UNAVCO

GPS Support to the National Science Foundation Office of Polar Programs Antarctic Program

2004-2005 Season Report

GPS Support to the National Science Foundation

Office of Polar Programs

Antarctic Program

2004-2005 Season Report

May 16, 2005

Beth Bartel
Jim Greenberg
Bjorn Johns

UNAVCO, Inc.
6350 Nautilus Dr.
Boulder, CO 80301
(303) 381-7470
www.unavco.org

Support funded by the National Science Foundation Office of Polar Programs
Supplement to EAR-0321760 - Support of UNAVCO Community and Facility Activities

Cover photo: UNAVCO engineer Jim Greenberg works in -30° Celsius to upgrade the CONZ continuous GPS site from a Trimble 5700 to a Trimble NetRS receiver.

Table of Contents:

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. The UNAVCO web site (www.unavco.org) provides comprehensive and historical information related to UNAVCO support to NSF/OPP.

A "satellite" facility is staffed at McMurdo Station, Antarctica 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. Twenty projects received support in 2004/2005 as requested prior to the field season, and four additional projects were added during the field season (Figure 1). Table 1 summarizes Antarctic projects using UNAVCO support, while Appendix A provides more detailed discussions of individual projects. Three off-season projects in South America and Greenland are also in progress and will be included in the 2005/2006 annual report.

The 2004/2005 season also marked an increased effort to better address support needs related to long-term or permanent GPS stations in the Antarctic. This was in response to the NSF requesting UNAVCO to provide a more cost effective and standardized "one stop shopping" for GPS, power, and communication systems. The scope of this effort is still evolving with both the NSF and scientists providing considerable feedback, and a section of this report is dedicated to expanded capabilities for continuous data collection.

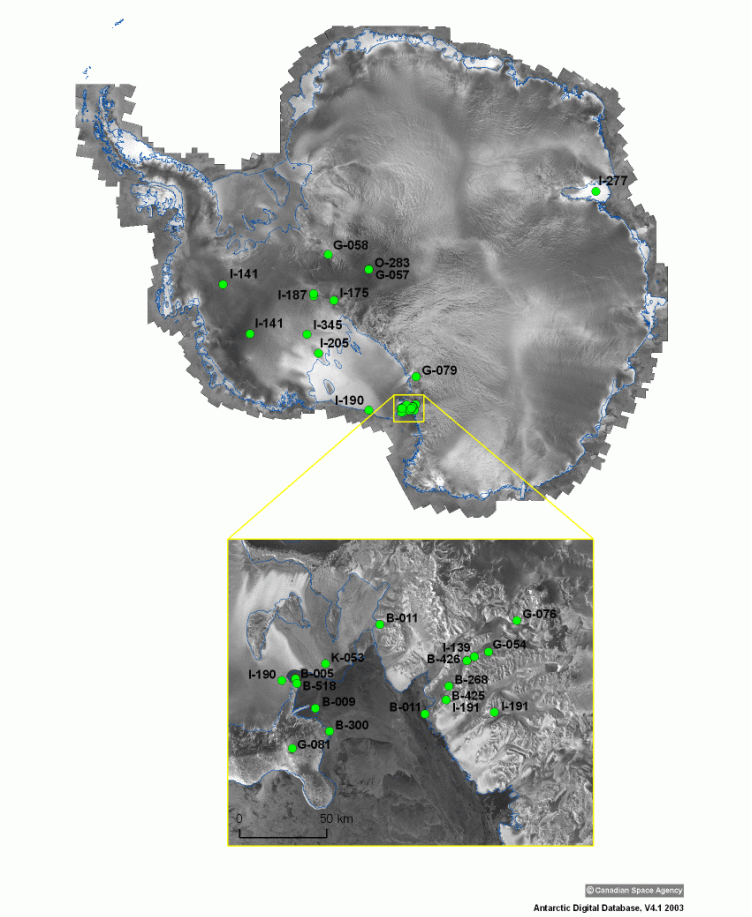

Figure 1: Locations of projects which utilized UNAVCO services during the 2004-05 mainbody season. Figure compliments of Jessica Walker, Raytheon Polar Services Company.

