UNAVCO

University NAVSTAR Consortium

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

2002-2003 Season Report

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

UNAVCO maintains a "satellite" facility 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-one projects received support in 2002/2003 as requested prior to the field season, and three additional projects were added during the field season. Of these twenty-four projects, three were operational. UNAVCO also provided substantial technical support to New Mexico Tech (G-081) for the development and installation of four integrated seismic/GPS stations funded by an NSF Major Research Initiative (MRI) (Figure 1). Table 1 summarizes Antarctic projects using UNAVCO support, while Appendix A provides more detailed discussions of individual projects.

Figure 1: Mt Erebus MRI site NAUS at Nausea Knob.

Table 1 – 2002-2003 Antarctic Support Provided

Project	Point of Contact	Support Effort (%)	Eqp. Loan	Field Support	Training	Data Archived	Data processed	Preseason Request
G-081	Bartel	11	Yes	Yes	Yes	Yes	No	Yes
I-205	Anandakrishna	11	Yes	Yes	Yes	Yes	No	Yes
G-058	Schutt	9	Yes	No	Yes	Yes	No	Yes
I-153	Hamilton/Stearn	9	Yes	No	Yes	Yes	No	Yes
I-161	Kavanaugh	9	Yes	No	Yes	Yes	No	Yes
I-209	Petit	6	Yes	No	Yes	Yes	No	Yes
B-042-F	Nylen	5	Yes	Yes	Yes	Yes	No	Yes
G-053	Sletten	4	Yes	Yes	No	Yes	Yes	Yes
B-017	Davis	3	Yes	Yes	No	Yes	Yes	Yes
B-019	Craig	3	Yes	No	Yes	NA	NA	Yes
B-042-D	Doran	3	Yes	Yes	No	Yes	Yes	Yes
G-054	Lewis	3	Yes	Yes	No	Yes	Yes	Yes
G-183	Lancaster	3	Yes	Yes	No	Yes	Yes	No
Ice Pier Monitoring	Stone	3	Yes	Yes	No	Yes	Yes	Yes
RPSC Environmental: Cape Hallett	Gilbert	3	Yes	Yes	No	Yes	Yes	Yes
B-009	Ireland	2	Yes	Yes	No	NA	NA	Yes
B-042-M	Cozzetto	2	Yes	Yes	No	Yes	Yes	No
B-042-V	Barrett	2	Yes	Yes	No	Yes	Yes	Yes
B-197	Kooyman	2	Yes	Yes	No	Yes	No	Yes
G-052	Hothem	2	Yes	No	No	No	No	No
G-064	Renne	2	Yes	No	Yes	Yes	Yes	Yes
I-186	Scambos	2	Yes	No	No	No	No	Yes
O-283	Thom	2	Yes	No	Yes	Yes	Yes	Yes
RPSC Environmental: Streams	Gilbert	2	Yes	Yes	No	Yes	Yes	Yes

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 research group. For the 2002/2003 season most training was provided at McMurdo Station or in the field, but training was also provided before the field season to I-161 field team members Jeff Kavanaugh and Andy Bliss at the UNAVCO Facility in Boulder.

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.

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. As in previous seasons, an effort was made to ensure that most data processing was completed before field teams left McMurdo. UNAVCO also continues to provide post-season data processing support using commercial software, the NASA - Jet Propulsion Laboratory (JPL) Auto-GIPSY on-line data processing service, 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.

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. A new benchmark, AS14 (Cape Hallett Astro 14) will be added to the UNAVCO website.

Meta-data from all UNAVCO-supported Antarctic projects can be accessed on-line 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 are also submitted to the National Snow and Ice Data Center (NSIDC) Antarctic Data Coordination Center.

[1] Chuck Kurnik (10/02-02/03) and Shad O'Neel (10/02-12/02).

Equipment

Science Pool

UNAVCO provides GPS equipment for both geodetic surveying and mapping applications. Thirty-four geodetic quality dual-frequency receivers from the UNAVCO pool (19 Trimble 4000 SSE/SSi receivers, three Trimble 4700 receivers, three Trimble 4800 receivers, and nine Trimble 5700 receivers) 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. Because 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.

