



Geodetic Technologies Support to the
National Science Foundation

Office of Polar Programs Antarctic Program

2008 - 2009 Season Report

Submitted by

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www.unavco.org/polar



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Geodesy Advancing Earth Science Research

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Summary

UNAVCO provides year-round support for scientific applications of geodetic technologies (GPS, ground based LiDAR, remote autonomous power and communications) 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. Resources and expertise from the other core UNAVCO support areas, including NSF-EAR investigator support, NASA-Global GNSS Network operations, the EarthScope/Plate Boundary Observatory facility construction and operation, and the UNAVCO community data archive are leveraged to apply state-of-the-art technologies at a reasonable cost.

A "satellite" facility is staffed at McMurdo Station, Antarctica during the austral summer research season, providing a full range of support services including ground based LiDAR and GPS equipment, training, project planning, field support, system fabrication, technical consultation, data processing, and data archiving. Twenty four projects received support in 2008/2009. UNAVCO continues to maintain permanent GPS stations in the McMurdo region, at South Pole Station, at WAIS Divide camp, and at Palmer Station. Table 1 summarizes Antarctic projects using UNAVCO support, while Appendix A provides more detailed discussions of individual projects.

The ongoing Major Research Infrastructure (MRI) funded engineering effort Development of a Power and Communication System for Remote Autonomous GPS and Seismic Stations in Antarctica focused on the development challenges of operating year-round GPS systems on the Polar Plateau, and results were applied to the immediate needs of the Recovery Lakes region investigations with systems deployed from the Norway-US IPY traverse (Figure 1). The MRI engineering effort is currently focused on project wrap-up and documentation, with a project completion date of 30 September 2009.

In 2007, UNAVCO received support for a second MRI proposal, *Acquisition of a Terrestrial Laser Scanning System For Polar Research*, and at that time procured a terrestrial laser scanner (TLS) LiDAR system for NSF-OPP funded research support. An Optech ILRIS 3D system was purchased at the end of 2007, and was successfully fielded in Antarctica during the 2008-09 season on six separate PI projects. This survey instrument is complimentary to the suite of GPS equipment already available, and allows for much higher spatial density surveys of short distances. The instrument proved robust and capable in most situations, and current efforts are directed at easing the data processing that is necessary after the field surveys. Considerable demand is expected in future seasons, for applications such as soil surface mapping, quantification of landforms, and change detection of slopes, rock glaciers, glaciers, and volcanoes.

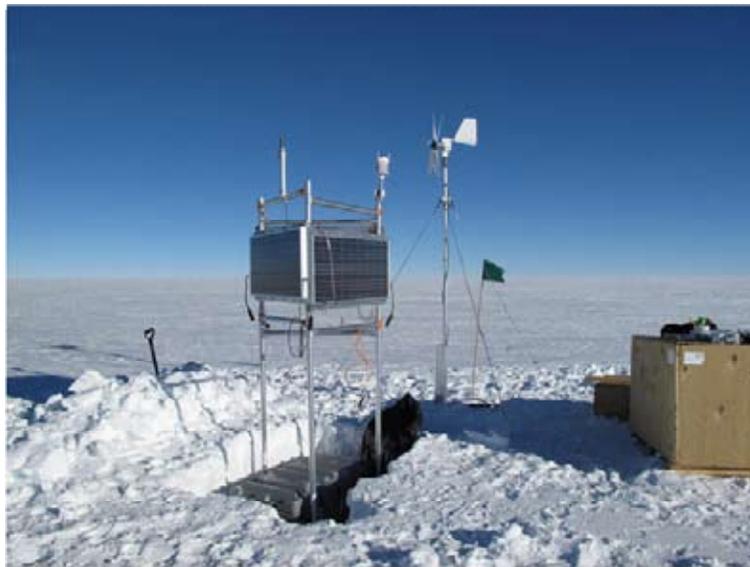


Figure 1: First Polar plateau GPS design systems deployed at Recovery Lakes. The system enclosure is buried as a buffer against extreme temperature swings, has high efficiency vacuum panel insulation, Iridium communications, active heating, and wind and solar power sources for year-round autonomous operation. Photo: Ted Scambos.

