

A scenic landscape photograph of a boardwalk or pier extending over a body of water. Several people are silhouetted against the bright sky, walking along the boardwalk. The water reflects the light, creating a shimmering effect. In the background, there are dark, silhouetted hills or mountains under a cloudy sky. The overall mood is serene and atmospheric.

# Getting to know EarthScope Plate Boundary Observatory & UNAVCO

Shelley Olds, UNAVCO

**UNAVCO**

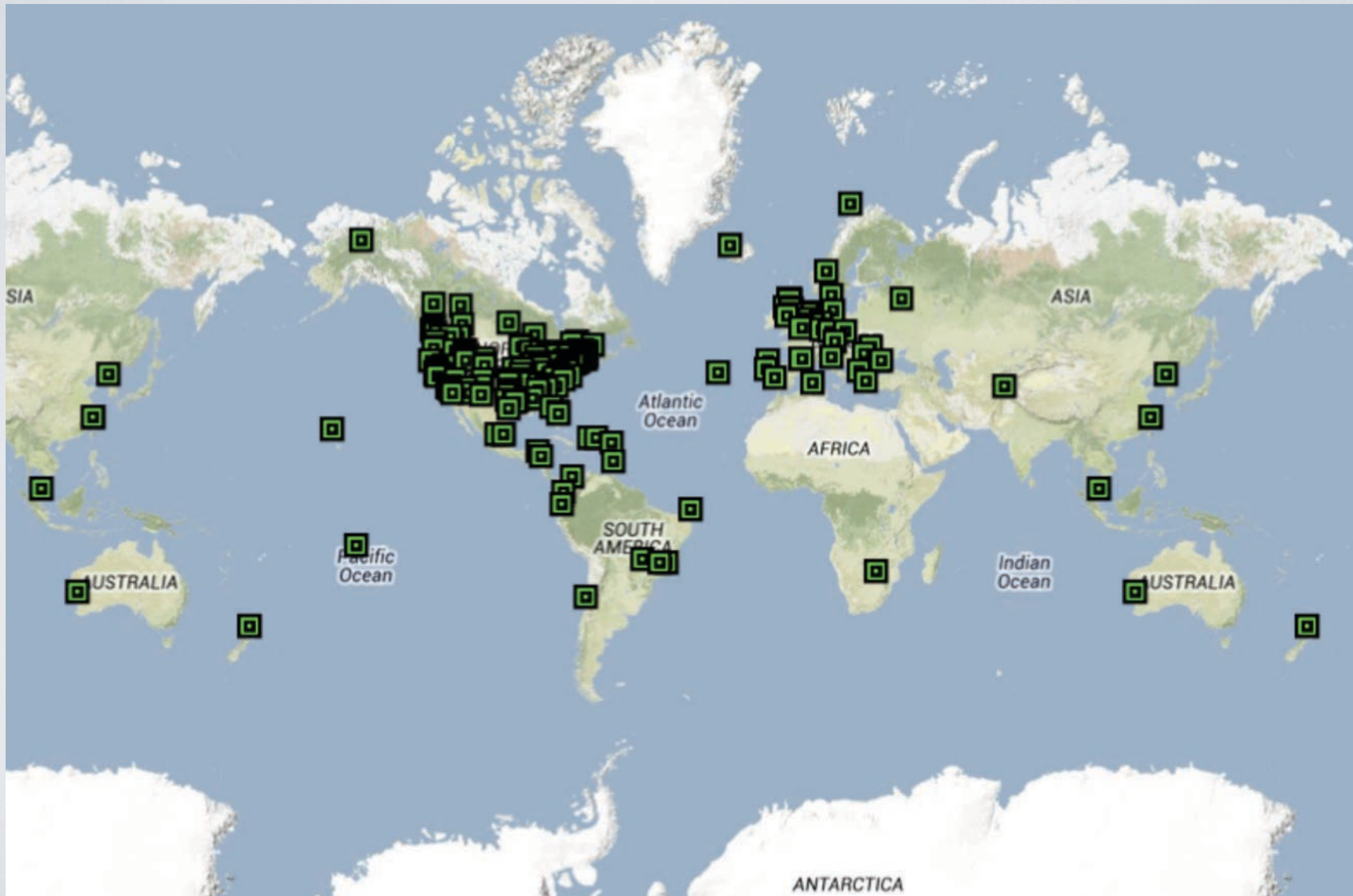
- NSF and NASA funded
- Non-profit
- Consortium
- Membership-governed
- **Facilitates geoscience research and education using geodesy**
- Operates the Nation's geodesy facility, including the Plate boundary Observatory on behalf of NSF



Broaden the use of UNAVCO data and products by a wide audience of educational and research users



# UNAVCO Consortium Members



# Meet the Plate Boundary Observatory

Geodesy Advancing  
Geosciences &  
EarthScope (GAGE)

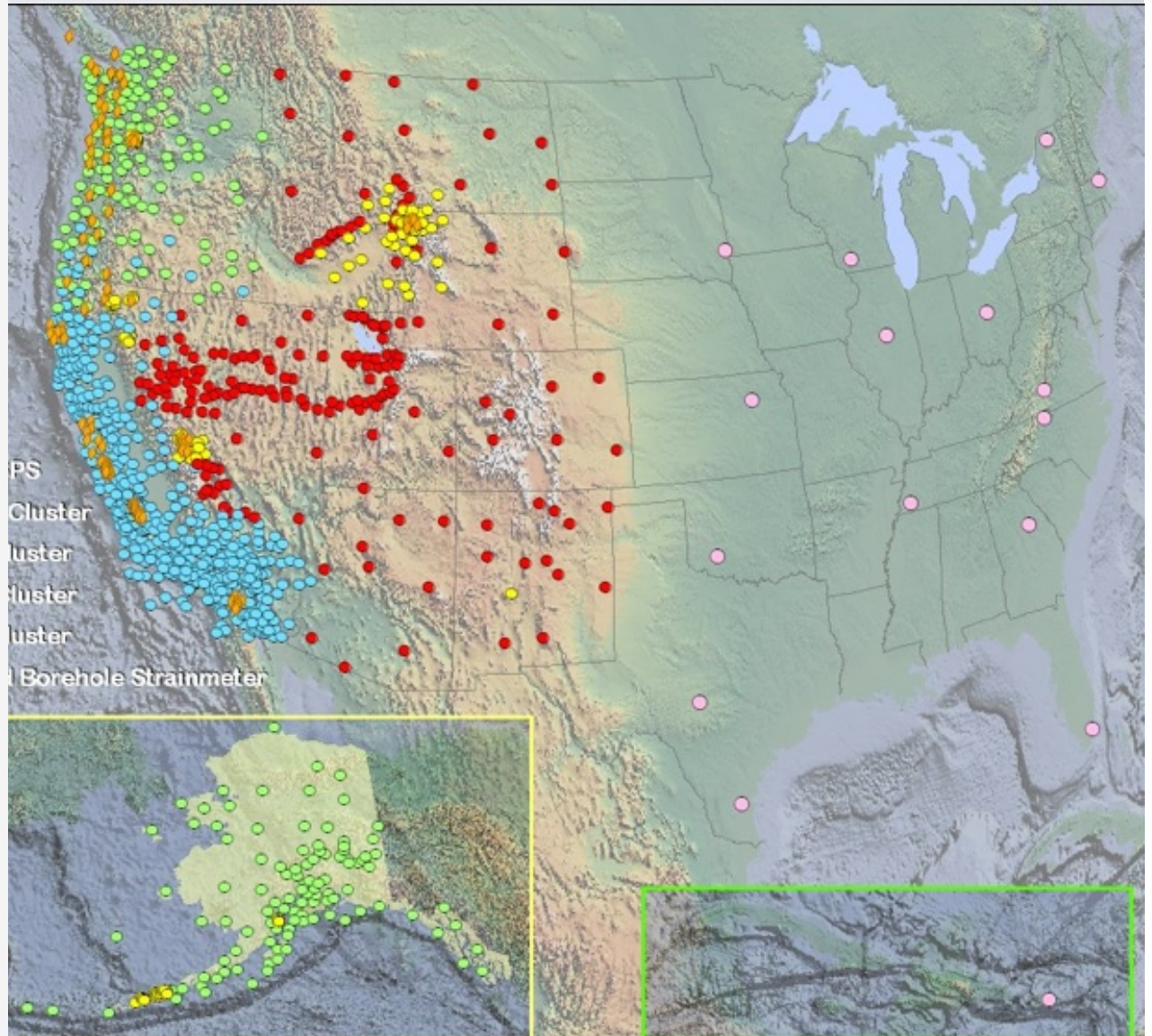
Continent-scale  
network

- GPS
- Borehole strainmeters
- Laser strainmeters
- LiDAR

Focus:

