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

2011 Annual Report

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Cover photo – Large iceberg in Kangia Ice Fjord near Ilulissat, Greenland

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Summary

UNAVCO is the National Science Foundation's pre-eminent national facility for earth science applications of the Global Positioning System (GPS) and complimentary equipment including LiDAR and related power and communications systems. The range of services provided to the National Science Foundation's Office of Polar Programs Arctic Sciences Section (NSF-OPP/ARC) includes equipment, training, project planning, field support, proposal assistance, technical consultation, data processing, and data archiving on a year-round basis. Permanent station network support services are also provided, from the initial engineering and installations through operations, maintenance, and data archival and distribution. Sustaining engineering activities are ongoing to meet the technical challenges such as providing robust telemetry and power systems at remote high-latitude locations. Resources and expertise from the other core UNAVCO support areas, including NSF-EAR investigator support, NASA-Global GNSS Network (GGN) operations, the EarthScope/Plate Boundary Observatory facility operation, and the UNAVCO community data archive are leveraged to apply state-of-the-art technologies at a reasonable cost.

Twenty-two Principal Investigator based Arctic projects encompassing a range of applications were supported during 2011 (Figures 1 and 2). Three infrastructure and operational projects were also supported, including training users of the Barrow and Summit Camp DGPS systems, and providing technical support for the Toolik Field Station GPS system. Table 1 summarizes projects supported. Brief project descriptions are no longer provided (Appendix A in previous reports) as that information is captured in the project database and in FastLane. The UNAVCO web site (www.unavco.org/polar) provides comprehensive and historical information related to Polar Programs support.

Figure 1 – Alaska research project locations in 2011.

Figure 2 – Greenland project locations in 2011

Table 1 – 2011 Projects Supported

Project	Funding Source	Point of Contact	Eqp Loan	Quantity Receivers/TLS	Field Support	Training
Alaska:						
Arctic Carbon	ARC- 0747195	Ted Schuur	X	2		
Barrow ITEX SAON GPS	ARC-0856628	Craig Tweedie	X	2		
Barrow ITEX SAON TLS	ARC-0856628	Craig Tweedie	X	TLS	X	
Barrow GPS Base	ARC-UNAVCO CA	Joe Pettit	X	3	X	
CALM	ARC-0856421	Nicolai Shiklomanov	X	3		
Denali	ARC-0714567	Karl Kreutz	X	2		
McCall Glacier	ARC-1023509	Matt Nolan	X	4		
Russell Fiord	ARC-0949775	Daniel Lawson	X	6		
Thermocarst	ARC-0806341	Michael Gooseff	X	2+TLS		
Toolik Field Station GPS	ARC-UNAVCO CA	Jason Stuckey	X	3		
Yakutat	ARC-0806463	Roman Motyka	X	11		
Greenland:						
Basal Sliding	ARC-0909495	Joel Harper	X	3		X
East Greenland Glacier Dynamics	ARC-0710891	Meredith Nettles	X			
GLISN	ARC-0922983	David Simpson				X
Greenland Fractures	ARC-1023364	Sarah Das	X	22	X	
Greenland Meltwater	ARC-0909454	Ginny Catania	X	7		
Helheim Glacier-Ocean-Ice Interaction	ARC-0806393	David Holland	X	Power systems		
Icesheet Accumulation	ARC-0909499	Rick Forster	X	4		
Icesheet Hydrology	ARC-0909388	Marco Tedesco	X	8		
Nuuk Fjords	ARC-0909552	Martin Truffer	X	10		
POLENET-GNET	ARC-1111882	Michael Bevis	X	38+11 spares	X	
Summit GPS Base	ARC-UNAVCO CA	Joe Pettit	X	2		X
Sermilik Fjord	ARC-0909274	Gordon Hamilton	X	10		
Thule Permafrost	ARC-1023462	Ronald Sletten	X	2		
Other:						
Shetland Islands	ARC-1026911	Gerald Bigelow	X	2+TLS	X	X

