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GPS SUPPORT TO THE NATIONAL SCIENCE FOUNDATION
OFFICE OF POLAR PROGRAMS
ARCTIC SCIENCES

2005 ANNUAL REPORT

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

2005 Annual Report

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Cover photo: JATO Takeoff by New York Air National Guard at Summit Camp, Greenland, June 2005. Photo: John Burkhart, University of California Merced.

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Summary

UNAVCO provides 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-deployment planning, field support, and post-deployment follow-up for a number of Arctic projects on a year-round basis. The range of services include GPS equipment, training, project planning, field support, proposal assistance, technical consultation, data processing, and data archiving. Permanent station support is also available, from the initial engineering and installations through operations and maintenance. Development, system engineering, and testing activities are ongoing to meet the technical challenges such as providing robust telemetry and power systems at remote high-latitude locations.

Fourteen projects encompassing a range of applications were supported during 2005 (Figure 1). Infrastructure and operational projects include a hardware upgrade and training in Barrow, a training session in Fairbanks for Toolik Field Station Staff, and a site survey of Summit Camp. The Table 1 summarizes projects using UNAVCO support, and Appendix A provides more detailed descriptions of the individual projects. The UNAVCO web site (www.unavco.org) provides comprehensive and historical information related to Polar Programs support.

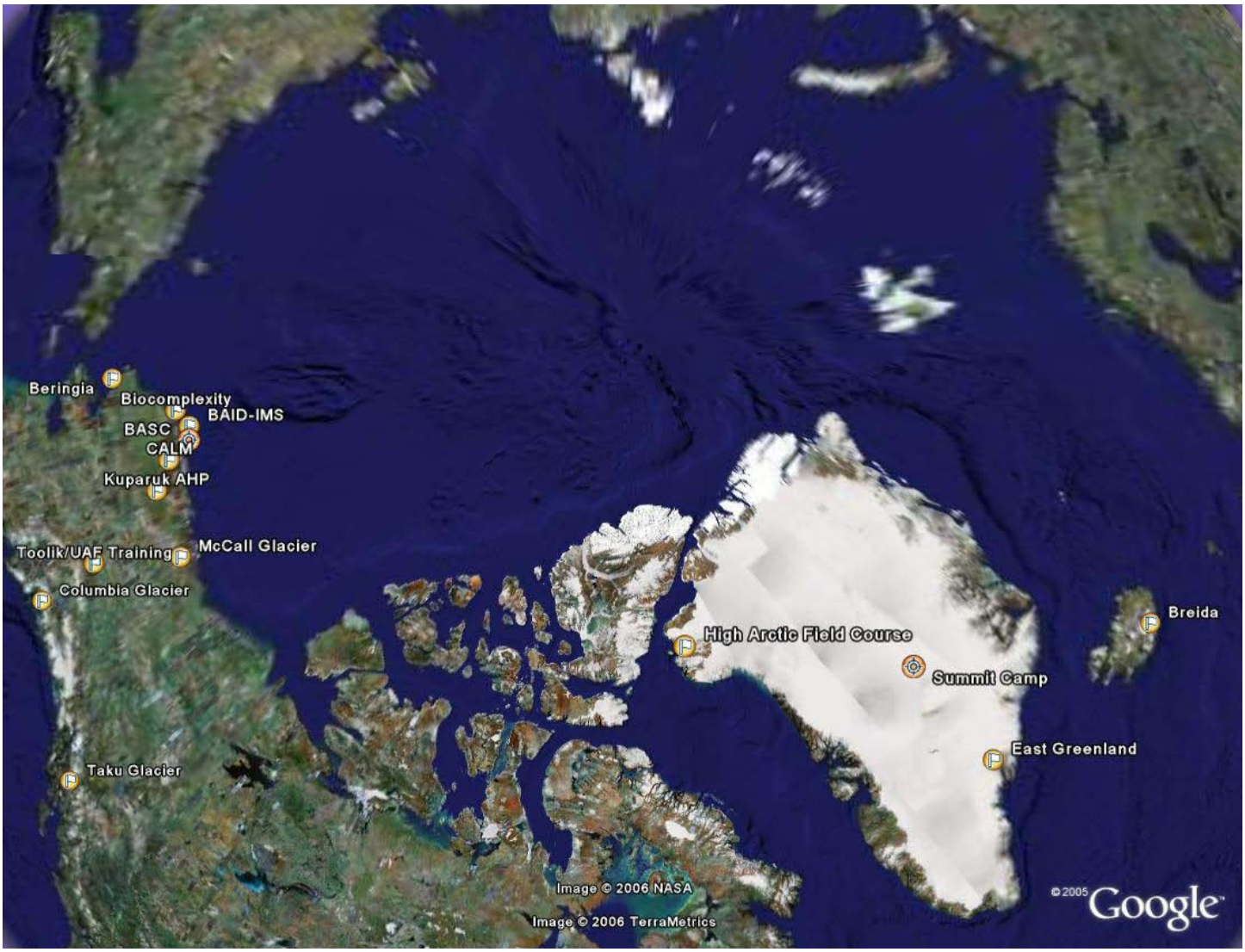

Figure 1 – NSF-OPP Arctic projects supported in 2005.

