UNAVCO, Inc

GPS Support to the National Science Foundation
Office of Polar Programs
Arctic Sciences

2003 Annual Report

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Cover photo: Real-time kinematic mass balance survey of McCall Glacier, Alaska Brooks Range. Photo: M. Nolan.

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Summary

UNAVCO provides year round support for scientific applications of the Global Positioning System (GPS) to the National Science Foundation's Office of Polar Programs (NSF/OPP) Arctic Sciences Section. This support includes pre-season planning, field support, and post-season follow-up, as well as development work for supporting new applications. A full range of support services are available, including GPS equipment, training, project planning, field support, technical consultation, data processing, and data archiving. Eight Principal Investigator based projects encompassing a range of applications were supported during 2003 (Figure 1). UNAVCO also updated Greenland camp drawings for Veco Polar Resources, performed on-site maintenance and training for continued use of the differential GPS surveying system at the Barrow Arctic Science Consortium facility in Barrow, Alaska, and provided survey equipment for summer use at the Toolik Field Station. Table 1 summarizes projects using UNAVCO support, while Appendix A provides more detailed discussions of individual project support. The UNAVCO web site (www.unavco.org) provides comprehensive and historical information related to Polar Programs support.

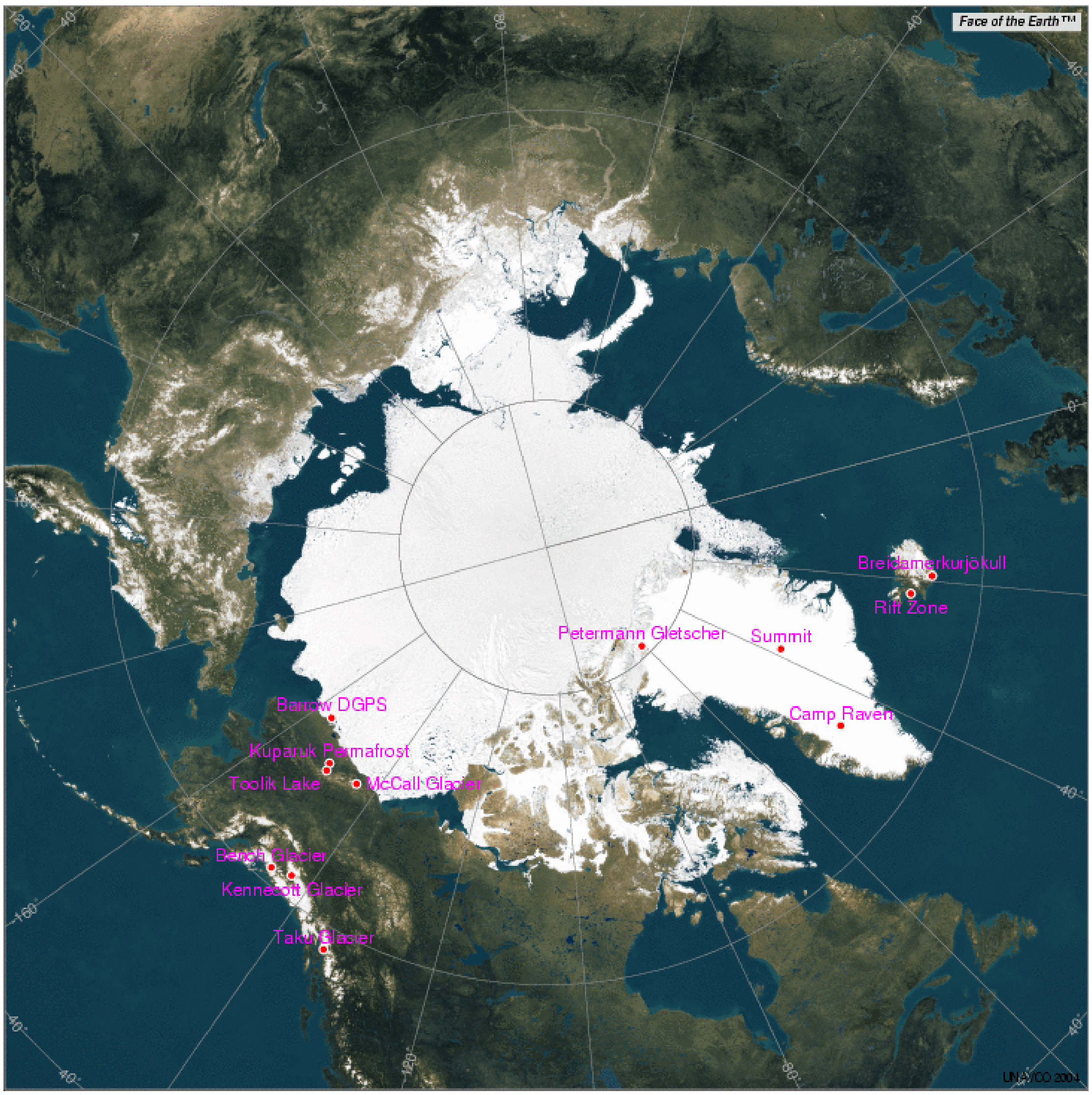


Figure 1 – NSF-OPP Arctic projects supported in 2003.

Table 1 – 2003 UNAVCO Support Provided

Project	Point of Contact	Eqp. Loan	Field Support	Training	Data Archived	Data processed
Barrow DGPS	Glenn Sheehan	No	Yes	Yes	N/A	N/A
Bench Glacier	Tad Pfeffer	Yes	Yes	Yes	Yes	Yes
Greenland Petermann Gl.	Konrad Steffen	Yes	No	No	No	No
Greenland Summit	Mark Begnaud	Yes	Yes	No	Yes	Yes
Iceland Breidamerkurjokull	Slawek Tulaczyk	Yes	Yes	Yes	Yes	No
Iceland Rift Zone	Tim Dixon	Yes	No	No	No	No
Kennecott Glacier	Robert Anderson	Yes	No	No	No	No
Kuparuk Permafrost	Frederick Nelson	Yes	No	No	Yes	No
McCall Glacier	Matt Nolan	Yes	Yes	Yes	Yes	Yes
Taku Glacier	Martin Truffer	Yes	Yes	Yes	Yes	No
Toolik Lake	Andrew Balser	Yes	No	No	N/A	N/A