Science Support

The UNAVCO facility provides project management, equipment, and field engineering support for principal investigator projects and for installing, operating and maintaining continuous GPS networks worldwide. New technology development and evaluation of commercially available products for research applications is undertaken as needed, and GPS data and data products are archived for future applications. The following highlights some of the resources and capabilities available for science project support:

- Expertise in program and project management, field engineering, technical support, and training
- Equipment and laboratory facilities for maintaining repairing, testing, and deploying equipment
- Systems integration and software development capabilities for custom applications
- Formal systems for property management, import/export, shipping and logistics; grant administration, project financial management, tracking, and reporting; established processes and procedures for supporting scientific research

These capabilities are drawn upon to provide support tailored to the needs of Arctic research projects as summarized below.

Training

Flexible options for field team training include 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. Project specific training was provided as noted in Table 1.

The following course from UNAVCO's Short Course Series and Workshops was relevant to and attended by polar investigators:

Post-processing and Real Time Kinematic GPS data analysis with Track and TrackRT
April 26-27, 2011

The workshop will be taught by Tom Herring and feature kinematic processing using Track and it's real-time counterpart TrackRT. The track portion will focus on both moving object analyses such as precise aircraft trajectories and slower movements such as ice streams and ocean buoys, and will also examine strategies for observing seismic surface waves. The TrackRT portion will focus on installation requirements, command file tuning, and interactions with TrackRT while it is running. Grants to assist students with travel expenses may be available. This course will be a combination of lecture, discussion, and tutoring. Participants should have a reasonable knowledge of GPS theory and Unix and have used the software enough to be proficient in standard processing. Tutoring will be based on data sets participants bring on their own laptops.

Instructor: Tom Herring (MIT)

Field Support

Field support is provided to groups that desire technical assistance for their geodetic GPS surveys. Direct field support was provided as noted in Table 1. Remote technical support is also provided via telephone, email, and on-line documentation.

Data Processing

Post-processing of differential GPS and LiDAR data is required to achieve millimeter to centimeter level precision, and UNAVCO supports data processing for field projects using commercial surveying software (Trimble TGO and TBC), GAMIT/GLOBK/TRACK (see above), and on-line data processing services such as Canadian Spatial Reference System and OPUS. The EarthScope/Plate Boundary Observatory data analysis system is used to generate daily positions and position timeseries for several Arctic permanent stations. Precipitable water vapor data can also be determined from GPS permanent station data using the University Corporation for Atmospheric Research (UCAR) COSMIC program's GPS-met analysis capabilities. GPS position timeseries are provided for GNET station KAGA, Summit Camp, and Barrow, and GPS-met data are produced for Atqasuk, Barrow, and Summit Camp.

LiDAR data processing is required to form the basic deliverable, a merged and geo-referenced point cloud. Vendor specific software is used including Riegl Ryscan Pro and Optech Polyworks.

Data Archiving

All GPS and LiDAR data handled by UNAVCO are archived at the Boulder archive to ensure data safeguarding and future accessibility. The data are organized by project name and year in an open access, searchable on-line database. 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. Standards and requirements for LiDAR data are under development. In 2011 a new community data policy went into effect setting expectations for immediate open data access in most cases (www.unavco.org/community/policies_forms/DataPolicy.html).

Science Advisory Committee

The Polar Network Science 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. This committee, which reports to both the IRIS and UNAVCO Board of Directors, 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. There is current discussion about expanding the role of this committee to represent all UNAVCO and IRIS OPP support activities, not just those related to networks. Further information including the charter is available at http://www.unavco.org/community/governance/committees/committees.html#pnsc. Current membership is:

Carol Raymond, Jet Propulsion Laboratory – Chair
Andrew Nyblade, Pennsylvania State University – Vice Chair
Erik Ivins – Jet Propulsion Library
Matt Lazzara – University of Wisconsin, Madison
Doug MacAyeal – University of Chicago
Meredith Nettles – Columbia University
Mike Ritzwoller – University of Colorado
Leigh Stearns – University of Kansas

Equipment and Technology

GPS Equipment Pool

GPS equipment is available for geodetic surveying, mapping, and permanent station applications. Thirty-four new Trimble NetR9 geodetic receivers were purchased, for a total of 123 NSF-OPP Arctic Sciences receivers in the UNAVCO pool (Table 2).