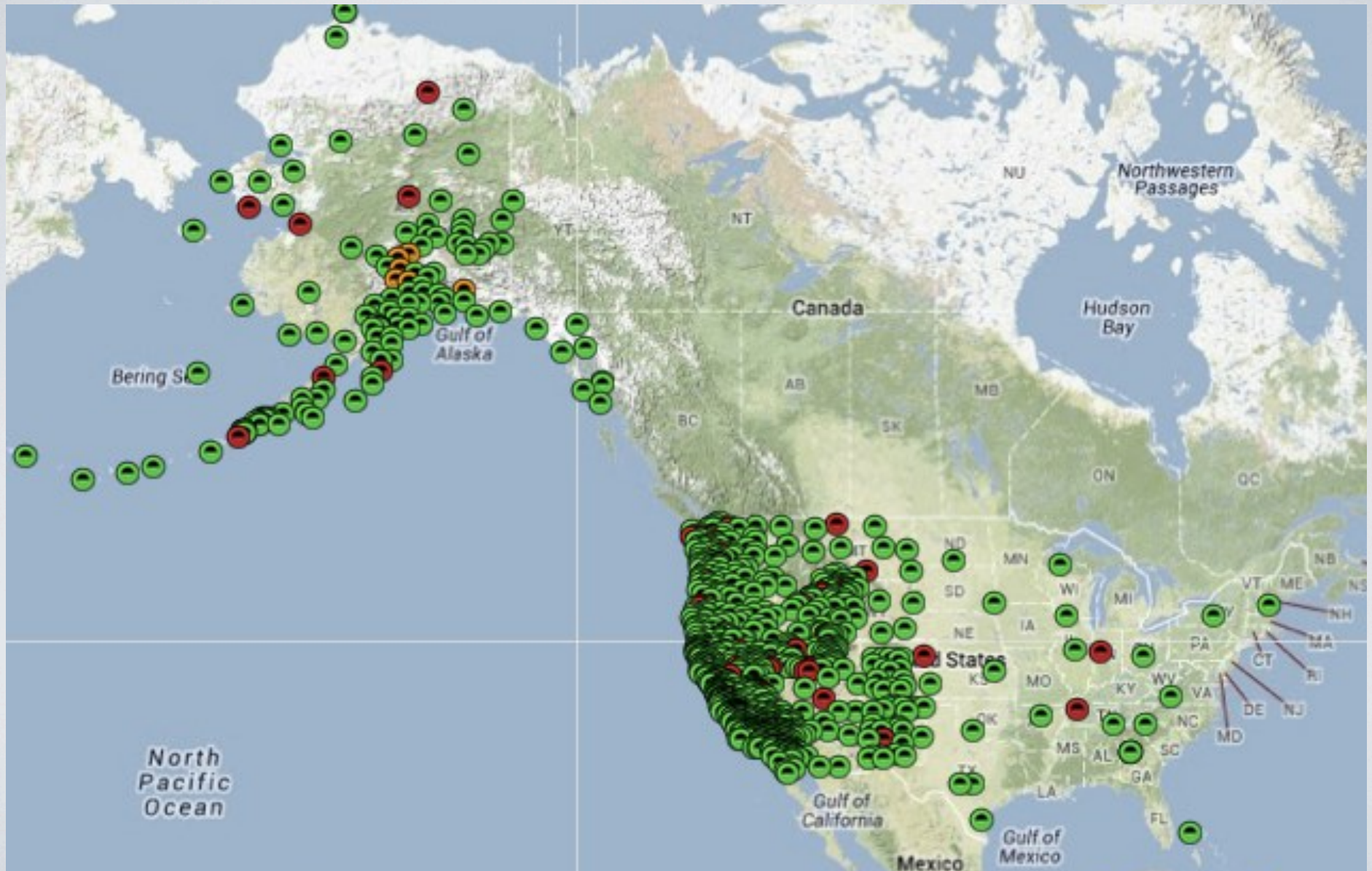
- Extended plate boundary

Operated by UNAVCO





# EarthScope PBO GPS Network





# Plate Boundary Observatory Instruments

GPS: 1100 Continuous



5 Laser Strainmeters



74 Borehole Strainmeters  
and 78 Borehole Seismometers



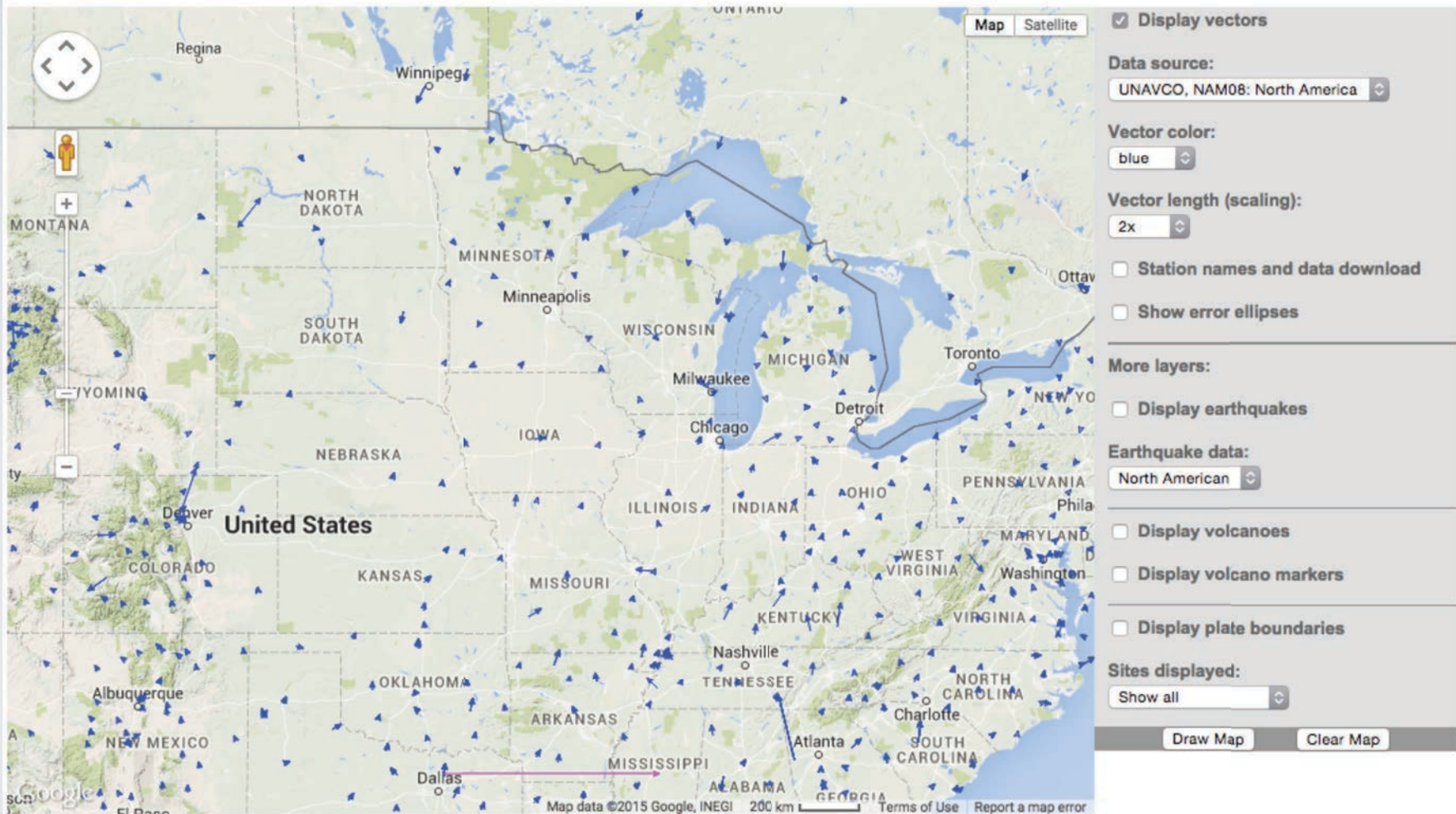
26 Shallow Borehole  
Tiltmeters





# Plate motions from GPS using a stable North America reference frame

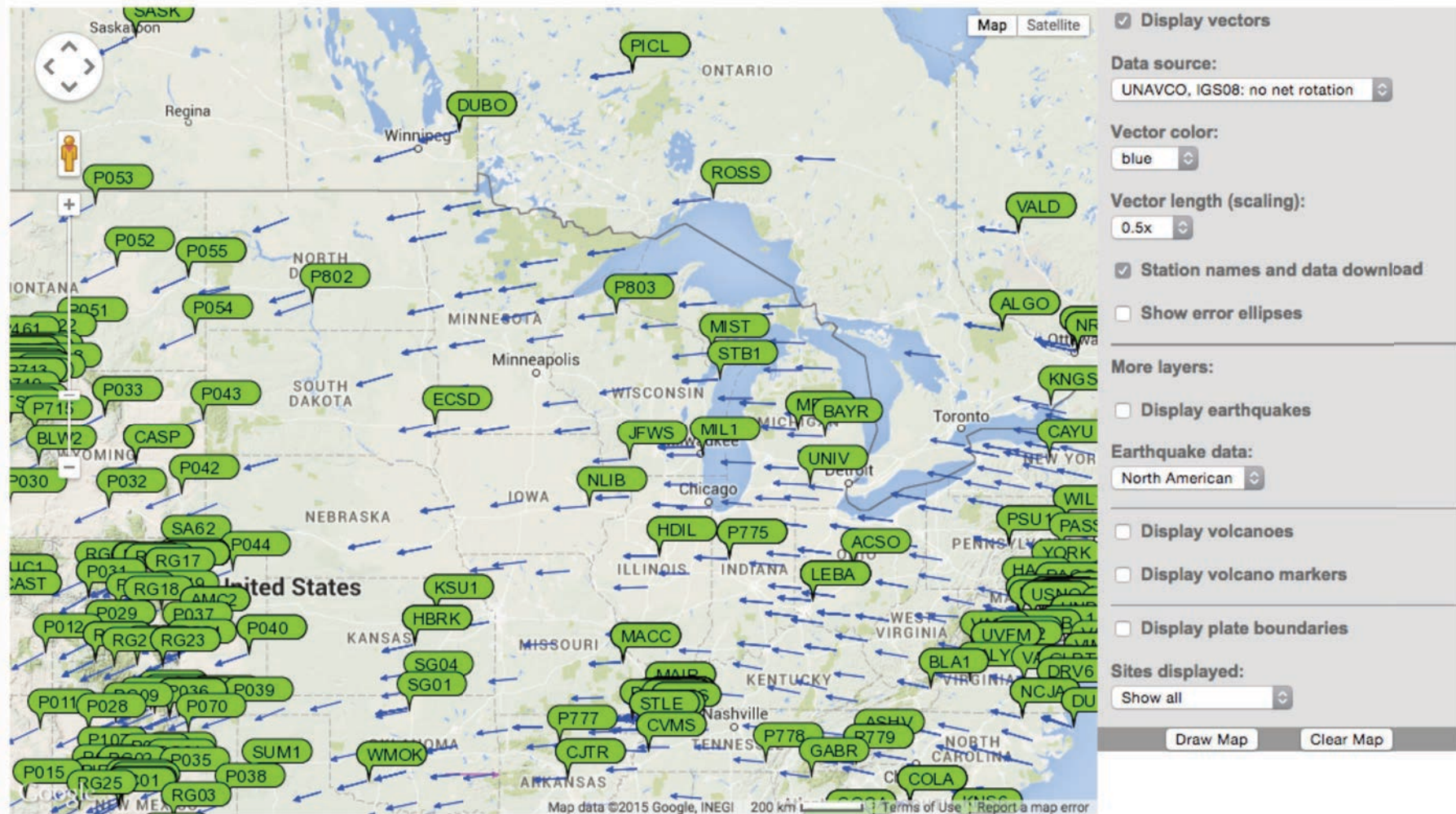
## GPS Velocity Viewer





# Plate motions from another perspective: world reference frame

## GPS Velocity Viewer



### Key

#### GPS Symbols:



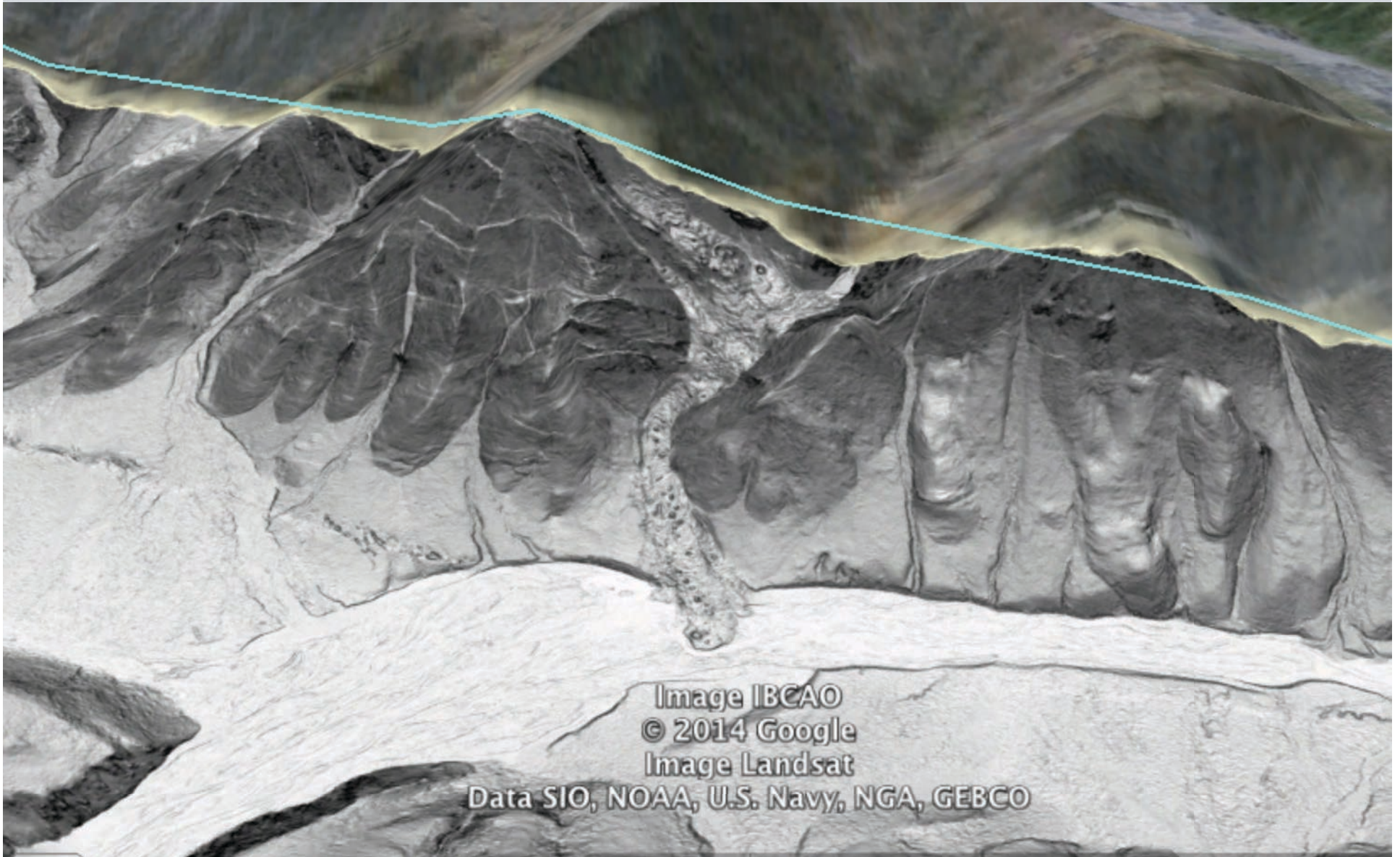
Velocity vector  
and error ellipse

25 mm/year speed scale



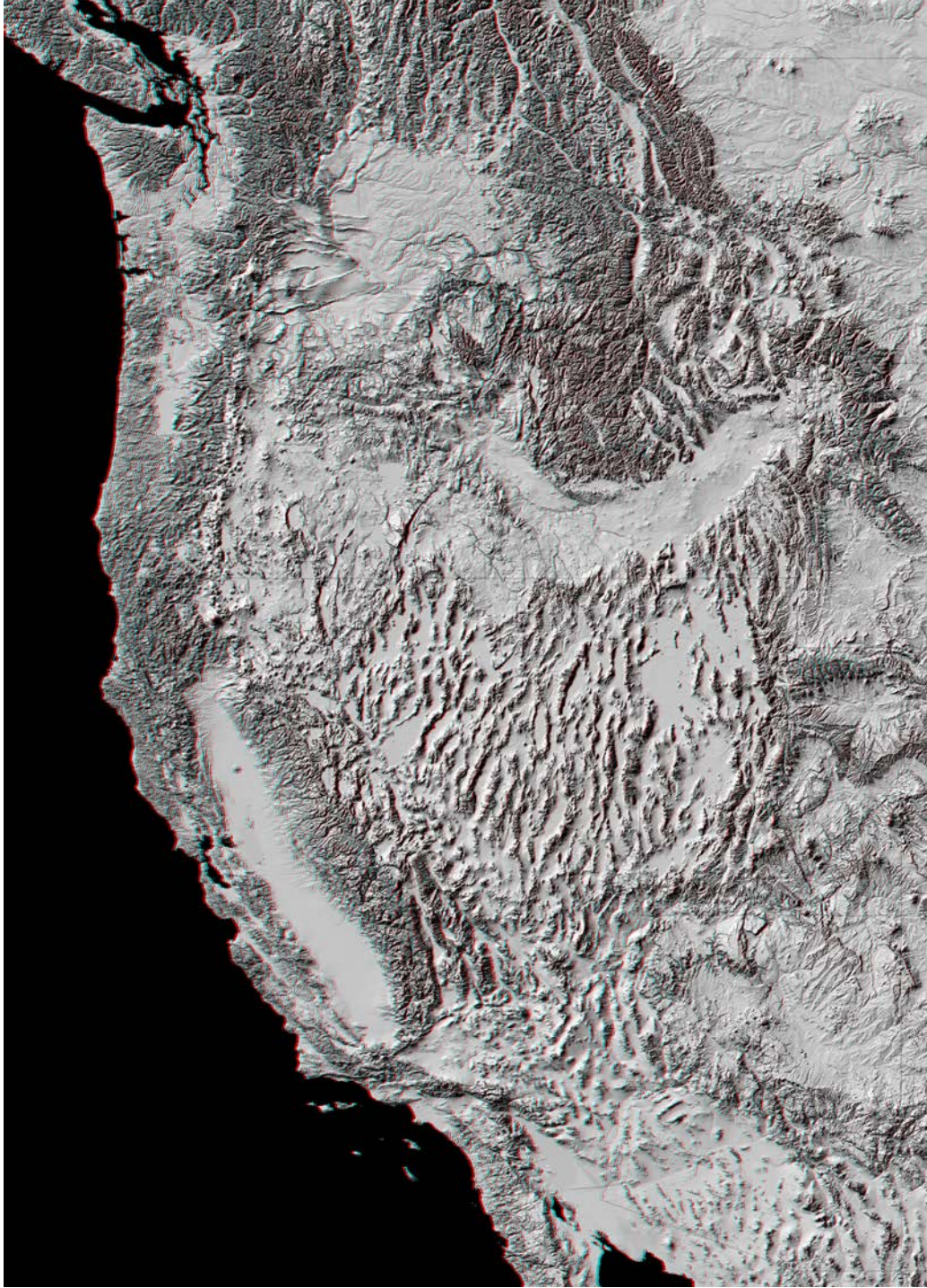
# LiDAR – looking below the trees

Open Topography: <http://www.opentopography.org/>





# Western US in 3D



WESTERN UNITED STATES



Courtesy: Parul Morin, National Center for Earth-surface Dynamics  
Data Repository  
[http://www.nced.umn.edu/Data\\_Repository.html](http://www.nced.umn.edu/Data_Repository.html)  
[retrieved on 08 March 2015]



## ● Training

Technical short courses, educational workshops, evaluation, new delivery methods

## ● Education Materials

Curriculum development (Strain module, GETSI project [NSF-TUES], existing learning materials

## ● Communications

Website, outreach materials, social media, conferences

## ● Workforce Development

RESESS, RESESS Alumni network, Science Workshop mentoring

- Tutorials & How to's
- Lessons
- Student worksheets
- Animations
- How to download data

Based on time series inversion algorithm (2001) and Berardinelli

**Computer Instructions**


Visualizing Relationships between Earthquakes, Volcanoes, and Plate Boundaries in the Western U.S. Using the EarthScope Jr. Data Tool

**Part I**  
Starting at [www.unavco.org](http://www.unavco.org)  