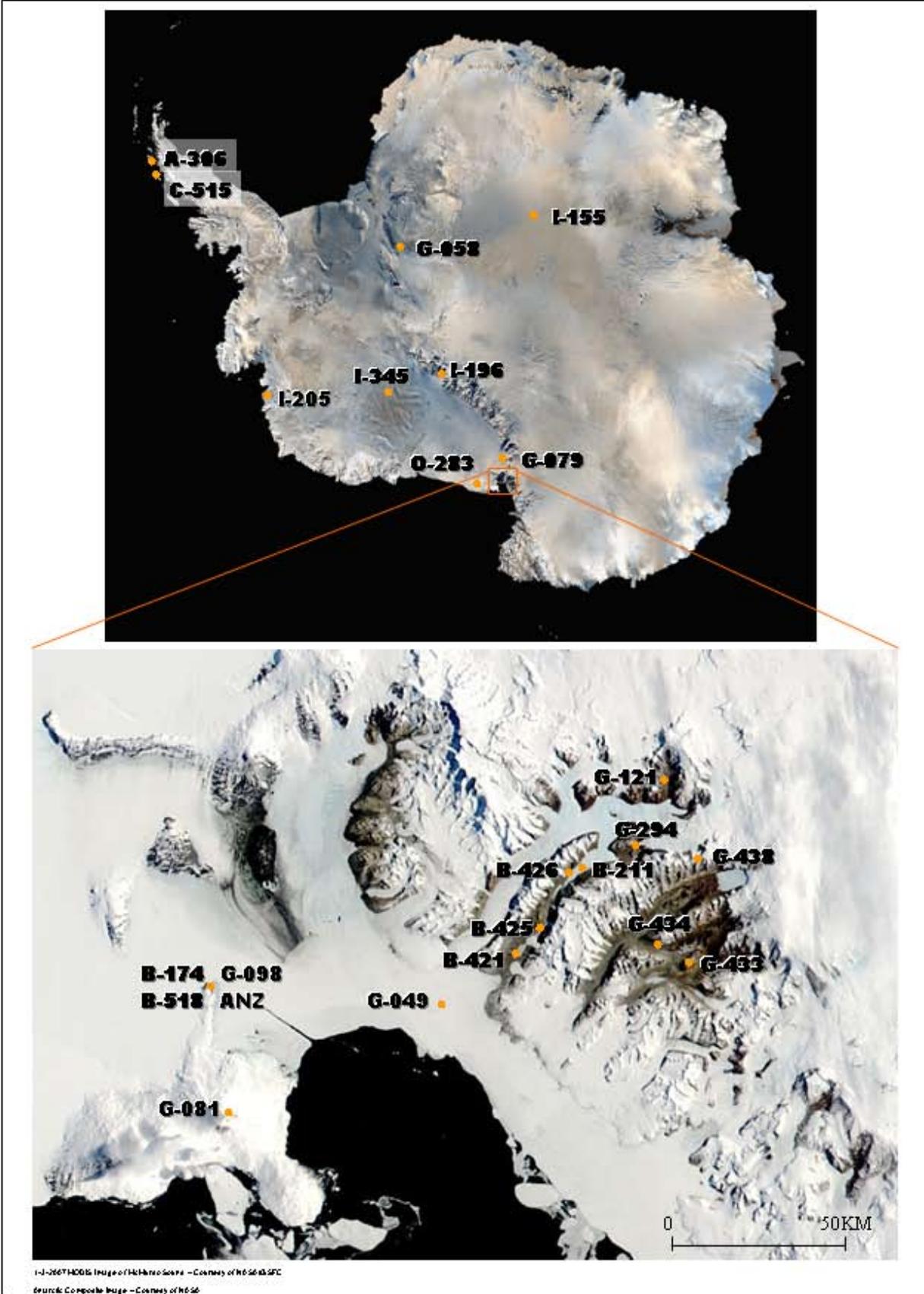


Figure 2: Project locations with UNAVCO support during the 2008 - 2009 field season.

Table 1: 2008- 2009 Antarctic Campaign Project Support Provided

Project	Principal Investigator	Support Effort %	Equipment Load	Field Support	Training	Data Archived	Data Processed	Preseason Request
A-306	Inan, Umran	1	Y	N	N	N	N	Y
B-174	Kim, Stacy	3	Y	Y	Y	Y	Y	Y
B-211	Doran, Peter	2	Y	N	Y	Y	Y	Y
B-421	Mcknight, Diane	3	Y	Y	N	Y	Y	N
B-425	Fountain, Andrew	2	Y	Y	N	Y	Y	Y
B-426	Doran, Peter	2	Y	Y	Y	Y	Y	Y
B-518	Kennicutt, Mahlon	1	Y	N	Y	N	N	Y
C-515	LARISSA - Domack	15	Y	Y	Y	Y	N	Y
G-049	Pekar, Stephen	3	Y	Y	N	Y	Y	Y
G-058	Harvey, Ralph	1	Y	N	N	N	N	Y
G-079	POLENET	34	Y	Y	Y	Y	N	Y
G-081	Kyle, Philip	2	Y	Y	Y	Y	Y	Y
G-098	Blankenship, Donald	1	Y	N	N	N	N	N
G-121	Sletten, Ronald	4	Y	Y	Y	Y	Y	Y
G-294	Ashworth, Allan	3	Y	Y	Y	Y	Y	Y
G-433	Stone, John	2	Y	N	Y	Y	Y	Y
G-434	Morin, Paul	4	Y	N	Y	N	N	Y
G-438	Mukhopadhyay, Sujoy	2	Y	Y	Y	Y	Y	Y
I-155	Albert, Mary	6	Y	N	Y	Y	N	Y
I-196	Hall, Brenda	2	Y	N	N	N	N	Y
I-205	Anandakrishnan, Sridhar	3	Y	N	N	Y	N	Y
I-345	Tulaczyk, Slawomir	2	Y	N	Y	Y	N	Y
O-283	Lazzara, Matthew	1	Y	N	N	Y	Y	Y
ANZ	Mahony, Andy	1	Y	N	N	N	N	N

Long-term Continuous Data Collection and Network Support

Technology Development

The joint IRIS/UNAVCO MRI project *Development of a Power and Communication System for Remote Autonomous GPS and Seismic Stations in Antarctica* has made substantial progress to enable reliable year-round operation of remote autonomous systems. The development efforts of this project are complete, and standardized power and communication system kits for rapid deployment and robust data collection are now available to the broader community (Figure 3). Test-beds at both McMurdo and South Pole stations are used to test new technologies before deploying them to more remote locations for science data collection. The polar technology project website, www.unavco.org/polartechnology, provides a community resource and includes technical reports and detailed information on individual components and systems for users interested in adopting any of the products from this MRI funded effort.