Table 1: 2005 UNAVCO Support Provided

Project	Funding Source	Point of Contact	Eqp. Loan	Field Support	Training	Data Archived	Data processed
Barrow BAID-IMS	OPP-0454996	Craig Tweedie	X		X		
Barrow Biocomplexity	OPP-0421588	Craig Tweedie	X		X		
Barrow GPS Base	OPP	Glenn Sheehan	X	X	X		
Beringia - Oden Cruise	OPP-0454997	Craig Tweedie	X		X		
CALM	OPP-0352958	Frederick Nelson	X			X	
Columbia Glacier	OPP-0327345	Tad Pfeffer	X				
East Greenland	NASA EOS/ 03-0251-0627	Gordon Hamilton	X				
Greenland Summit Camp	OPP	Mark Begnaud	X	X		X	X
High Arctic Field Course	OPP-0221606	Ron Sletten	X	X	X	X	X
Iceland Breidamerkurjokull	OPP-0136141	Slawek Tulaczyk	X				
Kuparuk AHP	OPP-0327440	Andrew Balser	X	X	X		
McCall Glacier	OPP-0229705	Matt Nolan	X		X		
Taku Glacier	OPP-0221307	Roman Motyka	X				
Toolik Lake/UAF Training	OPP	Andrew Balser	X	X	X		

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. Focused multi-day training sessions were held at the University of Alaska, Fairbank (UAF) for Toolik Field Station and other UAF staff, and in Thule, Greenland as a key component of the High Arctic Field Camp project (Figure 2). GPS system training was provided in Barrow to Michigan State University research assistants Adrian Aguirre and Edith Jaurrieta.

Figure 2 – Hand-on GPS training was provided as part of the High Arctic Field Course held in Thule, Greenland.

Field Support

Field support is provided to groups that desire technical support for their geodetic GPS surveys. Direct field support was provided for Barrow GPS system maintenance, the Toolik Field Station GPS system, the Summit Camp site survey (Figure 3), for the Thule High Arctic Field Course, and for the McCall Glacier project. Remote technical support is also provided to Arctic research projects via telephone, email, and documentation on the web.

Figure 3 – UNAVCO field engineer Seth White surveys the Summit Camp layout to update facility maps.

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 Canadian Spatial Reference System on-line data processing service, and advanced post-processing techniques for problem data sets. This season data processing support was provided for the Summit Camp survey and the Thule High Arctic Field Course projects.

Data Archiving

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

Equipment

Science Pool

UNAVCO provides GPS equipment for geodetic surveying, mapping, and permanent station applications. Six new Trimble R7 geodetic survey receivers and seven Trimble NetRS reference station receivers were purchased, for a total of twenty-three NSF-OPP Arctic Sciences receivers in the UNAVCO pool, including five receivers deployed long term at the Barrow Arctic Science Consortium and Toolik Field Station. Fifteen additional receivers from the UNAVCO pool were provided for project support throughout the field season to meet high-precision GPS demands from the Arctic research community, including long term continuous data collection. All necessary ancillary equipment such as data processing software, solar panels, batteries, chargers, tribrachs, tripods, and cables was also provided.

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. To ensure the continued success of the Barrow system to local science users, UNAVCO schedules an annual maintenance/training visit, usually in conjunction with related specific project requests. This year, Beth Bartel from UNAVCO visited Barrow in late May to support the DGPS system at BASC. The base station was replaced with an Ethernet based Trimble NetRS receiver to provide better remote access and improved base station functionality. The original base receiver was put in use as a second BASC rover receiver. On-site training was also provided to Michigan State University undergraduate research assistants. These students were tasked to manage the equipment during the summer.

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.

Toolik Field Station Differential GPS System

A Trimble 5700 real-time kinematic (RTK) differential GPS (DGPS) system (Figure 9) is available for dedicated use at the Toolik Field Station to meet the surveying needs of researchers working in the vicinity of Toolik Lake on the north side of Alaska's Brooks Range. The real-time capability increases the system versatility in proximity of the station (for example it allows for stakeouts of pre-determined points), while the post-processing capability using Trimble Geomatics Office software extends the system radius to over 100km from the station.