> Click on **maptools** under the Education and Outreach section

Click on **EarthScope Voyager Jr.** -The direct link is: <http://jules.unavco.org/VoyagerJr/EarthScope> A map of North America will load in several seconds.

Next, click on the map two times to obtain a zoom view of the western United States.

Click on map to zoom in



**Worksheet**

Visualizing Relationships between Earthquakes, Volcanoes, and Plate Boundaries

**Part I: Comparing earthquake and volcano locations**

**will need:**

- Internet access (Mac and PC-compatible) or the map packet
- Dry erase pens and transparency paper with map of Western U.S. OR color pencils

**Instructions**

Work in pairs of two. In your teams, designate one person to study the Earthquake map and one person to study the Volcano map. Separately study your designated map and answer the questions below.

**Earthquake Map Questions:** Study where earthquakes are and are not located. Mark the approximate locations of several earthquake "clusters" using a dry erase on the map of the western United States printed on a transparency or from the last page of the worksheet.

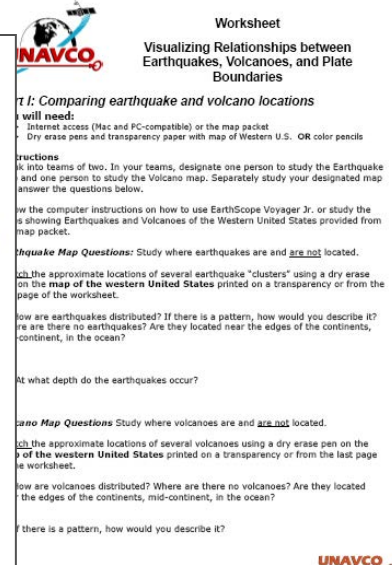
How are earthquakes distributed? If there is a pattern, how would you describe it? Are there no earthquakes? Are they located near the edges of the continents, continent, in the ocean?

At what depth do the earthquakes occur?

**Volcano Map Questions** Study where volcanoes are and are not located. Mark the approximate locations of several volcanoes using a dry erase pen on the map of the western United States printed on a transparency or from the last page of the worksheet.

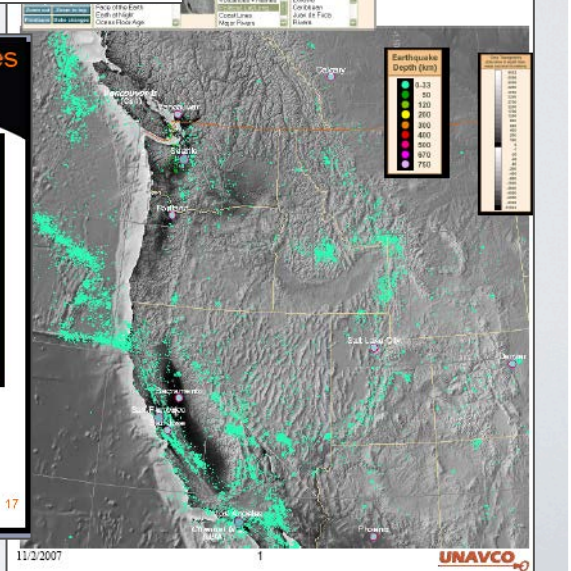
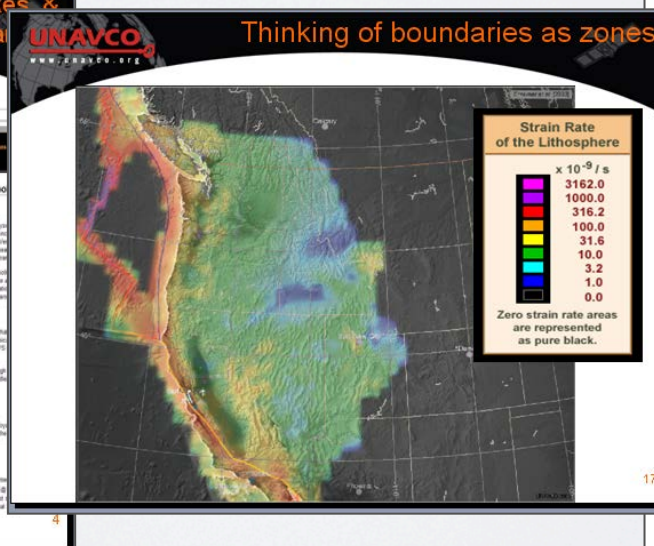
How are volcanoes distributed? Where are there no volcanoes? Are they located near the edges of the continents, mid-continent, in the ocean?

