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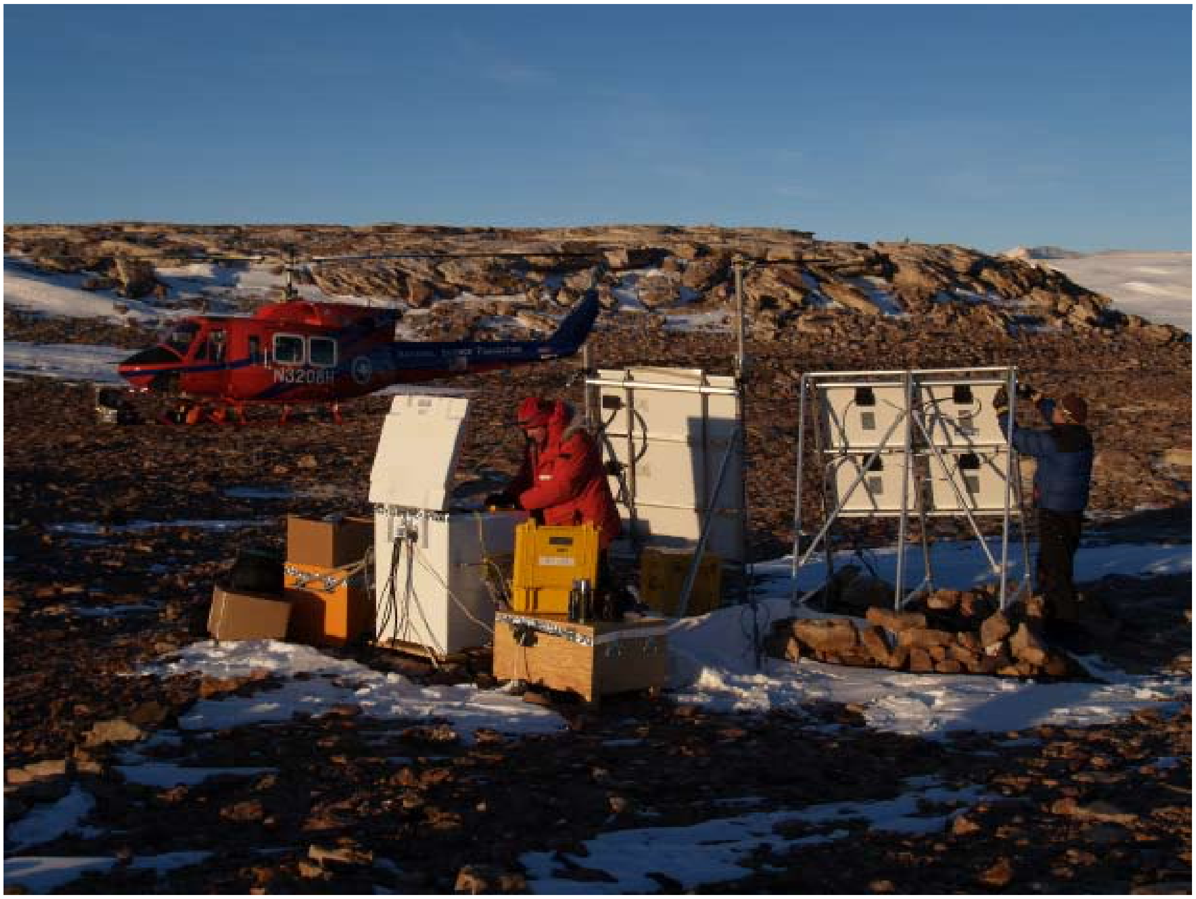
GNSS SUPPORT TO THE NATIONAL SCIENCE FOUNDATION

OFFICE OF POLAR PROGRAMS
ANTARCTIC PROGRAM



2006-2007 SEASON REPORT

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

2006-2007 Season Report

1 August 2007

Submitted by

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Support funded by the National Science Foundation Office of Polar Programs

Supplement to EAR-03 1760 - Support of UNAVCO Community and Facility Activities

Cover photo: UNAVCO engineers Seth White and Thomas Nylen servicing the Mt. Fleming continuous GPS site.

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Summary

UNAVCO provides year-round support for scientific applications of the Global Navigation Satellite Systems (GNSS)[1] 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 (http://facility.unavco.org/polar) provides comprehensive and historical information related to UNAVCO's 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 Global Positioning System (GPS) equipment, training, project planning, field support, system fabrication, technical consultation, data processing, and data archiving. Twenty-four projects received support in 2006/2007 as requested prior to the field season, and three 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.

During 2006/2007 UNAVCO continued to maintain permanent GPS stations in the McMurdo region, at South Pole Station and WAIS Divide camp. A new GPS base receiver and an additional rover receiver were delivered to Palmer Station for infrastructure and science applications. A "next generation" permanent station prototype was installed at Minna Bluff, as part of the newly funded joint IRIS-UNAVCO MRI project which will provide more cost effective and standardized "one stop shopping" for GPS, seismic, power, and communication systems.

Three additional staff were recently added to the UNAVCO Polar Services team due to the significantly increased scope of activities resulting from major projects such as the technology development MRI and the IPY POLENET project. This group of six staff provides technical support specifically tailored to polar project and network requirements. Resources and expertise from the other core UNAVCO support areas are leveraged, including NSF-EAR investigator support, NASA-Global GNSS Network (GGN) operations, the EarthScope/Plate Boundary Observatory facility construction and operation, and the UNAVCO community data archive.

1. GNSS refers to all modern satellite navigation systems, including GPS, the Russian GLONASS, and the emerging European Galileo systems. While UNAVCO's support continues to be based on GPS, new hardware is beginning to incorporate the reception of other signals and we expect this trend to continue as new products emerge on the market..