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. Training tailored to the Barrow DGPS system was provided at the UNAVCO Facility to Bob Bulger, Allison Graves, and Matt Irinaga. Training was provided in the field to Andy Mahoney (Barrow DGPS), Fabian Walter (Bench Glacier), Throstur Thorsteinsson (Iceland Breidamerkurjokull), Matt Nolan (McCall Glacier), and Adam Bucki (Taku Glacier).

Field Support

UNAVCO provides remote engineering support to Arctic research projects via telephone, email, and documentation on the web. Field support is also available to groups that desire technical support for their geodetic GPS surveys. Direct field support was provided for Barrow DGPS system maintenance, and for the Bench Glacier, Greenland Summit (Figure 2), Iceland Breidamerkurjokull, McCall Glacier, and Taku Glacier projects.

Figure 2 – UNAVCO engineers setting up for a survey on the Greenland ice cap.

Data Processing

Post-processing of differential GPS data is required to achieve centimeter level precision. UNAVCO supports data processing in the field using Trimble Geomatics Office (TGO) software. Post-season data processing support is also provided, using TGO software, the NASA - Jet Propulsion Laboratory (JPL) Auto-GIPSY on-line data processing service, and advanced post-processing techniques for problem data sets. Data processing was provided to Bench Glacier, Greenland Summit, and McCall Glacier projects.

Data Archiving

All GPS data handled by UNAVCO are archived at the UNAVCO Boulder archive to ensure data safeguarding and future accessibility. The data are sorted by project name and year. 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.

Equipment

Science Pool

UNAVCO provides complete GPS equipment for both geodetic surveying and mapping applications. A fourth state-of-the-art Trimble 5700 geodetic survey receiver was purchased for the UNAVCO pool on behalf of NSF-OPP Arctic Sciences, and 20 additional receivers from the UNAVCO pool provided for arctic project support throughout the field season to meet the increasing high-precision GPS demand from the Arctic research community (Figure 3), including long term continuous data collection (Figure 4). All necessary ancillary equipment such as data processing software, solar panels, batteries, chargers, tribrachs, tripods, and cables was also provided. Future equipment upgrades will include additional receivers, power systems, and other equipment to support long term continuous data collection.