If there is a pattern, how would you describe it?



**Part I: Comparing Locations of Earthquakes & Volcanoes**

Go to: <http://www.unavco.org/>



# UNAVCO Highlights, and Snapshots reading literacy with science



We challenge ourselves to transform human understanding of the changing Earth by enabling the integration of innovative technologies, open geodetic observations, and research, from pole to pole.

## WHAT'S HOT [view all »](#)

New Video: UNAVCO (Explained in 3 Minutes).

Notice to UNAVCO GPS Data Product Users: File Format Update on March 25th 2013.

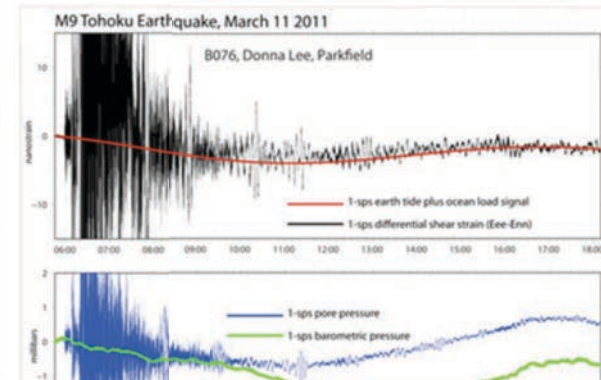
## HIGHLIGHTS [view all »](#)



**Event Response:**  
**Mw 8.2 Earthquake 95km NW of Iquique, Chile**  
April 3, 2014


A magnitude Mw 8.2 earthquake ruptured the subduction zone off the coast of northern Chile at 11:46:46 p.m. GMT on April 1, 2014. The event occurred in the "Iquique seismic gap", a...

## SCIENCE SNAPSHOTS [view all »](#)




**UNAVCO's Strainmeters Record the Arrival of Tsunamis on the west coast of North America**  
August 15, 2012

UNAVCO's Plate Boundary Observatory includes 75 borehole strainmeters installed predominantly throughout the west coast of North America. Strainmeters work by detecting changes in the size of the borehole, and are...



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[Instrumentation](#)
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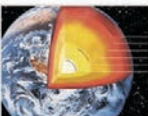


UNAVCO, A NON-PROFIT UNIVERSITY-GOVERNED CONSORTIUM, FACILITATES GEOSCIENCE RESEARCH AND EDUCATION USING GEODESY.

Solid Earth  
Cryosphere  
Environmental & Hydrogeodesy  
Ocean  
Atmosphere  
Human Dimensions  
Technology


## Science

UNAVCO is a university-governed consortium uniquely positioned to advance and support the geodesy community's science goals. Over the last decade, UNAVCO's scope has expanded significantly with many **Collaborations** to serve new science communities and including those who focus on the deformation of ice, the Earth's response to ground water, sea level, and other aspects of the hydrosphere, and renewed interest in imaging the structure of the atmosphere. **Community Science** showcases the UNAVCO community's applications of space geodesy and science products, and highlights their science.




### Solid Earth

Earth and the tools we use to study it are constantly changing. The tectonic plates are continuously in motion, though so slowly that even with our highest precision instruments we need months or years of observations to measure it. Over the last several decades, the advent of space-based geodetic techniques have improved our ability to measure tectonic plate motion by several orders of magnitude in spatial and temporal resolution



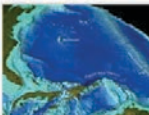


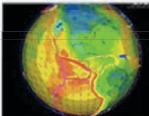
### Cryosphere

Ice covers approximately 10% of Earth's land surface at the present, with most of the ice mass being contained in the Greenland and Antarctica continental ice sheets. Designing and undertaking geodetic experiments that enable researchers to improve our understanding of ice



### Environmental & Hydrogeodesy

Through its sensitivity to mass redistribution and accurate distance measurements, geodesy is uniquely posed to answer fundamental questions about issues relating to water and the environment. Geodetic observations are enabling us, for the first time, to follow the motion of water within Earth's system at global

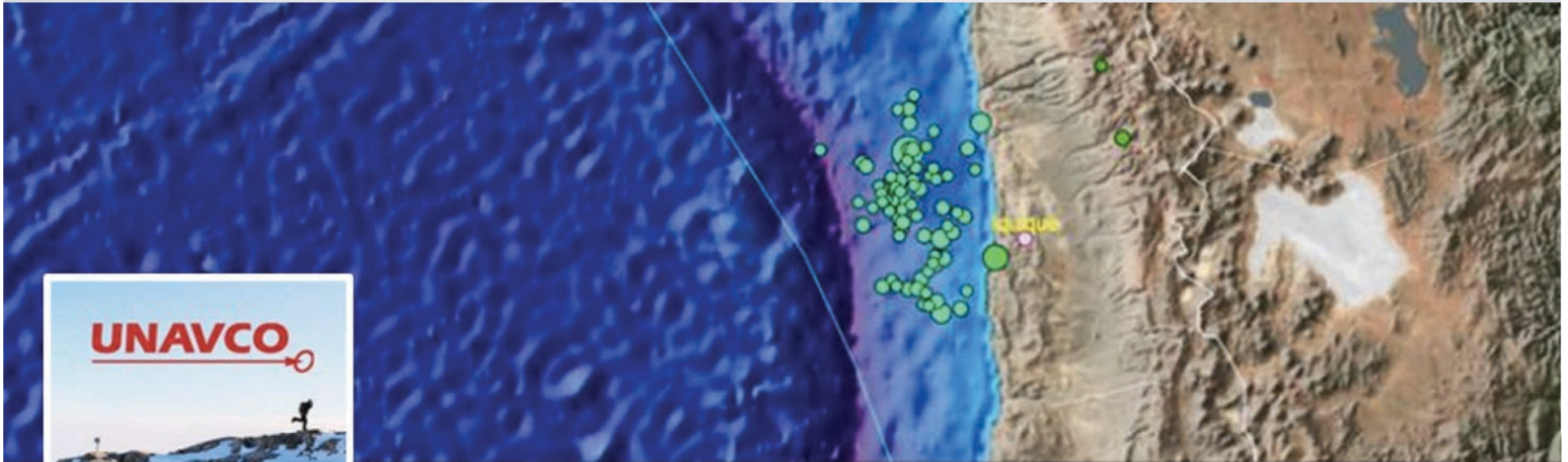
|  |  |
|--|--|
|  <h3>Ocean</h3>              | <p>Seventy five percent of Earth's crust is unobservable using solely electromagnetic energy-based geodetic techniques. Seafloor geodesy can now expand geodetic positioning to off-shore</p> <p>environments. Researchers can see the effects of changes in Earth's crust far beyond what we can measure with instruments placed solely on dry land.</p> <p><a href="#">Ocean Science Snapshots »</a></p>   |
|  <h3>Atmosphere</h3>        | <p>Space geodesy utilizes electromagnetic signals propagating through the atmosphere of Earth, providing information on tropospheric temperature and water vapor and on ionospheric</p> <p>electron density. Thus, in the early twenty-first century, the goal of geodesy has evolved to include study of the kinematics and dynamics of both Earth's atmosphere and the solid Earth.</p> <p><a href="#">Atmosphere Science Snapshots »</a></p>  |
|  <h3>Human Dimensions</h3> | <p>Natural hazard mitigation, the effects of climate change, and optimum use of water resources are major areas of concern for humankind today. Geodetic research associated with earthquakes and volcanoes have far-reaching goals of providing early warnings and mitigating future</p> <p>hazard events on a global scale. As the population density increases and more people live in proximity to seismically active faults, understanding the nature of earthquakes remains a vital goal of the Earth sciences.</p> <p><a href="#">Human Dimensions Science Snapshots »</a></p>                                      |
|  <h3>Technology</h3>       | <p>The incorporation and calibration of new technologies as an extension of geodetic research is a burgeoning opportunity that is being avidly embraced by the scientific community. High-resolution images and 3D/4D topography maps both inspire and facilitate field-based tests of a</p> <p>new generation of quantitative models of mass transport mechanisms. Open access to data, tools and facilities for processing, analysis, and visualization, and new algorithms and workflows are transforming the landscape of geodetic scientific collaboration.</p> <p><a href="#">Technology Science Snapshots »</a></p> |





## Social Media

Follow UNAVCO on   Facebook



**UNAVCO**  
5.0 ★★★★★

(5 ratings)

959 likes · 100 talking  
about this · 52 were  
here

Update Page Info

 Like

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Message



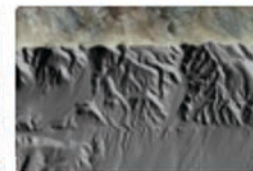
Non-Profit Organization

UNAVCO, a non-profit university-governed consortium, facilitates geoscience research and education using geodesy.

About



Photos



Events

 959



Likes

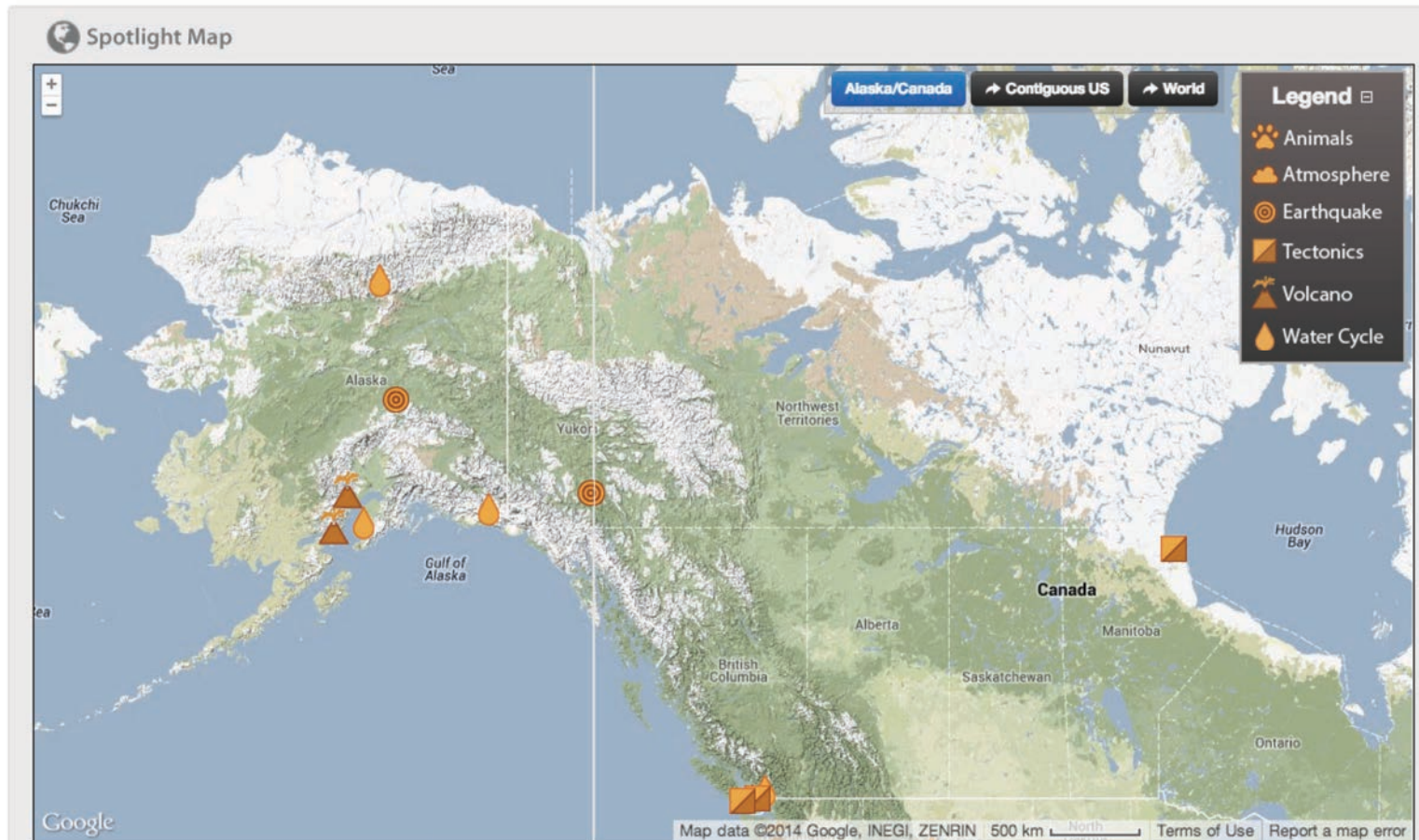
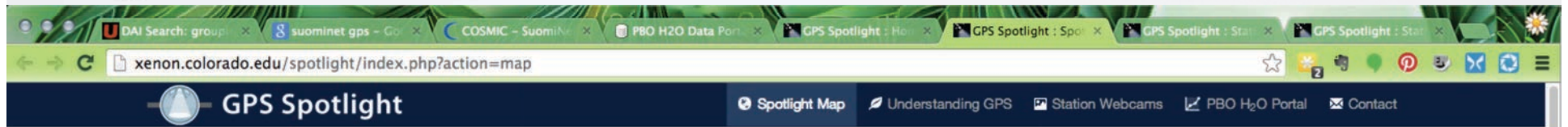