Table 1 – 2004-2005 Antarctic Support Provided

Project	Point of Contact	Support Effort (%)	Eqp. Loan	Field Support	Training	Data Archived	Data processed	Preseason Request
B-005	Palmintier	1	Yes	No	Yes	Yes	Yes	No
B-009	Proffitt	1	Yes	Yes	No	Yes	Yes	No
B-011	Uhle	2	Yes	Yes	No	Yes	Yes	Yes
K-053	Copland	1	Yes	No	Yes	No	No	No
G-054	Marchant	2	Yes	Yes	No	Yes	Yes	Yes
G-057/058	Schutt	3	Yes	No	No	Yes	No	Yes
G-076	Putkonen	2	Yes	No	Yes	No	No	Yes
G-079	Willis	17	Yes	Yes	Yes	No	No	Yes
G-081	Kyle	5	Yes	Yes	No	Yes	Yes	Yes
I-139	Pettit	4	Yes	Yes	Yes	Yes	No	Yes
I-141	Link	4	Yes	No	No	No	No	Yes
I-175	Conway	4	Yes	No	No	Yes	Yes	Yes
I-187	Ackert	1	Yes	No	Yes	Yes	Yes	Yes
I-190	Thom	1	Yes	Yes	Yes	Yes	Yes	Yes
I-191	Kreutz	2	Yes	Yes	Yes	Yes	Yes	Yes
1-205	Voigt	27	Yes	No	Yes	No	No	Yes
B-268	Gooseff	1	Yes	Yes	Yes	Yes	No	Yes
I-277	Fricker	8	Yes	No	Yes	No	No	Yes
O-283	Lazzara	1	Yes	No	Yes	Yes	Yes	Yes
B-300	Jaros	1	Yes	No	Yes	Yes	Yes	No
I-345	Catania	8	Yes	No	Yes	No	No	Yes
B-425	Nylen	2	Yes	Yes	No	Yes	Yes	Yes
B-426	Doran	1	Yes	Yes	No	Yes	Yes	Yes
B-518	Klein	1	Yes	No	Yes	No	No	Yes

Science Support

Training

UNAVCO offers flexible options for field team training, including training before deployment to the field, training in the field, and data processing training as needed after data have been collected. The level of training is tailored to the experience of each research group. For the 2004/2005 season most training was provided at McMurdo Station or in the field, but training was also provided before the field season to several groups at UNAVCO's Boulder facility. Participants of a general training course held at the UNAVCO Facility in Boulder in April included members of G-058, G-081, I-139, I-190, B-300, and O-283. Dennis Darnell, of I-277, also received training at UNAVCO prior to the field season.

Field Support

UNAVCO engineers[1] were present at McMurdo Station throughout the mainbody season. The primary responsibilities of the field engineers are managing the large equipment pool and providing technical support to field projects. The field engineers also maintain the DGPS infrastructure and the Mount Erebus continuous station network data collection computer, and train the Raytheon Polar Services Company (RPSC) science technician on maintaining these systems over the winter. Pre-season support was also provided to G-079, I-190, I-205, I-277, and I-345 in the form of equipment and/or technical assistance.

Data Processing

Post-processing of differential GPS data is necessary to achieve the centimeter level precision required for most projects. UNAVCO supports data processing in the field using commercial software. Many groups are trained to process their data in the field to ensure data quality before pull-out. UNAVCO also continues to provide post-season data processing support using commercial software, on-line data processing services, and advanced post-processing techniques for problem data sets.

Data Archiving

All GPS data handled by UNAVCO are archived, both locally at McMurdo Station and at the UNAVCO Boulder archive, to ensure data safeguarding and future accessibility. Antarctic 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—and all investigators are encouraged to archive their data soon after project completion. Meta-data from all UNAVCO-supported Antarctic projects can be accessed on-line by field season and project event number. UNAVCO-supported GPS project meta-data are also submitted to the National Snow and Ice Data Center (NSIDC) Antarctic Data Coordination Center.

Data collected to geodetic standards are archived by site name and precise site coordinates, and site descriptions are readily available on-line. 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 new GPS benchmarks CLKG (Clark Glacier) and COMG (Commonwealth Glacier) were added to the on-line benchmark database.

[1] Jim Greenberg (10/04-12/04) and Beth Bartel (10/04-02/05).

Equipment

Science Pool

Seventy-seven geodetic quality dual-frequency receivers from the UNAVCO pool (10 Trimble NetRS, 16 Trimble R7, 28 Trimble 5700, four Trimble 4700, one Trimble 4800, and 18 Trimble 4000 SSE/SSi) were provided for Antarctic support throughout the field season. All necessary ancillary equipment, such as data processing software, solar panels, batteries, chargers, tribrachs, tripods, and cables, was also provided.

UNAVCO is in the process of increasing the number of new receivers in the pool to better meet the extended GPS deployment needs. Prior to the field season, seventeen new Trimble R7 GPS campaign receivers and one Trimble NetRS reference station receiver were purchased. After the field season, an additional 10 NetRS receivers were purchased, bringing the total U.S. Antarctic Program (USAP) pool to 57 units. These new receivers have a built-in web browser interface and large internal memory and work well for long-term (several months) deployments. They are also being evaluated for suitability at remote Antarctic permanent stations with real-time communications for data retrieval. Table 2 provides a summary of the USAP receivers in the pool.