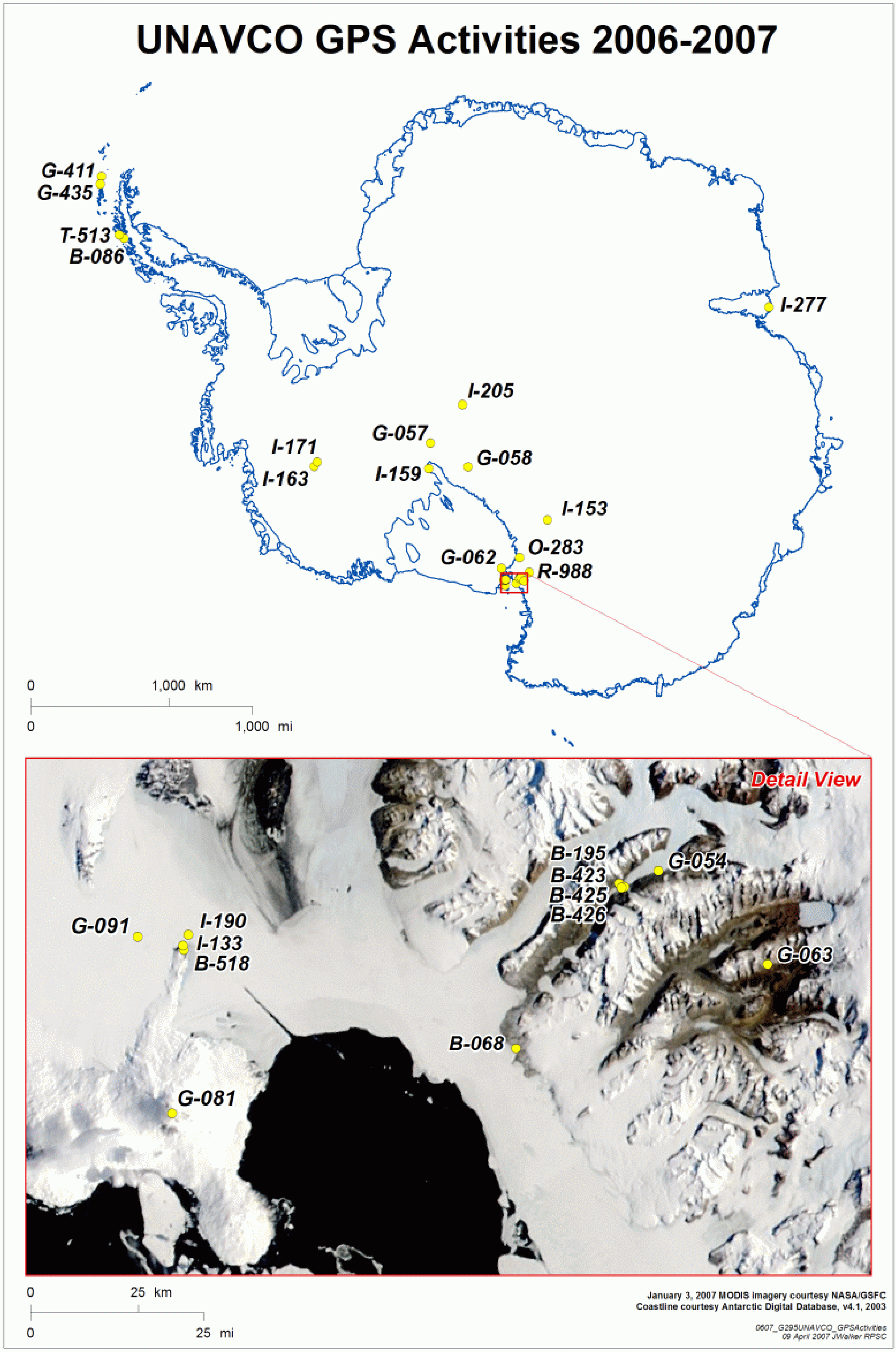

Figure 1: Project locations with UNAVCO support during the 2006-2007 field season.

Table 1: 2006-2007 Antarctic Support Provided

Project	Principal Investigator	Support Effort %	Equipment Load	Field Support	Training	Data Archived	Data Processed	Preseason Request
B-068M	Hall	2	Y	N	N	Y	Y	Y
B-086	Naveen	3	Y	N	Y	Y	Y	Y
B-195M	Priscu	5	Y	Y	N	Y	Y	N
B-423M	Virginia	5	Y	Y	N	Y	Y	Y
B-425M	Fountain	2	N	Y	N	Y	Y	N
B-426M	Doran	5	Y	Y	Y	Y	N	Y
B-518M	Kennicutt	2	Y	N	Y	Y	N	Y
G-054M	Marchant	5	Y	Y	Y	Y	Y	Y
G-057M	Harvey	2	Y	N	N	Y	N	Y
G-058M	Harvey	2	Y	N	N	Y	N	Y
G-062M	Wilch	3	Y	N	Y	Y	N	Y
G-063M	Marchant	5	Y	N	Y	Y	Y	Y
G-081M	Kyle	5	Y	Y	Y	Y	Y	Y
G-091M	Harwood	11	Y	Y	Y	Y	Y	Y
G-411	Hallet	3	Y	N	Y	Y	N	Y
G-435	Simms	3	Y	N	Y	Y	N	Y
I-133M	Prentice	5	Y	N	Y	Y	N	Y
I-153M	Mayewski	3	Y	N	Y	N	N	Y
I-159M	Catania	3	Y	N	Y	Y	N	Y
I-163M	Raymond	3	Y	N	Y	Y	N	Y
I-171M	Waddington	3	Y	N	Y	Y	N	Y
I-190M	MacAyeal	5	Y	N	N	Y	Y	Y
I-205P	Anandakrishnan	3	Y	N	Y	Y	N	Y
I-277	Fricker	3	Y	N	N	N	N	Y
O-283M	Stearns	6	Y	Y	Y	Y	Y	Y
R-988M	Hallman	2	Y	N	Y	Y	Y	N
T-513	Booth	1	Y	Y	N	Y	Y	Y

Science Support

Training

UNAVCO offers flexible options for project training, including training prior to field deployment, training in the field, and post-processing data training. The level of training is tailored to the experience of each project. For the 2006/2007 season most of the training was provided in McMurdo or in the field. Training was provided before the field season to “Peninsula side” projects B-086 (Naveen), G-411 (Hallet), G-435 (Simms) and the Raytheon Polar Services Company (RPSC) Palmer Research Associate at UNAVCO’s Boulder facility.