# Exhibits





# GPS Spotlights



<http://xenon.colorado.edu/spotlight/index.php?action=map>



# Data for Educators for resources you can use

## GPS data that show... ... tectonic plates moving

### GPS Data Products

| Station Id | Location                      |
|------------|-------------------------------|
| ALBH       | Albert Head, Victoria, Canada |
| BEMT       | Twentynine Palms, CA          |
| NEAH       | Neah Bay, WA                  |
| SBCC       | Mission Viejo, CA             |
| SEAT       | Seattle, WA                   |

### Educational resources using these stations

- Using GPS Time Series Plots to Determine Plate Motion in California
- Using GPS Data to Visualize the Influence of a Subducting Plate in the Pacific Northwest
- Visualizing Relationships between Earthquakes, Volcanoes, and Plate Boundaries in the Western United States
- Episodic Tremor and Slip: The Case of the Mystery Earthquakes

## ... movement on different sides of a fault

### GPS Data Products

| Station Id | Location             |
|------------|----------------------|
| BEMT       | Twentynine Palms, CA |
| SBCC       | Mission Viejo, CA    |

### Educational resources using these stations

- Using GPS Time Series Plots to Determine Plate Motion in California
- Visualizing Relationships between Earthquakes, Volcanoes, and Plate Boundaries in the Western United States

## ... rebound of plates after an earthquake!

### GPS Data Products

| Station Id | Location      |
|------------|---------------|
| CAND       | Parkfield, CA |
| CARH       | Parkfield, CA |

### Educational resources using these stations

- Using GPS Time Series Plots to Determine Plate Motion in California

## ... movement on a subduction zone

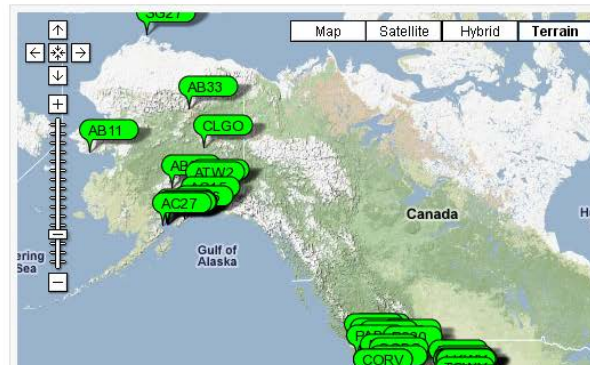
### GPS Data Products

| Station Id | Location          |
|------------|-------------------|
| NEAH       | Neah Bay, WA      |
| PABH       | Pacific Beach, WA |
| P020       | Lind, WA          |
| SC03       | Ellensburg, WA    |
| SEAT       | Seattle, WA       |

### Educational resources using these stations

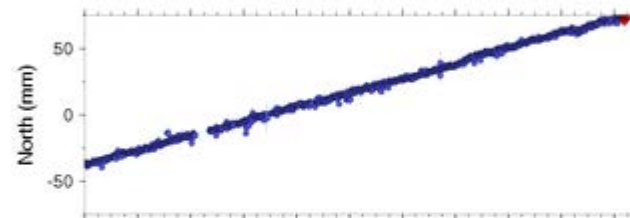
- Using GPS Data to Visualize the Influence of a Subducting Plate in the Pacific Northwest
- Visualizing Relationships between Earthquakes, Volcanoes, and Plate Boundaries in the Western United States
- Episodic Tremor and Slip: The Case of the Mystery Earthquakes

## Selected GPS Stations



## Station Information: SLAC

### Time Series Plot



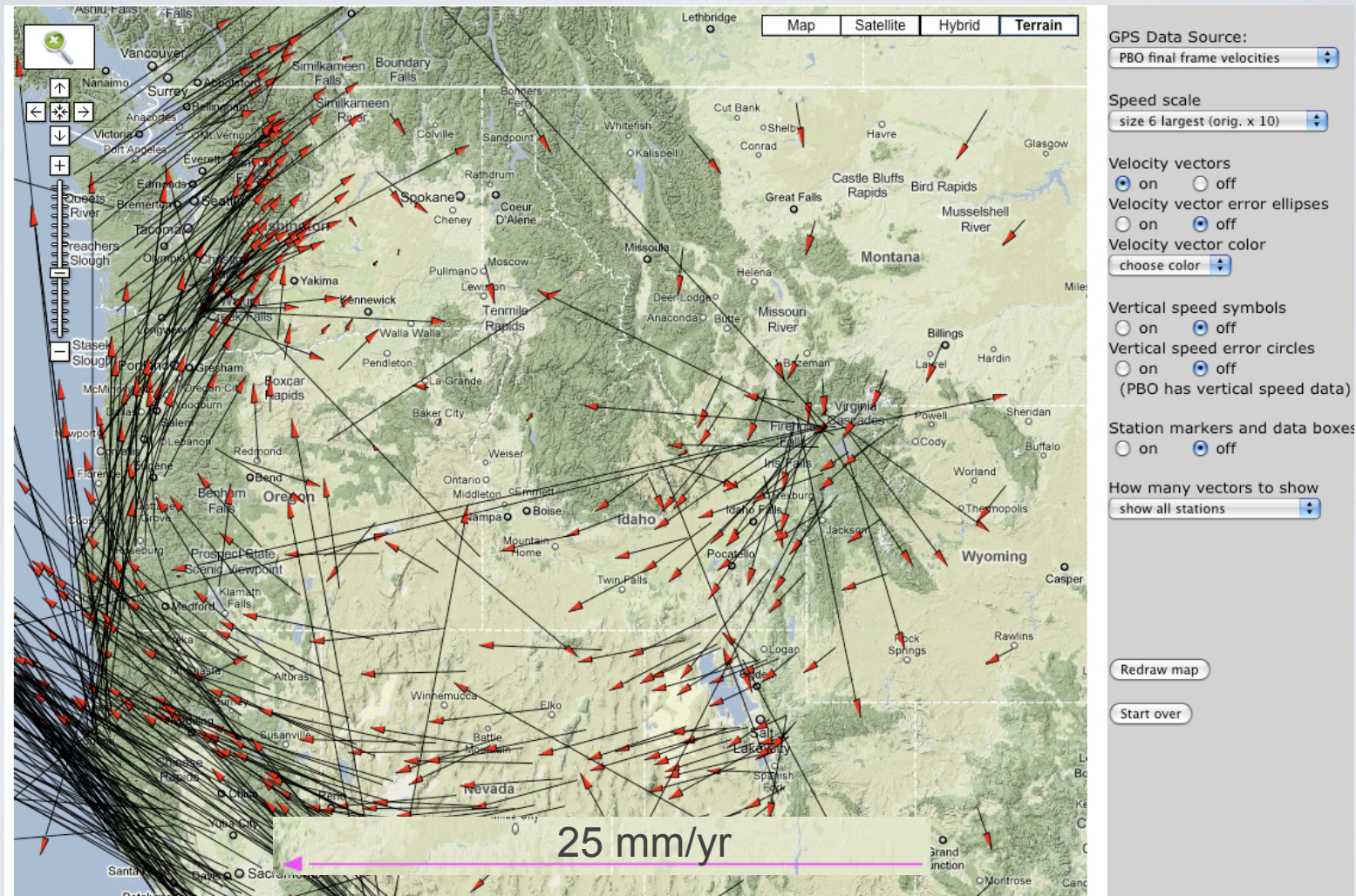
Download Time Series Data  
Excel-compatible format - [CSV]

- Visual display of station locations
- Interesting data
- Full data plot
- Quick data preview
- Excel readable formats
- Associated learning activities

[http://www.unavco.org/edu\\_outreach/data.html](http://www.unavco.org/edu_outreach/data.html)