Figure 3: Student Mason Fried and PI Eugene Domack finishing the Hugo Island installation as part of the Larsen Ice Shelf System, Antarctic (LARISSA) project.

Table 2: POLENET network status as of 30 June 2009

Site	Agency	Communication	Status as of 20 May 2009
BRIP	OSU	Iridium	Operational
BURI	LINZ	Iridium	Operational
COTE	OSU	Radio	Operational
CRDI	OSU	Iridium	GPS down since Aug. 2008 – maint. TBD
DEVI	OSU	Iridium	Operational
DTHW	OSU	Iridium	Comms down since Apr 2009 – maint. TBD
DUPT	Hamilton College	Iridium	Operational
FIE0	OSU	None	N/A
FLM5	OSU	Radio	Operational
FTP4	OSU	Iridium	Operational
HAAG	OSU	Iridium	Comms down since Apr. 2008 – maint. TBD
HOWN	OSU	Iridium	Operational
HUGO	Hamilton College	Iridium	Comms down since Apr 2009 – maint. in prog.
IGGY	OSU	Iridium	Comms down since Apr 2009 – maint. TBD
LWN0	OSU	Iridium	Operational
MIN0	OSU	Iridium	Operational
PATN	OSU	Iridium	Comms down since May 2009 – maint. TBD
PECE	OSU	Iridium	Comms down since Feb. 2008 – maint. TBD
RAMG	OSU	Iridium	Operational
ROB4	LINZ	Radio	Operational
SUGG	OSU	Iridium	Comms down since Aug. 2008 – maint. TBD
VNAD	Hamilton College	Iridium	Operational
WAIT	OSU	Iridium	Operational
WHN0	OSU	Iridium	Operational
WILN	OSU	Iridium	Comms down since Oct 2008 – maint. TBD

LARISSA



Figure 6: LARISSA CGPS station DUPT on Duthiers Point on the entrance to Paradise Harbor.

LARISSA: Larsen Ice Shelf System, Antarctica is a National Science Foundation funded initiative that brings an international, interdisciplinary team together to address a significant regional problem with global change implications, the abrupt environmental change in Antarctica’s Larsen Ice Shelf System. As part of this effort, three bedrock CGPS stations were installed along the western side of the Peninsula in April 2009 to measure post-glacial rebound to help reconstruct the detailed configuration of the northern Antarctic Peninsula Ice Sheet (APIS) during the Last Glacial Maximum (LGM) and subsequent retreat (Figure 6). Six more CGPS sites will be installed in early 2010 – three on bedrock on the east (Weddell Sea) side of the Peninsula, and three on outlet glaciers from the Bruce Plateau. The bedrock CGPS stations are also a part of the POLENET IPY project.

Erebus Network

Technical support, maintenance, data handling, and archive services are provided for the operation of the Mt. Erebus GPS Network (Philip Kyle PI). A maintenance visit was made to the CONZ site (Figure 7) to help assure operation throughout the winter. At the McMurdo end of the communication link, the entire system was moved to a designated server, improving reliability while isolating the system from other Ethernet activities inside Building 71. External antennas and cable connections were inspected for weather damage. A McMurdo-wide IP change was implemented that included the GPS systems routed through building 71. One NetRS failed during the transition, but this was quickly replaced by a spare receiver that had been prepared for this contingency.



Figure 7: UNAVCO engineer Thomas Nylen performs maintenance at the CONZ site on Mt Erebus.

South Pole Station

The South Pole base system AMU2 is maintained for both local and global GPS operations. The system continues to perform with minimal attention. A backup GPS receiver and antenna are kept on-site as a precaution against a wintertime failure when supplying spares is not possible. The data are archived at UNAVCO and NASA-CDDIS and available online. Requests for high rate GPS data in support of airborne projects in the vicinity is common, and this year such data were provided for G-098 (D. Blankenship PI). Network security issues involving the AMU2 receiver are currently being addressed by UNAVCO and RPSC.

Palmer Station

The Palmer GPS system is maintained for both local and global GPS operations and includes a community base station (PAL2), a real-time kinematic (RTK) GPS system, and the NASA GGN station PALM. The UNAVCO base system PAL2, which uses the same antenna as PALM, provides centimeter level RTK differential corrections to properly equipped users in the vicinity of Palmer Station. A rover RTK GPS receiver is available for researcher use at and in the vicinity of Palmer, and the survey controller of this system was upgraded to a TSC2 model to remain standardized with similar systems in Greenland and Alaska. Publicly available geodetic data are archived at UNAVCO with minimal latency, and high rate (1Hz) data are available on station and from JPL. Requests for high rate GPS data in support of airborne projects in the vicinity is common, and this year such data were provided for NASA and British Antarctic Survey (BAS) projects. Network security issues involving the PAL2 receiver are currently being addressed by UNAVCO and RPSC.