An 8-person, three-day course was taught by UNAVCO at the University of Alaska, Fairbanks in April 2005. The class was a hands-on introduction to scientific surveying using UNAVCO GPS equipment, specifically Trimble 5700/R7s. Static, fast static, kinematic, and real-time kinematic techniques were covered. The purpose of the class was to familiarize participants (Toolik Field Station (TFS) staff Andrew Balser and Lael Rogal in particular) with the capabilities of GPS, as well as to provide practical instruction in using the instruments for individual field projects. The base station receiver at TFS was also replaced with a Trimble NetRS networked receiver to allow for better remote management. The previous base receiver was put to use a second rover unit and a spare and remote deployable RTK base.

Appendix A - Detailed Summary of Support Provided

Barrow BAID-IMS (Pat Webber – Michigan State University)

A dedicated rover RTK receiver system and training to five students was provided to locate and document the location of extant and historical research sites within the area of interest of the Barrow Area Information Database and Internet Map Server (BAID-IMS).

Barrow Biocomplexity (Walter Ochel – San Diego State University)

Training and a dedicated rover receiver system was provided. This project examines how biological and physical processes interact to control carbon uptake, storage and release in Arctic tundra ecosystems and how the self-organizing nature of these interactions varies across multiple spatial and temporal scales. A semi-permanent RTK repeater, set up at the tramway computer building, was also provided.

Barrow GPS Base (Glenn Sheehan – Barrow Arctic Science Consortium)

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. To ensure the continued success of the Barrow system to local science users, UNAVCO schedules an annual maintenance/training visit, usually in conjunction with related specific project requests. This year, Beth Bartel from UNAVCO visited Barrow in late May to support the DGPS system at BASC. The base station was replaced with an Ethernet based Trimble NetRS receiver to provide better remote access and improved base station functionality. The original base receiver was put in use as a second BASC rover receiver. On-site training was also provided to Michigan State University research assistants. These students were tasked to manage the equipment during the summer.

Beringia - Oden Cruise (Craig Tweedie – Michigan State University)

Two receivers and training were provided to conduct static and kinematic field surveys at multiple sites in the Beringian Arctic including remote sites in Russia and Alaska. The project objective is to determine the impact of decadal time scale land cover change on plot to landscape-level carbon flux at multiple sites throughout the Beringia region.

Circumpolar Active Layer Monitoring Network (Frederick Nelson – University of Delaware)

UNAVCO provided two GPS receivers and data processing software. This was the fifth season this project used GPS to measure seasonal elevation changes in the permafrost active layer 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.

Columbia Glacier (Tad Pfeffer – University of Colorado, Boulder)

UNAVCO provided five GPS receivers to measure near terminus speeds and longitudinal stretching rates on Columbia Glacier near Valdez, Alaska. Two of these receivers were the new trimble NetRS ethernet receivers, provided to project collaborator Rob Fatland for the purpose of developing IP protocol seismic and GPS sensor networks.The GPS data will be used in conjunction with passive seismic data to study the timing, location, and geometry of fracture events leading to calving. Tidewater calving is an important part of glacier dynamics, sea level rise, and ice/ocean interaction, but it is still poorly understood. During retreat, tidewater glacier mass balance is dominated by calving, rather than direct climate forcing. Columbia Glacier, the last of the Alaskan tidewater glaciers to retreat, is presently discharging icebergs into the ocean at a rate of approximately around 22 km3 yr-1.

East Greenland (Gordon Hamilton - University of Maine)

The aim of this project is quantify changes in Arctic glaciers and ice caps using satellite remote sensing data. Six receivers were provided for ground measurements on glaciers in East Greenland. The objectives include (1) mapping changes in glacier boundaries through comparison of modern and archival image data (2) assessing volume changes by differencing digital elevation models derived from stereo satellite images, and (3) examining the causes of observed changes. The latter objective involves studies of ice dynamics. Specific ice dynamics issues being addressed include: (1) what volume of ice is being discharged via outlet glaciers? (2) what is the calving flux of large outlet glaciers?, and (3) are outlet glacier velocities changing with time, e.g., as a result of increased meltwater generation? Information about glacier dynamics is being derived from analysis of sequential high resolution satellite imagery (primarily from the ASTER

sensor). Remote sensing techniques yield dense arrays of velocity vectors for numerous glaciers. The field objectives include measurements of ice flow velocities on selected large outlet glaciers, including Kangerdlugssuaq Glacier in East Greenland. The results will be compared with satellite remote sensing based estimates. Flow speeds of selected glaciers are in excess of 2-4 km/yr, allowing for reliable velocity results with short survey durations. Survey markers were installedd on safe regions near the calving fronts of several glaciers. After installation, rapid static GPS surveys were performed (1 hour duration, using a reference station on bedrock nearby, <10 km distant). A second rapid static survey was conducted 1-2 days later, yielding ice velocities.