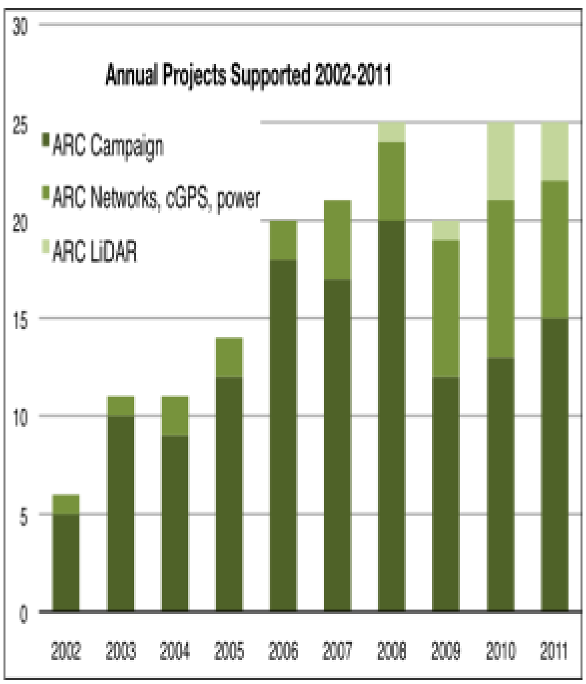
Eight of these receivers are deployed long-term at Atqasuk, Barrow, Summit Camp, and Toolik Field Station, and 38 are deployed as part of the US portions of the GNET network (Table 3). (The University of Luxemburg and the Danish Technical University (DTU) paid for the equipment at the remaining six GNET sites.) Thirty-eight 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 (Figures 3 and 4). Ancillary equipment such as data processing software, solar panels, batteries, chargers, tribrachs, tripods, and cables is also provided.

Table 2 – Arctic Equipment Pool

Item	Qty	Features and Applications	Average Age (yr)
Trimble 5700	7	Low power, high memory receiver suited for both short term and continuous data collection.	10
Trimble R7	19	Same as the 5700, but also capable of tracking the new L2C GPS signal.	8
Trimble R8	1	1 TNL HB450	5
Trimble NetRS	61	Reference station receiver with computer and web browser interface.	5
Trimble NetR8	1	Reference station receiver with computer and web browser interface.	2
Trimble NetR9	34	Reference station receiver with computer and web browser interface.	1
LiDAR scanner	1	Optech ILRIS 36D Terrestrial laser scanner	4

Table 3 – Equipment Deployed Long Term at Remote Facilities

Location	GPS receivers	Radio modems	Other equipment (value > $1000)
Atqasuk former ARM Facility	1 TNL NetRS		
Barrow Science Center	1 TNL NetRS 1 TNL R8 1 TNL R7	1 TNL HB450 2 PC RFM96-2W	2 TSC2 survey controllers
Summit Camp	1 TNL NetR8 1 TNL R7	1 TNL HB450	1 TSC2 survey controller 1 Vaisala WXT510 metpack
Toolik Field Station	1 TNL NetR8 1 TNL 5700	1 PC LPB Base 3 PC RFM96W Rovers 1 PC RFM96-35W	1 TSC2 survey controller
GNET (OSU+UNAVCO)	38 NetRS	36 Iridium	



