UNAVCO

University NAVSTAR Consortium

GPS Support to the National Science Foundation Office of Polar Programs

2000-2001 Season Report

GPS Support to the National Science Foundation
Office of Polar Programs

2000-2001 Season Report

June 15, 2001

Bjorn Johns
Chuck Kurnik

University NAVSTAR Consortium (UNAVCO)
University Corporation for Atmospheric Research
3340 Mitchell Lane
Boulder, CO 80301
(303) 497-8034
www.unavco.ucar.edu

Support funded by the National Science Foundation Office of Polar Programs
Scientific Program Order No. 2 (EAR-9903413) to Cooperative Agreement No. 9732665

Cover photo: Canada Glacier Energy Balance Survey – B-042-L (photo by Gayle Dana)

Table of Contents:

Summary

UNAVCO provides year round support for scientific applications of the Global Positioning System (GPS) to the National Science Foundation's Office of Polar Programs (NSF/OPP). This support includes pre-season planning, field support, and post-season follow-up, as well as development work for supporting new applications. UNAVCO maintains a "satellite" facility at McMurdo Station, 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. Projects were also supported on the Antarctic Peninsula and in Alaska. A total of 29 projects, encompassing a range of applications, were supported throughout the 2000/01 field season. The UNAVCO Polar web site (www.unavco.ucar.edu/polar) provides comprehensive and historical information related to UNAVCO support to NSF/OPP.

Twenty two projects received UNAVCO support as requested prior to the field season, and seven additional projects, including the Acoustic Doppler Current Profiler (ADCP) reconnaissance, were added during the field season. In support of New Mexico Tech (G-081), UNAVCO installed a dual-frequency continuous GPS station on Mount Erebus. The low cost single frequency continuous GPS network was expanded to three systems for technology demonstration and evaluation. Table 1 summarizes projects using UNAVCO support, while Appendices A and B provide more detailed discussions of individual project support.

Support to NSF-OPP Arctic projects is a new addition to the UNAVCO Polar support umbrella and details of Arctic project support will be included in future annual reports. The incremental cost of supporting these additional projects, which typically occur during the northern summer, is provided by the OPP Arctic Program on a project-by-project basis with funds included in the overall OPP funding action to UNAVCO/UCAR. One Arctic project, a survey of Bench Glacier in Alaska, was supported during summer 2000 and is included in this report. Current projects supported during the summer of 2001 include permafrost deformation studies near Barrow, Prudhoe Bay, and Toolik Lake, and coastal erosion studies at Point Barrow.

In addition to the science project support, the differential GPS system at McMurdo and Taylor Valley was evaluated for functionality after Selective Availability (the GPS position error introduced by the Department of Defense) was terminated, providing significantly improved performance from low cost hand-held, autonomous GPS receivers.

Table 1 – 2000-2001 UNAVCO Support Provided

Project	Point of Contact	Support Effort (%)	Eqp. Loan	Field Support	Training	Data Archived	Data processed	Preseason Request
I-153	Hamilton	11	Yes	No	Yes	Yes	No	Yes
G-081	Kyle	9	Yes	Yes	Yes	Yes	Yes	Yes
G-052	Hothem	7	Yes	No	No	No	No	Yes
G-180	Anandakrishnan	7	Yes	No	Yes	Yes	No	Yes
Peninsula Environmental	Harris	5	Yes	No	Yes	No	No	Yes
B-025	Priscu	4	Yes	Yes	No	Yes	Yes	Yes
B-042-L	Dana	4	Yes	Yes	Yes	Yes	Yes	Yes
I-157	Engelhardt	4	Yes	Yes	No	Yes	Yes	Yes
I-163	Scambos	4	Yes	No	Yes	Yes	No	Yes
B-034	Emslie	3	Yes	No	Yes	Yes	Yes	No
B-042-D	Doran	3	Yes	Yes	No	Yes	Yes	Yes
B-042-F	Johnston	3	Yes	Yes	No	Yes	Yes	Yes
B-042-M	Conovitz	3	Yes	No	Yes	Yes	No	No
E-318	Kennicutt	3	Yes	No	Yes	No	Real-time	Yes
G-053	Hallet	3	Yes	Yes	Yes	Yes	Yes	Yes
G-054	Marchant	3	Yes	Yes	No	Yes	Yes	Yes
G-058	Schutt	3	Yes	No	Yes	Yes	Yes	Yes
I-171	Hawley	3	Yes	No	Yes	Yes	No	Yes
I-190	MacAyeal	3	Yes	No	Yes	Yes	Yes	Yes
I-196	Hall	3	Yes	Yes	No	Yes	Yes	Yes
ADCP	Robbins/Powell	3	Yes	No	Yes	Yes	Yes	No
I-175	Stone	2	Yes	No	Yes	Yes	Yes	Yes
O-283	Stearns	2	Yes	No	Yes	No	Yes	Yes
B-005	DeVries	1	Yes	Yes	No	Yes	Real-time	No
B-024	Lisle	1	Yes	Yes	No	Yes	Real-time	No
G-098	Blankenship	1	No	No	No	Yes	Yes	Yes
Lake Hoare Camp Survey	Scanniello	1	Yes	Yes	No	No	Yes	No
Scott Base	Cleary	1	No	No	Yes	No	No	No
Bench Glacier	McGregor	Arctic	Yes	No	Yes	No	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 2000/01 season most training was provided at McMurdo Station or in the field, but training was also provided before the field season to I-163 (Ted Scambos), Antarctic Peninsula Environmental Management (Colin Harris), and the Alaska Bench Glacier project (Kelly MacGregor).