Greenland Summit Camp (Mark Begnaud – VECO Polar Pesources)

At the request of VECO, several surveying tasks were completed at Summit Camp at the highest point of the Greenland ice sheet. The camp layout and infrastructure had changed significantly since the last UNAVCO survey in 2003, so the camp was re-surveyed and the camp plan drawing was updated to reflect the current layout. Two topographic surveys of the snow levels in and around the camp were also performed using snowmobile-mounted GPS systems. The first topographic survey was done to establish the baseline snow level on a fine grid within the immediate camp perimeter. This survey will be used in combination with future topographic surveys to assess the effectiveness of various measures intended to reduce drifting. The second topographic survey was an experiment to assess the feasibility of using snowmobile-mounted GPS to monitor changes in snow height within a snow accumulation study area near the camp. If this technique can replace the current “manual” accumulation measurements, these measurements can be performed much more rapidly and will yield a finer spatial resolution of accumulation in the study area. This visit was also used as a reconnaissance opportunity to develop a proposal and plan to provide UNAVCO supported GPS infrastructure at Summit Camp for both operational and science surveys.

High Arctic Field Training (Jeffrey Welker – University of Alaska Anchorage)

UNAVCO provided one field engineer and three GPS receiver systems to help instruct and field assist the three-week High Arctic Field Course lead by Ron Sletten (University of Washington) and Jeffrey Welker (University of Alaska, Anchorage). The course included twelve students from a variety of universities and of both biology and geology backgrounds and at different stages of their academic careers. The course was staged in Thule, Greenland, with a six-day trip to nearby Green Valley. One of the main goals is looking at carbon cycling by studying both the ecology and soil chemistry of arctic ecosystems. UNAVCO support was used to map out various permafrost features, including stripes and polygons, and to install and measure markers to determine downslope creep rates of these features and of solifluction lobes in Green Valley. Rates of these processes are as of yet poorly constrained.

Iceland Breidamerkurjokull (Slawek Tulaczyk – University of California, Santa Cruz)

Three GPS receiver systems were provided to this project to study the glacier-scale physics of soft-bedded ice motion. 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. It may also 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.

Kuparuk Arctic Hyporheic Zone (William Bowden – University of Vermont)

This project studies the responses of arctic tundra stream geomorphology, hyporheic zone hydrology, and biogeochemical cycling to climate change. In particular, the researchers expect that hyporehic exchange dynamics in tundra streams are controlled by 1) channel features (pools, riffles, etc.), and 2) depth of thaw beneath the stream channel. Altered arctic climate will likely alter stream flows and therefore the fluvial geomorphic structure of stream channels. They hypothesize that the potential for hyporheic exchange increases as the climate warms and active layers deepen. At the same time, increased exchange of water between the stream and the hyporheic zone could be driving more or different types of hyporheic biogeochemical cycling, which may alter stream nutrient budgets. UNAVCO equipment and field engineer support was provided at the Toolik Field Station to set up a mobile RTK base and rover, and integrate NMEA output with a field GPR unit in real-time, to survey multiple sites in the Kuparuk River watershed, north slope, Alaska.

McCall Glacier (Matt Nolan – University of Alaska, Fairbanks)

Four GPS receivers, real-time kinematic (RTK) equipment, and training 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. RTK GPS was used to precisely reoccupy points previously surveyed through airborne laser altimetry surveys and conventional surveys on the ground. Velocity transects were also surveyed, and three receivers were left for the summer field season to provide continuous position measurements.

Taku Glacier (Roman Motyka – University of Alaska, Fairbanks))

Taku Glacier is located in southeast Alaska near Juneau, and is currently advancing into proglacial sediments and deforming them into bulges. UNAVCO provided five GPS receivers that were used to study the temporal evolution of the deformational bulges in front of the glacier, and to measure the nearby glacial strain. Comparing these measurements to earlier ones allows the quantification of the excavation of subglacial sediments. The data were archived at UNAVCO after the field season.

Toolik Lake/UAF Training (Andrew Balser – University of Alaska, Fairbanks))

An eight-person, three-day course was taught by UNAVCO Field Engineer Beth Bartel at the University of Alaska, Fairbanks in April 2005. The class was a hands-on introduction to scientific surveying using UNAVCO GPS equipment, specifically Trimble 5700/R7s. Static, fast static, kinematic, and real-time kinematic techniques were covered. The purpose of the class was to familiarize participants (Toolik Field Station staff in particular) with the capabilities of GPS, as well as to provide practical instruction in using the instruments for individual field projects. The base station receiver at TFS was also replaced with a Trimble NetRS networked receiver to allow for better remote management. The previous base receiver was put to use a second rover unit and a spare and remote deployable RTK base.