Field Support

Two UNAVCO engineers, Seth White (10/06 to 12/06) and Thomas Nylen (10/06 to 02/07), staffed the McMurdo Station UNAVCO office during the mainbody season. The primary responsibilities of the field engineers are managing the large equipment pool, providing technical support to field projects, and supporting infrastructure such as the McMurdo GPS base station system, the South Pole GPS reference station, the WAIS Divide GPS station, and the Mount Erebus and TAMDEF continuous station networks. Training is also provided to the RPSC Research Associate on maintaining these systems over the winter. Off-season equipment and technical assistance were also provided to B-086, G-091, G-411, G-435, and I-277.

Data Processing

Post-processing of differential GPS data is necessary to achieve the centimeter level precision required for most projects. UNAVCO supports field data processing using Trimble Geomatics Office commercial software and the Canadian Spatial Reference System on-line data processing service. Most science 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 referrals for advanced post-processing requirements.

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 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. Metadata from all UNAVCO-supported Antarctic projects are accessible on-line by field season and project event number.

Data collected to geodetic standards are archived by site name and precise site coordinates, and site descriptions are readily available on-line (http://facility.unavco.org/data/data.html). As this database of precise GPS coordinates continues to grow, future projects benefit by having pre-established geodetic control in their field study areas.

Equipment

Science Pool

Sixty-one geodetic quality dual-frequency receivers (11 Trimble NetRS, 22 Trimble R7, 22 Trimble 5700, five Trimble 4700, and one Trimble 4000 SSi) were provided from the UNAVCO pool for Antarctic support throughout the field season. All necessary ancillary equipment, such as data processing software, solar panels, batteries, bipods, chargers, enclosures, tribrachs, tripods, and cables, was also provided.

The receiver pool is upgraded and expanded annually to better meet the extended GPS deployment needs. The total U.S. Antarctic Program (USAP) pool of receivers prior to the season was 60 units, and an additional 10 receivers were purchased In February 2007. To meet the full demands of opposite peak field seasons, equipment from the OPP-Arctic and USAP pools are shared. Table 2 provides a summary of major USAP equipment in the pool.

Table 2: The UNAVCO USAP Equipment Pool

Receiver model	Qty	Features and Applications	Average age (yr)
Trimble 4000	1	Front panel display for field programming and ease of use and educational value. One receiver is retained for training applications, while the seven other receivers were provided to researchers on permanent loan.	9
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.	8
Trimble 5700	17	Modern low power, high memory receiver suited for both short term and continuous data collection.	5
Trimble R7	30	Same as the 5700, but also capable of tracking the new L2C GPS signal.	3
Trimble NetRS	18	State-of-the-art reference station receiver with computer and web browser interface, well suited for continuous data collection applications.	3
Trimble Survey controllers	7	Handheld controller used with Trimble 5700 for field programming and survey measurements.	
Pacific Crest RTK Radios	7	Low power radios for RTK surveys	

Long-term Continuous Data Collection and Network Support

Remote permanent station and network support activities were provided for the 2006-2007 season. This work is a continuation of development activities initiated two years earlier, and it has resulted in engineering, network operation, and data management support with several new systems deployed or upgraded as detailed below. Technical challenges still remain to enable year-round operation of remote autonomous systems envisioned for future geophysical research initiatives. Meeting these challenges requires a focused engineering effort, and UNAVCO, together with the Incorporated Research Institutions for Seismology (IRIS) were recently awarded with a Major Research Infrastructure (MRI) grant. The overarching goal of the MRI is to team with the Antarctic GPS and seismology scientists to design and build the next generation power and communication system for autonomous polar station operation. Knowledge and experience gained from the MRI effort are immediately applied to the support UNAVCO provides in Antarctica, especially for developing and supporting remote permanent GPS stations (Figure 2). The timing of this initiative is fortuitous because of the extensive network of continuously recording GPS and seismic stations across the Antarctic continent planned for the International Polar Year (2007-2009).

The standardized GPS equipment tested and developed during the MRI is added to the UNAVCO equipment pool. These items are requested directly from UNAVCO through the RPSC Support Information package (SIP) process. 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. The www.unavco.org/polartechnology web page serves as the main repository of information, technology, and hardware that are outputs from the MRI project and related development efforts. A more detailed discussion of the MRI project activities will be provided in the IRIS and UNAVCO annual project reports. Recent activities associated with the current continuous data collection systems maintained by G-295 are discussed below. A summary of the equipment at each site is listed in Table 3.

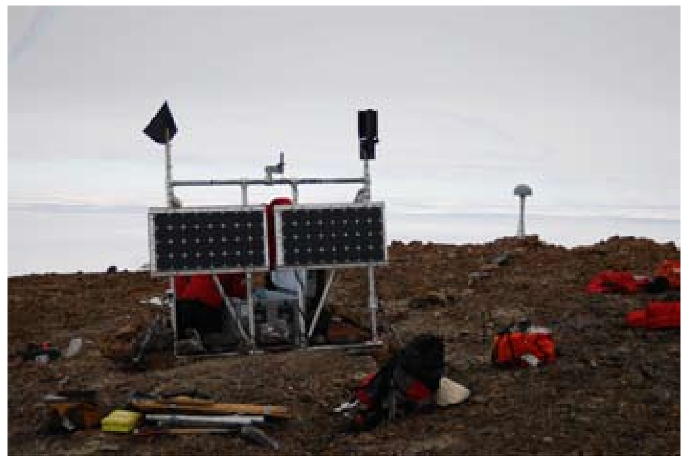

Figure 2: Minna Bluff prototype of next generation remote polar GPS station built to withstand the most severe weather, operate year-round, and be deployed with a maximum of two light aircraft flights.

