thomas Nylen for various applications in Taylor Valley for the entire field season.

B-042-W (Diana Wall)

A Garmin DGPS receiver was provided to research assistant Andy Parsons for the duration of the field project to measure the location of soil study plots. These sample locations, part of the McMurdo Dry Valleys LTER program, help determine the effects of natural environmental conditions on the abundance and distribution of soil biota.

B-043 (Sam Bowser)

Sam Bowser requested a survey of the New Harbor research area, where the field team studies the unique shallow water occurrence of agglutinated foraminifera, a dominant member of cold, deep-sea sediment ecosystems. GPS was used to obtain sub-meter positions of the shoreline, the sea-ice moat, and dive holes. UNAVCO provided field support, data processing, and data archiving for this project, which was performed with the new Trimble 4700 receiver system in kinematic mode. The coordinates obtained will be used for mapping purposes and to geo-reference the specific research sites and ocean floor features, such as iceberg scours, so they can be recovered in future seasons. A handheld Garmin DGPS receiver was also provided to field assistant Doug Coons to survey dive hole locations.

B-044 (Chris Fritsen)

UNAVCO performed early and late season re-surveys of lake ice profiles originally surveyed in November 1998, as requested by co-PI Ed Adams. The goal of the surveys is to digitize the wind and sun formed surface roughness of the lake ice and to provide a surface measurement method of ice thickness. Repeat surveys measure seasonal and annual variations of surface topography, which may affect annual lake ice melting and the lake biosystem. The new backpack mounted Trimble 4700 system was used for the kinematic surveys, and provided a more robust survey method than the sled mounted system used the previous season. A handheld Garmin DGPS receiver was used to relocated the transect endpoints during the surveys. Data processing and archiving were provided after the field surveys. Prior to the field season, data processing support was provided to Dr. Adams for outstanding data sets collected during the previous field season.

G-052 (Jerry Mullins)

Five Trimble 4000 SSi geodetic receivers, choke ring antennas, and solar panels were provided to Larry Hothem for the OSU/USGS Transantarctic Mountain Deformation Monitoring (TAMDEF) GPS project. This project measures fault motion and post-glacial of the Transantarctic mountains with episodic GPS campaigns.

G-053 (Bernard Hallet)

UNAVCO performed a second epoch survey to measure surface displacements in Beacon Valley, which may occur due to sub-surface ice in the valley floor. This survey (October 1999) was a repeat of the initial survey from January 1999, and will reveal surface velocities as small as 2 cm/year. The G-053 field team did not deploy to the field in the 1999/2000 season, but requested that UNAVCO conduct the survey so they could use the results to better plan their next field season. Six geodetic receiver systems, field support, data processing, and data archiving were provided. ASA surveyor Dennis Kenley assisted with the fieldwork. TAMDEF survey mark (BEA4) on University Peak was used for the reference receiver location.

G-054 (David Marchant)

David Marchant received support from UNAVCO and ASA surveyor Jeff Scanniello to survey aerial photography and topographical map control points features from several Beacon Valley and Pivot Peak locations. The coordinates obtained will be used to better map alpine boulder-belt moraines and other geological features. Two geodetic receivers and field support were provided, as well as data processing and archiving after the field surveys.

G-058 (Ralph Harvey)

Support was provided to obtain precise coordinates for survey reference marks at both the Beardmore Glacier and Elephant Moraine research areas. These reference marks are used as geo-referenced GPS control points for local surveys of meteorite locations in the area, allowing the meteorite spatial data to be used in a GIS database. The stake coordinates also provide ice velocity information when re-surveyed at future site visits. Field researcher John Schutt received a brief training at McMurdo and was provided two geodetic receivers. The Elephant Moraine data were archived and processed by UNAVCO after the field season using the JPL Auto-GIPSY point-positioning automated data processing service.

G-063 (Michael Prentice)

Support was provided to position tag ground penetrating radar (GPR) data recorded at several dry valley locations during the second part of a pilot project by the University of New Hampshire and CRREL. By simultaneously using GPR and GPS, the GPR profiles of underlying stratigraphy can be accurately referenced to surface features and locations. The GPS equipment was also used to obtain geo-referenced control for GIS applications. Two geodetic receivers were provided for the project, including one new Trimble 4700, which is well suited for the backpack, mounted kinematic surveys. UNAVCO also provided data processing software, training to field assistant Jennifer Horseman, field assistance, post-processing support, and data archiving.