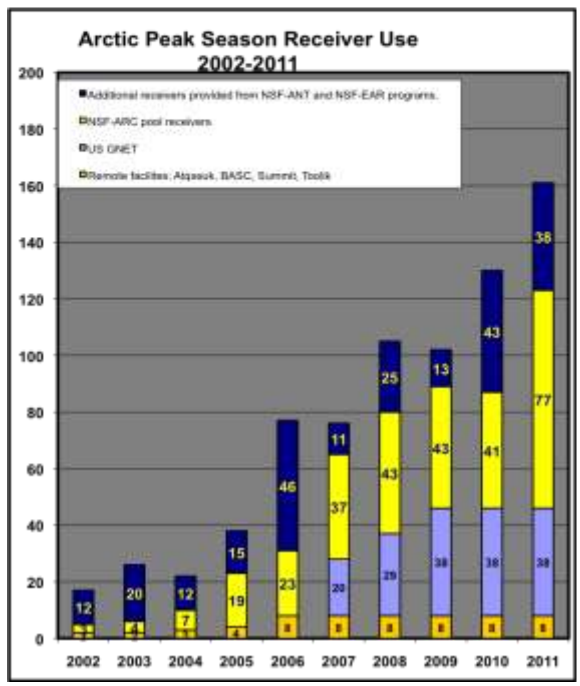


Figure 3 (left) – Arctic projects by type and program - showing recent growth in LiDAR, networks, cGPS applications, and power systems which all require substantially more effort to support than the traditional campaign projects (which have on average increased in scale).

Figure 4 (right) - Growth of Arctic GPS receiver pool in response to larger campaign projects, long-term deployments, and networks.

LiDAR

In 2011 three LiDAR projects were supported in Alaska and the Shetland Islands (Figures 4 and 5). It is worth noting that the polar LiDAR instrument is approaching obsolescence and most polar LiDAR projects are supported with newer equipment borrowed from the EAR pool.

Figure 5 (left) – Shetland Islands Quendale Valley settlement in the midst of excavation. Layers of sand can be seen in the section of earth in the middle of the photo. At this site, approximately 2 meters of sand dramatically buried the site, forcing its inhabitants to abandon their home. (G. Bigelow PI).

Figure 6 (right) – Screenshot of LiDAR image of the excavated settlements - main excavation site is located on the left. It is clear from this computer-generated perspective that the house is part of a much larger habitation defined by the greater rectangular shape that extends below the site. This feature is not obvious from the ground and is an example of how TLS data can be useful in identifying features in a landscape.

Technology Development

In 2011 the Iridium Router-based Unrestricted Digital Internetworking Connectivity (RUDICS) based communications for geodetic GNSS networks and other sensors was put into service at selected field sites. Enhanced features include the ability to host standard "network appliance" devices using the Ethernet interface and TCP/IP protocol, improved bandwidth, reduced power consumption, cold hardening, improved system control, and eliminating the need for an Iridium modem at the data retrieval hub. Other technology development initiatives include testing the "plateau" wind turbine system in a windier "margin" environment, developing smaller systems optimized for glaciology applications in high ablation areas (Figure 7), and working with the AWS team to collocate GPS and weather stations and use a single communication link for the data. Significant effort has also gone into testing and integrating the new Trimble NetR9 GPS receiver for use in winter-over systems.

Figure 7 – Installation of winter-over GPS systems on the Greenland Fractures project. The systems are designed for rapid installation in high ablation areas, and further design upgrades are in progress including a method of "floating" the solar panel assembly on the ice surface to lower the center of gravity and improving the water tightness of the enclosures.

Atqasuk GPS Base Station

The Atqasuk, Alaska GPS station is located at the former ARM Climate Research Facility (ACRF). Although this facility was decommissioned in early 2011 it is still powered, and in August 2011 CH2M Hill Polar Services and SRI International installed a new communications link. The main purpose of this base station (ATQK) is to provide a local source of geodetic quality differential corrections for GPS data post-processing of surveys in the Atqasuk area on the Alaska North Slope. The Trimble NetRS receiver is operated remotely by UNAVCO specifically for users who have requested base GPS data in Atqasuk similar to that provided in Barrow. The station runs continuously and data are available from UNAVCO. Higher sample rate data are also recorded on the receiver in hourly files, and are made available to users as needed. All data are available via the Internet, and there is no need for users to have physical access to the receiver.

Barrow Differential GPS System

2011 was a year of change, with the day-to-day support of the UNAVCO equipment in Barrow transferred from BASC to CH2M Hill and Umiaq. The details of this new relationship were initiated but not finalized.