Table 3: UNAVCO/USAP Equipment Deployed Long Term at Remote Locations

Location	GPS receivers	Radio modems	Other equipment (value > $1000)
Boulder Iridium Hub		1 NAL A3LA Iridium	1 data management computer
Cape Roberts	(Owned by LINZ)	1 FreeWave FGR115	
Fishtail Point	1 TNL NetRS	1 NAL A3LA Iridium	
McMurdo Station	2 TNL NetRS	1 PC RFM96-2W 1 FreeWave FGR1153 Intuicom ethernet bridge	1 Vaisala WXT-510 metpack
Minna Bluff	1 TNL NetRS	1 NAL A3LA Iridium	1 Chokering antenna
Mt. Fleming	1 TNL R7	1 FreeWave FGR115	
Palmer Station	1 TNL NetRS 1 TNL R7		1 TSCe survey controller
South Pole Station	3 TNL NetRS		
Truncated Cones	1 TNL NetRS	1 FreeWave FGR115 1 Intuicom ethernet bridge	
WAIS Divide camp	1 TNL NetRS	2 Intuicom ethernet bridge	

1. Operation and maintenance was provided for the three year-around POLENET stations (Cape Roberts, Fishtail Point, and Mt. Fleming) which are located in the Trans-Antarctic Mountains. The stations were installed and maintained by G-079 (TAMDEF, T. Wilson) and UNAVCO during previous seasons, and all three operated continuously through the winter. However, each station also suffered setbacks that required maintenance during the 2006-2007 season.

   a. The Trimble NetRS receiver at Fishtail Point failed in September 2006 due to a faulty memory card – a now-known issue that has resulted in an across the board recall of receivers manufactured with the faulty memory card. The receiver was replaced in October 2006, and the site operated until mid-April 2007 when all contact was suddenly lost. It is possible strong winds caused some damage to the station as winds up to 40 m s-1 were record at the "nearby" Mulock AWS station. A maintenance visit is planned for October 2007 to diagnose and repair the system.

   b .Data retrieval from Cape Roberts and Mt. Fleming is through the Truncated Cones repeater site on Mt. Erebus. Data are downloaded daily and delivered directly to the UNAVCO data archive. The repeater, installed during the 2004-2005 season, was damaged during a major winter storm on May 1, 2006, with winds in excess of 200 km h-1. A new repeater antenna with extra support was installed during the 2006-2007 (Figure 3). Additional batteries were also installed for the repeater radio. The system failed in June, and a maintenance visit is planned for October 2007.

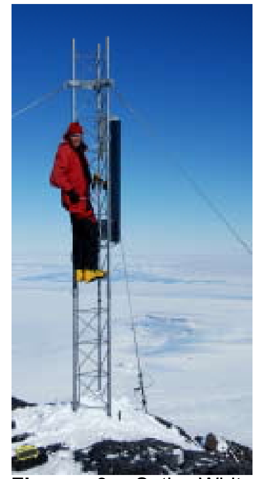

Figure 3: Seth White installs a new ruggedized antenna at the Mt. Erebus radio repeater site.

   c. While at the three POLENET sites, UNAVCO engineers also conducted a footprint survey of the existing survey bolts located near the POLENET permanent stations. The survey provides a mean to differentiate between region tectonic motions and local motions.

2. Three winterover systems were designed, built, and installed for the I-139 (Hallet) study of seasonal variations in mechanics of dry-land glacier calving on Taylor Glacier. These systems include solar power, batteries, power management, and receiver systems. One of the systems suffered a power system failure that coincided with a sharp temperature drop, and a regulator failure is suspected. This particular winterover system design has since been refined further and standardized with the MRI project system design.

3. The permanent station at WAIS Divide Camp continued summer operations during the 2006-2007 season (Figure 4). UNAVCO installed the community GPS base station in November 2005 to support local GPS projects and provide a consistent time series for the duration of the camp. This base station at the camp was used by several science groups during the summer season, including I-163 (Raymond) and I-171 (Waddington). The wireless ethernet link to WAIS camp was upgraded to download data automatically to the computer at the camp. Although it currently functions as a summer-only site, the potential to upgrade it for winter-over operation is available if requested by the WAIS community. Publicly available data from this site are archived at UNAVCO.

4. The Palmer GPS base station was upgraded to a new system that both meets the U.S. Geological Survey (USGS) and global geodetic community data requirements and is standardized for UNAVCO operation and maintenance support. The UNAVCO base system PAL2 uses the same antenna as the USGS base station PALM and provides centimeter level differential corrections to properly equipped users in the vicinity of Palmer Station. Publicly available data are archived at UNAVCO with minimal latency. The new Trimble NetRS receiver is connected directly to the internet, and can be accessed and operated remotely, resulting in a substantial time savings for the Palmer Research Associate. The UNAVCO base is equipped with a real-time kinematic (RTK) GPS base radio, and a second GPS receiver is available at Palmer Station which allows for centimeter level surveys in real-time in the immediate vicinity of the station. The upgrade to "UNAVCO standard" equipment allows for effective technical support to both the RPSC research Associate and visiting scientists.

Figure 4: The WAIS Divide GPS station was installed for multi-year operation in a high snow accumulation area.

5. The South Pole base system AMU2 has operated normally since it was installed last season, and no maintenance was necessary. On-site backup equipment was upgraded and delivered to the RPSC South Pole Research Associate. The data are archived at UNAVCO and available online.

6. UNAVCO maintains a community base station, MCMD and a real-time kinematic (RTK) GPS system at McMurdo. The GPS base station is in Building 71 near Arrival Heights, and differential corrections from this receiver are broadcast from a radio transmitter on Crater Hill. The RTK system was used by B-518 (Kennicutt) for navigating to sample locations for an environmental impact assessment in the McMurdo vicinity. The GPS receiver is connected directly to the internet and accessible from the UNAVCO facility in Boulder and over the local McMurdo network. In addition to the RTK functionality, this receiver also collects 15 second and 2Hz sample rate data for geodetic applications. The 15 second data are available from the UNAVCO archive, and serve as a backup to the MCM4 data distributed by NASA. The high rate data are available on request and are held for 30 days.