Table 2 – USAP Receivers in the UNAVCO Equipment Pool

Receiver model	Qty	Features and Applications	Average age
Trimble 4000	8	Front panel display for field programming and ease of use and educational value. Seven of these will be retired prior to the 2005-2006 field season, and one will be kept for training applications.	9 yrs
Trimble 4700	4	Robust receiver for short term data collection and kinematic surveys where a handheld survey controller is used. These continue to be fully subscribed every field season, and one serves as the McMurdo RTK base.	5 yrs
Trimble 5700	17	Modern low power, high memory receiver ideally suited for both short term and continuous data collection.	3 yrs
Trimble R7	17	Same as the 5700, but also capable of tracking the new L2C GPS signal, once available.	1 yr
Trimble NetRS	11	State-of-the-art reference station receiver with built in computer and web browser interface, well suited for continuous data collection applications.	0.5 yr

The oldest receivers in the pool (Trimble 4000s) are becoming a support liability due to different ancillary equipment and connector sizes, insufficient memory for most continuous data collection, larger size and weight for transport, data communication difficulties with modern computers, and increased failure rate due to age. It was UNAVCO's intent to remove these from the pool prior to the past field season, but the large receiver demand resulted in them being deployed one last time as part of the pool. The remaining receivers will be provided on long term loan to individual Antarctic researchers based on merit of the intended use.

Figure 2: Jim Greenberg and Effendi Sihombing stage GPS equipment in UNAVCO's Boulder facility for shipment to McMurdo.

Differential GPS System

UNAVCO maintains a real-time kinematic (RTK) DGPS system at McMurdo which allows for centimeter level surveys in real-time in the immediate vicinity of McMurdo Station. The GPS base station is in Building 71 at Arrival Heights, and differential corrections from this receiver are broadcast from a radio transmitter on Crater Hill. The system was used by B-518 (Kennicutt) for navigating to sample locations for an environmental impact assessment in the McMurdo vicinity. Next season's field plan includes replacing the GPS base station with a Trimble NetRS receiver. This receiver would be accessible over the local area network, allowing remote control of the receiver. In addition to the RTK/DGPS functionality, this receiver will also collect high rate (2 Hz) base station data useful for applications such as survey aircraft positioning.

Expanded Capabilities for Long-term Continuous Data Collection

The 2004/2005 season marked an increased effort to better address support needs related to long-term or permanent GPS stations in the Antarctic. This was in response to the NSF requesting UNAVCO to provide a more cost effective and standardized "one stop shopping" for GPS, power, and communication systems. The goal is to provide a cost effective, centralized source for Antarctic permanent station equipment and the associated technical expertise to ensure its successful deployment and robust data collection. This also includes addressing long-term operation and maintenance issues and the implementation of sites configured to global standards. UNAVCO is in a unique position to provide cradle-to-grave support including field engineering and equipment support for initial station installations, network engineering for dataflow monitoring, and data management and archiving services for data dissemination and archival. The scope of this effort is still evolving with both the NSF and science community providing considerable feedback.

Development activities

The limited success of remote GPS observatories in the Antarctic highlights the need for focused development activities. Within the USAP much of the development to date has occurred through iterations conducted under multi-year science grants, and collectively much headway has been made and several science teams have the capability to deploy solid operational systems. At the same time, little effort has been put into providing standardized systems that are readily available off-the-shelf to the greater community. Certain technological barriers related to communications and overall system autonomy also remain unresolved. UNAVCO's recent developmental activities have focused on several specific items:

1. **Developing a supply, maintenance, and support system for the well understood components such as solar power systems and enclosures.** The direct benefit to the science users are that such items can be requested directly from UNAVCO along with GPS equipment, without the need for further specifying individual components. The equipment is made available on the ice, and spares are on hand for field contingencies. The benefit to the overall program is time and cost savings from the economy of scale of consolidated purchases, a pool approach for re-use of equipment after individual projects are completed, and familiarity of the system design by UNAVCO staff in the field.

2. **Establishing local test capabilities.** A Thermotron environmental test chamber (Figure 3), with a -70C to +70C temperature range, was purchased for various project applications and provides an ideal controlled environment for testing individual components outside manufacturers' temperature specifications, as is typically the operational norm in Antarctica. Currently the lead acid batteries supplied by UNAVCO are being tested to accurately quantify the reduced capacity and permanent damage resulting from extreme (-50C) cold. This test chamber is also available for community use on a non-interference basis.

Figure 3: Environmental test chamber recently acquired by UNAVCO.