G-081 (Philip Kyle)

Philip Kyle requested UNAVCO support to install and survey a GPS deformation network on Mount Erebus. A nine monument geodetic GPS network (Figure 11) was established to measure short and long term deformation. Four monuments (ABBZ, BOMZ, HOOZ, and SISZ) surround the crater on mid-level outcrops at the 1800-meter elevation level, and are collocated with permanent short-period continuous monitoring seismic stations. Five more monuments (CONZ, EAST, ELHT, HELZ, and NAUS) circle the crater on outcrops in the old caldera at the 3200-meter level. All nine monuments were surveyed in December 1999, and each monument was occupied for a minimum of three full (UTC) days per episodic visit. The monument ELHT, at the Erebus lower hut, serves as a local reference station and was run for the duration of the entire survey.

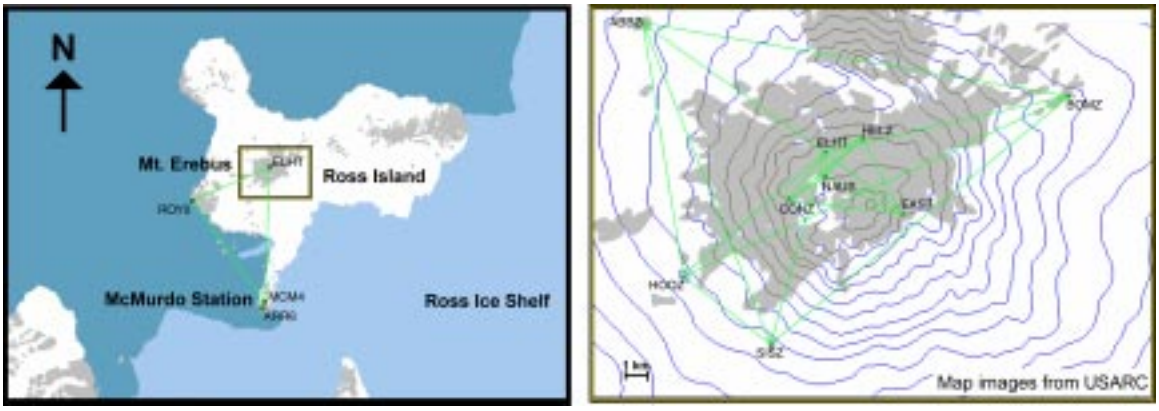

Figure 11 – Mount Erebus GPS deformation network

The IGS reference station MCM4 at McMurdo Station provides continuous reference data to isolate Mt. Erebus volcanic deformation from other deformation processes affecting Ross Island as a whole. Three monuments from the OSU/USGS Trans Antarctic Deformation Network (TAMDEF) are also included in the survey network. Sites ERE0 near the Erebus Lower Hut, ROY0 at Cape Royds, and ARR6 at the Hut Point Astro pier provide commonality between the networks, and will relate any observed Mt. Erebus deformation to larger scale deformation measured by the TAMDEF network. The ARR6 monument also serves as a reference mark to monitor MCM4 stability.

Five Trimble 4000 SSi geodetic quality receivers, field support, and data archiving were provided for the deformation survey. UNAVCO also provided two receivers, data processing software, and training to research assistant Jean Wardell to track helicopter flight profiles during plume sampling flights.

Prior to the field season, data processing support at UNAVCO was provided to research assistant Chris Harpel for data collected during the 1997/98 field season.

G-084 (Ian Whillans)

Three geodetic quality receivers were provided to research assistant Blue Spikes to measure ice flow in the Allan Hills meteorite concentration region. Five receivers were also provided for the TAMDEF survey – this support was requested by the USGS and is included under G-052 (Mullins).

G-098 (Donald Blankenship)

The Support Office for Aerogeophysical Research (SOAR) requested UNAVCO technical support to process data from GPS base station locations at Williams Field and the Mid-C camp. UNAVCO post-processed the data at McMurdo to provide accurate reference coordinates to use with the airborne geophysical surveys, and provided Trimble GPSurvey data processing software to the field team.