7. The McMurdo equipment staging facilities were expanded to meet the growing need for permanent stations installations. The Crary Lab is an excellent base of operations for UNAVCO, but as the UNAVCO support role continues to grow so does the on-ice space requirements. Both the volume of equipment handled as well as the stock and inventory requirements that accompany continuous GPS station installation and maintenance highlight the need for larger workspace and additional storage. For the 2006-2007 season, UNAVCO acquired a dedicated outside storage container for this expanded volume of materials and supplies that would otherwise occupy shared lab and loading dock space (Figure 5). **The long-term desire still remains to obtain dedicated space at McMurdo Station, rather than space that must be formally requested in the RPSC Support Information Package every year.**

Figure 5: UNAVCO uses a dedicated milvan to accommodate McMurdo Station storage needs beyond those available in the Crary Lab.

8. In preparation of long term deployments of GNSS systems associated with campaign and MRI efforts a dedicated Polar shop (Figure 6) and staging area was set up at the UNAVCO Facility last year. This workspace includes a complete stock of tools and hardware, and represents a significant increase in capability to meet the growing needs of the scientific community for robust, rapidly deployable, year-round GNSS systems.

Figure 6: Thomas Nylen working on a remote permanent station system slated for deployment in Greenland.

Staff

UNAVCO's scope of OPP related work continues to grow, driven by larger projects, an increased focus on permanent station technology, and the related operations and maintenance. With more, and more complex projects to support the field engineering and equipment technician staff requirements have grown, and Table 4 provides a current snapshot of the full-time OPP supported staff at UNAVCO. Past experience has shown that the average project requires two field engineer weeks for technical support (planning, training, field support, technical support, data processing, and data archiving) and one technician week for equipment preparation, testing, shipping, check-in, and repair. Very large projects, such as the IPY POLENET effort, are handled separately with an additional experienced engineer and the Polar Services project manager assigned to handle the project needs, and this increased staffing for IPY is included in Table 4. In addition to direct project support, staff spend about eight weeks each per year on professional development, documentation, maintaining group infrastructure, etc.

Table 4: Full-time UNAVCO staff supported by OPP

Name	Position	OPP funding sources (ANT/ARC/MRI)
Bjorn Johns	Project manager	50 / 40 / 10
Thomas Nylen	Field engineer	50 / 50 / 0
Joe Pettit	Field engineer	50 / 50 / 0
Marianne Okal	Field engineer	75 / 25 / 0
Scotty Coleman	Project technician	50 / 50 / 0
Seth White	Senior engineer	0 / 0 / 100

Project manager/senior engineer: Dedicated to managing and providing engineering oversight for the UNAVCO polar programs support activities. Coordinates resource sharing and optimization across projects; proposes, defines and assigns projects; supports project budgeting, monitoring and reporting; and directly manages polar support staff, sets work quality standards and monitors performance. Provides MRI project oversight, maintains productive support relationships with PIs, remote facilities support staff, external agencies, and committees.

Field engineer: Provide front-line technical support such as training, remote assistance, and field engineering services for year-round field season activities. Manage program PI project activities, and support the numerous community GPS base stations. Engineer and assemble equipment to meet diverse field project needs. Design and develop systems to best meet evolving support requirements. Specify and install permanent station designs, and integrate sensor, power, and communications hardware. Provide permanent station operation and maintenance support. During the northern summer Arctic field season (April-August), each engineer is expected to handle approximately one major project per month that requires significant technical and/or field support. The Antarctic field season planning is also a field engineering responsibility during this time, and one field engineer is deployed to Antarctica for the full austral summer, October-February. A second engineer is also required to cover the early Antarctic season workload, October-December. Engineers are also expected to provide training and routine technical support to PI projects between field assignments and contribute to reporting and project documentation.

Project technician: Provides equipment preparation, testing, repair, and fabrication services for polar field project support (~45 projects per year), and supports three polar engineers (1 funded by the MRI). The 20 annual Arctic projects are supported as independent events that each require about one week for preparation, testing, check-in, and repair, while the Antarctic field season requires about eight weeks total for the same equipment handling services. Between project preparations efforts the technician is also expected to contribute to Standard Operating Procedures for new hardware and processes, maintain the equipment database accuracy, and maintain the equipment preparation infrastructure in top condition.

Senior engineer: Dedicated to the MRI power and communication systems development project, and works with field engineers to apply MRI developed products to PI projects.

Future Plans

The recently reviewed 5-year *UNAVCO Community and Facility Proposal: Geodesy Advancing Earth Science Research* includes a polar specific work scope to continue present activities at a level commensurate with projections of demand, and address new activities with separate justification and funding requests:

1. The receiver pool will be maintained at the current level, with new systems phased in as next-generation technology is available. Expansion of the receiver pool would be addressed separately and justified based on specific project needs.

2. A one-stop-shopping service will be provided for power and communications solutions for remote geophysical instrumentation with power and data needs similar to GPS systems. This capability is a deliverable from the IRIS/UNAVCO MRI, and we will maintain a warehouse inventory of standard components to facilitate a rapid response to projects needs.

3. Staff time for engineering development, technical support, and training will be increased to include 0.2 FTE of the proposed development and testing position that will advance the adaptation of new GNSS technologies to improving measurement accuracy. We also expect to increase outsourcing of custom fabrication, improve the R7 campaign systems for longer deployments, and update training materials and documentation as appropriate. Other activities that would be pursued with separate funding requests include the engineering resources required to support significant increases in field support during the International Polar Year (such as the POLENET project), develop a community TLS support capability (see 4. below), and hosting workshops and short courses to address community needs such as better high-end data processing resources for ice dynamics applications (see 5. below) and developing “high-risk systems” for fast moving and calving glaciers.