UNAVCO also maintains a test platform consisting of an enclosure and solar power system that is used for testing and validating instrumentation and communication equipment at the Niwot Ridge Tundralab. This site is located at 11,600 feet on the continental divide at the University of Colorado Mountain Research Station facility, and is subject to extreme winds, spindrift, and rime icing. University of Colorado infrastructure at the site provides current and historical meteorological data, a web camera, and internet access, making it an ideal 'back-yard' test site for Polar technology.

3. **Field testing of Ethernet spread-spectrum radios for close-to-station communications**. The Intuicom Ethernet bridge radio is widely used by UNAVCO in project applications world-wide. It provides a line-of-sight wireless connection between Internet infrastructure and remote sites, and several units can be deployed in multi-node networks. The radios are currently in use between McMurdo, Mt. Erebus, and Mt. Fleming.

4. **Integrating Iridium serial modems with GPS receiver.** For the most remote sites, Iridium satellite communications provide the most practical means for data retrieval. The system is low power, provides global coverage, and uses a non-directional antenna that eliminates the need to align the antenna in the field. Hardware and software are currently being tested for robust field applications. An initial trial deployment in Antarctica in January 2005 yielded mixed results – the system performed well in tests at McMurdo and initially at the Fish Tail Point remote GPS site, but failed shortly after the field installation. The exact components were re-tested after the field season, without a conclusive duplication of the failure mode seen. Potential solutions are being pursued, and the overall communication strategy is solid based on feedback from other Iridium users in the Polar technology community (who typically do not have the same data transfer needs as that required for geodetic GPS data). The Iridium system is still a promising tool as solutions are pursued for the initial setbacks. Aggressive testing and evaluations are currently in progress.

5. **Field testing of compact weather station.** The science community consensus is that collecting meteorological data is desirable if power and communications are available at remote sites. A WXT-510 weather station was borrowed from Vaisala for evaluation for suitability in Polar applications. The unit is appealing as it allows for pressure, temperature, humidity, wind speed, and wind direction data to be embedded in the GPS data file. The unit is relatively low cost, has no moving parts, and is advertised as "good, not great". The unit was tested at the Niwot Ridge site (Figure 4), and initial results indicate the need for further testing. With satisfactory performance, such units could be standard issue at remote GPS sites with communication links. The additional observables would provide value for meteorology, engineering evaluations, local operations, and GPS meteorology measurements of atmospheric precipitable water vapor.

Figure 4: Testing a weather station integrated with the GPS receiver at the Niwot Ridge test facility.

6. **On-line documentation of remote station engineering efforts.** A web page was set up (www.unavco.org/facility/project_support/polar/remote/remote.html) to disseminate relevant specific information related to the support available from UNAVCO for long-term continuous data collection. The content of this page will grow as appropriate to reflect operational capabilities.

Field highlights

Ethernet modem communications established to Transantarctic Mountains and Mt. Erebus GPS sites. In support of G-079/TAMDEF (Wilson), a radio repeater (Figure 5a) was set up at Truncated Cones on Mt. Erebus. The repeater is operated by UNAVCO, and allows for standard radio modem communications to remote GPS sites within a 120 degree sector from Cape Roberts in the north to Black Island and beyond in the south (Figure 5b). The site was set up in November 2004 specifically to download data from the TAMDEF site on Mt. Fleming, and data files were pulled to the UNAVCO archive until a power problem stopped the GPS site in March 2005. As of May 2005 the communication links are still responding. Additional sites could be added to the network, and Land Information New Zealand is hoping to use the repeater to establish communications to the Cape Roberts GPS next field season. In support of G-081 (Kyle), the continuous GPS station at Truncated Cones was upgraded to an internet-enabled Trimble NetRS receiver, also with daily data transfers to the UNAVCO archive.

Figure 5a: Repeater tower at Truncated Cones. Note antenna on the left side of the tower.

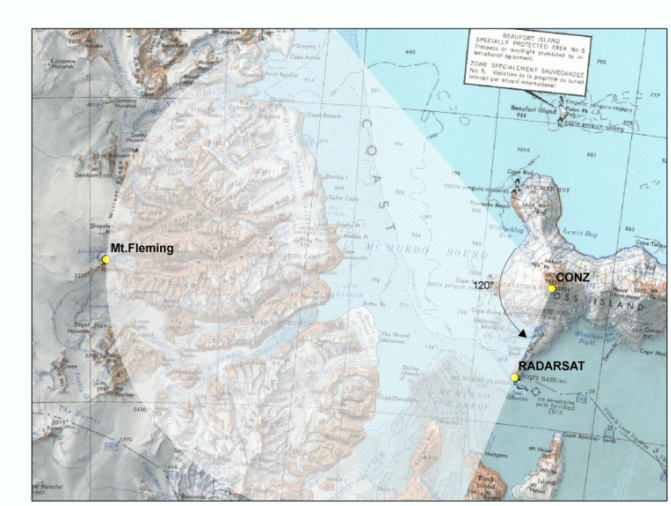

Figure 5b: Extent of radio communications from the repeater site at Truncated Cones.