Field Support

UNAVCO engineers[1] were present at McMurdo Station throughout the mainbody season. The primary responsibilities of the field engineer are managing the large equipment pool and providing technical support to field projects. The field engineer also maintains the DGPS infrastructure and the Mount Erebus continuous station network data collection computer, and trains 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 (unless the McMurdo DGPS RTK broadcast is used) to achieve the centimeter level precision required for most projects. UNAVCO supports data processing in the field using Trimble GPSurvey software. As in previous seasons, an effort was made to ensure that most data processing was completed before field teams that do not have their own data processing resources left McMurdo. UNAVCO also continues to provides post-season data processing support, using GPSurvey software, the NASA - Jet Propulsion Laboratory (JPL) Auto-GIPSY on-line data processing service, and advanced post-processing techniques for problem data sets.

Data 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. The data are sorted by project event number and by Antarctic field season. UNAVCO archiving services are available to all NSF sponsored geodetic GPS projects – not just those directly supported by UNAVCO – 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. This season a GPS control point was added to the database from Cape Ross (ROS1).

Meta-data from all UNAVCO supported 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] Bjorn Johns (10/00-12/00) and Chuck Kurnik (10/00-2/01)

Equipment

Science Pool

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

Mount Erebus Continuous GPS Stations

In December 1999, two single frequency (L1) systems were installed on Mount Erebus to operate through the Antarctic winter as a technology demonstration and evaluation project. These systems were powered by a solar charged system with no charging available during the winter months. To conserve power they were only run for three hours per day. One system at Hooper's Shoulder (HOOZ) operated through the winter. The second system at Truncated Cones (CONZ) experienced a timer hardware failure and shut down during the winter.

