UNAVCO's Network of the Americas (MOTA)

Background, Current Status, and Science Applications





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1. UNAVCO history, the GAGE Instrumentation Program

2. PBO, TLALCONet, COCONet -> Network of the Americas (NOTA)

3. Components of a typical NOTA station

4. UNAVCO data products and science applications









UNAVCO Background

- UNAVCO: a non-profit university-governed consortium, started in 1984
- Mission: Facilitate geoscience research and education using geodesy
- Comprised of 128 U.S. Academic Members
- 134 Associate Members in the U.S. and abroad in over 120 countries
- Membership has increased over 9% since 2016

INFRASTRUCTURE



DATA CENTER





EDUCATION AND COMMUNITY ENGAGEMENT





Continuously Observing Networks Network Of The Americas (GNSS and borehole operations) POLENET: GNET (Danish Contract) & ANET NASA Global GNSS Network (GGN) Principal Investigator Support NSF EAR & OPP funded PI and community projects RAPID Instrument Response Campaign and long-term GNSS deployments Geodetic Instrumentation Testing & Support

GAGE Geodetic Infrastructure Program







the project

SAFAR edapiling Component



 Funded by NSF
Funded by NSF
Popsci and the structure and evolution of the North American continent and the popsci and the processes that cause earthquakes and volcanic eruptions
Project started in 2003 - continues through 2018 Three Components - Geodetic, Seismic, and Drilling • Deploys thousands of seismic, GPS, and other geophysical instruments • France To structure and evolution of the North American • **Project time the 2003 2018** he cause earthquakes and vo • Three components: geodetic, seismic, and drilling A collaboration between scientists educators, policy make
Total budget: \$500 M over the life of the project
public to learn about and utilize exciting scientific discoveri
Deploy thousands of GPS, seismic, and other

being made. geophysical instruments Fotal EarthScope Budget: ~\$500M over the I













reveal the grinding and strain on the rocks that occur when the two sides of the fault slide past each other during an earthquake. And ver the course of 10 years, small crews have hauled a moveable array of 400 seismographs across the country using backhoes and sweat. By the time the stations reach the East Coast next year, the will have collected data from almost 2,000 locations.

What's In It For You

Collectively, EarthScope's measurements could help explain the forces behind geological events such as earthquakes and volcani ruptions, leading to better detection. So far, data from the project has shown that rocks in the San Andreas Fault are weaker tha those outside it and that the plume of magma under Yellowstone's supervolcano is even bigger than previously suspected.

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EarthScope Plate Boundary Observatory (PBO)

\$200 M invested by NSF over 15 years: • Construction phase (2003-2008) – \$100 M • O+M phase 1 (2008-2013) - \$54 M

- O+M phase 2 (2013-2018) \$46 M

Tectonically strategic deployment of: • 1131 cGPS

- 78 borehole strainmeters
- 5 long baseline strainmeters
- 26 tiltmeters
- 145 meteorological instruments





- Combined cGPS-Met networks in Mexico and 25°the Caribbean Basin for the study of climate, atmospheric processes, the earthquake cycle, and tectonic processes
- COCONet 2010-2018 ~\$6M
- 42 participating partners
 - stations
- TLALOCNet 2015-2018 ~\$2M
- Build 6 new stations, upgrade 18 existing stations

TLALOCNet (Tnet) and COCONet

• Build 50 new stations, upgrade 50 existing









Network of the Americas

Federation of NSF-funded cGNSS networks across the Americas



- Federated in 2018
- Funding \$71.4 M until 2023
- across 31 countries
- are RT capable
- 87% uptime

• **PBO + TLALOCNet+COCONet = NOTA**

• Currently 1148 cGNSS stations distributed

• 789 stations are fully GNSS capable and 985



Deep Drilled Braced Monument

(DDBM)

NOTA GNSS Station, Monuments



GNSS Antenna cross section

Rooftop Monument

NOTA GNSS Station, Power

Meteorological Device

Broadband Global Area Network (BGAN)

NOTA GNSS Station, communications

Very Small (VSAT)

NOTA GNSS Data Products

PRODUCT

Standard rate (15 sec)

High rate (1, 2, 5 Hz)

Real time stream (1 Hz)

Survey-mode (campaign)

Standard rate (15 sec)

High rate data (1, 2, 5 Hz)

Survey-mode (campaign)

Position solution time series

Velocity solutions

Position offsets (e.g. coseismic)

Tropospheric parameter estimates

Position solution QA parameters

Position solutions (loose)

Position solutions (constrained)

FORMAT	FREQUENCY	
Raw, BINEX	Hourly, daily	
Raw, BINEX	Hourly, daily	
RTCM, BINEX	Real time	
Raw, RINEX	Daily, varies	

RINEX	Daily, varies	
RINEX	Hourly, varies	
RINEX	Daily, varies	

ASCII, CSV	Daily	MIT
ASCII, CSV	Monthly	MIT
ASCII	Varies	MIT
ASCII	Daily	CWU
ASCII	Daily, varies	UNR
SINEX	Daily	CWU
SINEX	Daily	MIT

Position Time Series: Earthquakes

MIDA (MIDA_SCGN_CN1993) NAM08

Processed Daily Position Time Series

Position Time Series: Hydrogeodesy

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Tectonic Motion of the Western U.S.

NOTA Velocity Field – Regional Tectonics

Tectonic Motion of the Caribbean

985 STATIONS, 1-SPS STREAMS:

- Academia, USGS
- entities
- (NMEA string)

STREAMS ACCESSED BY ALL SECTORS **OF SOCIETY:**

- Government agencies: USGS, NOAA, state level transportation departments
- Commercial entities: Surveyors, Construction
- Academia: Universities, Schools, **Research Groups**
- ~4,000 active connections at any given time

NOTA Real Time Streams

• **BINEX:** Primarily used by

• **RTCM:** Used by commercial

• **PPP:** Precise Point Positioning

Shake Alert: An Earthquake Early Warning System for the West Coast of the **United States**

30 Year M≥6.7 Probabilit

ShakeAlert[®] delivery partners are connected to the processing center

> Sensors positioned about 6-12 miles apart

Adapted from Erin Burkett (USGS) and Jeff Goertzen (Orange County Register). Updated by ShakeAlert® team (2020).

https://www.shakealert.org (9/12/22)

ata LDEO-Columbia, NSF, NOAA © 2020 Google Image Landsat / Copernicus SIO NOAA II S Navy NGA GERC

M 7.1, 17 Km NNE of Ridgecrest, CA, 2019-07-06

GNSS For Earthquake Early Warning

Seconds After Origin Time

Snow Depth

GPS provides remote snow depth measurements in hard-to-reach areas.

Ice Height

Changing ice heights indicate how much freshwater is stored by or being lost from glaciers.

Sea Level

As a tide gauge, GPS can measure local, regional, and global changes in sea level.

Vegetation

GPS can measure the onset of plant growth, plant aging, maximum vegetation growth, and the length of the growing season.

Soil Moisture

Soil moisture measured over broad regions indicates how much precipitation evaporated back into the atmosphere.

Many Other Science Applications

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lonosphere

The GPS satellite signal is delayed by charged particles caused by solar storms. This layer can also be displaced by tsunamis, yielding information for tsunami early warning.

Troposphere

The GPS satellite signal is delayed by water vapor that can turn into rain. This informs forecasting of flash floods and hurricanes.

Mission Cal/Val

Measuring the delay in the GPS satellite signal as it passes through the atmosphere is important for calibrating and validating satellite datasets.