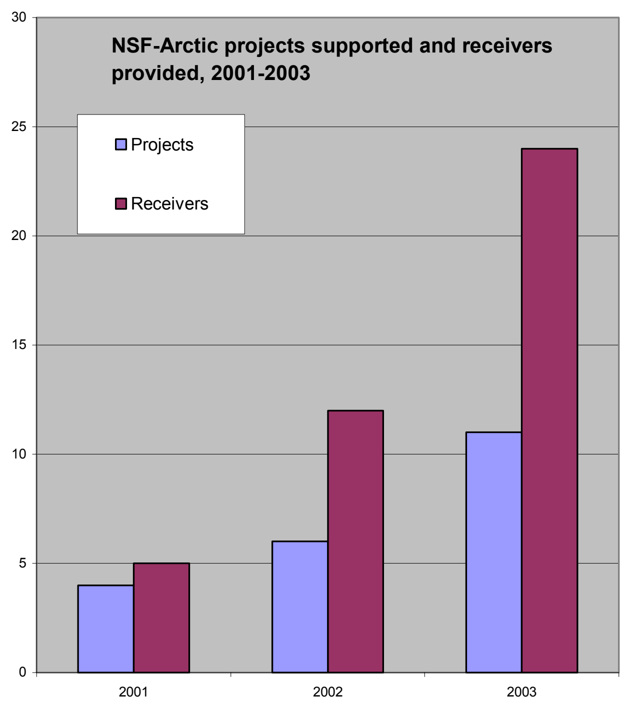


Figure 3 – Growth in Arctic projects receiving UNAVCO support.

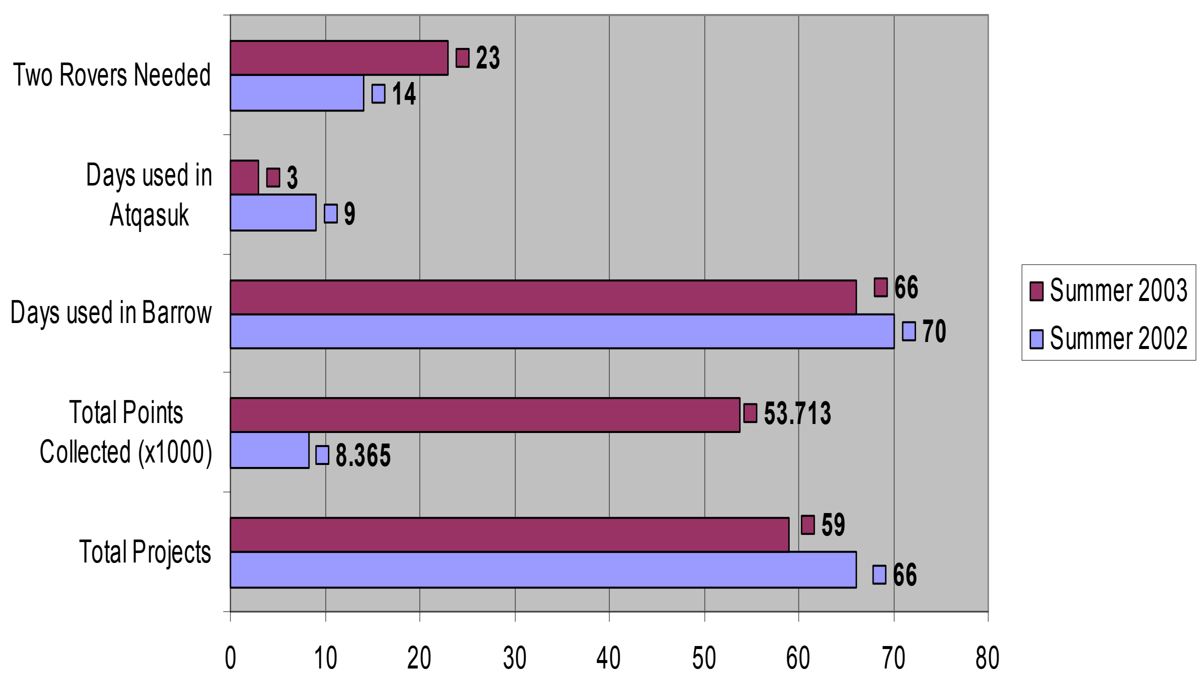
Figure 4 - Continuous data collection set-up on Taku Glacier, Alaska after seasonal snow melt. Photo: R. Motyka.