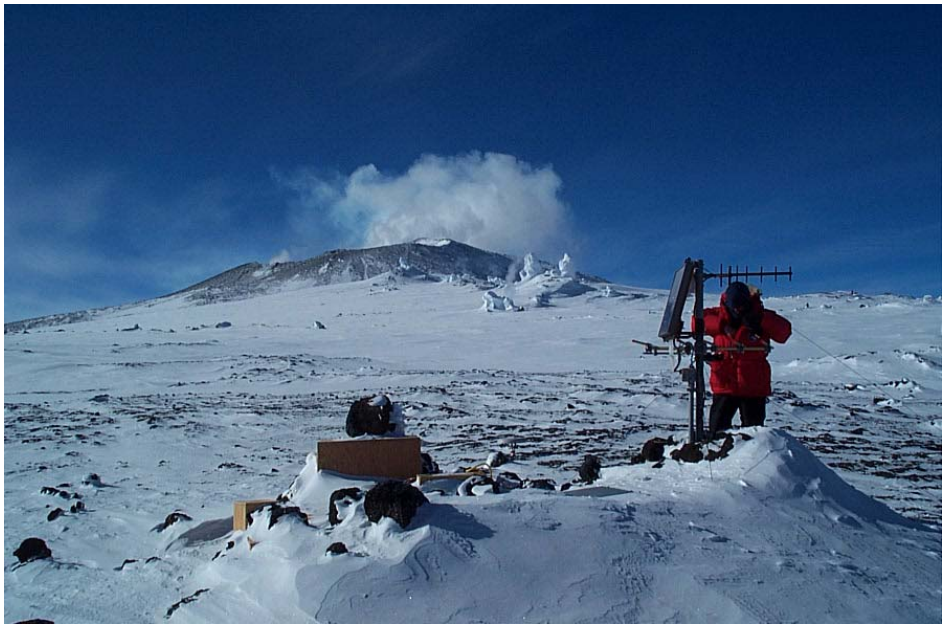

Figure 1 – Continuous GPS and seismic station CONZ on Mount Erebus

In December 2000, a dual-frequency (L1/L2) receiver was installed on Mount Erebus at Truncated Cones (Figure 1) and an additional single-frequency (L1) system (E1) was added to the existing L1 network. The L1 system from Truncated Cones was moved to Nausea Knob. The Trimble 4000SSE dual-frequency system provides an accurate reference point for the more extensive single-frequency network and is downloaded daily via radio modem. Based on the timer failure last season, the timers were removed from the systems with the understanding that solar powered sites will likely shut down during the winter. Two sites (E1 and CONZ) were connected to the wind generators installed by the G-081 field team to provide winter power to the seismic and GPS network. Preliminary indications suggest that the wind generator system is not providing adequate winter power and as of June 1, 2001, the only GPS site still submitting continuous data is the solar-only L1 site at Hooper's Shoulder. The dual-frequency system at Truncated Cones will be replaced with a lower powered receiver during the 2001/02 season. Technology is driving down both receiver cost and power consumption, and upgrading the existing Mount Erebus GPS network will be a minimal effort considering the existing infrastructure already in place.

The Mount Erebus data download computer was moved this season from the Crary Lab to Building 71 (McMurdo Ground Station) near Arrival Heights. There is a clear radio line-of-sight from there to Mount Erebus, as well as Internet access. This move reduced the complexity of the data path by removing the previous short-haul modem link between the Crary Lab and the old water plant building on Observation Hill.

Differential GPS System

Testing done after Selective Availability (SA) was turned off in May 2000 revealed +/-5 meter horizontal, +/-20 meter vertical accuracy using handheld GPS units. With this significantly improved autonomous GPS accuracy the DGPS system is no longer necessary for meter level surveys of large features such as fish holes or for rescue vehicle navigation purposes. The system is still used for sub-meter real-time surveys and is now operated exclusively in the survey grade Real Time Kinematic (RTK) mode. This season the UNAVCO DGPS equipment was used by B-005, B-024, and E-318 in the vicinity of McMurdo Station. In addition, the RPSC surveyors used the system with their own equipment for the annual ice runway layout and other survey jobs. The DGPS base was relocated to a different room within Building 71 (McMurdo Ground Station) at the request of the local Honeywell contractors.

Geographical Information Systems (GIS) Products

The increased popularity of GIS with USAP research projects has created a demand for geo-referenced coordinates of physical features. UNAVCO has assisted several projects in obtaining geo-referenced spatial data for several seasons. Examples include control points for aerial photography, boundary surveys, and digitized physical features for mapping and other applications. Many of these data sets are of potential interest to users other than the project team that originally collected the data. A section for GIS Data Products has been added to the UNAVCO Polar web page (Figure 2) to make such data sets of general interest readily available. Relevant future data sets will be added annually as they are collected. Data sets include:

Taylor Valley lakes perimeters

Lake Brownworth perimeter

New Harbor shoreline

McMurdo Ice Shelf one month tidal response

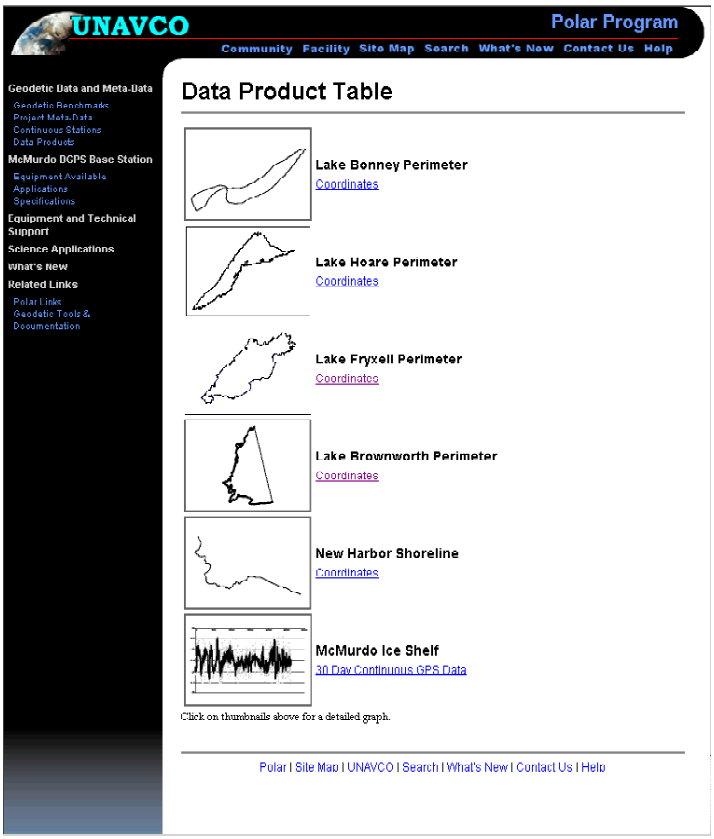

Figure 2 – GIS data products available from www.unavco.ucar.edu/polar

Appendix A - Detailed Summary of Antarctic Support Provided

B-005 (Art DeVries)

Ben Hunt requested assistance in locating a dive hole, a conductivity-depth-temperature (CDT) monitoring gauge, and a prolific fishing spot. In all cases, the work required locating holes in the sea ice. A Trimble 4700 with DGPS capability was used. Dr. DeVries' research may require returning to these specific locations in future seasons. UNAVCO provided field support and data archiving.

B-024 (John Lisle)

Dr. Lisle asked that UNAVCO survey several dive holes in the sea ice immediately west of McMurdo so that they can be re-located in following seasons. These holes provide access to the sea floor where data are gathered to study the interaction between human and seal digestive bacteria. A Trimble 4700 with DGPS capabilities was used. UNAVCO provided field support, data processing, and data archiving.

B-025 (John Priscu)

As part of their LTER research, John Priscu and Ed Adams are studying how ablation relates to the surface roughness of Lake Bonney in Taylor Valley. They requested that UNAVCO perform continuous kinematic surveys along several transects to collect this type of data. Surveys were performed at two different times during the season, one in late November 2000 and one in late January 2001. The survey was performed for the first time in November 1998. Repeat surveys provide insight into annual and seasonal variation in surface roughness as well as lake level. In each case, a Trimble 4700 was used as a rover and a Trimble 4000 was used as a base station. UNAVCO provided field support, data processing, and data archiving.

B-034 (Steve Emslie)

Steve Emslie is studying ancient penguin rookeries in the Ross Island/Scott Coast area and is interested in obtaining accurate elevations above sea level at each site. UNAVCO provided training, a Garmin Etrex handheld GPS receiver/altimeter, a Trimble 4000 geodetic receiver, and ancillary equipment for approximately one month. Upon return of the equipment, UNAVCO processed and archived the data, and provided the PI with coordinates and geoid elevations.

B-042-D (Peter Doran)

Peter Doran requested GPS support to re-survey the location of ablation stakes and "floating boulders" on the surface of Lake Hoare. This survey was done for the first time in December 1999. The ablation stakes provide insight into the ablation rate, translation, and rotation of ice on Lake Hoare, and the floating boulders provide insight into ice movement. Data processing and archiving were provided after the field season.

B-042-F (Andrew Fountain)

Field support was provided to survey topographical transect endpoints and a longitudinal elevation profile of a melt channel on Taylor Glacier. This work helps in understanding the melt water contribution of the Taylor Valley glaciers to the ecosystem and is part of the McMurdo Dry Valleys LTER program. Data processing and archiving were provided after the field surveys. A handheld Garmin receiver/altimeter was also provided for the season to field assistant Thomas Nylen for various applications in Taylor Valley.

B-042-L (Berry Lyons)

Gayle Dana requested GPS support to map the outline of three snow-patches on the south side of Lake Hoare and two on the Canada Glacier (Figure 3). The patches were surveyed three times in November 2000. During the GPS surveys Dr. Dana would measure depth, temperature and density of the patches. As a formal collaborator in the LTER project Dr. Dana models the energy and mass balance in Taylor Valley. UNAVCO provided field support, data processing, and archiving after the field surveys.