Iridium satellite communications tested for remote data retrieval. A GPS receiver and Iridium modem were deployed at TAMDEF site Fish Tail Point. While ultimately the system did not work as intended, the field deployment served as a proof-of-concept and will lead to a more robust system for the 2005-06 field season. A system that allows for occasional power cycles and system resets to the Iridium modem will be tested prior to next field season.

Winter continuous data collection on Kamb Ice Stream. Six GPS receiver systems were left on Kamb Ice Stream to collect data through the winter, and they will be retrieved next field season. UNAVCO provided complete systems to I-345 (Tulaczyk) for this effort, which in addition to GPS included enclosures, solar panels, and batteries. The specific effort for this project served as a prototype for complete systems for glaciological applications, which will be improved and standardized for next field season.

Custom packaging for extended summer deployments. A custom packaging system was developed for the Trimble NetRS receiver. These new receivers represent state-of-the-art permanent station technology with built in web server and Ethernet connectivity. The also contain nearly 1Gb of internal memory for long term autonomous data collection applications. To make them better suited for pool use and multi-project deployments, UNAVCO packages the receiver in a robust shipping case/enclosure, pre-wired with a power regulator and sealed connections for the GPS antenna, solar panels, and external battery banks (Figure 6). Several such systems were provide to the I-210 (Anandakrishnan) TIDES project.

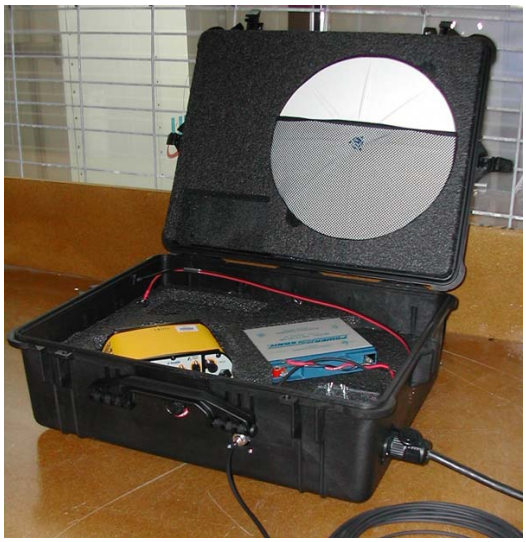

Figure 6: NetRS custom package developed at UNAVCO before the 2004/05 field season.

Future plans

The following activities are planned to improve all aspects of system design issues

1. **Develop a standardized system design.** Standard GPS, power, and communication systems at remote GPS installations are essential for efficient maintenance and operations. UNAVCO has a long history of all aspects of GPS network operations and is putting considerable effort into applying this experience to Antarctic applications. A prototype Antarctic remote site is being built near Boulder to speed up the development cycle. This effort is intended to showcase UNAVCO's approach to remote sites, and allow hands-on access to the development for interested community members away from Antarctica. It also serves as a test bed for systems integration, and as an opportunity to validate a design before committing to deploy it in Antarctica. Any technical solution requires buy-in from the USAP GPS community to succeed, and a built-up working model provides an excellent opportunity to incorporate experience from the community and respond to constructive critique.

2. **Facilitate community cooperation and communication.** A specific management plan amongst interested stakeholders, including project scientists, UNAVCO, the U.S. Geological Survey (USGS), the Incorporated Research Institutions for Seismology (IRIS), and NSF is essential for successful and cost effective deployment, maintenance, and operation of future Antarctic GPS and seismic networks that extend beyond the immediate science needs of a single project. GPS efforts to date have been very project specific, in terms of both principal investigators and geographic study areas. With the International Polar Year (IPY) on the immediate horizon, larger network proposals are under development, and UNAVCO hosted a recent workshop attended by GPS and seismic research principals. The immediate outcome of the workshop was an IPY Expression of Intent for Polar Earth Observing Network (POLENET), and upcoming action items include an IPY proposal for the June 30, 2005 deadline, as well as a more detailed proposal with scientific rationale and a management plan to be submitted to OPP in the context of IPY.

3. **Support the creation of Polar Networks Steering Committee.** A formal mechanism for scientific input and project direction is necessary should a large Antarctic network initiative come to fruition. This allows for direct, top down feedback to supporting facilities such as IRIS and UNAVCO, and provides the formal body to approve key technical and site location issues that were either not adequately addressed in, or have changed from, the project proposal.