Barrow Differential GPS System

A Trimble 5700 real-time kinematic (RTK) differential GPS (DGPS) system is available for dedicated use at the Barrow Arctic Science Consortium (BASC) to meet the surveying needs of researchers working at BASC. RTK broadcasts provide real-time surveying capability within a seven kilometer radius of BASC, and a portable repeater is available to ensure line-of-sight radio coverage for RTK work within the Barrow Environmental Observatory (BEO). A dedicated GPS data processing computer is set up at the BASC facility, and by collecting and post-processing data centimeter-level accuracy can be realized over 100 kilometers away from the Barrow base station, including the Atqasuk research sites.

UNAVCO is available for year-round technical support to users of this system, while BASC provides the day to day operational support including equipment scheduling, equipment issue, and local technical support. Users who intend to use the system for a significant amount of field surveying are strongly encouraged to arrange for training at the UNAVCO Facility prior to their field season.

During 2003, several steps were taken to ensure the continued success of the Barrow system to local science users. Prior to the summer season, a group from BASC (Bob Bulger, Allison Graves, and Matt Irinaga) visited UNAVCO for a three day "Barrow specific" training session. Bjorn Johns from UNAVCO visited Barrow in early June to provide system maintenance and on-site training. And during the summer season, local technical support was augmented by Michigan State University researcher Craig Tweedie and undergraduate research assistant Shawn Serbin. In addition to managing the equipment, they supported several local requests for survey data collection, and provided system training. Figure 5 provides statistical system-use data compiled by the Michigan State University group. Due to the volume of field use, a normal amount of associated equipment damage is occurring, and the need for additional equipment is emerging. Such maintenance and upgrade issues are handled both by BASC and UNAVCO as appropriate. Specifically, BASC had provided additional batteries and charging capability for the roving system, and UNAVCO added a tripod and tribrach to the system and repaired a damaged receiver.



	Total Projects	Total Points Collected (x1000)	Days used in Barrow	Days used in Atqasuk	Two Rovers Needed
Summer 2003	59	53.713	66	3	23
Summer 2002	66	8.365	70	9	14

Figure 5 – Barrow DGPS system statistical use data provided by Michigan State University field support staff.

Appendix A - Detailed Summary of Support Provided

Barrow DGPS (Glenn Sheehan)

A Trimble 5700 real-time kinematic (RTK) differential GPS (DGPS) system is available for dedicated use at the Barrow Arctic Science Consortium (BASC) to meet the surveying needs researchers working at BASC. During 2003, several steps were taken to ensure the continued success of the Barrow system to local science users. Prior to the summer season, a group from BASC (Bob Bulger, Allison Graves, and Matt Irinaga) visited UNAVCO for a three day "Barrow specific" training session. Bjorn Johns from UNAVCO visited Barrow in early June to provide system maintenance and on-site training. And during the summer season, local technical support was augmented by Michigan State University researcher Craig Tweedie and undergraduate research assistant Shawn Serbin. In addition to managing the equipment, they supported 59 individual project requests for survey data collection, and provided system training. Due to the volume of field use, a normal amount of associated equipment damage is occurring, and the need for additional equipment is emerging. Such maintenance and upgrade issues are handled both by BASC and UNAVCO as appropriate. Specifically, BASC had provided additional batteries and charging capability for the roving system, and UNAVCO added a tripod and tribrach to the system and repaired a damaged receiver.

Bench Glacier (Tad Pfeffer)

UNAVCO provided five Trimble 5700 GPS receivers, field support, data processing, and data archiving to measure temporal and spatial variations of surface speeds of Bench Glacier in Alaska's Chugach Mountains. A robotic total station was used to track 25 points on the glacier surface within a region ca. 500 meters on a side, and GPS was used within that same confined region as a supplement to provide closely-spaced control points on the glacier surface. Used together the GPS provides reference and control for the optical survey and the optical survey extends the areal coverage of the small number of GPS receivers over a wider area. Two receivers were left to collect data over the winter.

Greenland Petermann Gletscher (Konrad Steffen)

UNAVCO provided two GPS antennas for ice flow velocity and position measurements at Petermann Gletscher's floating ice tongue. The Petermann Gletscher is the largest and most influential outlet glacier in northern Greenland, draining an area of 71,580 km2, with a discharge of 12 cubic km of ice per year. Remote sensing results suggest that its ice discharge exceeds that required to maintain the ice sheet interior in a state of mass equilibrium by 63%, and its grounding line is retreating at an anticipated rate at nearly one meter per year. Its floating ice tongue is only a few meters above sea level at the ice front, so it is highly vulnerable to ice thinning. If confirmed by in-situ observations and if this trend continues for several decades, the rate of thinning would be sufficient to threaten the stability and survival of the ice tongue.