McMurdo Station

Field activities are supported from UNAVCO's office and shop space in the Crary Lab at McMurdo Station. This is an excellent base of operations for UNAVCO, but as the UNAVCO support role has grown so has 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. The UNAVCO milvan is well utilized throughout the season and left full during the winter as the primary UNAVCO on-ice storage location. The long-term desire still remains to obtain dedicated space at McMurdo Station, rather than work from space that must be formally requested in the RPSC Support Information Package every year and requires frequent shuttling of equipment to and from a storage container on another part of the station. During the 2008-09 field season, UNAVCO was once again provided dedicated space in Crary Lab room 239 which met the project needs well and contributed to the success of the mission.

The McMurdo GPS system is maintained for both local and global GPS operations and includes a community base station (MCM4), a real-time kinematic (RTK) GPS system, and the NASA GNSS Global Network (GGN) station MCM4. The data are available from UNAVCO and NASA archives. Last year, the MCMC receiver, part of the NASA GGN equipment at the site, was temporarily replaced with an NSF-OPP NetRS receiver after showing signs of failure. This unit was replaced with another NASA receiver at the beginning of the 2008-09 season. UNAVCO receivers were

moved on to a dedicated server within Building 71 this season, isolating communications from a previously shared NASA hub. Network security issues involving the MCMD receiver are currently being addressed by UNAVCO and RPSC.

WAIS Divide Camp

The permanent station at WAIS Divide Camp continues to provide summertime continuous data. UNAVCO installed the community GPS base station in November 2005 to support local projects and provide a consistent time series for the duration of the camp. The wireless ethernet link to WAIS camp allows automatic data downloads to the computer at the camp, and UNAVCO supports camp staff in setting up a data download routine for the season. Publicly available data from this site are archived at UNAVCO.

Community Equipment Pool

GPS Receivers

One hundred and twelve geodetic quality dual-frequency receivers (59 Trimble NetRS, 37 Trimble R7, 13 Trimble 5700, 3 Trimble 4700) were provided from the UNAVCO pool for Antarctic support (including POLENET) 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 annually to best meet the current science needs. The UNAVCO GPS pool increased by 27 systems to a total of 115 NSF-OPP USAP receivers. This includes 18 new NetRS receivers fielded for the POLENET project. To meet the full demands of opposite peak field seasons, equipment from the OPP-Arctic and USAP pools are shared. Table 3 provides a summary of the major USAP equipment in the pool.

LiDAR Terrestrial Laser Scanner

UNAVCO received support for the MRI proposal *Acquisition of a Terrestrial Laser Scanning System for Polar Research* and purchased an Optech ILRIS 3D LiDAR system for NSF-OPP funded research support. This survey instrument is complimentary to the suite of GPS equipment already available, allowing for much higher spatial density surveys of short distances. The instrument was in consistent demand and performed well during the 2008-09 Antarctic field season, for applications including change detection (Mt. Erebus lava lake, Beacon Valley polygons, and Dry Valley glaciers) and geological landform mapping (Figure 8). Efforts are continuing to further develop the necessary software and IT support to enable the community to process the acquired data sets to obtain merged and geo-referenced point cloud images. The related **INTERFACE** project (**INTER**disciplinary alliance for digital **F**ield data **AC**quisition and **E**xploration), also managed by UNAVCO, is expected to further this effort and help geoscientists with the technical hurdles in obtaining precise high resolution 3D surface data.



Figure 8: Hasnan Basagic using the Terrestrial Laser Scanner to image a rock glacier in the Dry Valleys.

Table 3: The UNAVCO/USAP Equipment Pool

Item	Qty	Features and Applications	Average age (yr)
Trimble 4700	4	Robust receiver for short term data collection and kinematic surveys where a handheld survey controller is used.	10
Trimble 5700	17	Modern low power, high memory receiver suited for both short term and continuous data collection.	7
Trimble R7	28	Same as the 5700, but also capable of tracking the new L2C GPS signal.	5
Trimble NetRS	66	State-of-the-art reference station receiver with computer and web browser interface, well suited for continuous data collection applications.	3
Trimble survey controllers	9	Handheld controller used with Trimble R7 and 5700 for field programming and survey measurements.	-
Pacific Crest RTK radios	14	Low power radios for RTK surveys	-
LiDAR scanner	1	Optech ILRIS 36D Terrestrial laser scanner	2
Pan/tilt base	1	Optech - for ILRIS 36D scanner	2

Equipment Deployed Long Term

Table 4 provides an overview of UNAVCO/USAP equipment deployed long term at remote locations. While the applications differ, the equipment is standardized as much as possible to limit the efforts of tracking and maintaining the systems.