4. Evaluate terrestrial laser scanning (TLS) technology for polar applications. UNAVCO recently submitted two proposals for the acquisition of tripod based LiDAR units for PI project applications. One of these proposals was targeted specifically to support NSF-OPP investigators and was funded in July. TLS offers an unprecedented capability to image at centimeter-level resolution 2.5 dimensional surfaces such as topography and fully 3 dimensional shapes such as rock or ice outcrops with overhanging features (Figure 7). TLS is applicable to problems with areal extents at the 100m to km level where detailed analysis is needed. Concurrent GPS measurements can provide accurate georeferencing of the TLS data and absolute 3D coordinates. Coincident high-resolution digital photography allows for the generation of photorealistic 3D images. TLS measurements complement SAR, airborne LiDAR, and spaceborne LiDAR techniques in providing smaller-scale, higher-resolution plots of important areas and in filling in areas inaccessible by these other techniques. The goal of the NSF-OPP proposals is to acquire a single TLS unit for a pilot project to evaluate the merits of adding TLS equipment and support expertise to the list of services available from UNAVCO, and Antarctic field testing may occur in January 2008.

Figure 7: (a) TLS-controlled by GPS in Alvord desert. (b) 10 m digital elevation model of normal fault cutting ancient lake shorelines. (c) 30 cm TLS-derived digital elevation model of fault-lake shore relations provides details of the structure that were not previously seen illuminating the complex fault structure and displacement history.

5. Explore long-term solutions for advanced data processing support. The commercial data processing software supported by UNAVCO works well for new users and smaller projects. However, several projects could benefit from using more rigorous and adaptable academic data processing software. Proficiency in such software requires regular use, and UNAVCO is well positioned to work with the science community to develop a solution that relies upon community expertise to reduce barriers to entry for new users. Possible solutions include the establishment of a community processing center where new users can work through their data with expert assistance present and supporting commercial software that better meets the needs of the glaciology community.

6. Support of the community base stations will continue with systems upgrades as appropriate based on new technologies, equipment wear, and user demand.

7. Network operations and maintenance will be provided for all NSF-OPP supported permanent (i.e. those that are intended to outlive science grant periods of performance) GNSS stations. This capability will include a robust Iridium download center, network monitoring, maintenance expertise amongst the polar support staff, annual maintenance needs addressed in field season planning, and system upgrades planned as community needs evolve and hardware capabilities expand (such as the anticipated expansion from GPS to GPS + GLONASS + Galileo). All data from UNAVCO network operations are safeguarded within, and distributed from the UNAVCO community data archive.

Present and Future Challenges

The day to day project support continues to operate smoothly due to combined experience and dedication of UNAVCO, RPSC, and NSF staff. When issues arise they tend to be dealt with effectively and expediently. However, there are a few challenges that will require special attention in the immediate future:

1. **Dedicated workspace at McMurdo Station.** UNAVCO has maintained a summer presence at McMurdo Station since 1994, yet there is no dedicated UNAVCO workspace. Each season involves requesting space in the SIP, setting up the shop for the season, and packing up at the end of the year. Last year a milvan was obtained to provide overflow storage in an accessible location, and this has helped alleviate pressure on shared space in the Crary Lab. The desire still remains to obtain dedicated space at McMurdo Station on the order of 500-1000 square feet for an office, equipment preparation, and staging, rather than each season negotiating for, setting up, and packing up the UNAVCO workspace. This is an issue that has been raised repeatedly at outbriefs and in conversations with NSF and RPSC, and we intend to bring it up again with RPSC. Any breakthrough will likely require strong support from NSF as both our sponsor and the contractor customer. The UNAVCO space requirements will only grow with IPY and the equipment heavy projects such as POLENET receiving UNAVCO support.

2. **Terrestrial Laser Scanner (TLS) support.** UNAVCO was recently awarded an MRI proposal for a pilot project to explore the feasibility of providing TLS support to the USAP science community based on a shared resource pool. The instrumentation is complex and expensive, and successful support will likely require an investment in additional staff time, hardware, and software to allow for high quality sustainable support. The MRI proposal will likely be followed with an increase in the proposed scope of work.

3. **Operating an Iridium data download center.** We are investing in the hardware and software required to support a reliable Iridium data download center to meet the remote station communication demands of network initiatives beginning in IPY. This provides a significant economy of scale for USAP GPS users with data and archiving handled as a facility service. However, the success of this system relies on Iridium airtime access via NSF, and as a major Iridium user in the program UNAVCO, NSF, and RPSC will need to remain coordinated on SIM card allotments and technology enhancements.

Appendix A - Detailed Summary of Support Provided

B-068M (Hall)

Dr. Hall's group spent the 2006-2007 field season locating and excavating elephant seal remains near Explorers Cove and Cape Bird. A previous geologic field campaign discovered these remains, and yield information about the extent and habits of the seals in this area which they no longer inhabit. Climate records will also be extracted from the remains. UNAVCO provided two receivers, ancillary equipment and pre-field training to B-068. They used GPS to mark the exact locations of the remains. UNAVCO also post-processed their data using permanent station data from the TAMDEF Cape Roberts and the G-081M Truncated Cones GPS stations.

Figure 8: Thomas Mueller mapping area of Petermann Island.

B-086E (Naveen)

Ron Naveen and his team monitor penguin and seabird populations on Petermann Is, which is near Palmer Station. The long-term monitoring project is a part of the international Antarctic Site Inventory program. B-068 used GPS equipment loaned from UNAVCO to map the island in greater detail (Figure 8). Besides two GPS receivers and ancillary equipment UNAVCO provided two days of training in Boulder prior to the group's deployment and help with processing upon completion of the field season.

B-195M (Priscu)

Dr. Mikucki, participating in the polar postdoctoral program, is conducting research on the microbial ecology of Blood Falls. Her research is a continuation of previous work conducted with the McMurdo Long-term Ecological Research (LTER) project. Dr. Mikucki requested UNAVCO equipment and engineering services to locate sampling sites and all exposures of iron precipitates around the perimeter of Taylor Glacier, including Blood Falls. UNAVCO provided two GPS receivers, an engineer to assist with the field measurements and data post-processing.

Figure 9: Breana Simmons measures new sampling locations near Lake Fryxell.

