POLENET
THE POLAR EARTH OBSERVING NETWORK
INVESTIGATING THE POLAR REGIONS
FROM THE INSIDE OUT
www.polenet.org
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POLENET (The Polar Earth Observing Network) is a global network dedicated to observing the polar regions in a changing world.

The project is focused on collecting GPS and seismic data from autonomous systems deployed at remote sites spanning much of the Antarctic and Greenland ice sheets. GPS and seismic measurements together provide a means to answer critical questions about ice sheet behavior in a warming world. Combining POLENET measurements of gravity, sea level, and the atmosphere will link ice sheet change to the global earth system. Scientists define Earth’s global ice volume as a “mass budget” with ice shrinking and growing in different places around the world. Coordinating satellite measurements with ground-based POLENET measurements will evaluate the ice sheet “budgets” of both polar regions, providing a deeper understanding of how polar ice sheets contribute to changing sea levels around the world.

The unprecedented scale of the POLENET sensor network will allow investigation of systems-scale interactions of the solid earth, the cryosphere, the oceans and the atmosphere. POLENET data will enable new studies of the inner earth, tectonic plates, the earth’s magnetic field, climate and weather, and the solar wind, and will lead to as yet unimagined discoveries about the critical polar regions of our planet.
Quick Facts

Number of sites:
In all, there will be over 100 stations, some permanent, some temporary. 17 sites of the A-NET project have both seismic and GPS equipment and make up what is called the "backbone network" that may remain in place as part of a long-term measurement network.

Who can use the data:
All data are being made publically available. Researchers from around the world can access these data for a variety of applications, including atmospheric, meteorological, geological, glaciological, and climate studies.

Project Funding:
POLENET science projects are funded by national funding agencies and polar research institutes. Several major POLENET projects, including A-NET, G-NET, GAMSEIS and LARISSA, are funded by the National Science Foundation (NSF), with contributions from partnering nations. In 2006 the National Science Foundation awarded Major Research Infrastructure (MRI) funding to UNAVCO and IRIS/PASSCAL to design and build power and communication systems for autonomous polar station operation. Logistical support is provided by the U.S. Antarctic Program, the Arctic Research Support and Logistics Program, and corresponding polar logistics programs in POLENET partner nations.

Interesting bits and pieces:
- First quasi-continuous, autonomous GPS stations at remote sites in Antarctica were deployed in the late 1990’s.
- Air support in Antarctica includes LC-130, Twin Otter and Basler Turbo 6 fixed-wing aircraft, and A-Star and Bell 212 helicopters.
- Communications equipment consists of HF and VHF radios, Iridium satellite phones, GOES satellite system for internet.
- A single installation of a GPS and seismic site includes over 3,000 pounds of equipment and takes, on average, about four hours to install, depending on weather conditions and proximity of the aircraft to the installation site.

Timespan of project:
Deployment of autonomous stations at remote polar sites commenced over a decade ago, but major networks of remote stations were first deployed beginning with the International Polar Year 2007-08. Some stations are designed to make measurements for a 2-3-year time span, whereas a ‘backbone array’ of remote stations will remain in place until 2013 and possibly longer term.
Planning for an array of remote instrument installations to study the polar Earth system began over a decade ago under the auspices of SCAR (the Scientific Committee on Antarctic Research).

Implementation plans and assembly of the consortium of nations crystallized during planning for the International Polar Year (IPY) 2007-08. The program is built on the success of predecessor projects like JPL-MBL and TAM, ANUBIS, TAMDEF, WAGN, and TAMSEIS. Experience from these projects, combined with technological advances, is allowing POLENET to greatly expand the scale of deployments and to ensure the legacy of these groundbreaking projects.

POLENET is a core project for the fourth International Polar Year (IPY). The IPY, organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO), is actually the fourth polar year, following those in 1882-83, 1932-33, and 1957-58. The IPY involves over 200 projects, with thousands of scientists from over 60 nations examining a wide range of physical, biological and social research topics. During the IPY, POLENET launched sites spanning the polar regions, dramatically increasing the scale of polar GPS and seismic observations to unprecedented levels.
POLENET is a consortium of 28 nations involving geoscientists, engineers, students and mountaineers, as well as the support personnel of national polar programs. The project is led by Dr. Terry Wilson and based out of The Ohio State University in the United States.

During austral summers (September-March), the POLENET research teams conduct field work in Antarctica. During boreal summers (April-August) the teams focus their field work in the Arctic regions.

The world's ice sheets are located in some of Earth's harshest and most isolated environments. Conducting field work in such remote places presents many challenges. The Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) and UNAVCO provide specialized cold-hardened equipment, field support, and training for field teams. POLENET equipment can withstand average wind speeds of 50 miles per hour and temperatures that can plunge to below -60° F (-51° C). Due to these extreme conditions, regular maintenance is required to ensure all gear functions properly.
Expected Outcomes

• Measurements of vertical and horizontal solid-earth deformation at mm/yr accuracy, providing first comprehensive view of bedrock motions across polar regions.