Table 4: UNAVCO/USAP Equipment deployed Long Term at Remote Locations

Location	GPS receivers	Communication modems	Other equipment (value > \$1000)
McMurdo Station GPS Base MCM4/MCMD	1 TNL NetRS	1 PC RFM96-2W	
McMurdo Station Mt. Erebus/TAM data hub		1 FreeWave FGR115 2 Intuicom Ethernet bridge	
McMurdo Station Ob-Hill testbed	6 TNL NetRS	5 NAL A3LA Iridium	1 Vaisala WXT-510 metpack
Mt. Erebus Abbot Peak	1 TNL R7		
Mt. Erebus MACZ	1 TNL NetRS	1 Intuicom Ethernet bridge	1 Vaisala WXT-510 metpack
Mt. Erebus Truncated Cones	1 TNL NetRS	1 FreeWave FGR115 1 Intuicom Ethernet bridge	
Palmer Station GPS base PALM/PAL2	1 TNL NetRS 1 TNL R7		1 TSC2 survey controller
Pine Island Glacier	2 TNL NetRS	2 NAL A3LA Iridium	
POLENET	2 TNL R7 21 TNL NetRS	1 FreeWave FGR115 1 Intuicom Ethernet bridge 20 NAL A3LA Iridium	10 Vaisala WXT-520 metpack
Recovery Lakes	2 TNL NetRS	2 NAL A3LA Iridium	2 Vaisala WXT-520 metpack
South Pole Station GPS base AMU2	2 TNL NetRS		
South Pole Station testbed	1 TNL NetRS	1 NAL A3LA Iridium	
WAIS Divide camp	1 TNL NetRS	2 Intuicom Ethernet bridge	
Whillans Ice Stream	1 TNL NetRS 9 TNL R7	1 NAL A3LA Iridium	
Total:	53	42	15

Science Support Services

The UNAVCO Facility provides GPS project management, equipment and field engineering support, and data services for principal investigator projects and for installing, operating and maintaining continuous GPS networks world-wide. These capabilities are drawn upon to provide support tailored to the needs of Antarctic research scientists as summarized below.

Science Advisory Committee

The Polar Networks Science Committee includes members of the polar GPS and seismic communities:

- Doug Wiens, Washington University - Chair
- Terry Wilson, Ohio State University – Vice Chair
- Sridhar Anandakrishnan, Pennsylvania State University
- Rick Aster, New Mexico Tech
- Mark Fahnstock, University of New Hampshire (new member)
- Meredith Nettles, Columbia University (new member)
- Carol Raymond, Jet Propulsion Laboratory
- Bob Smalley, University of Memphis

This committee allows for the direct participation of the polar science community in UNAVCO as a consortium that provides them with considerable resources in the era of large polar GPS networks such as POLENET. The committee reports to both the IRIS and UNAVCO Board of Directors and is expected to coordinate input from the science research community regarding polar networks and science requirements, advise and engage on polar GPS and proposal initiatives, and assist with the development of acquisition proposals for polar remote station components and systems. This year the committee was expanded to include two new members to better represent Arctic science.

Training

UNAVCO offers flexible options for project training, including training prior to and during field deployment, as well as training in post-processing data. The training is tailored to the experience level of each project team. For the 2008/2009 season all of the training was provided in Antarctica with the exception of G-434 Morin which was held at the PI's home institution.

Field Support

Three UNAVCO engineers, Thomas Nylen, Joe Pettit and Marianne Okal, were present at McMurdo Station 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 reference station, the WAIS Divide GPS station, and the Mount Erebus and POLENET continuous station networks. Training is also provided to the RPSC science technician on maintaining systems over the winter. Direct field support was provided to projects as noted in Table 1.

Data Processing

Post-processing of differential GPS and Ground Based LiDAR data is necessary to achieve the centimeter level precision required for most projects. UNAVCO supports GPS 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 the end of their field activities. UNAVCO also continues to provide post-season data processing support using commercial software, on-line data processing services, short courses, 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 project data are sorted by project event number and Antarctic field season. Permanent station data are organized by network and site ID and are in most cases publicly available. 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.



Figure 9: New benchmark BON1 installed on the helicopter pad at the Lake Bonney camp.

Data collected to geodetic standards are archived by site name and precise site coordinates, and site descriptions are readily available on-line (www.unavco.org/polar). 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 geodetic benchmark, BON1, was installed at Lake Bonney and tied in to the old Lake Bonney monument, BONN. This new installation is affixed to the railing of the helicopter pad near the main Lake Bonney camp (Figure 9). The old control point was in danger of inundation from rising lake levels.

Education and Outreach

Broader Impacts in the education and outreach arenas for UNAVCO's Polar support include four main areas:

- an internship for a student underrepresented in STEM fields through the RESESS program (Research Experiences in Solid Earth Science for Students),
- work toward an Active Earth Display highlighting the UNAVCO community's Arctic and Antarctic research,
- an active role in presenting Polar research at the National Meeting of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), and
- incorporation of cryospheric applications of geodesy in a published paper and in the new UNAVCO science applications page.

Two interns completed polar research during the summer of 2008 which was published in *Earth, Wind, Sky, and Air*, which was distributed to the geoscience community at professional meetings in late 2008. The pdf can be found at http://resess.unavco.org/docs/EWSS_2008.pdf These two interns presented their research at the 2009 national meeting of the Society for the Advancement of Chicanos and Native Americans in Science:

Stephen Hernandez, Lineament analysis for the McMurdo Dry Valleys Region, Antarctica. Mentors: Stephanie Konfal and Terry Wilson Kelly Carroll, all from Ohio State University

Ezer Patlan, Drilling induced Fracture (DIF) characterization and stress pattern analysis of the Southern McMurdo Sound (SMS) Core, Victoria Land Basin, Antarctica. Mentors: Terry Wilson, Cristina Millan, Kelly Carroll, Ohio State University.