The science team is performing a detailed analysis of the glacier floating ice tongue in front of Petermann Gletscher that integrates key field observations with remote sensing data. The field program is designed to obtain the in-situ observations to confirm, validate, and calibrate the remote sensing estimates of basal melting, derive reliable estimates of surface melt from an energy balance model, observe changes in ice volume with precision, and understand the contribution of ice dynamics, surface melt and bottom melt to volume changes of floating ice. GPS and interferometric synthetic aperture radar (InSAR) are used to detect changes in flow rate with time. The results will provide invaluable insights into dynamics and climatic processes of northern Greenland glaciers. Findings from Dr. Steffen's research and its implications to global climate change were featured on June 8, 2004 by the New York Times.

Greenland Summit (Mark Begnaud)

Veco Polar Resources requested UNAVCO assistance to update the Summit Camp facility drawings to account for changes in camp layout over the past two years. This request was also used to provide polar environment survey training to a new UNAVCO field engineer (Beth Bartel). The survey was completed during one National Guard flight week, with just one day spent at Summit Camp due to flight weather delays from Kangerlussuak. During the weather delays, a site survey of Camp Raven was made as an "opportunity project" (Figure 6). UNAVCO also processed the data, updated skiway endpoint precise coordinates, and produced new and updated drawings for Veco.

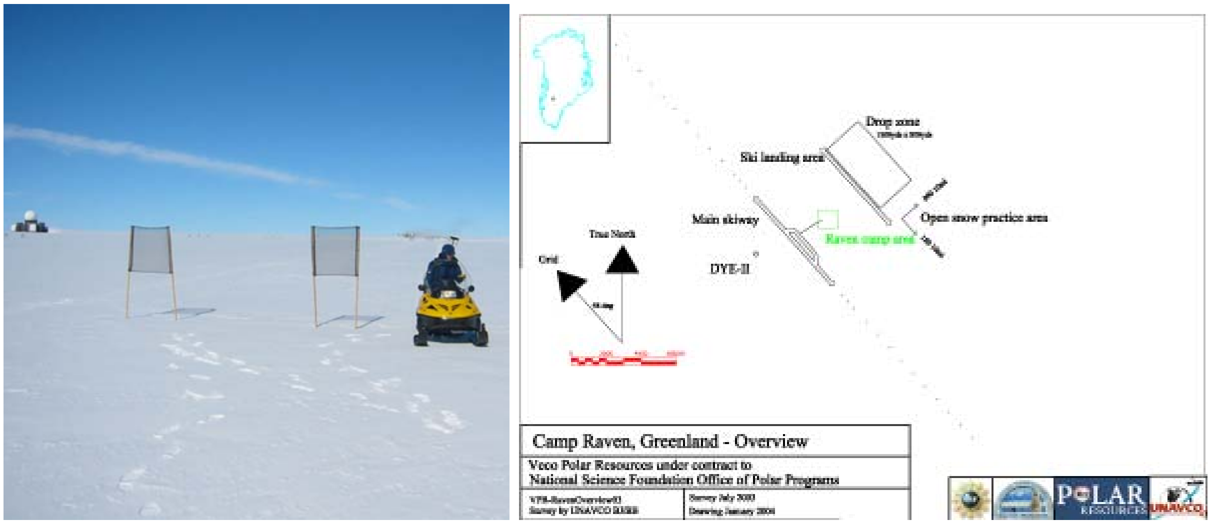


Figure 6 – Mapping survey of Camp Raven, Greenland ice cap.

Iceland Breidamerkurjokull (Slawek Tulaczyk)

Four receivers, training, and field support was provided to this project to study the glacier-scale physics of soft-bedded ice motion. The receivers were deployed for the summer season, and additional antennas were provided for a second survey effort in August. Due to logistical constraints, much of the fieldwork was performed on Myrdalsjokull rather than on Breidamerkurjokull as originally intended. The field teams conducted surveys with ice-penetrating and ground-penetrating radar and GPS. Additional data will be generated from satellite imagery using Synthetic Aperture Radar Interferometry.