• Prediction of mass fluxes of polar ice sheets, improved models of glacial isostatic adjustment, and better modeling and prediction of sea-level change.

• First tests of glacial isostatic adjustment models for the Antarctic interior.

• Integration of geodetic observations with complementary seismic imaging studies.

• First higher-resolution continental-scale seismic images of the structure and characteristics of the deep earth beneath polar regions.

• Understanding crustal and mantle dynamics that cause earthquakes and volcanoes, including the nature of links with ice-mass change.

• Improved understanding of the Earth’s inner core.

• Improved understanding of secular variation of Earth’s magnetic field, and core structure and dynamics, including quantification of rapid field decrease that may signal a reversal of the Earth’s field.

• Establish a framework for ongoing international geophysical observation networks.

Antarctica, near Mount Coates
GPS

(Geographic Positioning Systems)
GPS sites are installed on hard rock. Because most of the polar regions are covered with a thick, icy blanket, these stations tend to be established on nunataks. Nunataks are isolated peaks of rock projecting above a surface of ice or snow. The GPS sites register incoming microwave signals from satellites. Over time, whether it is a result of plate tectonics or glacial isostatic adjustment (crustal movement caused by the melting of and consequential release from the weight of the polar ice), the GPS data measures the slightest movement of the surface from its original location.

Seismology
Using the speed of waves that emanate from earthquakes, seismology maps the thickness and mechanical strength of layers in the earth’s interior. For example, seismology can map regions of slow wave speeds, which are indicative of warm Earth layers below the surface. Such layers are weaker and may rise quickly when the ice sheets shrink. They also pass extra heat upward to the base of the ice sheets, causing the ice to become slippery and more likely to slide rapidly into the ocean.
Battery banks powered by solar panels and wind turbines. Iridium satellite antenna to transmit GPS data.

Early remote instrument deployments in the polar regions were limited by the necessity for a power grid source. Using technology for self-powered instruments is dramatically expanding the scale of territory that can be measured. For example, current A-NET deployments for the 2009-2010 season span a region that is roughly equivalent to the area of the United States east of the Mississippi River.

Autonomous stations now rely on renewable energy sources to keep them operational. Solar panels are effective in the summer months when sunlight is abundant. In the winter months, however, when the poles are covered in constant darkness, wind power becomes important and the solar energy previously stored in battery banks is used to power the stations. Communication satellites are used to transmit GPS data from the remote sites to the scientists. The voluminous seismic data, however, must still be collected by returning to the stations.
Aristotle was one of the first to attempt an explanation of earthquakes based on natural phenomena. He postulated that winds within the earth caused the occasional shaking of the earth's surface.

Empirical observations of the effects of earthquakes were rare until 1750, when England was uncharacteristically rocked by a series of five strong earthquakes. These earthquakes were followed on Sunday, November 1, 1755, by a cataclysmic shock and tsunami that killed an estimated 70,000 people, leveling the city of Lisbon, Portugal, while many of its residents were in church. This event marks the beginning of the modern era of seismology, prompting numerous studies into the effects, locations, and timing of earthquakes.

As access to and communication between various parts of the world became more common, earthquake observations from around the world could be combined.

Around 132 AD, Chinese scientist Chang Heng invented the first seismoscope, an instrument that could register the occurrence of an earthquake. Heng's invention was called the dragon jar. When an earthquake occurred, a ball dropped from a dragon's mouth and was caught by the frog's mouth.

To learn more about the history of seismology and GPS technology, visit polenet.org.
The polar regions offer a unique perspective on interactions between the solid earth, cryosphere, hydrosphere, and atmosphere. The polar regions are directly linked to the global climate system and dynamically reflect changes happening around the world.

It wasn't until relatively recently that Global Positioning System (GPS) technology available to science became capable of measuring the tiny, millimeter-scale displacements that characterize solid-earth motions and sophisticated enough to enable long-term observations in harsh, polar environments.

GPS technology was made possible by a combination of scientific and engineering advances, particularly the development of the world's most accurate timepieces: atomic clocks that are precise to within a billionth of a second. What began as a classified military operation has since expanded into a global tool that provides uniquely detailed and accurate measurements of our planet.

**Major Advancements:**

**1957:** The Soviet Union launches a satellite (Sputnik) into space. MIT researchers notice that radio signals from this satellite, or "artificial star" could determine distinct positions on the ground.

**1978:** The U.S. Department of Defense launches NAVSTAR (Navigation System with Timing and Ranging), strictly for military use.