Two Trimble real-time kinematic (RTK) differential GPS (DGPS) rover systems are available for dedicated use at the Barrow science facility to meet the surveying needs of researchers. UNAVCO provides year-round technical support to users of this system and maintains a web page with the relevant system technical information, while Umiaq and CH2M Hill handle the day-to-day operational support including equipment scheduling and issue .To ensure the continued success of the Barrow system to local science users, UNAVCO staff makes annual maintenance/training visits, often in conjunction with related project requests. Field engineers Marianne Okal and Lisa Siegel visited Barrow in conjunction with supporting a LiDAR project. System information, including access to GPS data, is available on the station web page at www.unavco.org/polar.

Summit GPS Base System

A permanent GPS base station and rover system is maintained at Summit Camp with real-time kinematic (RTK) surveying capability. The system consists of a continuously operating base receiver and a roving receiver with ancillary equipment. UNAVCO provides training to Summit science techs on demand, year-round technical support to users of this system, and a web page with the relevant system technical information. In addition to providing precision mapping and topographic surveying capability, the system also allows measurement of ice motion and provides data for atmospheric studies. Station information, including access to GPS data, is available on the station web page at www.unavco.org/polar. This year the base station receiver was upgraded to a Trimble NetR8.

Toolik Field Station Differential GPS System

A permanent GPS base station and rover system is maintained 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 extends the system radius to over 100km from the station. This year the base station receiver was upgraded to a Trimble NetR8.

GNET and GLISN

The POLENET Greenland IPY project (GNET) is an international effort led by Michael Bevis of the Ohio State University to install approximately fifty continuous GPS stations around the Greenland perimeter to apply bedrock geodesy to measure the response to past and present day ice sheet mass change (Figure 8). The US NSF funded portion of this project provides for 38 stations (including the UNAVCO led site KAGA). Most of the sites are remote and rely on solar and wind power and satellite data retrieval. Data management is provided by UNAVCO, and an Iridium based download system allows for full data retrieval from the remote stations, with on-line access at facility.unavco.org/data. Stations situated in villages are managed by GNET Danish collaborator Danish Technical University (DTU) and are currently downloaded as the opportunities arise. Figure 9 and Table 4 show the UNAVCO supported network and status at the end of December 2011.

In 2011 the maintenance effort was concentrated on the northwest and northern sites. Due to weather the field season was split into two separate deployments. UNAVCO provided the necessary equipment, shipping to Greenland (with CH2MHill Polar Services support), and field support. During the second field deployment several sites were inadvertently miswired and an additional last minute repair trip was necessary. Details of this incident, lessons learned, and future preventative measures were written up in a separate report.

Also in 2011 IRIS installed three GPS stations as part of the Greenland Icesheet Monitoring Network (GLISN). UNAVCO provided training to the IRIS/PASSCAL field team, and is downloading, archiving, and distributing the GPS data.

Figure 8 – The POLENET/GNET network. GLISN stations with UNAVCO supported GPS are also shown.

Table 4 – GNET network status as of 31 December 2011

Site ID and health	Site "owner"	Communication link	Status 31 December 2011
MIK2	OSU	Iridium	Operational
KUAQ	OSU	Iridium	Comms link intermittent
PLPK	OSU	Iridium	System down since Oct. 2011 – maintenance required.
KSNB	OSU	Iridium	Operational
HEL2	U. Lux	Iridium	Operational
KBUG	OSU	Iridium	Comms link down since Jun. 2011 – maintenance recommended.
LYNS	OSU	Iridium	Operational
TREO	OSU	Iridium	Operational
HJOR	OSU	Iridium	Operational
UTMG	OSU	Iridium	Station rebuild required.
TIMM	OSU	Iridium	Comms link down since Apr. 2011 – maintenance recommended.
NNVN	U. Lux	Iridium	Operational but a rebuild is recommended.
SENU	OSU	Iridium	Operational
KAGA	UNAVCO	Iridium	Operational
QAAR	OSU	None	Data download by DTU
RINK	U. Lux	Iridium	Operational
UPVK	DTU	None	Data download by DTU
SRMP	U. Lux	Iridium	Operational
KULL	OSU	None	Data download by DTU
ASKY	OSU	Iridium	Comms link down since Nov. 2011.
DKSG	OSU	Iridium	Operational
MARG	OSU	Iridium	Operational
KAGZ	OSU	Iridium	Operational but a power system upgrade recommended.
SCBY	OSU	Iridium	Operational
KMOR	OSU	Iridium	Operational
HRDG	OSU	Iridium	Operational
JWLF	OSU	Iridium	Operational
KMJP	OSU	Iridium	Operational
JGBL	OSU	Iridium	Operational
LEFN	OSU	Iridium	Operational