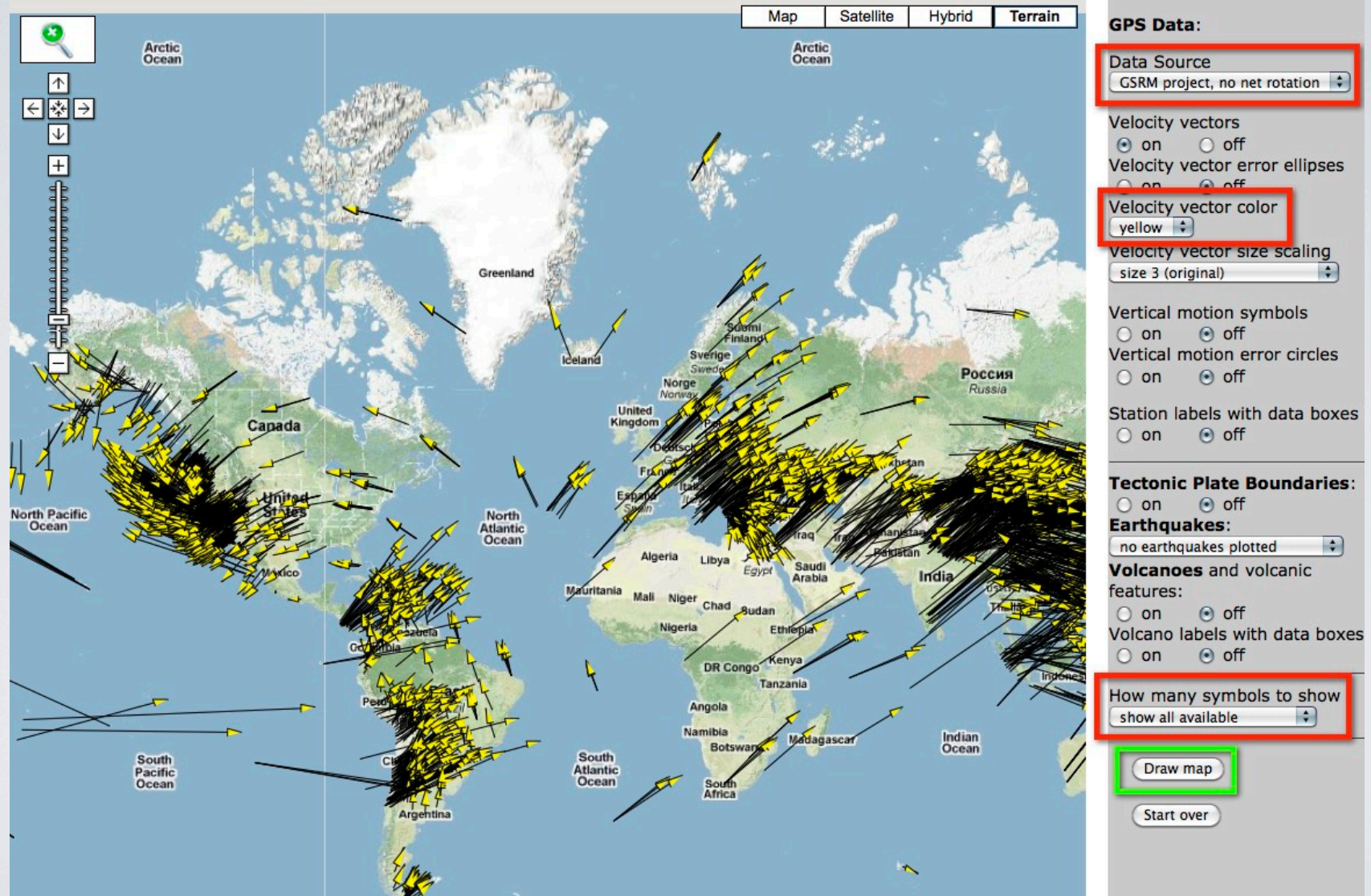
# Use Data Tools



Data Source: UNAVCO Plate Boundary Observatory: North American Reference Frame  
UNAVCO GPS Velocity Viewer



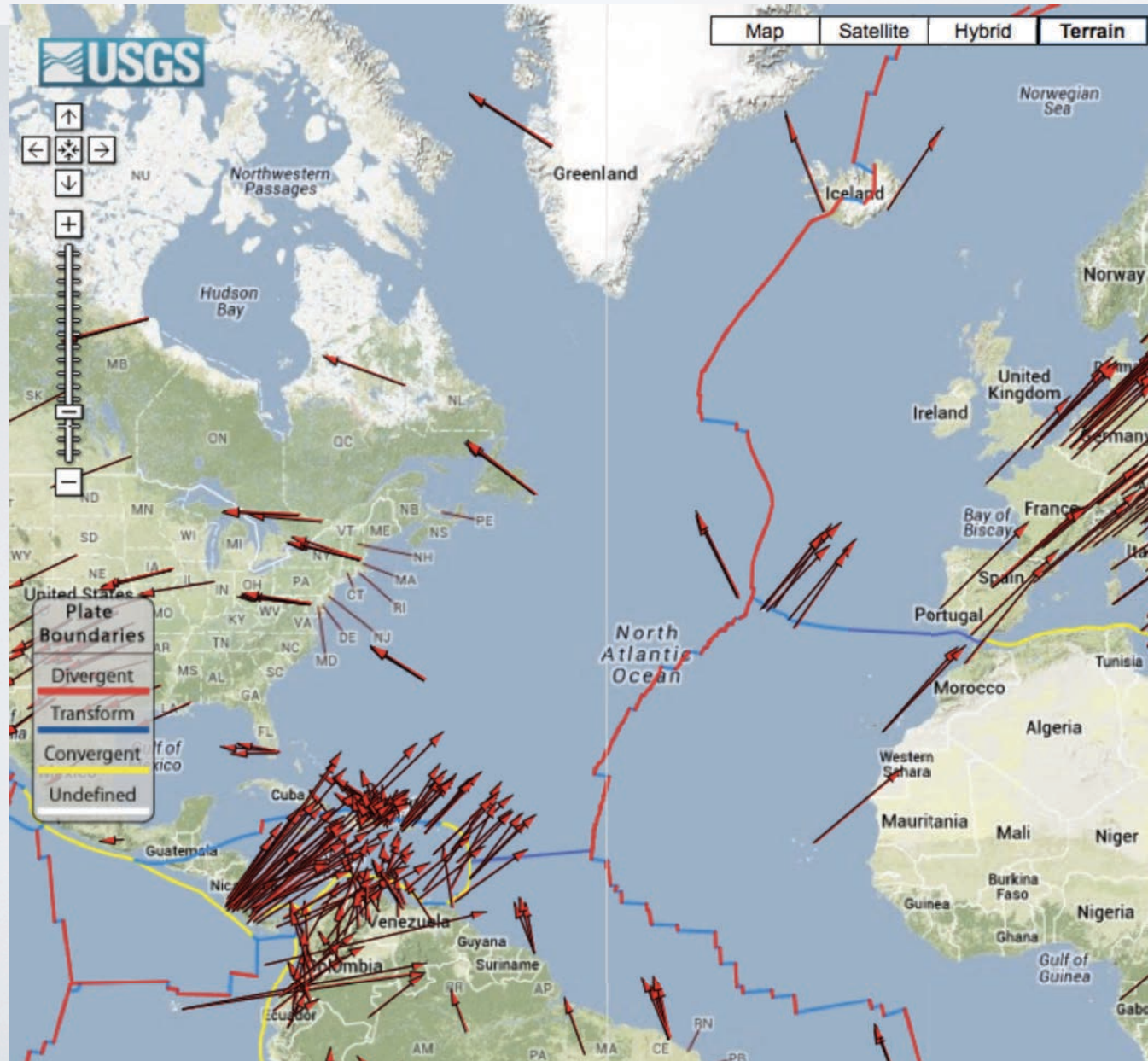
# GPS Velocity Viewer



Data source: Global Strain Rate Map Project ; Reference Frame: No Net Rotation  
 UNAVCO GPS Velocity Viewer:  
<http://facility.unavco.org/data/maps/GPSVelocityViewer/GPSVelocityViewer.html>

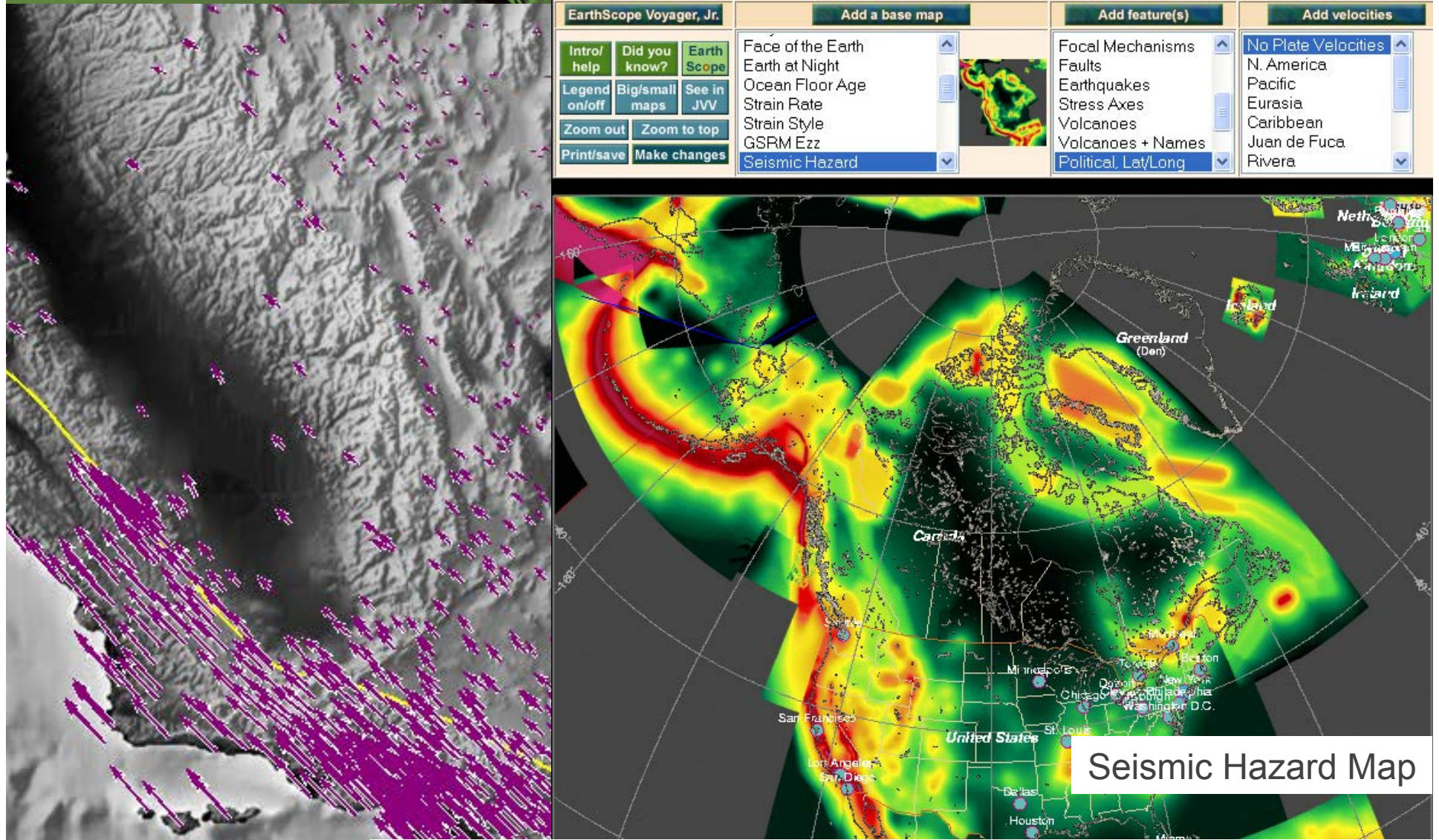


# Comparing Plate Movement





# Jules Verne & EarthScope Voyager Jr.

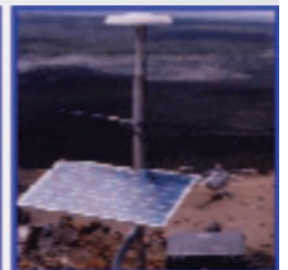


Velocity Vector

[http://www.unavco.org/edu\\_outreach/maptools.html](http://www.unavco.org/edu_outreach/maptools.html)



- Plate movement
- Earthquakes
- Volcanoes
- Glacial movements and isostatic adjustment
- Hydrologic changes
- Atmospheric – water vapor