Figure 3 – Kinematic Survey of Snow-patches on the Canada Glacier

B-042-M (Diane McKnight)

UNAVCO provided a Trimble 4000 receiver to research assistant Peter Conovitz to survey stream channel benchmarks in Taylor Valley. These marks are used to reference local optical surveys of the channel topography 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.

G-052 (Jerry Mullins)

The US Geographical Survey (USGS) performed several multi-day surveys in the area of the Scott Coast and the Dry Valleys in the continuing effort to map, monitor, and provide geodetic control of the McMurdo Sound region (Figure 4). UNAVCO supported this effort with four geodetic receivers, chokering antennas, and solar panels.

Figure 4 – Hut Point GPS control point ARR6

G-053 (Bernard Hallet)

UNAVCO performed a survey to measure surface displacements in Beacon Valley which occur due to sub-surface ice beneath the valley floor (Figure 5). This survey in December 2000 was a repeat of the initial survey from January 1999 and will reveal surface velocities as small as 1 cm/year. Three 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. A brief continuous kinematic survey of frost polygons was also performed as a demonstration of work that can be done in the future.

Figure 5 – Beacon Valley surface displacement benchmark

G-054 (David Marchant)

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

G-058 (Ralph Harvey)

Support was provided to obtain precise geo-referenced coordinates for GPS control points for local surveys of meteorite locations, allowing the meteorite spatial data to be used in a GIS database. The work was done in the Meteorite Hills area. Field researcher John Schutt received training at McMurdo and was provided one geodetic receiver. The data were archived and processed by UNAVCO using the JPL Auto-GIPSY point-positioning automated data processing service.

G-081 (Philip Kyle)

Philip Kyle requested UNAVCO support to survey the nine monument GPS deformation network that was installed on Mount Erebus during the 1999/2000 season (Figure 6). UNAVCO personnel deployed three geodetic receivers early in the field season, and the G-081 team deployed two more and finished the survey using a total of five receivers. The network is used to monitor deformation of the volcano caused by the migration of magma. UNAVCO provided data archiving after the season. UNAVCO also provided two receivers, data processing software, and training to research assistant Jean Wardell to track helicopter flight profiles during plume sampling flights.

Figure 6 – Cape Royds control point ROY0 used for Mount Erebus deformation survey

In addition to the episodic campaign style survey, a continuously operating dual-frequency receiver was installed on one of the deformation network monuments (CONZ), and a third receiver was added to the existing L1 network. The L1 download computer was moved from the Crary Lab to Building 71 (McMurdo Ground Station) to eliminate a short-haul modem link and simplify the data transfer process. The L1 network and the dual-frequency receiver are downloaded to a single computer in Building 71 and the data are archived by UNAVCO.

G-098 (Don Blankenship)

The Support Office for Aerogeophysical Research (SOAR) requested UNAVCO technical support to process data from GPS base stations at Williams Field and the Vostok camp. UNAVCO post-processed the data at McMurdo to provide accurate reference coordinates to use with the airborne geophysical survey near Williams Field. Logistical issues and weather-delays prevented UNAVCO from processing data collected at Vostok while SOAR personnel were in the field. UNAVCO has archived the data.

I-153 (Gordon Hamilton)

UNAVCO provided five geodetic quality receivers and a Linux-based laptop computer to co-PI Gordon Hamilton for snow surface measurements on the U.S. component of the International Trans-Antarctic Scientific Expedition (ITASE) traverse on the West Antarctic Ice Sheet. The aim of this traverse is to develop a better understanding of the last 200 years of West Antarctic climate and environmental change through multidisciplinary research. Four receivers were used on the traverse for local measurements and the fifth was left at Byrd Camp as a reference station. The laptop computer was used to automatically download the reference receiver at Byrd Camp while it was unattended for six weeks. The data were archived at UNAVCO after the field season.

I-157 (Hermann Engelhardt)

GPS support was requested to perform an ice stream velocity survey on Ice Stream C to characterize the ice velocities around the project drill sites (Figure 7). Previous GPS and GPR surveys combined with satellite images and aerial photography revealed an elliptically shaped "sticky spot" on the ice stream. The survey was performed near the downstream end of this spot. In November 2000 a velocity profile line of stakes was installed and a "Stop-and-Go" kinematic survey was performed. The survey was repeated in January 2001 to determine displacement and velocity. Full field support was provided for each survey. All data processing was performed by UNAVCO and the data were archived after the field season.