BLAS	OSU	Iridium	Operational
NRSK	OSU	Iridium	Comms link down since Dec. 2011,
GROK	OSU	Iridium	Operational
GMMA	OSU	Iridium	Operational
YMER	OSU	Iridium	Operational
DMHN	DTU	None	Operational
LBIB	OSU	Iridium	Operational
DANE	OSU	Iridium	Operational
WTHG	OSU	Iridium	Comms link down since Nov. 2011.
HMBG	OSU	Iridium	Operational
MSVG	OSU	Iridium	Comms link down since Nov. 2011.
DGJG	OSU	Iridium	Operational
VFDG	OSU	Iridium	Operational
Green	Station is operational with real-time data retrieval.		
Yellow	Station is most likely collecting data, but without communications we cannot be certain.		
Red	A site visit is required to resume data collection.		

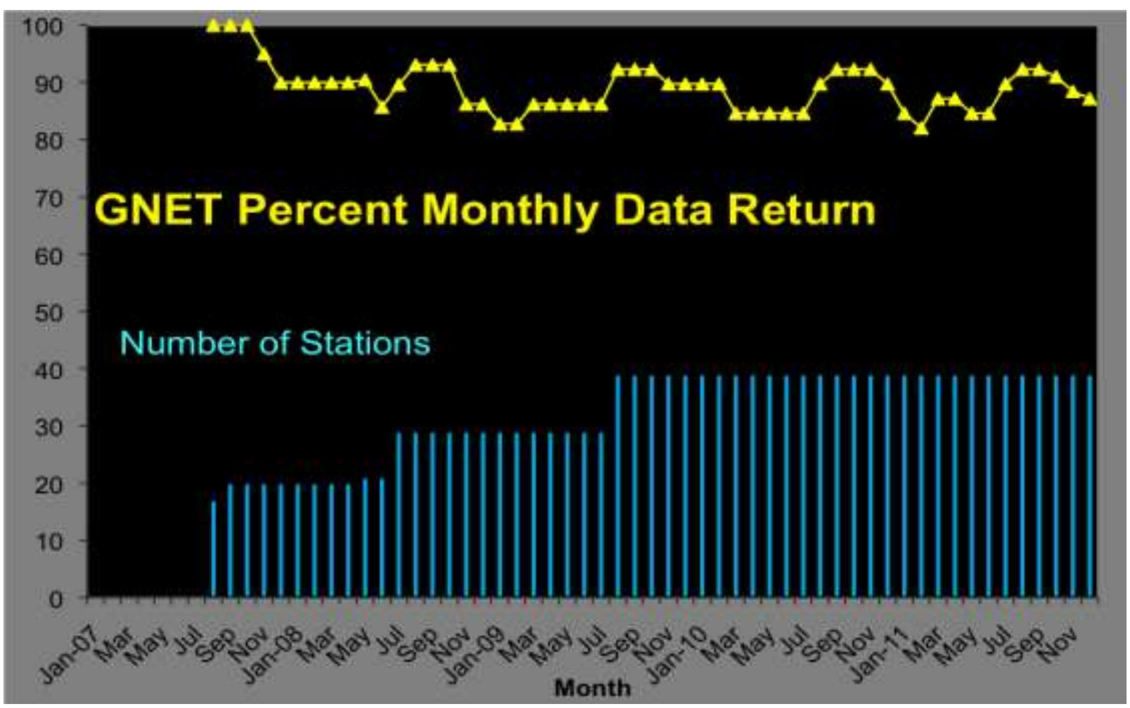


Figure 9 - GNET remote stations have achieved consistent 80-90% data return through 2011.