Stephen Hernandez continued as POLENET/RESESS intern in 2009 and is also part of the IRIS cohort of students. He is doing research in 2009 with Dr. Doug Weins of Washington University on shearing of seismic waves under the

polar sheet in central Antarctica.

The SACNAS meeting in 2008 highlighted the International Polar Year. UNAVCO supported this by sponsoring the afternoon field trip for around 100 student participants in visiting areas outside Salt Lake City to see results of past glacial events and past climate change. Dr. Terry Wilson of POLENET organized the scientists, and UNAVCO paid for this event as well as the booth which incorporated the POLENET project.

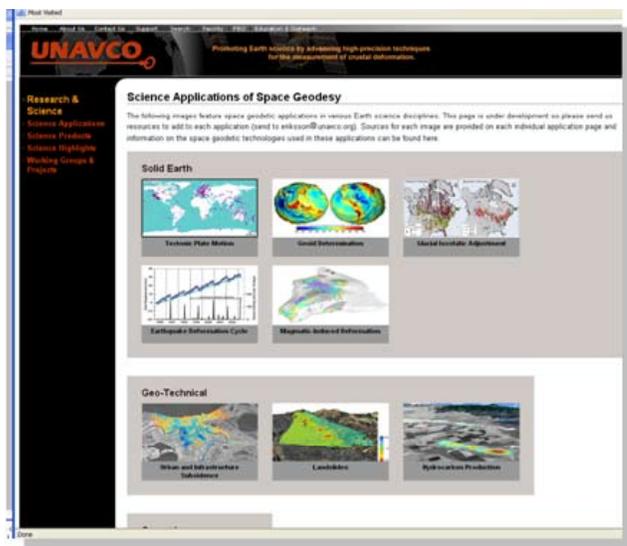
UNAVCO is leading efforts with IRIS and POLENET Education and Outreach teams to create a touchscreen kiosk Active Earth Display (AED) based on GPS and seismic work at the poles. Goals of the POLENET AED include introducing users to ice dynamics, what it's like to work in Antarctica, the use of GPS in polar science, and the global significance of studying the polar regions--specifically, the effect of climate change and how climate change can be measured in the polar regions. A newly



Figure 10: Stephen Hernandez (pictured in second row, third from right) split his time as a POLENET, RECESS and IRIS intern in the summer of 2009.

designed and developed game allows users to try their hands at designing a power system to run the GPS equipment through three years (including three polar nights!) of study. We have a contract with a web design firm to complete this interactive game by September 1, 2009.

The *Science Applications* has been revamped, with community scientists contributing content to the broadening scope of geodesy in geoscience www.unavco.org/geodesy21century. The inauguration of this website coincided with publication of the May 5 issue of EOS on which a comprehensive overview of geodetic applications in the geosciences. This peer-reviewed article has a potential readership of 52,000 AGU members. Modern applications of geodesy to the cryosphere are highlighted in both the paper and on the website.



Appendix A - Detailed Summary of Support Provided

A-306 (Inan)

UNAVCO continued to supply support to Dr. Inan by providing a GPS RTK system at Palmer Station. Dr. Inan uses this system to accurately relocate his VLF antenna on the glacier behind the station.

B-174 (Kim)

Dr. Stacey Kim returned to McMurdo with SCINI, an underwater ROV that presents a form factor allowing the robot to be launched through a 6 inch diameter hole in the sea ice. Underwater navigation is controlled via precisely positioned transducers dropped through the ice. UNAVCO assisted in pre-locating multiple dive holes and transducer positions for the instrument (Figure 11). Unavco also provided RTK equipment and training, allowing the group to set up dive locations in a variety of field location.



Figure 11 - UNAVCO engineer Marianne Okal measures the location of a dive hole for B-174 (Kim), Oct 2008.

B-211 (Doran)

Dr. Doran and the B-211 team participated in the ENDURANCE AUV project at Lake Bonney. UNAVCO provided GPS gear for PPK measurements, training and post processing to help calibrate the ENDURANCE navigation system.

B-421 (McKnight)

Dr. McKnight came to UNAVCO with a late season request for both GPS and ground based LiDAR support to augment her ongoing research in the Taylor Valley. A UNAVCO Field engineer traveled to Lake Fryxell and Lake Bonney to take GPS measurements and scan features of interest. The LiDAR efforts were limited to Lake Fryxell. UNAVCO provided post processing and data archiving.

B-425 (Fountain)

Dr. Andrew Fountain, a McMurdo LTER participant, returned to the Taylor Valley to continue research on the Commonwealth, Canada and Taylor glaciers. This year UNAVCO provided ground based LiDAR technology to B-425 to scan aspects of the Commonwealth glacier and the Don Juan Pond. The LiDAR support included fielding an engineer as well as performing post processing and archiving of data.