Figure 7 – Ice Stream C kinematic survey

I-163 (Charles Raymond)

Ted Scambos attended training in the operation of the Trimble 4000 and Trimble processing software at UNAVCO before the field season. During the season he deployed three geodetic receivers on Ice Stream C to measure velocity profiles near the shear margins as part of the study of the recent history of the Siple Coast glaciers.

I-171 (Ed Waddington)

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

I-175 (John Stone)

John Stone requested a geodetic receiver to obtain accurate elevations at his sampling locations in Marie Byrd Land, where he is studying the history of the West Antarctic Ice Sheet using cosmogenic and isotope dating of moraine boulders and ice-abraded bedrock. After the season UNAVCO processed the data using precise satellite orbits and provided both geoid and ellipsoid referenced elevations. The data are archived at UNAVCO.

G-180 (Sridhar Anandakrishnan)

Four Trimble 4000 receivers were provided to Sridhar Anandakrishnan to measure the tidal effect on ice stream velocity at three locations on Ice Stream D. One receiver was downstream of the grounding line, one near the grounding line, and one upstream of the grounding line. The fourth receiver was placed near the Siple Dome summit as a fixed reference point. UNAVCO provided training before receiver deployment, data processing technical support, and data archiving.

I-190 (Doug MacAyeal)

Dr. MacAyeal is studying C16, the most recent large iceberg to calve from the Ross Ice Shelf. Data were collected and processed in two modes. A USCG helicopter flew the outline of one corner of the berg to collect rough data regarding the location and orientation, and the base station data were processed in kinematic mode relative to MCM4 to provide velocity information. UNAVCO provided three geodetic receivers to the field team as well as training, data processing support and data archiving after the season.

I-196 (Brenda Hall)

UNAVCO and RPSC surveyor Jeff Scanniello performed continuous kinematic and rapid static surveys for Brenda Hall to map paleo-shorelines at Cape Ross. The data will be used in generating relative sea level curves to determine the timing of Holocene deglaciation. Two geodetic receivers were provided for this effort and UNAVCO processed and archived the data.

O-283 (Chuck Stearns)

UNAVCO provided a Trimble 4800 receiver, training, and data processing software to the Automated Weather Station field team in an ongoing effort to provide accurate site elevations used in climate models. These surveys are conducted as “opportunity surveys” during scheduled maintenance visits to the AWS sites.

E-318 (Chuck Kennicutt)

Chuck Kennicutt requested support in locating randomly generated UTM coordinates at McMurdo Station where samples are taken as part of an environmental monitoring program. UNAVCO provided a Trimble 4700 DGPS system and a Garmin Etrex handheld unit as well as training in the operation of the equipment.

Acoustic Depth Current Profiler Reconnaissance (Ross Powell)

Although Ross Powell was not in Antarctica for the 2000-2001season, he wanted to know how much lateral movement there is in the sea ice in the Granite Harbor area in preparation for a proposed future drilling project. This lateral movement results in shear stress on the drill bit. Two Trimble geodetic receivers were provided to Rob Robbins, a member of the field team, on three different occasions. UNAVCO provided training, equipment, data processing support and data archiving for the project.

Antarctic Peninsula Environmental Management (Colin Harris)

Colin Harris of the Scott Polar Research Institute received UNAVCO support for NSF sponsored work to develop environmental management plans for sensitive areas on the Antarctic Peninsula. UNAVCO provided training prior to the field season, two geodetic receivers that were hand-carried to Antarctica via the British Antarctic Survey logistics channel, and data processing support after the field season.

Lake Hoare Camp Survey (Jeff Scanniello)

UNAVCO conducted rapid static surveys of two control points at the Lake Hoare camp for use as control in conventional camp surveys. The camp at Lake Hoare is surveyed every few years so that changes can be documented.

Scott Base (Peter Cleary)

UNAVCO provided consulting in the set up of a Trimble 4000 receiver base station at Scott Base, used to generate satellite-based DGPS corrections for a New Zealand hydrologic survey off the northern Victoria Land Coast.

Appendix B - Detailed Summary of Arctic Support Provided

Bench Glacier, Alaska (OPP98-18251, Robert Anderson)

UNAVCO support was requested for a project to study how glaciers carve and sculpt alpine landscapes. The fieldwork is on the well-defined Bench Glacier in the Chugach Range in Alaska. GPS was used to measure temporal and spatial variations of surface speeds and to map the topography and outline of the glacier. UNAVCO provided two geodetic quality receivers, training in Boulder, and data processing assistance after the field season (summer of 2000).