I-151 (Nelia Dunbar)

Three geodetic quality receivers, a field computer, and data processing software were provided for mapping tephra layers in the summit crater of Mount Moulton. One receiver, a new backpack mounted Trimble 4700, was especially well suited for this application due to its improved user interface, portability, and smaller battery requirement. The tephra layers in the horizontally exposed section of ice range from 15,000 to 480,000 years in age, and were sampled for geochemical analysis. UNAVCO provided training at McMurdo, and post processing support after the field season using both Trimble GPSurvey and the JPL Auto-GIPSY data processing service.

I-153 (Paul Meyewski)

UNAVCO provided five geodetic quality receivers and a GPSurvey data processing hardware key to co-PI Gordon Hamilton for snow surface measurements on the U.S. component of the International Trans-Antarctic Scientific Expedition (ITASE) traverse on the West Antarctic Ice Sheet. The aim of this traverse is to develop a better understanding of the last 200 years of West Antarctic climate and environmental change through multidisciplinary research. Interference cause by the field team's Iridium telephone on the Tucker Snow Cat mounted GPS was tested and verified at McMurdo Station to determine a safe distance from which the satellite telephone could be used while collecting GPS data.

I-166 (Beata Csatho)

Beata Csatho was provided two geodetic quality receivers for calibration and validation of ice volume change measurements with the SOAR laser suite. The goal of this research is to establish the capability of the SOAR facility to accurately and precisely determine surface elevation, a service of particular interest to investigators studying the change in the Antarctic ice sheet.

I-169 (Ian Whillans)

Gordon Hamilton was provided three geodetic quality receivers and a GPSurvey data processing hardware key to measure shear margin strain of several West Antarctic ice streams. These surveys were part of the second year of a three year project to study stress transmission at Ice Streams B, D, and E.

I-171 (Ed Waddington)

Research assistant Bob Hawley was provided two geodetic receivers to measure vertical offsets between Siple Dome borehole locations. As part of the study of past climatic conditions in Antarctica, the researchers are analyzing the temperatures from an array of 200 meter deep boreholes to determine spatial variability of surface temperature in the Siple Dome region during the last few decades. The GPS survey correlates vertical strain in the firn layer from two 100 meter deep boreholes, needed to properly interpret the temperature measurements.

O-283 (Chuck Stearns)

A Trimble 4800 geodetic quality receiver was provided to Rob Holmes and John Cassano to survey accurate locations of Automated Weather Station sites around McMurdo Sound and on the West Antarctic Ice Sheet. Precise elevations of these sites were desired to better use the meteorological data. Although meter level results are sufficient, the geodetic receiver was provided due to the long baselines for the West Antarctic sites. UNAVCO provided data processing and archiving after the field surveys.

E-318 (Chuck Kennicutt)

A DGPS Trimble GeoExplorer receiver and Pathfinder Office software was used by research assistant Diana Allsup to map soil sampling points in and around McMurdo Station. These sample locations are used to study the temporal and spatial scales of both natural and anthropogenic change in terrestrial and marine habitats.

Italian Geodetic Survey/USGS (Alessandro Capra and Larry Hothem)

Two geodetic quality choke ring antennas from UNAVCO were provided to the USGS to help make up for four USGS choke ring antennas that were lent to the Italian program. (UNAVCO antennas were not provided directly to the Italians due to time constraints on their availability.) The effort was made to provide the Italian program with the same choke ring antennas used on the TAMDEF network, to better accommodate data sharing. UNAVCO facilitated the shipment of antennas from McMurdo to the Italian Terra Nova Bay station.

RADARSAT (Ken Jezek and Bob Onstott)

UNAVCO received a last minute request to provide ground control data for a RADARSAT ice velocity mapping project. The goal of this pilot project is to produce a continent wide ice velocity map using interferometric synthetic aperture radar (INSAR) techniques. UNAVCO operated a geodetic quality Trimble 4000 SSi receiver at the Long Duration Balloon facility at Williams Field for a full month, and installed and surveyed a nearby makeshift radar reflector (four 55-gallon drums bundled together). The survey was timed to coincide with two satellite observation periods, and ran continuously for a full month to get a full lunar cycle tidal signature. After the field observations, the raw data were archived and provided to the PIs.