B-423M (Virginia)

Dr. Ross Virginia and his group are a part of the McMurdo LTER project, with a focus on the response of soil biota to changes in climate substrate chemistry. As part of the third 6-yr funding period, they are establishing new soil plots at Lake Fryxell (Figure 9) and the west lobe of Lake Bonney. They requested UNAVCO field assistance, ancillary equipment and data post-processing to measure the location of the new sampling location. Location of their old sample plots and snow fences were also measured.

B-425M (Fountain)

Dr. Andrew Fountain, who is also part of the McMurdo LTER, was asked by NSF to remove equipment installed by I-139M the prior two seasons. As mention above, UNAVCO installed three GPS stations on and near Taylor Glacier the previous season for I-139. The receivers collected data for one hour each day during the winter. The three GPS systems were removed in November. UNAVCO provided field support for removal of the equipment, and data processing and archiving of winter GPS data.

Figure 10: Seth White and B-426M team member Miroljub Medved install a GPS base station at Lake Hoare.

B-426M (Doran)

The positions of ablation stakes on lakes Fryxell, Hoare, and Bonney were re-measured to determine motion of surface ice on these perennial frozen lakes (Figure 10). Additionally the location of benchmarks used for lake level measurements in Wright and Victoria valleys were determined. UNAVCO provided two Trimble GPS receivers, training in McMurdo and the field, engineering field support, data processing, and data archiving.

B-518M (Kennicutt)

Dr. Kennicutt and his team are studying the temporal and spatial impact of human activities in the McMurdo vicinity. The group used the McMurdo real-time kinematic (RTK) GPS system to determine their sampling locations. Besides equipment, UNAVCO provided training to B-518.

G-054M (Marchant)

Dr. Marchant and his group are studying buried ice and microclimates of the Dry Valleys. Originally UNAVCO support was not requested, but in McMurdo they requested the use of one Trimble 5700/R7 to measure the location of their radar lines. Besides equipment UNAVCO assisted them with post-processing and data archival.

Additionally UNAVCO provided field assistance to G-054 when they re-measured bolts, which were installed in December 2004 on gelifluction lobes east of the Stocking glacier (Figure 11). They want to determine the surface flow velocities of the lobes, which will help them better understand these flow features in Antarctica. UNAVCO provided three Trimble 5700/R7 receivers for the field campaign, post- processing support and data archiving.

Figure 11: GPS base station used to measure gelifluction lobes in Taylor Valley.

G-057M, G0528M (Harvey)

The field team performed local stop-and-go kinematic surveys of meteorite locations. The spatial data is used in their GIS database. This season the meteorites were collected in the Grosvenor Mountains, on the Scott / Reedy/ Klein glacier, near the Graves Nunataks, on the Robeson, Amundsen and Scott Glaciers and in the Wisconsin Range. UNAVCO provided two Trimble 5700 receivers and data archiving.

G-062M (Wilch)

Dr. Wilch and his team mapped the volcanic and glacial lithofacies at the eastern end of Minna Bluff to better understand the cryospheric history of the region. They utilized UNAVCO equipment to perform kinematic surveys of the volcanic units. UNAVCO provided training, three Trimble 5700/R7 receivers and data archival.

G-063M (Marchant)

Dr. Marchant and his group examined ancient lake sediments to infer paleoclimates and ecological conditions in the dry valleys. Precise locations were needed to accurately correlate beds in the mapped stratigraphy near Mt. Boreas and the Friis Hills. UNAVCO provided training, two Trimble 5700/R7 receivers, assistance with post-processing and data archival for mapping and measuring rock units (Figure 12).

Figure 12: Kelly Gorz and Andrew Podoll map the area near Mt. Boreas in the McMurdo Dry Valleys.

G-081M (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. Two Trimble 5700/R7 and one 4700 receivers were provided to the field team for mapping activities and campaign occupations. UNAVCO also continued involvement in maintenance of the permanent GPS network on Erebus. The Trimble NetRS at site CONZ was replaced because of a faulty flashcard. Modifications to the repeater antenna were made and batteries for the repeater radio were added by UNAVCO. The Trimble R7 receiver at Abbott Peak was downloaded at the beginning and end of the season. 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 to the science community.

G-091M (Harwood)

The ANDRILL project drilled almost 1300 meters into the sea floor at a location near Williams Field. A major concern during the drilling operation was that the riser pipe would get coupled with the sea ice, as it fluctuated with the tides. The installation of a GPS system allowed the monitoring of the tidal motions of the sea ice, and provided a check for their riser instruments. UNAVCO installed the GPS system at the drilled site and processed the data every day. Additionally, UNAVCO installed a GPS station on the Dailey Is (Figure 13), which will be used as a base for next season's drilling project.

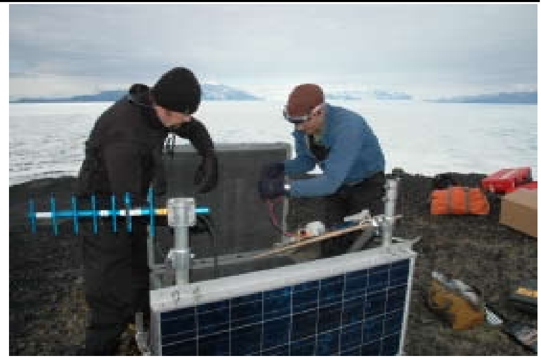

Figure 13: RPSC Research Associate Jason Fryenton and UNAVCO Engineer Thomas Nylen install a GPS system on the Dailey Island in preparation of next season's G-091 drilling project.

G-411N (Hallet) and G-435N (Simms)

These two projects examined the role of glacier dynamics in determining glacial sediment yields through a combination of techniques and resources from glaciology and marine geology from Patagonia to the Antarctic Peninsula. This season they focused their research on the Antarctica Peninsula. Two receivers and ancillary equipment were provided to each group for short-term rapid static surveys on glaciers and beaches on the Antarctic Peninsula. Half the equipment was loaded on the Nathaniel B. Palmer research vessel in McMurdo before it left for Argentina and the other half was sent from Boulder. Training was provided in Boulder to both groups prior to deployment.