B-426 (Doran)

Dr. Doran's team returned to measure the positions of ablation stakes on lakes Fryxell, Hoare, and Bonney, helping to determine the motion of surface ice on these perennially frozen lakes. UNAVCO trained one new member of the B-426 team in GPS techniques and provided him with a pair of Trimble 5700 GPS receiver systems for his field work. UNAVCO also assisted in field measurements at Lake Hoare (Figure 12), and the placement of a lake level bolt at Lake Vida. Additional support included data processing and data archiving.



Figure 11: Maceij Obryk, G-426 field team member measures ablation stakes on Lake Hoare.

B-518 (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. UNAVCO provided refresher training and one RTK system.

C-515 (Domack)

LARISSA: Larsen Ice Shelf System, Antarctica is a National Science Foundation funded initiative that brings an international, interdisciplinary team together to address a significant regional problem with global change implications, the abrupt environmental change in Antarctica's Larsen Ice Shelf System. As part of this effort, three bedrock CGPS stations were installed along the western side of the Peninsula in April 2009 to measure post-glacial rebound to help reconstruct the detailed configuration of the northern Antarctic Peninsula Ice Sheet (APIS) during the Last Glacial Maximum (LGM) and subsequent retreat. Six more CGPS sites will be installed in early 2010 – three on bedrock on the east (Weddell Sea) side of the Peninsula, and three on outlet glaciers from the Bruce Plateau. The bedrock CGPS stations are also a part of the POLENET IPY project.

UNAVCO assisted with the installations and providing training for future installations to the LARISSA PI.



Figure 12: UNAVCO Field Engineer Joe Pettit operates the mobile GPS system used to measure a 50 km seismic shot line for G-049 at New Harbor, Nov 2008.

G-049 (Pekar)

The ANDRILL crew continued with its project this season to explore potential new drill sites in the Ross Sea region. This year those efforts were focused in New Harbor where over 50 km of multi channel seismic shot data was taken (Figure 13). UNAVCO engineers measured the location of each point along the shot line, set at 100 meter intervals, and provided the group with highly accurate coordinates along their seismic grid. The data was processed and archived.

G-058 (Harvey)

As part of its annual search for meteorites, the G-058 field team performed local stop-and-go kinematic surveys of meteorite locations. This season meteorite collection was focused in the LaPaz Icefield. UNAVCO provided G-058 with three Trimble 5700 receivers and data archiving.

G-081 (Kyle)

Dr. Kyle requested UNAVCO support for both campaign and permanent station GPS activities on Mt. Erebus as a means to carefully monitor the deformation of the volcano from internal magma dynamics. Training, two Trimble 5700/R7 systems, data processing and archiving were provided to the field team for mapping



Figure 14: UNAVCO Ground Based LiDAR shown imaging the lava lake within the caldera of Mt Erebus, Dec 2009.

activities along seismic shot lines and campaign occupations. The TLS LiDAR scanner was used to scan a time series of the lava lake within the main caldera (Figure 14). Despite difficulties with weather and visibility within the crater, the scanning was deemed successful.

UNAVCO also performed maintenance to two of three permanent GPS systems on Erebus. The Trimble R7 data card at Abbott Peak was swapped out at the end of the season and the data archived. The telemetry system was modified at Bldg 71, with the Ethernet connections moved to a designated server. Data from the seven telemetered Erebus permanent stations continue to be downloaded daily to McMurdo Station, and transferred to the UNAVCO data archive where they are available on-line to the science community.

G-098 (Blankenship)

UNAVCO engineers provided assistance to Blankenship's team by helping them overcome technical difficulties with their own GPS gear. High rate data was also provided from McMurdo and South Pole GPS base stations.

G-121 (Sletten)

Dr. Sletten returned to the Dry Valleys with the purpose of studying soil dynamics and the movement of salts and subsurface ice at sites of varying ages, ice content, and microclimates. This involved revisiting field sites in the Taylor, Victoria and Beacon Valleys. UNAVCO supplied both GPS and ground based LiDAR along with a Field Engineer to profile polygon features found on the valley floors. UNAVCO provided training, three Trimble 5700 GPS receivers, ground based LiDAR, processing and data archiving.

G-294 (Ashworth)

UNAVCO provided Ashworth with both GPS and ground based LiDAR assistance. Ashworth and his team profiled several features in the Upper Taylor Valleys using both GPS and ground based LiDAR (Figure 15). Of particular interest was a LiDAR scan of a scarp that has been particularly important Dr. Ashworth's research.