Three new Trimble 5700 GPS receivers were purchased for the USAP pool, bringing the total to six. These receivers are the latest addition to the UNAVCO pool and offer low power consumption and high-capacity data logging memory. They are ideal for semi-continuous autonomous operation and are in high demand in the Antarctic GPS community. This season, these receivers were used by I-161 (Cuffey, Taylor Glacier), I-153 (Mayewski, ITASE Traverse), G-081 (Kyle, Mt. Erebus), and I-209 (Conway, Inland WAIS), and all parties were extremely enthusiastic about the performance. One of these receivers ran all winter in 2002 at the Lower Erebus Hut with no gaps in data.

The proposal *Acquisition of New GPS Equipment for the UNAVCO Community Pool in Support of Current and Emerging Solid-Earth Sciences Research Applications*, submitted to the NSF-EAR Instrumentation and Facilities (I&F) Program, was recently funded. This grant provides UNAVCO with 30 new receivers over the next three years, and the first ten are expected in May 2003. As new equipment becomes available for pool use, the current pool receivers will be phased out of the pool and into NSF-EAR funded research projects for use in permanent GPS installations. A similar upgrade, to the USAP pool is in progress, and the older receivers could be retired to Antarctic PI institutions for educational use, or used in continuous applications at Antarctic field stations.

Differential GPS System

UNAVCO maintains a real-time kinematic (RTK) DGPS system at McMurdo and a repeater for DGPS applications in the Taylor Valley. This season the power supply at the transmitter and the repeater at Peak 1882 were replaced. The system was used by B-019 (Connell) for navigating to yeast-sampling locations in the Taylor Valley and by B-009 (Garrot) in a proof-of-concept application in the Big Razorback area. Garrot's group is developing a system to obtain the weight of Weddell seals from photographs and they are interested in locating the seals to the meter level. Line-of-sight to Crater Hill at McMurdo is required to receive the corrections broadcast by the RTK system, and DGPS radio reception is sporadic near the north shore of each of The Dellbridge Islands. A portable repeater was deployed at various locations to solve this problem.

GPS Applications at Onset Delta

An ambitious project to collect over 200 km of active seismic reflection data was performed by the I-205 group this year. Seismic lines were surveyed, drilled, and shot at multiple locations in the onset regions of both Ice streams C and D. The main goal of the research is to determine if basal conditions are responsible for the onset of ice stream flow. The Siple Coast ice streams are especially important to the marine based West Antarctic Ice Sheet because they are far from being in balance when considering mass equilibrium. UNAVCO played an important role in organizing real-time kinematic (RTK) GPS surveys that were used to establish the locations of shot holes along the seismic lines (Figure 2). In the past, this task was performed using optical or chain-drag methods, but GPS methods proved to be faster, less weather dependent, and more accurate than traditional methods.

Obtaining real-time cm-level GPS results requires a fairly complicated set-up similar to the McMurdo DGPS system. The system, which consisted of two Trimble 4000 RTK base stations and two Trimble 4700 roving receivers, was used to stake out shot holes every 300 meters along seismic lines in the Ice Stream C and D regions. The end points of the lines had been picked off maps and hand-held GPS receivers were used to navigate into the general vicinity of the line. The RTK system was then used to stake out the shot holes with a precision of two to ten centimeters.

In addition to surveying the seismic lines, two Trimble 5700 receivers were deployed in the Onset D region to log data over the course of the entire field season. One receiver was located at the On-D camp, at the approximate centerline of the ice stream. The second receiver was deployed along the margin of the ice stream, such that baselines will document velocity and strain rate variations over the summer. A third receiver was used to measure ice velocity at the Upstream C region for several weeks as well. Of most interest are vertical variations that may be caused by upstream propagation of the ocean tide. The receivers were also used to re-occupy over 100 poles near the On-D camp for a velocity campaign initiated in 2001.