**1983:** GPS ceases being restricted to military purposes and is made available for public use.

President Ronald Reagan declassifies the system in response to a Soviet interceptor aircraft shooting down civilian airliner KAL 007 that strayed into prohibited airspace due to navigational errors, killing all 269 people on board.

**1990:** The Gulf War temporarily deactivates public use of GPS because the military is in need of more receivers. Public access returns in 1993 with the decision that it will be available free of charge to the entire world.

**1995:** Full Operational Capacity was declared by NAVSTAR with the placement and activation of the last of the 24 satellites. (This number had increased from the original 11 that were planned). The satellites orbit 12,000 miles high, weighing 2,000 pounds each, and circle the globe every 12 hours.
Led by Ohio State University, A-NET is a GPS/Seismic network spanning West Antarctica. A-NET is unique in that its backbone network consists of both GPS and seismic instrumentation, allowing for a more complete understanding of the interactions between the ice sheets and the underlying bedrock. A-NET is using improved technologies to record measurements year-round and to transmit data from remote sites to archives in the USA.

Ohio State University (lead)
Jet Propulsion Lab / Cal Tech
New Mexico Tech
Penn State University
Central Washington University
Univ. of Memphis
Univ. of Texas – Inst. For Geophysics
Washington University
U.S. Geological Survey
With facility support from:
PASSCAL
UNAVCO
A-NET Partner Project: GIACAP
GIA Constraints for the Antarctic Peninsula
Eight new GPS receivers will be installed on bedrock in the southern Antarctic Peninsula for improvements in GIA model accuracy and GRACE-based ice mass change estimates. These sites will act as a regional densification of the A-NET project, a major part of the IPY POLENET project.

Newcastle Upon Tyne, United Kingdom

A-NET Partner Project: VLNDEF
Victoria Land Network for DEFormation Control
VLNDEF consists of 28 GPS sites on bedrock in northern Victoria Land, led by Dr. Alessandro Capra of University of Modena and Reggio Emilia, Italy and supported by Progetto Nazionale di Ricerca in Antartide (PNRA). VLNDEF includes the continuously-operating GPS station at Mario Zucchelli Station and 4 remote GPS stations operating quasi-continuously.

A-NET Partner Project: LARISSA
LARsen Ice Shelf, Antarctica
LARISSA is a multi-disciplinary NSF-funded study of the LARsen Ice Shelf System, Antarctica, led by Dr. Eugene Domack, Hamilton College, USA. In 2008-9 and 2010-11, 6 new continuous GPS systems will be installed on bedrock by UNAVCO to measure GIA in the region of the former Larsen B embayment as part of LARISSA and the A-NET project of POLENET.

Hamilton College
Belgium-Ghent University
Argentina-Argentine Antarctic Institute
Ukraine-National Antarctic Scientific Center in Kiev
Korean Polar Research Institute
G-NET  Greenland Network

Led by Ohio State University’s division of Geodetic Science, G-NET is a network of 46 continuous GPS stations spread across Greenland. This network will map the steady vertical velocity field associated with postglacial rebound and improve our understanding of ice mass changes in Greenland, allowing scientists to quickly detect and analyze any abrupt changes in the rate of ice loss in this region.

Ohio State University
University of Luxembourg
UNAVCO Inc
Danmarks Rumcenter
Gamburtsev Antarctic Mountains Seismic Experiment

Led by Pennsylvania State University and Washington University at St. Louis, GAMSEIS is deploying broadband seismometers to image the structure of the Gamburtsev Subglacial Mountains. These images will provide insight into what is driving these mountains upward and how this motion has shaped the formation of the East Antarctic Ice Sheet.

Washington University
Penn State University
Japanese National Institute of Polar Research (NIPR)
Institut de Physique du Globe de Strasbourg, France
Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy
Chinese Academy of Geological Sciences, Beijing, China
University of Tasmania, Australia
LAP-NET Lapland Network

Led by the University of Oulu in Finland, LAPNET is installing over 50 seismic stations, some temporary and some permanent, across the Arctic regions of Finland, Sweden, Norway, and Russia. The project collects waveforms of seismic phases travelling through Earth and records instances of glacial earthquakes. The waveform data will be compiled into a database that will be available to the global geophysical community.

Sodankylä Geophysical Observatory at the University of Oulu, Finland
Institute of Seismology, Helsinki, Finland
Swedish National Seismological Network, Uppsala University, Sweden
Institute of Geospheres Dynamics, RAS, Moscow, Russia
Geophysical Institute of Academy of Sciences, Prague, Czech Republic
University of Grenoble, France
University of Strasbourg, France

Institute of Geodesy and Geophysics, Vienna
University of Technology, Austria
Institute of Geophysics ETH Zurich, Switzerland
GeoForschungsZentrum Potsdam, Germany
NORSAR, Norway
University of Leeds, United Kingdom
Long-Term Network and Local Dense Arrays

Seismic and geodetic measurements are being made at permanent research stations maintained by Antarctic Treaty nations, and by Arctic nations. Such sites provide invaluable long-term data sets that are integral to POLENET science objectives. In addition, many nations are deploying local arrays of instruments in relative proximity to research stations that densify measurements in many sectors of the continental-scale POLENET networks.