# Study & Apply Geodesy & Measuring Gravity

Geodesy is the science of ...  
measuring Earth's

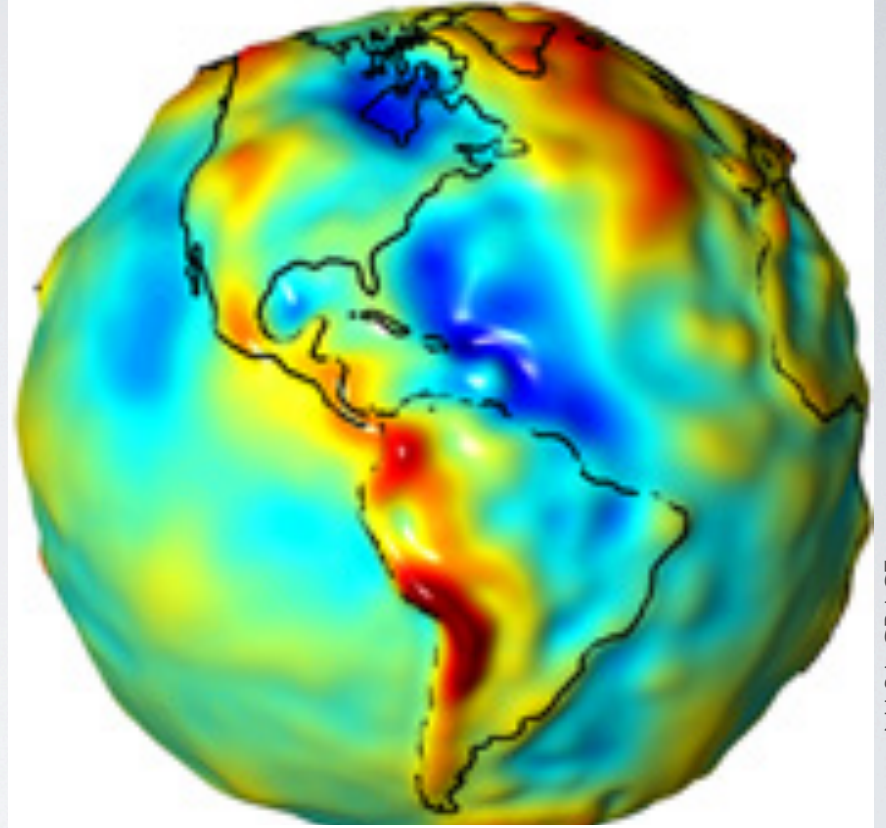
**size**, *shape*

*orientation*,

Gravitational *Field*

And

variations of these  
with time



NASA GRACE

Map showing variations in the strength of  
the gravitational force over the surface of  
the Earth

Blue = less gravity  
Red = more gravity



# Anatomy of a High-precision Permanent GPS Station



GPS antenna inside of dome

Monument solidly attached into the ground with braces.

**If the ground moves, the station moves.**

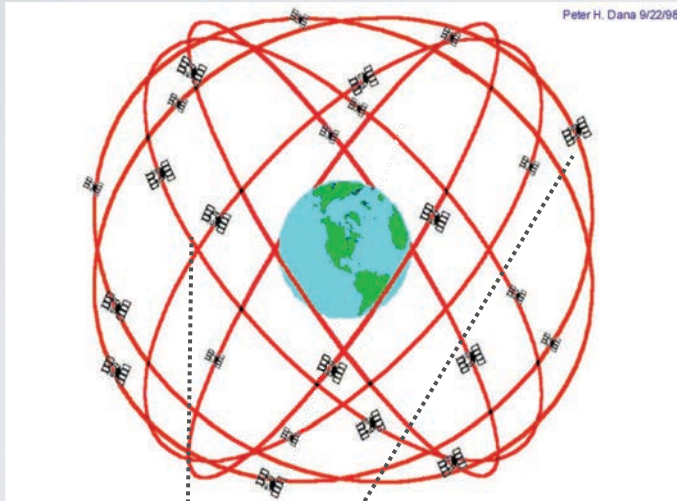
Solar panel for power

Equipment enclosure

- GPS receiver
- Power/batteries
- Communications/ radio/ modem
- Data storage/ memory



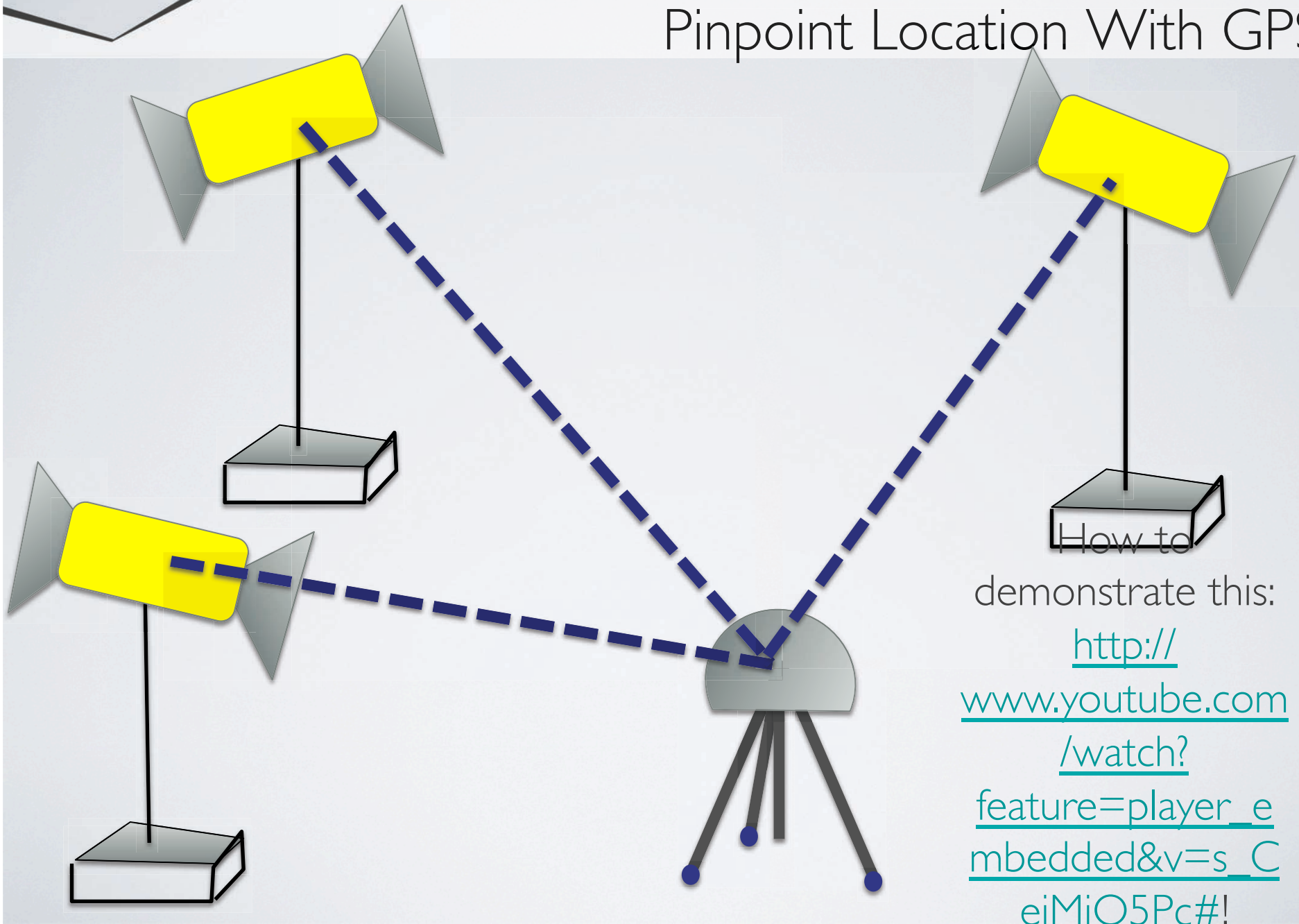
# Introduction: GPS Basics



- Four satellite signals are needed to locate the receiver in 3D space.
- The fourth satellite is also used for time accuracy.
- Position can be calculated within to a millimeter.
- Needs ground control and time quality



# Demonstration Pinpoint Location With GPS

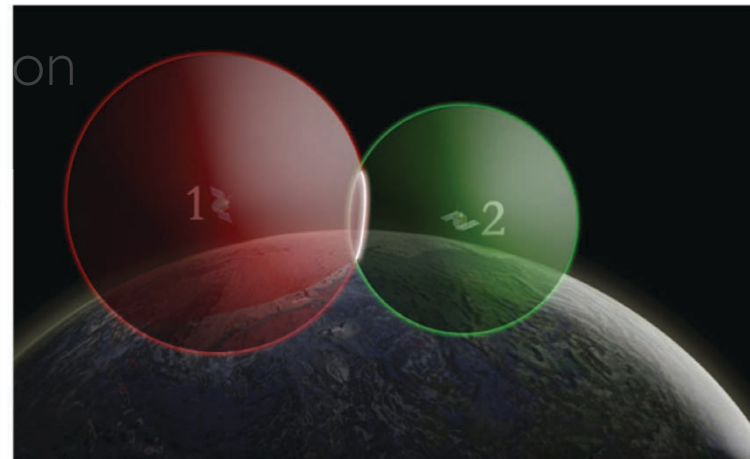
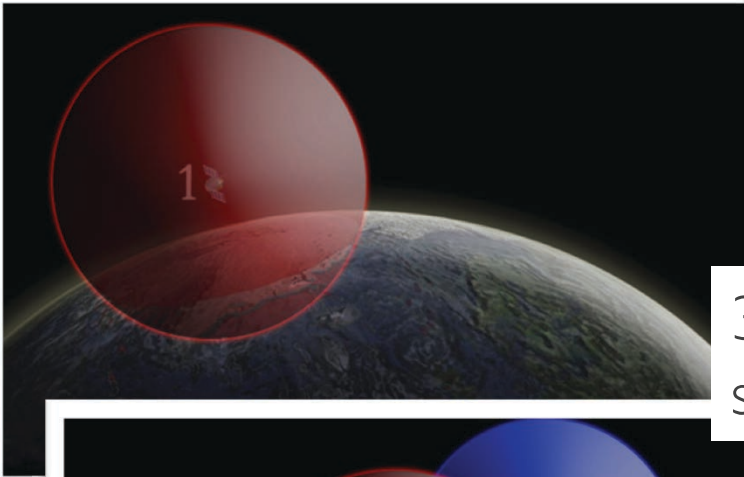


How to  
demonstrate this:  
[http://  
www.youtube.com  
/watch?  
feature=player\\_e  
mbedded&v=s\\_C  
eiMiO5Pc#!](http://www.youtube.com/watch?feature=player_embedded&v=s_CeiMiO5Pc#!)



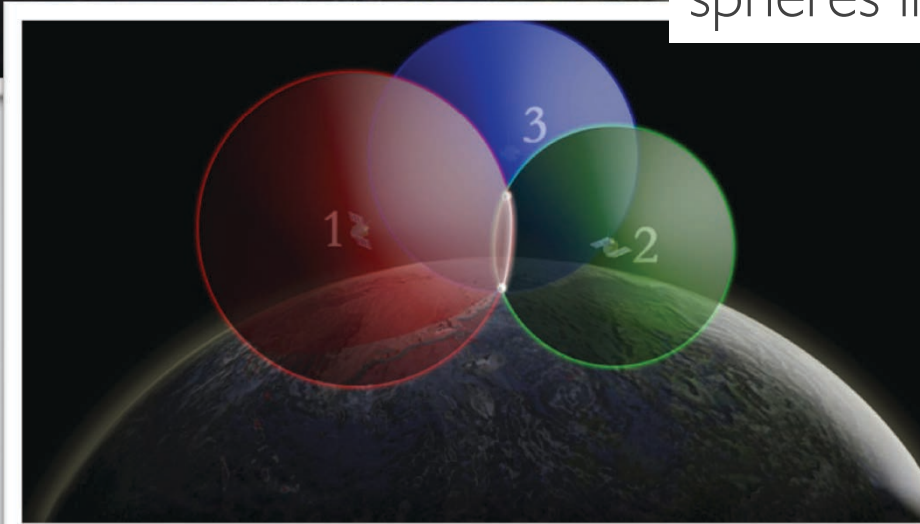
# One way to find your location – 4 intersecting spheres

One satellite,  
the GPS could be anywhere on  
the edge of the sphere.