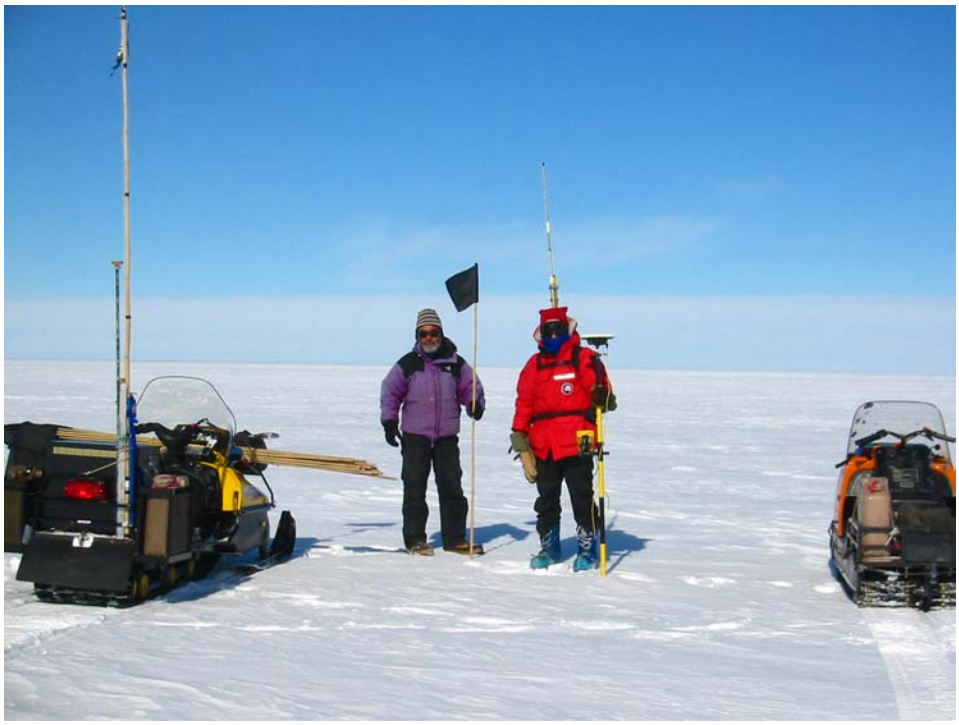

Figure 2: Surveying in the seismic line DT1 in the onset region of Ice Stream D.

Operational Support at Cape Hallett

Cape Hallett Station has been the focus of environmental monitoring for several years. The station was built in the middle of a penguin rookery on Seabee Hook during IGY. It was in use until the early 1970's when it burnt and was subsequently closed. Since then, the camp has slowly been reduced to its current size of four small buildings and a 100,000-gallon fuel tank.

This season, Chuck Kurnik of UNAVCO accompanied Geoff Gilbert, Brian Granbery (RPSC Environmental) and Elizabeth Morton (Berg Field Center) on the trip to Cape Hallett. The goal of the visit was to sample soil around the fuel tank and several pools that had been identified and cordoned off last season. UNAVCO's primary role was to provide accurate coordinates for each of the 200-plus sample locations. Additional GPS work included mapping the outline of the pools, the coastline of Seabee Hook, and the location of the fuel tank and buildings in the camp, and obtaining groundwater and permafrost heights from pits dug by the remediation team.

Two base stations were set up, one on the USGS Fisher benchmark (FISH), and one on Astro 14 (AS14). These ran continuously for the duration of the work, except for a few hours when the GPS data were processed and verified. All GPS data collected were post-processed with respect to one or both of these benchmarks. Sample and building locations were obtained using stop-and-go points, and the coastline, fuel tank, and pools were mapped using the continuous kinematic method. Stop-and-go surveys involve stopping and collecting data for about one minute at each location providing horizontal accuracies of 2 centimeters. Continuous kinematic surveys allow the user to collect a "breadcrumb" trail, making it ideal for collecting the outline of a feature. Horizontal positions are less accurate (in the 5-10 cm range) primarily due to set-up error inherent in mounting the GPS antenna on a backpack. The coastline of Seabee Hook and the camp map will be added the "GIS Products" section of the UNAVCO Antarctic website.

Accurate groundwater/permafrost heights were obtained using fast static data collection (20 minutes per point) and processed against both base stations (Figure 3). Using two base stations provides redundancy and allows errors in baseline length to be distributed between the unknown point and each base station. Using this methodology, heights within 5mm were achieved.

Figure 3: Surveying precise ground water heights at Cape Hallett.