4. **Explore cooperation with IRIS.** UNAVCO and IRIS enjoy solid working relationships at all levels. While the modes of operation in Antarctica are substantially different, future initiatives are likely to lead to potential collaborations such as sharing workspace at McMurdo Station, cross training staff on the basics of GPS and seismic systems troubleshooting and maintenance, and coordinating development for joint GPS and seismic initiatives.

5. **Obtain more suitable workspace at McMurdo Station**. The Crary Lab has been an excellent base of Antarctic operations for UNAVCO, but its future suitability has been questioned both by UNAVCO and by McMurdo Station long range planners. Both the volume of equipment now handled as well as the stock and inventory requirements that accompany continuous GPS station installation and maintenance highlight the need for a workspace that can also serve as a year-round storage. Dedicated space, rather than space that has to be formally requested in the SIP every year, seems appropriate.

6. **Increase FTE time at McMurdo Station.** Traditionally, the Antarctic season workload requires one field engineer at McMurdo Station from mid-October through early February, and a second engineer to assist during peak demand for approximately eight weeks at the start of the field season. The increased role in continuous GPS station support makes it necessary to consider the potential need for a second engineer for most of the season due to both the increase in workload and the different skill sets required for permanent station support vs. campaign field project support. The continuous station support role would likely be staffed with two engineers in pre- and post-holiday deployment, and the direct impact on the program would be a request for a third UNAVCO deployment slot based on tasking.

Appendix A - Detailed Summary of Support Provided

B-005 (Art DeVries)

Dr. DeVries' group studies the physiology of fish and larvae found in the cold Antarctic waters to see how ice grows in biological tissues and how antifreeze glycoproteins inhibit it. UNAVCO provided training, one Trimble 4700, data processing, and archiving for the measurement of locations of underwater instruments to make future recovery of these instruments more efficient.

B-009 (Robert Garrott)

Robert Garrott's group studies the dynamics of the seal populations in Erebus Bay. The group is measuring the location of each seal and the locations of water holes and cracks in hopes of learning what makes some seal colonies better (with a higher population) than others. UNAVCO provided instrumentation, field support (Figure 7), and data processing to obtain high-precision results.

Figure 7: Using GPS for high-precision spatial control of the Big Razorback island seal colony.

B-011 (Maria Uhle)

Algal mats grow in and moss grows around ponds which develop and migrate as a result of differential melting of ground ice in the hummocky moraines in the Dry Valleys. B-011 is studying the effect of these pond ecosystems on the carbon cycle of the Dry Valleys. 1.5" PVC pipe markers drilled into the ground last season were surveyed again with fast-static methods and will be monitored for changes. Pond shorelines and vertical profiles of topography around the ponds were mapped using post-processing kinematic methods. Field support in both Hjorth and Garwood valley, data processing, and data archiving were provided.

K-053 (Wendy Lawson)

Dr. Lawson's group seeks to understand the climatic response of the McMurdo Ice Shelf through mathematical modeling, analysis of satellite images, and field-based methods including GPS to determine ice velocities. UNAVCO provided two Trimble 5700 receivers to supplement the group's equipment pool.

G-054 (Dave Marchant)

Expansion bolts were installed in 19 boulders embedded in multiple gelifluction lobes east of the Stocking glacier (Figure 8). A Trimble 5700 receiver base station and another Trimble 5700 rover were used to measure the locations of the pins relative to a pin in a boulder determined from aerial photographs to be below the active flow. Future measurements will reveal surface flow velocities, which can be used to better understand these flow features in Antarctica which Dr. Marchant believes may be used as present and past climatic indicators. UNAVCO provided equipment, field, and processing support, and also data archiving.

Figure 8: A Zephyr antenna is used to measure surface flow in Taylor valley.

G-057, G-058 (Ralph Harvey)

The field team performed local stop-and-go kinematic surveys of meteorite locations, allowing the meteorite spatial data to be used in their GIS database. Most of the meteorites were collected from the LaPaz ice fields, approximately 250 miles from Amundsen-Scott South Pole Station. Search efforts were also undertaken at the Cumulus Hills, Roberts Massif, Larkman Nunatak, Mount Pratt, and MacAlpine Hills in the upper Shackleton Glacier and Beardmore Glacier regions. UNAVCO provided five Trimble 4000 receivers, data archiving, and base station coordinates using the JPL Auto-GIPSY point-positioning automated data processing service.

G-076 (Jaakko Putkonen)

Dr. Putkonen's group is using cosmogenic dating methods to determine past ice dynamics within the McMurdo Dry Valleys. UNAVCO provided a Trimble 4000 base receiver and a Trimble 4700 rover receiver to measure the locations of pins in boulders on gelifluction flows within the valleys. These newly-placed pins will be remeasured in the future to determine flow rates of these features. Training and data processing support were also provided.