One research objective is testing the hypothesis that the force balance and the rate of motion of Breidamerkurjokull on the Vatnajokull ice cap, Iceland is controlled by the underlying till bed and not by other factors such as sticky spots, longitudinal stretching/compression, and marginal shear. Understanding the physics that govern ice motion is needed to make predictions on the future behavior of mountain glaciers and ice sheets in the context of the ongoing climate change and sea-level rise. Breidamerkurjokull, an outlet glacier draining, has played a significant role in developing a new paradigm of glacier motion in which the ice itself rides passively on top of a deforming till bed. The data will be used to calculate the spatial distribution of basal shear stress and basal resistance. This research should improve the current understanding of ice-till interactions and of their control over flow of ice masses and may help predict whether modern ice masses will harm local or global societal interests through, for instance, changes in the global sea level or surges of mountain glaciers.

Iceland Rift Zone (Tim Dixon)

UNAVCO provided three receivers to collect an additional epoch of GPS measurements in order to capture the displacement field nearly two decades after a major rifting event at the spreading plate boundary in north Iceland between 1975 and 1985. The rifting episode resulted in up to 9 m of crustal widening, followed by a regional, post-spreading anelastic deformation transient involving up to a further 26 cm of crustal widening over the next decade, and decaying in amplitude with time.

Figure 7 – Site Ljosufjoll marks the spreading axis for this subaerial segment of the Mid-Atlantic Ridge. Photo: P. La Femina.

The ground control network measured prior to 1993 was only 240 km wide, and did not span the zone of post-spreading accelerated deformation. Therefore, additional GPS surveys were conducted in 1993 and 1995 that extended the earlier network to a width of 450 km. The objective was to acquire data at large distances from the plate boundary in order to constrain the width of the rheological plate boundary.

The 2003 survey (Figure 7) occupied about 70 points up to 300 km from the plate boundary, with the objective to refine the rheological model for Iceland. This work will improve the ability to forecast future large events whose magnitude and timing are influenced by both co-event elastic, and post-event anelastic stress loading from earlier events. The results could provide insights into the post-event deformation transient phenomenon at other plate boundaries and regions.

Kennecott Glacier (Robert Anderson)

UNAVCO provided two GPS receivers to graduate student Mike Loso for exploratory, pre-proposal data collection on the Kennecott Glacier near McCarthy, Alaska. The proposal calls for a larger scale GPS survey to link ice dynamics and subglacial hydrology on a large, temperate Alaskan glacier. This work would expand on previous data sets collected on Bench Glacier.

Kuparuk Permafrost (Frederick Nelson)

UNAVCO provided two GPS receivers, data processing software, and training to research assistant Jon Little. GPS was used to measure seasonal elevation changes in the permafrost active layer in the Kuparuk River basin and surrounding areas on the Alaskan North Slope. The Barrow DGPS base station was also utilized by this project during data collection in Barrow. The data were archived at UNAVCO after the field season.

McCall Glacier (Matt Nolan)

Five GPS receivers, real-time kinematic equipment, field support, data processing, and data archiving support were provided. This project studies the mass balance and dynamics of McCall Glacier as an index for glacier contributions of fresh water inputs into the Arctic Ocean. Real-time kinematic (RTK) GPS was used to precisely reoccupy points previously surveyed through airborne laser altimetry surveys and conventional surveys on the ground. New velocity transects were also surveyed, and two receivers were left for the summer field season to provided continuous position measurements. In addition, baseline surveys of several nearby glaciers were also conducted (Figure 8).

Figure 8 – Kinematic survey of Scott Glacier, Alaska Brooks Range. Photo: K. Scott.

Taku Glacier (Martin Truffer)

UNAVCO provided four GPS receivers, training, and field support. Taku Glacier is located in SE Alaska near Juneau, and is currently advancing into proglacial sediments and deforming them into bulges. GPS was used to study the temporal evolution of the deformational bulges in front of the glacier, and to measure the nearby glacial strain. Ground penetrating radar and radar echo sounding were also used to measure ice thickness. Comparing these measurements to earlier ones allows the quantification of the excavation of subglacial sediments. Surveys were also conducted on the Mendenhall Glacier (Figure 9) while waiting for weather to improve to fly to Taku Glacier.

Figure 9 – Inside Mendenhall Glacier, southeast Alaska.

Toolik Lake (Andrew Balser)

UNAVCO provided two geodetic GPS receivers and data processing software to Toolik Lake GIS Manager Andrew Balser. Although there is already excellent mapping grade GPS equipment at the Toolik Field Station, there is also a need for centimeter level precision for various science applications as demonstrated with a similar equipment loan in 2002. The installation of a dedicated survey grade system similar to the Barrow DGPS system is slated for the start of the 2003 field season.