Appendix A - Detailed Summary of Support Provided

B-009 (Bob Garrot)

Dr. Garrott studies the dynamics of the Erebus Bay Weddell seal population. In addition to annual census surveys, the team is developing a digital photography system to estimate seal weights from body morphometrics. The DGPS system was used this season in a proof-of-concept project which consisted of setting up a portable RTK repeater at various locations to alleviate poor line-of-sight around the Dellbridge Islands. The group will integrate the RTK system with the photography system to obtain meter-level resolution of seal locations during the census.

B-017 (Randy Davis)

Major crack systems and seal holes southwest of Tent Island were surveyed for Dr. Davis this season. UNAVCO provided field support using Trimble 4700 systems, data processing and archiving. Dr. Davis' group applies "dead-reckoning" methods to study dive paths of Weddell seals, and the GPS surveys will be used in conjunction with the group's seal tracking efforts.

B-019 (Laurie Connell)

Dr. Connell's group is studying the role yeasts play in the polar desert environment. Their work this season included taking soil samples and installing experiments in Taylor Valley. Meter-level accuracy was required navigating to pre-generated sampling locations and this was achieved using the UNAVCO DGPS system in Taylor Valley. UNAVCO provided one Trimble 4700 RTK system, ancillary equipment and training during the season. The Peak 1882 repeater provided DGPS corrections for the real-time surveys.

B-042-D (Peter Doran)

Dozens of boulders lie on the permanently frozen surface of Lake Hoare, providing a unique opportunity to study the dynamics of the lake ice. Survey marks have been installed on 14 boulders (Figure 4) scattered about the lake surface, and these marks are surveyed annually. Two ablation stakes were also surveyed to measure lake ice displacement and translation. UNAVCO provided field support with Trimble 4700 receivers, Trimble Geomatics Office post processing software, and data archiving services.

Figure 4: Floating Boulder survey on Lake Hoare.

B-042-F (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 two Trimble 5700 receivers on Commonwealth Glacier and one nearby to be used as the base station (Figure 5). The data will be used in calculating the spreading rate of the glacier. UNAVCO support included training, field assistance, and data archiving.

Figure 5: Base station for Commonwealth Glacier spreading rate survey, B-042-F.

B-042-M (Diane McKnight)

UNAVCO provided field support, a Trimble 4800 base station and a Trimble 4700 rover with backpack to map the topography of a relic channel as part of the LTER study of the streams and their contribution to the annual water budget and ecosystem in the Dry Valleys. Data processing and data archiving were also provided.

B-042-V (Ross Virginia)

Dr. Virginia studies the link between climate, soil, and the local ecosystem as part of the McMurdo Dry Valleys LTER program. Last season the group sampled soil around Highland Pond in the Kukuri Hills. This season, UNAVCO mapped this pond using kinematic GPS and provided two geodetic GPS receivers, data processing and data archiving.

G-052 (Jerry Mullins)

UNAVCO provided ancillary equipment to the USGS in their efforts to survey ground control points at the Cape Crozier Emperor penguin rookery.

G-053 (Bernard Hallet)

UNAVCO performed a repeat survey of the Beacon Valley floor network to measure surface displacements which occur due to sub-surface ice beneath the valley floor. This was the fifth survey since the network was installed and surveyed in January 1999, and will reveal surface velocities less than 1 cm/year. An eight mark strain network was also installed and surveyed this season at the head of Mullins Valley. Four geodetic receiver systems, field support, data processing, and data archiving were provided. TAMDEF survey mark BEA4 on University Peak was used for the reference receiver location.

G-054 (David Marchant)

Dr. Marchant received support from UNAVCO and RPSC surveyor John Sale to survey aerial photography and topographical map control point features from several Wright Valley and Taylor Valley locations (Figure 6). The coordinates obtained will be used to determine elevations of isotope-dating sample locations. One geodetic receiver and field support were provided, as well as data processing and archiving after the field surveys.

Figure 6: Photo-identifiable boulder used in G-054 ground control survey.

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 near the Goodwin Nunatak and McAlpine Hills area, and reconnaissance was done in the Pecora Escarpment area. Field researchers John Schutt and Nancy Chabot received training at McMurdo in kinematic data collection and Trimble Geomatics Office data processing software. The teams were provided with four Trimble 4000 receivers. UNAVCO also provided data archiving and assistance using the JPL Auto-GIPSY point-positioning automated data processing service.