Two satellites,  
GPS could be  
on the circle  
where  
spheres  
intersect.

3 satellites:  
spheres intersect in 2 places.



4 satellites,  
spheres  
intersect in  
one place.



# Thank You!

Contact: Shelley Olds

[Education –at- unavco.org](mailto:Education-at-unavco.org)

<http://www.unavco.org/>

Follow UNAVCO on



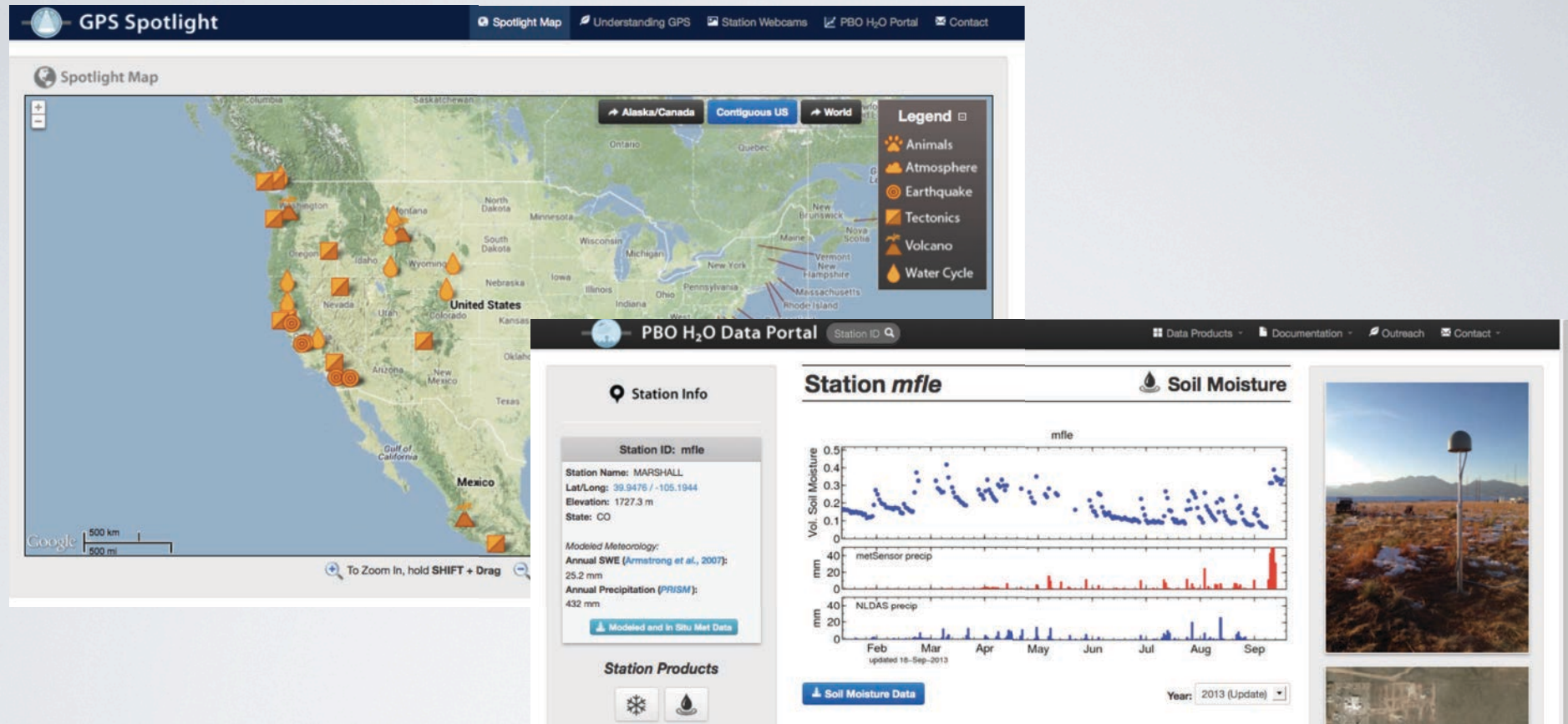
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Facebook Twitter



# Websites shown during demonstration

Learn more about how GPS works and the science learned through research



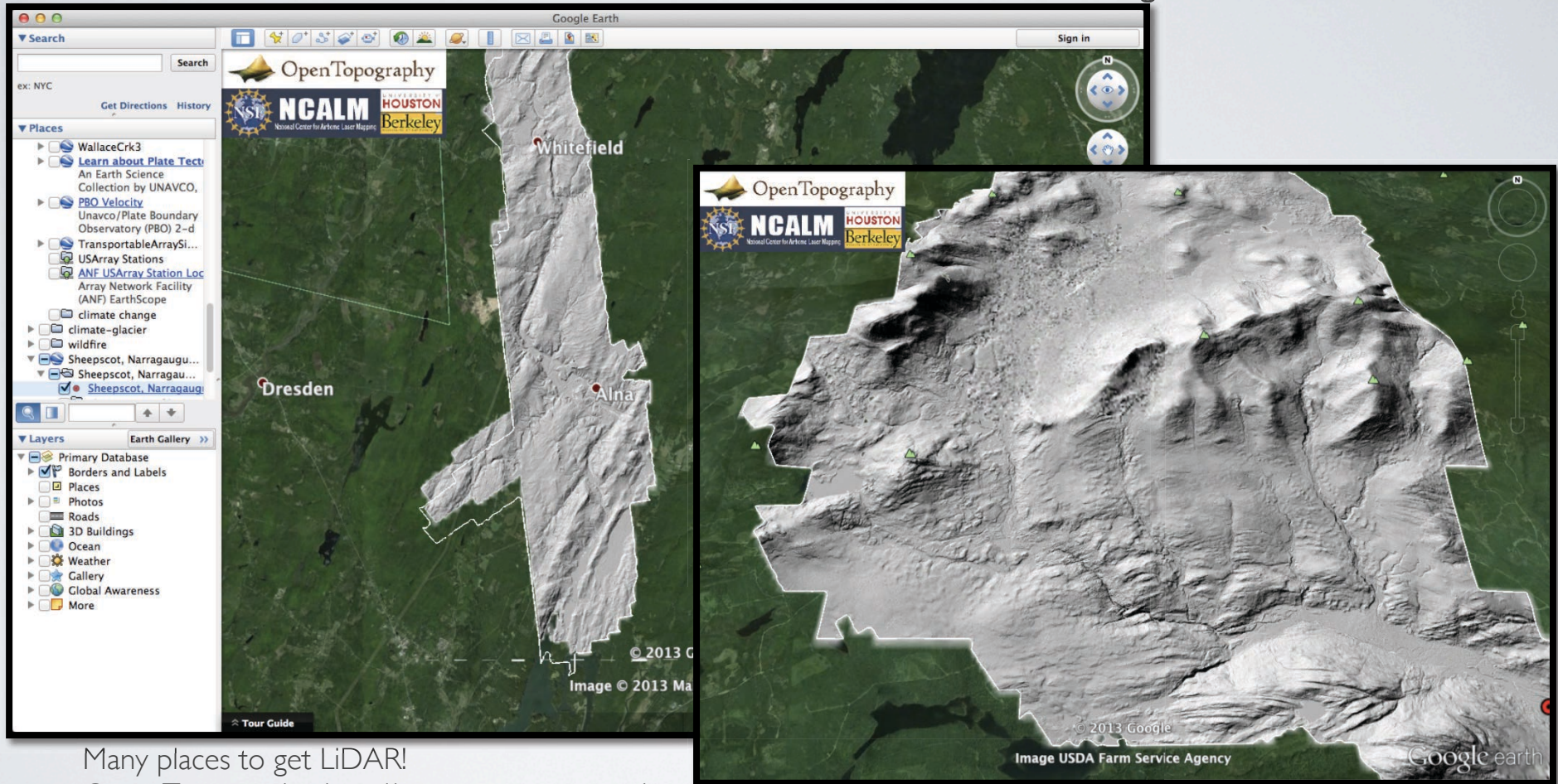
GPS Spotlight: <http://xenon.colorado.edu/spotlight/index.php>

PBO H<sub>2</sub>O: <http://xenon.colorado.edu/portal/index.php>



# Websites shown during demonstration

See the ground and forests with LiDAR



Many places to get LiDAR!

Open Topography: <http://www.opentopography.org/>

New York: <http://gis.ny.gov/elevation/lidar-coverage.htm>

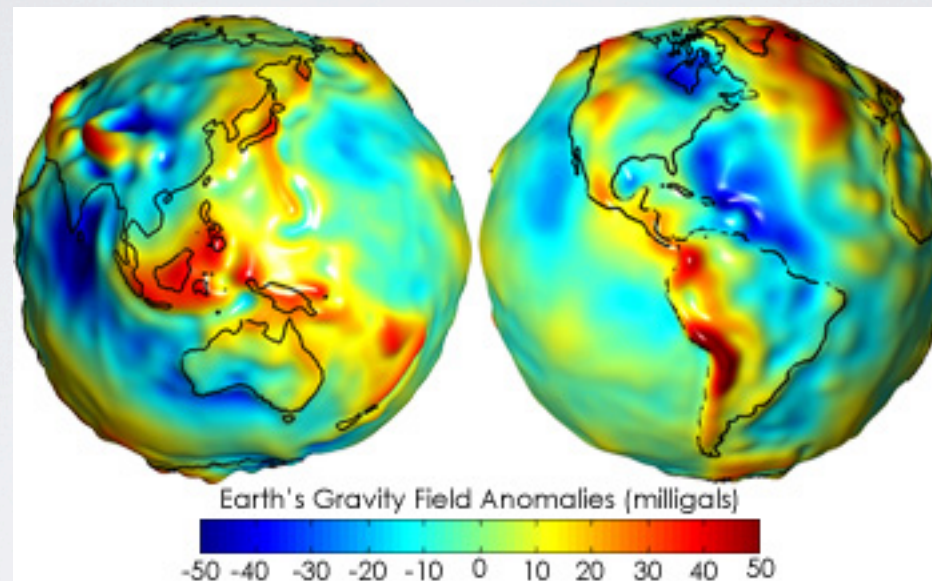
Maine: <http://www.maine.gov/megis/projects/lidar.shtml>

Vermont: [http://vcgi.vermont.gov/warehouse/products/ALL-LDR\\_MIX\\_LIDAR\\_STATE\\_ALL](http://vcgi.vermont.gov/warehouse/products/ALL-LDR_MIX_LIDAR_STATE_ALL)

New Hampshire: <http://www.granit.unh.edu/resourcelibrary/specialtopics/lidar/>



# About GRACE



<http://earthobservatory.nasa.gov/Features/GRACE/page3.php>



# Measuring the Plates Move