G-079 (Terry Wilson)

Dr. Wilson's group is studying the crustal motions around the Ross Sea area associated with glacio-isostatic adjustment (uplift or subsidence resulting from unloading or loading of crust by glaciers) and with active rifting of the Terror rift system. This group's application demands the highest possible precision allowed by GPS. UNAVCO provided ten Trimble 5700/R7 GPS receivers for campaign measurements and a Trimble NetRS receivers and a Trimble R7 receiver for winter-over sites. Additionally, UNAVCO worked with G-079 to upgrade two continuously-operating sites to telemeter their data back in near-real-time. The site at Mt. Fleming was equipped with a Trimble NetRS receiver which sends data to McMurdo via a repeater installed this season at Truncated Cones on Mt. Erebus. Iridium was tested as a means to send data back from Fishtail Point (Figure 9).

Figure 9: G-079 and UNAVCO staff at Fishtail Point, continuous site FTP1.

G-081 (Philip Kyle)

Dr. Kyle requested UNAVCO support for both campaign and permanent station GPS activities on Mt. Erebus to measure the deformation of the volcano caused by the migration of magma. Three receivers and field support were provided to resurvey six geodetic monuments on and around Mt. Erebus which are not monitored by continuous geophysical instruments. Velocity stakes on the Barne Glacier were re-surveyed as well to better determine the glacier's velocity to constrain the age of an ash layer found in the glacier's ice. UNAVCO continued involvement in maintenance and upgrading of the permanent GPS network on Erebus. The Trimble 5700 at site CONZ was replaced with a Trimble NetRS. Data are transferred via IP link to Boulder, Colorado, where the data are archived. The 5700 receiver at Abbott Peak was replaced by a Trimble R7 to test the R7's capability to run through the winter in the cold climate. Data from the seven telemetered Erebus permanent stations are downloaded daily to McMurdo Station, and transferred to the UNAVCO data archive where they are on-line and publicly available. GPS data collected since 1999 are showing displacements on the order of millimeters per year.

I-139 (Bernard Hallet)

Taylor glacier is the most frequently calving glacier in the Dry Valleys. I-139 is using small arrays of geophysical instruments at the glacier's terminus to better understand the dynamics of dry-land calving. Instruments include strain gauges, tilt sensors, thermistors, seismometers, and GPS receivers to measure strain within small networks. UNAVCO provided one Trimble 4000 base station and one Trimble 4700 rover for kinematic surveying of geographical features and photo sites, and an additional Trimble 5700 rover and field support for the initial surveying of the three strain arrays. Four Trimble 5700s, field support, data processing, and data archiving were provided for a late-season resurvey of the strain networks (Figure 10).

Figure 10: Dr. Erin Pettit lowers a Trimble 5700 GPS system to RPSC field safety mountaineer Brennan Brunner.

I-141 (Jack Holt)

The primary objective of Dr. Holt's project is to determine boundary conditions for the major glacier drainages in the Amundsen Sea Embayment, including ice surface topography, subglacial topography, gravity and magnetic anomalies. UNAVCO provided three Trimble 5700 receivers and one Ashtech chokering antenna to aid in positioning data needed for airborne geophysical surveys.

I-175 (Howard Conway)

Dr. Conway and Dr. Stone's group is working to define the Holocene history of Reedy glacier through both geological and geophysical means. Learning the history of Reedy glacier, and in particular determining whether the glacier is in continued retreat, will lend insight into the recent and current dynamics of the West Antarctic ice sheet. UNAVCO provided three Trimble 5700 receivers for kinematic surveying, one Trimble 4800 receiver for measuring sample locations, training, and processing and archiving of the data.

I-187 (Howard Borns)

The goal of this project is to reconstruct past ice sheet elevations in the Ohio Range in the southernmost Transantarctic Mountains near the onset region of the Mercer Ice Stream (formerly Ice Stream A). The group will use the information to better understand past ice sheet dynamics, including the possibility of gravitational collapse, in order to predict future ice sheet behavior. Two Trimble 5700 GPS receivers, training in data collection, data processing, and data archiving were provided by UNAVCO for mapping of glacial features.

I-190 (Douglas McAyeal)

Two Trimble 5700s, training, data processing assistance, and archiving were provided to measure the motion over four days of a site on the seaward side of the crack which is separating the 'Nascent berg' from the rest of the Ross ice shelf. Additionally, two 5700s, field support, and data processing were provided to measure a strain array on the McMurdo ice shelf.