G-064 (Paul Renne)

Dr. Renne's group is calibrating the production of cosmogenic argon in the McMurdo Dry Valleys to be used in a new type of dating procedure. Samples were collected at several locations in the Dry Valleys and GPS data were collected at each location. The data are used to obtain precise elevations which will be used in the calibration process. UNAVCO provided one geodetic receiver, training, data processing, and archiving.

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. Six receivers, training, and data archiving support were provided to field assistant Beth Bartel to re-survey the nine monument GPS deformation network that was installed on Mount Erebus during the 1999/2000 season, and GPS data collected since 1999 are showing displacements on the order of millimeters per year. Velocity stakes on the Barne Glacier were also re-surveyed this season.

In addition, four permanent GPS/seismic MRI sites were installed this season. UNAVCO provided support to this effort prior to the field season with GPS receiver selection and purchasing, GPS-specific development support, and planning GPS data management and archiving. Three of the MRI sites were located at previous L1 GPS sites at Hooper Shoulder (HOOZ), Nausea Knob (NAUS), and E1 (E1GP). The L1 systems were re-installed at Abbot Peak (ABBZ), McIntosh (MAC) and Bomb Peak (BOMZ). Data from all of the Erebus permanent stations are downloaded daily to McMurdo Station, and transferred to the UNAVCO data archive where they are on-line and publicly available. Early in the season, a continuously operating Trimble 5700 receiver was retrieved from the deformation network monument ELHT at the Erebus Lower Hut. The receiver was powered by the wind and solar electric system at Lower Erebus Hut, and it ran for the entire 2002 winter.

I-153 (Paul Mayewski)

Five GPS receivers and training were provided to ITASE GPS manager Gordon Hamilton. The equipment was used extensively to locate the traverse path and radar pulses. UNAVCO also provided four receivers to Leigh Stearns for surveys of "coffee can" sites that estimate accumulation rates at various locations around the West Antarctic Ice Sheet. The project GPS data were archived after the field season.

I-161 (Kurt Cuffey)

Dr Cuffey's group is studying the dynamics of the Taylor Glacier from Taylor Dome to Lake Bonney. They are using radar to examine the internal structure of the glacier and a GPS network of over 250 stakes to measure velocity. UNAVCO provided pre-season training at the Boulder Facility, seven geodetic receivers during the season, and processing assistance and archiving after the season.

G-183 (Nicholas Lancaster)

Dr Lancaster's group is studying wind flow regimes and wind transport of sediment in the Dry Valleys (Figure 7). Instrumentation to measure wind speed and turbulence was installed at each site. This season, GPS was used experimentally to quantify local roughness. UNAVCO personnel supplied two geodetic receivers, performed continuous kinematic surveys, and processed and archived the data.