I-133M (Prentice)

The extent of ice during the Last Glacial Maximum (LGM) was investigated by Dr. Prentice and his team. There is uncertainty in the size of local lakes in the McMurdo Dry Valleys during and after the LGM. By using ground penetrating radar and analysis of former deltas I-133 wants to help constrain the size of the lakes. UNAVCO provided two GPS receivers, ancillary equipment, software and pre-field training to I-133. An additional GPS receiver was maintained at a benchmark near Lake Hoare as a back-up base station, since I-133 was using a temporary benchmark near their camp.

I-153M (Mayewski)

Five GPS receivers and training were provided to ITASE GPS manager Gordon Hamilton. The equipment was shared by 3 science groups (Hamilton/UMaine, Jacobel/St Olaf, Arcone/CRREI) during their traverse from Taylor Dome towards the South Pole. The equipment was used extensively to locate the traverse path and radar pulses.

I-159M (Catania)

The ice stream outlet dynamics in the Kamb/Whillans ice stream region were investigated to understand the ice flow history. Five GPS receivers were used to measure the velocity of the ice streams (Figure 14). Equipment and GPS software training were provided in McMurdo before deployment.

Figure 14: An I-159 team member measures the position of an ice velocity pole in west Antarctica.

I-163M (Raymond)

The field team used ice-penetrating radar to detect spatial variations of ice crystal fabric over a wide area near the West Antarctic Ice Sheet (WAIS) divide, which separates ice flowing towards the Ross and Amundsen seas. Since ice crystal orientations reveal the ice flow history, these data will be of great interest to the upcoming WAIS divide drilling project. UNAVCO provided six Trimble 5700 receivers for measuring radar tracks and strain grids in several key locations. The group used the WAIS GPS station as a base station for their some of the measurements. Training was provided in McMurdo for I-163 prior to deployment to the field.

I-171M (Waddington)

The location of the ground penetrating radar and boreholes were determined using one 5700 receivers provided to I-171. The WAIS GPS receiver was used as a base when processing the GPS data. Equipment and post-processing training was provided before I-171 deployed to WAIS camp.

I-178M (Hamilton)

Re-survey of previous ITASE sites was completed between Byrd and South Pole stations to determine the velocity of the West Antarctica Ice Sheet. Three GPS receivers and ancillary equipment were loaned to I-178. Training was provided prior to deployment to the field.

I-190M (MacAyeal)

Two Trimble R7 receivers, training, and data processing assistance were provided to measure the motion of the C-16 iceberg and the sea ice area near the ice runway. I-190 is exploring options for retrieving the receiver on C-16. The GPS data collected from the ice runway will also be used by G-091M, since their 2007-08 drill site is not that far from the sea ice runway.

I-205P (Anandakrishnan)

Dr. Anandakrishnan and his team are studying the subglacial Lake Amundsen−Scott, which is near the South Pole. I-205 used seismic experiments to characterize the subsurface lake. UNAVCO provided two 5700 receivers, ancillary equipment and an RTK system. The RTK system was used to locate predetermined grid points. Equipment and post-processing training was provided to I-205 in McMurdo prior to deployment to the South Pole.

I-277 (Fricker)

This multi-year study is focused on an active rift system at the front of the Amery Ice Shelf. UNAVCO provided an additional six Trimble 5700/R7 receivers during the 2006-07 season. During the previous season the projected deployed six Trimble 5700/R7s GPS receivers to measure the velocity the ice shelf. The receivers were stored in Hobart until this season to avoid substantial shipping costs and importation paperwork.

O-283M (Stearns)

UNAVCO provided a GPS receiver, ancillary, training, field support, data processing, and data archiving to the Automated Weather Station (AWS) field team in an ongoing effort to produce accurate site elevations used in climate models (Figure 15). These surveys are conducted as “opportunity surveys” during scheduled maintenance visits to the AWS sites. The science community also uses the GPS data to determine the motion of the Ross Ice Shelf.

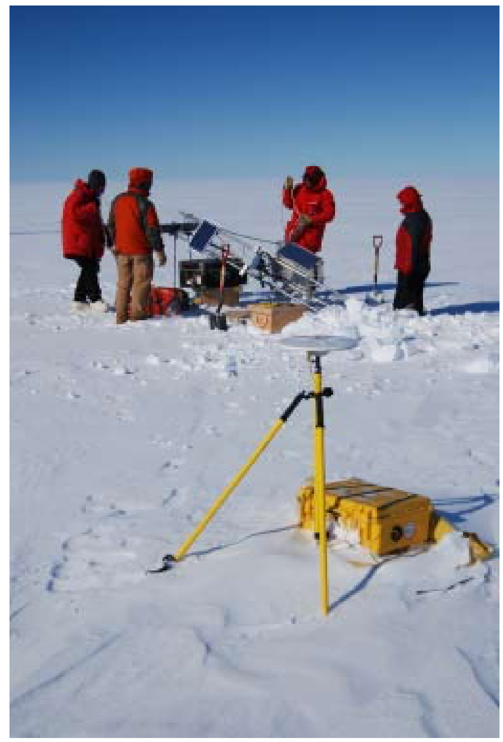

Figure 15: O-283 team members install the Lorne AWS, while a GPS receiver measures its precise position.

R-988M (Hallman)

Mr. Hallman and his group tested and evaluated aircraft mounted Synthetic Aperature Radar (SAR) system for crevasse detection, mapping, and hazard mitigation. To ground-truth the SAR data it was necessary to determine the positions of ground reflectors within a meter. UNAVCO provided training, one Trimble R7 receiver, post-processing and data archival. The permanent stations at MCM (MCMD) and at Mt. Fleming (FLM5) were used as base stations to process the rover data.

T-513 (Booth)

The T-513 group operates a network of ultraviolet radiation sensors at McMurdo, South Pole Palmer. UNAVCO determined the location of the sensors at McMurdo and South Pole stations, while the RPSC Palmer science technician measured the instrument at Palmer using UNAVCO equipment.