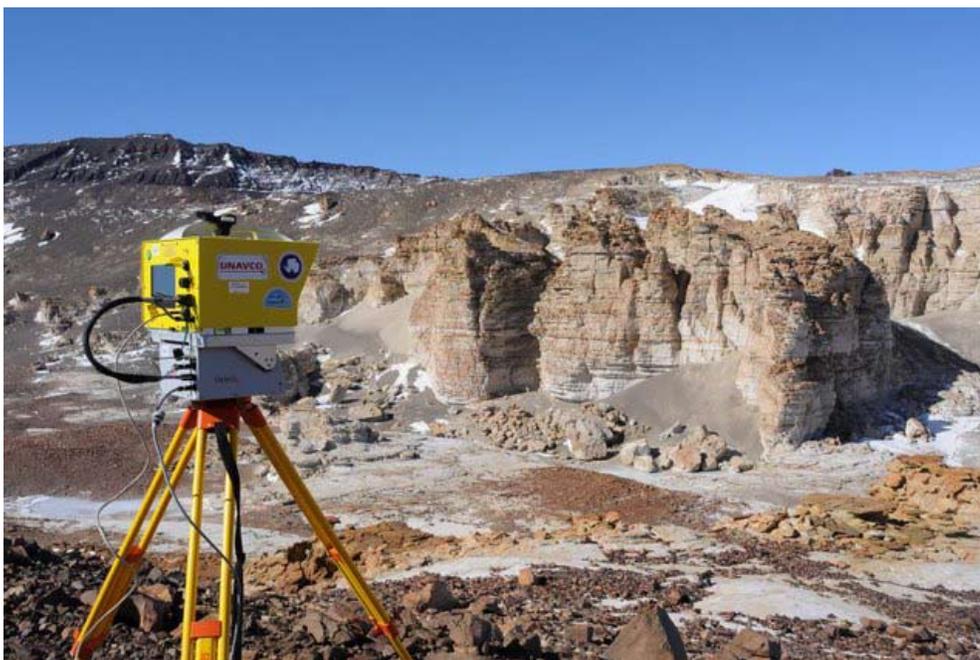


Figure 15: Ground Based LiDAR scanning rock features in the Asgard Range, Dec 2009.

G-433 (Stone)

Dr. Stone and his team conducted coring operations on several peaks in the Dry Valleys region. Precision GPS was used to carefully mark the locations of these drill holes. UNAVCO provided both GPS instruments training and data archiving to the group. The gear provided consisted of a pair of Trimble R7's for simple fast-static measurements of the drill holes.

G-434 (Morin)

Paul Morin and the Antarctic Geospatial Information Center (AGIC) team were provided in depth training on the use of Trimble GPS and ground based LiDAR systems. Their intent this season was to begin detailed mapping of the McMurdo region, with an emphasis on features in the Dry Valleys. The team was provided 5 GPS systems and the ground based LiDAR. Some assistance in post processing was also provided.

G-438 (Mukhopadhyay)

Dr. Mukhopadhyay's team spent time in the Asgard Range mapping surface profiles with a GPS PPK system and the ground based LiDAR. A UNAVCO field engineer accompanied the team into the field to perform the LiDAR measurements as well as to get them started on the PPK measurements. UNAVCO provided data post processing and data archiving.

I-155 (Albert)

During the Troll Station traverse, the I-155 crew installed two continuously operating MRI style autonomous GPS systems to monitor the Recovery Lakes site. Thanks to an easily assembled design and solid training ahead of time, the installation went flawlessly. The team also borrowed two Trimble campaign receivers for stop and go kinematic surveys along the traverse. They performed their own post processing. Data from the Recovery Lakes systems is being archived at UNAVCO.

I-196 (Hall)

In a continued effort to reconstruct the glacial history of the Scott Glacier, I-196 again focused on describing the glacier's evolution from the last glacial maximum to the present day. Constraints on the thinning of the Scott Glacier since the last glacial maximum will be used to bracket the timing of the grounding-line retreat past the glacier mouth. This will help establish whether the Holocene retreat of the West Antarctic Ice Sheet is ongoing, or if it has ended. For their field season, the team was given 3 Trimble R7/5700's and one Trimble 4700 GPS system.

I-205 (Anandakrishnan)

A total of 18 GPS receivers (13 Trimble NetRS, 8 Trimble R7) were provided to I-205 to populate a network covering the Thwaites ice stream at WAIS Divide, where the team is advancing their study of the regional ice stream dynamics. The team performed their own post processing, and UNAVCO is archiving this season's data. Due to time and weather constraints one GPS system was left in the field.

I-345 (Tulaczyk)

Dr. Slawek Tulaczyc spent time this year mapping elevation change anomalies along the West Antarctic Ice Sheet (WAIS) and studying their correlation to subglacial water movement. In addition to his regular GPS campaign work, Dr. Tulaczyk serviced a network of 10 autonomous GPS Systems that he deployed last season, set along the Whillans Ice Stream. One of these systems, a complete MRI kit with Iridium communications plus solar and wind power, provided data through the previous austral winter with just an eight week data gap in late winter. UNAVCO provided Trimble GPS PPK and RTK instrumentation, training and data archiving services.

O-283 (Lazarra)

UNAVCO provided one Trimble 5700 GPS receiver, training, data processing, and data archiving to the Automated Weather Station (AWS) field team in their ongoing effort to produce accurate site elevations used in climate models. These surveys are conducted on an "opportunity" basis during scheduled maintenance visits to the AWS sites.

ANZ (Mahoney)

A late season request was submitted by Antarctica New Zealand for a single GPS fast static system to be used over the winter. Andy Mahoney, a wintering scientist with Scott Base found that he needed a precision GPS receiver to help track sub surface drifters (neutrally buoyant pingers) released under the sea ice in McMurdo Sound. He submitted a request for support to the NSF and permission was quickly granted. UNAVCO provided training on use of the Trimble instrument.