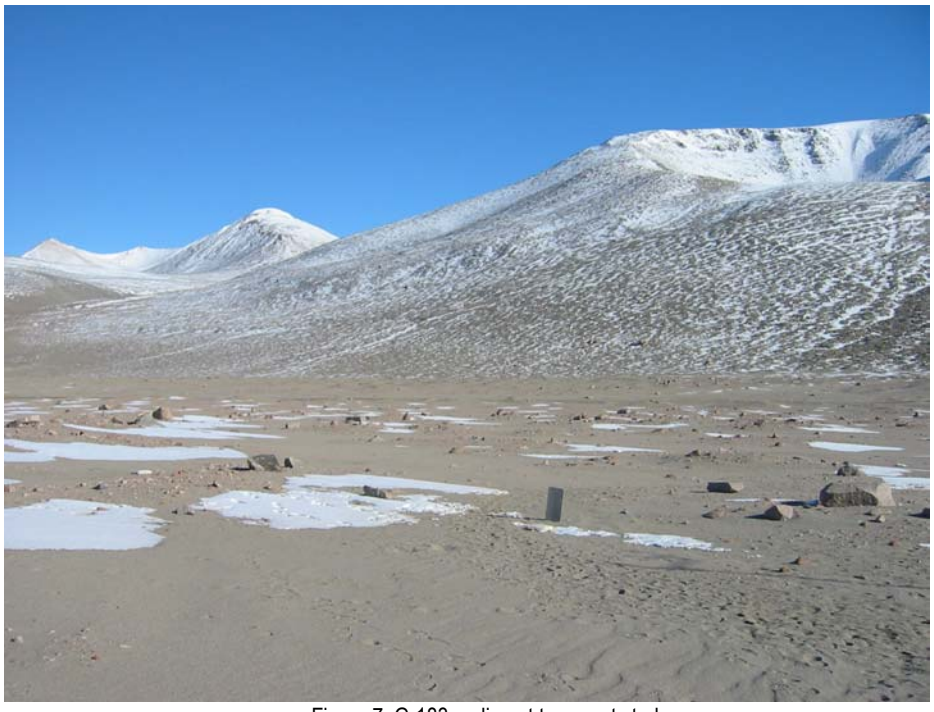

Figure 7: G-183 sediment transport study area.

I-186 (Ted Scambos)

Dr Scambos and his group are studying recently discovered "megadunes" in East Antarctica to understand their effects on ice core interpretation. UNAVCO provided two receivers for mapping the topography of the area using kinematic GPS.

B-197 (Jerry Kooyman)

Drs. Kooyman and Ponganis are studying the effects of iceberg B15 on the penguin rookery at Cape Crozier. They are attempting to use satellite imagery to perform a census of the colonies in the area. For ground control, the researchers placed large orange markers around one colony. UNAVCO surveyed these control points (Figure 8), and performed a continuous kinematic survey around the extents of the colony. For this project, UNAVCO provided equipment, field support and data archiving.

Figure 8: Ground control points for B-197.

I-205 (Sridhar Anandakrishnan)

UNAVCO provided two complete real-time kinematic (RTK) systems (four receivers), training and extensive field support to stake-out geophones and shot holes to the centimeter level. The goal of the project is to characterize the ice and basal conditions at the onset of Ice Stream D in West Antarctica.

I-209 (Howard Conway)

Dr Conway's group is using GPS to determine present-day velocity fields and ice-penetrating radar to determine sub-surface ice characteristics in the western divide area of the West Antarctic Ice Sheet (WAIS). The work is in support of the WAISCORES deep drilling project, scheduled to begin in the 2005-2006 season. UNAVCO provided three Trimble 5700 receivers, training, and archiving after the season.

O-283 (Chuck Stearns)

UNAVCO provided a Trimble 4800 receiver, training, data processing support, 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.

Ice Pier Monitoring (NSF)

In Winter 2002 large cracks were discovered in the ice pier in Winter Quarters Bay. The cracks are too large to fix, so a new pier must be built. Before the new pier can be built, the old one must be towed out of the bay. It will then be set adrift in McMurdo Sound and per the Marine Protection, Research, and Sanctuaries Act (MPRSA), it's location must monitored for one year. NSF tasked UNAVCO to track the

pier using GPS and ARGOS. Prior to the field season UNAVCO worked with Service ARGOS, a GPS supplier, and others in the Antarctic science community to design and specify the system (Figure 9). The system was to be installed after ship-offload 2003, however, efforts to repair the pier had succeeded and it can be used for one more season. After the monitor is installed UNAVCO will update a website periodically showing the location of the pier and archive the raw GPS/ARGOS data.

Figure 9: GPS/ARGOS unit.

RPSC Environmental Support (Gilbert)

Chuck Kurnik along with Geoff Gilbert and Brian Granbery of the RPSC Environmental department and Elizabeth Morton of the Berg Field Center, were sent to Cape Hallett to gather soil and water samples as part of continuing remediation efforts there. The GPS support provided by UNAVCO included mapping several pools suspected of being contaminated, surveying water and soil sample locations, providing accurate ground water and permafrost elevations, and mapping Seabee Hook and the existing camp. UNAVCO provided three GPS receivers and ancillary equipment, field support, data processing and data archiving.

UNAVCO measured another two possible stream diversions at McMurdo Station being considered by the RPSC Environmental department. These streams will bypass fuel storage and spill contaminated areas. Accurate vertical elevation profiles are required to determine the feasibility of re-routing existing streams and horizontal positions are used for GIS purposes. UNAVCO surveyed the possible routes using two Trimble 4700 receivers. Data from both surveys were processed and archived.