Figure 11: Anne Benninger (RPSC) and Beth Bartel (UNAVCO) drill a hole for a new survey marker near Clark glacier.

I-191 (Karl Kreutz)

Field support and two receivers were provided at both the Clark and the Commonwealth glaciers. At both locations a 20-pole array surrounding the present ice core and camp was measured with the rover while a newly-established base marker was measured in nearby bedrock (Figure 11). The base markers were added to the UNAVCO online monument database. The base stations and poles will be measured in future years to determine ice velocities surrounding the cores. The core and velocity data will be used to understand climate variability during the past 2,000 years (late Holocene). UNAVCO also processed and archived the data

I-205 (Sridhar Anandakrishnan)

The second season of the TIDES project was focused on the high frequency, fine scale motion of Whillans Ice Stream. I-205 aimed to measure in detail the flow-speed response to tidal forcing by installing 36 GPS receivers on the ice plain of Whillans Ice Stream up to tributaries B2 and B1. Improved knowledge of ice-stream behavior will contribute to researchers' ability to assess the potential for rapid ice-sheet change affecting global sea levels. UNAVCO provided the majority of I-205's pool of GPS receivers with a total of 28 Trimble GPS systems (8 NetRSs, 8 R7s, 4 5700s, 8 4000s).

B-268 (Michael Gooseff)

Dr. Gooseff's group is taking a coordinated hydrologic, biogeochemical, and molecular microbial approach to studying the characteristics of the aquatic-terrestrial transition zones in the Dry Valleys of Antarctica. UNAVCO provided two Trimble 5700 GPS receivers, training in the field, processing support, and archiving to aid the group in mapping out the extent of the wetted zone (Figure 12) and the locations of samples taken around studied lakes and streams.

Figure 12: Ken Hill (B-268) surveys the extent of the wetted zone at Lake Fryxell.

I-277 (Helen Fricker)

UNAVCO provided six Trimble 5700 receivers for velocity measurements of the Amery Ice Shelf. Training was provided at UNAVCO in Boulder, Colorado in the summer of 2004.

O-283 (Chuck Stearns)

UNAVCO provided a Trimble 5700 receiver early season and a Trimble 4800 receiver/antenna late season, training, data processing, and data archiving to the Automated Weather Station field team in an ongoing effort to produce accurate site elevations used in climate models. These surveys are conducted as "opportunity surveys" during scheduled maintenance visits to the AWS sites.

B-300 (Yu-Ping Chin)

Dr. Chin's group is focusing on Pony Lake, on Cape Royds, to study dissolved organic matter in an environment lacking higher plants. Water from this pond will also be used as an International Humic Substances Society (IHSS) fulvic acid standard. UNAVCO provided a Trimble 5700 base and a 5700 rover receiver and ancillary equipment for kinematic surveying of the pond's shoreline to help determine the volume of the pond. Data processing and archiving were also provided.

I-345 (Slawek Tulaczyk)

I-345 aims to determine whether Kamb Ice Stream in the West Antarctic Ice Sheet is in the process of restarting, and to understand the mechanism enabling or preventing surging depending on their findings. UNAVCO built six winter-over systems (4 Trimble 5700s, 2 Trimble 4000s) designed to log continuously and maintain power partway through the winter. Each system is equipped with solar panels, and will start logging data again when the sun comes back in the spring. UNAVCO also provided three more Trimble 5700 systems for summer use.

B-425 (Andrew Fountain)

Alpine glaciers in the Taylor Valley are significant contributors of water to the completely contained lake system. Estimates of mass balance for these glaciers require both ablation/accumulation measurements and motion surveys. UNAVCO assisted Thomas Nylen with the installation of three Trimble 5700 receivers on Commonwealth Glacier (Figure 13) and one nearby to be used as the base station. The data will be used in calculating the spreading rate of the glacier. An additional 5700 was used for a kinematic survey of the area around the survey to determine the slope of the glacier's surface. UNAVCO support included equipment loan, field assistance, data processing, and data archiving.

Figure 13: One of three Trimble 5700s set up on a survey post on the Commonwealth glacier.

B-426 (Peter Doran)

The positions of ablation stakes on Lakes Fryxell, Hoare, and Bonney were measured to determine motion of surface ice on these frozen lakes. UNAVCO provided field support, two Trimble geodetic receivers, data processing, and data archiving.

B-518 (Mahlon Kennicutt)

Dr. Kennicutt's group is working to determine the temporal and spatial scales of human disturbance in the McMurdo vicinity. The group used a UNAVCO 4700 system for real-time kinematic (RTK) measurements of sample locations. The McMurdo base station established and maintained by UNAVCO, MCMD, was used for real-time corrections. Training was provided in McMurdo.