Ice Runway
McMurdo Station
Antarctica
A NET
GPS and Seismic Sites and Logistics Pertaining to 2009-2010 Field Season

A sense of scale: West Antarctica is roughly the size of the United States east of the Mississippi River.
Maintenance
Due to extreme winds and cold temperatures, stations require varying levels of maintenance to ensure continual collection of data.

Fuel Cache
Fuel caches are located at strategic points around the continent. Routes are carefully planned around these locations to ensure equipment and field parties can reach the distant installation sites and have enough fuel to return safely to base camp.

Patriot Hills
Patriot Hills is the only private seasonally occupied camp in Antarctica. It is located in the Heritage Range, Ellsworth Mountains, next to a group of hills that gives it its name. Operated by Antarctic Logistics & Expeditions LLC (ALE), the only organization providing expedition support and tours to the interior of Antarctica. The camp is situated near a blue ice runway that allows wheeled jet cargo aircraft to land. ALE is contracted by NSF to provide a support base for A-NET work in the region.

Fossil Bluff (BAS)
Used intermittently from 1961 to present. Closed for the 1976 winter when Rothera became fully operational. Occupied intermittently for summer seasons since then.

WAIS Divide
The West Antarctic Ice Sheet (WAIS) Divide is a deep ice core drilling project run by the United States Antarctic Program and funded by the National Science Foundation. A-NET currently has a seismic site installed at WAIS Divide and will land here for refueling missions during the field season.

Rothera Research Station (BAS)
Rothera is a principal BAS (British Antarctic Survey) logistics centre for support of Antarctic field science. There is a 900m long crushed rock runway allowing an air link with South America and the Falkland Islands, the Biscoe Wharf provides safe mooring for ships.
**Siple Dome Camp**
Two people are stationed at Siple, which is normally used only as a refueling station for LC-130, Basler, and Twin Otter flights across West Antarctica. In current plans, the A-NET team will have a small base camp at Siple to deploy West Antarctic stations while the Byrd Camp is being built.

**McMurdo Station**
McMurdo Station is an American Antarctic research center located on the southern tip of Ross Island on the shore of McMurdo Sound in Antarctica. It is operated by the United States Antarctic Program, managed by the Office of Polar Programs of NSF. The station is the largest community in Antarctica, capable of supporting roughly 1,200 residents, and serves as the United State's main science facility, and the logistics base for half the continent. All personnel and cargo from the A-NET project first pass through McMurdo.

**Byrd Camp**
Commissioned on January 1, 1957, the original station lasted about four years before it began to collapse under the snow. Construction of a second underground station began in 1960, and it was used until 1972. The station was then converted into a summer-only field camp until it was abandoned in 2004-05. The National Science Foundation has constructed a new camp in 2009 to support a number of scientific projects in West Antarctica, including A-NET. The camp, located about 1,400 kilometers from the United States Antarctic Program's main facility, McMurdo Station, will support up to 50 people.
Education and Outreach

Everyone has an opportunity to directly engage with the POLENET team during their 2009-2010 season by going to http://polenet.org, where you can find a collection of podcasts delivered from the ice, as well as photos, interactive maps, and a chance to ask a scientist any questions you have.

The podcast series covers a wide variety of POLENET operations—from getting to Antarctica to setting up a GPS frame in extreme conditions, to how you brush your teeth in a remote West Antarctic camp!

If you are a K-12 or undergraduate educator, these short, engaging podcasts can bring a meaningful connection to real science currently shaping our understanding of Earth systems. Go to http://polenet.org to find short, informational, and engaging podcasts and opportunities for your students to interact with POLENET researchers.

POLENET can be an exciting addition to your classroom if you are teaching any of the following curricula:

- Observation And Measurements
- Models Of The Earth
- Earthquakes, Volcanoes, and Plate Tectonics
- Shaping The Earth’s Surface
- Earth History
- Weather And Climate
- Energy and the Environment

For more info, contact: Megan Berg • Berg.132@osu.edu • Ohio State University • (614) 688-4691
Attention Media and Press Officers, Artists and Writers:
If you are interested in reporting on POLENET, there are opportunities for media organizations, news agencies, writers, and artists to travel to Antarctica. You can learn more at http://www/nsf.gov/

The POLENET project is open to working with a wide range of media reporters and developers and is committed to ensuring that accurate, captivating information is accessible.

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